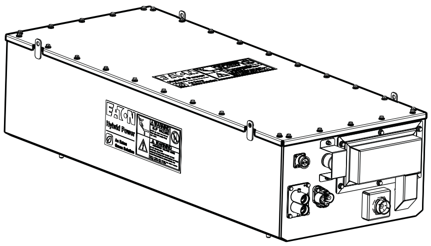
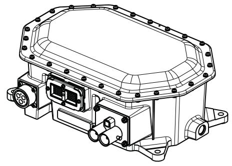
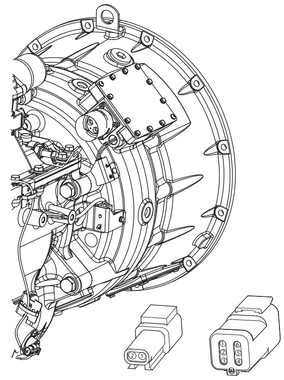
Troubleshooting Guide



MY09 PEC



MY09 Inverter



MY09 Motor Generator
with Connectors

Eaton Hybrid Drive Systems MY09 TRTS2000 EN-US

October 2015

MY09 PEC Models

EH-8E406A-U/P
EH-8E406A-UP
EH-8E406A-UPG
EH-8E406A-CD
EH-8E406A-CDG
EH-8E406A-CDR
EH-8E406A-T
EH-6E706B-CD
EH-6E706B-P
EH-6E706B-UPG

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Roadranger
SUPPORT

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General Information

Pretest Procedure

Fault Isolation Procedure

Symptom Isolation Procedure

Appendix

Warnings & Cautions

Warnings and Cautions

Throughout this service manual there are paragraphs that are marked with a title of DANGER, WARNING, or CAUTION. These special paragraphs contain specific safety information and must be read, understood, and heeded before continuing the procedure or performing the step(s).

Danger: Danger indicates you will be severely injured or killed if do not follow the indicated procedure.

Warning: Warning indicates an immediate hazard, which could result in severe personal injury if you do not follow the indicated procedure.

Caution: Caution indicates vehicle or property damage could occur if you do not follow the indicated procedure.

Note: Note indicates additional detail that will aid in the diagnosis or repair of a component/system.

Caution: Follow the specified procedures in the indicated order to avoid personal injury:

1. If the high-voltage cones are around the vehicle and the lockout is installed on the PEC, the only person that should be allowed to start the vehicle is the person who signed the lockout tag.
2. Before working on a vehicle or leaving the cab while the engine is running, you should place the Shift Lever in “N” set the parking brake, and block the wheels.
3. For safety reasons, always engage the service brakes prior to selecting gear positions from “N.”
4. Before starting a vehicle always be seated in the driver's seat, select “N” on the shift control, and set the parking brakes.
5. In vehicles with ePTO, the engine and/or Motor/Generator can start in ePTO mode. Never perform any maintenance or work on vehicle, while in this mode.
6. 12-volt Battery (+) and (-) must be disconnected prior to any welding on any Hybrid equipped vehicle.

Caution: Follow the specified procedures in the indicated order to avoid equipment malfunction or damage.

Caution: Do not release the parking brake or attempt to select a gear until the air pressure is at the correct level.

Caution: To avoid damage to the transmission during towing place the Shift Lever in “N” and lift the drive wheels off the ground or disconnect the driveline.

High-Voltage Warnings & Cautions

- Use CO_2 or Dry Chemical Fire Extinguishers.
- The high-voltage wiring is covered in orange insulation or convoluted tubing and marked with warning labels at the connectors.
- All Eaton® Hybrid Diesel/Electric vehicles will be marked 'Hybrid' on the outside of the vehicle, along with the shift label on the dash.
- Refer to OEM for specific location of chassis mounted hybrid components.
- Do NOT cut into the orange high-voltage cables.
- Do NOT cut into or open the Power Electric Carrier (PEC).
- Do NOT cut into or open the DC/DC converter.
- Do NOT cut into or open the Inverter.

A buffer zone must be set up and high-voltage insulated rubber gloves (class 0 with leather protectors) are required prior to working on high-voltage. Failure to follow these instructions may result in **severe personal injury or death.**

The rubber-insulated gloves that must be worn while working on the high-voltage system are class 0 with leather protectors. The rubber gloves should be tested before every use following the rubber insulation gloves testing procedure (see “Insulated Rubber Glove Test” on page 3). Failure to follow these instructions may result in **severe personal injury or death.**

Before inspecting or working on any high-voltage cables or components the “High-Voltage Service Shutdown Procedure” on page 5 should be followed. Failure to follow these instructions may result in **severe personal injury or death.**

The Lockout and Tag-out devices should only be removed by the technician that placed the Lockout and Tag-out devices on the vehicle. Failure to follow these instructions may result in **severe personal injury or death.**

High-voltage rubber insulated gloves (class 0 with leather protectors) must be worn when working on any high-voltage cables. The “High-Voltage Service Shutdown Procedure” on page 5 must be followed prior to removing any high-voltage cables. Failure to follow these instructions may result in **severe personal injury or death.**

High-voltage cables and wiring are orange and contain a warning label at the connectors. High-voltage components are marked with a label. High-voltage rubber insulated gloves (class 0 with leather protectors) must be used when working on any of these components. Failure to follow these instructions may result in **severe personal injury or death.**

Insulated Rubber Glove Test and High-Voltage Work Area

Insulated Rubber Glove Test

Warning: The rubber-insulated gloves that must be worn while working on the high-voltage system are class 0 with leather protectors. The rubber gloves should be tested before EVERY use by following the procedure below. Failure to follow these instructions may result in severe personal injury or death.

The insulated rubber gloves that must be worn while working on the high-voltage system are class 0 rated. They must be inspected before each use and must always be worn in conjunction with the leather outer glove:

- Roll the glove up from the open end until the lower portion of the glove begins to balloon from the resulting air pressure. If the glove leaks any air it must not be used. Any hole in the insulated rubber glove is a potential entry point for high-voltage.
- The gloves should not be used if they exhibit any signs of wear and tear.
- The leather gloves must always be worn over the rubber insulating gloves in order to protect them.
- The rubber insulating gloves must be ASTM Class 0 electrical insulating rubber gloves with leather protectors.

High-Voltage Work Area Requirements

Warning: A buffer zone must be set up and ASTM Class 0 electrical insulating rubber gloves with leather protectors are required prior to working on any high voltage. Failure to follow these instructions may result in severe personal injury or death.

The buffer zone is required only when working on the high-voltage DC or AC systems and is called out both in the “High-Voltage Service Shutdown Procedure” on page 5 and the individual repair procedures:

- Position the vehicle in the service bay.
- Position 4 orange cones around the corners of the vehicle to mark off a 1m (3 ft.) perimeter around the vehicle.
- Do not allow any unauthorized personnel into the buffer zone during repairs involving high voltage. Only personnel trained for service on the high-voltage system are permitted in the buffer zone.

High-Voltage Service Shutdown and Power-Up Procedure

A buffer zone must be set up and ASTM Class 0 electrical insulating rubber gloves with leather protectors are required prior to working on high-voltage. Failure to follow these instructions may result in **severe personal injury or death.**

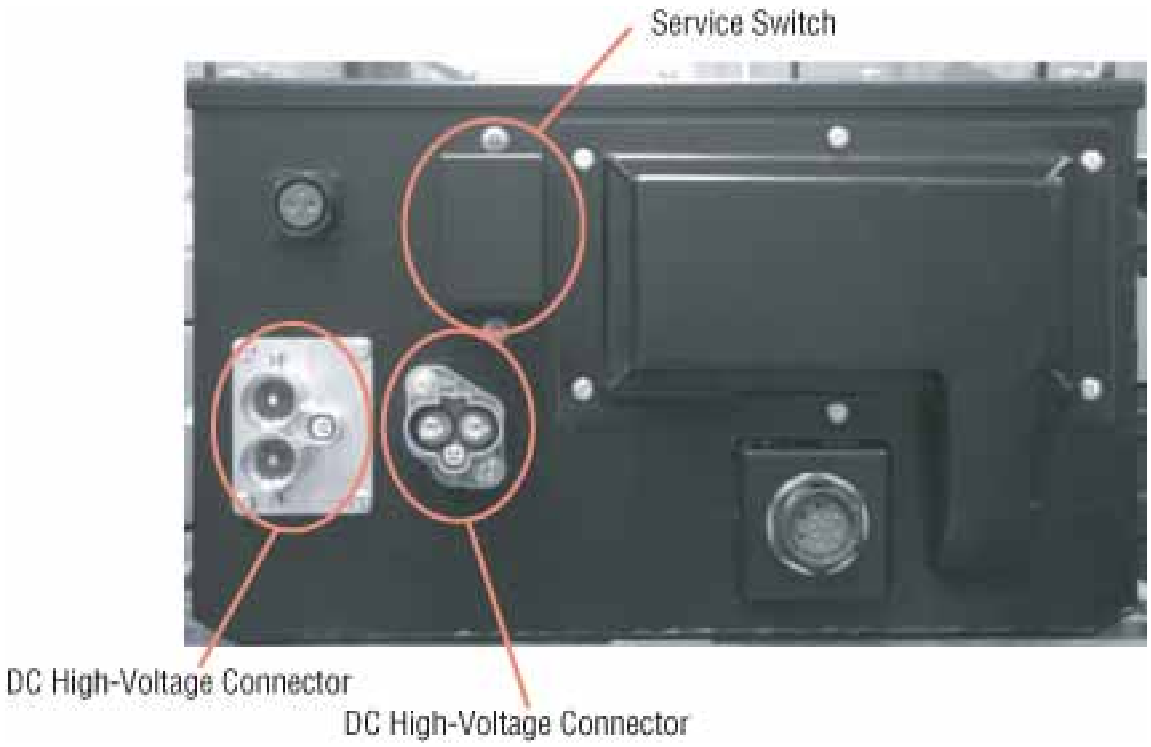
The rubber-insulated gloves that must be worn while working on the high-voltage system are class 0 with leather protectors. The rubber gloves should be tested before use following the rubber insulation gloves testing procedure (see “Insulated Rubber Glove Test” on page 3). Failure to follow these instructions may result in **severe personal injury or death.**

Before inspecting or working on any high-voltage cables or components the “High-Voltage Service Shutdown Procedure” on page 5 should be followed. Failure to follow these instructions may result in **severe personal injury or death.**

The lockout and Tag-out devices should only be removed by the technician that placed the Lockout Tag-out devices on the vehicle. Failure to follow these instructions may result in **severe personal injury or death.**

ASTM Class 0 electrical insulating rubber gloves with leather protectors must be worn when working on any high-voltage cables. The “High-Voltage Service Shutdown Procedure” on page 5 must be followed prior to removing any high-voltage cables. Failure to follow these instructions may result in **severe personal injury or death.**

High-voltage cables and wiring are orange and contain a warning label at the connectors. High-voltage components are marked with a label. ASTM Class 0 electrical insulating rubber gloves with leather protectors must be used when working on any of these components. Failure to follow these instructions may result in **severe personal injury or death.**



High-Voltage Service Shutdown Procedure

1. Follow “High-Voltage Work Area” procedure (see “High-Voltage Work Area Requirements” on page 3).
2. Locate the red Power Electric Carrier (PEC) service switch on the front of the PEC and push to the Off position.
3. Remove the service switch cover and install the Lockout Bracket (J48506).
4. Fasten tag to the Lockout Bracket.
5. Ensure the PEC service switch cannot move from the Off position.
6. Allow the system to set for a minimum of 5 minutes to discharge high-voltage.
7. Connect ServiceRanger and view the Data Monitor PID 116 “High-Voltage Battery Potential.” Use SPN 520323 for J1939 connection “Battery Voltage RB” (Relay Box).
8. The voltage should be 30 volts or less. If the voltage is above 30 volts, do not work on the vehicle and contact Eaton® at 1-800-826-HELP (4357).
9. Turn ignition key off and proceed to repair or troubleshooting step.

Note: The voltage drops to 0 when the key is turned off.

High-Voltage Service Power-Up Procedure

1. Install all high-voltage connectors back into their locked positions.
2. Remove the Lockout Bracket and tag **ONLY IF YOU ARE THE PERSON WHO IS WORKING ON THE VEHICLE.**
3. Reinstall the protection bracket over the service switch.
4. Pull the service switch out and let vehicle set for 2 minutes.
5. Start vehicle when appropriate.

Diagnostic Tools and Service Publications

Eaton Tools

- Visit Roadranger.com

Tool	Description
ServiceRanger version 3	ServiceRanger PC-based Diagnostic Tool
ServiceRanger version 4	ServiceRanger PC-based Diagnostic Tool

SPX/OTC Tools

- Contact SPX / OTC at (800) 328-6657

Tool	Description
J49818	Eaton Hybrid Tool Safety Kit - Basic PPE (Items listed below can be ordered separately)
J48603	ASTM Class 0 electrical insulating rubber gloves with leather protectors (1000 volt)
J48605	Hybrid Safety Cones (set of 4)
J48506	Lockout Switch Plate
J48906	Lockout Tags (per 25)

Tool	Description
J49819	Eaton Hybrid Tool Safety Kit - Basic Plus PPE (Items listed below can be ordered separately)
J48603	ASTM Class 0 electrical insulating rubber gloves with leather protectors (1000 volt)
J48605	Hybrid Safety Cones (set of 4)
J48506	Lockout Switch Plate
J48906	Lockout Tags (per 25)
J48907	Orange Magnetic Sign
J48608	Hybrid Non-Conductive Safety Pole
J48908	Glove Bag

Tool	Description
Misc. Service Tools	Items listed below are ordered separately
J48624	Nexiq USB-Link Communication Adapter
J43318-A*	Pin Adapter Kit - Interface Harness Diagnostics
J48735*	Alignment Pins - Hybrid Motor/Gen to Transmission Main Case
AMB-45*	Digital Megohmmeter - High-Voltage Leakage Detection
J49111*	Clutch Alignment Tool
J46708*	Fluke Digital Multimeter
J48505	Input Shaft Turning Socket
J48507	Lifting Fixture - Power Electronics Carrier
J48502	Jack Adapter Plate - Hybrid Drive Unit
5019	Transmission Jack - Low Lift
5078	Transmission Jack - High Lift
J48577	Engine/Transmission Stand Adapter Plate - Hybrid Drive Unit
J29109-A	Engine/Transmission Stand - 6000 lb. Rating

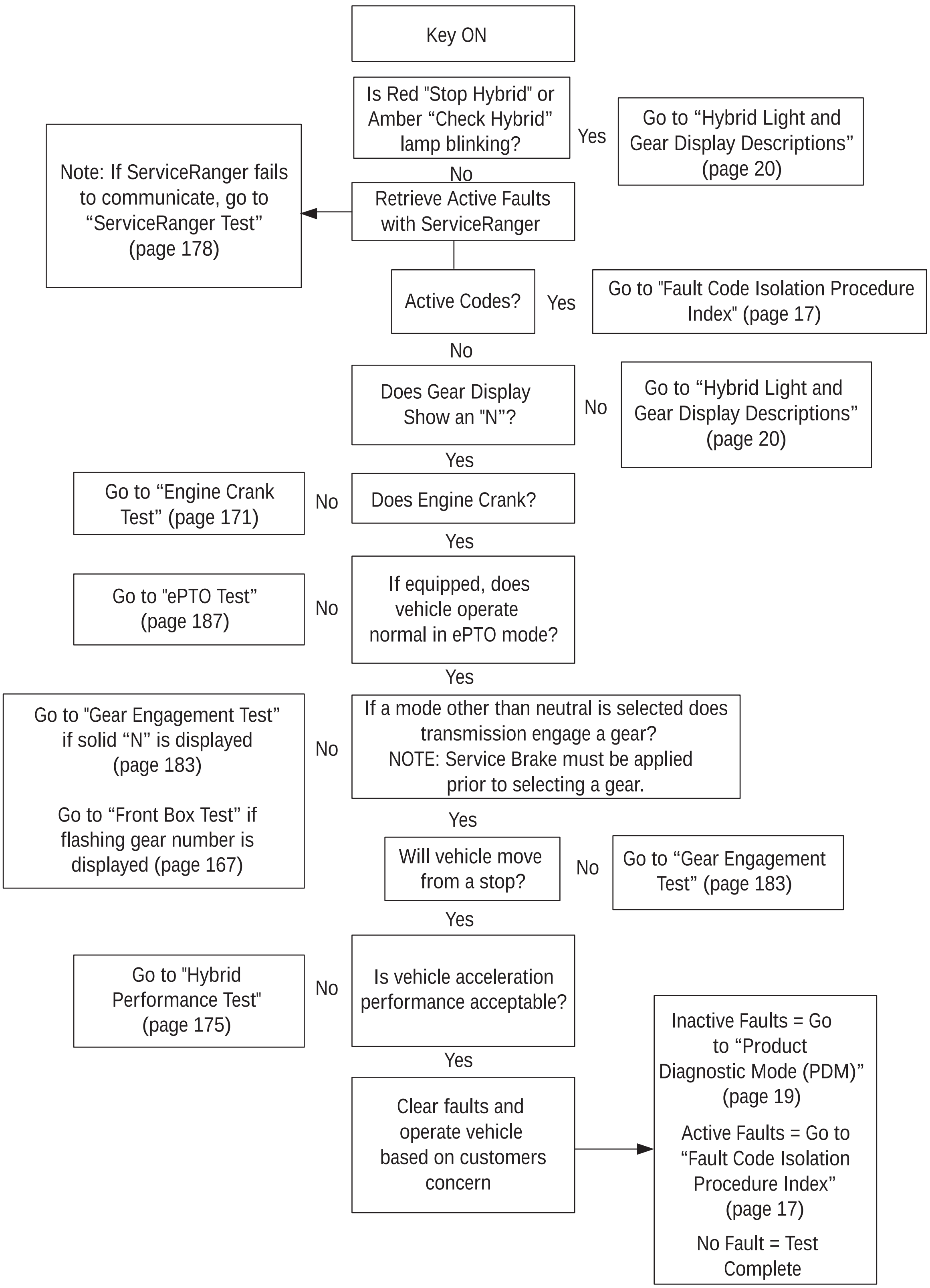
Tool	Description
J48893	Hybrid PPE/Service Tool Kit (includes J49819 kit and items from Miscellaneous Service Tools highlighted with *)

Service Publications

1. Visit Roadranger.com

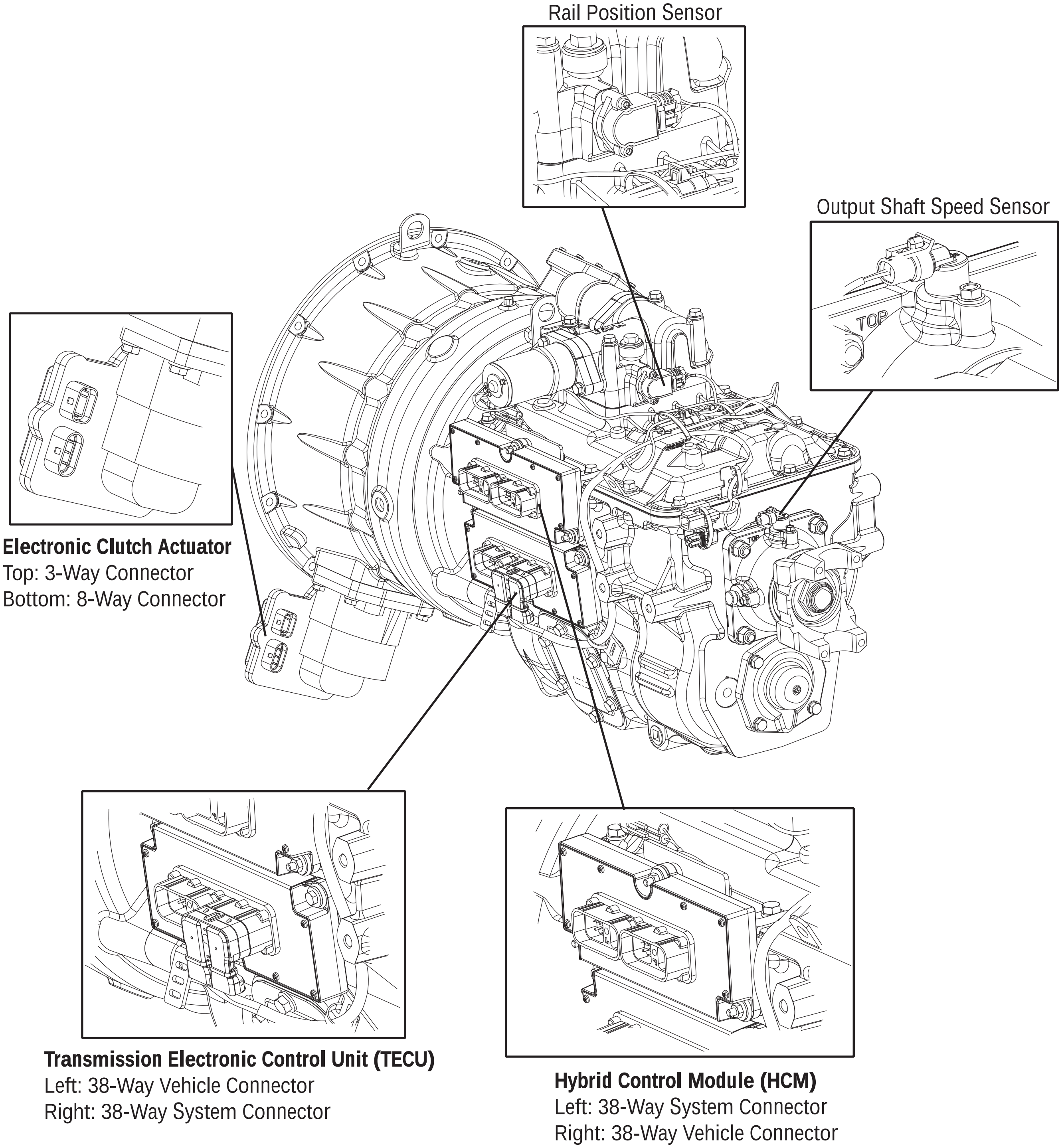
TRSM2000	Service Manual (covers external components on transmission and hybrid components)
TRSM0110	Service Manual (covers internal transmission repairs only)
TRTS2000	Troubleshooting Guide
TRTS2001	Troubleshooting Guide for Alternative PEC and Alternative APG
TRDR1000	Drivers Instructions
TRDR1110	First Responder Guide
CLMT-0365	Eaton 365 mm Clutch Installation Procedure

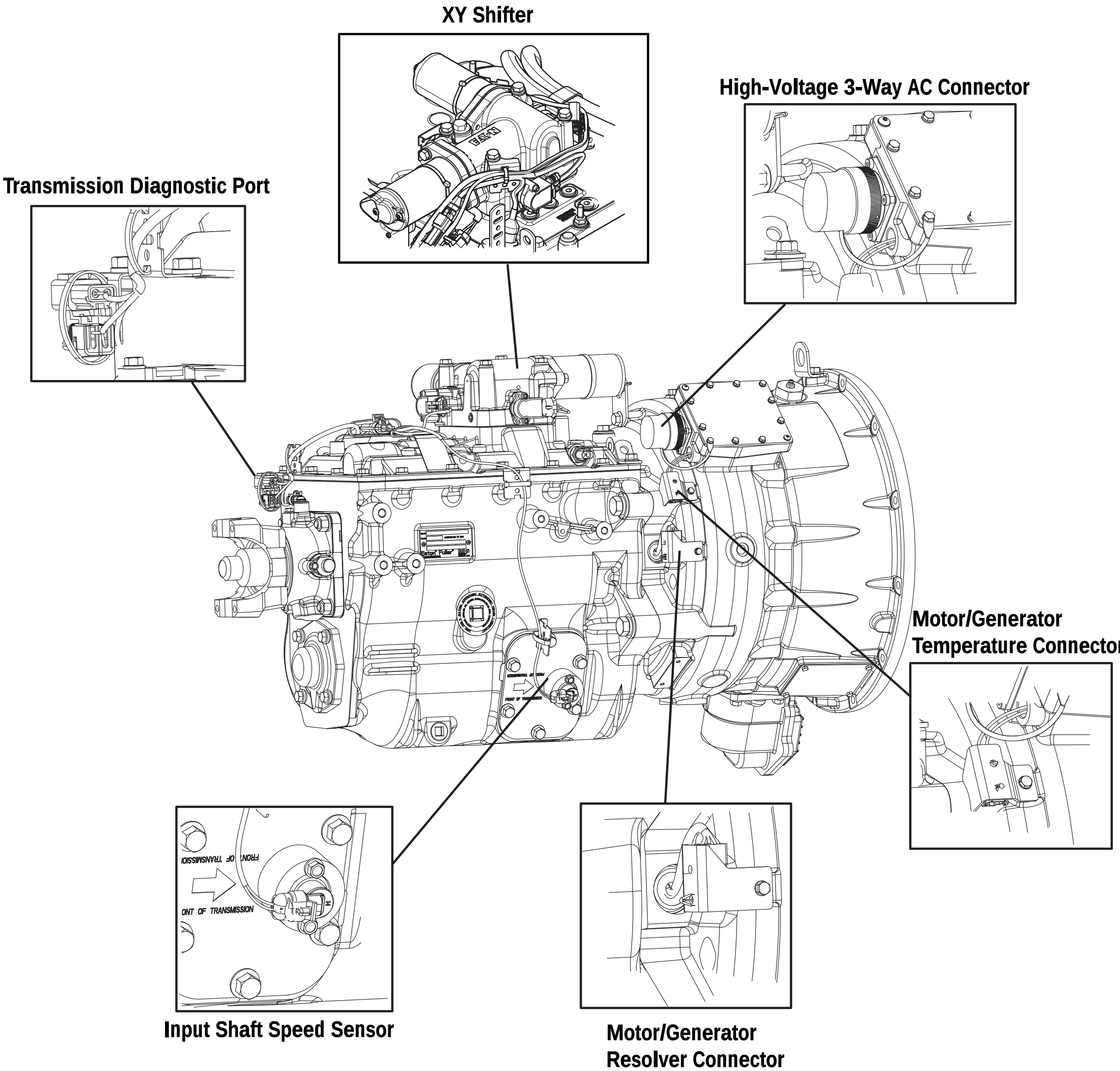
Hybrid Diagnostic Procedure



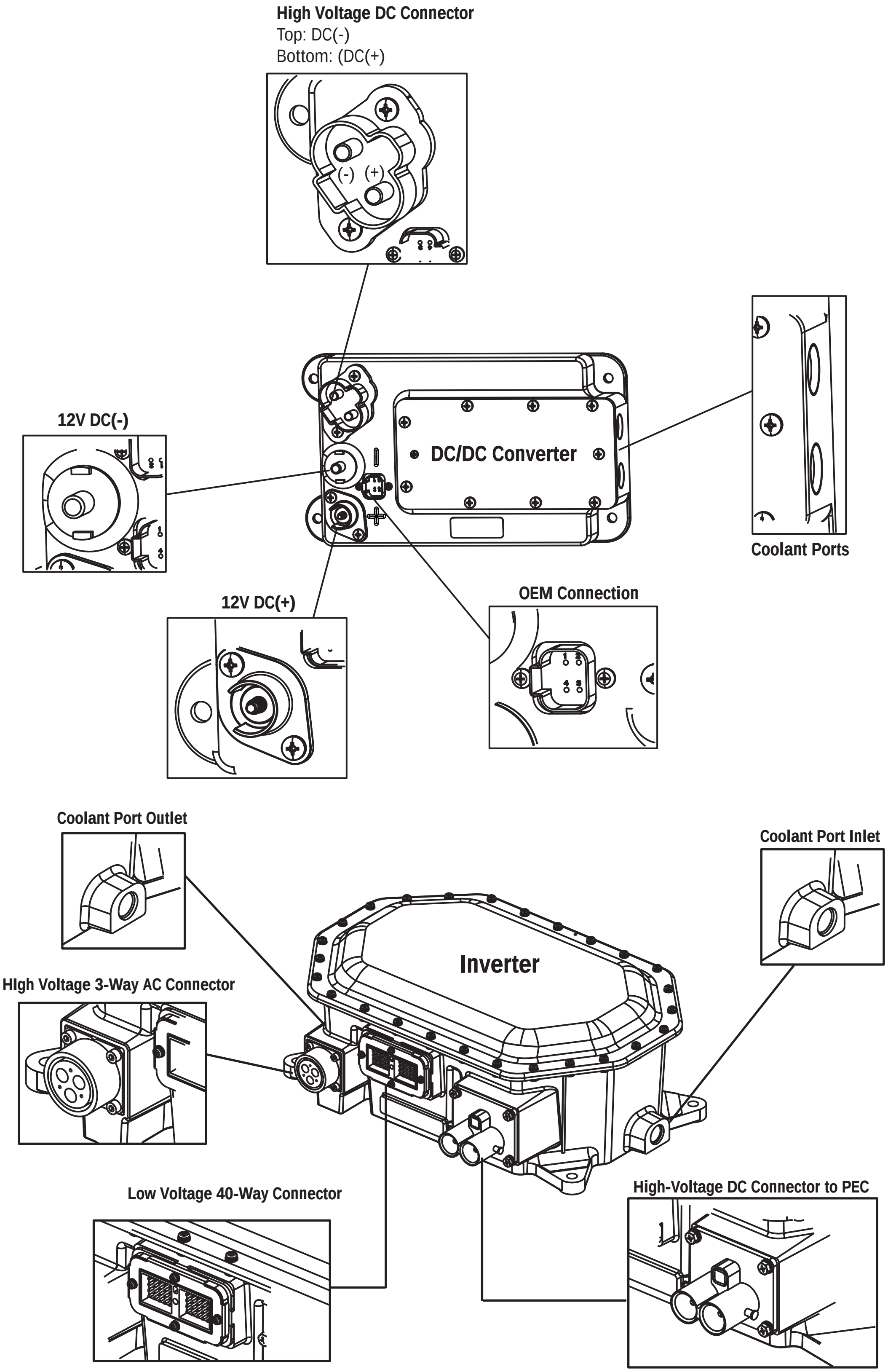
Hybrid Component and Connector Locations

Transmission Wiring Connections

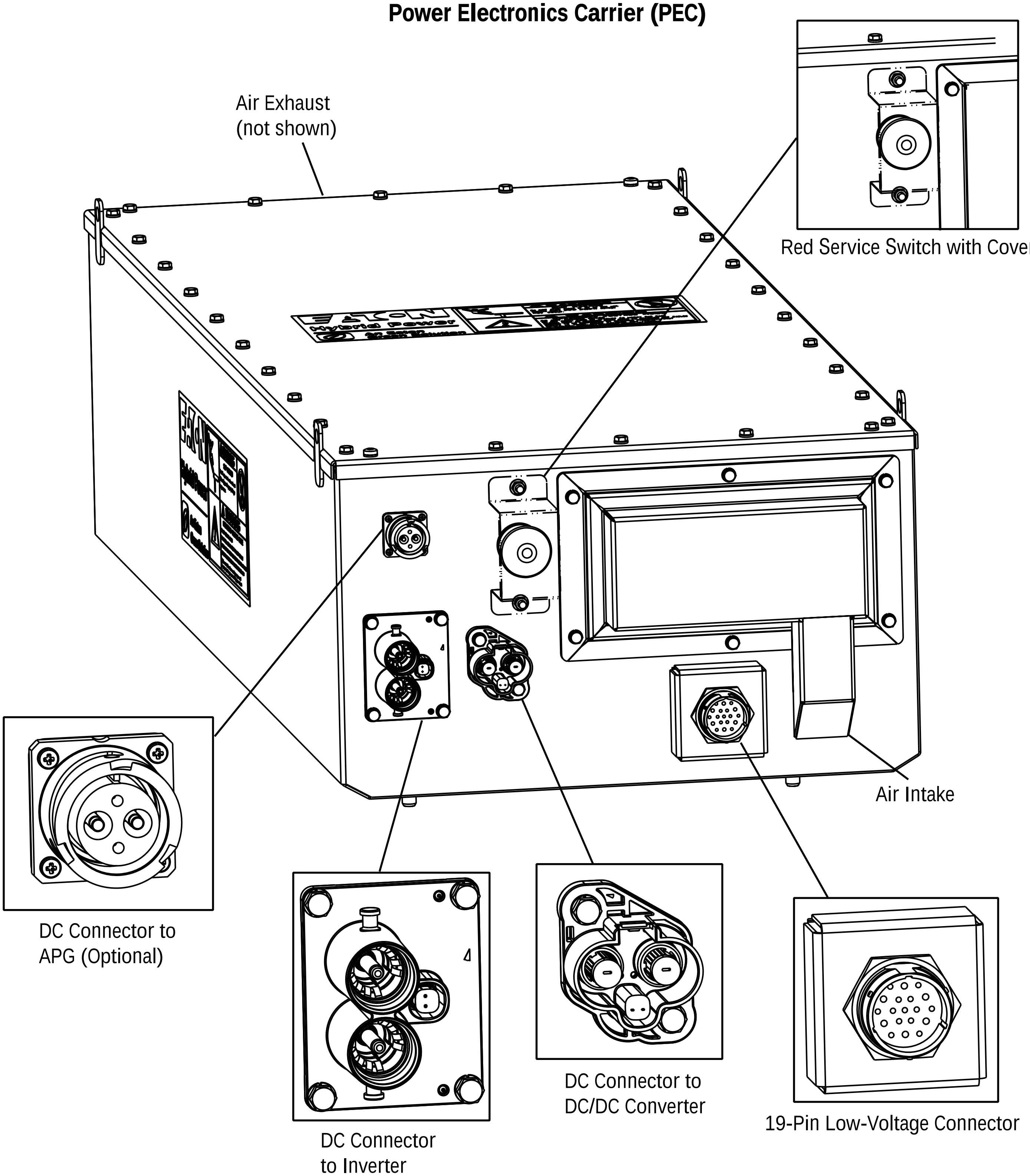



XY Shifter
High-Voltage 3-Way AC Connector
Transmission Diagnostic Port
Motor/Generator
Temperature Connector
FRONT OF TRANSMISSION
Input Shaft Speed Sensor
Motor/Generator
Resolver Connector

Component Wiring Connections



Power Electronics Carrier (PEC)



Fault Code Retrieval and Clearing

All Eaton® Hybrid systems require the use of ServiceRanger for all diagnostics. To view fault codes or clear them, follow the procedures below.

View Active and Inactive Faults

1. Connect ServiceRanger to the 9-Way Diagnostic Connector.
2. Go to the Tools menu and select the “Communication” tab.
3. Select the appropriate communication device for J1587 and J1939.
4. Select “Connect” on the main page.
5. Select the “View Fault Codes” tab.

Note: Initial use requires all steps; however, subsequent uses require only steps 4 and 5.

Clear Inactive Faults

1. Connect ServiceRanger to the 9-Way Diagnostic Connector.
2. Go to the Tools menu and select the “Communication” tab.
3. Select the appropriate communication device for J1587 and J1939.
4. Select “Connect” on the main page.
5. Select the “View Fault Codes” tab.
6. Select the “Clear Faults” button.

Note: Initial use requires all steps, however subsequent uses require only steps 4 and 5.

Fault Code Isolation Procedure Index

Fault Code	SPN	FMI	Description	Page Number
56	161	2, 3, 4, 5, 10	Input Shaft Speed Sensor	page 186
58	191	2, 3, 4, 5	Output Shaft Speed Sensor	page 190
59	639	2, 9	J1939 Communication Link (HCM)	page 194
60	625	2, 9	CAN Communication Link (HCM)	page 199
61	772	5, 6	Rail Select Motor	page 203
63	773	5, 6	Gear Select Motor	page 215
64	788, 520198, 520199, 524035	0, 12, 13, 21–28	ECA	page 227
65	520203	2, 5	ECA Speed Sensor	page 231
66	520271	3, 4, 14	ECA Battery Voltage	page 235
67	520274	3, 4, 5	ECA Ignition Voltage	page 238
68	520231	12, 13, 14	Grade Sensor	page 243
70	188, 518, 539, 544	0, 1, 2, 7	Engine Failed to Respond (HCM)	page 247
71	520275	7	Failed to Disengage Gear	page 250
72	520277	7	Failed to Select Rail	page 254
73	520278	7	Failed to Engage Gear	page 258
74	93, 190	7	Engine Failed to Respond (TECU)	page 262
75*	520276	14	Power Down In Gear	page 265
76	520250	3, 4, 16, 18	High-Voltage Battery 1 Potential Voltage	page 268
78	520232	6	High-Voltage Battery 1 Current	page 271
82	520233	0, 16	High-Voltage Battery 1 Temperature	page 274
83	751	12, 13	Invalid Shifter Range	page 279
84	751	13	Shift Control Device Not Configured	page 284
85	639	12	Shift Control Device Incompatible	page 290
88	520223	2, 9	Inverter CAN Message (HCM)	page 294
89	520234	2, 9	PEC CAN Message (HCM)	page 300
94	520237	9	Transfer Case Message	page 308
95	520249	3, 4	12-volt Cranking Relay	page 311
97	3460	3, 4, 5, 7, 14	PTO Engagement	page 316
101	520238	0, 22–31	High-Voltage Battery	page 322
103	520265	22–26	Battery Control Unit Communication	page 325
105	520240	22–30	Battery Control Unit	page 329
107	520242	1	High-Voltage Battery Leak Detection	page 332
108	520268	3, 4	Battery Control Unit Power Supply	page 342
110	520220	21–29	Inverter	page 346
111	520260	12–28	Inverter Communication	page 349
112	520221	3, 4	Inverter Voltage	page 355

Fault Code	SPN	FMI	Description	Page Number
113	520222	6, 14	Inverter Current	page 359
114	520261	3, 4	Inverter Power Supply	page 364
115	520223	0	Inverter Temperature	page 368
116	521210, 521211, 521212	3, 4, 5	High-Voltage Relays	page 373
116	520224	10, 14, 20	High-Voltage Relays	page 373
117	520251	3, 14, 29	PEC Relay Cut Request	page 382
118	520252	3, 4, 5	Auxiliary High-Voltage Relay Control Circuit	page 386
120	520275	3, 4	APG Unit 1 - AC Voltage	page 395
122	520277	6, 14, 15	APG Unit 1 - Output	page 398
123	520278	3, 4	APG Unit 1 - High Voltage Battery	page 403
125	520280	0	APG Unit 1 - Over Temperature	page 406
126	520281	25, 26, 27	APG Unit - Configuration	page 409
127	520282	0	APG Unit 1 - Ambient Air Over Temperature	page 412
128	520283	9	APG Unit 1 - CAN	page 415
165	520320	2	APG Unit 1 -Configuration Error	page 419

Symptom-Driven Diagnostics Index

Symptom	Isolation Procedure	Page Number
Power-up no crank and gear display shows a dash “-”	Front Box Test	page 423
Power-up no crank and gear display shows a “N”	Engine Crank Test	page 428
Power-up no crank and gear display shows double dash “--”, double stars “**” or blank	Power Up Sequence Test	page 21
Power-up vehicle cranks and gear display shows “--”, “**” or blank	Refer to OEM for gear display issue	N/A
Vehicle acceleration performance is not acceptable	Hybrid Performance Test	page 432
Transmission will not engage a gear from neutral and warning tone sounds (solid N in gear display)	Gear Engagement Test	page 441
Transmission will not move from a stop (solid gear number in gear display)	Gear Engagement Test	page 441
Transmission will not engage a gear from neutral (flashing gear number in gear display).	Front Box Test	page 423
Red Service light on the Push Button Shift Control is on/blinking	Fault Code Retrieval and Clearing	page 13
Amber “Check Hybrid” light on the dash is on	Fault Code Retrieval and Clearing	page 13
Red “Stop Hybrid” light on the dash is on	Fault Code Retrieval and Clearing	page 13
ePTO mode does not operate as expected	ePTO Test	page 445

Product Diagnostic Mode (PDM)

Product Diagnostic Mode (PDM) is used to help diagnose Inactive codes that may have been set during normal driving. This diagnostic mode increases the sensitivity of the fault sensing capabilities.

This procedure tests loose, degraded and intermittent connections. See "Fault Code Isolation Procedure Index" on page 14. Use the Index as a guide to the wiring and connectors that are associated with the Inactive fault codes. Flex the wiring harness and connectors and attempt to recreate the fault after activating PDM.

PDM is only to be used by a trained service technician in an authorized dealer.

To enter PDM mode:

Note: The vehicle will not start in Product Diagnostic Mode (PDM). Turn vehicle key "OFF" and allow the system to power down to exit PDM.

1. Vehicle must be stationary, engine must not be running, vehicle parking brake must be set.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector.
3. Select the "View Fault Codes" screen.
4. Perform two key clicks of the ignition switch starting with the key on, and ending with the key on.

Note: An "88" may show up in the dash at key on, which is a normal power-up test of the display.

5. The gear display will flash a solid "PD" (Product Diagnostic Mode) and the mode will be activated.
6. Flex the wiring harness and connectors and attempt to recreate the fault.
7. If a fault becomes Active during PDM, ServiceRanger will display the fault with a status of Active.
8. If a fault is detected, exit PDM mode and perform the corresponding fault code troubleshooting procedure. See "Fault Code Isolation Procedure Index" on page 14.

Note: Active codes set during PDM mode will not be stored as Inactive.

9. To exit PDM mode, power the system down by turning the key off.

PDM will only work with the following Inactive codes

9, 10, 14, 16, 17, 18, 19, 22, 24, 32, 33, 34, 35, 36, 38, 39, 40, 48, 49, 50, 51, 52, 56, 58, 59, 60, 61, 63, 76, 87, 88, 89, 95, 118

Hybrid Light and Gear Display Descriptions

All Eaton® hybrid systems use a combination of 3 lights to indicate failures of different operating systems and the ability of the vehicle to drive. These lights include the red "Service" light, amber "Check Hybrid" light, and the red "Stop Hybrid" light.

Red "Service" Light

- Light is located on the Push Button Shift Control and reads "Service".
- Light is turned on and off by the Transmission Electronic Control Unit (TECU) for automated transmissions faults over the High Integrity Link (HIL).
- Light also comes on momentarily at key on as part of the TECU self-test.

Amber "Check Hybrid" Light

- Light is located near the middle of the dash. It is amber and reads "Check Hybrid."
- Light is turned on and off indirectly by the Hybrid Control Module (HCM) and directly by the Body Controller over J1939.
- Light is turned on when a hybrid system fault is Active.
- When the amber light is on, the vehicle can still be driven; however, the vehicle may operate without hybrid electric assist.

Red "Stop Hybrid" Light

- Light is located near the middle of the dash. The light is red and reads "Stop Hybrid".
- Light is turned on and off indirectly by the HCM and directly by the Body Controller over J1939.
- Light is turned on when a hybrid system fault is Active.
- When the light is on, vehicle should not be driven. Transport the vehicle to the OEM truck dealership.

Blinking Amber "Check Hybrid" Light

The majority of vehicles have a red Stop Switch on the front of the Power Electric Carrier (PEC). If this switch is pushed in, the amber "Check Hybrid" light will blink.

- To reset, pull switch out and turn key off for 2 minutes. Continue to the diagnostic test for the fault that is currently Active.
- If the light remains on, go to "Hybrid Diagnostic Procedure" on page 8 and start with step 3 "Retrieve Active Faults with ServiceRanger."
- There should be an Active Fault Code 76 FMI 4, or Fault Code 116, FMI 10.

"ST" in Gear Display

"ST" in the gear display indicates a driver triggered Snapshot was recorded. Snapshot is a diagnostic tool used to capture specific data from the HCM at the time of a fault. Snapshot is only available on models with an Eaton Push Button Shift Control. It is triggered through two different means:

- Fault code triggered - Specific faults will trigger the HCM to capture a Snapshot file for later retrieval. This method will not display an "ST" in the gear display.
- Driver triggered - If the driver chooses to capture a Snapshot of an event he/she needs to decide if he/she wants TECU or HCM data. To capture a TECU Snapshot select, "Low" and the up button twice. To capture a HCM Snapshot select, "Drive" or "Low" and the up button and down button in the following order: up, down, up, down.

"PD" in Gear Display

A "PD" in the gear display indicates the TECU and HCM are in a special diagnostic mode called Product Diagnostic Mode (PDM). For more details on the mode and its operation, See "Product Diagnostic Mode (PDM)" on page 18.

“CA” in Gear Display

“CA” in gear display indicates HCM is detecting a clutch abuse situation.

- If the HCM detects a clutch abuse situation it will first tone the Push Button Shift Control and flash a “CA” in the gear display.
- If the clutch abuse situation continues, the hybrid system will allow only an electric launch in addition to continuing the tone and the “CA.”
- If the clutch abuse continues while driving, the hybrid system will open the clutch when vehicle speed is below 5mph and allow the clutch to cool.

“OS” in Gear Display

“OS” in the gear display indicates the HCM is detecting a motor overspeed situation. The vehicle will upshift in Drive and Low automatically; however, if the vehicle is in manual mode, close to motor overspeed and the driver fails to upshift, the vehicle will:

- Display an “OS” indicating the driver needs to press the service brake pedal to slow the vehicle; or,
- The HCM will either upshift the vehicle or reduce torque to prevent the motor from going overspeed.

“F” in Gear Display

“F” in the gear display indicates the TECU has detected an Active fault. This fault can be accessed with ServiceRanger. See “Fault Code Isolation Procedure Index” on page 14.

Dash “-” in Gear Display

A “-” in the gear display indicates the transmission is stuck in gear. See “Symptom-Driven Diagnostics Index” on page 17.

Stars “**” in Gear Display

Two stars “**” in the gear display indicates the gear display has power, but no communication on the data link. See “Symptom-Driven Diagnostics Index” on page 17.

Two Dashes “- -” in Gear Display

Two dashes “- -” in the gear display indicates the gear display has power, and there is no communication present on the data link, or the TECU isn’t communicating with the display. See “Symptom-Driven Diagnostics Index” on page 17.

Blank Gear Display

A blank gear display indicates the display has lost power, or the TECU isn’t communicating with the gear display. See “Symptom-Driven Diagnostics Index” on page 17.

Power-Up Sequence Test

Overview

This test must be performed only when experiencing a “vehicle won’t crank” with a double dash “- -”, double star “**”, or blank gear display. The Electrical Pretest must be performed prior to this procedure.

Detection

The power-up self-check is performed automatically at each key on. Turn key on and watch the “Service” light. If power up stops with the “Service” light constantly on, or it never comes on, self-check has failed.

Fallback

There is no fallback for this test and the vehicle will not crank if the Transmission Electronic Control Unit (TECU) or power supply harness has failed.

Possible Causes

This may be caused by any of the following:

- TECU power supply
- TECU

Additional Tools

- Basic hand tools
- Battery load tester
- Eaton® Test Adapter Kit J43318
- Digital volt/ohm meter J46708

Component Identification

See “Wiring Diagrams” on page 453.

Power-Up Sequence Test

A ***Purpose:*** *Perform Electrical Pretest*

1. Perform the “Electrical Pretest” on page 24.
2. Is problem still present after the Electrical Pretest?
   - Yes, replace the **Transmission Electronic Control Unit (TECU)**. Return to the “Hybrid Diagnostic Procedure” on page 8.
   - No, test is complete. Return to the “Hybrid Diagnostic Procedure” on page 8.

Electrical Pretest

Overview

This test must be performed prior to diagnosing certain specific hybrid faults. This test verifies the quality of the standard battery system and the main power and ground supplies to the Hybrid Control Module (HCM), Transmission Electronic Control Unit (TECU), and Electronic Clutch Actuator (ECA).

Note: This test is called out in the procedures when it is required.

Detection

The power-up self-check is performed automatically each time the key is turned on. Turn the key on and watch the “Service” light. If power-up stops with the “Service” light constantly on, or it never comes on, self-check has failed.

Fallback

A weak power supply can cause many issues such as shift performance, power-up or failure to crank.

Possible Causes

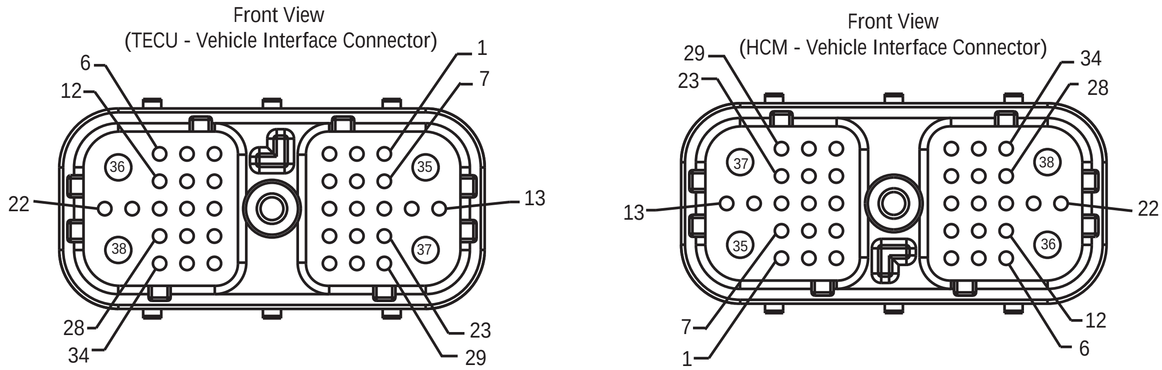
Low-voltage can be caused by the following:

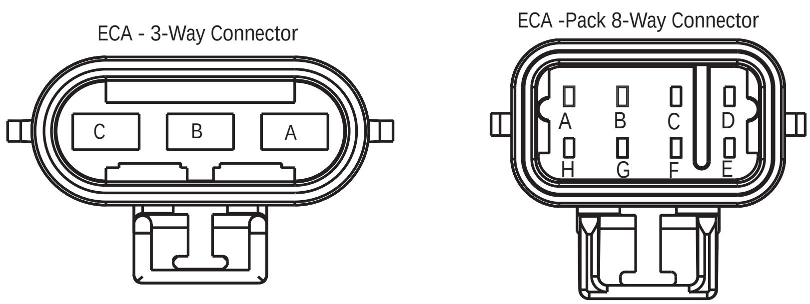
- Low batteries
- Charging system
- Power harness connections or fuses to TECU, HCM or ECA

Additional Tools

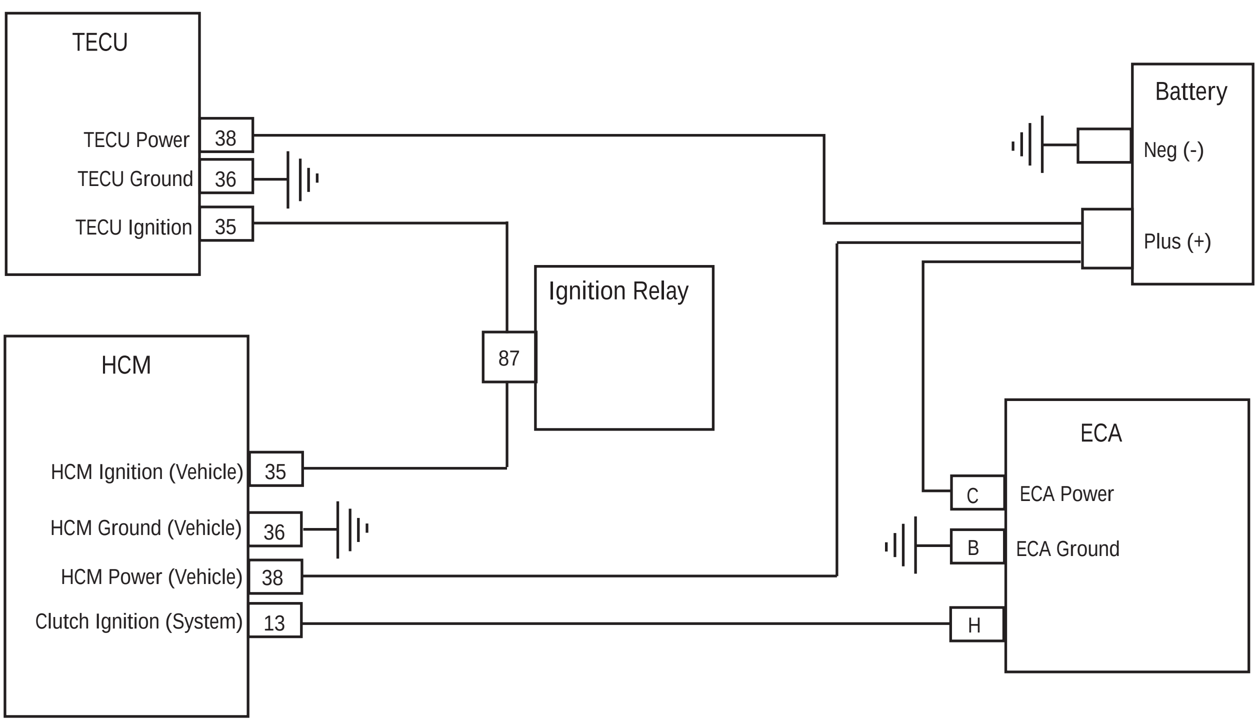
- Basic hand tools
- Battery load tester
- Eaton® Test Adapter kit J43318
- Digital volt/ohm meter J46708
- ServiceRanger

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for connector locations



Electrical Pretest

A

Purpose: *Verify chassis battery voltage.*

1. Key off.
2. Inspect starter, battery and in line fuse holder connections on Electric Clutch Actuator (ECA), Hybrid Control Module (HCM), and Transmission Electronic Control Unit (TECU) for integrity.

   Note: ECA, HCM and TECU use a 30-amp fuse. Refer to OEM for locations.
3. Measure voltage across batteries.
   - If voltage is between 11–13 volts on a 12-volt system, proceed with battery load test. Repair or replace batteries as required, go to **Step B.**
   - If voltage is outside of range, repair or replace batteries and charging system as required. Repeat this step.

Connection	Measurement
Starter Battery to ECA	
Starter Battery to HCM	
Starter Battery to TECU	

B

Purpose: *Verify ECA battery voltage and ignition status.*

1. Key on.
2. Connect ServiceRanger to 9-Way Diagnostic Connector in the cab.
3. Select the “Data Monitor” option and view the following parameters under the hybrid (clutch actuator) list:
   - PID 132 “Clutch Actuator Battery Voltage.”
   - PID 160 “Clutch Actuator Ignition Switch Status.”

   Note: If the clutch parameters can not be viewed on ServiceRanger you must check the power supply to the ECA with a voltmeter.
   - If PID 132 is within 0.6 volts of battery voltage and PID 160 reads "1", go to **Step C.**
   - If either voltage is out of range, repair main power or ignition supply to the ECA. Repeat this step.

Parameter	Reading
PID 132 Clutch Actuator Battery Voltage	
PID 160 Clutch Actuator Ignition Switch Status	

C ***Purpose:*** *Verify HCM battery voltage and ignition status.*

1. Select the “Data Monitor” option and view the following parameters under the Hybrid Control Module list:
   - PID 165 Battery Potential Voltage
   - PID 166 Ignition Switch Status

   Note: If the Battery Potential Voltage or Ignition Switch Status can not be viewed on ServiceRanger, you must check the power supply to the HCM with a voltmeter.

   - If PID 165 is within 0.6 volts of battery voltage and PID 166 reads "1", go to **Step D.**
   - If either voltage is out of range, repair the main power or ignition supply to the HCM. Repeat this step.

Parameter	Reading
PID 165 Battery Potential Voltage	
PID 166 Ignition Switch Status	

D ***Purpose:*** *Verify TECU battery and switched voltage.*

1. Select the “Data Monitor” option and view the following parameters under the hybrid Transmission list:
   - PID 168 Battery Potential Voltage.
   - PID 158 Battery Potential Voltage Switched.

   Note: If the Battery Potential Voltage or Battery Potential Voltage Switched can not be viewed on ServiceRanger, you must check the power supply to the TECU with a voltmeter.

   - If PID 168 is within 0.6 volts of battery voltage and PID 158 is within 0.6 volts of ignition voltage, test is complete. Return to the fault or symptom procedure that directed you to this step.
   - If either voltage is out of range, repair main power or ignition supply to the TECU. Repeat this step.

Parameter	Reading
PID 168 Battery Potential Voltage	
PID 158 Battery Potential Voltage Switched	

Hybrid Electrical Pretest

Overview

This test must be performed prior to diagnosing certain specific Hybrid faults. This test verifies the power supply for the Inverter and the Power Electric Carrier (PEC).

Note: You must perform the Electrical Pretest before performing the Hybrid Electrical Pretest.

Note: This test is called out in the procedures where it is required.

Detection

The power-up self-check is performed automatically each time the key is turned on. Turn the key on and watch the “Service” light. If power-up stops with the “Service” light constantly on, or it never comes on, self-check has failed.

Fallback

Loss of ignition power causes the hybrid system to be inoperable. In this situation, the vehicle will run under diesel power only.

Possible Causes

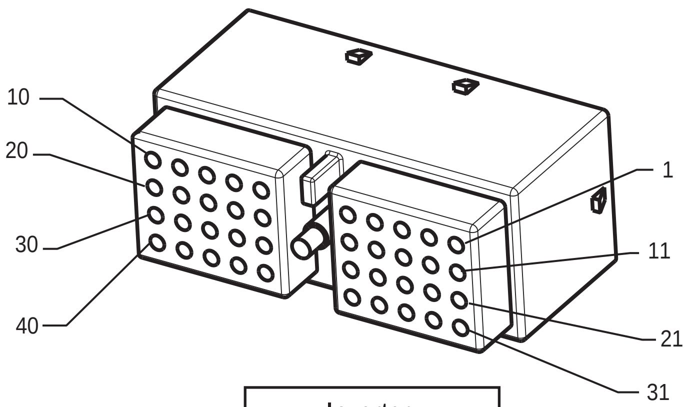
Low-voltage can be caused by power harness connections from Inverter or PEC.

Additional Tools

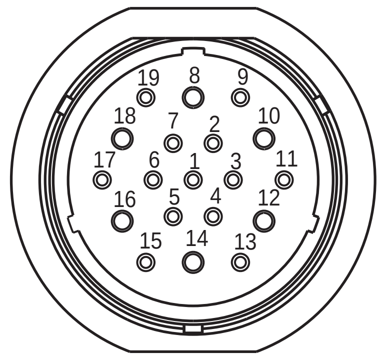
- Basic hand tools
- ASTM Class 0 electrical insulating rubber gloves with leather protectors J48603
- Lockout bracket J48506
- Lockout tags
- Battery load tester
- Eaton Test Adapter kit J43318
- Digital volt/ohm meter J46708
- ServiceRanger

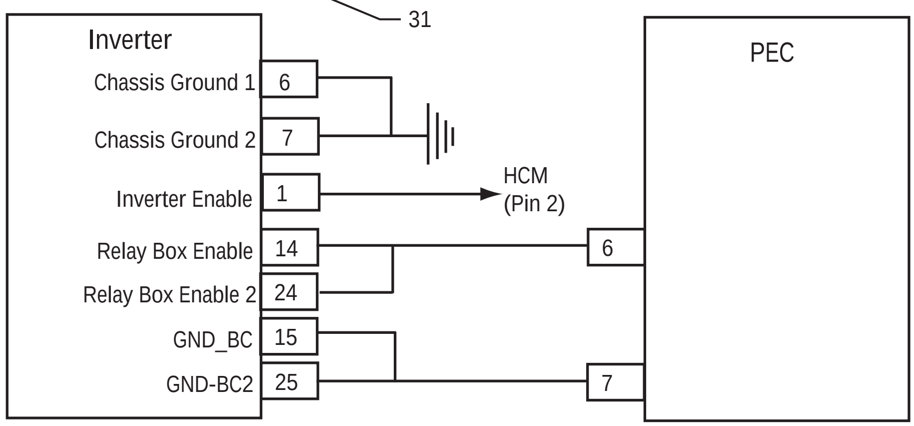
Component Identification

Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)

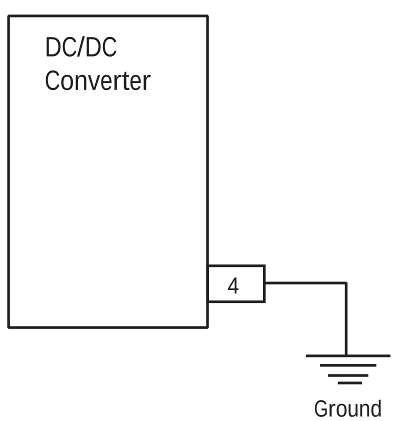


Deutsch 19 - Way Mating Connector View
(PEC - Low Voltage Connector)

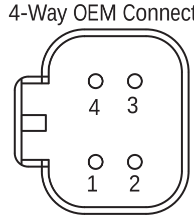




NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



DC/DC Converter
4-Way OEM Connector



Hybrid Electrical Pretest

A ***Purpose:*** *Verify Inverter ground continuity.*

1. Perform the Electrical Pretest, then continue to Step 2.
2. Key off.
3. Disconnect the Inverter 40-Way Connector.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Measure resistance from Pin 6 to battery negative and then from Pin 7 to battery negative:
   - If resistance is 0–0.3 ohms from Pin 6 to battery negative and from Pin 7 to battery negative, go to **Step B.**
   - If resistance is outside of range, repair the Inverter Ground Harness. Repeat this step.

Connection	Measurement
Pin 6 to Battery Negative	
Pin 7 to Battery Negative	

B ***Purpose:*** *Verify voltage at Inverter 40-Way Connector.*

1. Connect a volt/ohm meter to the Inverter 40-Way Connector Pin 1 and Pin 6.
2. Key on.
3. Observe Volt/Ohm Meter voltage reading:
   - If voltage is 11–13 volts, go to **Step C.**
   - If voltage is outside of range, repair the harness from the HCM. Repeat this step.

Connection	Measurement
Pin 1 to Pin 6	

C

Purpose: *Verify continuity of Inverter to PEC ground wire.*

1. Key off.
2. Reconnect the Inverter 40-Way Connector.
3. Disconnect the Power Electric Carrier (PEC) 19-Way Connector.
4. Measure resistance from PEC Pin 7 to battery negative.
   - If resistance from Pin 7 to battery negative is 0–0.3 ohms, go to **Step D.**
   - If resistance is outside of range, repair the Inverter to PEC ground wire. Repeat this step.

Connection	Measurement
Pin 7 to Battery Negative	

D

Purpose: *Verify voltage at PEC 19-Way Connector.*

1. Connect a volt/ohm to the PEC 19-Way Connector Pin 6 and Pin 7.
2. Key on.
3. Observe volt/ohm voltage reading.
   - If voltage is 11–13 volts and vehicle has ePTO feature on Push Button, go to **Step E.**
   - If voltage is 11–13 volts and vehicle does not have ePTO feature, test is complete. Reconnect PEC 19-Way Connector. Go to “Fault Code Isolation Procedure Index” on page 14.
   - If voltage is outside of range, repair the power supply harness from the Inverter. Repeat this step.

Connection	Measurement
Pin 6 to Pin 7	

E | ***Purpose:*** *Verify continuity of DC/DC Ground Wire.*

1. Key off.
2. Reconnect PEC 19-Way Connector.
3. Disconnect DC/DC Converter 4-Way Connector.
4. Measure resistance from DC/DC Converter 4-Way Connector Pin 4 to battery negative:
   - If resistance between Pin 4 and battery negative is 0–0.3 ohms.
   - Test is complete. Reconnect the 4-Way Connector. Go to “Fault Code Isolation Procedure Index” on page 14.
   - If resistance is outside of range, repair the Ground Harness from the DC/DC Converter to battery negative. Repeat this step.

Connection	Measurement
Pin 4 to Battery Negative	

Fault Code 1 - Motor/Generator Current Sensor

J1939 SA 239 SPN 520225 FMI 0, 6, 15

Overview

The high-voltage motor/generator assembly is connected to the Inverter Assembly through an AC high-voltage cable that contains 3 separate cables. During operation, the Inverter monitors the amperage in the AC cables through a current sensor, mounted inside the Inverter. This Inductive Sensor produces an output based on amperage present in the cables.

Detection

Fault is detected when the Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 6 is set when Inverter detects current input from the motor/generator greater than 100 amps for 150 MS.

FMI 0 is set when the Inverter detects current input from the motor/generator greater than 200 amps for 0.3 MS.

FMI 15 is set when the sensor offset is out of range at initial check.

Fallback

When Fault Code 1 is set, the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in Hybrid Control Module (HCM) memory.
- Electric motor/generator assist and regeneration are disabled; however, the high-voltage relays remain powered.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

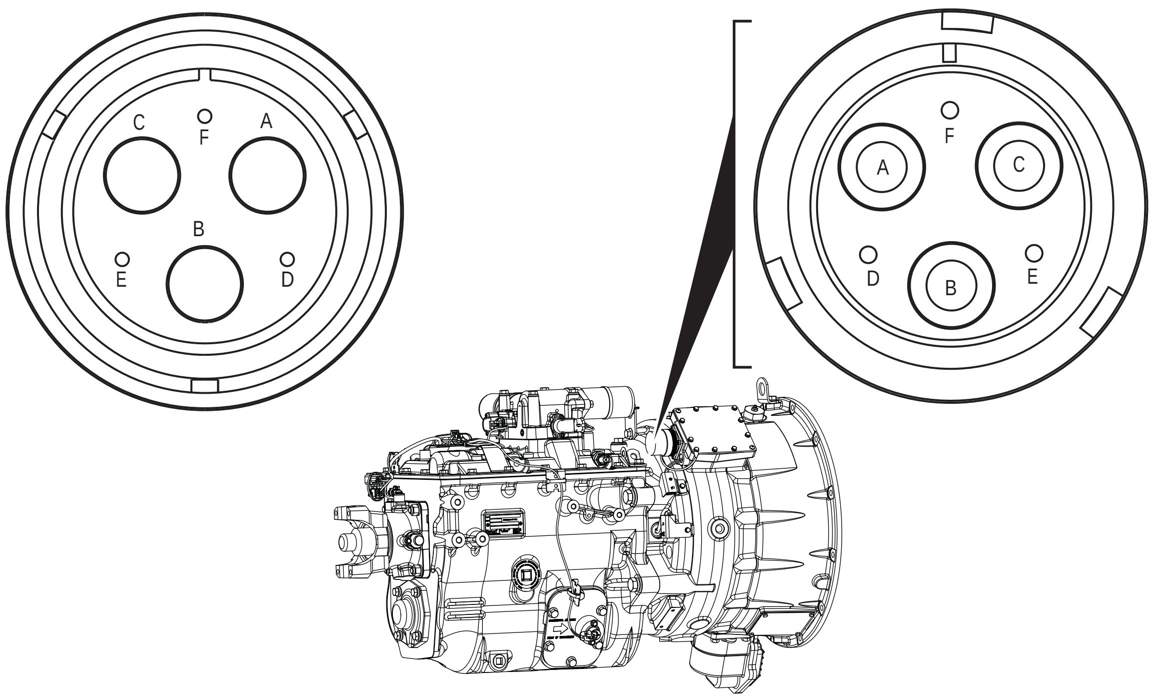
This fault code can be caused by any of the following:

- **FMI 0, 6**
  - Inverter
  - Motor/Generator
  - AC Cable
- **FMI 15**
  - Inverter

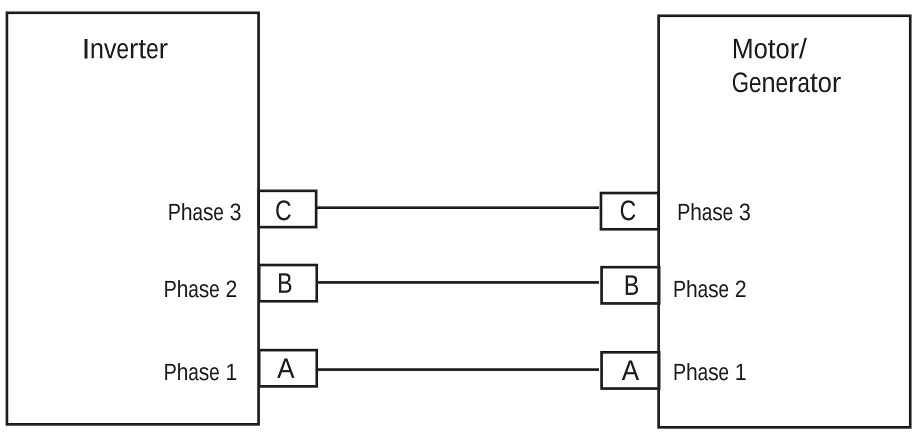
Component Identification

High-Voltage AC Harness Connector View
(Amphenol Connector)

High-Voltage AC Motor/Gen Connector View
(Amphenol Connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 1 - Motor/Generator Current Sensor

A ***Purpose:*** *Check for fault code status and continuity of high-voltage circuitry.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 1 is Active.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Remove the AC cable from the motor/generator and Inverter.
5. Measure resistance of each circuit in the AC high-voltage cable; A-A, B-B, C-C:
   - If resistance for each circuit is less than 1 ohm, go to **Step B.**
   - If resistance is outside of range, replace the AC high-voltage cable and go to **Step V.**
   - If FMI 15 is Active, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

B ***Purpose:*** *Verify continuity of high-voltage circuitry to ground.*

1. Measure resistance of each circuit to ground in the AC high-voltage cable.
   - If resistance between each circuit and ground is 5M ohms or greater, go to **Step C.**
   - If resistance is outside of range, replace the AC high-voltage cable, then go to **Step V.**

Connection	Measurement
Pin A to ground	
Pin B to ground	
Pin C to ground	

C ***Purpose:*** *Verify continuity of high-voltage circuitry.*

1. Key off.
2. Measure the resistance between the following AC High-Voltage Cable Pins: A-A, B-B, C-C:
   - If resistance of each phase is 5M or greater, go to **Step D.**
   - If resistance is outside of range, replace the AC high-voltage cable, then go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

D ***Purpose:*** *Verify continuity of Motor/Generator phases.*

1. Measure resistance of each motor/generator phase at the following pins: A-A, B-B, C-C:
   - If resistance of each phase is less than 10 ohms, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If resistance is outside of range, replace the motor/generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 1 appears, find error in testing, go to **Step A.**
   - If a code other than 1 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 2 - Motor/Generator Temperature Sensor

J1939 SA 239 SPN 520226 FMI 3

Overview

The Motor/Generator Temperature Sensor is a thermistor located inside the motor/generator. The Temperature Sensor resistance varies based on the temperature of the motor/generator. The Inverter supplies a 5 volt reference voltage to the sensor and measures any volt drop in the circuit.

When the motor/generator temperature is warm the sensor resistance is low and the Inverter detects low voltage (0.2 volts equals 536 °F [280 °C]). When the motor/generator is cold the sensor resistance is high and the Inverter detects high voltage (4.1 volts equals 32 °F [0 °C]).

Detection

Fault is detected when the Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 3 is set when the sensor voltage is greater than 4.1 volts for 10 seconds, while the Inverter temperature is over 95 °F (35 °C) or if the sensor output voltage is less than 0.2 volts for 10 seconds.

Fallback

When Fault Code 2 is set, the following conditions occur:

- Amber “Check Hybrid” light illuminates
- Fault is stored in Hybrid Control Module (HCM) memory
- High-voltage motor/generator assist is available, but at a reduced amount

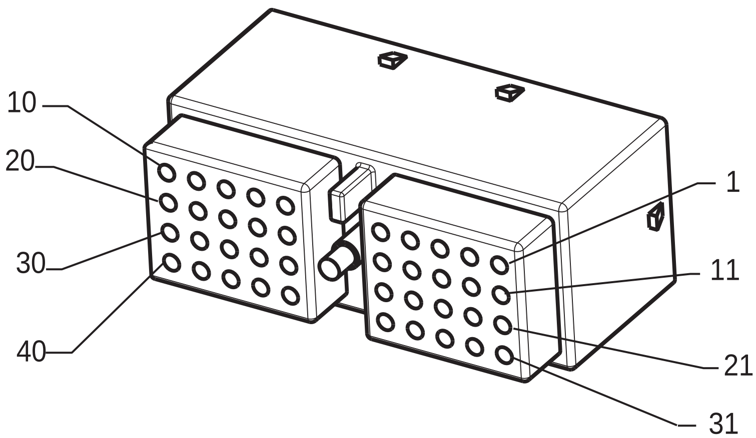
Possible Causes

This fault code can be caused by any of the following:

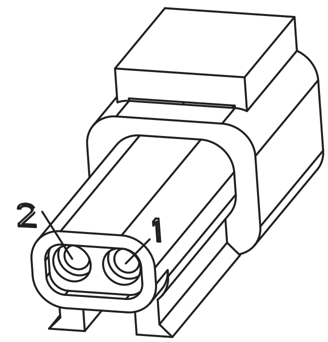
- FMI 3
  - Motor/generator
  - Short/open Temperature Sensor wires between the motor/generator and the Inverter
  - Inverter

Component Identification

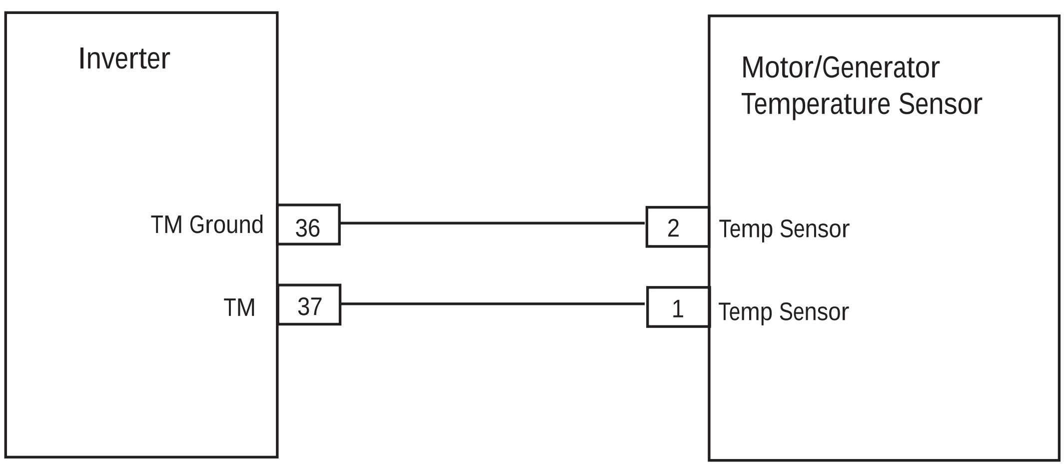
Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)



Terminal Side - Harness Connector
Temperature Sensor
(Deutsch 2-pin connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 2 - Motor/Generator Temperature Sensor

A ***Purpose:*** *Check for fault code status and continuity of Motor/Generator Temperature Sensor circuit.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 2 is Active.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Disconnect the Temperature Sensor Connector at the motor/generator.
5. Measure resistance at the motor/generator 2-Way Temperature Sensor Connector from Pin 1 to Pin 2:
   - If resistance is 0.8K ohms–301.7K ohms, go to **Step B.**
   - If resistance is outside of range, replace the Motor/Generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin 1 to Pin 2	

B ***Purpose:*** *Verify continuity of Inverter and Motor/Generator Temperature Sensor circuit.*

1. Key off.
2. Disconnect the Inverter 40-Way Connector.
3. Reconnect the motor/generator2-Way Temperature Sensor Connector.
4. Measure resistance at the following; Inverter 40-Way Connector Pin 37 to Pin 36, Inverter 40-Way Connector Pin 37 to ground:
   - If resistance is 0.8K–301.7K ohms between Pin 37 and Pin 36 and resistance between Pin 37 and ground is 10K ohms or greater, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If resistance is outside of range, repair the open or short to ground in the harness between the Inverter 40-Way Connector and the motor/generator 2-Way Connector, then go to **Step V.**

Connection	Measurement
Pin 36 to Pin 37	
Pin 37 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 2 appears, find error in testing. Restart troubleshooting, then go to **Step A.**
   - If a code other than 2 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 3 - Motor/Generator Temperature

J1939 SA 239 SPN 520227 FMI 0

Overview

The Motor/Generator temperature is measured through a thermistor sensor, which is located internal to the unit. The sensor changes value based on the temperature. The Inverter supplies a 5-volt reference voltage to the sensor and measures the volt drop in the circuit.

When the motor/generator temperature is warm the sensor resistance is low and the Inverter detects a low-voltage (0.2 volts equals 536 °F [280 °C]). When the motor/generator is cold, the sensor resistance is high and the Inverter detects a high-voltage (4.1 volts equals 32 °F [0 °C]).

Detection

Fault is detected when Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 0 is set when the temperature sensor value is greater than 365 °F (185 °C) for 1 second.

Fallback

When Fault Code 3 is set, the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in Hybrid Control Module (HCM) memory.
- Electric motor/generator assist and regeneration are disabled; however, the high-voltage relays remain powered.
- HCM continues to control the hybrid vehicle in a diesel only mode.
- Transmission defaults start gear to 1st.

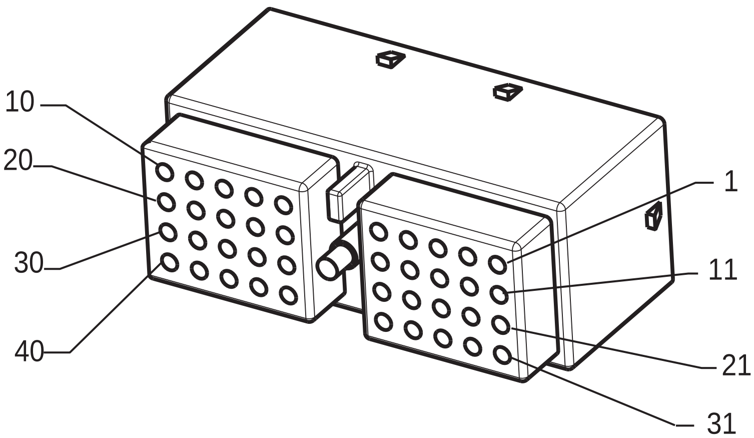
Possible Causes

This fault code can be caused by any of the following:

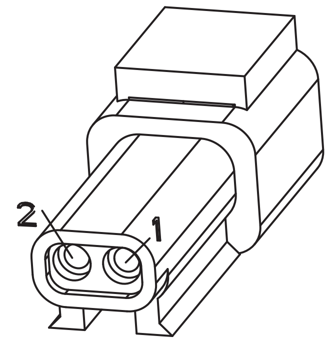
- FMI 0
    - Motor/generator
    - Inverter
    - Liquid cooling system (e.g. low coolant, no coolant flow, coolant pump, radiator, radiator fan, reservoir)

Component Identification

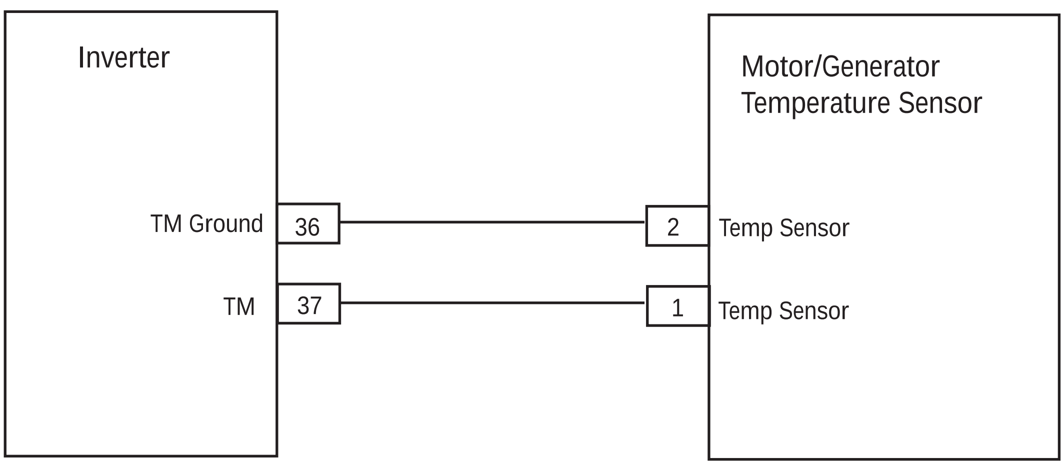
Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)



Terminal Side - Harness Connector
Temperature Sensor
(Deutsch 2-pin connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 3 - Motor/Generator Temperature

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 3 is Active.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Key on.
4. Select the Data Monitor option and view PID 113 “Motor/Generator Temperature” in the Power Electronics list.
5. Observe PID 113 again after 20 minutes:
   - If PID 113 Motor/Generator Temperature dropped from the first reading, go to **Step B.**
   - If PID 113 Motor/Generator Temperature remained the same, go to **Step H.**

Parameter	Reading
Initial Temp.	
20 Min. Temp.	

B

Purpose: *Verify level of hybrid system coolant.*

1. Key off.
2. Observe coolant level after system has cooled down to ensure it is filled to proper level:
   - If coolant is within the recommended limits, go to **Step C.**
   - If coolant is below recommended limits, refer to the OEM for coolant type and fill procedures. Check for source of coolant leak. When refilling the system, it should be pressurized or vacuum bled of air to ensure the coolant properly flows during normal operation.

C

Purpose: *Verify integrity of hybrid cooling system components.*

1. Key off.
2. Visually inspect the hybrid liquid cooling system radiator for debris, obstruction to airflow or sharp bends in the coolant lines:
   - If the radiator is free of debris and the coolant lines are not bent sharply, go to **Step D.**
   - If the radiator has debris, air flow is obstructed or coolants lines are bent sharply, repair the problem and go to **Step V.**

D ***Purpose:*** *Verify operation of hybrid Coolant Pump.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Connector in the cab.
3. Select the “Advanced Product Functions” option and select the “Cooling Pump” option.
4. Enable the “Cooling Pump” option:
   - If the Coolant Pump turns on, go to **Step E.**
   - If the Coolant Pump does not turn on, go to **Step F.**

E ***Purpose:*** *Verify operation of hybrid Heat Exchanger Fan.*

1. Select the “Advanced Product Functions” option and select the “Heat Exchanger Fan” option.
2. Enable the “Heat Exchanger Fan” option:
   - If the Heat Exchanger Fan turns on, system needs to be purged of air to allow the coolant to flow. Bleed the air by using a coolant system pressurizing tool or a vacuum tool and go to **Step V.**
   - If the Heat Exchanger Fan does not turn on, go to **Step G.**

F ***Purpose:*** *Verify voltage at hybrid Coolant Pump.*

1. Key on.
2. Disconnect the Coolant Pump 2-Way Connector.
3. Select the “Advanced Products Function” option and select “Cooling Pump.”
4. Enable the “Cooling Pump” option.
5. Measure voltage at the 2-Way Connector from Pin A to Pin B:
   - If voltage between Pin A and Pin B is +/- 0.2 volts of battery voltage, refer to OEM for Coolant Pump problems.
   - If voltage between Pin A and Pin B is outside of range, refer to OEM for repair procedures on Cooling Pump Power Harness or damaged fuse.

