

2017 ELECTRICAL**12 V Starting and Charging - Bolt EV****SPECIFICATIONS****FASTENER SPECIFICATIONS****Reusable Threaded Fastener Tightening Specifications**

Application	Specification
	Metric (English)
NOTE: <i>All fasteners listed in this table can be reused after removal.</i>	
Auxiliary Battery Negative Cable Fastener	22 N.m (16 lb ft)
Auxiliary Battery Positive Cable Fastener	22 N.m (16 lb ft)
Auxiliary Battery Positive Cable Nut	22 N.m (16 lb ft)
Battery Distribution Fuse Block Nut	22 N.m (16 lb ft)
Battery Negative Cable Clamp Ground Wire Fastener	5 N.m (44 lb in)
Battery Negative Cable Extension Cable Fastener - Lower	22 N.m (16 lb ft)
Battery Negative Cable Extension Cable Fastener - Upper	15 N.m (11 lb ft)
Battery Negative Cable Fastener	5 N.m (44 lb in)
Battery Negative Cable Nut	9 N.m (80 lb in)
Battery Positive and Negative Cable Ground Nut	22N.m (16 lb in)
Battery Positive Cable Clamp Fastener	5 N.m (44 lb in)
Battery Positive Cable Nut - 12V battery	22 N.m (16 lb in)
Battery Positive Cable Nut - Module	15 N.m (11 lb ft)
Battery Retainer Assembly Bolt	8 N.m (71 lb in)
Battery Tray Bolt	11.5 N.m (102 lb in)
Battery Tray Support Nut	9 N.m (80 lb in)
Body Wiring Harness Nut	5 N.m (44 lb in)
Engine Wiring Harness Bracket Bolt	9 N.m (80 lb in)
Engine Wiring Harness Bracket Nut	9 N.m (80 lb in)
Engine Wiring Harness Junction Block Bolt	1.5 N.m (13 lb in)

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

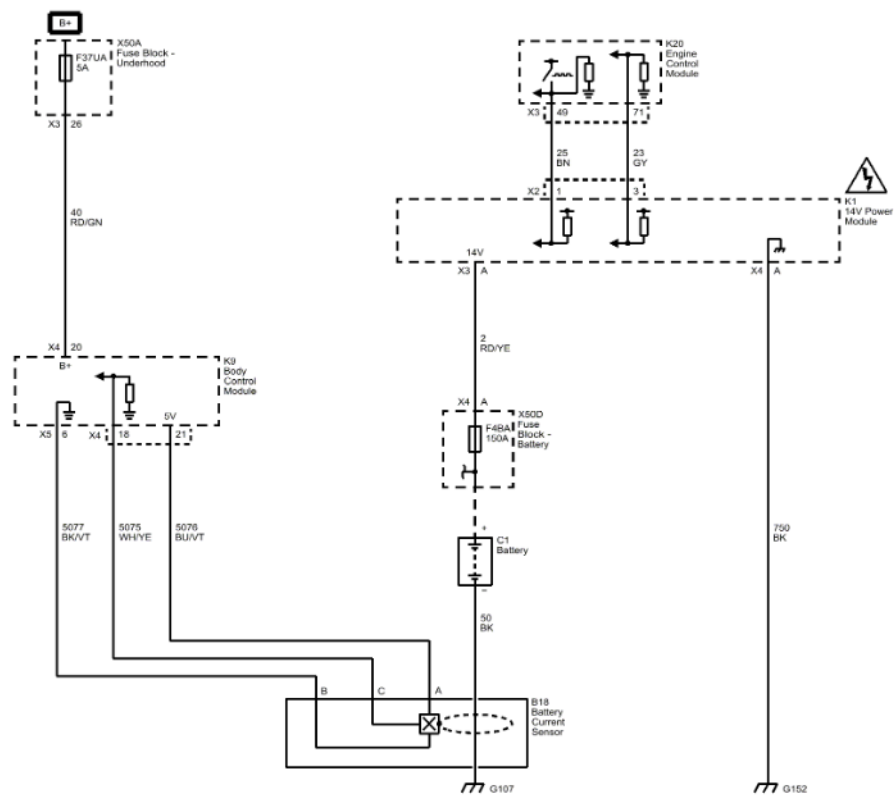


Fig. 1: 12V Battery Management

Courtesy of GENERAL MOTORS COMPANY

DIAGNOSTIC INFORMATION AND PROCEDURES

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

Diagnostic Instructions

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

DTC Descriptors

DTC 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. Vehicle OFF, disconnect the T18 battery charger cord set. Measure and record the 12 V battery voltage at the battery terminals. The battery voltage should stabilize between 12.4 and 12.8 V within a few minutes of turning the Vehicle OFF.
 - If not within the specified range, refer to **Battery Inspection/Test**.

2. Vehicle ON, accessories OFF, measure and record the 12 V battery voltage at the battery terminals. The voltage should be at least 0.5 V greater than the voltage measured in step 1 but less than 15 V.
 - If not within the specified range, refer to [DC Power Conversion Test](#).
3. Observe the appropriate module scan tool B+ and ignition voltage parameters. The voltage readings should be within 1 V of the battery voltage.

Circuit/System Testing

NOTE: Use the schematic to identify the following:

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

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

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

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

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	-	-

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
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 08

The BCM is awake.

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 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](#)

Scan Tool Reference

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 B 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 ON.
4. Test for 4.8 - 5.2 V between the 5 V reference circuit terminal A and ground.
 - **If less than 4.8 V**
 1. 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 ON.
 2. Test for less than 1 V between the 5 V reference circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8 - 5.2 V**
5. Test for 4.8 - 5.2 V between the signal circuit terminal C and ground.
 - **If less than 4.8 V**
 1. 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 ON.
 2. Test for less than 1 V between the signal circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8 - 5.2 V**
6. Test or replace the B18 Battery Current Sensor.

B1516 66

1. Verify that the B18 Battery Current Sensor is installed securely around the negative battery cable, with the tape tab pointing away from the negative terminal on the C1 Battery.

cardiagn.com

 - **If the B18 Battery Current Sensor is not installed correctly**

Remove and reinstall the B18 Battery Current Sensor properly.

- **If the B18 Battery Current Sensor is installed correctly**

2. Replace the B18 Battery Current Sensor.

Repair Instructions

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

- [Battery Current Sensor Replacement](#)
- [Control Module References](#) for BCM replacement, programming, and setup.

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

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 P0AF7: 14V POWER MODULE HIGH TEMPERATURE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: [Diagnostic System Check - Vehicle](#)
- Review the description of Strategy Based Diagnosis: [Strategy Based Diagnosis](#)
- An overview of each diagnostic category can be found here: [Diagnostic Procedure Instructions](#)

DTC Descriptor

DTC P0AF7

14V Power Module High Temperature

Circuit/System Description

The 14 V power module, also called the accessory DC power control module. The 14 V power module is an electronic device that takes the place of the generator on a traditional vehicle. On a hybrid or electric vehicle the 14 V power module converts high voltage (300 V) direct current (DC) to low voltage (12 V) DC for accessory electrical operation and to charge the 12 V battery. Normally, the 14 V power module only supplies 12 V DC when the vehicle is under a normal drive cycle. There are certain instances when the vehicle is being charged through a standard wall socket where the 14 V power module operation is required to sustain the 12 V battery. The 14 V power module is capable of supplying up to 130 Amps of 12 V DC.

Conditions for Running the DTC

- The ignition is ON.
- The run/crank voltage is 9 V or greater.

Conditions for Setting the DTC

The 14V Power Module Status is Voltage Conversion Disabled or Limited - Due to High Operating Temperature.

Actions Taken When the DTC Sets

- The charging system light will illuminate, and Service Battery Charging System will display on the Driver Information Center.
- DTC P0AF7 is a Type C DTC.

Conditions for Clearing the DTC

DTC P0AF7 is a Type C DTC.

Diagnostic Aids

This DTC may set due to inadequate cooling of the 14V power module. A faulty hybrid/EV electronics coolant pump, hybrid/EV electronics coolant fan, or restricted coolant lines could cause high 14V power module operating temperatures.

Reference Information

Schematic Reference

- [Hybrid/EV Controls Schematics](#)

Description and Operation

- [Hybrid Modes of Operation Description](#)
- [Hybrid/EV Cooling System Description and Operation](#)

DTC Type Reference

[Powertrain Diagnostic Trouble Code \(DTC\) Type Definitions](#)

[Circuit/System Verification](#)

1. Inspect for proper coolant level in the radiator surge tank.

- **If coolant level is low**

Refer to [Drive Motor Generator Power Inverter Module Cooling System Draining and Filling](#) .
Repair the cause of low coolant level.

- **If coolant level is OK**

2. Inspect the hybrid/EV cooling system for leaks.

- **If a leak is found**

Repair or replace the leaking component. Refer to the appropriate repair.

- **If a leak is not found**

3. Inspect the hybrid/EV cooling hoses for pinches or obstructions.

- **If a concern is found**

Repair or replace hoses as necessary.

- **If a concern is not found**

4. Inspect the hybrid/EV electronics cooling system radiator for debris or obstruction.

- **If a concern is found**

Repair or replace the restricted or damaged components as necessary.

- **If a concern is not found**

5. Inspect for proper operation of the hybrid/EV system coolant pump.

- **If a concern is found**

Repair or replace the coolant pump as necessary.

- **If a concern is not found**

6. If the DTC sets: Replace - 14V Power Module

[Repair Instructions](#)

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

For replacement of 14V Power Module - [Accessory DC Power Control Module Replacement](#)

DTC U3001, U3003, U3006-U3009, U3013, U3014, U3018, U3019, OR U3500-U350B: CONTROL MODULE

[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 U3001](#)

Control Module Improper Shutdown

DTC U3003

Battery Voltage

DTC U3006

Control Module Input Power 1

DTC U3007

Control Module Supply Circuit 2

DTC U3008

Control Module Ground 1

DTC U3009

Control Module Ground 2

DTC U3013

Control Module Input Power 3

DTC U3014

Control Module Input Power 4

DTC U3018

Control Module Supply Circuit 1-2 Not Plausible

DTC U3019

Control Module Supply Circuit 3-4 Not Plausible

DTC U3500

Control Module Input Power "A" Circuit Range/Performance

DTC U3501

Control Module Supply Circuit 1 Low Voltage

DTC U3502

Control Module Supply Circuit 1 High Voltage

DTC U3503

Control Module Input Power "A" Circuit Intermittent/Erratic

DTC U3504

Control Module Input Power "B" Circuit Range/Performance

DTC U3505

Control Module Supply Circuit 2 Low Voltage

DTC U3506

Control Module Supply Circuit 2 High Voltage

DTC U3507

DTC U3508

Control Module Input Power "C" Circuit Range/Performance

DTC U3509

Control Module Supply Circuit 3 Low Voltage

DTC U350A

Control Module Supply Circuit High Voltage

DTC U350B

Control Module Input Power "C" Circuit Intermittent/Erratic

Circuit/System Description

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

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

The system voltage returns to normal operating range.

Diagnostic Aids

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

Reference Information

Schematic Reference

Control Module References

Connector End View Reference

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**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the battery terminals.
2. Verify the battery voltage stabilizes between 12.4 and 12.8 V within a few minutes of turning the ignition OFF.
 - **If battery voltage is less than 12.4 V or more than 12.8 V**
Refer to **Battery Inspection/Test**.
 - **If battery voltage is between 12.4 and 12.8 V**
3. Engine running, headlights ON, measure and record the battery voltage at the battery terminals.
4. Verify the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.
 - **If the voltage is not at least 1 V greater than the voltage measured in step 1 or is greater than 15 V.**
Refer to **Charging System Test**.
 - **If the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.**
5. Verify the appropriate control module 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 5 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 , refer to **Power Mode Mismatch**.
 - **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.

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**

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

[Battery 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

Special Tools

EL 50313 Battery Tester

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 case is not cracked, broken, or damaged, which may be indicated by battery acid leakage.
 - **If there is any apparent damage**

Replace the C1 Battery.
 - **If there is no damage**
2. Verify 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.

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

9. All OK.

Repair Instructions

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

Battery Replacement

BATTERY CHARGING

12 V Battery

The following procedure is for the 12 V battery only.

Special Tools

EL 50313 Midtronics GR8 Battery Tester Charger

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

Diagnostic Aids

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

- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the EL 50313 before charging.
- 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.

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 0Â°,Â°C (32Â°,Â°F)	% Charge at 25Â°,Â°C (75Â°,Â°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.

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.

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. cardiagn.com
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

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 vehicle 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 Vehicle OFF before going to sleep, like the HVAC and body control modules. Others such as the telematics communication interface control module and remote control door lock receiver 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, 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.
- The telematics communication interface control module current draw is very low, less than 40 mA, so the OnStar system is left in that "awake" 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 telematics communication interface control module 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 transmitters 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 the battery specification label on the original battery when testing the battery.

- The battery run down time will vary depending on the batteries reserve capacity. If the reserve capacity is higher, then the battery run down time 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 minute 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 - INDEX

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 min 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 s.
- Closing the door latches/ajar switch while leaving the doors open is recommended, this allows the vehicle systems to perform in a "doors closed" mode while allowing vehicle interior access that may be needed to complete the diagnostic steps.
- Locking doors will arm the vehicle content theft deterrent system if equipped. Failure to arm the system may cause a theft system fault to not be present during testing.
- There are many things that can prevent the vehicle from completely going to sleep and passing the parasitic draw test. Make sure all the conditions listed below are met before performing the parasitic current draw test.

- Vehicle OFF
- Retained Accessory Power RAP OFF - open and close the driver door after Vehicle OFF
- Scan tool not communicating with a vehicle control module - in some cases it may need to be disconnected from the data link connector.
- 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 Vehicle OFF inactive or OFF
- Wait up to 2 min or longer, after all other listed conditions are met

Using an Inductive Pickup Probe

1. Connect an inductive pickup probe to the negative battery cable that can read down to 1 mA.
2. Vehicle 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. Vehicle 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. Vehicle 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 digital multimeter 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 Instructions

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

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

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

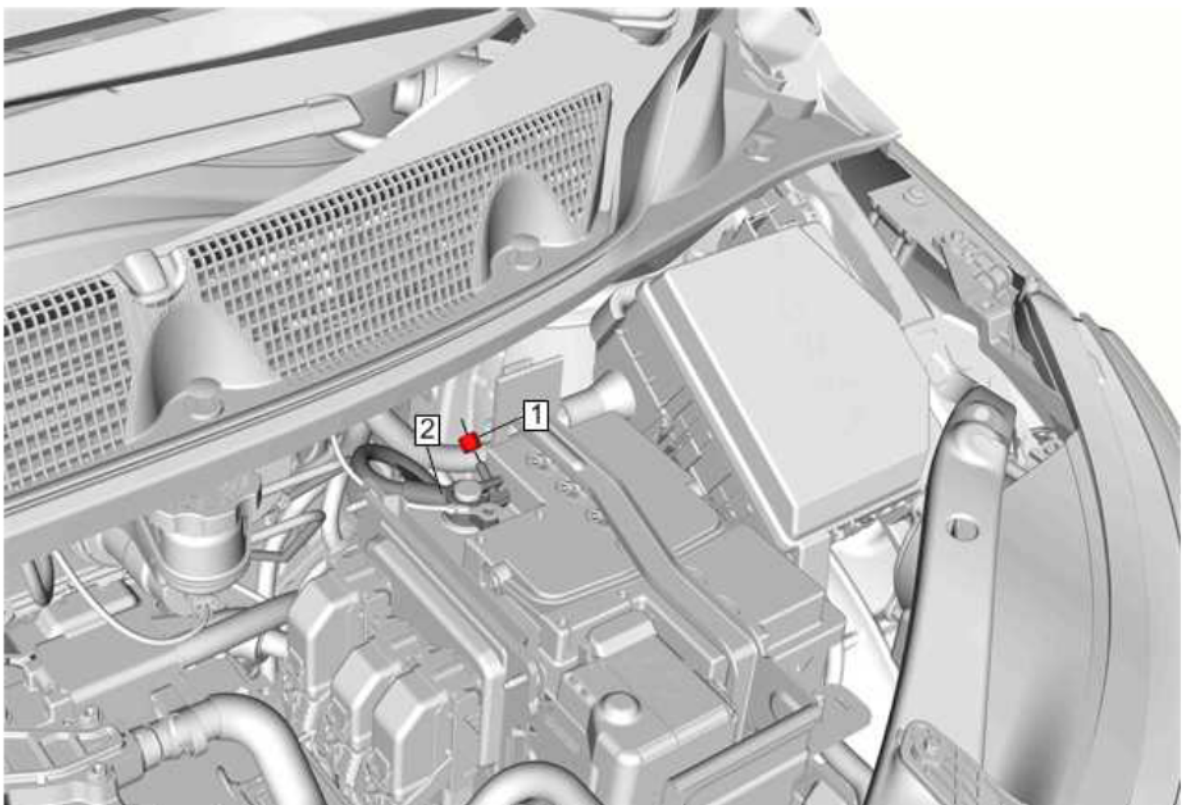


Fig. 2: Battery Negative Cable

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Turn the ignition OFF. 2. Disconnect and remove all 12V battery chargers and the AC charger cable from the hybrid battery charger receptacle.	
1	Battery Negative Cable Fastener WARNING: Refer to Battery Disconnect Warning CAUTION: Refer to Fastener Caution . Tighten 5 N.m (44 lb in)
2	Battery Negative Cable

BATTERY DISTRIBUTION FUSE BLOCK REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

