SCHEMATIC WIRING DIAGRAMS

HYBRID/EV ENERGY STORAGE WIRING SCHEMATICS

Power, Ground, Serial Data, and Internal Battery Communication

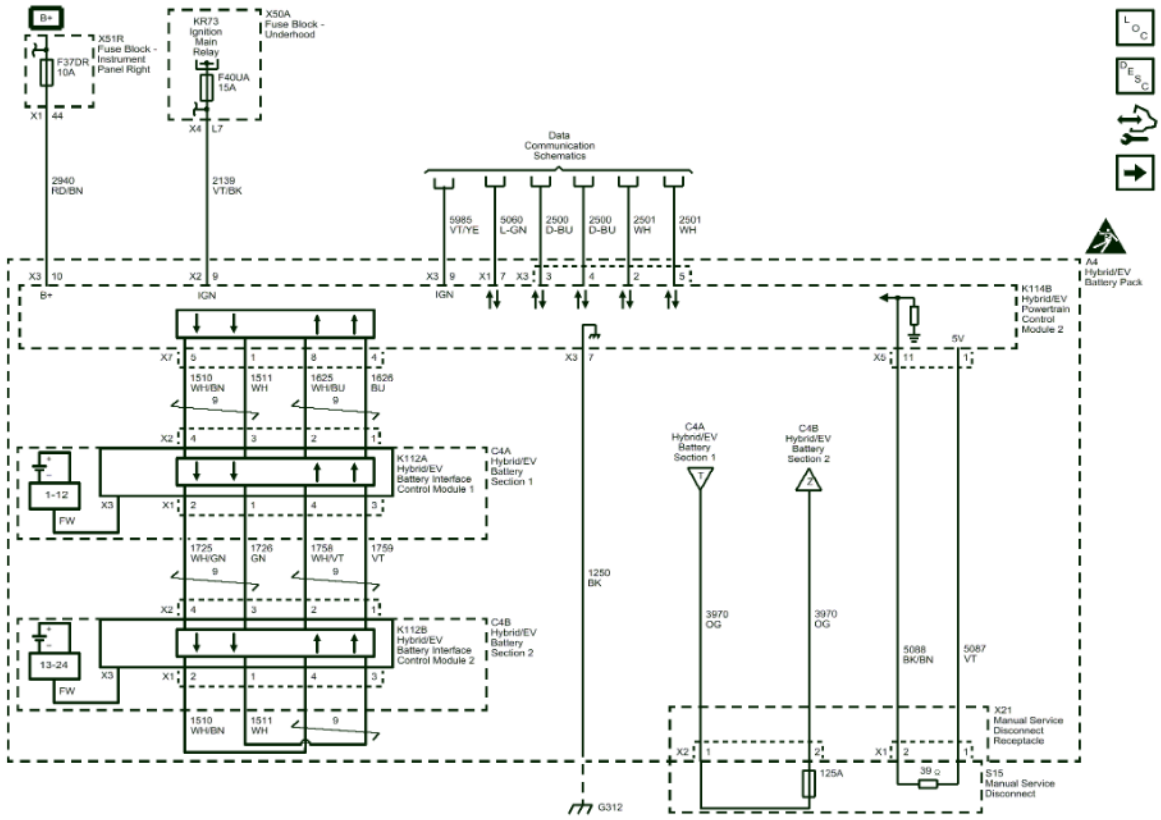


Fig. 1: Power, Ground, Serial Data, and Internal Battery Communication
Courtesy of GENERAL MOTORS COMPANY

High Voltage Contactors Control

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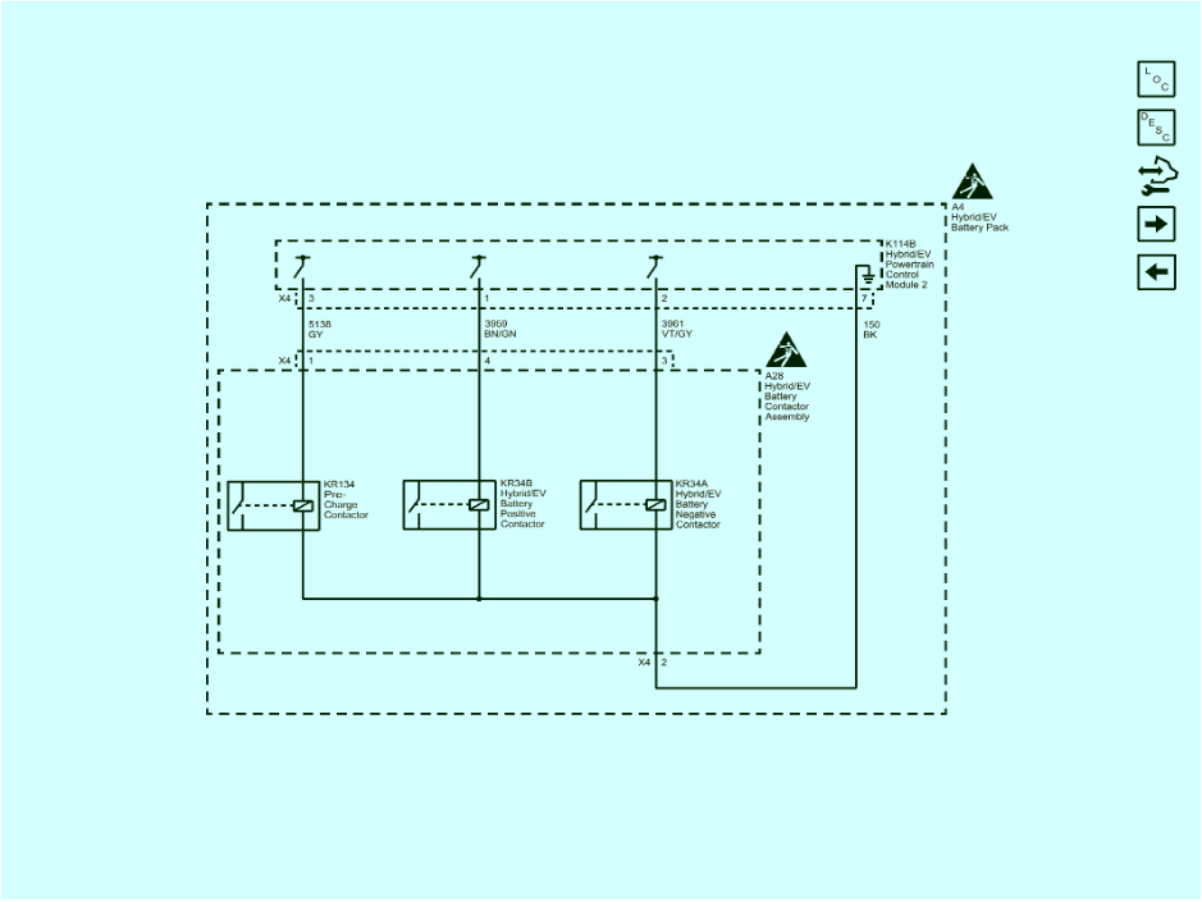


Fig. 2: High Voltage Contactors Control
Courtesy of GENERAL MOTORS COMPANY

Hybrid/EV Battery Sections 1 and 2

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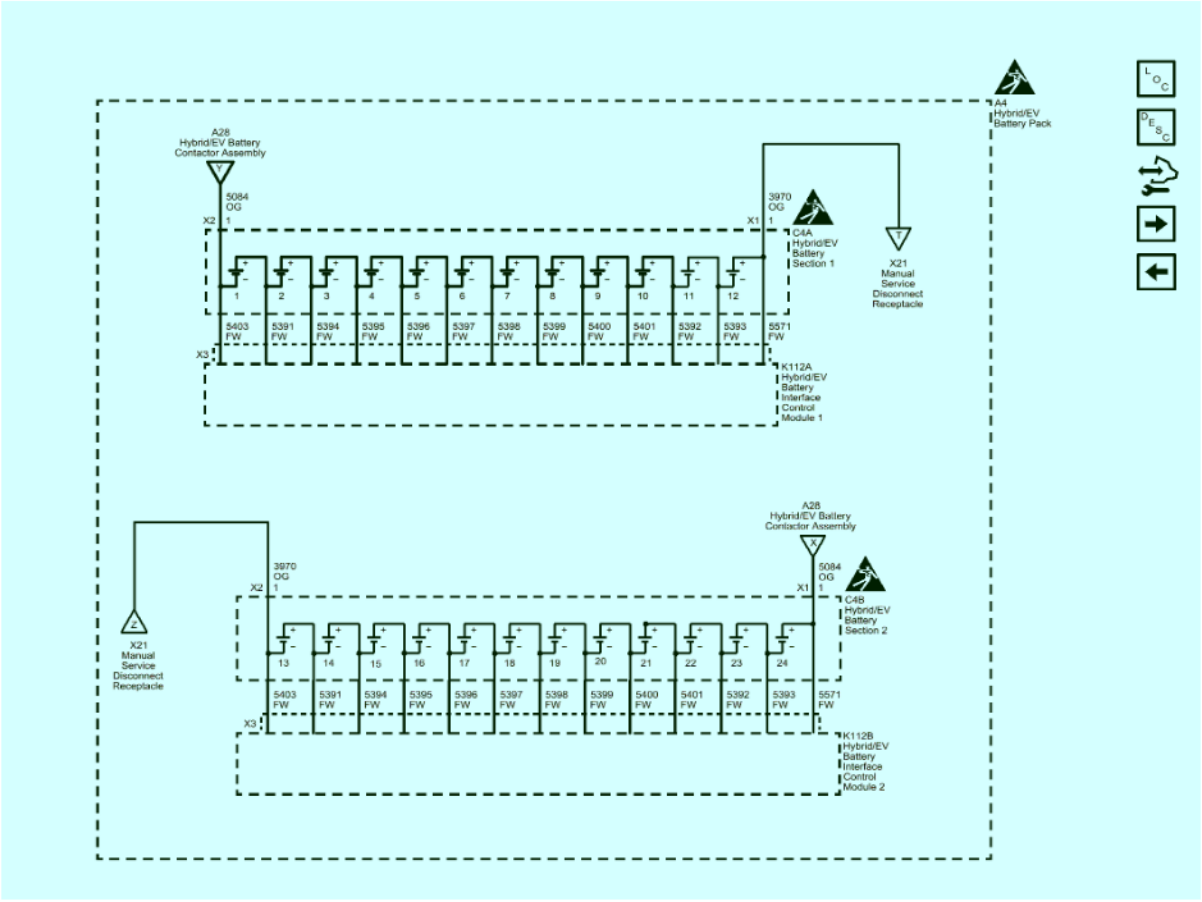


Fig. 3: Hybrid/EV Battery Sections 1 and 2
Courtesy of GENERAL MOTORS COMPANY

High Voltage Contactors

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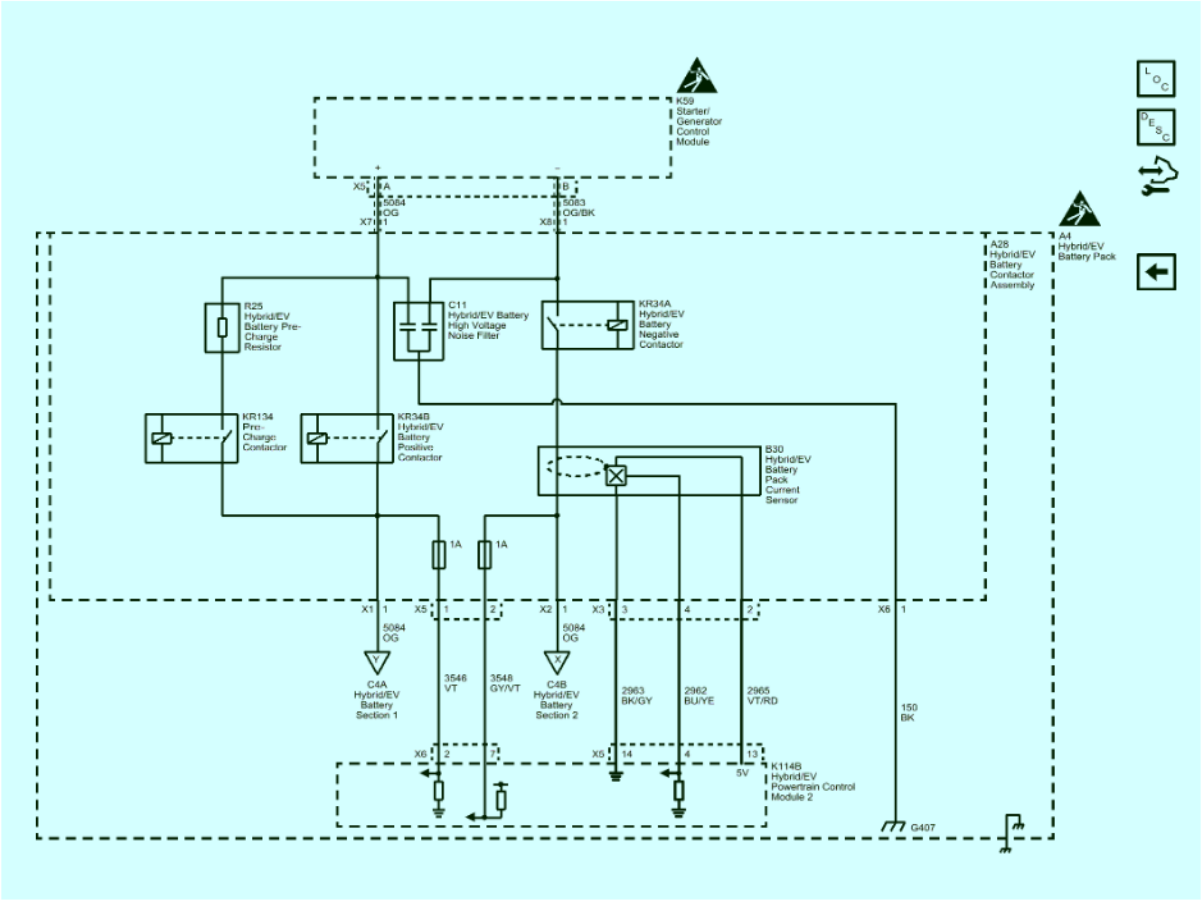


Fig. 4: High Voltage Contactors
Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

High Voltage Battery Components 1

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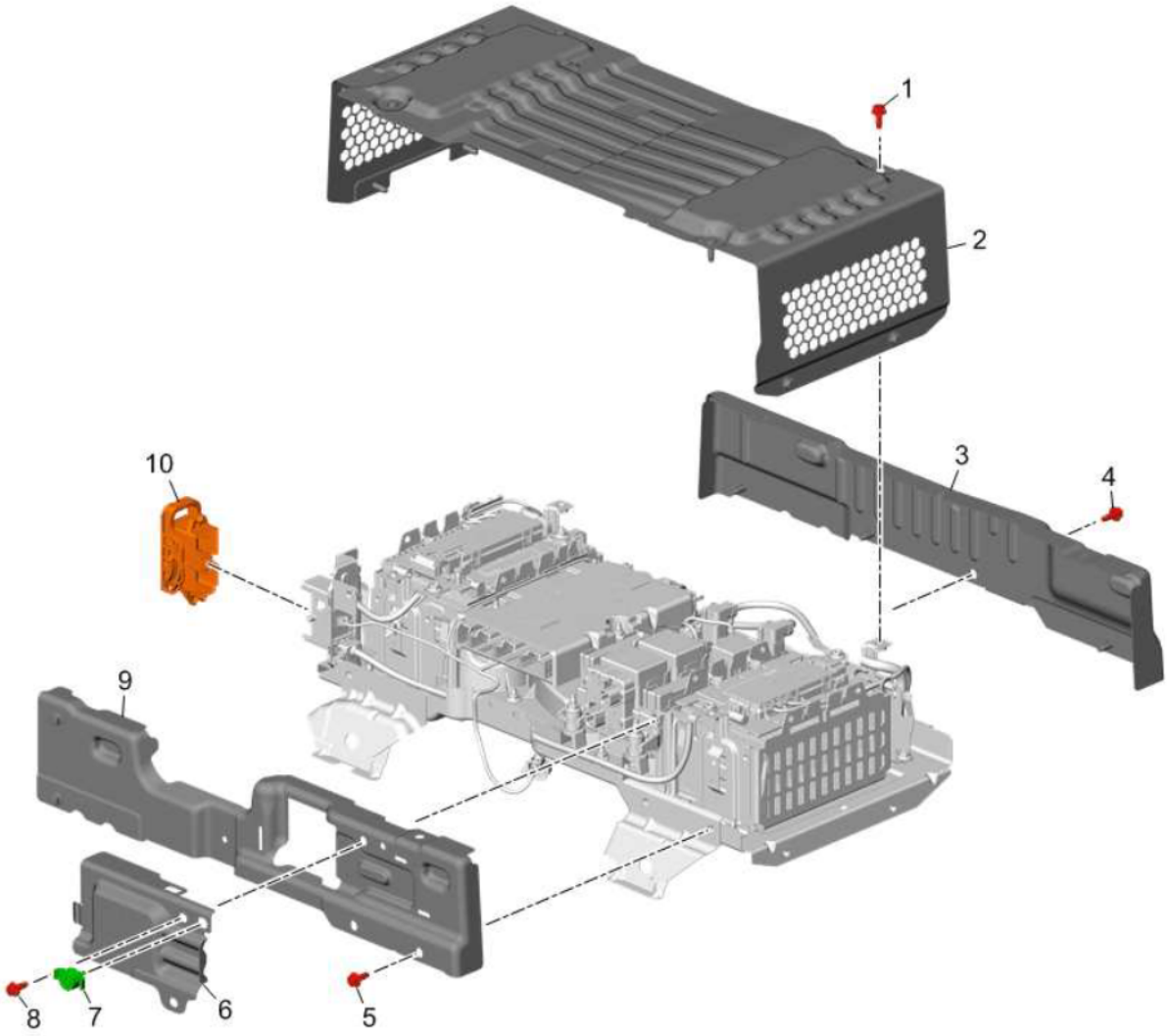


Fig. 5: High Voltage Battery Components 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	High Voltage Battery Cover Bolt
2	High Voltage Battery Cover
3	High Voltage Battery Cover - Left Side
4	High Voltage Battery Cover Bolt
5	High Voltage Battery Cover Bolt
6	High Voltage Cover
7	High Voltage Locking Safety Push-Pin
8	High Voltage Cover Bolt
9	High Voltage Battery Cover - Right Side
10	Drive Motor Battery High Voltage Manual Disconnect Lever

High Voltage Battery Components 2

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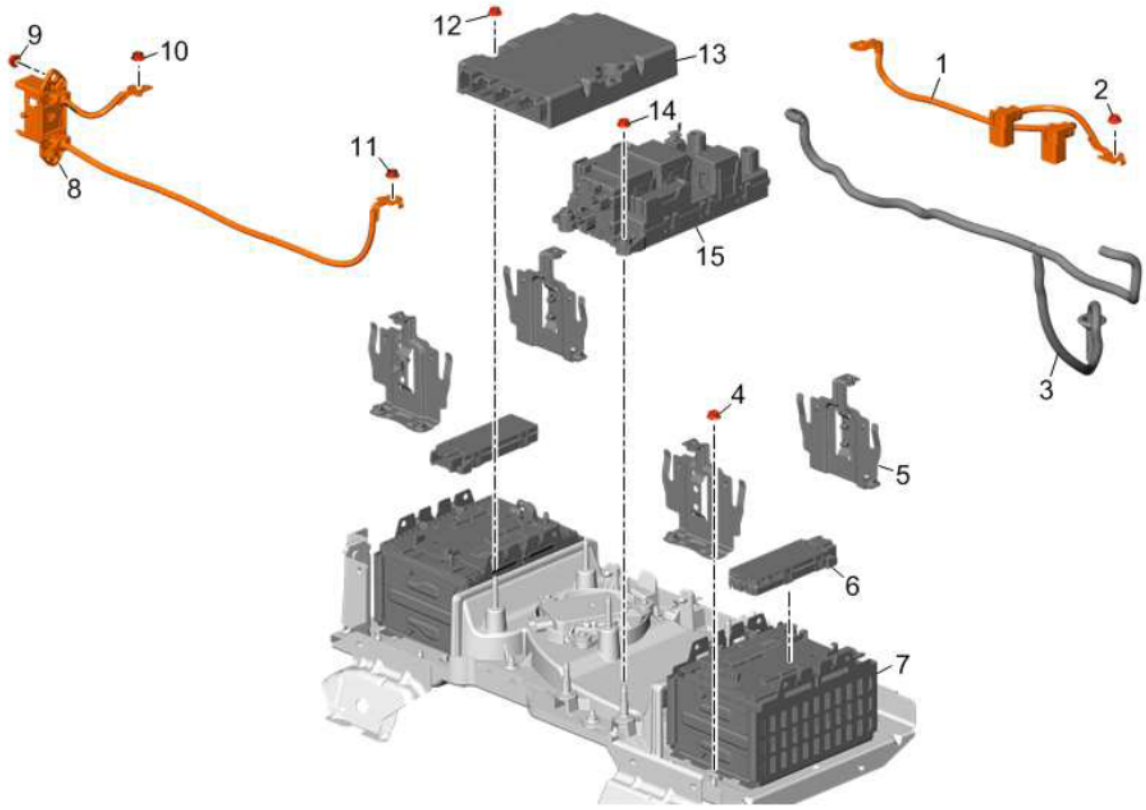


Fig. 6: High Voltage Battery Components 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Auxiliary Battery Negative Cable
2	Auxiliary Battery Negative Cable Fastener
3	Cell Battery Vent Tube
4	Battery Hold Down Retainer Nut
5	Battery Hold Down Retainer
6	High Voltage Battery Interface Control Module
7	Cell Battery Module
8	High Voltage Battery Disconnect Cable
9	High Voltage Battery High Voltage Manual Disconnect Connector Fastener
10	High Voltage Battery Negative Cable Fastener
11	High Voltage Battery Positive Cable Fastener
12	Hybrid Powertrain Control Module 2 Mounting Nut
13	Hybrid Powertrain Control Module 2
14	Generator Battery Disconnect Relay Mounting Nut
15	Generator Battery Disconnect Relay

High Voltage Battery Cooling Components

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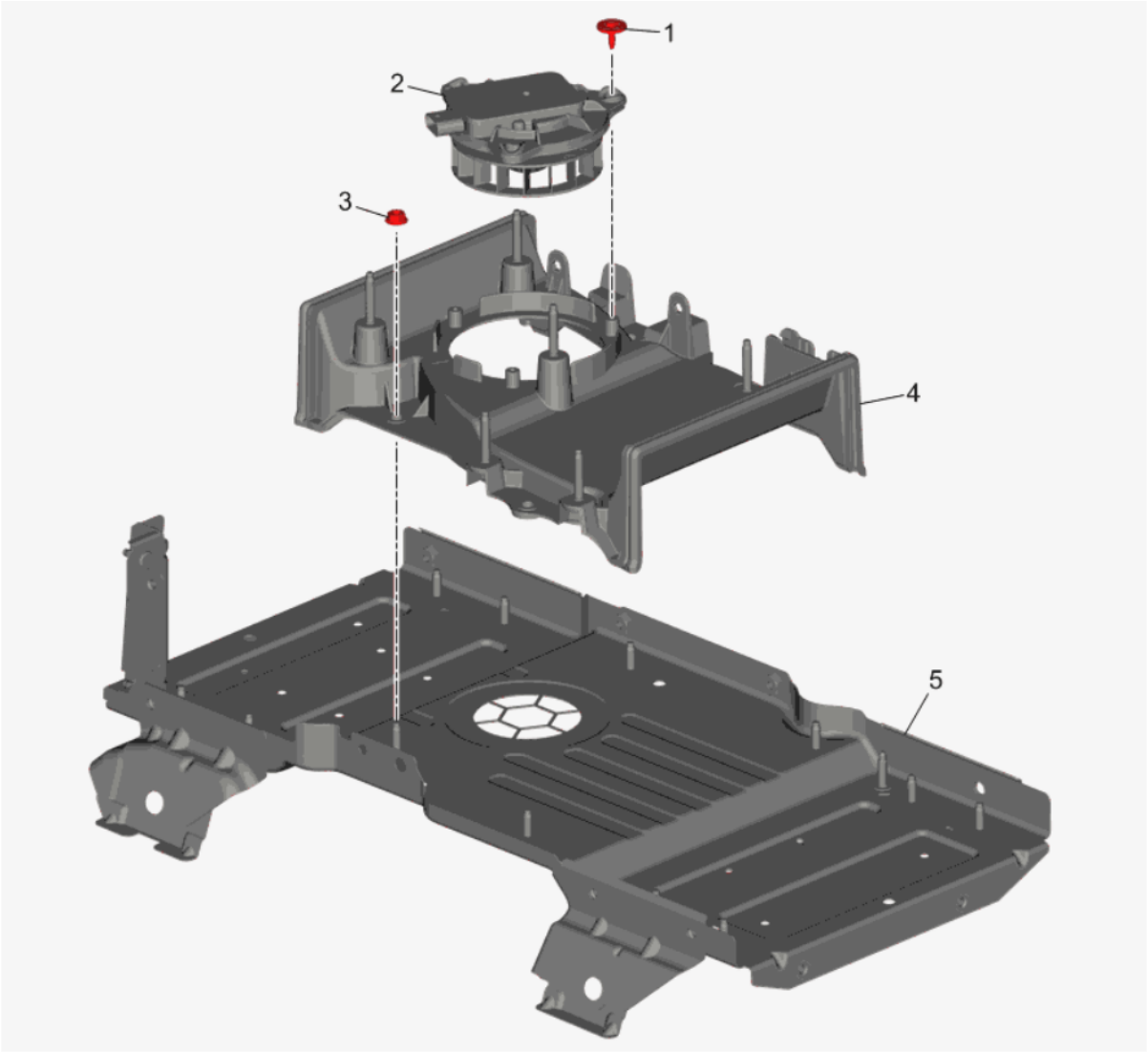


Fig. 7: High Voltage Battery Cooling
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Motor Generator Battery Cooling Blower Fastener
2	Drive Motor Generator Battery Cooling Blower
3	Battery Cooling Air Inlet Duct Mounting Nut
4	Battery Cooling Air Inlet Duct
5	High Voltage Battery Tray

HYBRID ENERGY STORAGE COMPONENT VIEWS

Hybrid/EV Battery Pack Internal Components

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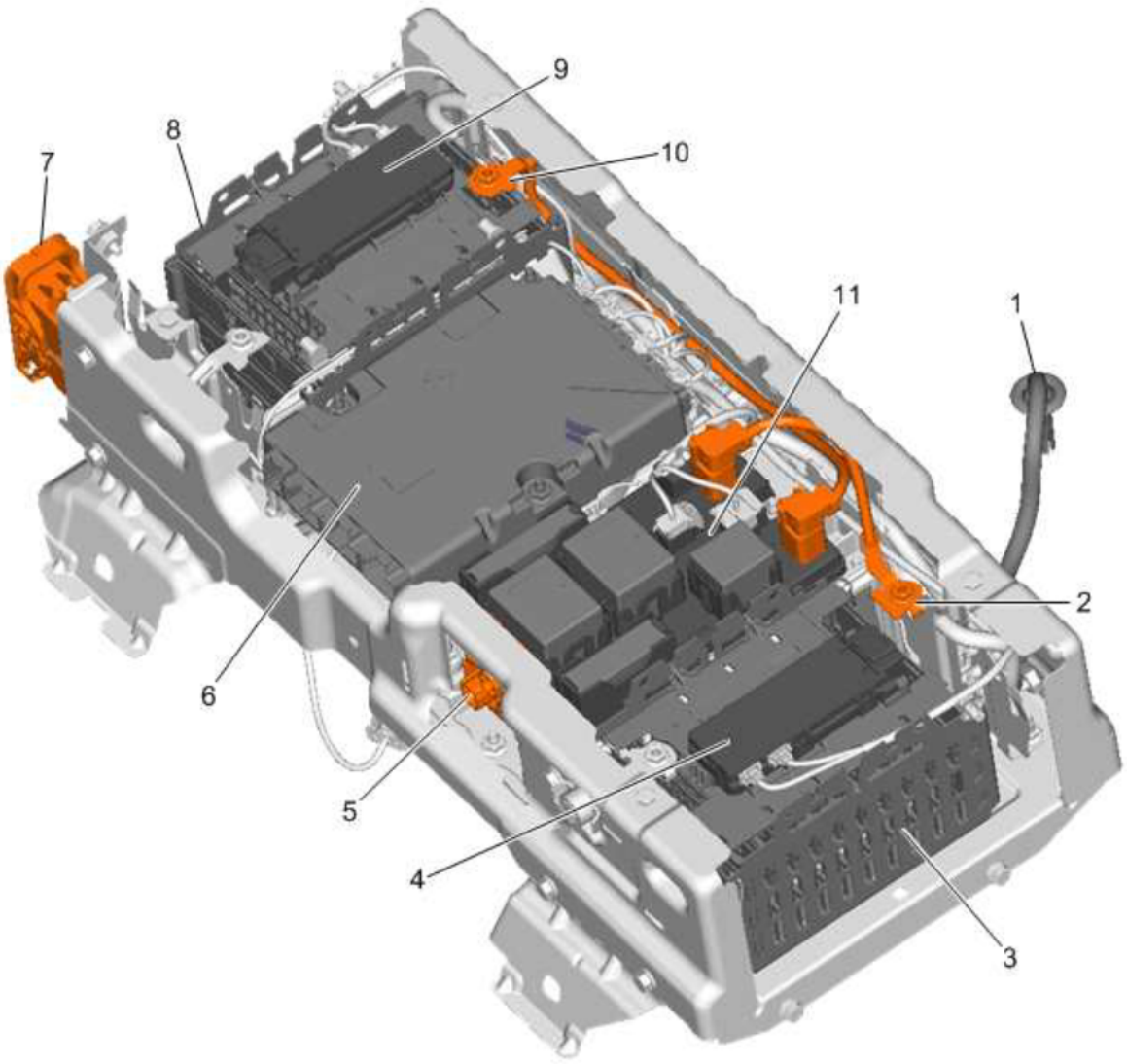


Fig. 8: Hybrid/EV Battery Pack Internal Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Battery Vent
2	Hybrid/EV Battery Pack Negative Terminal
3	Hybrid/EV Battery Section 1
4	Battery Interface Control Module
5	High Voltage vehicle connection
6	Hybrid/EV Powertrain Control Module 2
7	Manual Service Disconnect
8	Hybrid/EV Battery Section 2
9	Battery Interface Control Module
10	Hybrid/EV Battery Pack Positive Terminal
11	Generator Battery Disconnect Relay Assembly

DIAGNOSTIC INFORMATION AND PROCEDURES

HIGH VOLTAGE SAFETY

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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.

WARNING: **High voltage circuits should only be tested using a digital multimeter (DMM) and test leads with at least a CAT III rating, such as the J 39200-A Digital Multimeter. Failure to follow the procedures may result in serious injury or death.**

WARNING: **This vehicle is equipped with a high voltage battery that is completely isolated from the chassis ground. Never utilize AC powered test equipment to probe the high voltage system. Serious injury, death and component damage could occur if the high voltage system is grounded through the electric utility.**

Failure to follow the procedure exactly as written may result in serious injury or death.

Special Tools

EL-48900 HEV Safety Kit

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

Precautions when Performing Service or Inspections

- Always verify that the high voltage has been disabled before working on or around high voltage components, wires, cables, or harnesses.
- Remove all metal objects such as rings and watches.

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- The **EL-48900** HEV safety kit contains safety cones. Place the safety cones around the vehicle to alert other technicians that you are working on the high voltage system.
- Remove all vehicle keys and secure in a location outside the vehicle. If the vehicle is equipped with push button start, the keys must remain at least 3 meters (15 feet) from the vehicle.
- Ensure that the manual service disconnect lever is secured in the open position with a zip tie.
- Always wear certified and tested high voltage insulation gloves when inspecting or testing any high voltage wires and components.
- Use the "One Hand" rule:
  - Work with only one hand whenever possible.
  - Keep the other hand behind your back.
- DO NOT carry any metal objects such as a mechanical pencil or a measuring tape that could fall and cause a short circuit.
- After removing any high voltage wires, protect and insulate the terminal ends immediately with ULÂ® Listed or equivalent insulation tape rated at a minimum of 600 V.
- Always tighten the high voltage terminal fasteners to the specified torque. Insufficient or excessive torque will cause malfunctions or damage.
- After finishing work on the high voltage systems and before closing the manual service disconnect lever, inspect for the following:
  - Verify high voltage system integrity and that all connectors are installed.
  - Verify that all tools or loose components have been removed.

Labels for Components, Wire Harness, and Connectors

The wire harnesses and cables for high voltage circuits are encased in an orange colored covering. In addition, the high voltage energy storage device (battery) is affixed with a RED DANGER label and other high voltage components (e.g. Starter/Generator) are affixed with ORANGE WARNING labels.

High Voltage Insulation Glove Inspection Procedure

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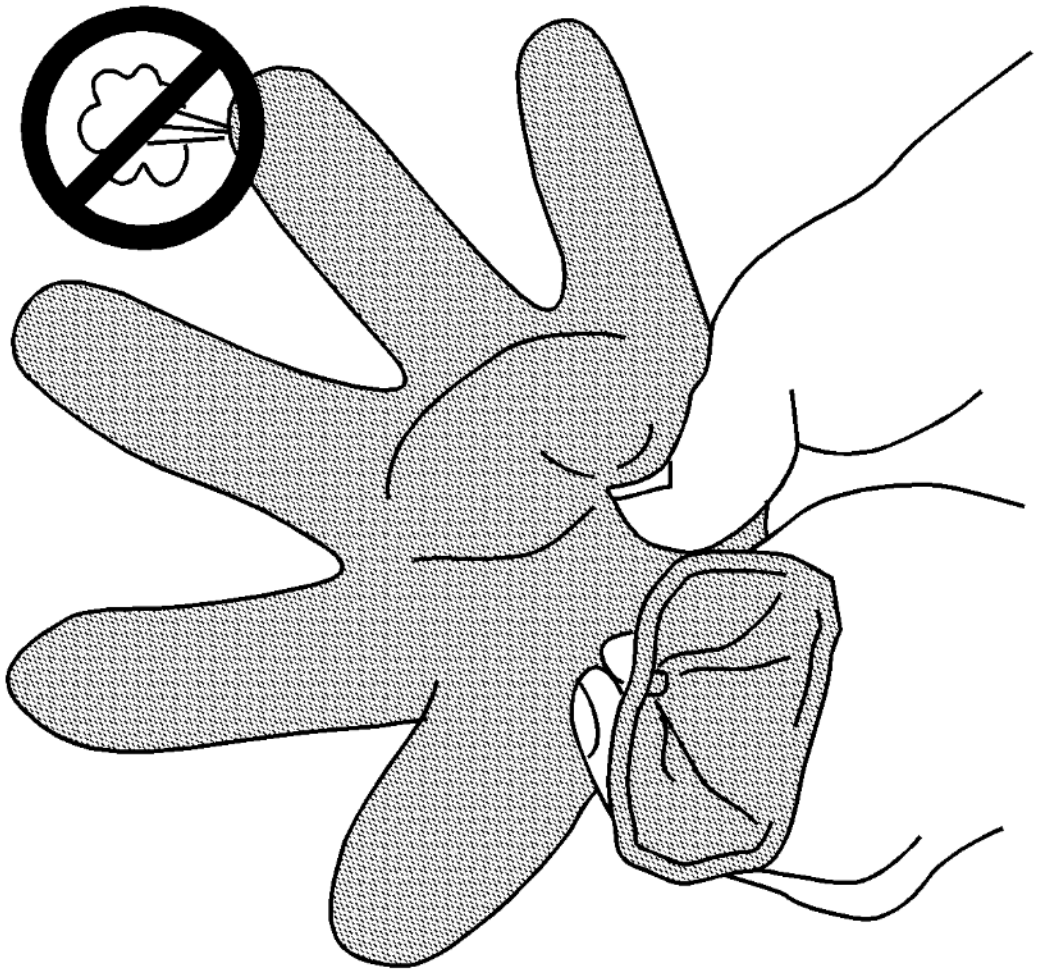


Fig. 9: Glove Inspection Procedure
Courtesy of GENERAL MOTORS COMPANY

The following procedure visually and functionally inspects the insulation gloves to be used while performing service on high voltage systems. This inspection procedure should be performed prior to any procedure that requires the use of class "0" insulation gloves rated at 1000 V.

1. Remove glove from leather protector.
2. Inflate glove and seal opening. Pinch the opening closed tightly to prevent any air loss.
3. Press glove to increase pressure.
4. Inspect for any of the following conditions:
    - Pin holes
    - Air leaks
    - Wear, tears, or abrasions
    - Damp or wet material
    - Certified up-to-date
    - If any of the above conditions exist, do not use the gloves.

HIGH VOLTAGE DISABLING

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Diagnostic Instructions

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

Circuit/System Description

The High Voltage Disabling procedure will perform the following tasks:

- 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.

NOTE: **The High Voltage Disable procedure only de-energizes the high voltage circuits and components outside of the Hybrid/EV battery pack, dangerous voltage levels always exist within the Hybrid/EV battery pack.**

You have to verify high voltage disabling by measuring the applicable connectors for safe voltage level with a DMM.

Diagnostic Aids

Review the **High Voltage Connectors** information for connector identification and the approved procedures for disconnecting and connecting high voltage connectors.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

Drive Motor Battery System Description

Electrical Information Reference

Circuit Testing

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-48900 HEV Safety Kit

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

Circuit/System Testing

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.

1. Review the high voltage safety information. Refer to **High Voltage Safety**.
2. Disconnect and remove all 12 V Battery Chargers.
3. Remove the key from the vehicle and secure in a place outside the vehicle.

NOTE: **The 12 V battery must be disconnected to ensure proper test results.**

4. Disconnect the 12 V battery. Refer to **Battery Negative Cable Disconnection and Connection**

NOTE: **If disabling for servicing the hybrid/EV battery pack or high voltage cables you will need the S15 Manual Service Disconnect to use as a tool to remove the High Voltage Locking Push-Pin safety feature.**

5. Remove the S15 Manual Service Disconnect. Refer to **Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)**. Place the S15 Manual Service Disconnect in a secure place outside the vehicle. Cover the exposed high voltage opening with ULÂ® listed, or equivalent, insulation tape rated at a minimum of 600 V.

NOTE: **5 min must elapse before removing any high voltage connectors. Removal of non-high voltage components is allowed during this wait time.**

6. Wait 5 min before continuing, to allow the high voltage capacitors to discharge.

NOTE: **A 9 V DC battery or the vehicles 12 V battery can be used to test the DMM.**

7. Verify the test DMM by measuring a known good 9 to 12 V battery.
   - **If the DMM does not properly measure the test battery**

     Repair or replace the DMM and repeat all voltage measurements.

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- **If the DMM properly measures the test battery**

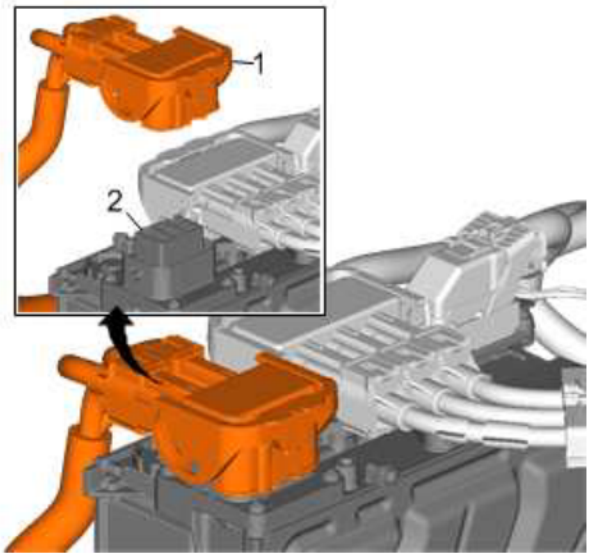


Fig. 10: A4 Hybrid/EV Battery Pack High Voltage Harness Connector
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Wear your High Voltage Insulation gloves until you have determined that a high voltage exposure risk is no longer present.**

8. Disconnect the A4 Hybrid/EV Battery Pack high voltage harness connector (1) at the K59 Starter/Generator Control Module.

NOTE: **5 min must have elapsed since removing the S15 Manual Service Disconnect before continuing to allow the high voltage capacitors to discharge and ensure proper test results.**

9. Verify the voltage measures less than 3 V at the K59 Starter/Generator Control Module connector (2) at the following points:
   - High voltage DC (-300 V) negative terminal to vehicle chassis ground.
   - High voltage DC (+300 V) positive terminal to vehicle chassis ground.
   - High voltage DC (+300 V) positive terminal and high voltage DC (-300 V) negative terminal.
   - **If 3 V or greater**

     Leave the DMM connected to the terminals until the voltage drops below 3 V to allow the high voltage capacitors to discharge. Continue to the next step once the voltage is below 3 V.

   - **If less than 3 V**

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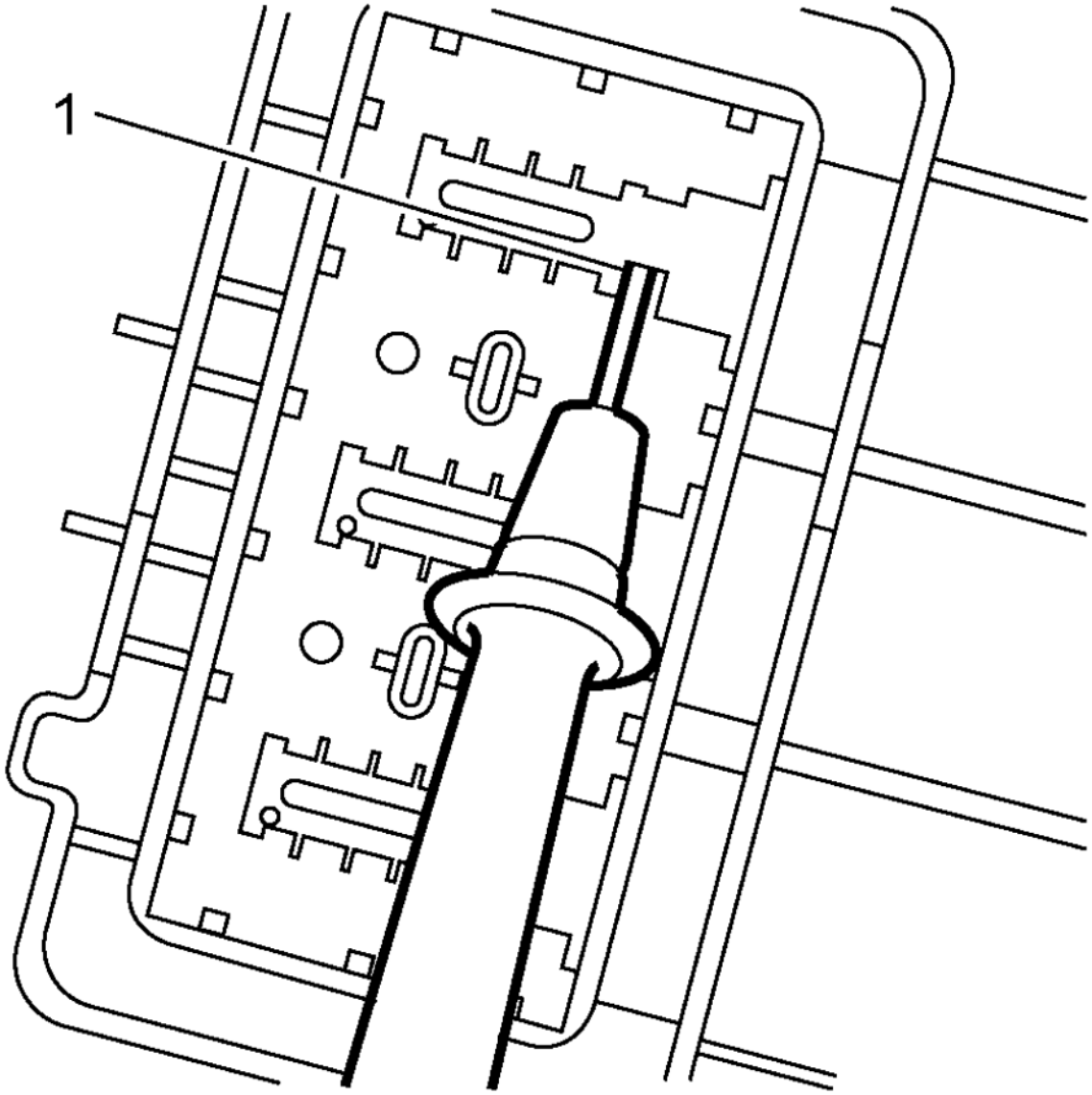


Fig. 11: Probing Long Slot
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A DMM probe will not fit in the terminal slot. Measure for voltage by probing the long slot provided at the rear of each terminal. The 3 phase AC connector is shown, the HV DC connector is similar.**

10. Verify the voltage measures less than 3 V at the HV DC harness connector (1) to the K59 Starter/Generator Control Module at the following points:
    - High voltage DC (-300 V) negative terminal to vehicle chassis ground.
    - High voltage DC (+300 V) positive terminal to vehicle chassis ground.
    - High voltage DC (+300 V) positive terminal and high voltage DC (-300 V) negative terminal.
    - **If 3 V or greater**

      There is a stuck closed contactor and a loss of isolation within the A4 Hybrid/EV Battery Pack. Refer to **Hybrid/EV Battery Voltage Present**.

    - **If less than 3 V**

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11. Verify the test DMM by measuring a known good 9 to 12 V battery.
    - **If the DMM does not properly measure the test battery**

      Repair or replace the DMM and repeat all voltage measurements.

    - **If the DMM properly measures the test battery**
12. The K59 Starter/Generator Control Module is discharged. You may perform K59 Starter/Generator Control Module or General vehicle service or continue if additional high voltage component service is required.
    - **If you do not need to perform additional high voltage component service**

      HV Disable for K59 Starter/Generator Control Module is complete.

    - **If you need to perform additional high voltage component service**
13. Remove the center console to gain access to the hybrid/EV battery pack Battery Closeout Cover.

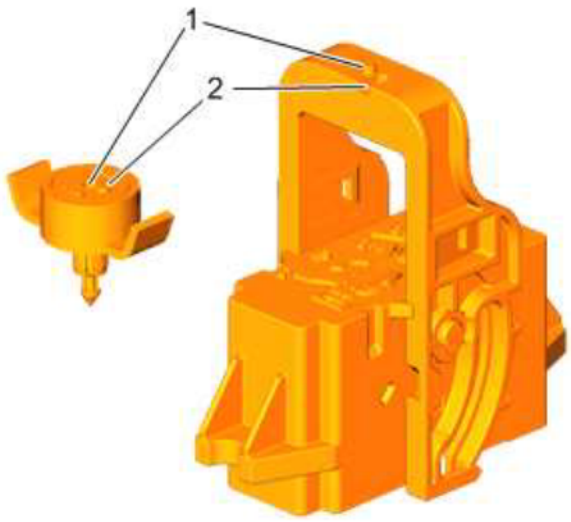


Fig. 12: S15 Manual Service Disconnect
Courtesy of GENERAL MOTORS COMPANY

NOTE: **You will need the S15 Manual Service Disconnect to use as a tool to remove the High Voltage Locking Push-Pin safety feature.**

14. Identify the feature on the high voltage locking push-pin at the A4 Hybrid/EV Battery Pack Battery Positive and Negative Cable Cover that aligns to the feature on the S15 Manual Service Disconnect (1, 2). The S15 Manual Service Disconnect will act like a key to remove the high voltage locking push-pin.

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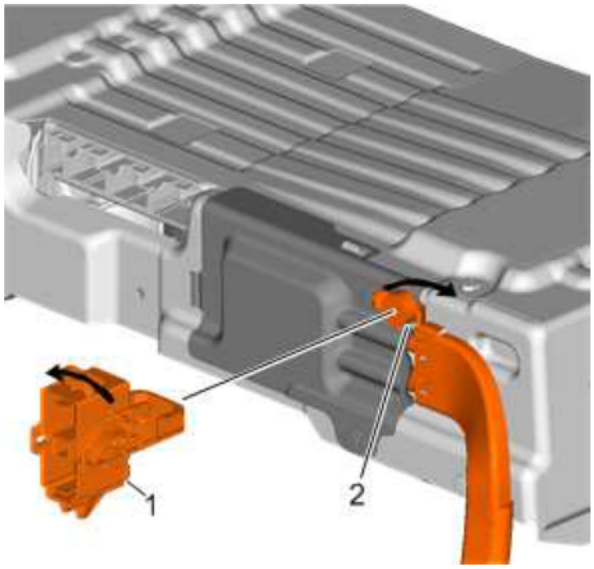


Fig. 13: S15 Manual Service Disconnect
Courtesy of GENERAL MOTORS COMPANY

15. Remove the high voltage locking push-pin (2) from the A4 Hybrid/EV Battery Pack Battery Positive and Negative Cable Cover assembly using the key feature of the S15 Manual Service Disconnect (1).

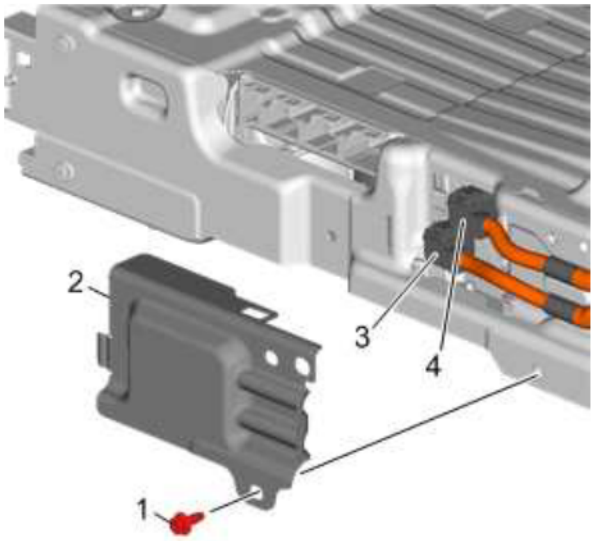


Fig. 14: Battery Positive And Negative Cable Closeout Cover
Courtesy of GENERAL MOTORS COMPANY

16. Remove the Battery Positive and Negative Cable Closeout Cover assembly fasteners (1) and cover (2).
17. Disconnect the A4 Hybrid/EV Battery Pack negative and positive connectors (3, 4).
18. Verify the voltage measures less than 3 V at the A4 Hybrid/EV Battery Pack at the following points:
    - High voltage DC (-300 V) negative terminal to vehicle chassis ground.
    - High voltage DC (+300 V) positive terminal to vehicle chassis ground.
    - High voltage DC (+300 V) positive terminal and high voltage DC (-300 V) negative terminal.
    - **If 3 V or greater**

      There is a stuck closed contactor and a loss of isolation within the A4 Hybrid/EV Battery Pack.

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Refer to **Hybrid/EV Battery Voltage Present**.

- **If less than 3 V**

NOTE: **A 9 V DC battery or the vehicles 12 V battery can be used to test the DMM.**

19. Verify the test DMM by measuring a known good 9 to 12 V battery.
    - **If the DMM does not properly measure the test battery**

      Repair or replace the DMM and repeat all voltage measurements.

    - **If the DMM properly measures the test battery**
20. The external high voltage connectors at the A4 Hybrid/EV battery pack are discharged. You may perform A4 Hybrid/EV battery pack removal or any high voltage component on-vehicle service as required.

    HV Disable is complete.

HIGH VOLTAGE ENABLING

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**

Circuit/System Description

The High Voltage Enabling procedure will perform the following tasks:

- Identify how to enable high voltage.
- Verify high voltage system integrity and that all connectors are installed.

Diagnostic Aids

Review the **High Voltage Connectors** information for connector identification and the approved procedures for disconnecting and connecting high voltage connectors.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

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.

1. Review the high voltage safety information prior to performing the High Voltage Enabling procedure. Refer to **High Voltage Safety**
2. Ensure that the 12 V battery is disconnected. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**

NOTE:

- **Always tighten the high voltage fasteners to the specified torque. Insufficient or excessive torque will cause malfunctions or damage.**
- **The high voltage connectors that have been disconnected do not require a specific sequence when connecting.**

3. After finishing work on the high voltage systems and before installing the S15 Manual Service Disconnect, inspect for the following:
   - Verify that all tools or loose components have been removed.
   - Inspect any disconnected 300 V Battery Positive and Negative cable seals for being deformed, missing, or damaged. Replace any seals that are deformed, missing, or damaged.
   - Verify high voltage system integrity and that all connectors are installed.
   - Verify that all high voltage interlock circuit connectors and covers are installed except any that cover the 12V battery.
   - Install any components or connectors that have been removed or replaced during diagnosis.

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4. Install the S15 Manual Service Disconnect (1). Refer to **Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)**
5. Connect the 12 V battery. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .
6. Ignition ON.
7. Verify if the A4 Hybrid/EV Battery Pack or the K114B Hybrid/EV Powertrain Control Module 2 has been replaced.
    - **If the A4 Hybrid/EV Battery Pack or the K114B Hybrid/EV Powertrain Control Module 2 has been replaced**

      Program the K114B Hybrid/EV Powertrain Control Module 2. Refer to **Control Module References** . Continue to the next step once programming is complete.

    - **If the A4 Hybrid/EV Battery Pack or the K114B Hybrid/EV Powertrain Control Module 2 has not been replaced**
8. Ignition ON, perform the driver window express learn and clear all DTC Information with a scan tool. Refer to **Window Motor Programming - Express Function** .
9. Ignition OFF and all vehicle systems OFF. It may take up to 5 min for all vehicle systems to power down.
10. Ignition ON.
11. Verify with a scan tool no DTCs are set.
    - **If any DTCs are set**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

    - **If no DTCs are set**
12. Open the hood to start and idle the engine for 2 min.
13. Ignition OFF and wait 5 min.
14. Ignition ON. Verify with the scan tool the Hybrid Powertrain Control Module and Hybrid Powertrain Control Module 2 DTC Information that the following DTCs have Ran Since Code Clear and have not set:
    - Contactor DTCs P0AD9, P0ADD, P0AE4, and P1EC0.
    - Pre-charge DTCs P0C78 and P3061.
    - High voltage loss of isolation DTCs P0AA6 and P1AF0.
    - **If any DTCs are set**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

    - **If the DTCs have Not Ran Since Code Clear**
    1. Review and operate the vehicle according to the applicable DTC Conditions for Running and ensure the DTCs run and pass.
    2. Verify with the scan tool the Hybrid Powertrain Control Module and Hybrid Powertrain Control Module 2 DTC Information that the specified DTCs have Ran Since Code Clear and have not set:
        - If any DTCs are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .
        - If the DTCs have Ran and Passed
    3. Test drive the vehicle and verify no DTCs are set.

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- **If the DTCs have Ran and Passed**

15. Test drive the vehicle and verify no DTCs are set.

EL-48571 HIGH VOLTAGE BATTERY PIN OUT BOX REFERENCE

Special Tools

EL-48571-45 Battery Pin Out Box Adapter

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

Connector X3	Battery Module 1		Battery Module 2	
Selector Switch Position	Switch Number	Test Cells 1-12	Switch Number	Test Cells 13-24
A	1	1	1	13
	2	2	2	14
	3	3	3	15
	4	4	4	16
	5	5	5	17
	6	6	6	18
B	7	7	7	19
	8	8	8	20
	9	9	9	21
	10	10	10	22
	11	11	11	23
	12	12	12	24
C	15	Temperature Sensor 1	15	Temperature Sensor 3
	18	Temperature Sensor 2	18	Temperature Sensor 4

HIGH VOLTAGE CONNECTORS

Connector Type Identification

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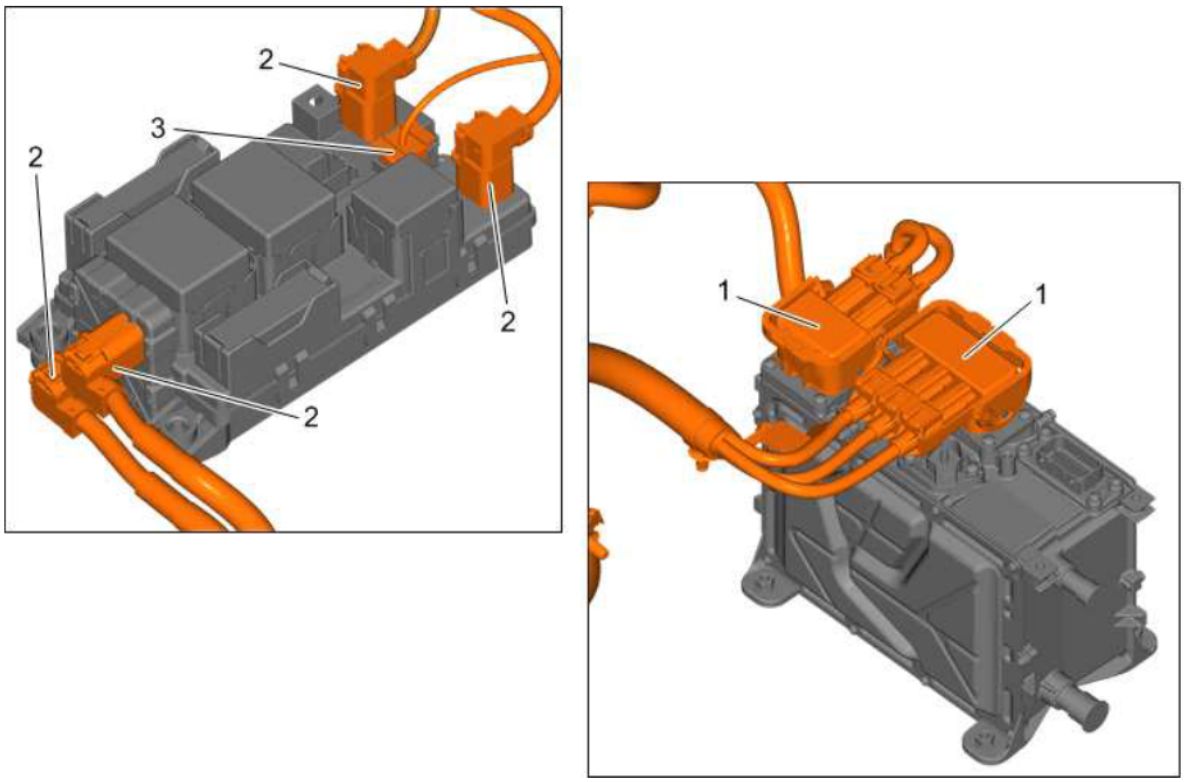


Fig. 15: Connector Type Identification
Courtesy of GENERAL MOTORS COMPANY

Connector Type		Connector Location	
Callout	Connector	Generator Control Module	Hybrid/EV Battery Assembly
1	PP1000	X	-
2	6.3 Mid-Power	-	X
3	HV280 Unsealed	-	X

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.

WARNING: **Ensure all High Voltage safety procedures are followed. Failure to follow the procedure exactly as written may result in serious injury or death.**

Review the high voltage safety information. Refer to **High Voltage Safety**.

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PP1000 Connector Procedure

PP1000 Disconnect Procedure

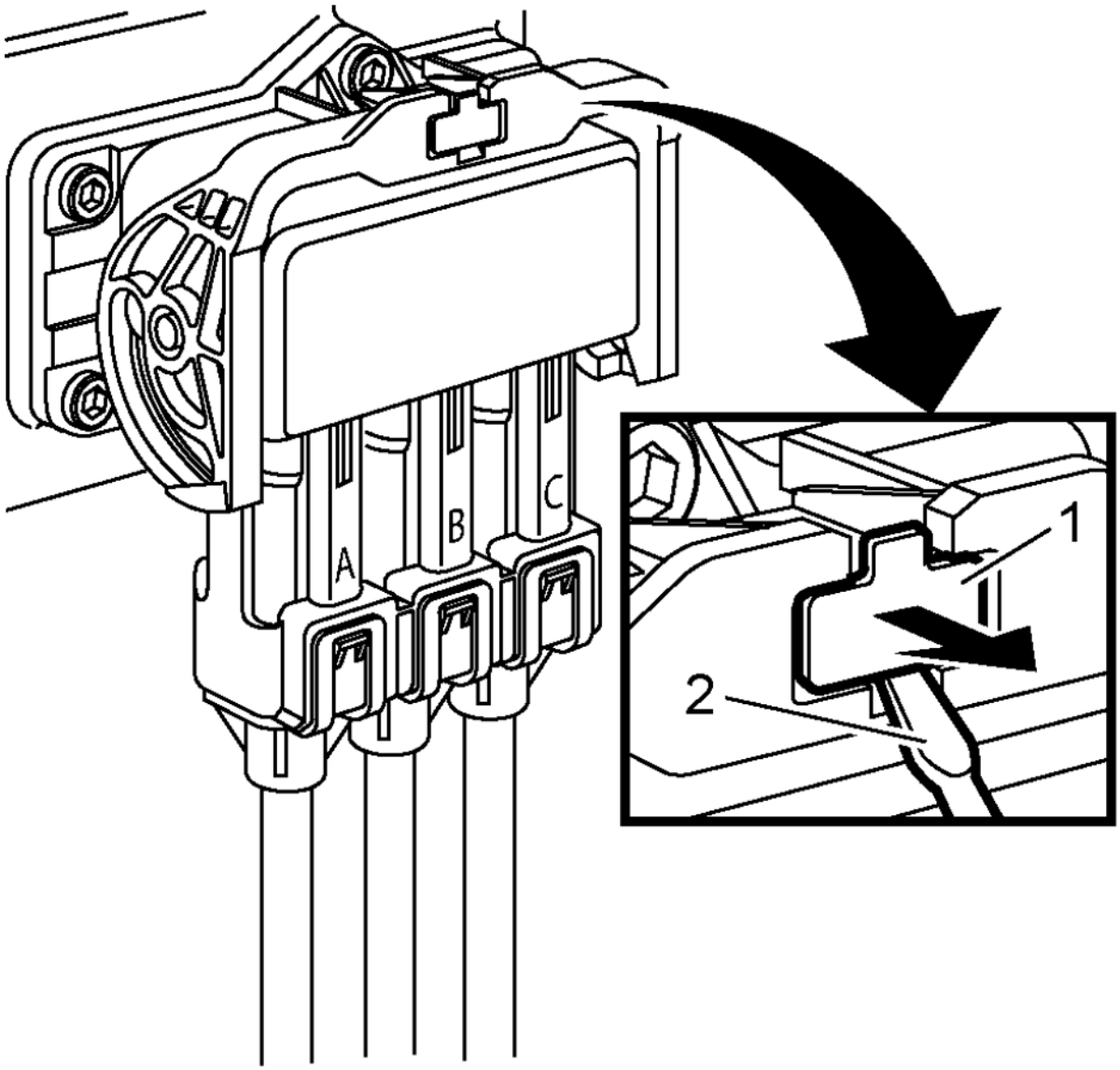


Fig. 16: Connector Position Assurance
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The use of a small screwdriver (2) may be necessary to assist in moving the CPA tab into the pre-stage position.**

1. Pull the connector position assurance (CPA) (1) tab back from the locked position to the pre-stage position. There will be an audible click sound when the CPA tab is in the correct position.