Connection	Measurement
Pin A to Pin B	

G ***Purpose:*** *Verify voltage at hybrid Heat Exchanger Fan.*

1. Key on.
2. Disconnect the Heat Exchanger Fan 2-Way Connector.
3. Select the "Advanced Products Function" option and select the "Heat Exchanger Fan."
4. Enable the "Heat Exchanger Fan" option.
5. Measure voltage at the 2-Way Connector from Pin A to Pin B:
   - If voltage between Pin A and Pin B is +/- 0.2 volts of battery voltage, refer to OEM for Heat Exchanger Fan problem.
   - If voltage between Pin A and Pin B is outside of range, refer to OEM for repair procedures on Heat Exchanger Fan power harness or damaged fuse.

Connection	Measurement
Pin A to Pin B	

H ***Purpose:*** *Verify continuity of Inverter circuitry.*

1. Key off.
2. Disconnect the Inverter 40-Way Connector.
3. Measure resistance between Pin 36 and Pin 37, and Pin 37 to ground of the Inverter 40-Way Connector:
   - If resistance is 0.8K–301.7K ohms between Pin 37 and Pin 36 and resistance between Pin 37 and ground is 10K ohms or greater, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If resistance is outside the range, go to **Step I.**

Connection	Measurement
Pin 36 to Pin 37	
Pin 37 to Ground	

I

Purpose: *Verify continuity of Temperature Sensor circuit.*

1. Key off.
2. Disconnect the Motor/Generator Temperature Sensor 2-Way Connector located on the right side of the Motor/Generator.
3. Measure resistance between the 2-Way Temperature Sensor Connector from Pin 1 to Pin 2:
   - If resistance is 0.8K–301.7K ohms, repair the shorted HCM System Harness between the Inverter 40-Way Connector and Motor/Generator 2-Way Connector.
   - If resistance is outside the range, replace the Motor/Generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin 1 to Pin 2	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 3 appears, find error in testing, go to **Step A.**
   - If a code other than 3 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 4 - Motor/Generator Rotation Speed Sensor

J1939 SA 239 SPN 520228 FMI 0, 2, 3, 21–27

Overview

The motor/generator Rotation Speed Sensor is mounted to the back of the motor/generator around the Input Shaft. The sensor (two-piece design) is a rotor mounted to the Input Shaft and a Sensing Ring mounted to the motor housing. The Sensing Ring is supplied with low-voltage during operation. The rotor turns inducing a voltage fluctuation into the Sensing Ring, which is then converted into a digital signal for motor/generator RPM. Voltage output and frequency is low at idle and increases with RPM.

Detection

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- FMI 2 does not set if there is an Active Transmission Input Shaft Speed Sensor fault.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 0: Set when the motor/generator speed exceeds the normal allowable range.

FMI 2: Set when the motor/generator speed is different than Transmission Input Shaft Speed by more than 100 RPM for at least 10 seconds.

FMI 3: Set when the resolver circuit is shorted to ground.

FMI 21: Set when a resolver signal line short to 12-volt battery or ground is detected.

FMI 22, 24, 25: Set when the combination of the analog-to-digital converter signals is a mismatch.

FMI 23: Set when there is an analog-to-digital converter output error signal for 100 MS.

FMI 26: Set when the rotation sensor speed is greater than 6000 min-1 for 10 MS.

FMI 27: Set when the Inverter detects an error in the initial check.

Fallback

When Fault Code 4 is set, the following conditions occur:

- The amber “Check Hybrid” light illuminates.
- Fault is stored in Hybrid Control Module (HCM) memory.
- Electric motor/generator assist and regenerate are disabled; however, the high-voltage relays remain powered.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

FMI 0 or 26

- Long extended grades may require intermittent use of the service brakes to slow the vehicle

FMI 3, 21

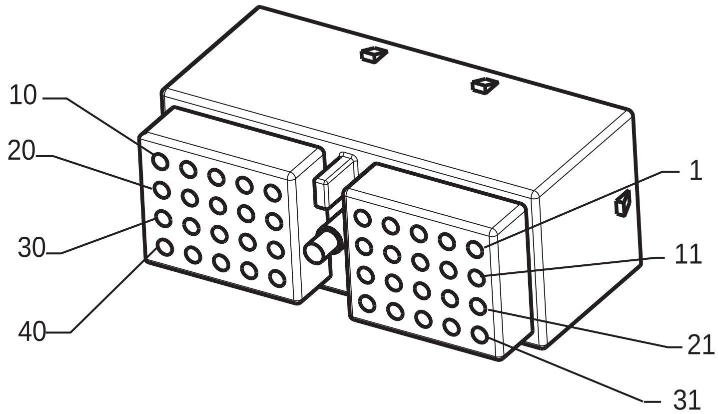
- Inverter
- Resolver Harness between the motor/generator and Inverter

FMI 2, 22, 23, 24, 25, 27

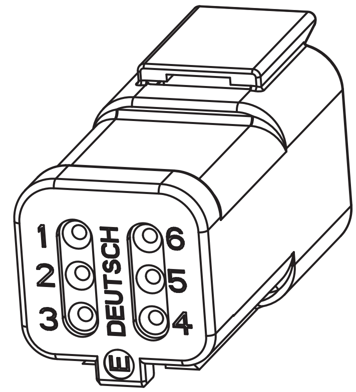
- Inverter
- Motor/generator
- Resolver Harness between the motor/generator and Inverter
- Water in Inverter or Resolver wire connector.

Component Identification

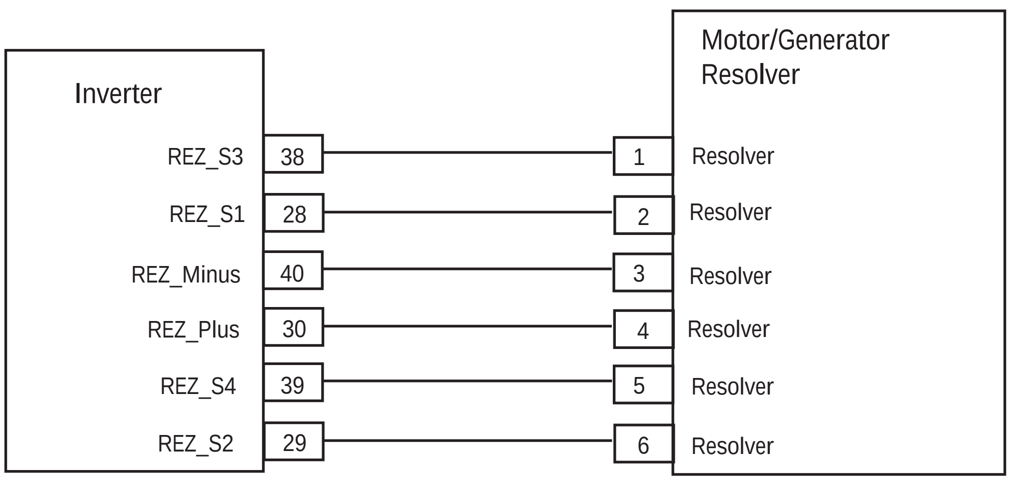
Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)



Terminal Side - Harness Connector
Resolver
(Deutsch 6-pin connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 4 - Motor/Generator Rotation Speed Sensor

A

Purpose: *Check for Active or Inactive fault code status, perform Electrical Pretest and Hybrid Electrical Pretest. Verify FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Perform Electrical Pretest and Hybrid Electrical Pretest.
5. Check Inverter part number.
   - If Inverter is part number 4306453, contact Eaton Call Center at 1-800-826-HELP (4357)
6. Which FMIs are present?
   - If FMI 22, 24, 25 or 27 are listed, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If FMI 2, 23 or 26 are listed, go to **Step B.**
   - If FMI 3 or 21 is listed, go to **Step F.**
   - If FMI 0 is listed, go to **Step G.**

B

Purpose: *Verify continuity of Resolver and Inverter components.*

1. Key off.
2. Disconnect the 40-Way Low-Voltage Connector at the Inverter.
3. Inspect for water intrusion inside wire connector.
4. Determine if resistance for the Resolver at the 40-Way Harness Connector between the following pins is within the range listed:
   - Pin 30 to Pin 40 is 8.6–10.5 ohms
   - Pin 28 to Pin 38 is 28–34 ohms
   - Pin 29 to Pin 39 is 23–27 ohms

Note: An auto-ranging digital volt/ohm meter must be used.

- If resistance is outside of range for any of the readings, go to **Step E.**
- If resistance is within range, go to **Step C.**

Connection	Measurement
Pin 30 to Pin 40	
Pin 28 to Pin 38	
Pin 29 to Pin 39	

C ***Purpose:*** *Verify continuity of Resolver and Inverter components.*

1. Key off.
2. Disconnect the 40-Way Low-Voltage Connector at the Inverter.
3. Measure Resolver resistance at the 40-Way Harness Connector between the following pins:
   - Pin 38 to Pin 40
   - Pin 38 to Pin 30
   - Pin 28 to Pin 40
   - Pin 28 to Pin 30
   - Pin 28 to ground
   - Pin 38 to ground
   - Pin 30 to ground
   - Pin 40 to ground
     - If resistance is open or OL, replace Inverter.
     - If resistance is anything other than OL, go to **Step D.**

Connection	Measurement
Pin 38 to Pin 40	
Pin 38 to Pin 30	
Pin 28 to Pin 40	
Pin 28 to Pin 30	
Pin 28 to ground	
Pin 38 to ground	
Pin 30 to ground	
Pin 40 to ground	

D ***Purpose:*** *Verify continuity of Resolver Harness circuitry.*

1. Disconnect the 6-Way motor/generator Resolver Connector (the connector going into the motor).
2. Measure the Resolver resistance at the 6-Way Harness Connector between the following pins:

   Note: An auto-ranging digital volt/ohm meter must be used.

   - Pin 1 to Pin 3
   - Pin 1 to Pin 4
   - Pin 2 to Pin 3
   - Pin 2 to Pin 4
   - Pin 1 to ground
   - Pin 2 to ground
   - Pin 3 to ground
   - Pin 4 to ground
     - If resistance is open or OL, repair wiring between Resolver and Inverter.
     - If resistance is anything other than OL, replace the motor/generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin 1 to Pin 3	
Pin 1 to Pin 4	
Pin 2 to Pin 3	
Pin 2 to Pin 4	
Pin 1 to ground	
Pin 2 to ground	
Pin 3 to ground	
Pin 4 to ground	

E

Purpose: *Measure resistance of Resolver circuit at motor/generator.*

1. Disconnect 6-Way Resolver wire connector at motor/generator.
2. Determine if resistance on the following pins falls within the listed range:
   - Pin 1 to Pin 2 is between 28–34 ohms
   - Pin 3 to Pin 4 is between 8.6–10.5 ohms
   - Pin 5 to Pin 6 is between 23–27 ohms

   - If resistance is outside of range, replace the motor/generator (Resolver is not serviceable). After repairs are made go to **Step V.**
   - If resistance is within range, repair wiring between Resolver and Inverter. After repairs are made go to **Step V.**

Connection	Measurement
Pin 1 to Pin 2	
Pin 3 to Pin 4	
Pin 5 to Pin 6	

F

Purpose: *Verify the resistance at the Inverter.*

1. Key off
2. Disconnect 40-Way Low Voltage Connector at the Inverter.
3. Measure Resolver resistance at the 40-Way Harness connector between the following pins:
   - Pin 28 to Pin 1
   - Pin 28 to Pin 6
   - Pin 29 to Pin 1
   - Pin 29 to Pin 6
   - Pin 38 to Pin 1
   - Pin 38 to Pin 6
   - Pin 39 to Pin 1
   - Pin 39 to Pin 6

   Note: An auto-ranging digital volt/ohm meter must be used.

   - If resistance is open or OL replace inverter. After repair is made go to **Step V.**
   - If resistance is anything other than OL go to H.

Connection	Measurement
Pin 28 to Pin 1	
Pin 28 to Pin 6	
Pin 29 to Pin 1	
Pin 29 to Pin 6	
Pin 38 to Pin 1	
Pin 38 to Pin 6	
Pin 39 to Pin 1	
Pin 39 to Pin 6	

G

Purpose: *Verify overspeed condition by test driving the vehicle.*

1. Test drive vehicle to verify an overspeed condition. This may require a downhill road condition, verify with customer the road condition when fault was set.
   - If FMI 0 is set in a true overspeed condition, vehicle will need to be slowed down to prevent overspeed condition.
   - If possible, update HCM software version number 672 or higher. If vehicle has HCM with primary hardware version 4306455, the most current software version available is 663. To update software version 672 or higher requires an HCM with hardware version 4306473. Hardware version number can be found in Service Ranger under Product Configurations, HCM, Primary Hardware Version.

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 4 appears, find error in testing, go to **Step A.**
   - If a code other than 4 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 5 - Motor/Generator AC Cable

J1939 SA 239 SPN 520229 FMI 21–29

Overview

The motor/generator AC Cables are connected from the motor/generator to the Inverter. These cables carry up to 500 volts 3-phase AC when the vehicle is in operation.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- FMIs 25–27 require the Motor/Generator RPM to be greater than 500 RPM.
- FMI 28 requires the Motor/Generator RPM to be less than 500 RPM.
- FMI 29 requires the Motor/Generator RPM to be less than 50 RPM.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 21: Set when the AC interlock circuit is open.

FMI 22, 23, 24: Set when the 2-phase motor current is more than 360 amps for 0.9 MS.

FMI 25, 26, 27: Set when the Inverter detects a single open wire and motor current is less than 8 amps for 200 MS at speeds greater than or equal to 500 RPM and current command from the Inverter is greater than 20 amps.

FMI 28: Set when motor/generator current is less than 8 amps for 200 MS at a speed less than 500 RPM and current command greater than 20 amps.

FMI 29: Set during initialization, the Inverter checks if the AC cable is connected between the motor and Inverter by sending out 20 amps for 200 MS and checking the feedback.

Fallback

When Fault Code 5 is set, the following conditions occur:

- Red “Stop Hybrid” light illuminates.
- Fault is stored in Hybrid Control Module (HCM) memory.
- Inverter shuts high-voltage system off.
- HCM continues to control the hybrid vehicle in diesel-only mode.
- If FMI 28 or 29 is present at power up, the vehicle does not crank.

Possible Causes

This fault code can be caused by any of the following:

FMI 21

- AC Cable Interlock

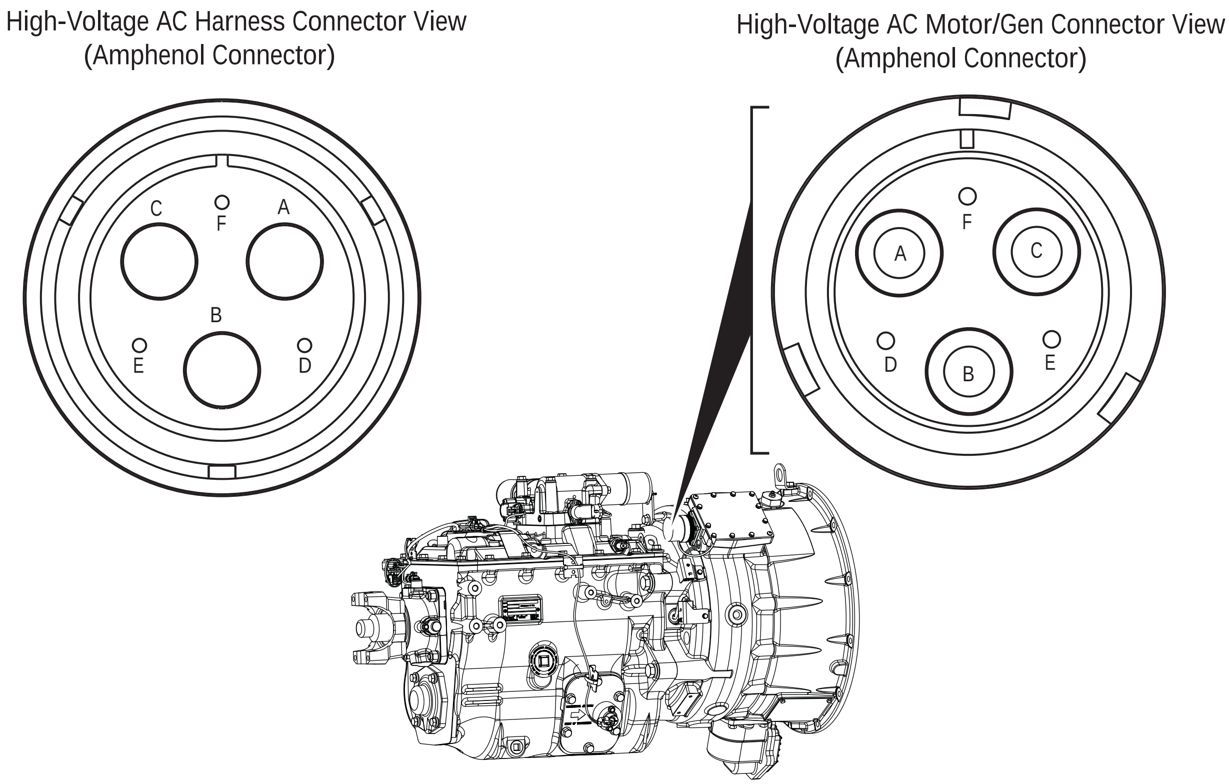
FMI 22, 23, 24

- Inverter
- Motor/generator
- AC Cable

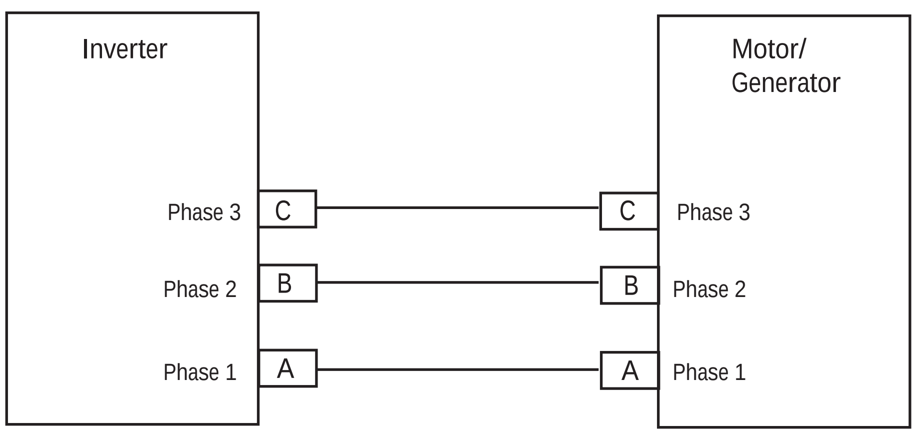
FMI 25, 26, 27, 28, 29

- Motor/generator
- AC Cable

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 5 - Motor/Generator AC Cable

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which faults and FMIs are present?
   - If Fault Code 5 FMI 21 is Active, go to **Step E.**
   - If Fault Code 5 FMI 22, 23 or 24 are Active, go to **Step B.**
   - If Fault Code 5 FMI 25, 26, 27, 28 or 29 are Active, go to **Step C.**

B

Purpose: *Verify continuity of high-voltage cable.*

1. Key off.
2. Remove AC High-Voltage Cable at the Motor/Generator and Inverter.
3. Measure the resistance between the following AC Cable pins: Pin C and Pin B; Pin B and Pin A; Pin A and Pin C:
   - If resistance between each phase is 5M ohms or greater, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, replace the AC High-Voltage Cable, then go to **Step V.**

Connection	Measurement
Pin C to Pin B	
Pin B to Pin A	
Pin A to Pin C	

C ***Purpose:*** *Verify continuity of high-voltage cable.*

1. Disconnect the AC High-Voltage Cable from the Inverter and motor/generator.
2. Measure the resistance of the AC high-voltage cable from the Inverter Connector to the Motor/Generator Connector on each of the following pins: Pin A and Pin A; Pin B and Pin B; Pin C and Pin C:

   Note: An auto-ranging digital volt/ohm meter must be used.

   - If the resistance of each circuit is 1ohm or less, go to **Step D.**
   - If resistance is outside of range, replace the AC High-Voltage Cable, then go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

D ***Purpose:*** *Verify continuity of high-voltage cable.*

1. Measure the resistance of the AC High-Voltage Cable from the Inverter Connector to the Motor/Generator Connector on each of the following pins: Pin C and Pin B; Pin B and Pin A; Pin A and Pin C:

   Note: An auto-ranging digital volt/ohm meter must be used.

   - If the resistance of each phase is 10 ohms or less, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If resistance is outside of range, replace the Motor/Generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin C to Pin B	
Pin B to Pin A	
Pin A to Pin C	

E ***Purpose:*** *Verify high-voltage cable connections.*

1. Check the AC Cable Connectors at the motor/generator and Inverter to ensure they are properly connected:
   - If connections are loose or not properly connected, reconnect AC Cables to component and go to **Step V.**
   - If connections are not loose and are properly connected, go to **Step F.**

F ***Purpose:*** *Verify continuity of interlock circuit.*

1. Disconnect the AC cable from the motor/generator and Inverter.
2. Measure the interlock circuit resistance from the Inverter Connector and the Motor/Generator Connector at the following pins: Pin D and Pin D; Pin E and Pin E

   Note: An auto-ranging digital volt/ohm meter must be used.

   - If the resistance is 0–0.3 ohms, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If resistance is outside of range, replace the AC cable between the Inverter and Motor/Generator, then go to **Step V.**

Connection	Measurement
Pin D to Pin D	
Pin E to Pin E	

V	***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the fault code.
6. Check for fault codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 5 appears, find error in testing, go to **Step A.**
   - If a code other than 5 appears, go to Fault Code Isolation Procedure Index on page 14.

Fault Code 6 - No HCM Operation

J1939 SA 239 SPN 629 FMI 14

Overview

The Hybrid Control Module (HCM) is mounted to the transmission and contains software to control both the hybrid power electronics as well as the transmission operation.

Detection

Fault is detected when HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 14 is set when HCM can not complete writing to the Electrically Erasable Programmable Read-Only Memory (EEPROM) during shut down.

Fallback

When Fault Code 6 is set, the following conditions occur:

- Amber “Check Hybrid” light illuminates if the HCM sets the fault after power up.
- If the fault occurs at power up, the vehicle may not crank.

Possible Causes

This fault code can be caused by the following:

- FMI 14
  - HCM

Component Identification

Note: No schematic for this code.

Fault Code 6: Troubleshooting

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
   - If Fault Code 6 is Active, replace HCM (only when Fault Code 6 is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000.
   - If Fault Code 6 is Inactive, test is complete.

Fault Code 7 - Improper HCM Configuration

J1939 SA 239 SPN 629 FMI 13

Overview

The Hybrid Control Module (HCM) is mounted to the transmission and contains software to control both the hybrid power electronics as well as the transmission operation.

Detection

HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 13 is set at key on if the HCM data is not read from memory within 1 second.

Fallback

When Fault Code 7 is set, the following conditions occur:

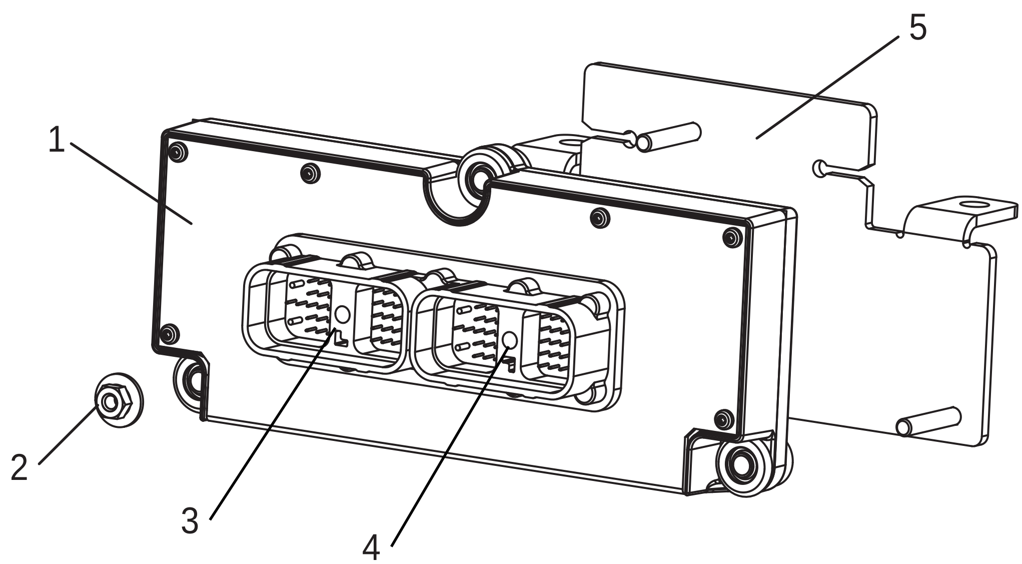
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- If this fault occurs at power up, the vehicle does not crank.

Possible Causes

This fault code can be caused by any of the following:

FMI 13: Improper Electronic Control Unit (ECU) configuration software.

Component Identification



1. Hybrid Control Module (HCM)
2. Nut (3)
3. 38-Way System Connector Plug-in
4. 38-Way Vehicle Connector Plug-in
5. Mounting Plate

Fault Code 7 - Improper HCM Configuration

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Turn key off for 2 seconds.
3. Key on.
4. Is Fault Code 7 Active?
   - If Fault Code 7 is Active, replace the HCM (only if the fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000.
   - If Fault Code 7 is Inactive, test is complete.

Fault Code 8 - Loss of Switched Ignition Power Fault (HCM)

J1939 SA 239 SPN 158 FMI 4

Overview

Hybrid Control Module (HCM) is mounted to the transmission and contains the software that controls both the hybrid power electronics as well as the transmission operation. The HCM ignition power is a single 12-volt feed that is fused and runs through the HCM 38-Way Vehicle Connector.

Detection

Output Shaft speed must be greater than 0 RPM.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 4 is set when the HCM loses ignition power during operation for 2 seconds or longer.

Note: When troubleshooting an Inactive code, see “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 8 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates if the vehicle is moving.
- Fault is stored in HCM memory.
- Red “Service” light illuminates, and an “F” flashes in the gear display, if the fault occurs prior to power up.
- Fault is stored in Transmission Electronic Control Unit (TECU) memory due to lack of communication with the HCM.
- If faults occurs while the vehicle is moving, the transmission remains in place and the clutch opens when the vehicle comes to an idle. The clutch closes and the vehicle operates in 1st and reverse from stop.
- If this fault occurs at power up, the vehicle does not crank.

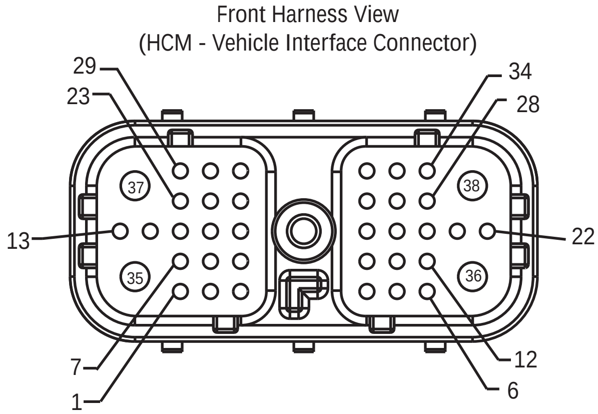
Possible Causes

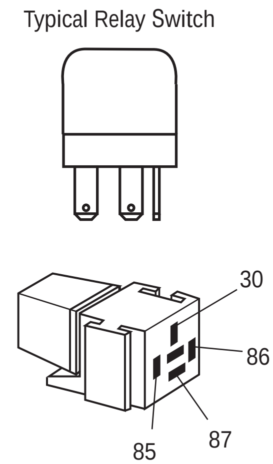
This fault code is caused by any of the following:

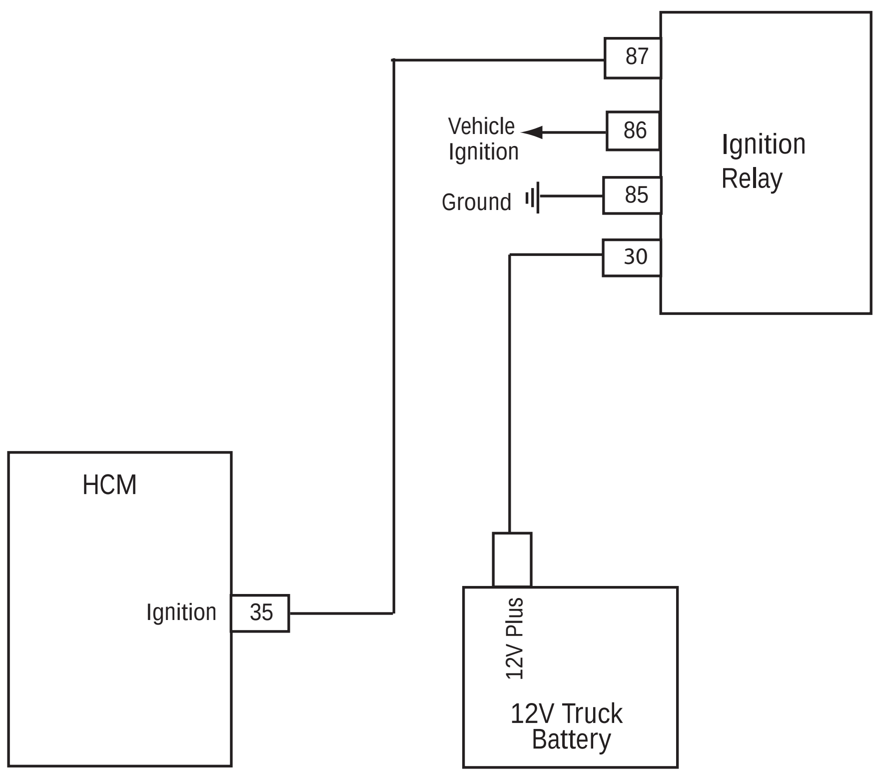
- FMI 4
  - Ignition power supply to HCM
  - HCM

Component Identification

NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations







Fault Code 8 - Loss of Switched Ignition Power Fault (HCM)

A

Purpose: *Check for Active or Inactive fault code status and perform electrical pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Perform Electrical Pretest.
   - If Fault Code 8 is Active after performing the Electrical Pretest, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If Fault Code 8 is Inactive after performing the Electrical Pretest, go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 8 appears, find error in testing, go to **Step A.**
   - If a code other than 8 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 9 - Weak Battery Voltage

J1939 SA 239 SPN 168 FMI 14

Overview

The Hybrid Control Module (HCM) is mounted to the transmission and it contains all of the software to control both the hybrid power electronics as well as the transmission operation. The HCM main battery power is a 12-volt feed that is fused and runs through the HCM 38-Way Vehicle Connector with the main ground wire returning to the battery negative terminal.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- HCM System Battery Voltage Low Fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 14 is set when the HCM battery voltage drops below 9 volts for 10 seconds.

Note: When troubleshooting an Inactive code, see "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 9 is set the following conditions occur:

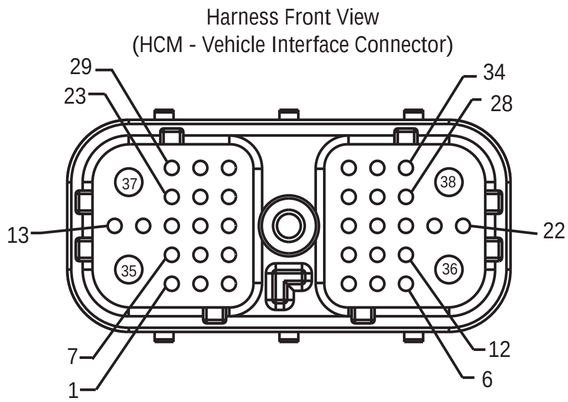
- Amber "Check Hybrid" light illuminates.
- Red "Hybrid Stop" lamp will display if there are additional fault codes caused by the low or weak voltage. This feature was added with HCM Software 1107 and higher.
- Fault is stored in HCM memory.

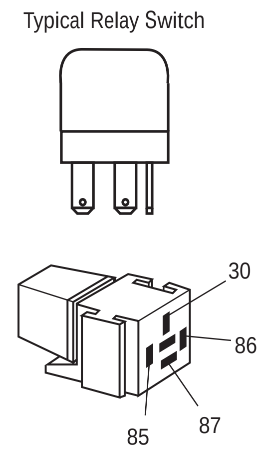
Possible Causes

This fault code can be caused by any of the following:

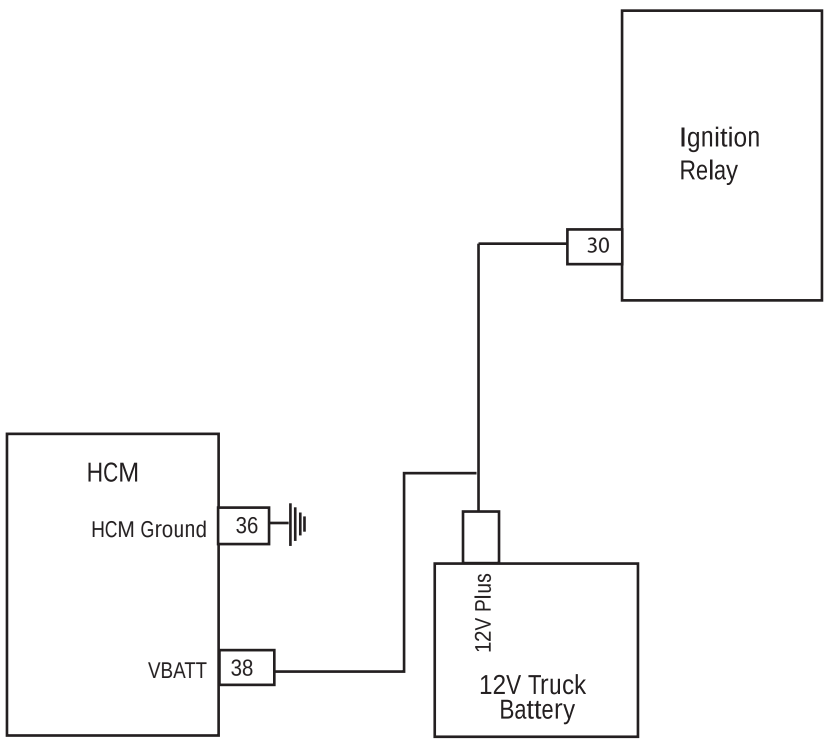
- FMI 14
  - Power supply harness to the HCM.
  - Low batteries or bad main power connection.
  - Charging system.

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 9 - Weak Battery Voltage

A ***Purpose:*** *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Perform Electrical Pretest:
   - If Fault Code 9 is Active after performing the Electrical Pretest, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000 (only if Fault Code is Active), go to **Step V.**
   - If Fault Code 9 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 9 appears, find error in testing, go to **Step A.**
   - If a code other than 9 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 10 - Low Battery Voltage (HCM)

J1939 SA 239 SPN 168 FMI 4

Overview

The Hybrid Control Module (HCM) is mounted to the transmission and it contains all of the software to control both the hybrid power electronics as well as the transmission operation. The HCM main battery power is a 12-volt feed that is fused and runs through the HCM 38-Way Vehicle Connector with the main ground wire returning to the battery negative terminal.

Detection

Fault is detected when HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 4 is set when the HCM battery voltage drops below 7 volts for more than 1 second.

Note: When troubleshooting an Inactive code, see “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 10 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Red “Hybrid Stop” lamp will display if there are additional fault codes caused by the low or weak voltage. This feature was added with HCM Software 1107 and higher.
- Fault is stored in HCM memory.

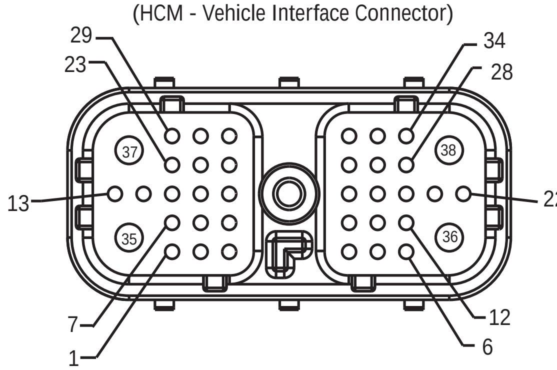
Possible Causes

This fault code can be caused by any of the following:

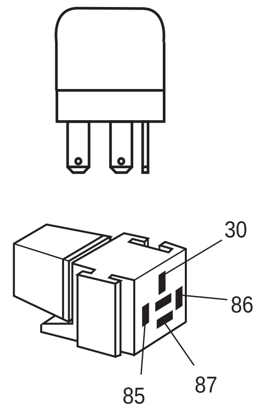
- FMI 4
  - Power Supply Harness to the HCM
  - Low batteries or bad power connection
  - Charging system

Component Identification

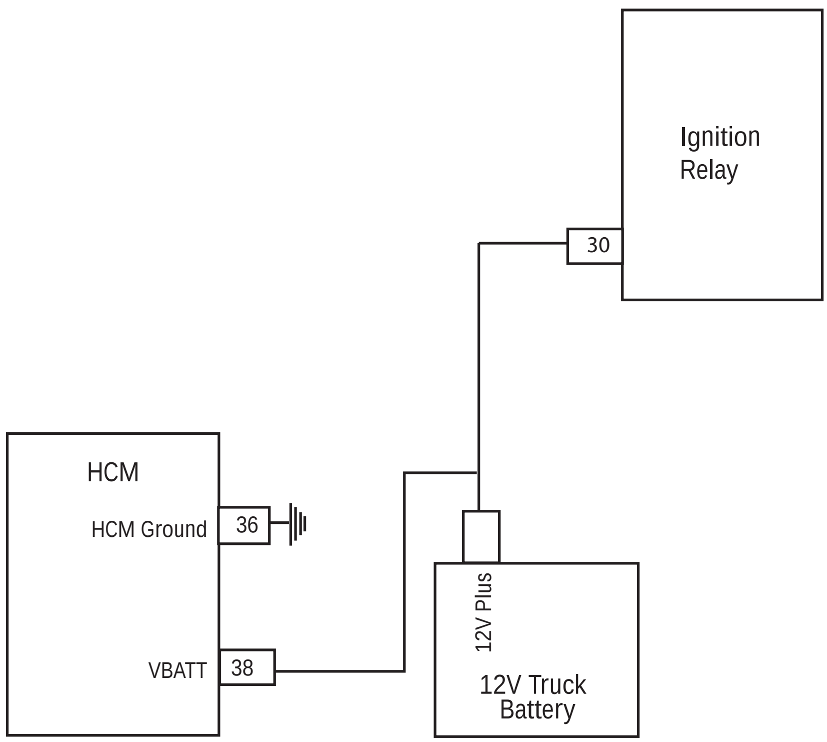
Harness Front View
(HCM - Vehicle Interface Connector)



Typical Relay Switch



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 10 - Low Battery Voltage (HCM)

A ***Purpose:*** *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 10 is Active.
3. Perform Electrical Pretest:
   - If Fault Code 10 is still Active after performing the Electrical Pretest, replace HCM (only if Fault Code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, go to **Step V.**
   - If Fault Code 10 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 10 appears, find error in testing, go to **Step A.**
   - If a code other than 10 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 11 - No TECU Operation

J1587 MID 130 SID 254 FMI 12
J1939 SA 3 SPN 629 FMI 12

Overview
The Transmission Electronic Control Unit (TECU) is mounted to the transmission and contains all of the software to control the transmission operation; however, the Hybrid Control Module (HCM) controls the operation of the TECU during hybrid operation.

Detection
Fault is detected when HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active
The following conditions may set the fault Active:

FMI 12 is set if the TECU detects an intermittent failure in the Electric Shifter position.

Fallback
When Fault Code 11 is set the following conditions occur:

- Red “Service” light illuminates and an “F” flashes in the gear display only if the fault occurs after power up.
- Fault is stored in TECU memory.
- If the fault code occurs after power up, the transmission remains in the current gear and the clutch opens.

Possible Causes
This fault code can be caused by any of the following:

- FMI 12
  - Electric Shifter

Component Identification

Note: No schematic for this code.

Fault Code 11 - No ECU Operation

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector:
   - If Fault Code 11 is Active, replace Electric Shifter. See **Electric Shifter Removal and Installation** procedure in TRSM2000 (only if fault code is Active).
   - If Fault Code 11 is Inactive, test is complete.

Fault Code 12 - Improper ECU Configuration (TECU)

J1587 MID 130 SID 254 FMI 13
J1939 SA 3 SPN 629 FMI 13

Overview

The Transmission Electronic Control Unit (TECU) is mounted to the transmission and contains software that controls the transmission operation; however, the HCM controls the operation of the TECU during hybrid mode.

Detection

Fault is detected when HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 13 is set when the ECU is not reading valid information from memory, including the transmission table and calibration values within 1 second of power up.

Fallback

When Fault Code 12 is set the following conditions occur:

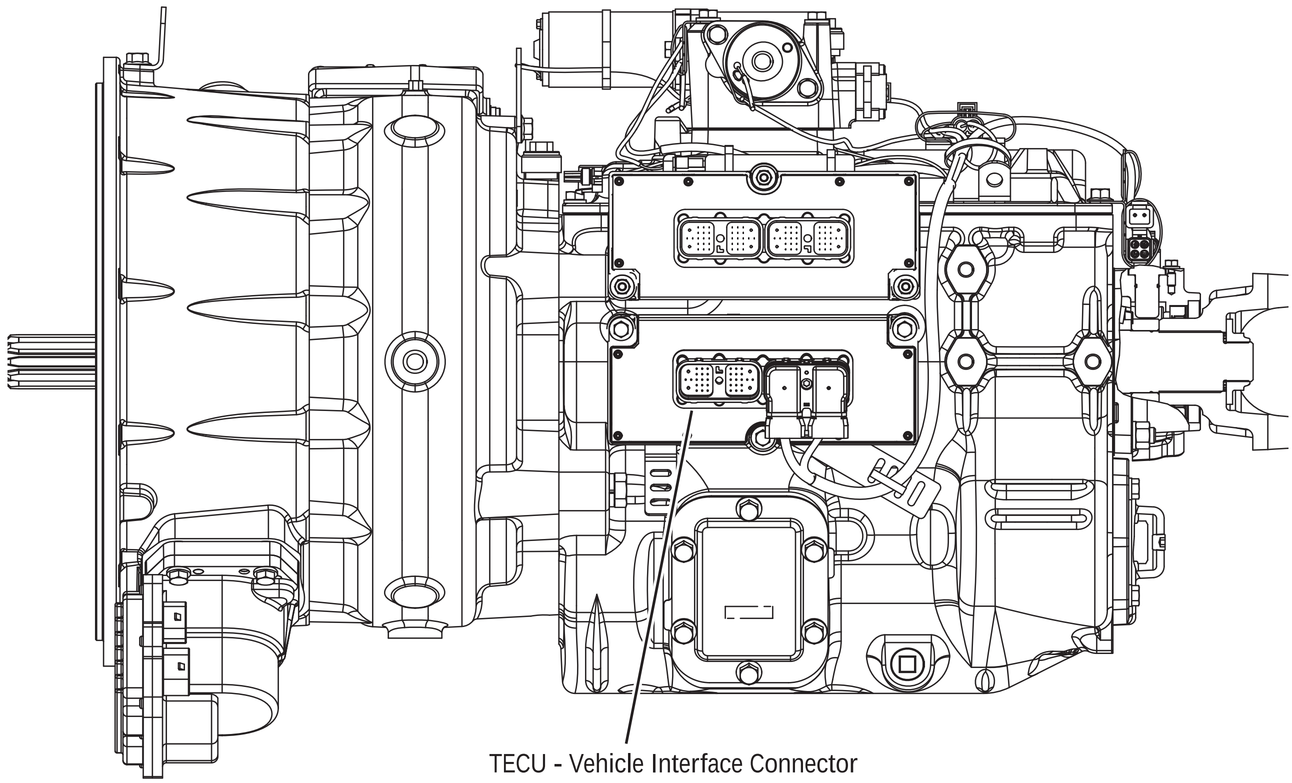
- Red “Service” light illuminate and an “F’ flashes in the gear display.
- If the fault occurs at power up the vehicle does not crank.

Possible Causes

This fault code can be caused by any of the following:

- FMI 13
  - Improper ECU configuration software.

Component Identification



Fault Code 12 - Improper ECU Configuration (TECU)

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector:
   - If Fault Code 12 is Active, replace the **Transmission Electronic Control Unit (TECU)** (only if the fault code is Active).
   - If Fault Code 12 is Inactive, test is complete.

Fault Code 14 - Invalid Shifter Range

J1587 SID 18, 19 PID 18, 19 FMI 2, 3, 4
J1939 SA 3 SPN 751 FMI 2, 3, 4

Overview

The Transmission Electronic Control Unit (TECU) is connected to the shift device, which sends driver mode selection data. The only compatible shift devices are the Eaton® Push Button Shift Control (PBSC) and OEM-supplied Shift Lever (if equipped with park). The TECU checks the vehicle for the type of shift device during the first power up.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- TECU is being powered up for the first time and no shift device has been configured.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 2: Set when the shifter is not returning a valid position (PRNDH1)

FMI 3: Set when the Hall-Effect Sensor voltage is higher than expected

FMI 4: Set when the Hall-Effect Sensor voltage is lower than expected

Note: When troubleshooting an Inactive code, see "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 14 is set the following conditions occur:

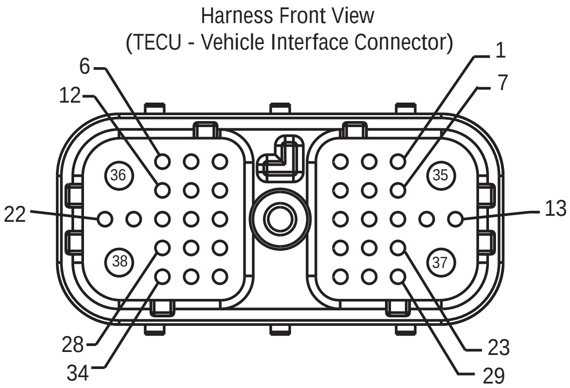
- An "F" appears in the gear display.
- Fault is stored in TECU memory.
- TECU changes to AutoShift control.
- Engine does not crank.

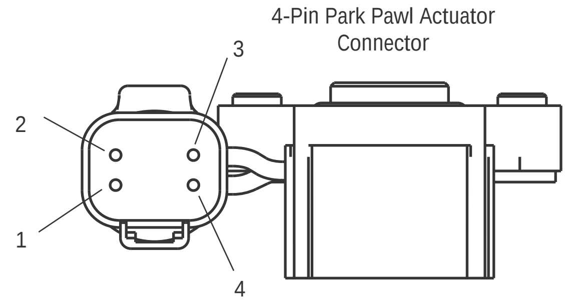
Possible Causes

This fault code can be caused by any of the following:

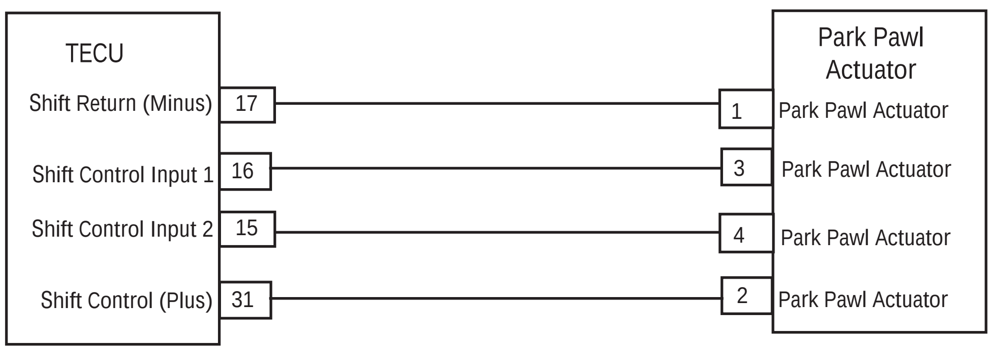
- FMI 2
  - Shifter is in between detent positions or sensor is out of calibration.
- FMI 3
  - Hall-Effect Sensor input is shorted high or sensor ground in open.
- FMI 4
  - Hall-Effect Sensor input is open circuit or shorted to ground.

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 14 - Invalid Shifter Range

A

Purpose: *Verify supply voltage at Shift Lever.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Disconnect the 4-Way Connector to the Park Pawl Actuator.
3. Key on.
4. Check for 12-volt supply to 4-Pin Connector at Pin 1 and Pin 2.
   - If voltage between Pin 1 and Pin 2 is between 8–14 volts of battery voltage, go to **Step B.**
   - If voltage is outside the range, go to **Step D.**

Connection	Measurement
Pin 1 to Pin 2	

B

Purpose: *Verify voltage of Shift Lever in neutral position.*

1. With the Actuator/Shift Lever in the Neutral position check voltage on Pin 3 to ground, Pin 4 to ground.
   - If voltage is between 2.25–2.75 volts, go to **Step C.**
   - If voltage is outside the range, replace the Sensor. See the **Park Pawl Mechanism Sensor Removal and Installation** procedure in TRSM2000, go to **Step V.**

Connection	Measurement
Pin 3 to Ground	
Pin 4 to Ground	

C

Purpose: *Verify continuity of TECU Harness.*

1. Disconnect the TECU Harness 38-Way Connector.
2. Check continuity between 38-Way Connector Pin 15 and 4-Way Connector Pin 4, 38-Way Connector Pin 16 and 4-Way Connector Pin 3.
   - If continuity is good, replace the **Transmission Electronic Control Unit (TECU)** and go to **Step V.**
   - If an open is found, repair or replace the TECU Harness, then go to **Step V.**

Connection	Measurement
38-Way Pin 15 to 4-Way Pin 4	
38-Way Pin 16 to 4-Way Pin 3	

D

Purpose: *Verify continuity of TECU Harness.*

1. Disconnect the TECU Harness 38-Way Connector.
2. Check continuity between 38-Way Connector Pin 17 and 4-Way Connector Pin 1, 38-Way Connector Pin 31 and 4-Way Connector Pin 2.
   - If continuity is good, replace the **Transmission Electronic Control Unit (TECU)** and go to **Step V.**
   - If an open is found, repair or replace the TECU Harness, then go to **Step V.**

Connection	Measurement
38-Way Pin 17 to 4-Way Pin 1	
38-Way Pin 31 to 4-Way Pin 2	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 14 appears, find error in testing, go to **Step A.**
   - If a code other than 14 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 16 - High Integrity Link (HIL)

J1587 MID 130 SID 248 FMI 2
J1939 SA 3 SPN 625 FMI 2

Overview

The High Integrity Link (HIL) is a high-speed twisted pair 500K proprietary data link that connects the Transmission Electronic Control Unit (TECU) to the Push Button Shift Control (PBSC). Each module contains an internal 120 ohm resistor. The HIL transmits information such as driver mode selection and fault information to illuminate the “Service” light.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- TECU Driver Interface Configuration is set to High-Integrity Link (HIL).

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 2 is set when the TECU loses communication for 5 seconds or more with the PBSC.

Note: When troubleshooting an Inactive code, See “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 16 is set the following conditions occur:

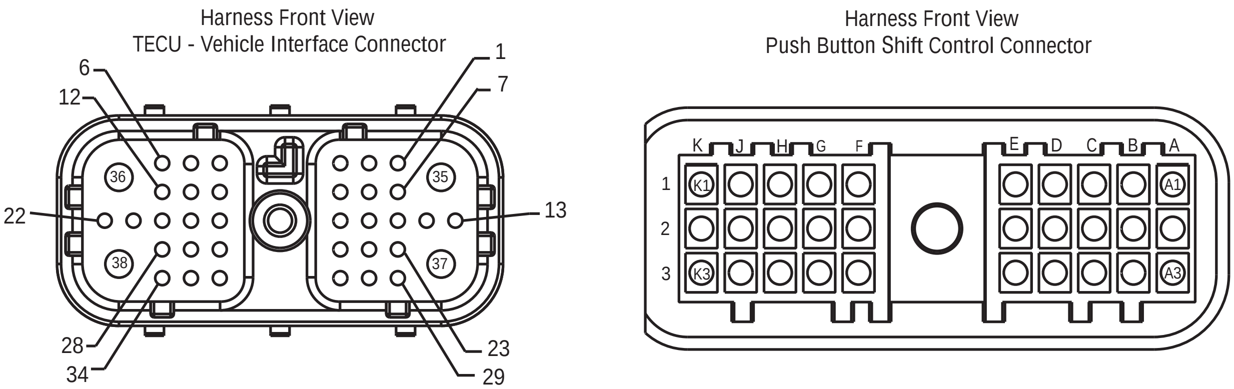
- “F” appears in the gear display.
- Push Button Mode Light flashes next to the selected mode and the “Service” light remains off.
- Push Button Lights illuminate and then remain off if the data link fails at power up.
- Fault is stored in TECU memory.
- Operation mode changes to Auto Shift Fallback.
- If the fault code is Active during power up, the Transmission does not engage a gear.
- If the fault code is Active while driving, the Transmission remains in current gear and then shifts into default gear once the vehicle stops. The clutch opens at idle and closes if the throttle is pressed. The vehicle moves into the default start gear only.

Possible Causes

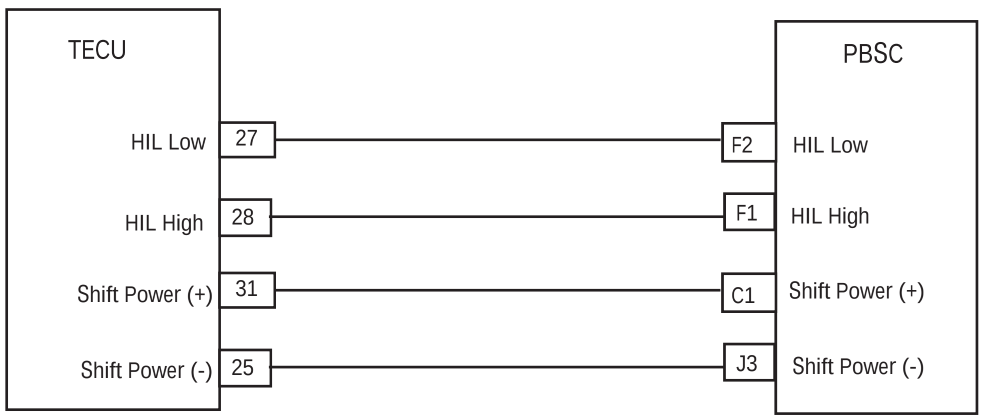
This fault code can be caused by any of the following:

- FMI 2
  - HIL Data Link
  - PBSC
  - TECU
  - Power Supply Harness from TECU to PBSC

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 16 - High Integrity Link (HIL)

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 16 is Active.
3. Key on and observe the red push button “Service” light.
   - If the red “Service” light turns on, go to **Step C.**
   - If the red “Service” light does not turn on, go to **Step B.**

B

Purpose: *Verify voltages at Vehicle Harness.*

1. Disconnect Shift Control 30-Way Connector.
2. Key on.
3. Measure voltage on 30-Way Connector Pin J3 and Pin C1.
   - If voltage is within 0.6 volts of battery voltage, go to **Step C.**
   - If out of range, go to **Step D.**

Connection	Measurement
Pin J3 to Pin C1	

C

Purpose: *Verify voltage at Push Button Shift Controller.*

1. Key off.
2. Disconnect the 30-Way Push Button Shift Control Connector.
3. Key on.
4. Connect voltmeter leads to Pin F1 and Pin F2.

   Note: Make sure the volt/ohm meter is on the proper scale (around 10 volts AC).

   - If the voltage is 0.10 volts AC or greater, replace Push Button Shift Control (only if fault code is Active). See the **Shift Control Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If the voltage is out of range, go to **Step F.**

Connection	Measurement
Pin F1 to Pin F2	

D *Purpose:* *Verify continuity from Vehicle Harness to Push Button Shift Controller.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.

   Note: On Peterbilt units, disconnect gear display.
4. Measure resistance between Shift Control 30-Way Connector Pin J3 and Vehicle Harness 38-Way Connector Pin 25.
   - If resistance between Pin J3 and Pin 25 is 0–0.3 ohms, go to **Step E.**
   - If any of the above conditions are not met, repair Vehicle Harness between the Shift Control and TECU, then go to **Step V.**

Connection	Measurement
Pin J3 to Pin 25	

E *Purpose:* *Verify continuity from Push Button Shift Controller circuits to ground.*

1. Key off.
2. Measure the resistance between Shift Control 30-Way Connector Pin C1 and Vehicle Harness 38-Way Connector Pin 31, and between Shift Control 30-Way Connector Pin C1 and ground.
   - If resistance between Pin C1 and Pin 31 is 0–0.3 ohms and resistance between Pin C1 and ground is 10K ohms or greater, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If any of the above conditions are not met, repair Vehicle Harness between the TECU and Shift Control, then go to **Step V.**

Connection	Measurement
Pin C1 to Pin 31	
Pin C1 to Ground	

F

Purpose: *Verify continuity from Push Button Shift Controller circuits to ground.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure resistance between:
   - Shift Control 30-Way Connector Pin F1 and Vehicle Harness 38-Way Connector Pin 28
   - Shift Control 30-Way Connector Pin F1 and ground
     - If resistance between Pin F1 and Pin 28 is 0–0.3 ohms and if resistance between Pin F1 and ground is 10K ohms or greater, go to **Step G.**
     - If any of the above conditions are not met, repair Vehicle Harness between the Shift Control and TECU, then go to **Step V.**

Connection	Measurement
Pin F1 to Pin 28	
Pin F1 to Ground	

G

Purpose: *Verify continuity from Vehicle Harness to Push Button Shift Controller.*

1. Key off.
2. Measure resistance between:
   - Shift Control 30-Way Connector Pin F2 and Vehicle Harness 38-Way Connector Pin 27.
   - Shift Control 30-Way Connector Pin F2 and ground.
     - If resistance between Pin F2 and Pin 27 is 0–0.3 ohms and resistance between Pin F2 and ground is 10K ohms or greater, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
     - If any of the above conditions are not met, repair Vehicle Harness between the Shift Control and TECU, then go to **Step V.**

Connection	Measurement
Pin F2 to Pin 27	
Pin F2 to Ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 16 appears, find error in testing, go to **Step A.**
   - If a code other than 16 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 17 - Start Enable Relay

J1587 MID 130 SID 237 FMI 3, 4
J1939 SA 3 SPN 626 FMI 3, 4

Overview

The Start Enable Relay is wired into the Transmission Electronic Control Unit (TECU) on the coil side of the relay. At key on, the HCM determines which starting method to use (high-voltage motor/generator, or engine Starter). If the HCM uses the standard Engine Starter, the 12-volt Cranking Relay is energized. This supplies battery power to the Start Enable Relay main feed, which then powers the Starter Solenoid.

Detection

TECU ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 3: TECU detects an open or short to VBATT in the control circuit of the Start Enable Relay for 1 second or greater.

FMI 4: TECU detects a short to ground in the control circuit of the Start Enable Relay for 1 second or greater.

Note: When troubleshooting an Inactive code, see “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 17 is set the following conditions occur:

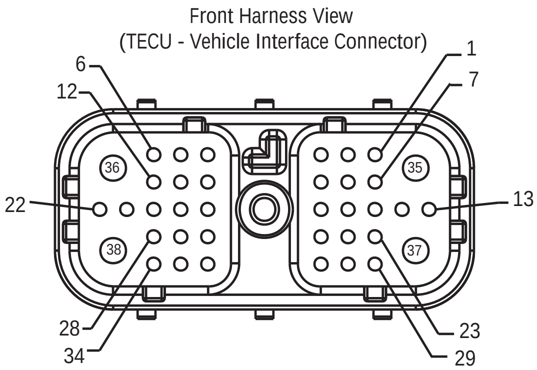
- Red “Service” light illuminates and an “F’ flashes in the gear display.
- Fault is stored in TECU memory.
- If the fault sets at power up the engine still cranks, provided the high-voltage batteries have a sufficient State of Charge (SOC).
- If the fault sets while driving, the vehicle continues to operate.

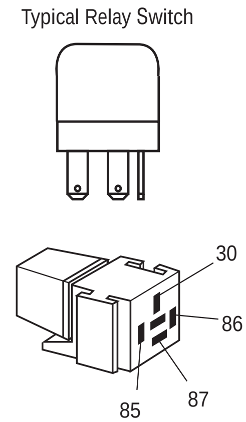
Possible Causes

This fault code can be caused by any of the following:

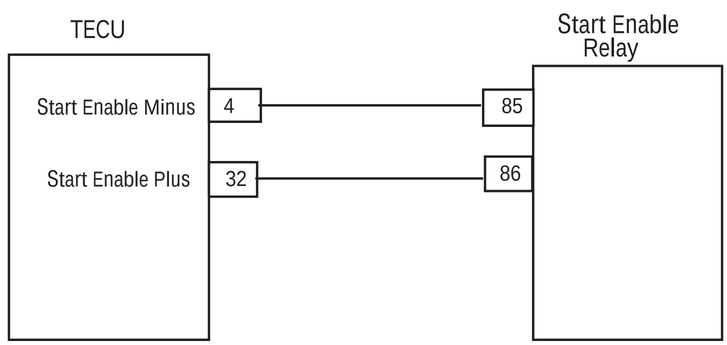
- FMI 3, 4
  - Loose or corroded connections, bent or burned pins, short to ground, open or short to VBATT on the circuit
  - Start Enable Relay
  - TECU

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Note: Refer to “Hybrid Component and Connector Locations” on page 9 for connector locations.

Fault Code 17 - Start Enable Relay

A

Purpose: *Check for active or inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Exchange current Start Enable Relay with another relay and see if fault returns.
   - If fault does not return with new relay, replace Start Enable Relay (only if fault code is Active), then go to **Step V.**
   - If fault returns with new relay, go to **Step B.**

B

Purpose: *Verify FMI set.*

1. Which FMIs were listed from Step A?
   - If FMI 3 is listed, go to **Step C.**
   - If FMI 4 is listed, go to **Step E.**

C

Purpose: *Verify continuity of Transmission Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the Transmission Harness 38-Way Connector.
4. Measure resistance between Vehicle Harness 38-Way Connector Pin 32 and Pin 4.
   - If resistance between Pin 32 and Pin 4 is 40–120 ohms, go to **Step D.**
   - If resistance is outside of range, repair the Vehicle Harness for an open circuit, then go to **Step V.**

Connection	Measurement
Pin 32 to Pin 4	

D

Purpose: *Verify voltages at Transmission Harness.*

1. Key on.
2. Measure voltage between Vehicle Harness 38-Way Connector Pin 32 and ground.

   Note: The voltage only reads 5 volts for 1–2 seconds.

   - If the voltage between Pin 32 and ground is 5 volts, replace the **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If the voltage between Pin 32 and ground is 12 volts, repair the short to VBATT on the harness. Voltage should remain at 5 volts for 1–2 seconds after initial key on, go to **Step V.**

Connection	Measurement
Pin 32 to ground	

E

Purpose: *Verify continuity of Transmission Harness circuits to ground.*

1. Key off.
2. Disconnect battery cable.
3. Disconnect the Transmission Harness 38-Way Connector.
4. Measure the resistance between Vehicle Harness 38-Way Connector Pin 32 and ground.
   - If the resistance between Pin 32 and ground is 10K ohms or greater, replace the **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If the resistance is outside of range, repair the Vehicle Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin 32 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 17 appears, find error in testing, go to **Step A.**
   - If a code other than 17 appear, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 18 - ECA Communication Fault

J1939:SA 239 SPN 520200 FMI 2, 9

Overview

The Electric Clutch Actuator (ECA) controls the position of the Clutch Assembly. The ECA communicates with the Hybrid Control Module (HCM) over the proprietary Controller Area Network (CAN) Data Link to change position, show faults or include other operation information.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- ECA ignition voltage is greater than 8.5 volts.
- HCM CAN Data Link error is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 9 is set when the ECA loses communication on the CAN Data Link for 2 seconds.

Note: When troubleshooting an Inactive code, refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 18 is set the following conditions occur:

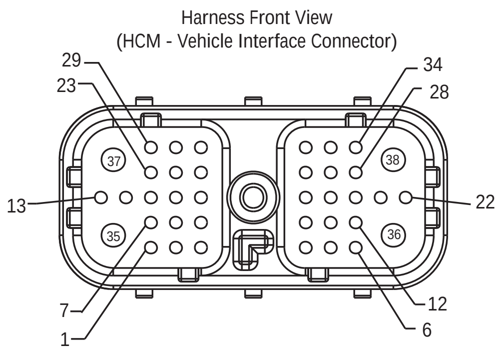
- Red “Stop Hybrid” light displays.
- Fault is stored in HCM memory.
- ECA either maintain current clutch position or move to the last position commanded by the HCM. Upon approaching idle, the clutch opens and remains in this state.
- If the fault occurs at power-up, the vehicle does not crank.

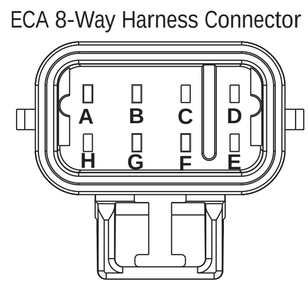
Possible Causes

This fault code can be caused by any of the following:

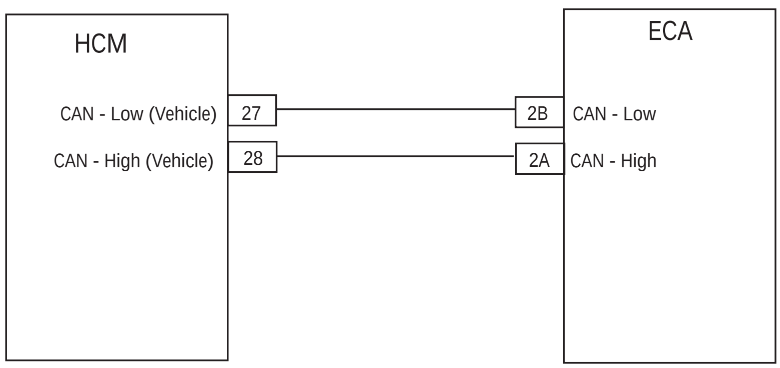
- FMI 2, 9
  - CAN Data Link from the ECA to the link
  - ECA

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 18 - ECA Communication Fault

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Which FMIs are present?
   - If Fault Code 18 is Active, go to “Fault Code 19 - CAN ECA Message Fault (HCM)” on page 101.
   - If Fault Code 18 is not Active, test is complete, go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 18 appears, find error in testing, go to **Step A.**
   - If a code other than 18 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 19 - CAN ECA Message Fault (HCM)

J1939: SA 239 SPN 520273 FMI 2, 9

Overview

Controller Area Network (CAN) is a high-speed twisted pair 500K proprietary data link with one 120 ohm resistor at each end of the link. Hybrid Control Module (HCM) is connected to the CAN Data Link at the 38-Way Connector. This link is used to transmit information to the HCM as well as communicate or receive data from the other modules on the network like the Electric Clutch Actuator (ECA).

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- HCM CAN Communication Link Fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

FMI 9: Set when the HCM fails to receive ECA data (e.g., clutch position) for at least 30 consecutive messages, and it is still communicating with other modules on CAN.

FMI 2: Only Active in PDM and is set when the HCM does not receive 3 consecutive messages from the ECA.

Note: When troubleshooting an Inactive code, refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 19 is set the following conditions occur:

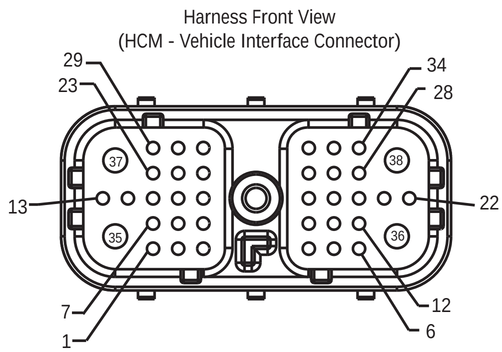
- Red “Stop Hybrid” light displays.
- Fault is stored in HCM memory.
- Operation mode changes to AutoShift only mode.
- If the fault sets at power up, engine does not crank.
- Electric motor/generator assist and regeneration are disabled; however, the high-voltage relays remain powered.
- If the fault occurs while driving, the ECA will either maintain current clutch position or move to the last position commanded by the HCM.
- Transmission defaults start gear to 1st.

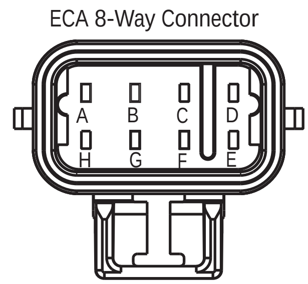
Possible Causes

This fault code can be caused by any of the following:

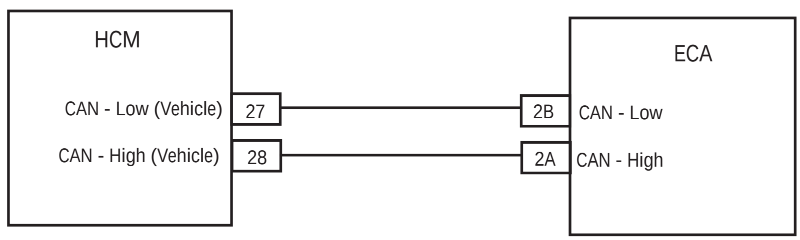
- FMI 9, 2
  - CAN Data Link
  - No power or ground to ECA
  - ECA

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 19 - CAN ECA Message Fault (HCM)

A ***Purpose:*** *Check for Active or Inactive fault code status and perform Electrical Pretest and Hybrid Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Perform Electrical Pretest.
   - If no issues found during the Electrical Pretest, go to **Step B.**
   - If issue was repaired during the Electrical Pretest, go to **Step V.**

B ***Purpose:*** *Verify continuity of ECA circuitry.*

1. Key off.
2. Disconnect ECA 8-Way Connector.
3. Check ECA 8-Way Connector for water intrusion and corrosion.
4. Measure resistance between ECA 8-Way Connector Pin A and Pin B.

   Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin A and Pin B is between 50–70 ohms, go to **Step C.**
   - If resistance is outside of range, repair CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin A to Pin B	

C

Purpose: *Verify continuity of ECA circuitry.*

1. Key off.
2. Disconnect ECA 8-Way Connector 2.
3. Measure resistance between Pin A to ground and Pin B to ground.
   - If resistance is for either pin is 7k, go to **Step D.**
   - If result is 0-100 ohms, repair CAN Wire Harness. After repairs are made, go to **Step V.**

Connection	Measurement
Pin A to ground	
Pin B to ground	

D

Purpose: *Verify CAN Wire Harness is wired correctly.*

1. Key off.
2. Disconnect ECA 8-Way Connector 2.
3. Measure the resistance between the following pins. Determine if the resistance is within the range listed.
   - Pin A of the 9-way diagnostic connector to Pin H (under the dash) should be 0–0.3 ohms.
   - Pin A of the 9-way diagnostic connector (under the dash) to 19-way PEC Connector Pin 1 should be 0–0.3 ohms.
   - Pin B of the 9-way diagnostic connector (under the dash) to Pin J should be 0–0.3 ohms.
   - Pin B of the 9-way diagnostic connector (under the dash) to Pin 2 should be 19-way PEC Connector 0–0.3 ohms.
   - If the measurements are outside the range, repair CAN wiring harness. After repairs are made, go to **Step V.**
   - If the measurements are within the range, go to **Step E.**

Connection	Measurement
9-Way Pin A to Pin H (under the dash)	
9-Way Pin A to PEC Connector Pin 1	
9-Way Pin B to Pin J	
9-Way Pin B to Pin 2	

E **Purpose:** *Verify voltage of the ECA.*

1. Key on.
2. Check for 12-volt power on ECA 8-way connector Pin H with a digital volt/ohm meter.
   - If voltage is present, continue with Step 4.
   - If voltage is lower than 10 volts or there is no voltage, go to **Step F.**
3. Remove ECA 3-way connector and check for water intrusion and corrosion.
4. Check for voltage at ECA 3-way connector Pin C and Pin B with a digital volt/ohm meter.
   - If Pin C and Pin B both have voltage, replace the ECA. See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000. After repairs are made, go to **Step V.**
   - If Pin C and Pin B have less than 10 volts or no voltage, continue to Step 5.
5. Check Pin C for battery voltage, use negative battery post for ground. Check Pin B for ground, use positive battery post for 12 volt.
   - If problem found using battery post, repair ECA wiring harness.
   - If no problem found, find error in testing, go to **Step A.**

Connection	Measurement
8-way connector Pin H to volt meter	
3-way connector Pin C to volt meter	
3-way connector Pin B to volt meter	
Pin C to ground	
Pin B to ground	

F **Purpose:** *Measure continuity between HCM and ECA*

1. Key off.
2. Remove HCM S2 wire connector.
3. Measure resistance between HCM S2 connector Pin 13 and ECA 8-way Pin H.
   - If resistance is 0–0.3, replace HCM (see **Hybrid Control Module (HCM) Removal and Installation**). After repairs have been made, go to **Step V.**
   - If resistance is outside range, repair wiring harness.

Connection	Measurement
HCM S2 Connector Pin 13 to ECA 8-Way Pin H	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 19 appears, find error in testing, go to **Step A.**
   - If a code other than 19 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 22 - J1939 ABS Message Fault (HCM)

J1939: SA 239 SPN 563 FMI 2, 9, 14

Overview

J1939 is a high-speed twisted pair 250K data link with one 120 ohm resistor at each end of the link. The HCM is connected to the J1939 Data Link at the 38-Way Connector. This link is used to transmit information to the HCM as well as communicate or receive data from the other modules on the network like the ABS module.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Data Link communication fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the HCM fails to receive ABS messages and there are no Active J1939 faults. In PDM mode (FMI 2) this fault is set if 3 consecutive messages (EBC1) are not received.
- FMI 14 is set when the HCM receives an Active ABS signal (SPN563) out of range or the ABS "Fully Operational Signal" (SPN1243) is not present for 1 second.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 22 is set the following conditions occur:

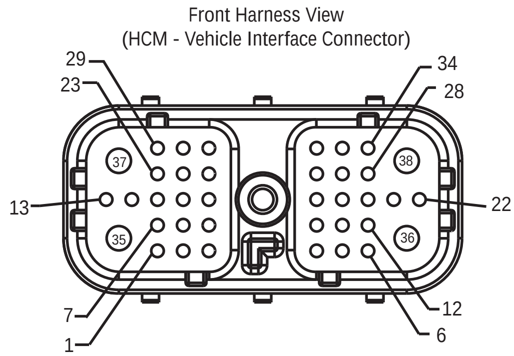
- Amber "Check Hybrid" light displays.
- Fault is stored in HCM memory.
- If the fault occurs while moving, the operation mode goes into AutoShift only.
- Electric motor/generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- Transmission defaults start gear to 1st.

Possible Causes

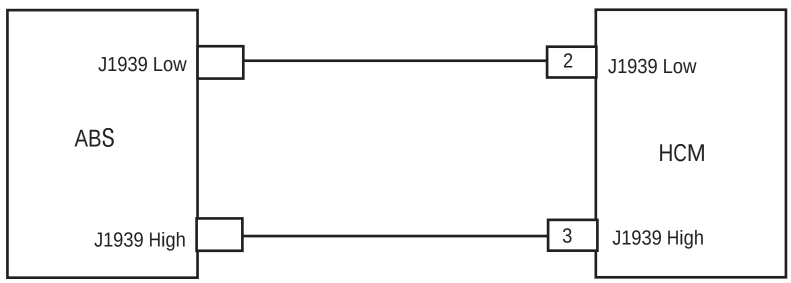
This fault code can be caused by any of the following:

- FMI 2, 9
  - J1939 Data Link
  - ABS Module
- FMI 14
  - ABS Module configured to communicate on J1708 or analog instead of J1939.
  - ABS Module reporting an Active fault.

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 22 - J1939 ABS Message Fault (HCM)

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve the Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Which FMIs are present?
   - If Fault Code 22 FMI 9 is listed, problem is with the Data Link Backbone ABS Module or with the J1939 Data Link from ABS Module to J1939. Refer to OEM for repair procedures.
   - If Fault Code 22 FMI 14 is listed, problem is with the Data Link ABS Module being configured for J1708 instead of J1939 communication, and/or with the ABS Module itself. Refer to OEM for repair procedures.

Fault Code 24 - J1939 HCM Message Fault (TECU)

J1939: SA 3 SPN 525 FMI 19
J1587: MID 130 SID 231 FMI 9

Overview

The Transmission Electronic Control Unit (TECU) communicates with the Hybrid Control Module (HCM) over the J1939 Data Link during vehicle operation to exchange requested gear and current gear information.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- No J1939 Data Link fault currently Active in the TECU.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the TECU fails to receive transmission data (such as requested gear) for 2 seconds or greater from the HCM, while still communicating with other modules on J1939.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 24 is set, the following conditions occur:

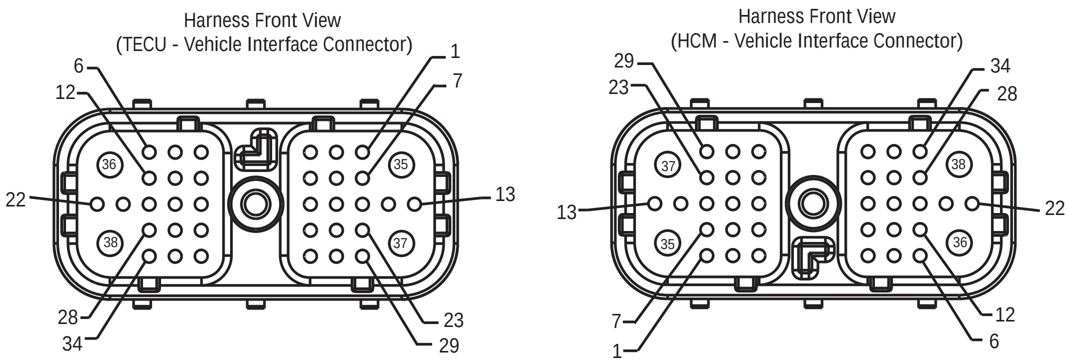
- Red "Service" light illuminates and an "F" and flashes in the gear display.
- Fault is stored in TECU memory.
- Operation mode changes to AutoShift Fallback
- If the fault sets at power up, the engine does not crank.
- If the fault sets while driving, the vehicle remains in current gear. When the vehicle stops, the clutch opens and remains in this position.
- Amber "Check Hybrid" light may display on the dash due to an Active Fault Code 48.

Possible Causes

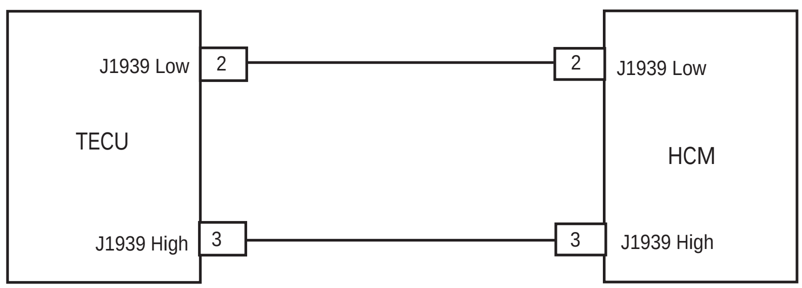
This fault code can be caused by any of the following:

- FMI 9
  - J1939 Data Link
  - HCM

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 24 - J1939 HCM Message Fault (TECU)

A

Purpose: *Check for active or inactive fault code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 24 is Active.
2. Perform Electrical Pretest.
   - If no issues found during the Electrical Pretest, go to **Step B.**
   - If issue was repaired during the Electrical Pretest, go to **Step V.**

B

Purpose: *Verify continuity of Vehicle Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect HCM Vehicle Harness 38-Way Connector.
4. Measure resistance between HCM Vehicle Harness 38-Way Connector Pin 2 and Pin 3.

   Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 2 and Pin 3 is between 50–70 ohms, replace HCM. See **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair J1939 Data link Harness, then go to **Step V.**

Connection	Measurement
Pin 2 to Pin 3	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 24 appears, find error in testing, go to **Step A.**
   - If a code other than 24 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 26 - Clutch Slip Fault

J1939: SA 239 SPN 522 FMI 10

Overview

The mechanical clutch assembly is controlled through the Electric Clutch Actuator (ECA) mounted on the clutch housing. The Hybrid Control Module (HCM) controls the ECA position and monitors several variables. Combined, these variables determine if a slip problem in the clutch exists when in the closed position.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- ECA ignition voltage is greater than 7 volts and less than 16 volts.
- There is no Active Fault Code 18 or 19 present.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 10 is set when the gear position is not neutral, the clutch is in the engaged position, the difference between the transmission Input Shaft Speed Sensor and the engine speed is greater than 150 RPM for 1 second or longer.

Note: A “CA” appears if the clutch is allowed to slip and create heat beyond a set point. Do not use the throttle as a hill hold device as it causes clutch damage and a CA.

Fallback

When Fault Code 26 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.

Possible Causes

This fault code can be caused by any of the following:

- FMI 10
  - Clutch Assembly

Component Identification

Note: No schematic for this code.

Fault Code 26 - Clutch Slip Fault

A *Purpose:* Check for Active or Inactive fault code status.