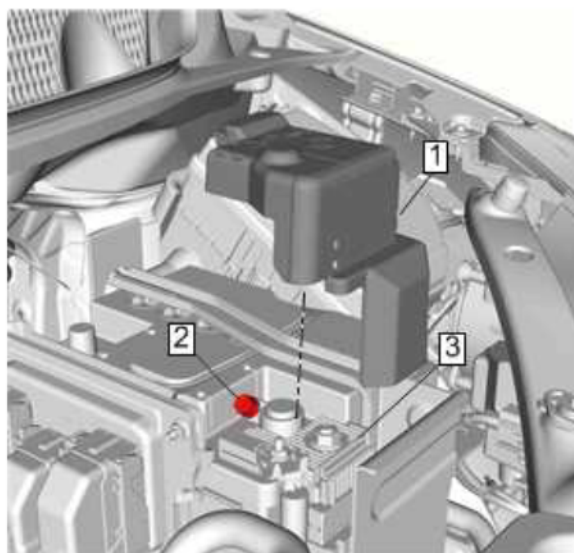


Fig. 3: Battery Positive Cable Protective Cover
 Courtesy of GENERAL MOTORS COMPANY

2. Remove Battery Positive Cable Protective Cover (1)

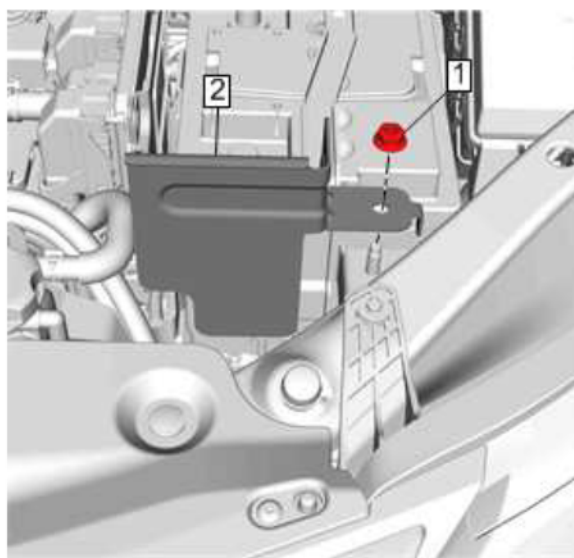


Fig. 4: Battery Tray Support Nut
Courtesy of GENERAL MOTORS COMPANY

3. Remove Battery Tray Support Nut (1)
4. Remove Battery Tray Support (2)

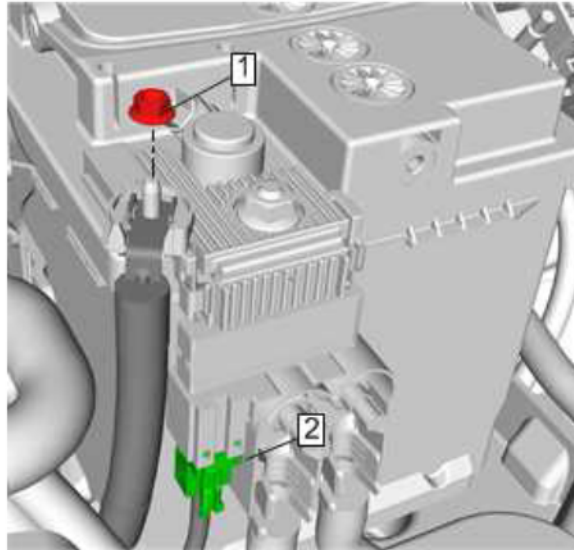


Fig. 5: Body Wiring Harness Nut And Connector
Courtesy of GENERAL MOTORS COMPANY

5. Remove Body Wiring Harness Nut (1)@Battery Distribution Fuse Block
6. Disconnect Body Wiring Harness Connector (2)@Battery Distribution Fuse Block

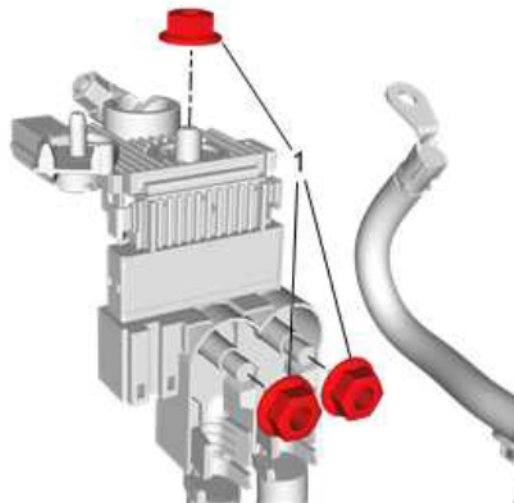


Fig. 6: Battery Distribution Fuse Block Nut
Courtesy of GENERAL MOTORS COMPANY

7. Remove Battery Distribution Fuse Block Nut (1)

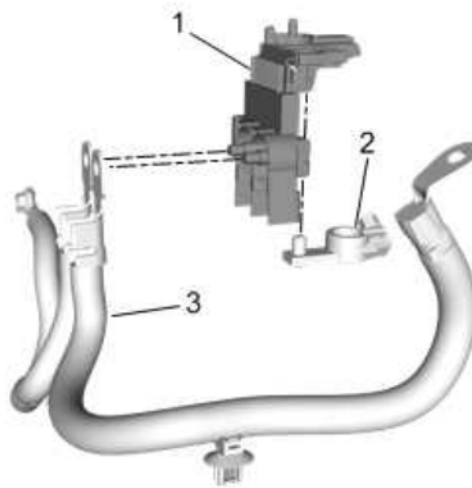


Fig. 7: Battery Positive Post Terminal And Cable

Courtesy of GENERAL MOTORS COMPANY

8. Remove Battery Positive Post Terminal (2) @ Battery Distribution Fuse Block (1)
9. Remove Battery Positive Cable (3) @ Battery Distribution Fuse Block (1)

Installation Procedure

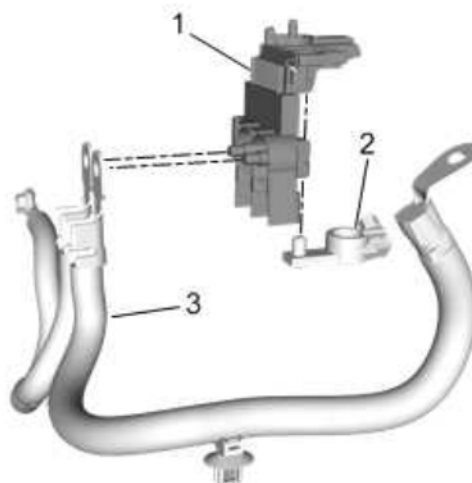
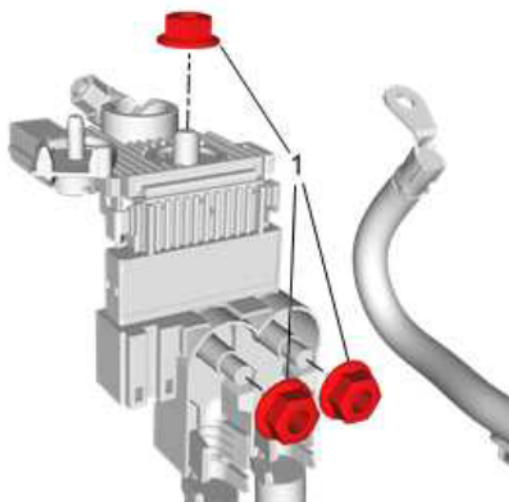


Fig. 8: Battery Positive Post Terminal And Cable

Courtesy of GENERAL MOTORS COMPANY

1. Install Battery Positive Post Terminal (2) @ Battery Distribution Fuse Block (1)
2. Install Battery Positive Cable (3) @ Battery Distribution Fuse Block (1)



CAUTION: Refer to **Fastener Caution** .

3. Install Battery Distribution Fuse Block Nut (1) and tighten 22 N.m (16 lb ft)

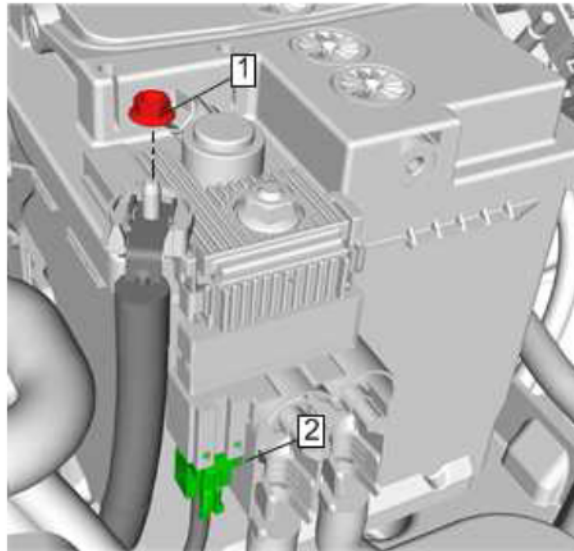


Fig. 10: Body Wiring Harness Nut And Connector
Courtesy of GENERAL MOTORS COMPANY

4. Connect Body Wiring Harness Connector (2) @Battery Distribution Fuse Block
5. Install Body Wiring Harness Nut (1) @Battery Distribution Fuse Block and tighten 5 N.m (44 lb in)

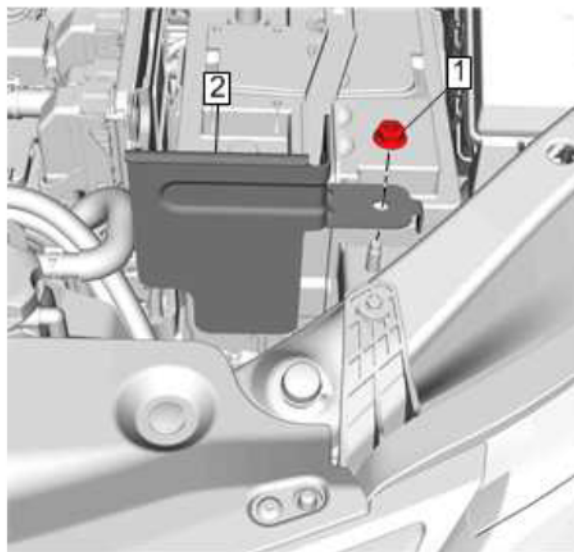


Fig. 11: Battery Tray Support Nut
Courtesy of GENERAL MOTORS COMPANY

6. Install Battery Tray Support (2)
7. Install Battery Tray Support Nut (1) and tighten 9 N.m (80 lb in)

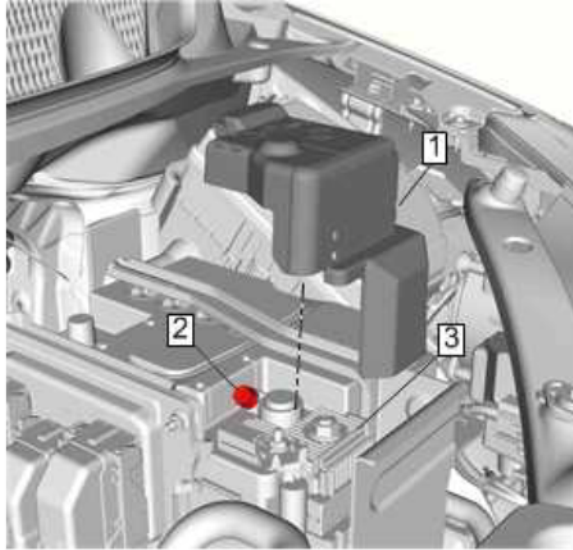


Fig. 12: Battery Positive Cable Protective Cover

Courtesy of GENERAL MOTORS COMPANY

8. Install Battery Positive Cable Protective Cover (1)
9. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

BATTERY CURRENT SENSOR REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
2. Remove Battery [Battery Replacement](#)

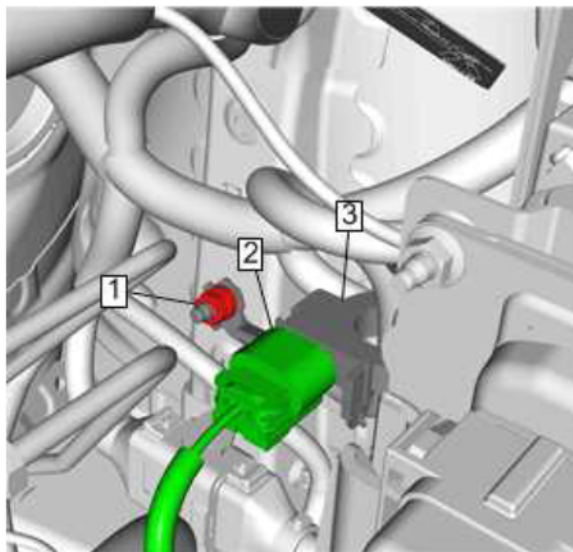


Fig. 13: Battery Current Sensor And Connector

Courtesy of GENERAL MOTORS COMPANY

3. Disconnect Battery Current Sensor Connector (2)
4. Remove Battery Positive and Negative Cable Ground Nut (1) @ Front Wheelhouse Panel
5. Remove Battery Current Sensor (3) Battery Tray

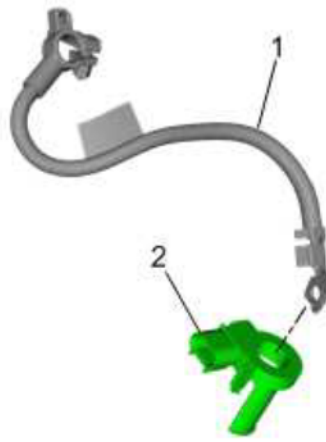


Fig. 14: Battery Current Sensor And Cable
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the orientation of the battery current sensor when removing.

6. Remove Battery Current Sensor (2) @ Battery Negative Cable (1)

Installation Procedure

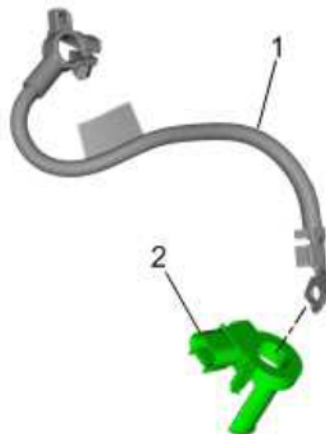
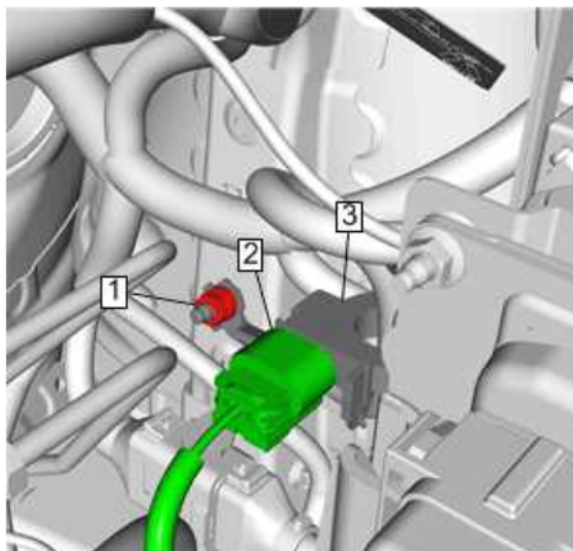


Fig. 15: Battery Current Sensor And Cable
 Courtesy of GENERAL MOTORS COMPANY

1. Install Battery Current Sensor (2) @ Battery Negative Cable (1)



CAUTION: Refer to [Fastener Caution](#) .

2. Install Battery Positive and Negative Cable Ground Nut (1) @ Front Wheelhouse Panel and tighten 22 N.m (16 lb ft)
3. Install Battery Current Sensor (3) Battery Tray
4. Connect Battery Current Sensor Connector (2)
5. Install Battery [Battery Replacement](#)
6. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

BATTERY NEGATIVE CABLE REPLACEMENT (HIGH VOLTAGE BATTERY TO BODY STRUCTURE)

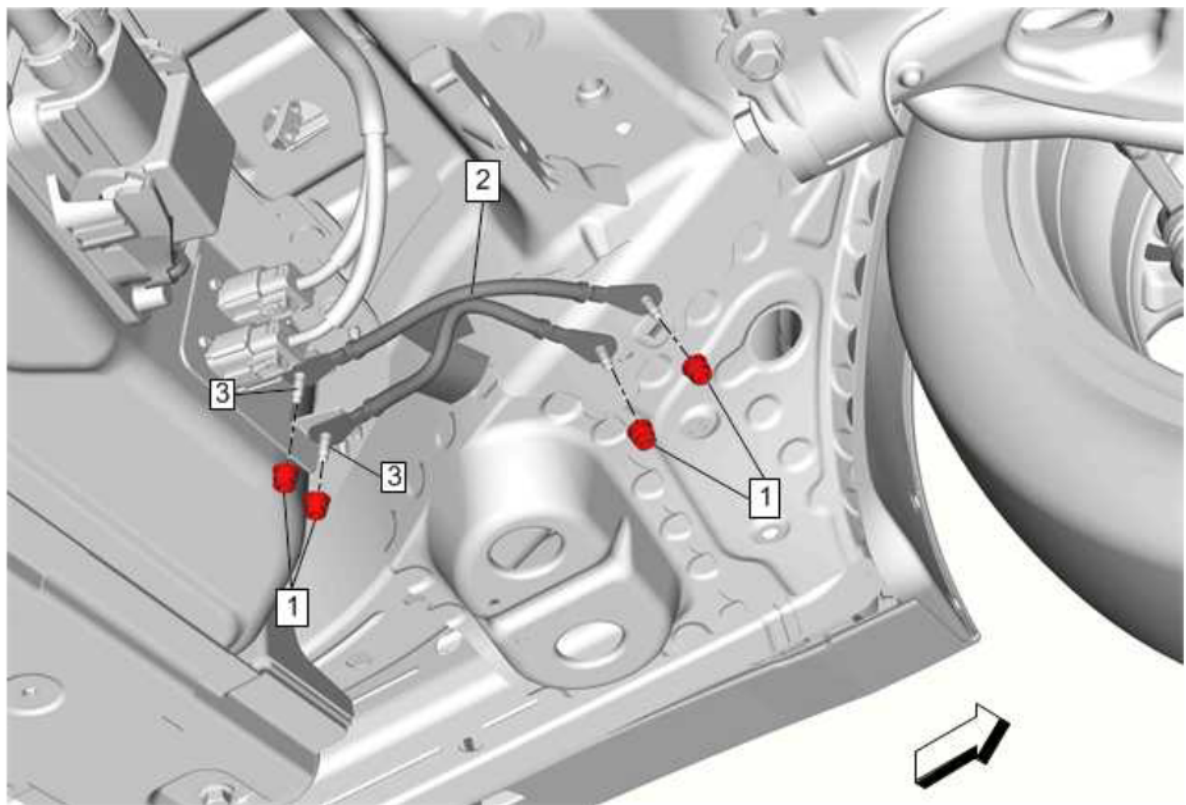


Fig. 17: Battery Negative Cable
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING:	
Ensure all High Voltage safety procedures are followed. Failure to follow the procedure exactly as written may result in serious injury or death.	
WARNING:	
Before working on any high voltage system, be sure to wear the following Personal Protection Equipment:	
• Safety glasses with appropriate side shields when within 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 at all times when working with the high voltage battery assembly, whether the system is energized or not.	
Failure to follow the procedure exactly as written may result in serious injury or death.	
Preliminary Procedure Raise and support the vehicle. Lifting and Jacking the Vehicle	

Callout	Component Name
1	Battery Negative Cable Nut (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten: 9 N.m (80 lb in) NOTE: Must take a pair of pliers to hold onto the ground bracket, then crack the nut and provide relief to the bracket.
2	Battery Negative Cable
3	High Voltage Battery Tray Ground Stud NOTE: If corrosion is visual on threads, wire brush threads.