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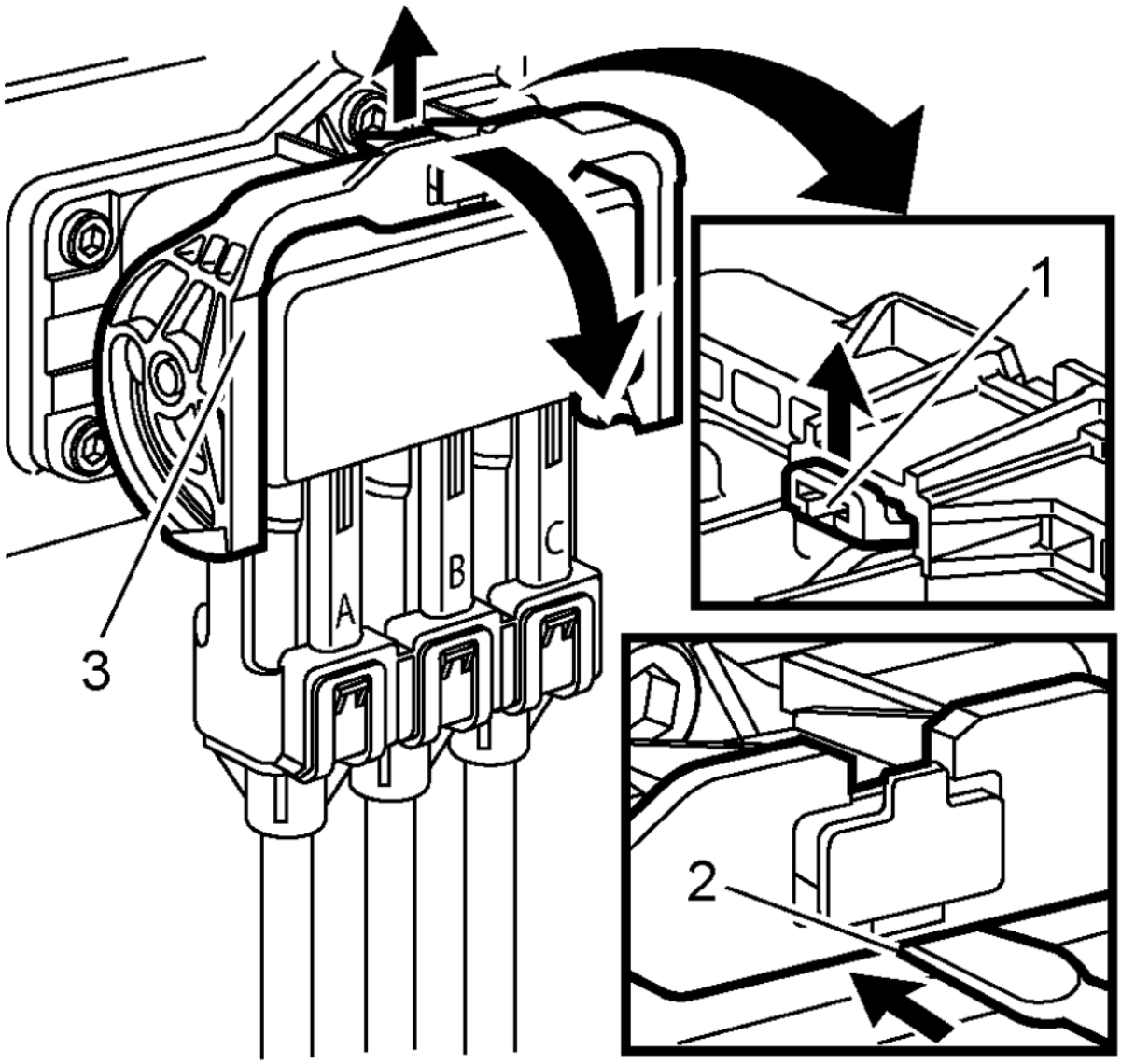


Fig. 17: Lever Lock
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Due to the location of the connector, the lever lock (1) may be difficult to access. The use of a small screwdriver may be used to disengage the lock.**

2. Identify the lever lock (1) on the connector. Slide a small screwdriver (2) underneath the rotating lever and toward the connector to disengage the lock.
3. While the screwdriver disengages the lock, rotate the lever back slightly. Remove the screwdriver and rotate the lever until the connector is in the partial-mate position.
4. Pull back on the connector to complete the disconnection.

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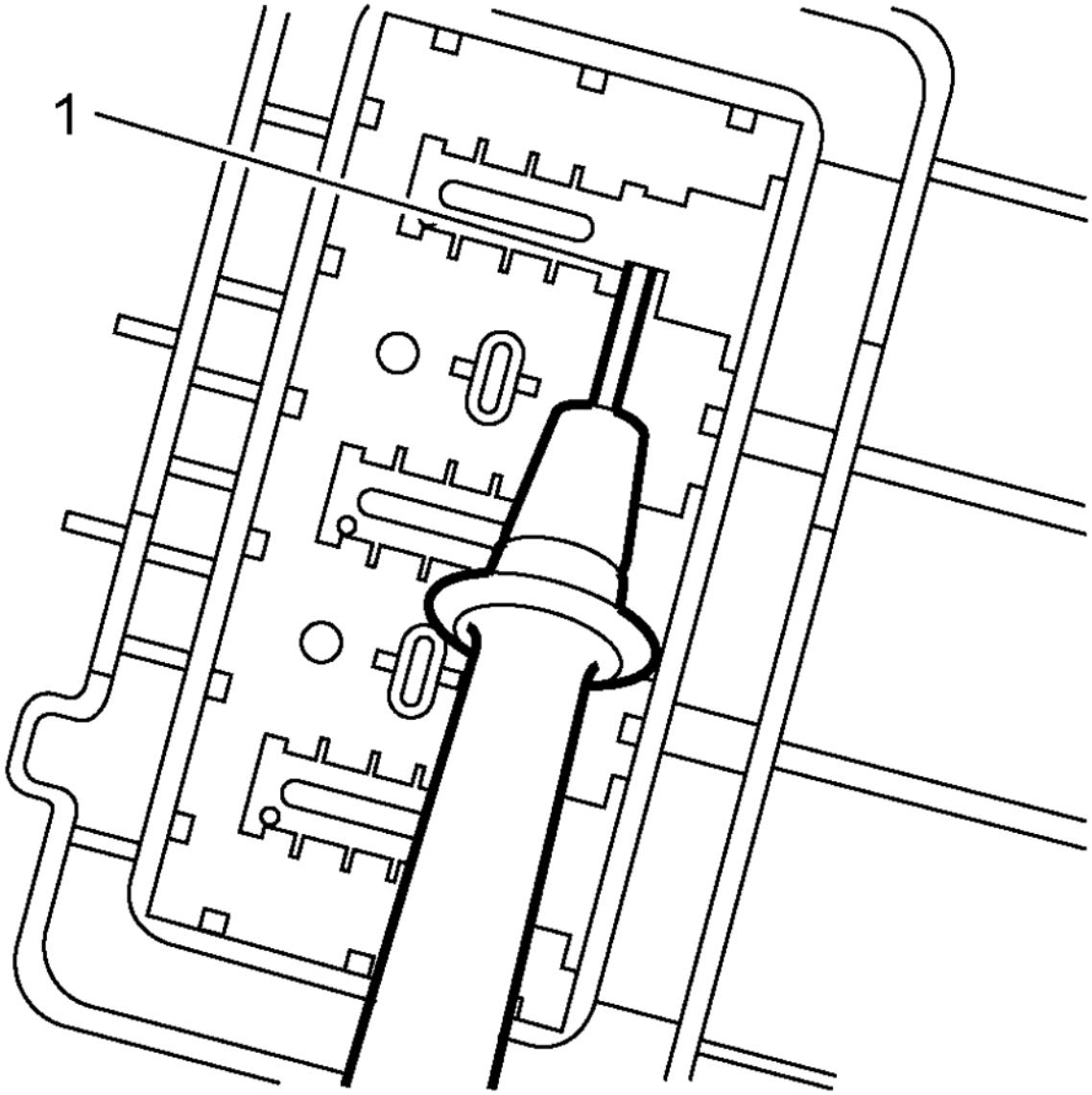


Fig. 18: Probing Long Slot
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A standard DMM probe will not fit in the terminal slot for this connector.**

5. To perform measurements at this connector, place a probe at an angle via the long slot (1) at the rear of each terminal.

PP1000 Connect Procedure

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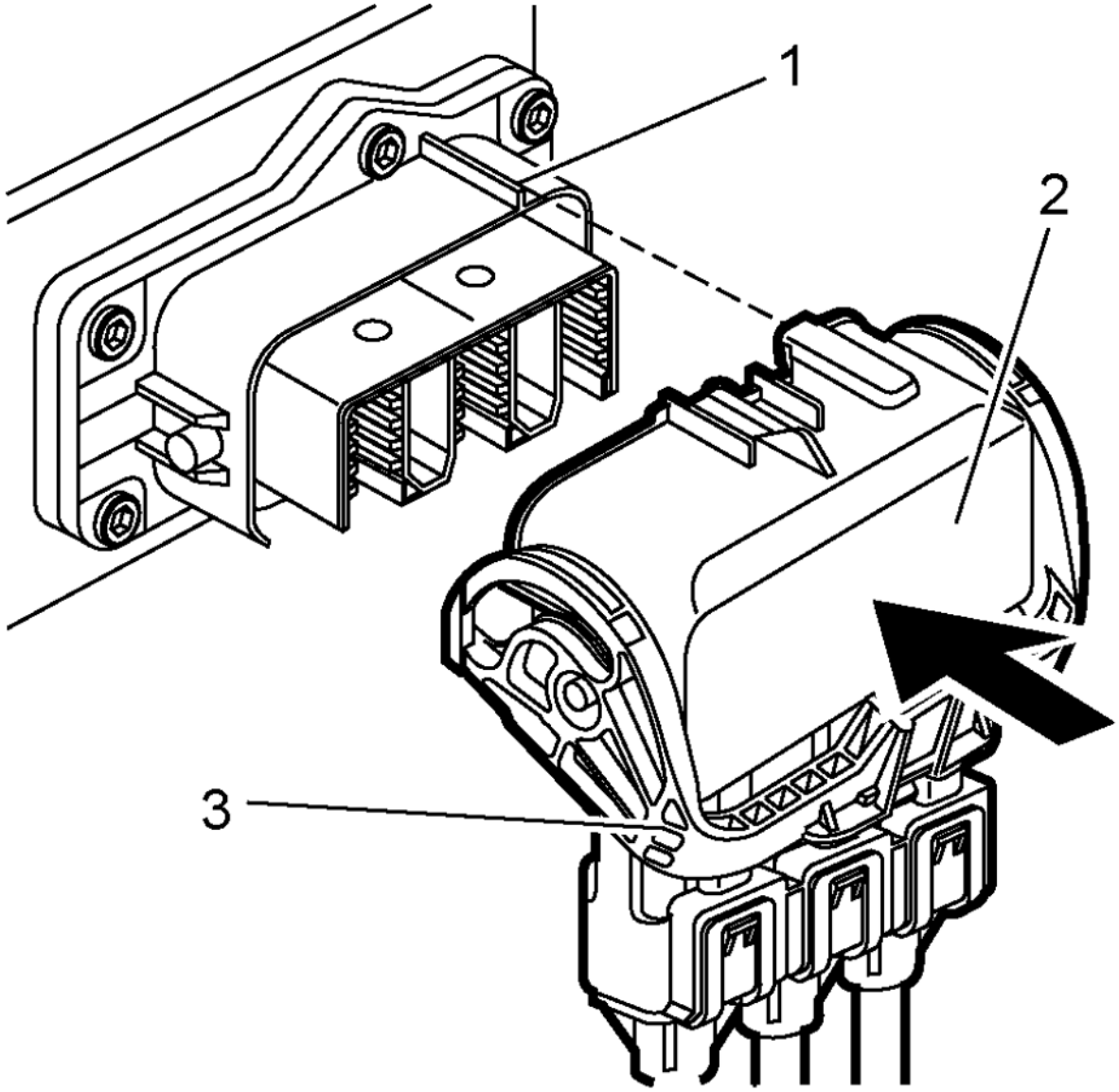


Fig. 19: CPA Lever
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the CPA tab is in the pre-stage position, and the lever is rotated to the pre-stage position.**

1. Align the connector (2) with the index features (1) and install the connector. When both assemblies partially mate, the lever (3) is released from the pre-stage position with a short movement and an audible click.

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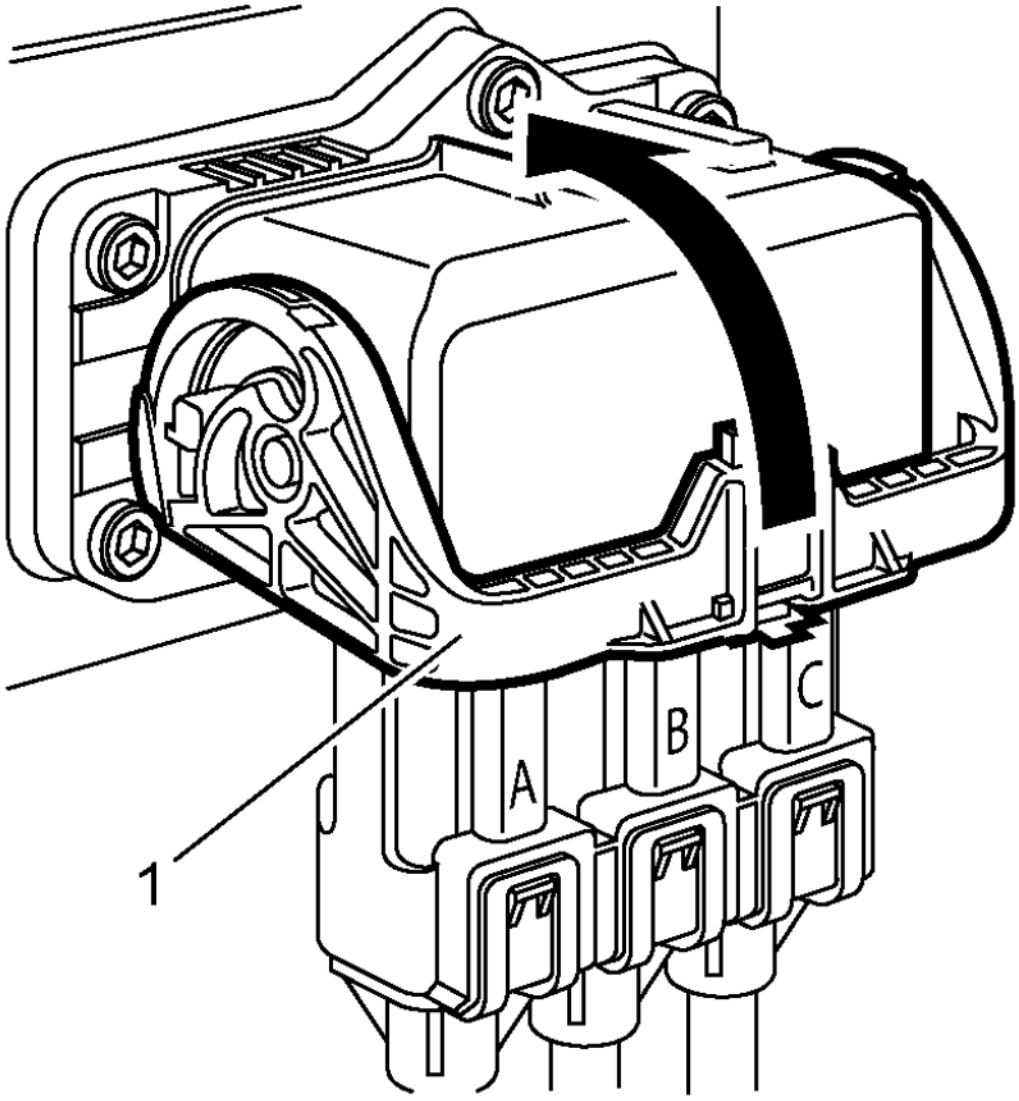


Fig. 20: CPA Lever
Courtesy of GENERAL MOTORS COMPANY

2. Rotate the lever (1) to the full-stage position. There will be a very audible click sound.

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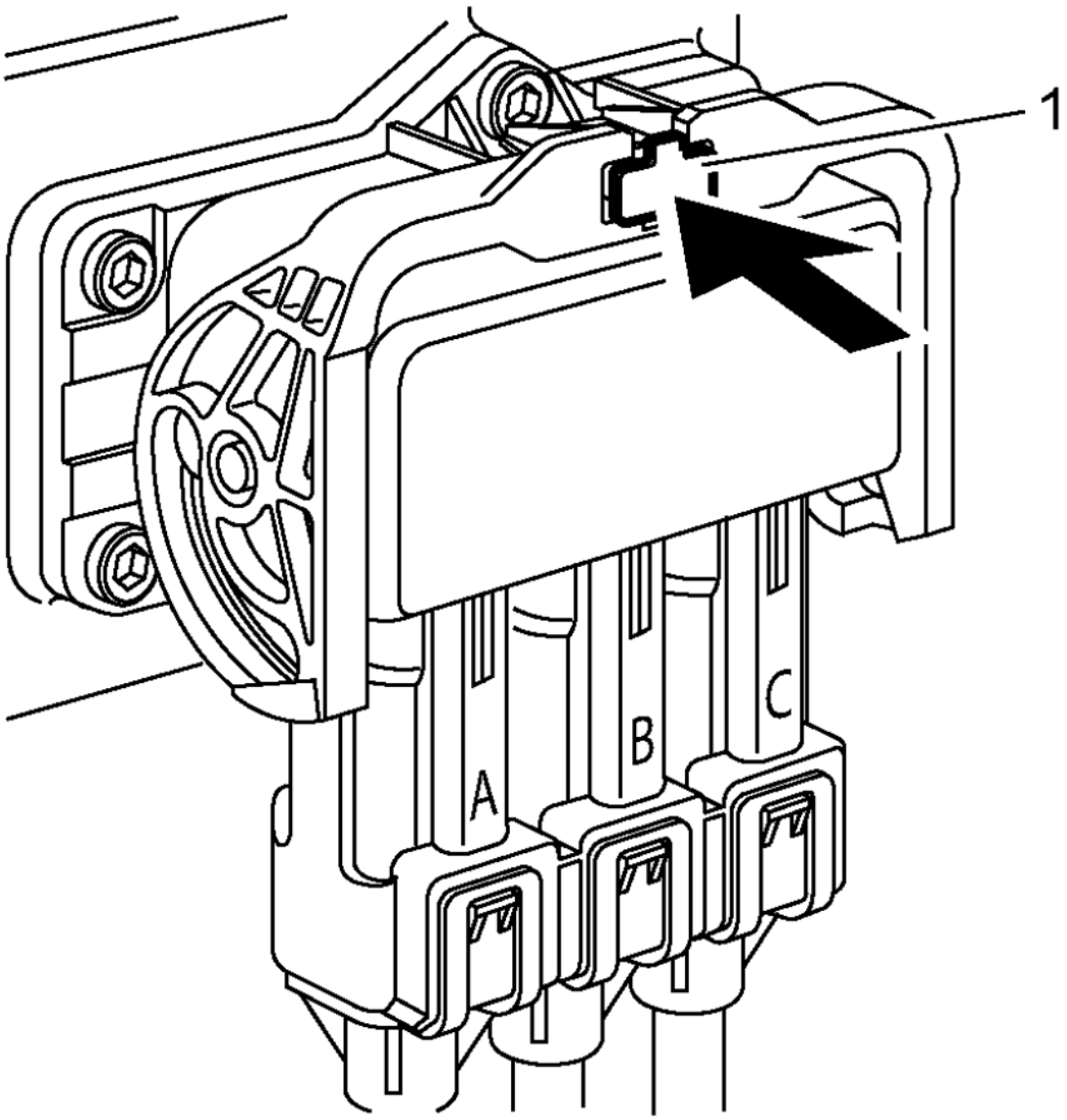


Fig. 21: CPA Tab
Courtesy of GENERAL MOTORS COMPANY

3. Push the CPA tab (1) to lock the connector in the full-stage position. There will be a very audible click sound when the connector is secured.

6.3 Mid-Power Connector Procedure

6.3 Mid-Power Disconnect Procedure

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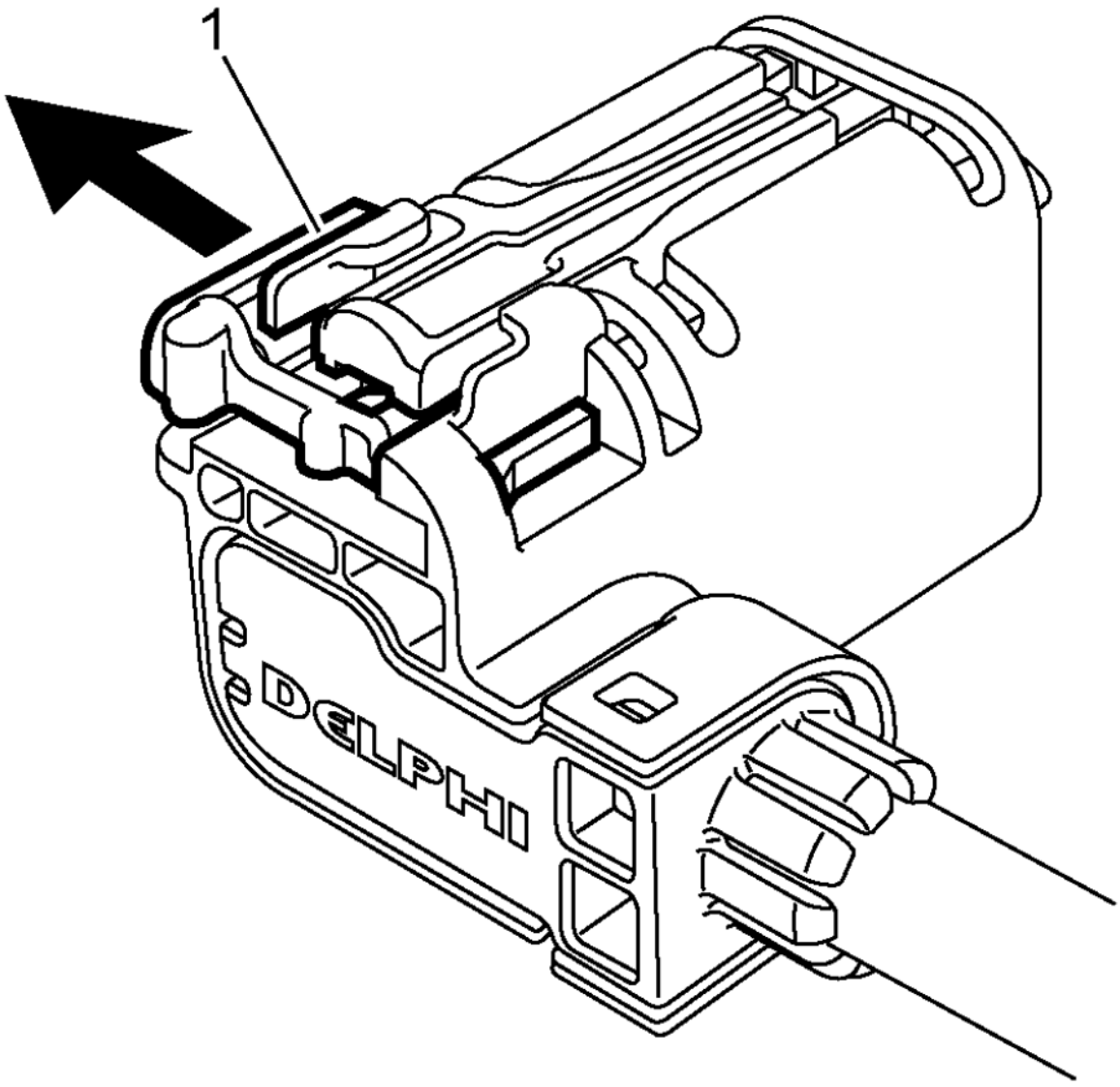


Fig. 22: Connector Position Assurance Tab
Courtesy of GENERAL MOTORS COMPANY

1. Pull the connector position assurance (CPA) (1) tab back from the locked position to the pre-stage position.

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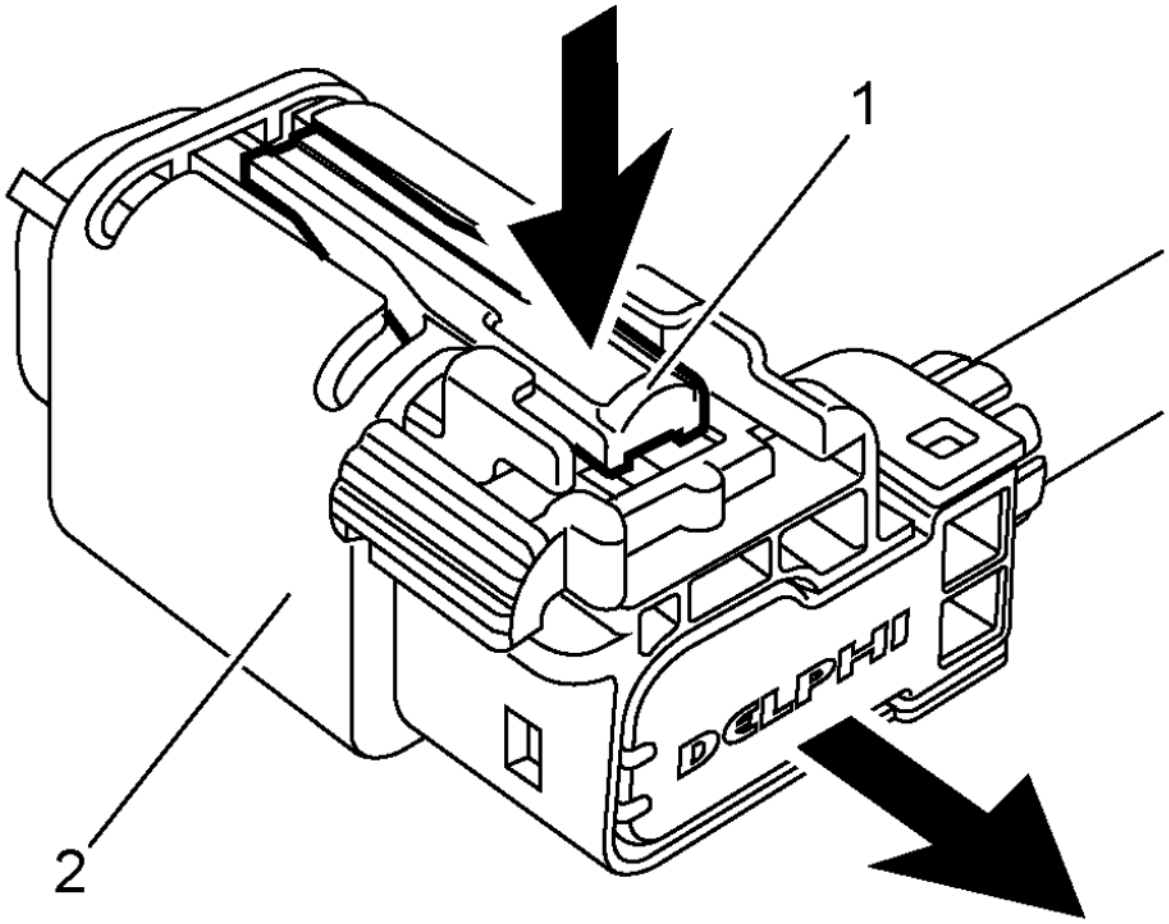


Fig. 23: Female Connector/Lock
Courtesy of GENERAL MOTORS COMPANY

2. Press firmly on the back of the female connector lock (1) and hold down, while pulling the female connector (2) assembly to disconnect.

6.3 Mid-Power Connect Procedure

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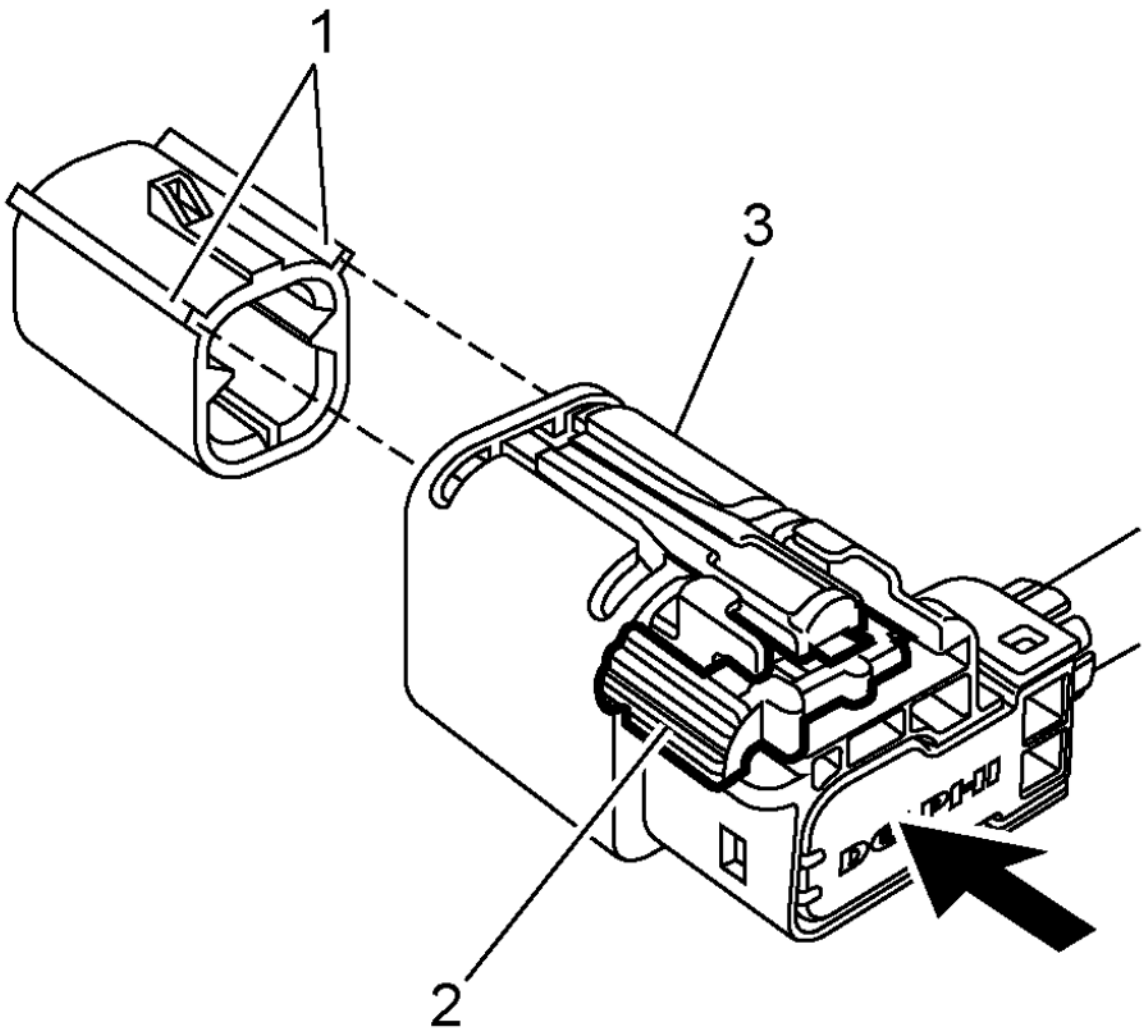


Fig. 24: CPA Tab
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the CPA tab (2) is in the pre-stage position.**

1. Align the connector with the index features (1) and install the connector by pushing on the sides of the connector (3). There will be a very audible click sound when the connector is in the full-stage position.

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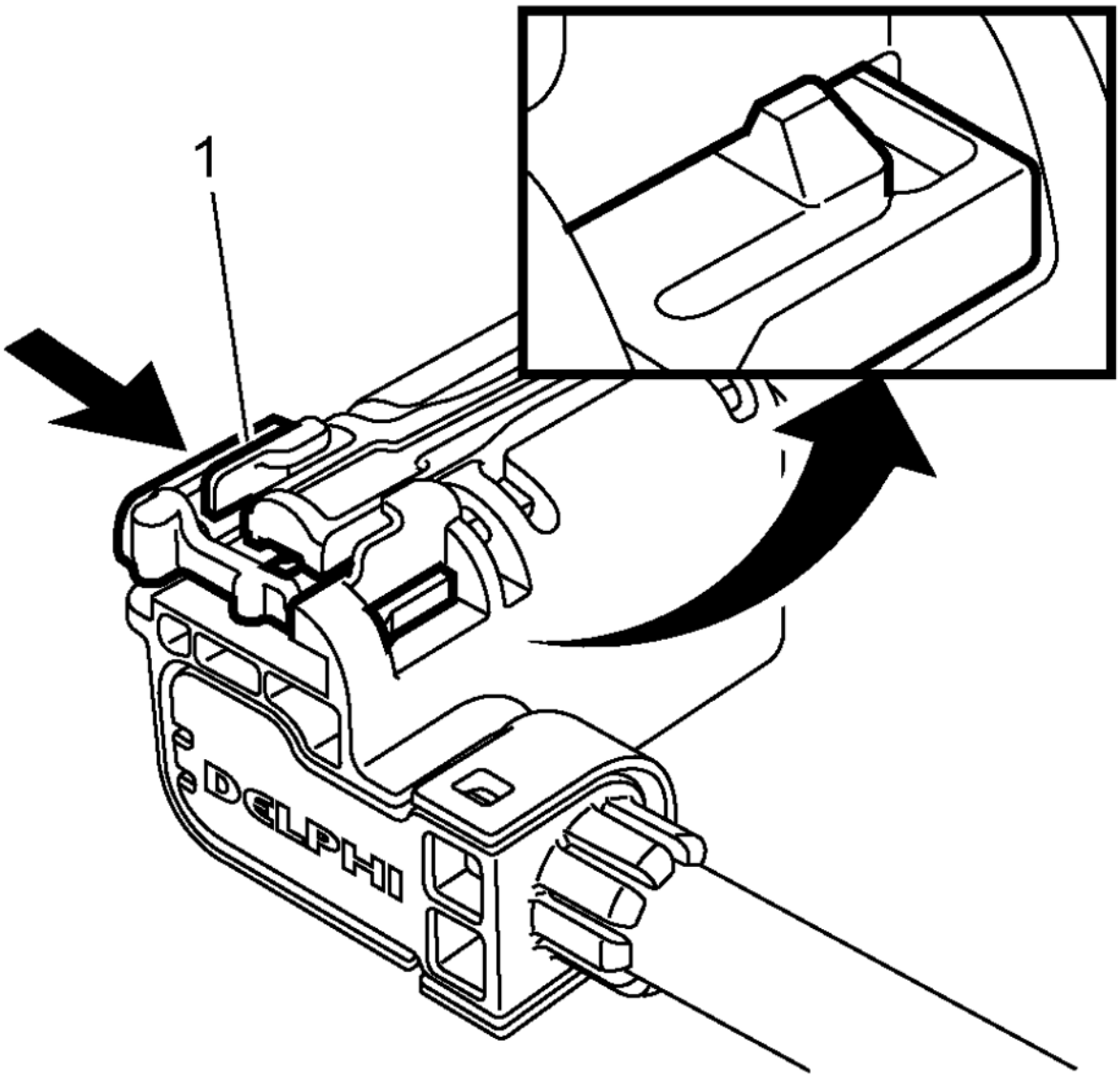


Fig. 25: Connector Full-Stage Position
Courtesy of GENERAL MOTORS COMPANY

2. Push the CPA tab (1) to lock the connector in the full-stage position. There will be a very audible click sound when the connector is secured.

HV280 Unsealed Disconnect Procedure

HV280 Unsealed Disconnect Procedure

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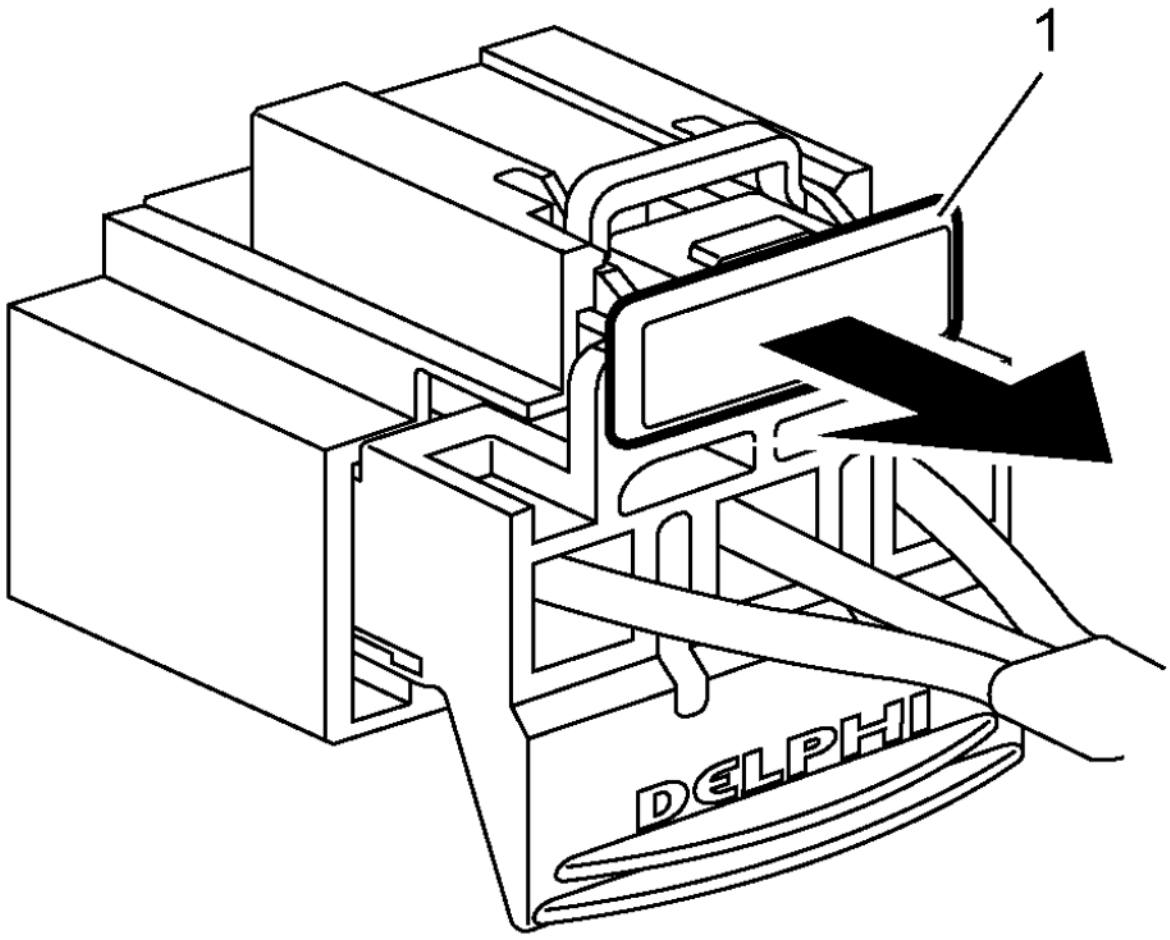


Fig. 26: CPA Tab Pre-Stage Position
Courtesy of GENERAL MOTORS COMPANY

1. Pull the connector position assurance (CPA) tab (1) back from the locked position to the pre-stage position.

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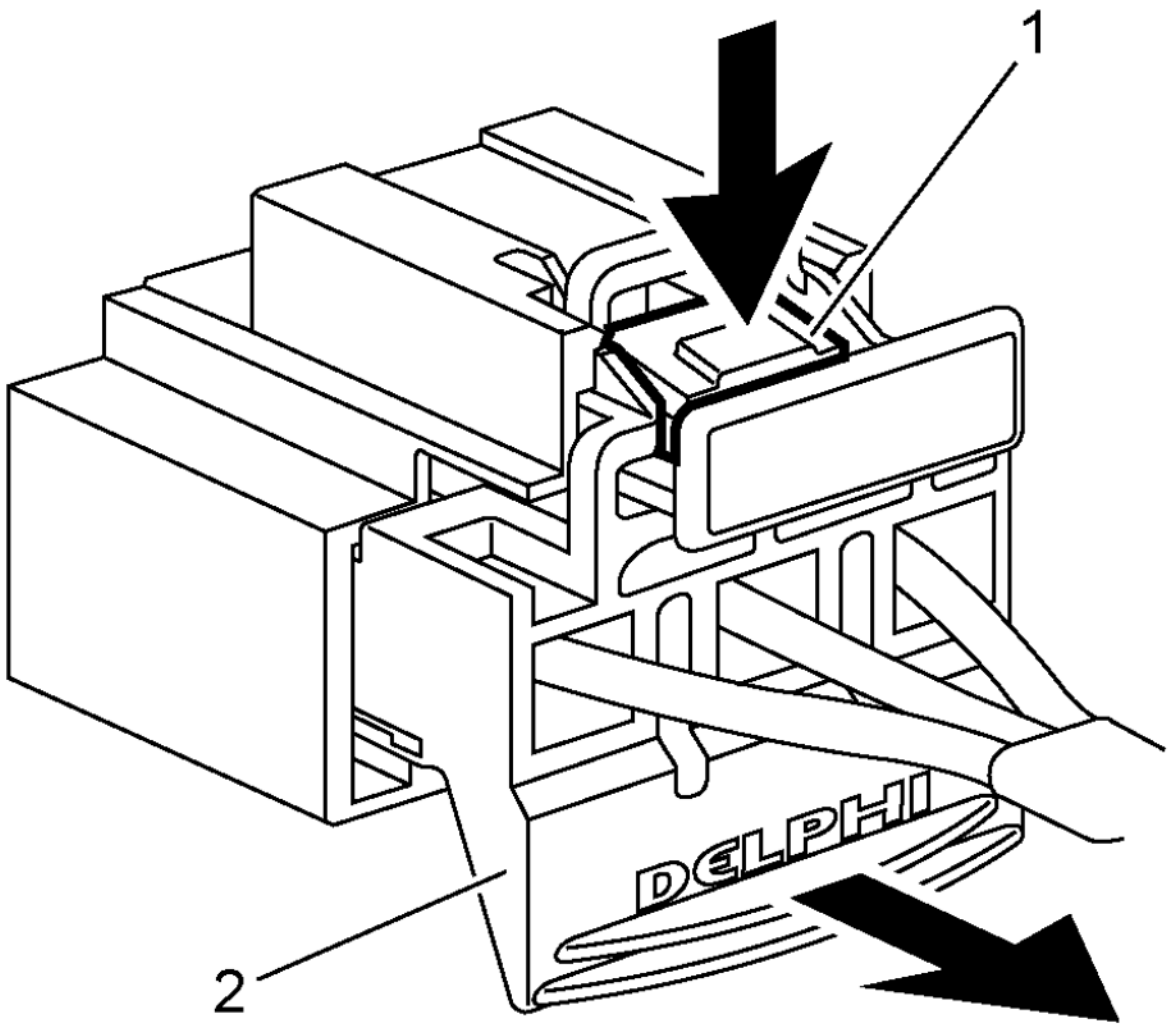


Fig. 27: Connector Lock
Courtesy of GENERAL MOTORS COMPANY

2. Locate and depress the connector lock (1). While the lock is depressed, disengage the connector (2).

HV280 Unsealed Connect Procedure

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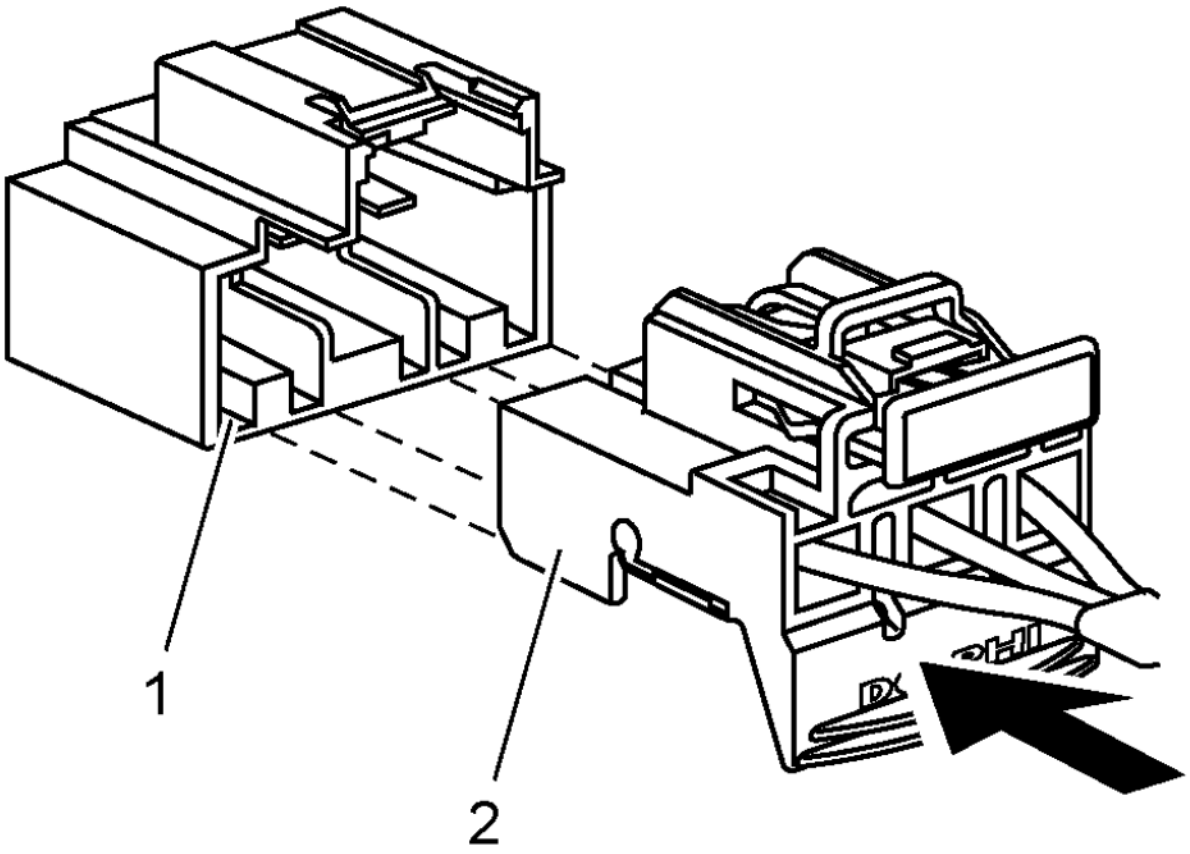


Fig. 28: Aligning Index Slots
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the CPA tab is in the pre-stage position. Ensure all index slots align with the connector.**

1. Align the connector with the index features (1) and install the connector (2). There will be a very audible click sound when the connector is in the full-stage position.

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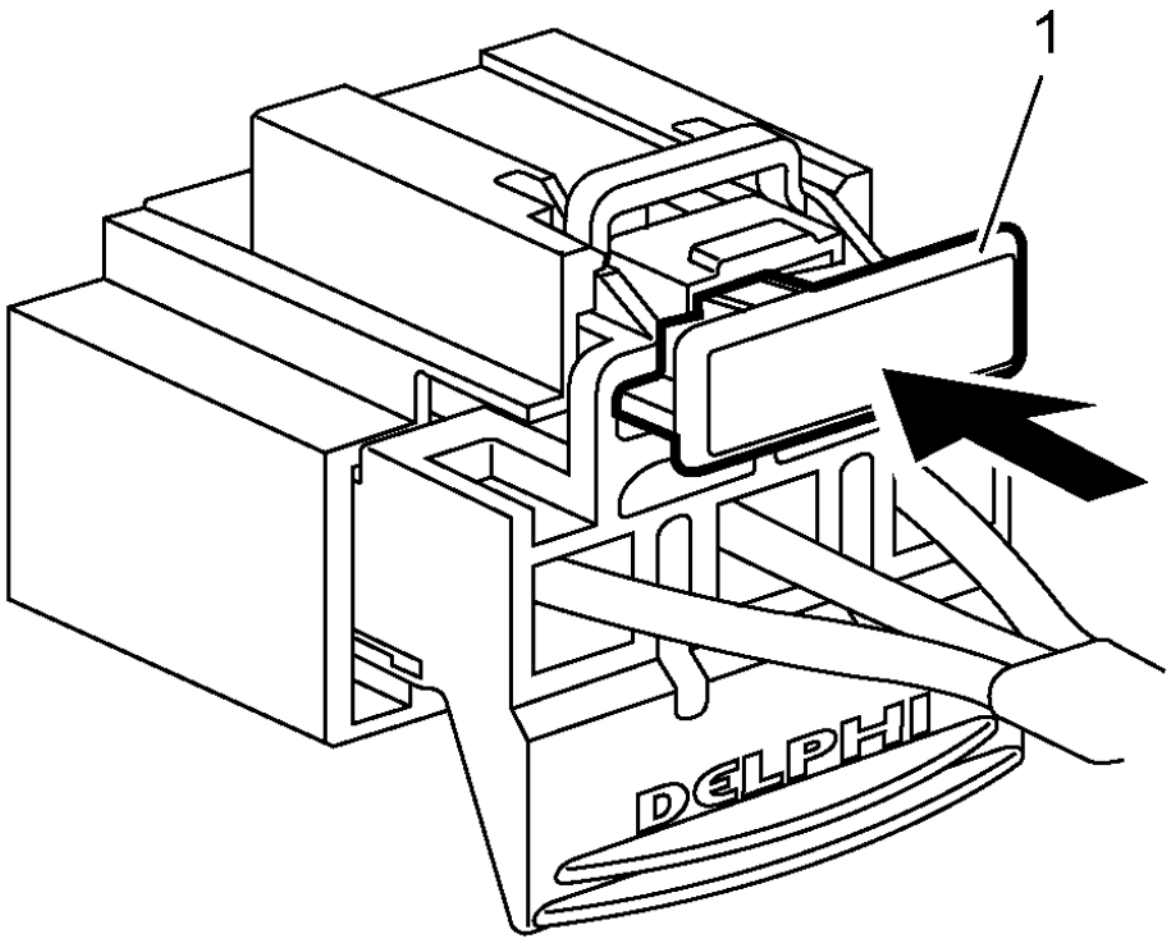


Fig. 29: CPA Tab
Courtesy of GENERAL MOTORS COMPANY

2. Push the CPA tab (1) to lock the connector in the full-stage position. There will be a very audible click sound when the connector is secured.

DTC P0697, P06A3, OR P06D2: 5V REFERENCE 3/4/5 (HYBRID/EV POWERTRAIN CONTROL MODULE 2)

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 P0697

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5V Reference 3 Circuit

DTCP06A3

5V Reference 4 Circuit

DTC P06D2

5V Reference 5 Circuit

Circuit/System Description

The hybrid/EV powertrain control module 2 has reference voltage supply circuits. Each reference circuit provides either internal or external reference voltage for various sensors. A short to ground or short to voltage on one reference circuit can affect all the components connected to the same reference supply.

Conditions for Running the DTC

The 12 V battery voltage is 9.1 V or greater.

Conditions for Setting the DTC

The hybrid/EV powertrain control module 2 detects a short to ground or voltage on any of the reference voltage supply circuits for greater than 0.5 s.

Actions Taken When the DTC Sets

DTCs P0697, P06A3, and P06D2 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0697, P06A3, and P06D2 are Type B DTCs.

Diagnostic Aids

The 5 V reference 1 and 2 circuits are not used on this application.

The 5 V reference 3 circuit provides 5 V reference to the internal high voltage measuring and isolation detection circuits.

The 5 V reference 4 circuit provides 5 V reference to the B30 Hybrid/EV Battery Pack Current Sensor.

The 5 V reference 5 circuit provides 12 V reference to the circuits listed below:

- Pre-Charge, Main positive and Main Negative high voltage contactor relay PWM control circuits.
- G14 Hybrid/EV Battery Pack Cooling Fan, enable feedback and control circuits.
- Hood Switch

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

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COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition On .
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
3. Verify the DTC does not set.
    - **If DTC P06A3 sets**

      Refer to Circuit/System Testing.

    - **If DTC P0697 or P06D2 sets**

      Replace the Hybrid/EV Powertrain Control Module 2 .

    - **If the DTC does not set**
4. All OK.

Circuit/System Testing

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:

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- **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. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to **High Voltage Disabling** .
2. Remove the A4 Hybrid/EV Battery Pack top cover. Refer to **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement** .

NOTE: **The B30 Hybrid/EV Battery Pack Current Sensor is a non-serviceable part of the A28 Hybrid/EV Battery Contactor Assembly.**

3. Disconnect the 4-wire harness connector X3 on the A28 Hybrid/EV Battery Contactor Assembly.
4. Connect the 12 V battery.
5. Ignition ON, engine OFF.
6. Test for 4.5-5.5 V between the 5 V reference circuit and ground.
   - **If less than 4.5 V**
   1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2.
   2. Test for infinite resistance between the 5V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K114B Hybrid/EV Powertrain Control Module 2.
   - **If greater than 5.5 V**
   1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2.
   2. Ignition ON, engine OFF. 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 K114B Hybrid/EV Powertrain Control Module 2.
   - **If between 4.5 and 5.5 V**
7. Replace the A28 Hybrid/EV Battery Contactor Assembly.

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Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for A28 Hybrid/EV Battery Contactor Assembly
- **Control Module References** for Hybrid/EV Powertrain Control Module 2 replacement, programming, and setup.

DTC P0A7F: HYBRID/EV BATTERY PACK

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 P0A7F

Hybrid/EV Battery Pack Life

Circuit/System Description

The Hybrid/EV Powertrain Control Module 2 calculates the high voltage battery pack capability and determines the high voltage battery pack end of life.

Conditions for Running the DTC

- Vehicle ON.
- The system voltage is at least 9.1 V.
- Hybrid battery temperature is between -10Â°C (14Â°F) and 50Â°C (122Â°F).
- Hybrid battery state of charge is between 30% and 100%.
- None of the following DTCs are set: P0A9C, P0A9D, P0A9E, P0ABB, P0ABC, P0ABD, P0AC1, P0AC2, P0AC6, P0AC7, P0AC8, P0ACB, P0ACC, P0ACD, P0AE9, P0AEA, P0AEB, P1EBA, or U179C.

Conditions for Setting the DTC

- Battery voltage and current is varying. Requires more than 10 minutes of city driving.
- The Hybrid/EV Powertrain Control Module 2 calculates the power limits is less than the KW end of life power threshold.

Actions Taken When the DTC Sets

DTC P0A7F is a type B DTC.

Conditions for Clearing the DTC

DTC P0A7F is a type B DTC.

Diagnostic Aids

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Removing the manual service disconnect before disconnecting the 12 V battery may cause a DTC P0A7F to set.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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- **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

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

NOTE: **Removing the manual service disconnect before disconnecting the 12 V battery may cause a DTC P0A7F to set. Incorrectly performing the High Voltage Disabling procedure steps will cause false DTCs to set and result in misdiagnosis of vehicle components.**

1. Verify that no other DTCs are set.
   - **If any other DTCs are set**

     Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

   - **No other DTCs are set**
2. Verify DTC P0A7F is set.
   - **If DTC P0A7F is set**

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1. Record Freeze Frame Failure record data. Clear the DTC. Ignition OFF, disconnect the 12 V battery. Refer to:**Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**
2. Wait 30 seconds. Reconnect the 12 V battery. Refer to:**Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**
3. Review and operate the vehicle according to the DTC Conditions for Running. Operate the vehicle for more than 10 minutes of city driving.
4. Verify that DTC P0A7F does not reset.
    - If DTC P0A7F resets, replace the A4 Hybrid/EV Battery Pack.
    - If DTC P0A7F does not reset
5. All OK.

- **If DTC P0A7F is not set**

3. All OK.

Repair Instructions

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

High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)

DTC P0AA1, P0AA4, P0AD9, P0ADB-P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7, OR P1EC0: HYBRID/EV BATTERY POSITIVE/NEGATIVE/PRECHARGE CONTACTOR

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 P0AA1

Hybrid/EV Battery Positive Contactor Circuit Stuck Closed

DTC P0AA4

Hybrid/EV Battery Negative Contactor Circuit Stuck Closed

DTC P0AD9

Hybrid/EV Battery Positive Contactor Control Circuit

DTC P0ADB

Hybrid/EV Battery Positive Contactor Control Circuit Low Voltage

DTC P0ADC

Hybrid/EV Battery Positive Contactor Control Circuit High Voltage

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DTC P0ADD

Hybrid/EV Battery Negative Contactor Control Circuit

DTC P0ADF

Hybrid/EV Battery Negative Contactor Control Circuit Low Voltage

DTC P0AE0

Hybrid/EV Battery Negative Contactor Control Circuit High Voltage

DTC P0AE4

Hybrid/EV Battery Precharge Contactor Control Circuit

DTC P0AE6

Hybrid/EV Battery Precharge Contactor Control Circuit Low Voltage

DTC P0AE7

Hybrid/EV Battery Precharge Contactor Control Circuit High Voltage

DTC P1EC0

Hybrid/EV Battery System Contactor(s) Stuck Open

Circuit/System Description

The hybrid/EV battery pack is also known as the high voltage battery or the generator battery.

The hybrid/EV battery contains 3 high voltage contactors. The high voltage contactors allow the high voltage DC batteries to be connected to the vehicle or contain the high voltage DC within the hybrid/EV battery assembly. The high voltage contactors consist of a main positive high voltage contactor, main negative high voltage contactor, and a recharge positive high voltage contactor. The contactors close and open in a specific sequence controlled by the hybrid/EV powertrain control module 2. The hybrid/EV powertrain control module 2 supplies 12 V to the control circuit for each high voltage contactor.

Conditions for Running the DTC

P0AA1, P0AA4

All high voltage contactors have been open for more than 2 minutes.

OR

All high voltage contactors are open and propulsion bus voltage is less than 30% of hybrid/EV battery voltage.

P0AD9, P0ADB, P0ADC, P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7

The 12 V battery voltage is greater than 9.1 V.

P1EC0

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- The 12 V battery voltage is greater than 9.1 V.
- The main positive and negative contactors have been closed for more than 1 second.

Conditions for Setting the DTC

P0AA1

The positive bus voltage is greater than 21 V.

P0AA4

The negative bus voltage is greater than 21 V.

P0AD9, P0ADD P0AE4

The hybrid/EV powertrain control module 2 has detected an open in the control circuit for the corresponding contactor.

P0ADB, P0ADF, P0AE6

The hybrid/EV powertrain control module 2 has detected a short to ground in the control circuit for the corresponding contactor.

P0ADC, P0AE0, P0AE7

The hybrid/EV powertrain control module 2 has detected a short to voltage in the control circuit.

P1EC0

The main bus voltage is less than 80% of hybrid/EV battery voltage.

Actions Taken When the DTC Sets

DTCs P0AA1, P0AA4, P0AD9, P0ADB, P0ADC, P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7, and P1EC0 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0AA1, P0AA4, P0AD9, P0ADB, P0ADC, P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7, and P1EC0 are Type B DTCs.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON, engine OFF.
2. Verify that DTC P0AA1, P0AA4, P0AD9, P0ADB, P0ADC, P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7 or P1EC0 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**

   NOTE: The following setup steps must be performed exactly in order to exercise the contactors.

3. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
4. OPEN the driver door using outside door handle. Leave driver door OPEN.

   NOTE: The brake pedal must remain depressed throughout the remainder of the contactor steps.

5. PRESS and HOLD the brake pedal.

   NOTE: DO NOT turn on the Ignition.

6. Command the Hybrid/EV Battery Contactors ALL OPEN with a scan tool.
7. Disconnect the S15 Manual Service Disconnect.

   NOTE: DO NOT use the scan tool Release Control button to turn OFF any of the contactors. Once the Release Control button is pushed the Circuit/System

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Verification will need to be restarted from the beginning.