1. Is Fault Code 64 also Active?
   - Yes, go to “Fault Code 64 - ECA Fault” on page 227.
   - No, go to **Step B.**

B *Purpose:* Verify fault codes present.

1. Is Fault Code 27 FMI 13 also Active?
   - Yes, go to “Fault Code 27 - Clutch Disengagement Fault” on page 117.
   - No, go to **Step C.**

C *Purpose:* Verify operation of the clutch.

1. Key on.
2. Start engine.
3. Drive the vehicle under load in highest gear possible. At a steady speed, quickly and fully press and hold the throttle.
   - If Fault Code 26 is Active, replace clutch. See CLMT-0365 for installation procedures, then go to **Step V.**
   - If Fault Code 26 is not Active, test is complete, go to **Step V.**

V *Purpose:* Verify repair.

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 26 appears, find error in testing, go to **Step A.**
   - If a code other than 26 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 27 - Clutch Disengagement Fault

J1939: SA 239 SPN 788 FMI 7, 14

Overview

The mechanical clutch assembly is controlled through the Electric Clutch Actuator (ECA) that is mounted on the clutch housing. The Hybrid Control Module (HCM) controls the ECA position and monitors several variables to determine if there is a slip in the clutch when it is in the closed position.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- ECA ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when engine torque is greater than 400 N•m, and engine torque commanded is less than 0–0.3 seconds, and clutch position commanded is open for 1 second with the gear position confirmed in neutral.
- It may also set if the clutch input speed is greater than 300 RPM, the clutch output speed is greater than 300 RPM, the clutch is commanded open for 1 second, and the selected gear is neutral with everything above being true for 10 seconds.
- FMI 14 is set when the HCM has commanded the ECA to disengage the clutch and the Input Shaft Speed is greater than 315 RPM for more than 11 seconds with the transmission in neutral and the engine running.

Fallback

When Fault Code 27 is set the following conditions occur:

- Red “Stop Hybrid” light illuminates for FMI 7.
- Amber “Check Hybrid” light illuminates for FMI 14.
- Fault is stored in HCM memory.
- If this fault occurs while driving, the vehicle operates and the transmission shifts to neutral once the vehicle stops.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Clutch Assembly
  - ECA
- FMI 14
  - Clutch Assembly
  - Cross-Shafts

Component Identification

Note: No schematic for this code.

Fault Code 27 - Clutch Disengagement Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 27 is Active.
2. If Fault Code 64 is listed:
   - If Fault Code 27 FMI 7 or 14 are listed with an Active Fault Code 64, go to “Fault Code 64 - ECA Fault” on page 227.
   - If Fault Code 27 FMI 7 is listed with no Active Fault Code 64, go to **Step B.**
   - If Fault Code 27 FMI 14 is listed with no Active Fault Code 64, go to **Step C.**

B

Purpose: *Verify FMI set.*

1. Key on.
2. Start engine.
3. Launch vehicle and drive until 6th gear is obtained. Then slow down to a stop.
4. Repeat the launch 5 times.
5. Is FMI 7 Active:
   - If FMI 7 is Active, Replace the Clutch. See CLMT0365 for installation procedure, then go to **Step V.**
   - If FMI 7 is not Active, test is complete, go to **Step V.**

C

Purpose: *Verify integrity of the Cross-Shaft Assembly.*

1. Key off.
2. Remove ECA from transmission housing.
3. Attempt to rotate the Cross-shaft and Yoke Assembly by hand:
   - If the Cross-Shaft Assembly rotates by hand from the Release Bearing to the Transmission Case, replace the Clutch. See CLMT0365 for installation procedure, then go to **Step V.**
   - If the Cross-Shaft Assembly does not rotate by hand, replace the Cross-Shaft, bushings and grease. Repeat this step.

V	***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 27 appears, find error in testing, go to **Step A.**
   - If a code other than 27 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 32 - Loss of Switched Ignition Power Fault (TECU)

J1939: SA 3	**SPN 43**	**FMI:12**
J1587: MID 130	**PID 43**	**FMI 2**

Overview

The Transmission Electronic Control Unit (TECU) is mounted to the transmission and it contains all of the software to control the transmission operation; however, the Hybrid Control Module (HCM) controls the operation of the TECU during hybrid operation. Ignition circuit is fused, and the electrical current is provided from the Key Switch. Application of this input initiates the power up sequence.

Detection

Fault is detected when:

- Output Shaft speed must be greater than 0 RPM.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when TECU looses ignition power during operation for 2 seconds or greater.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 32 is set the following conditions occur:

- Red “Service” light illuminates and an “F” flashes in the gear display.
- Fault is stored in TECU memory.
- Operation mode changes to AutoShift Fallback.
- If the fault sets at power up, the engine does not crank.
- If the fault sets while driving, vehicle remains in current gear and clutch opens when the vehicle approaches idle. Default start gear is engaged and the clutch closes if the throttle is pressed.
- No lights illuminate on the Push Button if the fault occurs prior to power up or while in neutral. Only the current mode light illuminate if the fault occurs while driving.The Push Button starts to tone when vehicle approaches a stop and continues until power is returned.

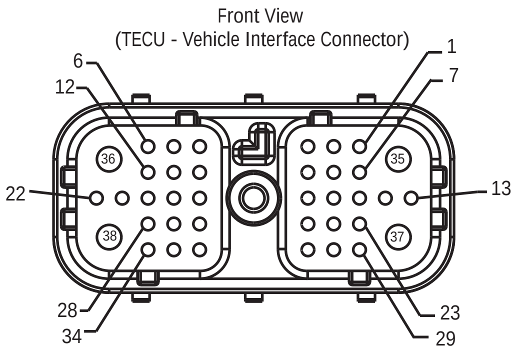
Possible Causes

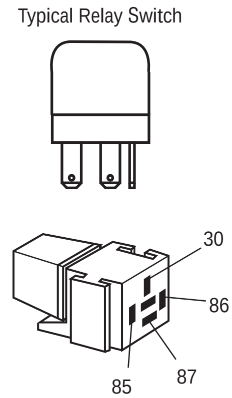
This fault code can be caused by any of the following:

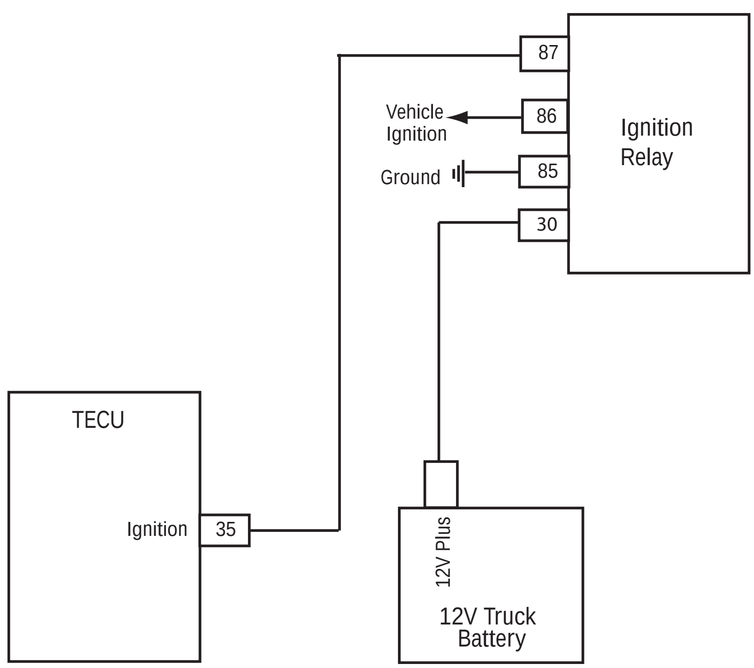
- FMI 2
  - Ignition power supply to TECU
  - TECU

Component Identification

NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations







Fault Code 32 - Loss of Switched Ignition Power Fault (TECU)

A ***Purpose:*** *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 32 is Active.
2. Perform Electrical Pretest:
   - If Fault Code 32 is Active after performing Electrical Pretest, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If Fault Code 32 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 32 appears, find error in testing, go to **Step A.**
   - If a code other than 32 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 33 - Low Battery Voltage Fault (TECU)

J1939: SA 3 SPN 168 FMI 4
J1587: MID 130 PID 168 FMI 4

Overview

Transmission Electronic Control Unit (TECU) is mounted to the transmission and it contains all of the software to control the transmission operation; however, the Hybrid Control Module (HCM) controls the operation of the TECU during normal hybrid mode. The HCM main battery power is a 12-volt feed that is fused and runs through the HCM 38-Way Vehicle Connector with the main ground wire returning to the battery negative terminal.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 4 is set when the TECU battery voltage drops below 7 volts for more than 1 second.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 33 is set the following conditions occur:

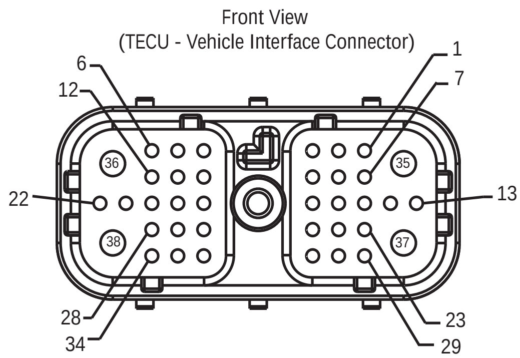
- Fault is stored in TECU memory.
- TECU switches to AutoShift Fallback mode.
- No lights are illuminated on the Push Button.
- If this fault occurs prior to power up, the vehicle will not crank.
- If this fault occurs while driving, the vehicle maintains current gear. Clutch opens when the vehicle stops.

Possible Causes

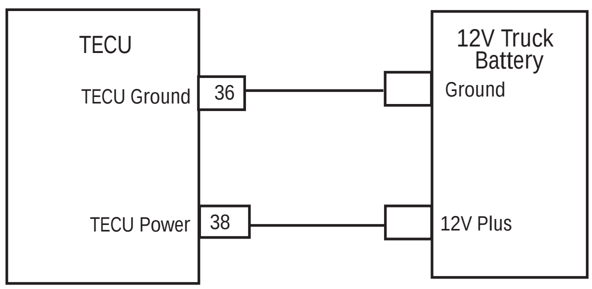
This fault code can be caused by any of the following:

- FMI 4
  - Power Supply to TECU
  - Low batteries or bad main power connection
  - Charging system
  - TECU

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 33 - Low Battery Voltage Fault (TECU)

A

Purpose: *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 33 is Active.
2. Perform Electrical Pretest.
   - If Fault Code 33 is Active after performing the Electrical Pretest, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If Fault Code 33 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 33 appears, find error in testing, go to **Step A.**
   - If a code other than 33 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 34 - Weak Battery Voltage Fault (TECU)

J1939: SA 3S PN 168 FMI 14
J1587: MID 130 PID 168 FMI 14

Overview

The Transmission Electronic Control Unit (TECU) is mounted to the transmission and it contains all of the software to control the transmission operation; however, the Hybrid Control Module (HCM) controls the operation of the TECU during normal hybrid mode. The HCM main battery power is a fused 12-volt feed and runs through the HCM 38-Way Vehicle Connector with the main ground wire returning to the battery negative terminal.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 14 is set when the TECU battery voltage drops below 9 volts for 10 seconds.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 34 is set the following conditions occur:

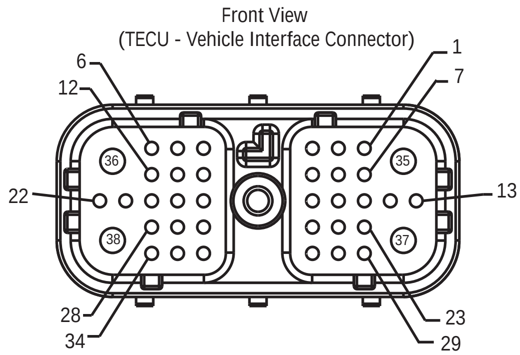
- Fault is stored in TECU memory.
- TECU switches to AutoShift Fallback mode.
- If this fault occurs while moving, it causes a 1-speed fallback.
- If the vehicle is stopped, the starting gear and reverse can be engaged.

Possible Causes

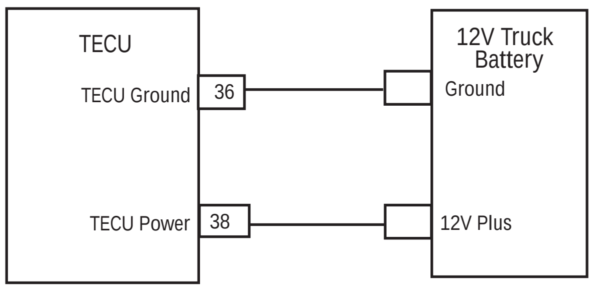
This fault code can be caused by any of the following:

- FMI 14
  - Power supply to TECU
  - Low batteries or bad main power connection
  - Charging system
  - TECU

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 34 - Weak Battery Voltage Fault (TECU)

A ***Purpose:*** *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Perform Electrical Pretest.
   - If Fault Code 34 is Active after performing the Electrical Pretest, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If Fault Code 34 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 34 appears, find error in testing, go to **Step A.**
   - If a code other than 34 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 35 - J1939 Communication Link Fault (TECU)

J1939: SA 3 SPN 639 FMI 12
J1587: MID 130 SID 231 FMI 2

Overview

J1939 is a high-speed twisted pair 250K data link with a 120 ohm resistor at each end. The Transmission Electronic Control Unit (TECU) is connected to the J1939 Data Link at the 38-Way Connector. This link is used to transmit information to the Hybrid Control Module (HCM) as well as communicate or receive data from the other modules on the network like the engine Electronic Control Unit (ECU).

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU Battery Voltage Low fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the TECU loses communication with all modules on the J1939 Data Link for 5 seconds or greater.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 35 is set the following conditions occur:

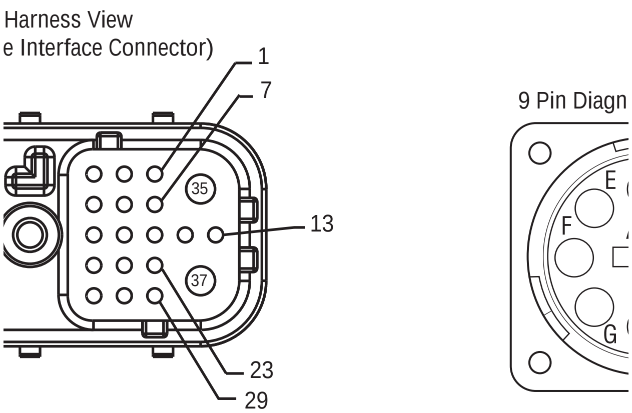
- Red “Service” light illuminates and an “F” flashes in the gear display.
- Fault is stored in TECU memory.
- Operation mode changes to AutoShift Fallback.
- If the fault sets at power up, the engine will not crank.
- If the fault sets while driving, the vehicle remains in current gear and the clutch opens once vehicle speed approaches idle.

Possible Causes

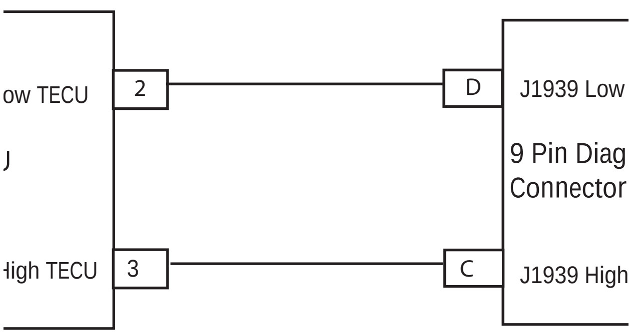
This fault code can be caused by any of the following:

- FMI 2
  - J1939 Data Link
  - TECU

Component Identification



Hybrid Component and Connector Location pag



Fault Code 35 - J1939 Communication Link Fault (TECU)

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Select the “Vehicle Components” screen and view the various modules that are reporting on the J1939 link:
   - If TECU is not reporting on J1939, but the HCM is listed, go to **Step B.**
   - If neither the HCM nor the TECU are reporting on J1939, go to **Step C.**

B

Purpose: *Verify continuity of vehicle interface circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure resistance between Vehicle Harness 38-Way Connector Pin 2 and Pin 3.

   Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 2 and Pin 3 is between 50–70 ohms, replace **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If resistance is outside of range, repair the J1939 Data link Harness, then go to **Step V.**

Connection	Measurement
Pin 2 to Pin 3	

C

Purpose: *Verify continuity of Transmission Harness Diagnostic Connector.*

1. Key off.
2. Measure resistance between the 9-way Diagnostic Connector Pin C and Pin D.
   - If resistance between Pin C and Pin D is between 50–70 ohms, go to **Step D.**
   - If resistance is 70 ohms or greater, one or more of the terminating resistors on the J1939 Data Link Harness is missing or out of range, or there is an open in the link, go to **Step V.**
   - If resistance is 50 ohms or less, an additional terminating resistor is present, repair the J1939 Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin C to Pin D	

D

Purpose: *Verify continuity of Transmission Harness Diagnostic Connector circuits to ground.*

1. Key off.
2. Measure the resistance between the following 9-way Diagnostic Connector Pins.
   - Pin C to ground, attempt to communicate with another vehicle to ensure ServiceRanger is working. If ServiceRanger fails to communicate with another vehicle, call 1-800-826-HELP (4357).
   - Repair J1939 Data link Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin C to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 35 appears, find error in testing, go to **Step A.**
   - If a code other than 35 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 36 - J1939 Engine Message Faults

J1939: SA 3	**SPN 639**	**FMI 14**
J1587: MID 130	**SID 231**	**FMI 14**

Overview

J1939 is a high-speed twisted pair 250K data link with one 120 ohm resistor at each end of the link. The Transmission Electronic Control Unit (TECU) is connected to the J1939 Data Link at the 38-way Connector. This link is used to transmit information to the Hybrid Control Module (HCM) as well as communicate with the other modules on the network (e.g., Engine Control Unit (ECU)).

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU Battery Voltage Low fault is not Active.
- TECU J1939 Data Link fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 14 is set when the TECU fails to receive ECU data for 5 seconds or greater, and it is still communicating with other modules on J1939.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 36 is set the following conditions occur:

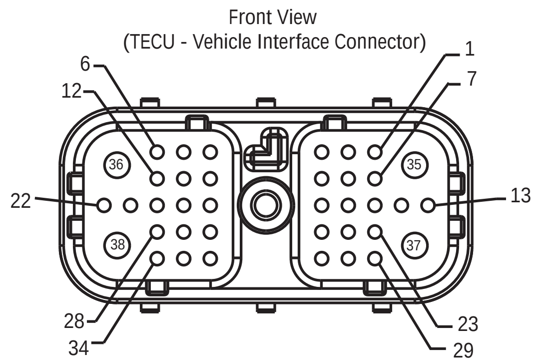
- Red “Service” light illuminates and an “F” flashes in the gear display.
- Fault is stored in TECU memory.
- If the fault occurs while moving, the TECU goes into AutoShift Fallback.
- Once the vehicle stops, start and reverse gears can be selected and the transmission operates in AutoSelect mode.
- If the fault occurs at power up, the vehicle will crank.

Possible Causes

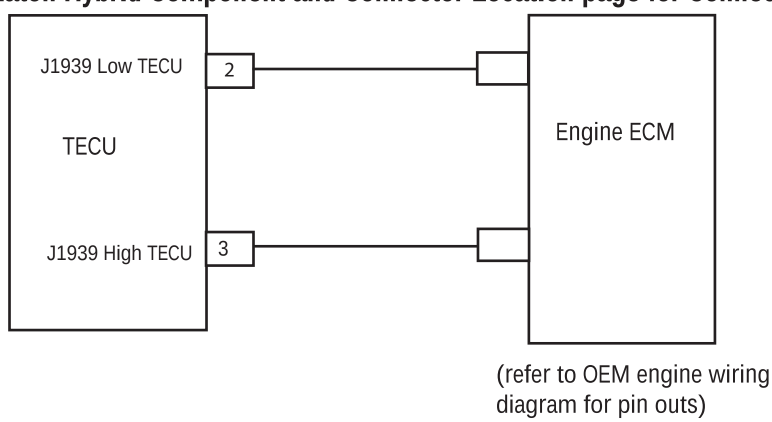
This fault code can be caused by any of the following:

- FMI 14
  - J1939 Data Link
  - ECU

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 36 - J1939 Engine Message Faults

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector:
   - If Fault Code 36 is Active, fault is either:
     - ECU
     - Data link from ECU to J1939 Data Link Backbone. Refer to OEM for repair procedure.
   - If Fault Code 36 is Inactive, test is complete.

Fault Code 37 - Power Supply Fault (TECU)

J1939: SA 3 SPN 610 FMI 5
j1587: MID130 SID 251 FMI 5

Overview

The Transmission Electronic Control Unit (TECU) is mounted to the transmission and contains the software that controls the transmission operation; however, the Hybrid Control Module (HCM) controls the operation of the TECU during normal hybrid mode. The TECU main battery power is a fused,12-volt feed that runs through the TECU 38-Way Vehicle Connector with the main ground wire returning to the battery negative terminal.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU only runs this test if the Electric Shifter is being cycled from neutral to gear.

Note: Changing the start gear from neutral allows this test to run.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 5 is set when the TECU power supply resistance is measured before and during an Electric Shifter test that results with a measurement of 0.4 ohms or greater.

Fallback

When Fault Code 37 is set the following conditions occur:

- Fault is stored in TECU memory.

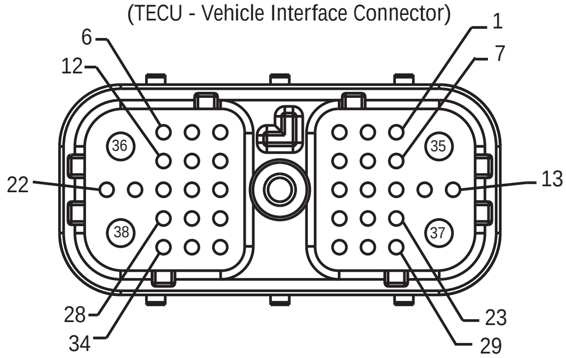
Possible Causes

This fault code can be caused by any of the following:

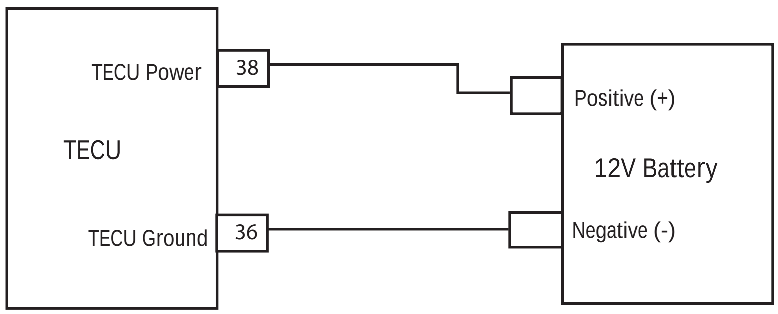
- FMI 5
  - Power supply to TECU
  - Low batteries or bad main power connection
  - Broken or corroded battery interconnect straps may also be the cause of high resistance readings.

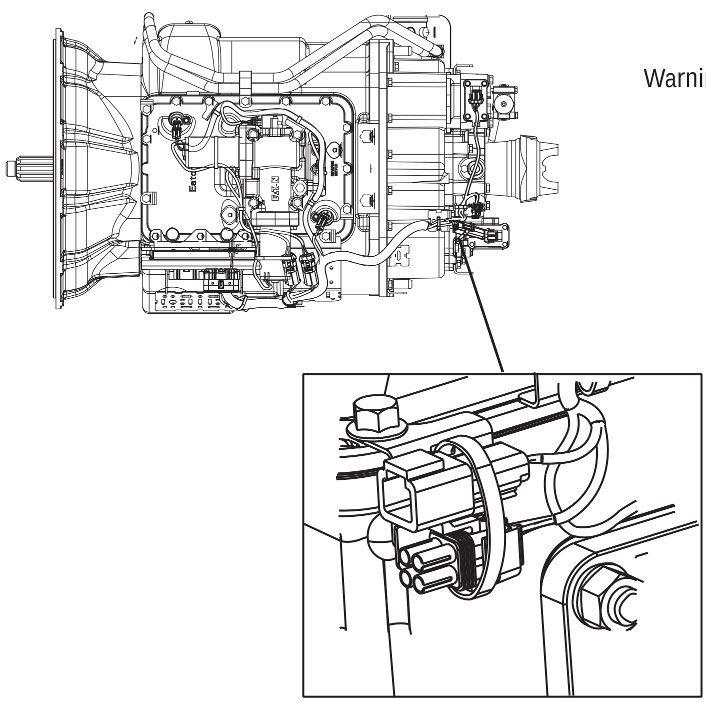
Component Identification

Front View
(TECU - Vehicle Interface Connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations

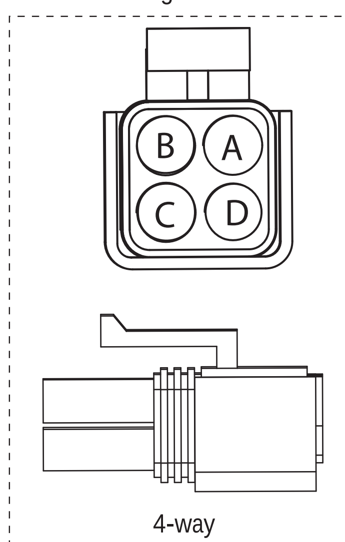




4-Pin Diagnostic Port
(Located at the left rear
corner of the transmission.)

Warning! - Do Not Load Test at Diagnostic Port

4-Pin Diagnostics Port



B - Service Bat. +
C - Service Bat. -
A - Service Ignition +

Fault Code 37 - Power Supply Fault (TECU)

A

Purpose: *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 37 is Active.
2. Perform Electrical Pretest.
   - If Fault Code 37 is Active after performing the Electrical Pretest, go to **Step B.**
   - If Fault Code 37 is Inactive after performing the Electrical Pretest, clear codes and go to **Step V.**

B

Purpose: *Verify voltage at Transmission Harness Diagnostic Connector.*

1. Locate diagnostic port on Transmission Harness
2. Key on.
3. Measure voltage between Pin C and the battery negative post.
   - If voltage between Pin C and battery negative post is 0.7 volts or less, go to **Step C.**
   - If voltage is outside of range, repair battery ground supply to TECU, then go to **Step V.**

Circuit Voltage	Measurement
Pin C to negative (-) post	

C

Purpose: *Verify voltages at Transmission Harness Diagnostic Connector.*

1. Locate diagnostic port on Transmission Harness.
2. Key on.
3. Measure voltage between Pin B and Pin C.
   - If voltage between Pin B and Pin C is within 0.6 volts of battery voltage, go to **Step D.**
   - If voltage is outside of range, repair battery power supply to TECU. Fuse may be blown. Repeat test.

Connection	Measurement
Pin B to Pin C	

D

Purpose: *Verify voltages at Transmission Harness Diagnostic Connector.*

1. Key on.
2. Measure voltage between Pin A and Pin C.
   - If voltage between Pin A and Pin C is within 0.6 volts of battery voltage, go to **Step E.**
   - If voltage is outside of range, repair Ignition power supply to ECU. Fuse may be blown. Repeat test.

Connection	Measurement
Pin A to Pin C	

E ***Purpose:*** *Verify integrity of Vehicle Harness connections.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the Vehicle Harness 38-Way Connector.
4. Inspect Vehicle Harness 38-Way Connector Terminals Pin 36 and Pin 38, in-line fuse holder and power supply connections for integrity and corrosion.
   - If no problem found, go to **Step V.**
   - If problem is found, repair power/ground path for the main power supply, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If Fault Code 37 appears, find error in testing, go to **Step A.**
   - If a code other than 37 appears, "Fault Code Isolation Procedure Index" on page 14.

Fault Code 38 - Battery Fan Relay Fault

J1939: SA 239 SPN 520243 FMI 3, 4, 5, 14

Overview

The Battery Fan Relay is normally an open relay that is connected to the Hybrid Control Module (HCM) on the control side. When the HCM wants to turn on the relay, it powers the control circuit, which closes the relay contacts. The relay powers the Battery Fan located in the Power Electric Carrier (PEC), which provides the cooling for the high-voltage batteries.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the HCM detects a short to battery in the in the coil circuit of the Battery Fan Relay.
- FMI 4 is set when the HCM detects a short to ground in the coil circuit of the Battery Fan Relay.
- FMI 5 is set when the HCM detects an open in the coil circuit of the Battery Fan Relay.
- FMI 14 is set when the following conditions are true for 10 minutes; the high-voltage battery temperature is greater than 131°F (55 °C), the difference between the minimum and maximum battery temperatures is less than 33 °F (1 °C), and there are no battery temperature faults from the Battery Control Module.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 38 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.

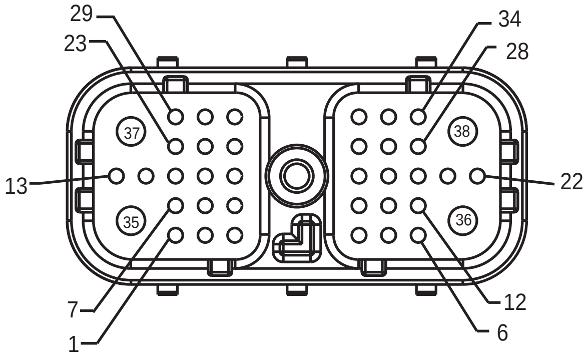
Possible Causes

This fault code can be caused by any of the following:

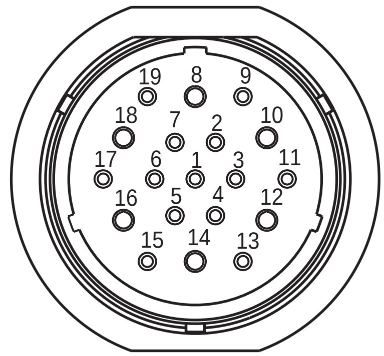
- FMI 3, 4, 5
  - Vehicle harness from HCM to Battery Fan Relay
  - Battery Fan Relay
  - HCM
- FMI 14
  - Battery Fan Relay
  - Battery Fan
  - Plugged Air Filter
  - Battery Fan Relay main power supply

Component Identification

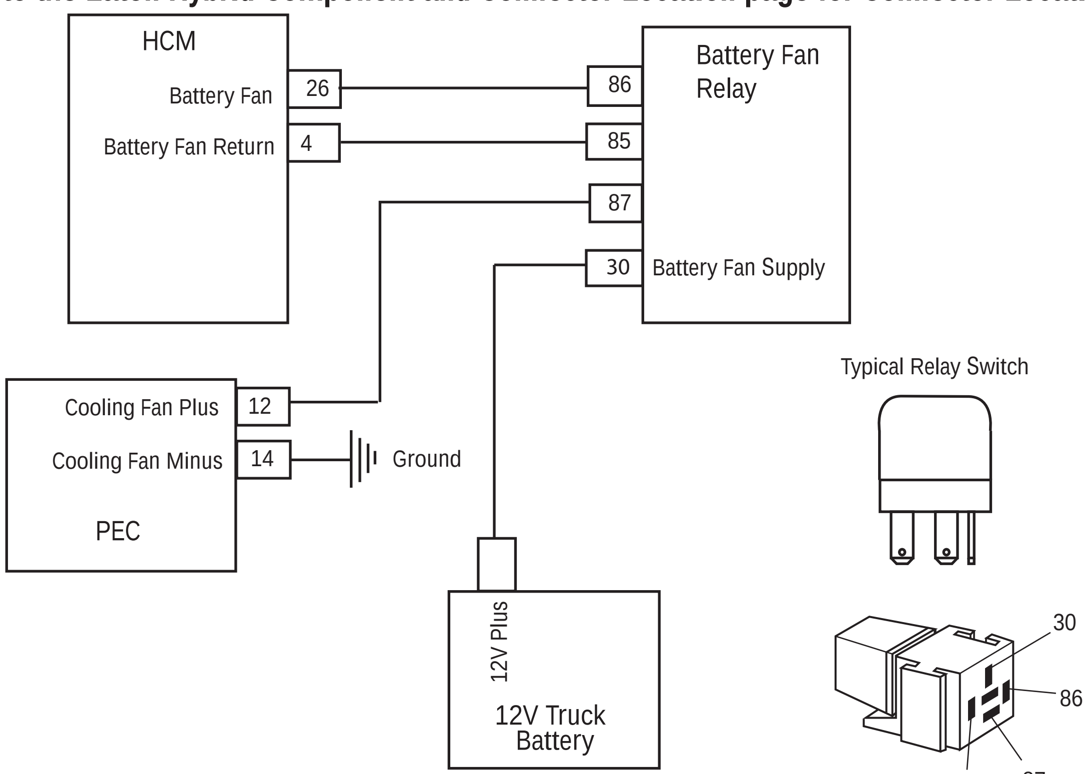
Front Harness View
(HCM - Hybrid System Interface Connector)



Harness Connector View
(PEC 19 - Way)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 38 - Battery Fan Relay Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 38 is Active.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Change Battery Fan Relay with another relay to see if fault returns:
   - If fault does not return with new relay, replace the Battery Fan Relay, then go to **Step V.**
   - If fault returns with new relay, go to **Step B.**

B

Purpose: *Verify FMI present.*

1. Which FMIs were listed in Step A?

   Note: The Battery Fan Relay must be wired according to Eaton® requirements (shown on previous page) for test to work properly. If wired differently, consult OEM for correct wiring schematic.

   - If FMI 5 is listed, go to **Step C.**
   - If FMI 3 is listed, go to **Step D.**
   - If FMI 4 is listed, go to **Step E.**
   - If FMI 14 is listed, go to **Step F.**

C

Purpose: *Verify continuity of HCM Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between the HCM System Harness 38-Way Connector Pin 26 and Pin 4:
   - If the resistance between Pin 26 and Pin 4 is 40–120 ohms, replace HCM (only if fault code is active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM 2000, then go to **Step V.**
   - If the resistance is outside the range, repair the HCM Harness for an open circuit, then go to **Step V.**

Connection	Measurement
Pin 26 to Pin 4	

D **Purpose:** *Verify voltages of HCM Harness circuits.*

1. Key on.
2. Measure voltage between HCM Harness 38-Way Connector Pin 26 and ground at key on.
   - If voltage between Pin 26 and ground is 0 volts, replace the HCM (only is fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM 2000, then go to **Step V.**
   - If voltage between Pin 26 and ground is 12 volts, repair the short to VBATT on the HCM Harness, then go to **Step V.**

Connection	Measurement
Pin 26 to ground	

E **Purpose:** *Verify continuity of HCM Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between HCM Harness 38-Way Connector Pin 26 and ground:
   - If resistance between Pin 26 and ground is 10K ohms or greater, replace HCM (Only if Fault Code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM 2000, then go to **Step V.**
   - If resistance is outside of range, repair the HCM Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin 26 to ground	

F

Purpose: *Verify condition of PEC Air Filter element.*

1. Key off.
2. Remove and inspect the Air filter on the PEC inlet and Exhaust Screen on the PEC outlet. See the **MY09 Air Filter Removal and Installation** (or **Alternative PEC Main Air Filter and Blue Pre-Filter Removal and Installation**, or **4-Battery Air Filter Removal and Installation**) procedures in TRSM2000:
   - If the Air Filter and Exhaust Screen are clean and free from debris, go to **Step G.**
   - If the Air Filter is dirty or the Exhaust Screen is plugged, replace the Air Filter and clean the Exhaust Screen, then go to **Step V.**

G

Purpose: *Verify operation of PEC Battery Fan.*

1. Key off.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab.
3. Key on.
4. Select the following options from ServiceRanger menus: “Advanced Product Function,” “Hybrid Control Module,” and “Launch APF.”
5. At the “Product Test” screen, select “Battery Fan Relay”:
   - If airflow can be felt from the PEC air inlet and exhaust, and if fault code is Active, contact Eaton® at 1-800-826-4357.
   - If airflow can not be felt from the PEC air inlet and exhaust, go to **Step H.**

H

Purpose: *Verify voltages of PEC Harness circuits.*

1. Key on.
2. Disconnect the 19-Way Connector at the PEC.
3. Measure voltage at the 19-Way Connector from Pin 12 to Pin 14.
   - If voltage between Pin 12 and Pin 14 is +/- 0.2 volts of battery voltage, replace the PEC Fan. See the **MY09 PEC Cooling Fan Removal and Installation** (or **Alternative PEC Cooling Fan Removal and Installation**, or **4-Battery PEC Cooling Fan Removal and Installation**) procedures in TRSM2000, then go to **Step V.**
   - If voltage between Pin 12 and Pin 14 is outside of range, repair wiring or relay problem. Refer to OEM.

Connection	Measurement
Pin 12 to Pin 14	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 38 appears, find error in testing, go to **Step A.**
   - If a code other than 38 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 39 - Heat Exchanger Relay Fault

J1939: SA 239 SPN 520247 FMI 3, 4, 5

Overview

The Heat Exchanger Fan Relay is normally an open relay connected to the Hybrid Control Module (HCM) on the control side. When the HCM turns on the relay, it powers the control circuit, closing the relay contacts. The relay powers the Heat Exchanger Fan located on the Hybrid Liquid Cooling System Radiator. The fan is used to provide additional airflow in certain situations like slow driving or ePTO operation.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the HCM detects a short to battery in the coil circuit of the Heat Exchanger Fan Relay.
- FMI 4 is set when the HCM detects a short to ground in the coil circuit of the Heat Exchanger Fan Relay.
- FMI 5 is set when the HCM detects an open in the coil circuit of the Heat Exchanger Fan Relay.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 39 is set the following conditions occur:

- Amber "Check Hybrid" light illuminates
- Fault is stored in HCM memory

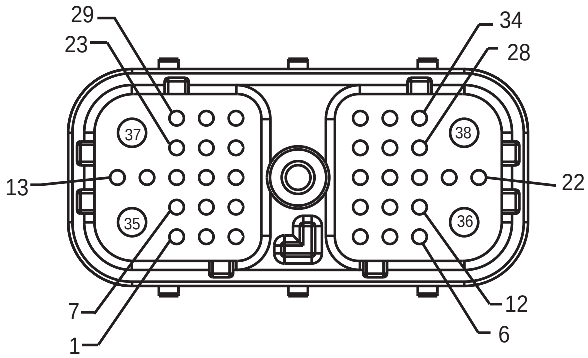
Possible Causes

This fault code can be caused by any of the following:

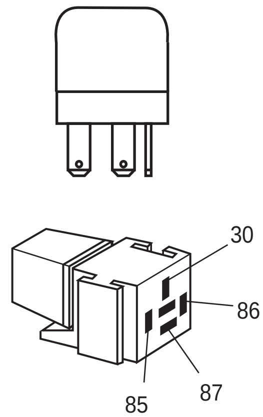
- FMI 3, 4, 5
  - Vehicle Harness from HCM to Heat Exchanger Relay
  - Heat Exchanger Relay
  - HCM
  - Heat Exchanger Relay Fuse

Component Identification

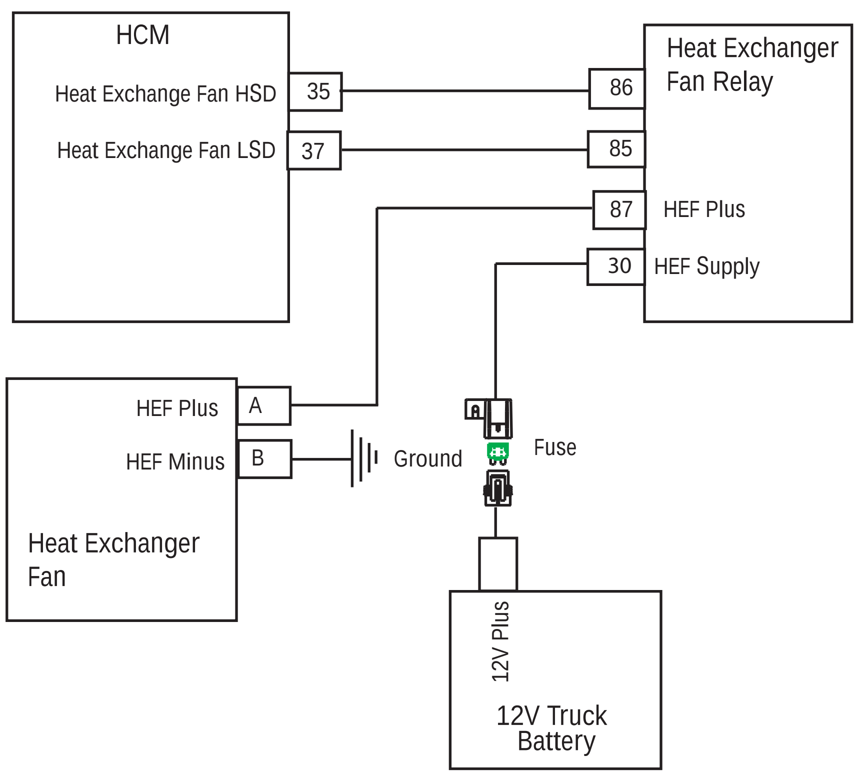
Harness Front View
(HCM - Hybrid System Interface Connector)



Typical Relay Switch



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 39 - Heat Exchanger Relay Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Replace Heat Exchanger Fan Relay with another relay and see if the fault returns.
   - If fault does not return with new relay, replace the Heat Exchanger Fan Relay, then go to **Step V.**
   - If fault returns with new relay, go to **Step B.**

B

Purpose: *Verify configuration of HCM.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector.
3. Select “Configurations” menu and pick the Hybrid Control Module option.
4. Determine if there is an option for Heat Exchanger Fan?
   - The Heat Exchanger Fan option is shown and the vehicle has the Hybrid Cooling System Heat Exchanger Fan installed, go to **Step C.**
   - The Heat Exchanger Fan option is shown and the vehicle does not have the Hybrid Cooling System Heat Exchanger Fan installed, Write down the model number on the Transmission Tag and contact Eaton at 1-800-826-HELP (4357).

C

Purpose: *Verify FMI present.*

1. Which FMIs were listed from Step A?

   Note: The Heat Exchanger Fan Relay must be wired according to Eaton requirements (shown on previous page) for this test to work properly. If wired differently consult OEM for correct wiring schematic.

   - If FMI 5 is listed, go to **Step D.**
   - If FMI 3 is listed, go to **Step E.**
   - If FMI 4 is listed, go to **Step F.**

D ***Purpose:*** *Verify continuity of HCM System Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between HCM Harness 38-Way Connector Pin 35 and Pin 37.
   - If resistance between Pin 35 and Pin 37 is 40–120 ohms, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the HCM Harness for an open circuit or blown fuse, then go to **Step V.**

Connection	Measurement
Pin 35 to Pin 37	

E ***Purpose:*** *Verify voltages of HCM Harness circuits to ground.*

1. Key on.
2. Measure the voltage between HCM Harness 38-Way Connector Pin 35 and ground.
   - If voltage between Pin 35 and ground is 0 volts, replace the HCM (only if fault code is Active)). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If voltage between Pin 35 and ground is 12 volts, repair the short to VBATT on the harness, then go to **Step V.**

Connection	Measurement
Pin 35 to ground	

F ***Purpose:*** *Verify continuity of HCM Harness circuits to ground.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between HCM Harness 38-Way Connector Pin 35 and ground.
   - If resistance between Pin 35 and ground is 10K ohms or greater, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the Vehicle Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin 35 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 39 appears, find error in testing, go to **Step A.**
   - If a code other than 39 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 40 - Cooling Pump Relay Fault

J1939: SA 239 SPN 520248 FMI 3, 4, 5, 14

Overview

The Cooling Pump Relay is normally an open relay connected to the Hybrid Control Module (HCM) on the control side. When the HCM turns on the relay, it powers the control circuit, closing the relay contacts. The relay powers the Cooling Pump which circulates the coolant on the hybrid liquid system.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the HCM detects a short to battery in the coil circuit of the Cooling Pump Relay.
- FMI 4 is set when the HCM detects a short to ground in the coil circuit of the Cooling Pump Relay.
- FMI 5 is set when the HCM detects an open in the coil circuit of the Cooling Pump Relay.
- FMI 14 is set when the following occur for 10 minutes or longer:
  - Inverter temperature is greater than 122 °F (50 °C)
  - Difference between the maximum battery temperature and the Inverter temperature is greater than 68 °F (20 °C)
  - No battery temperature or motor temperature faults exist

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When fault code is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.

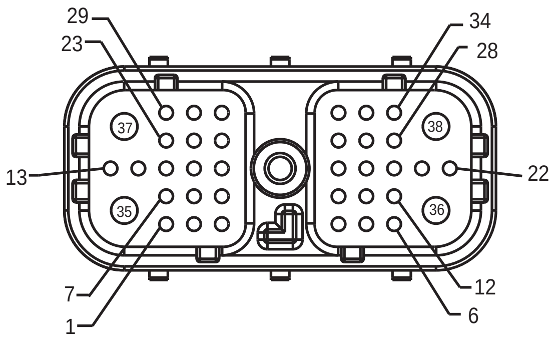
Possible Causes

This fault code can be caused by any of the following:

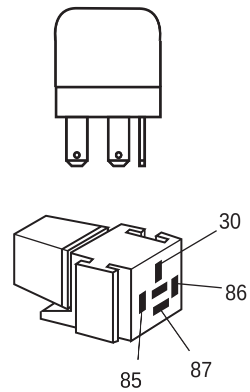
- FMI 3, 4, 5
  - Vehicle harness from HCM to Cooling Pump Relay
  - Cooling Pump Relay
  - HCM
- FMI 14
  - Cooling Pump Relay
  - Cooling Pump
  - Cooling Pump Relay main power supply
  - Low coolant
  - Low coolant flow
  - Plugged radiator
  - Fan operation

Component Identification

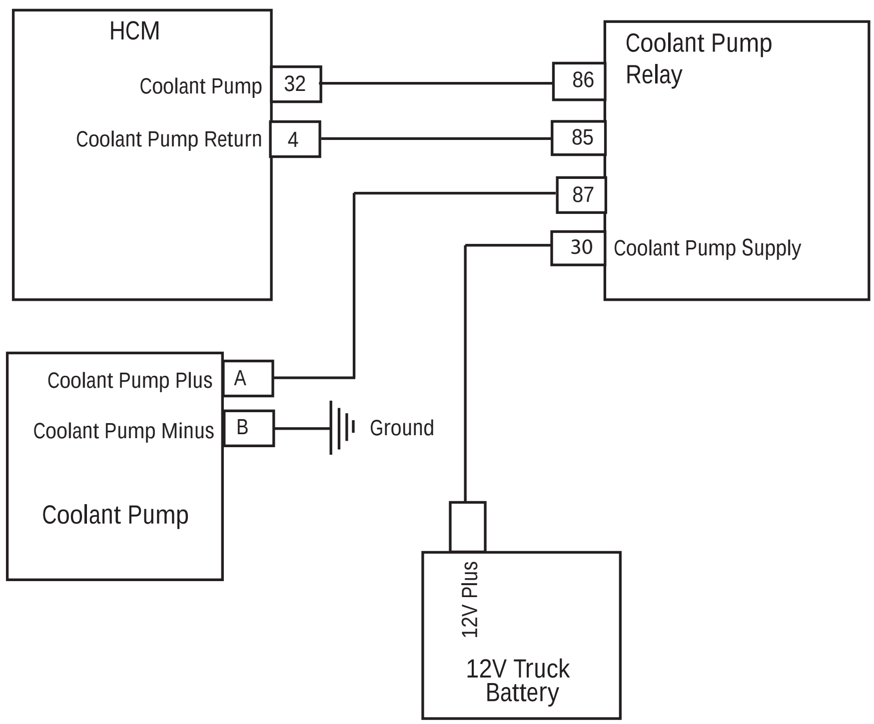
Harness Front View
(HCM - Hybrid System Interface Connector)



Typical Relay Switch



NOTE: Refer to the Eaton Hybrid Componet and Connector Location page for Connector Locations



Fault Code 40 - Cooling Pump Relay Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 40 is Active.

⚠ **Danger:** See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Replace Cooling Pump Relay with another relay and see if fault returns.
   - If fault does not return with new relay, replace the Cooling Pump Relay, then go to **Step V.**
   - If fault returns with new relay, go to **Step B.**

B

Purpose: *Verify FMIs present.*

1. Which FMIs were listed from Step A?

   Note: The Cooling Pump Relay must be wired according to Eaton® requirements (shown on previous page) for this test to work properly. If wired differently, consult OEM for correct wiring schematic.

   - If FMI 5 is listed, go to **Step C.**
   - If FMI 3 is listed, go to **Step D.**
   - If FMI 4 is listed, go to **Step E.**
   - If FMI 14 is listed, go to **Step F.**

C

Purpose: *Verify continuity of HCM System Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between the HCM Harness 38-Way Connector Pin 32 and Pin 4.
   - If resistance between Pin 32 and Pin 4 is 40–120 ohms, replace HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the Vehicle Harness for an open circuit, then go to **Step V.**

Connection	Measurement
Pin 32 to Pin 4	

D

Purpose: *Verify voltages of HCM Harness circuits to ground.*

1. Key on.
2. Measure voltage between HCM Harness 38-Way Connector Pin 32 and ground at key on.
   - If voltage between Pin 32 and ground is 0 volts, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If voltage between Pin 32 and ground is 12 volts, repair the short to VBATT on the HCM Harness, then go to **Step V.**

Connection	Measurement
Pin 32 to ground	

E

Purpose: *Verify continuity of HCM Harness circuits to ground.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure the resistance between the HCM System Harness 38-Way Connector Pin 32 and ground.
   - If resistance between Pin 32 and ground is 10K ohms or greater, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation**) procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the Vehicle Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin 32 to ground	

F

Purpose: *Verify level of hybrid system coolant.*

1. Key off.
2. Check coolant level in the liquid cooling system:
   - If the coolant is within the recommended limits, go to **Step G.**
   - If the coolant is below the recommended limits, refer to OEM for coolant type and fill procedure, then go to **Step V.**

G

Purpose: *Verify operation of hybrid system Coolant Pump.*

1. Key off.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab.
3. Key on.
4. Select the following options in ServiceRanger: “Advanced Product Functions,” “Hybrid Control Module,” and “Launch APF.”
5. Select “Product Tests” and “Coolant Pump Relay.”
6. Listen for the Coolant Pump to turn on and watch for coolant flowing in the reservoir:
   - If the coolant pump operates and coolant flows through the reservoir with the fault code still Active, contact Eaton® at 1-800-826-4357.
   - If the coolant pump does not operate, go to **Step H.**
   - If the coolant pump operates, but coolant does not flow, check for kinks or sharp bends in the coolant lines. If lines are clear, contact OEM for issues with coolant pump.

H

Purpose: *Verify voltages at hybrid system coolant pump.*

1. Key on.
2. Disconnect the 2-Way Connector at the Coolant Pump.
3. Measure voltage at the 2-Way Connector from Pin A to B.
   - If voltage between Pin A and Pin B is within ±0.2 volts of battery voltage, refer to OEM for Coolant Pump problem.
   - If voltage between Pin A and Pin B is outside of range, repair wiring or relay problem. Refer to OEM.

Connection	Measurement
Pin A to Pin B	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
    - If no codes, test is complete.
    - If Fault Code 40 appears, find error in testing, go to **Step A.**
    - If a code other than 40 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 48 - J1939 Transmission Message Fault (HCM)

J1939: SA 239 SPN 523 FMI 2, 9

Overview

J1939 is a high-speed twisted pair 250K data link with a 120 ohm resistor at each end of the link. The Hybrid Control Module (HCM) is connected to the J1939 Data Link at the 38-Way Connector. The link is used to transmit information to the HCM as well as communicate or receive data from the other modules on the network like the Transmission Electronic Control Unit (TECU).

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Data Link communication fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the HCM fails to receive TECU data (like current gear) for 30 consecutive messages or greater, and it is still communicating with other modules on J1939.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 48 is set the following conditions occur:

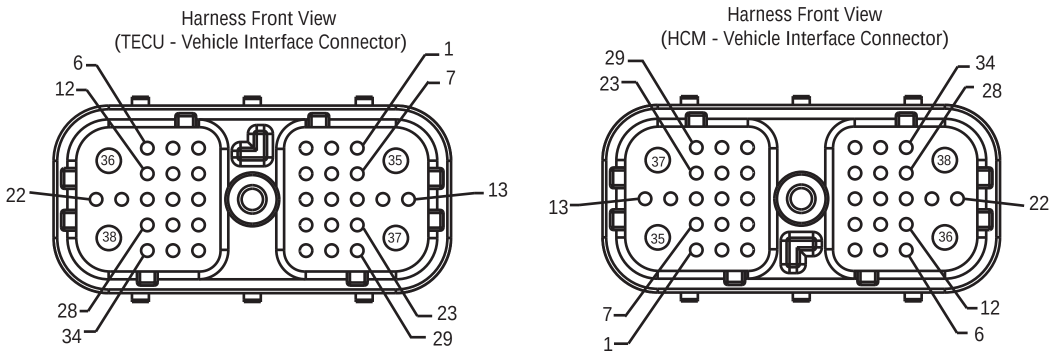
- Amber "Check Hybrid" light illuminates.
- Fault is stored in HCM memory.
- Red "Service" light may display and a "F" may flash in the gear display due to an Active Fault Code 24.
- Operation mode is changed to AutoShift only.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- If fault sets at power up, the engine will not crank.
- If fault sets while driving, the vehicle will shift; however, when the vehicle stops the clutch opens and remains in the open position.
- Transmission defaults start gear to 1st.

Possible Causes

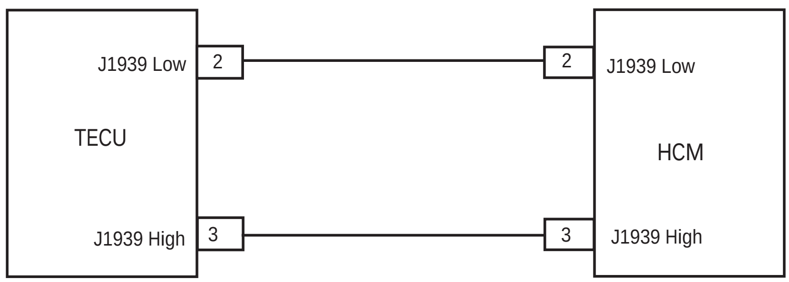
This fault code can be caused by any of the following:

- FMI 2, 9
  - J1939 Data Link
  - TECU

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 48 - J1939 Transmission Message Fault (HCM)

A

Purpose: *Verify continuity of Vehicle Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure the resistance between the Vehicle Harness 38-Way Connector Pin 2 and Pin 3.

   Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 2 and Pin 3 is between 50–70 ohms, replace **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If resistance is outside of range, repair J1939 Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin 2 to Pin 3	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 48 appears, find error in testing, go to **Step A.**
   - If a code other than 48 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 49 - J1939 Engine Message Fault (HCM)

J1939: SA 239 SPN 190 FMI 2, 9

Overview

J1939 is a high-speed twisted pair 250K data link with one 120 ohm resistor at each end of the link. The Hybrid Control Module (HCM) is connected to the J1939 Data Link at the 38-Way Connector. This link is used to transmit information to the HCM as well as communicate or receive data from the other modules on the network.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Data Link communication fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the HCM fails to receive data from engine Electronic Control Unit (ECU) for 30 consecutive messages or greater, and it is still communicating with other modules on J1939.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 49 is set the following conditions occur:

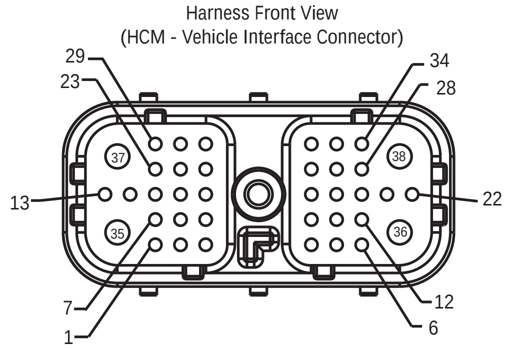
- Amber "Check Hybrid" light appears in gear display.
- Fault is stored in HCM memory.
- Operation mode changes to AutoShift only.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- Transmission defaults start gear to 1st.

Possible Causes

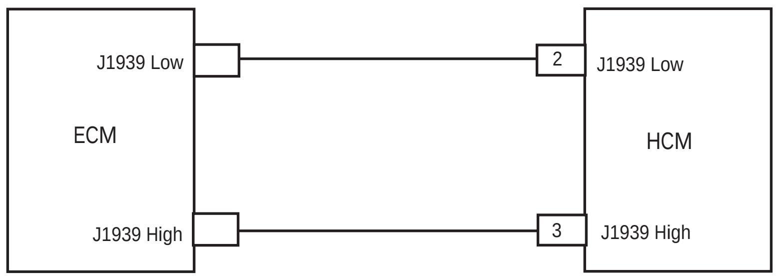
This fault code can be caused by any of the following:

- FMI 9
  - J1939 Data Link from Engine ECU
  - ECU

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 49 - J1939 Engine Message Fault (HCM)

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
   - If Fault Code 49 is Active, problem is either:
     - Engine ECU
     - Data link from Engine ECU to J1939 data link backbone. Refer to OEM for repair procedure.
   - If Fault Code 49 is Inactive, test is complete.

Fault Code 50 - J1939 Body Controller Message Fault (HCM)

J1939: SA 239 SPN 701 FMI 2, 9

Overview

J1939 is a high-speed twisted pair 250K data link with a 120 ohm resistor at each end of the link. The Hybrid Control Module (HCM) is connected to the J1939 Data Link at the 38-Way Connector. This link transmits information to the HCM as well as communicate or receive data from the other modules on the network.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Data Link communication fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the HCM is in PDM mode and fails to receive messages from the body controller for 1 second.
- FMI 9 is set when the HCM fails to receive messages from the body controller for seconds.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 50 is set the following conditions occur:

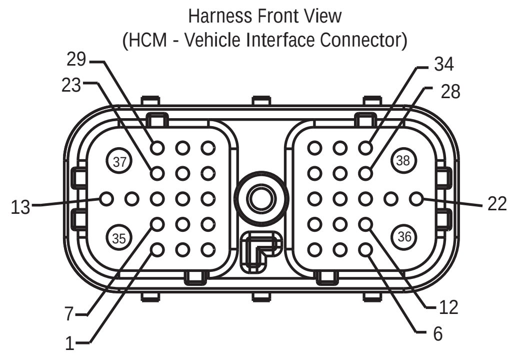
- Fault is stored in HCM memory.
- HCM disables ePTO operation, since parameters like hydraulic demand are unavailable.

Possible Causes

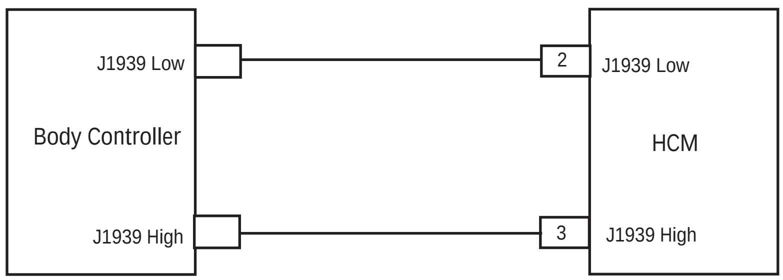
This fault code can be caused by any of the following:

- FMI 2, 9
  - J1939 Data Link
  - Body Controller

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 50 - J1939 Body Controller Message Fault (HCM)

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.

- If Fault Code 50 is Active, problem is either:
  - Body Controller
  - Data link from Body Controller to J1939 Data Link backbone.

  Refer to OEM for repair procedure.
- If Fault Code 50 is Inactive, test is complete.

Fault Code 51 - Rail Position Sensor Fault

J1939: SA 3 SPN 60 FMI 2, 3, 4, 10
J1587: MID 130 PID 60 FMI 2, 3, 4, 10

Overview

The Rail Position Sensor provides feedback on the position of the Shift Finger. The Transmission Electronic Control Unit (TECU) delivers a constant 5-volt reference to 1 terminal of the Rail Position Sensor. The signal output from Rail Position Sensor provides a regulated voltage signal from 0.5–4.5 volts. The last terminal provides a ground for the Rail Position Sensor to the TECU.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- FMIs 3 and 4 will not set if the TECU System Battery Voltage Low Fault is Active.
- FMI 2 does not set if FMI 3, 4 are Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 sets when the TECU detects the Rail Sensor voltage is outside the range of 0.5–4.5 volts for 1 second or longer.
- FMI 3 sets when the TECU detects the Rail Sensor supply voltage is 5% above the expected supply voltage for 1 second or longer.
- FMI 4 sets when the TECU detects the Rail Sensor supply voltage is 5% below the expected supply voltage for 1 second or longer.
- FMI 10 (refer to troubleshooting guide TRTS0930).

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 51 sets the following conditions occur:

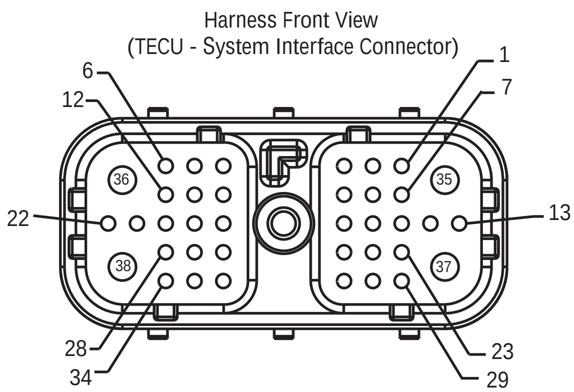
- Red “Service” light illuminates and “F” flashes in the gear display.
- Fault is stored in TECU memory.
- If this fault occurs while moving, the transmission remains in the current gear and the clutch opens when the vehicle stops.
- Operation mode changes to AutoShift Fallback.

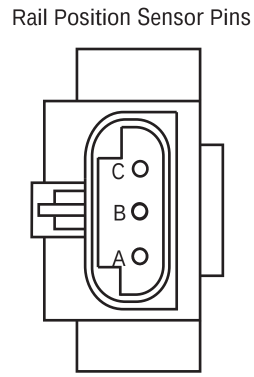
Possible Causes

This fault code can be caused by any of the following:

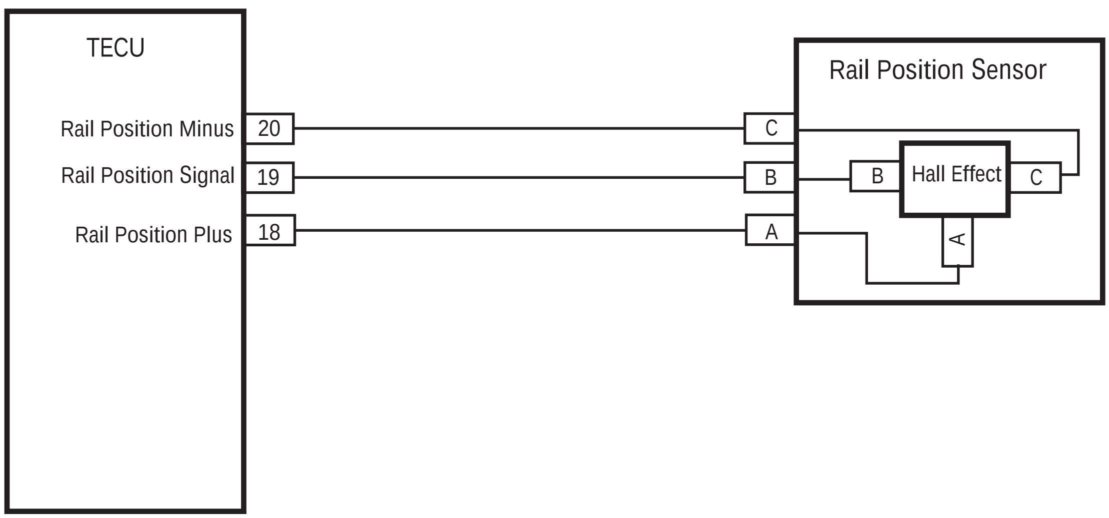
- FMI 2, 10
  - Transmission Harness
  - Rail Position Sensor
  - TECU
- FMIs 3, 4
  - TECU

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 51 - Rail Position Sensor Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Which FMIs are present?
   - If FMI 3 or 4 is listed, replace the **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If FMI 2, 10 is listed, go to **Step B.**

B

Purpose: *Verify continuity of Transmission Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the Transmission Harness 38-Way Connector.
4. Measure resistance between the Transmission Harness 38-Way Connector Pin 18 to Pin 19, and Pin 18 to Pin 20.
   - If Pin 18 and Pin 19 resistance is between 100–200 ohms, and if Pin 18 and Pin 20 resistance is 5K–7K ohms, go to **Step C.**
   - If any of the above conditions are not met, go to **Step D.**

Connection	Measurement
Pin 18 to Pin 19	
Pin 18 to Pin 20	

C

Purpose: *Verify continuity of Transmission Harness circuits to ground.*

1. Measure resistance between Transmission Harness 38-Way Connector Pin 18 to ground.
    - If resistance is 10K ohms or greater, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
    - If resistance is less than 10K ohms, go to **Step D.**

Connection	Measurement
Pin 18 to ground	

D

Purpose: *Verify continuity of Transmission Harness Rail Position Sensor circuit.*

1. Disconnect Transmission Harness from Rail Select Sensor.
2. Measure resistance between Rail Select Sensor Pin A to Pin C, and Pin A to Pin B.
    - If Pin A to Pin C resistance is between 5K–7K, and if Pin A to Pin B resistance is 100–200 ohms. Replace the Transmission Harness. See the **Transmission Harness Removal and Installation** procedure in TRSM2000, then go to **Step V.**
    - If any of the above conditions are not met, replace Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
Pin A to Pin C	
Pin A to Pin B	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 51 appears, find error in testing, go to **Step A.**
   - If a code other than 51 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 52 - Gear Position Sensor Fault

J1939: SA 3 SPN 59 FMI 2, 3, 4
J1587: MID 130 PID 59 FMI 2, 3, 4

Overview

The Rail Position Sensor provides feedback on the position of the Shift Finger. The Transmission Electronic Control Unit (TECU) delivers a constant 5-volt reference to 1 terminal of the Rail Position Sensor. The signal output from Rail Position Sensor provides a regulated voltage signal from 0.5–4.5 volts. The last terminal provides a ground for the Rail Position Sensor to the TECU.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- FMI 3, 4 set if the TECU System Battery Voltage Low fault is Active. FMI 2 does not set if FMI 3, 4 is Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 sets when the transmission controller detects the rail sensor voltage is above 4.5 volts or below 0.5 volts for 1 second of longer.
- FMI 3 sets when the TECU detects the Rail Sensor supply voltage is 5% above the expected supply voltage for 1 second or longer.
- FMI 4 sets when the TECU detects the Rail Sensor supply voltage is 5% below the expected supply voltage for 1 second or longer.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 51 sets the following conditions occur:

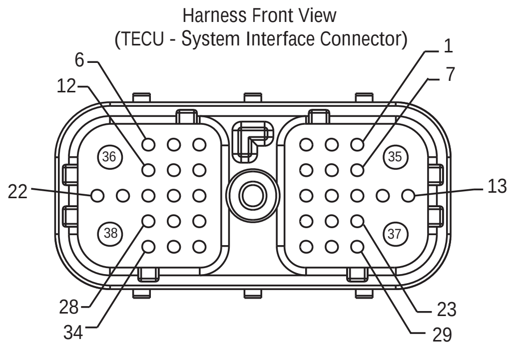
- Red “Service” light illuminates and “F” flashes in the gear display.
- Fault is stored in TECU memory.
- If this fault occurs while moving, the transmission remains in the current gear and the clutch opens when the vehicle stops.
- Operation mode changes to AutoShift Fallback.

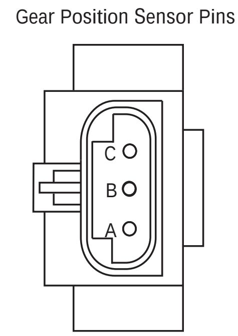
Possible Causes

This fault code can be caused by any of the following:

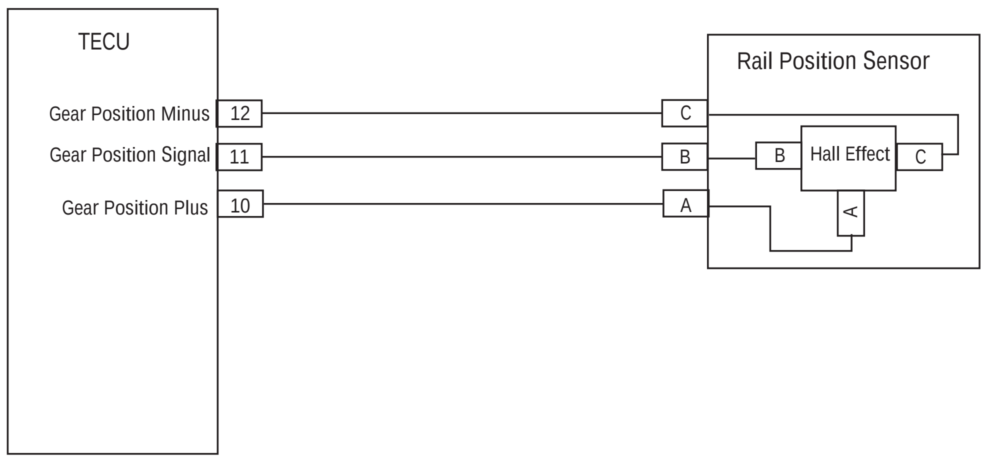
- FMI 2
  - Transmission Harness
  - Rail Position Sensor
  - TECU
- FMI 3, 4
  - TECU

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 52 - Gear Position Sensor Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Which FMIs are Active?
   - If FMI 3 or 4 are Active, replace the **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If FMI 2 is listed, go to **Step B.**

B

Purpose: *Verify continuity of Transmission Harness sensor circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the Transmission Harness 38-Way Connector.
4. Measure resistance between the Transmission Harness 38-Way Connector Pins.
   - If Pin 18 and Pin 19 resistance is 100–200 ohms, and if Pin 18 and Pin 20 resistance is 5K–7K ohms, go to **Step C.**
   - If any of the above conditions are not met, go to **Step D.**

Connection	Measurement
Pin 18 to Pin 19	
Pin 18 to Pin 20	

C

Purpose: *Verify continuity of Transmission Harness sensor circuits to ground.*

1. Measure resistance between Transmission Harness 38-Way Connector Pin 18 to ground.
   - If resistance is 10K ohms or greater, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If resistance is less than 10K ohms, go to **Step D.**

Connection	Measurement
Pin 18 to ground	

D

Purpose: *Verify continuity of Transmission Harness Gear Position Sensor circuit.*

1. Disconnect Transmission Harness from Rail Select Sensor.
2. Measure resistance between Rail Select Sensor Pins.
   - If Pin A and C resistance is 5K–7K, and if Pin A and Pin B resistance is 100–200 ohms. Replace the Transmission Harness. See the **Transmission Harness Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If any to the above conditions are not met, replace Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
Pin A to Pin C	
Pin A to Pin B	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See "Fault Code Retrieval and Clearing" on page 13.
    - If no codes, test is complete.
    - If Fault Code 52 appears, find error in testing, go to **Step A.**
    - If a code other than 52 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 53 - DC/DC Converter Fault

J1939: SA 239 SPN 520244 FMI 12, 14

Overview

The DC/DC Converter is connected to the high-voltage Power Electric Carrier (PEC), which provides 340 volts DC. The voltage is stepped down to 12-volts DC by the DC/DC Converter. The converter maintains the vehicle 12-volt system during engine off PTO operation. The converter maintains a steady 12.6 volts output and increases the amperage with vehicle demand up to 1.5 kw or 120 amps.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 12 and FMI 14 set for the following reasons:
  - Vehicle voltage drop is greater than 0.7 volts at the start of ePTO mode.
  - Vehicle battery voltage is equal to or less than 11.3 volts.
  - If there is no converter to battery cable fault, power drop across the converter is less than 900 watts (FMI 12), or power drop across the converter is greater than 1500 watts (FMI 14).

Fallback

When Fault Code 53 is set the following conditions occur:

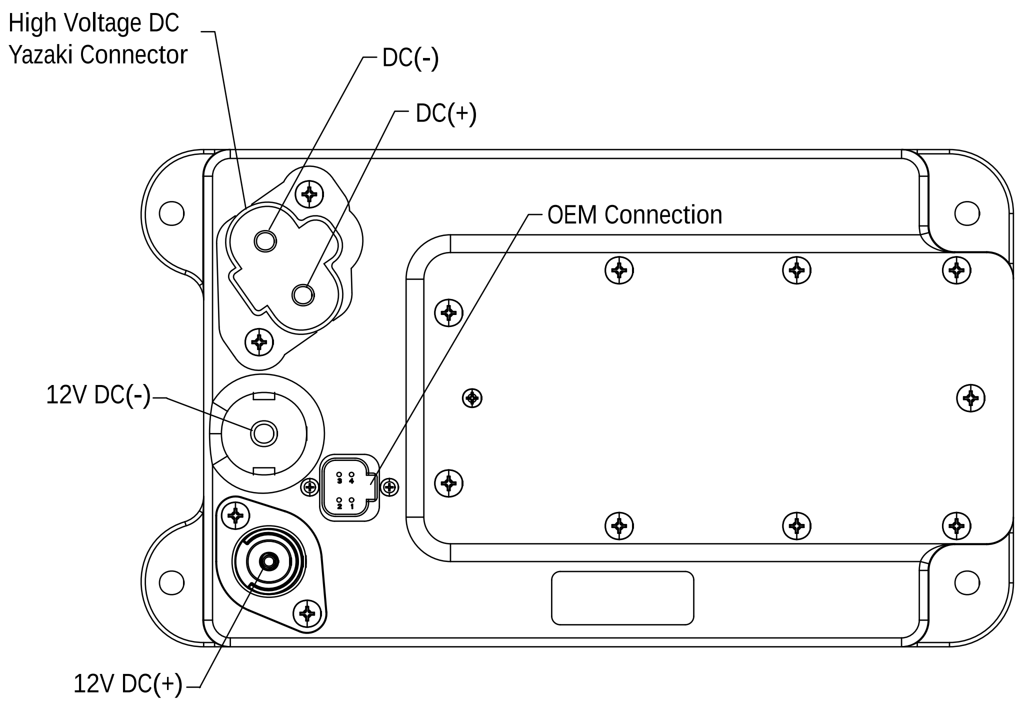
- Amber “Check Hybrid” light displays.
- Fault is stored in HCM memory.
- HCM requires the engine to power the PTO and maintain the 12-volt system.

Possible Causes

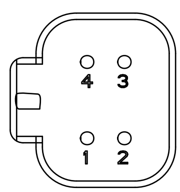
This fault code can be caused by any of the following:

- FMI 12: DC/DC Converter
- FMI 14: Vehicle load is above the maximum 1.5 kw output of the Converter

Component Identification



Deutsch 4-Way OEM Connector



DC/DC Converter
1. Top: DC negative (-); Bottom: DC positive (+)
2. 12-volt DC negative (-)
3. 12-volt DC positive (+)
4. OEM connection
5. Coolant Ports

Fault Code 53 - DC/DC Converter Fault

A ***Purpose:*** *Check for Active and Inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 12 is listed, replace the DC/DC Converter. See the **DC/DC Converter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If FMI 14 is listed, the vehicle 12-volt demand exceeds the capacity of the DC/DC Converter. Loads must be removed from the 12-volt system to maintain a maximum of 1.5 kw total usage.

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 53 appears, find error in testing, go to **Step A.**
   - If a code other than 53 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 54 - DC/DC Converter Output Voltage Fault

J1939: SA 239 SPN 520245 FMI 2, 4

Overview

The DC/DC Converter is connected to the high-voltage Power Electric Carrier (PEC), which provides 340 volts DC. The voltage is stepped down to 12-volts DC by the DC/DC Converter. The converter maintains the vehicle 12-volt system during engine off PTO operation. The converter maintains a steady 12.6 volts output and increases the amperage with vehicle demand up to 1.5 kw or 120 amps.

The DC/DC Converter also produces a feedback voltage from the 4-Way Connector. Voltage output is a 0–5 volt signal that shows 5 volts when the Converter output is at 14.2 (±0.2) volts. If the Converter output decreases, the feedback signal decreases accordingly.

Detection

Fault is detected when:

- Hybrid Control Module (HCM) ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the DC/DC voltage feedback signal reads greater than 15 volts or less than 10 volts and ePTO mode is engaged.
- FMI 4 is set when the voltage feedback is less than 15 volts and greater than 10 volts, and the difference between voltage feedback and vehicle battery voltage is greater than 0.5 volts for 1 second or more.

Fallback

When Fault Code 54 sets the following conditions occur:

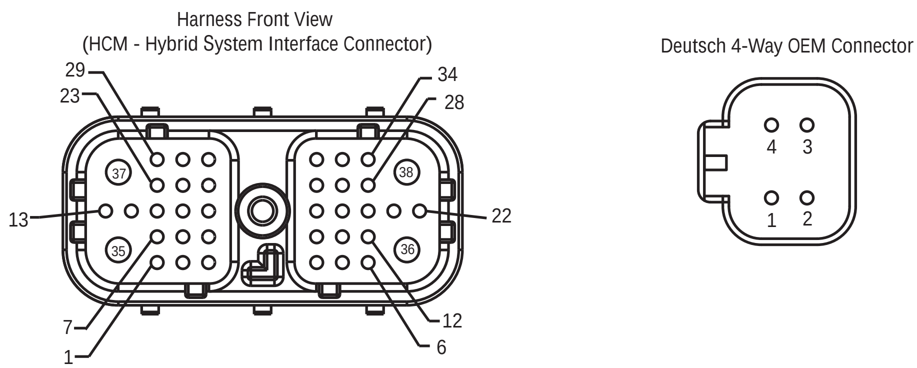
- Amber “Check Hybrid” light illuminates
- Fault is stored in HCM memory
- Depending on the voltage from the vehicle battery, the engine may continue to operate the 12-volt system in ePTO mode.

Possible Causes

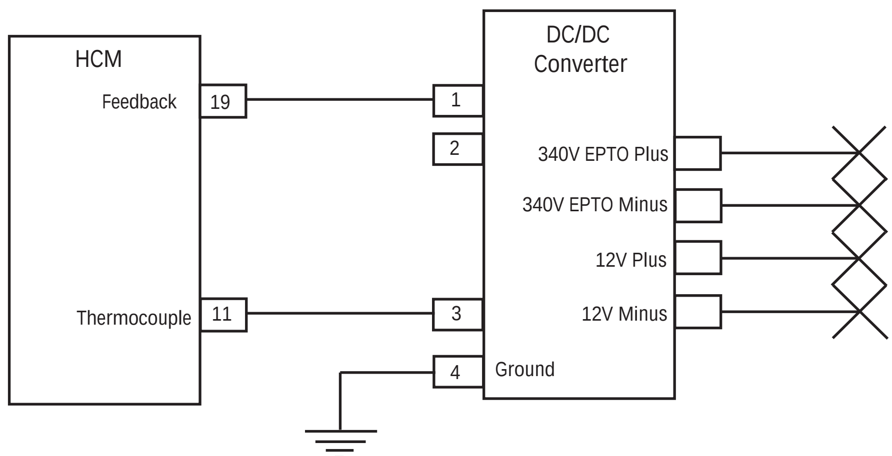
This fault code can be caused by any of the following:

- FMI 2: Voltage Feedback wire from DC/DC Converter to HCM
- FMI 4: Power cables from the 12-volt battery to the DC/DC Converter
- FMI 4: Power supply to HCM

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 54 - DC/DC Converter Output Voltage Fault

A

Purpose: *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 2 is listed, go to **Step B.**
   - If FMI 4 is listed, go to **Step C.**

B

Purpose: *Verify voltage from DC/DC Converter to HCM.*

1. Key on.
2. Select ePTO mode with the push button on the Shift Lever.
3. Measure voltage at the DC/DC Converter 12-volt Output Terminals.
   - If voltage is greater than 10 volts, repair the open or shorted circuit from Pin 1 of the DC/DC Converter to Pin 19 of the HCM, then go to **Step V.**
   - If voltage is less than 10 volts, replace the DC/DC Converter. See the **DC/DC Converter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Circuit Voltage	Measurement
DC/DC Converter Output Terminals	

C

Purpose: *Verify DC/DC Converter output voltage.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector.
3. View the following Data Monitor parameters while in neutral.
   - PID 121 “DC/DC Converter Output Voltage” If voltage at the DC/DC Converter is 12–14 volts, go to **Step D.**
   - PID 165 “Battery Potential Voltage” If voltage is outside of the 12–14-volt range, repair the open circuit or fuse in the main power supply from the DC/DC Converter to the 12-volt battery, then go to **Step V.**

Parameter	Reading
PID 121 “DC/DC Converter Output”	
PID 165 “Battery Potential Voltage”	

D

Purpose: *Verify voltage of DC/DC Converter.*

1. Key on.
2. View the Data Monitor parameters.
   - If PID 121 is 0.5 volts less than PID 165, repair the voltage feedback wire that goes from Pin 1 of the DC/DC Converter to Pin 19 of the HCM, then go to **Step V.**
   - If PID 165 is 0.5 volts less than PID 121, repair or replace the DC/DC Converter Power Supply Harness that powers the 12-volt battery system, then go to **Step V.**

Parameter	Reading
PID 121 “DC/DC Converter Output”	
PID 165 “Battery Potential Voltage”	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 54 appears, find error in testing, go to **Step A.**
   - If a code other than 54 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 56 - Input Shaft Speed Sensor Fault

J1939: SA 3 SPN 161 FMI 2, 3, 4, 5, 10
J1587: MID 130 PID 161 FMI 2, 3, 4, 5, 10

Overview

Input Shaft Speed Sensor is located on the 6-bolt PTO Cover, which is standard on the right side of the transmission. The Input Shaft Speed Sensor is a magnetic pickup that produces an AC voltage as the countershaft gear teeth move past the end. The Input Shaft Speed Sensor output increases and decreases in correlation with the speed of the countershaft.