BATTERY NEGATIVE CABLE REPLACEMENT (12V BATTERY TO BODY STRUCTURE)

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
2. Remove the battery. [Battery Replacement](#)

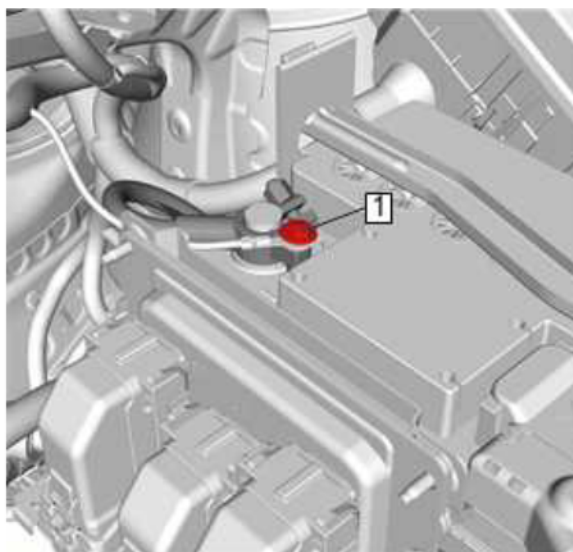


Fig. 18: Small Ground Wire And Bolt

Courtesy of GENERAL MOTORS COMPANY

3. Remove the small ground wire and bolt (1) from the battery negative cable clamp.

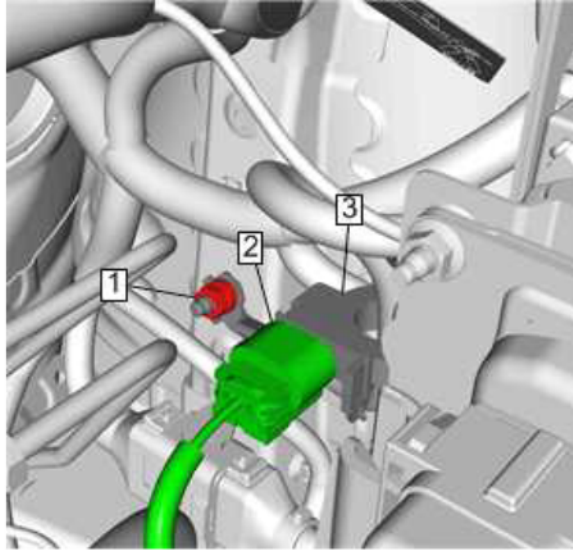


Fig. 19: Battery Current Sensor And Connector

Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Battery Current Sensor Connector (2)
5. Remove Battery Positive and Negative Cable Ground Nut (1) @ Front Wheelhouse Panel
6. Remove Battery Current Sensor (3) Battery Tray

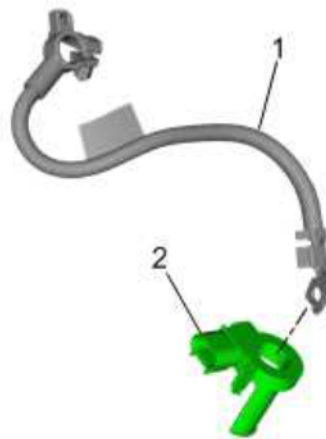


Fig. 20: Battery Current Sensor And Cable

Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the orientation of the battery current sensor when removing.

7. Remove Battery Current Sensor (2) @ Battery Negative Cable (1)

Installation Procedure

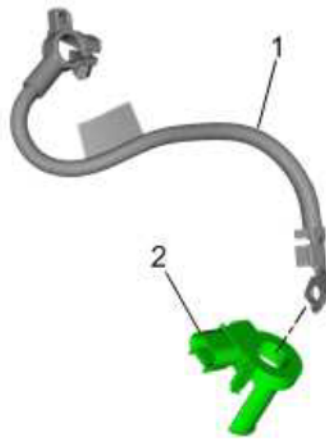


Fig. 21: Battery Current Sensor And Cable
 Courtesy of GENERAL MOTORS COMPANY

1. Install Battery Current Sensor (2) @ Battery Negative Cable (1)

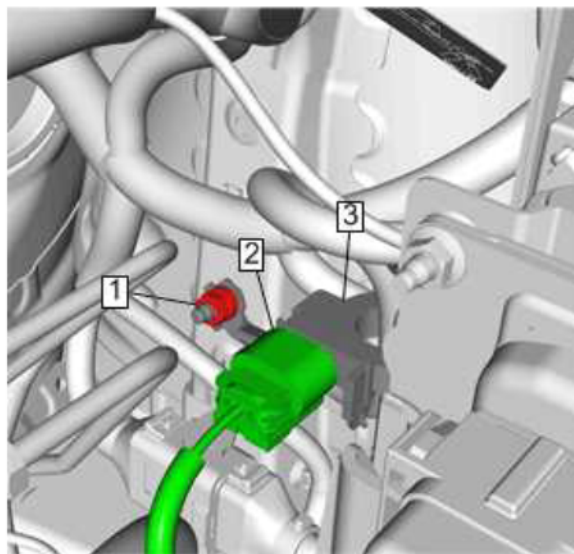


Fig. 22: Battery Current Sensor And Connector
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

2. Install Battery Positive and Negative Cable Ground Nut (1) @ Front Wheelhouse Panel and tighten 22 N.m (16 lb ft)
3. Install Battery Current Sensor (3) Battery Tray
4. Connect Battery Current Sensor Connector (2)

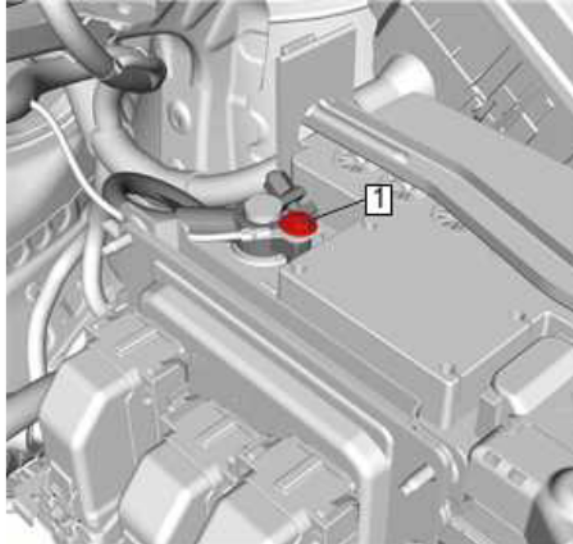


Fig. 23: Small Ground Wire And Bolt
 Courtesy of GENERAL MOTORS COMPANY

5. Install the small ground wire and bolt (1) to the battery negative cable clamp. Tighten the bolt (1) to 5 N.m (44 lb in)
6. Install the battery. [Battery Replacement](#)
7. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

BATTERY NEGATIVE CABLE EXTENSION CABLE REPLACEMENT

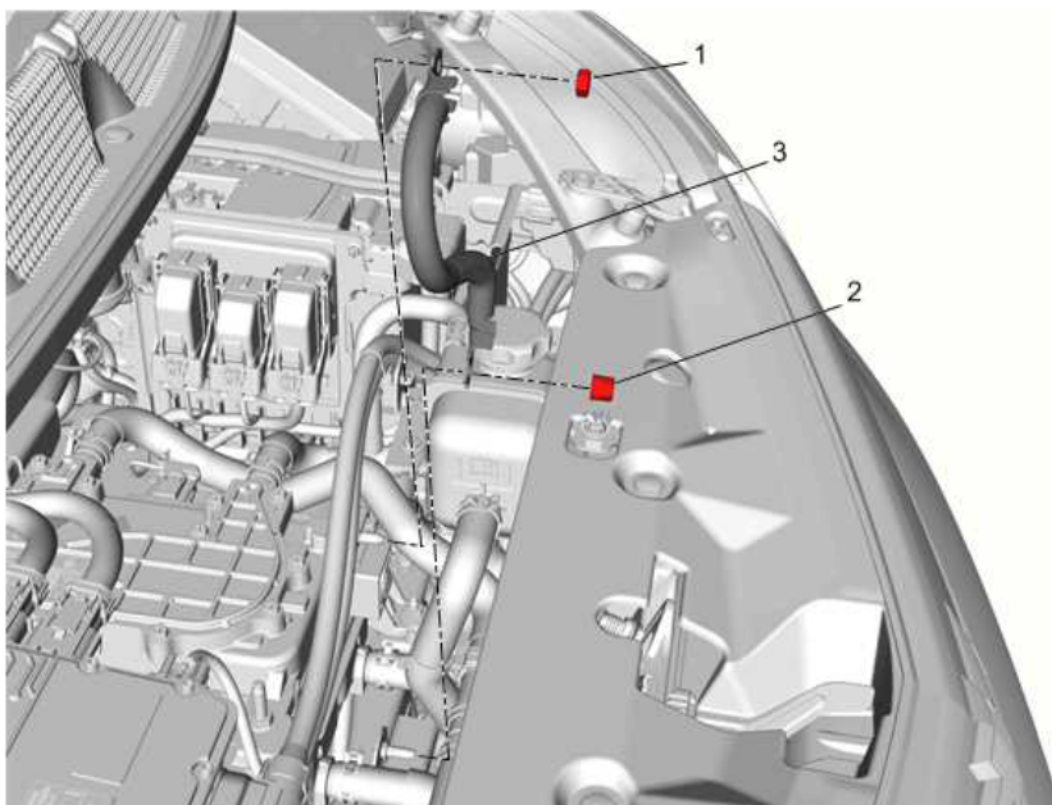


Fig. 24: Battery Negative Cable Extension Cable
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
cardiagn.com	

Callout	Component Name
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 meters (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. 1.	
1	Battery Negative Cable Extension Cable Fastener CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)
2	Battery Negative Cable Extension Cable Fastener Tighten 22 N.m (16 lb ft)
3	Battery Negative Cable Extension Cable

AUXILIARY BATTERY NEGATIVE CABLE REPLACEMENT (DU TO CHASSIS STRUCTURE, 2ND CABLE)

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
2. Remove Front Compartment Air Deflector [Front Compartment Air Deflector Replacement](#)
3. Remove Front Wheelhouse Liner - Right Side [Front Wheelhouse Liner Replacement](#)

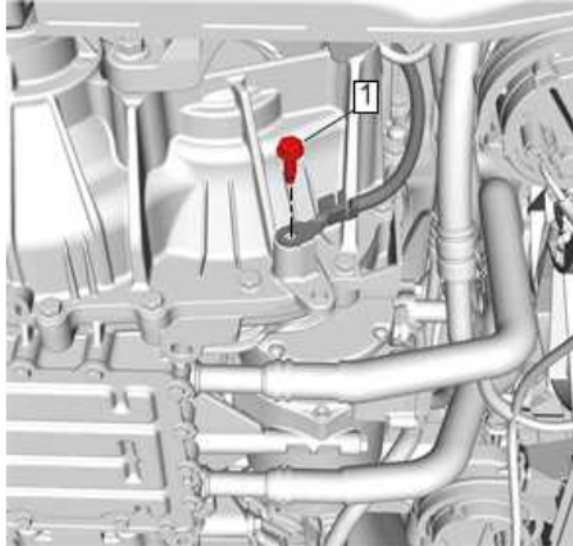


Fig. 25: Auxiliary Battery Positive Cable Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Remove Auxiliary Battery Positive Cable Fastener (1) @ Automatic Transmission

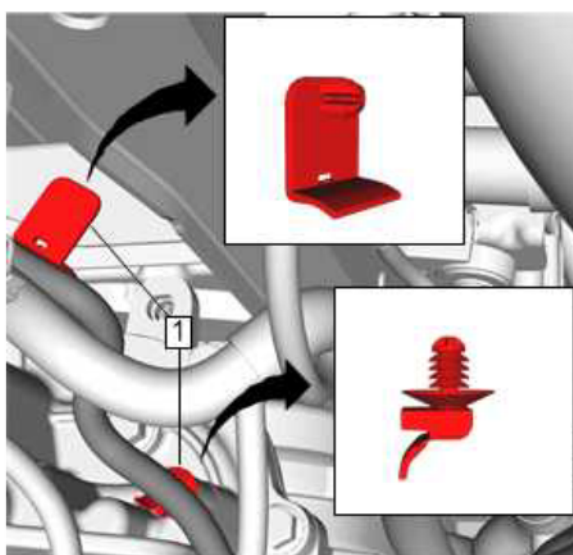


Fig. 26: Auxiliary Battery Positive Cable Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Detach Auxiliary Battery Positive Cable Retainer (1) @Automatic Transmission

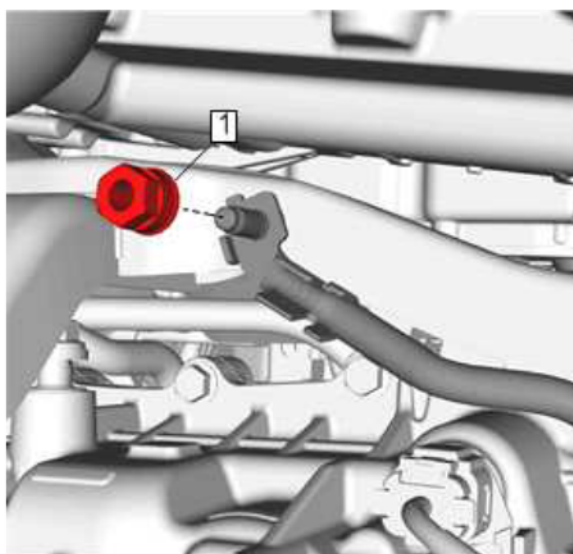


Fig. 27: Auxiliary Battery Positive Cable Nut
Courtesy of GENERAL MOTORS COMPANY

6. Remove Auxiliary Battery Positive Cable Nut (1)

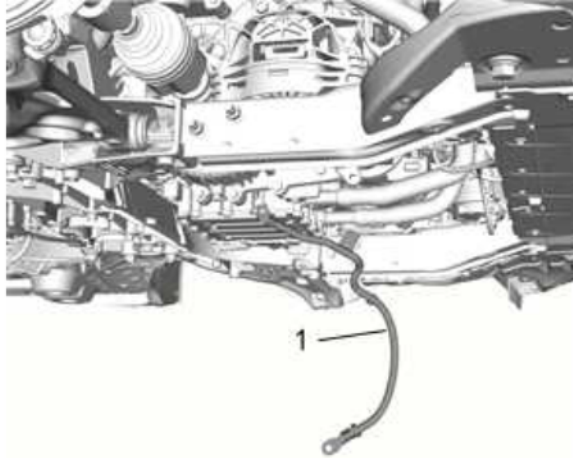


Fig. 28: Auxiliary Battery Positive Cable
Courtesy of GENERAL MOTORS COMPANY

7. Remove Auxiliary Battery Positive Cable (1)

Installation Procedure

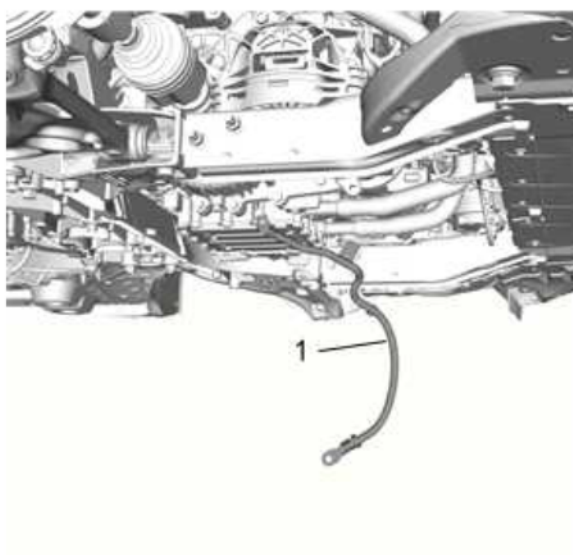


Fig. 29: Auxiliary Battery Positive Cable
Courtesy of GENERAL MOTORS COMPANY

1. Install Auxiliary Battery Positive Cable (1)

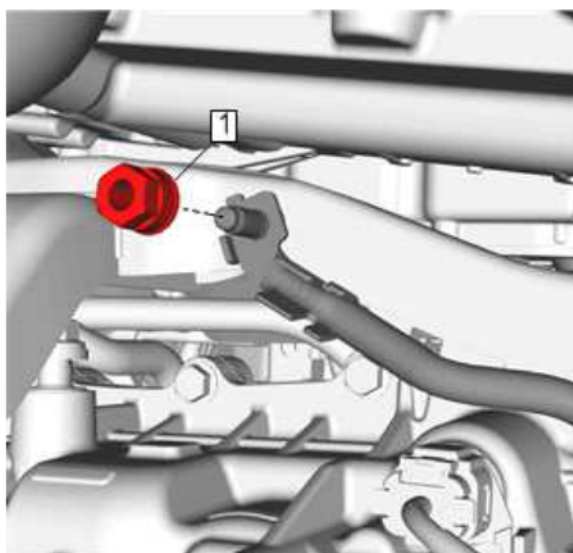


Fig. 30: Auxiliary Battery Positive Cable Nut
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