8. Command the Hybrid/EV Battery Negative Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.

NOTE: **It is normal for the contactors to only make noise while opening.**

9. Verify the Hybrid/EV Battery Negative Contactor is heard opening.
    - **If the Hybrid/EV Battery Negative Contactor operation cannot be heard**

      Refer to Circuit/System Testing.

    - **If the Hybrid/EV Battery Negative Contactor operation is heard**
10. Command the Hybrid/EV Battery Positive Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.
11. Verify the Hybrid/EV Battery Positive Contactor is heard opening.
    - **If the Hybrid/EV Battery Positive Contactor operation cannot be heard**

      Refer to Circuit/System Testing.

    - **If the Hybrid/EV Battery Positive Contactor operation is heard**
12. Command the Hybrid/EV Battery Precharge Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.
13. Verify the Hybrid/EV Battery Precharge Contactor is heard opening.
    - **If the Hybrid/EV Battery Precharge Contactor operation cannot be heard**

      Refer to Circuit/System Testing.

    - **If the Hybrid/EV Battery Precharge Contactor operation is heard**
14. Release scan tool control. Install the S15 Manual Service Disconnect.
15. Allow Hybrid/EV powertrain control modules to enter sleep mode by performing the following:
    1. Turn the Ignition OFF.
    2. Ensure the scan tool is not communicating with any control modules by returning to the Home screen.
    3. Shut all doors. Do NOT depress the brake pedal or activate any vehicle controls such as the parking lights, etc.
    4. Ensure the scan tool is accessible without having to open doors or otherwise cause control module wake-up.

       NOTE: **Sleep mode is usually entered within two minutes after shutting off the vehicle.**

    5. Wait 5 minutes with the vehicle in the prescribed condition so that the modules may enter sleep mode.
16. With a scan tool, verify the Hybrid/EV Powertrain Control Module 2 has gone to sleep by ensuring communication is not present.
    - **If communication is present**

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Repeat the previous step.

- **If communication is not present**

17. Ignition ON. Verify the scan tool hybrid/EV powertrain control module 1 High Voltage Circuit and hybrid/EV powertrain control module 2 Hybrid/EV Battery Pack Voltage is within 10 V of each other.
    - **If not within 10 V of each other**

      Refer to Circuit/System Testing.

    - **If within 10 V of each other**
18. Ignition OFF.
19. Verify the scan tool hybrid/EV powertrain control module 1 High Voltage Circuit parameter is less than 3 V and hybrid/EV powertrain control module 2 Hybrid/EV Battery Pack Voltage is between 40-108 V.
    - **If not within the specified ranges**

      Refer to Circuit/System Testing.

    - **If within the specified ranges**
20. All OK.

Circuit/System Testing

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. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to **High Voltage Disabling**.

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2. Remove the A4 hybrid/EV battery pack top cover. Refer to **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**.
3. Disconnect the X4 harness connector at the A28 Hybrid/EV Battery Contactor Assembly.
4. Test for less than 10 Ω between the ground circuit terminal 2 and ground.
    - **If more than 10 Ω**
    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**

NOTE: **Connecting the 12 V battery with the S15 manual service disconnect removed may set other DTCs.**

5. Connect the 12 V battery. Ignition ON.
6. Verify that a test lamp does not illuminate between each A28 Hybrid/EV Battery Contactor Assembly harness connector control circuit terminals listed below and ground:
    - Terminal 1 X4
    - Terminal 3 X4
    - Terminal 4 X4
    - **If the test lamp illuminates on any circuit**
    1. Ignition OFF, disconnect the X4 harness connector at the K114B Hybrid Powertrain Control Module 2. Ignition ON.
    2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K114B Hybrid Powertrain Control Module 2.
    - **If the test lamp does not illuminate on all circuits**
7. Ignition OFF, disconnect the X4 harness connector at the K114B Hybrid Powertrain Control Module 2.
8. Test for infinite resistance between each A28 Hybrid/EV Battery Contactor Assembly harness connector control circuit terminals listed below and ground:
    - Terminal 1 X4
    - Terminal 3 X4
    - Terminal 4 X4
    - **If less than infinite resistance on either circuit**

      Repair the short to ground on the circuit.

    - **If infinite resistance on both circuits**
9. Test for less than 2 Ω between the harness connector terminals listed below:
    - Terminal 1 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 3 X4 at the K114B Hybrid Powertrain Control Module 2
    - Terminal 3 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 2 X4 at the K114B Hybrid Powertrain Control Module 2
    - Terminal 4 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 1 X4 at the K114B

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Hybrid Powertrain Control Module 2

- **If 2 Ω or greater on any circuit**

  Repair the open/high resistance in the circuit.

- **If less than 2 Ω on all circuits**

10. Replace the A28 Hybrid/EV Battery Contactor Assembly.
11. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
    - **If the DTC sets**

      Replace the K114B Hybrid Powertrain Control Module 2.

    - **If the DTC does not set**
12. All OK.

Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for A28 Hybrid/EV Battery Contactor Assembly replacement.
- **Control Module References** for hybrid/EV powertrain control module 2 replacement, programming and setup.

DTC P0AA6: HYBRID/EV BATTERY VOLTAGE SYSTEM ISOLATION LOST

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 P0AA6

Hybrid/EV Battery Voltage System Isolation Lost

Circuit/System Description

Vehicles equipped with high voltage storage and propulsion capability are designed with the high voltage circuits isolated from the vehicle chassis. If either the positive or negative high voltage Direct Current (DC) circuits lose this isolation to the vehicle chassis, one or more diagnostic trouble codes (DTCs) may set.

Conditions for Running the DTC

- The hybrid powertrain control module 2 is awake.
- All the contactors are open.
- DTCs P0AA7 or P0AA8 are not set.
- Tests once per ignition cycle.

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Conditions for Setting the DTC

- The hybrid powertrain control module 2 has detected active isolation resistance is less than 78K Ω if P0AA6 is failing for the first time, or less than 102K Ω if P0AA6 has failed at least once in the last 10 key cycles.
- 5 out of 10 tests (key cycles) have failed.

Actions Taken When the DTC Sets

P0AA6 is a Type A DTC.

Conditions for Clearing the DTC

- P0AA6 is a Type A DTC.
- P0AA6 requires one passing test at greater than 102K Ω resistance.

Diagnostic Aids

- A single high voltage contactor stuck closed may set this DTC.
- Condensation or water intrusion into the hybrid/EV battery pack may cause P0AA6 to set.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

- **Drive Motor Battery System Description**
- **Hybrid/EV System High Voltage Isolation Description**

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

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Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Verify that DTC P0AA1, P0AA4, P0ADC, P0AE0, or P0AE7 is not set.
   - **If any DTC is set**

     Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**
2. Verify with a scan tool the hybrid powertrain control module 2, Isolation Test Resistance parameter is greater than 102k Ω.
   - **If the parameter is 102k Ω or less**

     Refer to Circuit/System Testing.

   - **If the parameter is greater than 102k Ω**
3. All OK.

Circuit/System Testing

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.

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1. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to **High Voltage Disabling**.
2. Replace the A4 Hybrid/EV Battery Pack.

Repair Instructions

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

- **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

DTC P0AA7-P0AAA, P1E0C, OR P1E0D: HYBRID/EV BATTERY VOLTAGE ISOLATION

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 P0AA7

Hybrid/EV Battery Voltage Isolation Sensing Circuit

DTC P0AA8

Hybrid/EV Battery Voltage Isolation Sensing Circuit Performance

DTC P0AA9

Hybrid/EV Battery Voltage Isolation Sensing Circuit 1 Low Voltage

DTC P0AAA

Hybrid/EV Battery Voltage Isolation Sensing Circuit 1 High Voltage

DTC P1E0C

Hybrid/EV Battery Voltage Isolation Sensing Circuit 2 Low Voltage

DTC P1E0D

Hybrid/EV Battery Voltage Isolation Sensing Circuit 2 High Voltage

Circuit/System Description

Vehicles equipped with high voltage storage and propulsion capability are designed with the high voltage circuits isolated from the vehicle chassis. If either the positive or negative high voltage Direct Current (DC) circuits or any of the high voltage Alternating Current (AC) phase circuits lose this isolation to the vehicle chassis, one or more diagnostic trouble codes (DTCs) may set.

The hybrid/EV powertrain control module 2 performs active isolation testing to monitor the internal Hybrid/EV

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battery pack HV circuits for chassis isolation. The hybrid/EV powertrain control module 2 switches fixed resistors between the high voltage system and vehicle chassis. The difference between the switched-to-chassis state and the unswitched state is used to calculate a resistance-to-chassis value.

Conditions for Running the DTC

P0AA7

- Ignition OFF.
- The hybrid/EV contactors have been open for greater than 8 seconds.
- DTCs P0AAA, P0AA8, P0AA9, P1E0C, and P1E0D are not set.
- Active Isolation resistors have been switched ON and then OFF.

P0AAA, P0AA8, P0AA9, P1E0C P1E0D

Active Isolation testing is not in progress.

Conditions for Setting the DTC

P0AA7

The difference between the switched ON state and switched OFF state is less than 5 V.

P0AA8

The difference is greater than 5 V when the sum of sensor circuit 1 and sensor circuit 2 is subtracted from total hybrid/EV battery pack voltage.

P0AA9, P1E0C

The Isolation sensor voltage is less than 5 V.

P0AAA, P1E0D

The Isolation sensor voltage is greater than 333 V.

Actions Taken When the DTC Sets

DTCs P0AA7, P0AA8, P0AA9, P0AAA, P1EC0 and P1E0D are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0AA7, P0AA8, P0AA9, P0AAA, P1EC0 and P1E0D are Type B DTCs.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

1. Ignition On
2. Verify DTC P0AA6 is not set.

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- **If the DTC is set**

  Refer to:**DTC P0AA6**.

- **If the DTC is not set**

3. Verify DTC P1AF0 is not set.
   - **If the DTC is set**

     Refer to:**DTC P1AF0** .

   - **If the DTC is not set**

4. Replace the component:K114B Hybrid/EV Powertrain Control Module 2

Repair Instructions

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

Control Module References for K114B Hybrid/EV Powertrain Control Module 2 replacement, programming and setup.

DTC P0ABB, P0ABC, OR P0ABD: HYBRID/EV BATTERY VOLTAGE SENSOR

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 P0ABB

Hybrid/EV Battery Voltage Sensor Performance

DTC P0ABC

Hybrid/EV Battery Voltage Sensor Circuit Low Voltage

DTC P0ABD

Hybrid/EV Battery Voltage Sensor Circuit High Voltage

Circuit/System Description

The hybrid/EV battery sections consist of lithium-ion batteries connected in series to make up the 86V DC battery.

Each of the two hybrid battery sections contains 12 cells that are connected in series using internal bus bars. The battery sections are externally connected in series using high voltage cables. Each individual cell group is rated at 3.6V, for a nominal system voltage of 86V DC.

A voltage sense circuit is attached to each individual cell. Each of these circuits terminate at a Hybrid Battery

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Interface Control Module located on the top surface of the battery section. The interface modules are connected to each other and the hybrid/EV powertrain control module 2 via serial data.

The hybrid/EV powertrain control module 2 determines the high voltage system/battery voltage level in several ways:

- Monitoring the K112 hybrid/EV battery interface control module serial data for sense circuits that terminate at each individual hybrid/EV battery cell group
- Summing the individual cell group voltage values to obtain a total hybrid/EV battery pack voltage
- Monitoring fused sense circuits that terminate at the high voltage negative and positive battery connections of the A28 hybrid/EV battery contactor assembly
- Monitoring the serial data high voltage value observed by the K59 Starter/Generator Control Module

The hybrid/EV powertrain control module 2 may compare these values against each other to verify accuracy.

Conditions for Running the DTC

P0ABB

- The 12 V battery voltage is greater than 9.1V.
- DTCs P0B3B-P0BB1 are not set.

P0ABC, P0ABD

The 12 V battery voltage is greater than 9.1 V.

Conditions for Setting the DTC

P0ABB

The hybrid/EV powertrain control module 2 detects difference of greater than 10 V between the summed cell group voltage and the voltage measured at battery side of the main contactors.

P0ABC

The hybrid/EV powertrain control module 2 detects the terminal voltage is less than 4.8 V on the battery side of the main contactors.

P0ABD

The hybrid/EV powertrain control module 2 detects the terminal voltage is greater than 116.5 V on the battery side of the main contactors.

Actions Taken When the DTC Sets

DTCs P0ABB, P0ABC, and P0ABD are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0ABB, P0ABC, and P0ABD are Type B DTCs.

Diagnostic Aids

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- The hybrid/EV battery pack high voltage manual service disconnect is out, not installed correctly, or a blown manual service disconnect fuse may cause P0ABB and/or P0ABC to set.
- The hybrid/EV battery pack high voltage manual service disconnect was removed, out of sequence, or was out during a service procedure with the 12 V battery connected may cause P0ABB and/or P0ABC to set.
- The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Hybrid Energy Storage Component Views

Description and Operation

Drive Motor Battery System Description

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

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON.
2. Verify that no other DTCs are set.
    - **If any DTCs are set**

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Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

- **If no other DTCs are set**

NOTE: **The S15 manual service disconnect lever must be installed for proper testing results.**

3. Verify with a scan tool, the hybrid/EV powertrain control module 2 Sum of all Hybrid/EV Battery Section Voltages parameter and the Hybrid/EV Battery Pack Voltage parameters are between 4.8-116.5 V and within 10 V of each other.
   - **If not within the specified range and not within 10 V of each other**

     Refer to Circuit/System Testing.

   - **If within the specified range and within 10 V of each other**
4. All OK.

Circuit/System Testing

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. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to:**High Voltage Disabling**
2. Remove the S15 Manual Service Disconnect.
3. Test for less than 10 Ω across the S15 Manual Service Disconnect fuse terminals.
   - **If 10 ohms or greater**

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Replace the S15 Manual Service Disconnect.

- **If less than 10 ohms**

4. Remove the A4 hybrid/EV battery pack top cover. Refer to:**High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**.
5. Disconnect the A28 hybrid/EV battery contactor assembly high voltage connectors X1 positive (300V) and X2 negative (300V).
6. Install a known good S15 manual service disconnect.

WARNING: **High voltage circuits should only be tested using a digital multimeter (DMM) and test leads with at least a CAT III rating, such as the J 39200-A Digital Multimeter. Failure to follow the procedures may result in serious injury or death.**

NOTE: **You are testing high voltage.**

7. Test for 39-108 V between the X2 negative (300 V) C4A and X1 positive (300 V) C4H battery cable terminals.
   - **If not within the specified range**

     Replace the A4 Hybrid/EV Battery Pack. After the repair is complete, perform the **Clear Secured High Voltage DTCs** reset function.

   - **If within the specified range**
8. Disconnect the A28 hybrid/EV battery contactor assembly high voltage sense circuit connector X5.
9. Reconnect the A28 hybrid/EV battery contactor assembly high voltage connectors X1 and X2.

NOTE: **You are testing high voltage.**

10. Test for 39-108V between the X5 terminal 1 positive (300 V) and terminal 2 negative (300 V) at the A28 hybrid/EV battery contactor assembly.
    - **If not within the specified range**

      Replace the A28 Hybrid/EV Battery Contactor Assembly or the sense circuit fuse(s) as applicable.

    - **If within the specified range**
11. Remove the S15 manual service disconnect.
12. Disconnect the K114B hybrid/EV powertrain control module 2 connector X6.

NOTE: **The A28 hybrid/EV battery contactor assembly high voltage sense lead connector X5 must remain disconnected.**

13. Test for infinite resistance between high voltage sense circuits connector X6 terminals 2 and 7 to ground.
    - **If less than infinite resistance**

      Repair the short to ground on the circuit.

    - **If infinite resistance**
14. Test for less than 2 Ω in each voltage sense circuit end to end.

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- **If 2 ohms or greater**

  Repair the open/high resistance in the circuit.

- **If less than 2 ohms**

15. Replace the K114B Hybrid/EV Powertrain Control Module 2.
16. After the repair is complete, the **Clear Secured High Voltage DTCs** reset function must be performed.

Repair Instructions

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

- **Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)** for S15 manual service disconnect replacement.
- **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**
- **Generator Battery Disconnector Relay Replacement** for A28 hybrid/EV battery contactor assembly replacement.
- **Control Module References** for K114B hybrid/EV powertrain control module 2 replacement, programming and setup.

DTC P0AC1 OR P0AC2: HYBRID/EV BATTERY LOW RESOLUTION CURRENT SENSOR

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 P0AC1

Hybrid/EV Battery Low Resolution Current Sensor Circuit Low Voltage

DTC P0AC2

Hybrid/EV Battery Low Resolution Current Sensor Circuit High Voltage

Circuit/System Description

The B30 hybrid/EV battery pack current sensor is a non-serviceable part of the A28 hybrid/EV battery contactor assembly mounted inside the hybrid/EV battery pack. The negative high voltage busbar that goes to the contactor relay passes through the hybrid/EV battery pack current sensor. The hybrid/EV battery pack current sensor detects the amperage that flows in and out of the hybrid/EV batteries. The hybrid/EV powertrain control module 2 supplies and monitors a 5 V reference signal to the hybrid/EV battery pack current sensor. The hybrid/EV battery pack current sensor returns a signal between 0 and 5 V to the hybrid/EV powertrain control module 2. The hybrid/EV battery pack current sensor signal is in proportion to the amperage going in and out of the hybrid/EV battery pack. A signal voltage of the hybrid/EV battery pack current sensor greater than 3.24 V indicates that the hybrid/EV battery is being charged and a signal voltage less than 3.24 V indicates discharging.

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Conditions for Running the DTC

The 12 V battery voltage is greater than 9.1 V.

Conditions for Setting the DTC

DTC P0AC1

The hybrid/EV powertrain control module 2 detects that the hybrid/EV battery pack current is less than -365.1 A.

DTC P0AC2

The hybrid/EV powertrain control module 2 detects that the hybrid/EV battery pack current is greater than +274.6 A.

Actions Taken When the DTC Sets

DTC P0AC1 and P0AC2 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0AC1 and P0AC2 are Type B DTCs.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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

Special Tools

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EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON, all accessories OFF.

   NOTE: **Typical current in a parked vehicle with all accessories OFF is between 1 A and 10 A.**

2. Verify the scan tool hybrid/EV powertrain control module 2 Hybrid/EV Battery Pack Current parameter is between -365.1 A and +274.6 A and changes with the amount of current draw on the hybrid/EV battery pack.
   - **If not within the specified range**

     Refer to Circuit/System Testing.

   - **If within the specified range**
3. All OK.

Circuit/System Testing

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. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to:**High Voltage Disabling**

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2. Remove the A4 Hybrid/EV Battery Pack top cover. Refer to:**High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**
3. Disconnect the 4-wire harness connector X3 on the A28 Hybrid/EV Battery Contactor Assembly.
4. Connect the 12 V battery, Ignition OFF.
5. Test for less than 10 Ω between the low reference circuit terminal 3 and ground.
    - **If 10 ohms or greater**
    1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2.
    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 K114B Hybrid/EV Powertrain Control Module 2.
    - **If less than 10 ohms**
6. Ignition ON
7. Test for 4.8-5.5 V between the 5 V reference circuit terminal 2 and the low reference terminal 3.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2.
    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 K114B Hybrid/EV Powertrain Control Module 2.
    - **If greater than 5.5 V**
    1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2, Ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K114B Hybrid/EV Powertrain Control Module 2.
    - **If within the specified range**
8. Verify the scan tool Hybrid/EV Battery Pack Current parameter is less than 0 A.
    - **If 0 A or greater**
    1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2, Ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K114B Hybrid/EV Powertrain Control Module 2.
    - **If less than 0 A**
9. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 2.
10. Verify the scan tool Hybrid/EV Battery Pack Current parameter is greater than 0 A.
    - **If 0 A or less**

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1. Ignition OFF, disconnect the X5 harness connector at the K114B Hybrid/EV Powertrain Control Module 2.
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 K114B Hybrid/EV Powertrain Control Module 2.

- **If greater than 0 A**

11. Replace the B30 Hybrid/EV Battery Pack Current Sensor.

Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for B30 Hybrid/EV Battery Pack Current Sensor replacement
- **Control Module References** for K114B Hybrid/EV Powertrain Control Module 2 replacement, programming, and setup.

DTC P0AFA OR P0AFB: HYBRID/EV BATTERY SYSTEM VOLTAGE LOW/HIGH

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 P0AFA

Hybrid/EV Battery System Voltage Low Voltage

DTC P0AFB

Hybrid/EV Battery System Voltage High Voltage

Circuit/System Description

The hybrid/EV powertrain control module 2 determines the high voltage system/battery voltage level in several ways:

- Monitoring the K112 hybrid/EV battery interface control module serial data for sense circuits that terminate at each individual hybrid/EV battery cell group
- Summing the individual cell group voltage values to obtain a total hybrid/EV battery pack voltage
- Monitoring sense circuits that terminate at the high voltage negative and positive battery connections of the A28 hybrid/EV battery contactor assembly
- Monitoring the serial data high voltage value observed by the K59 Starter/Generator Control Module

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The hybrid/EV powertrain control module 2 may compare these values against each other to verify accuracy.

Conditions for Running the DTC

- {Model year 2016 Only} None of the following DTCs are set; P0ABB, P0ABC, P0ABD, P0B3B, P0B3C, P0B3D, P0B3E, P0B40, P0B41, P0B42, P0B43, P0B45, P0B46, P0B47, P0B48, P0B4A, P0B4B, P0B4C, P0B4D, P0B4F, P0B50, P0B51, P0B52, P0B54, P0B55, P0B56, P0B57, P0B59, P0B5A, P0B5B, P0B5C, P0B5E, P0B5F, P0B60, P0B61, P0B63, P0B64, P0B65, P0B66, P0B68, P0B69, P0B6A, P0B6B, P0B6D, P0B6E, P0B6F, P0B70, P0B72, P0B73, P0B74, P0B75, P0B77, P0B78, P0B79, P0B7A, P0B7C, P0B7D, P0B7E, P0B7F, P0B81, P0B82, P0B83, P0B84, P0B86, P0B87, P0B88, P0B89, P0B8B, P0B8C, P0B8D, P0B8E, P0B90, P0B91, P0B92, P0B93, P0B95, P0B96, P0B97, P0B98, P0B9A, P0B9B, P0B9C, P0B9D, P0B9F, P0BA0, P0BA1, P0BA2, P0BA4, P0BA5, P0BA6, P0BA7, P0BA9, P0BAA, P0BAB, P0BAC, P0BAE, P0BAF, P0BB0, or P0BB1.
- {Model year 2017 and newer} None of the following DTCs are set: P0ABB, P0ABC, or P0ABD.

Conditions for Setting the DTC

DTC P0AFA

The Hybrid Battery Pack Voltage as measured at the A28 hybrid/EV battery contactor assembly connection is less than:

- 39.46 V at 10Â°C (50Â°F) or less
- 43.15 V at greater than 10Â°C (50Â°F)

OR

{Model Year 2016 Only} The Minimum Hybrid Battery Cell Group Voltage is less than:

- 1.64 V at 10Â°C (50Â°F) or less
- 1.80 V at greater than 10Â°C (50Â°F)

DTC P0AFB

The Hybrid Battery Pack Voltage as measured at the A28 hybrid/EV battery contactor assembly connection is greater than 108 V.

OR

{Model Year 2016 Only} The Maximum Hybrid Battery Cell Group Voltage in the hybrid battery is greater than 4.50 V.

Actions Taken When the DTC Sets

- DTCs P0AFA and P0AFB are type A DTCs.
- Once the vehicle has been turned OFF the contactors will be prevented from closing until the fault is cleared.

Conditions for Clearing the DTC

- DTCs P0AFA and P0AFB are type A DTCs.
- The **Clear Secured High Voltage DTCs** reset function must be performed with a scan tool before clear

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codes.

Diagnostic Aids

- The hybrid/EV battery pack high voltage manual service disconnect is not installed correctly, or a blown manual service disconnect fuse may cause P0AFA to set.
- {Model Year 2016 Only} A cell group low voltage condition may recover above the Conditions for Setting the DTC after an extended contactor-open condition. Whenever a Cell low voltage DTC has set but appears OK during Circuit/System Verification, operate the vehicle under high voltage battery load conditions to ensure cell group voltages do not drop too low while under load.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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

Special Tools

- **EL-48571** High Voltage Battery Pin Out Box
- **EL-48571-45** Battery Pinout Box Adapter
- **EL-48900** HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0B3B, P0B3C, P0B3D, P0B3E, P0B40, P0B41, P0B42, P0B43, P0B45, P0B46,

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P0B47, P0B48, P0B4A, P0B4B, P0B4C, P0B4D, P0B4F, P0B50, P0B51, P0B52, P0B54, P0B55, P0B56, P0B57, P0B59, P0B5A, P0B5B, P0B5C, P0B5E, P0B5F, P0B60, P0B61, P0B63, P0B64, P0B65, P0B66, P0B68, P0B69, P0B6A, P0B6B, P0B6D, P0B6E, P0B6F, P0B70, P0B72, P0B73, P0B74, P0B75, P0B77, P0B78, P0B79, P0B7A, P0B7C, P0B7D, P0B7E, P0B7F, P0B81, P0B82, P0B83, P0B84, P0B86, P0B87, P0B88, P0B89, P0B8B, P0B8C, P0B8D, P0B8E, P0B90, P0B91, P0B92, P0B93, P0B95, P0B96, P0B97, P0B98, P0B9A, P0B9B, P0B9C, P0B9D, P0B9F, P0BA0, P0BA1, P0BA2, P0BA4, P0BA5, P0BA6, P0BA7, P0BA9, P0BAA, P0BAB, P0BAC, P0BAE, P0BAF, P0BB0, or P0BB1 is not set.

- **If any of the DTCs are set**

  Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

- **If none of the DTCs are set**

3. Verify the scan tool hybrid/EV powertrain control module 2 parameter Hybrid/EV Battery Pack Voltage is between 39.46-108 V.
   - **If not within the specified range**

     Refer to Circuit/System Testing, Hybrid Battery Pack Voltage Diagnosis.

   - **If within the specified range**

   NOTE: A cell group low voltage condition may recover above the Conditions for Setting the DTC after an extended contactor-open condition. Whenever a Cell low voltage DTC has set but appears OK during Circuit/System Verification, operate the vehicle under high voltage battery load conditions to ensure cell group voltages do not drop too low while under load.

4. Verify the scan tool parameter Hybrid/EV Battery 1-24 voltages are between 1.64-4.50V and all readings are within 0.03V of each other.
   - **If not within the specified range**

     Refer to Circuit/System Testing, Hybrid Battery 1-24 Cell Group Diagnosis.

   - **If within the specified range**
5. All OK.

Circuit/System Testing

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

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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.

Hybrid Battery Pack Voltage Diagnosis

1. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to **High Voltage Disabling**
2. Remove the S15 manual service disconnect.
3. Test for less than 10 Ω across the S15 manual service disconnect fuse terminals 1 and 2 X2.
   - **If 10 ohms or greater**

     Replace the S15 manual service disconnect and repeat Circuit/System Verification.

   - **If less than 10 ohms**
4. Remove the A4 hybrid/EV battery pack top cover. Refer to **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**
5. Disconnect the A28 hybrid/EV battery contactor assembly high voltage connectors X1 and X2.
6. Install a known good S15 manual service disconnect.

WARNING: **High voltage circuits should only be tested using a digital multimeter (DMM) and test leads with at least a CAT III rating, such as the J 39200-A Digital Multimeter. Failure to follow the procedures may result in serious injury or death.**

NOTE: **You are testing high voltage.**

7. Test for 39.46-108 V between the X2 negative (300 V) C4A and X1 positive (300 V) C4H battery cable terminals.
   - **If not within the specified range**

     Replace the A4 Hybrid/EV Battery Pack. After the repair is complete with a scan tool, the **Clear Secured High Voltage DTCs** reset function must be performed.

   - **If within the specified range**
8. Disconnect the A28 hybrid/EV battery contactor assembly high voltage sense circuit connector X5.
9. Reconnect the A28 hybrid/EV battery contactor assembly high voltage connectors X1 and X2.

NOTE: **You are testing high voltage.**

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10. Test for 39.46-108 V between the X5 terminal 1 negative (300 V) and terminal 2 positive (300 V) at the A28 hybrid/EV battery contactor assembly.
    - **If not within the specified range**

      Replace the A28 Hybrid/EV Battery Contactor Assembly or the sense circuit fuse(s) as applicable.

    - **If within the specified range**
11. Remove the S15 manual service disconnect.
12. Disconnect K114B hybrid/EV powertrain control module 2 connector X6.

NOTE: **The A28 hybrid/EV battery contactor assembly high voltage sense lead connector X5 must remain disconnected.**

13. Test for infinite resistance between high voltage sense circuit terminals 2 and 7, X6 and ground.
    - **If less than infinite resistance**

      Repair the short to ground on the circuit.

    - **If infinite resistance**
14. Test for less than 2 Ω in each high voltage sense circuit end to end.
    - **If 2 ohms or greater**

      Repair the open/high resistance in the circuit.

    - **If less than 2 ohms**
15. Replace the K114B Hybrid/EV Powertrain Control Module 2.
16. After the repair is complete, the **Clear Secured High Voltage DTCs** reset function must be performed.

Hybrid Battery 1-24 Cell Group Diagnosis

1. Ignition OFF, disable the high voltage at the A4 hybrid/EV battery pack. Refer to **High Voltage Disabling**.
2. Remove the A4 hybrid/EV battery pack top cover. Refer to:**High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

NOTE: **The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group and corresponding DTC.**

3. Disconnect the harness connector to the K112 Hybrid/EV Battery Interface Control Module at the appropriate C4 Hybrid/EV Battery Section.
4. Connect the **EL-48571** High Voltage Battery Pin Out Box with the **EL-48571-45** Battery Pinout Box Adapter to the appropriate battery section.
5. Insert the DMM probes into the **EL-48571** test cavities.
6. Measure and record the voltage of each of the cell groups by cycling the **EL-48571** through each of the switch positions. Refer to **EL-48571 High Voltage Battery Pin Out Box Reference**
7. Verify each cell group voltage reading is between 1.64-4.50V.
    - **If not within the specified range**

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Replace the appropriate C4 Hybrid/EV Battery Section.

- **If within the specified range**

8. Verify each cell group voltage reading is within 0.03 V of each other.
    - **If greater than 0.03 V**

      Replace the appropriate C4 hybrid/EV battery section.

    - **If 0.03 V or less**
9. Replace the appropriate K112 Hybrid/EV Battery Interface Control Module. After the repair is complete, the **Clear Secured High Voltage DTCs** procedure must be performed.

Repair Instructions

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

- **Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)**
- **Cell Battery Module Replacement (Cell Battery 1)Cell Battery Module Replacement (Cell Battery 2)**
- **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**
- **Generator Battery Disconnector Relay Replacement** for A28 hybrid/EV battery contactor assembly replacement.
- **Control Module References** for K112 hybrid/EV battery interface control module and K114B hybrid/EV powertrain control module 2 replacement, programming and setup.

DTC P0B3B-P0BB1: HYBRID/EV BATTERY 1-24

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 P0B3B

Hybrid/EV Battery 1 Circuit

DTC P0B3C

Hybrid/EV Battery 1 Circuit Performance

DTC P0B3D

Hybrid/EV Battery 1 Circuit Low Voltage

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DTC P0B3E

Hybrid/EV Battery 1 Circuit High Voltage

DTC P0B40

Hybrid/EV Battery 2 Circuit

DTC P0B41

Hybrid/EV Battery 2 Circuit Performance

DTC P0B42

Hybrid/EV Battery 2 Circuit Low Voltage

DTC P0B43

Hybrid/EV Battery 2 Circuit High Voltage

DTC P0B45

Hybrid/EV Battery 3 Circuit

DTC P0B46

Hybrid/EV Battery 3 Circuit Performance

DTC P0B47

Hybrid/EV Battery 3 Circuit Low Voltage

DTC P0B48

Hybrid/EV Battery 3 Circuit High Voltage

DTC P0B4A

Hybrid/EV Battery 4 Circuit

DTC P0B4B

Hybrid/EV Battery 4 Circuit Performance

DTC P0B4C

Hybrid/EV Battery 4 Circuit Low Voltage

DTC P0B4D

Hybrid/EV Battery 4 Circuit High Voltage

DTC P0B4F

Hybrid/EV Battery 5 Circuit

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DTC P0B50

Hybrid/EV Battery 5 Circuit Performance

DTC P0B51

Hybrid/EV Battery 5 Circuit Low Voltage

DTC P0B52

Hybrid/EV Battery 5 Circuit High Voltage

DTC P0B54

Hybrid/EV Battery 6 Circuit

DTC P0B55

Hybrid/EV Battery 6 Circuit Performance

DTC P0B56

Hybrid/EV Battery 6 Circuit Low Voltage

DTC P0B57

Hybrid/EV Battery 6 Circuit High Voltage

DTC P0B59

Hybrid/EV Battery 7 Circuit

DTC P0B5A

Hybrid/EV Battery 7 Circuit Performance

DTC P0B5B

Hybrid/EV Battery 7 Circuit Low Voltage

DTC P0B5C

Hybrid/EV Battery 7 Circuit High Voltage

DTC P0B5E

Hybrid/EV Battery 8 Circuit

DTC P0B5F

Hybrid/EV Battery 8 Circuit Performance

DTC P0B60

Hybrid/EV Battery 8 Circuit Low Voltage

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DTC P0B61

Hybrid/EV Battery 8 Circuit High Voltage

DTC P0B63

Hybrid/EV Battery 9 Circuit

DTC P0B64

Hybrid/EV Battery 9 Circuit Performance

DTC P0B65

Hybrid/EV Battery 9 Circuit Low Voltage

DTC P0B66

Hybrid/EV Battery 9 Circuit High Voltage

DTC P0B68

Hybrid/EV Battery 10 Circuit

DTC P0B69

Hybrid/EV Battery 10 Circuit Performance

DTC P0B6A

Hybrid/EV Battery 10 Circuit Low Voltage

DTC P0B6B

Hybrid/EV Battery 10 Circuit High Voltage

DTC P0B6D

Hybrid/EV Battery 11 Circuit

DTC P0B6E

Hybrid/EV Battery 11 Circuit Performance

DTC P0B6F

Hybrid/EV Battery 11 Circuit Low Voltage

DTC P0B70

Hybrid/EV Battery 11 Circuit High Voltage

DTC P0B72

Hybrid/EV Battery 12 Circuit

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DTC P0B73

Hybrid/EV Battery 12 Circuit Performance

DTC P0B74

Hybrid/EV Battery 12 Circuit Low Voltage

DTC P0B75

Hybrid/EV Battery 12 Circuit High Voltage

DTC P0B77

Hybrid/EV Battery 13 Circuit

DTC P0B78

Hybrid/EV Battery 13 Circuit Performance

DTC P0B79

Hybrid/EV Battery 13 Circuit Low Voltage

DTC P0B7A

Hybrid/EV Battery 13 Circuit High Voltage

DTC P0B7C

Hybrid/EV Battery 14 Circuit

DTC P0B7D

Hybrid/EV Battery 14 Circuit Performance

DTC P0B7E

Hybrid/EV Battery 14 Circuit Low Voltage

DTC P0B7F

Hybrid/EV Battery 14 Circuit High Voltage

DTC P0B81

Hybrid/EV Battery 15 Circuit

DTC P0B82

Hybrid/EV Battery 15 Circuit Performance

DTC P0B83

Hybrid/EV Battery 15 Circuit Low Voltage

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DTC P0B84

Hybrid/EV Battery 15 Circuit High Voltage

DTC P0B86

Hybrid/EV Battery 16 Circuit

DTC P0B87

Hybrid/EV Battery 16 Circuit Performance

DTC P0B88

Hybrid/EV Battery 16 Circuit Low Voltage

DTC P0B89

Hybrid/EV Battery 16 Circuit High Voltage

DTC P0B8B

Hybrid/EV Battery 17 Circuit

DTC P0B8C

Hybrid/EV Battery 17 Circuit Performance

DTC P0B8D

Hybrid/EV Battery 17 Circuit Low Voltage

DTC P0B8E

Hybrid/EV Battery 17 Circuit High Voltage

DTC P0B90

Hybrid/EV Battery 18 Circuit

DTC P0B91

Hybrid/EV Battery 18 Circuit Performance

DTC P0B92

Hybrid/EV Battery 18 Circuit Low Voltage

DTC P0B93

Hybrid/EV Battery 18 Circuit High Voltage

DTC P0B95

Hybrid/EV Battery 19 Circuit

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DTC P0B96

Hybrid/EV Battery 19 Circuit Performance

DTC P0B97

Hybrid/EV Battery 19 Circuit Low Voltage

DTC P0B98

Hybrid/EV Battery 19 Circuit High Voltage

DTC P0B9A

Hybrid/EV Battery 20 Circuit

DTC P0B9B

Hybrid/EV Battery 20 Circuit Performance

DTC P0B9C

Hybrid/EV Battery 20 Circuit Low Voltage

DTC P0B9D

Hybrid/EV Battery 20 Circuit High Voltage

DTC P0B9F

Hybrid/EV Battery 21 Circuit

DTC P0BA0

Hybrid/EV Battery 21 Circuit Performance

DTC P0BA1

Hybrid/EV Battery 21 Circuit Low Voltage

DTC P0BA2

Hybrid/EV Battery 21 Circuit High Voltage

DTC P0BA4

Hybrid/EV Battery 22 Circuit

DTC P0BA5

Hybrid/EV Battery 22 Circuit Performance

DTC P0BA6

Hybrid/EV Battery 22 Circuit Low Voltage

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DTC P0BA7

Hybrid/EV Battery 22 Circuit High Voltage

DTC P0BA9

Hybrid/EV Battery 23 Circuit

DTC P0BAA

Hybrid/EV Battery 23 Circuit Performance

DTC P0BAB

Hybrid/EV Battery 23 Circuit Low Voltage

DTC P0BAC

Hybrid/EV Battery 23 Circuit High Voltage

DTC P0BAE

Hybrid/EV Battery 24 Circuit

DTC P0BAF

Hybrid/EV Battery 24 Circuit Performance

DTC P0BB0

Hybrid/EV Battery 24 Circuit Low Voltage

DTC P0BB1

Hybrid/EV Battery 24 Circuit High Voltage

Circuit/System Description

The hybrid/EV battery sections consist of lithium-ion batteries connected in series to make up the 86 V DC battery.

Each of the two hybrid battery section contains 12 cells that are connected in series using internal bus bars. The battery sections are externally connected in series using high voltage cables. Each individual cell group is rated at 3.6V , for a nominal system voltage of 86 V DC.

A voltage sense circuit is attached to each individual cell. Each of these circuits terminate at a Hybrid Battery Interface Control Module located on the top surface of the battery section. The interface modules are connected to each other and the hybrid/EV powertrain control module 2 via serial data.

Conditions for Running the DTC

DTC P0B3B, P0B3D, P0B3E, P0B40, P0B42, P0B43, P0B45, P0B47, P0B48, P0B4A, P0B4C, P0B4D, P0B4F, P0B51, P0B54, P0B52, P0B56, P0B57, P0B59, P0B5B, P0B5C, P0B5E, P0B60, P0B61, P0B63, P0B65, P0B66, P0B68, P0B6A, P0B6B, P0B6D, P0B6F, P0B70, P0B72, P0B74, P0B75, P0B77, P0B79,

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P0B7A, P0B7C, P0B7E, P0B7F, P0B81, P0B83, P0B84, P0B86, P0B88, P0B89, P0B8B, P0B8D, P0B8E, P0B90, P0B92, P0B93, P0B95, P0B97, P0B98, P0B9A, P0B9C, P0B9D, P0B9F, P0BA1, P0BA2, P0BA4, P0BA6, P0BA7, P0BA9, P0BAB, P0BAC, P0BAE, P0BB0, P0BB1

All of the following conditions exist:

- The 12 V battery voltage is greater than 9.1 V.
- DTC U179C is not set.

DTC P0B3C, P0B41, P0B46, P0B4B, P0B50, P0B55, P0B5A, P0B5F, P0B64, P0B69, P0B6E, P0B73, P0B78, P0B7D, P0B82, P0B87, P0B8C, P0B91, P0B96, P0B9B, P0BA0, P0BA5, P0BAA, P0BAF

All of the following conditions exist:

- The 12 V battery voltage is greater than 9.1 V.
- No Hybrid/EV Battery Circuit, Circuit High Voltage and Circuit High Voltage DTCs are set.

Conditions for Setting the DTC

Battery Circuit

- DTCs P0B3B, P0B40, P0B45, P0B4A, P0B4F, P0B54, P0B59, P0B5E, P0B63, P0B68, P0B6D, P0B72, P0B77, P0B7C, P0B81, P0B86, P0B8B, P0B90, P0B95, P0B9A, P0B9F, P0BA4, P0BA9, and P0BAE are Type B DTCs.
- The hybrid/EV battery energy control module detects resistance on the sense circuit is greater than 30 Ω.

Circuit Performance

- DTCs P0B3C, P0B41, P0B46, P0B4B, P0B50, P0B55, P0B5A, P0B5F, P0B64, P0B69, P0B6E, P0B73, P0B78, P0B7D, P0B82, P0B87, P0B8C, P0B91, P0B96, P0B9B, P0BA0, P0BA5, P0BAA, and P0BAF are Type B DTCs.
- The faulted cell group does not change voltage.

Low Voltage

- DTCs P0B3D, P0B42, P0B47, P0B4C, P0B51, P0B56, P0B5B, P0B60, P0B65, P0B6A, P0B6F, P0B74, P0B79, P0B7E, P0B83, P0B88, P0B8D, P0B92, P0B97, P0B9C, P0BA1, P0BA6, and P0BAB are Type B DTCs.
- Any hybrid/EV battery voltage sense signal is less than:
  - {Model Year 2016} 0.2 V
  - {Model year 2017 and newer} 1.64 V

High Voltage

- DTCs P0B3E, P0B43, P0B48, P0B4D, P0B52, P0B57, P0B5C, P0B61, P0B66, P0B6B, P0B70, P0B75, P0B7A, P0B7F, P0B84, P0B89, P0B8E, P0B93, P0B98, P0B9D, P0BA2, P0BA7, and P0BAC are Type B DTCs.
- Any hybrid/EV battery voltage sense signal is greater than:
  - {Model Year 2016} 4.9 V
  - {Model year 2017 and newer} 4.5 V

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Actions Taken When the DTC Sets

- DTCs P0B3B-P0BB1 are Type B DTCs.
- If any of these DTCs are set, the vehicle will operate in a reduced power mode.
- If additional fault conditions occur, this may cause the contactors to open at anytime.
- Low Voltage and High Voltage DTCs: The **Clear Secured High Voltage DTCs** reset function must be performed with a scan tool before clear codes.

Conditions for Clearing the DTC

- DTCs P0B3B-P0BB1 are Type B DTCs.
- Ignition must be cycled from ON to OFF.

Diagnostic Aids

The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group and corresponding DTC.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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

Special Tools

- **EL-48571** High Voltage Battery Pin Out Box
- **EL-48571-45** Battery Pinout Box Adapter
- **EL-48900** HEV Safety Kit

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Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool Hybrid/EV Battery 1-24 voltages are between 1.64-4.50 V and all readings are within 0.03 V of each other.
   - **If not within the specified range**

     Refer to Circuit/System Testing.

   - **If within the specified range**
3. All OK.

Circuit/System Testing

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. Ignition OFF, disable high voltage at the A4 Hybrid/EV Battery Pack. Refer to: **High Voltage Disabling**
2. Remove the A4 Hybrid/EV Battery Pack top cover. Refer to:**High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

NOTE: The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group and corresponding DTC.

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3. Disconnect the harness connector to the K112 Hybrid/EV Battery Interface Control Module at the appropriate C4 Hybrid/EV Battery Section as indicated by the voltages observed during Circuit/System Verification.
4. Connect the **EL-48571** High Voltage Battery Pin Out Box with the **EL-48571-45** Battery Pinout Box Adapter to the appropriate battery section.
5. Insert the DMM probes into the **EL-48571** test cavities.
6. Measure and record the voltage of each of the cell groups by cycling the **EL-48571** through each of the switch positions. Refer to **EL-48571 High Voltage Battery Pin Out Box Reference**
7. Verify each cell group voltage reading is between 1.64-4.50 V.
    - **If not within the specified range**

      Replace the appropriate C4 Hybrid/EV Battery Section.

    - **If within the specified range**
8. Verify each cell group voltage reading is within 0.03 V of each other.
    - **If greater than 0.03 V**

      Replace the appropriate C4 Hybrid/EV Battery Section.

    - **If 0.03 V or less**
9. Replace the appropriate K112 Hybrid/EV Battery Interface Control Module.

Repair Instructions

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

- **Cell Battery Module Replacement (Cell Battery 1)Cell Battery Module Replacement (Cell Battery 2)**
- **Control Module References** for K112 Hybrid/EV Battery Interface Control Module replacement, programming and setup.

DTC P0C78 OR P3061: HYBRID/EV BATTERY SYSTEM PRECHARGE

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 P0C78

Hybrid/EV Battery System Precharge Time Too Long

DTC P3061

Hybrid/EV Battery Precharge High Current

Circuit/System Description

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The hybrid/EV battery contains 3 high voltage contactors. The high voltage contactors allow the high voltage DC batteries to be connected to the vehicle or contain the high voltage DC within the hybrid/EV battery assembly. The high voltage contactors consist of a main positive high voltage contactor, main negative high voltage contactor, and a precharge positive high voltage contactor. The contactors close and open in a specific sequence controlled by the hybrid/EV powertrain control module 2. The hybrid/EV powertrain control module 2 supplies 12 V to the control circuit for each high voltage contactor.

The hybrid/EV powertrain control module 2 determines the high voltage system/battery voltage level in several ways:

- Monitoring the K112 Hybrid/EV Battery Interface Control Module serial data for sense circuits that terminate at each individual hybrid/EV battery cell group.
- Summing the individual cell group voltage values to obtain a total hybrid/EV battery pack voltage.
- Monitoring sense circuits that terminate at the high voltage negative and positive battery connections of the A28 Hybrid/EV Battery Contactor Assembly.
- Monitoring the serial data high voltage value observed by the T6 power inverter module.

The hybrid/EV powertrain control module 2 may compare these values against each other to verify accuracy.

Conditions for Running the DTC

- K114B Hybrid/EV Powertrain Control Module 2 battery voltage sensor has not failed.
- K59 Starter/Generator Control Module bus voltage sensor has not failed.
- Precharge is active.

Conditions for Setting the DTC

P0C78

During Precharge, the bus voltage has not reached 95% of battery voltage within 700 ms.

P3061

- {Model Year 2016} During Precharge, the bus current is greater than 3 amps for 88 ms continuously.
- {Model year 2017 and newer} During Precharge, the bus current is greater than 6 amps for 88 ms continuously.

Actions Taken When the DTC Sets

- DTC P0C78 is a Type B DTC.
- DTC P3061 is a Type A DTC.
- The contactors will be opened.

Conditions for Clearing the DTC

- DTC P0C78 is a Type B DTC.
- DTC P3061 is a Type A DTC.

Reference Information

Schematic Reference

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- **Hybrid/EV Energy Storage Schematics**
- **Hybrid/EV Controls Schematics**

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

Drive Motor Battery System Description

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

Special Tools

EL-48900 HEV Safety Kit

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0AA1, P0AA4, P0AD9, P0ADB, P0ADC, P0ADD, P0ADF, P0AE0, P0AE4, P0AE6, P0AE7, or P1EC0 is not set.
   - **If any of the DTCs are set**

     Refer to: **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If none of the DTCs are set**

     NOTE: The following setup steps must be performed exactly in order to exercise the contactors.

3. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
4. OPEN the driver door using outside door handle. Leave driver door OPEN.

   NOTE: The brake pedal must remain depressed throughout the remainder of the contactor steps.

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5. PRESS and HOLD the brake pedal.

NOTE: **DO NOT turn on the ignition.**

6. Command the Hybrid/EV Battery Contactors ALL OPEN with a scan tool.
7. Disconnect the S15 Manual Service Disconnect.

NOTE: **DO NOT use the scan tool Release Control button to turn OFF any of the contactors. Once the Release Control button is pushed the Circuit/System Verification will need to be restarted from the beginning.**

8. Command the Hybrid/EV Battery Negative Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.

NOTE: **It is normal for the contactors to only make noise while opening.**

9. Verify the Hybrid/EV Battery Negative Contactor is heard opening.
    - **If the Hybrid/EV Battery Negative Contactor operation cannot be heard**

      Refer to Circuit/System Testing, Contactor Diagnosis.

    - **If the Hybrid/EV Battery Negative Contactor operation is heard**
10. Command the Hybrid/EV Battery Positive Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.
11. Verify the Hybrid/EV Battery Positive Contactor is heard opening.
    - **If the Hybrid/EV Battery Positive Contactor operation cannot be heard**

      Refer to Circuit/System Testing, Contactor Diagnosis.

    - **If the Hybrid/EV Battery Positive Contactor operation is heard**
12. Command the Hybrid/EV Battery Precharge Contactor between CLOSED and ALL OPEN with a scan tool while listening for the contactor to open.
13. Verify the Hybrid/EV Battery Precharge Contactor is heard opening.
    - **If the Hybrid/EV Battery Precharge Contactor operation is not heard**

      Refer to Circuit/System Testing, Contactor Diagnosis.

    - **If the Hybrid/EV Battery Precharge Contactor operation is heard**
14. Release scan tool control. Install the S15 Manual Service Disconnect.
15. Allow Hybrid/EV powertrain control modules to enter sleep mode by performing the following:
    1. Turn the Ignition OFF.
    2. Ensure the scan tool is not communicating with any control modules by returning to the Home screen.
    3. Shut all doors. Do NOT depress the brake pedal or activate any vehicle controls such as the parking lights, fuel door release, etc.
    4. Ensure the scan tool is accessible without having to open doors or otherwise cause control module wake-up.

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NOTE: **Sleep mode is usually entered within two minutes after shutting off the vehicle.**

5. Wait 5 minutes with the vehicle in the prescribed condition so that the modules may enter sleep mode.

16. With a scan tool, verify the Hybrid/EV Powertrain Control Module 2 has gone to sleep by ensuring communication is not present.
    - **If communication is present**

      Repeat the previous step.

    - **If communication is not present**

17. Ignition ON. Verify the scan tool hybrid/EV powertrain control module 2 High Voltage Inverter Voltage and Hybrid/EV Battery Pack Voltage are within 10 V of each other.
    - **If not within 10 V of each other**

      Refer to Circuit/System Testing, System Bus Diagnosis.

    - **If within 10 V of each other**

18. All OK.

Circuit/System Testing

Contactor Diagnosis

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.

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1. Ignition OFF, disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to:**High Voltage Disabling**.
2. Remove the A4 Hybrid/EV Battery Pack top cover. Refer to:**High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**.
3. Disconnect the X4 harness connector at the A28 Hybrid/EV Battery Contactor Assembly.
4. Test for less than 10 Ω between the ground circuit terminal 2, X4 and ground.
   - **If more than 10 Ω**
5. Test for less than 2 Ω in the ground circuit end to end.
   - **If 2 ohms or greater**

     Repair the open/high resistance in the circuit.
   - **If less than 2 ohms**

     Repair the open/high resistance in the ground connection.
   - **If less than 10 ohms**

NOTE: **Connecting the 12V battery with the S15 Manual Service Disconnect removed may set other DTCs.**

6. Connect the 12 V battery. Ignition ON.
7. Verify that a test lamp does not illuminate between each A28 Hybrid/EV Battery Contactor Assembly harness connector control circuit terminals listed below and ground:
   - Terminal 1 X4
   - Terminal 3 X4
   - Terminal 4 X4
   - **If the test lamp illuminates on any circuit**
   1. Ignition OFF, disconnect the X4 harness connector at the K114B Hybrid Powertrain Control Module 2. Ignition ON.
   2. Test for less than 1 V between the A28 Hybrid/EV Battery Contactor Assembly harness connector control circuit terminals listed below and ground:
      - Terminal 1 X4
      - Terminal 3 X4
      - Terminal 4 X4
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K114B Hybrid Powertrain Control Module 2.
   - **If the test lamp does not illuminate on all circuits**
8. Ignition OFF, disconnect the X4 harness connector at the K114B Hybrid Powertrain Control Module 2.
9. Test for infinite resistance between each A28 Hybrid/EV Battery Contactor Assembly harness connector control circuit terminals listed below and ground:
   - Terminal 1 X4
   - Terminal 3 X4
   - Terminal 4 X4
   - **If less than infinite resistance on either circuit**

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Repair the short to ground on the circuit.

- **If infinite resistance on both circuits**

10. Test for less than 2 Ω between the harness connector terminals listed below:
    - Terminal 1 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 3 X4 at the K114B Hybrid Powertrain Control Module 2
    - Terminal 3 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 2 X4 at the K114B Hybrid Powertrain Control Module 2
    - Terminal 4 X4 at the A28 Hybrid/EV Battery Contactor Assembly and terminal 1 X4 at the K114B Hybrid Powertrain Control Module 2
    - **If 2 Ω or greater on any circuit**

      Repair the open/high resistance in the circuit.

    - **If less than 2 Ω on all circuits**
11. Replace the A28 Hybrid/EV Battery Contactor Assembly.
12. Verify that DTC P0C78 or P3061 does not set while operating the vehicle within the Conditions for Running the DTC.
    - **If DTC P0C78 or P3061 sets**

      Replace the K114B Hybrid Powertrain Control Module 2.

    - **If DTC P0C78 or P3061 does not set**
13. All OK.

System Bus Diagnosis

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**

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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. Ignition OFF, disable the high voltage at the K59 Starter/Generator Control Module and the A4 Hybrid/EV Battery Pack. Refer to:**High Voltage Disabling**.
2. Test for greater than 1 M Ω between the K59 Starter/Generator Control Module high voltage connector X5 terminals A and B.
   - **If less than the specified range**
   1. Replace the K59 Starter/Generator Control Module.
   2. Verify that DTC P0C78 or P3061 does not set while operating the vehicle within the Conditions for Running the DTC.
      - If the DTC sets, replace the A28 hybrid/EV battery contactor assembly
      - If the DTC does not set, All OK.
   - **If greater than the specified range**
3. Replace the A28 Hybrid/EV Battery Contactor Assembly.
4. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
   - **If the DTC sets**

     Replace the K114B Hybrid Powertrain Control Module 2.

   - **If the DTC does not set**
5. All OK.

Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for A28 hybrid/EV battery contactor assembly
- **Control Module References** for K59 Starter/Generator Control Module or K114B Hybrid/EV Powertrain Control Module 2 replacement, programming and setup.

DTC P1E92, P1E93, P1E98, P1E99, P1FD5, P1FD6, P1FDF, P1FE0, P1FE9, OR P1FEA: HYBRID/EV BATTERY INTERFACE CONTROL MODULE

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 P1E92

Hybrid/EV Battery Interface Control Module 1 Cell Balancing Circuit

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DTC P1E93

Hybrid/EV Battery Interface Control Module 1 5V Reference Circuit

DTC P1E98

Hybrid/EV Battery Interface Control Module 2 Cell Balancing Circuit

DTC P1E99

Hybrid/EV Battery Interface Control Module 2 5V Reference Circuit

DTC P1FD5

Hybrid/EV Battery Interface Control Module 1 Voltage Sensor Circuit Low Voltage

DTC P1FD6

Hybrid/EV Battery Interface Control Module 2 Voltage Sensor Circuit Low Voltage

DTC P1FDF

Hybrid/EV Battery Interface Control Module 1 Voltage Sensor Circuit High Voltage

DTC P1FE0

Hybrid/EV Battery Interface Control Module 2 Voltage Sensor Circuit High Voltage

DTC P1FE9

Hybrid/EV Battery Interface Control Module 1 Voltage Sensor Performance

DTC P1FEA

Hybrid/EV Battery Interface Control Module 2 Voltage Sensor Performance

Circuit/System Description

To maintain a similar state of charge among all cell groups, the hybrid/EV powertrain control module 2 monitors the cell group voltages and determines which cell groups need energy removed in order to maintain the battery groups at a similar state of charge. This is known as cell balancing. There is a transistor switched resistor wired in parallel with each cell group internal to the hybrid/EV battery interface control module. The hybrid/EV powertrain control module 2 sends a command to the hybrid/EV battery interface control module to begin cell balancing.

Conditions for Running the DTC

P1E92, P1E98

- The 12 V battery voltage is greater than 9.1 V.
- None of the following DTCs are set: P0B3B, P0B40, P0B45, P0B4A, P0B4F, P0B54, P0B59, P0B5E, P0B63, P0B68, P0B6D, P0B72, P0B77, P0B7C, P0B81, P0B86, P0B8B, P0B90, P0B95, P0B9A, P0B9F, P0BA4, P0BA9 or U179C.

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P1E93, P1E99, P1FD5, P1FD6, P1FDF, P1FE0

- The 12V battery voltage is greater than 9.1V.
- DTC U179 is not set.

P1FE9, P1FEA

- The 12 V battery voltage is greater than 9.1 V.
- No cell sense circuit open DTCs are set: P0B3B, P0B40, P0B45, P0B4A, P0B4F, P0B54, P0B59, P0B5E, P0B63, P0B68, P0B6D, P0B72, P0B77, P0B7C, P0B81, P0B86, P0B8B, P0B90, P0B95, P0B9A, P0B9F, P0BA4, P0BA9

  AND

  No cell sense circuit low voltage DTCs are set: P0B3D, P0B42, P0B47, P0B4C, P0B51, P0B56, P0B5B, P0B60, P0B65, P0B6A, P0B6F, P0B74, P0B79, P0B7E, P0B83, P0B88, P0B8D, P0B92, P0B97, P0B9C, P0BA1, P0BA6, P0BAB

  AND

  No cell sense circuit high voltage DTCs are set: P0B3E, P0B43, P0B48, P0B4D, P0B52, P0B57, P0B5C, P0B61, P0B66, P0B6B, P0B70, P0B75, P0B7A, P0B7F, P0B84, P0B89, P0B8E, P0B93, P0B98, P0B9D, P0BA2, P0BA7, P0BAC.

Conditions for Setting the DTC

The applicable hybrid/EV battery interface control module has detected an internal cell balancing switch or circuit fault.

Actions Taken When the DTC Sets

- DTC P1E92, P1E93, P1E98, P1E99, P1FD5, P1FD6, P1FDF, P1FE0, P1FE9, and P1FEA are Type B DTCs.
- Cell balancing is disabled.

Conditions for Clearing the DTC

DTC P1E92, P1E93, P1E98, P1E99, P1FD5, P1FD6, P1FDF, P1FE0, P1FE9, and P1FEA are Type B DTCs.

Reference Information

Description and Operation

Drive Motor Battery System Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

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EL-48900 HEV Safety Kit

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

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 will perform the following tasks:

- **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.**

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

1. Verify that no other DTCs are set.
   - **If any other DTCs are set**

     Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If no other DTCs are set**
2. Verify that P1E92, P1E93, P1E98, P1E99, P1FD5, P1FD6, P1FDF, P1FE0, P1FE9, or P1FEA is set.
   - **If the DTC is set**
   1. Disable the high voltage at the A4 Hybrid/EV Battery Pack. Refer to:**High Voltage Disabling**.
   2. Replace the applicable K112 Hybrid/EV Battery Interface Control Module.
   - **If none of the DTCs are set**
3. All OK.

Repair Instructions

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

Control Module References for K112 hybrid/EV battery interface control module replacement, programming and setup.

DTC P1EAB OR P1EAC: BATTERY ENERGY CONTROL MODULE HYBRID/EV BATTERY, HYBRID/EV BATTERY CELL OVERVOLTAGE

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**

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DTC Descriptor

DTC P1EAB

Battery Energy Control Module Hybrid/EV Battery Cell High Voltage

DTC P1EAC

Hybrid/EV Battery Cell Overvoltage Signal Circuit Performance

Circuit/System Description

The hybrid/EV battery interface control modules perform a cell overvoltage SENSE CIRCUIT test, once, every power up cycle. When run/crank input signal transitions high and after a calibrated delay, the hybrid/EV battery interface control module informs the hybrid/EV powertrain control module 2, via serial data communication bus that it is about to run the diagnostics on the overvoltage sense circuit. The hybrid/EV battery interface control modules then proceed to command, via internal serial data, each of its internal sense circuits to run the check on its output.

Conditions for Running the DTC

- The hybrid/EV battery interface control modules and hybrid/EV powertrain control module 2 are awake and communicating.
- DTC P0B3B, P0B3D, P0B3E, P0B40, P0B42, P0B43, P0B45, P0B47, P0B48, P0B4A, P0B4C, P0B4D, P0B4F, P0B51, P0B54, P0B52, P0B56, P0B57, P0B59, P0B5B, P0B5C, P0B5E, P0B60, P0B61, P0B63, P0B65, P0B66, P0B68, P0B6A, P0B6B, P0B6D, P0B6F, P0B70, P0B72, P0B74, P0B75, P0B77, P0B79, P0B7A, P0B7C, P0B7E, P0B7F, P0B81, P0B83, P0B84, P0B86, P0B88, P0B89, P0B8B, P0B8D, P0B8E, P0B90, P0B92, P0B93, P0B95, P0B97, P0B98, P0B9A, P0B9C, P0B9D, P0B9F, P0BA1, P0BA2, P0BA4, P0BA6, P0BA7, P0BA9, P0BAB, P0BAC, P0BAE, P0BB0, or P0BB1 is not set
- The 12 V battery voltage is greater than or equal to 9.1 V.
- Ignition must be cycled from OFF to ON.
- Ignition is ON for greater than 5 seconds.
- Hybrid powertrain control module 1 detects high voltage bus is greater than 48 V.