Detection

Fault is detected when:

- Transmission Electronic Control Unit (TECU) ignition voltage is greater than 7 volts and less than 16 volts.
- FMI 10 requires the transmission to be in neutral and the vehicle speed must be within range.
- FMI 2 will not set if there is already an Active FMI 5 for the Input or Output Shaft Speed Sensors.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the TECU compares Input Shaft speed to the Output Shaft speed and they are inconsistent for 1 second or greater.
- FMI 3 and 4 are set when the TECU detects a short to ground, short to battery, and the Input Shaft speed is 0 for 1 second or greater.
- FMI 5 is set when the TECU detects an open circuit and the Input Shaft Speed Sensor is 0 for 1 second or greater.
- FMI 10 is set when the TECU detects a difference in speed of 200 RPM or greater between the Input Shaft speed and the Input shaft speed for 10 MS or greater.

Note: When troubleshooting an Inactive code refer to “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 56 is set the following conditions occur:

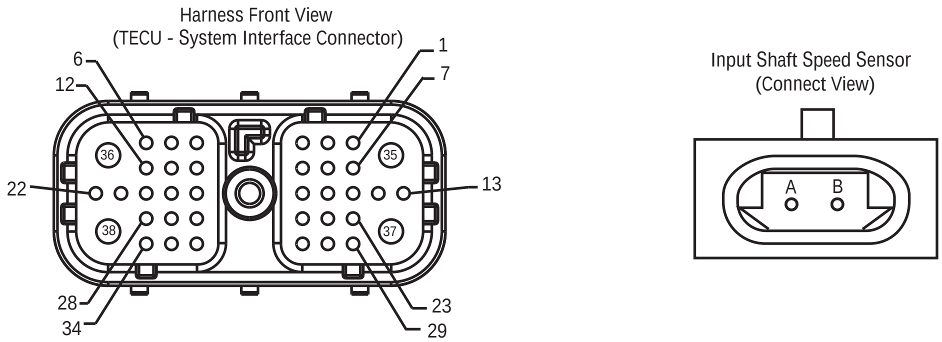
- Red “Service” light illuminates and “F” flashes in the gear display.
- Fault is stored in TECU memory.
- Operation mode changes to AutoShift Fallback.
- If fault occurs while moving, the transmission remains in current gear and the clutch opens when the vehicle stops.
- If this fault occurs at power up, the vehicle cranks, but the transmission does not engage a gear.

Possible Causes

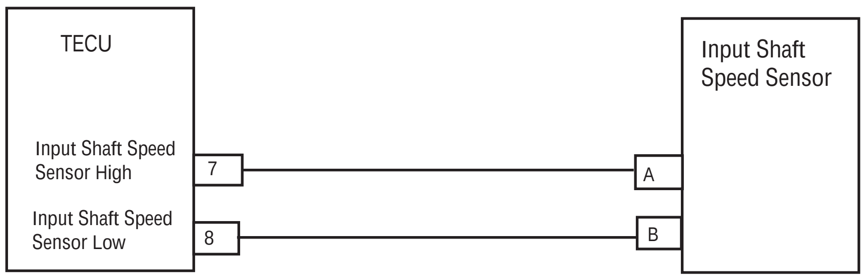
This fault code can be caused by any of the following:

- FMI 2, 10
  - Input Shaft Speed Sensor
  - TECU
  - Transmission Harness
  - Damaged transmission gearing
  - Contamination on the Input Shaft Speed Sensor
- FMI 3, 4, 5
  - Input Shaft Speed Sensor
  - TECU
  - Transmission Harness

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 56 - Input Shaft Speed Sensor Fault

A

Purpose: *Verify continuity of Transmission Harness sensor circuits.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Disconnect negative battery cable.
4. Disconnect the Transmission Harness 38-Way Connector.
5. Measure the resistance between the Transmission Harness 38-Way Connector Pin 7 to Pin 8, and Pin 7 and ground.
   - If resistance is 2K–4.5K ohms, and Pin 7 to ground is 10K ohms or greater, go to **Step B.**
   - If resistance is outside of the range, go to **Step D.**

Connection	Measurement
Pin 7 to Pin 8	
Pin 7 to ground	

B

Purpose: *Verify voltages of Transmission Harness sensor circuits and ground.*

1. Key on.
2. Measure the voltage from between the Transmission Harness 38-Way Connector Pin 7 and ground.
   - If voltage is 0 volts, go to **Step C.**
   - If voltage is 11–13 volts, repair the short to battery in the Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin 7 to ground	

C

Purpose: *Verify integrity of Input Shaft Speed Sensor.*

1. Inspect Input Shaft Speed Sensor for contamination or damage.
   - If no problem found, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If problem is found, or you were sent here from Step D or E, replace the Input Shaft Speed Sensor. See the **Input Shaft Speed Sensor Removal and Installation** procedure in TRSM2000 and inspect the Countershaft Gear for damage, then go to **Step V.**

D

Purpose: *Verify continuity of Input Shaft Speed Sensor.*

1. Disconnect the Transmission Harness from Input Shaft Speed Sensor.
2. Measure resistance between Input Shaft Speed Sensor Pin A and Pin B.
   - If resistance is 2K–4.5K ohms, go to **Step E.**
   - If resistance is outside of range, go to **Step C.**

Connection	Measurement
Pin A to Pin B	

E

Purpose: *Verify continuity of Input Shaft Speed Sensor to ground.*

1. Measure resistance between Input Shaft Speed Sensor Pin A and ground.
   - If resistance is 10K ohms or greater, replace Transmission Harness. See the **Transmission Harness Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is less than 10K ohms, go to **Step C.**

Connection	Measurement
Pin A to ground	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Verify proper installation of Speed Sensor.
4. Key on.
5. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
6. Drive the vehicle and attempt to recreate the code.
7. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 56 appears, find error in testing, go to **Step A.**
   - If a code other than 56 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 58 - Output Shaft Speed Sensor Fault

J1939: SA 3 SPN 191 FMI 2, 3, 4, 5
J1587: MID 130 PID 191 FMI 2, 3, 4, 5

Overview

The Output Shaft Speed Sensor is located at 12 o'clock on the Rear Bearing Cover. It is a magnetic pickup that produces an AC voltage as the Tone Wheel teeth move past the end of the sensor. The amount of AC voltage output from the Output Shaft Speed Sensor increases and decreases in correlation with the speed of the Output Shaft.

Detection

Fault is detected when:

- Transmission Electronic Control Unit (TECU) ignition voltage is greater than 7 volts and less than 16 volts.
- FMI 2 sets if an Active FMI 5 for the Input or Output Shaft Speed Sensors already exists.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the TECU detects a difference between the Output Shaft speed and the Input Shaft speed for 1 second or greater.
- FMI 3, 4 are set when the TECU detects a short to ground, short to battery or the Output Shaft speed is 0 for 1 second or greater.
- FMI 5 is set when the TECU detects an open circuit and the Output Shaft Speed Sensor is 0 for 1 second or greater.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 58 is set the following conditions occur:

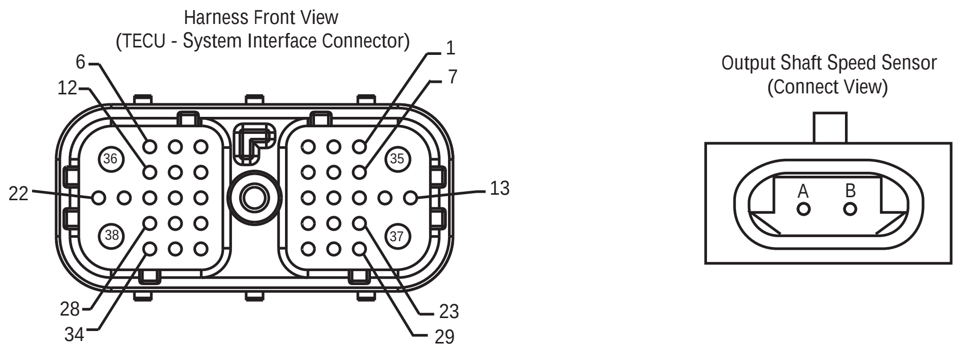
- Red "Service" light illuminates and an "F" flashes in the gear display.
- Fault is stored in TECU memory.
- Operation mode changes to AutoShift Fallback.
- If this fault occurs while moving, the transmission remains in the current gear and the clutch opens when the vehicle stops.

Possible Causes

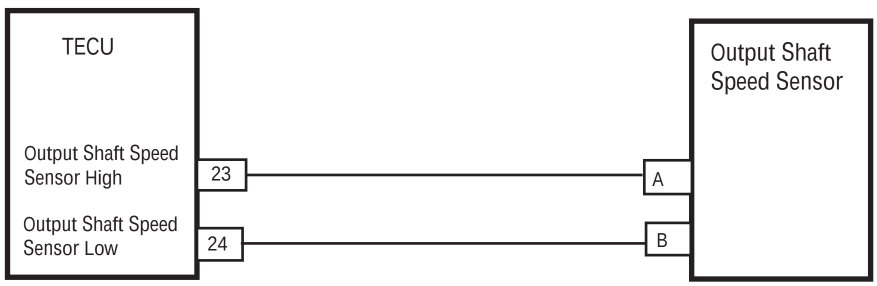
This fault code can be caused by any of the following:

- FMI 2
  - Output Shaft Speed Sensor
  - TECU
  - Transmission Harness
  - Damaged transmission gearing
  - Contamination on the Output Shaft Speed Sensor
- FMI 3, 4, 5
  - Output Shaft Speed Sensor
  - TECU
  - Transmission Harness

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 58 - Output Shaft Speed Sensor Fault

A

Purpose: *Verify continuity of Transmission Harness sensor circuits.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Disconnect negative battery cable.
4. Disconnect the Transmission Harness 38-Way Connector.
5. Measure resistance between the Transmission Harness 38-Way Connector Pin 23 to Pin 24, and Pin 23 to ground.
   - If resistance is 2K–4.5K ohms, and Pin 23 to ground is 10K ohms or greater, go to **Step B.**
   - If resistance is outside of the range, go to **Step D.**

Connection	Measurement
Pin 23 to Pin 24	
Pin 23 to ground	

B

Purpose: *Verify voltage of Transmission Harness sensor circuits to ground.*

1. Key on.
2. Measure voltage between the Transmission Harness 38-way connector Pin 23 and ground.
   - If voltage is 0 volts, go to **Step C.**
   - If voltage is 11–13 volts, repair the short to battery in the Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin 23 to ground	

C

Purpose: *Verify integrity of Output Shaft Speed Sensor.*

1. Inspect Output Shaft Speed Sensor for contamination or damage.
   - If no problem found, replace **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
   - If problem is found or sent here from Step D or Step E, replace Output Shaft Speed Sensor. See the **Output Shaft Speed Sensor Removal and Installation** procedure in TRSM2000 and inspect the Tone Wheel for damage, looseness or corrosion, then go to **Step V.**

D

Purpose: *Verify continuity of Output Shaft Speed Sensor.*

1. Disconnect the Transmission Harness from the Output Shaft Speed Sensor.
2. Measure resistance between Output Shaft Speed Sensor Pin A and Pin B.
   - If resistance is 2K–4.5K ohms, go to **Step E.**
   - If resistance is outside of range, go to **Step C.**

Connection	Measurement
Pin A to Pin B	

E

Purpose: *Verify continuity of Output Shaft Speed Sensor and ground.*

1. Measure resistance between Output Shaft Speed Sensor Pin A and ground.
   - If resistance is 10K ohms or greater, replace Transmission Harness. See the **Transmission Harness Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is less than 10K ohms, go to **Step C.**

Connection	Measurement
Pin A to ground	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Verify proper installation of speed sensor.
4. Key on.
5. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
6. Drive the vehicle and attempt to recreate the code.
7. Check for codes: See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 58 appears, find error in testing, go to **Step A.**
   - If a code other than 58 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 59 - J1939 Communication Link Fault (HCM)

J1939: SA 239 SPN 639 FMI 2, 9

Overview

J1939 is a high-speed twisted pair 250K data link with a 120 ohm resistor at each end. The Hybrid Control Module (HCM) is connected to the J1939 Data Link at the 38-Way Connector. This link is used to transmit or receive information from other modules on the network (e.g., Transmission Electronic Control Unit (TECU) or engine Electronic Control Unit (ECU)).

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set in Product Diagnostic Mode (PDM) and occurs when the HCM loses communication with any other module on the J1939 Data Link for 3 consecutive messages.
- FMI 9 is set when the HCM loses communication with all modules on the J1939 Data Link for 30 consecutive messages or more.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 59 is set the following conditions occur:

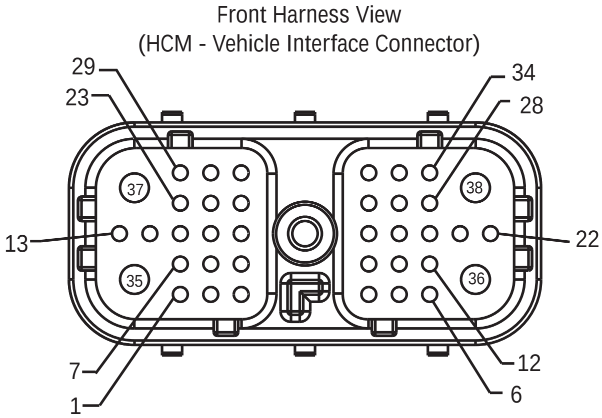
- Amber “Check Hybrid” and red “Stop Hybrid” lights do not display, since the lights are controlled over the J1939 Data Link.
- Fault is stored in HCM memory.
- Operation mode changes to AutoShift Only.
- If the fault sets at power up, the engine does not crank.
- If the fault sets while driving, the vehicle shifts; however, when the vehicle stops, the clutch opens and remains open.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- You may see a red “Service” light, and “F” flashing in the gear display due to the Active Fault Codes 24, 35 or 36.

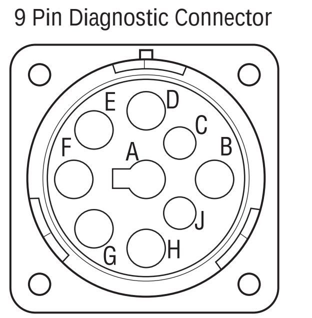
Possible Causes

This fault code can be caused by any of the following:

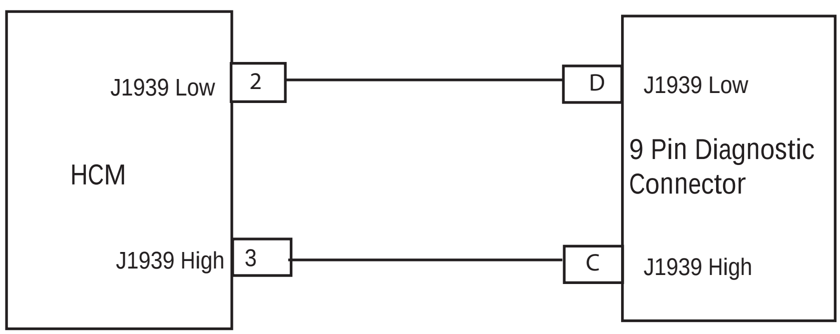
- FMI 2, 9
  - J1939 Data Link
  - HCM

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 59 - J1939 Communication Link Fault (HCM)

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Select the “Vehicle Components” screen and view the various modules that are reporting on the J1939 link.
   - If the HCM is not reporting on J1939 but the TECU is, go to **Step B.**
   - If neither the HCM nor TECU are reporting on J1939, go to **Step C.**

B

Purpose: *Verify continuity of Vehicle Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect HCM Vehicle Harness 38-Way Connector.
4. Measure resistance between HCM Vehicle Harness 38-Way Connector Pin 2 and Pin 3.

   Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 2 and Pin 3 is between 50–70 ohms, replace HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair J1939 Data link Harness, then go to **Step V.**

Connection	Measurement
Pin 2 to Pin 3	

C ***Purpose:*** *Verify continuity of Diagnostic Connector J1939 circuits.*

1. Key off.
2. Measure the resistance between Pin C and Pin D on the 9-Way Diagnostic Connector.
   - If resistance between Pin C and Pin D is 50–70 ohms, go to **Step D.**
   - If resistance is 70 ohms or greater, one or more of the terminating resistors on the J1939 Data Link harness is missing, out of range, or there is an open in the link. Repair the J1939 Data Link Harness, then go to **Step V.**
   - If resistance is 50 ohms or less, there is an additional terminating resistor present. Repair the J1939 Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin C to Pin D	

D ***Purpose:*** *Verify continuity of Diagnostic Connector J1939 circuits.*

1. Key off.
2. Measure resistance between Pin C and ground on the 9-Way Diagnostic Connector.
   - If resistance between Pin C and ground is 10K ohms or greater, Attempt to communicate with another vehicle and ensure ServiceRanger is working. If ServiceRanger fails to communicate with another vehicle, call 1-800-826-HELP (4357).
   - If resistance is outside of range, repair J1939 Data link Harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin C to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 59 appears, find error in testing, go to **Step A.**
   - If a code other than 59 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 60 - CAN Communication Link Fault

J1939: SA 239 SPN 625 FMI 2, 9

Overview

The Controller Area Network (CAN) is a high-speed, twisted pair 500K proprietary data link that connects the Hybrid Control Module (HCM) to the Electric Clutch Actuator (ECA), Power Electric Carrier (PEC) and Inverter. The link contains a 120 ohm resistor at each end. The link is used to transmit information specific to clutch position or power electronics operations.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when all modules lose communication with HCM on the CAN Data Link for 30 consecutive messages or more.
- FMI 2 is set in Product Diagnostic Mode (PDM) when the CAN loses communication with the HCM for 3 consecutive messages.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 60 is set, the following conditions occur:

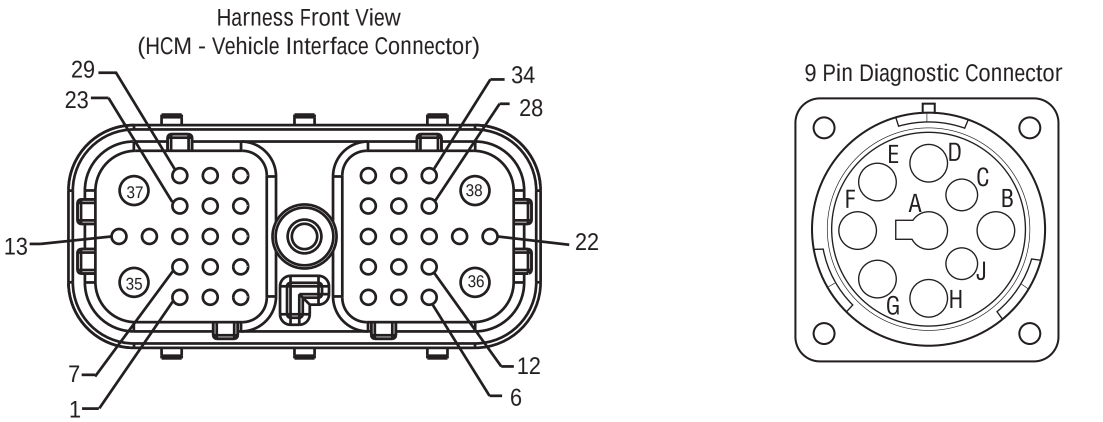
- Red "Stop Hybrid" light illuminates.
- Fault is stored in HCM memory.
- Operation mode changes to AutoShift only.
- If the fault sets at power up, the engine does not crank.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- If the fault sets while driving, the clutch either closes or opens and remains in this position until fixed.
- Transmission defaults starting gear to 1st.

Possible Causes

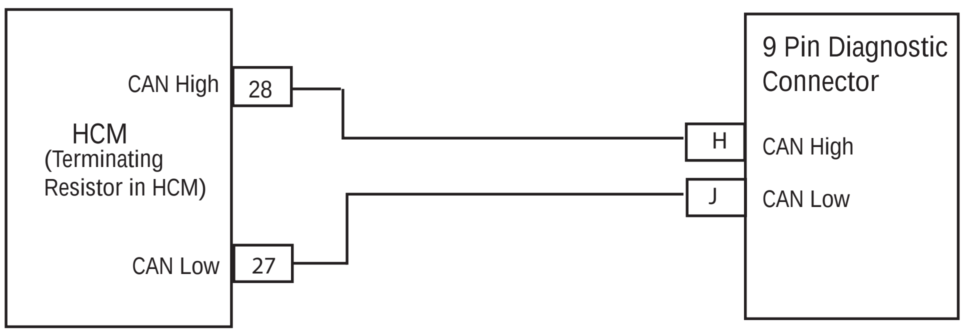
This fault code can be caused by any of the following:

- FMI 2, 9
  - CAN Data Link
  - HCM

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 60 - CAN Communication Link Fault

A ***Purpose:*** *Verify continuity of Diagnostic Connector circuits.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Measure the resistance between the following:
   - Pin H and Pin J on 9-Way Diagnostic Connector
   - Pin A and Pin B on 3-Way Connector
   - Pin 1 and Pin 2 on 2-Way Connector

Note: The 3-Way and 2-Way Data Link Connectors are located next to the 9-Way Diagnostic Connector.

Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

- If resistance between Pin H and Pin J, Pin A and Pin B, or Pin 1 and Pin 2 is between 50–70 ohms, go to **Step B.**
- If resistance is more than 70 ohms, one or more of the terminating resistors on the CAN Data Link Harness is either missing or out of range, or there is an open in the link. Repair CAN Data Link Harness, then go to **Step V.**
- If resistance is less than 50 ohms, there is an additional terminating resistor present. Repair the CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin H to Pin J	
Pin A to Pin B	
Pin 1 to Pin 2	

B ***Purpose:*** *Verify continuity of Vehicle Harness J1939 circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect HCM Harness 38-Way Connector.
4. Measure resistance between HCM Harness 38-Way Connector Pin 27 and Pin 28.

Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale)

- If resistance between Pin 27 and Pin 28 is between 110–130 ohms, replace HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
- If resistance is outside of range, repair the CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin 27 to Pin 28	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If Fault Code 60 appears, find error in testing, go to **Step A.**
   - If a code other than 60 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 61: Rail Motor Circuit Fault

J1587: MID 130	**SID 39**	**FMI 1, 5, 6, 12**
J1939: SA 3	**SPN 772**	**FMI 1, 5, 6, 12**

Overview

The Hybrid Transmission is equipped with an X-Y Shifter that selects a transmission gear. The X-Y Shifter motors are controlled with electrical current supplied by the TECU to move the Shift Finger either side-to-side (rail selection) or fore-and-aft (gear engagement and disengagement). Fault Code 61 indicates a failure with the circuit controlling the Rail Motor and the side-to-side movement of the X-Y Shift Finger.

Detection

The system can identify an issue with the X-Y Shifter Rail Motor circuit, the TECU rail motor controller or the power and ground connections to the TECU under the following conditions:

- FMI 1 and 12 can be detected when the X-Y Rail Motor is energized
- FMI 5 and 6 can be detected when the X-Y Rail Motor is not energized

Conditions to Set Fault Code Active

FMI 1 – Data Valid but Below Normal: Transmission fails to complete a shift and the measured current draw of the Rail Motor is below expected values.

FMI 5 – Current Below Normal or Open Circuit: TECU detects an open circuit or a short-to-ground condition on the Rail Motor circuit for 0.5 second at power up or prior to a shift.

FMI 6 – Current Above Normal or Shorted Circuit: TECU detects a short-to-power on the Rail Motor circuit for 0.5 seconds at power up or prior to a shift.

FMI 12 – Bad Intelligent Device: Transmission fails to complete a shift and the TECU detects intermittent fluctuations in supply voltage due to poor connections, shorted Rail Motor circuit or a hardware failure of the TECU.

Fallback

All FMIs

- “F” flashes in the gear display.
- Service light flashes (if equipped).
- Engine may not crank.
- Transmission may not engage a gear from neutral.
- Transmission does not shift while the vehicle is moving.
- Until the fault becomes Inactive, driver may have to shut off engine with transmission in gear.

Conditions to Set Fault Code Inactive

FMI 1, 12: This fault is set Inactive when the shift is completed.

FMI 5, 6: This fault is set Inactive when the open or short circuit condition is not detected for 0.5 seconds.

Possible Causes

FMI 1, 5

- Transmission Harness
  - Terminals bent, spread, corroded or loose
  - Wiring shorted to ground, shorted to power or open
- X-Y Shifter Rail Motor
  - Terminals bent, spread, corroded or loose
  - Rail Motor shorted to ground, partial short to ground, shorted to power or open
  - Rail Motor internal failure
- TECU
  - Internal failure

FMI 6

- Transmission Harness
  - Wiring shorted to power
- TECU
  - Internal failure

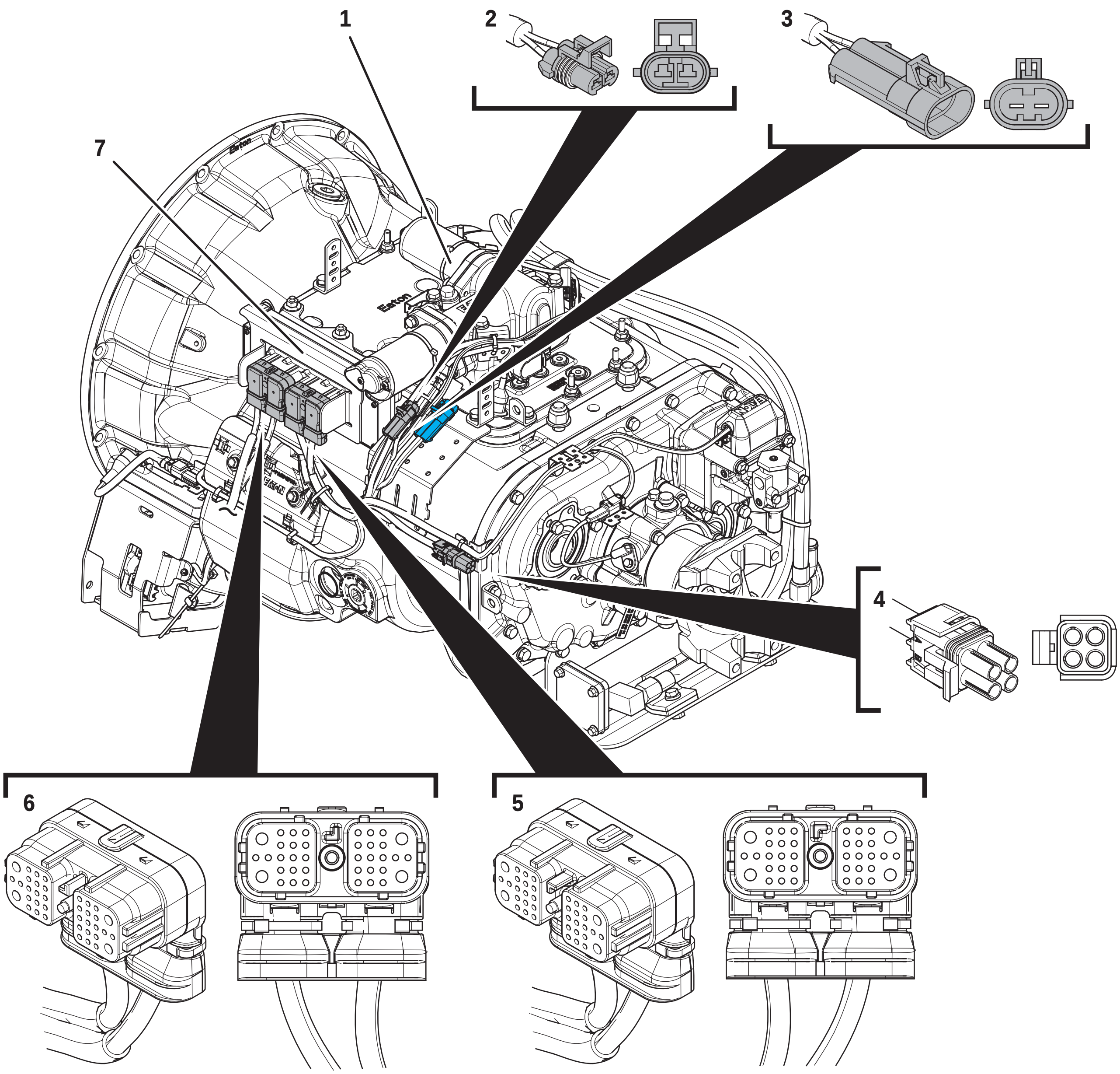
FMI 12

- OEM Power Supply
  - Poor power or ground supply to TECU (may be in conjunction with Fault Codes 33 or 34)
  - Battery failure
  - Terminals bent, spread, corroded or loose
  - Wiring shorted to ground, shorted to power or open
- OEM Batteries
  - Internal failure
- OEM 30-amp Battery Fuse
  - Terminals bent, spread, corroded or loose
  - Fuse missing or improperly seated
- TECU
  - Internal failure

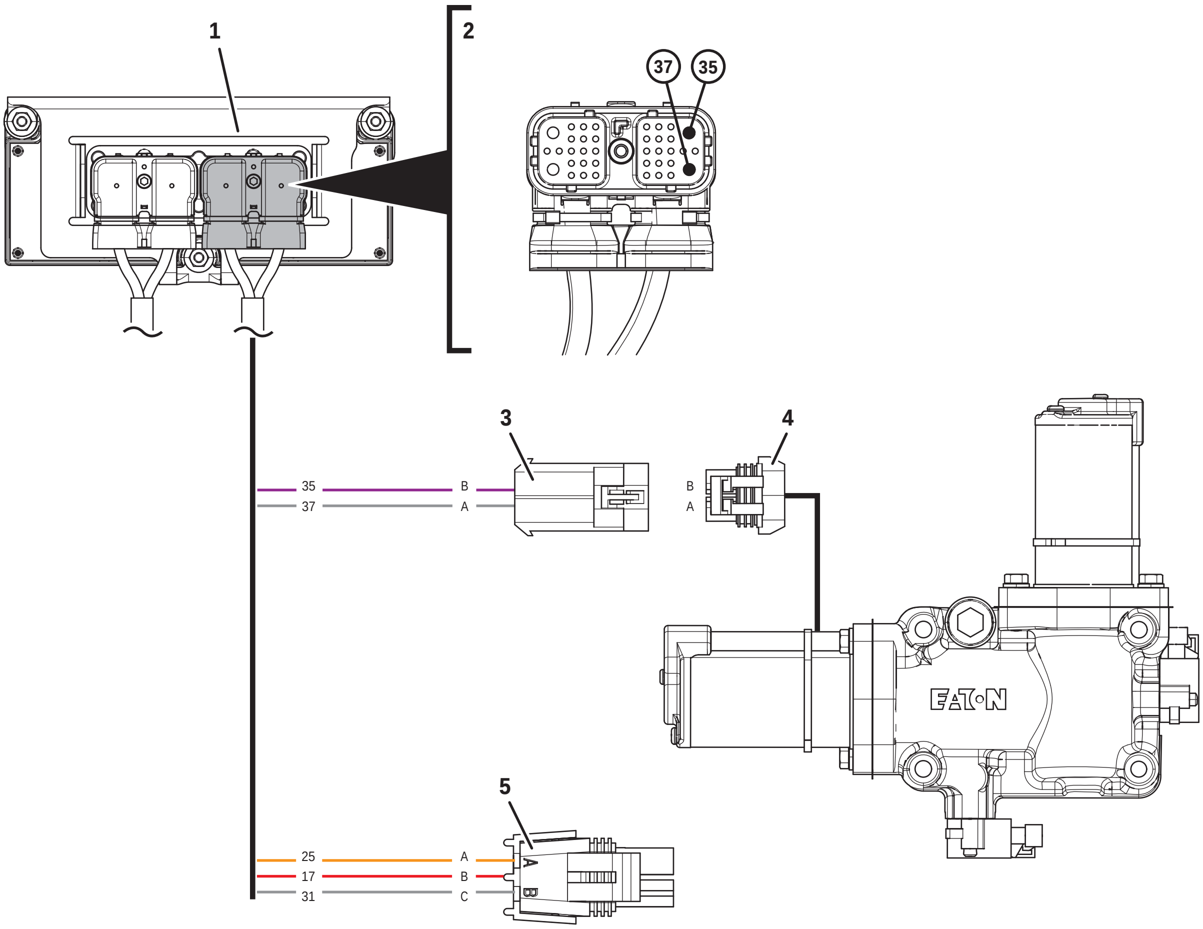
Additional Tools

Roadranger Pin Out Adapter Jumper Kit (Part Number RR1009HY)

Component Identification



1. X-Y Shifter
2. 2-Way Rail Motor Connector (black)
3. 2-Way Rail Motor Connector Body (black)
4. 4-Way Diagnostic Connector
5. 38-Way Transmission Harness Connector
6. 38-Way Vehicle Harness Connector
7. Transmission Electronic Control Unit (TECU)



1. Transmission Electronic Control Unit (TECU)
2. 38-Way Transmission Harness Connector
3. 2-Way Rail Motor Connector Body (black)
4. 2-Way Rail Motor Connector (black)
5. 4-Way Diagnostic Connector

Switched Battery from TECU	Ignition Voltage	Signal Input	Battery Voltage
Switched 5V Power from TECU	Relay/Solenoid Output Driver	Communication	Ground

Fault Code 61: Rail Motor Circuit

A

Purpose: *Check for Active or Inactive fault codes.*

1. Key on with engine off.
2. Connect ServiceRanger.
3. Retrieve Snapshot and VPA data by creating a *Service Activity Report* within ServiceRanger.
4. Update transmission software to latest available level.

Caution: To avoid damaging the TECU, use an Eaton-approved communications adapter and ensure all satellite systems are disabled before updating software.

5. Retrieve and record the transmission fault codes and FMIs, and their occurrences and timestamps.
   - If either Fault Code 33 or 34 are Active, troubleshoot it first per *Fault Code Isolation Procedure*.
   - If Fault Code 61 is Active and Fault Code 33 or Fault Code 34 are Inactive or not set, go to **Step D.**
   - If Fault Code 61 is Inactive and Fault Code 33 or Fault Code 34 are Inactive or not set, go to **Step B.**

B

Purpose: *Verify condition of power and ground supply.*

1. Perform the "Electrical Pretest Gen1 ECA" on page 61. Record the reading(s) from the Load Test in Step C of the *Electrical Pretest* in the table.
   - If the *Electrical Pretest* fails, repair per *Electrical Pretest* instructions. Retest vehicle operation.
   - If the *Electrical Pretest* passes, go to **Step C.**

Battery	Voltage Drop	Load Test Status (Pass/Fail)
1		
2		
3		
4		
5		

C

Purpose: *Use Product Diagnostic (PD) Mode to locate intermittent failures.*

1. Set parking brakes and chock wheels.
2. Place transmission in PD Mode. See more about "Product Diagnostic (PD) Mode" on page 6.

3. Wiggle wiring and connections between the 38-Way OEM Vehicle Harness Connector at the TECU and vehicle battery supply. Look for signs of rubbing or chafing.
4. Wiggle wiring and connections between 38-Way Transmission Harness Connector at the TECU and the black (X-Rail Motor) 2-Way Transmission Harness Connector.
5. Wiggle wiring and connections between 38-Way Connector at the TECU and the blue (Y-Gear Motor) 2-Way Transmission Harness Connector.
6. Exit PD Mode by powering down.

Important: Allow 2–3 minutes for the TECU to perform a complete power-down sequence before proceeding.

- If any faults set Active while wiggling the Vehicle Harness, refer to OEM guidelines for repair or replacement of the OEM wiring. Go to **Step V.**
- If any fault sets Active while wiggling the Transmission Harness, replace the Transmission Harness. Go to **Step V.**
- If no faults set Active while wiggling either harness, go to **Step D.**

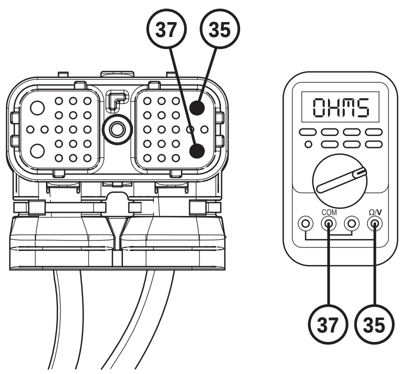
D

Purpose: *Verify which FMI set.*

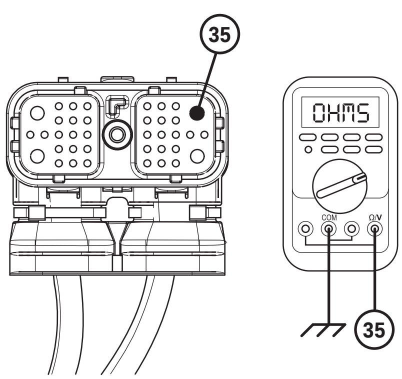
1. Determine which FMI set for Fault Code 61.
   - If FMI 1 or 12 set, go to **Step E.**
   - If FMI 5 set and is Active, go to **Step E.**
   - If FMI 5 set and is Inactive, go to **Step K.**
   - If FMI 6 set, replace TECU. Go to **Step V.**

E ***Purpose:*** *Verify proper resistance through the Transmission Harness and Rail Motor.*

1. Key off.
2. Disconnect 38-Way Transmission Harness Connector from the TECU.
3. Verify that the 38-Way Connector is free from corrosion; there are no bent, spread, or loose terminals; and there is no damage to the connector body.
4. Measure resistance between 38-Way Connector Pin 35 and Pin 37. Record reading.



5. Measure resistance between 38-Way Connector Pin 35 and ground.



6. Compare reading(s) in table.
   - If both readings are in range, go to **Step F.**
   - If either readings is out of range, go to **Step H.**

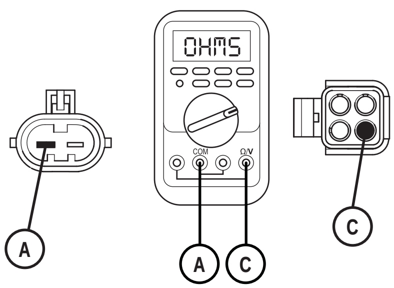
Pins	Range	Reading(s)
35 to 37	2.0 ohms or less	
35 to Ground	Greater than 10k ohms or Open Circuit (OL)	

F ***Purpose:*** *Verify which FMI set.*

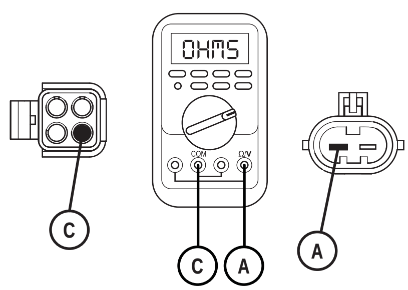
1. Determine which FMI set for Fault Code 61.
   - If FMI 1 set, replace X-Y Shifter and Transmission Harness. Go to **Step V.**
   - If FMI 5 set, go to **Step G.**
   - If FMI 12 set, go to **Step H.**

G ***Purpose:*** *Verify internal circuit resistance of the TECU.*

1. Reconnect 38-Way Transmission Harness to the TECU.
2. Disconnect black 2-Way Rail Motor Connector from the Transmission Harness.
3. Remove cover of 4-Way Diagnostic Connector
4. Measure resistance between the 2-Way Connector Body Pin A and the 4-Way Connector Pin C. Record reading in table.



5. Reverse meter leads and take the same measurement between the 2-Way Connector Body Pin A and the 4-Way Connector Pin C. Record reading in table.

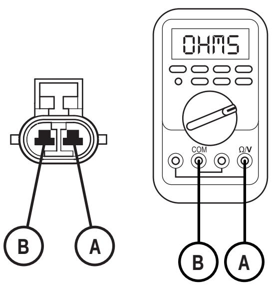


6. Compare readings to specified range in table.
   - If both readings are in range, replace the X-Y Shifter. Go to **Step V.**
   - If either readings is out of range, replace the TECU. Go to **Step V.**

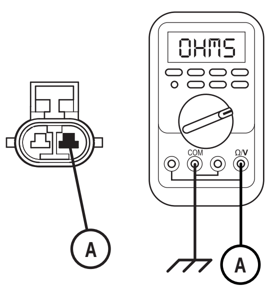
Pins	Range	Reading(s)
A to C	15k ohms or greater	
C to A	15k ohms or greater	

H ***Purpose:*** *Verify the resistance of the X-Y Rail Motor and verify motor is not shorted to ground.*

1. Key off.
2. Disconnect black 2-Way Rail Motor Connector from the Transmission Harness.
3. Verify the 2-Way Connector is free from corrosion, terminals are not bent, spread, or loose and there is no damage to the connector body.
4. Measure resistance between the black 2-Way Connector Pin A and Pin B. Record reading in table.



5. Measure resistance between the 2-Way Connector Pin A and Ground. Record reading in table.



6. Compare reading(s) in table.
   - If reading(s) is in range, go to **Step I.**

     If reading(s) is out of range, replace the X-Y Shifter. Go to **Step V.**

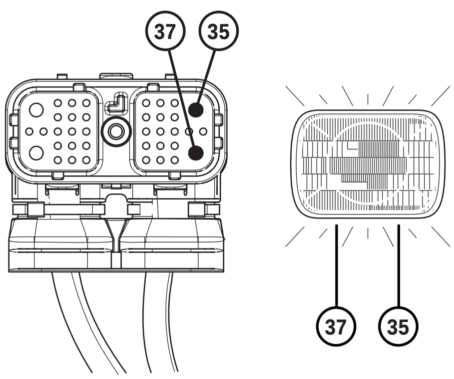
Pins	Range	Reading(s)
A to B	2.0 ohms or less	
A to Ground	Greater than 10k ohms or Open Circuit (OL)	

I ***Purpose:*** *Verify which FMI set.*

1. Determine which FMI set for Fault Code 61.
   - If FMI 1 set, replace the Transmission Harness. Go to **Step V.**
   - If FMI 5 set, replace the Transmission Harness. Go to **Step V.**
   - If FMI 12 set, go to **Step J.**

J ***Purpose:*** *Load Test the vehicle power supply to the TECU.*

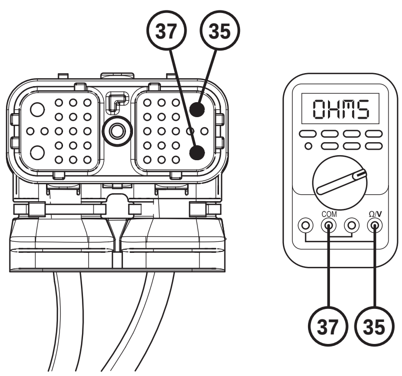
1. Key off.
2. Verify TECU battery power and ground supply from the OEM Vehicle Harness is connected properly and not corroded, damaged or loose.
3. Disconnect 38-Way Vehicle Harness Connector at the TECU.
4. Verify that the 38-Way Connector is free from corrosion; terminals are no bent, spread, or loose; and there is no damage to the connector body.
5. Load test the vehicle Power Supply Harness with an external load source. Use a sealed beam headlamp or blower motor attached to Pin 35 (power) and Pin 37 (ground). Load test for 5 minutes to verify the harness will carry a load with the 30-amp fuse installed.



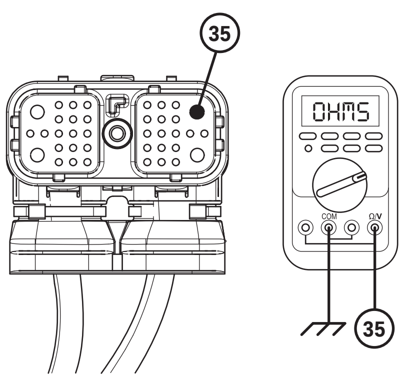
6. Wiggle the harness during the Load Test from the vehicle batteries to the TECU.
   - If issues are found with the Vehicle Harness or connectors, refer to OEM guidelines for repair or replacement of OEM wiring and continue Load Test.
   - If the Vehicle Harness does not carry a load, refer to OEM guidelines for repair or replacement of OEM wiring. Go to **Step V.**
   - If no issues are found with the Vehicle Harness or connectors and the power supply carries a load, replace the TECU. Go to **Step V.**

K ***Purpose:*** *Verify proper resistance through the Transmission Harness and Rail Motor.*

1. Key off.
2. Disconnect 38-Way Transmission Harness Connector from the TECU.
3. Verify that the 38-Way Connector is free from corrosion, terminals are not bent, spread, or loose; and there is no damage to the connector body.
4. Measure resistance between 38-Way Connector Pin 35 and Pin 37. Record reading(s) in table.



5. Measure resistance between 38-Way Connector Pin 35 and ground. Record reading(s) in table.

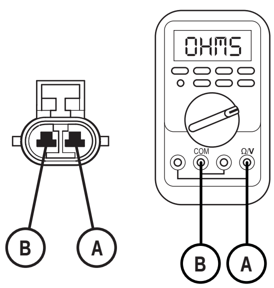


6. Compare reading(s) in table.
   - If reading(s) is in range, replace the X-Y Shifter. Go to **Step V.**
   - If reading(s) is out of range, go to **Step L.**

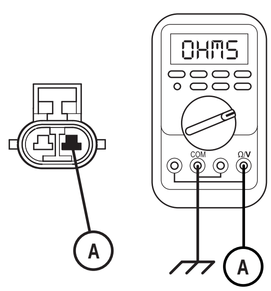
Pins	Range	Reading(s)
35 to 37	15k ohms or greater	
35 to Ground	Greater than 1.0M ohms or Open Circuit (OL)	

L **Purpose:** *Verify the internal resistance of the X-Y Shifter Rail Motor and verify motor is not shorted to ground.*

1. Key off.
2. Disconnect black 2-Way Rail Motor Connector from the Transmission Harness.
3. Verify the 2-Way Connector is free from corrosion; terminals are not bent, spread, or loose, and there is no damage to the connector body.
4. Measure resistance between the 2-Way Connector Pin A and Pin B. Record reading(s) in table.



5. Measure resistance between the 2-Way Connector Pin A and ground. Record reading(s) in table.



6. Compare reading(s) to specified range in table.
   - If reading(s) is in range, replace the Transmission Harness. Go to **Step V.**
   - If reading(s) is out of range, replace the X-Y Shifter. Go to **Step V.**

Pins	Range	Reading(s)
A to B	2.0 ohms or less	
A to Ground	Greater than 1.0M ohms or Open Circuit (OL)	

V **Purpose:** *Verify repair.*

1. Key off.
2. Reconnect all connectors and verify that all components are properly installed.
3. Key on with engine off.
4. Clear fault codes using ServiceRanger.
5. Drive vehicle and attempt to reset the code or duplicate the previous complaint.
6. Check for fault codes using ServiceRanger.
   - If no codes set and the vehicle operates properly, test complete.
   - If Fault Code 61 sets Active during the test drive, go to **Step A.**
   - If a fault code other than 61 sets, troubleshoot per *Fault Code Isolation Procedure Index*.

Fault Code 63: Gear Motor Circuit Fault

J1587: MID 130 SID 40 FMI 1, 5, 6, 12
J1939: SA 3 SPN 773 FMI 1, 5, 6, 12

Overview

The Hybrid Transmission is equipped with an X-Y Shifter that selects a transmission gear. The X-Y Shifter motors are controlled with current supplied by the TECU to move the Shift Finger either side-to-side (rail selection) or fore-and-aft (gear engagement and disengagement). Fault Code 63 indicates a failure of the circuit controlling the Gear Motor and the fore-and-aft movement of the X-Y Shift Finger.

Detection

The system can identify an issue with the X-Y Shifter Gear Motor circuit, the TECU gear motor controller or the power and ground connections to the TECU under the following conditions:

- FMI 1 and 12 can be detected when the X-Y Gear Motor is energized
- FMI 5 and 6 can be detected when the X-Y Gear Motor is not energized

Conditions to Set Fault Code Active

FMI 1 – Data Valid but Below Normal: Transmission fails to complete a shift and the measured current draw of the Gear Motor is below expected values.

FMI 5 – Current Below Normal or Open Circuit: TECU detects an open circuit or a short-to-ground condition on the Gear Motor circuit for 0.5 seconds at power up or prior to a shift.

FMI 6 – Current Above Normal or Shorted Circuit: TECU detects a short-to-power on the Gear Motor circuit for 0.5 seconds at power up or prior to a shift.

FMI 12 – Bad Intelligent Device: Transmission fails to complete a shift and the TECU detects intermittent fluctuations in supply voltage due to poor connections, shorted Gear Motor circuit or a hardware failure of the TECU.

Fallback

All FMIs

- "F" flashes in the gear display.
- Service light flashes (if equipped).
- Engine may not crank.
- Transmission may not engage a gear from neutral.
- Transmission does not shift while the vehicle is moving.
- Until the fault becomes Inactive, driver may have to shut off engine with transmission in gear.

Conditions to Set Fault Code Inactive

FMI 1, 12: This fault is set Inactive when the shift is completed.

FMI 5, 6: This fault is set Inactive when the open or short circuit condition is not detected for 0.5 seconds.

Possible Causes

FMI 1, 5

- Transmission Harness
  - Terminals bent, spread, corroded or loose
  - Wiring shorted to ground, shorted to power or open
- X-Y Shifter Gear Motor
  - Terminals bent, spread, corroded or loose
  - Wiring shorted to ground, shorted to power or open
  - Rail Motor shorted to ground, partial short to ground, shorted to power or open
  - Rail Motor internal failure
- TECU
  - Internal failure

FMI 6

- Transmission Harness
  - Wiring shorted to power
- TECU
  - Internal failure

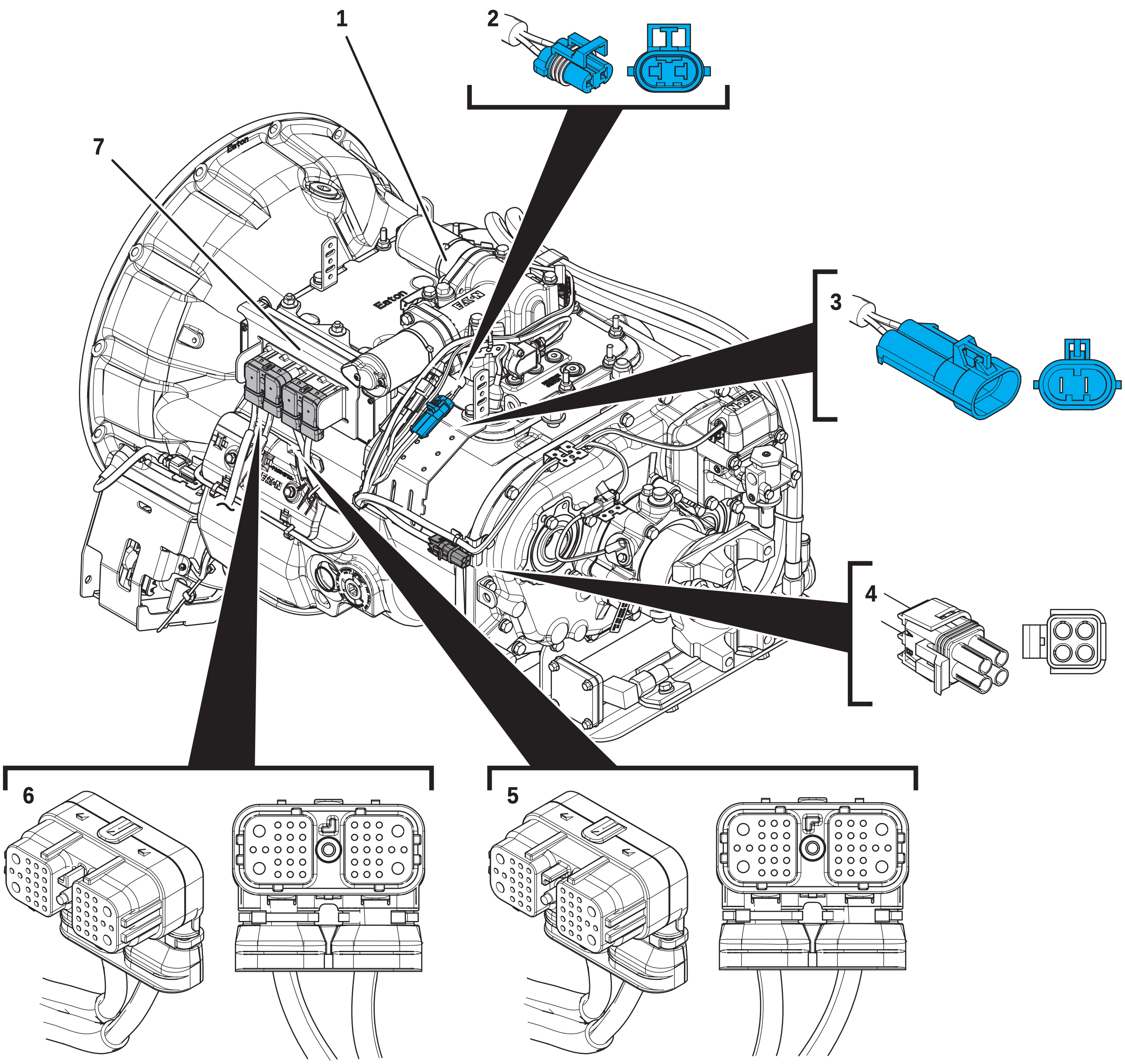
FMI 12

- OEM Power Supply
  - Poor power or ground supply to TECU (may be in conjunction with Fault Codes 33 or 34)
  - Battery failure
  - Terminals bent, spread, corroded or loose
  - Wiring shorted to ground, shorted to power or open
- OEM Batteries
  - Internal failure
- OEM 30-amp Battery Fuse
  - Terminals bent, spread, corroded or loose
  - Fuse missing or improperly seated
- TECU
  - Internal failure

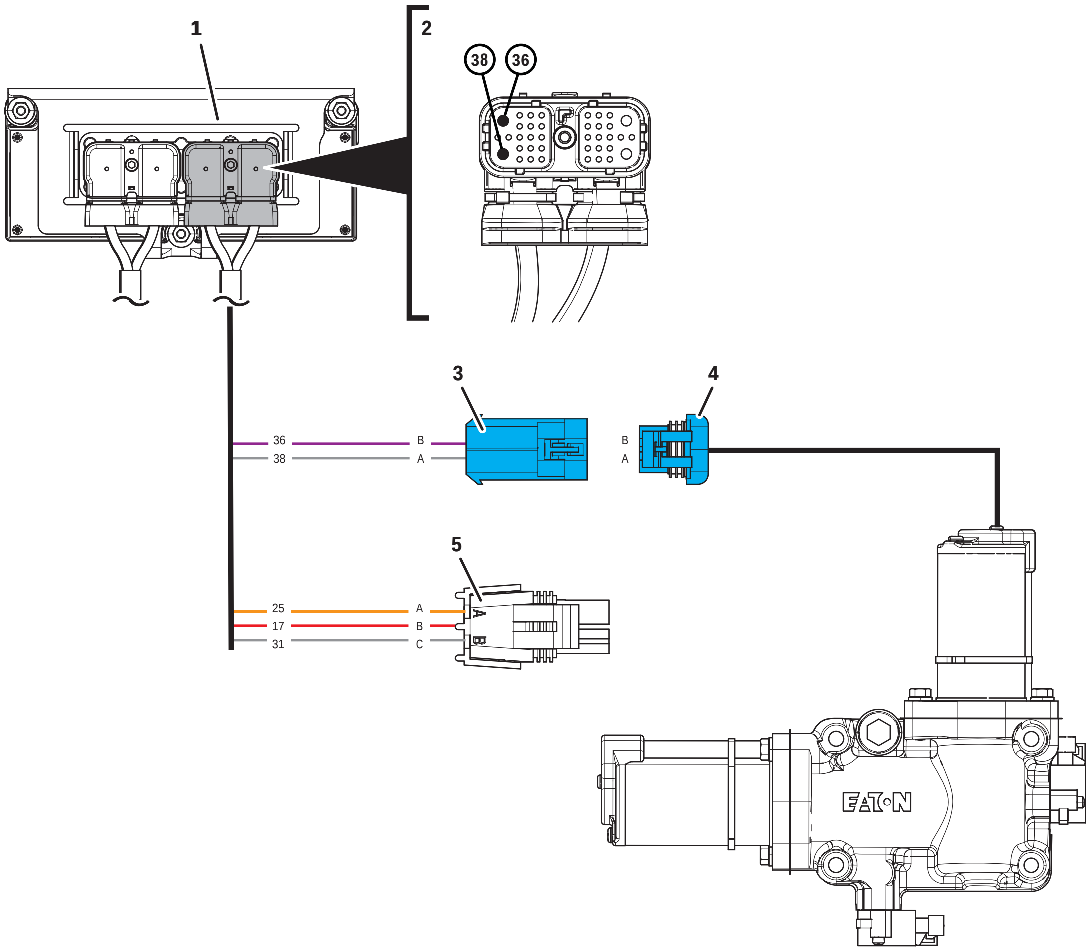
Additional Tools

Roadranger Pin Out Adapter Jumper Kit (Part Number RR1009HY)

Component Identification



1. *X-Y Shifter*
2. *2-Way Gear Motor Connector (blue)*
3. *2-Way Gear Motor Connector Body (blue)*
4. *4-Way Diagnostic Connector*
5. *38-Way Transmission Harness Connector*
6. *38-Way Vehicle Harness Connector*
7. *Transmission Electronic Control Unit (TECU)*



1. Transmission Electronic Control Unit (TECU)
2. 38-Way Transmission Harness Connector
3. 2-Way Gear Motor Connector Body (blue)
4. 2-Way Gear Motor Connector (blue)
5. 4-Way Diagnostic Connector

Switched Battery from TECU
Switched 5V Power from TECU
Ignition Voltage
Relay/Solenoid Output Driver
Signal Input
Communication
Battery Voltage
Ground

Fault Code 63 Troubleshooting

A ***Purpose:*** *Check for Active or Inactive fault codes.*

1. Key on with engine off.
2. Connect ServiceRanger.
3. Retrieve Snapshot and VPA data by creating a *Service Activity Report* within ServiceRanger.
4. Update transmission software to latest available level.

Caution: To avoid damaging the TECU, use an Eaton-approved communications adapter and ensure all satellite systems are disabled before updating software.

5. Retrieve and record the transmission fault codes and FMIs, and their occurrences and timestamps.
   - If either Fault Code 33 or 34 are Active, troubleshoot it first. Troubleshoot per *Fault Code Isolation Procedure*.
   - If Fault Code 63 is Active and Fault Code 33 or 34 are Inactive or not set, go to **Step D.**
   - If Fault Code 63 is Inactive and Fault Code 33 or 34 are Inactive or not set, go to **Step B.**

B ***Purpose:*** *Verify condition of power and ground supply.*

1. Perform the “Electrical Pretest Gen1 ECA” on page 61. Record the reading(s) from the Load Test in Step C of the *Electrical Pretest* in the table below.
   - If the *Electrical Pretest* fails, repair per *Electrical Pretest* instructions. Retest vehicle operation.
   - If the *Electrical Pretest* passes, go to **Step C.**

Battery	Voltage Drop	Load Test Status (Pass/Fail)
1		
2		
3		
4		
5		

C

***Purpose:** Use Product Diagnostic (PD) Mode to locate intermittent failures.*

1. Set parking brakes and chock wheels.
2. Place transmission in PD Mode. See more about “Product Diagnostic (PD) Mode” on page 6.

3. Wiggle wiring and connections between the 38-Way Vehicle Harness Connector at the TECU and vehicle battery supply. Look for signs of rubbing or chafing.
4. Wiggle wiring and connections between 38-Way Transmission Harness Connector at the TECU and the black (X-Rail Motor) 2-Way Transmission Harness Connector.
5. Wiggle wiring and connections between 38-Way Connector at the TECU and the blue (Y-Gear Motor) 2-Way Transmission Harness Connector.
6. Exit PD Mode by powering down.

Important: Allow 2–3 minutes for the TECU to perform a complete power-down sequence before proceeding.

- If any faults set Active while wiggling the Vehicle Harness, refer to OEM guidelines for repair or replacement of the OEM wiring. Go to **Step V.**
- If any fault sets Active while wiggling the Transmission Harness, replace the Transmission Harness. Go to **Step V.**
- If no faults set Active while wiggling either harness, go to **Step D.**

D

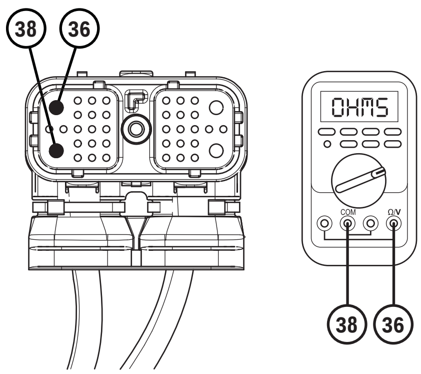
***Purpose:** Verify which FMI set.*

1. Determine which FMI set for Fault Code 63.
   - If FMI 1 or 12 set, go to **Step E.**
   - If FMI 5 set and is Active, go to **Step E.**
   - If FMI 5 set and is Inactive, go to **Step K.**
   - If FMI 6 set, replace TECU. Go to **Step V.**

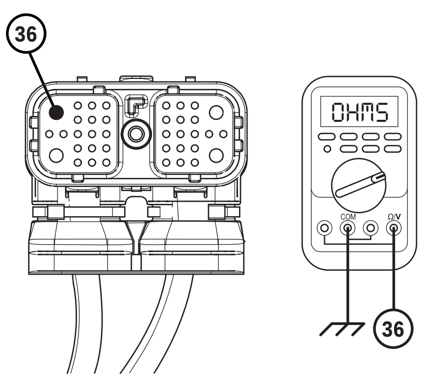
E

Purpose: *Verify proper resistance through the Transmission Harness and Gear Motor.*

1. Key off.
2. Disconnect 38-Way Transmission Harness Connector from the TECU.
3. Verify that the 38-Way Connector is free from corrosion; terminals are not bent, spread, or loose terminals; and there is no damage to the connector body.
4. Measure resistance between 38-Way Connector Pin 36 and Pin 38. Record reading(s) in table.



5. Measure resistance between 38-Way Connector Pin 36 and ground. Record reading(s) in table.



6. Compare reading(s) to specified range in table:
   - If reading(s) is in range, go to **Step F.**
   - If reading(s) is out of range, go to **Step H.**

Pins	Range	Reading(s)
36 to 38	2.0 ohms or less	
36 to Ground	Greater than 10k ohms or Open Circuit (OL)	

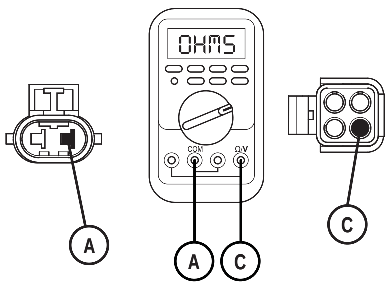
F

Purpose: *Verify which FMI set.*

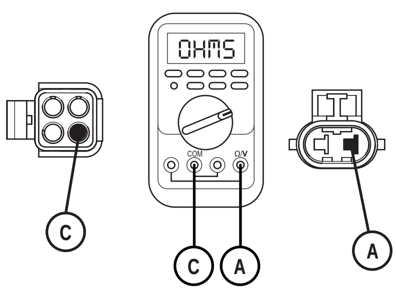
1. Determine which FMI set for Fault Code 63.
   - If FMI 1 set, replace X-Y Shifter and Transmission Harness. Go to **Step V.**
   - If FMI 5 set, go to **Step G.**
   - If FMI 12 set, go to **Step H.**

G ***Purpose:*** *Verify internal circuit resistance of the TECU.*

1. Reconnect 38-Way Transmission Harness to the TECU.
2. Disconnect blue 2-Way Gear Motor Connector from the Transmission Harness.
3. Remove connector cover of the 4-Way Diagnostic Connector.
4. Measure resistance between the 2-Way Connector Pin A and the 4-Way Connector Pin C. Record reading(s) in table.



5. Reverse meter leads and take the same measurement between the 2-Way Connector Pin A and the 4-Way Connector Pin C. Record reading(s) in table.



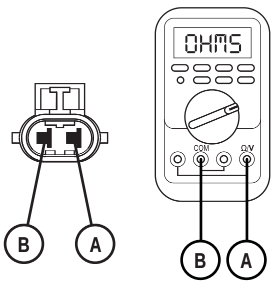
6. Compare reading(s) to specified range in table.
   - If reading(s) is in range, replace the X-Y Shifter. Go to **Step V.**
   - If reading(s) is out of range, replace the TECU. Go to **Step V.**

Pins	Range	Reading(s)
A to C	15k ohms or greater	
C to A	15k ohms or greater	

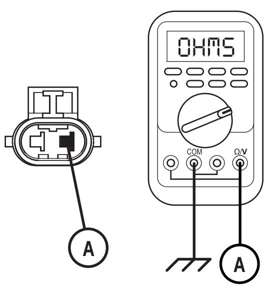
H

Purpose: *Verify the resistance of the X-Y Gear Motor and verify motor is not shorted to ground.*

1. Key off.
2. Disconnect blue 2-Way Gear Motor Connector from the Transmission Harness.
3. Verify 2-Way Connector is free from any corrosion; the terminals are not bent, spread or loose, and there is no damage to the connector body.
4. Measure resistance between the 2-Way Connector Pin A and Pin B. Record reading(s) in table.



5. Measure resistance between the 2-Way Connector Pin A and ground. Record reading.



6. Compare reading(s) to specified range in table.
   - If reading(s) is in range, go to **Step I.**
   - If reading(s) is out of range, replace the X-Y Shifter. Go to **Step V.**

Pins	Range	Reading(s)
A to B	2.0 ohms or less	
A to Ground	Greater than 10k ohms or Open Circuit (OL)	

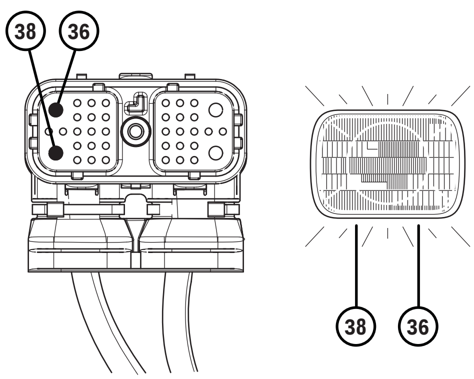
I

Purpose: *Verify which FMI set.*

1. Determine which FMI set for Fault Code 63.
   - If FMI 1 set, replace Transmission Harness. Go to **Step V.**
   - If FMI 5 set, replace Transmission Harness. Go to **Step V.**
   - If FMI 12 set, go to **Step J.**

J ***Purpose:*** *Load Test the vehicle power supply to the TECU.*

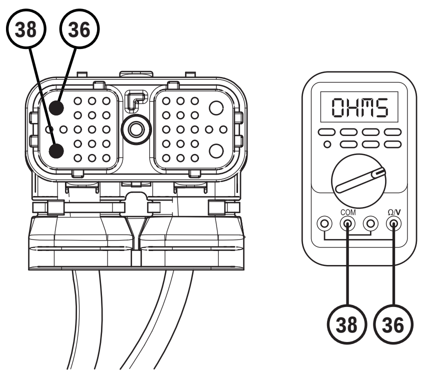
1. Key off.
2. Verify TECU battery power and ground supply from the Vehicle Harness is connected properly and not corroded, damaged, or loose.
3. Disconnect 38-Way Vehicle Harness Connector at the TECU.
4. Verify that the 38-Way Connector is free from corrosion, there are no bent, spread, or loose terminals, and there is no damage to the connector body.
5. Load test the vehicle power supply harness with an external load source. Use a sealed beam headlamp or blower motor attached to Pin 36 (power) and Pin 38 (ground). Load Test for 5 minutes to verify the harness will carry a load with the 30-amp fuse installed.



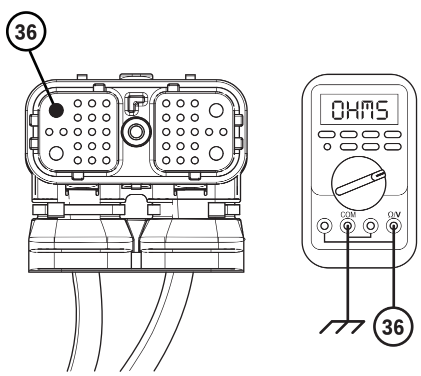
6. Wiggle the harness during the Load Test from the vehicle batteries to the TECU.
   - If issues are found with the Vehicle Harness or connectors, refer to OEM guidelines for repair or replacement of OEM wiring and continue Load Test.
   - If the Vehicle Harness does not carry a load, refer to OEM guidelines for repair or replacement of OEM wiring. Go to **Step V.**
   - If no issues are found with the Vehicle Harness or connectors and the power supply carries a load, replace the TECU.
     Go to **Step V.**.

K ***Purpose:*** *Verify proper resistance through the Transmission Harness and Gear Motor.*

1. Key off.
2. Disconnect 38-Way Transmission Harness Connector from the TECU.
3. Verify that the 38-Way Connector is free from corrosion, there are no bent, spread, or loose terminals, and there is no damage to the connector body.
4. Measure resistance between 38-Way Connector Pin 36 and Pin 38. Record reading in table.



5. Measure resistance between 38-Way Connector Pin 36 and ground. Record reading in the table.

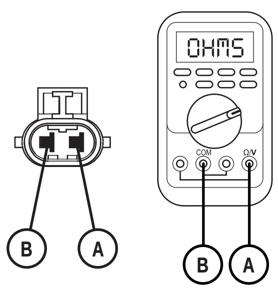


6. Compare reading(s) to specified range in table:
   - If reading(s) is in range, replace the X-Y Shifter. Go to **Step V.**
   - If reading(s) is out of range, go to **Step L.**

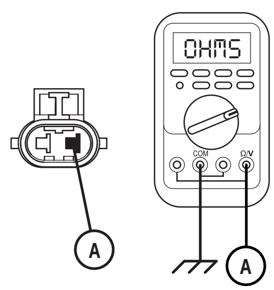
Pins	Range	Reading(s)
36 to 38	15k ohms or greater	
36 to Ground	Greater than 1.0M ohms or Open Circuit (OL)	

L | ***Purpose:*** *Verify the internal resistance of the X-Y Shifter Gear Motor and verify motor is not shorted to ground.*

1. Key off.
2. Disconnect blue 2-Way Gear Motor Connector from the Transmission Harness.
3. Verify that the 2-Way Connector is free from corrosion, there are no bent, spread, or loose terminals, and there is no damage to the connector body.
4. Measure resistance between the 2-Way Connector Pin A and Pin B. Record reading in the table.



5. Measure resistance between the 2-Way Connector Pin A and ground. Record reading in table.



6. Compare resistances to specified range in table.
   - If both resistances are in range, replace the Transmission Harness. Go to **Step V.**
   - If either resistance is out of range, replace the X-Y Shifter. Go to **Step V.**

Pins	Range	Reading(s)
A to B	2.0 ohms or less	
A to Ground	Greater than 1.0M ohms or Open Circuit (OL)	

V | ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and verify that all components are properly installed.
3. Key on with engine off.
4. Clear fault codes using ServiceRanger.
5. Drive vehicle and attempt to reset the code or duplicate the previous complaint.
6. Check for fault codes using ServiceRanger.
   - If no codes set and the vehicle operates properly, test complete.
   - If Fault Code 63 sets Active during the test drive, go to **Step A.**
   - If a fault code other than 63 sets, troubleshoot per *Fault Code Isolation Procedure Index*.

Fault Code 64 - ECA Fault

J1939: SA 239 SPN 788, 520198, 520199, 524035 FMI 0, 12, 13, 21–28

Overview

The Electric Clutch Actuator (ECA) controls the position of the clutch assembly. A main power 3-Way Connector supplies electricity to the ECA directly from the 12-volt battery. The ECA also connects to the Hybrid Control Module (HCM) and the Engine Speed Sensor through an 8-Way Connectors. The ECA communicates with the HCM and Engine Speed Sensor over the proprietary Controller Area Network (CAN) Data Link to change position, show faults or include other operational information.

Detection

Fault is detected when:

- ECA ignition voltage is greater than 8.5 volts.
- ECA Battery Voltage is greater than 7.8 when ignition voltage is greater than 8.5 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 12 is set for an internal ECA failure.
- FMIs 22–28 are set for excessive motor current or incorrect shaft position.
- FMI 0 is set when the ECA Inverter temperature exceeds 266 °F (130 °C).
- FMI 13 is set when the ECA can not find the Clutch Release Bearing touch point after 3 attempts.

Fallback

When Fault Code 64 is set the following conditions occur:

- Red “Stop Hybrid” light illuminates for FMI 12, 21, 22, 23, 24, 26, 27, or 28.
- Amber “Check Hybrid” light illuminates for FMI 0, 13, or 25.
- Fault is stored in HCM memory.
- If the fault occurs while driving, the ECA either maintains current clutch position or moves to the last position commanded by the HCM.
- If the fault occurs at power up, the vehicle does not crank.

Possible Causes

This fault code can be caused by any of the following:

- FMI 12
  - ECA
- FMI 21–28
  - Excessive debris buildup on/around the ECA.
  - Binding cross-shafts.
- FMI 0
  - Missing exhaust shield or exhaust to close to ECA.

Component Identification

Note: No schematic for this code.

Fault Code 64 - ECA Fault

A

Purpose: *Verify FMIs present.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Which FMIs are present?
   - If FMI 0 is present, check for damaged or missing exhaust shielding on the ECA. Replace or reroute exhaust to reduce internal ECA temperature, then go to **Step V.**
   - If FMI 12 is listed, replace the ECA. See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If FMIs 21–28 are listed, go to **Step B.**

B

Purpose: *Verify integrity of ECA motor.*

1. Disconnect the 12-volt battery cables.
2. Remove the ECA from the Clutch Housing. See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000.
3. Check the ECA and Clutch Housing for debris build up.
4. Rotate the Clutch Release Shaft by hand to check for binding.
   - If no excessive debris is found, and Clutch Release Shaft rotates without binding, replace ECA. See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If excessive debris is found around ECA or inside the Clutch Housing, remove debris build up around ECA area.
   - If the Clutch Release Shaft binds when rotated, replace or repair Clutch Release Shaft and upper bushing as needed for proper shaft rotations, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes appear, test is complete.
   - If Fault Code 64 appears, find error in testing, go to **Step A.**
   - If a code other than 64 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 65 - ECA Speed Sensor Fault

J1939: SA 239 SPN 520203 FMI 2, 5

Overview

Electric Clutch Actuator (ECA) controls the position of the clutch assembly. A Main Power 3-Way Connector supplies electricity to the ECA directly from the 12-volt battery. The ECA also connects to the Hybrid Control Module (HCM) and the Engine Speed Sensor through an 8-Way Connector. The ECA communicates with the HCM and Engine Speed Sensor over the proprietary Controller Area Network (CAN) Data Link to change position, show faults or include other operational information.

Detection

Fault is detected when:

- ECA ignition voltage is greater than 8.5 volts.
- Fault Code 18 or Fault Code 87 are Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when HCM detects engine speed at idle, but does not detect ECA engine speed.
- FMI 5 is set when the ECA detects an open on the ECA Speed Sensor Signal circuit at key on.

Fallback

When Fault Code 65 is set the following conditions occur:

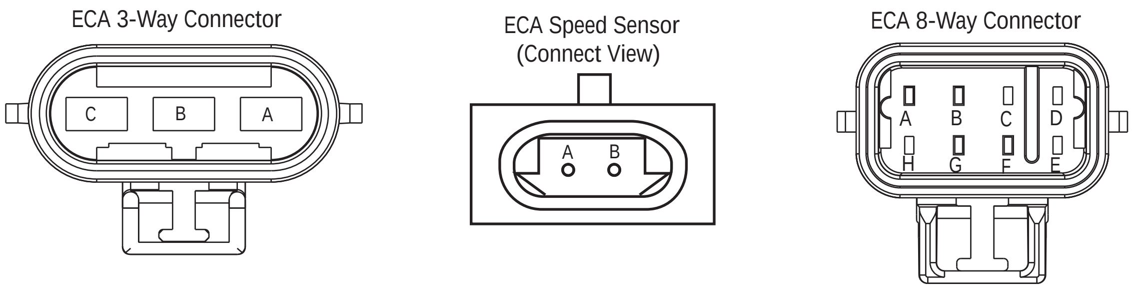
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.

Possible Causes

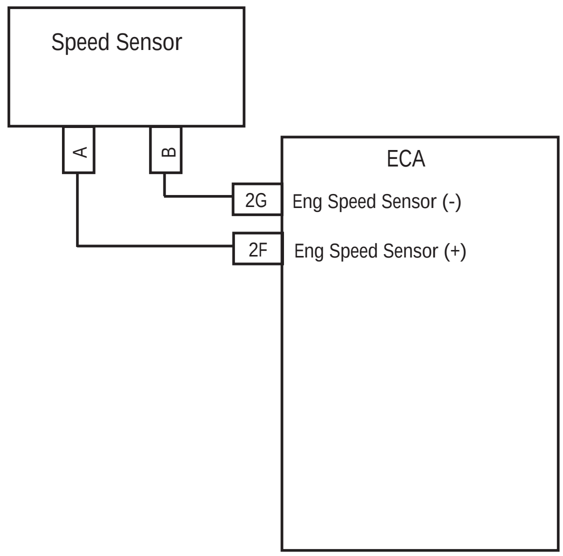
This fault code can be caused by any of the following:

- FMI 2, 5
  - ECA Speed Sensor
  - ECA Speed Sensor Harness
  - ECA

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 65 - ECA Speed Sensor Fault

A

Purpose: *Verify FMIs present.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Which FMIs are listed?
   - If FMI 5 is listed, go to **Step B.**
   - If FMI 2 is listed, go to **Step C.**

B

Purpose: *Verify continuity of ECA Harness.*

1. Check resistance between ECA 8-Way Connector Pin F and Pin G.
   - If resistance between ECA 8-Way Connector Pin F and Pin G is 140–180 ohms, go to **Step C.**
   - If resistance is out of range, repair the open circuit in the Speed Sensor or the ECA Speed Sensor Harness from the ECA to the Speed Sensor, then go to **Step V.**

Connection	Measurement
Pin F to Pin G	

C

Purpose: *Verify continuity of ECA Harness and ground.*

1. Key off.
2. Check resistance between ECA 8-Way Connector Pin F and ground.
   - If resistance is 10K or greater, go to **Step D.**
   - If resistance is out of range, repair the short to ground in the Speed Sensor or the ECA Harness from the ECA to the Speed Sensor, then go to **Step V.**

Connection	Measurement
Pin F to ground	

D ***Purpose:*** *Verify voltage of ECA Harness and ground.*

1. Key on.
2. Measure voltage from the ECA 8-Way Connector Pin G and ground.
   - If voltage is 0 at key on and FMI 5 is Active, replace the ECA (only if fault code is Active). See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is 0 at key on and FMI 2 is Active, go to **Step E.**
   - If voltage is greater than 0 at key on, repair the short to power on the ECA Speed Sensor Harness, then go to **Step V.**

Connection	Measurement
Pin G to ground	

E ***Purpose:*** *Verify integrity of ECA Speed Sensor.*

1. Key off.
2. Remove the ECA Speed Sensor and examine end for damage or debris build up.
   - If the Speed Sensor shows no cracks or signs of metallic debris build up, go to **Step F.**
   - If the Speed Sensor is damaged or has debris build up, replace or clean the ECA sensor, then go to **Step V.**

F ***Purpose:*** *Verify integrity of Engine Flywheel.*

1. Inspect the engine Flywheel to ensure no missing or damaged teeth.
   - If Flywheel teeth are intact and in good condition, reinstall flywheel sensor until it touches the flywheel. Then rotate the flywheel counterclockwise 1/2 to 1 full turn. Tighten jam nut and drive vehicle. If fault returns, replace the ECA Speed Sensor, then go to **Step V.**
   - If Flywheel teeth are damaged or missing, problem is with the Flywheel. Contact your OEM for repair procedures.

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 65 appears, find error in testing, go to **Step A.**
   - If a code other than 65 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 66 - ECA Battery Voltage Fault

J1939: SA 239 SPN 520271 FMI 3, 4, 14

Overview

The Electric Clutch Actuator (ECA) controls the position of the clutch assembly. The ECA has a main power 3-Way Connector that directly connects to the 12-volt battery positive and negative terminals.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- ECA ignition voltage is greater than 8.5 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the ECA battery voltage is above 17 volts for 10 MS or greater.
- FMI 4 is set when the ECA battery voltage is below 8.5 volts for 10 MS or greater.
- FMI 14 is set when the ECA battery voltage is below 8.5 volts for 10 MS or greater, but the HCM reports the battery voltage is within range.

Fallback

When Fault Code 66 is set the following conditions occur:

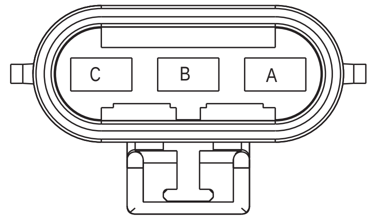
- Red “Stop Hybrid” light illuminates.
- Fault is stored in HCM memory.
- If the fault occurs while driving, the ECA either maintains current clutch position or moves to the last position commanded by the HCM, then the ECA holding device will engage.
- If the fault occurs at power up, the vehicle will not crank.

Possible Causes

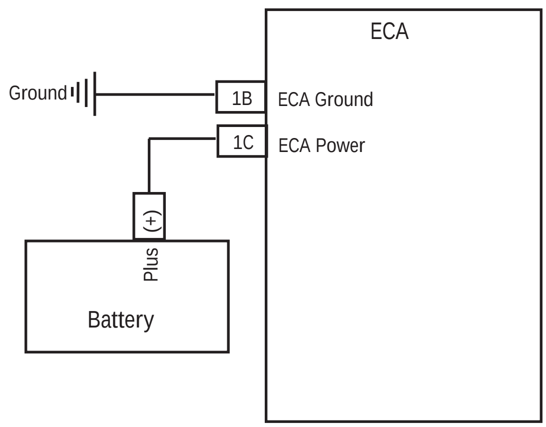
This fault code can be caused by any of the following:

- FMI 3
  - Charging system
  - ECA
- FMI 4
  - ECA power supply harness, connections and fuse holder
  - Low batteries or bad main power connection
  - Charging system
  - ECA
- FMI 14
  - ECA power supply harness, connections and fuse holder

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 66 - ECA Battery Voltage Fault

A

Purpose: *Verify FMI present and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Perform Electrical Pretest.
   - If FMI 3 or 4 is Active after performing the Electrical Pretest, replace the ECA. See the **Electric Clutch Actuator Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If FMI 14 is Active after performing the Electrical Pretest, replace the ECA Harness, then go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 66 appears, find error in testing, go to **Step A.**
   - If a code other than 66 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 67 - ECA Ignition Voltage Fault

J1939: SA 239 SPN 520274 FMI 3, 4, 5

Overview

The Electric Clutch Actuator (ECA) controls the position of the clutch assembly. The ECA has a 8-Way Connector that supplies ignition power to the ECA from the Hybrid Control Module (HCM).