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

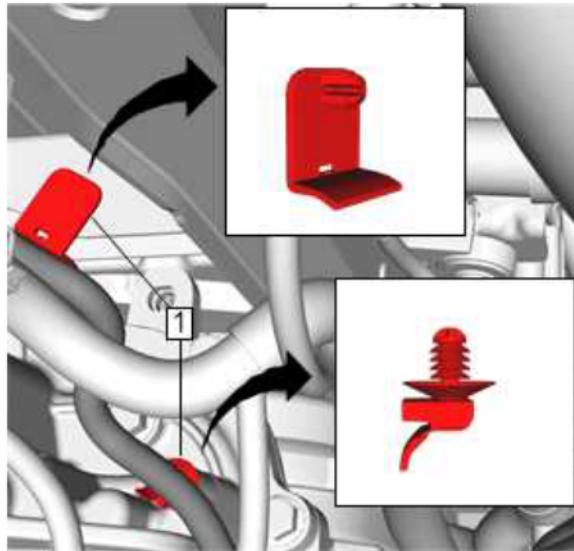


Fig. 31: Auxiliary Battery Positive Cable Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Attach Auxiliary Battery Positive Cable Retainer (1) @Automatic Transmission

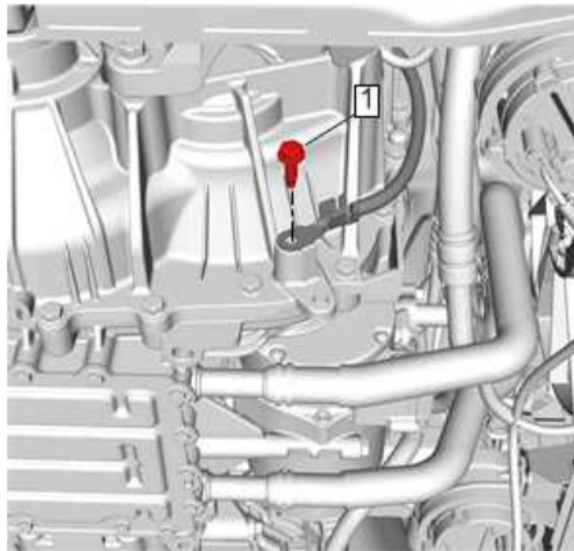


Fig. 32: Auxiliary Battery Positive Cable Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Install Auxiliary Battery Positive Cable Fastener (1) @ Automatic Transmission and tighten 22 N.m (16 lb ft)
5. Install Front Wheelhouse Liner - Right Side [Front Wheelhouse Liner Replacement](#)
6. Install Front Compartment Air Deflector [Front Compartment Air Deflector Replacement](#)
7. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

AUXILIARY BATTERY NEGATIVE CABLE REPLACEMENT (CHASSIS STRUCTURE TO FRONT COMPARTMENT SIDE RAIL)

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
2. Remove Battery Tray [Battery Tray Replacement](#)

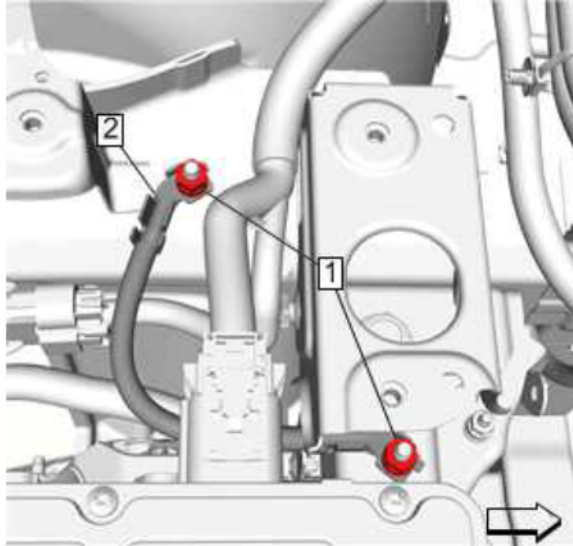


Fig. 33: Auxiliary Battery Negative Cable Fastener
Courtesy of GENERAL MOTORS COMPANY

3. Remove Auxiliary Battery Negative Cable Fastener (1) @ Power Electric Carrier Frame

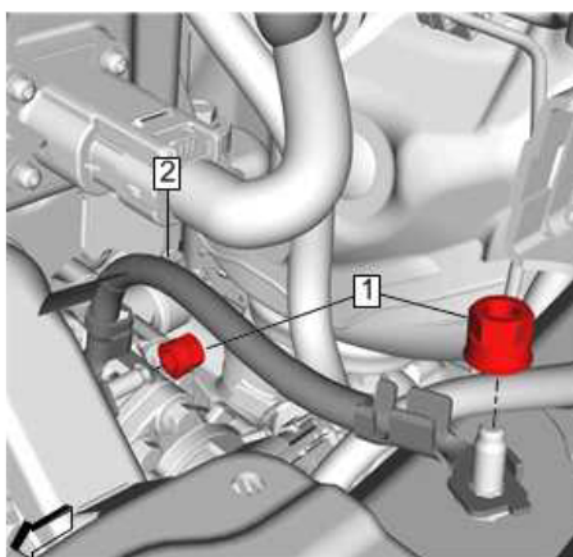


Fig. 34: Auxiliary Battery Negative Cable Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Remove Auxiliary Battery Negative Cable Fastener (1) @ Power Electric Carrier Frame

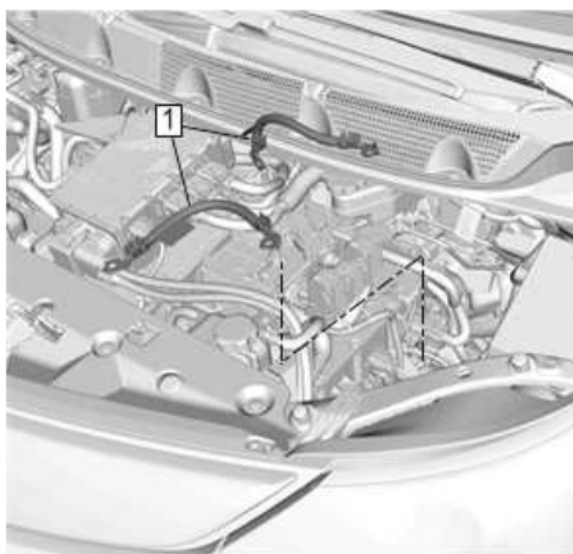


Fig. 35: Battery Negative Cable
Courtesy of GENERAL MOTORS COMPANY

5. Remove Auxiliary Battery Negative Cable (1)

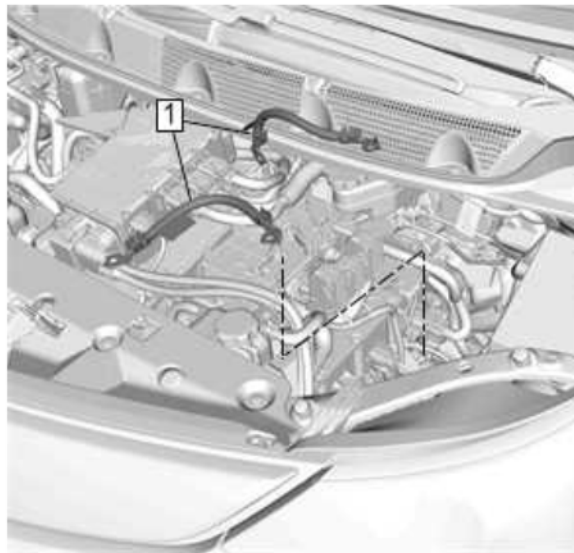


Fig. 36: Battery Negative Cable

Courtesy of GENERAL MOTORS COMPANY

1. Install Auxiliary Battery Negative Cable (1)

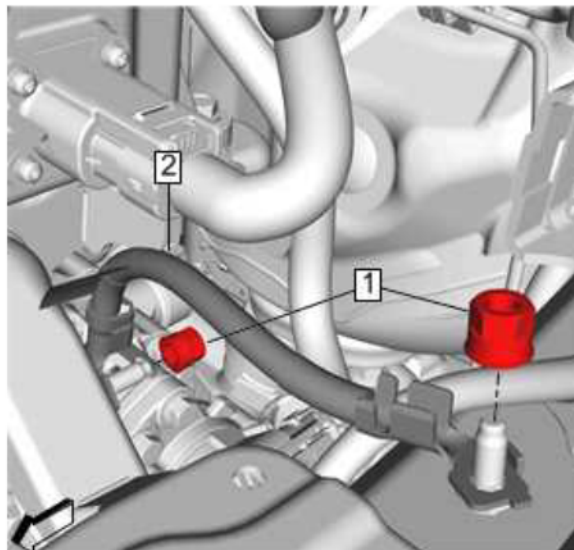
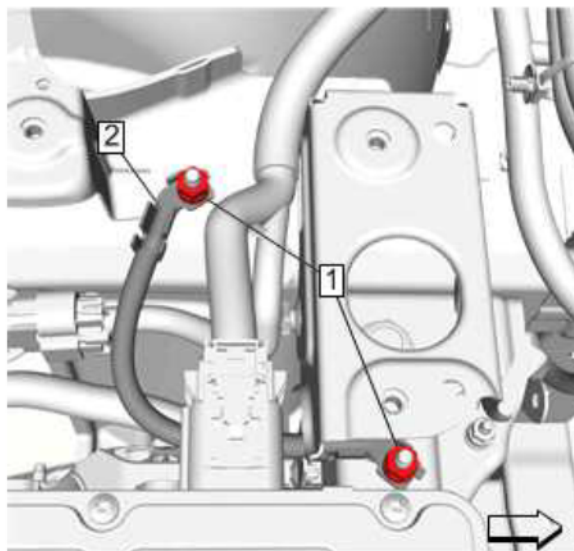


Fig. 37: Auxiliary Battery Negative Cable Fastener

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

2. Install Auxiliary Battery Negative Cable (2)
3. Install Auxiliary Battery Negative Cable Fastener (1) and tighten 22 N.m (16 lb ft)



4. Install Auxiliary Battery Negative Cable (2)
5. Install Auxiliary Battery Negative Cable Fastener (1) and tighten 22 N.m (16 lb ft)
6. Install Battery Tray [Battery Tray Replacement](#)
7. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)

AUXILIARY BATTERY NEGATIVE CABLE REPLACEMENT (DU TO CHASSIS STRUCTURE, 1ST CABLE)

Removal Procedure

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 meters (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.

1. Disable the high voltage system. [High Voltage Disabling](#)
2. Remove Front Compartment Air Deflector [Front Compartment Air Deflector Replacement](#)

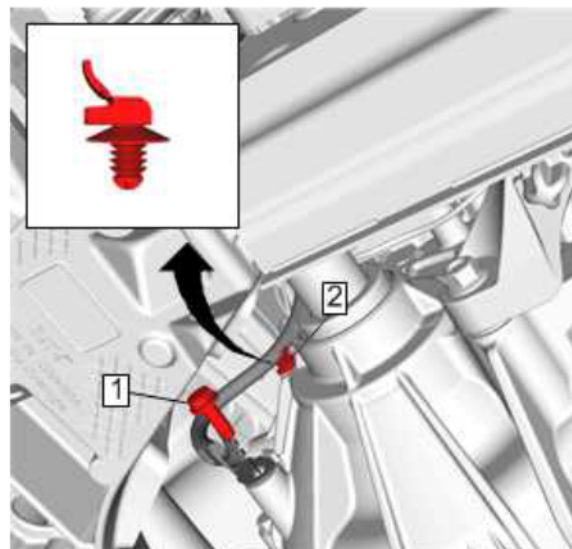


Fig. 39: Auxiliary Battery Negative Cable Fastener And Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Remove Auxiliary Battery Negative Cable Fastener (1)
4. Detach Auxiliary Battery Negative Cable Retainer (2)
5. Remove High Voltage Battery Heater **High Voltage Battery Heater Replacement**

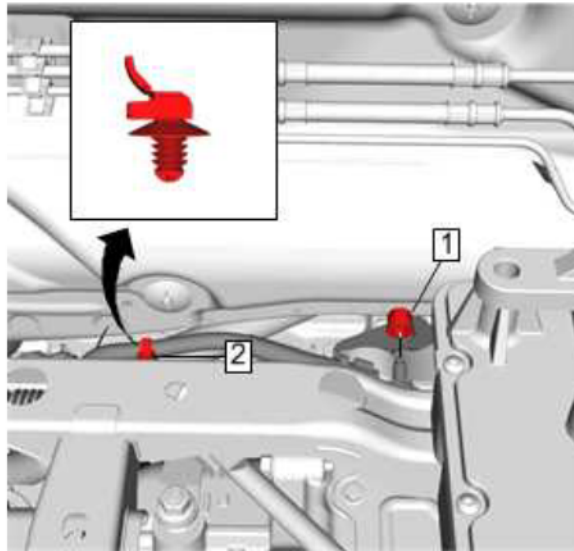


Fig. 40: Auxiliary Battery Negative Cable Fastener And Retainer
Courtesy of GENERAL MOTORS COMPANY

6. Remove Auxiliary Battery Negative Cable Fastener (1)
7. Detach Auxiliary Battery Negative Cable Retainer (2)

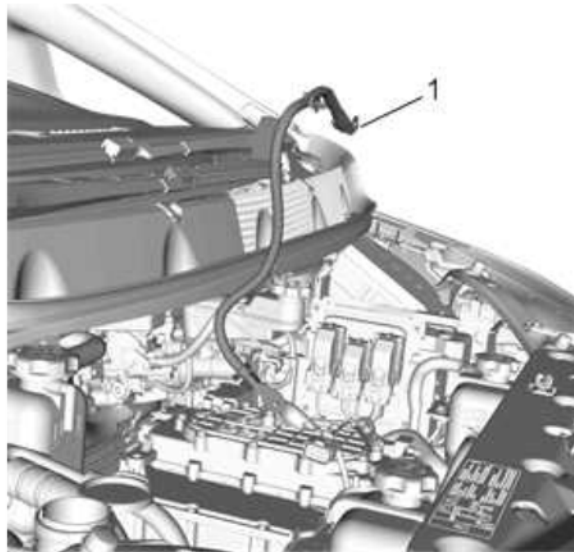


Fig. 41: Auxiliary Battery Negative Cable
Courtesy of GENERAL MOTORS COMPANY

8. Remove Auxiliary Battery Negative Cable (1)

Installation Procedure

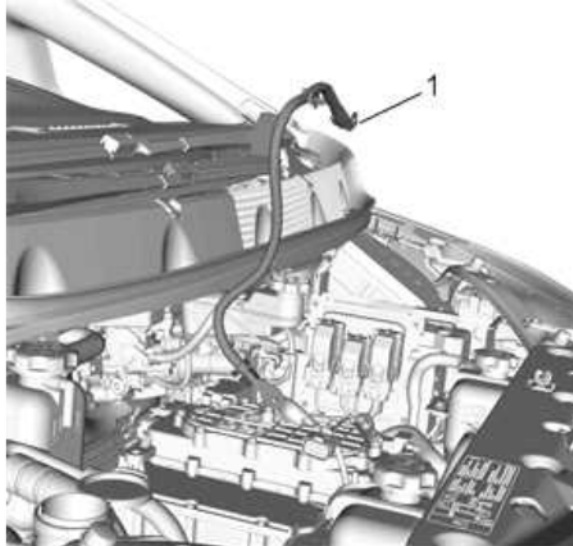


Fig. 42: Auxiliary Battery Negative Cable
Courtesy of GENERAL MOTORS COMPANY

1. Install Auxiliary Battery Negative Cable (1)

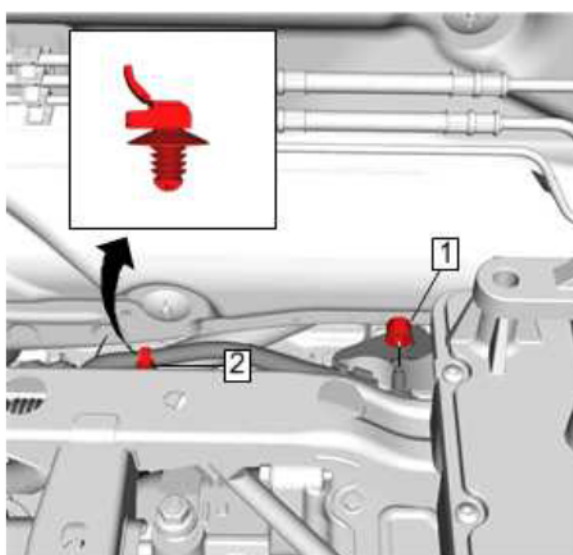


Fig. 43: Auxiliary Battery Negative Cable Fastener And Retainer
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

2. Attach Auxiliary Battery Negative Cable Retainer (2)
3. Install Auxiliary Battery Negative Cable Fastener (1) and tighten 22 N.m (16 lb ft)
4. Install High Voltage Battery Heater [High Voltage Battery Heater Replacement](#)