Conditions for Setting the DTC

DTC P1EAB

A cell group voltage of greater than 4.5 V is detected.

OR

The hybrid/EV powertrain control module 2 has detected a fault with the overvoltage sense circuit.

DTC P1EAC

The hybrid/EV powertrain control module 2 has detected a fault with the overvoltage sense circuit.

Actions Taken When the DTC Sets

- DTC P1EAB is a Type A DTC.
- DTC P1EAC is a Type B DTC.

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- If any of these DTCs are set, the vehicle will operate in a reduced power mode.

DTC P1EAB

Once the Ignition has been turned OFF all the contactors will be prevented from closing.

Conditions for Clearing the DTC

- DTC P1EAB is a Type A DTC.
- DTC P1EAC is a Type B DTC.
- Ignition cycled from ON to OFF after code clear.

DTC P1EAB

After the repair for DTC P1EAB, perform the **Clear Secured High Voltage DTCs** repair instruction.

Diagnostic Aids

The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group and corresponding hybrid/EV battery interface control module.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

Drive Motor Battery System Description

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

Circuit/System Verification

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1. Ignition ON, engine OFF.
2. Verify that DTC P0B3B, P0B3D, P0B3E, P0B40, P0B42, P0B43, P0B45, P0B47, P0B48, P0B4A, P0B4C, P0B4D, P0B4F, P0B51, P0B54, P0B52, P0B56, P0B57, P0B59, P0B5B, P0B5C, P0B5E, P0B60, P0B61, P0B63, P0B65, P0B66, P0B68, P0B6A, P0B6B, P0B6D, P0B6F, P0B70, P0B72, P0B74, P0B75, P0B77, P0B79, P0B7A, P0B7C, P0B7E, P0B7F, P0B81, P0B83, P0B84, P0B86, P0B88, P0B89, P0B8B, P0B8D, P0B8E, P0B90, P0B92, P0B93, P0B95, P0B97, P0B98, P0B9A, P0B9C, P0B9D, P0B9F, P0BA1, P0BA2, P0BA4, P0BA6, P0BA7, P0BA9, P0BAB, P0BAC, P0BAE, P0BB0, or P0BB1 is not set.
   - **If any of the DTCs are set**

     Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If none of the DTCs are set**
3. Verify that DTC P1EAB or P1EAC is not set.
   - **If DTC P1EAB, P1EAC is set**

     Refer to Circuit/System Testing.

   - **If DTC P1EAB or P1EAC is not set**
4. All OK.

Circuit/System Testing

1. Ignition ON.
2. Verify the hybrid/EV powertrain control module 2 scan tool Maximum Hybrid/EV Battery Module Voltage parameter is 4.5 V or less.
   - **If greater than 4.5 V**

     Perform the applicable DTC diagnosis for the battery module indicating high voltage. Refer to:**DTC P0B3B-P0BB1**.

   - **If 4.5 V or less**
3. Determine which hybrid/EV battery interface control module has set the DTC by verifying the scan tool hybrid/EV powertrain control module 2 parameter Battery Interface Control Modules Over Voltage Status.
4. Replace the appropriate K112 Hybrid/EV Battery Interface Control Module as indicated by the scan tool parameter.

Repair Instructions

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

- **Control Module References** for K112 hybrid/EV battery interface control module replacement, programming and setup.

DTC P1EAD OR P1EAE: HYBRID/EV INTERFACE CONTROL MODULE 1/2 CELL OVERVOLTAGE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System**

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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 P1EAD

Hybrid/EV Interface Control Module 1 Cell Overvoltage Signal Circuit

DTC P1EAE

Hybrid/EV Interface Control Module 2 Cell Overvoltage Signal Circuit

Circuit/System Description

The hybrid/EV battery interface control modules perform a cell overvoltage SENSE CIRCUIT test, once, every power up cycle. When run/crank input signal transitions high and after a calibrated delay, the hybrid/EV battery interface control module informs the hybrid/EV powertrain control module 2, via serial data communication bus that it is about to run the diagnostics on the overvoltage sense circuit. The hybrid/EV battery interface control modules then proceed to command, via internal serial data, each of its internal sense circuits to run the check on its output.

Conditions for Running the DTC

- The hybrid/EV battery interface control modules and hybrid/EV powertrain control module 2 are awake and communicating.
- DTC P0B3B, P0B40, P0B45, P0B4A, P0B4F, P0B54, P0B59, P0B5E, P0B63, P0B68, P0B6D, P0B72, P0B77, P0B7C, P0B81, P0B86, P0B8B, P0B90, P0B95, P0B9A, P0B9F, P0BA4, P0BA9, P0BAE, U185A or U0111 is not set.
- The 12 V battery voltage is greater than or equal to 9.1 V.
- Ignition must be cycled from OFF to ON.
- Ignition is ON for greater than 5 seconds.
- Hybrid powertrain control module 1 detects high voltage bus is greater than 48 V.

Conditions for Setting the DTC

The hybrid/EV powertrain control module 2 has detected a fault with the overvoltage sense circuit.

Actions Taken When the DTC Sets

- DTCs P1EAD and P1EAE are type B DTCs.
- If any of these DTCs are set, the vehicle will operate in a reduced power mode.

Conditions for Clearing the DTC

- DTCs P1EAD and P1EAE are type B DTCs.
- Ignition Power cycled from ON to OFF after code clear.

Diagnostic Aids

The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense

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circuit terminal locations appropriate to each cell group and corresponding hybrid/EV battery interface control module.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

Drive Motor Battery System Description

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

Circuit/System Verification

1. Ignition ON, engine OFF.
2. Verify DTC P1EAD, P1EAE is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. All OK.

Circuit/System Testing

1. Ignition On .
2. Verify the hybrid/EV powertrain control module 2 scan tool Maximum Hybrid/EV Battery Module Voltage parameter is 4.5 V or less.
   - **If greater than 4.5 V**

     Perform the applicable DTC diagnosis for the battery module indicating high voltage. Refer

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to:**DTC P0B3B-P0BB1**.

- **If 4.5 V or less**

3. Replace the appropriate K112 Hybrid/EV Battery Interface Control Module as indicated by the DTC.

Repair Instructions

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

- **Control Module References** for K112 hybrid/EV battery interface control module replacement, programming and setup.

DTC P1EBA: HYBRID/EV BATTERY LOW RESOLUTION CURRENT SENSOR

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 P1EBA

Hybrid/EV Battery Low Resolution Current Sensor Exceeded Learning Limit

Circuit/System Description

The B30 hybrid/EV battery pack current sensor is a non-serviceable part of the A28 hybrid/EV battery contactor assembly mounted inside the hybrid/EV battery pack. The negative high voltage busbar that goes to the contactor relay passes through the hybrid/EV battery pack current sensor. The hybrid/EV battery pack current sensor detects the amperage that flows in and out of the hybrid/EV batteries. The hybrid/EV powertrain control module 2 supplies and monitors a 5 V reference signal to the hybrid/EV battery pack current sensor. The hybrid/EV battery pack current sensor returns a signal between 0 and 5 V to the hybrid/EV powertrain control module 2. The hybrid/EV battery pack current sensor signal is in proportion to the amperage going in and out of the hybrid/EV battery pack. A signal voltage of the hybrid/EV battery pack current sensor greater than 3.24 V indicates that the hybrid/EV battery is being charged and a signal voltage less than 3.24 V indicates discharging.

Conditions for Running the DTC

- The 12 V battery voltage is greater than 9.1 V.
- The high voltage main contactors are open (during wake-up).
- DTC P0AC1 or P0AC2 is not set.

Conditions for Setting the DTC

The hybrid/EV powertrain control module 2 detects that the battery pack current sensor learn offset is greater than 8 A.

Actions Taken When the DTC Sets

DTC P1EBA is a Type B DTC.

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Conditions for Clearing the DTC

DTC P1EBA is a Type B DTC.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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

Special Tools

EL-48900 HEV Safety Kit

For Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P1EBA is not set.
    - **If the DTC is set**
    1. Program the hybrid/EV powertrain control module 2.
    2. Verify the DTC does not set.
        - If the DTC sets, replace the A28 Hybrid/EV Battery Contactor Assembly.
        - If the DTC does not set
    3. All OK.
    - **If the DTC is not set**
3. All OK.

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Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for A28 Hybrid/EV Battery Contactor Assembly replacement
- **Control Module References** for K114B Hybrid/EV Powertrain Control Module 2 replacement, programming, and setup.

DTC P1F17: SYSTEM ISOLATION / IMPACT SENSOR FAULT - HYBRID/EV BATTERY SYSTEM CONTACTORS OPEN

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 P1F17

System Isolation / Impact Sensor Fault - Hybrid/EV Battery System Contactors Open

Circuit/System Description

The hybrid/EV powertrain control module 2 will set DTC P1F17 if the hybrid/EV powertrain control module 1 has detected a passive loss of isolation in combination with the supplemental inflatable restraint sensors are not working or has lost communications with the hybrid/EV powertrain control module 1 and the supplemental inflatable restraint module.

Conditions for Running the DTC

Ignition On .

Conditions for Setting the DTC

- DTC P1AF0, P1AF2 or P1E22 is set in the hybrid/EV powertrain control module 1.

  AND

- DTCs B0083-B0088 are set in the supplemental inflatable restraint module.

  OR

- DTC P1AF0, P1AF2 or P1E22 is set in the hybrid/EV powertrain control module 1.

  AND

- DTC U184E is set.

  OR

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- The hybrid/EV powertrain control module 2 has lost communications with the hybrid/EV powertrain control module 1 and the supplemental inflatable restraint module.

  AND

- DTC U184E is set.

  OR

- The hybrid/EV powertrain control module 2 has lost communications with the hybrid/EV powertrain control module 1.

  AND

- DTCs B0083-B0088 are set in the supplemental inflatable restraint module.

Actions Taken When the DTC Sets

- DTC P1F17 is a Type A DTC.
- All of the contactors will be prevented from closing.

Conditions for Clearing the DTC

- DTC P1F17 is a Type A DTC.
- The **Clear Secured High Voltage DTCs** reset function must be performed with a scan tool before clear codes.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Drive Motor Battery System Description

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

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Control Module References

Circuit/System Verification

1. Ignition On .
2. Verify that no other DTCs are set.
    - **If any other DTCs are set**

      Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

    - **If none of the DTCs are set**
3. Verify DTC P1F17 is not set.
    - **If DTC P1F17 is set**
    1. Verify the K36 Inflatable Restraint Sensing And Diagnostic Module is programmed with the correct software calibration.
        - If the correct software is not installed, program the K36 Inflatable Restraint Sensing And Diagnostic Module.
        - If the correct software is installed
    2. Perform the **Clear Secured High Voltage DTCs** repair instruction.
    3. Verify that DTC P1F17 does not set while operating the vehicle within the Conditions for Running the DTC.
        - If DTC P1F17 is set, replace the K114B Hybrid Powertrain Control Module 2.
        - If DTC P1F17 is not set
    4. All OK.
    - **If DTC P1F17 is not set**
4. All OK.

Repair Instructions

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

Control Module References for K114B hybrid/EV powertrain control module 2 and inflatable restraint sensing and diagnostic module replacement, programming and setup.

DTC P3240 OR P3241: HYBRID/EV BATTERY INTERFACE CONTROL MODULE 1/2 CELL OVERVOLTAGE

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 P3240

Hybrid/EV Battery Interface Control Module 1 Cell Overvoltage

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DTC P3241

Hybrid/EV Battery Interface Control Module 2 Cell Overvoltage

Circuit/System Description

The hybrid/EV battery interface control modules perform a cell overvoltage SENSE CIRCUIT test, once, every power up cycle. When run/crank input signal transitions high and after a calibrated delay, the hybrid/EV battery interface control module informs the hybrid/EV powertrain control module 2, via serial data communication bus that it is about to run the diagnostics on the overvoltage sense circuit. The hybrid/EV battery interface control modules then proceed to command, via internal serial data, each of its internal sense circuits to run the check on its output.

Conditions for Running the DTC

- The hybrid/EV battery interface control modules and hybrid/EV powertrain control module 2 are awake and communicating.
- DTC P0B3B, P0B40, P0B45, P0B4A, P0B4F, P0B54, P0B59, P0B5E, P0B63, P0B68, P0B6D, P0B72, P0B77, P0B7C, P0B81, P0B86, P0B8B, P0B90, P0B95, P0B9A, P0B9F, P0BA4, P0BA9, P0BAE, U185A or U0111 is not set.
- The 12 V battery voltage is greater than or equal to 9.1 V.
- Ignition must be cycled from OFF to ON.
- Ignition is ON for greater than 5 seconds.
- Hybrid powertrain control module 1 detects high voltage bus is greater than 48V.

Conditions for Setting the DTC

A cell group voltage of greater than 4.5 V is detected.

Actions Taken When the DTC Sets

- DTCs P3240 and P3241 are type A DTCs.
- If any of these DTCs are set, the vehicle will operate in a reduced power mode.
- Once Ignition has been turned OFF all the contactors will be prevented from closing.

Conditions for Clearing the DTC

- DTCs P3240 and P3241 are type A DTCs.
- After the repair, perform the **Clear Secured High Voltage DTCs** repair instruction.

Diagnostic Aids

The Hybrid/EV Battery Section schematics in Energy Storage identify the battery section and voltage sense circuit terminal locations appropriate to each cell group and corresponding hybrid/EV battery interface control module.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

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Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Description and Operation

Drive Motor Battery System Description

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

Circuit/System Verification

1. Ignition ON, Engine OFF.
2. Verify that DTC P3240 or P3241 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. All OK.

Circuit/System Testing

1. Ignition On .
2. Verify the hybrid/EV powertrain control module 2 scan tool Maximum Hybrid/EV Battery Module Voltage parameter is 4.5 V or less.
   - **If greater than 4.5 V**

     Perform the applicable DTC diagnosis for the battery module indicating high voltage. Refer to: **DTC P0B3B-P0BB1**.

   - **If 4.5 V or less**
3. Replace the appropriate K112 Hybrid/EV Battery Interface Control Module as indicated by the DTC.

Repair Instructions

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

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- **Control Module References** for K112 hybrid/EV battery interface control module replacement, programming and setup.

LOSS OF ISOLATION ON THE HIGH VOLTAGE MAIN BUS

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**

Circuit/System Description

Vehicles equipped with high voltage energy storage are designed with the high voltage circuits isolated from the vehicle chassis. If either the positive or negative high voltage Direct Current (DC) circuits or any of the high voltage Alternating Current (AC) phase circuits lose this isolation to the vehicle chassis, one or more diagnostic trouble codes (DTCs) may set.

The vehicle utilizes Passive and Active isolation testing to determine the amount of isolation between the high voltage and the chassis.

Passive isolation testing is performed within the generator control module and tests whenever the high voltage main contactors are closed. Utilizing a high impedance resistor network, passive isolation detection monitors all high voltage components including the hybrid/EV battery pack and isolation loss results in DTCs P1AF0 and/or P1B11. Real-time status of passive isolation detection can be determined by observing the delta between the Drive Motor Control Module Positive Supply Isolation Voltage and Drive Motor Control Module Negative Supply Isolation Voltage scan tool parameters.

Active isolation testing is performed by the hybrid powertrain control module 2 and tests after the high voltage main contactors open. Utilizing a switched resistance, active isolation detection monitors the internal Hybrid/EV battery pack and isolation loss results in DTC P0AA6. Status for the prior active isolation detection event can be determined by observing the hybrid powertrain control module 2 Isolation Test Resistance scan tool parameter. Real-time status observation requires the HPCM2 scan tool control function Hybrid/EV Battery Pack Isolation Test.

Diagnosis for isolation requires testing with high voltage potential. Special insulation testing multimeters such as the EL-50772 utilize their own internal high voltage and must be used to test the isolation capability of high voltage components and circuits. Refer to **Troubleshooting With an Insulation Multimeter**.

Diagnostic Aids

Prior to disabling high voltage:

The Drive Motor Control Module Positive Supply Isolation Voltage and Drive Motor Control Module Negative Supply Isolation Voltage parameters provide a real-time indication of isolation status. The parameters will shift in respect to one another relative to the level of isolation loss. The greater the delta, or difference, between parameters, the less isolation exists between high voltage and the vehicle chassis.

Certain isolation loss concerns may only appear during high moisture environmental conditions. Drive the vehicle thru an underbody spraying-style car wash while monitoring the delta between Positive Supply Isolation Voltage and the Negative Supply Isolation Voltage scan tool parameters.

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After disabling high voltage:

High Voltage cables disconnected at each end from their respective modules must be tested with the insulation meter connected to their shield circuit and not to vehicle chassis.

The **EL-50772** insulation meter , when set to the 500 V scale, indicates 550M Ω when measuring infinite or open circuit conditions. An equivalent meter may display 'infinite' value in a different manner.

Reference Information

Schematic Reference

- **Hybrid/EV Energy Storage Schematics**
- **Hybrid/EV Controls Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Hybrid/EV System High Voltage Isolation Description for:

- Passive Isolation circuit detail
- Active Isolation circuit detail
- Complete High Voltage system schematic

Electrical Information Reference

Troubleshooting With an Insulation Multimeter

Scan Tool Reference

Control Module References

Special Tools

- **EL-48900** HEV Safety Kit
- **EL-50772** Insulation Multimeter

Equivalent regional tools:Refer to:**Special Tools**.

Circuit/System Verification

1. Remove any battery chargers.
2. Ignition ON.
3. Verify that DTC P0AA1, P0AA4, P0AD9, P0ADD, P0AE4, or P1EC0 is not set.
    - **If any DTC is set**

      Refer to:DTC P0AA1, P0AA4, P0AD9, P0ADD, P0AE4, or P1EC0.

    - **If none of the DTCs are set**

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4. Verify that DTC P0AA6, P0AA7, P0AA8, P0AA9, P0AAA, P1E0C, or P1E0D is not set.
    - **If any DTC is set**

      Refer to:**DTC P0AA6**, or **DTC P0AA7-P0AAA, P1E0C, or P1E0D**.

    - **If none of the DTCs are set**
5. Ignition ON and engine running, observe the scan tool Drive Motor Control Module Positive Supply Isolation Voltage and the Drive Motor Control Module Negative Supply Isolation Voltage scan tool parameters.
6. Is the delta, or difference, between the Positive Supply Isolation Voltage and the Negative Supply Isolation Voltage scan tool parameters greater than 3.5 volts?
    - **If the delta is greater than 3.5 volts**

      Refer to Circuit/System Testing.

    - **If the delta is 3.5 volts or less**
7. Turn the ignition OFF, open and close the drivers door and wait two minutes.
8. PRESS and HOLD the brake pedal and activate the HPCM2 scan tool control function Hybrid/EV Battery Pack Isolation Test. The battery pack isolation test will complete in less than a minute. Verify the Isolation Test Resistance parameter when the test is complete is greater than 75K Ω.
    - **If the resistance is 75K Ω or less**

      Refer to:**DTC P0AA6**.

    - **If the resistance is greater than 75K Ω**
9. All OK, review Diagnostic Aids.

Circuit/System Testing

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.

WARNING: This vehicle is equipped with a high voltage battery that is completely isolated from the chassis ground. Never utilize AC powered test

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equipment to probe the high voltage system. Serious injury, death and component damage could occur if the high voltage system is grounded through the electric utility.

Failure to follow the procedure exactly as written may result in serious injury or death.

NOTE: **Wear your High Voltage Insulation gloves until you have determined that a high voltage exposure risk is no longer present.**

1. Disable the high voltage for servicing at the A4 Hybrid/EV Battery Pack. Refer to **High Voltage Disabling**.
2. Disconnect the A4 Hybrid/EV Battery pack high voltage harness connector at the K59 Starter/Generator Control Module if not already disconnected during the High Voltage Disabling procedure.
3. Disconnect the A15 Starter/Generator high voltage harness connector at the K59 Starter/Generator Control Module if not already disconnected during the High Voltage Disabling procedure.
4. Disconnect both HV connectors at the A4 Hybrid/EV Battery Pack if not already disconnected during the High Voltage Disabling procedure.

NOTE: **Only perform the following continuity tests using the EL-50772 Insulation Multimeter or equivalent.**

5. Ensure only the **EL-50772** Insulation Multimeter or equivalent is used with this procedure. Select the Isolation Test setting, then select the 500 V range. Refer to **Troubleshooting With an Insulation Multimeter** for important usage instructions.
6. Test for 550M Ω between the circuit terminals listed below and the cable shield, using the **EL-50772** Insulation Multimeter :
   - A4 Hybrid/EV Battery Pack high voltage harness connector terminal +300 V, X7
   - A4 Hybrid/EV Battery Pack high voltage harness connector terminal -300 V, X8
   - **If less than 550M Ω**

     Replace the 300 V DC cable assembly.

   - **If 550M Ω**
7. Test for 550M Ω between the circuit terminals listed below and the cable shield:
   - A15 Starter/Generator 3 phase harness connector Terminal U, X2
   - A15 Starter/Generator 3 phase harness connector Terminal V, X2
   - A15 Starter/Generator 3 phase harness connector Terminal W, X2
   - **If less than 550M Ω**
   1. Disconnect the high voltage harness at the A15 Starter/Generator. Refer to **Generator Control Module 3-Phase Cable Assembly Replacement** .
   2. Retest for 550M Ω between the harness circuit terminals listed below and the cable shield:
      - A15 Starter/Generator 3 phase harness connector Terminal U, X2
      - A15 Starter/Generator 3 phase harness connector Terminal V, X2
      - A15 Starter/Generator 3 phase harness connector Terminal W, X2
      - If 550M Ω, replace the A15 Starter/Generator.

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- If less than 550M Ω, replace the 300 V 3 phase cable assembly.

- **If 550M Ω**

NOTE: **There may be up to a 5 second delay for proper test results to be displayed, always Press and Hold the EL-50772 test button until maximum measurement values are observed.**

8. Test for 1.1M Ω or greater between each K59 Starter/Generator Control Module high voltage circuit terminal and the chassis of the control module.
   - **If less than 1.1M Ω**

     Replace the K59 Starter/Generator Control Module.

   - **If 1.1M Ω or greater**
9. All OK, review Diagnostic Aids.

Component Testing

1. Perform component testing only after high voltage is disabled.
2. Test with the **EL-50772** insulation multimeter or equivalent, set only at 500 V.

HV Component	Component Setup	Insulation Multimeter Test Point	EL-50772 Expected Results
K59 Starter/Generator Control Module	None	1. Each HV terminal, both AC and DC, to module housing. 2. Test continuously for several seconds until maximum measurement is obtained.	1.1 to 1.2M Ω
A15 Starter/Generator	Disconnect cable from K59 Starter/Generator Control Module	1. Any HV 3 phase terminal to stator ground. 2. Test continuously for several seconds until maximum measurement is obtained.	550M Ω
300-V Battery Positive and Negative Cables	Disconnect cables at both ends	HV Pos+ terminal to cable shield/HV Neg- terminal to cable shield	550M Ω
300-V 3 Phase Cables	Disconnect cables at both ends	HV phase terminal to cable shield	550M Ω

Repair Instructions

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

- **300-Volt Battery Positive and Negative Cable Replacement**
- **Starter Generator Replacement**
- **Generator Control Module 3-Phase Cable Assembly Replacement**
- **Control Module References** for the K59 Starter/Generator Control Module replacement, programming and setup.

HYBRID/EV BATTERY VOLTAGE PRESENT

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**

Circuit/System Description

The hybrid/EV battery contains 3 high voltage contactors. The high voltage contactors allow the high voltage DC batteries to be connected to the vehicle or contain the high voltage DC within the hybrid/EV battery assembly. The high voltage contactors consist of a main positive high voltage contactor, main negative high voltage contactor, and precharge positive high voltage contactor. The contactors close and open in a specific sequence controlled by the hybrid/EV powertrain control module 2. The hybrid/EV powertrain control module 2 supplies 12 V to the control circuit for each high voltage contactor.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **Testing for Intermittent Conditions and Poor Connections**

Description and Operation

Drive Motor Battery System Description

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

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Scan Tool Reference

Control Module References

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools: Refer to:**Special Tools**.

Circuit/System Testing

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.

WARNING: **This vehicle is equipped with a high voltage battery that is completely isolated from the chassis ground. Never utilize AC powered test equipment to probe the high voltage system. Serious injury, death and component damage could occur if the high voltage system is grounded through the electric utility.**

Failure to follow the procedure exactly as written may result in serious injury or death.

1. Review the high voltage safety information prior to performing the High Voltage Disabling procedure. Refer to **High Voltage Safety**
2. Verify the High Voltage Disabling procedure has been performed.
   - **The procedure has not been performed**

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Refer to:**High Voltage Disabling** before continuing to the next step.

- **The procedure has been performed**

NOTE: **You will have to remove the A4 Hybrid/EV Battery Pack cover with the battery pack in-vehicle to gain access to the A28 Hybrid/EV Battery Contactor Assembly connector.**

3. Ignition OFF. Disconnect the low voltage harness connector X4 at the A28 Hybrid/EV Battery Contactor Assembly.

NOTE: **Ensure the K114B Hybrid Powertrain Control Module 2 connectors to the vehicle harness are all connected.**

4. Vehicle in Service Mode.
5. Ignition ON. Test for less than 9.5 V at the following points and ground:
   - X4, Terminal 1
   - X4, Terminal 3
   - X4, Terminal 4
   - **If 9.5 V or greater**
   1. Ignition OFF, disconnect the X4 harness connector at the K114B Hybrid Powertrain Control Module 2. Ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K114B Hybrid Powertrain Control Module 2.
   - **If less than 9.5 V**
6. Replace the A28 Hybrid/EV Battery Contactor Assembly.

Repair Instructions

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

- **Generator Battery Disconnector Relay Replacement** for A28 Hybrid/EV Battery Contactor Assembly replacement.
- **Control Module References** for K114B hybrid powertrain control module 2 replacement, programming and setup.

TROUBLESHOOTING WITH AN INSULATION MULTIMETER

Special Tools

EL-50772 Insulation Multimeter

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

Diagnosis for isolation loss requires insulation testing with high voltage potential. Special multimeters that utilize their own built-in high voltage, such as the **EL-50772** Insulation Multimeter , test the isolation capability of high voltage components and circuits. Understanding an insulation multimeter and how it functions is necessary to obtain proper test results.

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How to Use the Insulation Multimeter

1. Read all instructions and warnings that came with your insulation multimeter.

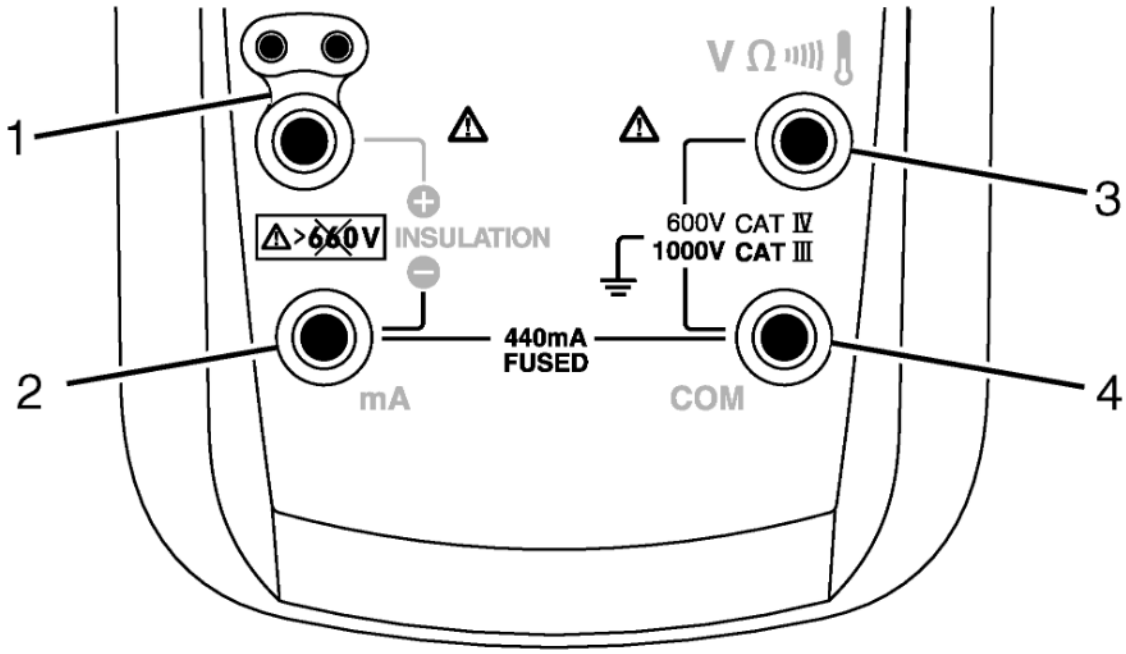


Fig. 30: Ports
Courtesy of GENERAL MOTORS COMPANY

2. Plug into the correct ports (1, 2) for insulation testing. This is easy to get wrong especially if you use the **EL-50772** for standard DMM testing too. Do NOT use ports (3, 4) for insulation testing.
3. Always test at the 500V range.

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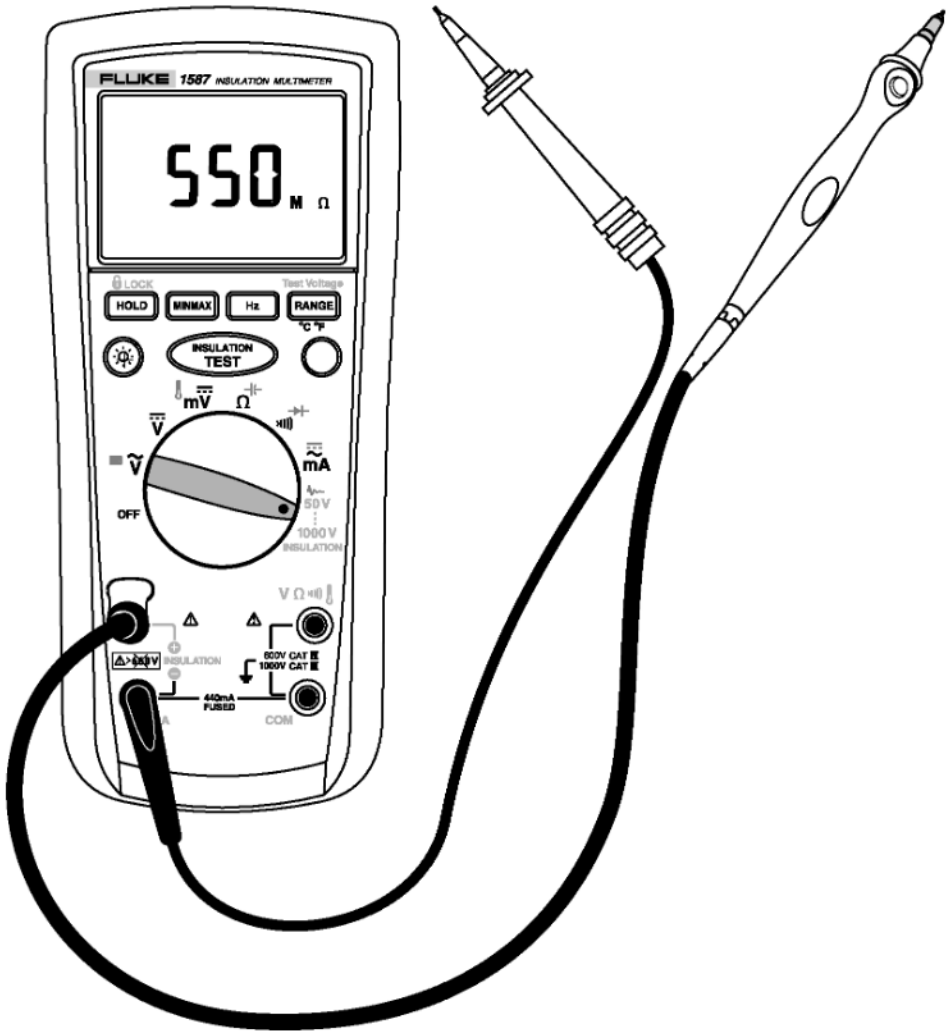


Fig. 31: Insulation Multimeter (550)
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4. With the test leads not connected to anything, press and hold test button to know how your meter displays an infinite measurement. The **EL-50772** will display 550M Ω when measuring an open circuit while set to the 500V range.

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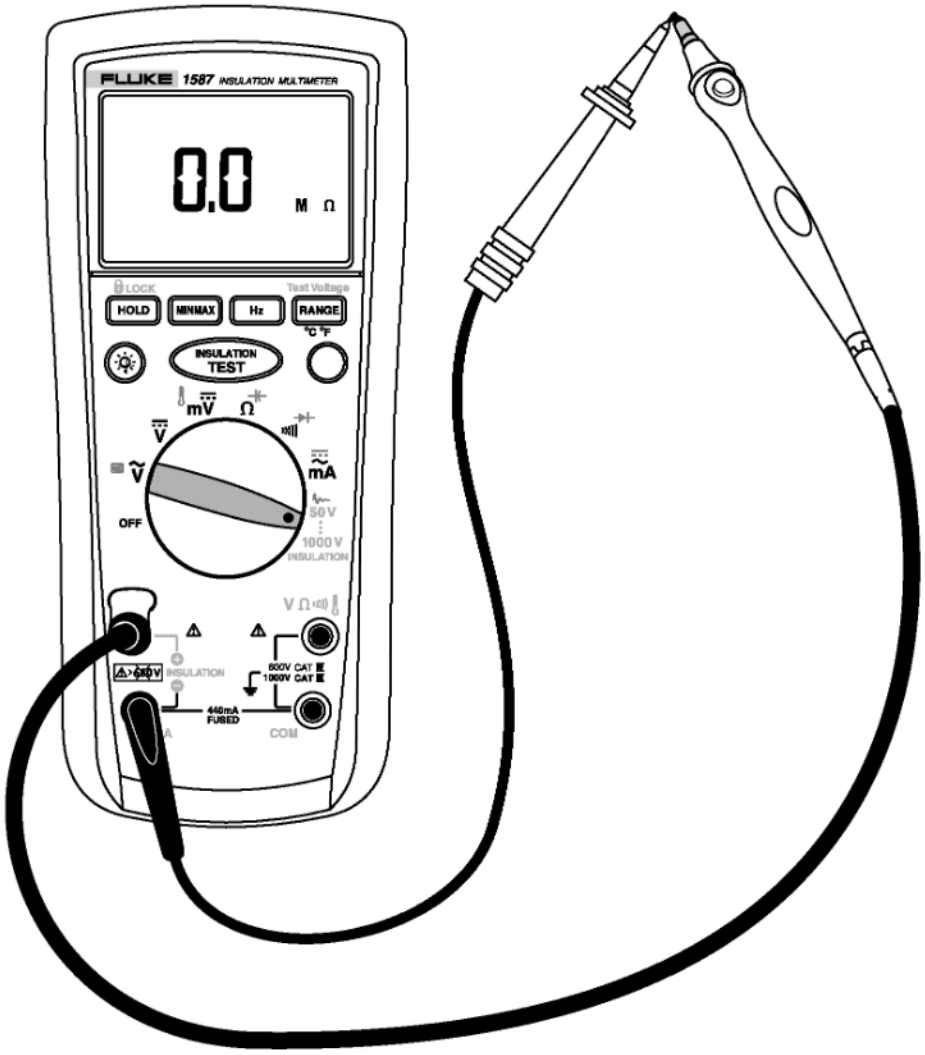


Fig. 32: Insulation Multimeter (0.0)
Courtesy of GENERAL MOTORS COMPANY

5. With the test leads connected together, press and hold test button to know how your meter displays continuity. The **EL-50772** will display 0.0 Ω.

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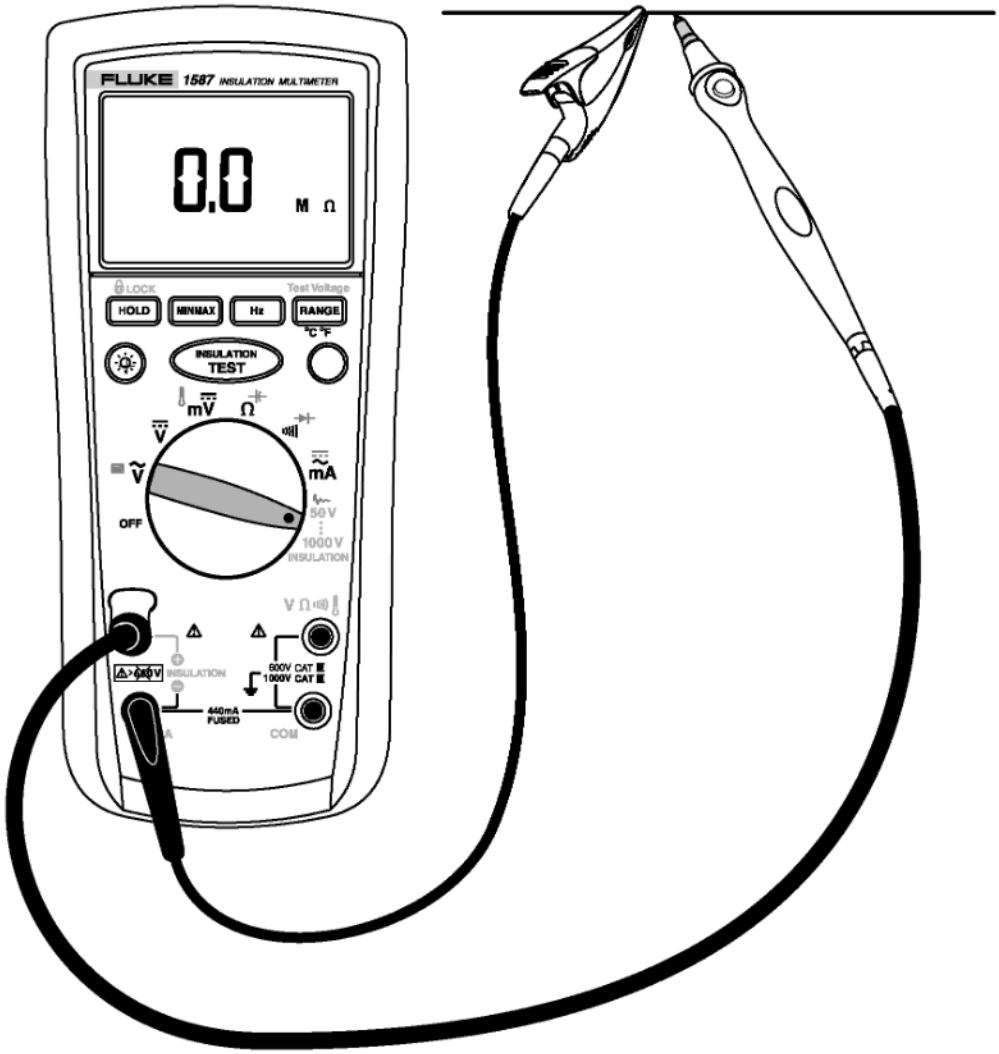


Fig. 33: View Of Insulation Multimeter (0.0)
Courtesy of GENERAL MOTORS COMPANY

6. When performing insulation testing you need a good ground reference. When possible use an alligator clamp to attach the ground lead. Typically, the reference point will be to vehicle chassis except cable testing which requires connection to the cable shield termination at the connector and not to the chassis.
7. Verify your ground connection prior to every test measurement at a suitable ground location near your test point. The **EL-50772** should display 0.0 Ω, indicating continuity.
8. When testing components with large capacitance or inductance, such as certain modules and larger motor stators, it may be necessary to hold the test for a few seconds until the maximum resistance value is displayed.

REPAIR INSTRUCTIONS

HIGH VOLTAGE SYSTEM INSPECTION

Circuit/System Description

WARNING: Damage to a Lithium Ion hybrid/EV battery pack could result in fire, loss of electrical isolation or exposure to high voltage. Until the high voltage system inspection has been completed, store the vehicle with hybrid/EV battery pack

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installed outside in a secure area away from buildings and other vehicles and protected from rain, snow and other moisture. Remove the hybrid/EV battery pack high voltage manual disconnect lever and store it in a secure place outside the vehicle. Cover the exposed high voltage opening with ULÂ® listed, or equivalent, insulation tape rated at a minimum of 600 V.

Failure to follow these precautions could result in personal injury, death and property damage.

The Inspection Process

The high voltage system and Hybrid/EV battery pack inspection process consists of two levels of inspection:

1. Component Initial Inspection
2. High Voltage Operation Inspection

Results of the inspection processes may result in:

- Repair, or replacement and recycling of the Hybrid/EV Battery
- Replacement of high voltage components

Vehicle Collision Detection/High Voltage Lockout

The supplemental inflatable restraint system supplements the protection offered by the seat belts. The supplemental inflatable restraint sensing and diagnostic module determines the severity of a collision with the assistance of impact sensors located at strategic points on the vehicle. The hybrid powertrain control module 2 will open the high voltage contactor relays, placing the vehicle in a high voltage lockout state and disabling the vehicle whenever a crash event of sufficient intensity has been detected.

The supplemental inflatable restraint module transmits through serial data to the hybrid powertrain control module 2 both the crash event status and whenever a sensor fault is detected.

NOTE: **The Crash Event Detected/Air Bag Deployed high voltage lockout state will remain active until cleared by the Clear Secured High Voltage DTCs procedure.**

A complete inspection of the high voltage system must be performed if the vehicle has been involved in a collision.

High Voltage Battery Moisture Exposure

The Lithium Ion hybrid/EV battery pack should be replaced and recycled as applicable whenever internal components have been exposed to moisture.

Reference Information

Schematic Reference

- **Hybrid/EV Energy Storage Schematics**
- **Hybrid/EV Controls Schematics**

Description and Operation

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Drive Motor Battery System Description

Scan Tool Reference

Control Module References

Special Tools

EL-48900 HEV Safety Kit

Equivalent regional tools: **Special Tools**.

Component Initial Inspection

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.

WARNING: **High voltage circuits should only be tested using a digital multimeter (DMM) and test leads with at least a CAT III rating, such as the J 39200-A Digital Multimeter. Failure to follow the procedures may result in serious injury or death.**

WARNING: **This vehicle is equipped with a high voltage battery that is completely isolated from the chassis ground. Never utilize AC powered test equipment to probe the high voltage system. Serious injury, death and component damage could occur if the high voltage system is grounded through the electric utility.**

Failure to follow the procedure exactly as written may result in serious injury or

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death.

1. Disconnect the 12 V battery.
2. Remove the S15 Manual Service Disconnect. If vehicle damage does not allow for access to the S15 Manual Service Disconnect, remove the damaged portion of the vehicle until such time as the S15 Manual Service Disconnect can be removed. Refer to:**Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)**.
3. Inspect the Hybrid/EV battery pack for evidence of exposure to fire, either directly or in close proximity.
   - **If exposure to fire is evident**

     NOTE: **Never return a damaged battery pack or section to the Warranty Parts Center (WPC), Electronic Service Center (ESC) or Battery Service Center (BSC).**

     Replacement and recycle of the Hybrid/EV battery pack is required. Vehicle dismantlers should refer to www.recyclemybattery.com.

   - **If not exposed to fire**
4. Inspect the Hybrid/EV battery pack enclosure for damage including foreign object intrusion.
   - **If damage is evident**

     NOTE: **Never return a damaged battery pack or section to the Warranty Parts Center (WPC), Electronic Service Center (ESC) or Battery Service Center (BSC).**

     Replacement and recycle of the Hybrid/EV battery pack is required. Vehicle dismantlers should refer to www.recyclemybattery.com.

   - **If not damaged**
5. Inspect the vehicle for exposure to water at a level higher than the Hybrid/EV Battery Pack mounting surface.
   - **If the vehicle was exposed to high flood**

     NOTE: **Never return a damaged battery pack or section to the Warranty Parts Center (WPC), Electronic Service Center (ESC) or Battery Service Center (BSC).**

     Replacement and recycle of the Hybrid/EV battery pack is required. Vehicle dismantlers should refer to www.recyclemybattery.com.

   - **If the vehicle was not flooded**
6. Inspect the Hybrid/EV Battery Pack for evidence of direct exposure to moisture.
   - **If the Hybrid/EV Battery Pack was exposed to moisture**

     NOTE: **Never return a damaged battery pack or section to the Warranty Parts Center (WPC), Electronic Service Center (ESC) or Battery Service Center (BSC).**

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Replacement and recycle of the Hybrid/EV battery pack is required. Vehicle dismantlers should refer to www.recyclemybattery.com.

- **If the Hybrid/EV Battery Pack was not exposed to moisture**

7. Inspect each high voltage component listed below for visible damage. Record the results on the High Voltage Component Inspection Table below.
   - K59 Starter/Generator Control Module
   - A15 Starter/Generator
   - All High voltage orange cables
   - **If any high voltage component inspection failed**
   1. Perform the **High Voltage Disabling** procedure and replace the damaged components before attempting to operate the vehicle
   2. Once you have confirmed or repaired all high voltage component visual integrity, perform High Voltage Operation Inspection below.
   - **If all high voltage component inspection passed**

     Perform High Voltage Operation Inspection below.

High Voltage Component Inspection Table

High Voltage Component	Inspection (passed/failed)
K59 Starter/Generator Control Module	Â
A15 Starter/Generator	Â
All High voltage orange cables	Â

High Voltage Operation Inspection

NOTE: **The vehicle must have a functioning 12 V system and serial data communications to continue.**

NOTE: **You will have to turn the ignition switch to the Crank position. Ensure the vehicle is capable of engine operation to continue.**

1. Verify you have successfully passed the Component Initial Inspection.
   - **If the Component Initial Inspection has failed or not been performed**

     DO NOT CONTINUE. Restart the Inspection procedure.

   - **If the Component Initial Inspection has passed**
2. Install the S15 Manual Service Disconnect. Refer to:**Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Center Console)Drive Motor Battery High Voltage Manual Disconnect Lever Replacement (with Front Center Seat)**.
3. Connect the 12 V battery.
4. Ignition ON. With a scan tool select the Hybrid/EV powertrain Control Module 2, Hybrid Battery Pack Contactor Open Reasons data list. Verify if either the Crash Event Detected or Air Bag Deployed parameters indicate YES.
   - **If either parameter displays YES**

     The high voltage contactors may be prevented from closing. The vehicle may not start. Perform the

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Clear Secured High Voltage DTCs procedure and proceed to the next step.

- **If BOTH parameters indicate NO**

NOTE: **The engine must start to enable high voltage.**

5. Engine Running.
6. With a scan tool check for the following HV system DTCs: Contactor DTCs P0AA1, P0AA4, P0AD9, P0ADD, P0AE4, P1EC0, Isolation DTCs P0AA6, P1AF0, or P1B11, Precharge DTCs P0C76, P0C78 or P3061.
   - **If any DTCs are set**

     Perform the applicable DTC diagnosis/repair. Refer to:Diagnostic Trouble Code (DTC) List - Vehicle .

   - **If any of the listed DTCs have not run**

     Review the applicable Conditions for Running the DTC.

   - **If all the specified DTCs have ran and passed**

     High Voltage System Inspection passed.

DRIVE MOTOR BATTERY HIGH VOLTAGE MANUAL DISCONNECT LEVER REPLACEMENT (WITH CENTER CONSOLE)

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.

Removal Procedure

1. Disconnect the battery negative cable. Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)
2. Front Floor Console Grille - Remove - Front Floor Console Grille Replacement

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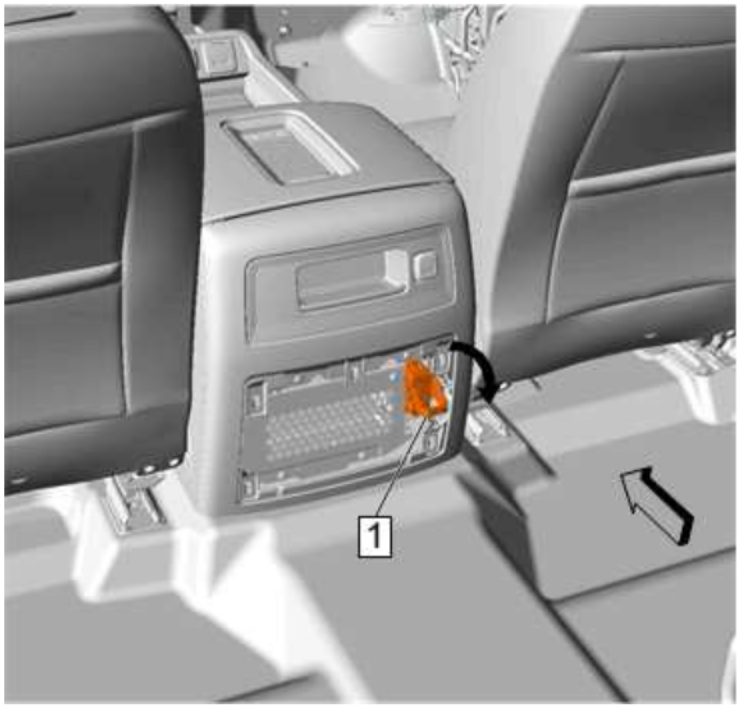


Fig. 34: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the drive motor battery high voltage manual disconnect lever handle downwards. 1

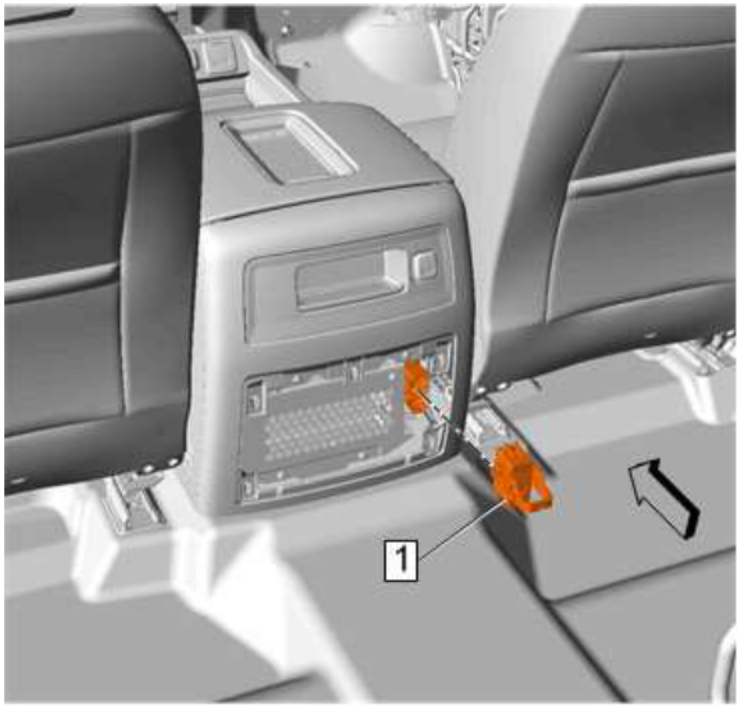


Fig. 35: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

4. Drive Motor Battery High Voltage Manual Disconnect Lever 1 - Disconnect

Installation Procedure

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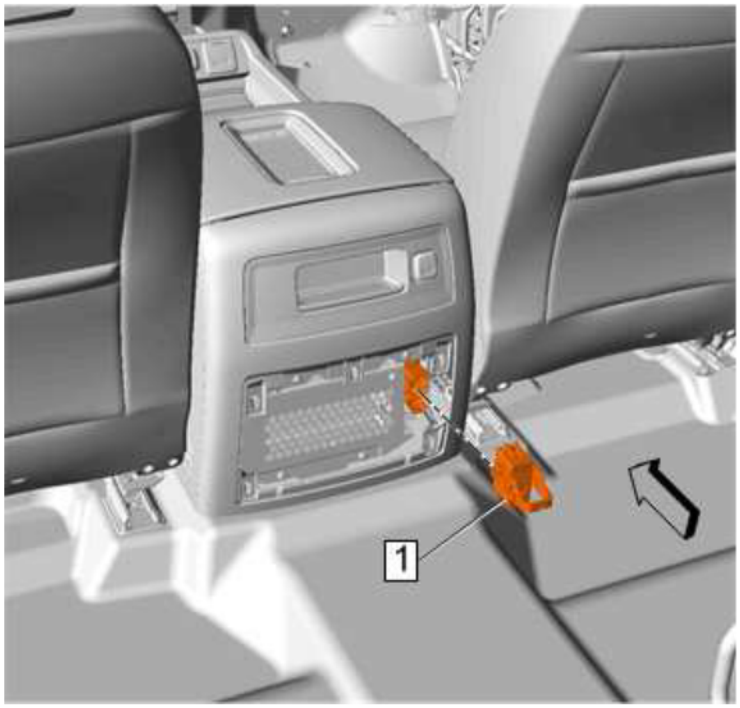


Fig. 36: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is imperative that the MSD is fully inserted in the base and locking pins are engaged before rotating cam lever upwards. When properly installed the MSD should be flush with the base.**

1. Drive Motor Battery High Voltage Manual Disconnect Lever 1 - Connect

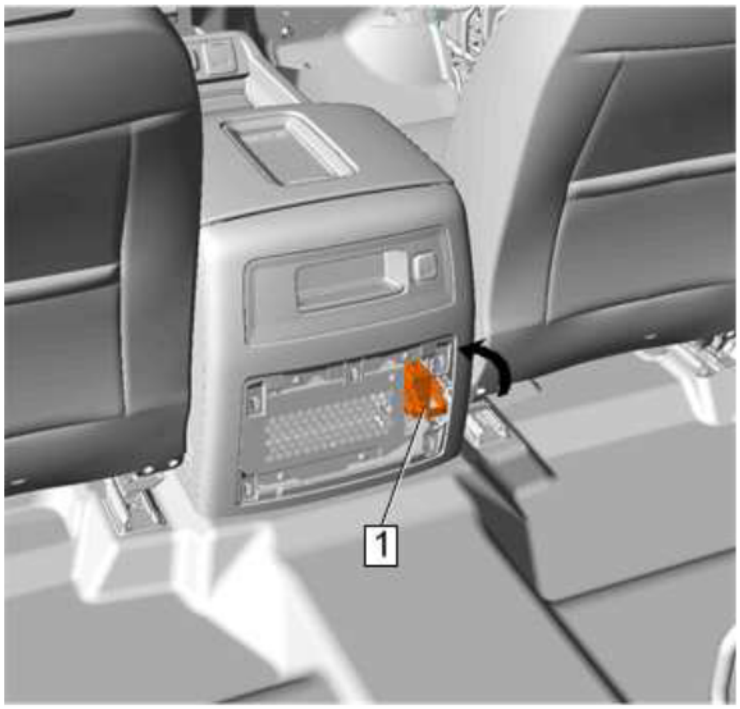


Fig. 37: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

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2. Rotate the drive motor battery high voltage manual disconnect lever handle upwards until the handle locks into the closed position. 1

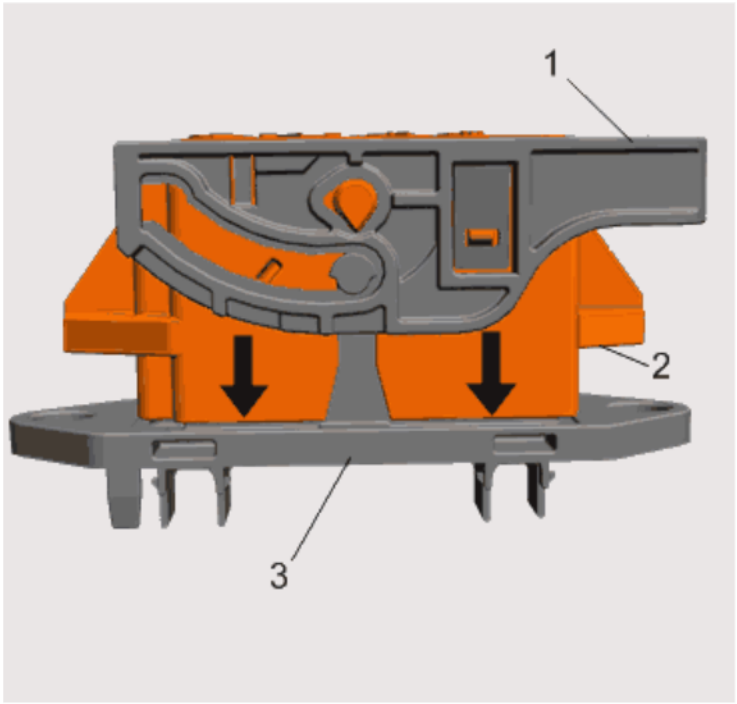


Fig. 38: Drive Motor Battery High Voltage Manual Disconnect Handle, Lever And Base
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Ensure that the drive motor battery high voltage manual disconnect lever (MSD) is fully inserted in the base and locking pins are engaged before rotating the cam lever down. When properly installed, the MSD will be flush with its mating surface. Failure to properly insert and lock the MSD may cause the MSD to disconnect, resulting in loss of 12V battery charging.

3. When rotating the drive motor battery high voltage manual disconnect handle (1) into the locked position, make sure the drive motor battery high voltage manual disconnect lever (2) is flush with the connector base (3).
4. Front Floor Console Grille - Install - **Front Floor Console Grille Replacement**
5. Connect the battery negative cable. **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**

DRIVE MOTOR BATTERY HIGH VOLTAGE MANUAL DISCONNECT LEVER REPLACEMENT (WITH FRONT CENTER SEAT)

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**

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- **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.