Detection

Fault is detected when:

- Hybrid Control Module (HCM) ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the ECA ignition voltage is shorted to the 12-volt system detected through the HCM prior to powering the ignition supply for the ECA.
- FMI 4 is set when the ECA ignition voltage is shorted to ground during key on and detected by the HCM.
- FMI 5 is set when the ECA ignition voltage is open circuit after key on.

Fallback

When Fault Code 67 is set the following conditions will occur:

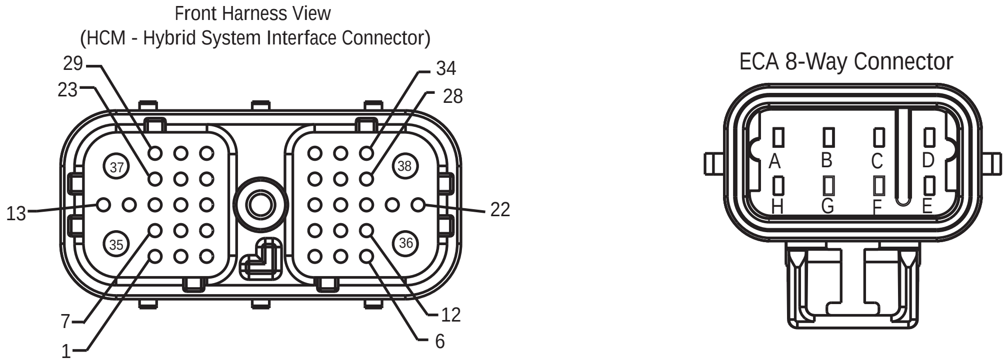
- Red “Stop Hybrid” light illuminates
- Fault is stored in HCM memory
- If the fault occurs while driving, the ECA either maintains current clutch position or moves to the last position commanded by the HCM. Then the ECA holding device can engage.
- If the fault occurs at power-up, the vehicle will not crank.

Possible Causes

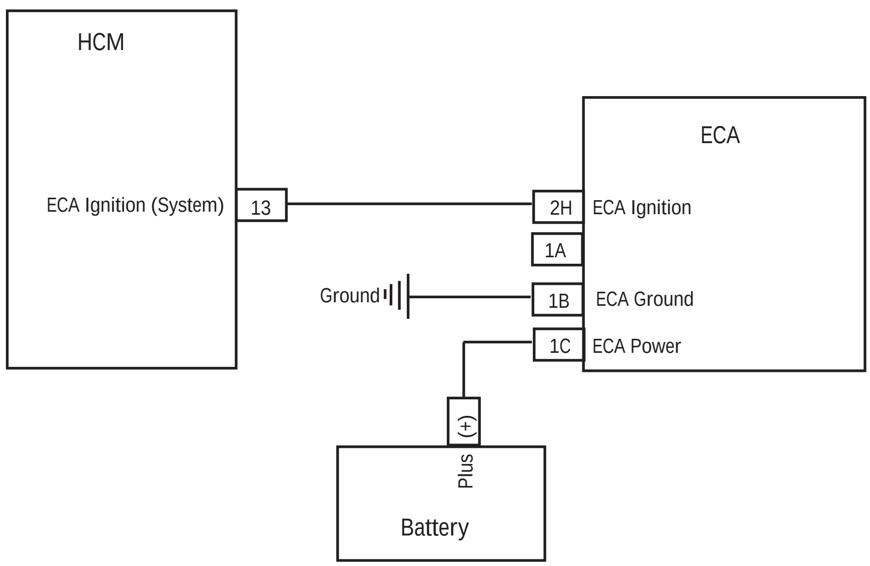
This fault code can be caused by any of the following:

- FMI 3, 4, 5
  - ECA ignition supply harness from HCM
  - HCM
  - ECA

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 67 - ECA Ignition Voltage Fault

A

Purpose: *Verify FMIs present.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Which FMIs are present?
   - If FMI 3 is listed, go to **Step B.**
   - If FMI 4 is listed, go to **Step C.**
   - If FMI 5 is listed, go to **Step E.**

B

Purpose: *Verify voltage of ECA Harness and ground.*

1. Key off.
2. Disconnect the ECA 8-Way Connector.
3. Measure voltage on the ECA 8-Way Connector from Pin H to ground.
   - If voltage is less than 0 volts, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is 11–13 volts, repair the short to battery in the Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin H to ground	

C

Purpose: *Verify voltage of ECA Harness and ground.*

1. Key off.
2. Disconnect the ECA 8-Way Connector.
3. Key on.
4. Measure voltage from the ECA 8-Way Connector from Pin H to ground.
   - If voltage from Pin H to ground is 11–13 volts, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is outside of range, go to **Step D.**

Connection	Measurement
Pin H to ground	

D

Purpose: *Verify continuity of HCM System Harness and ground.*

1. Key off.
2. Disconnect the HCM 38-Way System Harness Connector.
3. Measure the resistance between the HCM System Harness 38-Way Connector Pin 13 and ground.
   - If resistance from Pin 13 to ground is 10K ohms or greater, replace the HCM (see **Hybrid Control Module (HCM) Removal and Installation**), then go to **Step V.**
   - If resistance is outside of range, repair the Vehicle Harness from the ECA to the HCM, then go to **Step V.**

Connection	Measurement
Pin 13 to ground	

E

Purpose: *Verify continuity of HCM Harness and ECA Harness.*

1. Key off.
2. Disconnect the HCM Harness 38-Way Connector.
3. Measure the resistance between the HCM Harness 38-Way Connector and the ECA 8-Way Connector on HCM Pin 13 to ECA Pin H.
   - If the resistance between Pin 13 and Pin H is 0–0.3 ohms, replace the ECA (only if fault code is Active) (see **Electric Clutch Actuator Removal and Installation**), then go to **Step V.**
   - If resistance is outside of range, repair the open in the harness between the ECA and HCM, then go to **Step V.**

Connection	Measurement
Pin 13 to Pin H	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 67 appears, find error in testing, go to **Step A.**
   - If a code other than 67 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 68 - Grade Sensor Fault

J1939: SA 239 SPN 520321 FMI 12, 13, 14

Overview

The Grade Sensor is an internal component of the Hybrid Control Module (HCM). It calculates the vehicle grade needed for the Hill Start Assist (HSA) feature to function properly. HSA momentarily holds the Service Brakes at launch to allow single-foot pedal operation without the vehicle rolling back.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 12 is set when the grade sensor is not Active or present and HSA is enabled in the HCM configuration.
- FMI 13 is set when HSA is enabled in the HCM configuration but the grade sensor has not been calibrated.
- FMI 14 is set when the HCM is equipped with a Grade Sensor, HSA is enabled and the signal from the sensor is out of range.

Fallback

When Fault Code 68 is set the following conditions occur:

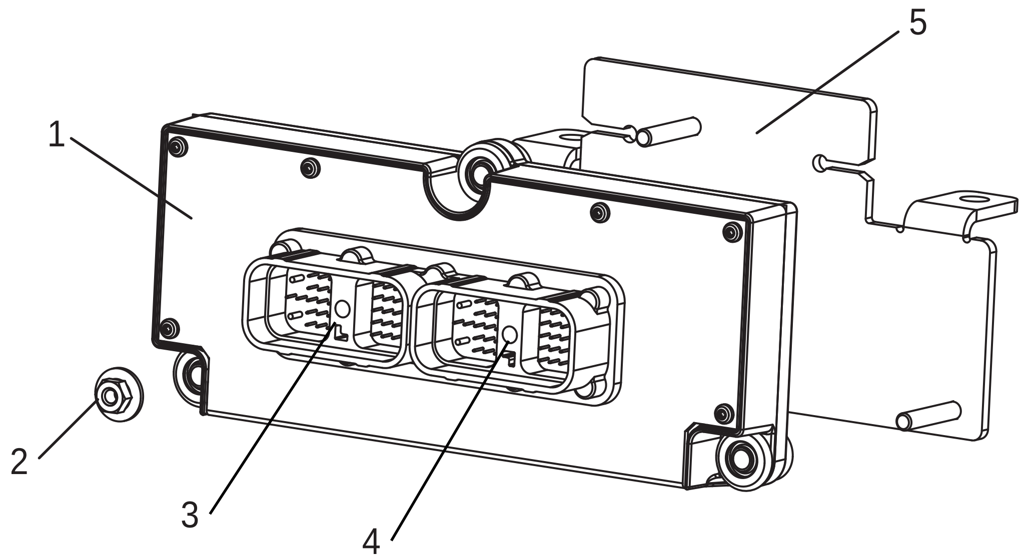
- Amber “Check Hybrid” light illuminates, but only if the vehicle is moving.
- Fault is stored in HCM memory.

Possible Causes

This fault code can be caused by any of the following:

- FMI 12
  - Incorrect HCM configuration
  - HCM
- FMI 13
  - Grade Sensor calibration
  - Incorrect HCM configuration
- FMI 14
  - HCM
  - Incorrect HCM mounting to transmission

Component Identification



1. Hybrid Control Module (HCM)
2. Nut (3)
3. 38-Way System Connector Plug-in
4. 38-Way Vehicle Connector Plug-in
5. Mounting Plate

Fault Code 68 - Grade Sensor Fault

A

Purpose: *Verify FMIs present.*

1. Key on.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
   - If FMI 12 is Active, go to **Step B.**
   - If FMI 13 is Active, go to **Step C.**
   - If FMI 14 is Active, go to **Step D.**

B

Purpose: *Verify HCM configuration.*

1. Key on.
2. Using ServiceRanger view the HCM configuration.
   - If HSA configuration is set at "HSA Enabled" and HSA feature is not needed, select "No HSA" from the drop down box. Save this configuration change by selecting download, then go to **Step V.**
   - If HSA configuration is set at "HSA Enabled" and HSA feature is needed, HCM must be changed to hardware version 3.7 or higher containing an internal Grade Sensor. Contact Eaton for correct HCM part number information.

C

Purpose: *Verify Grade Sensor is calibrated.*

1. Key on.
2. Using ServiceRanger, calibrate the Grade Sensor by selecting "Advanced Product" from the main menu.
3. Select "Hybrid Control Module."
4. Select "Grade Sensor Calibration" and follow the on-screen instructions:
   - If FMI 13 is not Active after calibrating, calibration complete, go to **Step V.**
   - If FMI 13 is Active after calibrating, contact Eaton at 1-800-826-HELP (4357).

D

Purpose: *Verify HCM is properly mounted.*

1. Key on.
2. Ensure the HCM is properly mounted to the transmission.
   - If HCM is not properly mounted or cap screws are loose, tighten HCM mounting cap screws, then go to **Step V.**
   - If HCM is properly mounted to the transmission, replace HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 68 appears, find error in testing, go to **Step A.**
   - If a code other than 68 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 70 - Engine Failed to Respond Fault (HCM)

J1939: SA 239 SPN 188, 518, 539, 544 FMI 0, 1, 2, 7

Overview

The Hybrid Control Module (HCM) controls engine torque and speed for transmission shifting by communicating with the engine Electronic Control Unit (ECU) over the J1939 Data Link.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Communication Link Fault (HCM) not Active.
- J1939 Engine Message Fault (HCM) not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when the HCM-commanded engine torque is less than 80% max engine torque.
- HCM-commanded engine torque is greater than 100 lb-ft, and the difference between commanded engine torque and engine torque feedback is greater than 80 lb-ft for more than 1 second.
- Engine speed or torque maps are received with an error.

Fallback

When Fault Code 70 is set the following conditions occur:

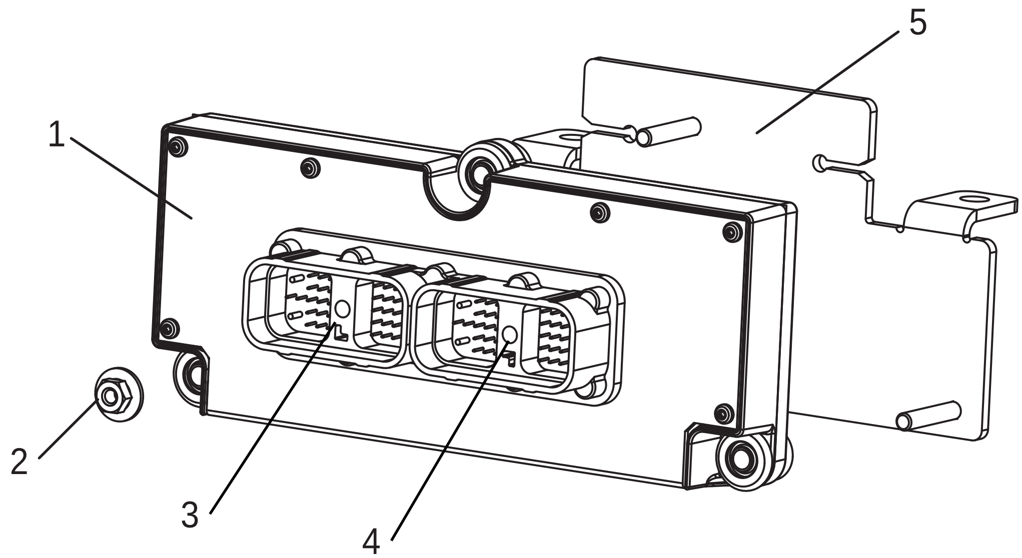
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- If the fault is set while driving, the vehicle may experience shifting problems.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Engine
  - Fuel system
  - Exhaust back pressure
  - Turbo charger
  - Air Intake Filter restriction
  - Unreported engine loads
  - Incorrect engine configuration settings for transmission assembly

Component Identification



1. Hybrid Control Module (HCM)
2. Nut (3)
3. 38-Way System Connector Plug-in
4. 38-Way Vehicle Connector Plug-in
5. Mounting Plate

Fault Code 70 - Engine Failed to Respond Fault (HCM)

A ***Purpose:*** *Check for Active or Inactive code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Retrieve codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If Fault Code 70 is Active, contact OEM. Engine is failing to respond to HCM commands during a shift, or the maps were received in error.
   - If Fault Code 70 is not Active, test is complete.

Fault Code 71 - Failed to Disengage a Gear

J1939: SA 3 SPN 520275 FMI 7
MID 130 SID 60 FMI 7

Overview

Transmission Electronic Control Unit (TECU) controls the Electric Shifter, which engages the different rails and gear positions. Electric Shifter is comprised of 2 electric motors – 1 changes the rail position and 1 changes gear position.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low fault is not Active.
- TECU System Battery Voltage Weak fault is not Active.
- TECU J1939 Communication Link fault is not Active.
- J1939 engine torque is zero ± 5% and J1939 engine speed is within 50 RPM of synchronization.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when the Electric Shifter fails three consecutive attempts to disengage a gear.

Fallback

When Fault Code 71 is set the following conditions occur:

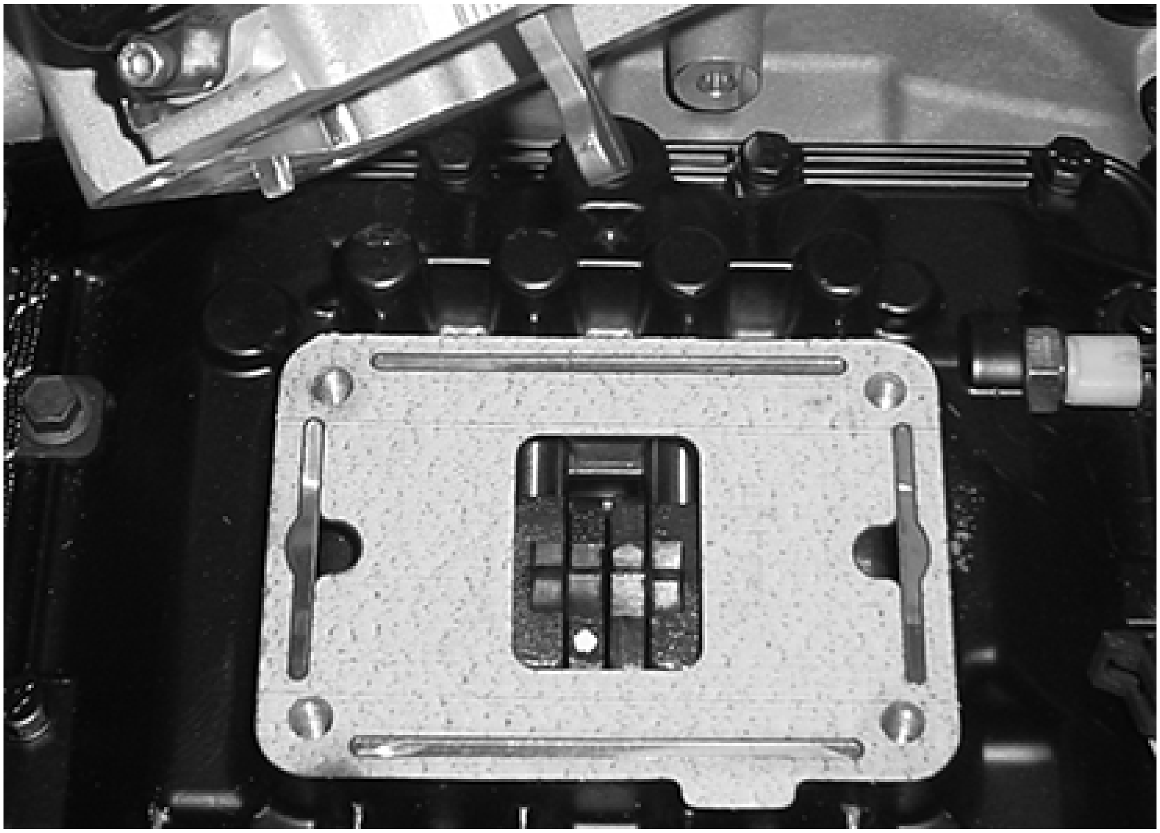
- Fault is stored in TECU memory.
- If the fault sets while driving, the vehicle maintains current gear and the clutch opens when the vehicle stops.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Dragging clutch
  - Electronic Clutch Actuator (ECA)
  - Shift Bar Housing
  - Electric Shifter
  - Gear Select Sensor
  - Yoke, Sliding Clutch, Mainshaft
  - TECU
  - Torque locked in gear

Component Identification



Note: For component location refer to the OEM service literature.

Note: Picture above shows the Shift Forks in the neutral position.

Fault Code 71 - Failed to Disengage a Gear

A

Purpose: *Verify gear display in neutral gear position.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Press N on the Push Button Shift Control.
4. Observe gear display:
   - If gear display shows "N", go to **Step V.**
   - If gear display shows "71", go to **Step B.**

B

Purpose: *Perform Electrical Pretest.*

1. Perform Electrical Pretest:
   - If no issues found during the Electrical Pretest, go to **Step C.**
   - If issue was repaired during the Electrical Pretest, go to **Step A.**

C

Purpose: *Perform manual Shift Bar Housing inspection.*

1. Key off.
2. Remove Electric Shifter from Shift Bar Housing to see which gear position is engaged.
3. Attempt to move the engaged rail back to neutral:
   - If rails move from the engaged position to neutral, go to **Step D.**
   - If rails do not move from the engaged position, attempt to take the torque off the driveline. If issue is still present, inspect the main case for a damaged Mainshaft, sliding clutch or fork, then go to **Step V.**

D ***Purpose:*** *Verify integrity of Shift Bar Housing components.*

1. Key off.
2. Inspect the following:
   a. Shift blocks are securely fastened to shift rails.
   b. Lubricant in the Electric Shifter is free from any excessive contamination.
   c. Two gear positions can not be engaged at the same time.
   - If no problem found, replace the Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If problem is found, repair as required and go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 71 appears, find error in testing, go to **Step A.**
   - If a code other than 71 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 72 - Failed to Select Rail Fault

J1939: SA 3 SPN 520277 FMI 7
MID 130 SID 59 FMI 7

Overview

The Transmission Electronic Control Unit (TECU) controls the Electric Shifter, which engages the different rails and gear positions. Electric Shifter is comprised of 2 electric motors – 1 changes the rail position and 1 changes gear position.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- TECU System Battery Voltage Weak Fault is not Active.
- This fault may occur at 15 seconds after power up.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when the Electric Shifter fails 5 consecutive attempts to engage a particular rail position.

Fallback

When Fault Code 72 is set the following conditions occur:

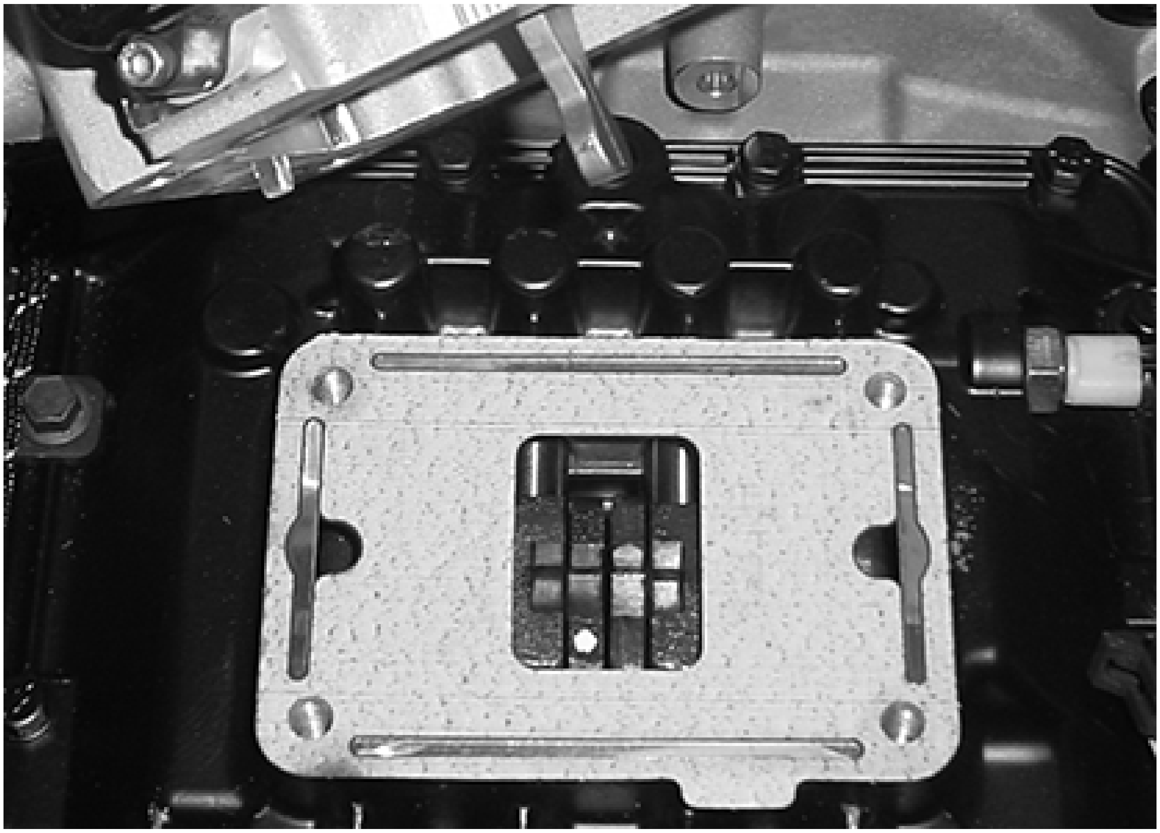
- Fault is stored in TECU memory.
- If the fault sets while driving, the vehicle continues to select proper rail position.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Shift Bar Housing
  - Electric Shifter
  - Rail Select Sensor
  - TECU

Component Identification



Note: No schematic for this code.

Note: For component location refer to the OEM service literature.

Note: The picture above shows the Shift Forks in the neutral position.

Fault Code 72 - Failed to Select Rail Fault

A

Purpose: *Verify gear display in neutral gear position.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Place shift device in Neutral.
4. Press Service Brake.
5. Observe gear display:
   - If you have an Active Fault Code 72, go to **Step B.**
   - If gear display shows solid gear, go to **Step V.**

B

Purpose: *Perform Electrical Pretest.*

1. Perform the Electrical Pretest:
   - If no issues were found during Electrical Pretest, go to **Step C.**
   - If issue was repaired during Electrical Pretest, go to **Step A.**

C

Purpose: *Verify integrity of Shift Bar Housing components.*

1. Key off.
2. Remove Electric Shifter* from Shift Bar Housing.
3. Inspect the following:
   - Shift blocks are fastened to shift rails securely.
   - Shift rails move into each gear position.
   - Lubricant in Electric Shifter is free from excessive contamination.
   - Two gear positions can not be engaged at the same time.
   - If no problem found, replace the Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If problem is found, repair as required, then go to **Step V.**

- * See the **Electric Shifter Removal and Installation** procedure in TRSM2000.

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test “Fault Code Isolation Procedure Index” on page 14is complete.
   - If Fault Code 72 appears, find error in testing, go to **Step A.**
   - If a code other than 72 appears, go to .

Fault Code 73 - Failed to Engage a Gear Fault

J1939: SA 3	**SPN 520278**	**FMI 7**
MID 130	**SID 58**	**FMI 7**

Overview

Transmission Electronic Control Unit (TECU) controls the Electric Shifter which engages the different rails and gear positions. The Electric Shifter is comprised of two electric motors—the Rail motor and Gear motor. The Rail motor changes the rail position and the Gear motor changes the gear position.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low fault is not Active.
- TECU System Battery Voltage Weak fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when the Electric Shifter fails 5 consecutive attempts to engage a particular gear position.

Fallback

When Fault Code 73 is set the following conditions occur:

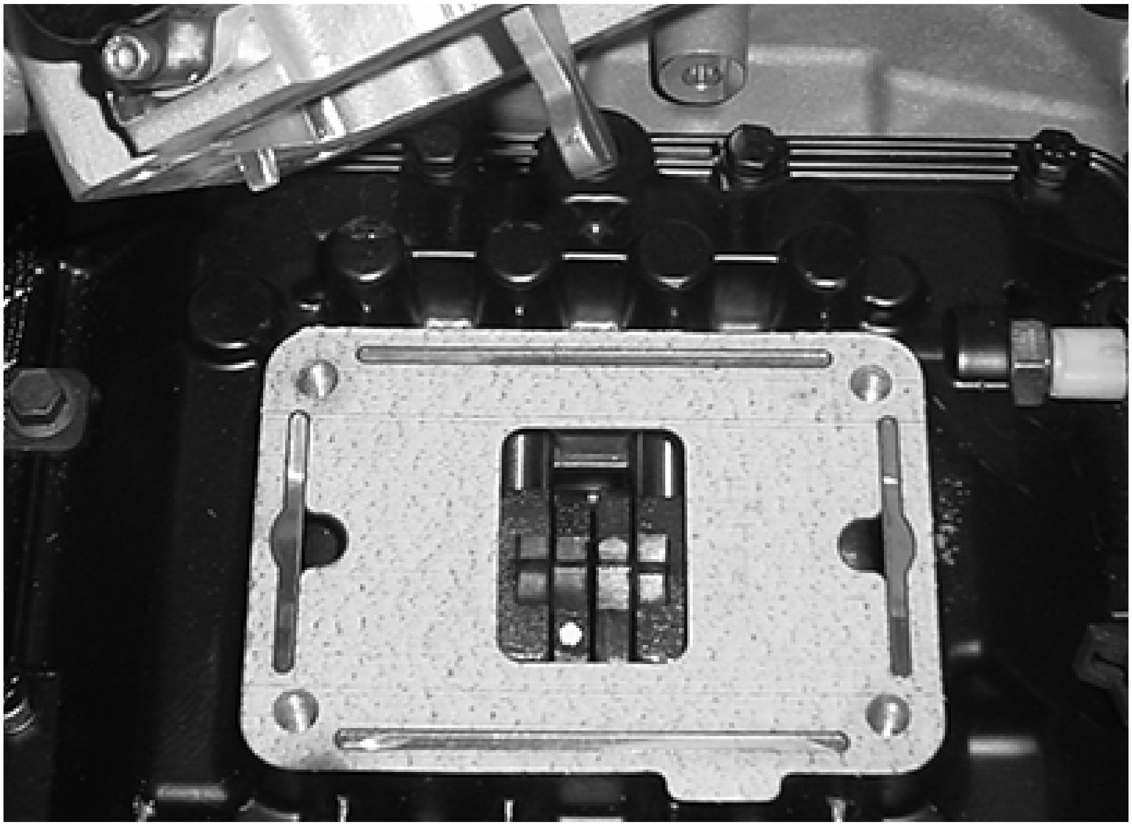
- Fault is stored in TECU memory.
- If the fault sets while driving, the vehicle maintains the current gear position.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Dragging Clutch
  - ECA
  - Shift Bar Housing
  - Electric Shifter
  - Gear Select Sensor
  - Yoke, Sliding Clutch, Mainshaft
  - TECU

Component Identification



Note: The picture above shows the Shift Forks in neutral position.

Note: For component location refer to the OEM service literature.

Fault Code 73 - Failed to Engage a Gear Fault

A

Purpose: *Verify gear display in neutral gear position.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Place shift device in Neutral.
4. Press Service Brake.
5. Place shift device in Drive.
6. Observe gear display:
   - If you have an Active Fault Code 73, go to **Step B.**
   - If gear display shows solid gear, go to **Step V.**

B

Purpose: *Perform Electrical Pretest.*

1. Perform the Electrical Pretest:
   - If no issues found during the Electrical Pretest, go to **Step C.**
   - If issue was repaired during the Electrical Pretest, go to **Step A.**

C

Purpose: *Verify integrity of Shift Bar Housing components.*

1. Key off.
2. Remove Electric Shifter from Shift Bar Housing.
3. Inspect the following:
   - Shift blocks are fastened to shift rails securely.
   - Lubricant in Electric Shifter is free from excessive contamination.
   - Two gear positions can not be engaged at the same time.
     - If no problem found, replace the Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
     - If problem is found, repair as required, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 73 appears, find error in testing, go to **Step A.**
   - If a code other than 73 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 74 - Engine Failed to Respond Fault (TECU)

J1939: SA 3 SPN 93, 190 FMI 7
MID 130 PID 93, 190 FMI 7

Overview

Transmission Electronic Control Unit (TECU) communicates with the engine Electronic Control Unit (ECU) over the J1939 Data Link during normal operation and engine control is governed by the ECU during hybrid mode. In non-hybrid mode, the TECU changes to AutoShift only or AutoShift Fallback. In these modes, the TECU is directly requesting changes in engine speed, torque or both instead of the Hybrid Control Module (HCM).

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- J1939 Communication Link fault (TECU) not Active.
- J1939 Engine Message fault (TECU) not Active.
- J1939 engine speed is greater than 300 RPM if the TECU is in speed control mode, or greater than 1000 RPM if the TECU is in torque control mode.
- Desired engine speed is less than J1939 engine configuration map speed.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 7 is set when the difference between actual engine percent torque and desired engine percent torque is greater than 50 for 2 continuous seconds.
- When the difference between desired engine speed and actual engine speed is greater than 400 RPM for 4 continuous seconds.

Fallback

When Fault Code 74 is set the following conditions occur:

- Fault is stored in TECU memory.
- If the fault sets while driving, the vehicle remains in current gear. Once the vehicle stops, start and reverse gears can be engaged.
- TECU changes to AutoShift Fallback mode.

Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - Engine
  - Fuel system
  - Exhaust back pressure
  - Turbo charger
  - Air Intake/Filter Restriction
  - Unreported engine loads
  - Incorrect engine configuration settings for transmission assembly

Component Identification

Note: No schematic for this code.

Note: For component location refer to the OEM service literature.

Fault Code 74 - Engine Failed to Respond Fault (TECU)

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Retrieve codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If Fault Code 74 is Active, contact the OEM. Engine is failing to respond to the transmissions command during a shift.
   - If Fault Code 74 is not Active, test is complete.

Fault Code 75 - Power Down in Gear

J1939: SA 3	**SPN 520276**	**FMI 14**
MID 130	**SID 60**	**FMI 14**

Overview

The Push Button Shift Control (PBSC) is connected to the Transmission Electronic Control Unit (TECU) over the High Integrity Link (HIL) to communicate driver mode selection and fault status. At power down, the PBSC should be placed in N to perform the proper calibration sequence and to prevent a torque locked transmission.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- PBSC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 14 is set when the TECU goes into the power-down sequence and a drive mode selection other than N is confirmed.

Fallback

When Fault Code 75 is set the following conditions occur:

- Fault is stored in TECU memory only as an Inactive fault because it only sets during the power-down sequence.

Possible Causes

This fault code can be caused by any of the following:

- FMI 14
  - Driver powered down in non-neutral mode.

Component Identification

Note: No schematic for this code.

Note: For component location refer to the OEM service literature.

Fault Code 75 - Power Down in Gear

A

Purpose: *Check for Active or Inactive fault code status.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on.
3. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If Fault Code 75 is Inactive, no action necessary. This code indicates the driver powered down the system prior to selecting neutral. Explain to driver, N must be selected on the Push Button Shift Control before powering down to prevent a stuck in gear situation or a power-up no crank situation.

Fault Code 76 - High Voltage Battery 1 Potential Voltage

J1939: SA 239 SPN 520250 FMI 3, 4, 16, 18

Overview

High-voltage batteries are 172 volts. They connect in series to produce 340 volts DC. The Power Electric Carrier (PEC) communicates with each battery to determine temperature, State Of Charge (SOC) and voltage. The PEC sends this information to the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- PEC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the PEC detects the high-voltage battery is greater than 417 volts for 240 MS.
- FMI 16 is set when the PEC detects the high-voltage battery is greater than 408 volts for 240 MS.
- FMI 4 is set when the PEC detects the high-voltage battery is less than 211 volts for 240 MS.
- FMI 18 is set when the PEC detects the high-voltage battery is less than 240 volts for 240 MS.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 76 is set the following conditions occur:

- Amber “Check Hybrid” light blinks when FMI 4 is set and displays solid when FMI 3, 16 and 18 are set.
- Fault is stored in HCM memory
- Inverter shuts high-voltage system off.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st

Possible Causes

This fault code can be caused by any of the following:

- FMI 3, 4
  - PEC
  - DC Cable
  - DC Interlock Loop
  - Inverter
  - Service Switch
  - Inertia Switch

Component Identification

Note: No schematic for this code.

Note: For component location, refer to OEM service literature.

Fault Code 76 - High Voltage Battery 1 Potential Voltage

A *__Purpose:__ Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Determine if the red Service Switch on the front of the PEC is pulled out. If the switch is pushed in, pull the switch out and turn the key off. After 2 minutes turn key on.
3. Key off.
4. Key on.
5. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
6. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

7. Which FMIs are present?
   - If Fault Code 76 is listed with Active Fault Code 101 and FMIs 27 and 28, go to procedure for “Fault Code 101 - High Voltage Battery Fault” on page 322.
   - If Fault Code 76 is listed with Active Fault Code 101 FMI 29, go to procedure for “Fault Code 101 - High Voltage Battery Fault” on page 322.
   - If Fault Code 76 with FMI 3 or 4 are listed with no other Active hybrid fault codes, contact Eaton at 1-800-826-HELP (4357).
   - If Fault Code 76 with FMI 3 or 4 are listed with other Active hybrid fault codes, go to procedure for other Active hybrid fault code(s).
   - If Fault Code 76 with FMI 16 or 18 are listed, test is complete. FMIs 16 and 18 require no action or replacement.

V *__Purpose:__ Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 76 appears, find error in testing, go to **Step A.**
   - If a code other than 76 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 78 - High Voltage Battery 1 Current Fault

J1939: SA 239 SPN 520232 FMI 6

Overview

The high-voltage batteries are 172 volts each connected in series to produce 340 volts DC. The Power Electric Carrier (PEC) communicates with each battery to determine temperature, State Of Charge (SOC) and voltage. The PEC sends the information to the Inverter.

Detection

Fault is detected when:

- The Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- The PEC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 6 is set when the PEC detects high-voltage battery current (greater than 200 amps) for 1 second.

Fallback

When Fault Code 78 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in Hybrid Control Module (HCM) memory.
- Inverter shuts off high-voltage system. HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

- FMI 6
  - PEC

Component Identification

Note: No schematic for this code.

Note: For component location refer to OEM service literature.

Fault Code 78 - High Voltage Battery 1 Current Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which fault codes are present?
   - If Fault Code 78 is listed with an Active Fault Code 113, go to procedure for Fault Code 113, FMI 6 on page 359.
   - If Fault Code 78 is listed with no Fault Code 113, replace the PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000, then go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 78 appears, find error in testing, go to **Step A.**
   - If a code other than 78 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 82 - High Voltage Battery 1 Temperature Fault

J1939: SA 239 SPN 520233 FMI 0, 16

Overview

The high-voltage batteries are 172 volts each. They are connected in series to produce 340 volts DC. The Power Electric Carrier (PEC) communicates with each battery to determine temperature, SOC, and voltage. This information is then sent to the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- PEC ignition voltage is greater than 7 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0 is set when the PEC detects high-voltage battery temperature is greater than 158 °F (70 °C) for 6.4 seconds.
- FMI 16 is set when the PEC detects high-voltage battery temperature is greater than 140 °F (60 °C) for 6.4 seconds.

Fallback

When Fault Code 82 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts high-voltage system off.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st

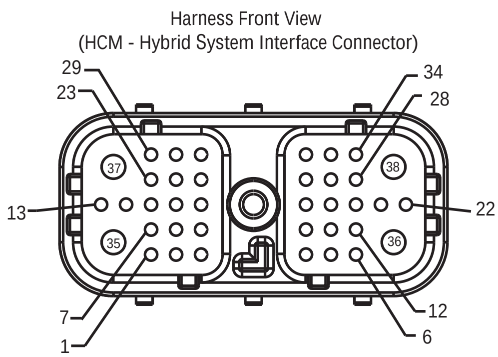
Note: The conditions above are only present for FMI 0.

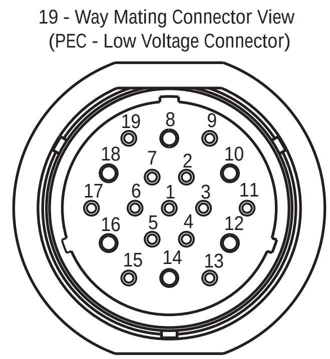
Possible Causes

This fault code can be caused by any of the following:

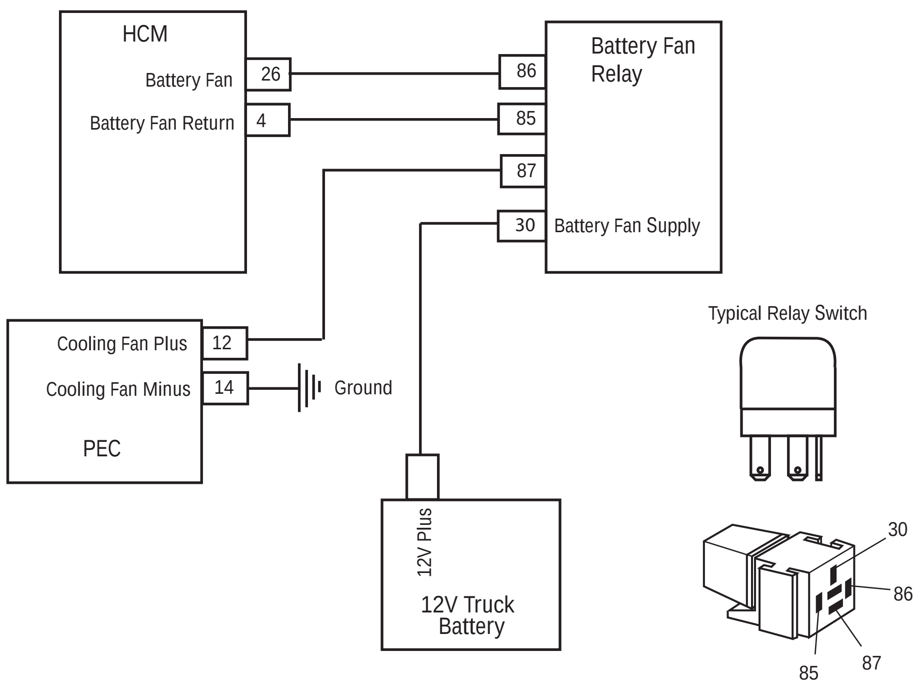
- FMI 0
  - Power Electric Carrier (PEC)
  - Battery Fan
  - Battery Fan Air Filter
  - Battery Fan Relay power supply harness
  - Battery Fan Relay
  - Battery Fan Exhaust Screen

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 82 - High Voltage Battery 1 Temperature Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page iv.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page vii. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which Faults are present?
   - If Fault Code 82 FMI 0 is listed, go to **Step B.**
   - If Fault Code 82 FMI 16 is listed, test is complete. FMI 16 requires no action or replacement.

B

Purpose: *Verify integrity of PEC Air Filter Element.*

1. Remove and inspect the Air Filter on the PEC Inlet and the Exhaust Screen on the PEC Outlet. See the **MY09 Air Filter Removal and Installation** (or **Alternative PEC Main Air Filter and Blue Pre-Filter Removal and Installation**, or **4-Battery Air Filter Removal and Installation**) procedures in TRSM2000:
   - If the Air Filter and Exhaust Screen are clean and free from debris, go to **Step C.**
   - If the Air Filter is dirty or the Exhaust Screen is plugged, replace the Air Filter and clean the Exhaust Screen, then go to **Step V.**

C

Purpose: *Verify operation of PEC fan.*

1. Key off.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab.
3. Key on.
4. Select “Product Tests” and then select Battery Fan Relay.
5. Check for airflow from the front and rear air ports in the PEC:
   - If airflow can be felt from the PEC air inlet and exhaust, go to **Step E.**
   - If airflow can not be felt from the PEC air inlet and exhaust, go to **Step D.**

D ***Purpose:*** *Verify voltage at PEC Connector.*

1. Key on.
2. Disconnect the 19-Way Connector at the PEC.
3. Measure voltage at the 19-Way Connector from Pin 12 to Pin 14:
   - If voltage between Pin 12 and Pin 14 is +/- 0.2 volts of battery voltage, replace the PEC cooling fan. See the **MY09 PEC Cooling Fan Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage between Pin 12 and Pin 14 is outside of range, repair Battery Fan Relay circuit. Refer to OEM.

Connection	Measurement
Pin 12 to Pin 14	

E ***Purpose:*** *Verify fault code present.*

1. Is Fault Code 105 FMI 29 listed Active:
   - Fault Code 105 FMI 29 is Active, replace the PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** (or **Alternative Power Electric Carrier (PEC) Removal and Installation**, or **4-Battery Power Electric Carrier (PEC) Removal and Installation**) procedures in TRSM2000, then go to **Step V.**
   - Fault Code 105 FMI 29 is not Active, Use ServiceRanger “Advanced Product Functions” menu and select the HCM option. Download the Snapshot file and contact Eaton at 1-800-826-HELP (4357).

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page xvi.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See "Fault Code Retrieval and Clearing" on page xvi.
   - If no codes, test is complete.
   - If Fault Code 82 appears, find error in testing, go to **Step A.**
   - If a code other than 82 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 83 - Invalid Shift Range

J1939: SA 3 SPN 751 FMI 12, 13
J1587 MID 130 SID 18/PID 18 FMI 12, 13

Overview

The Transmission Electronic Control Unit (TECU) is connected to the shift device, which transmits data about the drive mode selection. The only shift devices compatible with the TECU are the Eaton® Push Button Shift Control (PBSC) and OEM supplied Shift Lever (if equipped with park). The TECU determines the shift device during the first power up.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- TECU is being powered up for the first time and no shift device has been configured.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- Fault Code 83 is set when redundant sensor voltages do not agree.

Fallback

When Fault Code 83 is set the following conditions occur:

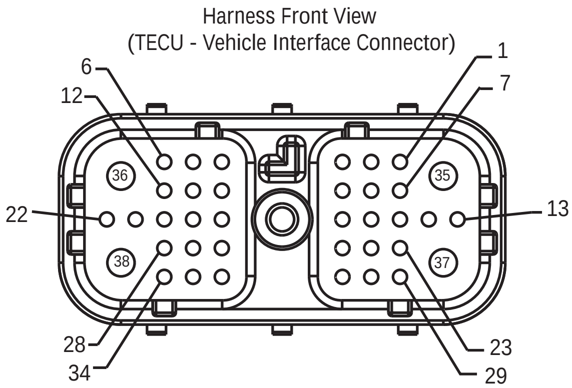
- “F” appears in the gear display
- Fault is stored in TECU memory
- TECU changes to AutoShift control
- Engine does not crank

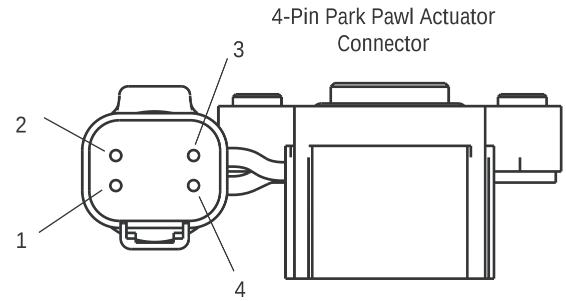
Possible Causes

This fault code can be caused by any of the following:

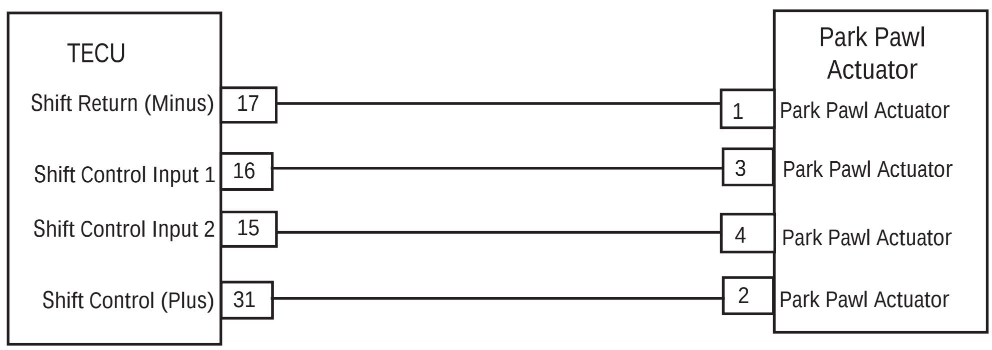
- Faulty Sensors
- Harness
- TECU

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 83 - Invalid Shift Range

A

Purpose: *Verify supply voltage to Shift Lever.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Disconnect the 4-Way Connector to the Park Pawl Actuator.
3. Key on.
4. Check for 12 volt supply at 4-Way Connector at Pin 1 and Pin 2:
   - If voltage between Pin 1 and Pin 2 is ±0.2 volts of battery voltage, go to **Step B.**
   - If voltage is outside the range, go to **Step D.**

Connection	Measurement
Pin 1 to Pin 2	

B

Purpose: *Verify voltage to Shift Lever in neutral gear position.*

1. With the Actuator/Shift Lever in the Neutral position, check voltage on the following pins:
   - Pin 3 to ground
   - Pin 4 to ground
   - If voltage is between 2.25V and 2.75V, go to **Step C.**
   - If voltage is outside the range, replace the Sensor. See the **Park Pawl Mechanism Sensor Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
Pin 3 to ground	
Pin 4 to ground	

C ***Purpose:*** *Verify continuity of Shift Lever circuits in Vehicle Harness.*

1. Disconnect the Vehicle Harness 38-way connector.
2. Check continuity between:
   - 38-way connector Pin 15 and 4-way connector Pin 4
   - 38-way connector Pin 16 and 4-way connector Pin 3
     - If continuity is okay, replace the **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
     - If an open is found, repair or replace the Harness. then go to **Step V.**

Connection	Measurement
38-Way Pin 15 to 4-Way Pin 4	
38-Way Pin 16 to 4-Way Pin 3	

D ***Purpose:*** *Verify continuity of Shift Lever circuits in Vehicle Harness.*

1. Disconnect the Vehicle Harness 38-way connector.
2. Check continuity between the following pins:
   - 38-way connector Pin 17 and 4-way connector Pin 1
   - 38-way connector Pin 31 and 4-way connector Pin 2
     - If continuity is okay, replace the **Transmission Electronic Control Unit (TECU)**. then go to **Step V.**
     - If an open is found, repair or replace the Harness. then go to **Step V.**

Connection	Measurement
38-Way Pin 17 to 4-Way Pin 1	
38-Way Pin 31 to 4-Way Pin 2	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 83 appears, find error in testing, go to **Step A.**
   - If a code other than 83 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 84 - Shift Control Device Not Configured Fault

J1939: SA 3 SPN 751 FMI 13, 14
J1587: MID 130 SID 18 FMI 13, 14

Overview

The Transmission Electronic Control Unit (TECU) is connected to the shift device, which transmits data about driver mode selection. The only compatible shift device is the Eaton® Push Button Shift Control (PBSC) and OEM supplied Shift Lever (if equipped with park). The TECU determines the shift device during the first power up.

Note: This fault code only sets Active.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- TECU is powered up for the first time and no shift device has been configured.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 13 is set when the TECU powers-up the first time and fails to recognize any valid shift device connected to the vehicle within 5 seconds.

Fallback

When Fault Code 84 is set the following conditions occur:

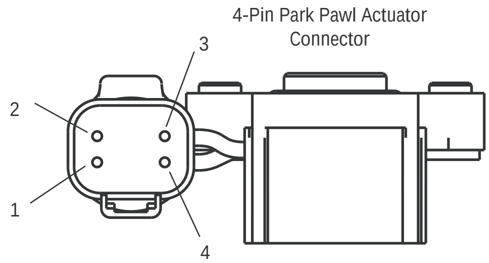
- Red “Service” light may or may not come on depending on the failure
- Fault is stored in TECU memory
- TECU changes to AutoShift Fallback mode
- Engine does not crank

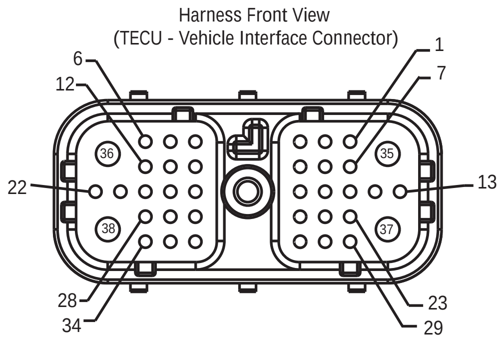
Possible Causes

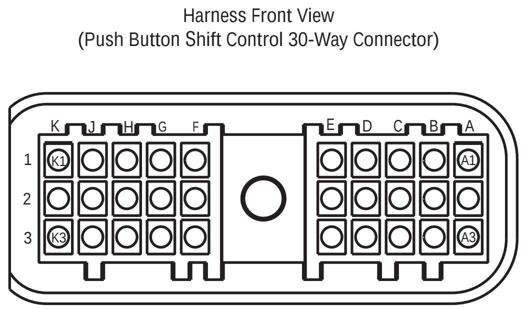
This fault code can be caused by any of the following:

- FMI 13
  - Vehicle Harness between TECU and shift control device is disconnected
  - PBSC
- FMI 14
  - Vehicle Harness between TECU and shift control device is disconnected
  - Shift Lever

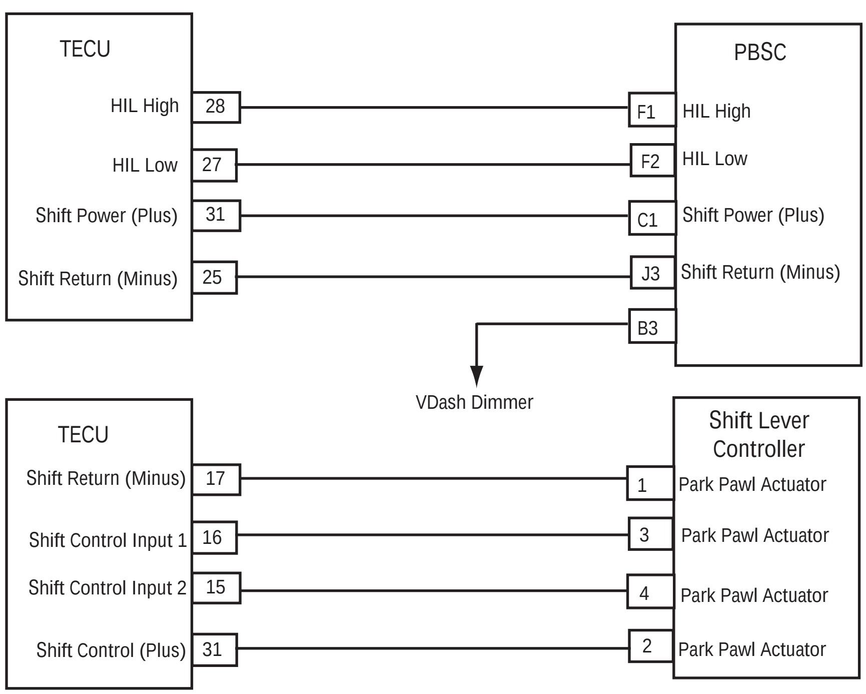
Component Identification







NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 84 - Shift Control Device Not Configured Fault

A

Purpose: *Verify status of Transmission Service Light.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key on and observe the Push Button Service Light:
   - If red "Service" light comes on, go to **Step B.**
   - If red "Service" light does not turn on, go to **Step C.**
   - If FMI 14 is present, Call 1-800-826-HELP (4357), then go to **Step V.**

B

Purpose: *Verify operation of PBSC Mode Lights.*

1. Key off and on while observing the green Mode Lights on the PBSC:
   - If green Mode Lights turn on, go to **Step F.**
   - If green Mode Lights do not turn on, replace PBSC. See the **Shift Control Removal and Installation** procedure in TRSM2000, then go to **Step V.**

C

Purpose: *Verify voltage to PBSC.*

1. Key off.
2. Disconnect the PBSC 30-Way Connector.
3. Key on.
4. Measure the voltage between Pin J3 and Pin C1 on the 30-Way Connector:
   - If voltage is within 0.6 volts of battery voltage, replace the PBSC. See the **Shift Control Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is out of range, go to **Step D.**

Connection	Measurement
Pin J3 to Pin C1	

D ***Purpose:*** *Verify continuity of Shift Lever circuits in Vehicle Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure the resistance between Pin J3 on the Shift Control 30-Way Connector and the Pin 25 on the Vehicle Harness 38-Way Connector:
   - If resistance between Pin J3 and Pin 25 is 0–0.3 ohms, go to **Step E.**
   - If resistance is out of range, repair the Vehicle Harness between the PBSC and the TECU, then go to **Step V.**

Connection	Measurement
Pin J3 to Pin 25	

E ***Purpose:*** *Verify continuity of Shift Lever circuits in Vehicle Harness*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure the resistance between the following:
   - Pin C1 on the Shift Control 30-Way Connector and Pin 31 on the Vehicle Harness 38-Way Connector
   - Pin C1 on the Shift Control and ground
     - If resistance between Pin C1 and Pin 31 is 0–0.3 ohms and resistance between Pin C1 and ground is 10K ohms or greater, replace the **Transmission Electronic Control Unit (TECU)** (only if fault code is Active), then go to **Step V.**
     - If resistance is out of range, repair the Vehicle Harness between the PBSC and the TECU, then go to **Step V.**

Connection	Measurement
Pin C1 to Pin 31	
Pin C1 to ground	

F

Purpose: *Verify AC voltage at PBSC.*

1. Key off.
2. Disconnect the shift control 30-Way Connector.
3. Key on.
4. Measure the AC voltage between Pin F1 and Pin F2:

   Note: Make sure the meter is on the AC auto feature or set to the AC 10 volts scale.

   - If voltage is 0.1 volts AC or greater, replace the Push Button Shift Control (PBSC). See the **Shift Control Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is 0.1 volts AC or less, go to **Step G.**

Connection	Measurement
Pin F1 to Pin F2	

G

Purpose: *Verify continuity between PBSC Harness and Vehicle Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure the resistance between the following:
   - Pin F1 on the shift control 30-Way Connector and Pin 28 on the Vehicle Harness 38-Way Connector
   - Pin F1 on the Shift Control 30-Way Connector and ground

   - If resistance between Pin F1 and Pin 28 is 0–0.3 ohms and resistance between Pin F1 and ground is 10K ohms or greater, go to **Step H.**
   - If resistance is out of range, repair the Vehicle Harness between the PBSC and the TECU, then go to **Step V.**

Connection	Measurement
30-Way F1 to 38-Way Pin 28	
30-Way Pin F1 to ground	

H ***Purpose:*** *Verify continuity between PBSC Harness and Vehicle Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect Vehicle Harness 38-Way Connector.
4. Measure the resistance between the following:
   - Pin F2 on the shift control 30-Way Connector and Pin 27 on the Vehicle Harness 38-Way Connector
   - Pin F2 on the Shift Control 30-Way Connector and ground
     - If resistance between Pin F2 and Pin 27 is 0–0.3 ohms and resistance between Pin F2 and ground is 10K ohms or greater, replace the **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
     - If resistance is out of range, repair the Vehicle Harness between the PBSC and the TECU, then go to **Step V.**

Connection	Measurement
30-Way Pin F2 to 38-Way Pin 27	
30-Way Pin F2 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 84 appears, find error in testing, go to **Step A.**
   - If a code other than 84 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 85 - Shift Control Device Incompatible Fault

J1939: SA 3 SPN 639 FMI 12
J1587: MID 130 SID 18 FMI 12

Overview

The Transmission Electronic Control Unit (TECU) is connected to the shift device, which transmits data about mode selection. The TECU checks the vehicle during the first power up to determine if the type of Push Button Shift Control (PBSC) device used is a compatible model.

Detection

Fault is detected when:

- TECU ignition voltage is greater than 7 volts and less than 16 volts.
- TECU System Battery Voltage Low Fault is not Active.
- High Integrity Link (HIL) Fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 12 is set anytime the TECU powers up and detects a non-compatible shift control device, or it does not receive a component ID 10 seconds after power up.

Fallback

When Fault Code 85 is set the following conditions occur:

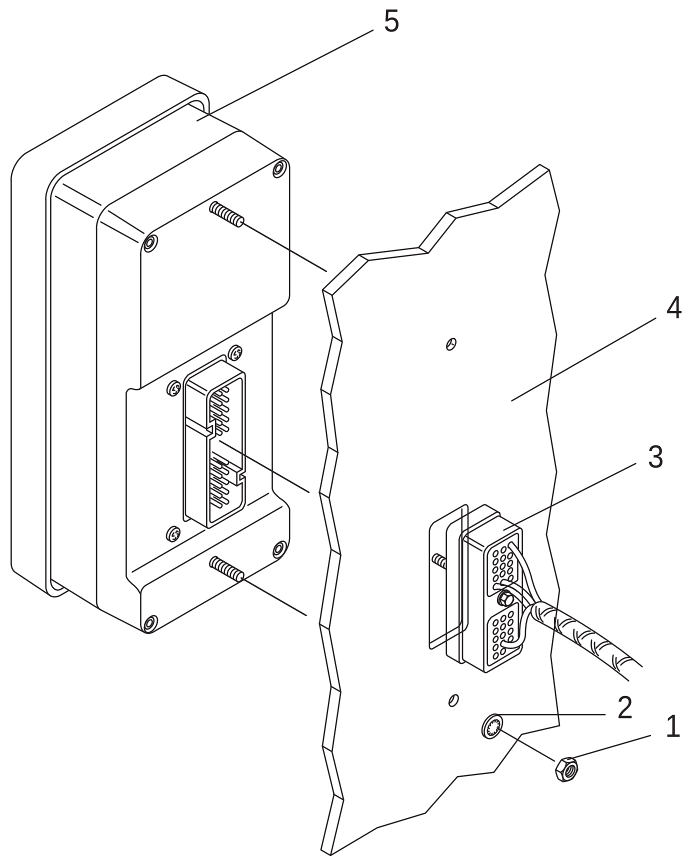
- Fault is stored in TECU memory
- TECU changes to AutoShift fallback mode
- Engine does not crank.

Possible Causes

This fault code can be caused by any of the following:

- FMI 12
  - Shift control device

Component Identification



1. Nut (2)
2. Washer(2)
3. Push Button Shift Control 30-Way Connector
4. Backing Plate
5. Push Button Shift Control

Fault Code 85 - Shift Control Device Incompatible Fault

A

Purpose: *Verify PBSC configuration.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Select the Roadranger Configurations menu and view the Transmission selection.
3. View the Push Button Type field for one of the following options:
   - EARNDM = Used with EH-8E306A-UPG transmissions (shown on Transmission Tag)
   - ERNDM = Used with EH-8E306A-UP transmissions (shown on Transmission Tag)
   - RNDML = Used with EH-8E306A-CD and EH-8E306A-U transmissions (shown on Transmission Tag)
   - If the Push-button Type field matches the Push-button installed in the vehicle, go to **Step B.**
   - If the Push-button Type field does not match the Push-button installed in the vehicle, change the Push-button Type Field or Push-button to match the transmission model number shown on the Transmission Tag. Use Step A.3. to determine correct Push-button for each model.

B

Purpose: *Verify HCM configuration.*

1. View the Hybrid Control Module selection under the Roadranger Configurations option in ServiceRanger.
2. View the System Configuration field for one of the following options:
   - UPG = Used in EH-8E306A-UPG Transmission
   - UP = Used in EH-8E306A-UP Transmissions
   - CD or U = Used in EH-8E306A-CD and EH-8E306A-U Transmissions
3. Compare the HCM System Configurations selection to the TECU Push-button Type selection:
   - If HCM System Configuration and TECU Push-button Type are the same, contact Eaton at 1-800-826-HELP (4357).
   - If HCM System Configuration and TECU Push-button Type are different, install an HCM with the correct configuration to match the Transmission Tag. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 85 appears, find error in testing, go to **Step A.**
   - If a code other than 85 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 88 - Inverter CAN Message Fault (HCM)

J1939: SA 239 SPN 520223 FMI 2, 9

Overview

The Inverter communicates with the Battery Control Unit (BCU) located in the Power Electronics Carrier (PEC) and the Hybrid Control Module (HCM) on the Controller Area Network (CAN) high-speed proprietary data link. The data link is a two wire twisted pair with two 120 ohm resistors located in the link. Fault Code 88 will only be set with Hybrid Control Module (HCM) software level 663 and lower. HCM software 671 and greater will set a fault code 111 for the inverter CAN message fault.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- HCM CAN Data Link fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the HCM has not received a Inverter message for 30 consecutive message cycles.
- FMI 2 is only Active in Product Diagnostic Mode (PDM) and sets if 3 consecutive Inverter messages are not received by the HCM.

Note: When troubleshooting an Inactive code refer to the "Product Diagnostic Mode (PDM)" on page 18.

Fallback

When Fault Code 88 is set the following conditions occur:

- Amber "Check Hybrid" light illuminates.
- Fault is stored in HCM memory.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays will remain powered.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

- FMI 9, 2:
  - CAN Data Link
  - No power or ground to Inverter
  - HCM
  - Inverter

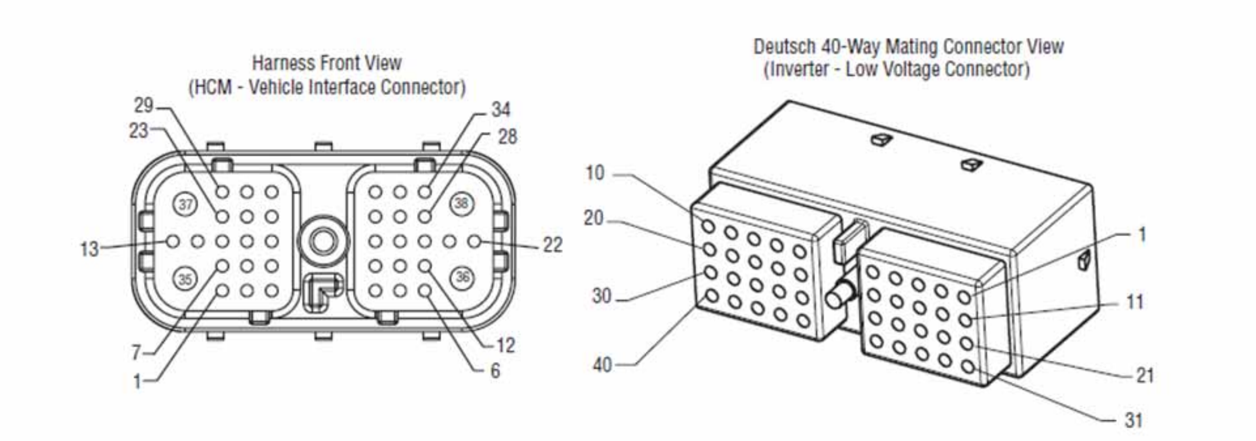
Conditions to Clear the Fault

Only inactive faults can be cleared from the TECU or HCM history using ServiceRanger. The TECU will automatically clear the faults from history after 200 hours and the HCM will automatically clear the faults from history after 200 hours of the fault staying inactive.

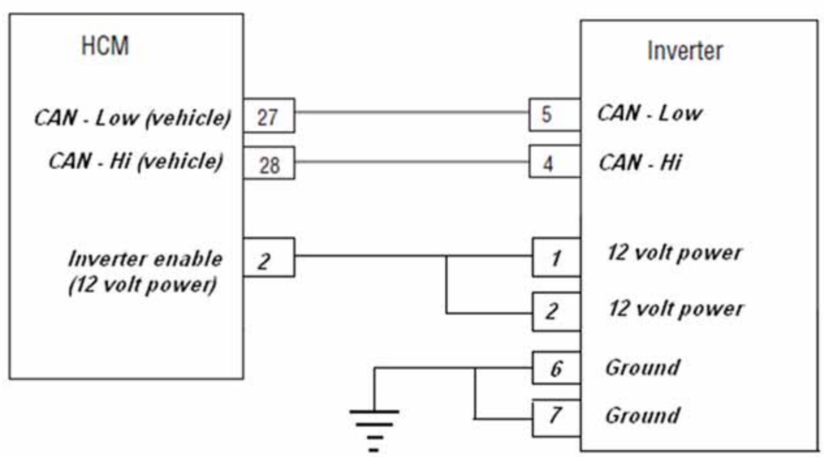
Additional Tools

- Basic Hand Tools
- Eaton Test Adapter Kit
- Digital Volt/Ohm Meter
- Service Ranger

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 88 - Inverter CAN Message Fault (HCM)

A

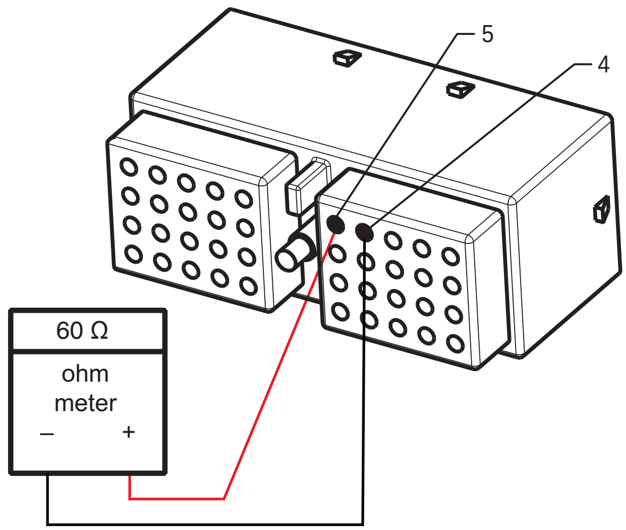
Purpose: *Check for Active or Inactive code status and perform Electrical Pretest.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Perform the Electrical Pretest on page 24 and the Hybrid Electrical Pretest on page 28.
   - If no issues are found during the Hybrid Electrical Pretest, go to **Step B.**
   - If issue was repaired during the Hybrid Electrical Pretest, go to **Step V.**

B

Purpose: *Verify continuity of inverter circuits.*

1. Key off.
2. Disconnect Inverter 40-Way Connector.
3. Measure resistance between Inverter 40-Way connector Pin 5 and Pin 4.



- If resistance is OL or outside 50–70 ohms, repair OEM CAN link harness. go to **Step V.**
- If resistance is between 50–70 ohms, go to **Step C.**

C

Purpose: *Verify CAN circuit for short to ground.*

1. Measure CAN to ground resistance on Inverter OEM connector:
   - Pin 1 to Inverter case
   - Pin 2 to Inverter case
     - If either resistance is 0–100 ohms, repair shorted CAN link circuit. go to **Step V.**
     - If both resistances are 7k ohms, go to **Step D.**

D

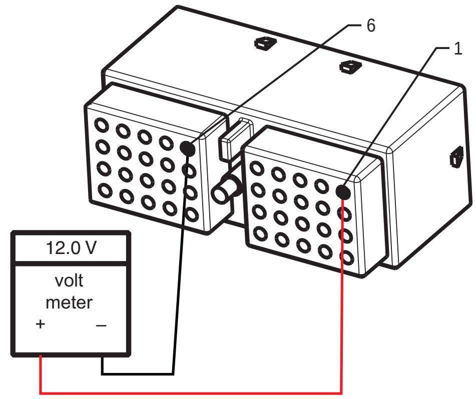
Purpose: *Verify CAN is populated in correct Connector PIN.*

1. Measure resistance between Inverter 40-Way Pin 4 and Dash 9-Way Diagnosis Connector Pin H. (If Pin H is not populated, find 3-Way Connector near 9-Way or terminating resistor Pin 1 near 9-Way.)
   - If resistance is 0–0.3 ohms, go to **Step E.**
   - If resistance is 60 ohms, repair CAN wiring (hi and low are wired wrong). go to **Step V.**

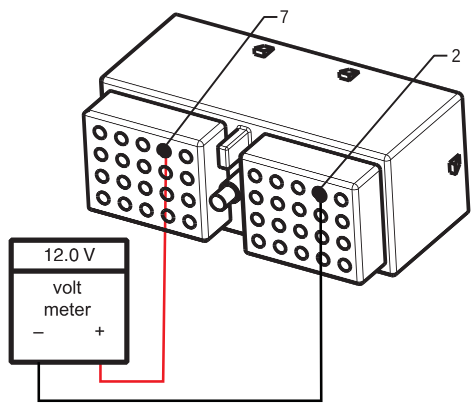
E

Purpose: *Verify power and ground to inverter.*

1. Key on, with Inverter 40-Way still disconnected.
2. Measure voltage on 40-Way connector:
   - Pin 1 to Pin 6



3. Measure voltage on 40-Way connector:
   - Pin 2 to Pin 7

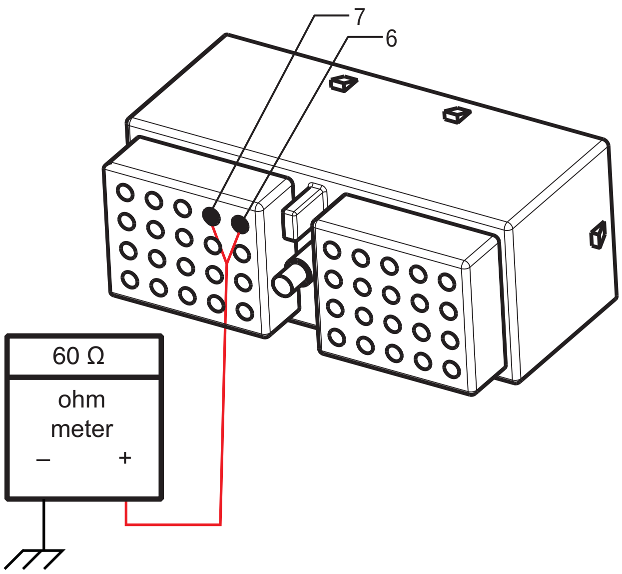


- If battery voltage (12 V +/- 1.2 V) is present, replace Inverter. go to **Step V.**
- If battery voltage is not present or less than 1.2 V of battery voltage, go to **Step F.**

F

Purpose: *Verify ground circuit to inverter.*

1. Measure resistance between Inverter 40-Way Connector Pin 6 and ground or Inverter 40-Way Connector Pin 7 and ground.

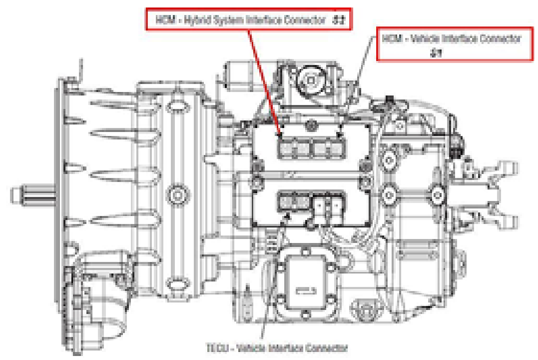


- If resistance is 0–0.3 ohms, go to **Step G.**
- If resistance is greater than 0.3 ohms, repair OEM ground circuit to Inverter. go to **Step V.**

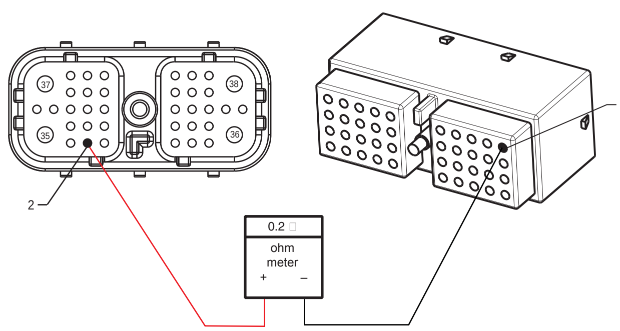
G

Purpose: *Measure the resistance between the HCM and the inverter.*

1. Key off.
2. Remove 38-Way Hybrid Vehicle Interface Connector.



3. Measure resistance on 38-Way Hybrid Vehicle Interface Connector (S2) Pin 2 to Inverter 40-Way Pin 1.



- If resistance is 0–0.3 ohms, replace HCM. go to **Step V.**
- If resistance is OL or greater than 0.3 ohms, repair OEM harness between HCM and Inverter. go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 88 appears, find error in testing, go to **Step A.**
   - If a code other than 88 appears, go to “Fault Code Isolation Procedure Index” on page 14/

Fault Code 89 - Battery Control Unit CAN Message Fault (HCM)

J1939: SA 239 SPN 520234 FMI 2, 9

Overview

The Hybrid Control Module (HCM) communicate with the Inverter communicates with the Battery Control Unit (BCU) located in the Power Electronics Carrier (PEC) and the HCM on the Controller Area Network (CAN) high-speed proprietary data link. The data link is a two wire twisted pair with two 120 ohm resistors located in the link.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- HCM CAN data link fault is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is only Active in Product Diagnostic Mode (PDM) and sets if 3 consecutive messages are not received by the HCM.
- FMI 9 is set when the HCM has not received a 1 message for 30 consecutive message cycles.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 89 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates
- Fault is stored in HCM memory
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered
- HCM continues to control the Hybrid vehicle in a diesel-only mode
- Transmission defaults start gear to 1st

Possible Causes

This fault code can be caused by any of the following:

- FMI 2, 9:
  - Inverter
  - CAN Data Link to Relay Box
  - Relay Box inside PEC
  - No power or ground to Relay Box

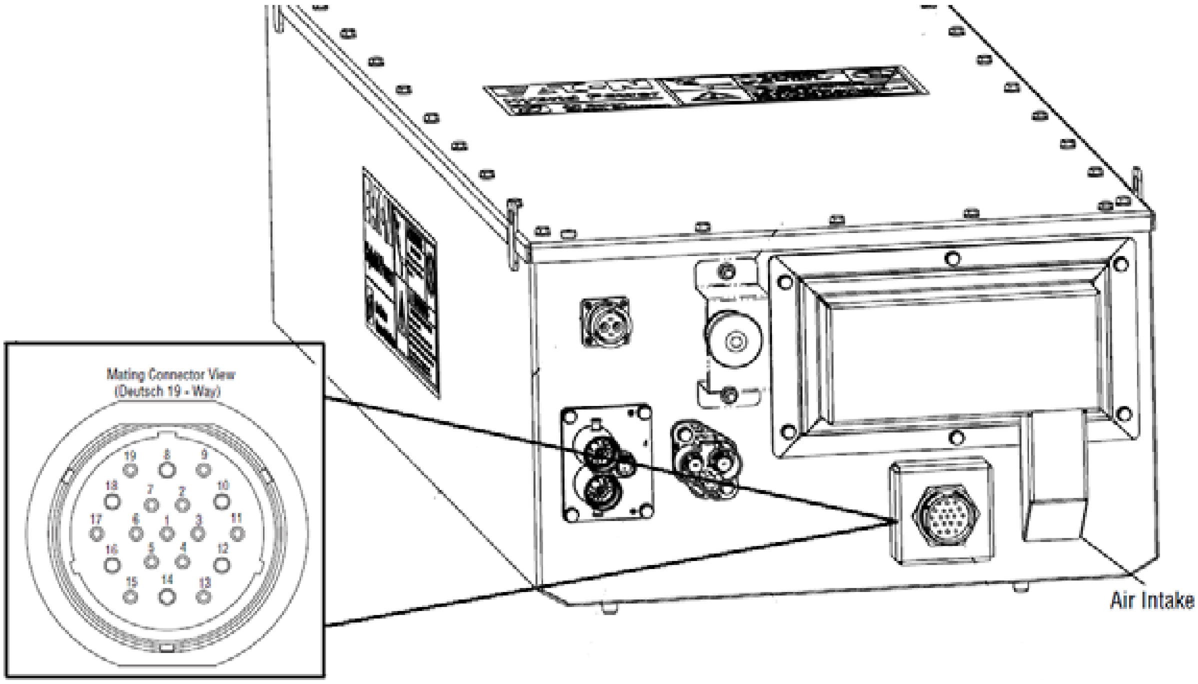
Conditions to Clear the Fault

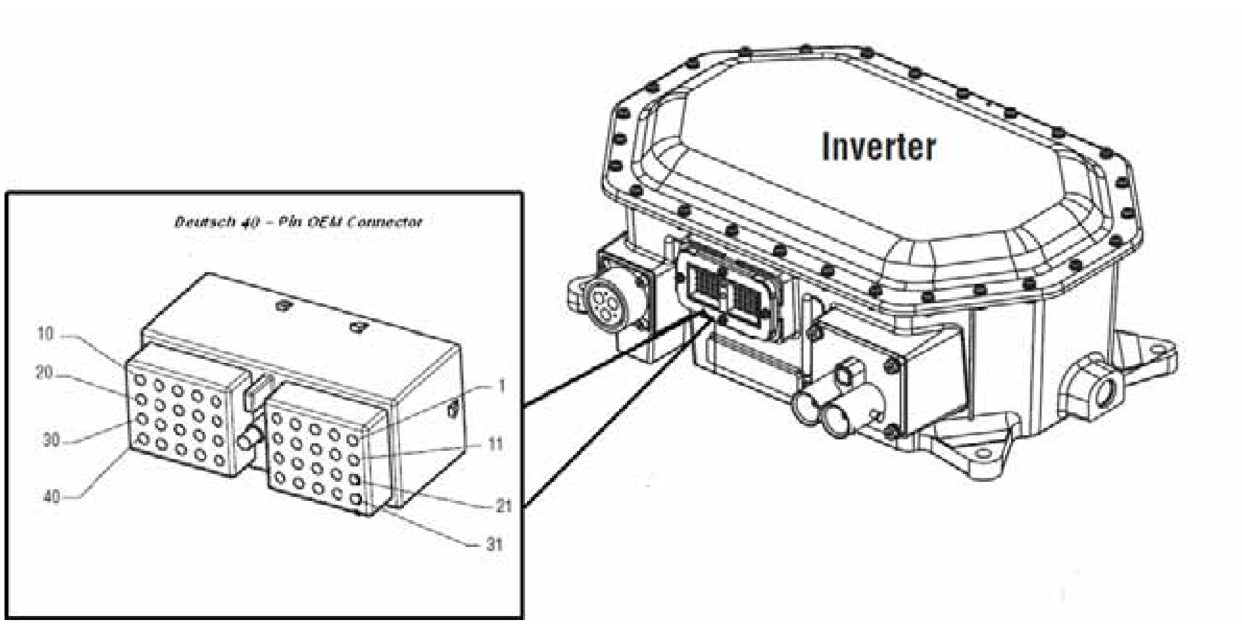
Only inactive faults can be cleared from the TECU or HCM history using ServiceRanger. The TECU will automatically clear the faults from history after 200 hours and the HCM will automatically clear the faults from history after 200 hours of the fault staying inactive.