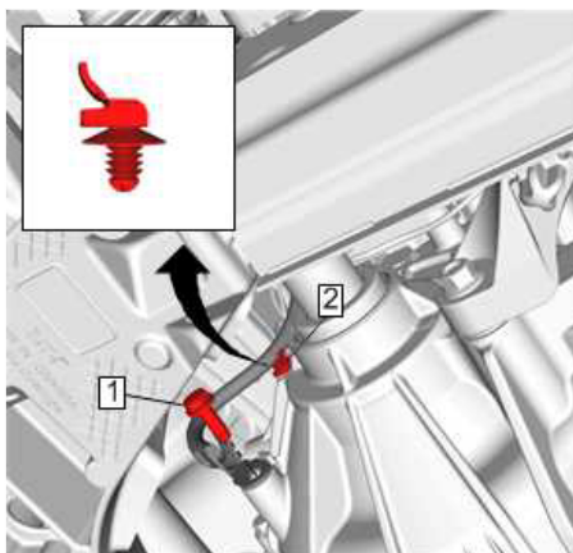


Fig. 44: Auxiliary Battery Negative Cable Fastener And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Attach Auxiliary Battery Negative Cable Retainer (2)
6. Auxiliary Battery Negative Cable Fastener (1) and tighten 22 N.m (16 lb ft)
7. Install Front Compartment Air Deflector **Front Compartment Air Deflector Replacement**
8. Enable the high voltage system. **High Voltage Enabling**

BATTERY POSITIVE CABLE REPLACEMENT

Removal Procedure

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

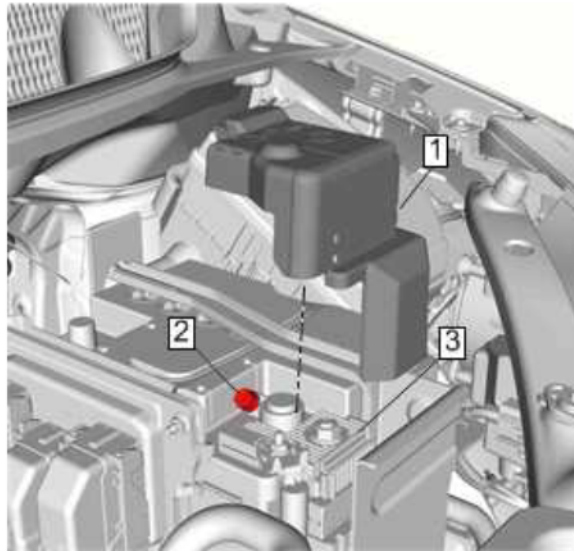


Fig. 45: Battery Positive Cable Protective Cover
Courtesy of GENERAL MOTORS COMPANY

2. Remove Battery Positive Cable Protective Cover (1)
3. Loosen Battery Positive Cable Clamp Fastener
4. Remove Battery Positive Cable (3) @ Battery Post

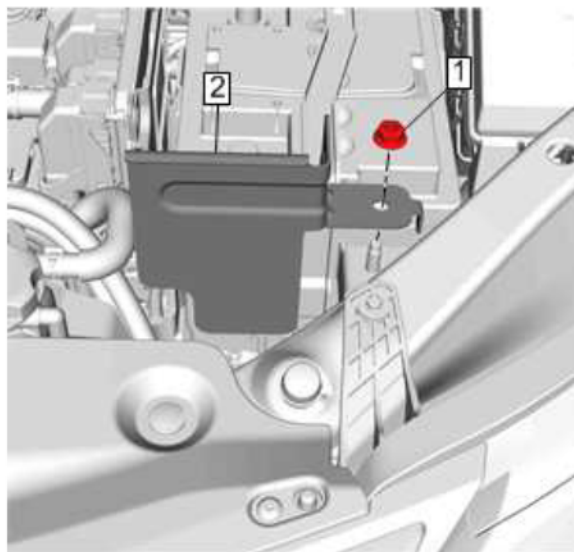


Fig. 46: Battery Tray Support Nut
Courtesy of GENERAL MOTORS COMPANY

5. Remove Battery Tray Support Nut (1)
6. Remove Battery Tray Support (2)

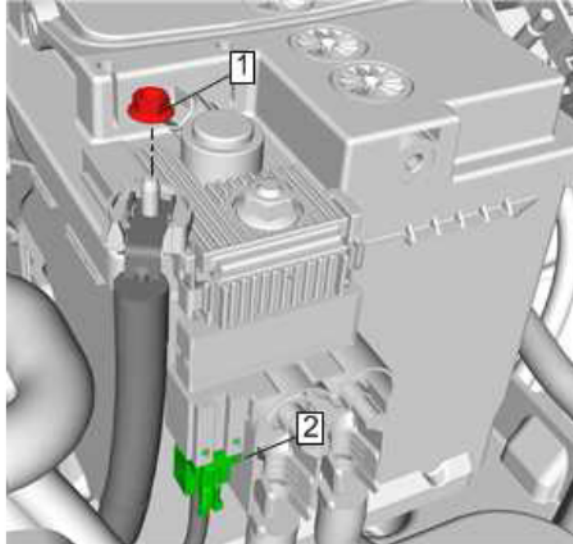


Fig. 47: Body Wiring Harness Nut And Connector

Courtesy of GENERAL MOTORS COMPANY

7. Remove Body Wiring Harness Nut (1) @ Battery Distribution Fuse Block
8. Disconnect Body Wiring Harness Connector (2) @Battery Distribution Fuse Block

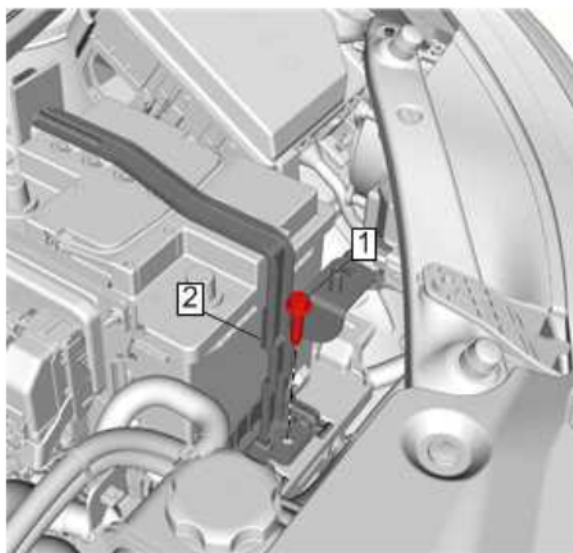


Fig. 48: Battery Retainer Assembly Bolt And Assembly

Courtesy of GENERAL MOTORS COMPANY

9. Remove Battery Retainer Assembly Bolt (1)
10. Remove Battery Retainer Assembly (2)

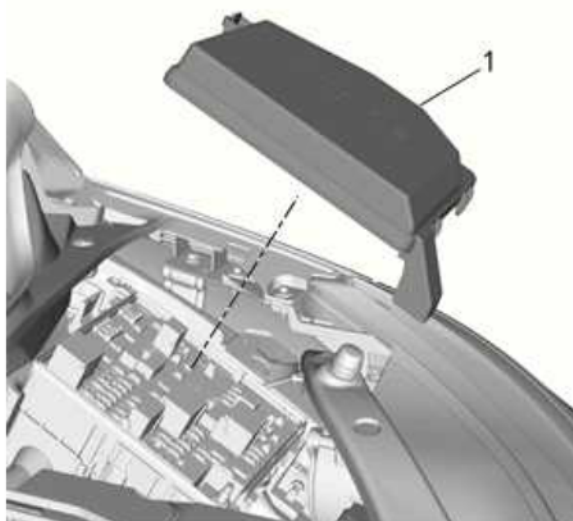


Fig. 49: Fuse Block Cover

Courtesy of GENERAL MOTORS COMPANY

11. Remove Remove Fuse Block Cover (1)

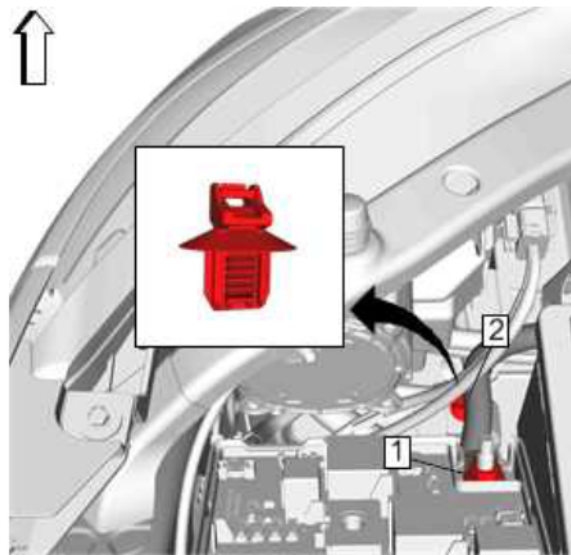


Fig. 50: Battery Positive Cable Nut And Retainer
Courtesy of GENERAL MOTORS COMPANY

12. Remove Battery Positive Cable Nut (1)

13. Battery Positive Cable Retainer (2)

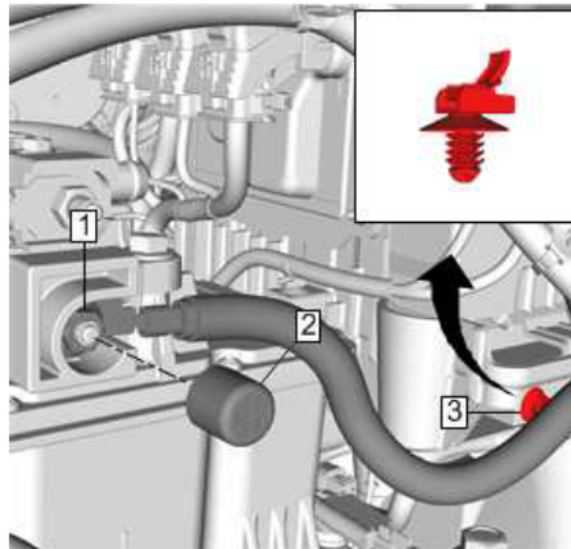


Fig. 51: Battery Positive Cable Protector And Retainer
Courtesy of GENERAL MOTORS COMPANY

14. Remove Battery Positive Cable Protector (2)

15. Remove Battery Positive Cable Nut (1)

16. Detach Battery Positive Cable Retainer (3)

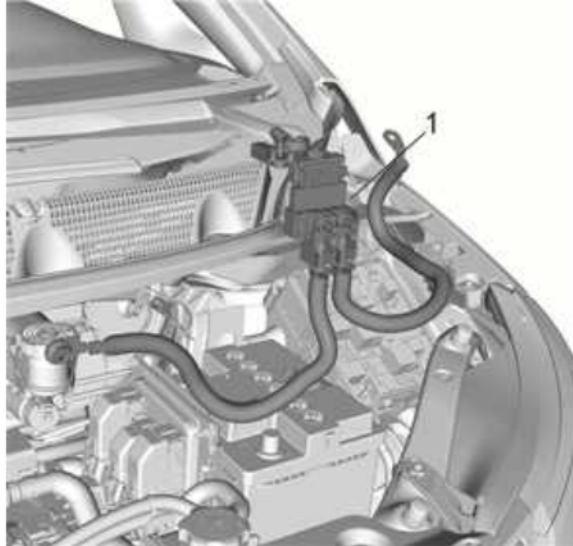


Fig. 52: Battery Positive Cable

Courtesy of GENERAL MOTORS COMPANY

17. Remove Battery Positive Cable (1)

Installation Procedure

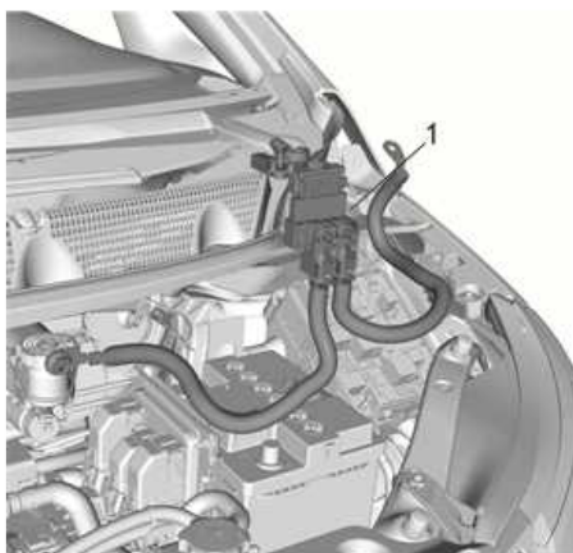


Fig. 53: Battery Positive Cable

Courtesy of GENERAL MOTORS COMPANY

1. Install Battery Positive Cable (1)

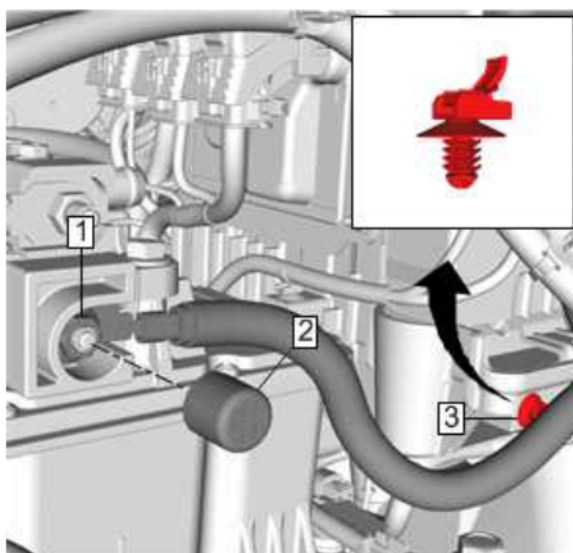


Fig. 54: Battery Positive Cable Protector And Retainer

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

2. Attach Battery Positive Cable Retainer (3)
3. Install Battery Positive Cable Nut (1) and tighten 15 N.m (11 lb ft)
4. Install Battery Positive Cable Protector (2)

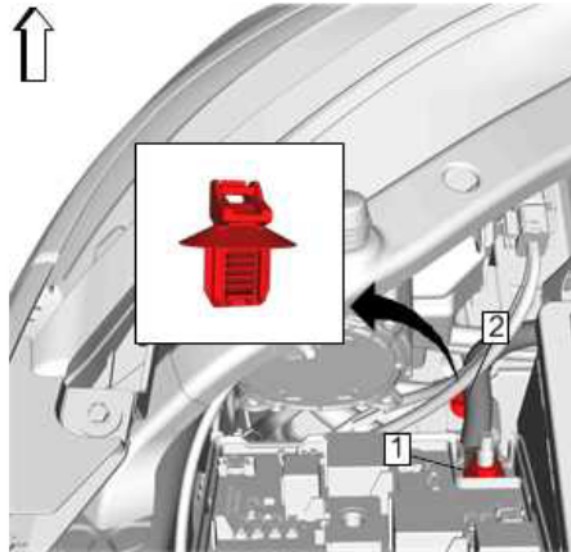


Fig. 55: Battery Positive Cable Nut And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Attach Battery Positive Cable Retainer (2)
6. Install Battery Positive Cable Nut (1) and tighten 22 N.m (16 lb ft)

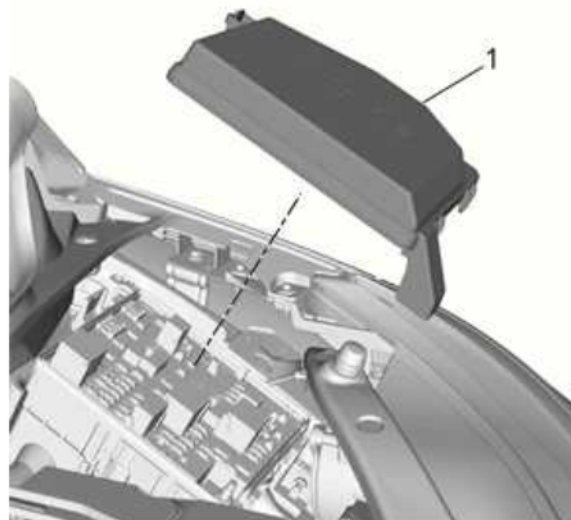


Fig. 56: Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

7. Install Fuse Block Cover (1)

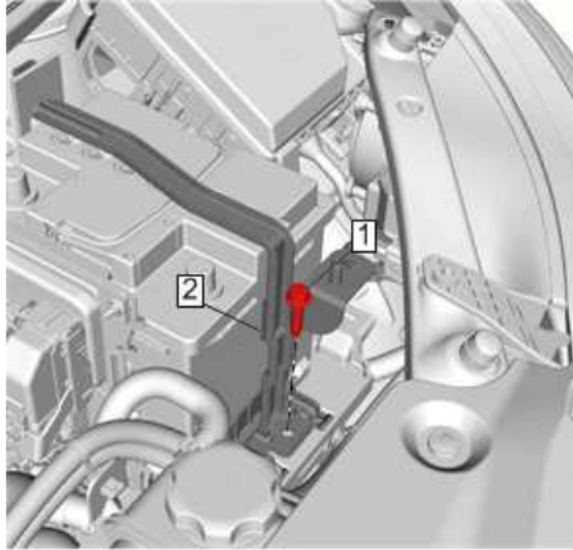


Fig. 57: Battery Retainer Assembly Bolt And Assembly
Courtesy of GENERAL MOTORS COMPANY

8. Install Battery Retainer Assembly (2)
9. Install Battery Retainer Assembly Bolt (1) and tighten 8 N.m (71 lb in)

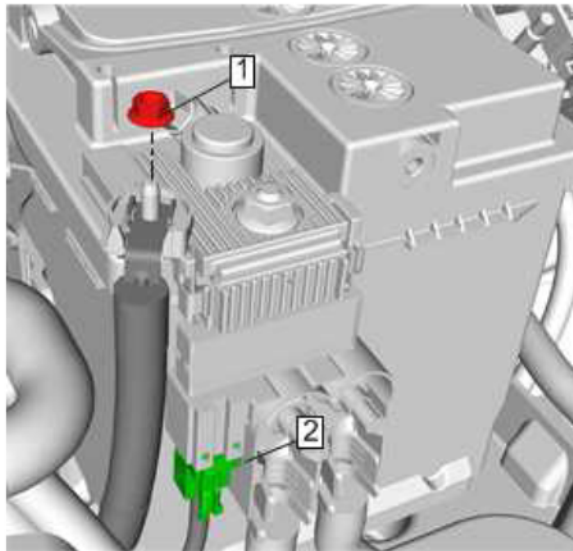


Fig. 58: Body Wiring Harness Nut And Connector
Courtesy of GENERAL MOTORS COMPANY