Removal Procedure

1. Disconnect the battery negative cable. **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**

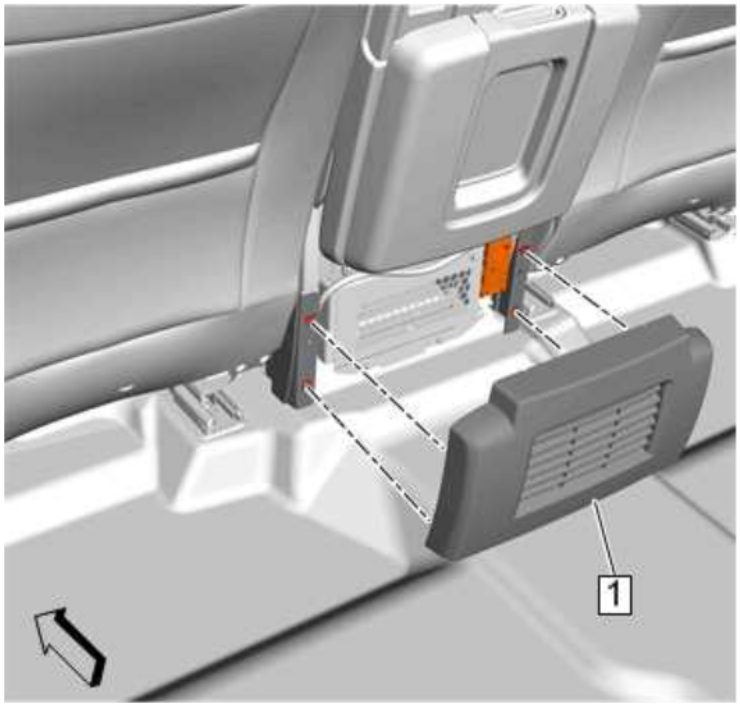


Fig. 39: Front Seat Center Armrest Hinge Cover
Courtesy of GENERAL MOTORS COMPANY

2. Front Seat Center Armrest Hinge Cover 1 - Remove

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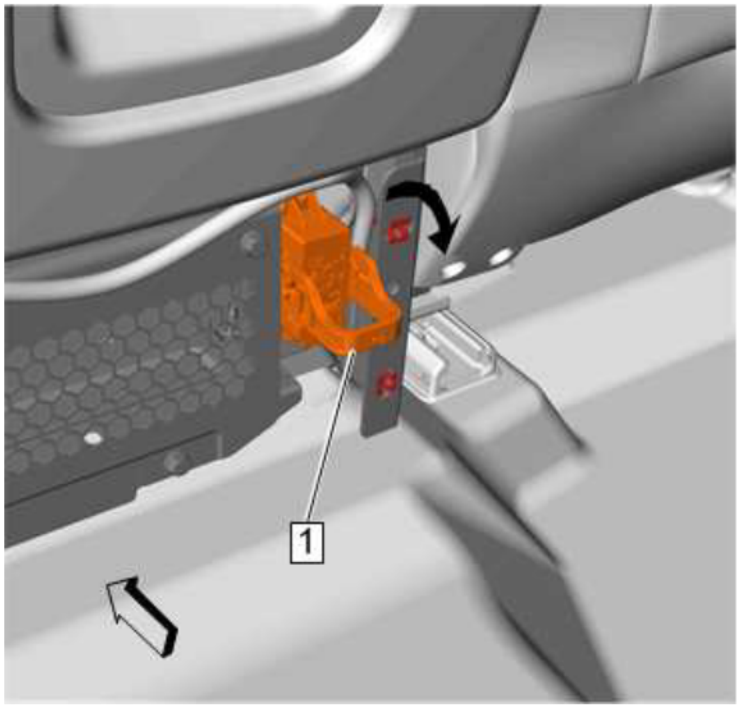


Fig. 40: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the drive motor battery high voltage manual disconnect lever handle downwards. 1

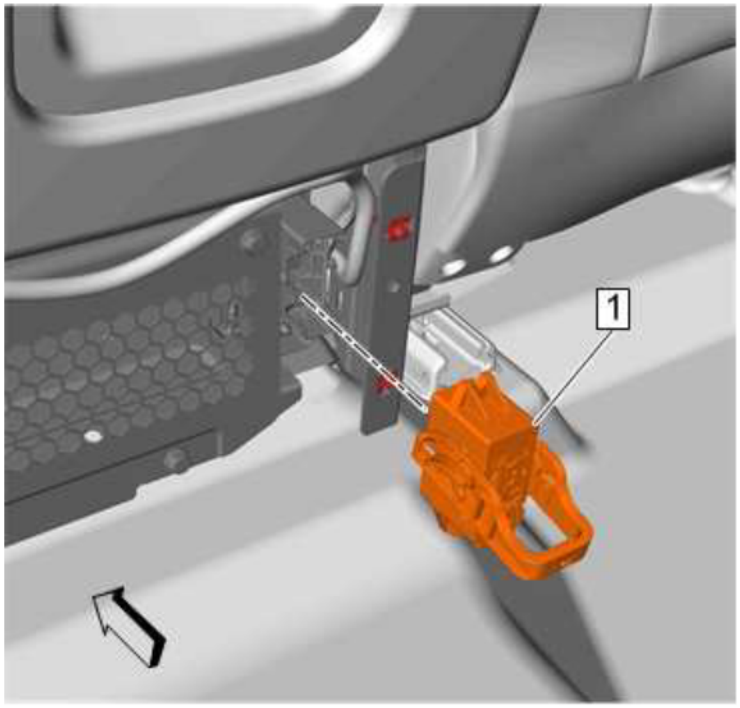


Fig. 41: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

4. Drive Motor Battery High Voltage Manual Disconnect Lever 1 - Disconnect

Installation Procedure

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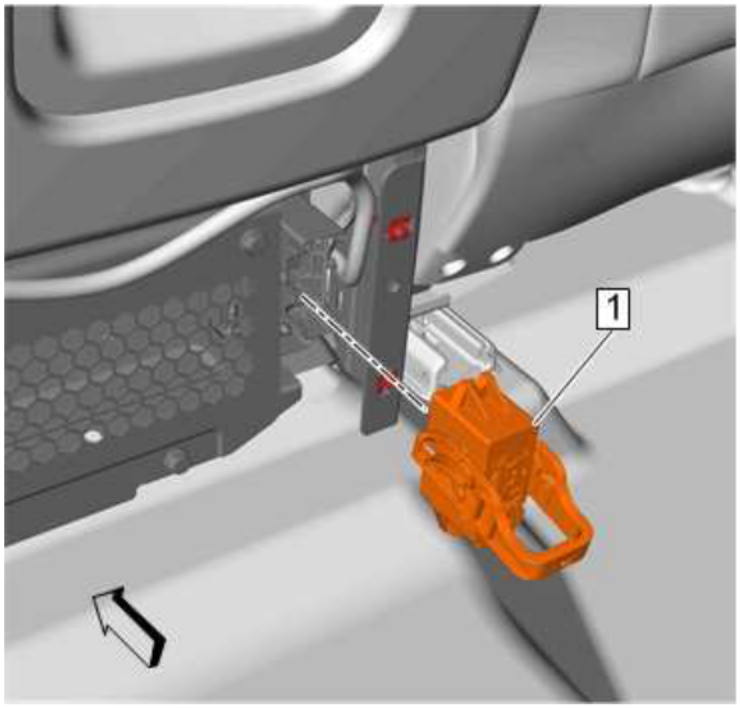


Fig. 42: Drive Motor Battery High Voltage Manual Disconnect Lever Handle
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is imperative that the MSD is fully inserted in the base and locking pins are engaged before rotating cam lever upwards. When properly installed the MSD should be flush with the base.**

1. Drive Motor Battery High Voltage Manual Disconnect Lever 1 - Connect

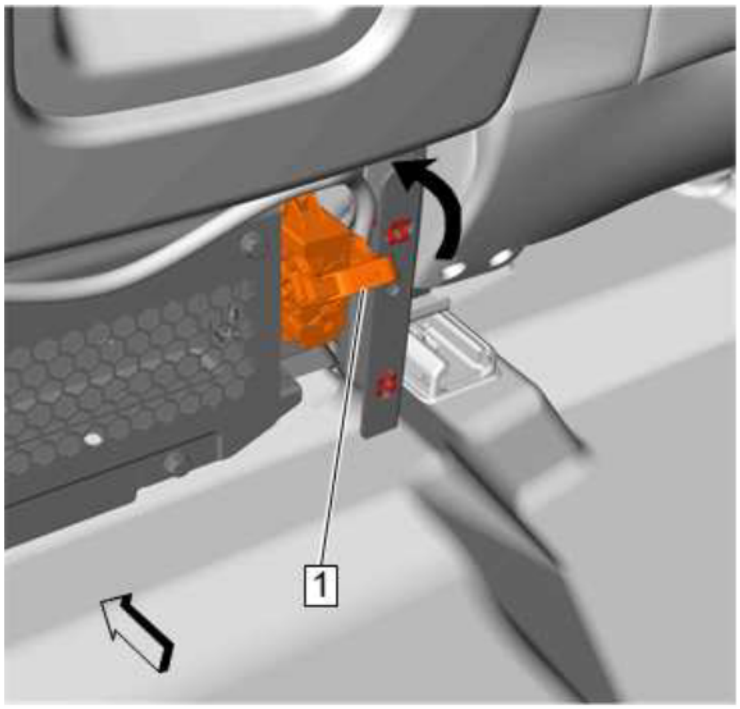


Fig. 43: Drive Motor Battery High Voltage Manual Disconnect Lever Closed Position
Courtesy of GENERAL MOTORS COMPANY

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2. Rotate the drive motor battery high voltage manual disconnect lever handle upwards until the handle locks into the closed position. 1

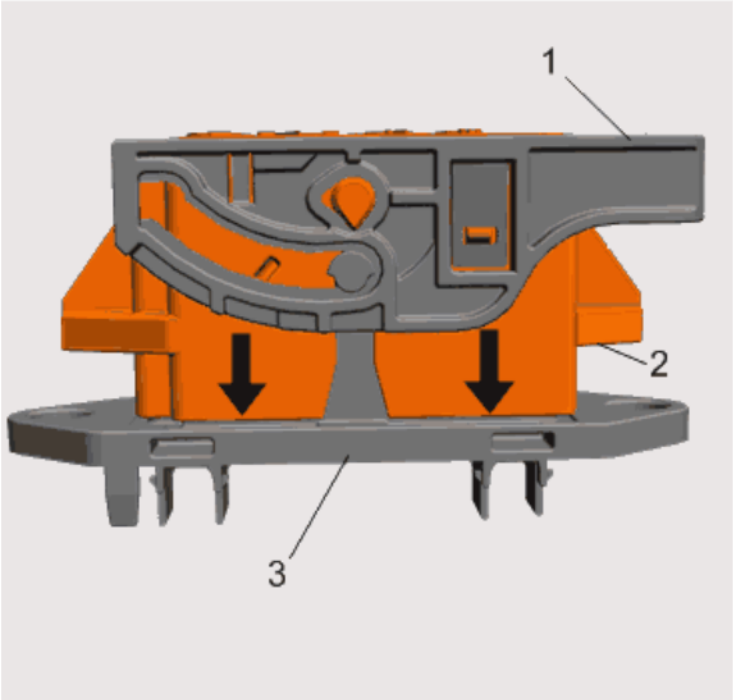


Fig. 44: Drive Motor Battery High Voltage Manual Disconnect Handle, Lever And Base
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Ensure that the drive motor battery high voltage manual disconnect lever (MSD) is fully inserted in the base and locking pins are engaged before rotating the cam lever down. When properly installed, the MSD will be flush with its mating surface. Failure to properly insert and lock the MSD may cause the MSD to disconnect, resulting in loss of 12V battery charging.

3. When rotating the drive motor battery high voltage manual disconnect handle (1) into the locked position, make sure the drive motor battery high voltage manual disconnect lever (2) is flush with the connector base (3).

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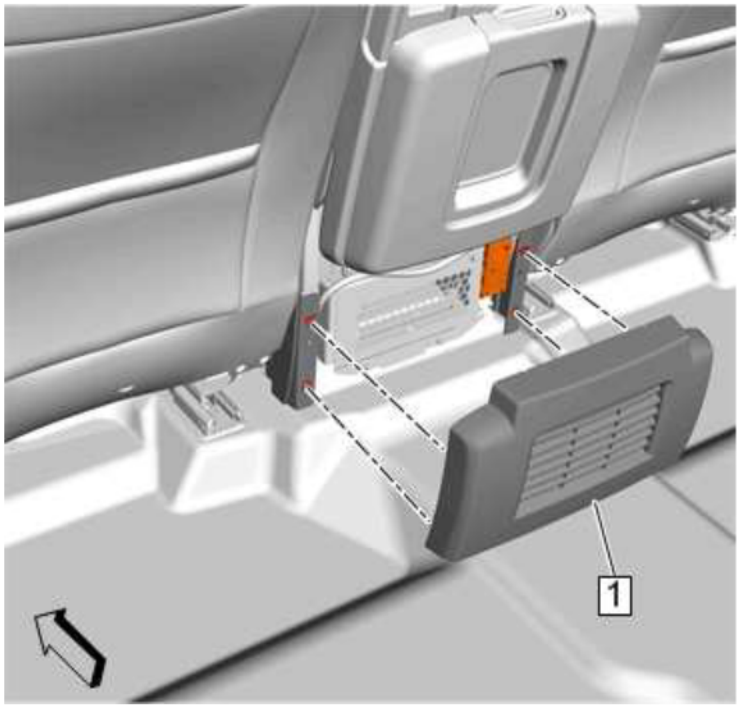


Fig. 45: Front Seat Center Armrest Hinge Cover
Courtesy of GENERAL MOTORS COMPANY

4. Front Seat Center Armrest Hinge Cover 1 - Install
5. Connect the battery negative cable. **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)**

HIGH VOLTAGE BATTERY COVER REPLACEMENT (BATTERY POSITIVE AND NEGATIVE CABLE)

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.

Removal Procedure

1. Disable the high voltage system. **High Voltage Disabling**
2. Front Floor Console Assembly - Remove - **Front Floor Console Assembly Replacement (without**

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HP5) Front Floor Console Assembly Replacement (with HP5)

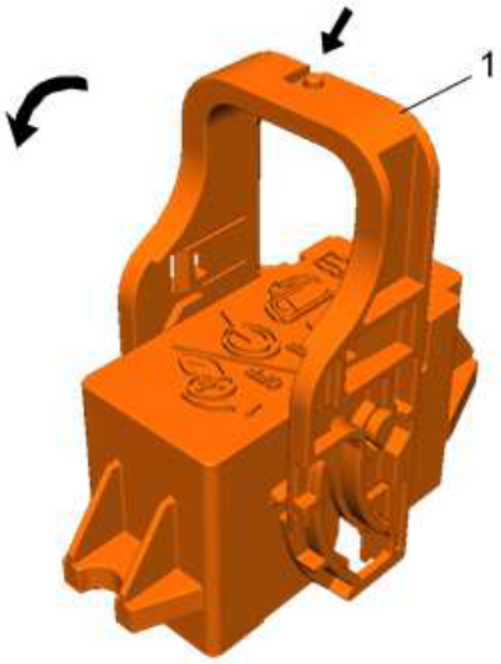


Fig. 46: Drive Motor Battery High Voltage Manual Disconnect Lever
Courtesy of GENERAL MOTORS COMPANY

3. Locate the high voltage locking safety push-pin unlocking tool at the end of the drive motor battery high voltage manual disconnect lever (1).

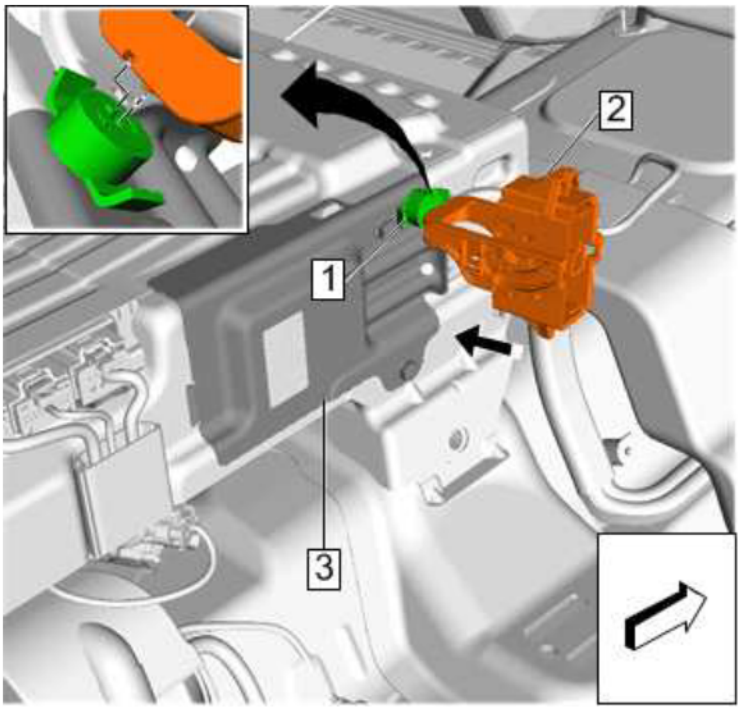


Fig. 47: High Voltage Locking Safety Push-Pin
Courtesy of GENERAL MOTORS COMPANY

4. Engage the post and slot of the drive motor battery high voltage manual disconnect lever (2), to the high

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voltage locking safety push-pin (1), which is attached to high voltage battery positive and negative cable cover (3).

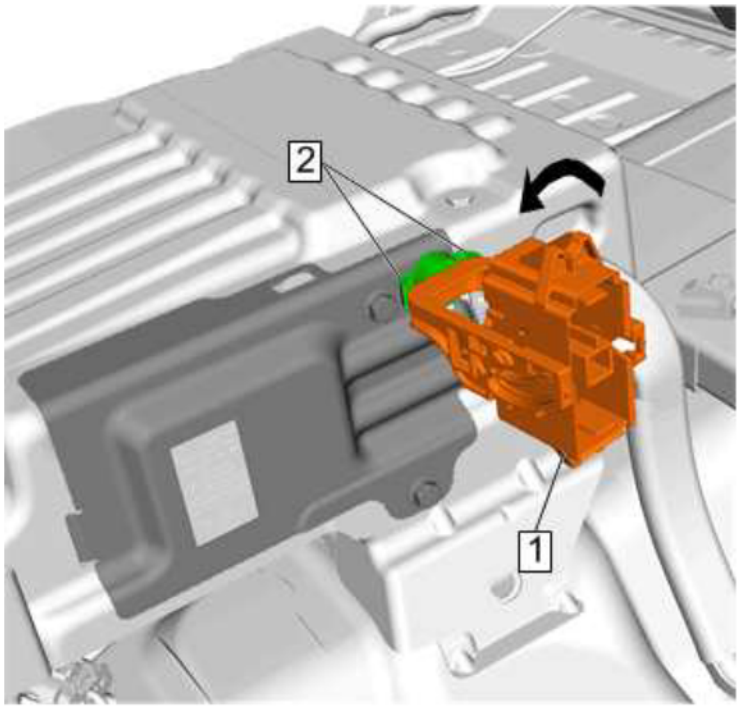


Fig. 48: High Voltage Locking Safety Push-Pin Tabs
Courtesy of GENERAL MOTORS COMPANY

5. While holding the high voltage locking safety push-pin tabs (2), rotate the drive motor battery high voltage manual disconnect lever (1) counter-clockwise until the center of the push-pin pops outwards.

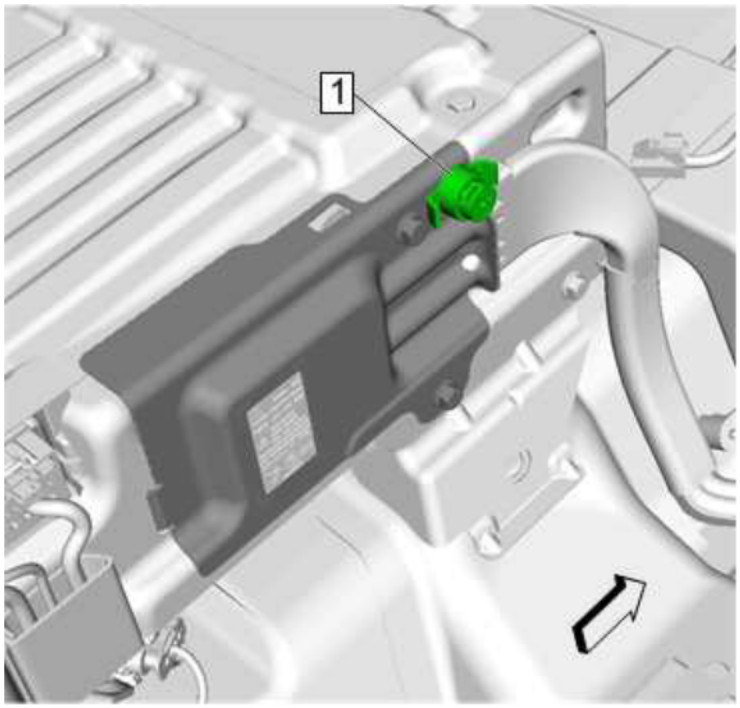


Fig. 49: High Voltage Locking Safety Push-Pin
Courtesy of GENERAL MOTORS COMPANY

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6. Remove the high voltage locking safety push-pin. 1

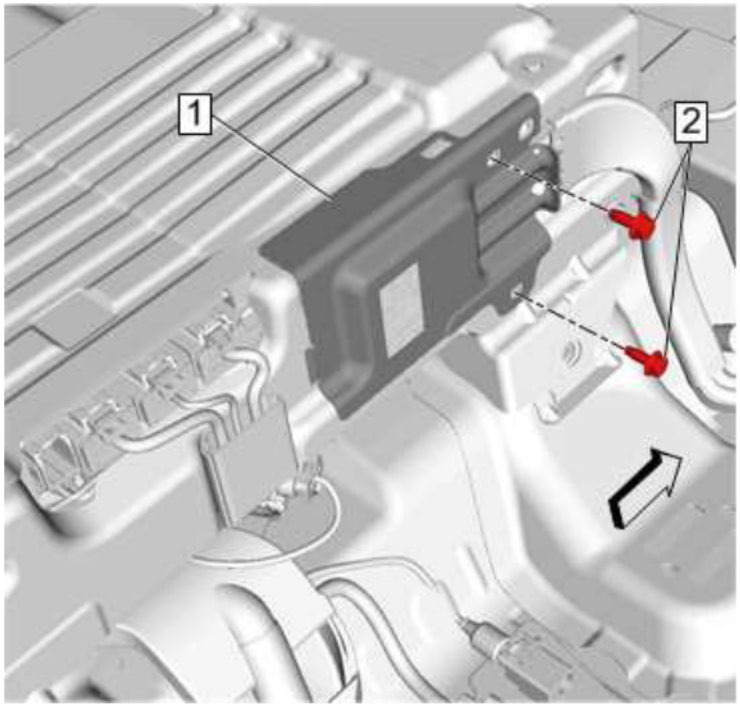


Fig. 50: High Voltage Cover
Courtesy of GENERAL MOTORS COMPANY

7. High Voltage Cover Bolt 2 - Remove
8. High Voltage Cover 1 - Remove

Installation Procedure

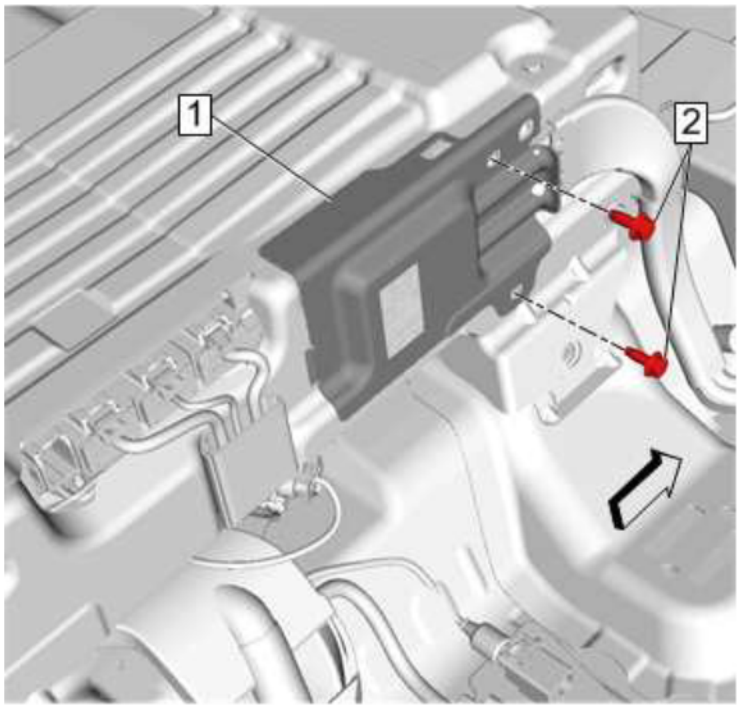


Fig. 51: High Voltage Cover
Courtesy of GENERAL MOTORS COMPANY

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1. High Voltage Cover 1 - Install

CAUTION: **Refer to Fastener Caution .**

2. High Voltage Cover Bolt 2 - Install and tighten 9 N.m (80 lb in)

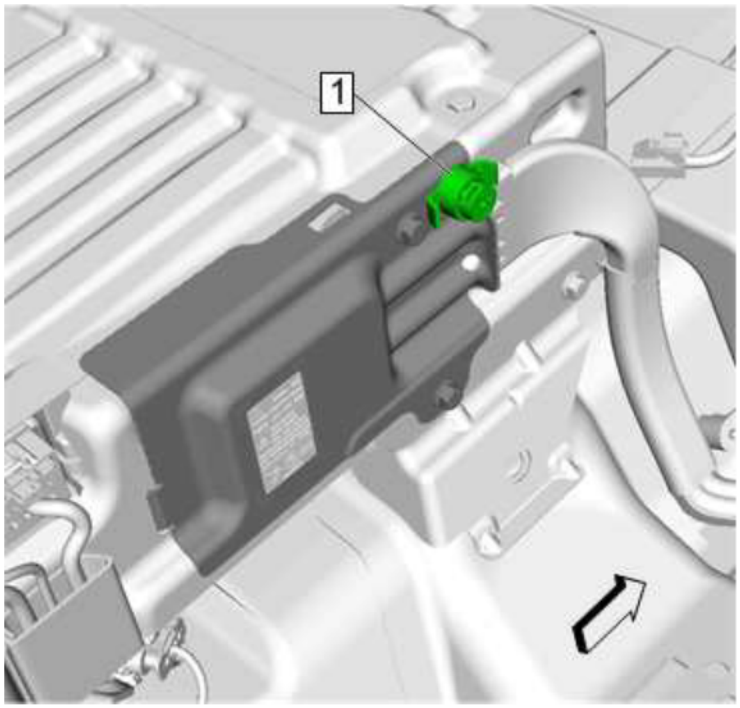


Fig. 52: High Voltage Locking Safety Push-Pin
Courtesy of GENERAL MOTORS COMPANY

3. Install the high voltage locking safety push-pin (1) and depress the center of the push-pin until it locks into place.
4. Enable the high voltage system. **High Voltage Enabling**
5. Front Floor Console Assembly - Install - **Front Floor Console Assembly Replacement (without HP5)** **Front Floor Console Assembly Replacement (with HP5)**

HIGH VOLTAGE BATTERY COVER REPLACEMENT

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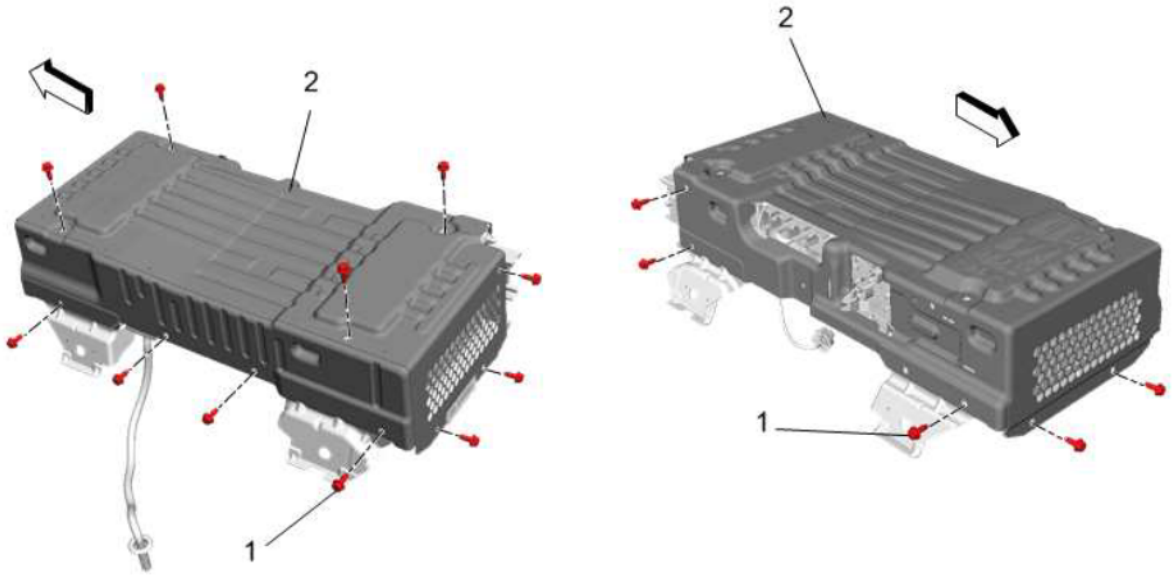


Fig. 53: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the high voltage battery from the vehicle. **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**	
1	**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**

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Callout	Component Name
	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. High Voltage Battery Cover Bolt CAUTION: Refer to Fastener

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Callout	Component Name
	Caution **Tighten** 9 N.m (80 lb in)
2	High Voltage Battery Cover

HYBRID POWERTRAIN CONTROL MODULE 2 REPLACEMENT

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.

Removal Procedure

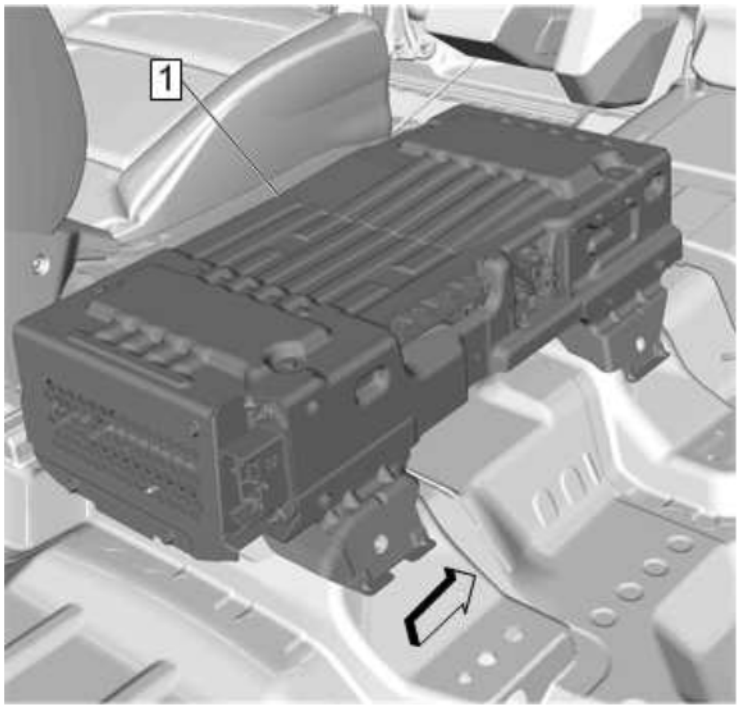


Fig. 54: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

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1. High Voltage Battery 1 - Remove - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

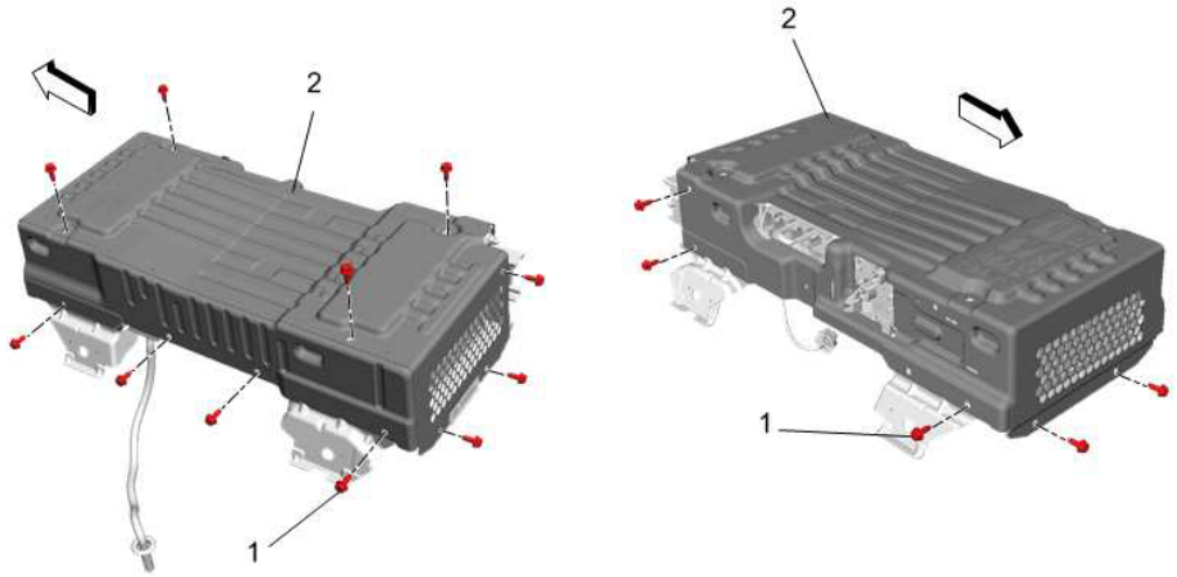


Fig. 55: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

2. High Voltage Battery Cover 2 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

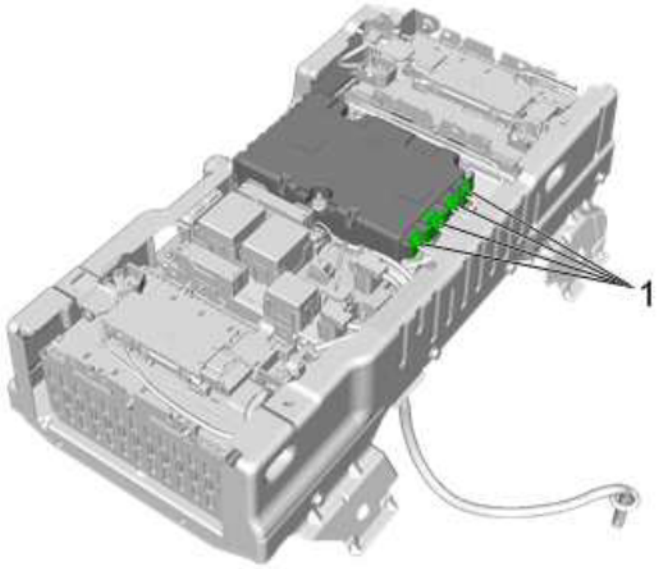


Fig. 56: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Electrical Connector 1 - Disconnect

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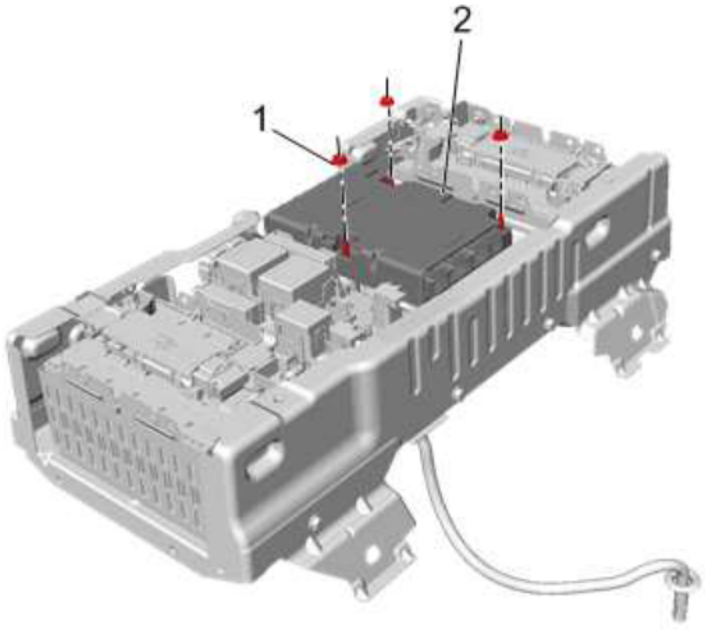


Fig. 57: Hybrid Powertrain Control Module 2
Courtesy of GENERAL MOTORS COMPANY

4. Hybrid Powertrain Control Module 2 Mounting Nut 1 - Remove
5. Hybrid Powertrain Control Module 2 (2) - Remove

Installation Procedure

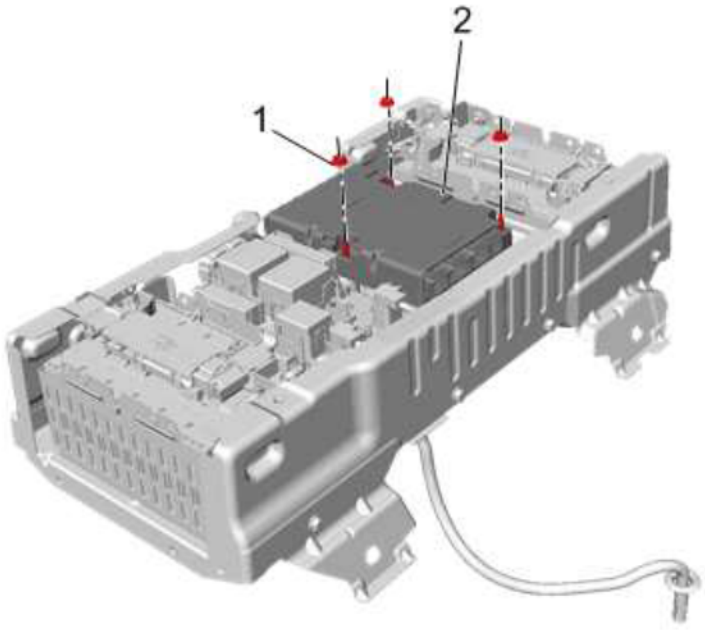


Fig. 58: Hybrid Powertrain Control Module 2
Courtesy of GENERAL MOTORS COMPANY

1. Hybrid Powertrain Control Module 2 - Install

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CAUTION: **Refer to Fastener Caution**

2. Hybrid Powertrain Control Module 2 Mounting Nut 1 - Install and tighten 9 N.m (80 lb in)

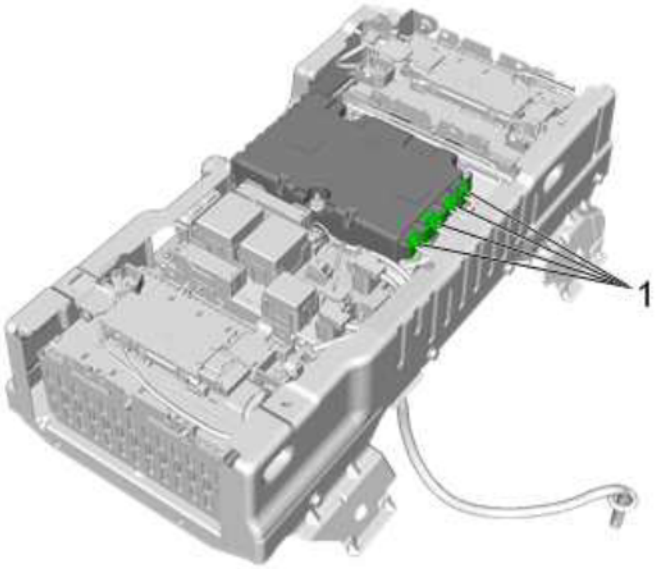


Fig. 59: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Electrical Connector 1 - Connect

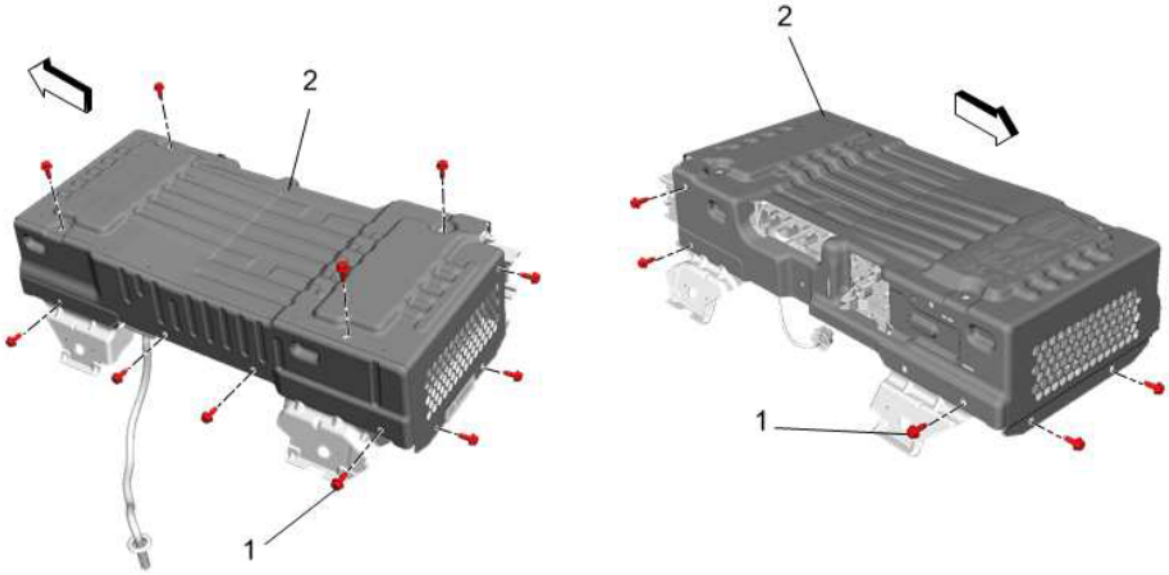


Fig. 60: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

4. High Voltage Battery Cover 2 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

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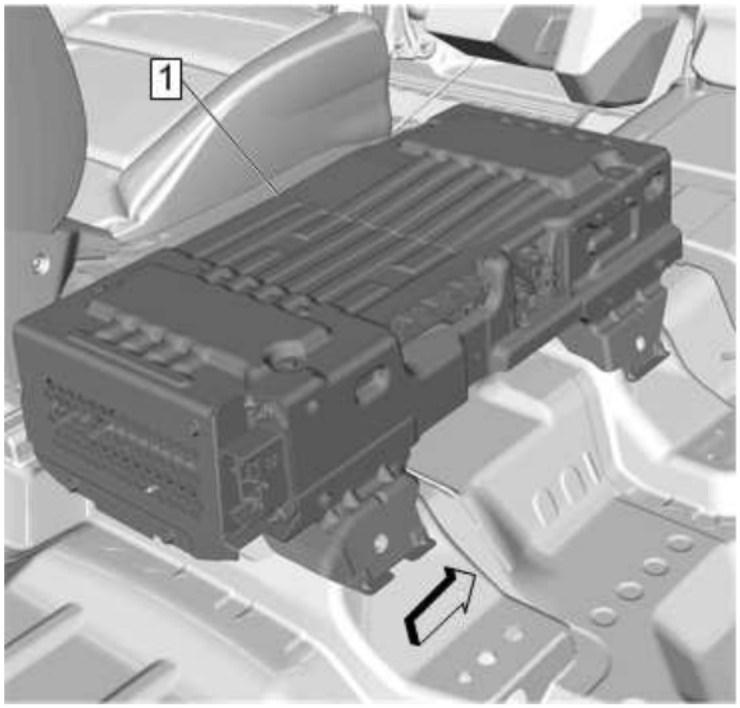


Fig. 61: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

5. High Voltage Battery 1 - Remove - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**
6. Enable the high voltage system. **High Voltage Enabling**
7. Reprogram the hybrid powertrain control module 2, refer to **Control Module References**

300-VOLT BATTERY POSITIVE AND NEGATIVE CABLE REPLACEMENT

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.

Removal Procedure

1. Disable the high voltage system. **High Voltage Disabling**

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2. Front Floor Console Assembly - Remove - **Front Floor Console Assembly Replacement (without HP5)** **Front Floor Console Assembly Replacement (with HP5)**

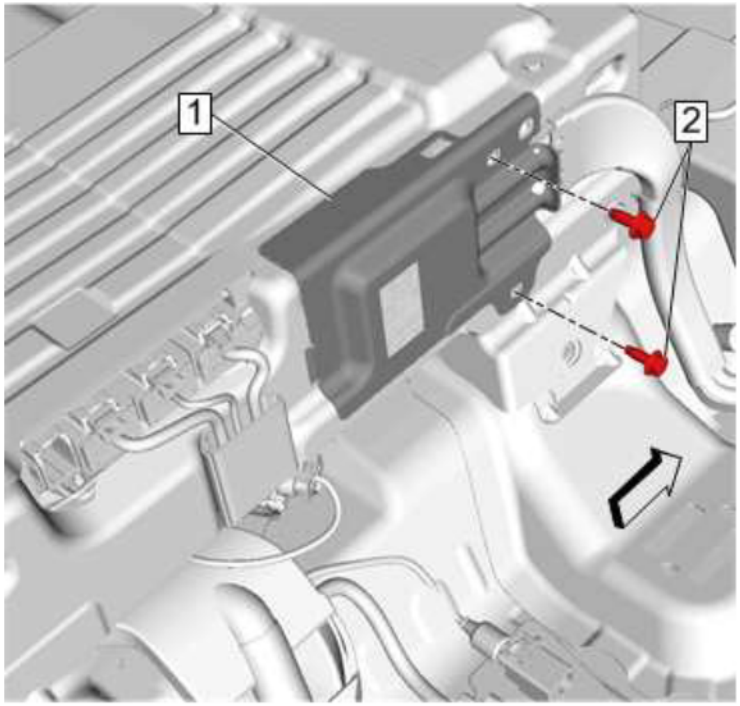


Fig. 62: High Voltage Cover
Courtesy of GENERAL MOTORS COMPANY

3. High Voltage Cover 1 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)** **High Voltage Battery Cover Replacement**
4. Front Floor Panel Carpet - Remove - **Floor Panel Carpet Replacement (Crew Cab)** **Floor Panel Carpet Replacement (Extended Cab)** **Floor Panel Carpet Replacement (Regular Cab)**

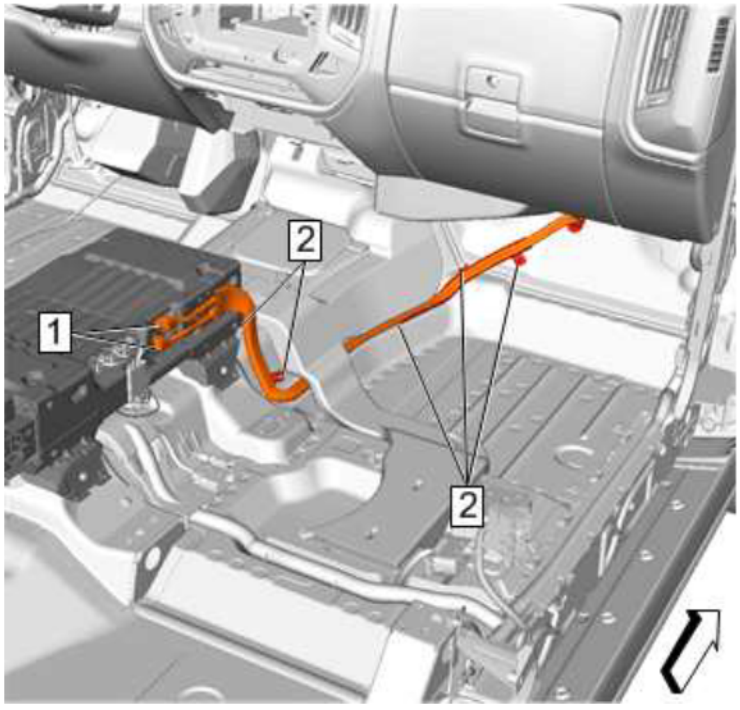


Fig. 63: Electrical Connector

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Courtesy of GENERAL MOTORS COMPANY

5. Electrical Connector 1 - Disconnect
6. Retainer 2 - Disengage
7. Remove the right front wheelhouse liner. **Front Wheelhouse Liner Replacement - Right Side**

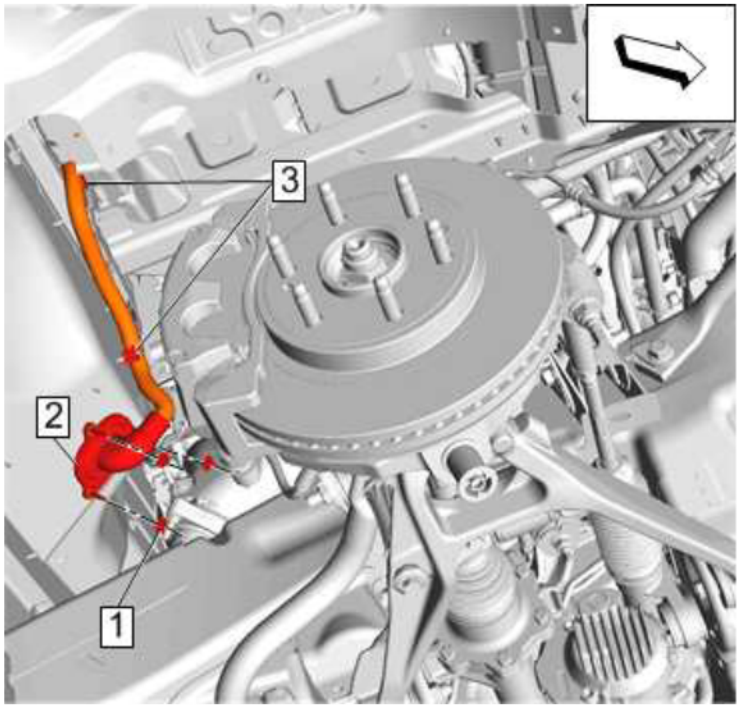


Fig. 64: Dash Panel Grommet
Courtesy of GENERAL MOTORS COMPANY

8. Dash Panel Grommet Fastener 1 - Remove
9. Dash Panel Grommet 2 - Remove
10. Retainer 3 - Disengage

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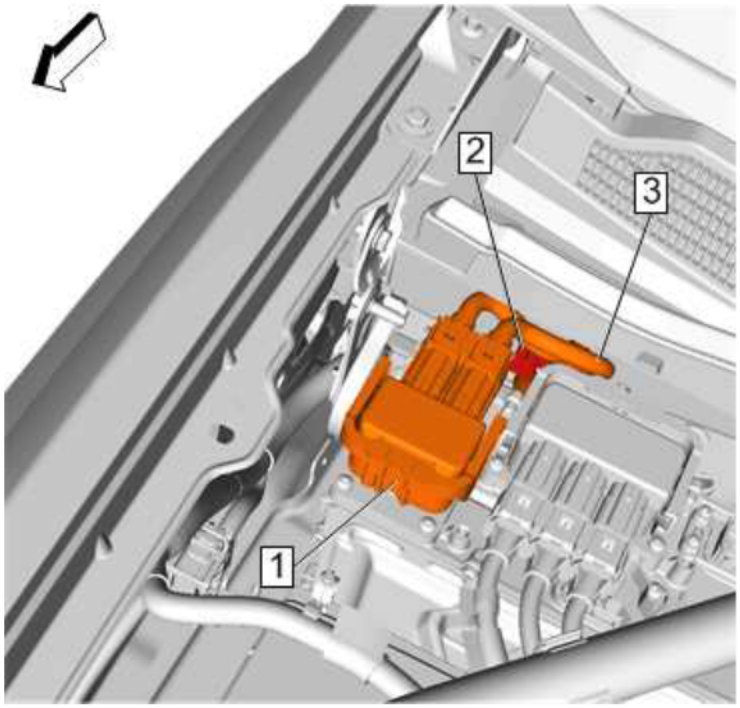


Fig. 65: 300-Volt Battery Positive and Negative Cable
Courtesy of GENERAL MOTORS COMPANY

11. Electrical Connector 1 - Disconnect
12. Retainer 2 - Disengage
13. 300-Volt Battery Positive and Negative Cable 3 - Remove

Installation Procedure

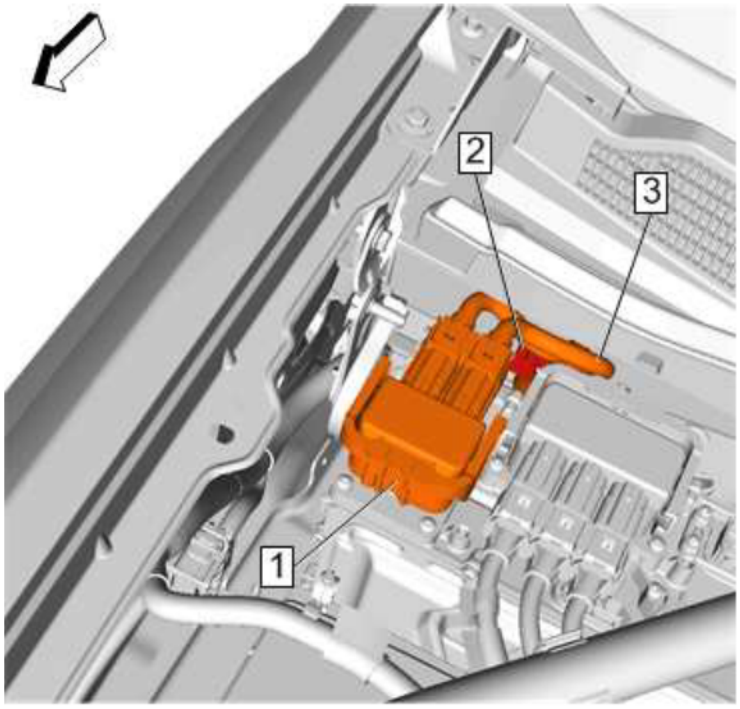


Fig. 66: 300-Volt Battery Positive and Negative Cable
Courtesy of GENERAL MOTORS COMPANY

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1. 300-Volt Battery Positive and Negative Cable 3 - Install
2. Retainer 2 - Engage
3. Electrical Connector 1 - Connect

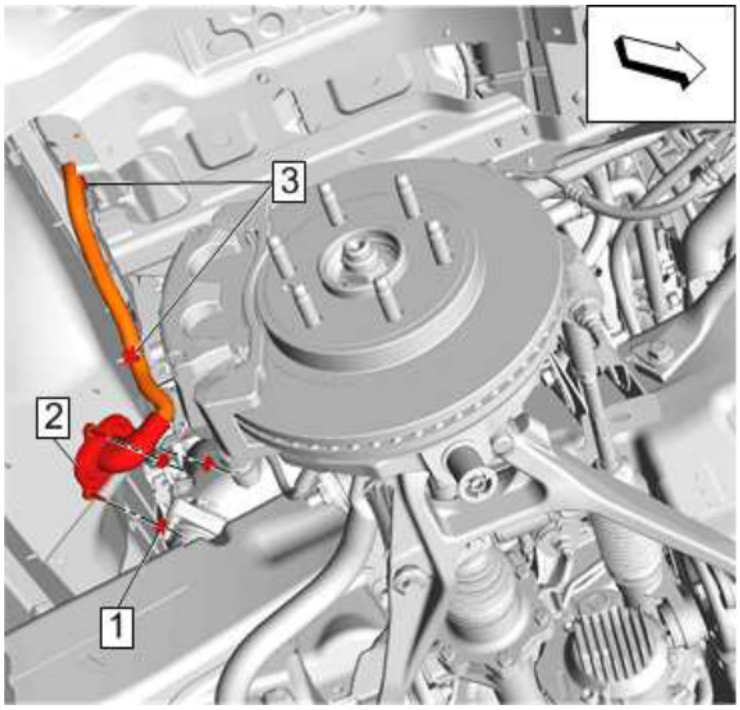


Fig. 67: Dash Panel Grommet
Courtesy of GENERAL MOTORS COMPANY

4. Dash Panel Grommet 2 - Install

CAUTION: **Refer to Fastener Caution**

5. Dash Panel Grommet Fastener 1 - Install and tighten 9 N.m (80 lb in)
6. Retainer 3 - Engage
7. Install the right front wheelhouse liner. **Front Wheelhouse Liner Replacement - Right Side**

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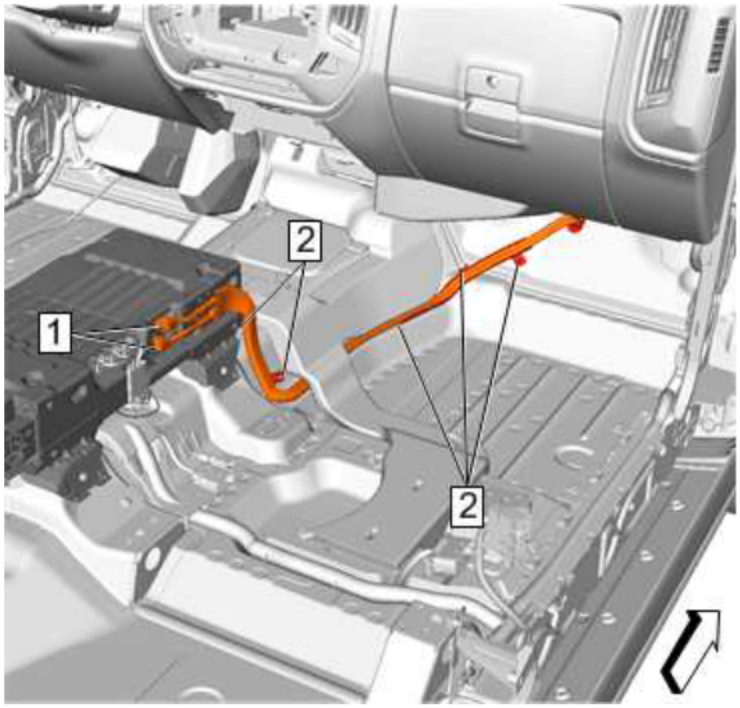


Fig. 68: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

8. Electrical Connector 1 - Connect
9. Retainer 2 - Engage

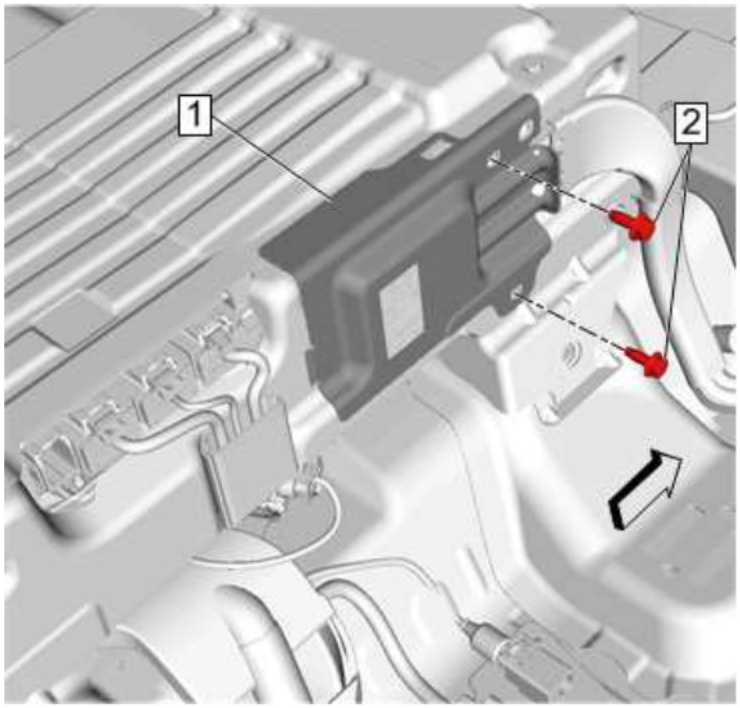


Fig. 69: High Voltage Cover
Courtesy of GENERAL MOTORS COMPANY

10. High Voltage Cover 1 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**
11. Front Floor Panel Carpet - Install - **Floor Panel Carpet Replacement (Crew Cab) Floor Panel Carpet**

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Replacement (Extended Cab) Floor Panel Carpet Replacement (Regular Cab)

12. Front Floor Console Assembly - Install - Front Floor Console Assembly Replacement (without HP5) Front Floor Console Assembly Replacement (with HP5)
13. Enable the high voltage system. High Voltage Enabling

HIGH VOLTAGE BATTERY DISCONNECT CABLE REPLACEMENT

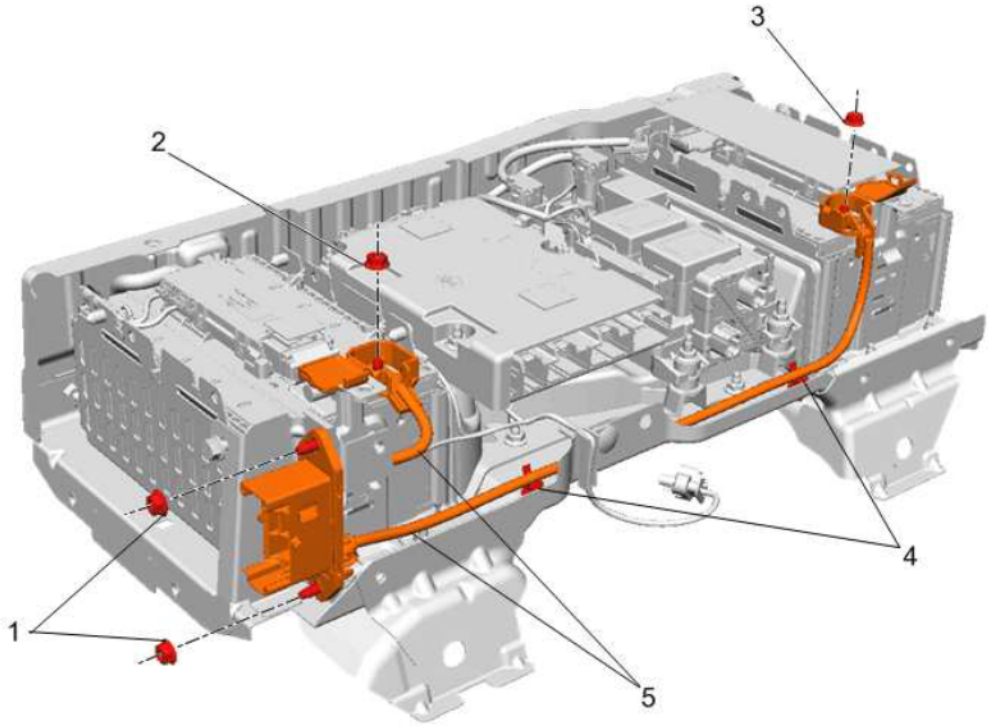


Fig. 70: High Voltage Battery Disconnect Cable
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the high voltage battery cover. High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement	
1	**WARNING:** **Ensure all High Voltage safety procedures are followed. Failure to follow the procedure exactly as written may result in serious**

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Callout	Component Name
	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.

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Callout	Component Name
	Failure to follow the procedure exactly as written may result in serious injury or death. High Voltage Battery High Voltage Manual Disconnect Connector Fastener **CAUTION:** **Refer to** **Fastener Caution** **Tighten** 9 N.m (80 lb in)
2	High Voltage Battery Negative Cable Fastener **Tighten** 9 N.m (80 lb in)
3	High Voltage Battery Positive Cable Fastener **Tighten** 9 N.m (80 lb in)
4	Retainer
5	High Voltage Battery Disconnect Cable

GENERATOR BATTERY DISCONNECTOR RELAY REPLACEMENT

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.