Additional Tools

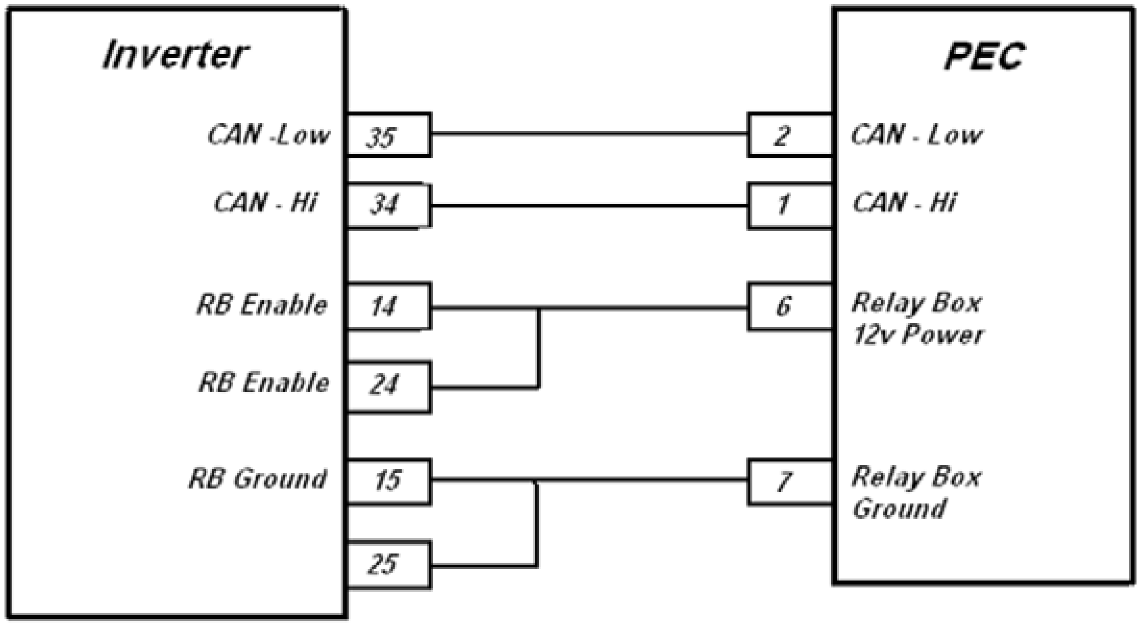
- Basic Hand Tools
- Eaton Test Adapter Kit
- Digital Volt/Ohm Meter
- ServiceRanger

Component Identification

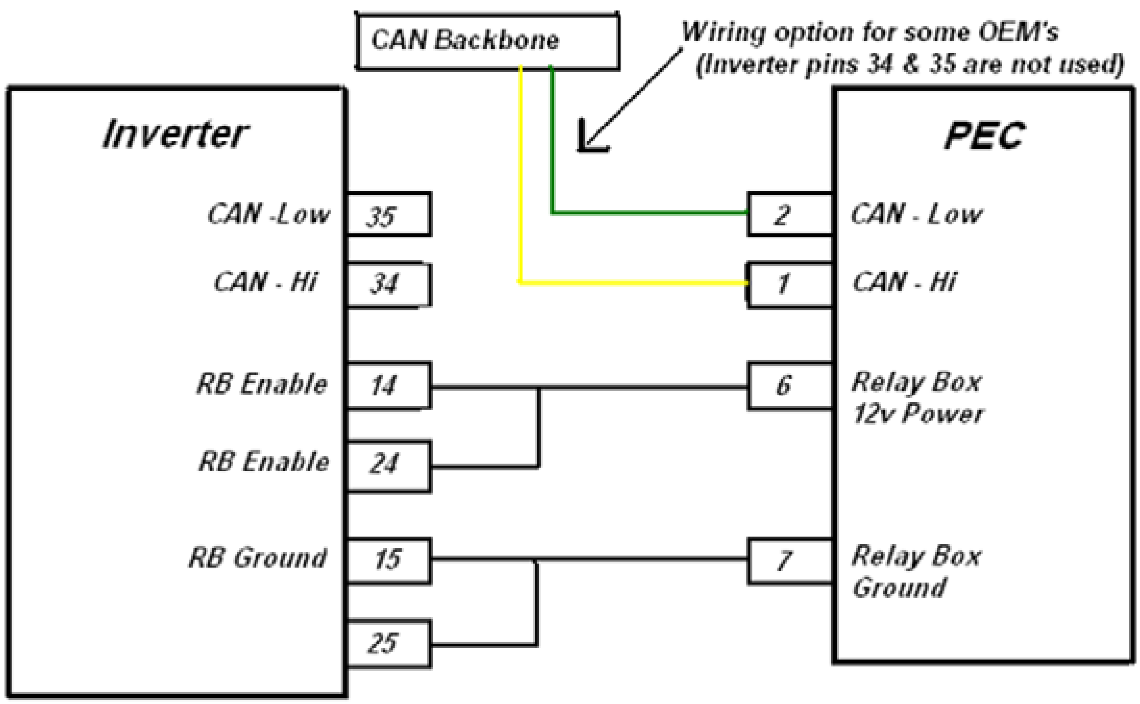




NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Or optional CAN wired directly to CAN Data Link Backbone (Inverter Pins 34 and 35 are not used):



Fault Code 89 - Power Electric Carrier CAN Message Fault (HCM)

A

Purpose: *Check for Active or Inactive fault code status and check HCM configurations.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Perform Electrical Pretest and Hybrid Electrical Pretest.
   - If no issues are found during either electrical test, go to **Step B.**
   - If issue was repaired during either electrical test, go to **Step V.**

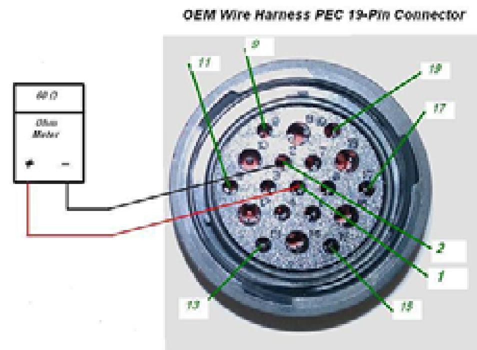
B

Purpose: *Verify continuity of PEC circuits.*

1. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect PEC 19-Way Connector.
3. Measure resistance on PEC 19-Way OEM Wire Harness Connector Pin 1 and Pin 2:



Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

- If resistance between Pin 1 and Pin 2 is between 50–70 ohms, go to **Step C.**
- If resistance is outside of range, go to **Step G.**

Connection	Measurement
Pin 1 to Pin 2	

C

Purpose: *Verify CAN circuit for short to ground.*

1. Measure resistance between PEC 19-Way OEM Wire Harness Connector Pin 1 and ground and between Pin 2 and ground:
   - If either resistance is 0–100 ohms, repair OEM CAN wiring circuit. go to **Step V.**
   - If both resistances are 7k ohms, go to **Step D.**

Connection	Measurement
Pin 1 and ground	
Pin 2 and ground	

D

Purpose: *Verify CAN is populated in correct Connector Pin.*

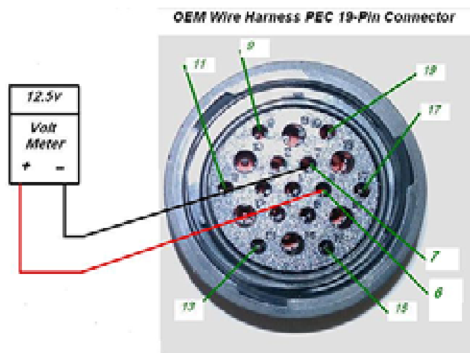
1. Measure resistance between PEC 19-Way Connector Pin 1 and Inverter 40-Way Connector Pin 4:
   - If resistance is 0–0.3 ohms, go to **Step E.**
   - If resistance is 60 ohms, repair CAN Wiring (hi and low are wired wrong), then go to **Step V.**

Connection	Measurement
19-Way Pin 1 and 40-Way Pin 4	

E

Purpose: *Verify power and ground to PEC.*

1. Reinstall 40-Way Connector at Inverter.
2. Key on.
3. Measure for voltage on PEC 19-Way OEM Wire Harness Connector Pins 6 and 7:

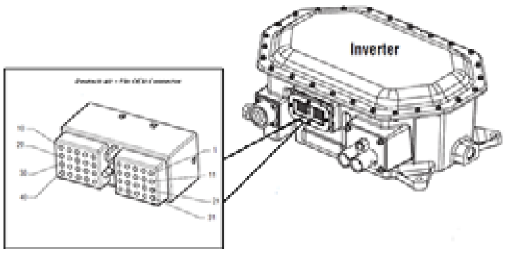


   - If Pins 6 and 7 have battery voltage (12 volts +/ - 1.2 volts), replace the PEC, then go to **Step V.**
   - If pins 6 and 7 have no voltage or less than 1.2 volts of battery voltage, go to **Step F.**

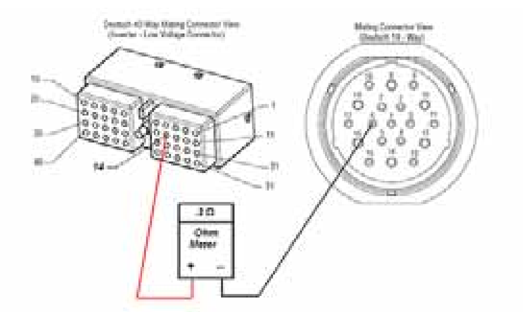
Connection	Measurement
Pin 6 and Pin 7	

F ***Purpose:*** *Verify continuity between Inverter and PEC.*

1. Key off.
2. Remove Inverter 40-Way Connector.



3. Measure resistance on OEM 40-Way Inverter Connector Pin 14 to OEM 19-Way PEC Connector Pin 6 and Inverter Connector Pin 15 to PEC Connector Pin 7:

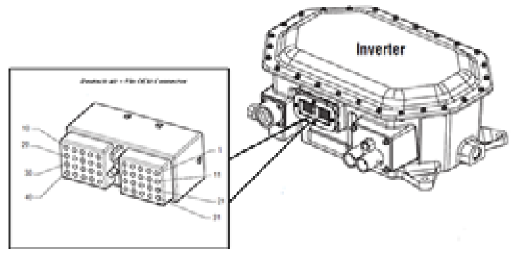


- If resistance from Pin 14 to Pin 6 is 0–0.3 ohms, and resistance from Pin 15 to Pin 7 is 0–0.3 ohms (also check terminal tension on Pins), replace the Inverter, then go to **Step G.**
- If resistance is OL or outside of range, repair OEM Wire Harness between Inverter and PEC, then go to **Step V.**

Connection	Measurement
40-Way Pin 14 to 19-Way Pin 6	
Inverter Connector Pin 15 to PEC Connector Pin 7	

G ***Purpose:*** *Verify CAN at PEC with Inverter.*

1. Key off.
2. Remove Inverter 40-Way Connector.

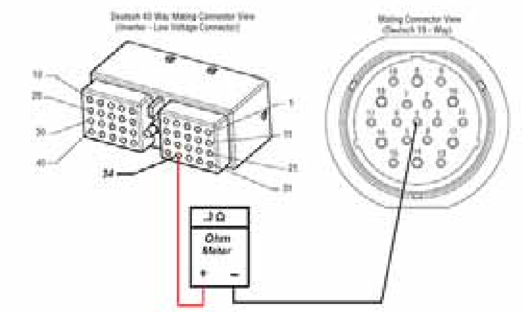


3. Check OEM Inverter Connector for Pins 34 and 35. If no pins are populated in connector, the PEC CAN Communication goes to CAN Backbone, not the Inverter:
   - If Pin 34 and Pin 35 are not populated, go to **Step I.**
   - If OEM Inverter Connector has Pins 34 and 35, go to **Step H.**

H

Purpose: *Verify continuity between Inverter circuits and PEC circuits.*

1. Measure resistance between Inverter 40-Way Connector Pin 34 and OEM 19-Way PEC Connector Pin 1 and Inverter 40-Way Connector Pin 35 and PEC 19-Way Connector Pin 2:



Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale)

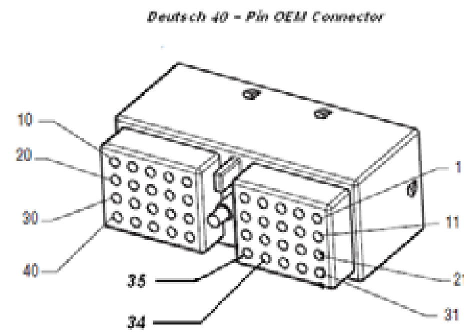
- If resistance between Pin 34 and Pin 1 is between 0–0.3 ohms, and resistance between Pin 35 and Pin 2 is between 0–0.3 ohms, replace the Inverter. See **MY09 Inverter Removal and Installation**), then go to **Step V.**
- If resistance is OL or outside of range, repair OEM Wire Harness between Inverter and PEC, then go to **Step V.**

Connection	Measurement
Pin 34 to Pin 1	
Pin 35 to Pin 2	

I

Purpose: *Verify continuity between PEC CAN and CAN Backbone.*

1. If the inverter 40-pin connector does not have Pins 34 and 35 populated then the CAN communication branch to 19-Way Connector at the PEC is wired directly to CAN Backbone:



- Repair OEM Wire Harness between the PEC and the CAN Communication Backbone, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 89 appears, find error in testing, go to **Step A.**
   - If a code other than 89 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 94 - Transfer Case Message Fault

J1939: SA 239 SPN 520237 FMI 9

Overview
On 4-wheel drive vehicles, the HCM receives transfer case messages from any OEM-installed controller over the J1939 link. The HCM uses messages to recalculate Output Shaft Speed Sensor information when the transfer case is in the 4-wheel low position.

Detection
Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active
The following conditions may set the fault Active:

- FMI 9 is set when the TC1 message is either out of range or has not been received for more than 30 seconds.

Fallback
When Fault Code 94 is set the following conditions occur:

- Fault is stored in HCM memory.
- Transmission shift quality is reduced when the transfer case is in 4-wheel low position.

Possible Causes
This fault code can be caused by any of the following:

- FMI 9
  - Incorrect OEM controller settings or programming.
  - Failed transfer case switch or wiring.

Component Identification

Note: No schematic for this code.

Fault Code 94 - Transfer Case Message Fault

A

Purpose: *Verify Active or Inactive fault code status and FMIs present.*

1. Ensure the red Service Switch on the front of the Power Electric Carrier (PEC) is pulled out. If the switch is pushed in pull the switch out and turn the ignition key off. After 2 minutes turn key on.
2. Key off.
3. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
4. Which FMIs are present?
   - If Fault Code 94 FMI 9 is listed, contact vehicle manufacture for assistance.
   - If Fault Code 94 is not Active, test is complete, go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 94 appears, find error in testing, go to **Step A.**
   - If a code other than 94 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 95 - 12-Volt Cranking Relay Fault

J1939: SA 239 SPN 520249 FMI 3, 4

Overview

The 12-volt Cranking Relay is wired into the Hybrid Control Module (HCM) on the coil side of the relay. At key on, the HCM determines which starting method to use —High-Voltage Motor/Generator, or Engine Starter.

If the HCM uses the Motor/Generator, the Clutch closes and the 12-volt Cranking Relay is de-energized. This disconnects the Main Battery Power Supply from the Start Enable Relay.

If the HCM uses the standard Engine Starter, the 12-volt Cranking Relay is energized. This supplies battery power to the Start Enable Relay main feed, which then powers the Starter Solenoid.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.
- Engine speed is 0 RPM or unknown.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set if the HCM detects an open or short to VBATT in the control circuit of the 12-volt cranking relay for 1 second or greater.
- FMI 4 is set if the HCM detects a short to ground in the control circuit of the 12-volt cranking relay for 1 second or greater.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Fallback

When Fault Code 95 is set the following conditions occur:

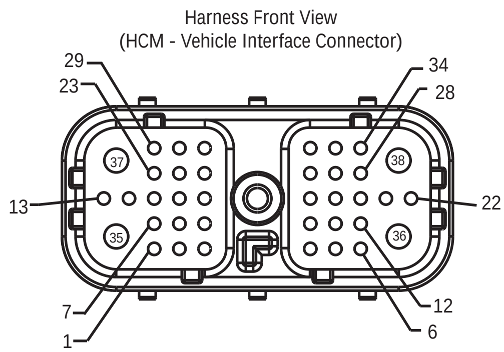
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- If the fault sets at power up, the engine will crank, provided the high-voltage batteries have a sufficient State of Charge (SOC).
- If the fault sets while driving, the vehicle will continue to operate.

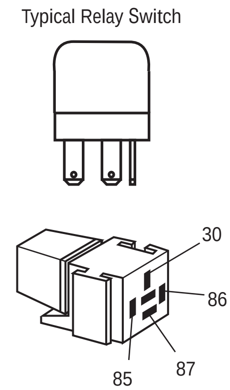
Possible Causes

This fault code can be caused by any of the following:

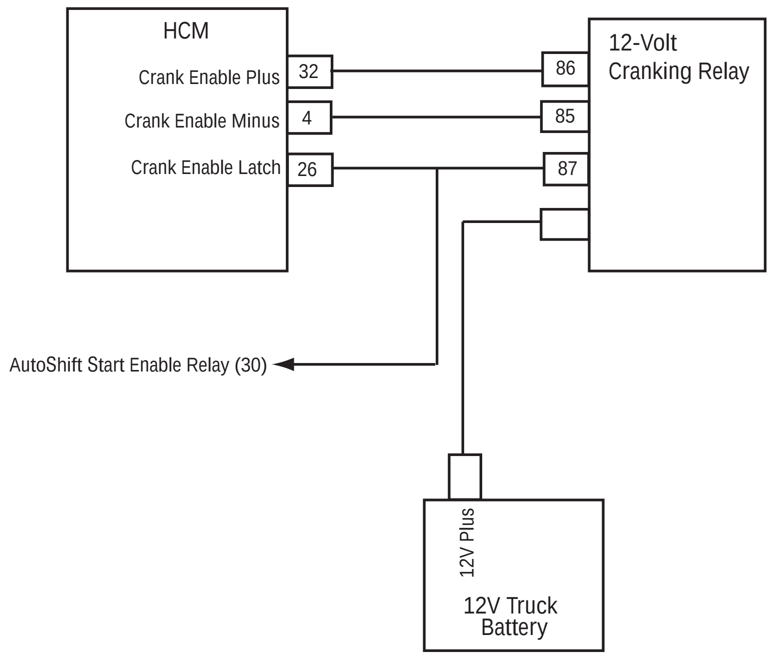
- FMI 3, 4
  - Vehicle Harness from HCM to 12-volt Cranking Relay
  - 12-volt Cranking Relay
  - HCM

Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 95 - 12-Volt Cranking Relay Fault

A

Purpose: *Verify operation of Cranking Relay.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using 9-Way Diagnostic Connector.
2. Replace the 12-volt Cranking Relay with another relay. See if fault returns:
   - If the fault does not return with new relay, go to **Step V.**
   - If the fault returns with new relay, go to **Step B.**

B

Purpose: *Verify FMI present.*

1. Which FMIs were listed from Step A?

   Note: The 12-Volt Cranking Relay must be wired according to Eaton® hybrid requirements (shown on previous page) for this test to work properly. If wired differently, consult OEM for correct wiring schematic.

   - If FMI 3 is listed, go to **Step C.**
   - If FMI 4 is listed, go to **Step E.**

C

Purpose: *Verify continuity of Vehicle Harness circuits.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Vehicle Harness 38-Way Connector.
4. Measure resistance between HCM Vehicle Harness 38-Way Connector Pin 32 and Pin 4:
   - If resistance between Pin 32 and Pin 4 is 40–120 ohms, go to **Step D.**
   - If resistance is outside of range, repair the Vehicle Harness for an open circuit, then go to **Step V.**

Connection	Measurement
Pin 32 to Pin 4	

D ***Purpose:*** *Verify voltage between Vehicle Harness circuits and ground.*

1. Key on.
2. Measure voltage between HCM Vehicle Harness 38-Way Connector Pin 32 and ground at key on:
   - If voltage between Pin 32 and ground is 5 volts, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage between Pin 32 and ground is 12 volts, repair the short to VBATT on the Harness, then go to **Step V.**

Connection	Measurement
Pin 32 to ground	

E ***Purpose:*** *Verify voltage between Vehicle Harness circuits and ground.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the HCM Vehicle Harness 38-Way Connector.
4. Measure voltage between HCM Vehicle Harness 38-Way Connector Pin 32 and ground:
   - If voltage between Pin 32 and ground is 10K ohms or greater, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the vehicle harness for a short to ground, then go to **Step V.**

Connection	Measurement
Pin 32 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
    - If no codes, test is complete.
    - If Fault Code 95 appears, find error in testing, go to **Step A.**
    - If a code other than 95 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 97 - PTO Engagement Fault

J1939: SA 239 SPN 3460 FMI 3, 4, 5, 7, 14

Overview

A PTO is an optional installation on the transmission. The PTO is an electric-over-air unit. The PTO is controlled either by the Hybrid Control Module (HCM) or the Body Controller.

Note: This fault is only set if the HCM is directly wired to the PTO. This can be determined by checking the HCM configuration. The PTO Feedback will read analog.

HCM Controlled PTO

The HCM-controlled PTO energizes the electric solenoid then air pressure engages the PTO. The PTO feedback signal is a 12-volt signal. Less than 1 volt indicates the PTO is engaged, and greater than 3 volts indicates the PTO is disengaged.

Body Controller-Operated PTO

The Body Controller-operated PTO energizes the electric solenoid and air pressure engages the PTO. When the user selects the ePTO option, the HCM sends a request to the Body Controller to activate the PTO. When the PTO is engaged, the Body Controller sends back a confirmation message.

Note: To determine which module is controlling the PTO connect to ServiceRanger and view the “Configurations” screen. Under HCM is a listing for “PTO Feedback.” The PTO-engaged parameter provides input from the HCM or the Body Controller on the current state of the PTO. This parameter is available in ServiceRanger under the Data Monitor, Hybrid ePTO list.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the HCM detects a short to the VBATT in the PTO control circuit.
- FMI 4 is set when the HCM detects a short to ground in the PTO control circuit.
- FMI 5 is set when the HCM detects an open in the PTO control circuit.
- FMI 7 is set when the HCM detects the transmission is in neutral and, if after 8 seconds from requesting PTO mode the PTO engaged signal reads disengaged.
- FMI 14 is set when the ePTO option on the Push Button Shift Control is selected and the HCM detects the transmission is not in neutral based on output shaft speed.

Fallback

When Fault Code 97 is set the following conditions occur:

- Fault is stored in HCM memory.
- If the PTO is engaged and the fault occurs, the PTO remains engaged until the ePTO request changes, or the air pressure drops below a set limit.
- If the PTO is not engaged, the “ePTO” light flashes on the Push Button Shift Console.

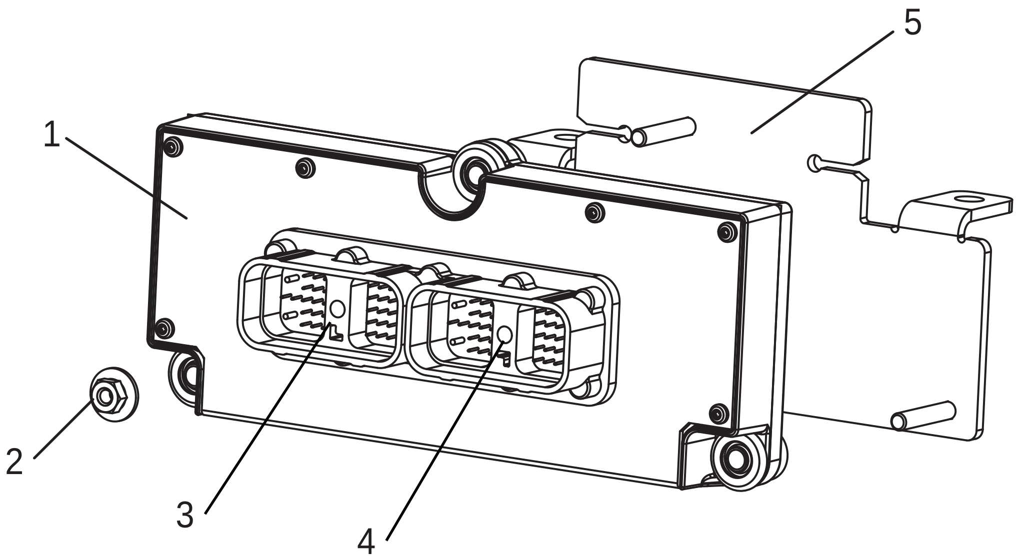
Possible Causes

This fault code can be caused by any of the following:

- FMI 7
  - PTO Air Solenoid
  - Low air pressure
  - PTO control circuit wires
  - PTO
  - PTO feedback circuit
  - HCM (only on HCM-controlled PTOs)
  - PTO Ball Switch

Note: FMI 7 only sets if the HCM is directly wired to the PTO. Determine wiring by selecting the Roadranger Configuration option, then view the HCM option. The PTO Feedback will read Analog.

Component Identification



1. Hybrid Control Module (HCM)
2. Nut (3)
3. 38-Way System Connector Plug-in
4. 38-Way Vehicle Connector Plug-in
5. Mounting Plate

Fault Code 97 - PTO Engagement Fault

A

Purpose: *Verify active or Inactive fault code status and FMIs present.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.
3. Which FMIs are present?
   - If Fault Code 97 FMI 3 is listed, go to **Step B.**
   - If Fault Code 97 FMI 4 or 5 are listed, go to **Step C.**
   - If Fault Code 97 FMI 7 is listed, go to **Step E.**
   - If Fault Code 97 FMI 14 is listed, contact Eaton at 1-800-826-HELP (4357).

B

Purpose: *Measure HCM for short to ground through the HCM Harness.*

1. Key off.
2. Disconnect the negative battery cable.
3. Disconnect the HCM System Harness 38-Way Connector.
4. Key on.
5. Measure the voltage from Pin 34 to ground on the HCM System Harness 38-Way Connector.
   - If voltage from Pin 34 to ground is 0 volts, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage from Pin 34 to ground is 11–13 volts, repair the Hybrid System Harness for a short to battery, then go to **Step V.**

Connection	Measurement
Pin 34 to ground	

C

Purpose: *Measure resistance of the HCM Harness to ground.*

1. Key off.
2. Disconnect the negative battery cable.
3. Disconnect the HCM System Harness 38-Way Connector.
4. Measure the resistance between the HCM System Harness 38-Way Connector and the following pins:
   - Pin 34 to Pin 6
   - Pin 34 to ground
   - If resistance between Pin 34 and Pin 6 is 0–0.3 ohms and resistance between 34 and ground is 10K ohms or greater, replace the HCM (only if fault code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is out of range, go to **Step D.**

Connection	Measurement
Pin 34 to 6	
Pin 34 to ground	

D

Purpose: *Measure the resistance of the Vehicle Harness.*

1. Key off.
2. Disconnect the PTO 2-Way Connector at the PTO.
3. Measure the resistance between the PTO 2-Way Connector at the following pins:
   - Pin A to Pin B
   - Pin A to ground
   - If resistance between Pin A and Pin B is 0–0.3 ohms and resistance between Pin A and ground is 10K ohms or greater, repair the Hybrid Harness for an open or short to ground, then go to **Step V.**
   - If resistance is outside of range, replace the PTO switch, then go to **Step V.**

Connection	Measurement
Pin A to Pin B	
Pin A to ground	

E

Purpose: *Measure voltage at the Signal Wire to ground.*

If Fault Code 97 FMI 3, 4, or 5 are Active the procedure in Step A:

1. Disconnect the PTO single signal wire at the PTO.
2. Key on.
3. Measure the voltage from the PTO Signal Wire Connector to ground:
   - If the voltage is 12 volts at key on, problem is with the faulty PTO engagement signal switch in the PTO. Contact your OEM for repair procedures.
   - If the voltage is less than 1 volt at key on, go to **Step F.**

Connection	Measurement
Signal Wire Connector to ground	

F

Purpose: *Verify continuity of the HCM circuit.*

1. Key off.
2. Disconnect the negative battery cable.
3. Disconnect the HCM Vehicle Harness 38-Way Connector.
4. Measure the resistance from the HCM Vehicle Harness 38-Way Connector Pin 18 to the opposite PTO end of the signal wire:
   - If the resistance from Pin 18 to the PTO end of the signal wire is 0–0.3 ohms, replace the HCM.See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If the resistance is outside of range, repair the open in the PTO signal wire from the HCM to the PTO, then go to **Step V.**

Connection	Measurement
Pin 18 to end of Signal Wire	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If Fault Code 97 appears, find error in testing, go to **Step A.**
   - If a code other than 97 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 101 - High Voltage Battery Fault

J1939: SA 239 SPN 520238, 520240, 520294, 520297, 520298, 520304, 520315 FMI 0, 1, 9, 11, 12, 15, 17, 22-31

Overview

The high-voltage batteries are 172 volts each connected in series to produce 340 volts DC. The Power Electric Carrier (PEC) communicates with each battery to determine temperature, State Of Charge (SOC) and voltage. This information is then sent to the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- PEC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0, 1, 9, 11, 12, 15, 17, 22-31 are set for various internal high voltage battery failures.

Fallback

When Fault Code 101 is set the following conditions occur:

- Red “Stop Hybrid” light illuminates for FMI 0.
- Amber “Check Hybrid” displays for FMI 22–29.
- Fault is stored in HCM memory.
- Depending on the FMI, Inverter or HCM shuts the high-voltage system off.
- HCM continues to control the hybrid vehicle in diesel-only mode.
- Transmission defaults start gear to 1st.

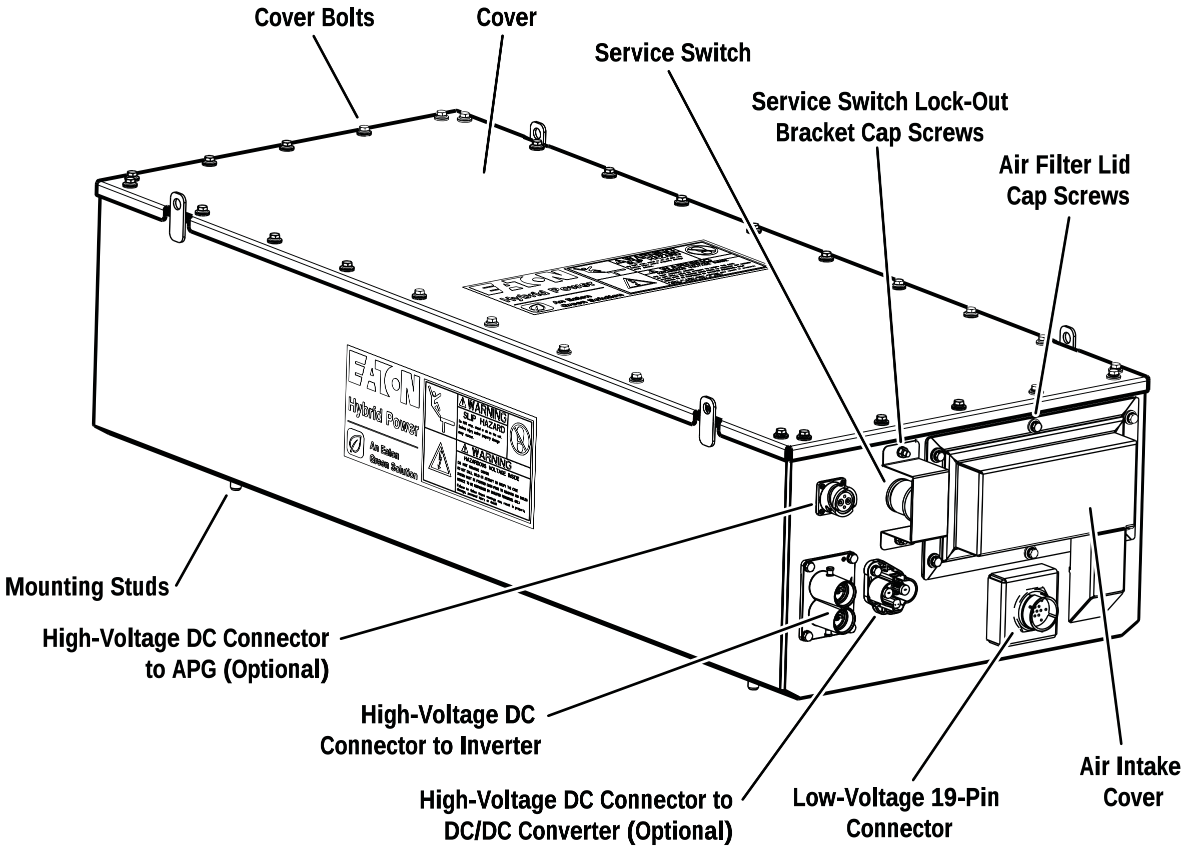
Possible Causes

This fault code can be caused by any of the following:

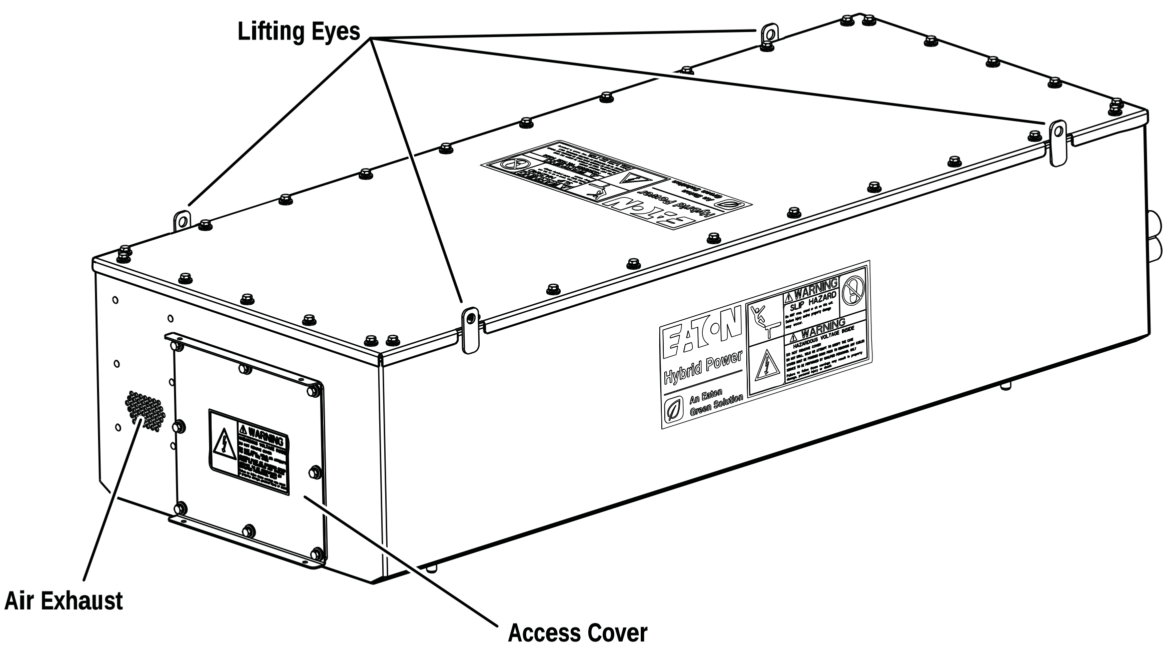
- FMI 0, 1, 9, 11, 12, 15, 17, 22-31
  - PEC

Component Identification

Front



Rear



Fault Code 101 - High Voltage Battery Fault

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Key on.
3. Retrieve fault codes and FMIs with ServiceRanger 4 using the 9 way diagnostic connector.
4. Is Fault Code 101 Active?
   - Monitor PEC High Voltage output with ServiceRanger 4 via Data Monitor / J1939 HV Battery / Parameter SPN 520232 Battery Voltage RB. If Voltage value is above 370 volts call 1 (800) 826-4357 and follow the Hybrid prompts for assistance.
   - If Fault Code 101 is Active and the Parameter SPN 520232 Battery Voltage RB is less than 370 volts, replace the PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If Fault Code 101 is Inactive and the Parameter SPN 520232 Battery Voltage RB is less than 370 volts, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key on.
2. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
3. Drive the vehicle and attempt to recreate the code.
4. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 101 appears, go to **Step A.**
   - If a code other than 101 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 103 - Battery Control Unit (BCU) Communication Fault

J1939: SA 239 SPN 520265, 520308 FMI 2, 22–26

Overview

The high-voltage batteries each contain a cell controller that communicates over a twisted pair data link to the BCU. The BCU is located in the Relay Box, which is in the Power Electronics Carrier (PEC). The BCU communicates through the PEC with each battery to determine temperature, State Of Charge (SOC) and voltage. That information is sent to the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- PEC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2, 22 is set when the PEC fails to communicate over the CAN Data Link for 30 MS.
- FMI 23 is set when the PEC fails to receive HCM data over the CAN Data Link for 2.5 seconds or greater after communication is established.
- FMI 24 is set when the PEC fails to receive Inverter data over the CAN Data Link for 2.5 seconds or greater after communication is established.
- FMI 25 is set when the PEC fails to transmit anything over the data link for 2 seconds.
- FMI 26 is set when the PEC detects an error on initial check.

Fallback

When Fault Code 103 is set the following conditions occur:

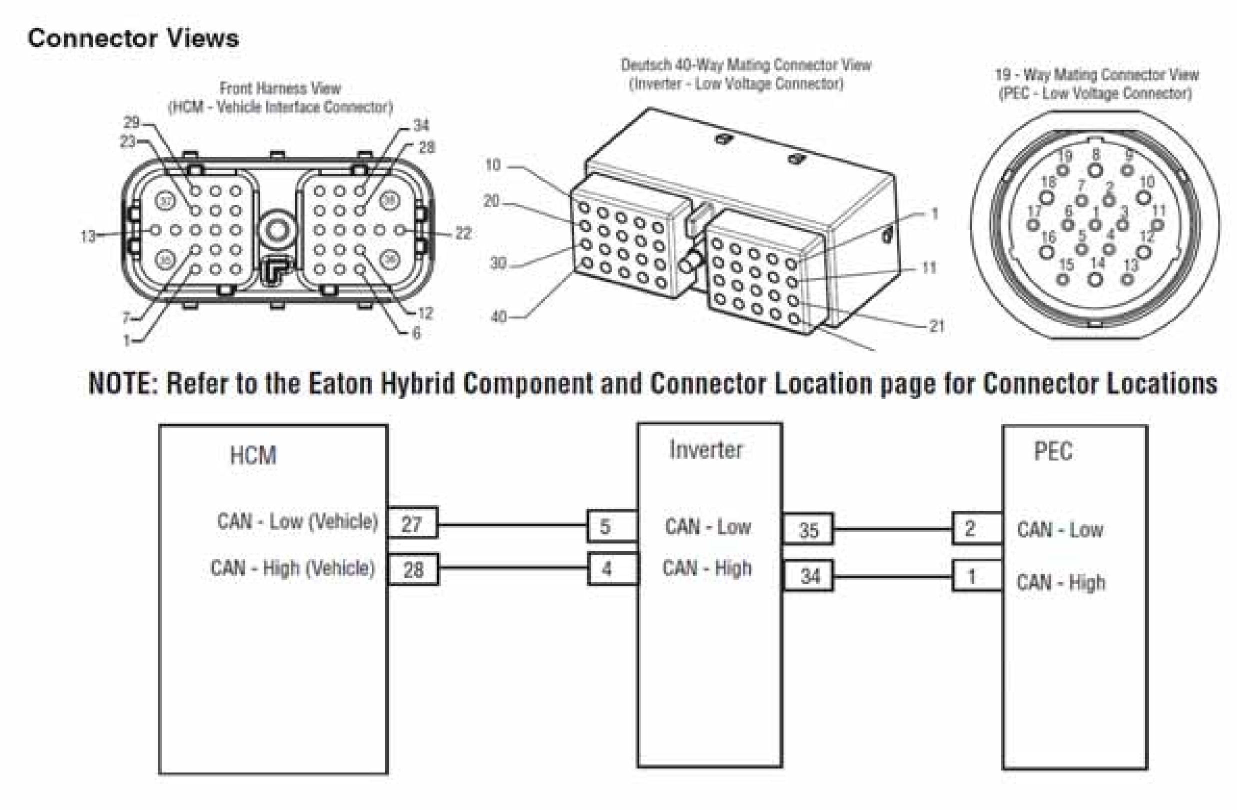
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st

Possible Causes

This fault code can be caused by any of the following:

- FMI 26
  - Relay Box
- FMI 2, 22, 25
  - Relay Box
  - CAN Data Link between PEC and Inverter
- FMI 23
  - Relay Box
  - CAN Data Link between PEC and HCM
- FMI 24
  - Relay Box
  - Inverter
  - CAN Data Link between PEC and Inverter

Component Identification



Fault Code 103 - Battery Control Unit Communication Fault

A

Purpose: *Perform the Electrical and Hybrid Pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Perform Electrical Pretest and Hybrid Electrical Pretest.
   - If no issues are found during either electrical test, go to **Step B.**
   - If issue was repaired during either electrical test, go to **Step V.**

B

Purpose: *Verify Active or Inactive fault code combinations.*

1. Key on.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Retrieve fault codes and FMIs with ServiceRanger 4 using the 9-Way Diagnostic Connector.
3. Which faults are present?
   - If Fault Code 103 FMI 26 is Active or Inactive and is the only fault code, replace the PEC. See the **MY09 PEC Removal and Installation** procedure on page 87 in TRSM2000, then go to **Step V.**
   - If Active or Inactive fault code 103 is listed with an Active or Inactive fault code 111, go to “Fault Code 111 - Inverter CAN Message Fault (HCM)” on page 349.
   - If Active or Inactive fault code 103 is listed with an Active or Inactive fault code 88, go to “Fault Code 88 - Inverter CAN Message Fault (HCM)” on page 294.
   - If Active or Inactive fault code 103 is listed with an Active or Inactive Fault Code 89, go to “Fault Code 89 - Battery Control Unit CAN Message Fault (HCM)” on page 300.

V ***Purpose:*** *Verify repair.*

1. Key on.
2. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
3. Drive the vehicle and attempt to recreate the code.
4. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 103 appears, find error in testing, go to **Step A.**
   - If a code other than 103 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 105 - Battery Control Unit Fault

J1939: SA 239 SPN 520305, 520307, 520295, 520300, 520240, 520250 FMI 0, 1, 2, 3, 4, 22-31

Overview

The high-voltage batteries each contain a cell controller that communicates over the Controller Area Network (CAN). CAN is a high-speed twisted pair 500K proprietary data link that connects the HCM to the Electric Clutch Actuator (ECA), Power Electric Carrier (PEC), Inverter and Auxiliary Power Generator (APG). The Battery Control Unit communicates through the PEC with each battery to determine temperature, State of Charge (SOC) and voltage. This information is then sent to the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- Battery Control Unit ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0, 1, 2, 3, 4, and 22-31 are set for various internal Battery Control Unit failures.

Fallback

When Fault Code 105 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

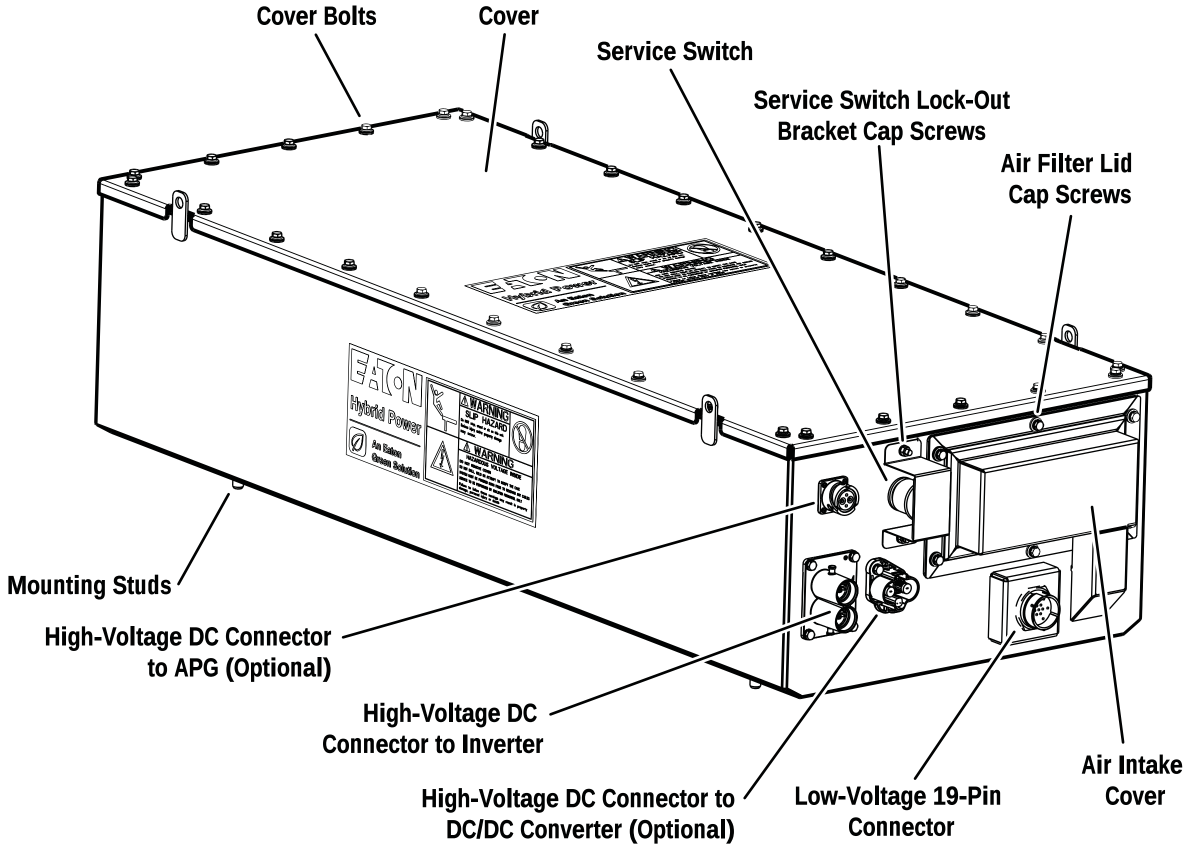
Possible Causes

This fault code can be caused by any of the following:

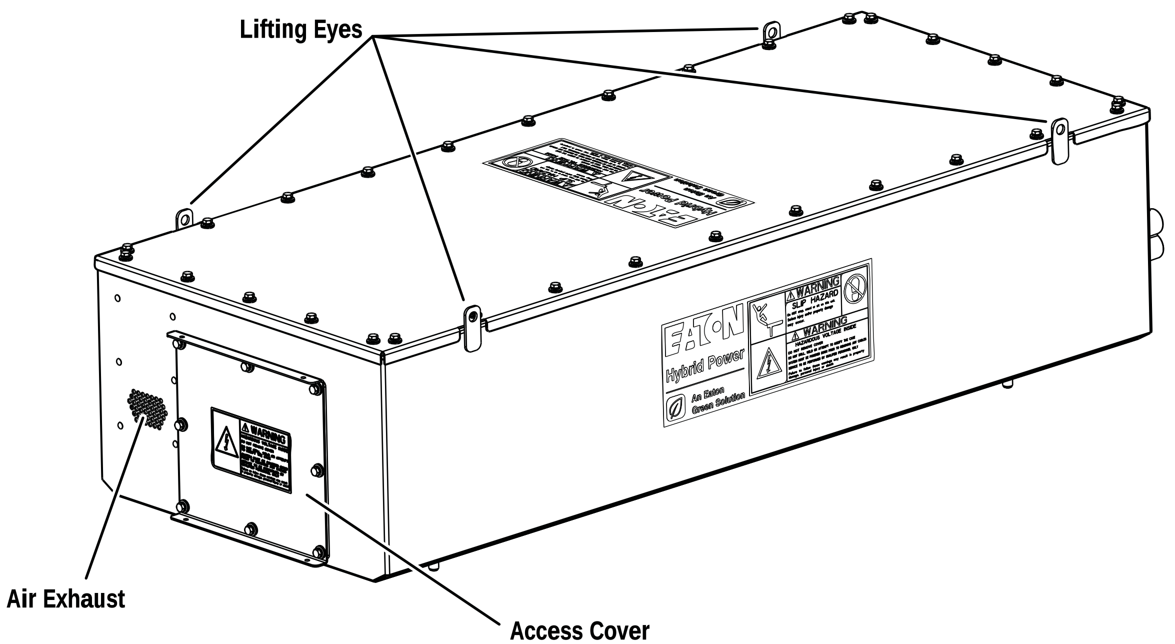
- FMI 0, 1, 2, 3, 4, 22-31
  - PEC

Component Identification

Front



Rear



Fault Code 105 - Battery Control Unit Fault

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Key on.
3. Retrieve fault codes and FMIs with ServiceRanger 4 using the 9-Way Diagnostic Connector.
4. Which fault codes are Active and Inactive?
   - If fault code 105 is key on Active and the only fault code Active, replace the PEC. See the **MY09 PEC Removal and Installation** procedure on page 87 in TRSM2000, then go to **Step V.**
   - If the fault code 105 is present with any other fault code then diagnose the other fault code.
   - If the Fault Code is Inactive and no other fault codes are present go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key on.
2. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
3. Drive the vehicle and attempt to recreate the code.
4. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 105 appears, find error in testing, go to **Step A.**
   - If a code other than 105 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 107 - High Voltage Battery Leak Detection Fault

J1939: SA 239 SPN 520303, 520240, 520242 FMI 1, 11, 30

Overview

The Battery Control Unit (BCU) within the Power Electronics Carrier (PEC) continuously monitors Hybrid high-voltage leakage being reported to the DC circuit of the PEC.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.
- PEC ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 1 is set when resistance between High Voltage cables and shielding is less than 220K Ohms for 5 seconds.
- FMI 11, 30 is set when there is an invalid leak detection signal for 2 minutes.

Fallback

When Fault Code 107 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

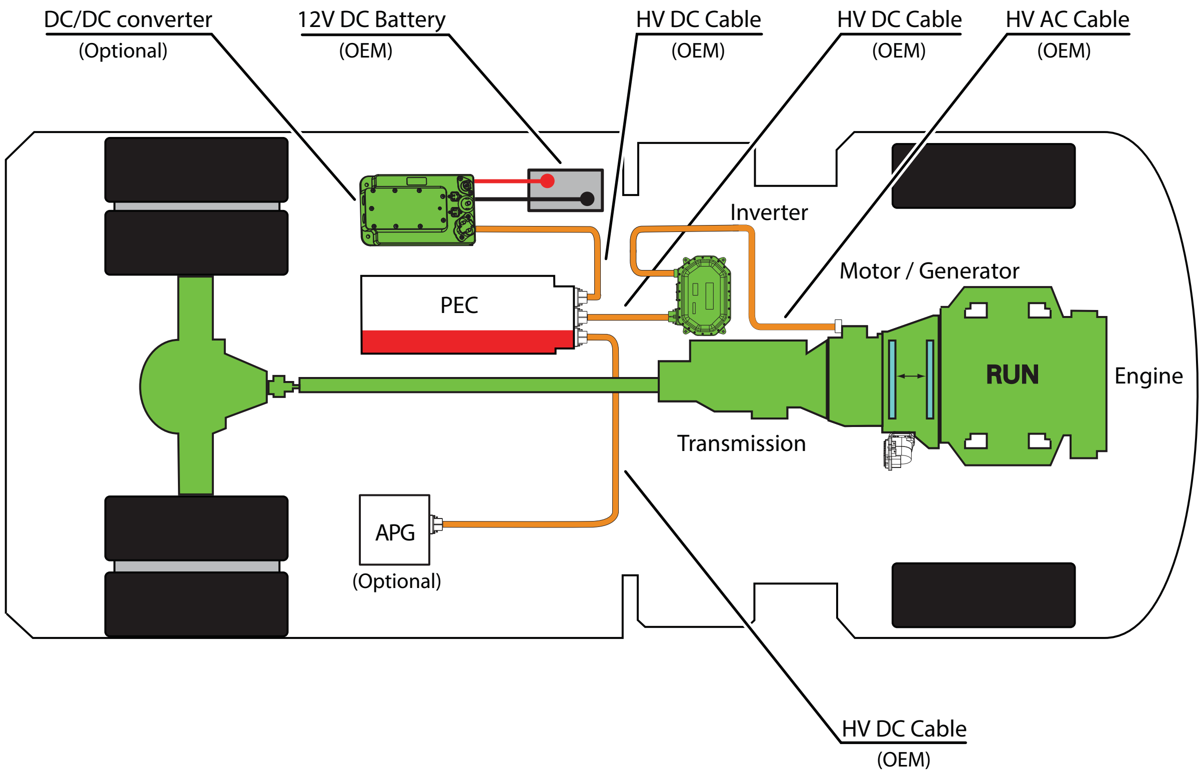
Possible Causes

This fault code can be caused by any of the following:

- FMI 1, 11, 30
  - High-voltage cable insulation damage
  - High-voltage component leaking
  - Water or moisture in a high-voltage connector or component.

Note: An air filter inspection should be performed prior to any trouble shooting steps for Fault Code 107. Reference TRSM2000 for air filter replacement / inspection procedure. Excessive water within the PEC may cause a Fault Code 107.

Component Identification



Fault Code 107 - High Voltage Battery Leak Detection Fault

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Key on.
3. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector:
   - If Fault Code 107 is Active, go to **Step B.**
   - If Fault Code 107 is Inactive, test is complete, go to **Step V.**

B ***Purpose:*** *Measure the resistance of the AC cable disconnected at the inverter to the motor / generator.*

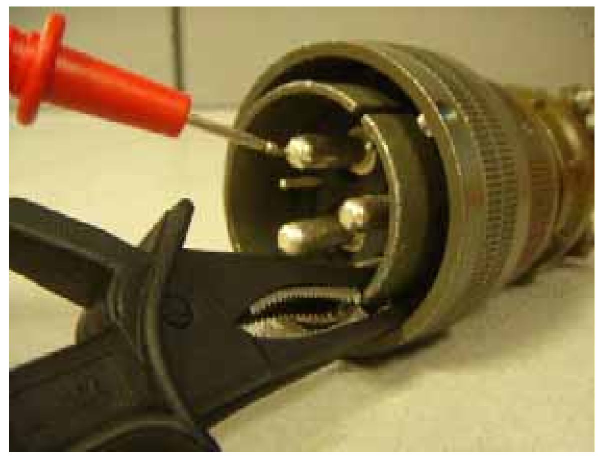
1. Is the vehicle equipped with an Auxiliary Power Generator (APG)? Is the fault code set while driving or when the APG is in being used? If Yes call (800) 826-4357 and follow the Hybrid Prompts for assistance.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Key off.
3. Disconnect the inverter AC connector at the inverter. The AC cable should not be disconcerted from the Motor/ Generator. Inspect AC cable connector and inverter AC connection for moisture or contamination.
4. Measure the resistance of the AC 3-phase pins:

   Note: The AC cable should still be connected to the Motor/Generator.

   - Pin A to Cable Shield
   - Pin B to Cable Shield
   - Pin C to Cable Shield



   - If moisture or contamination is found, this is a non-Eaton failure. See OEM for repair direction.
   - If resistance is OL or outside range, go to **Step E.**
   - If resistance is between 0–220K ohms, go to **Step C.**

Connection	Measurement
Pin A to Cable Shield	
Pin B to Cable Shield	
Pin C to Cable Shield	

C ***Purpose:*** *Measure the resistance of the AC cable that is disconnected from the Inverter and the motor / generator.*

1. If you are coming here from Step B a high voltage shutdown should have already been performed and the key should be in the “off” position. If this has been completed continue to step 2.

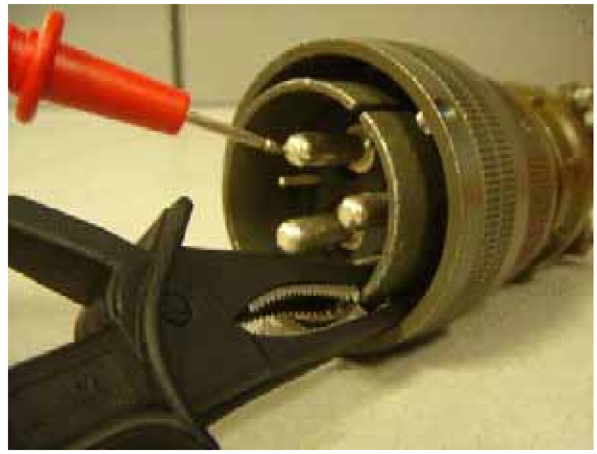
   Note: If the high voltage shutdown procedure has not performed return to the beginning of this procedure.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect the AC connector at the Motor/ Generator. The AC cable should now be disconnected at the Inverter and at the Motor / Generator. Inspect AC cable connector and AC connector at the Motor Generator for moisture or contamination.

   Note: If moisture or contamination is found, this is a non-Eaton failure. See OEM for repair direction.

3. Measure the resistance at the AC Cable between the following Pins:
   - Pin A to Cable Shield
   - Pin B to Cable Shield
   - Pin C to Cable Shield



- If resistance reading is “OL”, remeasure the AC cable on the inverter side.
- If resistance among any AC connector pin to Cable Shield in is OL, go to **Step D.**
- If any resistance/continuity is found replace OEM supplied AC Cable, go to **Step D.**

Connection	Measurement (Motor / Generator)	Measurement (Inverter)
Pin A to Cable Shield		
Pin B to Cable Shield		
Pin C to Cable Shield		

D ***Purpose:*** *Measure the resistance of each phase within the Motor / Generator to case.*

1. If you are coming here from Step C a high voltage shutdown procedure should have already been performed and the key has been turned off. If this has been completed continue to step 2.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. If you are coming here from Step 1 the high voltage AC Cable should be disconnected from the inverter and the Motor / Generator. If steps 1 and 2 have been completed continue to step 3.

3. Measure 3-phase sockets at the Motor / Generator.
   - Socket A to Motor / Generator case
   - Socket B to Motor / Generator case
   - Socket C to Motor / Generator case

- If any resistance or continuity is found, replace the Motor/Generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000. After repairs are made, go to **Step V.**
- If resistance is OL the Motor / Generator is not shorted to ground, go to **Step V.**

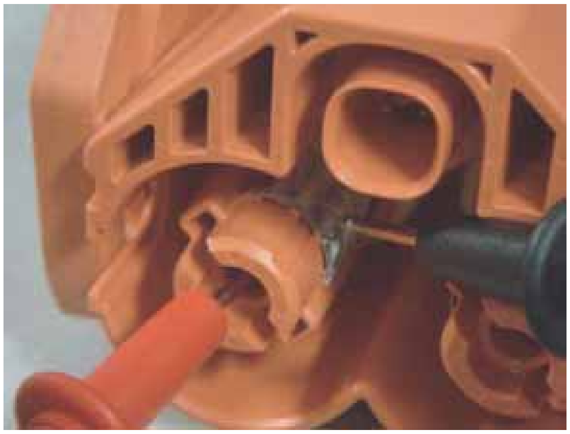
Connection	Measurement
Socket A to Motor / Generator Case	
Socket B to Motor / Generator Case	
Socket C to Motor / Generator Case	

E ***Purpose:*** *Verify the integrity of the High Voltage DC Cable.*

1. If you are coming here from Step B a high voltage shutdown should have already been performed and the key has been turned off. If this has been completed continue to step 2. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect the DC connector from the PEC. The DC connector at the Inverter should not be disconnected. Inspect DC cable connector and DC connector at the PEC for moisture or contamination. If moisture or contamination is found, this is a non-Eaton failure. See OEM for repair direction. If no moisture or contamination is found, proceed to step 3.
3. Measure the resistance at the DC Cable between the Positive (+) to Cable Shield and Negative (-) to Cable Shield.



- If resistance is open or OL, go to **Step G.**
- If resistance is 0-220K Ohms, go to **Step F.**

Connection	Measurement
Positive (+) to cable shielding	
Negative (-) to cable shielding	

F ***Purpose:*** *Verify the integrity of the High Voltage DC Cable.*

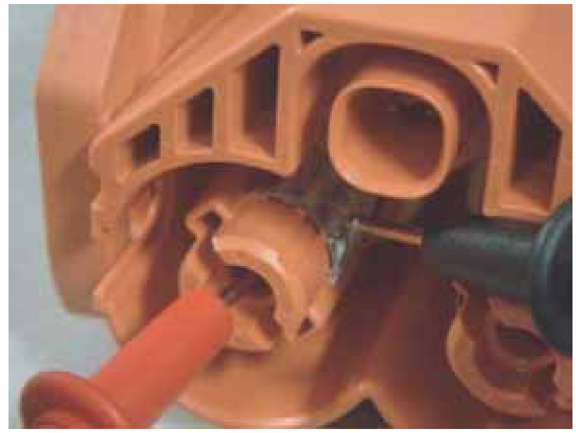
1. If you are coming here from Step E a high voltage shutdown should have already been performed and the key has been turned off. If this has been completed continue to step 2. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect the DC connector from the Inverter. The DC cable should be disconnected at the PEC and the Inverter. Inspect DC cable connector and DC connector at the Inverter for moisture or contamination.

   Note: If moisture or contamination is found, this is a non-Eaton failure. See OEM for repair direction.

3. Measure High Voltage DC cable End to End.
   - Positive (+) to Positive (+)
   - Negative (-) to Negative (-)
   - Positive (+) to Shield Ground
   - Negative (-) to Shield Ground



- If resistance is OL,go to **Step G.**
- If resistance is anything other than OL replace the High Voltage DC cable. After repairs are made, go to **Step V.**

Connection	Measurement
Positive (+) to Positive (End to End)	
Positive (+) to Shield Ground	
Negative (-) to Negative (End to End)	
Negative (-) to Shield Ground	

G

Purpose: *Verify the integrity of the Inverter.*

1. If you are coming here from Step F a high voltage shutdown should have already been performed and the key has been turned off. If this has been completed continue to step 2. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Measure the resistance within the Inverter positive to Case (Ground) on the Inverter High Voltage pins on the DC side.
   - Positive (+) to Inverter Case
   - Negative (-) to Inverter Case

- If open or OL, go to **Step H.**
- If resistance is 0-220K Ohms, replace the Inverter (see **MY09 Inverter Removal and Installation**). After repairs are made, go to **Step V.**

Connection	Measurement
Positive (+) to Inverter Case	
Negative (-) to Inverter Case	

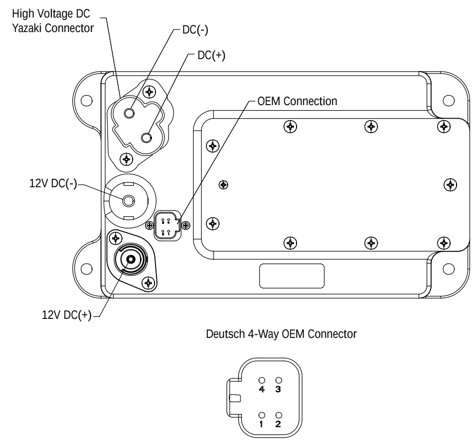
H

Purpose: *Verify components.*

1. If you are coming here from Step G a high voltage shutdown should have already been performed and the key has been turned off. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Verify unit is supplied with DC/DC Converter.



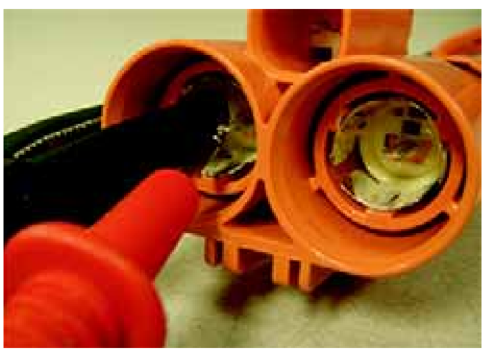
- If equipped with a DC/DC Converter, go to **Step I.**
- If no DC/DC Converter found see the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000 and perform repairs, then go to **Step V.**

I ***Purpose:*** *Verify integrity of the High Voltage DC/DC cable between the PEC and the DC/DC converter.*

1. If you are coming here from Step H a High Voltage shutdown should have already been performed and the key has been turned off. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect the DC/DC High-Voltage Cable at the PEC.
3. Measure the resistance to ground at the DC Cable Connector on both the positive and negative terminals to shield:
   - Positive (+) to Cable Shield
   - Negative (-) to Cable Shield



- If any resistance is between 0-220K Ohms, go to **Step J.**
- If resistance is OL, replace the PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000 and perform repairs, then go to **Step V.**

Connection	Measurement
Positive (+) to Cable Shield	
Negative (-) to Cable Shield	

J ***Purpose:*** *Verify the integrity of the High Voltage DC/DC cable between the PEC and the DC/DC Converter.*

1. If you are coming here from Step I a high voltage shutdown should have already been performed and the key has been turned off. If the high voltage shutdown procedure has not performed go back to Step A.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

2. Disconnect the DC/DC High-Voltage Cable at the DC/DC Converter. The High Voltage DC Cable should be disconnected from the PEC and the DC/DC Converter.
3. Measure resistance on DC/DC Cable.
   - Positive (+) to positive (+)
   - Negative (-) to negative (-)
   - Positive (+) to shield ground
   - Negative (-) to shield ground
4. Measure resistance at the inverter
   - Positive (+) to DC/DC case
   - Negative (-) to DC/DC case
   - If resistance is OL, find error in testing, go to **Step I.**
   - If resistance is anything other than OL, replace DC/DC Converter. See the **DC/DC Converter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
Cable (+) end to end	
Cable (-) end to end	
Cable (+) to shield ground	
Cable (-) to shield ground	
Inverter (+) to DC/DC case	
Inverter (-) to DC/DC case	

V ***Purpose:*** *Verify repair.*

1. Key on.
2. Clear codes. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
3. Drive the vehicle and attempt to recreate the code.
4. Check for codes. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 107 appears, find error in testing, go to **Step A.**
   - If a code other than 107 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 108 - Battery Control Unit Power Supply Fault

J1939: SA 239 SPN 520268 FMI 3, 4

Overview

The high-voltage batteries are 172 volts each connected in series to produce 340 volts DC. The Batter Control Unit (BCU) is part of the Power Electric Carrier (PEC). The BCU is located in the Relay Box and receives 12-volts ignition power and ground from the Inverter.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the BCU detects the ignition voltage is greater than 16 volts for 1 second.
- FMI 4 is set when the BCU detects the ignition voltage is less than 7 volts for 1 second.

Fallback

When Fault Code 108 is set the following conditions occur:

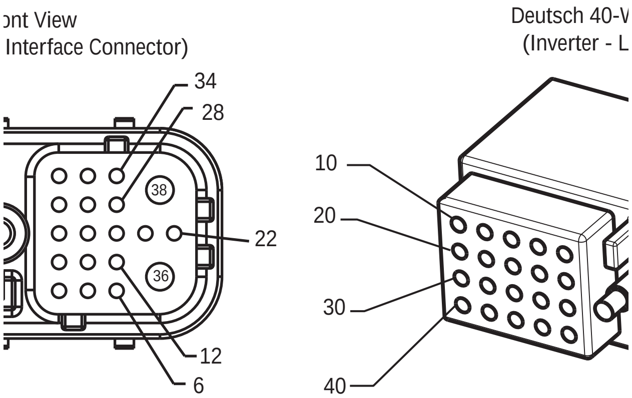
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st

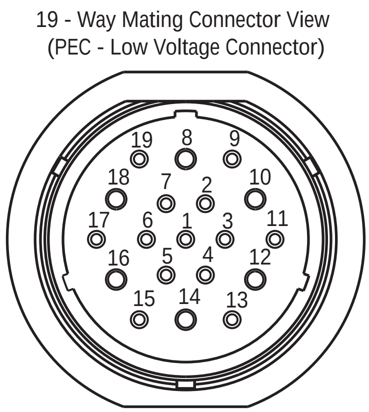
Possible Causes

This fault code can be caused by any of the following:

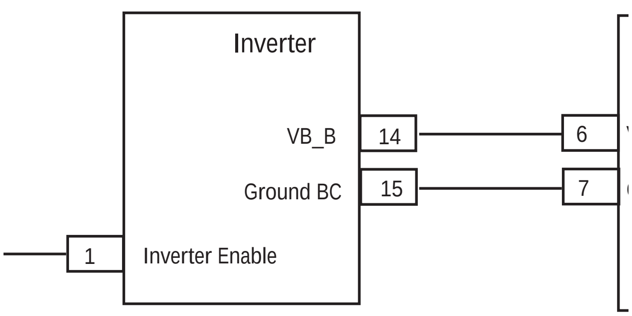
- FMI 4
  - Relay Box
  - Low-voltage harness from Inverter to Power Electric Carrier (PEC)
  - HCM
  - Low-voltage harness from HCM to Inverter
  - Inverter
- FMI 3
  - Relay Box

Component Identification





ybrid Component and Connector Location page fo



Fault Code 108 - Battery Control Unit Power Supply Fault

A

Purpose: *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which faults are present?
   - If Fault Code 108 FMI 3 or 4 are listed with an Active Fault Code 114, go to “Fault Code 114 - Inverter Power Supply Fault” on page 364.
   - If Fault Code 108 FMI 3 or 4 are listed with no Active Fault Code 114, go to **Step B.**

B

Purpose: *Verify voltage at PEC Connector.*

1. Disconnect the PEC 19-Way Connector.
2. Connect a multimeter to the PEC 19-Way Connector Pin 6 and Pin 7.
3. Place multimeter where it can be viewed, while standing next to the truck.
4. Key on.
5. Observe multimeter voltage reading:
   - If voltage between Pin 6 and Pin 7 is 11–13 volts, replace the BCU, then go to **Step V.**
   - If voltage between Pin 6 and Pin 7 is less than 7 volts, go to **Step C.**

Connection	Measurement
Pin 6 to Pin 7	

C

Purpose: *Verify continuity between PEC and Inverter Connectors.*

1. Key off.
2. Disconnect the Inverter 40-Way Connector.
3. Measure resistance on the Inverter 40-Way Connector Pin 14 to PEC 19-Way Connector Pin 6 and the Inverter 40-Way Connector Pin 15 to PEC 19-Way Connector Pin 7:
   - If resistance from Pin 14 to Pin 6 is 0–0.3 ohms and resistance from Pin 15 to Pin 7 is 0–0.3 ohms, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, replace the low-voltage harness from the PEC to the Inverter, then go to **Step V.**

Connection	Measurement
Pin 14 to Pin 6	
Pin 17 to Pin 7	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 108 appears, find error in testing, go to **Step A.**
   - If a code other than 108 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 110 - Inverter Fault

J1939: SA 239 SPN 520220 FMI 21–29

Overview

The Inverter assembly is connected to the high-voltage DC cable from the Power Electric Carrier (PEC) along with the high-voltage AC cable from the Motor/Generator. The Inverter inverts the DC to AC voltage to power the motor during electric assist and rectifies the AC back to DC to charge the high-voltage batteries during coasting or regenerative braking. The Inverter is also the main controller for the high-voltage system communicating to the PEC along with communicating to the HCM for overall system operation.

Detection

Fault is detected when:

- HCM is powered and ignition voltage is greater than 7 volts and less than 16 volts.
- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMIs 21–29 are set due to various internal failures of the Inverter.

Fallback

When Fault Code 110 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Depending on the internal failure, the Inverter may continue to operate with the fault logged, or shut down the high- voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode for most failures.
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

- FMIs 21–29
  - Inverter

Component Identification

Note: No schematic for this code.

Fault Code 110 - Inverter Fault

A ***Purpose:*** *Check for Active or Inactive fault code status.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If Fault Code 110 is Active, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If Fault Code 110 is Inactive, test is complete.

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 110 appears, find error in testing, go to **Step A.**
   - If a code other than 110 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 111 - Inverter CAN Message Fault (HCM)

J1939: SA 239 SPN 520260 FMI 2, 9 (Any Other FMIs Following 9)

Overview

The Inverter communicates with the Battery Control Unit (BCU) located in the Power Electronics Carrier (PEC) and the Hybrid Control Module (HCM) on the Controller Area Network (CAN) high-speed proprietary data link. The data link is a two wire twisted pair with two 120 ohm resistors located in the link.

Detection

Fault is detected when:

- The HCM ignition voltage is greater than 7 volts and less than 16 volts.
- The HCM CAN Data Link fault is not active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set when the HCM has not received an Inverter message for 30 consecutive message cycles.
- FMI 2 is only active in Product Diagnostic Mode and will set if 3 consecutive Inverter messages are not received by the HCM.

Fallback

When Fault Code 111 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Electric Motor/Generator Assist and Regeneration are disabled, however, the high-voltage relays remain powered.
- HCM continues to control the Hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

- FMI 2, 9:
  - CAN Data Link
  - No power or ground to Inverter
  - HCM
  - Inverter

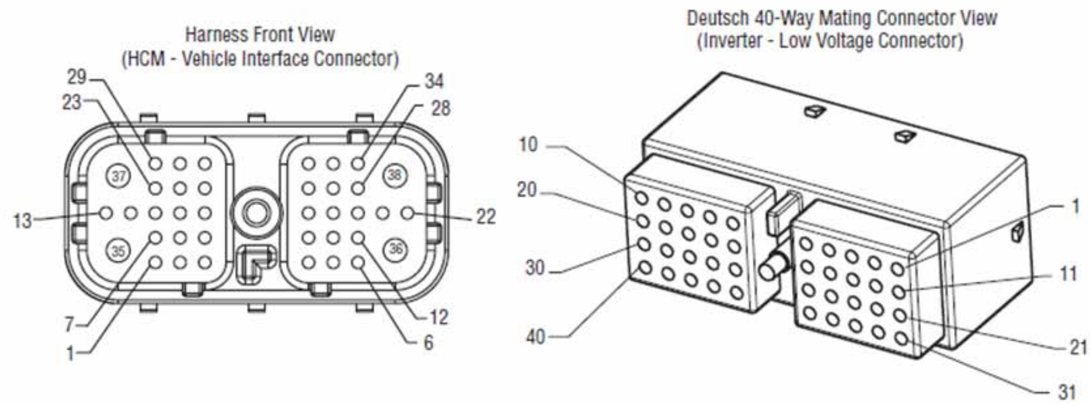
Conditions to Clear the Fault

Only inactive faults can be cleared from the TECU or HCM history using ServiceRanger. The TECU will automatically clear the faults from history after 200 hours and the HCM will automatically clear the faults from history after 200 hours of the fault staying inactive.

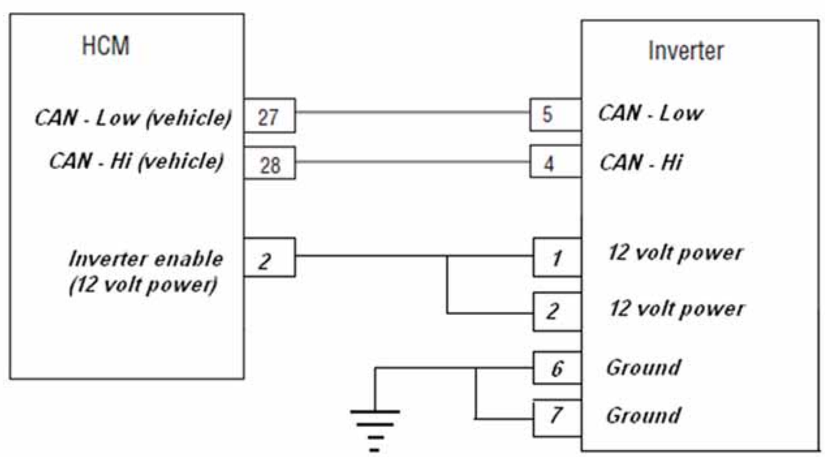
Additional Tools

- Basic Hand Tools
- Eaton Test Adapter Kit
- Digital Volt/Ohm Meter
- ServiceRanger

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 111 - Inverter CAN Message Fault (HCM)

A

Purpose: *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Key off for 2 minutes.
3. Key on.
4. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector. Verify Fault Code 111 is Active.
5. Perform Electrical Pretest and Hybrid Electrical Pretest:
   - If no issues are found during either electrical test, go to **Step B.**
   - If issue was repaired during either electrical test, go to **Step V.**

B

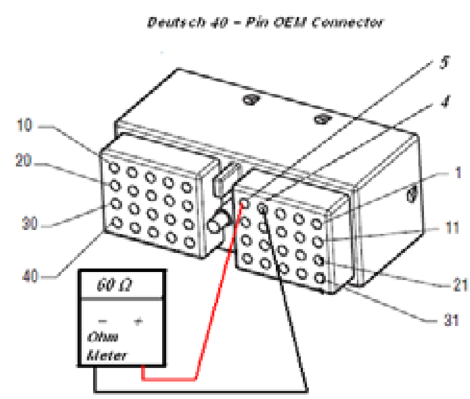
Purpose: *Verify FMIs present.*

1. Which FMIs are present for Active Fault Code 111?
   - If any FMIs other than 2 or 9 is set, check ServiceRanger HCM configurations. Inverter type should have 40-Pin selected. If 56-Pin is selected, change to 40-Pin, then go to **Step C.**

C

Purpose: *Verify continuity in Inverter Connector.*

1. Key off.
2. Remove 40-Way Connector at the Inverter.
3. Measure resistance between Inverter 40-Way Connector Pins 5 and 4:



- If resistance is OL or outside 50–70 ohms, repair the OEM CAN Link Harness, then go to **Step V.**
- If resistance is between 50–70 ohms, go to **Step D.**

Connection	Measurement
Pin 5 to Pin 4	

D

Purpose: *Verify CAN circuit for short to ground.*

1. Measure CAN to ground resistance on Inverter OEM Connector Pin 1 to Inverter Case and Pin 2 to Inverter Case:
   - If resistance is 7K ohms, go to **Step E.**
   - If resistance is 0–100 ohms, repair shorted CAN Link Circuit, then go to **Step E.**

E

Purpose: *Verify CAN terminals are in the correct location.*

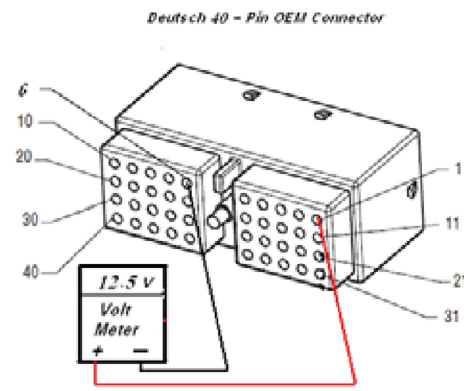
1. Measure resistance between Inverter 40-Way Connector Pin 4 and Dash 9-Way Diagnostic Connector Pin H (if Pin H is not populated, find 3-Way Connector near the 9-Way or Terminating Resistor Pin 1 near the 9-Way):
   - If resistance is 0–0.3 ohms, go to **Step F.**
   - If resistance is 60 ohms, repair CAN wiring (hi and low are wired wrong), then go to **Step F.**

Connection	Measurement
40-Way Pin 4 to 9-Way Diagnostic Connector Pin H	

F

Purpose: *Verify power and ground to Inverter.*

1. Key on (with Inverter 40-Way Connector still removed).
2. Measure voltage on OEM 40-Way Connector Pin 1 to Pin 6 and Pin 2 to Pin 7:



- If battery voltage is present, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
- If battery voltage is not present, go to **Step G.**

Connection	Measurement
Pin 1 to Pin 6	
Pin 2 to Pin 7	

G

Purpose: *Verify ground to Inverter.*

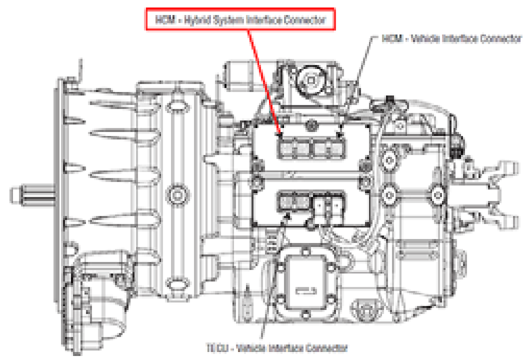
1. Measure resistance between OEM 40-Way Connector Pin 6 or 7 to ground:
   - If resistance to ground is 0–0.3 ohms, go to **Step H.**
   - If resistance is higher than 0.3 ohms, repair OEM ground circuit to Inverter, then go to **Step V.**

Connection	Measurement
40-Way Pin 6 or 7 to ground	

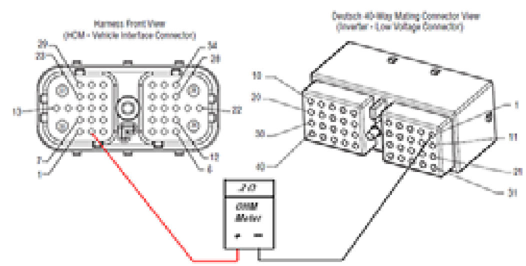
H

Purpose: *Verify power from HCM*

1. Key off.
2. Remove HCM 38-Way System Connector.



3. Measure resistance on HCM 38-Way OEM Connector Pin 2 to Inverter 40-Way Connector Pin 1:



   - If resistance is 0–0.3 ohms, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is OL or more than 0.3 ohms, repair OEM Harness between HCM and Inverter, then go to **Step V.**

Connection	Measurement
38-Way Pin 2 to 40-Way Pin 1	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 111 appears, find error in testing, go to **Step A.**
   - If a code other than 111 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 112 - Inverter Voltage Fault

J1939: SA 239 SPN 520221 FMI 1, 3, 4

Overview

The Inverter is connected to the Power Electronics Carrier (PEC) through a high-voltage DC cable, which supplies 340 volts from the batteries. During operation, the Inverter monitors the input voltage to determine an over or under voltage problem.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 1, 4 is set when the Inverter input voltage measured at the capacitor is less than 200 volts for 1 second, while the main relays in the Relay Box are on.
- FMI 3 is set when the Inverter input voltage measured at the capacitor is greater than 435 volts for 0.05 MS.