10. Connect Body Wiring Harness Connector (2) @Battery Distribution Fuse Block
11. Install Body Wiring Harness Nut (1) @ Battery Distribution Fuse Block and tighten 5 N.m (44 lb in)

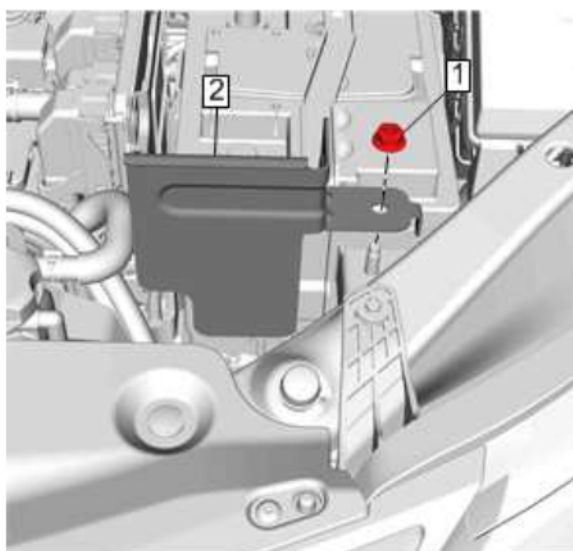


Fig. 59: Battery Tray Support Nut
Courtesy of GENERAL MOTORS COMPANY

12. Install Battery Tray Support (2)
13. Install Battery Tray Support Nut (1) and tighten 9 N.m (80 lb in)

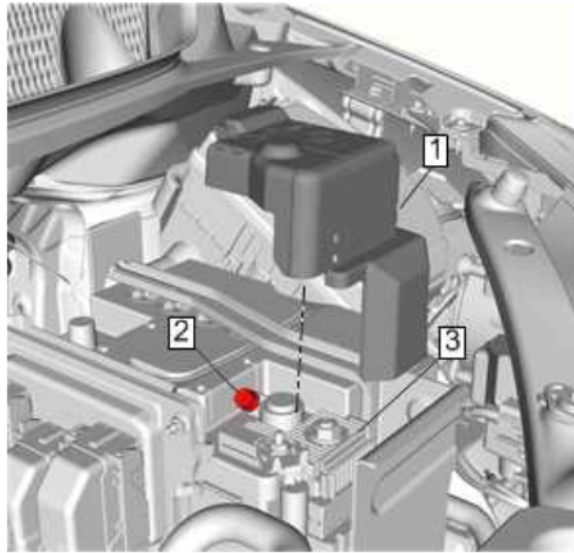


Fig. 60: Battery Positive Cable Protective Cover
Courtesy of GENERAL MOTORS COMPANY

14. Install Battery Positive Cable (3) @ Battery Post
15. Install Battery Positive Cable Clamp Fastener and tighten 5 N.m (44 lb in)
16. Install Battery Positive Cable Protective Cover (1)
17. Connect the battery negative cable. **Battery Negative Cable Disconnection and Connection**

ENGINE WIRING HARNESS JUNCTION BLOCK REPLACEMENT

Removal Procedure

Preliminary Procedures

1. Disconnect Battery Negative Cable **Battery Negative Cable Disconnection and Connection**
2. Remove Battery **Battery Replacement**



Fig. 61: Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

3. Remove Fuse Block Cover(1)

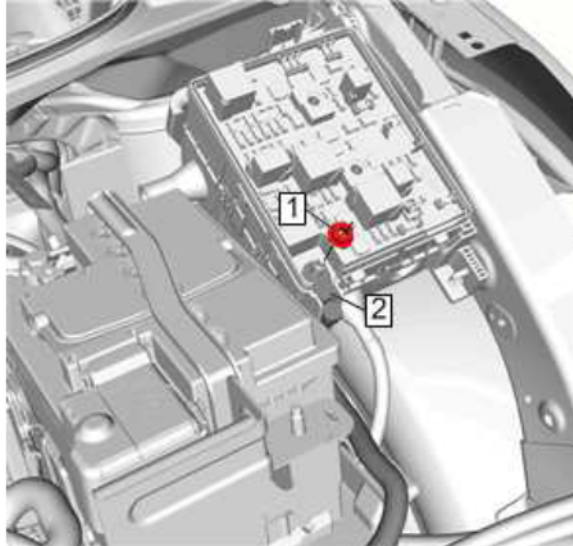


Fig. 62: Battery Positive Cable Nut

Courtesy of GENERAL MOTORS COMPANY

4. Remove the battery positive cable nut (1) and the cable (2) from the engine wiring harness junction block assembly.

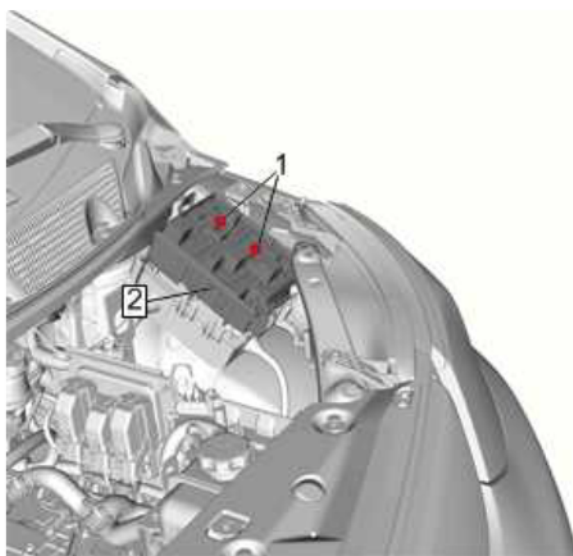


Fig. 63: Engine Wiring Harness Junction Block

Courtesy of GENERAL MOTORS COMPANY

5. Loosen Engine Wiring Harness Junction Block Bolt (1)
6. Release the seven retainers while removing the block.
7. Remove Engine Wiring Harness Junction Block(2)

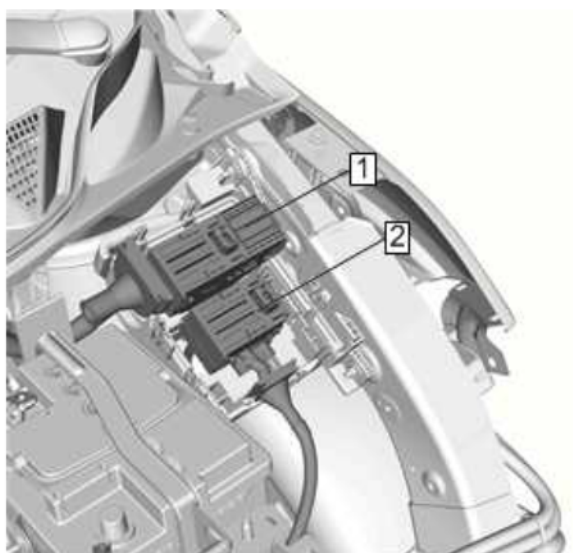


Fig. 64: Body Wiring Harness Assembly
Courtesy of GENERAL MOTORS COMPANY

8. Remove Body Wiring Harness Assembly (1) @Engine Wiring Harness Fuse Block Bracket
9. Remove Engine Wiring Harness Assembly (2)@Engine Wiring Harness Fuse Block Bracket

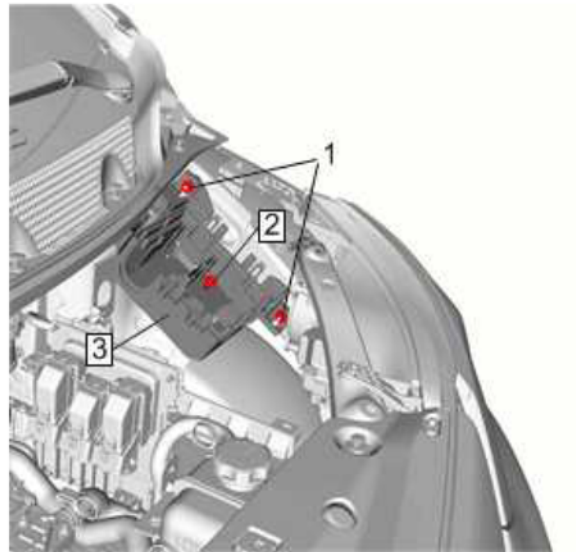


Fig. 65: Engine Wiring Harness Fuse Block Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

10. Remove Engine Wiring Harness Fuse Block Bracket Nut (1)
11. Remove Engine Wiring Harness Fuse Block Bracket Bolt (2)
12. Remove Engine Wiring Harness Fuse Block Bracket (3)

Installation Procedure

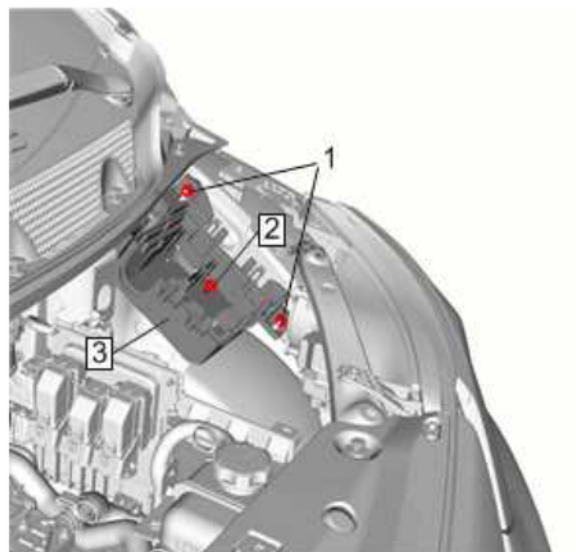


Fig. 66: Engine Wiring Harness Fuse Block Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

1. Install Engine Wiring Harness Fuse Block Bracket (3)
2. Install Engine Wiring Harness Fuse Block Bracket Bolt (2) and tighten 9 N.m (80 lb in)
3. Install Engine Wiring Harness Fuse Block Bracket Nut (1) and tighten 9 N.m (80 lb in)

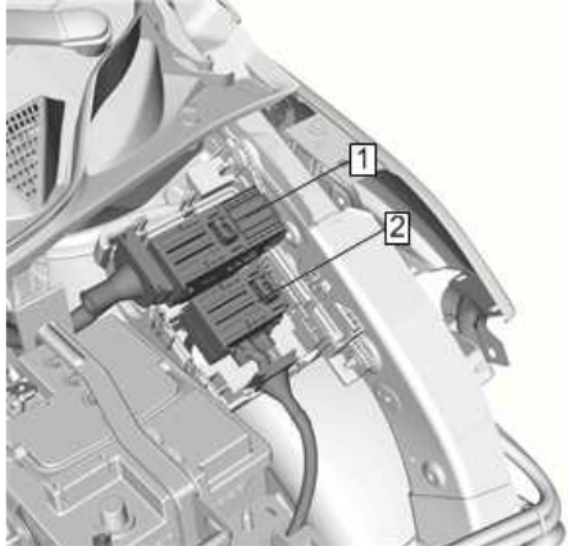


Fig. 67: Body Wiring Harness Assembly

Courtesy of GENERAL MOTORS COMPANY

4. Install Engine Wiring Harness Assembly (2)@Engine Wiring Harness Fuse Block Bracket
5. Install Body Wiring Harness Assembly (1)@Engine Wiring Harness Fuse Block Bracket

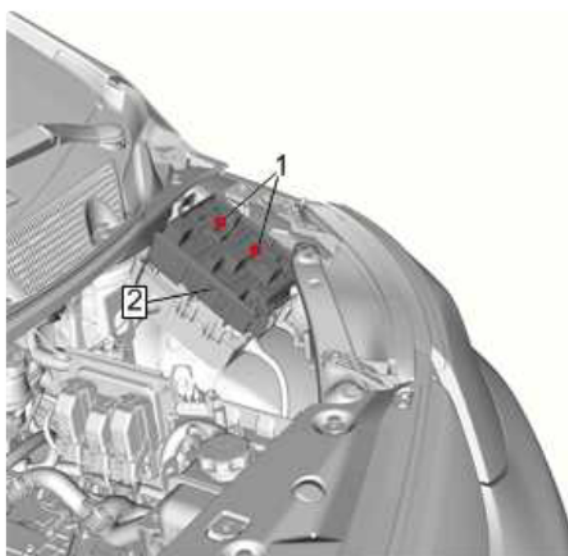


Fig. 68: Engine Wiring Harness Junction Block

Courtesy of GENERAL MOTORS COMPANY

6. Install Engine Wiring Harness Junction Block (2)
7. Install Engine Wiring Harness Junction Block Bolt (1) and tighten 1.5 N.m (13 lb in)

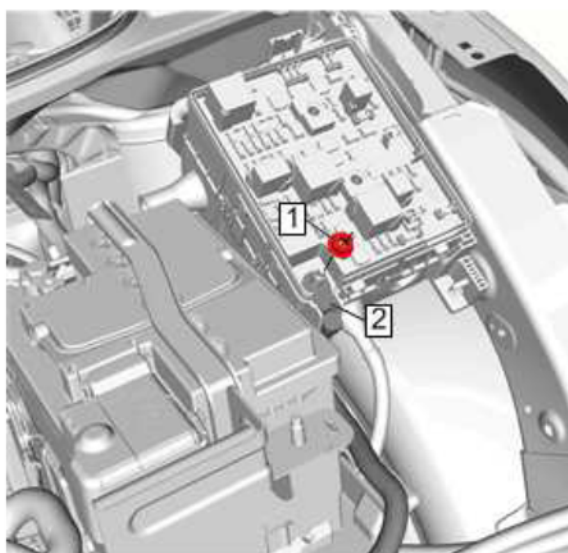


Fig. 69: Battery Positive Cable Nut

Courtesy of GENERAL MOTORS COMPANY

8. Install the battery positive cable nut (1) and the cable (2) to the engine wiring harness junction block assembly.
Tighten the nut to 22 N.m (16 lb ft)



Fig. 70: Fuse Block Cover

Courtesy of GENERAL MOTORS COMPANY

9. Install Fuse Block Cover(1)
10. Install Battery [Battery Replacement](#)
11. Connect Battery Negative Cable [Battery Negative Cable Disconnection and Connection](#)

BATTERY REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#).

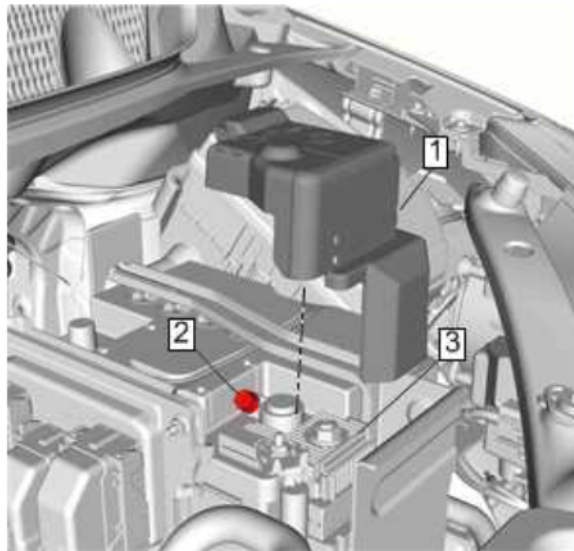


Fig. 71: Battery Positive Cable Protective Cover

Courtesy of GENERAL MOTORS COMPANY

2. Remove Battery Positive Cable Protective Cover (1)
3. Loosen Battery Positive Cable Clamp Fastener
4. Remove Battery Positive Cable (3) @ Battery Post

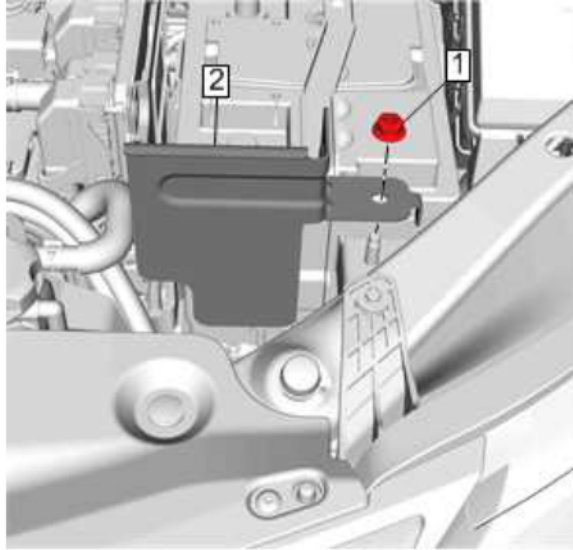


Fig. 72: Battery Tray Support Nut
Courtesy of GENERAL MOTORS COMPANY

5. Remove Battery Tray Support Nut (1)
6. Remove Battery Tray Support (2)

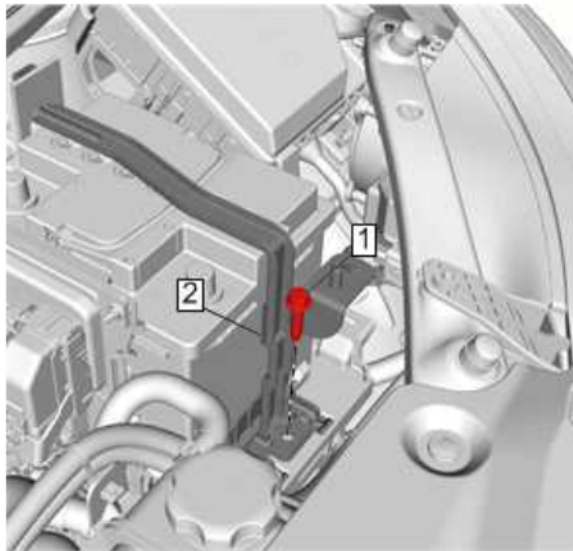


Fig. 73: Battery Retainer Assembly Bolt And Assembly
Courtesy of GENERAL MOTORS COMPANY