Removal Procedure

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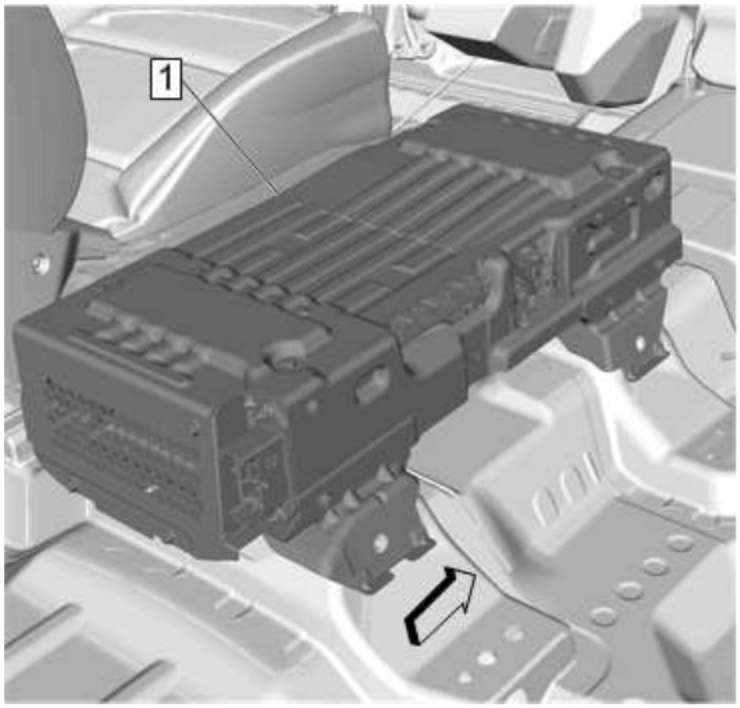


Fig. 71: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Remove - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

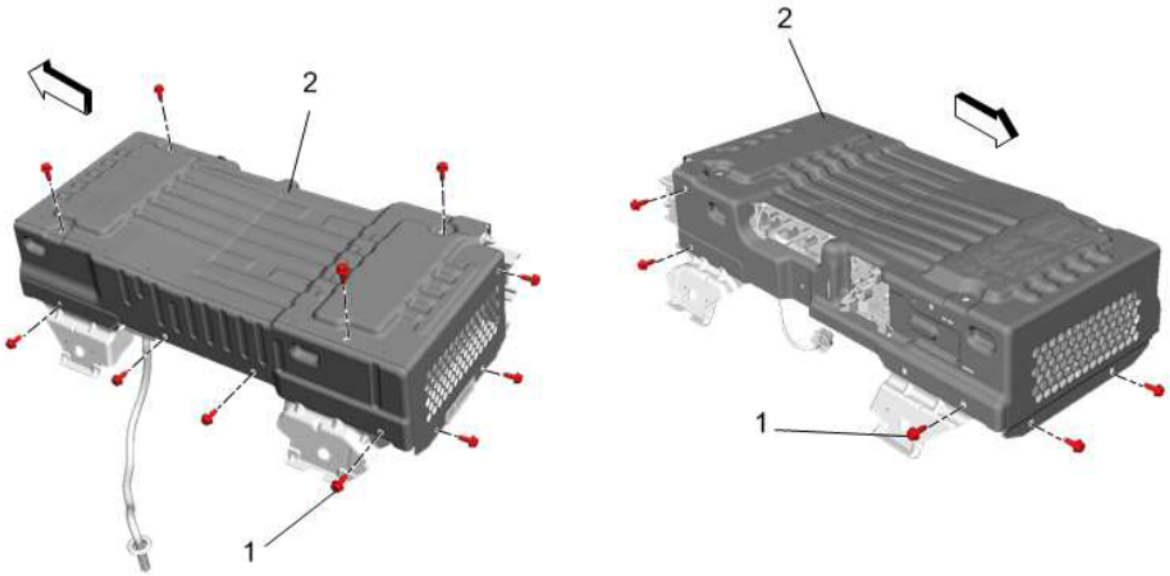


Fig. 72: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

2. High Voltage Battery Cover 2 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

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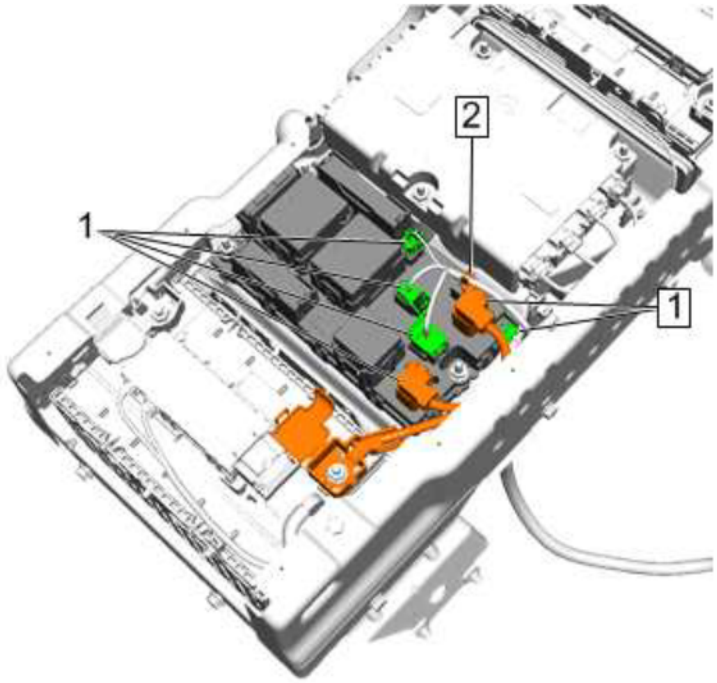


Fig. 73: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Electrical Connector 1 - Disconnect
4. Retainer 2 - Disengage

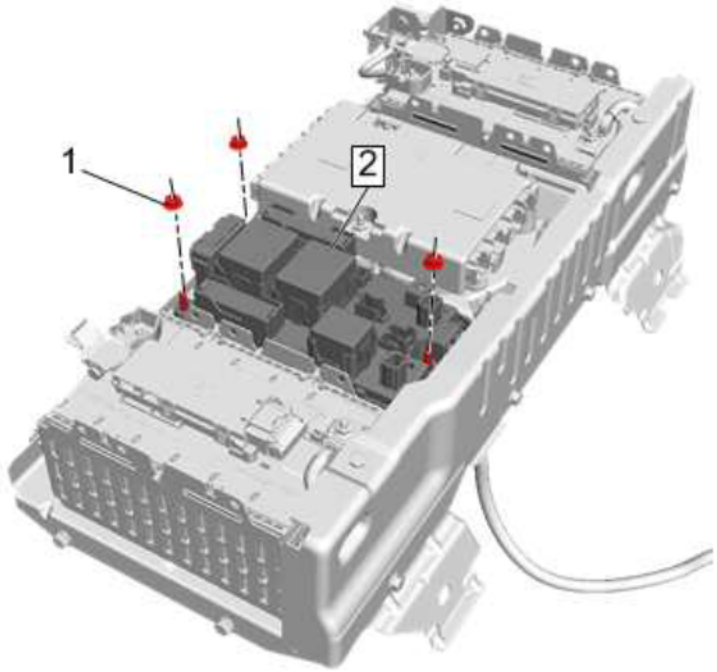


Fig. 74: Generator Battery Disconnect Relay
Courtesy of GENERAL MOTORS COMPANY

5. Generator Battery Disconnect Relay Mounting Nut 1 - Remove
6. Generator Battery Disconnect Relay 2 - Remove

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Installation Procedure

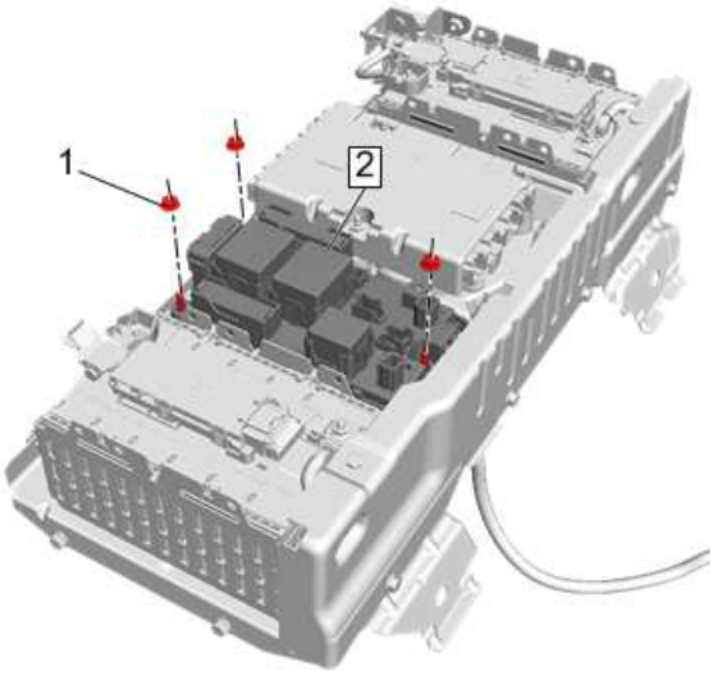


Fig. 75: Generator Battery Disconnect Relay
Courtesy of GENERAL MOTORS COMPANY

1. Generator Battery Disconnect Relay 2 - Remove

CAUTION: **Refer to Fastener Caution**

2. Generator Battery Disconnect Relay Mounting Nut 1 - Install and tighten 7 N.m (62 lb in)

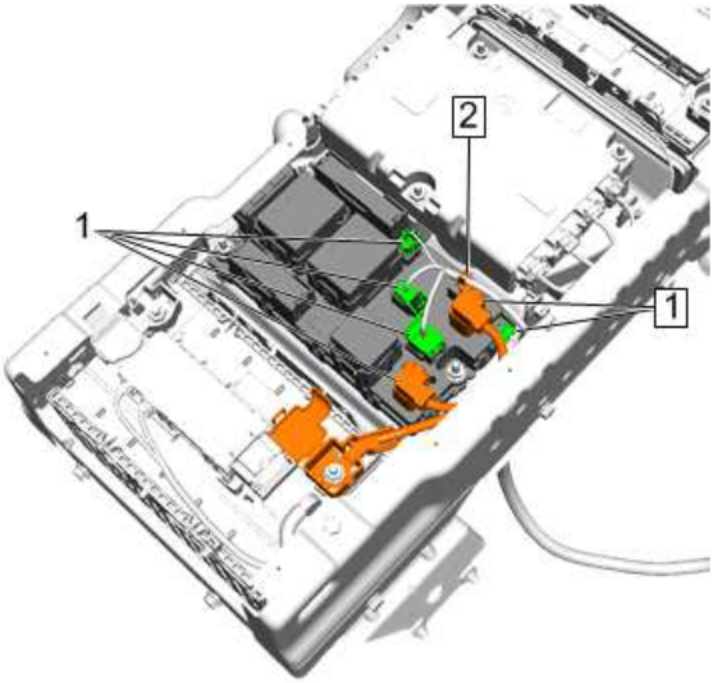


Fig. 76: Electrical Connector

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Courtesy of GENERAL MOTORS COMPANY

3. Electrical Connector 1 - Connect
4. Retainer 2 - Engage

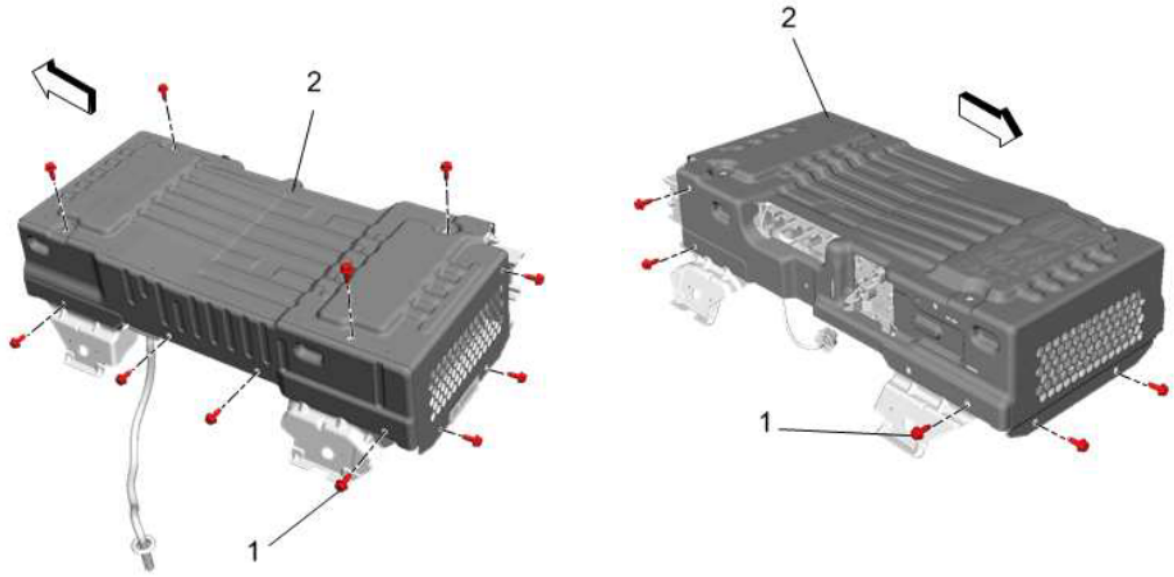


Fig. 77: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

5. High Voltage Battery Cover 2 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

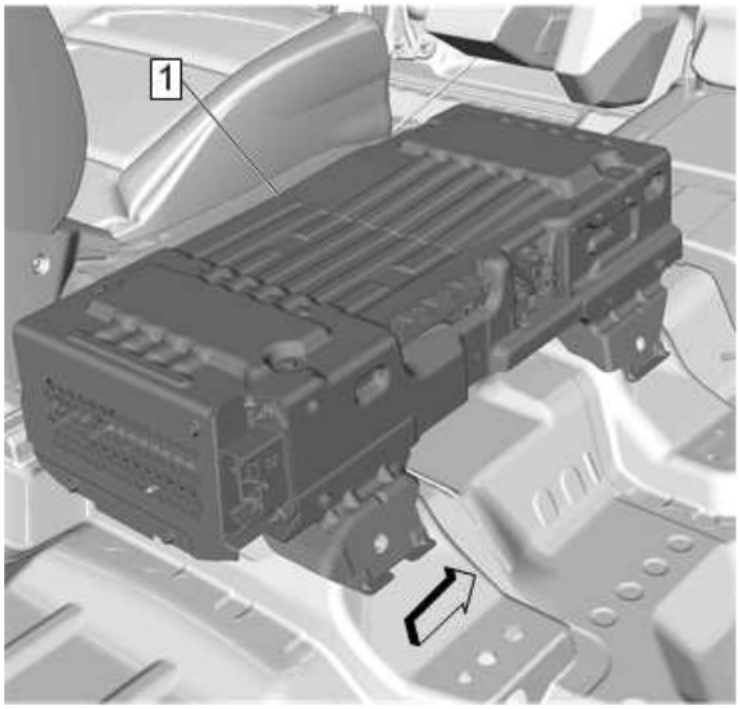


Fig. 78: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

6. High Voltage Battery 1 - Install - **High Voltage Battery Replacement and Shipping Preparation (with**

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Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)

7. Enable the high voltage system. High Voltage Enabling

CELL BATTERY MODULE REPLACEMENT (CELL BATTERY 1)

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.

Removal Procedure

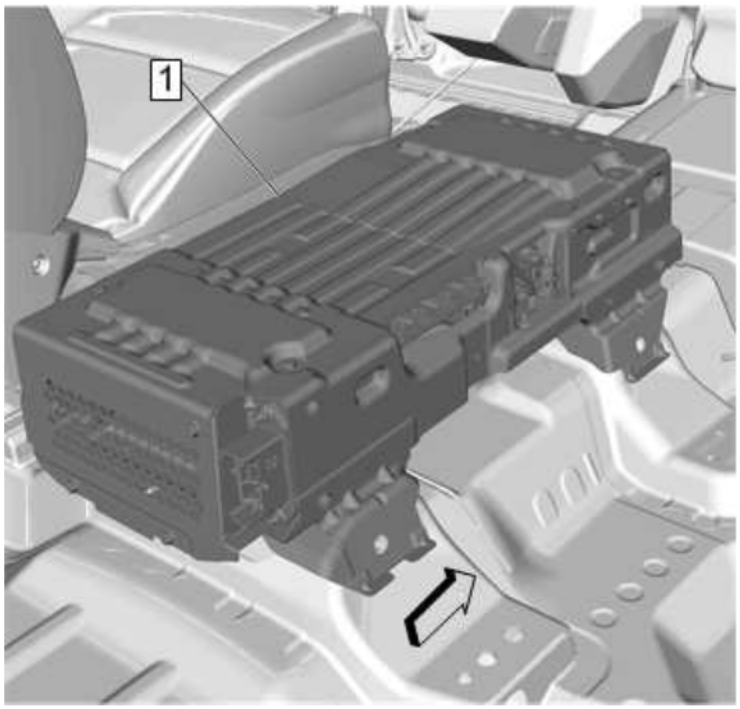


Fig. 79: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Remove - High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)

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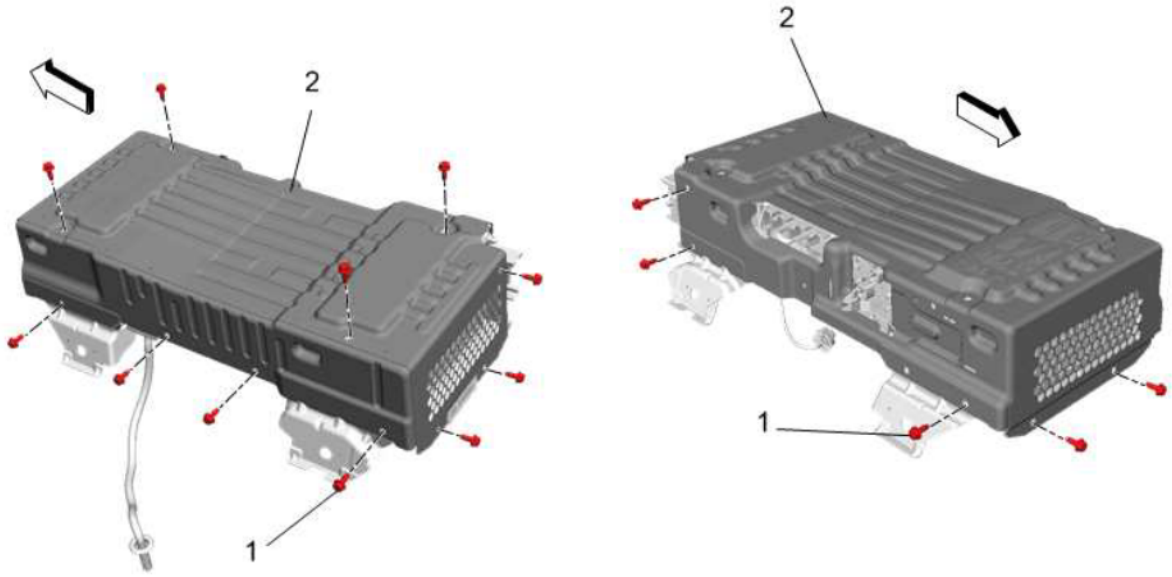


Fig. 80: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

2. High Voltage Battery Cover 2 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

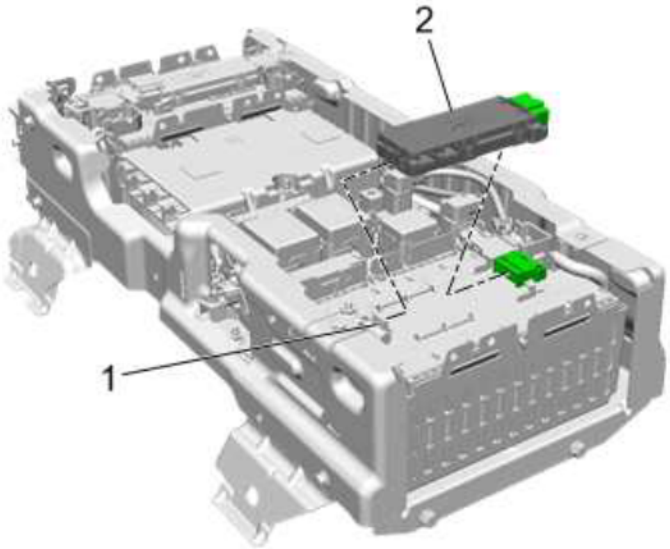


Fig. 81: High Voltage Battery Interface Control Module
Courtesy of GENERAL MOTORS COMPANY

3. High Voltage Battery Interface Control Module (2) - Remove - **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 1) High Voltage Battery Interface Control Module Replacement (Cell Battery Module 2)**

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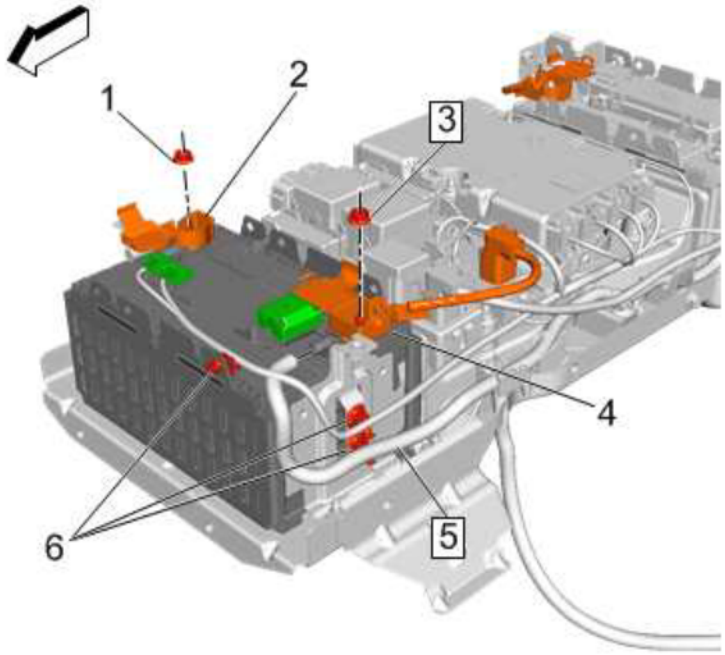


Fig. 82: Cell Battery 1 Components
Courtesy of GENERAL MOTORS COMPANY

4. High Voltage Battery Positive Cable Fastener 1 - Remove
5. High Voltage Battery Positive Cable 2 - Remove
6. High Voltage Battery Negative Cable Fastener 3 - Remove
7. High Voltage Battery Negative Cable 4 - Remove
8. Cell Battery Vent Tube 5 - Disengage
9. Retainer 6 - Disengage

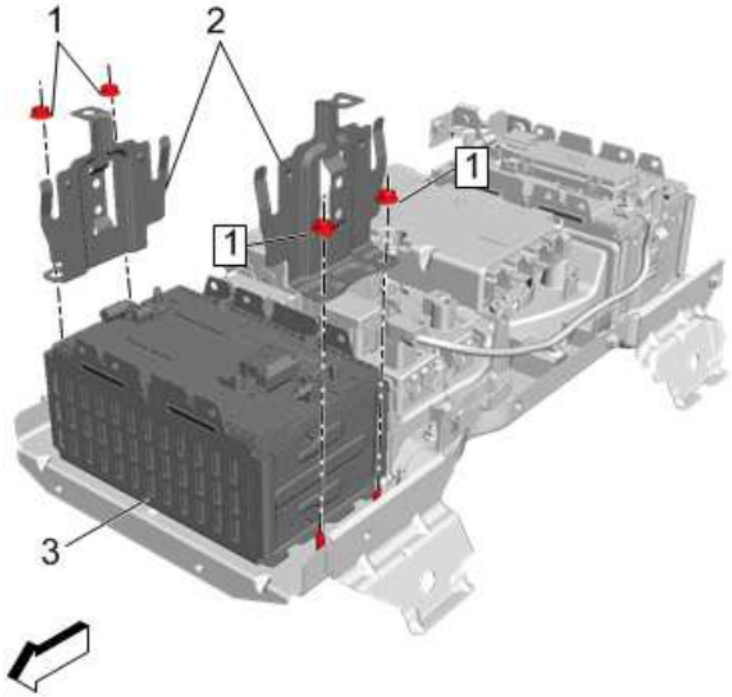


Fig. 83: Retainer Nuts

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Courtesy of GENERAL MOTORS COMPANY

10. Battery Hold Down Retainer Nut 1 - Remove
11. Battery Hold Down Retainer 2 - Remove
12. Cell Battery Module 3 - Remove

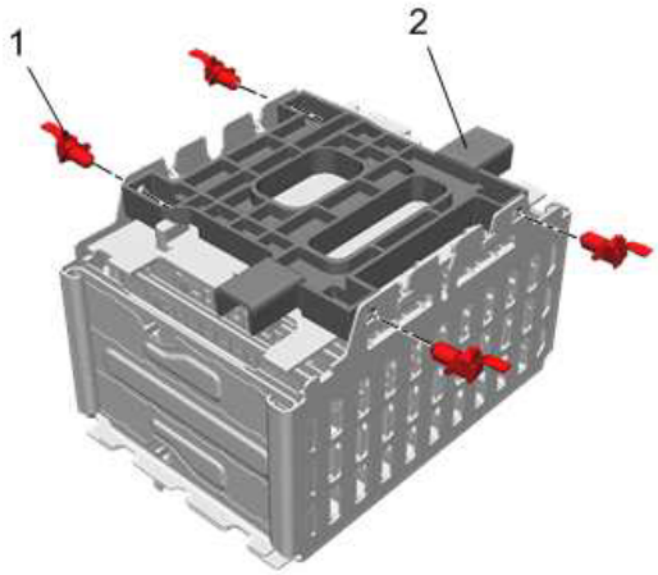


Fig. 84: Shipping Bracket
Courtesy of GENERAL MOTORS COMPANY

13. If replacing the cell battery module, insert the shipping bracket (2) that comes with the NEW cell battery.
14. Install the retainers. 1

Installation Procedure

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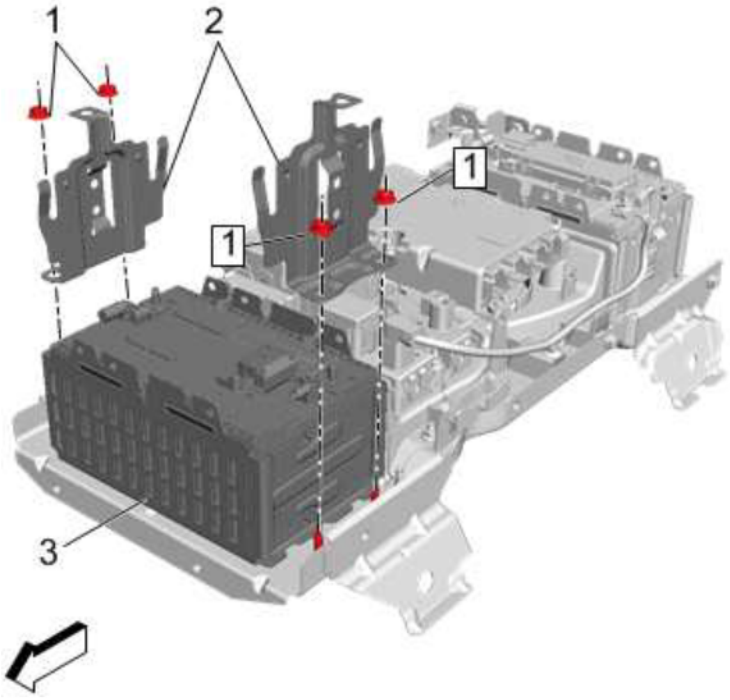


Fig. 85: Retainer Nuts
Courtesy of GENERAL MOTORS COMPANY

1. Cell Battery Module 3 - Install
2. Battery Hold Down Retainer 2 - Install

CAUTION: Refer to Fastener Caution

3. Battery Hold Down Retainer Nut 1 - Install and tighten 9 N.m (80 lb in)

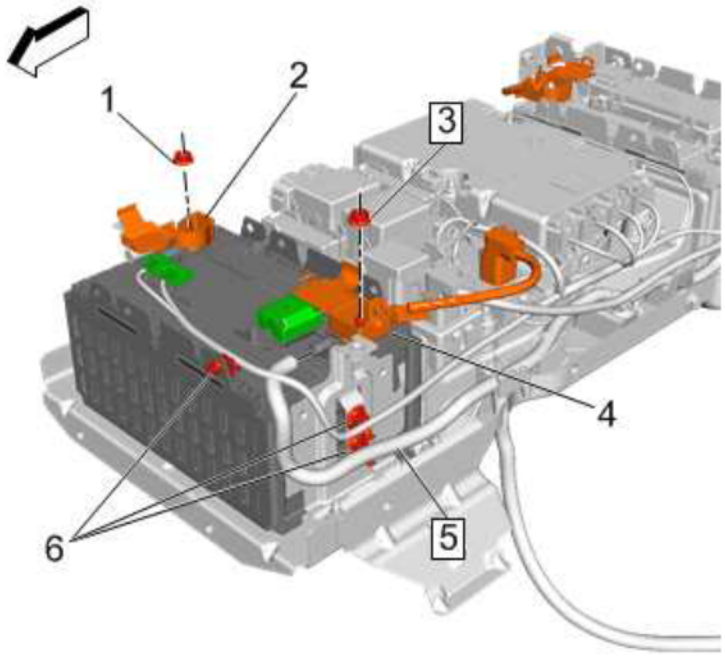


Fig. 86: Cell Battery 1 Components
Courtesy of GENERAL MOTORS COMPANY

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4. High Voltage Battery Positive Cable 2 - Install
5. High Voltage Battery Positive Cable Fastener 1 - Install and tighten 9 N.m (80 lb in)
6. High Voltage Battery Negative Cable 4 - Install
7. High Voltage Battery Negative Cable Fastener 3 - Install and tighten 9 N.m (80 lb in)
8. Cell Battery Vent Tube 5 - Engage
9. Retainer 6 - Engage

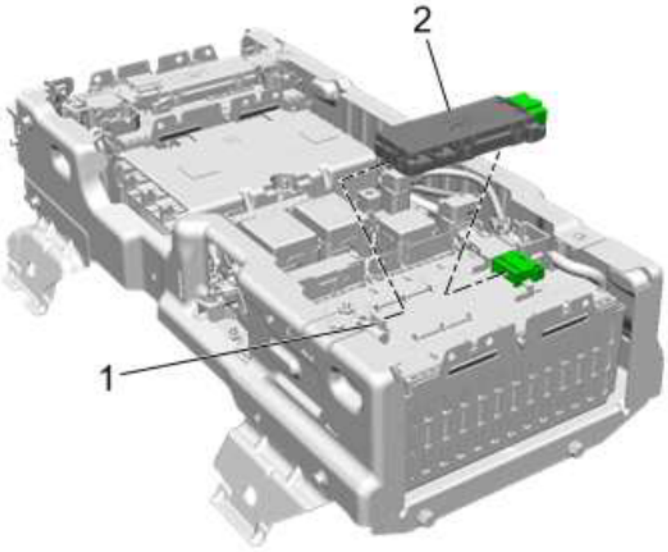
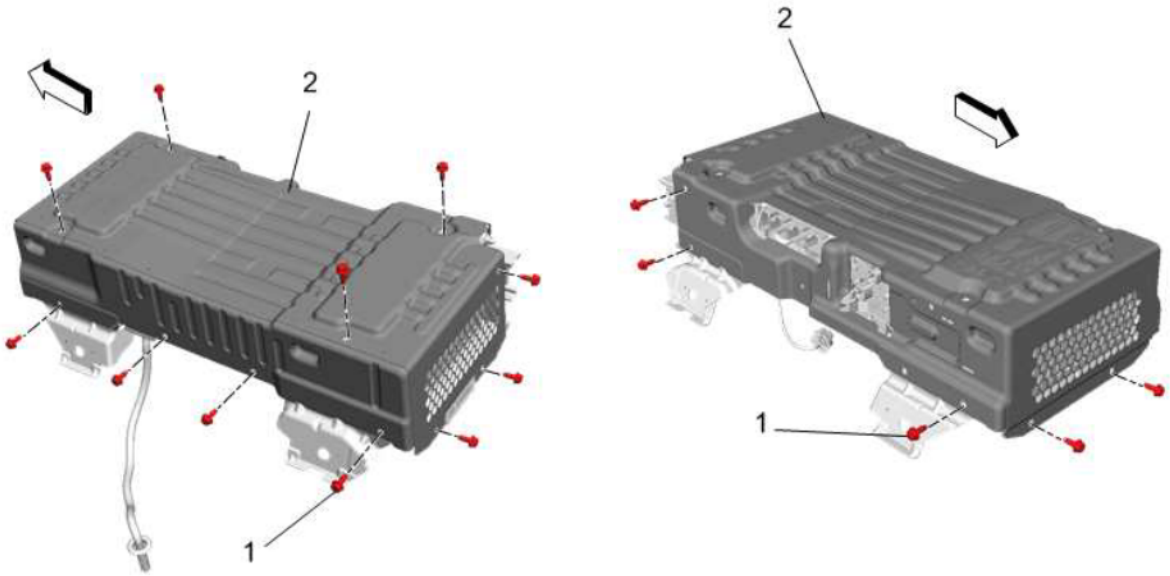


Fig. 87: High Voltage Battery Interface Control Module
Courtesy of GENERAL MOTORS COMPANY

10. High Voltage Battery Interface Control Module 2 - Install - **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 1)** **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 2)**



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Fig. 88: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

11. High Voltage Battery Cover 2 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

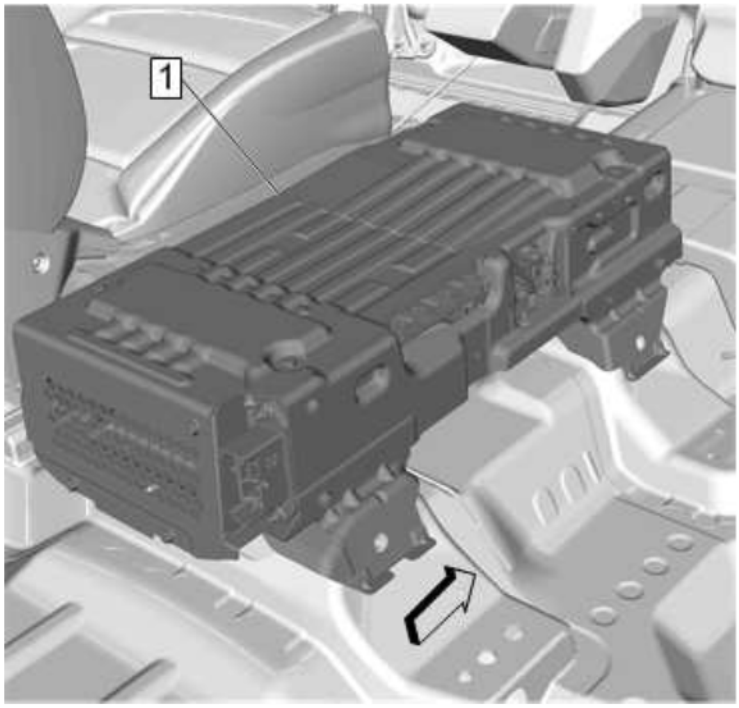


Fig. 89: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

12. High Voltage Battery 1 - Install - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

CELL BATTERY MODULE REPLACEMENT (CELL BATTERY 2)

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.

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Removal Procedure

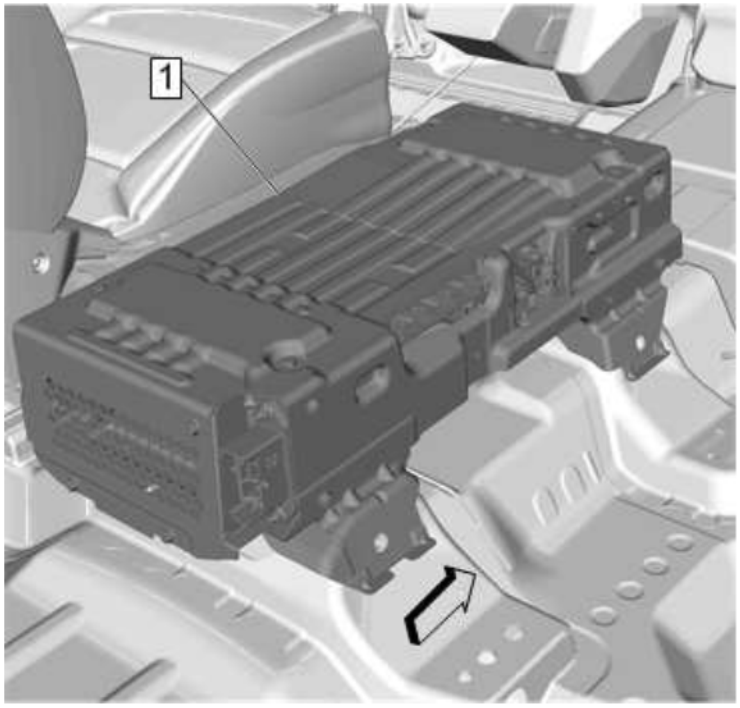


Fig. 90: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Remove - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

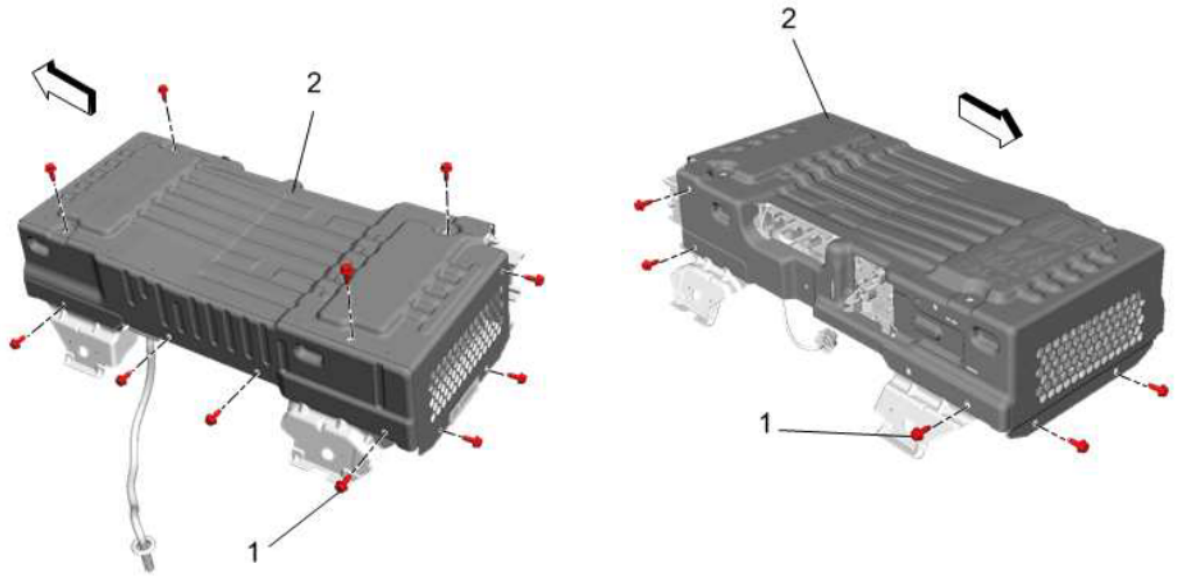


Fig. 91: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

2. High Voltage Battery Cover 2 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

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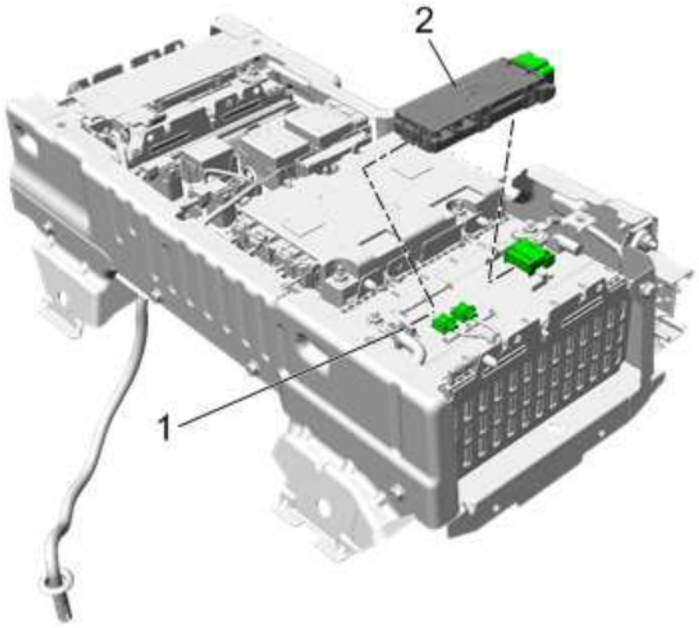


Fig. 92: Retaining Tab
Courtesy of GENERAL MOTORS COMPANY

3. High Voltage Battery Interface Control Module 2 - Remove - **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 1)** **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 2)**

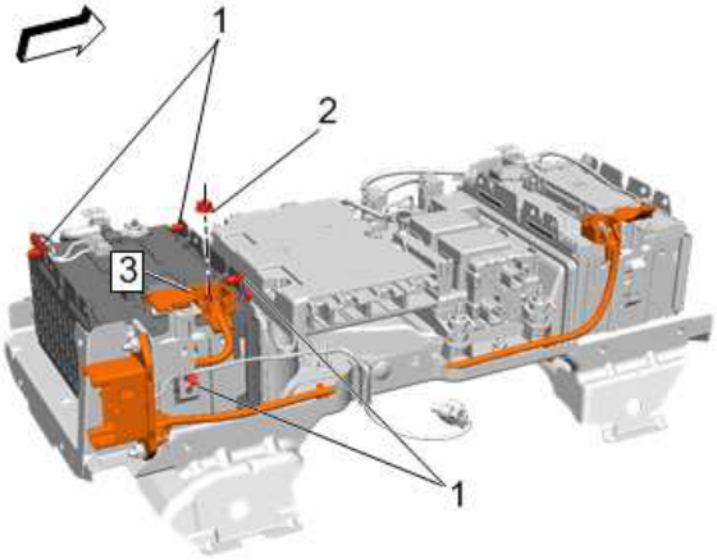


Fig. 93: High Voltage Battery Components
Courtesy of GENERAL MOTORS COMPANY

4. High Voltage Battery Negative Cable Fastener 2 - Remove
5. High Voltage Battery Negative Cable 3 - Remove

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6. Retainer 1 - Disengage

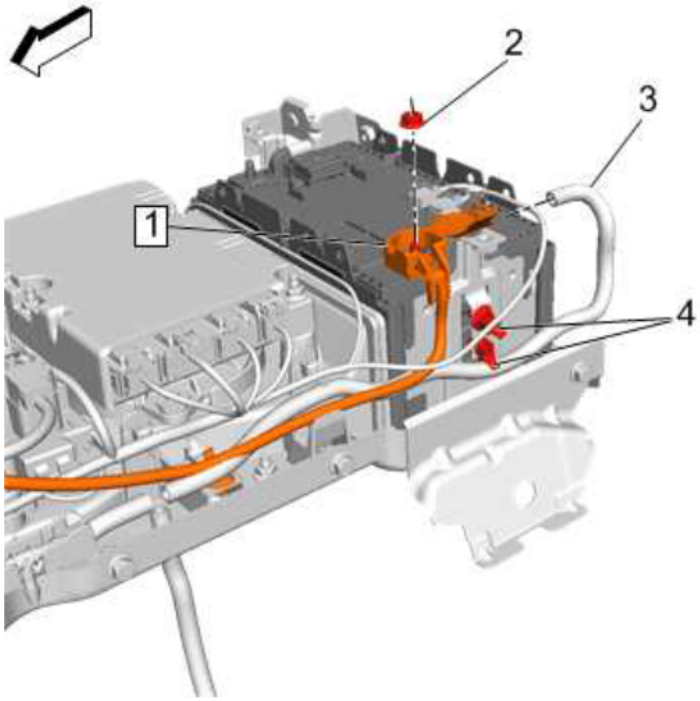


Fig. 94: Cell Battery 2 Components
Courtesy of GENERAL MOTORS COMPANY

7. High Voltage Battery Positive Cable Fastener 2 - Remove
8. High Voltage Battery Positive Cable 1 - Remove
9. Cell Battery Vent Tube 3 - Disengage
10. Retainer 4 - Disengage

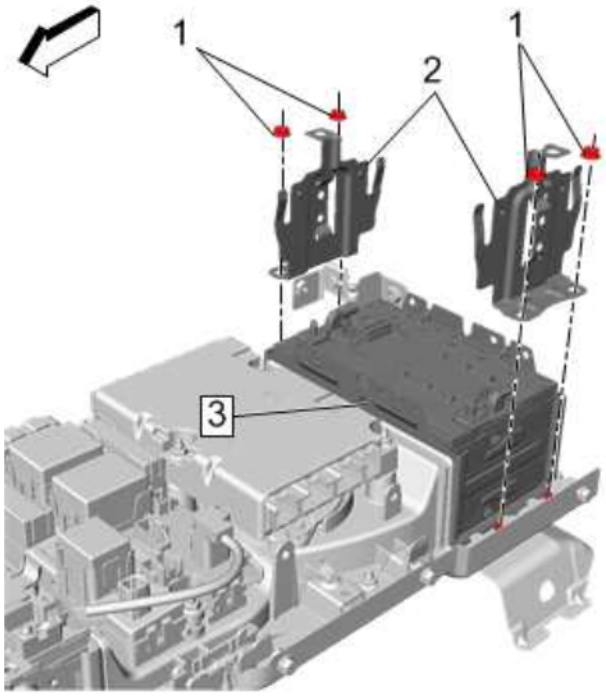


Fig. 95: Cell Battery Module 2

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Courtesy of GENERAL MOTORS COMPANY

11. Battery Hold Down Retainer Nut 1 - Remove
12. Battery Hold Down Retainer 2 - Remove
13. Cell Battery Module 3 - Remove

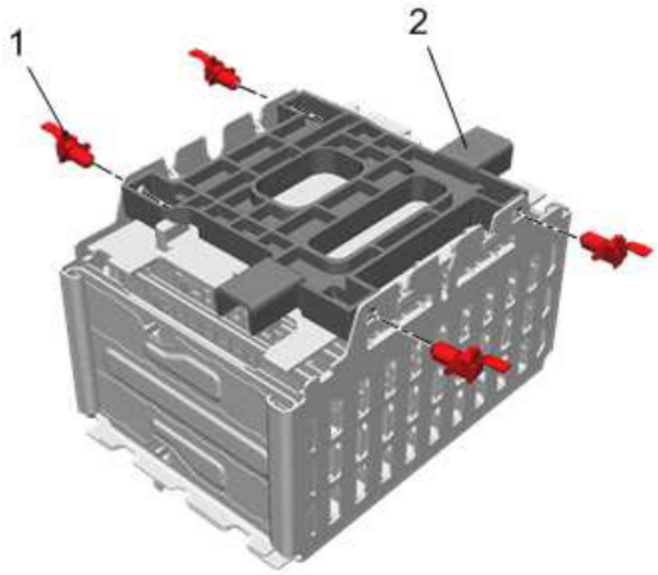


Fig. 96: Shipping Bracket
Courtesy of GENERAL MOTORS COMPANY

14. If replacing the cell battery module, insert the shipping bracket (2) that comes with the NEW cell battery.
15. Install the retainers. 1

Installation Procedure

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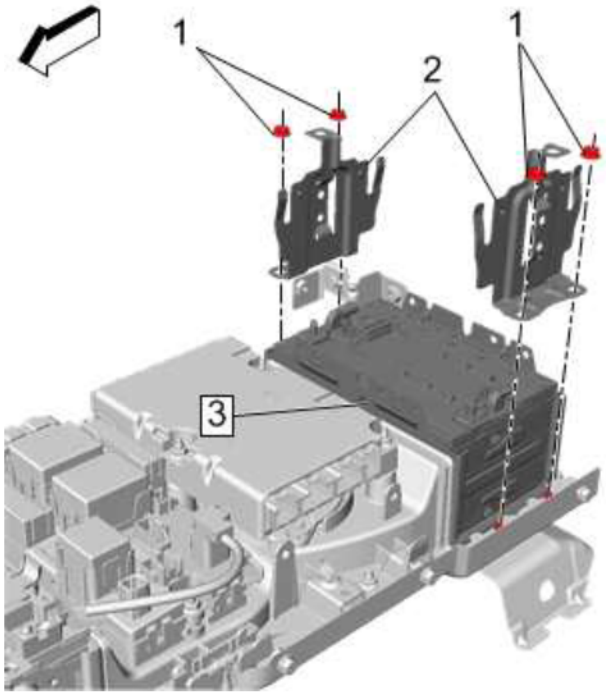


Fig. 97: Cell Battery Module 2
Courtesy of GENERAL MOTORS COMPANY

1. Cell Battery Module 3 - Install
2. Battery Hold Down Retainer 2 - Install

CAUTION: Refer to Fastener Caution

3. Battery Hold Down Retainer Nut 1 - Install and tighten 9 N.m (80 lb in)

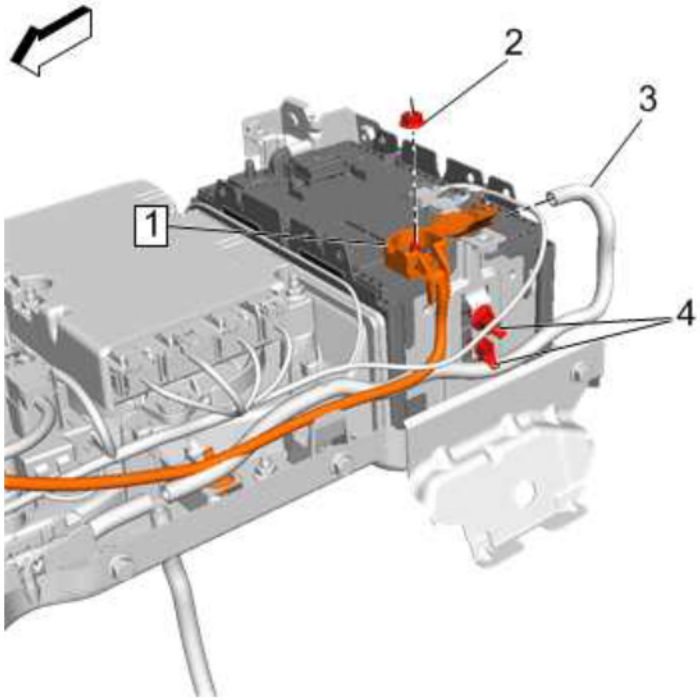


Fig. 98: Cell Battery 2 Components
Courtesy of GENERAL MOTORS COMPANY

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4. High Voltage Battery Positive Cable 1 - Install
5. High Voltage Battery Positive Cable Fastener 2 - Install and tighten 9 N.m (80 lb in)
6. Cell Battery Vent Tube 3 - Engage
7. Retainer 4 - Engage

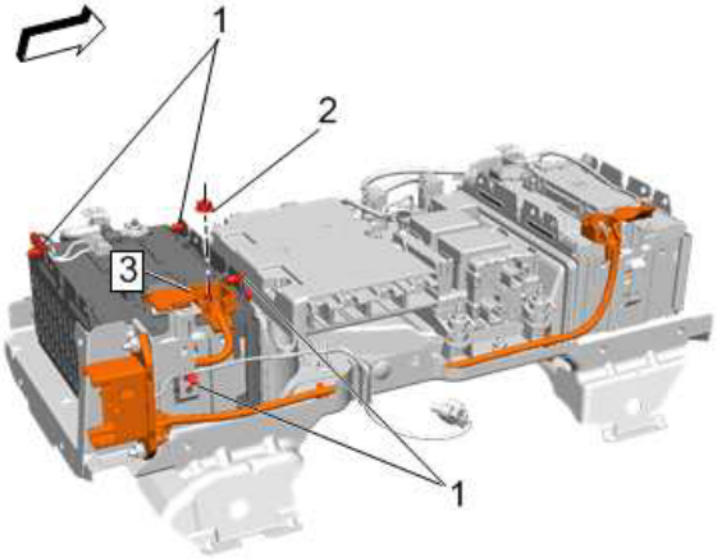
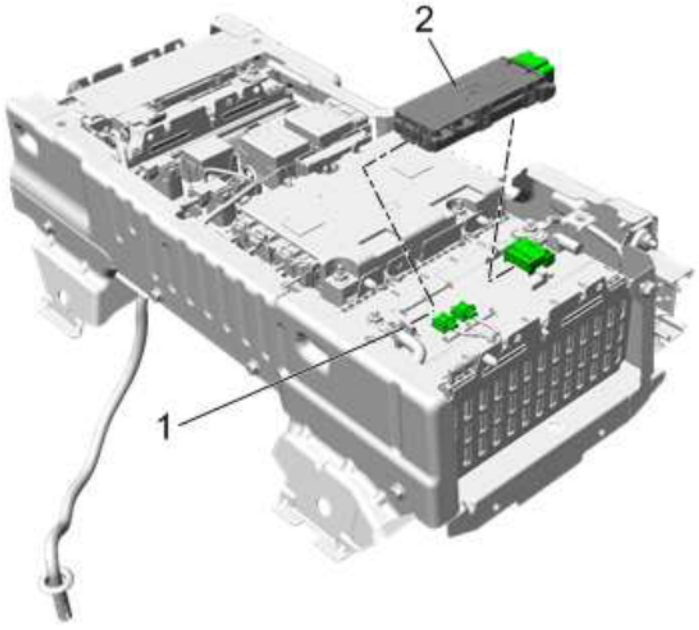


Fig. 99: High Voltage Battery Components
Courtesy of GENERAL MOTORS COMPANY

8. High Voltage Battery Negative Cable 3 - Install
9. High Voltage Battery Negative Cable Fastener 2 - Install and tighten 9 N.m (80 lb in)
10. Retainer 1 - Engage



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Fig. 100: Retaining Tab
Courtesy of GENERAL MOTORS COMPANY

11. High Voltage Battery Interface Control Module 2 - Install - **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 1)** **High Voltage Battery Interface Control Module Replacement (Cell Battery Module 2)**

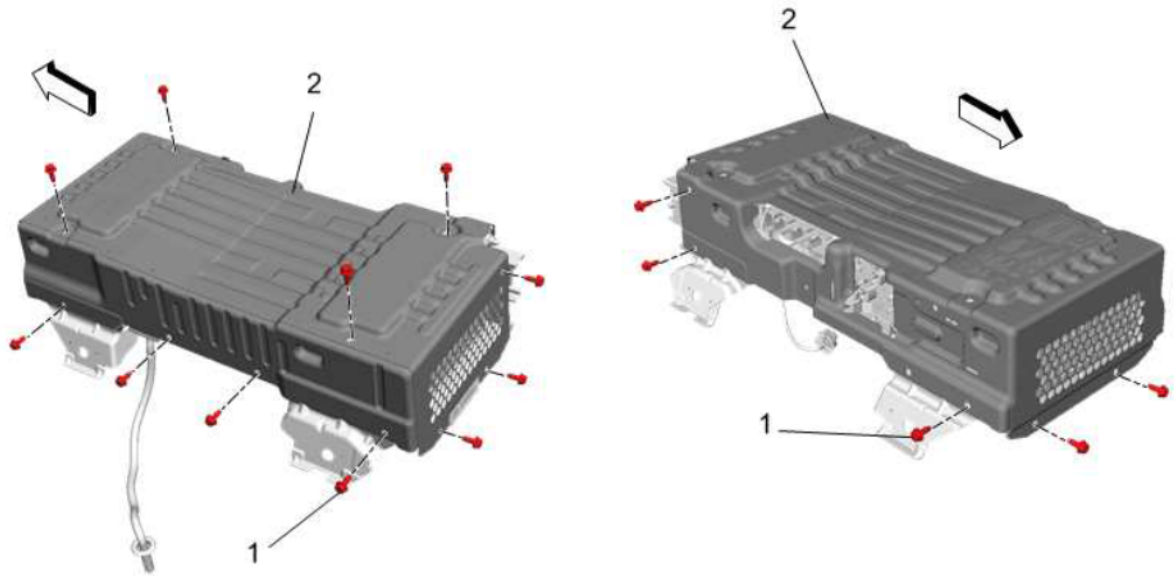


Fig. 101: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

12. High Voltage Battery Cover 2 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)** **High Voltage Battery Cover Replacement**

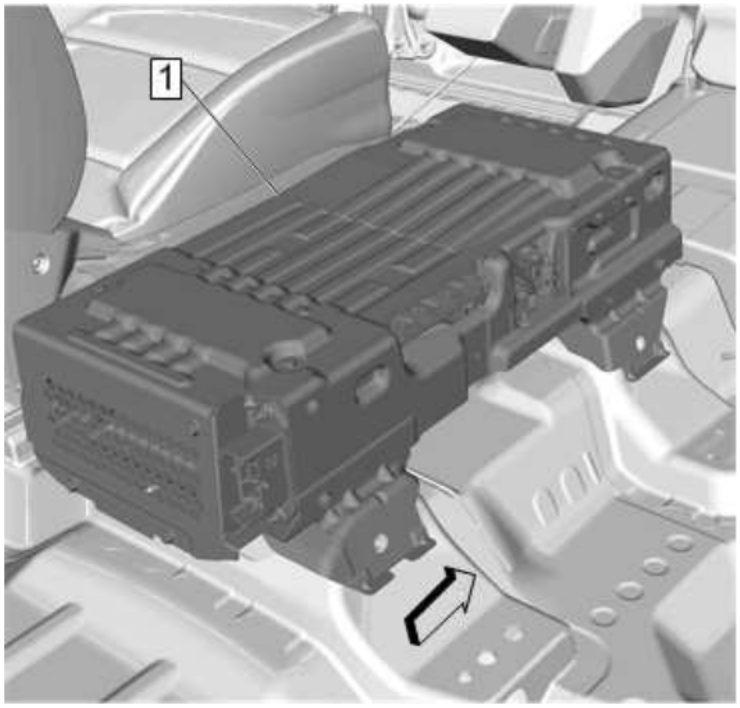


Fig. 102: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

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13. High Voltage Battery 1 - Install - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

HIGH VOLTAGE BATTERY REPLACEMENT AND SHIPPING PREPARATION (WITH CENTER CONSOLE)

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.

WARNING: **Ensure all high voltage battery covers/panels are installed prior to removal or installation of the high voltage battery assembly. Installing the covers/panels will eliminate the risk of contact with exposed high voltage contact points during removal or installation. Failure to follow the procedure exactly as written may result in serious injury or death.**

Removal Procedure

1. Front Floor Console Assembly - Remove - **Front Floor Console Assembly Replacement (without HP5) Front Floor Console Assembly Replacement (with HP5)**
2. Disable the high voltage system. **High Voltage Disabling**

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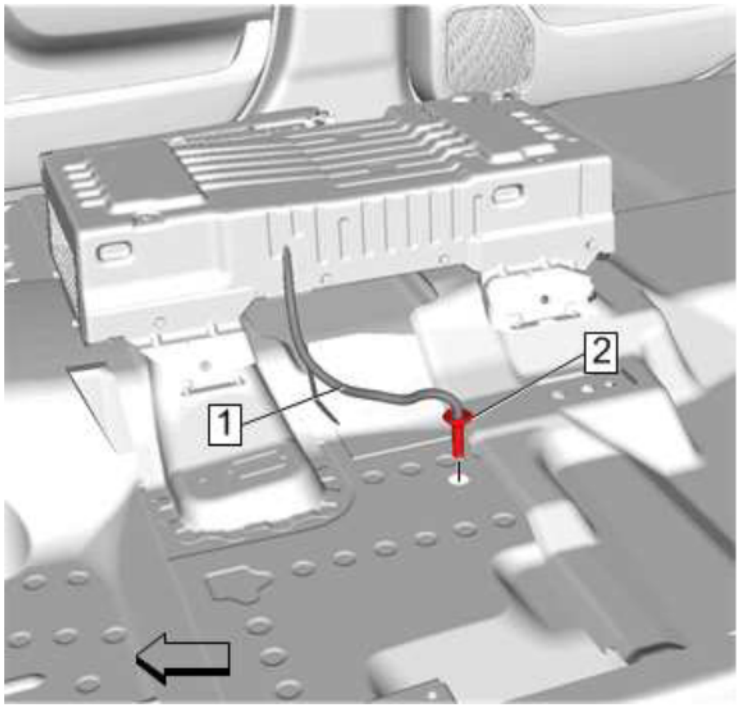


Fig. 103: Vent Tube Grommet
Courtesy of GENERAL MOTORS COMPANY

3. Peel back the floor carpet and disengage the vent tube grommet (2) and the high voltage battery vent tube (1), from the floor panel.

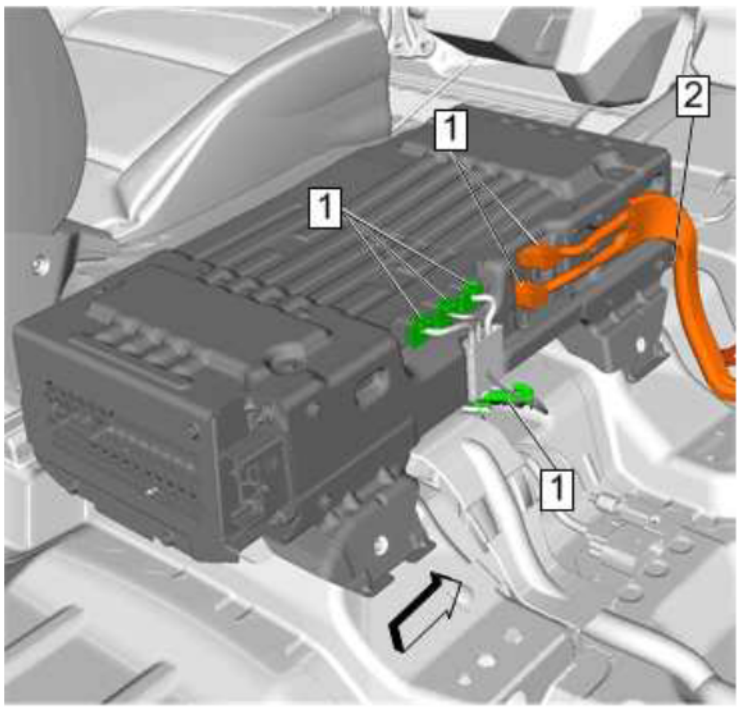


Fig. 104: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Electrical Connector 2 - Disconnect
5. Retainer 1 - Disengage

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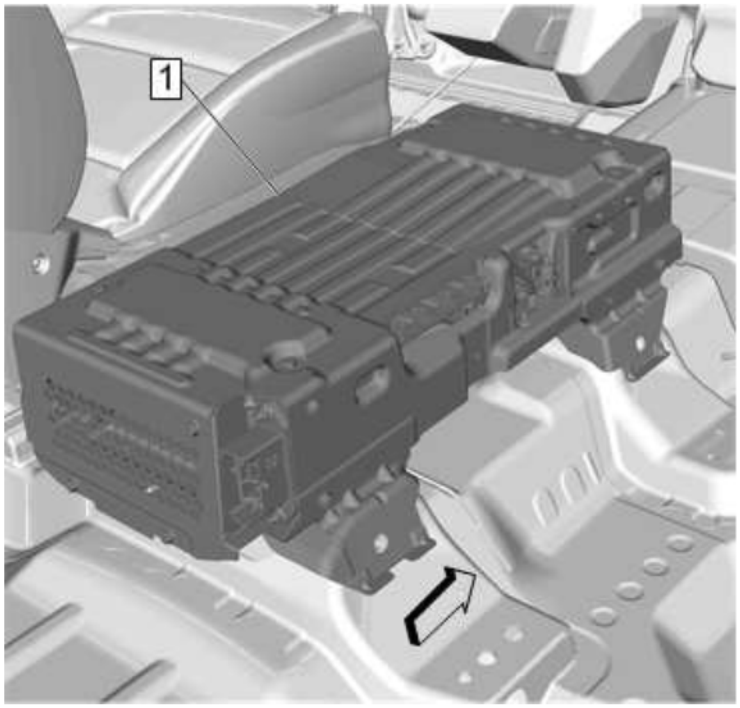


Fig. 105: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

6. High Voltage Battery 1 - Remove
7. If the high voltage battery is being replaced, perform the following return shipping instruction:

NOTE: **Never ship the returned high voltage battery with the drive motor battery high voltage manual disconnect lever installed.**

- Retain the drive motor battery high voltage manual disconnect lever handle for installation in the service replacement high voltage battery assembly.
- Retain the high voltage battery positive and negative cable cover for installation the service replacement high voltage battery assembly.
- Cover the exposed high voltage manual disconnect connector with UL listed, or equivalent, insulation tape rated at a minimum of 600V.
- Cover the exposed high voltage battery positive and negative cable connections with UL listed, or equivalent, insulation tape rated at a minimum of 600V.