Fallback

When Fault Code 112 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

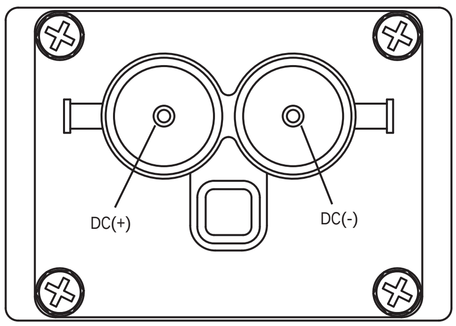
Possible Causes

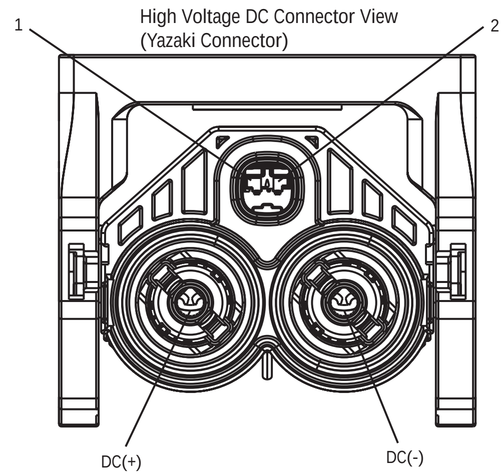
This fault code can be caused by any of the following:

- FMI 1, 3, 4
  - Inverter
  - PEC
  - DC High-Voltage Cable

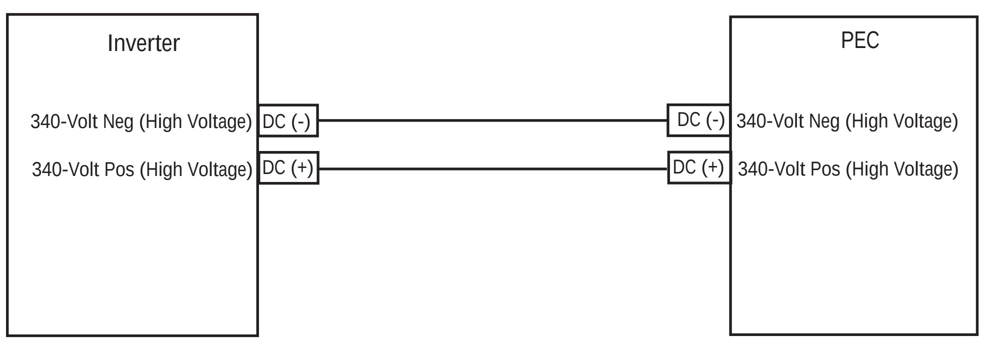
Component Identification

High-Voltage DC Connector to PEC





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 112 - Inverter Voltage Fault

A

Purpose: *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Key off.
3. Key on.
4. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

5. Which faults are present?
   - If Fault Code 112 FMI 3 is listed, contact Eaton at 1-800-826-HELP (4357).
   - If Fault Code 112, FMI 3 is listed with other Active hybrid fault codes beside 112, go to "Fault Code Isolation Procedure Index" on page 14.
   - If Fault Code 112 FMI 4 is listed, go to **Step B.**

B

Purpose: *Verify capacitance of Inverter DC High-Voltage Connector.*

1. Key off.
2. Disconnect the DC High-Voltage Connector at the Inverter.
3. Place the multimeter on uF option.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Place the leads into the 2 Inverter DC High-Voltage Sockets making sure the probes touch the terminals.
5. Record the measurement after 2 minutes.
   - If the uF reading is 1104uF–1656uF at 68 °F (20 °C), go to **Step C.**
   - If the uF reading is outside 1104uF–1656uF at 68 °F (20 °C), replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
DC positive (+) Socket	
DC negative (-) Socket	

C ***Purpose:*** *Verify continuity of circuits on the DC cable between PEC and Inverter.*

1. Key off.
2. Disconnect the DC High-Voltage Connector from the PEC.
3. Measure the resistance of each circuit on the DC cable from the PEC Connector to the Inverter Connector:
   - If the resistance for each circuit is 1 ohm or less, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is out of range, replace the DC High-Voltage Cable, then go to **Step V.**

Connection	Measurement
DC positive (+)	
DC negative (-)	
HVIL Pin 1	
HVIL Pin 2	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 112 appears, find error in testing, go to **Step A.**
   - If a code other than 112 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 113 - Inverter Current Fault

J1939: SA 239 SPN 520222 FMI 6, 14

Overview

The Inverter is connected to the Power Electronics Carrier (PEC) through a high-voltage DC cable which supplies 340 volts from the batteries. During operation, the Inverter monitors the output current to the Motor/Generator.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 6 is set when the Inverter IGBT current is greater than 800 amps for 0.05 MS or the motor cable is short.
- FMI 14 is set when motor torque commanded is 0 and current is reported by the Inverter.

Fallback

When Fault Code 113 is set the following conditions occur:

- Red “Stop Hybrid” light illuminates for FMI 6 and a amber Check Hybrid for FMI 14.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes

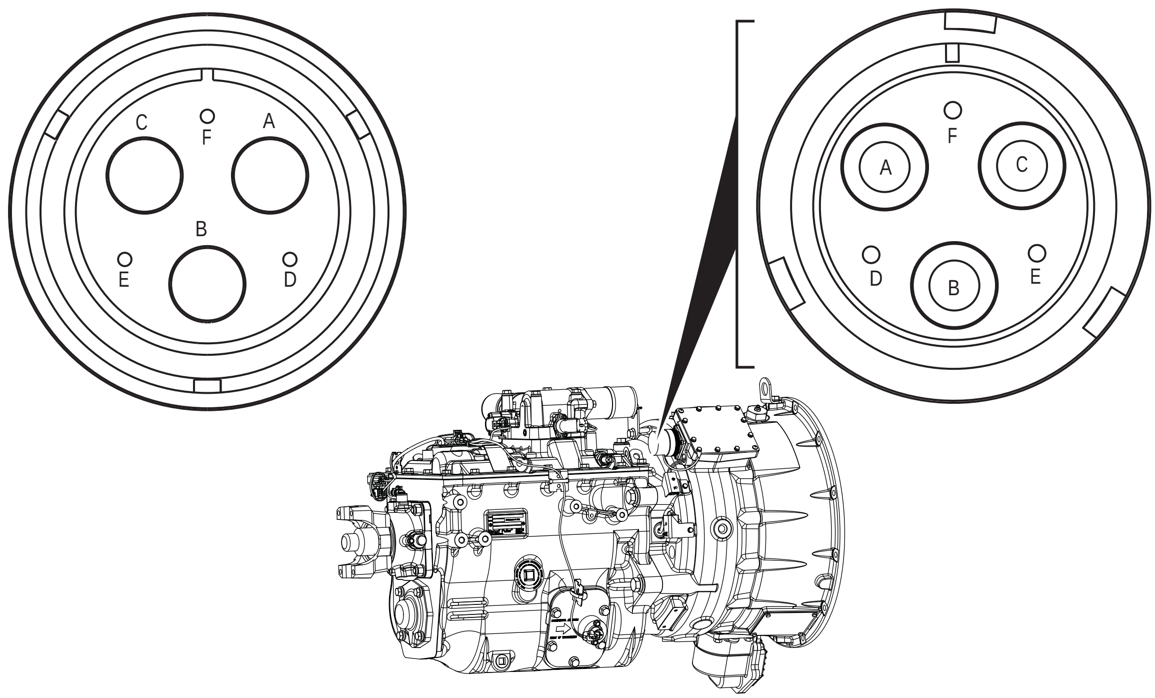
This fault code can be caused by any of the following:

- FMI 6
  - Inverter
  - Motor/Generator
  - AC High-Voltage Cables
- FMI 14
  - Motor/Generator
  - AC High-Voltage Cables

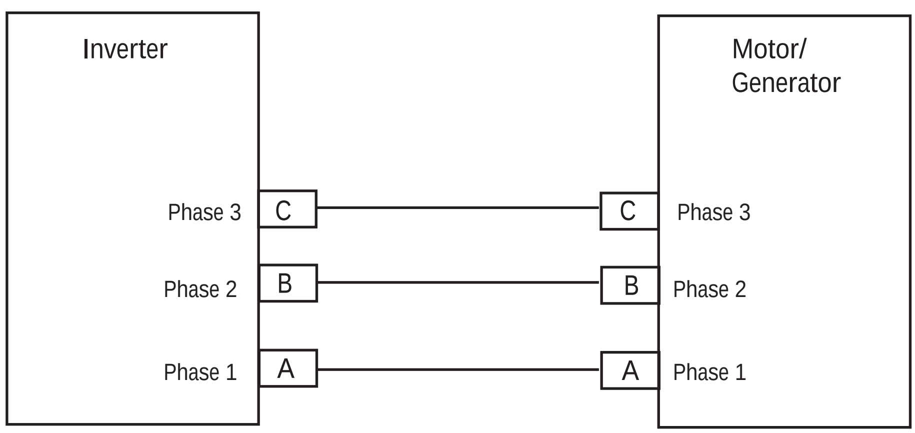
Component Identification

High-Voltage AC Harness Connector View (Amphenol Connector)

High-Voltage AC Motor/Gen Connector View (Amphenol Connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 113 - Inverter Current Fault

A

Purpose: *Verify FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If Fault Code 113 FMI 6 is listed, go to **Step B.**
   - If Fault Code 113 FMI 14 is listed, go to **Step D.**

B

Purpose: *Verify integrity of AC Cable.*

1. Visually inspect the AC Cable for signs of abrasion, cuts or exposed wiring.
2. Remove the AC High-Voltage Cable at the Motor/Generator and Inverter.
3. Measure the resistance between the following AC High-Voltage Cable Pins.
   - Pin A to Pin A
   - Pin B to Pin B
   - Pin C to Pin C

Note: An auto-ranging digital volt/ohm meter must be used.

- If resistance between each phase is 5M or greater, go to **Step C.**
- If resistance is outside of range, replace the AC High-Voltage Harness, then go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

C

Purpose: *Verify continuity of AC Cable to ground.*

1. Measure the resistance of each AC High-Voltage Cable Pin to ground:
   - If resistance between each Pin and ground is 5M or greater, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSm2000, then go to **Step V.**
   - If resistance is outside of range, replace the AC High-Voltage Cable, then go to **Step V.**

Connection	Measurement
Pin A to ground	
Pin B to ground	
Pin C to ground	

D

Purpose: *Verify continuity of Inverter to Motor/Generator connections of the AC Cable.*

1. Remove the AC High-Voltage Cable from the Inverter and Motor/Generator.
2. Measure the resistance of the AC High-Voltage Cable from the Inverter Connector to the Motor/Generator Connector on each of the following pins:
   - Pin A to Pin A
   - Pin B to Pin B
   - Pin C to Pin C

   Note: An auto-ranging digital Volt/Ohm Meter must be used.

   - If resistance is less than 1 ohm on each circuit, replace the Motor/Generator. See the **MY09 Motor/Generator Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, replace the AC High-Voltage Harness, then go to **Step V.**

Connection	Measurement
Pin A to Pin A	
Pin B to Pin B	
Pin C to Pin C	

V	***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 113 appears, find error in testing, go to **Step A.**
   - If a code other than 113 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 114 - Inverter Power Supply Fault

J1939: SA 239 SPN 520261 FMI 1, 3, 4

Overview
The Inverter assembly uses a 12V or 24V supply provided from the Hybrid Control Module (HCM) to power the Internal Control Board. The HCM provides ignition power to the Internal Control Board after it completes the power-up self check.

Detection
Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active
The following conditions may set the fault Active:

- FMI 1 is set when the internal 24V to 12V converter is out of range. Voltage conversion is done in the inverter. All PEC signals are 12 volts.
- FMI 3 is set when the Inverter ignition voltage is greater than 16 volts (12-volt system) and 32 volts (24-volt system) for 0.5 seconds.
- FMI 4 is set when the Inverter ignition voltage is less than 7 volts (on a 12-volt system) and 16 volts (on a 24-volt system) for 0.1 seconds.

Fallback
When Fault Code 114 is set the following conditions occur:

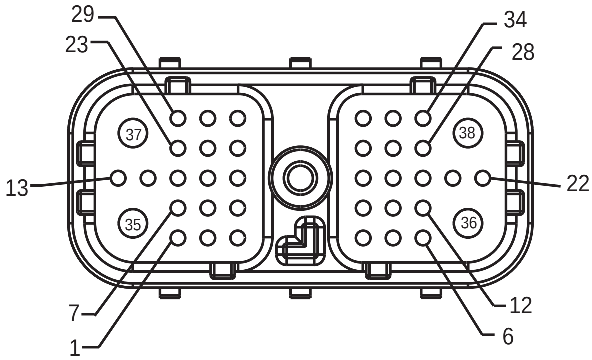
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Electric motor/generator assist and regeneration are disabled; however, the high-voltage relays remain powered.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

Possible Causes
This fault code can be caused by any of the following:

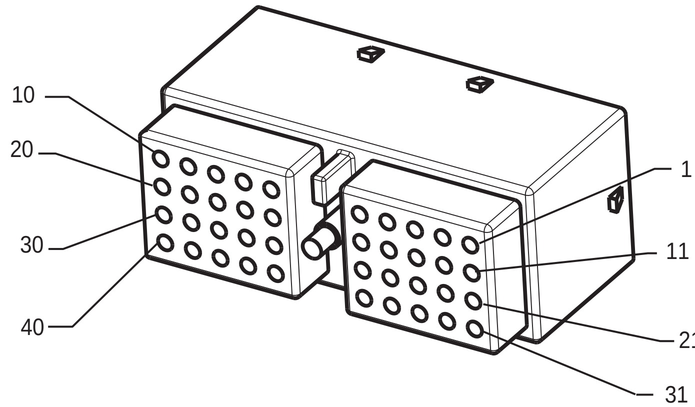
- FMI 1
  - Inverter
- FMI 3
  - Inverter
- FMI 4
  - HCM
  - Inverter
  - Power supply harness from HCM to Inverter

Component Identification

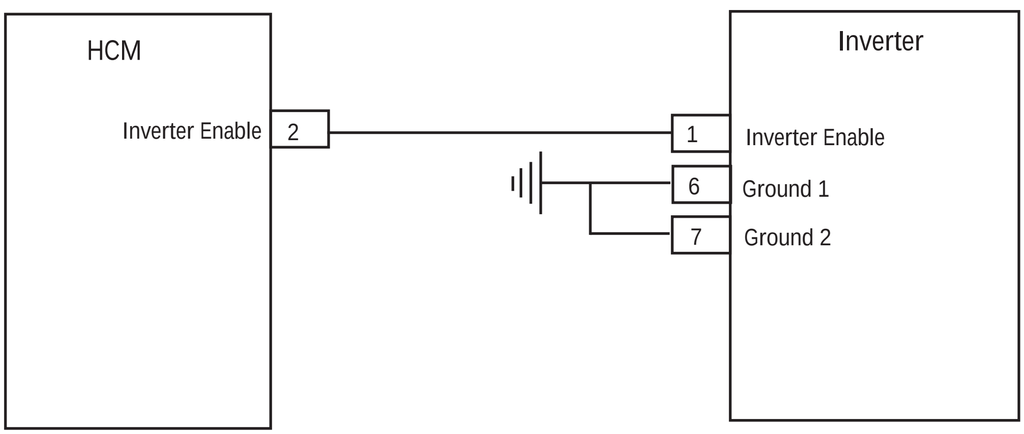
Front Harness View
(HCM - Hybrid System Interface Connector)



Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 114 - Inverter Power Supply Fault

A

Purpose: *Check for Active or Inactive fault code status and perform Electrical Pretest.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Perform Electrical Pretest:
   - If no issues found during the Electrical Pretest, go to **Step B.**
   - If issue was repaired during the Electrical Pretest, test is complete, go to **Step V.**

B

Purpose: *Verify FMI present.*

1. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
2. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Which FMIs are present?
   - If FMI 1 is listed, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000.
   - If Fault Code 114 FMI 3 or 4 is listed, go to **Step C.**
   - If Fault Code 114 is not present, test is complete, go to **Step V.**

C

Purpose: *Verify voltage present at Inverter.*

1. Key off.
2. Disconnect the Inverter 40-Way Connector.
3. Connect a multimeter to the Inverter 40-Way Connector Pin 1 and Pin 6.
4. Place multimeter where it can be viewed while standing next to the truck.
5. Key on.
6. Observe multimeter voltage reading:
   - If voltage is 11–13 volts (on a 12-volt system) or 23– 25 volts (on a 24-volt system), replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is greater than 16 volts (on a 12-volt system) or 32 volts (on a 24-volt system), repair the vehicle charging system. Refer to OEM for repair procedure.
   - If voltage is outside of range, go to **Step D.**

Connection	Measurement
Pin 1 to Pin 6	

D ***Purpose:*** *Verify continuity of circuits between HCM Harness and Inverter.*

1. Key off.
2. Disconnect the negative battery cable.
3. Disconnect the HCM Harness 38-Way Connector.
4. Measure resistance from the following:
   - Inverter 40-Way Connector Pin 1 to HCM 38-Way Connector Pin 2.
   - Inverter 40-Way Connector Pin 6 to ground.
     - If resistance from Pin 1 to Pin 2 is 0–0.3 ohms and resistance from Pin 6 to ground is 0 to OL, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
     - If resistance is outside of range, repair the open in the power or ground harness, then go to **Step V.**

Connection	Measurement
Pin 1 to Pin 2	
Pin 6 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 114 appears, find error in testing, go to **Step A.**
   - If a code other than 114 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 115 - Inverter Temperature Fault

J1939: SA 239 SPN 520223 FMI 0

Overview

The Inverter Temperature Sensor is a thermistor located inside the Inverter that changes in value based on the temperature. The Inverter supplies a 5-volt reference voltage to the sensor and measures the volt drop in the circuit.

When the Inverter temperature is warm the sensor resistance is low and the Inverter detects a low-voltage (0.1 volts equals 260 °F [127 °C]). When the Motor/Generator is cold the sensor resistance is high and the Inverter detects a high-voltage (4 volts equal -68 °F [-56 °C])

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0 is set with the Inverter temperature is greater than 206 °F (97 °C) for 100 MS or sensor broken.

Fallback

When Fault Code 115 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Electric Motor/Generator Assist and Regeneration are disabled; however, the high-voltage relays remain powered.
- HCM continues to control the hybrid vehicle in a diesel-only mode
- Transmission defaults start gear to 1st.

Possible Causes

This fault code can be caused by any of the following:

- FMI 0
  - Inverter
  - Liquid cooling system (low coolant, no coolant flow, coolant pump, radiator, radiator fan, reservoir)

Component Identification

Note: No schematic for this code.

Fault Code 115 - Inverter Temperature Fault

A

Purpose: *Verify Inverter temperature.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Key on.
4. Select the “Data Monitor” option and view PID 120 “Inverter Temperature” in the “Power Electronics list.
5. Observe PID 120 again after 20 minutes.
   - If PID 120 Inverter Temperature lowered from the 1st reading to 2nd reading, go to **Step B.**
   - If PID 120 Inverter Temperature remained constant, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Parameter	Reading
PID 120 “Inverter Temperature” - Initial	
PID 120 “Inverter Temperature” - After 20 min.	

B

Purpose: *Verify hybrid system coolant level.*

1. Key off.
2. Observe the coolant level after the system has cooled to see if it is filled to the proper level.
   - If the coolant is within the recommend limits, go to **Step C.**
   - If the coolant is below the recommended limits, refer to OEM for coolant type and fill procedure, then go to **Step V.**

C

Purpose: *Verify integrity of hybrid cooling system components.*

1. Visually inspect the hybrid liquid cooling system radiator for debris or obstruction to airflow and inspect the coolant lines for sharp bends.
   - If the radiator is free of debris and coolant lines are not kinked, go to **Step D.**
   - If the radiator is full of debris, the airflow is obstructed or the coolant lines are kinked, repair the problem, then go to **Step V.**

D ***Purpose:*** *Verify hybrid system Coolant Pump operation.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Connector in the cab.
3. Select the “Advanced Product Functions” option and select the “Cooling Pump” option.
4. Enable the “Cooling Pump” option.
   - If the coolant pump turns on, go to **Step E.**
   - If the coolant pump fails to turn on, go to **Step F.**

E ***Purpose:*** *Verify hybrid system Heat Exchanger Fan operation.*

1. Select the “Advanced Product Functions” option and select the “Heat Exchanger Fan” option.
2. Enable the “Heat Exchanger Fan” option.
   - If the Heat Exchanger Fan turns on, the system needs to be purged of air to allow the coolant to flow. Bleed the air by using a coolant system pressurizing tool or a vacuum tool.
     go to **Step V.**
   - If the Heat Exchanger Fan fails to turns on, go to **Step G.**

F ***Purpose:*** *Verify voltage at hybrid system Coolant Pump.*

1. Key on.
2. Disconnect the Coolant Pump 2-Way Connector.
3. Select the “Advanced Product Functions” option and select the “Cooling Pump” option.
4. Enable the “Cooling Pump” option.
5. Measure the voltage at the 2-Way Connector from Pin A to Pin B.
   - If voltage between Pin A and Pin B is ±0.2 volts of battery voltage, refer to OEM for Coolant Pump problem.
   - If voltage between Pin A and Pin B is outside of range, refer to OEM for Cooing Pump power harness repair procedure.

Connection	Measurement
Pin A to Pin B	

G

Purpose: *Verify voltage at hybrid system Heat Exchanger Fan.*

1. Key on.
2. Disconnect the Heat Exchanger Fan 2-Way Connector.
3. Select the “Advanced Product Functions” option and select the “Heat Exchanger Fan” option.
4. Enable the “Heat Exchanger Fan” option.
5. Measure the voltage at the 2-Way Connector from Pin A to Pin B:
   - If voltage between Pin A and Pin B is ±0.2 volts of battery voltage, refer to OEM for Heat Exchanger Fan problem.
   - If voltage between Pin A and Pin B is outside of range, refer to OEM for Heat Exchanger Fan power harness repair procedure.

Connection	Measurement
Pin A to Pin B	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 115 appears, find error in testing, go to **Step A.**
   - If a code other than 115 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 116 - High Voltage Relays Fault

J1939: SA 239 SPN 521210, 521211, 521212, 520224, 520311, 520312 FMI 3, 4, 5, 7, 10, 14

Overview

The High-Voltage Relays are located inside the Power Electronics Carrier (PEC) in the Relay Box unit. There is one Pre-Charge Relay on the positive side, an additional relay on the positive, and on the negative for a total of three relays. These relays are normally open when the system is off. The relays are controlled through the Inverter.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when a short to 12 volts is detected on the control side of a high-voltage relay.
- FMI 4 is set when a short to ground is detected on the control side of a high-voltage relay.
- FMI 5 and FMI 10 are set when an open circuit is detected on the control side of a high-voltage relay.
- FMI 7 and FMI 14 are set when the main negative relay is on and the inverter capacitor voltage decrease is less than 10-volts / 5 seconds when initial capacitor voltage was greater than 200 volts.

Fallback

When Fault Code 116 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates for FMI 10.
- Fault is stored in HCM memory.
- The hybrid system will be offline.
- Transmission defaults start gear to 1st in diesel-only mode.

Possible Causes

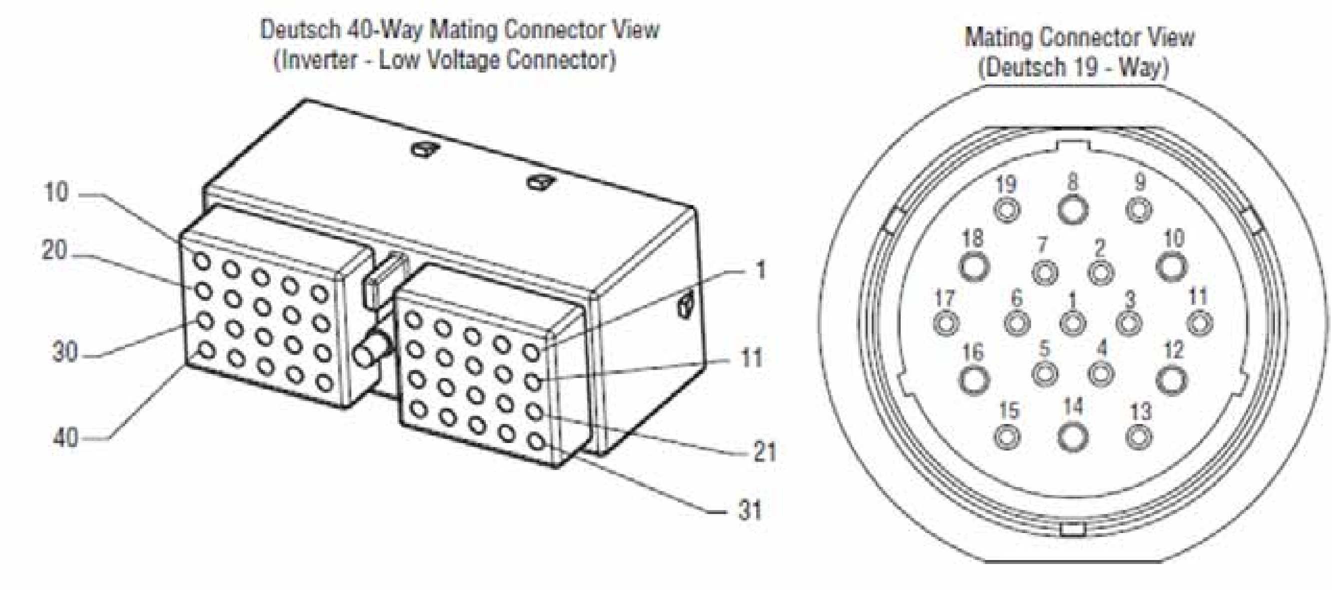
This fault code can be caused by any of the following:

- FMIs 3, 4, 5, 7, 10, 14
  - Relay Box
  - Inertia Switch
  - Inverter
  - Vehicle Wiring Harness between the Inverter and the PEC
  - Main High-Voltage Service Fuse is blown or missing
  - DC High-Voltage Cable Interlock
  - PEC Red Button Service Switch

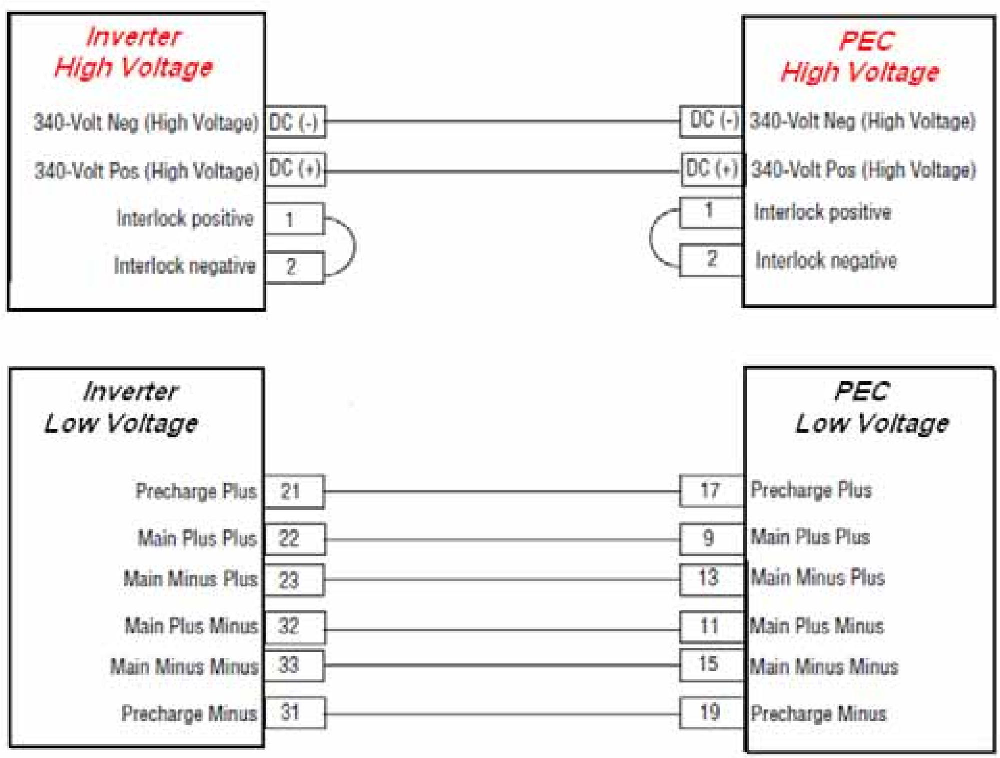
Conditions to Clear the Fault

Only inactive faults can be cleared from the TECU or HCM history using ServiceRanger. The TECU automatically clears the faults from history after 200 hours. The HCM automatically clears a fault from history after that fault has been Inactive 200 hours.

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 116 - High Voltage Relays Fault

A

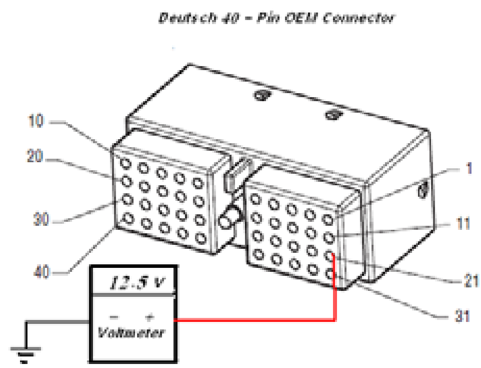
Purpose: *Verify FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Using ServiceRanger, record readings in “Data Monitor” under J1939 Data HV Battery: Parameter 520250 HV Battery1 potential voltage and parameter 520323 Battery Voltage RB. Watch voltage on Battery Voltage RB during key on and record voltage steps if any are present.
4. Which FMIs are present?
   - If Fault Code 116 FMI 3 is listed, go to **Step B.**
   - If Fault Code 116 FMI 4 is listed, go to **Step D.**
   - If Fault Code 116 FMI 5 or 10 is listed, go to **Step F.**
   - If Fault Code 116 FMI 7 is listed, go to **Step M.**

B

Purpose: *Verify continuity of PEC Connector circuits.*

1. Key off, wait 1 minute.
2. Disconnect the 40-Way Inverter Connector.
3. Key on (this will set a Fault Code 88, clear fault after repairing).
4. On Vehicle Harness, check for any voltage on pins 21, 31, 22, 32, 23 and 33 to ground:

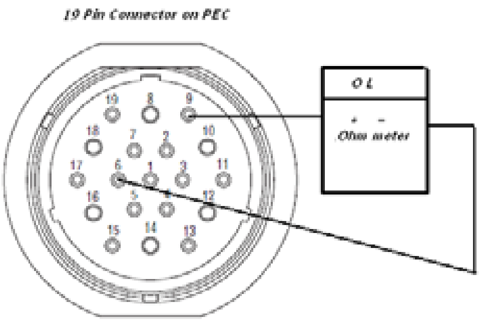


- If any voltage is found, remove 19-Way Connector on the PEC and recheck for voltage at Inverter 40-Pin, then go to **Step C.**
- If voltage is still present, repair Vehicle between Inverter and the 40-Pin, then go to **Step C.**
- If voltage is gone, go to **Step C.**

Connection	Measurement
Pin 21 to ground	
Pin 31 to ground	
Pin 22 to ground	
Pin 32 to ground	
Pin 23 to ground	
Pin 33 to ground	

C ***Purpose:*** *Verify continuity of PEC Connector circuits to ground.*

1. Key off.
2. Disconnect the PEC 19-Way Connector (red Service Switch should still be pulled out).
3. Measure the resistance on the following 19-Way Connector terminals:



- Pin 9 to Pin 6 and Pin 9 to Pin 12

- Pin 13 to Pin 6 and Pin 13 to Pin 12

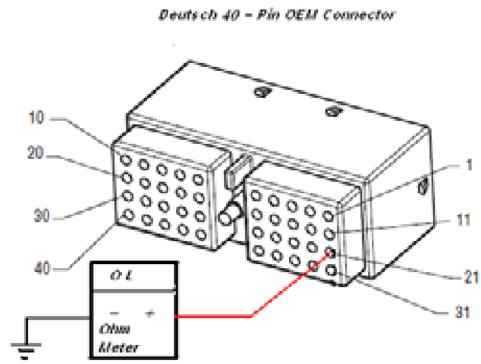
- Pin 17 to Pin 6 and Pin 17 to Pin 12

- If open circuit, go to **Step B.**
- If any resistance is found, replace the Relay Box. See the **MY09 PEC High-Voltage Relay Box Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Measurement
Pin 9 to Pin 6	
Pin 9 to Pin 12	
Pin 13 to Pin 6	
Pin 13 to Pin 12	
Pin 17 to Pin 6	
Pin 17 to Pin 12	

D ***Purpose:*** *Verify continuity of Inverter Connector circuits.*

1. Key off.
2. Disconnect the Inverter 40-Way Connector (19-Way Connector at PEC should be connected with red Service Switch pulled out).
3. On Vehicle Harness, check for resistance to ground on Pin 21 to ground, Pin 22 to ground and Pin 23 to ground:



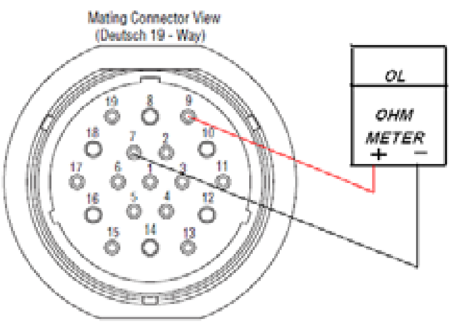
- If any resistance from the Inverter Connectors to ground is found, disconnect PEC 19-Way Connector and recheck the OEM 40-Way Connector.
- If resistance is still found with the 19-Way disconnected, repair the Vehicle Harness, then go to **Step V.**
- If resistance is gone with the 19-Way disconnected, go to **Step E.**
- If meter reads OL or Open Circuit, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

Connection	Initial Measurement	Recheck Measurement
Pin 21 to ground		
Pin22 to ground		
Pin 23 to ground		

E

Purpose: *Verify continuity of PEC Connector circuits to ground.*

1. Key off.
2. Disconnect the PEC 19-Way Connector.
3. On the PEC 19-Way Connector, measure:
   - Pin 9, Pin 13 and Pin 17 to ground
   - Pin 9 to Pin 7, Pin 9 to Pin 10, Pin 9 to PEC Mounting Stud
   - Pin 13 to Pin 7, Pin 13 to Pin 14, Pin 13 to PEC Mounting Stud
   - Pin 17 to Pin 7, Pin 17 to Pin 14, Pin 17 to PEC Mounting Stud



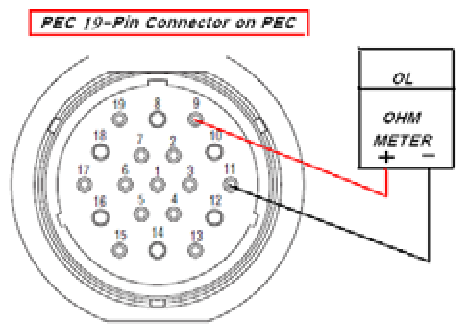
- If any resistance is found from the PEC Pins to ground, replace the Relay Box. See the **MY09 PEC High-Voltage Relay Box Removal and Installation** procedure in TRSM2000, then go to **Step V.**
- If meter reads OL, retesting is required, go to **Step D.**

Connection	Measurement
Pin 9 to ground Pin 13 to ground Pin 17 to ground	
Pin 9 to Pin 7 Pin 9 to Pin 10 Pin 9 to Mounting Stud	
Pin 13 to Pin 7 Pin 13 to Pin 14 Pin 13 to Mounting Stud	
Pin 17 to Pin 7 Pin 17 to Pin 14 Pin 17 to Mounting Stud	

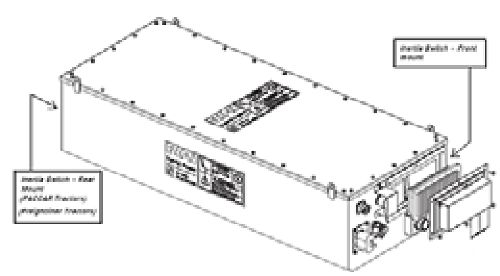
F

Purpose: *Verify continuity of PEC Connector circuits.*

1. Key off.
2. Disconnect the PEC 19-Way Connector.
   (Red Service Button on PEC should be pulled out.)
   (Do not perform “Hybrid Shutdown Procedure” yet.)
3. Measure resistance on the PEC Connector:
   - Pin 9 to Pin 11
   - Pin 13 to Pin 15
   - Pin 17 to Pin 19



- If the resistance between Pin 9 and Pin 11, and Pin 13 to Pin 15 are each 33–37 ohms and the resistance from Pin 17 to Pin 19 is 112–122 ohms, go to **Step G.**
- If any resistance is outside of range, reset the Inertia Switch located inside air filter opening or in Rear Access Panel by the High-Voltage Fuse. See the **MY09 PEC Inertia Switch Reset Procedures** procedure in TRSM2000, then go to **Step V.**



Connection	Measurement
9 to 11	
13 to 15	

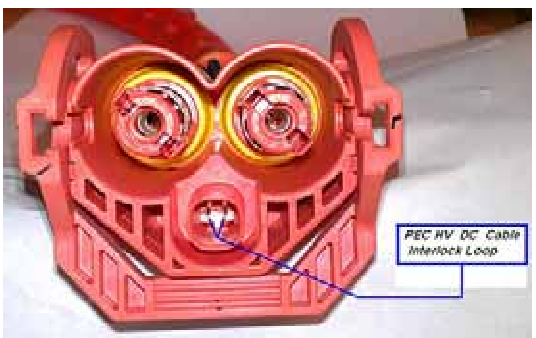
Connection	Measurement
17 to 19	

G

Purpose: *Check the high-voltage cable Interlock on the OEM Cable.*

1. Verify that the Inertia Switch is OK.
2. Measure resistance of the Interlock Pins on the OEM Cable.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.



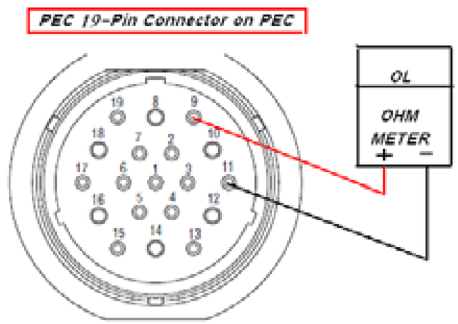
- If resistance is 0–0.3 ohms, replace the Relay Box. See the **MY09 PEC High-Voltage Relay Box Removal and Installation** procedure in TRSM2000, then go to **Step I.**
- If resistance is OL, replace the High-Voltage DC Cable, then go to **Step H.**

Connection	Measurement
Interlock positive (+)	
Interlock negative (-)	

H

Purpose: *Verify continuity of PEC Connector circuits to ground.*

1. Measure resistance on the PEC Connector (red Service Button Switch is pulled out):
   - Pin 9 to Pin 11
   - Pin 17 to Pin 19



- If any resistance is OL, replace the Relay Box (inspect wiring going into Relay Box before replacing). See the **MY09 PEC High-Voltage Relay Box Removal and Installation** procedure in TRSM2000, then go to **Step I.**

Connection	Measurement
Pin 9 to Pin 11	
Pin 17 to Pin 19	

I

Purpose:

1. Key off.
2. If vehicle is equipped with Export Power PEC, perform "High-Voltage Service Shutdown and Power-Up Procedure" on page 4, then remove High-Voltage DC/DC and/or APG High-Voltage Cable from the PEC. Install Interlock Caps if available:

- If vehicle is NOT equipped with Export Power, go to **Step K.**

J

Purpose:

1. After DC/DC and APG high-voltage cables are removed, pull out red Service Switch and connect 19-Way Connector at the PEC.
2. Key on:
   - If Fault Code 116/FMI 5 is still Active, go to **Step L.**
   - If Fault Code 116/FMI 5 is gone, go to **Step V.**

K

Purpose:

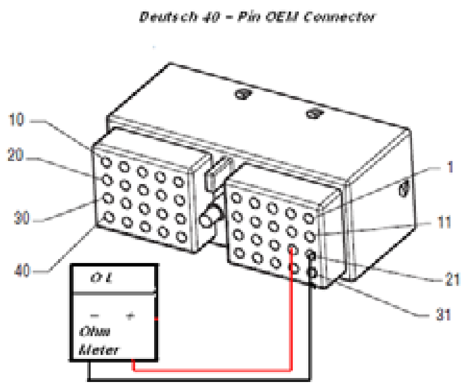
1. Key off.
2. Plug DC/DC and/or APG cables back into PEC and verify that Fault Code 116/FMI 5 is still Active:
   - If still Active, go to **Step L.**
   - If Inactive, the Auxiliary Relays inside the PEC are welded. Replace the PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation**, **Alternative Power Electric Carrier (PEC) Removal and Installation** or **4-Battery Power Electric Carrier (PEC) Removal and Installation** procedures in TRSM2000.

     Also, inspect the Auxiliary Relay Circuit for loose Interlock Connections causing relay chatter under load (see "Fault Code 118 - Auxiliary High Voltage Relay Control Circuit Fault" on page 386 for circuit description).

     After repairs are completed, go to **Step V.**

L ***Purpose:*** *Verify continuity of Inverter Connector circuits.*

1. Connect the PEC 19-Way Connector.
2. Disconnect the Inverter 40-Way Connector.
3. Measure resistance at the Inverter 40-Way OEM Connector Terminal at the following pins:
   - Pin 21 to Pin 31
   - Pin 22 to Pin 32
   - Pin 23 to Pin 33



- If the resistance between Pin 21 and Pin 31 is 112–122 ohms and the resistance from Pin 22 to Pin 32, and Pin 23 to Pin 33 are each 33–37 ohms, replace the Inverter (see **MY09 Inverter Removal and Installation**), then go to **Step V.**
- If resistance is out of range, repair the Vehicle Harness between the Inverter and the PEC, then go to **Step V.**

Connection	Measurement
Pin 21 to Pin 31	
Pin 22 to Pin 32	
Pin 23 to Pin 33	

M ***Purpose:*** *Measure battery voltage.*

1. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab.
2. Select the “Data Monitor” option.
3. View the following parameters in the high-voltage battery list:
   - HV Battery J1939 Data HV Battery: Parameter 520250 HV Battery1 Potential Voltage and Parameter 520323 Battery Voltage RB
4. Push in the red Service Button.
   - If the voltage readings on Battery1 Potential Voltage and Battery Voltage RB are within 10 volts of each other (Battery Voltage RB should drop to 30 volts when the red Service Switch was pushed in), replace the Relay Box. See the **MY09 PEC High-Voltage Relay Box Removal and Installation** procedure in TRSM2000, then go to **Step V.**

     Note: “High-Voltage Service Shutdown and Power-Up Procedure” on page 4 must be performed before removing high-voltage cable. (If main High-Voltage Relays are welded, remove high-voltage fuse located in Rear Access Panel before attempting any repairs).

   - If the voltage readings on Battery1 Potential Voltage and Battery Voltage RB are greater than 10 volts of each other (Battery Voltage RB should drop to 30 volts when the red Service Switch was pushed in), replace the Inverter (see **MY09 Inverter Removal and Installation**), then go to **Step V.**

Parameter	Reading
Battery1 Potential Voltage	
Battery Voltage RB	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Pull red Service Switch out.
4. Key on.
5. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
6. Drive the vehicle and attempt to recreate the code.
7. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 116 appears, find error in testing, go to **Step A.**
   - If a code other than 116 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 117 - Battery Control Unit Relay Cut Request Fault

J1939: SA 239 SPN 520251 FMI 3, 14, 29

Overview

The high-voltage relays are located inside the Power Electric Carrier (PEC). These relays are normally open when the system is off. The relays are controlled through the Inverter and monitored through a 5-volt input from the Inverter. If the relays are open, the voltage is around 5 volts and when the relays are closed the voltage is around 1 volt.

Detection

Fault is detected when:

- Inverter ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when Battery Control Unit (BCU) relay signal is set Active and the relay signal is set high for 0.02 seconds.
- FMI 14 is set when the BCU relay cut request is by a different Active BCU fault.
- FMI 29 is set when the Relay Off signal is Active.

Fallback

When Fault Code 117 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- Inverter shuts off high-voltage system.
- HCM continues to control the hybrid vehicle in a diesel-only mode.
- Transmission defaults start gear to 1st.

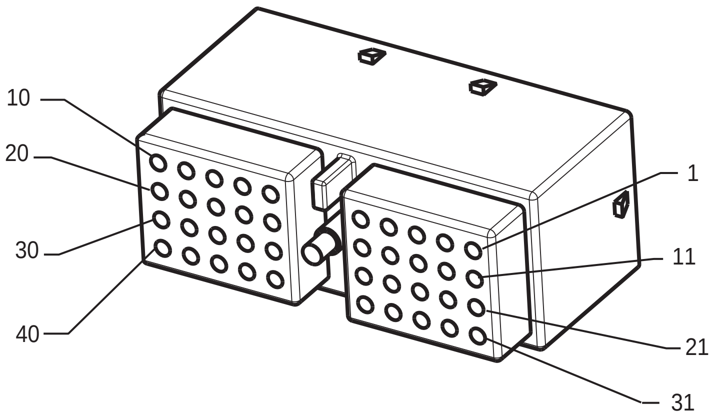
Possible Causes

This fault code can be caused by any of the following:

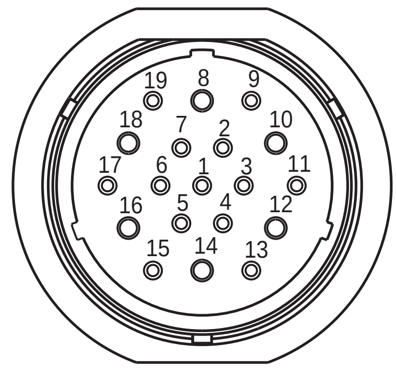
- FMI 3, 29
  - Inverter
  - Low-Voltage Wire Harness

Component Identification

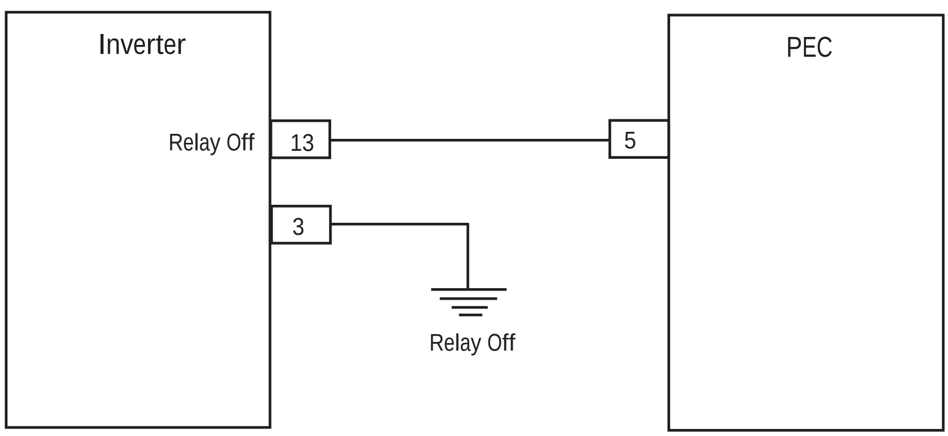
Deutsch 40-Way Mating Connector View
(Inverter - Low Voltage Connector)



Deutsch 19 - Way Mating Connector View
(PEC - Low Voltage Connector)



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 117 - Battery Control Unit Relay Cut Request Fault

A

Purpose: *Verify FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 14 is listed, test is complete. FMI 14 requires no action or replacement.
   - If FMI 3 or 29 are listed, go to **Step B.**

B

Purpose: *Verify fault codes present.*

1. View Active fault codes to see if any of the following are listed: 76, 78, 82, 101, 103, 105, 107, 108:
   - If any of the above fault codes are listed with Fault Code 117 FMI 3, go to tests for faults that are Active.
   - If none of the above fault codes are listed with FMI 3,
     go to **Step C.**
   - If none of the faults are listed with FMI 29,
     go to **Step D.**

C

Purpose: *Verify continuity between PEC Connector and Inverter Connector.*

1. Key off.
2. Disconnect the PEC 19-Way Connector.
3. Disconnect the Inverter 40-Way Connector.
4. Measure the resistance from the PEC 19-Way Connector Pin 5 to the Inverter 40-Way Connector Pin 13:
   - If the resistance between Pin 5 and Pin 13 is 0–0.3 ohms, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then
     go to **Step V.**
   - If resistance is outside of range, repair the HCM low-voltage Harness between the PEC and Inverter, then go to **Step V.**

Connection	Measurement
19-Way Pin 5 to 40-Way Pin 13	

D ***Purpose:*** *Verify continuity of Vehicle Harness and ground.*

1. Key off.
2. Remove the 40-Way Connector from the Inverter.
3. Use an ohm meter to measure the resistance from Pin 3 to ground at the Vehicle Harness:
   - If the resistance between Pin 3 to ground is 0–0.3 ohms, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair 40-Way Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin 3 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 117 appears, find error in testing, go to **Step A.**
   - If a code other than 117 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 118 - Auxiliary High Voltage Relay Control Circuit Fault

J1939: SA 239 SPN 520252 FMI 3, 4, 5

Overview

The auxiliary high-voltage relays, located in the Power Electric Carrier (PEC), are controlled by the Hybrid Control Module (HCM). At key on, high-voltage power is supplied from the Relay Box to the auxiliary high-voltage relays. When the ePTO option is selected on the Push Button Shift Control, the HCM energizes the control circuits for the main positive and main negative relays. The power then flows through the auxiliary high-voltage relays to the DC/DC Converter.

Detection

Fault is detected when:

- HCM ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when the HCM detects a short to battery in the coil circuit of the auxiliary high-voltage relay.
- FMI 4 is set when the HCM detects a short to ground in the coil circuit of the auxiliary high-voltage relay.
- FMI 5 is set when the HCM detects an open in the coil circuit of the auxiliary high-voltage relay.

Note: When troubleshooting an Inactive code refer to the “Product Diagnostic Mode (PDM)” on page 18.

Note: This fault may take up to 5 minutes to set if the code is Inactive. Leave key on for 5 minutes and proceed to FMI that is set.

Fallback

When Fault Code 118 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- The DC/DC Converter does not operate because the HCM de-energizes the auxiliary high-voltage relay circuit.

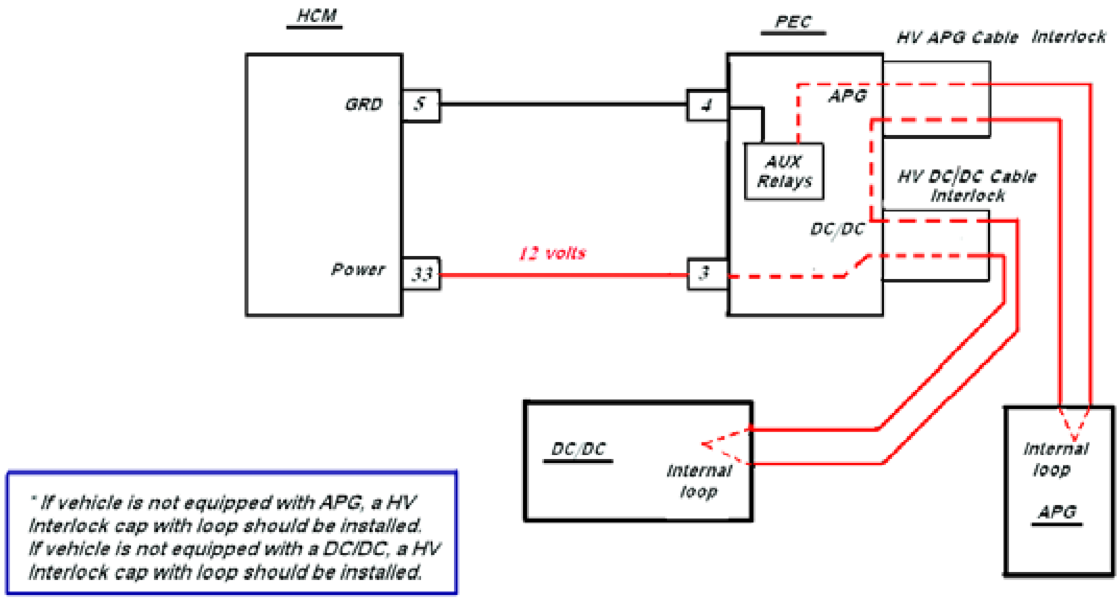
Possible Causes

This fault code can be caused by any of the following:

- FMI 3, 4, 5
  - OEM wiring from HCM to PEC
  - DC/DC cable high-voltage loop
  - DC/DC converter
  - Auxiliary Power Generator (APG) cable high-voltage loop (if equipped)
  - APG converter (if equipped)
  - Auxiliary high-voltage relay (inside PEC)

Component Identification

NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Fault Code 118 - Auxiliary High Voltage Relay Control Circuit Fault

A ***Purpose:*** *Verify Active or Inactive fault code status and FMIs present.*

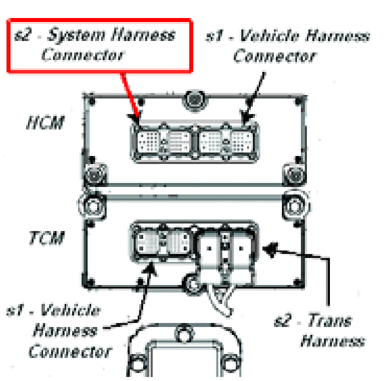
1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

⚠ **Danger:** See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

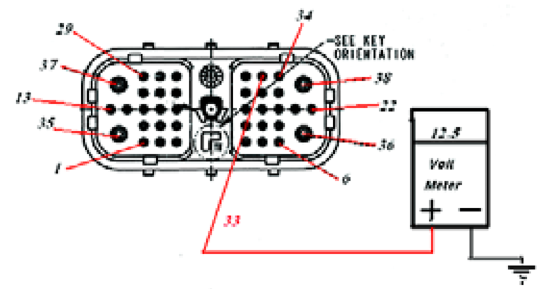
4. Which FMIs are present?
   - If FMI 3 is listed, go to **Step B.**
   - If FMI 4 is listed, go to **Step C.**
   - If FMI 5 is listed, go to **Step F.**

B ***Purpose:*** *Measure voltage of HCM Harness to ground.*

1. Key off.
2. Disconnect the HCM Harness 38-Way Connector.



3. Key on. Code 88 will set. Clear fault after testing.
4. Measure voltage on the following pins of the 38-Way wire harness:
   - Pin 33 to ground
   - Pin 5 to ground

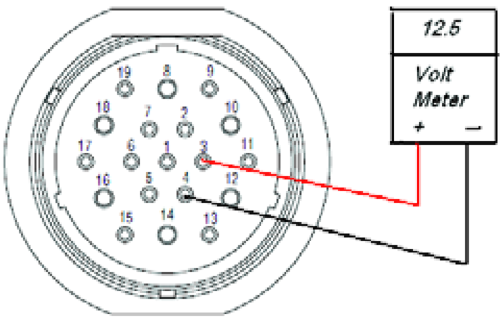


- If the voltage from Pin 33 to ground and Pin 5 to ground is 0 volts, replace the HCM (only if Fault Code is Active). See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM, then go to **Step V.**
- If the voltage is found on Pin 33 to ground or Pin 5 to ground, disconnect the 19-Way connector at PEC and retest.
- If voltage is still present, repair Vehicle Harness between HCM and PEC.
- If voltage is gone after retest, go to **Step C.**

Connection	Measurement
Pin 33 to ground	
Pin 5 to ground	

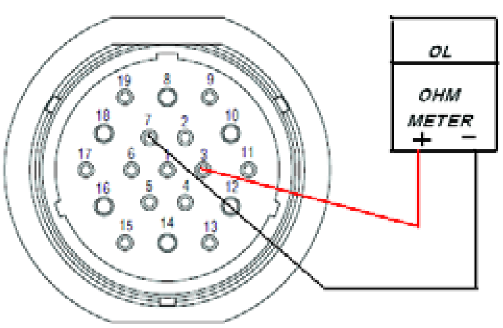
C ***Purpose:*** *Measure resistance of the HCM Harness circuit to ground.*

1. Key on.
2. Remove 19-Way Connector at PEC. Check for voltage on Pin 3 and Pin 4 on PEC.



- If any voltage is found perform the following steps:
  - Remove DC/DC high-voltage cable and retest.
  - Remove APG high-voltage cable and retest.
- Replace PEC if voltage is still present.

3. If no voltage is found, measure the resistance the PEC 19-Way Connector on the following pins:
   - Pin 3 to Pin 7
   - Pin 3 to Pin 10
   - Pin 3 to Pin 14
   - Pin 3 to PEC mounting stud

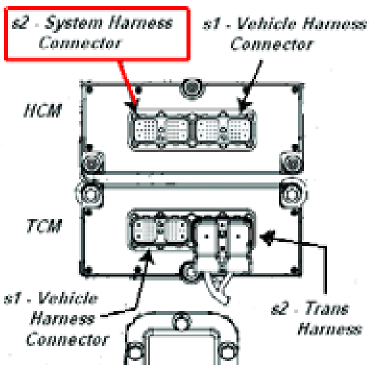


- If ohms are open circuit, reconnect DC/DC high-voltage cable and APG high-voltage cable and retest. If still an open circuit, go to **Step B.**
- If ohms show shorted circuit, remove DC/DC and APG high-voltage cables. If still shorted, replace the PEC. After repairs are made, go to **Step V.**
- If short is isolated to 1 high-voltage cable, check cable and component and ohm cable interlocks end-to-end. If those are good, replace shorted component (DC/DC Converter or APG Converter).

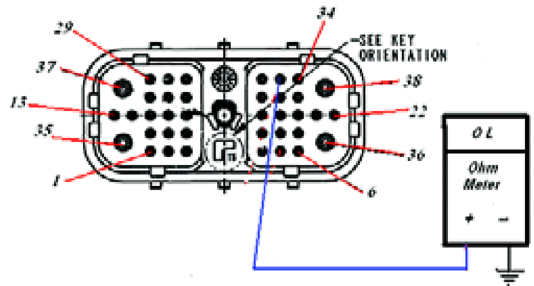
Connection	Measurement
Pin 3 (voltage)	
Pin 4 (voltage)	
Pin 3 to Pin 7 (resistance)	
Pin 3 to Pin 10 (resistance)	
Pin 3 to Pin 14 (resistance)	
Pin 3 to PEC mounting stud (resistance)	

D ***Purpose:*** *Test for a short to ground on the Vehicle Harness from the HCM to the PEC.*

1. Key off.
2. Disconnect the HCM 38-Way Connector. The PEC 19-Way Connector should be connected.



3. Measure the resistance of the 38-Way Connector on Pin 33 to ground.



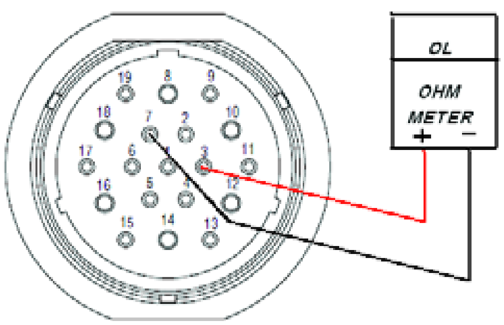
- If resistance is OL, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000.
- If resistance shows a short in circuit to ground, disconnect the 19-Way Connector at the PEC and retest Pin 33 to ground.
- If short is still present, repair the Vehicle Harness between the HCM and the PEC
- If short is gone, go to **Step E.**

Connection	Measurement
Pin 33 to ground	

E

Purpose: *Measure resistance from DC/DC Converter to ground.*

1. Key off.
2. Disconnect the 19-Way Connector from the PEC.
3. Measure resistance on the PEC 19-Way Connector on the following pins:
   - Pin 3 to Pin 7
   - Pin 3 to Pin 10
   - Pin 3 to Pin 14
   - Pin 3 to PEC mounting stud



- If resistance shows OL, go to **Step D.** Retest.
- If resistance shows short in circuit to ground, remove high-voltage DC/DC and APG cables one at a time to isolate circuit with short.
- If short is found in one of the auxiliary high-voltage cables, remove the high-voltage cable and ohm interlock pins end-to-end. If cable is good, replace shorted component (DC/DC Converter or APG Converter).
- If resistance still shows short with high-voltage cables removed, replace PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000. After repairs are complete, go to **Step V.**

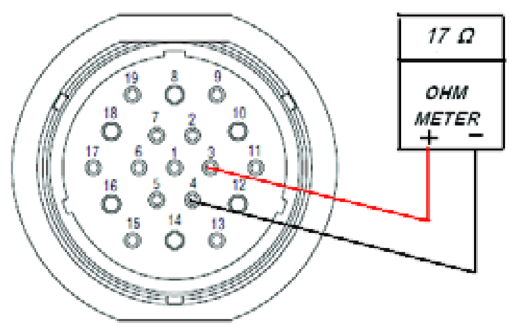
Connection	Measurement
Pin 3 to Pin 7	
Pin 3 to Pin 10	
Pin 3 to Pin 14	
Pin 3 to PEC mounting stud	

F

Purpose: *Measure resistance from DC/DC Converter to ground.*

1. Key off.

2. Remove the 19-Way Connector from the PEC.



3. Measure the resistance on the following pins on the PEC Connector:
   - Pin 3 to Pin 4
     - If resistance is 12–22 ohms, go to **Step I.**
     - If resistance is OL, go to **Step G.**

Connection	Measurement
Pin 3 to Pin 4	

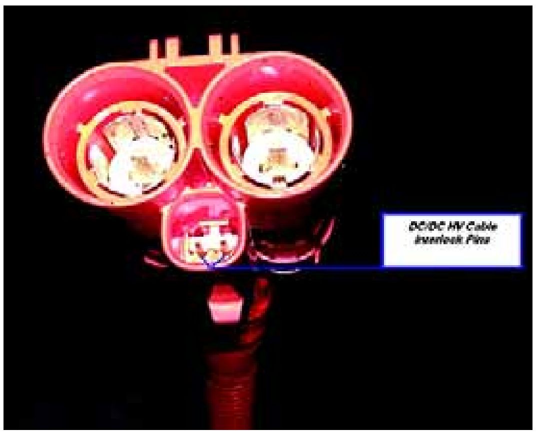
G

Purpose: *Verify continuity of the DC/DC cable*

1. Remove DC/DC High-Voltage Cable at PEC. Leave cable attached to DC/DC Converter.

   Note: If not equipped with DC/DC Converter, check Cap Interlock Loop.

2. Measure resistance on DC/DC High-Voltage Cable Interlock Pins.



- If resistance is 0–0.3 ohms, go to **Step H.**
- If resistance is OL, remove DC/DC High-Voltage Cable and ohm Interlock Pins end-to-end.
- If cable resistance is OL, replace DC/DC Cable.
- If cable resistance is 0–0.3 ohms, replace DC/DC Converter. See the **DC/DC Converter Removal and Installation** procedure in TRSM2000. After repairs are complete, go to **Step V.**

Connection	Measurement
DC/DC High-Voltage Interlock Pins	

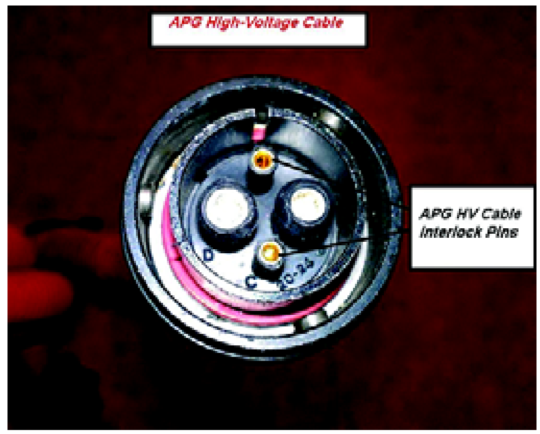
H

Purpose: *Verify continuity of the APG cable.*

1. Remove APG cable from PEC. Leave cable attached at APG end.

   Note: If not equipped with APG, check Cap Interlock Loop.

2. Measure resistance on APG High-Voltage Cable Interlock Pins.



- If resistance is 0–0.3 ohms, replace PEC. See the **MY09 Power Electric Carrier (PEC) Removal and Installation** procedure in TRSM2000. After repairs are made, go to **Step V.**
- If resistance is OL, remove APG High-Voltage Cable. Measure Interlock Pins end-to-end.
- If cable resistance is OL, replace APG High-Voltage Cable.
- If cable resistance is 0–0.3 ohms, replace APG. After making repairs, go to **Step V.**

Connection	Measurement
DC/DC High-Voltage Interlock Pins	

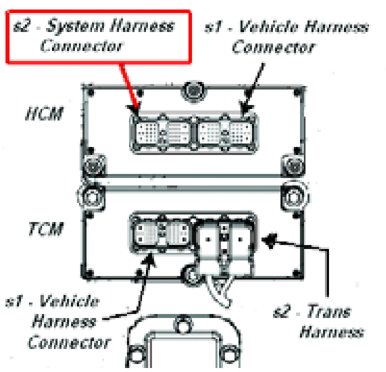
I

Purpose: *Measure resistance of the HCM.*

1. Key off.

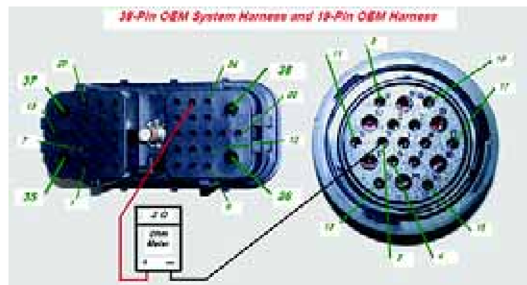
   Note: This step is performed after measuring the ohms on Pin 3 and Pin 4 and they measured between 12–22 ohms.

2. Remove the 38-Way Vehicle Harness Connector.



3. Remove the 19-Way Connector at the PEC.

4. Measure the following pins between the 38-Way Connector and the 19-Way Connector:
   - Pin 33 (38-Way Connector) to Pin 3 (19-Way Connector).
   - Pin 5 (38-Way Connector) to Pin 4 (19-Way Connector).



- If resistance is OL, repair Vehicle Harness between the HCM and the PEC.
- If resistance is between 0–0.3 ohms, replace HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000. After repairs are made, go to **Step V.**

Connection	Measurement
38-Way Pin 33 to 19-Way Pin 3	
38-Way Pin 5 to 19-Way Pin 4	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Key on.
4. Pull out red Service Switch on PEC.
5. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
6. Drive the vehicle and attempt to recreate the code.
7. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 118 appears, find error in testing, go to **Step A.**
   - If a code other than 118 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 120 - APG Unit 1 - AC Voltage Fault

J1939: SA 239 SPN 520275 FMI 3, 4

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter that is connected to the high voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120 volts AC power for utility applications.

Detection

Fault is detected when:

- APG inverter needs to be operating.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when output voltage is detected to be greater than or equal to 145 volts AC power.
- FMI 4 is set when output voltage is detected to be less than or equal to 75 volts AC power.

Fallback

When Fault Code 120 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- APG shuts down.

Possible Causes

This fault code can be caused by any of the following:

- FMI 3
  - APG
- FMI 4
  - Short phase to neutral in harness
  - Power Panel
  - APG
  - Potential output device causing surge

Component Identification

Note: No schematic for this code.

Fault Code 120 - APG Unit 1 - AC Voltage Fault

A

Purpose: *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If Fault Code 120 FMI 3 is Active, replace the APG, then go to **Step V.**
   - If Fault Code 120 FMI 4 is Active, go to **Step B.**

B

Purpose: *Verify integrity of APG.*

1. Key off.
2. Remove all loads from the APG.
3. Restart APG:
   - APG restarts, component external to APG is causing fault. Find faulty component, then go to **Step V.**
   - APG does not restart, replace the Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 120 appears, find error in testing, go to **Step A.**
   - If a code other than 120 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 122 - APG Unit 1 Output

J1939: SA 239 SPN 520277 FMI 6, 14, 15

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter that is connected to the high voltage DC bus of the Eaton hybrid electric vehicle system, and generates 60Hz single-phase 120 volt AC power for utility applications.

Detection

Fault is detected when:

- APG inverter needs to be operating.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 6 is set when multiple over current events are detected.
- FMI 14 is set when the APG has detected abnormally low impedance placed on output.
- FMI 15 is set when the APG output current limit (calculated or measure) was exceeded for the longer than allowed by the internal time limit.

Fallback

When FMI 6, 14, or 15 is set the following conditions occur:

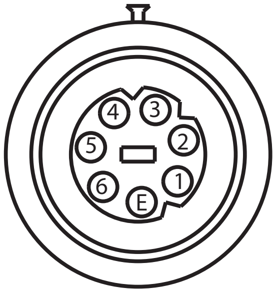
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- APG shuts down.

Possible Causes

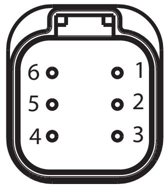
This fault code can be caused by any of the following:

- FMI 6, 15
  - Short phase to ground in harness
  - Output device causing surge
  - Power Panel
  - APG
- FMI 14
  - Component drawing excessive current

Component Identification



APG 7-way High-Voltage
AC Connector View



APG 6-way Low-Voltage
Connector View

Fault Code 122 - APG Unit 1 Output

A ***Purpose:*** *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If Fault Code 122, FMI 6 or 15 are Active, go to **Step B.**
   - If Fault Code 122 FMI 14 is Active, remove output devices, then go to **Step V.**

B ***Purpose:*** *Measure resistance from APG circuit to ground.*

1. Remove the 7-Way Connector at the APG.
2. Measure the resistance from the AC high-voltage cable on the following pins:
   - Pin 1 to ground
   - Pin 2 to ground
   - Pin 3 to ground
   - Pin 4 to ground
   - Pin 5 to ground
   - Pin 6 to ground

   - If the resistance is 10K ohms or greater, go to **Step C.**
   - If the resistance is less than 10K ohms, go to **Step D.**

Connection	Measurement
Pin 1 to ground	
Pin 2 to ground	
Pin 3 to ground	
Pin 4 to ground	
Pin 5 to ground	
Pin 6 to ground	

C

Purpose: *Measure resistance of APG circuit short to ground.*

1. Remove the 6-Way APG to Power Panel Connector from the APG.
2. Measure the resistance from the APG 6-Way Connector on the following pins:
   - Pin 1 to ground
   - Pin 2 to ground

   - If the resistance is 10K ohms or greater, replace the APG, then go to **Step V.**
   - If the resistance is less than 10K ohms, go to **Step E.**

Connection	Measurement
Pin 1 to ground	
Pin 2 to ground	

D

Purpose: *Measure resistance of APG circuit short to ground.*

1. Remove the 7-Way Connector at the Power Panel.
2. Measure the resistance from the AC high-voltage cable on the following pins:
   - Pin 1 to ground
   - Pin 2 to ground
   - Pin 3 to ground
   - Pin 4 to ground
   - Pin 5 to ground
   - Pin 6 to ground

   - If the resistance is 10K ohms or greater, replace the Power Panel, then go to **Step V.**
   - If the resistance is less than 10K ohms, replace the AC High-Voltage Harness, then go to **Step V.**

Connection	Measurement
Pin 1 to ground	
Pin 2 to ground	
Pin 3 to ground	
Pin 4 to ground	
Pin 5 to ground	
Pin 6 to ground	

E

Purpose: *Measure resistance of APG circuit short to ground.*

1. Remove the 6-Way APG to Power Panel Connector from the Power Panel.
2. Measure the resistance from the APG 6-Way Connector on the following pins:
   - Pin 1 to ground
   - Pin 2 to ground
   - If the resistance is 10K ohms or greater, replace the Power Panel, then go to **Step V.**
   - If the resistance is less than 10K ohms, replace the 6-Way Harness, then go to **Step V.**

Connection	Measurement
Pin 1 to ground	
Pin 2 to ground	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 122 appears, find error in testing, go to **Step A.**
   - If a code other than 122 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 123 - APG Unit 1 High Voltage Battery

J1939: SA 239 SPN 520278 FMI 3, 4

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter that is connected to the high voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications.

Detection

Fault is detected when:

- FMI 3, 4 - APG inverter needs to be operating.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 3 is set when high-voltage DC has been detected to exceed an upper limit.
- FMI 4 is set when high-voltage DC has been detected to drop below a lower limit.

Fallback

When Fault Code 123 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- APG shuts down, if operating.

Possible Causes

This fault code can be caused by any of the following:

- FMI 3
  - APG
- FMI 4
  - APG
  - Power Electric Carrier (PEC)
  - High-Voltage DC Cable

Component Identification

Note: No schematic for this code.

Fault Code 123 - APG Unit 1 High Voltage Battery

A

Purpose: *Check for Active or Inactive fault code status and FMIs present.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If Fault Code 123 FMI 3, or 4 is Active with an Active Hybrid System Fault, troubleshoot Active Hybrid Fault, then go to **Step V.**
   - If Fault Code 123 FMI 3, or 4 is Active without an Active Hybrid System Fault, replace the APG Inverter, then go to **Step V.**

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If Fault Code 123 appears, find error in testing, go to **Step A.**
   - If a code other than 123 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 125 - APG Unit 1 - Over Temperature

J1939: SA 239 SPN 520280 FMI 0

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter connected to the high-voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications. Fault Code 125 sets when the heat sink temperature exceeds the upper temperature limit for normal operation.

Detection

Fault is detected when:

- APG Inverter needs to be operating.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0 is set when the heat sink temperature at an unspecified module exceeds the upper temperature limit for normal operation.

Fallback

When Fault Code 125 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- APG shuts down, if operating.

Possible Causes

This fault code can be caused by any of the following:

- FMI 0
  - Cooling system
  - APG Temperature Sensor fault in range

Component Identification

Note: No schematic for this code.

Fault Code 125 - APG Unit 1 - Over Temperature

A ***Purpose:*** *Check for Active or Inactive fault code status and FMIs present.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 0 is Active, go to **Step B.**

B ***Purpose:*** *Verify proper coolant level.*

1. Observe the coolant level after the system has cooled verify it is filled to the proper level:
   - If the coolant is within the recommend limits, replace the APG Inverter, then go to **Step V.**
   - If the coolant is below the recommend limits, refer to OEM for coolant type and fill procedure, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If Fault Code 125 appears, find error in testing, go to **Step A.**
   - If a code other than 125 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 126 - APG Unit 1 Configuration

J1939: SA 239 SPN 520281 FMI 25, 26, 27

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter connected to the high-voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications.

Detection

Fault is detected when:

- APG Inverter needs to be operating.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 25 is set when a blown fuse is detected.
- FMI 26 is set when a low internal fan speed is detected.
- FMI 27 is set when there is an Inverter fault.

Fallback

When FMIs 25–27 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- APG does not start.

Possible Causes

This fault code can be caused by any of the following:

- FMIs 25–27
  - APG

Component Identification

Note: No schematic for this code.

Fault Code 126 - APG Unit 1 - Configuration

A ***Purpose:*** *Check for Active or Inactive fault code status and FMIs present.*

1. Review and follow the “Warnings & Cautions” on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMIs 25–27 are present, replace the APG. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If Fault Code 126 appears, find error in testing, go to **Step A.**
   - If a code other than 126 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 127 - APG Unit 1 Ambient Air Over Temperature

J1939: SA 239 SPN 520282 FMI 0

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter connected to the high-voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications. Ambient air temperature is measured with an internal sensor and sets a fault when the temperature reaches 140 °F (60 °C).

Detection

Fault is detected when:

- HCM is powered and ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 0 is set when the ambient temperature inside of the APG Inverter Case reaches 140°F (60°C).

Fallback

When FMI 0 is set the following conditions occur:

- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- APG shuts down.

Possible Causes

This fault code can be caused by any of the following:

- FMI 0
  - Faulty sensor
  - Ambient case temperature too high.

Component Identification

Note: No schematic for this code.

Fault Code 127 - APG Unit 1 Ambient Air Over Temperature

A ***Purpose:*** *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 0 is present, go to **Step B.**

B ***Purpose:*** *Verify proper coolant level.*

1. Ensure that the Inverter Cabinet is not exposed to external heat source.
2. Observe the coolant level after the system has cooled. Ensure it is filled to the proper level:
   - If the coolant is within the recommend limits, replace the APG Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If the coolant is below the recommended limits, refer to OEM for coolant type and fill procedure, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.
3. Key on.
4. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
5. Drive the vehicle and attempt to recreate the code.
6. Clear codes. See "Fault Code Retrieval and Clearing" on page 13.
   - If no codes, test is complete.
   - If code 127 appears, find error in testing, go to **Step A.**
   - If code other than 127 appears, go to "Fault Code Isolation Procedure Index" on page 14.

Fault Code 128 - APG Unit 1 CAN Fault

J1939: SA 239 SPN 520283 FMI 9

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter connected to the high-voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications. The Controller Area Network (CAN) is a high-speed twisted pair 500K proprietary data link that connects the HCM to the Electric Clutch Actuator (ECA), Power Electric Carrier (PEC), Inverter and APG. The link contains one 120 ohm resistor at each end. The link is used to transmit information specific to clutch position and power electronics operations.

Detection

Fault is detected when:

- HCM is powered and ignition voltage is greater than 7 volts and less than 16 volts.
- HCM Data Link fault (Fault Code 60) is not Active.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 9 is set if communication from the APG unit is not received for 7.5 seconds and it is expected to be received based on the configuration settings (vehicle type–model and number of APGs).

Fallback

When Fault Code 128 is set the following conditions occur:

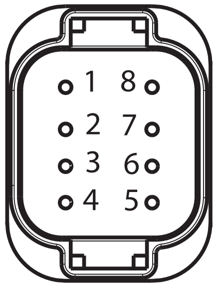
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.
- If the fault sets at command on, the APG remains off.
- If the fault sets during operation, the APG shuts off.

Possible Causes

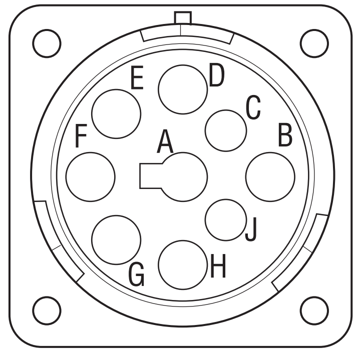
The following may cause this fault code:

- FMI 9
  - CAN Data Link near APG
  - APG

Component Identification



APG 8-way low-voltage harness connector



9-pin diagnostic connector

Fault Code 128 - APG Unit 1 - CAN Fault

A

Purpose: *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Which FMIs are present?
   - If FMI 9 is Active, go to **Step B.**

B

Purpose: *Verify resistance at the Diagnostic Connector.*

1. Measure the resistance between the following:
   - 9-Way Diagnostic Connector Pin H and Pin J
   - 2-Way Data Link Connector Pin 1 and Pin 2
   - 3-Way Data Link Connector Pin A and Pin B

Note: The 3-Way and 2-Way Data Link Connectors are located next to the 9-Way Diagnostic Connector.

Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

- If the resistance between Pin H and Pin J, Pin A and Pin B, or Pin 1 and Pin 2 is between 50–70 ohms,
go to **Step C.**
- If the resistance is more than 70 ohms, one or more of the terminating resistors on the CAN Data Link Harness is either missing or out of range, or there is an open in the link. Repair the OEM CAN Data Link Harness, then go to **Step V.**
- If the resistance is less than 50 ohms, there is an additional terminating resistor present. Repair the OEM CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
9-Way Pin H to Pin J	
2-Way Pin 1 to Pin 2	
3-Way Pin A to Pin B	

C

Purpose: *Verify resistance of APG Harness.*

1. Key off.
2. Disconnect the negative battery cable.
3. Disconnect the APG 8-Way Connector at the APG.
4. Measure the resistance between APG 8-Way Connector Pin 4 and Pin 5:

Note: Make sure the volt/ohm meter is on the proper scale (around 200 ohm scale).

- If the resistance between Pin 4 and Pin 5 is between 110–130 ohms, replace the APG Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
- If the resistance is outside the range, repair the CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin 4 to Pin 5	

V

Purpose: *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Key on.
4. Operate the APG and attempt to reset the code.
5. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.

- If no codes, test is complete.
- If Fault Code 128 appears, find error in testing, go to **Step A.**
- If a code other than 128 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Fault Code 165 - APG Unit 1 Configuration Error

J1939: SA 239 SPN 520320 FMI 2

Overview

The Auxiliary Power Generator (APG) is a 5kW/5kVA DC/AC inverter connected to the high voltage DC bus of the Eaton hybrid electric vehicle system. It generates 60 Hz single-phase 120V AC power for utility applications. The Hybrid Controller Module (HCM) can be configured for up to 2 APG units.

Detection

Fault is detected when:

- HCM is powered and ignition voltage is greater than 7 volts and less than 16 volts.

Conditions to Set Fault Code Active

The following conditions may set the fault Active:

- FMI 2 is set when the number of APGs responding on the link is different than the number of APGs configured in the HCM.

Fallback

When Fault Code 165 is set the following conditions occur:

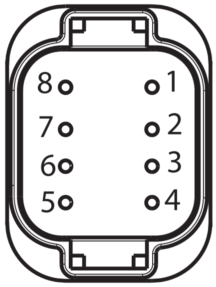
- Amber “Check Hybrid” light illuminates.
- Fault is stored in HCM memory.

Possible Causes

This fault code can be caused by any of the following:

- FMI 2
  - HCM configuration

Component Identification



APG 8-way low-voltage connector view

Fault Code 165 - APG Unit 1 - Configuration Error

A

Purpose: *Verify Active or Inactive fault code status and FMIs present.*

1. Review and follow the "Warnings & Cautions" on page 1.
2. Retrieve Active fault codes and FMIs with ServiceRanger using the 9-Way Diagnostic Connector.
3. Key off.

Danger: See "High-Voltage Service Shutdown and Power-Up Procedure" on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

4. Is fault code 165 Active?
   - If Fault Code 165 is Active, go to **Step B.**

B

Purpose: *Verify proper configuration of APGs on ServiceRanger.*

1. Does APG configuration in ServiceRanger match the number of installed APG units?
   - If yes, go to **Step C.**
   - If no, set configuration equal to number of installed APG units, then go to **Step V.**

C

Purpose: *Verify resistance of APG Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect the APG 8-Way Connector at the APG.
4. Measure the resistance between APG 8-Way Connector Pin 4 and Pin 5:

   Note: Make sure the volt/ ohm meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 4 and Pin 5 is between 50–70 ohms, replace the APG Inverter. See the **MY09 Inverter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If resistance is outside of range, repair the CAN Data Link Harness, then go to **Step V.**

Connection	Measurement
Pin 4 to Pin 5	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors and the negative battery cable.

Danger: See “High-Voltage Service Shutdown and Power-Up Procedure” on page 4. Follow the procedures to avoid shock, burn or death from improperly handled high-voltage.

3. Key on.
4. Operate the APG and attempt to reset the code.
5. Check for codes. See “Fault Code Retrieval and Clearing” on page 13.
   - If no codes, test is complete.
   - If code 131 appears, find error in testing, go to **Step A.**
   - If a code other than 131 appears, go to “Fault Code Isolation Procedure Index” on page 14.