7. Remove Battery Retainer Assembly Bolt (1)
8. Remove Battery Retainer Assembly (2)

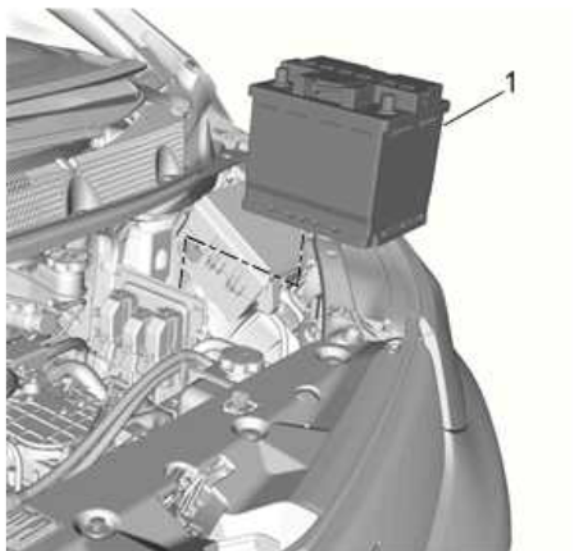


Fig. 74: Battery
Courtesy of GENERAL MOTORS COMPANY

9. Remove Battery (1)

Installation Procedure

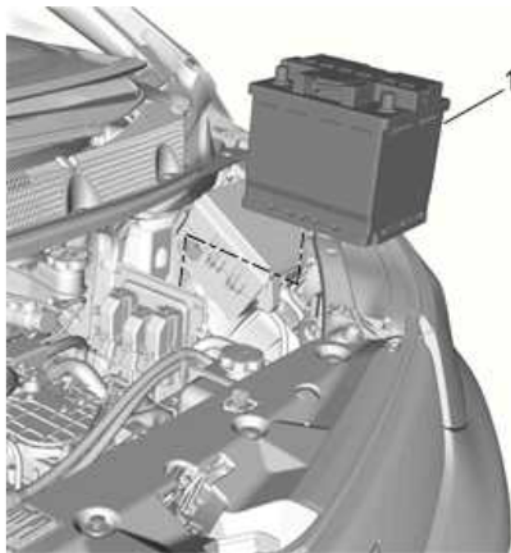


Fig. 75: Battery

Courtesy of GENERAL MOTORS COMPANY

1. Install Battery (1)

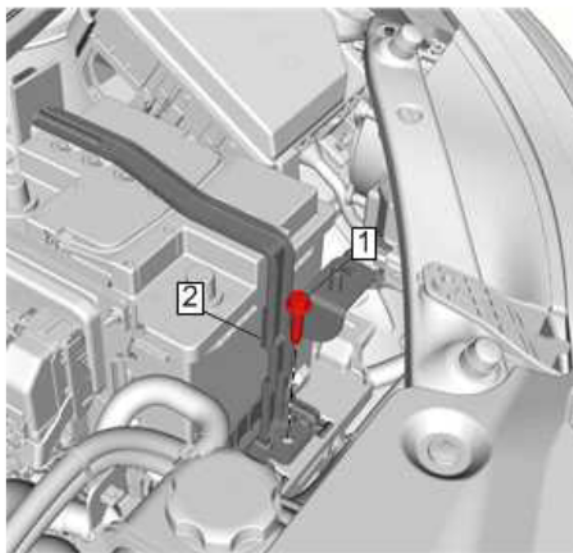


Fig. 76: Battery Retainer Assembly Bolt And Assembly

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. Install Battery Retainer Assembly (2)
3. Install Battery Retainer Assembly Bolt (1) and tighten 8 N.m (71 lb in)

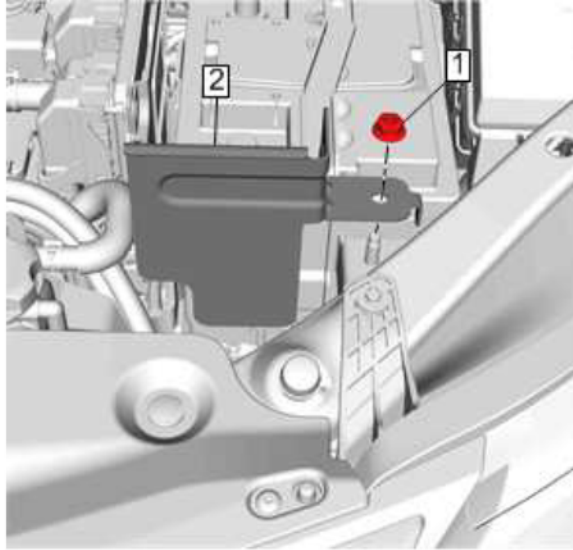


Fig. 77: Battery Tray Support Nut

Courtesy of GENERAL MOTORS COMPANY

4. Install Battery Tray Support (2)
5. Install Battery Tray Support Nut (1) and tighten 9 N.m (80 lb in)

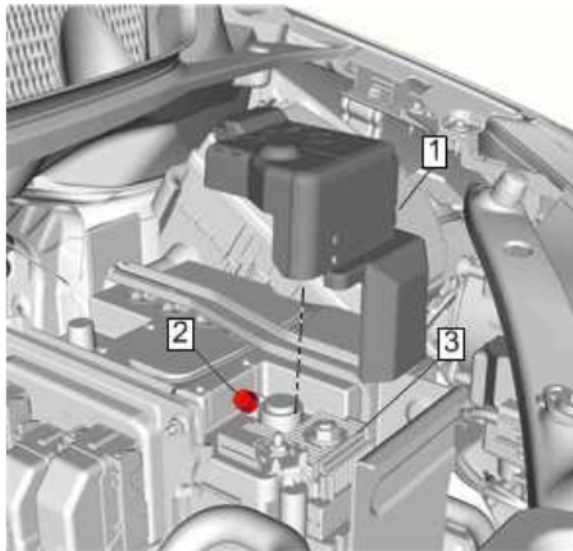


Fig. 78: Battery Positive Cable Protective Cover

Courtesy of GENERAL MOTORS COMPANY

6. Install Battery Positive Cable (3) @ Battery Post
7. Install Battery Positive Cable Clamp Fastener and tighten 5 N.m (44 lb in)
8. Install Battery Positive Cable Protective Cover (1)
9. Connect the battery negative cable. **Battery Negative Cable Disconnection and Connection.**

BATTERY TRAY REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. **Battery Negative Cable Disconnection and Connection.**
2. Remove the battery. **Battery Replacement**

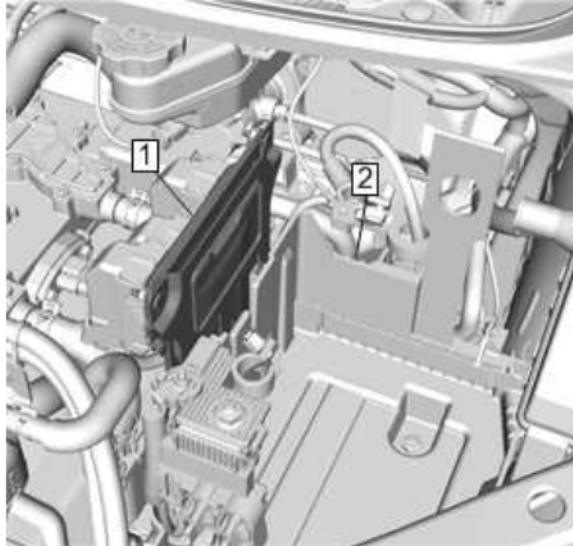


Fig. 79: Engine Control Module

Courtesy of GENERAL MOTORS COMPANY

3. Detach Engine Control Module (1) @ Battery Tray (2)

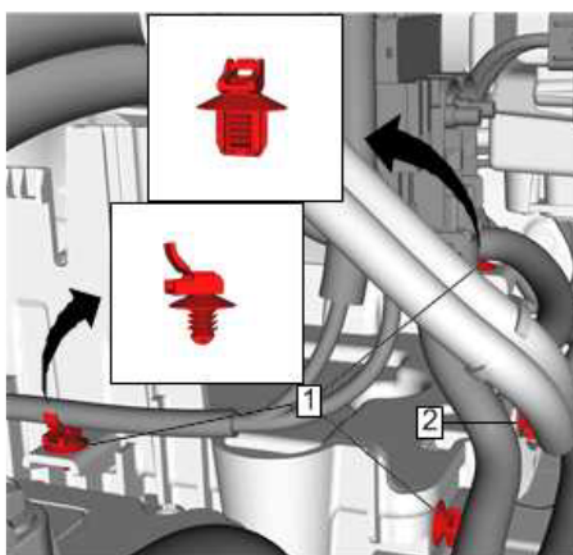


Fig. 80: Battery Positive Cable Retainer

Courtesy of GENERAL MOTORS COMPANY

4. Detach Battery Positive Cable Retainer (1) @ Battery Tray
5. Detach {If equipped} Drive Motor Battery Charger Receptacle Retainer (2) @ Battery Tray

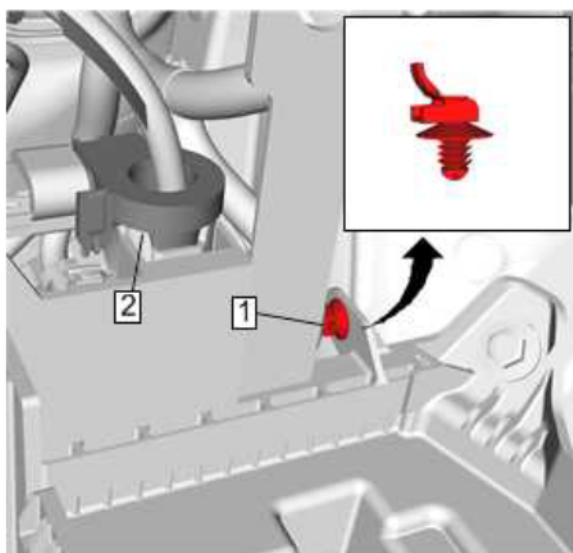


Fig. 81: Body Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

6. Detach {If equipped} Body Harness Retainer (1) @ Battery Tray
7. Remove Battery Current Sensor (2) @ Battery Tray

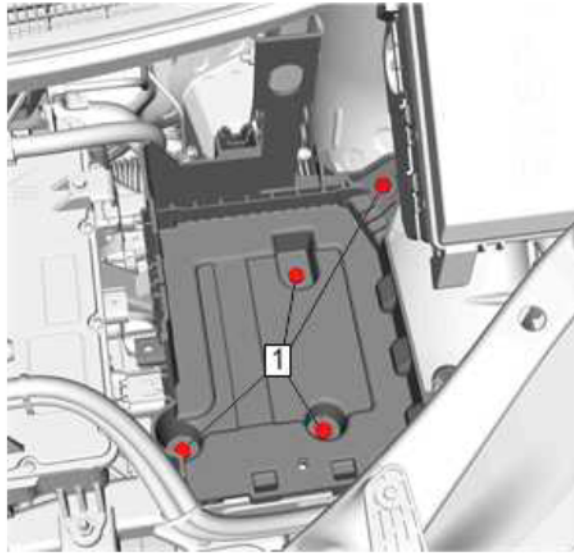


Fig. 82: Battery Tray Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Remove Battery Tray Bolt (1)

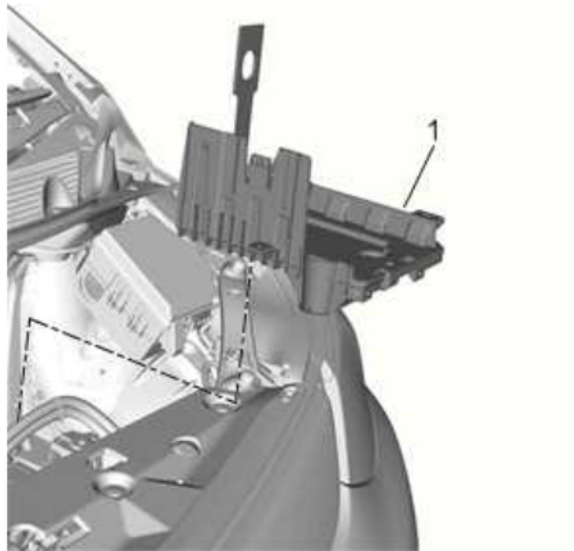
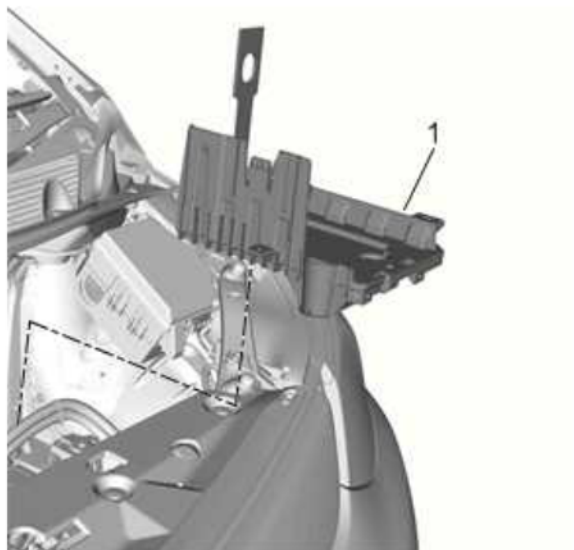


Fig. 83: Battery Tray

Courtesy of GENERAL MOTORS COMPANY

9. Remove Battery Tray (1)

Installation Procedure



1. Install Battery Tray (1)

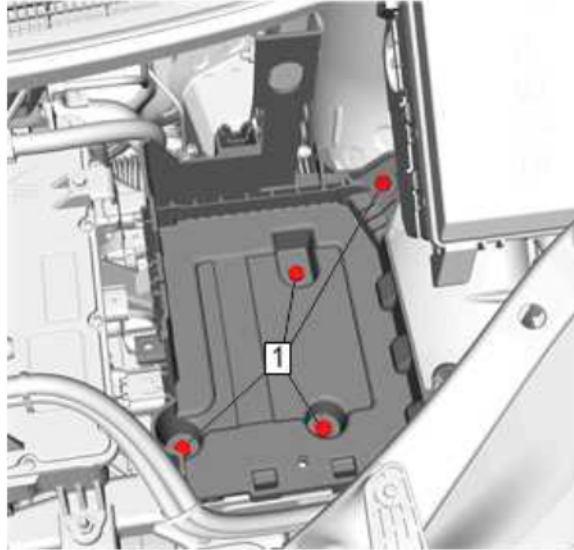


Fig. 85: Battery Tray Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

2. Install Battery Tray Bolt (1) and tighten 11.5 N.m (102 lb in)

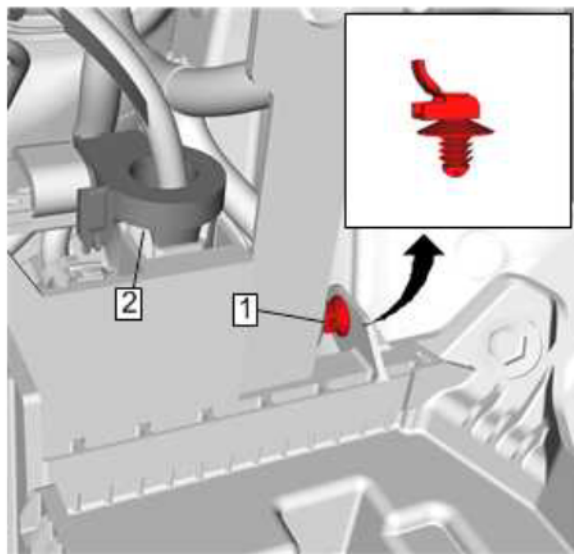


Fig. 86: Body Harness Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Attach {If equipped} Body Harness Retainer (1) @ Battery Tray
4. Install Battery Current Sensor (2) @ Battery Tray

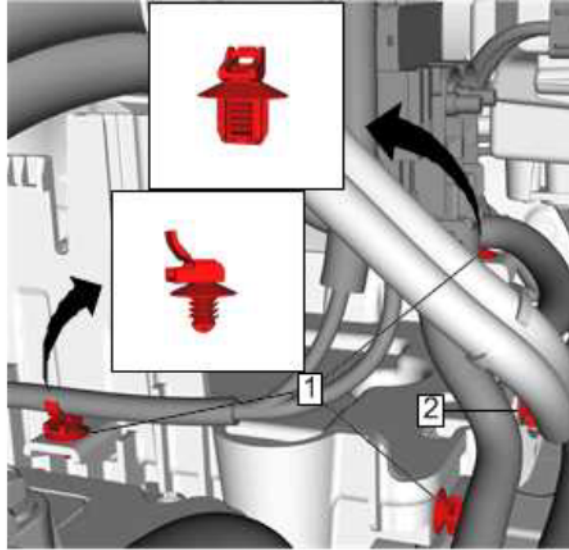


Fig. 87: Battery Positive Cable Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Attach Battery Positive Cable Retainer (1) @ Battery Tray
6. Attach {If equipped} Drive Motor Battery Charger Receptacle Retainer (2) @ Battery Tray

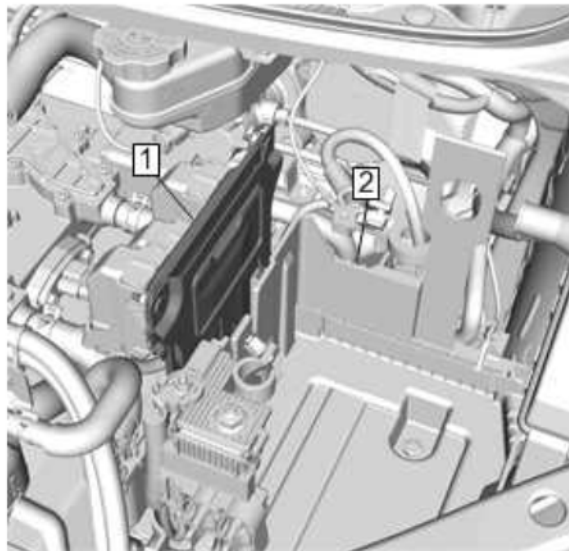


Fig. 88: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

7. Attach Engine Control Module (1) @ Battery Tray (2)
8. Install the battery. [Battery Replacement](#)
9. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#).