Installation Procedure

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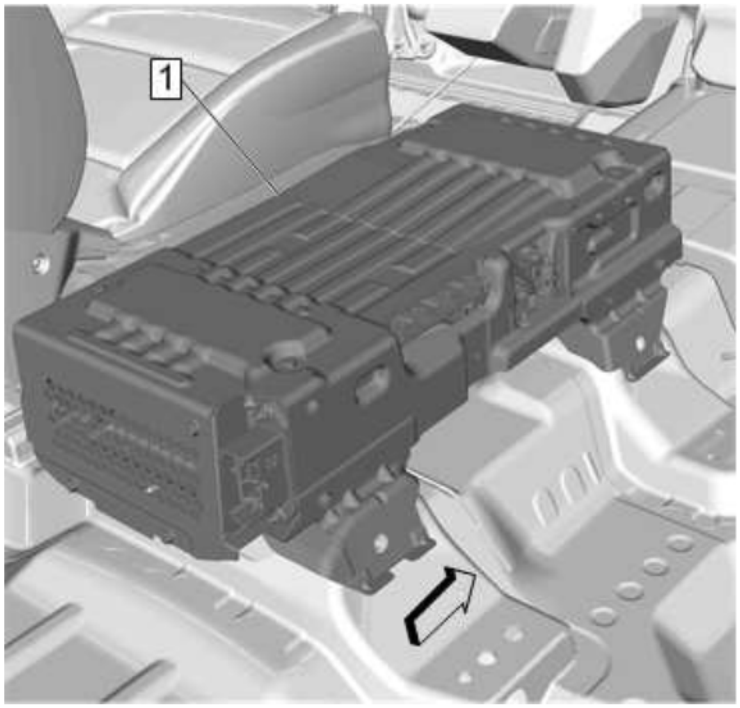


Fig. 106: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Install

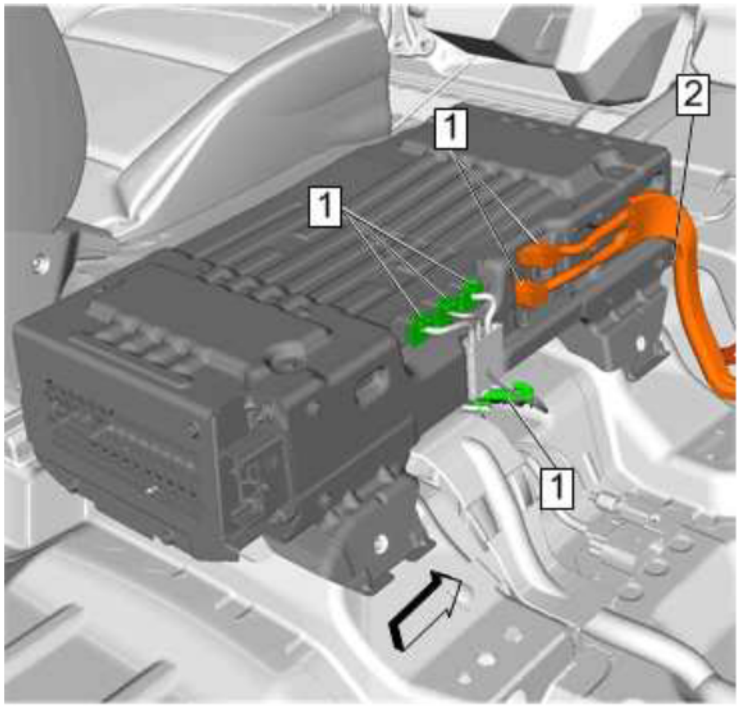


Fig. 107: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Electrical Connector 1 - Connect
3. Retainer 2 - Engage

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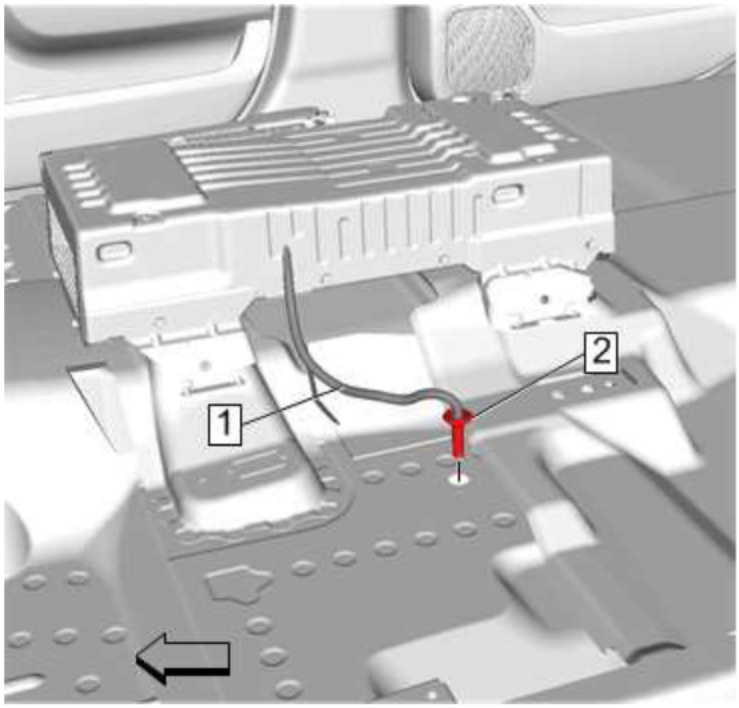


Fig. 108: Vent Tube Grommet
Courtesy of GENERAL MOTORS COMPANY

4. Install the high voltage battery vent tube (1) and the vent tube grommet (2), into the floor panel.
5. Front Floor Console Assembly - Install - **Front Floor Console Assembly Replacement (without HP5)** **Front Floor Console Assembly Replacement (with HP5)**
6. Enable the high voltage system. **High Voltage Enabling**

HIGH VOLTAGE BATTERY REPLACEMENT AND SHIPPING PREPARATION (WITH FRONT CENTER SEAT)

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.

WARNING: **Ensure all high voltage battery covers/panels are installed prior to removal or installation of the high voltage battery assembly. Installing the covers/panels**

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will eliminate the risk of contact with exposed high voltage contact points during removal or installation. Failure to follow the procedure exactly as written may result in serious injury or death.

Removal Procedure

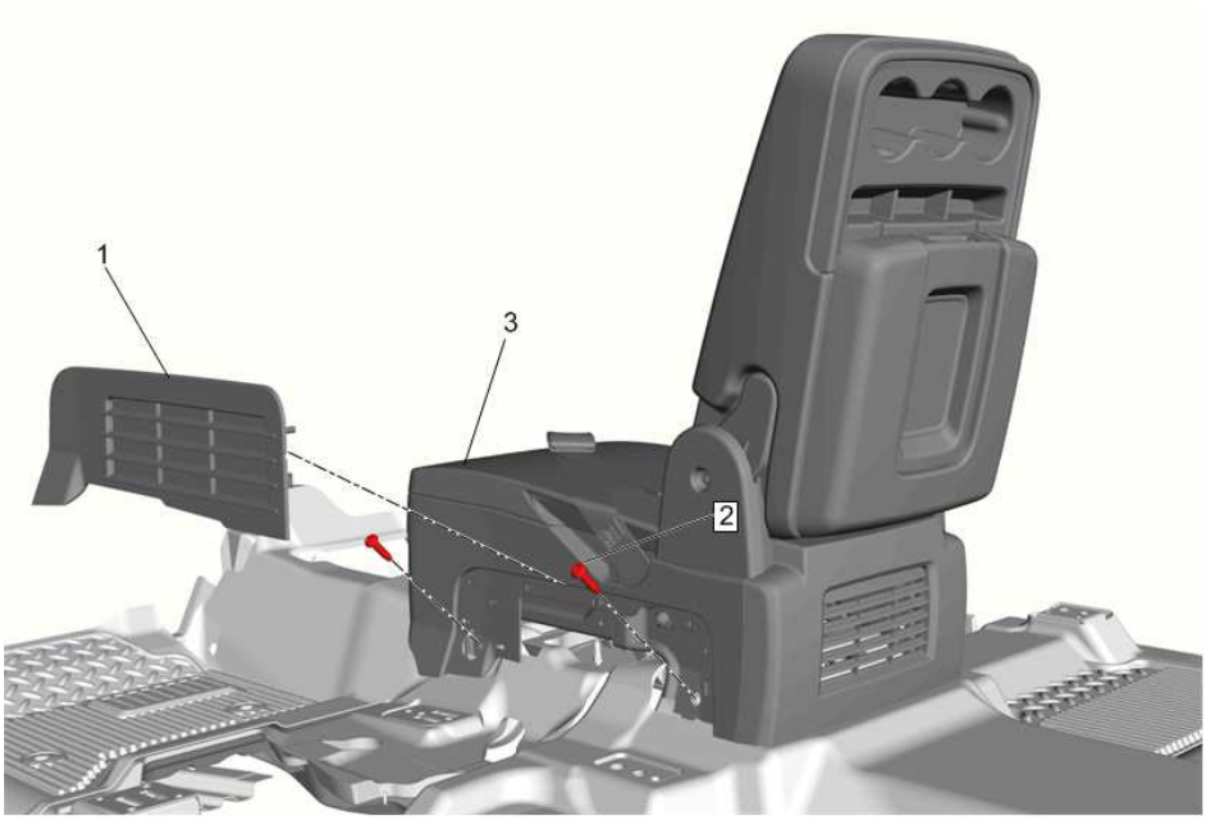


Fig. 109: Front Center Seat (HP5)
Courtesy of GENERAL MOTORS COMPANY

1. Front Center Seat 3 - Remove - **Front Center Seat Removal and Installation (Except HP5)** **Front Center Seat Removal and Installation (HP5)**
2. Disable the high voltage system. **High Voltage Disabling**

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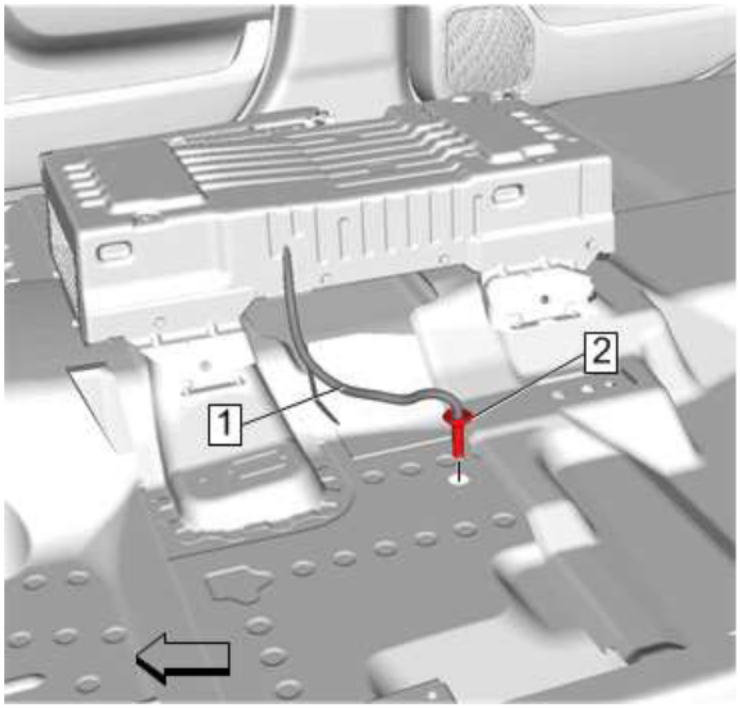


Fig. 110: Vent Tube Grommet
Courtesy of GENERAL MOTORS COMPANY

3. Peel back the floor carpet and disengage the vent tube grommet (2) and the high voltage battery vent tube (1), from the floor panel.

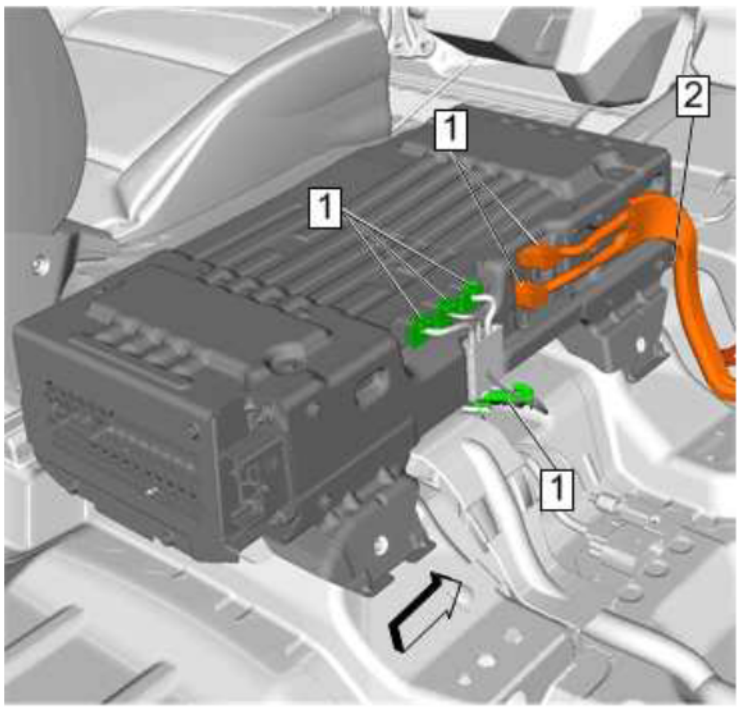


Fig. 111: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Electrical Connector 1 - Disconnect
5. Retainer 2 - Disengage

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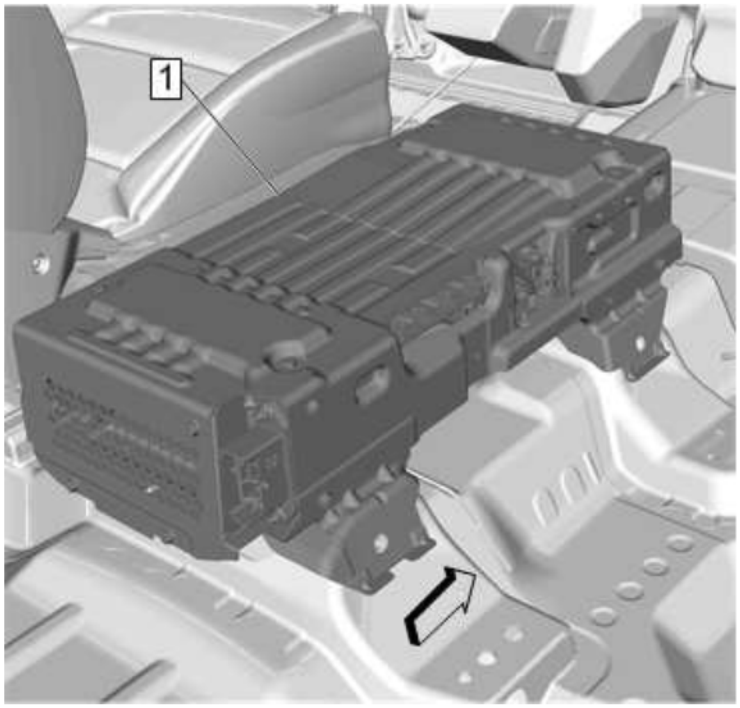


Fig. 112: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

6. High Voltage Battery 1 - Remove
7. If the high voltage battery is being replaced, perform the following return shipping instruction:

NOTE: **Never ship the returned high voltage battery with the drive motor battery high voltage manual disconnect lever installed.**

- Retain the drive motor battery high voltage manual disconnect lever handle for installation in the service replacement high voltage battery assembly.
- Retain the high voltage battery positive and negative cable cover for installation the service replacement high voltage battery assembly.
- Cover the exposed high voltage manual disconnect connector with UL listed, or equivalent, insulation tape rated at a minimum of 600V.
- Cover the exposed high voltage battery positive and negative cable connections with UL listed, or equivalent, insulation tape rated at a minimum of 600V.

Installation Procedure

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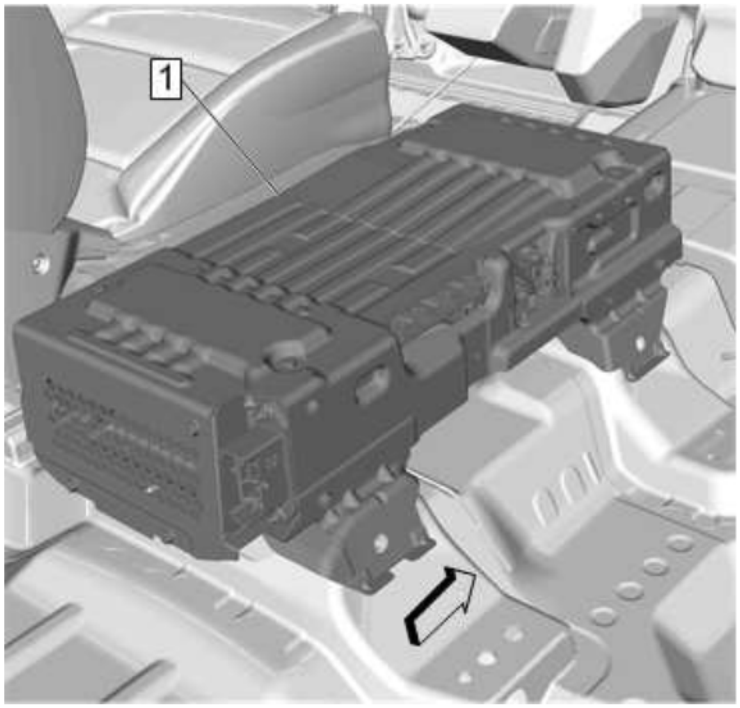


Fig. 113: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Install

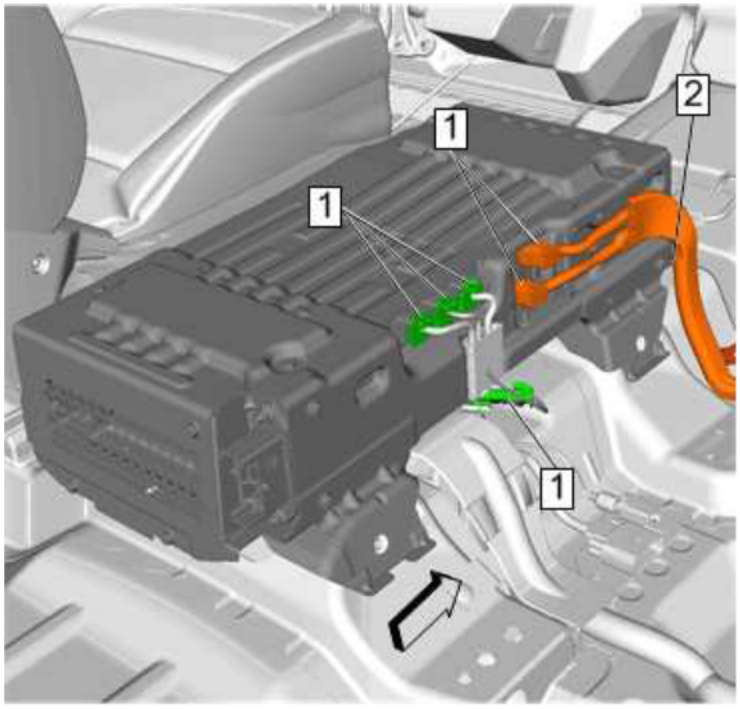


Fig. 114: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Electrical Connector 1 - Connect
3. Retainer 2 - Engage

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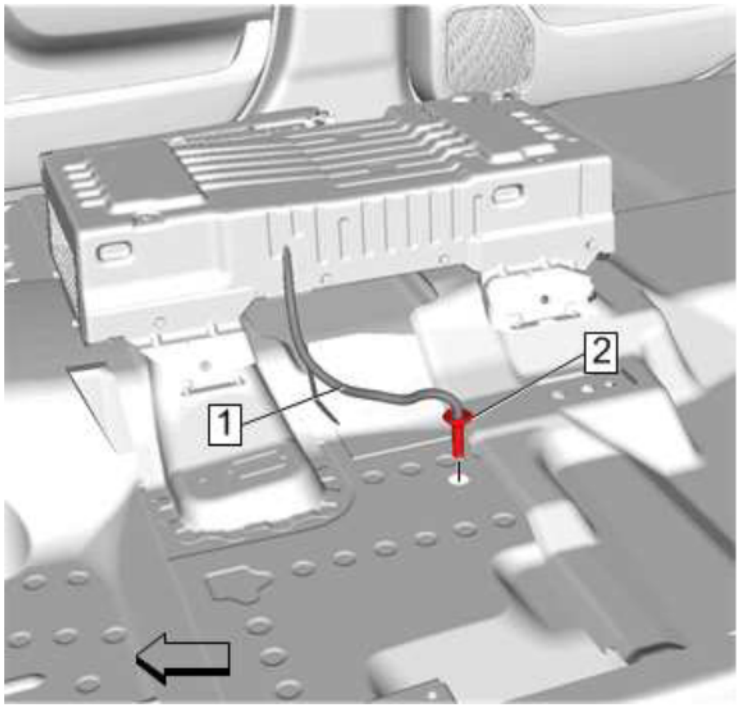


Fig. 115: Vent Tube Grommet
Courtesy of GENERAL MOTORS COMPANY

4. Install the high voltage battery vent tube (1) and the vent tube grommet (2), into the floor panel.



Fig. 116: Front Center Seat (HP5)
Courtesy of GENERAL MOTORS COMPANY

5. Front Center Seat 3 - Install - **Front Center Seat Removal and Installation (Except HP5) Front**

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Center Seat Removal and Installation (HP5)

6. Enable the high voltage system. High Voltage Enabling

CELL BATTERY VENT TUBE REPLACEMENT

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.

Removal Procedure

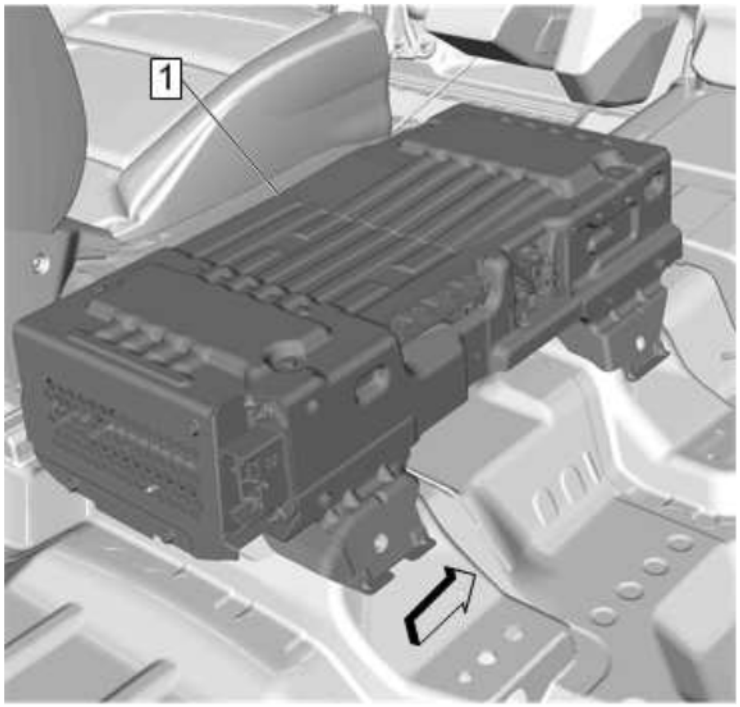


Fig. 117: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

1. High Voltage Battery 1 - Remove - High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)

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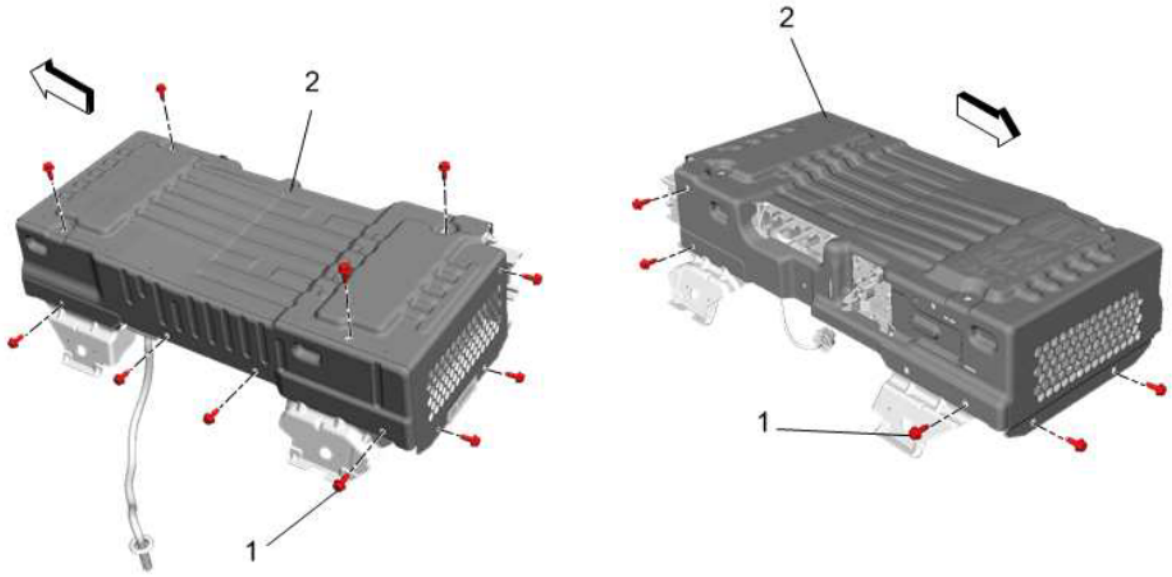


Fig. 118: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

2. High Voltage Battery Cover 2 - Remove - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

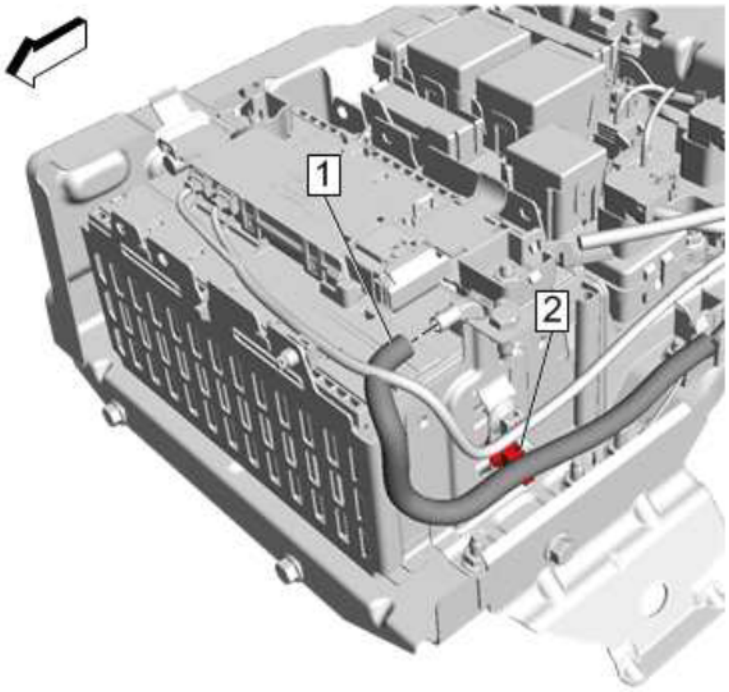


Fig. 119: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

3. Cell Battery Vent Tube 1 @Cell Battery Module - Disengage
4. Retainer 2 - Disengage

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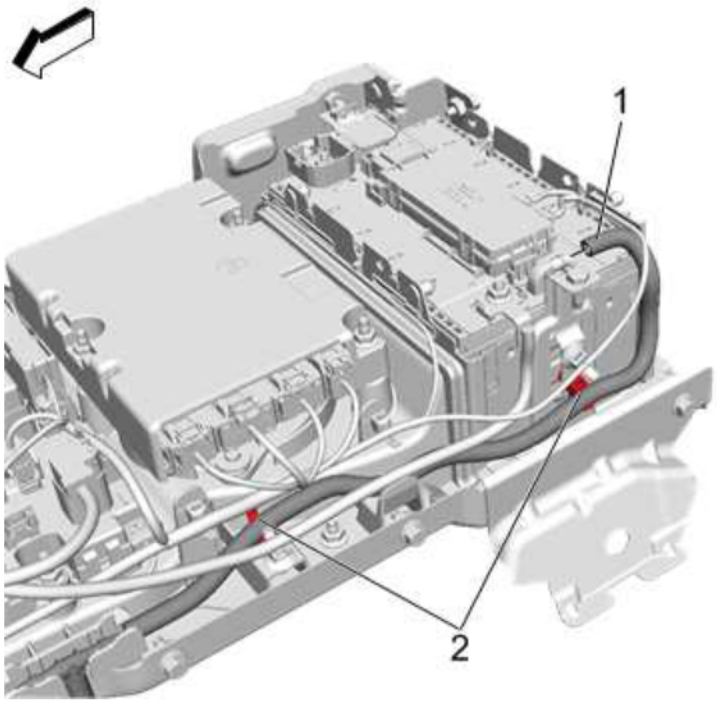


Fig. 120: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

5. Cell Battery Vent Tube 1 @Cell Battery Module - Disengage
6. Retainer 2 - Disengage

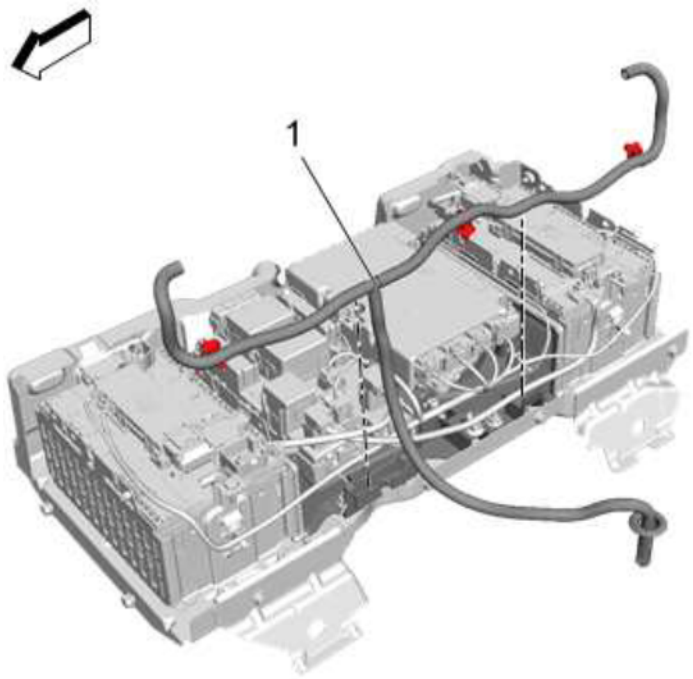


Fig. 121: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

7. Cell Battery Vent Tube 1 - Remove

Installation Procedure

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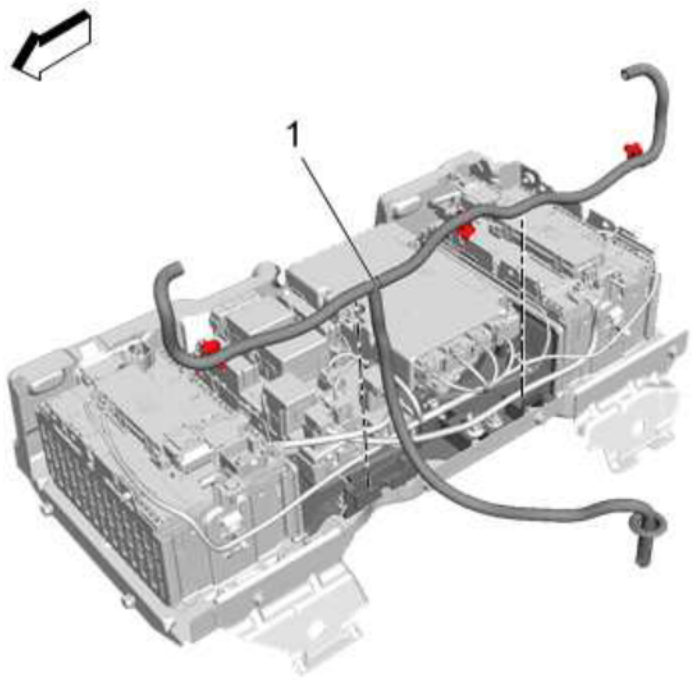


Fig. 122: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

1. Cell Battery Vent Tube 1 - Install

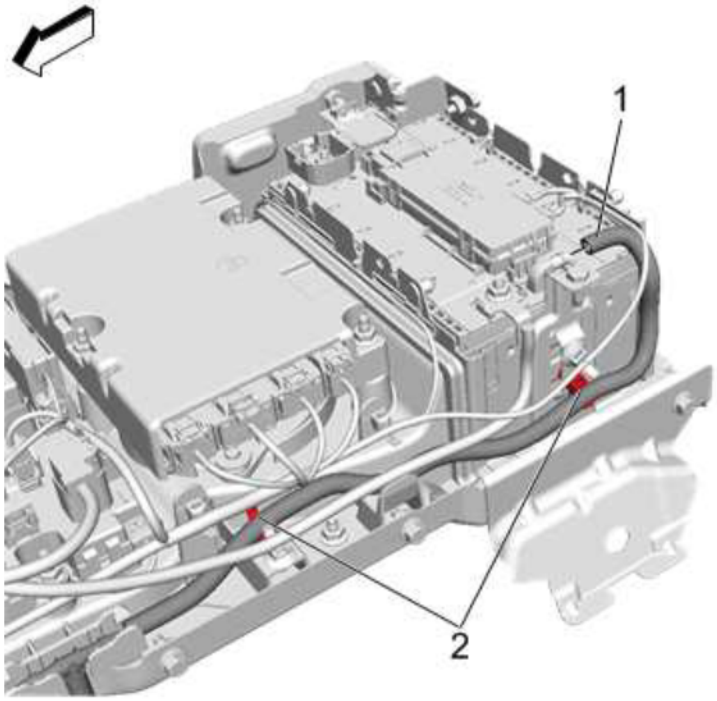


Fig. 123: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

2. Cell Battery Vent Tube 1 @Cell Battery Module - Engage
3. Retainer 2 - Engage

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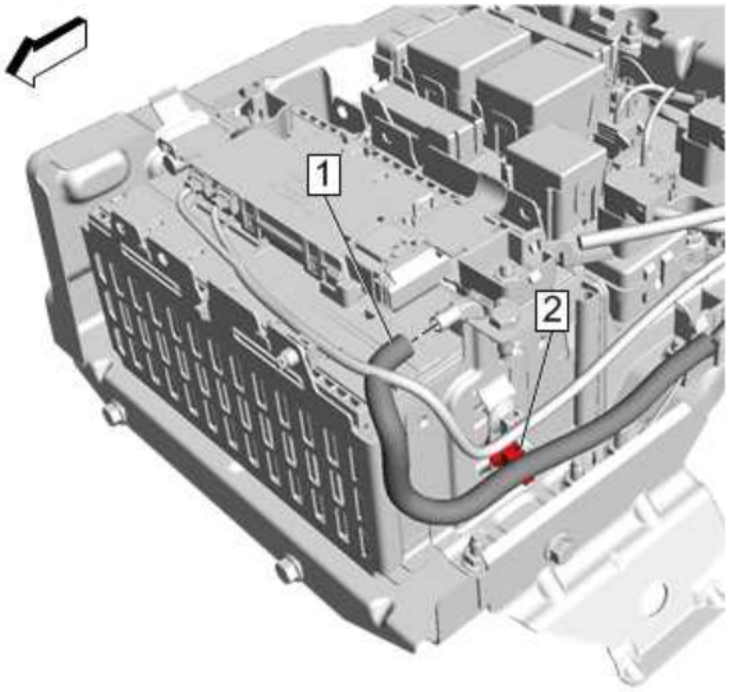


Fig. 124: Cell Battery Vent Tube
Courtesy of GENERAL MOTORS COMPANY

4. Cell Battery Vent Tube 1 @Cell Battery Module - Engage
5. Retainer 2 - Engage

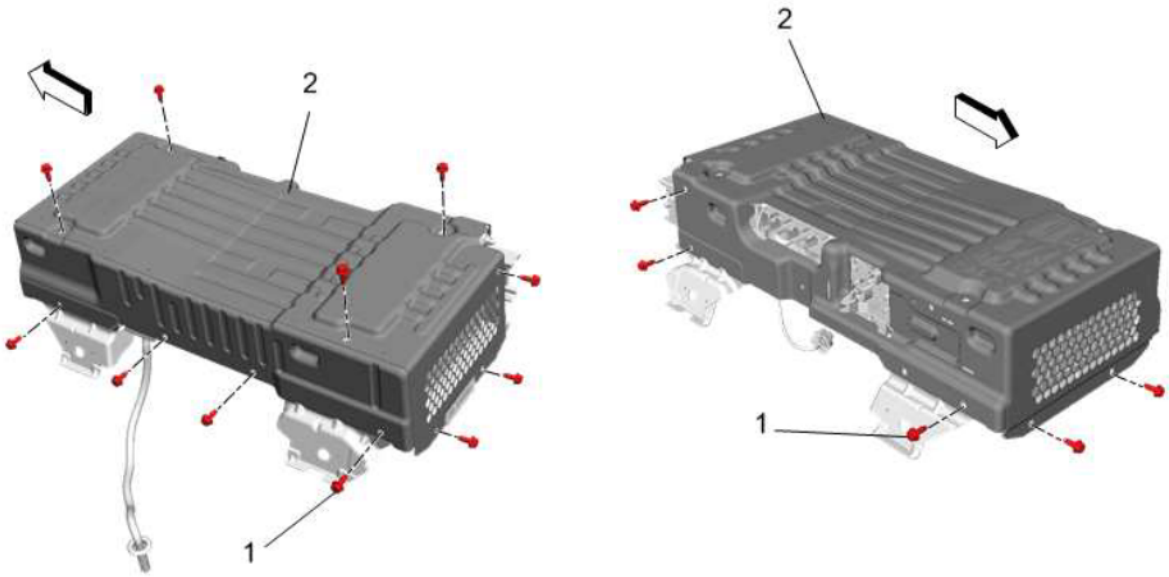


Fig. 125: High Voltage Battery Cover
Courtesy of GENERAL MOTORS COMPANY

6. High Voltage Battery Cover 2 - Install - **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**

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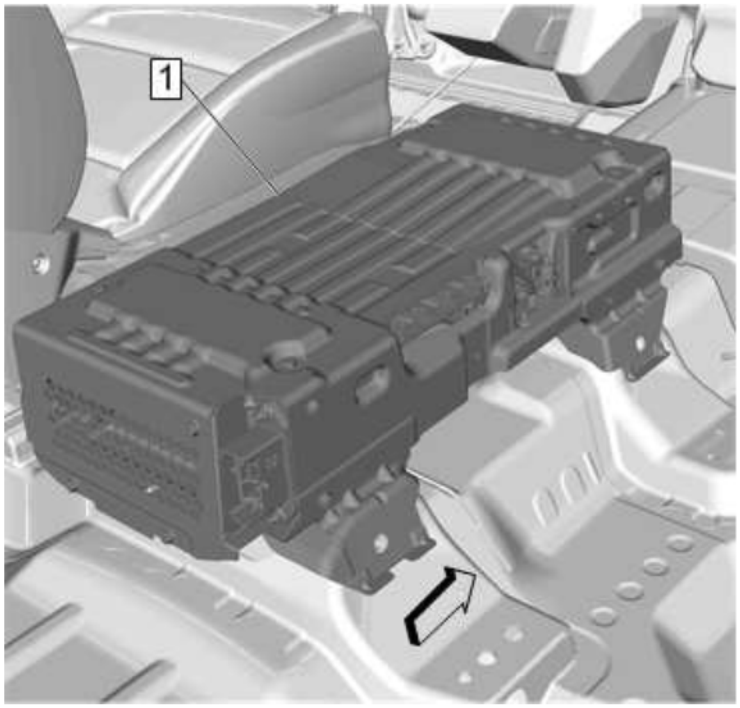
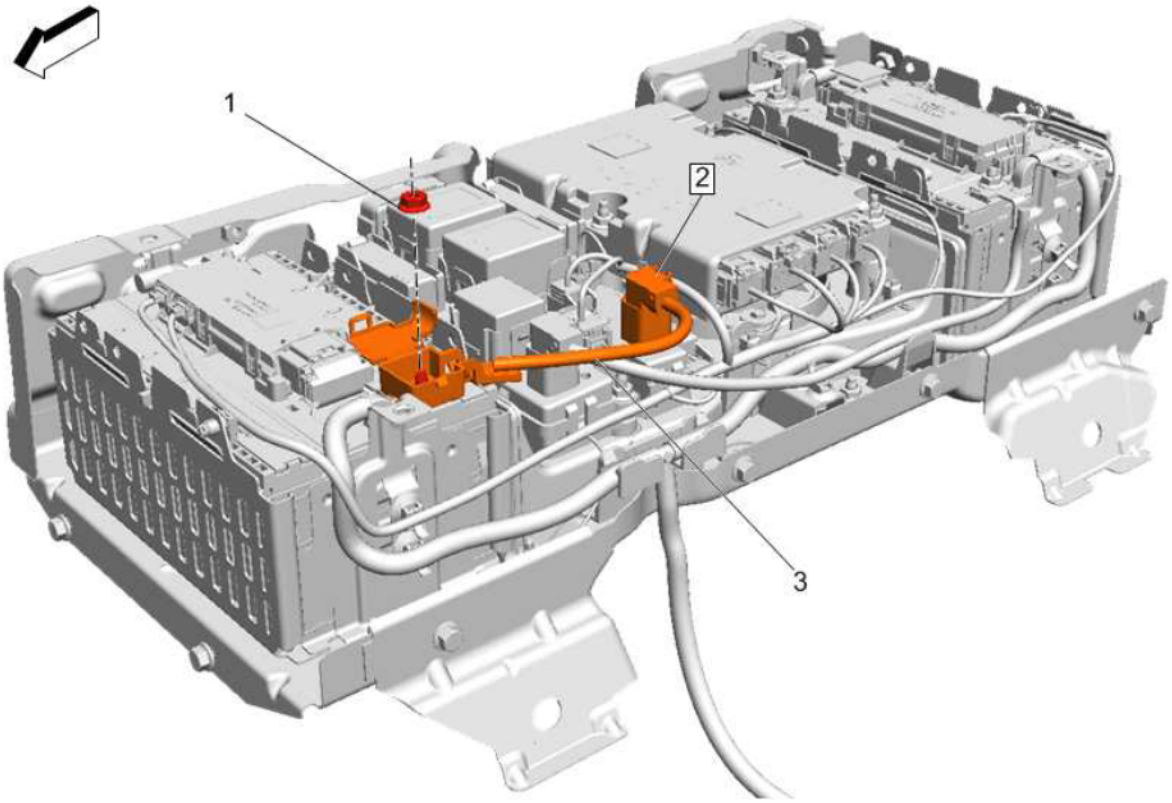


Fig. 126: High Voltage Battery
Courtesy of GENERAL MOTORS COMPANY

7. High Voltage Battery 1 - Install - **High Voltage Battery Replacement and Shipping Preparation (with Center Console)High Voltage Battery Replacement and Shipping Preparation (with Front Center Seat)**

AUXILIARY BATTERY CABLE REPLACEMENT (NEGATIVE CABLE)



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Fig. 127: Auxiliary Battery Cable (Negative Cable)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the high voltage battery cover. **High Voltage Battery Cover Replacement (Battery Positive and Negative Cable)High Voltage Battery Cover Replacement**	
1	**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**

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Callout	Component Name
	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.** Auxiliary Battery Negative Cable Fastener **CAUTION:** **Refer to Fastener Caution** **Tighten** 9 N.m (80 lb in)
2	Electrical Connector
3	Auxiliary Battery Negative Cable

CLEAR SECURED HIGH VOLTAGE DTCS

Circuit/System Description

The hybrid powertrain control modules 1 and 2 independently monitor for high voltage safety conditions such as airbag deploy events and certain high voltage system faults. When either module identifies one of these conditions, a DTC may set and the vehicle is placed into a 'high voltage lockout' state. While in the lockout state, the high voltage contactor relays are prevented from closing.

The purpose of the high voltage lockout state is to allow for high voltage system inspection prior to re-enabling. A complete inspection of the high voltage system and components must be performed if the vehicle has been involved in a collision. Perform the **High Voltage System Inspection** procedure, if necessary, prior to clearing

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a Secured High Voltage DTCs/lockout state.

Diagnostic Aids

- The following conditions may result in a HV lockout state without a corresponding DTC:
  - High voltage component replacement
  - Low 12 V battery event
  - SPS programming event
  - Airbag deployment/crash event detected: The Inflatable Restraint Sensing and Diagnostic Module may or may not set a DTC but will continue to broadcast a crash event status until reset.
- Performing a scan tool DTC Clear may clear the diagnostic that set the HV lockout state, but will not reset the lockout.
- Clearing powertrain DTCs will set the Inspection/Maintenance (I/M) system status indicators to NO.
- The Clear Secured High Voltage DTCs procedure must be completed when the following components, as applicable, are replaced:
  - K16 Hybrid/EV Battery Energy Control Module
  - K112A - K112H Hybrid/EV Battery Interface Control Module
  - A4 Hybrid/EV Battery Pack
  - K114A Hybrid/EV Powertrain Control Module 1
  - K114B Hybrid/EV Powertrain Control Module 2

Contactor Open Reasons Reset

The hybrid/EV powertrain control module 2, Hybrid/EV Battery Contactor Open Reasons scan tool parameter list identifies all past events that commanded contactors open. The parameters are reset only during reprogramming of the hybrid/EV powertrain control module 2. For this reason, any parameters indicating YES may be historic and not related to any current faults or conditions.

Reference Information

Special Tools

EL-49642 SPS Programming Support Tool

Equivalent regional tools:Refer to:**Special Tools** .

Circuit/System Verification

NOTE: **The engine must start to enable high voltage.**

1. Engine Running .
2. With a scan tool, verify the Hybrid/EV Powertrain Control Module 2 parameters Hybrid/EV Battery Positive Contactor Command and Hybrid/EV Battery Negative Contactor Command each indicate Closed.
   - **If the contactors are not commanded Closed**

     Refer to Circuit/System Testing.

   - **If the contactors are commanded Closed**

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3. A Secured High Voltage DTC HV lockout state is not present. All OK.

Circuit/System Testing

The Clear Secured High Voltage DTCs reset process requires scan tool interaction with **two or three different control modules in sequence** and can be completed using the following steps:

1. Install **EL-49642** SPS programming support tool.
2. Ignition ON. With a scan tool select the Hybrid/EV Powertrain Control Module 2, Hybrid Battery Pack Contactor Open Reasons data list. Verify if either the Crash Event Detected or Air Bag Deployed parameters indicate YES.
    - **If either parameter displays YES**
    1. Perform the **High Voltage System Inspection** procedure.
    2. If the results of the inspection procedure support enabling of the high voltage system, perform the Inflatable Restraint and Sensing Diagnostic Module function Reset High Voltage Disable Request After Crash Event Detected.
    3. Turn the vehicle OFF for 5 minutes.
    4. Proceed to next step.
    - **If BOTH parameters indicate NO**
3. Ignition ON. With a scan tool, clear All DTCs.

    NOTE: **A command reject may appear on the scan tool after the first Clear Secured High Voltage DTCs request. If this occurs, ignore this command reject and continue to the next step.**

4. With a scan tool, select Hybrid/EV Powertrain Control Module 2 Control Functions list. Select Clear Secured High Voltage DTCs and follow the on-screen instructions waiting 45 seconds before exiting the screen.
5. With a scan tool, select Hybrid/EV Powertrain Control Module Control Functions list. Select Clear Secured High Voltage DTCs. Select Continue button waiting 45 seconds before exiting the screen.
6. With a scan tool, select Hybrid/EV Powertrain Control Module 2 Control Functions list. Select Clear Secured High Voltage DTCs and follow the on-screen instructions.
7. With a scan tool, clear All DTCs.
8. Allow the Hybrid/EV powertrain Control Modules to enter sleep mode by performing the following:
    1. Ignition OFF.
    2. Ensure the scan tool is not communicating with any control modules by returning to the Home screen.
    3. Ensure the scan tool is accessible without having to open doors or otherwise cause control module wake-up.
    4. Shut all doors. Do NOT depress the brake pedal or activate any vehicle controls such as the parking lights, fuel door release, etc.

        NOTE: **Sleep mode is usually entered within two minutes after shutting off the vehicle. However, activating vehicle features may extend this time.**

    5. Wait 5 minutes with the vehicle in the prescribed condition so that the modules may enter sleep

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mode.

9. With a scan tool, verify the Hybrid/EV Powertrain Control Module 2 has gone to sleep by ensuring communication is not present.
    - **If communication is present**

      Repeat the previous step.

    - **If communication is not present**
10. Engine running.
11. Verify that no DTCs are set.
    - **If any DTCs are set**

      Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle** .

    - **If no DTCs are set**
12. All OK.

HYBRID/EV BATTERY CELL BALANCING

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**

Circuit/System Description

Hybrid/EV Battery Cell Balancing

The **EL-50332** Hybrid/EV Battery Service Tool is used to match the voltage level of a replacement battery section to the existing battery sections following a service event. The tool will charge or discharge the replacement section, as required, based on measured cell group voltage data. The **EL-50332** requires feedback from the battery energy control module during the balancing process. Communication is through the K114B Hybrid/EV Powertrain Control Module 2 X3 connector and a low voltage interface harness provided with the **EL-50332** Hybrid/EV Battery Service Tool. The charging and discharging is performed by direct connection to the replacement battery section positive and negative terminals.

Reference Information

Schematic Reference

Hybrid/EV Energy Storage Schematics

Connector End View Reference

Testing for Intermittent Conditions and Poor Connections

Description and Operation

Drive Motor Battery System Description

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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

Special Tools

- **EL-50332** Hybrid/EV Battery Service Tool
- **EL-50332-105** Universal Fuse Box
- **EL-50332-110** Vehicle Interface Module
- **EL-50332-120** High Voltage Interface Cable
- **EL-50332-125** Vehicle Interface Module Low Voltage 24-Pin Cable
- **EL-50332-145** Black Banana Jack Cable
- **EL-50332-150** Red Banana Jack Cable
- **EL-50332-155** Green Banana Jack Cable
- **EL-50332-170** High Voltage Alligator Clamps
- **EL-50332-175** 120 V Power Cable
- **EL-50332-175** 120 V Power Cable - EU
- **EL-50332-180** 250 V Power Cable - AUS
- **EL-50332-210** X3 HPCM2 Low Voltage Adapter Cable

Circuit/System Testing

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:

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- **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.

WARNING: **High voltage circuits should only be tested using a digital multimeter (DMM) and test leads with at least a CAT III rating, such as the J 39200-A Digital Multimeter. Failure to follow the procedures may result in serious injury or death.**

WARNING: **This vehicle is equipped with a high voltage battery that is completely isolated from the chassis ground. Never utilize AC powered test equipment to probe the high voltage system. Serious injury, death and component damage could occur if the high voltage system is grounded through the electric utility.**

Failure to follow the procedure exactly as written may result in serious injury or death.

WARNING: **Damage to a Lithium Ion hybrid/EV battery pack could result in fire, loss of electrical isolation or exposure to high voltage. Until the high voltage system inspection has been completed, store the vehicle with hybrid/EV battery pack installed outside in a secure area away from buildings and other vehicles and protected from rain, snow and other moisture. Remove the hybrid/EV battery pack high voltage manual disconnect lever and store it in a secure place outside the vehicle. Cover the exposed high voltage opening with ULÂ® listed, or equivalent, insulation tape rated at a minimum of 600 V.**

Failure to follow these precautions could result in personal injury, death and property damage.

Inspection Procedure

NOTE: **Before balancing a battery section, make sure all of the external EL-50332 components and cables are in good condition and working order.**

1. Connect the **EL-50332-145** Black Banana Jack Cable , **EL-50332-150** Red Banana Jack Cable , and **EL-50332-155** Green Banana Jack Cable to the **EL-50332-105** Universal Fuse Box.
2. Connect the **EL-50332-120** High Voltage Interface Cable to the **EL-50332-105** Universal Fuse Box.
3. Connect the **EL-50332-120** High Voltage Interface Cable to the **EL-50332** Hybrid/EV Battery Service Tool.
4. Connect the **EL-50332-210** X3 HPCM2 Low Voltage Adapter Cable to the **EL-50332-110** Vehicle Interface Module.
5. Connect the **EL-50332-125** Vehicle Interface Module Low Voltage 24-Pin Cable to the **EL-50332-110**

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Vehicle Interface Module.

6. Connect the **EL-50332-125** Vehicle Interface Module Low Voltage 24-Pin Cable to the **EL-50332** Hybrid/EV Battery Service Tool.

NOTE: **Refer to the Special Tools for the correct regional power cord.**

7. Connect the appropriate regional power cord to the **EL-50332** Hybrid/EV Battery Service Tool.
8. Connect the appropriate regional power cord into a known good power outlet.
9. Turn ON the **EL-50332** Hybrid/EV Battery Service Tool using the power switch.
10. At the MAIN MENU, select SECTION BALANCE, press the SELECT soft key.
11. At the TYPE menu, select EASSIST, press the NEXT soft key.
12. At the TARGET menu, select appropriate section to be balanced, press the NEXT soft key.
13. Connect the **EL-50332-155** Green Banana Jack Cable to the A4 Hybrid/EV Battery Pack ground stud.
14. Connect the **EL-50332-145** Black Banana Jack Cable to the appropriate section negative stud to be balanced. Refer to **Hybrid/EV Energy Storage Schematics** for Hybrid Battery Section 1 or Hybrid Battery Section 2.
15. Connect the **EL-50332-150** Red Banana Jack Cable to the appropriate section positive stud to be balanced. Refer to **Hybrid/EV Energy Storage Schematics** for Hybrid Battery Section 1 or Hybrid Battery Section 2.
16. Press the NEXT soft key.
17. Connect the **EL-50332-210** X3 HPCM2 Low Voltage Adapter Cable to the A4 Hybrid/EV Battery Pack.

NOTE: **Depending on the charge condition of the battery pack and the section being balanced, this process may take up to 4 hours to complete.**

18. Press the NEXT soft key.

NOTE: **The EL-50332 will now balance the selected section by charging/discharging, as appropriate. Target voltage varies based on measured pack cell group voltages. Initial balancing will be in a constant current mode (max 5 amp charge, 7.5 amp discharge). The tool will transition to a constant voltage mode (decreasing current) near the end of the event. A warranty code and pack voltage current data will be displayed at the conclusion of the balancing event.**

19. An audible tone will sound at the end of balancing or in the event of a fault condition.
    - **A fault condition was detected**

      Refer to the **EL-50332** Hybrid/EV Battery Service Tool Instruction Manual.

    - **Section balancing completed successfully**
20. At the Completed menu, press the NEXT soft key. Record warranty code. Press the EXIT soft key.
21. Disconnect the **EL-50332** Hybrid/EV Battery Service Tool from the Hybrid/EV Battery Pack.
22. All OK.

DESCRIPTION AND OPERATION

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DRIVE MOTOR BATTERY SYSTEM DESCRIPTION

Hybrid/EV Energy Storage System

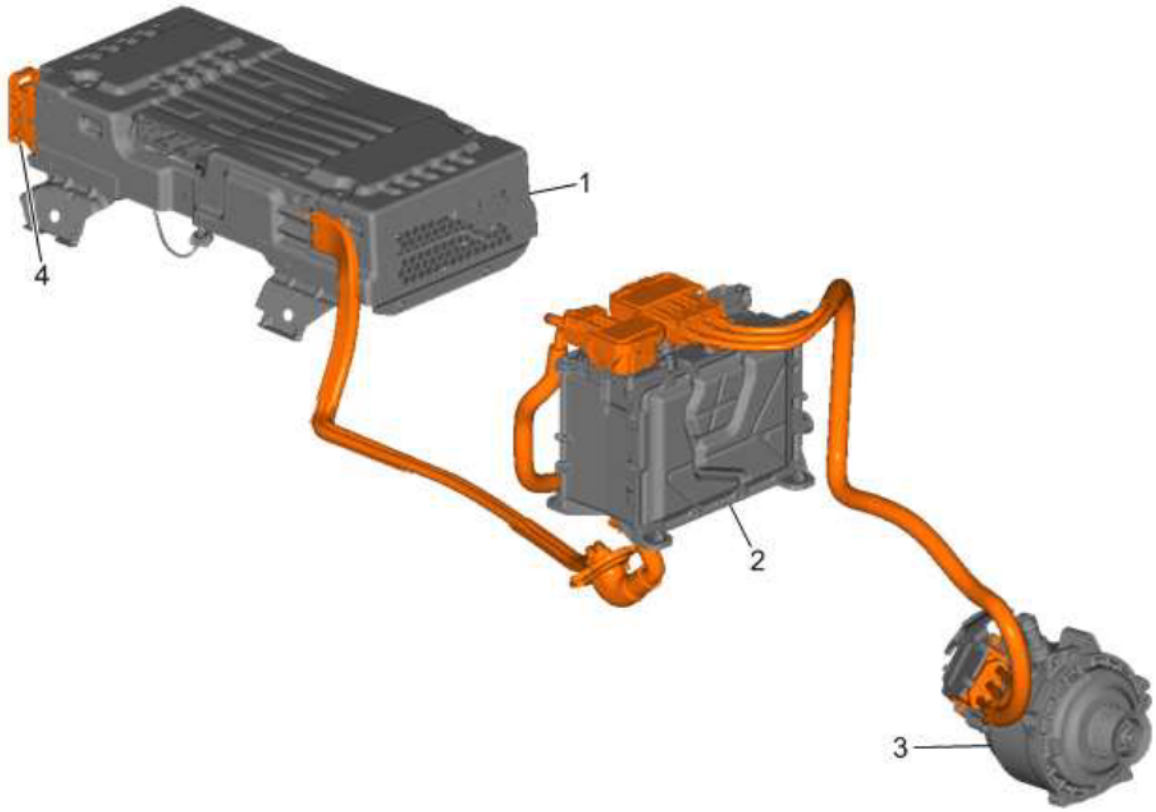


Fig. 128: Hybrid/EV Energy Storage System
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Callout	Component Name
1	High Voltage Battery Assembly
2	Starter/Generator Control Module
3	Starter/Generator
4	Manual Service Disconnect

The drive motor battery is also known as the high voltage battery assembly. The high voltage battery assembly stores 86V DC in two lithium-ion battery sections. Current flows from the battery sections through a series of contactors contained in the disconnect relay assembly and a manually operated service disconnect. This allows the system to control the disconnect of high voltage from the vehicle and also creates a redundant manual disconnect to ensure voltage is disabled when servicing high voltage components. The service disconnect contains an internal non-serviceable fuse.

To ensure optimum life of the lithium-ion batteries, the hybrid powertrain control module 2 monitors the state of charge of each battery cell. The system will equalize the state of charge of each cell through a balancing process. The hybrid powertrain control module 2 is also responsible for monitoring and controlling the charging and the discharging of the high voltage battery.

The high voltage battery is charged during normal vehicle driving. During normal operation, the high voltage battery is maintained at or near an optimum level of charge.

The High Voltage Battery Assembly is a modular battery pack assembly that not only contains the lithium-ion

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battery sections, but also many of the control modules and components used by the eAssist system.

The High Voltage Battery Assembly contains the following serviceable components:

- Hybrid/EV Battery Section 1
- Hybrid/EV Battery Section 2
- Hybrid/EV Powertrain Control Module 2
- Hybrid Battery Interface Control Modules
- Generator battery disconnect relay assembly - contains:
  - Main Contactors
  - Pre-Charge Contactor
  - Hybrid/EV Battery Pre-Charge Resistor
  - Hybrid/EV Battery Pack Current Sensor
- Hybrid/EV Battery Pack High Voltage Manual Disconnect Lever

High Voltage Battery Assembly

The High Voltage Battery Assembly is located in the passenger compartment of the vehicle, directly beneath the front floor console, and serves as a modular assembly to contain many of the eAssist control modules and system components. The High Voltage Battery Assembly may also be referred to as the following names:

- Energy Storage System
- Hybrid/EV Battery Pack
- Drive Motor Battery
- Generator Battery

The high voltage battery first consists of a metal tray that is fixed to the vehicle floor. This provides a strong mount for other components to secure to. Within the battery assembly, the hybrid/EV battery section 1 and hybrid/EV battery section 2 are located at each end. Directly between the battery sections is the hybrid/EV powertrain control module 2 and the generator battery disconnect relay assembly. A case cover is secured over the top of all components, effectively creating the High Voltage Battery Assembly and preventing access to any high voltage components without first disabling the high voltage system.

The lower metal tray also provides a mounting surface for the High Voltage Battery Assembly Cooling Fan and has an opening where air is drawn into the battery assembly to direct air through the internal components. Refer to **Hybrid Energy Storage Component Views**.

Hybrid/EV Battery Section 1 and Hybrid/EV Battery Section 2

The hybrid/EV battery section 1 and hybrid/EV battery section 2 are a pair of lithium-ion batteries connected in series to make up the 86V DC battery. They are also referred to as the Cell Battery Modules.

Each hybrid battery section contains 12 cells that are connected in series using internal bus bars. The two battery sections are each connected in series using high voltage cable. Each of the 24 individual cell groups is rated at 3.6V, for a nominal system voltage of 86V DC.

The hybrid battery sections are air cooled. Air is blown through the battery case to cool the individual cells. Attached to each section is a vent tube. In the event of a damaged battery, any outgassing will be vented to the outside of the vehicle.

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Within each section, a voltage sense circuit is attached to the individual cells. Additionally, two thermistors monitor the temperature of each section. All of these circuits terminate at a Hybrid Battery Interface Control Module located on the top surface of each battery section. The interface modules are connected to each other and the hybrid/EV powertrain control module 2 via serial data.

Hybrid/EV Powertrain Control Module 2

The hybrid/EV powertrain control module 2 is located between the hybrid/EV battery section 1 and hybrid/EV battery section 2. The module is responsible for monitoring the hybrid/EV battery section 1 and hybrid/EV battery section 2 parameters via the hybrid battery interface control modules.

The hybrid/EV powertrain control module 2 is responsible for the cell balancing process. During operation, individual cells may charge or discharge at different rates. To ensure proper battery health and optimal life, these voltages are balanced, with energy from a higher voltage cell being transferred to a lower voltage cell. This keeps the voltage consistent between all the cell groups. Cell balancing is an internal process of the hybrid battery interface control module. Internal gates allow energy to flow between cells using the same circuits that are used to monitor cell voltage.

Starter/Generator Control Module

The Starter/Generator Control Module is a multifunction module that is involved in many eAssist system operations. Mounted in the engine compartment, the Starter/Generator Control Module contains the hybrid/EV powertrain control module 1, drive motor control module and the 14V Power Module.

The hybrid/EV powertrain control module 1 is responsible for the following:

- Communicating with the hybrid/EV powertrain control module 2 to determine the status of the high voltage battery
- Controlling the battery and Starter/Generator cooling systems
- Host controller for DTC information for the drive motor control module and the 14V power module
- Supplying 12V to the vehicle

The drive motor control module is responsible for the following:

- Controlling the power inverter module, which converts high voltage direct current (DC) electrical energy to 3-phase alternating current (AC) electrical energy
- Monitoring the starter/generator

The 14V power module converts high voltage (86V) direct current (DC) to low voltage (12V) DC for accessory electrical operation and to charge the 12V battery.

High Voltage Battery and Starter/Generator Cooling

The Hybrid/EV Powertrain Control Module 2 uses temperature information from the hybrid battery interface control modules to control the Hybrid/EV Battery Pack Cooling Fan.

The Hybrid/EV Powertrain Control Module 1 monitors the Starter/Generator coolant temperature sensor and will control the Starter/Generator coolant pump relay, which controls the Starter/Generator coolant pump.

High Voltage Contactors

At times, it may be necessary to disconnect high voltage from the vehicle, both during normal operation and

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when a system fault is identified. The Hybrid/EV Powertrain Control Module 2 controls the main and pre-charge contactors to disconnect and connect high voltage from the vehicle.

High Voltage Isolation

The Starter/Generator Control Module and the Hybrid/EV Powertrain Control Module 2 each monitor the electrical potential between high voltage and the vehicle chassis. High voltage should always be isolated from the vehicle chassis by a certain amount of resistance. In the event that a high voltage leak path is detected to the vehicle chassis, the applicable control module will set a DTC and open the high voltage contactors.

Testing for loss of isolation requires special tools and procedures. Because of the high voltages present in the hybrid system, a loss of isolation may occur due to insulation breakdown. Insulation breakdown typically occurs only when high voltage is present. Conditions such as insulation breakdown cannot be diagnosed with a typical DMM because high voltage is not used by the DMM when measuring resistance. Refer to **Hybrid/EV System High Voltage Isolation Description**.

12V Output

The 14V Power Module within the Starter/Generator Control Module essentially takes the place of the generator on a traditional vehicle. The 14V Power Module converts high voltage DC to 12-16V DC for accessory electrical operation and to charge the 12V battery.

Main Contactors, Pre-Charge Contactor, and Pre-Charge Resistor

The high voltage contactors are switches that are controlled like a relay. To disable high voltage from outside of the battery pack, the main and pre-charge contactors are commanded open. This will open the contactors and physically disconnect the hybrid/EV battery positive and negative cables. To enable high voltage, first the main negative contactor is closed. Then the pre-charge positive contactor is closed. With the pre-charge contactor closed, current flows through the pre-charge resistor. Flowing through a pre-charge resistor allows high voltage to slowly build in the system. Once high voltage is brought up though the pre-charge contactor and resistor, the main positive contactor is closed and high voltage is active. Once the main positive contactor is closed, the pre-charge positive contactor is opened. If the high voltage builds too quickly or too slowly, the Hybrid/EV Powertrain Control Module 2 will set a fault.

Ground is applied at all times to each contactor. Each contactor is controlled by an independent high side driver in the Hybrid/EV Powertrain Control Module 2. When the control module commands the contactor closed, 12V B+ is applied to the contactor through the high side driver and the contactor is closed.

The contactors and the pre-charge resistor are located in the generator battery disconnect relay assembly. The generator battery disconnect relay assembly is a plastic tray that is secured next to the Hybrid/EV Powertrain Control Module 2. The generator battery disconnect relay assembly also contains the Hybrid/EV Battery Pack current sensor and high voltage fuses.

High Voltage Battery Current Sensor

The current sensor is a three-wire hall effect sensor that measures current flow in and out of the high voltage battery assembly. The Hybrid/EV Powertrain Control Module 2 applies 5 volt and provides a low reference to power the sensor. Current measurement is communicated to the control module via a 5V signal circuit.

The current sensor is a non-serviceable part of the generator battery disconnect relay assembly. The current sensor monitors current on the negative high voltage bus bar.

Drive Motor Battery High Voltage Manual Disconnect Lever and Generator Battery Fuse

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The Drive Motor Battery high voltage manual disconnect lever provides a redundant method to disconnect high voltage from vehicle when performing service on the system. With the lever removed, high voltage is physically disconnected from the two hybrid/EV battery sections. Together with the high voltage contactors, the manual disconnect provides a means of disconnecting high voltage at two points in the system.

Located within the disconnect lever, the generator battery fuse is used to prevent an overcurrent condition in the 86V DC system. The manual disconnect is also used as a tool to remove the High Voltage Locking Push-Pin safety feature. The locking push-pin prevents removal of the high voltage cable cover without first removing the manual disconnect from the high voltage battery assembly.

Vehicle Collision Detection

As a safety precaution, the Hybrid/EV Powertrain Control Module 2 monitors the collision event messages from the Inflatable Restraint Sensing and Diagnostic Module (SDM). This message is broadcast by the SDM via serial data to inform various control module that a collision event has occurred so they can take appropriate action. This message does not indicate the severity of the collision, nor does it indicate that airbag deployment has been commanded.

If a collision event message is received by the Hybrid/EV Powertrain Control Module 2, it will enter a collision event detected state and respond by opening the high voltage contactors.

If a collision event detected state has occurred, the **High Voltage System Inspection**, procedure must be performed to ensure the high voltage system has not been compromised. The collision event detected condition will remain active until cleared using the **Clear Secured High Voltage DTCs** procedure.

HYBRID/EV SYSTEM HIGH VOLTAGE ISOLATION DESCRIPTION

Loss of Isolation Description

Vehicles equipped with high voltage storage and propulsion capability are designed with the high voltage circuits isolated from the vehicle chassis. If either the positive or negative high voltage Direct Current (DC) circuits or any of the high voltage Alternating Current (AC) phase circuits lose this isolation to the vehicle chassis, one or more diagnostic trouble codes (DTCs) may set.

Similar to typical 12V vehicle systems, loss of isolation can be as simple as a direct conductor-to-chassis short. Unlike 12V systems however, the potential within high voltage systems means that insulation breakdown is also a cause for loss of isolation. Therefore diagnosis for isolation loss requires testing with high voltage potential. Special multi-meters that utilize their own built-in high voltage, such as the **EL-50772** Insulation Multimeter , are used to test the isolation capability of high voltage components and circuits. Additionally, monitoring certain scan tool parameters when high voltage is active may also help to identify which high voltage components and circuits may have lost their chassis isolation.

Vehicle Loss of Isolation Detection

The vehicle performs two independent tests for isolation:

1. Passive isolation testing which is performed within the power inverter module by the hybrid powertrain control module 1. The power inverter module is also known as the starter/generator control module.
2. Active isolation testing which is performed within the high voltage battery assembly by the hybrid powertrain control module 2.

Passive Isolation Testing

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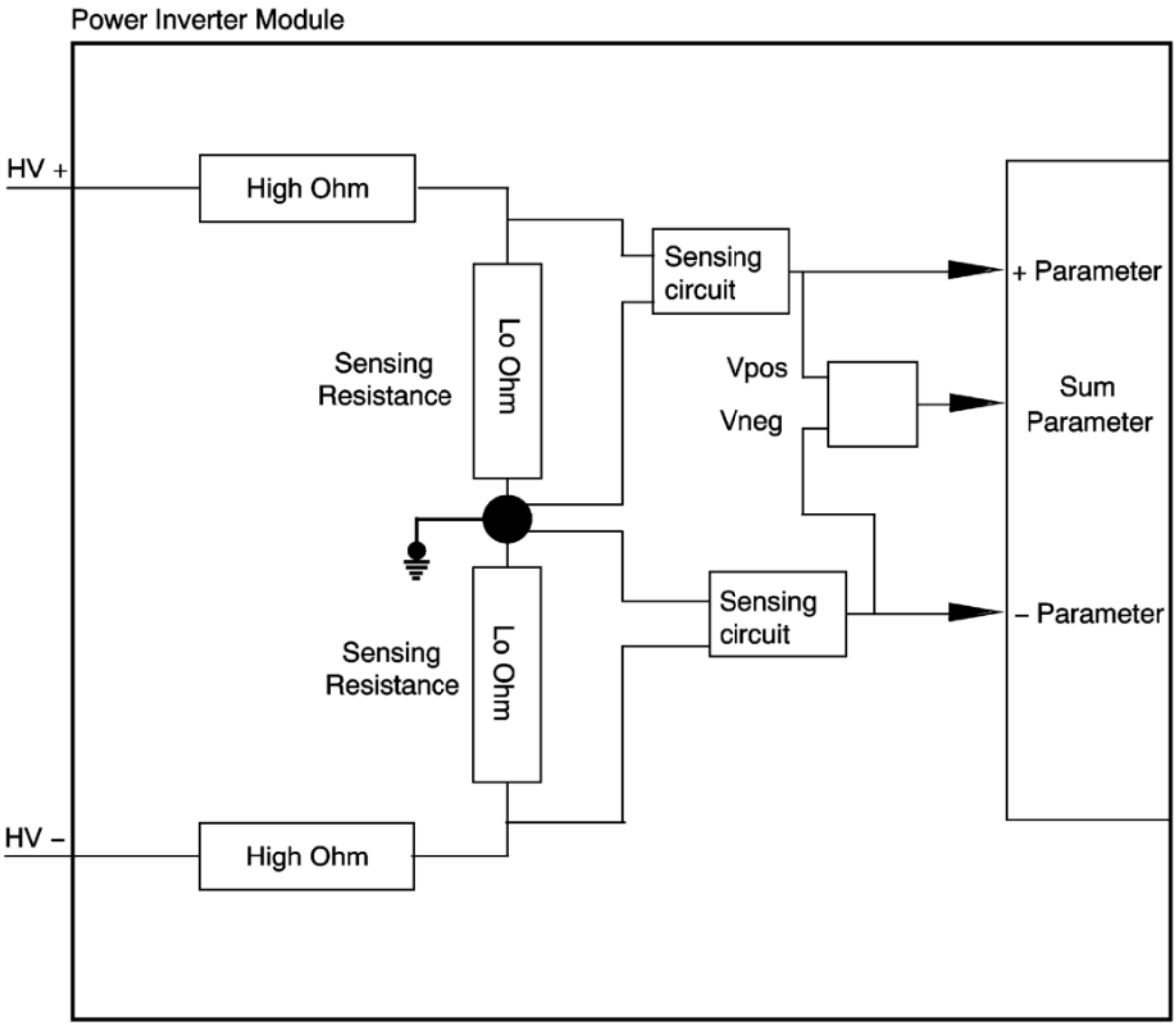


Fig. 129: Power Inverter Module Operation Graph
Courtesy of GENERAL MOTORS COMPANY

The starter/generator control module continuously performs isolation testing whenever high voltage to the module is present. The Drive Motor Control Module Positive Supply Isolation Voltage and the Drive Motor Control Module Negative Supply Isolation Voltage scan tool parameters give a real-time indication of Isolation status. With high voltage contactors closed and under normal operating conditions each of the parameters will indicate about half of the total high voltage battery assembly high voltage potential. When a loss of isolation condition is observed, the Voltage scan tool parameter values will shift in respect to each other. When the voltage shift exceeds a set ratio, DTCs P1AF0, P1AF2, or P1E22 will set as applicable.

Active Isolation Testing

Active isolation testing is dedicated to monitoring the internal high voltage battery assembly HV circuits. The hybrid/EV powertrain control module 2 switches fixed resistors between the high voltage system and vehicle chassis. The difference between the switched-to-chassis state and the unswitched state is used to calculate a resistance-to-chassis value. When resistance-to-chassis decreases below a set value, DTC P0AA6 will set.

Active isolation testing occurs when the main high voltage contactor relays are open. For this reason most testing of the high voltage battery assembly occurs just after the vehicle is shut off following a drive trip. The Isolation Test Resistance scan tool parameter indicates the resistance-to-chassis calculation determined when the last Active isolation test was performed.

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High Voltage System

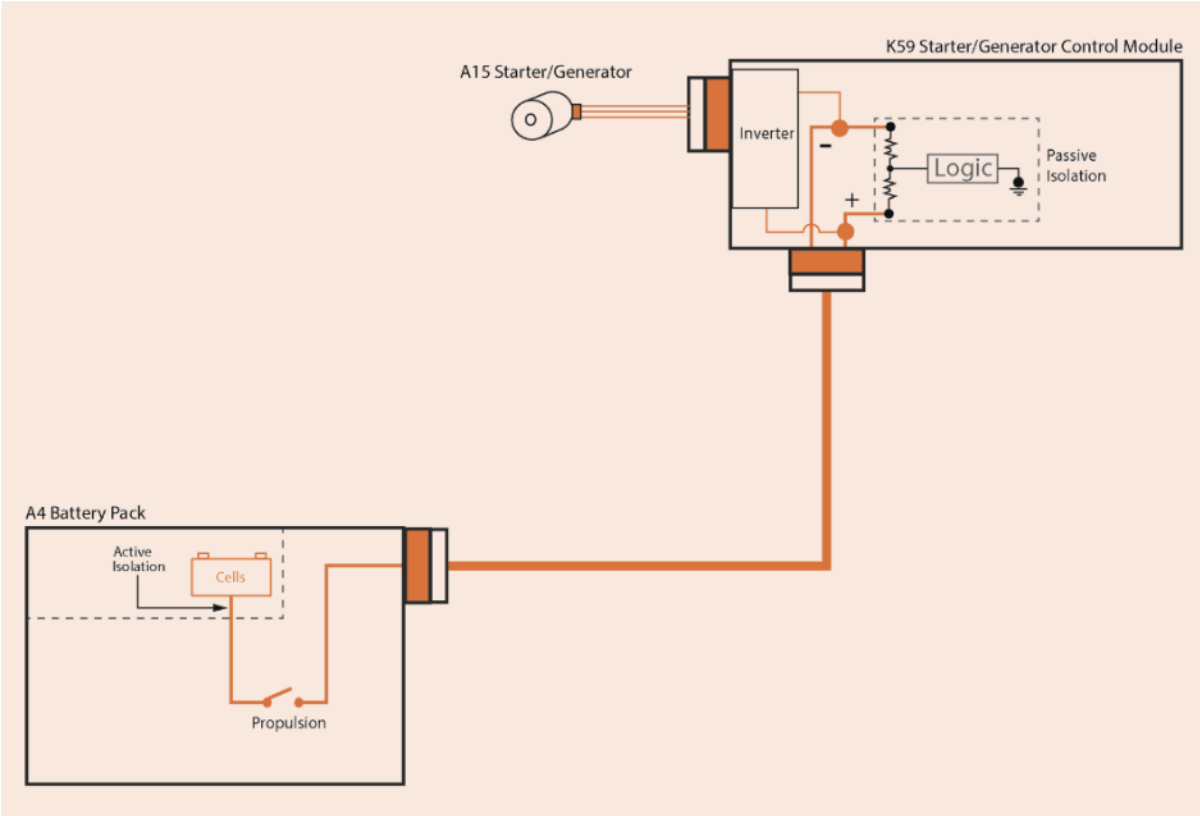


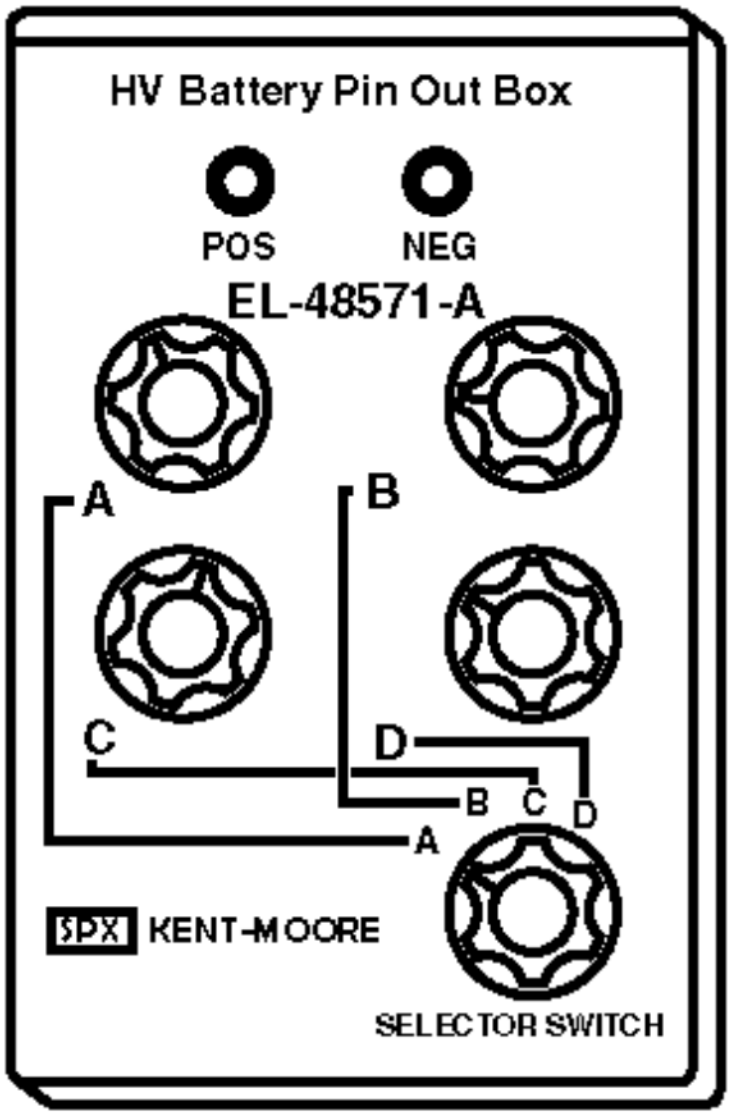
Fig. 130: High Voltage System
Courtesy of GENERAL MOTORS COMPANY

SPECIAL TOOLS AND EQUIPMENT

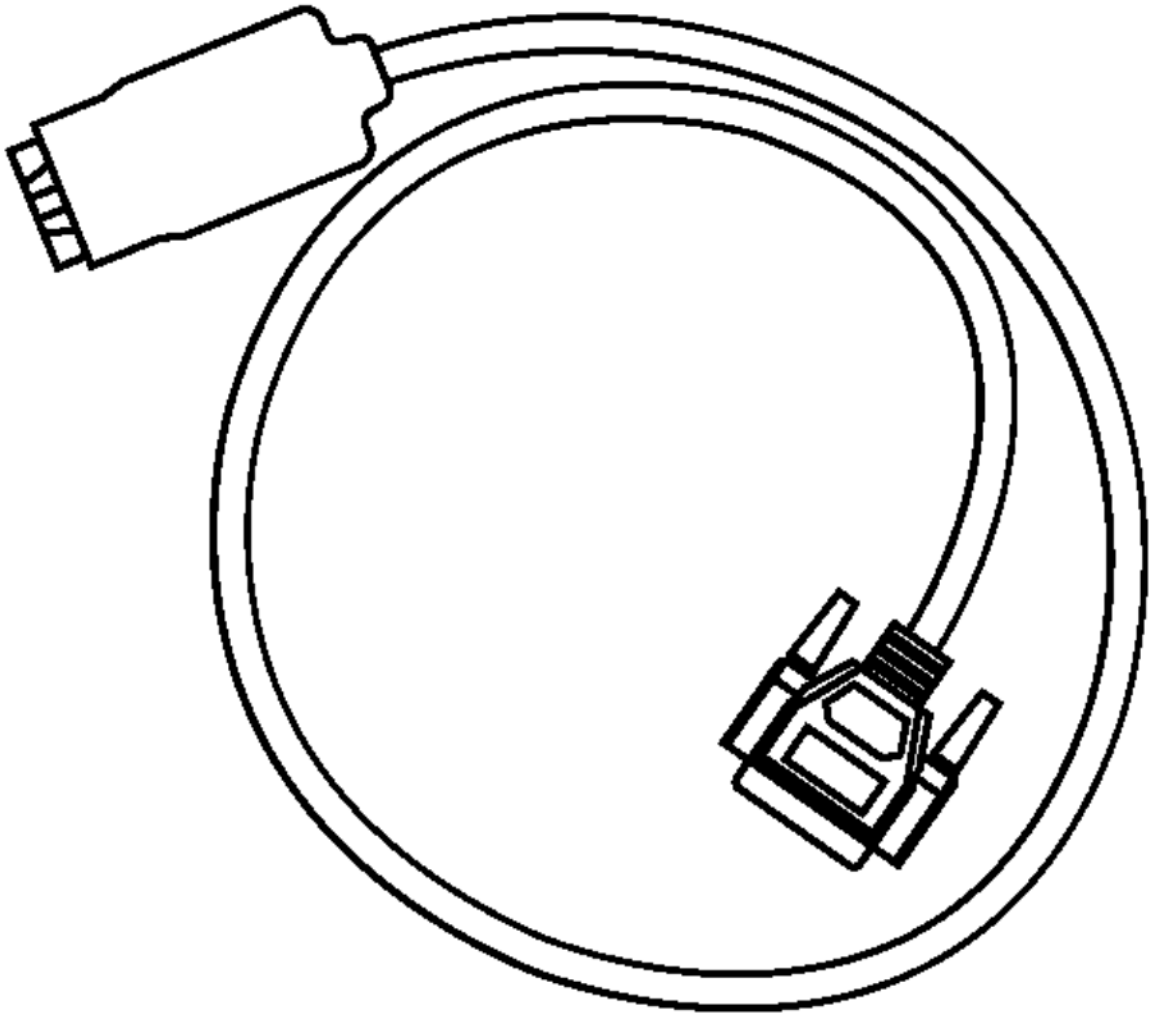
SPECIAL TOOLS

Illustration	Tool Number/ Description

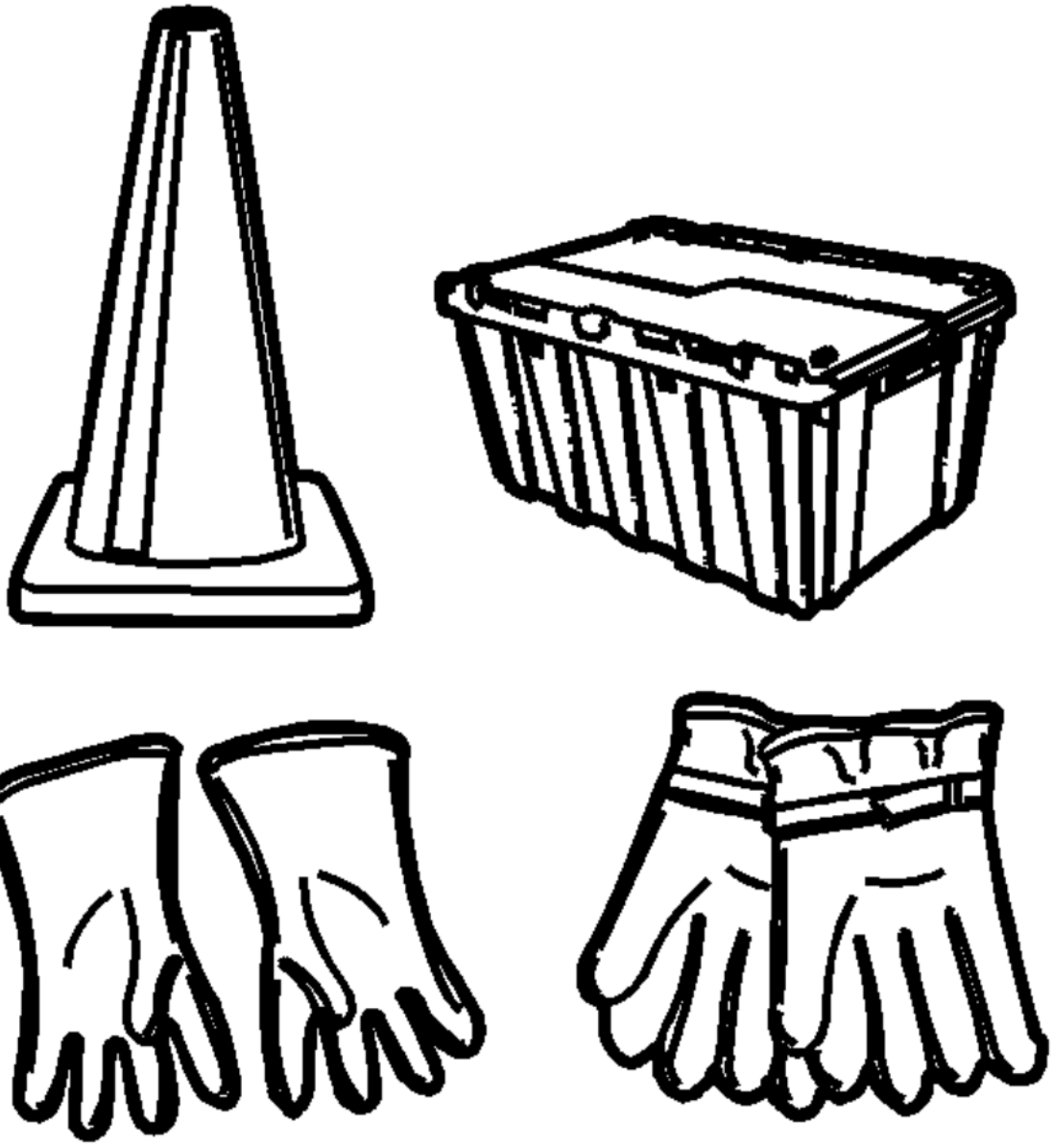
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Illustration	Tool Number/ Description
	EL-48571-A HV Pinout Box

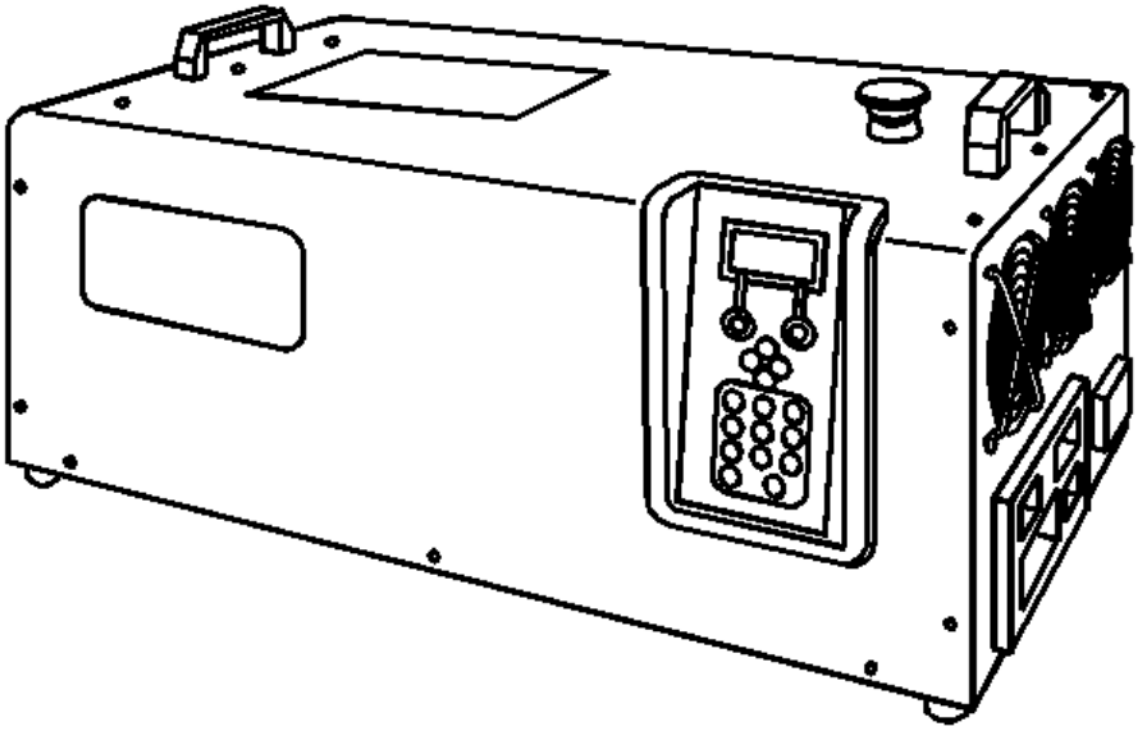
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Illustration	Tool Number/ Description
	EL-48571-45 Pinout Box Adapter Harness

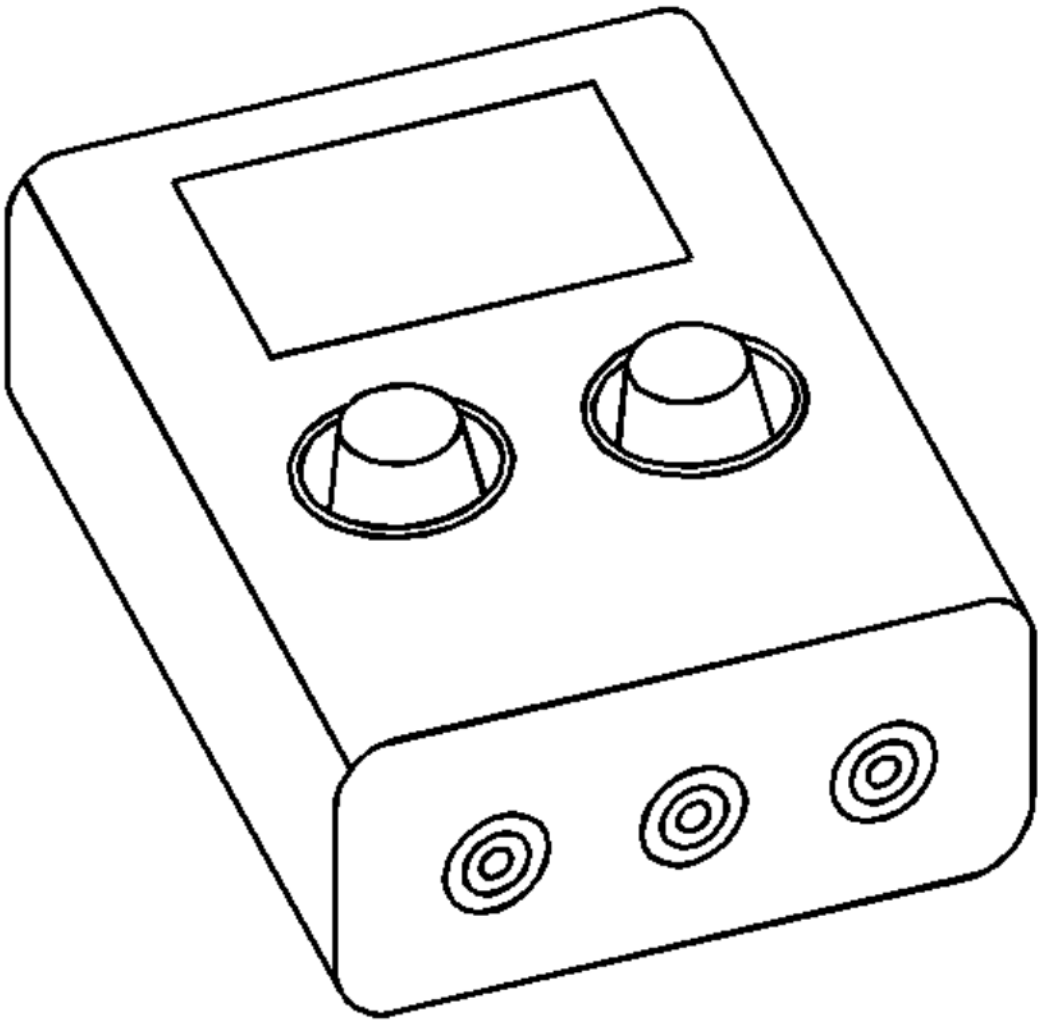
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Illustration	Tool Number/ Description
	EL-48900-A HV Safety Kit

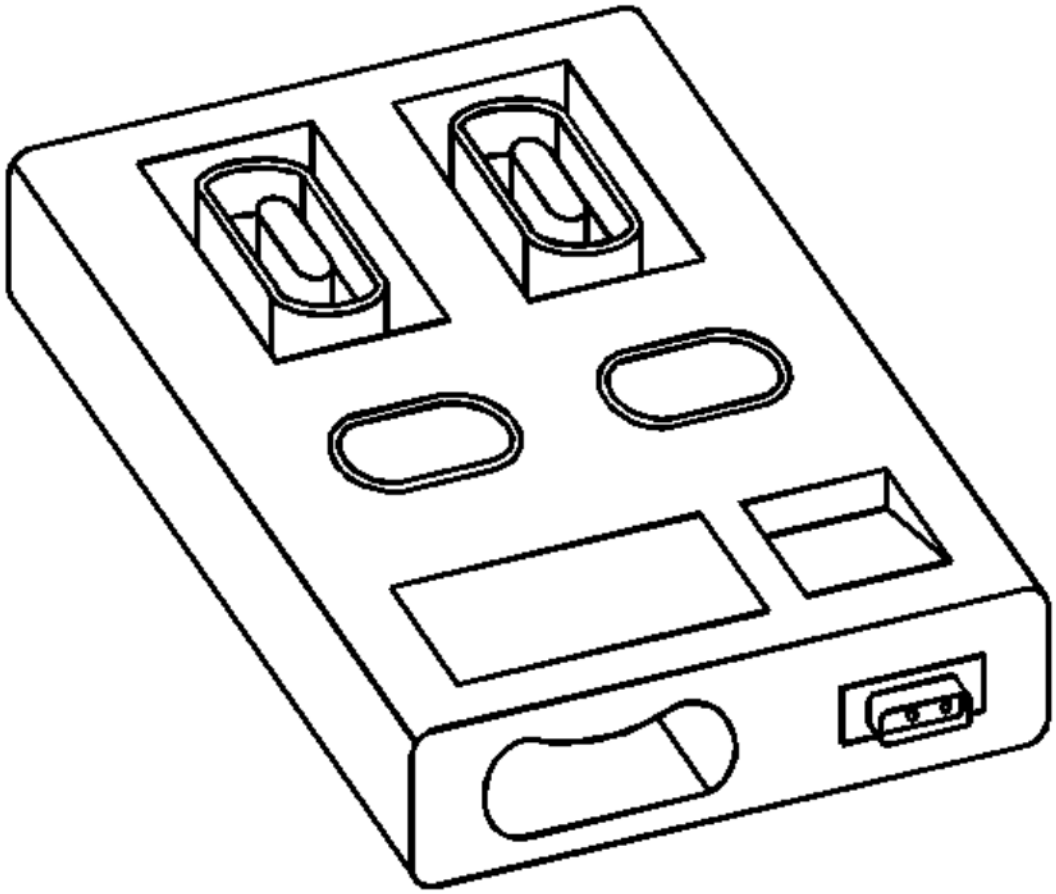
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Illustration	Tool Number/ Description
	EL-50332 Battery Discharge/Load Leveling Tool

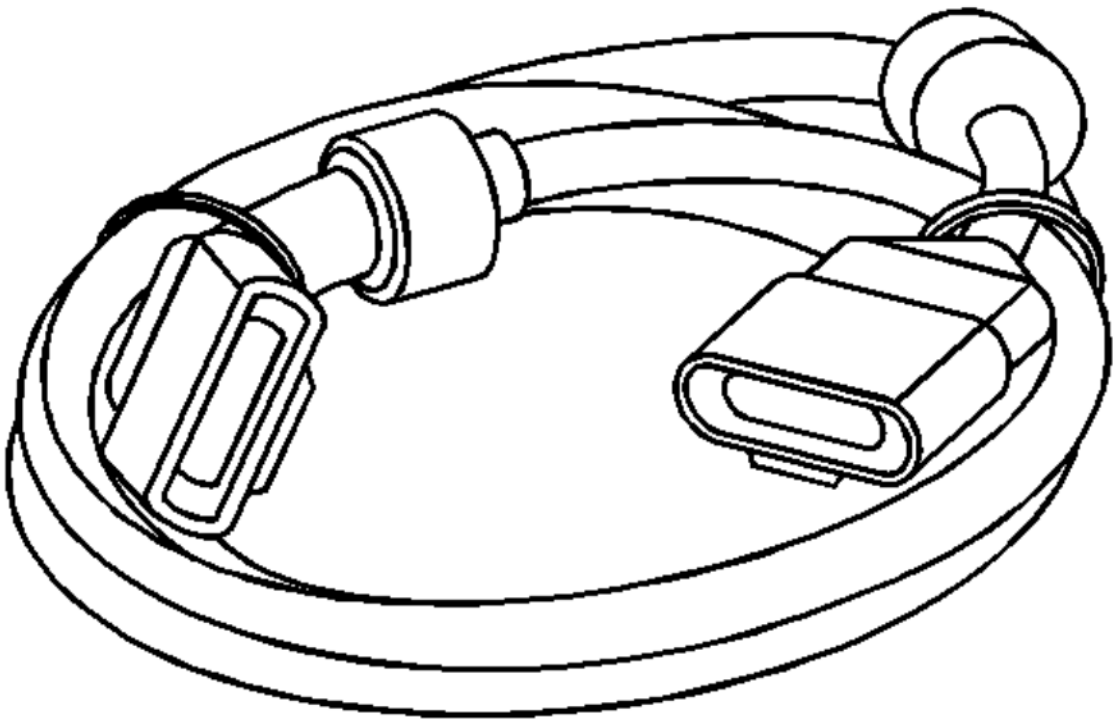
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Illustration	Tool Number/ Description
	EL-50332-105 Universal Fuse Box

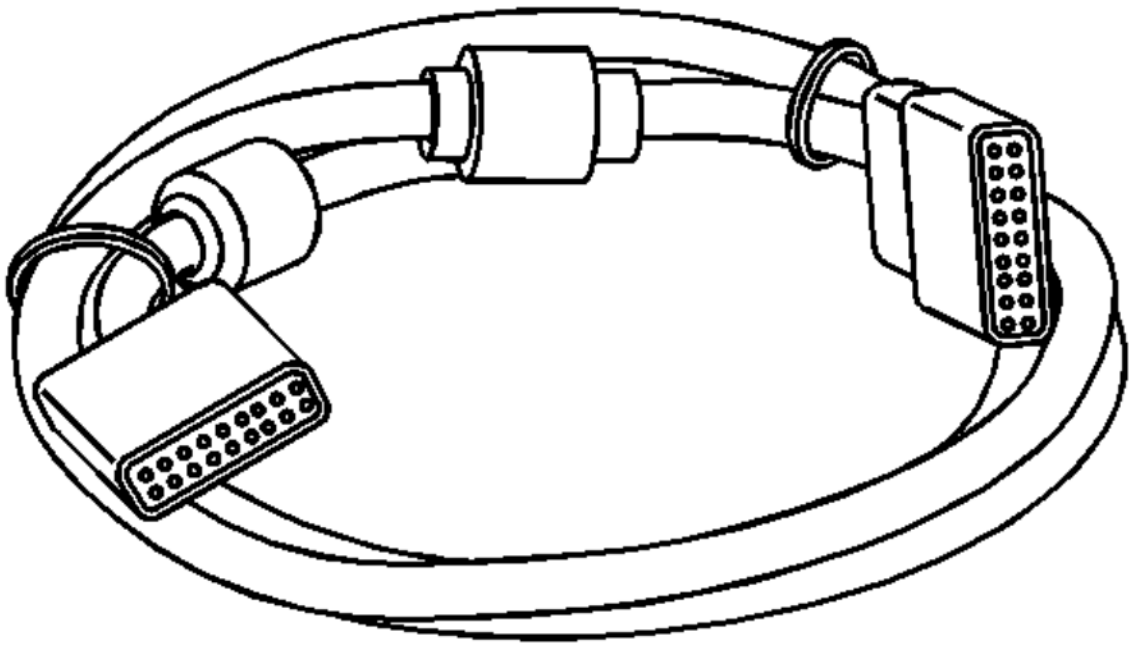
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Illustration	Tool Number/ Description
	EL-50332-110 Vehicle Interface Module

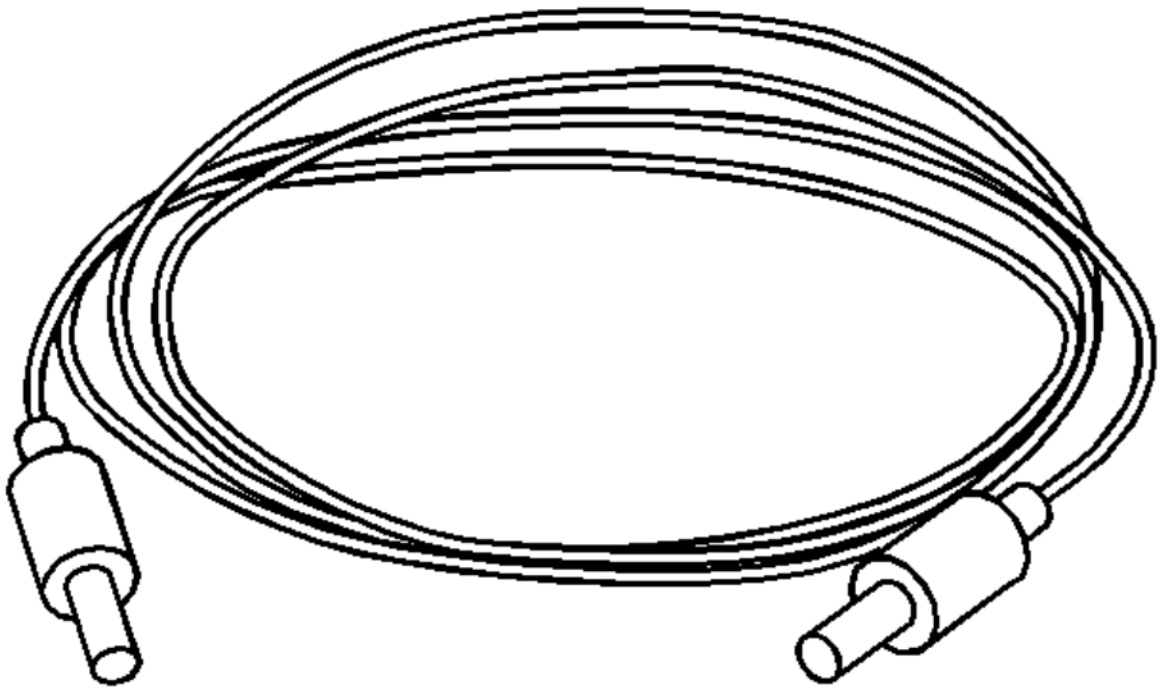
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Illustration	Tool Number/ Description
	EL-50332-120 High Voltage Interface Cable

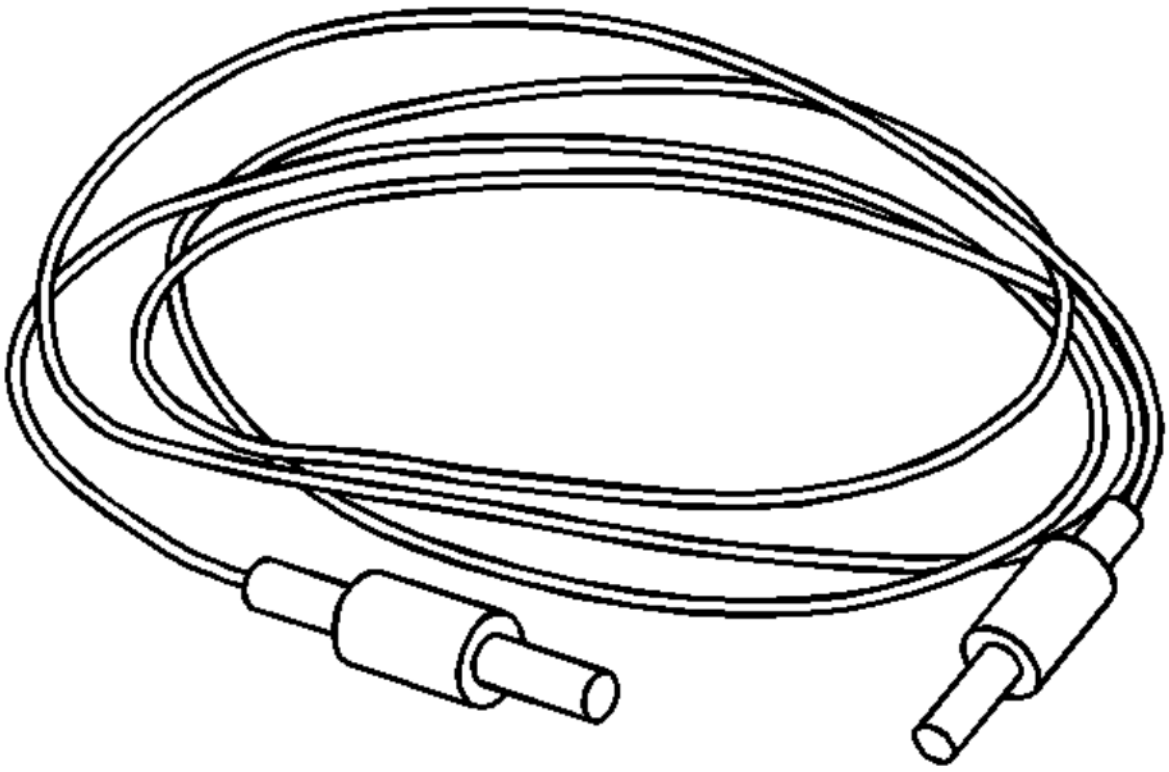
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Illustration	Tool Number/ Description
	EL-50332-125 Vehicle Interface Module Low Voltage 24-Pin Cable

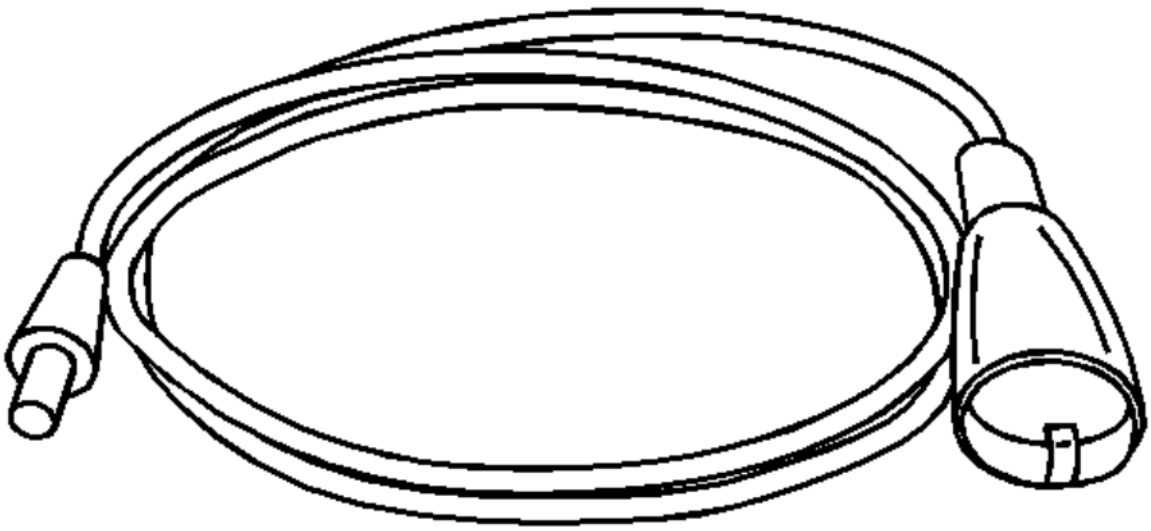
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Illustration	Tool Number/ Description
	EL-50332-145 Black HV Banana Jack Cable

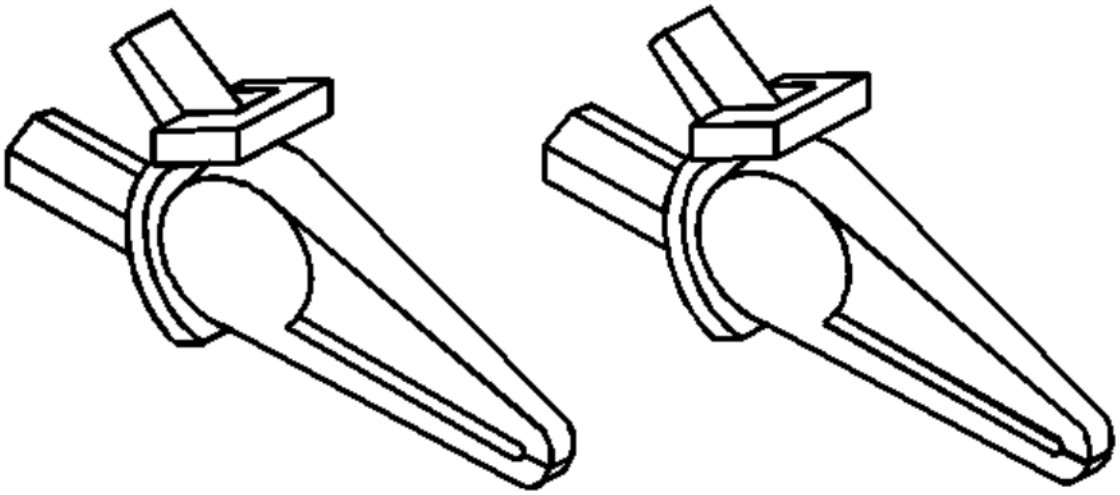
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Illustration	Tool Number/ Description
	EL-50332-150 Red HV Banana Jack Cable

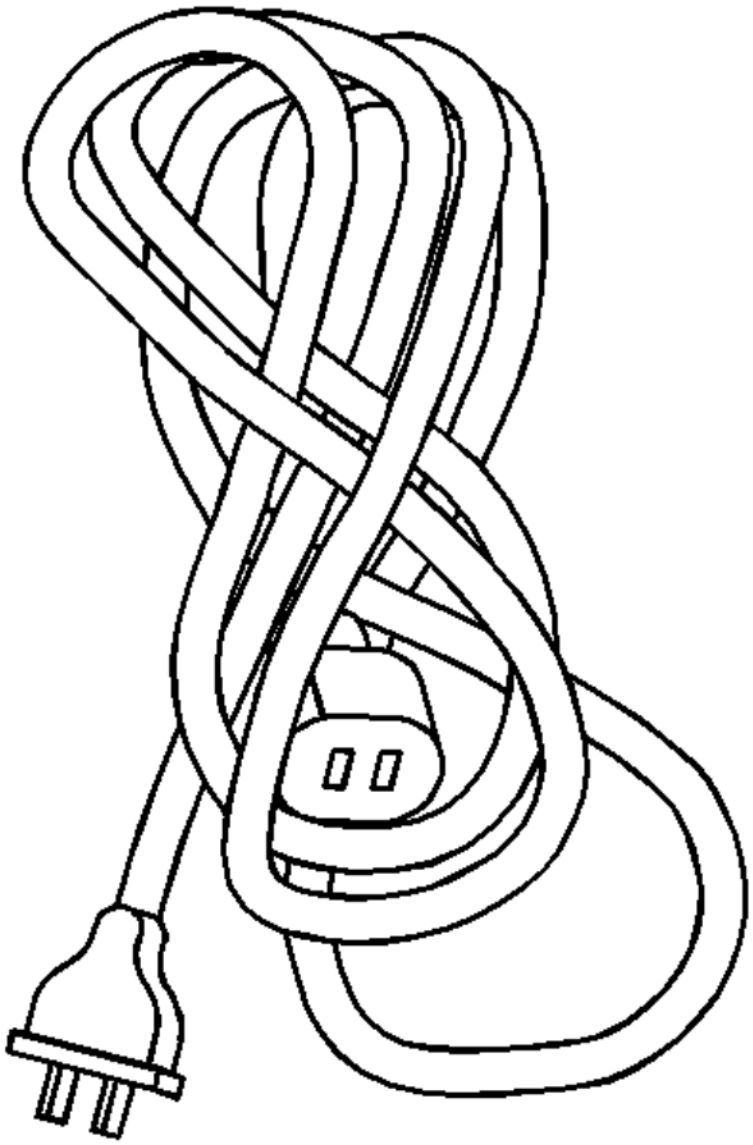
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Illustration	Tool Number/ Description
	EL-50332-155 Green HV Banana Jack Cable

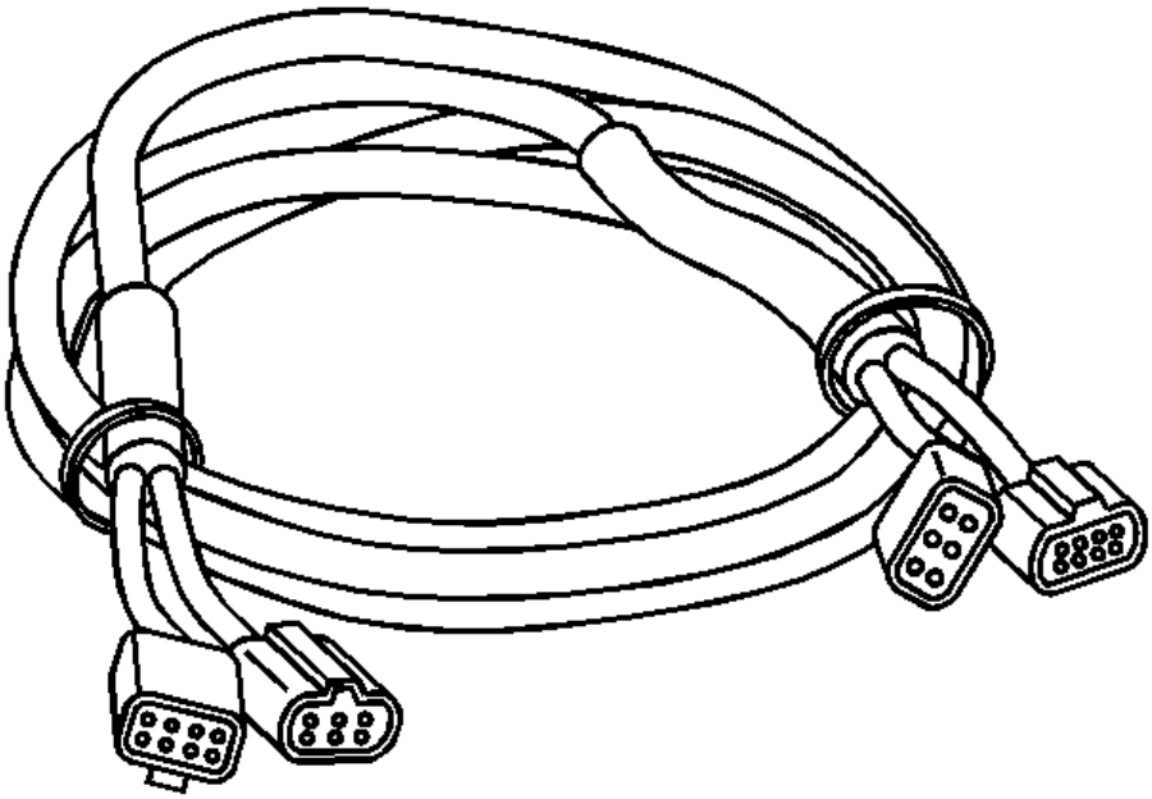
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Illustration	Tool Number/ Description
	EL-50332-170 High Voltage Alligator Clamps

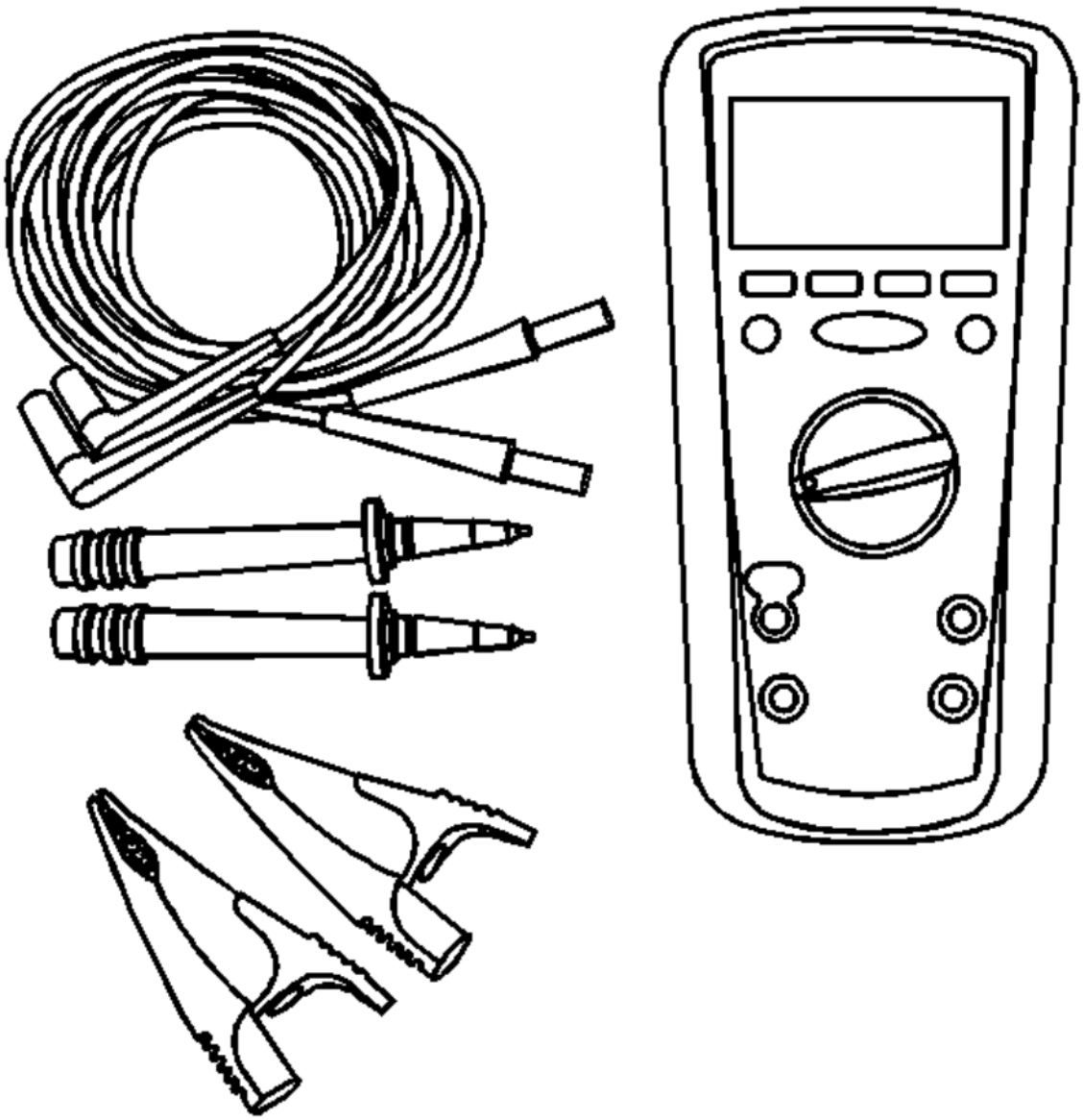
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Illustration	Tool Number/ Description
	EL-50332-175 120V Power Cable

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Illustration	Tool Number/ Description
	EL-50332-210 HPCM2 Low Voltage Adapter Cable

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Illustration	Tool Number/ Description
	EL-50772 Fluke 1587 Mega OHM Meter

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