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

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

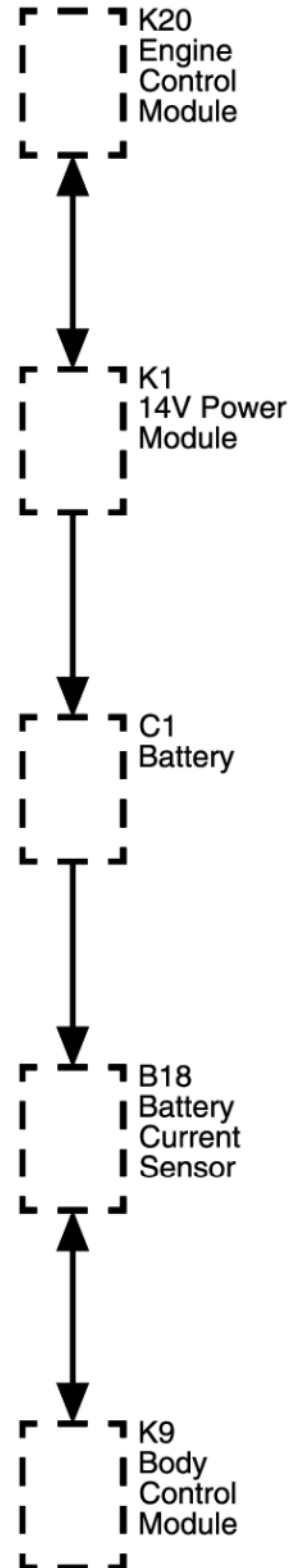


Fig. 89: Charging Block Diagram

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 14V 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.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description

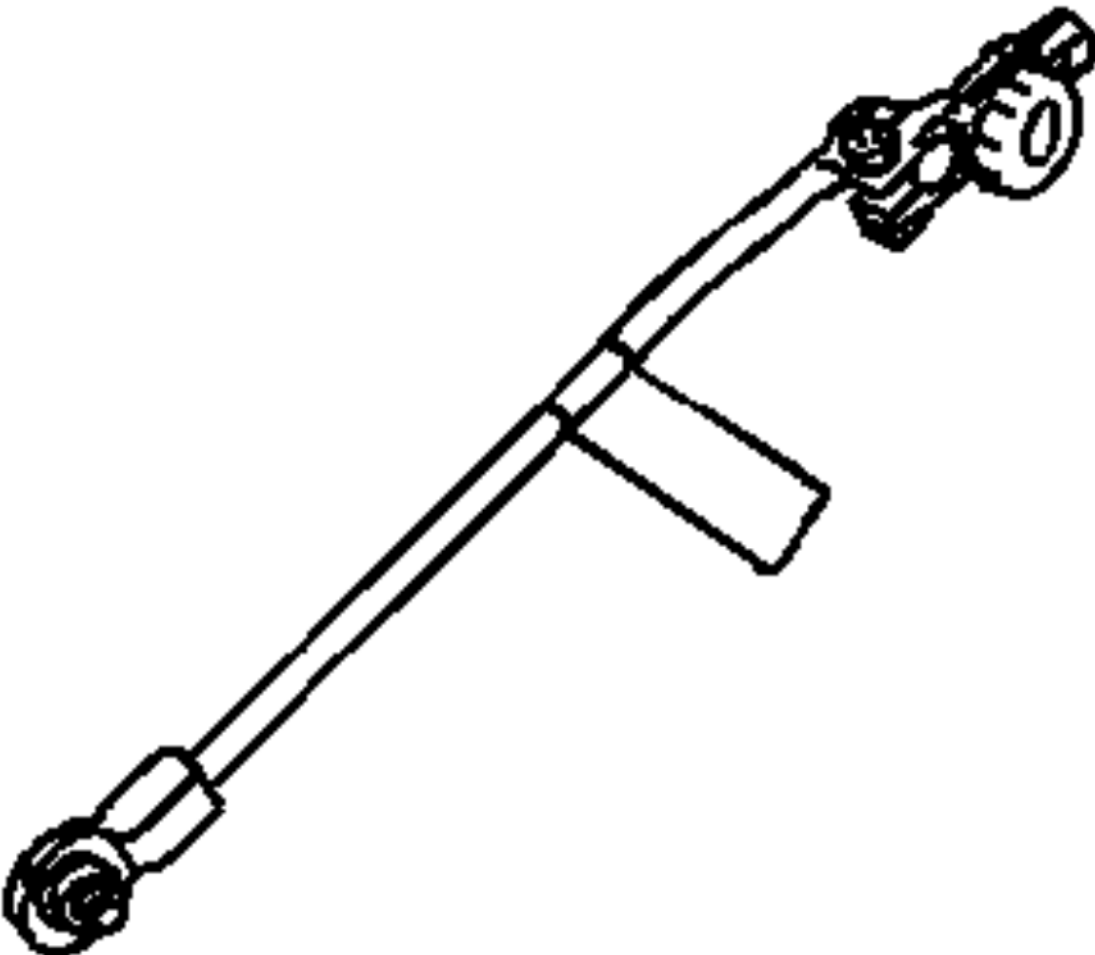
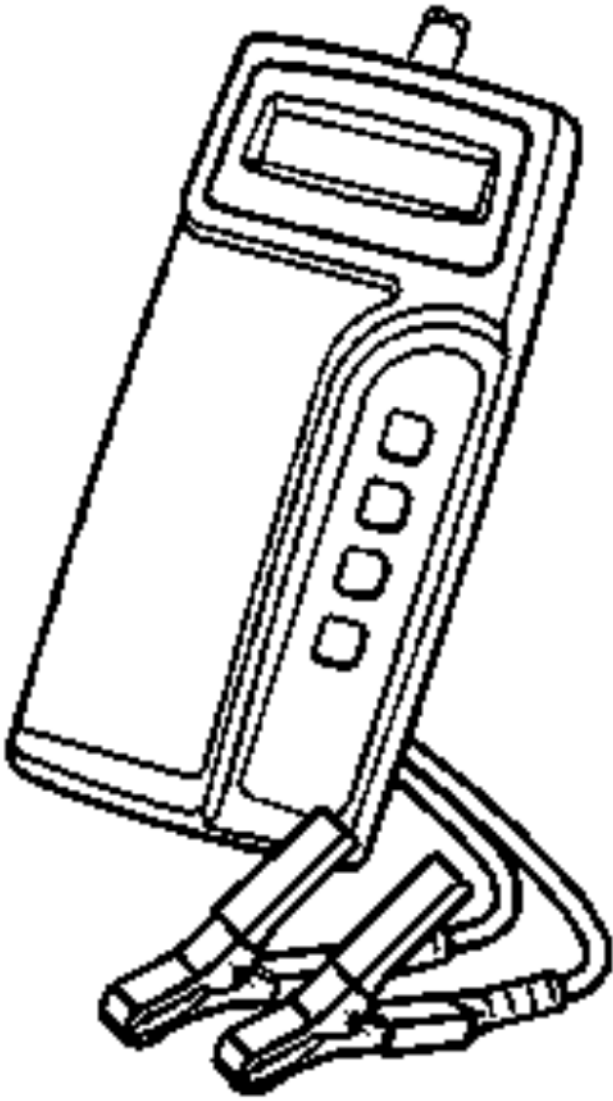
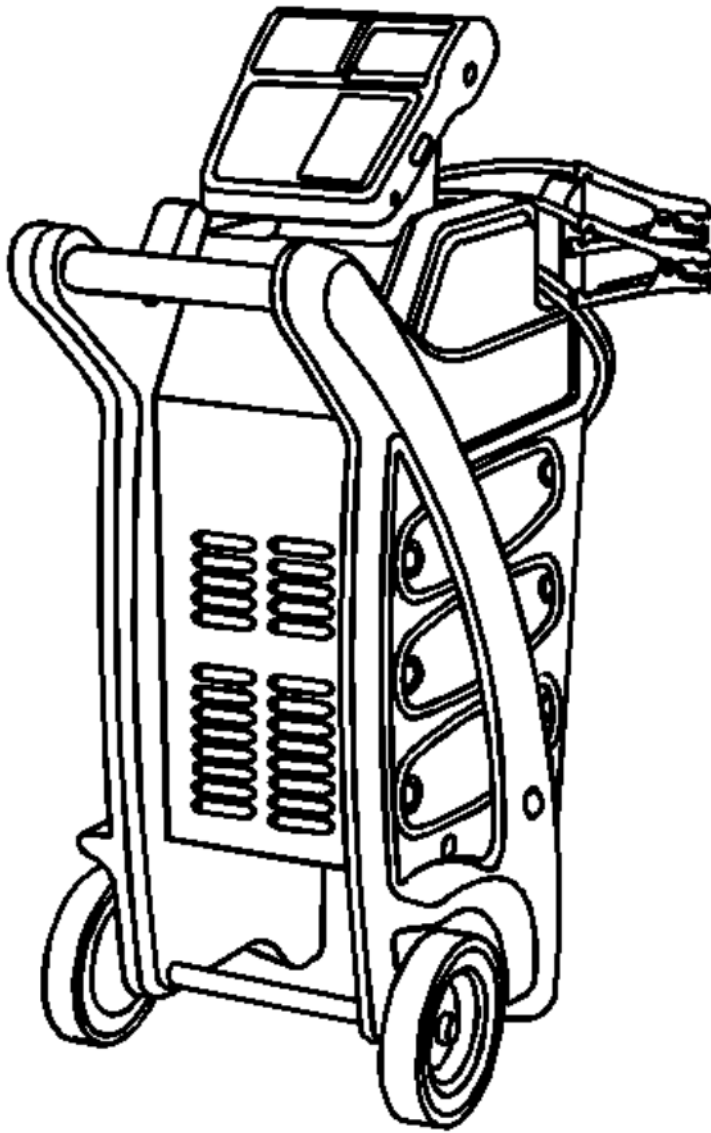
Illustration	Tool Number/Description
	EL 38758 EL 50074 J 38758 Parasitic Draw Test Switch
	J 42000 Battery Tester cardiagn.com

Illustration	Tool Number/Description
	



EL 50313
EL 42000
EL 50076
Battery Tester

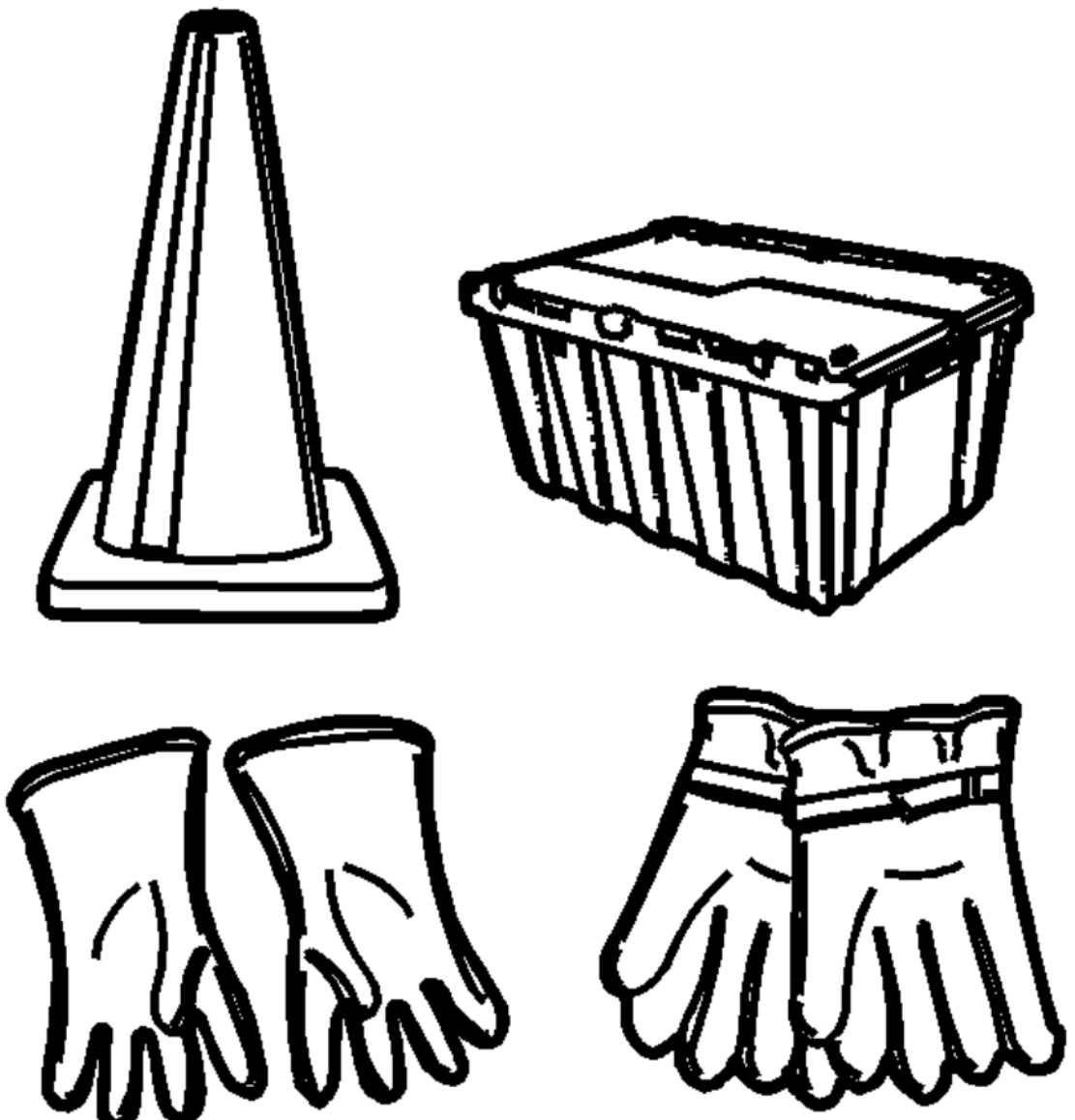
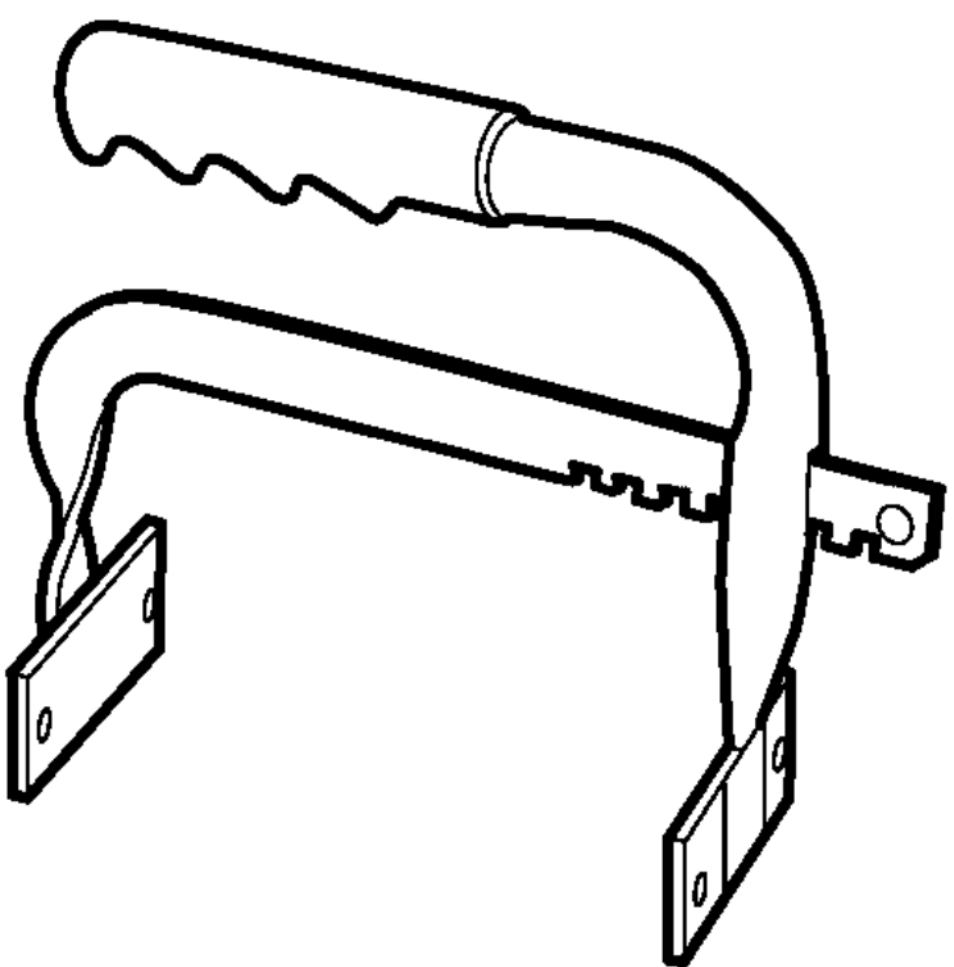
Illustration	Tool Number/Description
 The illustration shows four items: a traffic cone on the top left, a rectangular storage bin with vertical ridges on the top right, a pair of short gloves on the bottom left, and a pair of long gloves on the bottom right. All items are drawn in a simple, black-and-white line-art style.	EL-48900 HEV Safety Kit

Illustration	Tool Number/Description
	GE-49379 Battery Remover / Installer