Front Box Test

Overview

This symptom-driven test is performed if a dash (-) or flashing gear is displayed on the gear display, and there are no Active or Inactive codes. Turn the key on and watch the gear display. If the gear display shows a dash constantly, the Transmission Electronic Control Unit (TECU) was not able to confirm Front Box control. If the transmission displays a flashing gear when a forward or reverse mode is selected, the transmission is not able to engage the gear position.

Note: This symptom-based test should only be performed if when sent here from the Diagnostic Procedure and you have no Active fault codes.

Detection

The following symptoms may be experienced:

- Power up, no crank and the gear display shows a dash (-)
- Transmission does not engage a gear from neutral (flashing gear number is gear display).

Fallback

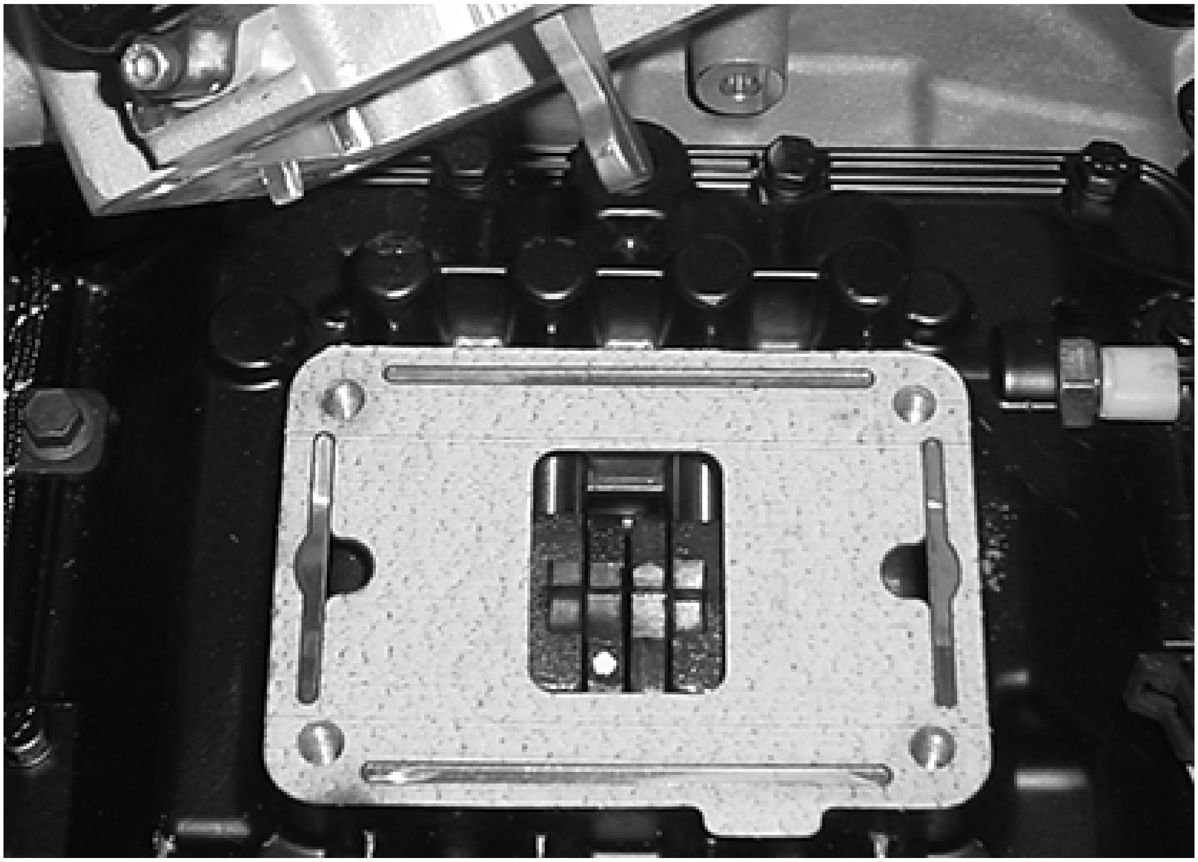
There is no fallback mode for this symptom; however, the vehicle will either not crank if the dash is present, or not engage a gear if the flashing gear is present when a non-neutral gear is selected.

Possible Causes

This symptom can be caused by any of the following:

- Low power to Gear Select Motor
- Electric Shifter
- Gear Select Sensor
- Yoke/Clutch/Main Shaft
- Shift Bar Housing
- Dragging clutch
- Torque locked in gear

Component Identification



Note: The picture above shows the shift forks in the neutral position.

Front Box Test

A ***Purpose:*** *Visually observe the Gear Display after power up.*

1. You should only perform this symptom test if you were sent here from the Diagnostic Procedure and you have no Active fault codes.
2. Key on.
3. Press N on the Push Button Shift Control.
4. Observe gear display.
   - If gear display shows: “N”, go to **Step B.**
   - If gear display shows: “-”, go to **Step C.**

Parameter	Reading
Gear Display	

B ***Purpose:*** *Visually observe the Gear Display when placing the transmission into Drive.*

1. Press service brake and select “D.”
2. Observe gear display.
   - If gear display shows a solid gear, test is complete.
   - If gear display shows a flashing gear with no arrows, go to **Step C.**

Parameter	Reading
Gear Display	

C ***Purpose:*** *Visually observe the Gear Display when placing the transmission into Drive.*

1. Key off.
2. Attempt to remove any type of torque lock on the vehicle drivetrain through one of the following methods:
   - Remove the Driveshaft
   - Lift the Drive Wheels off the ground
   - Roll the vehicle in neutral
3. Key on.
4. Observe gear display.
   - If gear display shows a solid “N”, go to **Step B.**
   - If gear display still shows a solid “-”, go to **Step D.**

Parameter	Reading
Gear Display	

D ***Purpose:*** *Perform Electrical Pretest*

1. Perform Electrical Pretest.
   - If no issues found during the Electrical Pretest, go to **Step E.**
   - If issue was repaired during the Electrical Pretest, go to **Step A.**

E ***Purpose:*** *Verify Electric Shifter performs a calibration sweep.*

1. Key on.
2. Listen for noise from the Electric Shifter calibrating/actuating then turn key off. Listen for the same noise again.
   - If the Electric Shifter can be heard calibrating/actuating, go to **Step F.**
   - If the Electric Shifter can not be heard calibrating, go to **Step F.**

F ***Purpose:*** *Remove Electric Shifter from the Shift Bar Housing and inspect the mechanical transmission.*

1. Key off.
2. Remove Electric Shifter from Shift Bar Housing.
3. Inspect the following:
   - Shift blocks are fastened to shift rails securely
   - Shift rails move into each gear position
   - Electric Shifter is free from any excessive lube contamination buildup
   - Two gear positions can not be engaged at the same time
   - If no problem found and you could not hear the Electric Shifter actuation in the previous step, replace the **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If no problem found and you could hear the Electric Shifter actuation in the previous step, replace the Electric Shifter. See the **Electric Shifter Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If problem is found, repair as required, then go to **Step V.**

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Place Shift Control into neutral.
4. Key on.
   - If gear display displays a solid "N", test is complete.
   - If gear display does not display a solid "N", find error in testing, go to **Step A.**

Parameter	Reading
Gear Display	

Engine Crank Test

Overview

This symptom-driven test is performed if a “N” is displayed on the gear display with no Active or Inactive codes and the vehicle will not crank.

The Hybrid Control Module (HCM) receives the input to crank from Pin 20 on the HCM 38-Way Vehicle Connector, which is wired to the key switch. The HCM normally powers the high-voltage Motor/Generator to start the engine. If the hybrid system is offline, the HCM uses the standard 12-volt Starter by energizing the 12-volt Cranking relay. This relay provides battery power to Pin 30 of the Start Enable Relay, which then powers the Starter Solenoid.

Note: This symptom-based test should only be performed if you were sent here from the Diagnostic Procedure and you have no Active fault codes.

Detection

The following symptoms may have been experienced:

- Vehicle does not crank or there is a solid “N” in the gear display.

Fallback

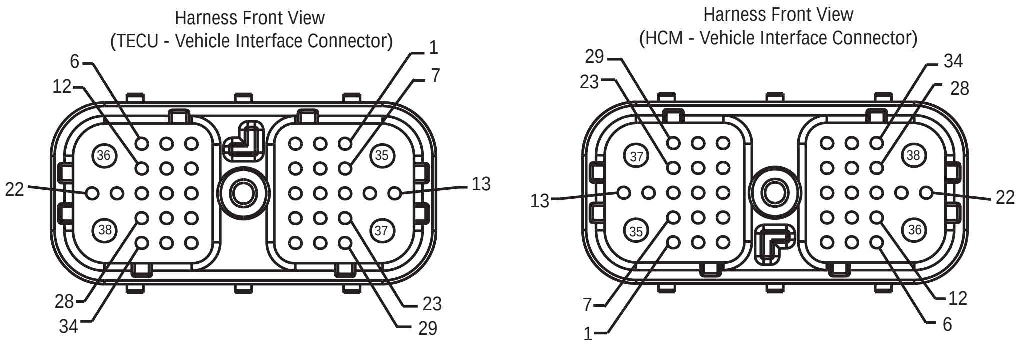
No fallback options are associated with this fault.

Possible Causes

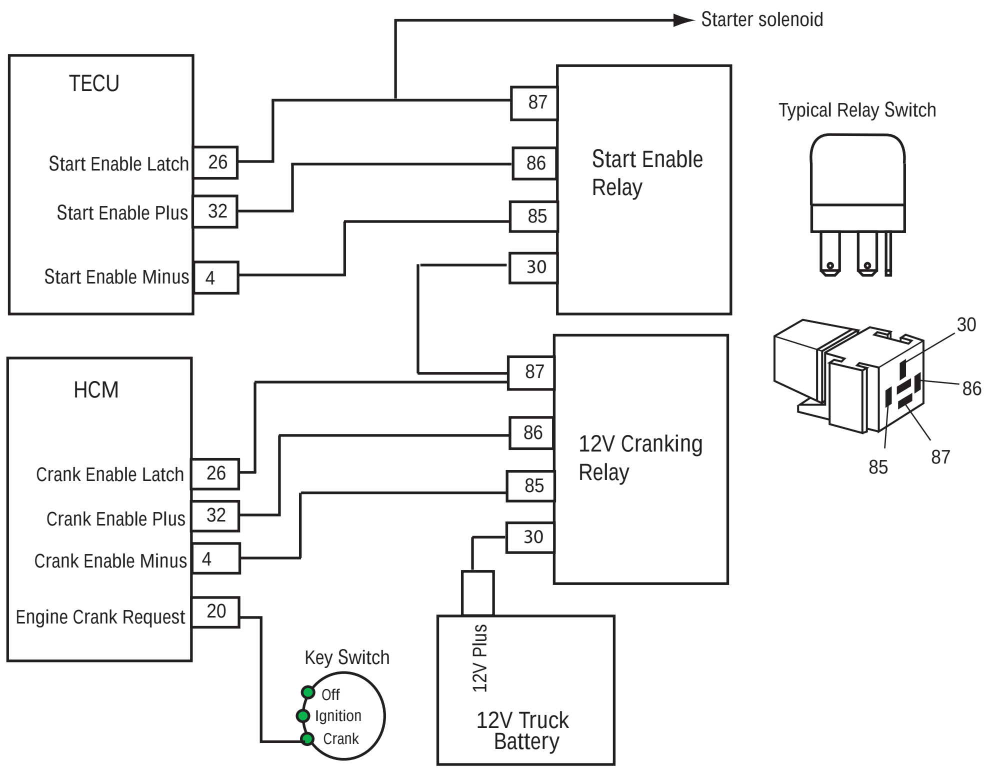
This symptom can be caused by any of the following:

- 12-volt Cranking Relay
- Start Enable Relay
- OEM Vehicle Harness
- Engine Starter
- 12-volt batteries
- Key switch input to Pin 20 of the HCM

Component Identification



NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations



Engine Crank Test

A

Purpose: *Visually observe the gear display after power up.*

1. You should only perform this symptom test if you were sent here from the “Hybrid Diagnostic Procedure” and you have no Active fault codes.
2. Key on.
3. Press “N” on the Push Button Shift Control:

   Note: The “ePTO” light must be off when using the key switch to start the vehicle.

   - If “N” is present on the gear display, go to **Step B.**
   - If “N” is not present on the gear display, refer to the diagnostic procedure for the correct symptom-based test to perform.

B

Purpose: *Verify Crank Request parameter.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector.
3. Select the Data Monitor option and view the “Crank Request” parameter.
   - If Crank Request reads 1 (Crank), go to **Step C.**
   - If Crank Request reads 0 (No Crank), go to **Step E.**

Parameter	Reading
“Crank Request”	

C

Purpose: *Verify integrity of the Cranking Relay.*

1. Substitute a different Start Enable and 12-volt Cranking Relay.
2. Attempt to crank engine.
   - If engine cranks, pinpoint which of the 2 relays was at fault and replace it. Then, go to **Step V.**
   - If engine does not crank, go to **Step D.**

D

Purpose: *Verify power to the Start Enable Relay.*

1. Key on.
2. Jumper Pin 87 of the Start Enable Relay Connector to battery power.
   - If engine cranks, repair open circuit between Pin 87 of the Start Enable Relay and battery. Refer to OEM for repair procedures.
   - If engine does not crank, problem is with Starter Solenoid or power harness to solenoid. Refer to OEM for repair procedures.

E ***Purpose:*** *Verify voltage to ground on HCM Harness.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect HCM Vehicle Harness 38-Way Connector.
4. Key in start position.
5. Measure voltage from HCM Vehicle Harness 38-Way Connector Pin 20 to ground:
   - If voltage is 11–13 volts, replace the HCM. See the **Hybrid Control Module (HCM) Removal and Installation** procedure in TRSM2000, then go to **Step V.**
   - If voltage is below 11 volts, repair the OEM vehicle harness, then go to **Step V.**

Connection	Measurement
Pin 20 to ground	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Place Shift Control into neutral.
4. Key on.
   - If engine starts, test is complete.
   - If engine does not start, find error in testing, go to **Step A.**

Hybrid Performance Test

Overview

The hybrid system uses a combination of diesel engine and electric power to provide varying levels of torque during vehicle operation. If the hybrid system has a fault, or if a hybrid component is above the optimum operating temperature, the vehicle reduces the amount of available Motor/Generator torque.

Note: Some faults codes affect the amount of torque available from the Motor/Generator which will be noticeable to the driver.

Note: This symptom-based test should only be performed if you were sent here from a diagnostic procedure and you have no Active fault codes.

Detection

The following symptoms may be experienced:

- Unacceptable vehicle acceleration performance.

Fallback

Some faults codes affect the amount of torque available from the Motor/Generator and will be noticeable to the driver.

Possible Causes

This symptom can be caused by any of the following:

- Hybrid liquid cooling system.
- Power Electric Carrier (PEC) air cooling system restriction or poor air flow.
- Reduce engine power.
- Truckload capacity above the rated amount.

Component Identification

Note: No schematic for this test.

Hybrid Performance Test

A ***Purpose:*** *Verify engine torque.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab and view the following Data Monitor parameters under the hybrid (engine and brake) list:
   - SPN 513 “Actual Engine Torque”
   - SPN 518 “Requested Engine Torque”
   - If actual torque is equal to requested torque, go to **Step B.**
   - If actual torque is less than requested torque, refer to OEM for engine power problem. Then go to **Step V.**

Parameter	Reading
SPN 513 “Actual Engine Torque”	
SPN 518 “Requested Engine Torque”	

B ***Purpose:*** *Verify battery temperature.*

1. Select the “Data Monitor” option and view the following parameter:
   - “Battery Temperature” PID 115
   - If battery temperature is below 40 °C, refer to OEM for engine power problem, then go to **Step V.**
   - If temperature if above 40 °C, inspect the battery cooling system for the following:
     - Plugged intake or exhaust ports
     - Restricted or plugged air filter
     - Failed battery cooling fan
   - Refer to the OEM for procedures and specifications. Make necessary repairs, then go to **Step V.**

Parameter	Reading
PID 115 “Battery Temperature”	

V ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Place shift control into neutral.
4. Key on.
   - If vehicle exhibits normal amount of power, test is complete.
   - If vehicle seems to produce lack of power, find error in testing, go to **Step A.**

ServiceRanger Test

J1939: SA 3 SPN FMI

Overview

The service tool ServiceRanger communicates with both the Hybrid Control Module (HCM) and the Transmission Electronic Control Unit (TECU) for all diagnostic information over the J1587 and J1939 Data Links. The tool connects to the standard 9-way diagnostic connector in the cab.

Note: All Hybrid systems require the new ServiceRanger Midas along with the Nexiq USB Communication Box.

Note: This symptom-based test should only be performed if when directed by the Symptom-Driven Diagnostic Index.

Detection

The following symptoms may have been experienced:

- ServiceRanger does not communicate with vehicle.

Fallback

No fallback condition exists for this symptom.

Possible Causes

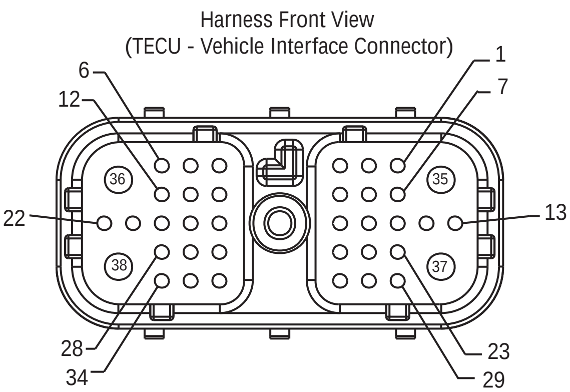
This fault code can be caused by any of the following:

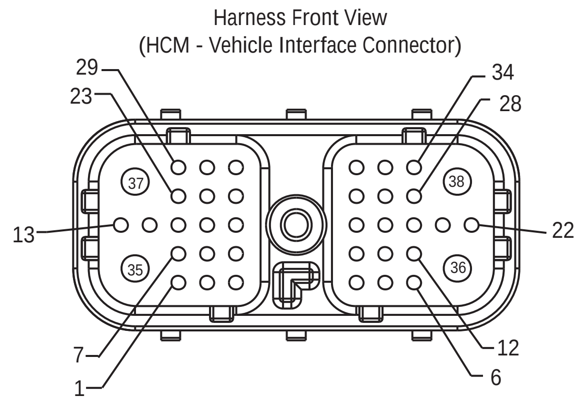
- Incorrect ServiceRanger software version
- Incompatible Communication Box
- J1939 or J1587 Data Link
- 9-way diagnostic connector power or ground
- HCM
- TECU

Additional Tools

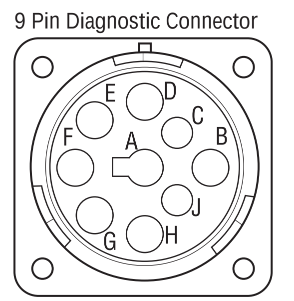
- Basic hand tools
- Eaton® Test Adapter Kit J43318
- Digital volt/ohm meter J46708
- ServiceRanger

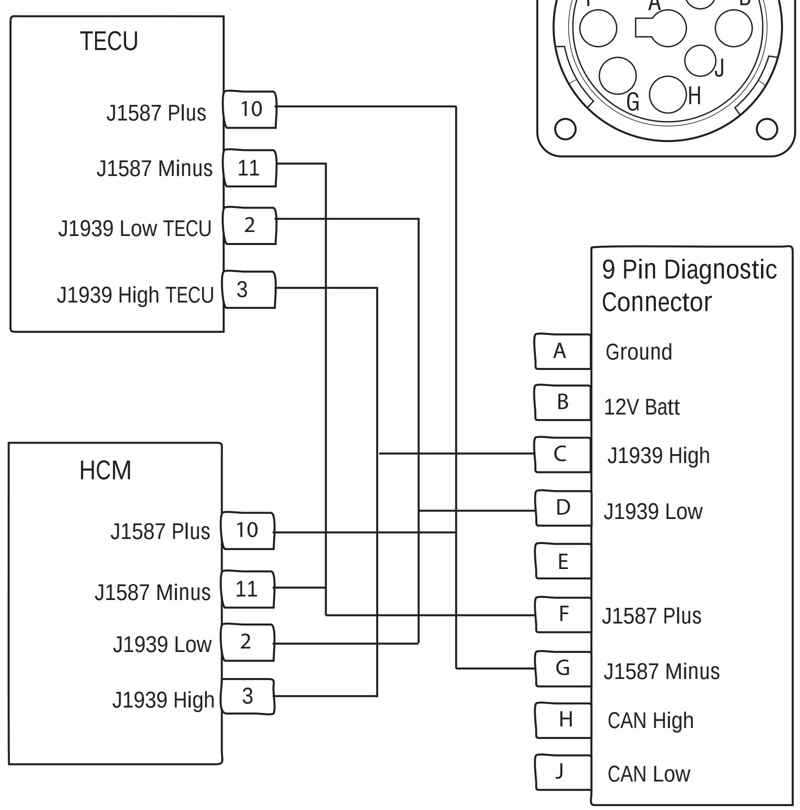
Component Identification





NOTE: Refer to the Eaton Hybrid Component and Connector Location page for Connector Locations





ServiceRanger Test

A

Purpose: *Verify ServiceRanger connects.*

1. You should only perform this symptom test when directed by the Symptom-Driven Diagnostic Index.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector in the cab.
3. Select the green “Connect” tab:
    - If the ServiceRanger screen comes up, go to **Step B.**
    - If ServiceRanger shows a “Failed to Connect” error message, go to **Step D.**

B

Purpose: *Verify both J-1587 and J-1939 are available.*

1. View the J1587 and J1939 connection icons at the bottom of the ServiceRanger screen:
    - If both data link lights are highlighted green, go to **Step C.**
    - If either data link light is highlighted red, go to **Step E.**

C

Purpose: *Verify both HCM and TECU available on J-1587 and J-1939.*

1. View the Vehicle Components selection in ServiceRanger and note if the HCM and TECU are both listed on J1587 and J1939:
    - If the TECU and HCM both appear on the list twice, ServiceRanger is communicating with the vehicle and has full functions available to it. Go to **Step V.**
    - If the TECU or HCM are missing from the list but the other modules are listed, go to **Step G.**

D

Purpose: *Verify voltage at 9-Way Diagnostic Connector.*

1. Key on.
2. Disconnect ServiceRanger from the 9-Way Diagnostic Connector.
3. Measure voltage at the 9-Way Diagnostic Connector from Pin A to Pin B:
    - If voltage is 11–13 volts, concern is with the Communication Box or Cable. Try another Communication Box and Cable. Go to **Step V.**
    - If voltage is out of range, repair the Power Supply to the 9-way connection, then go to **Step A.**

Connection	Measurement
Pin A to Pin B	

E *Purpose:* Verify J-1587 continuity at 9-Way Diagnostic Connector.

1. Key off.
2. Measure resistance between the following pins at the 9-way diagnostic connector:
   - F to G
   - F to ground
   - If resistance from Pin F to Pin G is 1.8K–2.5K ohms and resistance from Pin F to ground is 10k ohms or greater, go to **Step F.**
   - If resistance is outside of range, repair the Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin F to Pin G	
Pin F to ground	

F *Purpose:* Verify J-1939 continuity at 9-Way Diagnostic Connector.

1. Key off.
2. Measure resistance between the following pins at the 9-Way Diagnostic Connector:
   - C to D
   - C to ground
   - If resistance from Pin C to Pin D is 50–60 ohms and resistance from Pin C to ground is 10k ohms or greater, concern is with one of the following areas:
     - PC
     - Communication Box
     - Cables
   - Refer to the “Diagnostic Tools” section for list of compatible diagnostic tools. If concern is still present, contact Eaton at 1-800-826-HELP (4357).
   - If resistance is outside of range, repair the OEM Vehicle Harness, then go to **Step V.**

Connection	Measurement
Pin C to Pin D	
Pin C to ground	

G — ***Purpose:*** *Verify powers and grounds.*

1. Perform the Electric Pretest:
   - If the Electrical Pretest passes, and there is no communication with the HCM, go to **Step H.**
   - If the Electrical Pretest passes, and there is no communication with the TECU, go to **Step I.**
   - If the Electrical Pretest finds an issue, repair the concern and go to **Step A.**

H — ***Purpose:*** *Verify J-1939 continuity at HCM 38-Way Connector.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect HCM Harness 38-Way Connector.
4. Measure resistance between HCM Harness 38-Way Connector Pin 2 and Pin 3:

   Note: Make sure the Volt/Ohm Meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 2 and Pin 3 is between 50–70 ohms, replace the **Hybrid Control Module (HCM) Removal and Installation**, then go to **Step V.**
   - If resistance is outside of range, repair J1939 Data Link Harness between HCM and closest connector, then go to **Step V.**

Connection	Measurement
Pin 2 to Pin 3	

I — ***Purpose:*** *Verify J-1587 continuity at TECU 38-Way Connector.*

1. Key off.
2. Disconnect negative battery cable.
3. Disconnect TECU Harness 38-Way Connector.
4. Measure resistance between TECU Harness 38-Way Connector Pin 10 and Pin 11.

   Note: Make sure the Volt/Ohm Meter is on the proper scale (around 200 ohm scale).

   - If resistance between Pin 10 and Pin 11 is between 0–0.3 ohms, replace **Transmission Electronic Control Unit (TECU)**, then go to **Step V.**
   - If resistance is outside of range, repair J1939 Data Link Harness between HCM and closest connector, then go to **Step V.**

Connection	Measurement
Pin 10 to Pin 11	

V — ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Place Shift Control into neutral.
4. Key on:
   - If ServiceRanger communicates with both the HCM and the TECU, test is complete.
   - If ServiceRanger fails to communicate with the HCM and TECU, go to **Step A.** Find error in testing.

Gear Engagement Test

Overview

Hybrid Control Module (HCM) normally commands the different gears shifts which are completed through the Transmission Electronic Control Unit (TECU). The HCM also controls the Electric Clutch Actuator (ECA), which changes the position of the clutch.

Note: This symptom-based test should only be performed if you were sent here from a diagnostic procedure and you have no Active fault codes.

Detection

The following symptoms may have been experienced:

- Transmission does not engage a gear from neutral and warning tone sounds (solid “N” in gear display).
- Transmission does not engage a gear from neutral (flashing gear in gear display). This symptom is addressed in the Front Box symptom test.
- Transmission does not move from a stop (solid gear number in gear display).

Fallback

No fallback condition exists for this symptom.

Possible Causes

This symptom can be caused by any of the following:

- Transmission
- Service Brake Switch
- Boom/Outrigger switch

Component Identification

Messages from the Body Controller to the HCM

Signal	Value	Meaning	Description
Prohibit Driving	0	Allow Driving	Body Controller is requesting the HCM not allow gear engagement
	1	Prohibit Driving	

Messages from the Engine, Chassis, or Body Controller to the TECU

Signal	Value	Meaning	Description
Brake Switch	0	Not Applied	The ECU is confirming the current state of the service brake switch.
	1	Applied	

Gear Engagement Test

A ***Purpose:*** *Visually observe the gear display after power up.*

1. You should only perform this symptom test if you were sent here from a diagnostic procedure and you have no Active fault codes.
2. Press N on the Push Button Shift Control.
   - If "N" is present on the gear display, go to **Step B.**
   - If "N" is not present on the gear display, refer to the diagnostic procedure for the correct symptom-based test to perform.

B ***Purpose:*** *Visually observe the gear display when placing the transmission into Drive.*

1. Key on.
2. Start engine.
3. Press Service Brake and select D.
   - If gear display shows "N" and a warning tone sounds, go to **Step D.**
   - If gear display shows a flashing gear with no arrows, go to "Front Box Test" on page 423.
   - If gear display shows a solid gear, but vehicle does not move, go to **Step C.**

C ***Purpose:*** *Confirm the proper parameter configuration to prohibit driving.*

1. Key on.
2. Connect ServiceRanger and view the following:
   - Data Monitor parameter PID 154 "Prohibit Driving"
   - "Prohibit Driving" reads 0 (allow driving).
   - Contact Eaton at 1-800-826-HELP [4357].
   - "Prohibit Driving" reads 1 (prohibit driving).
   - Ensure boom and outriggers are fully retracted. Contact your OEM for repair procedures, then go to **Step V.**

Parameter	Reading
PID 154 Prohibit Driving	

D | ***Purpose:*** *Verify proper brake status signal.*

1. Key on.
2. View the following Data Monitor parameter while pressing the Service Brake.
   - SPN 597 “Service Brake Status”
   - If the Service Brake Switch status is pressed when you apply the brakes, contact Eaton at 1-800-826-HELP [4357].
   - If the Service Brake Switch does not change status, repair Service Brake wiring or switch. Contact your OEM for repair procedures then go to **Step V.**

V | ***Purpose:*** *Verify repair.*

1. Key off.
2. Reconnect all connectors.
3. Place Shift Control into neutral.
4. Key on.
   - If the transmission engages a gear and moves from a stop, test is complete.
   - If the transmission does not engage a gear or move from a stop, go to **Step A.** Find error in testing.

ePTO Test

Overview

The ePTO feature allows the diesel engine to remain off for extended periods of time during PTO usage. The DC/DC Converter is energized only in ePTO mode so it can charge the 12-volt battery system. The Hybrid Control Module (HCM) operates the Motor/Generator to power the transmission mounted PTO. If the high-voltage batteries get low, the HCM starts the engine with the Motor/Generator or the standard 12-volt system.

Select ePTO mode by pressing the Mode button on the Push Button Shift Control. Some applications use a Chassis or Body Controller to control the PTO and send information to the HCM. Other applications use the HCM to control and confirm engagement of the PTO. The Body Controlled option is referred to as the J1939 option and the HCM controlled is referred to as the Analog option.

Note: To determine which module is controlling the PTO, connect ServiceRanger and select the “Roadranger Configurations” screen. Under the Hybrid Control Module option is a listing for PTO Feedback, which is either Analog Controlled (HCM), or J1939 Controlled (Body Controller).

Note: This symptom-based test should only be performed as directed by a diagnostic procedure and you have no Active fault codes.

Detection

The following symptoms may be experienced:

- ePTO light does not illuminate when mode is selected.
- ePTO light flashes and the push button tone sounds.
- ePTO light is lit, but the hydraulic lift does not operate when the controls are used.
- ePTO light is lit, but the PTO pump fails to turn off after PTO usage.
- ePTO light is lit, but the diesel engine runs frequently or all the time.

Fallback

No fallback condition exists for this symptom.

Possible Causes

This symptom can be caused by any of the following:

- Transmission not in neutral
- HCM system fault
- TECU system fault
- PTO Pump
- HCM
- Body hydraulic pressure and demand switches
- Boom or Outrigger switches
- Hybrid System Harness
- Hood Switch
- PTO Ball Switch
- TECU
- PBSC

Component Identification

Messages from the Body Controller to the HCM

Parameter	Signal	Value	Meaning	Description
520354	OK to Crank	0	No OK	Body Controller will allow the Hybrid HCM to automatically start the engine in ePTO if necessary.
		1	OK	
520365	PTO Engaged	0	Disengaged	Body Controller is confirming the PTO is engaged.
		1	Engaged	
520353	Request Engine Run	0	No Request	Body Controller is requesting the HCM to start the engine.
		1	Request	
520352	Hydraulic Demand (PTO)	0	No Demand	Body Controller is requesting the Hybrid to turn the transmission and provide PTO power.
		1	Demand	
520351	PTO Engaged Command	0	False	TECU is sending the request to the HCM
		1	True	
520350	PTO Engaged Feedback	0	False	HCM is confirming it received the message
		1	True	

ePTO Test

A

Purpose: *Verify “ePTO” light operates.*

1. You should only perform this symptom test if you were sent here from a diagnostic procedure and you have no Active fault codes.
2. Key on.
3. Press “ePTO” on the Push Button Shift Control:
   - If “ePTO” light is lit on the Push Button Shift Control, go to **Step B.**
   - If “ePTO” light is not lit on the Push Button Shift Control, replace the Push Button Shift Control. See the **Shift Control Removal and Installation** procedure in TRSM2000. Make sure there are no Active fault codes 16, 35, 24, 48, or 59, then go to **Step V.**
   - If “ePTO” light is flashing on the Push Button Shift Control and the tone sounds, go to **Step F.**

B

Purpose: *Verify Hydraulic Lift operation.*

1. Use the controls to operate the hydraulic lift:
   - Hydraulic lift operates, go to **Step C.**
   - Hydraulic lift does not operate, go to **Step K.**

C

Purpose: *Determine the run time appropriate for application and verify PTO Pump shuts down.*

1. Release the controls on the hydraulic lift and let the vehicle set:

   Note: The run time may vary depending on the type of system and size of accumulators that need to be charged.

   - PTO Pump shuts off, go to **Step D.**
   - PTO Pump continues to operate, go to **Step L.**

D	***Purpose:*** *Verify the State of Charge and verify that diesel engine turns on and shuts down.*

1. Operate the hydraulic controls until the diesel engine turns on.
2. Connect ServiceRanger and select the Data Monitor option.
3. View the High-Voltage Battery list and view the PID 133 “Battery SOC.”
   - Diesel engine cycles on for some time then shuts back down, test complete, go to **Step V.**
   - Diesel engine never cycles on and PID 133 “Battery SOC” is less than 23%, problem with engine. The hybrid system attempts to start the engine when the SOC goes below 23%. Contact your OEM for repair procedures.
   - Diesel engine never cycles on and PID 133 “Battery SOC” is greater than 23%. Battery SOC must be below 23% before the hybrid system will request the engine to start. Continue to operate the hydraulic controls until the engine comes on.
   - Diesel engine cycles on, and never shuts down, and PID 133 “Battery SOC” is less than 68%, go to **Step E.**
   - Diesel engine cycles on, and never shuts down, and PID 133 “Battery SOC” is greater than 68%, go to **Step E.**

Parameter	Reading
PID 133 “Battery SOC”	

E	***Purpose:*** *Confirm “Request Engine Run” signal is present at low State Of Charge.*

1. Connect ServiceRanger to the 9-Way Diagnostic Connector.
2. View the Data Monitor parameter PID 152 “Request Engine Run”:
   - If PID 152 “Request Engine Run” reads 0 (no request) and PID 133 “Battery SOC” is less than 68%, power usage is enough to require the engine to remain on, so the system can deliver the power demands. If the power demands are reduced, the engine should shut down because the SOC will go over 68%.
   - If the PID 152 “Request Engine Run” reads 0 (No Request) and PID 133 “Battery SOC” is greater than 68%, contact Eaton at 1-800-826-HELP (4357).
   - If PID 152 “Request Engine Run” reads 1 (request) the Body Controller is requesting the engine to remain on. This may be a leak in the air system or a low 12-volt system. Contact your OEM for repair procedure.

Parameter	Reading
PID 152 “Request Engine Run”	
PID 133 “Battery SOC”	

F

Purpose: *Visually observe the Gear Display after power up.*

1. Observe the gear display:
   - If gear display shows a solid "N" or number, go to **Step G.**
   - If gear display shows a "PD", you are in diagnostic mode. Exit this mode by turning the key off for 2 minutes and then back on, then go to **Step F.**

G

Purpose: *Verify the Neutral light is operational.*

1. Press the "N" on the Push Button and observe the light.
   - Light is displayed solid, go to **Step H.**
   - Light is flashing, repair the problem with the transmission not achieving neutral, go to "Product Diagnostic Mode (PDM)" on page 18.

H

Purpose: *Confirm "ePTO Mode Confirmation" signal.*

1. Connect ServiceRanger to the 9-Way Diagnostic Connector.
2. View the Data Monitor parameter PID 164 "ePTO Mode Confirmation":
   - PID 164 "ePTO Mode Confirmation" reads 1 (true), go to **Step I.**
   - PID 164 "ePTO Mode Confirmation" reads 0 (false), go to **Step M.**

Parameter	Reading
PID 164 "ePTO Mode Confirmation"	

I

Purpose: *Confirm "PTO Engaged" signal.*

1. View the Data Monitor parameter PID 149 "PTO Engaged":
   - PID 149 "PTO Engaged" reads 1 (engaged), go to **Step J.**
   - PID 149 "PTO Engaged" reads 0 (disengaged), contact Eaton at 1-800-826-HELP (4357).

Parameter	Reading
PID 149 "PTO Engaged"	

J ***Purpose:*** *Confirm "ePTO Request" signal.*

1. View the Data Monitor parameter PID 163 "ePTO Request":
   - PID 163 "ePTO Request" reads 1 (true), contact Eaton at 1-800-826-HELP (4357).
   - PID 163 "ePTO Request" reads 0 (false), problem is with mechanical problem to the PTO, electrical power to PTO circuit, air pressure, or signal wire from PTO. Contact your OEM for repair procedures.

Parameter	**Reading**
PID 163 "ePTO Request"	

K ***Purpose:*** *Verify "Hydraulic Demand" and "Battery SOC" status during hydraulic operation.*

1. Operate the hydraulic lift while monitoring the Data Monitor parameters:
   - PID 151 "Hydraulic Demand" located in the "ePTO" list.
   - PID 133 "Battery SOC" located in the "HV Battery" list.
   - PID 151 "Hydraulic Demand" reads 1 (Demand) and PID 133 "Battery SOC" is greater than 23%, problem is with the PTO pump. Contact your OEM for repair procedure.
   - PID 151 "Hydraulic Demand" reads 1 (Demand) and PID 133 "Battery SOC" is less than 23%, problem is engine not starting to recharge the Hybrid System. The Hybrid System will request the engine to start when the SOC is less than 23%. Contact your OEM for repair procedures.
   - PID 151 "Hydraulic Demand" reads 0 (no demand), problem is with lack of hydraulic demand on the HCM from the Body Controller which can be caused by a faulty pressure switch/transducer. Contact your OEM for repair procedure.

Parameter	**Reading**
PID 151 "Hydraulic Demand"	
PID 133 "Battery SOC"	

L

Purpose: *Confirm “Hydraulic Demand” signal.*

1. Release the hydraulic controls.
2. Connect ServiceRanger and select the Data Monitor option.
3. View PID 151 “Hydraulic Demand” under the ePTO list.
   - PID 151 “Hydraulic Demand” reads 1 (demand), problem with the constant Hydraulic demand from the Body Controller. Contact your OEM for repair procedures.
   - PID 151 “Hydraulic Demand” reads 0 (no demand), contact Eaton at 1-800-826-HELP (4357).

Parameter	Reading
PID 151 “Hydraulic Demand”	

M

Purpose: *Verify no Active fault codes.*

1. Key on.
2. Connect ServiceRanger to the 9-Way Diagnostic Connector.
3. Ensure there are no TECU or HCM fault codes 66, 87, 18, 97, or 8:
   - No fault codes present, go to **Step N.**
   - Fault codes are present, go to “Product Diagnostic Mode (PDM)” on page 18.

N

Purpose: *Verify no output speed, transmission. is in neutral and no gear is requested.*

1. View the following Data Monitor parameters from the “Hybrid Transmission” list and make sure they match the required values:
   - PID 191 Output Shaft Speed = 0 RPM
   - SPN 524 Select Gear = 0
   - SPN 523 Current Gear = 0
   - If all the parameters on ServiceRanger match the values shown, go to **Step O.**
   - If the parameters on ServiceRanger do not match the values shown, turn the Ignition Key off for 2 minutes, power back up and read the values again. If the values read still do not match, contact Eaton at 1-800-826-HELP (4357).

Parameter	Reading
PID 191 “Output Shaft Speed”	
SPN 524 “Select Gear”	
SPN 523 “Current Gear”	

O — ***Purpose:*** *Confirm "OK to Crank" status.*

1. View the following Data Monitor parameters from the “Hybrid ePTO” list and make sure they match the required values:
   - PID 153 “OK to Crank” = 1 or 0
     - If PID 153 “OK to Crank” reads 1, contact Eaton at 1-800-826-HELP (4357).
     - If PID 153 “OK to Crank” reads 0, problem is with the Hood Switch reading open, or the Parking Brake Switch reading not applied. Contact your OEM for repair procedures.

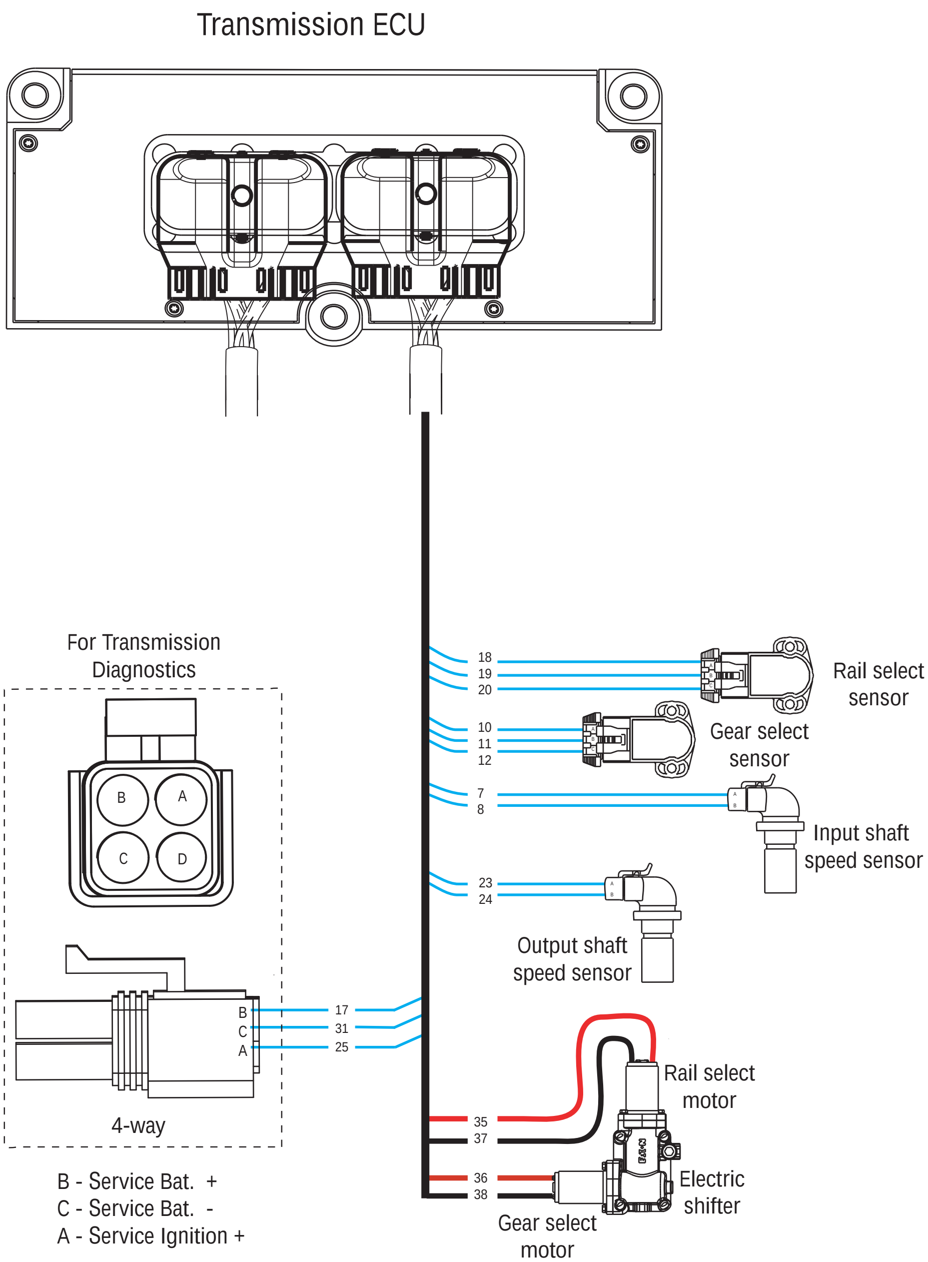
Parameter	Reading
PID 153 “OK to Crank”	

V — ***Purpose:*** *Verify repair.*

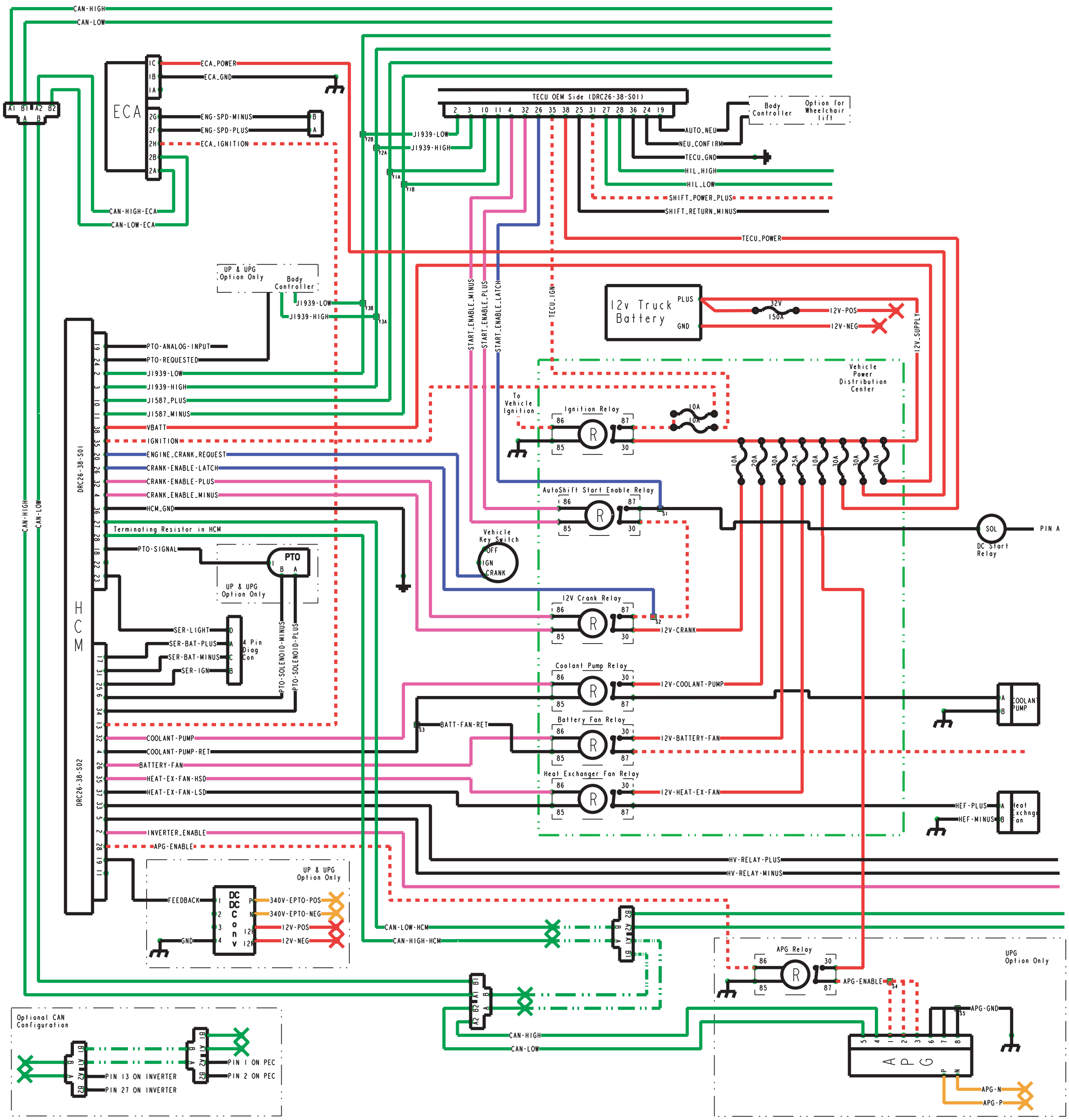
1. Key off.
2. Reconnect all connectors.
3. Key on.
4. Place Shift Control into ePTO Mode:
   - If PTO system operates, test is complete.
   - If PTO system does not operate, find error in testing, go to **Step A.**

Wiring Diagrams

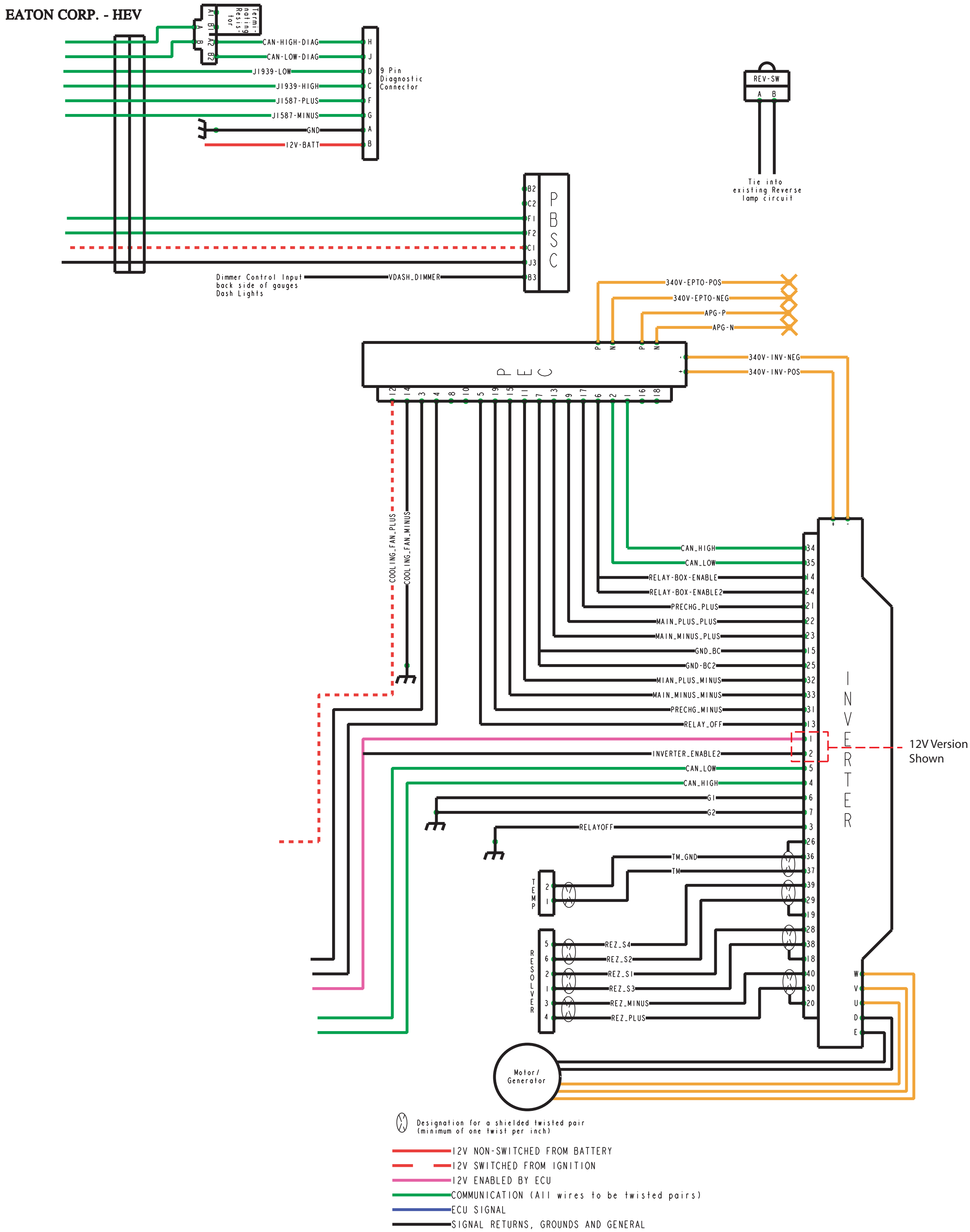
Hybrid Transmission ECU System Harness



Wiring Diagram with Push Button Shift Controller

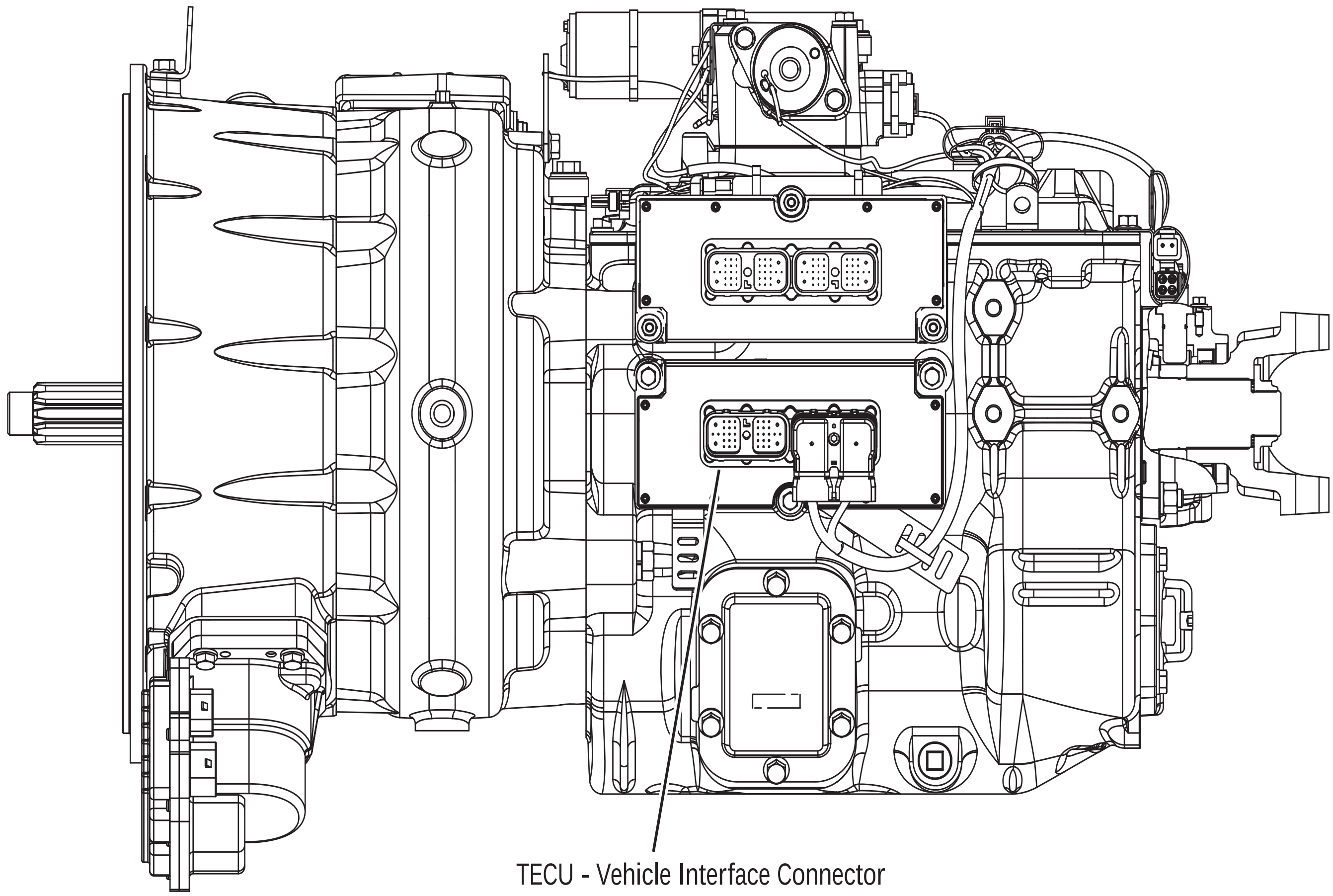


Wiring Diagram with Push Button Shift Controller (continued)

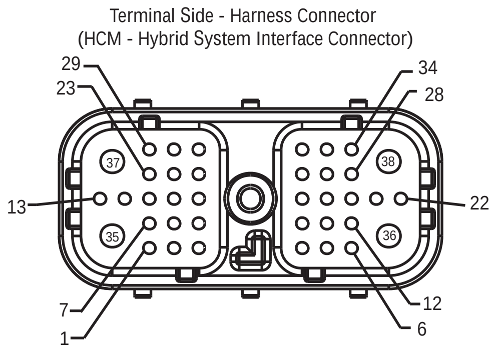


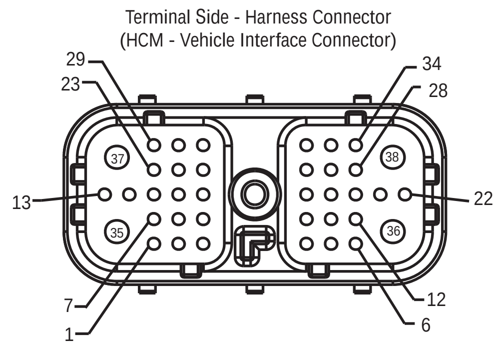
Connector Pin Description

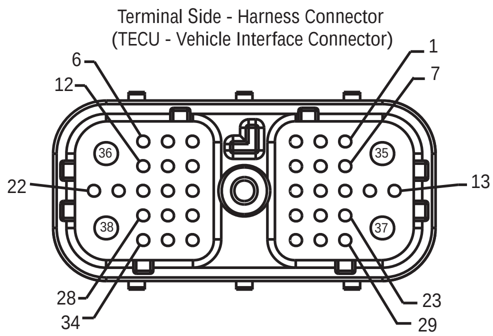
Hybrid and Transmission Connector Pins



TECU and HCM Connectors







Caution: Please note the location and orientation of the HCM and TECU Connectors.The back shell should always face down on the Harness Connectors.

Transmission Controller 38-Way (Vehicle Interface Connector)

Description	From	Pin #	To	Pin #	AWG
Not Used		1			Plug
J1939 Low (CAN)	TECU	2	1939 Backbone	B	18 TXL
J1939 High (CAN)	TECU	3	1939 Backbone	A	18 TXL
Start Enable Relay Minus	TECU	4	AS Start Enable Relay	85	18 TXL
Not Used		5			Plug
Not Used		6			Plug
Not Used		7			Plug
Not Used		8			Plug
Not Used		9			Plug
J1587 Plus	TECU	10	Splice into 1587	A	18 TXL
J1587 Minus	TECU	11	Splice into 1587	B	18 TXL
Not Used		12			Plug
Not Used		13			Plug
Not Used		14			Plug
Not Used		15			Plug
Not Used		16			Plug
Not Used		17			Plug
Not Used		18			Plug
Not Used		19			Plug
Not Used		20			Plug
Not Used		21			Plug
Not Used		22			Plug
Not Used		23			Plug
Not Used		24			Plug
Shift Control Power Minus	TECU	25	PBSC	J3	18 TXL
Start Enable Latch	TECU	26	AS Start Enable Relay	87	18 TXL
HIL Low (Proprietary CAN)	TECU	27	PBSC	F2	18 TXL
HIL High (Proprietary CAN)	TECU	28	PBSC	F1	18 TXL
Not Used		29			Plug
Not Used		30			Plug
Shift Control Power Plus	TECU	31	PBSC	C1	18 TXL
Start Enable Relay Plus	TECU	32	AS Start Enable Relay	86	18 TXL
Not Used		33			Plug
Not Used		34			Plug
Ignition	TECU	35	10A Fused Switched Power from Ignition Bus		12 GXL or 14SXL
Battery Minus	TECU	36	Ground at Battery or Starter		12 GXL
Not Used		37			Plug
Battery Plus	TECU	38	30A Fused Non-Switched		12 GXL

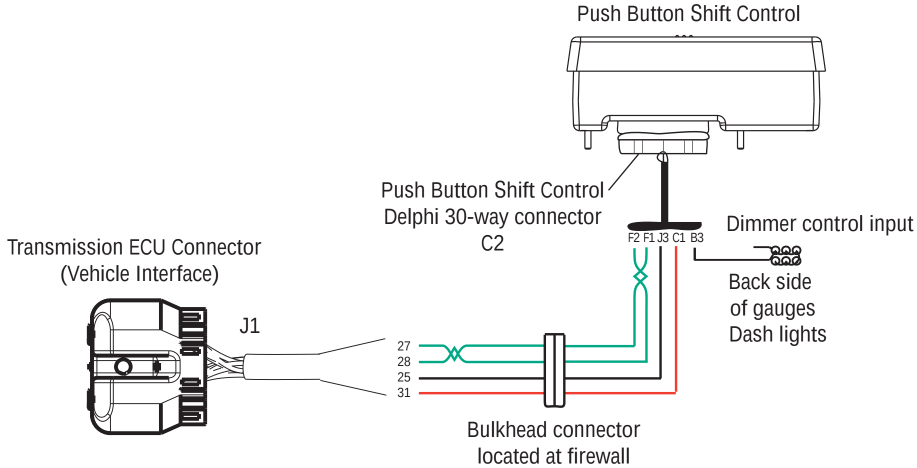
Hybrid Controller 38-Way (Vehicle Interface Connector)

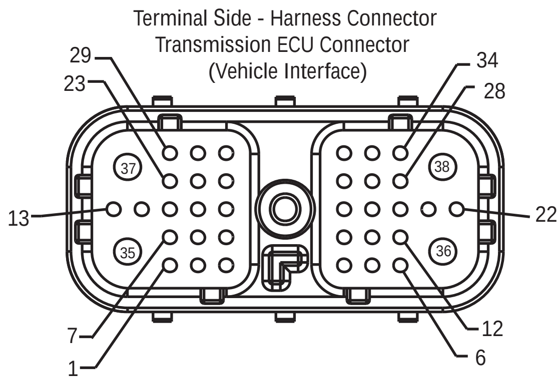
Description	From	Pin #	To	Pin #	AWG
Not Used		1			Plug
J1939 Low (CAN)	HCM	2	1939 Backbone	B	18 TXL
J1939 High (CAN)	HCM	3	1939 Backbone	A	18 TXL
12v Cranking Relay Minus	HCM	4	12v Cranking Relay	85	Plug
Not Used		5			Plug
Not Used		6			Plug
Not Used		7			Plug
Not Used		8			Plug
Not Used		9			Plug
J1587 Plus	HCM	10	Splice into 1587		18 TXL
J1587 Minus	HCM	11	Splice into 1587		18 TXL
Not Used		12			Plug
Not Used		13			Plug
Not Used		14			Plug
Not Used		15			Plug
Not Used		16			Plug
Not Used		17			Plug
PTO Signal	HCM	18	PTO		18 TXL
Not Used		19			Plug
Engine Crank Request	HCM	20	Crank Position on Switch		18 TXL
Not Used		21			Plug
Not Used		22			Plug
"Service" Light	HCM	23	4-Way Service Connector	D	18 TXL
PTO Request (Non J1939 BCU)	HCM	24	BCU		18 TXL
Not Used		25			Plug
12v Cranking Relay Latch	HCM	26	12v Cranking Relay	87	18 TXL
CAN Low (Proprietary CAN)	HCM	27	HEV Backbone	B	18 TXL
CAN High (Proprietary CAN)	HCM	28	HEV Backbone	A	18 TXL
Not Used		29			Plug
Not Used		30			Plug
Not Used		31			Plug
12v Cranking Relay Plus	HCM	32	12v Cranking Relay	86	18 TXL
Not Used		33			Plug
Not Used		34			Plug
Ignition	HCM	35	Fused 10A to Ignition Relay		12 GXL or 14SXL
Battery Minus	HCM	36	Battery Ground		12 GXL
Not Used		37			Plug
Battery Plus	HCM	38	Fused 30A Battery		12 GXL

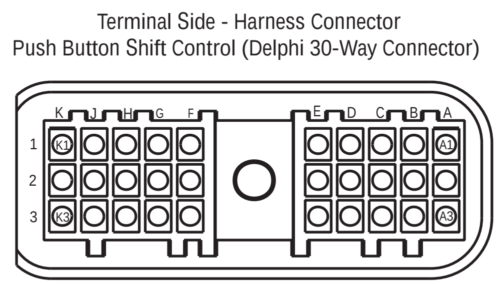
Hybrid Controller 38-Way (Hybrid System Interface Connector)

Description	From	Pin #	To	Pin #	AWG
Not Used		1			Plug
Inverter Enable	HCM	2	Fuse 5A	15	18 TXL
Not Used		3			Plug
Coolant Pump & Battery Fan Relay Minus	HCM	4	Coolant Pump Relay & Battery Fan Relay	85	18 TXL
High-Voltage Relay Minus	HCM	5	High-Voltage Relay	4	18 TXL
PTO Power Minus	HCM	6	PTO		18 TXL
Not Used		7			Plug
Not Used		8			Plug
Not Used		9			Plug
Not Used		10			Plug
DC/DC Converter Temperature	HCM	11	DC/DC Converter	3	18 TXL
Not Used		12			Plug
ECA Ignition	HCM	13	ECA	H	18 TXL
Not Used		14			Plug
Not Used		15			Plug
Not Used		16			Plug
Service Battery Plus		17	Service Port	A	18 TXL
Not Used		18			Plug
DC/DC Converter Feedback Voltage	HCM	19	DC/DC Converter	1	18 TXL
Not Used		20			Plug
Not Used		21			Plug
Not Used		22			Plug
Not used		23			Plug
Not Used		24			Plug
Service Ignition	HCM	25	Service Port	C	18 TXL
Battery Cooling Fan Relay Plus	HCM	26	Battery Cooling Fan	86	18 TXL
Not Used		27			Plug
APG Enable	HCM	28	APG	C	18 TXL
Not Used		29			Plug
Not Used		30			Plug
Service Battery Minus	HCM	31	Service Port	B	18 TXL
Coolant Pump Relay Plus	HCM	32	Coolant Pump Relay	86	18 TXL
High-Voltage Relay Plus	HCM	33	High-Voltage Relay	3	18 TXL
PTO Power Plus	HCM	34	PTO		18 TXL
Heat Exchanger Plus	HCM	35	HEF Relay	86	12 GXL or 14SXL
Not Used		36			Plug
Heat Exchanger Minus	HCM	37	HEF Relay	85	18 TXL
Not Used		38			Plug

Push Button Shift Control Connector



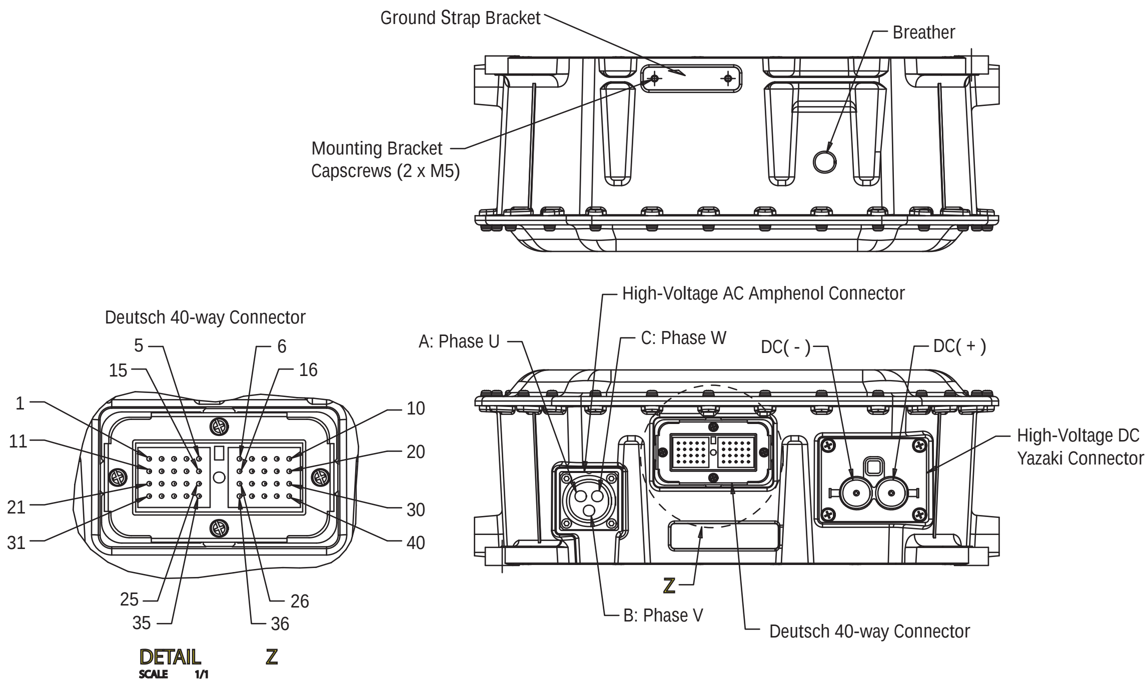




Push Button 30-Way Connector

Description	From	Pin #	To	Pin #	AWG
HIL High	PBSC	F1	TECU	28	18
HIL Low	PBSC	F2	TECU	27	18
Shift Control Power Minus	PBSC	J3	TECU	25	18
Shift Control Power Plus	PBSC	C1	TECU	31	18
Vdash	PBSC	B3	TECU	Spliced	18

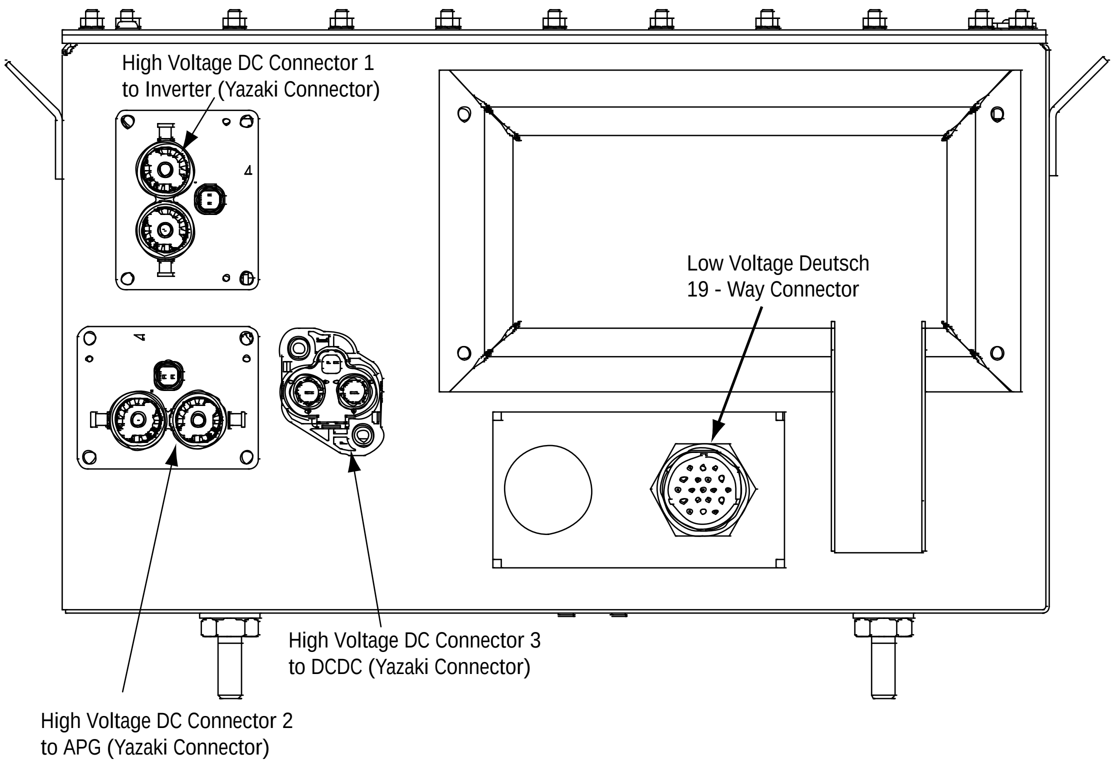
Inverter Connectors



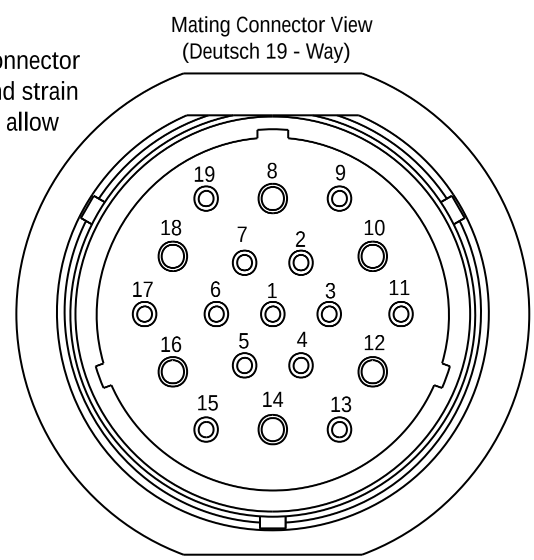
Inverter 40-Way Connector

Description	From	Pin #	To	Pin #	AWG
Relay Off (0)	Inverter	3	Chassis Gnd		16 TXL
CAN High 1	Inverter	4	HEV Backbone	A	16 TXL
CAN Low 1	Inverter	5	HEV Backbone	B	16 TXL
GND1	Inverter	6	Chassis Gnd		16 TXL
GND2	Inverter	7	Chassis Gnd		16 TXL
V-Batt1 (24V)	Inverter	9	PEC	2	16 TXL
V-Batt2 (24V)	Inverter	10	PEC	2	16 TXL
Relay Off	Inverter	13	PEC	5	16 TXL
Relay Box Enable 1	Inverter	14	PEC	6	16 TXL
GND (BC1)	Inverter	15	PEC	7	16 TXL
REZGS1	Inverter	18	Resolver Ground Shield 1		16 TXL
REZGS2	Inverter	19	Resolver Ground Shield 2		16 TXL
REZGR	Inverter	20	Resolver Ground R Shield		16 TXL
PRECHRG (+)	Inverter	21	PEC	17	16 TXL
Main (+) (+)	Inverter	22	PEC	9	16 TXL
Main (-) (+)	Inverter	23	PEC	13	16 TXL
Relay Box Enable 2	Inverter	24	PEC	6	16 TXL
GND (BC2)	Inverter	25	PEC	7	16 TXL
TM_S	Inverter	26	Temp Sensor Shield		16 TXL
REZS1	Inverter	28	Resolver	2	16 TXL
REZS2	Inverter	29	Resolver	6	16 TXL
REZ_Plus	Inverter	30	Resolver	4	16 TXL
PRECHRG (-)	Inverter	31	PEC	19	16 TXL
Main (+) (-)	Inverter	32	PEC	11	16 TXL
Main (-) (-)	Inverter	33	PEC	15	16 TXL
CAN High 2	Inverter	34	PEC	1	16 TXL
CAN-Low 2	Inverter	35	PEC	2	16 TXL
TMGND	Inverter	36	Temp Sensor	2	16 TXL
TM	Inverter	37	Temp Sensor	1	16 TXL
REZS3	Inverter	38	Resolver	1	16 TXL
REZS4	Inverter	39	Resolver	5	16 TXL
REZ_Minus	Inverter	40	Resolver	3	16 TXL

Power Electronics Carrier (PEC) Connectors



Caution: The PEC 19-way low-voltage connector needs to have the back shell and strain relief such that the unit will not allow water entry from direct spray.



19-Way Connector

Description	From	Pin #	To	Pin #	AWG
CAN High	PEC	1	Inverter	14	18
CAN Low	PEC	2	Inverter	28	18
HV Relay (+)	PEC	3	HCM	33	18
HV Relay (-)	PEC	4	HCM	5	18
RelayOff	PEC	5	Inverter	43	18
BCU (+)	PEC	6	Inverter	16	18
BCU (-)	PEC	7	Inverter	34	18
Main (+) +	PEC	9	Inverter	30	18
Main (+) -	PEC	11	Inverter	35	18
Main (-) +	PEC	13	Inverter	31	18
Main (-) -	PEC	15	Inverter	36	18
PreChg +	PEC	17	Inverter	29	18
PreChg -	PEC	19	Inverter	37	18
Battery Fan Plus	PEC	12	Battery Fan Cooling Relay	87	12
Battery Fan Minus	PEC	14	Battery Negative	-	12

PEC High-Voltage (DC) Connector to Inverter

Description	From	Pin #	To	Pin #	AWG
DC +	PEC	A	Inverter	A	15mm²
DC -	PEC	B	Inverter	B	15mm²
Loose Disconnect	PEC	1	PEC	2	0.8 mm² (18 AWG)

PEC High-Voltage (DC) Connector to DC/DC Converter

Description	From	Pin #	To	Pin #	AWG
DC +	PEC	A	DC/DC Converter	A	14 AWG
DC -	PEC	B	DC/DC Converter	B	14 AWG
Loose Disconnect	PEC	1	DC/DC Converter	1	0.8 mm² (18 AWG)
Loose Disconnect	PEC	2	DC/DC Converter	2	0.8 mm² (18 AWG)

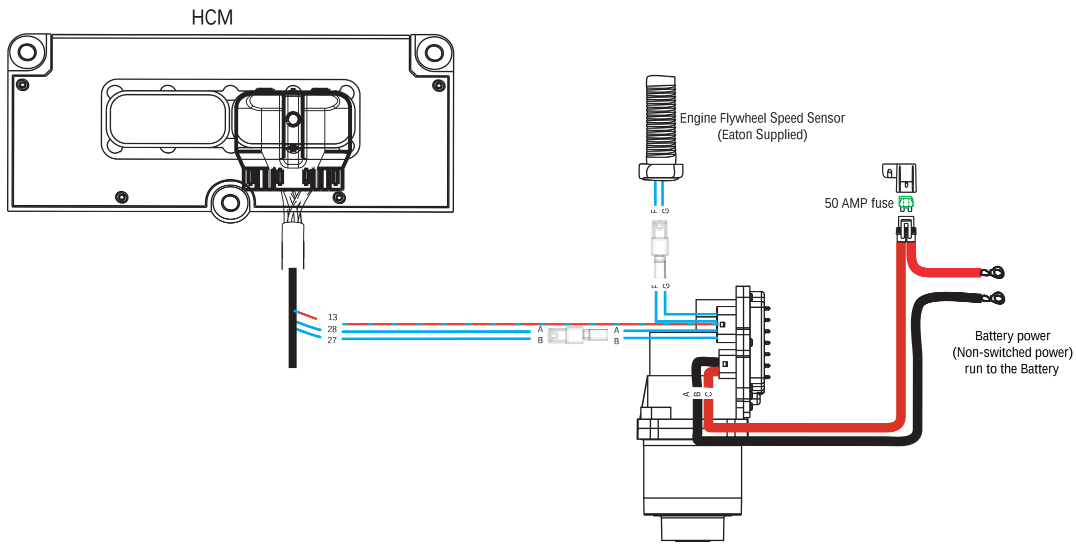
Inverter High-Voltage (AC) Connector

Description	From	Pin #	To	Pin #	AWG
Phase 1	Inverter	A	Motor/Gen	A	4 AWG
Phase 2	Inverter	B	Motor/Gen	B	4 AWG
Phase 3	Inverter	C	Motor/Gen	C	4 AWG

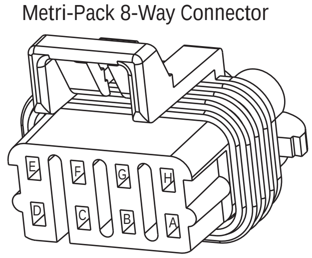
Inverter High-Voltage (DC) Connector

Description	From	Pin #	To	Pin #	AWG
DC +	Inverter	A	PEC	A	15mm²
DC -	Inverter	B	PEC	B	15mm²
Loose Disconnect	Inverter	1	Inverter	2	0.8 mm² (18 AWG)

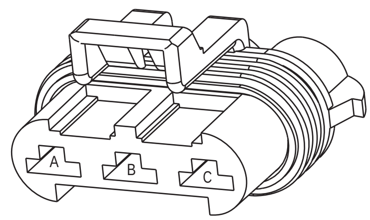
Electric Clutch Actuator (ECA) Connectors



Terminal Side - Harness Connector
Metri-Pack 8-Way Connector



Terminal Side - Harness Connector
Metri-Pack 3-Way Connector



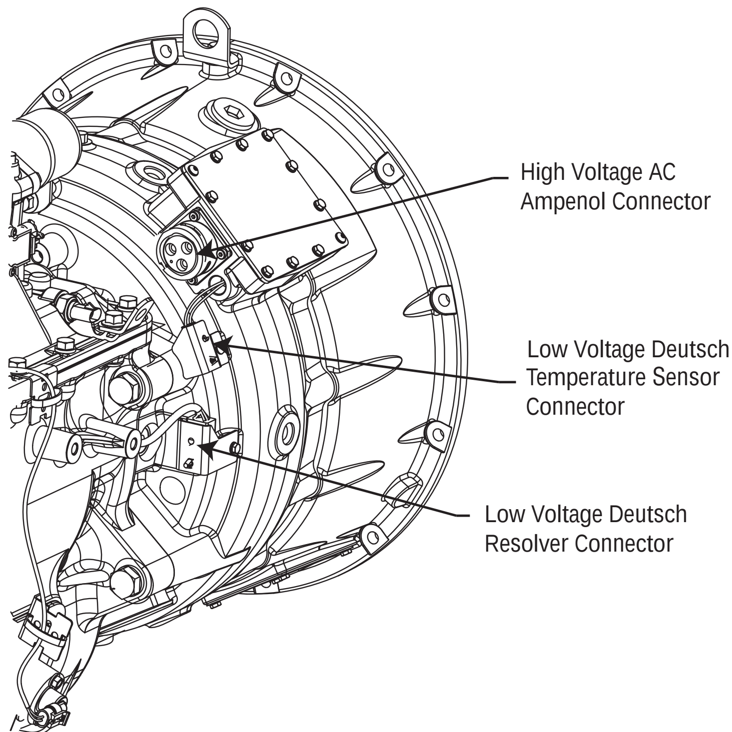
ECA 3-Way Connector

Description	From	Pin #	To	Pin #	AWG
Ignition	ECA	A	Not Used		Plug
Battery Minus	ECA	B	Chassis Ground	Battery -	12
Battery Plus	ECA	C	Fused 50 amp from Vbatt	Battery +	12

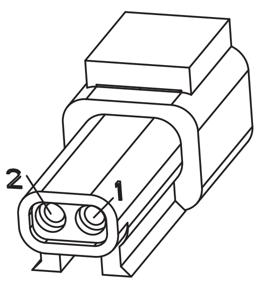
ECA 8-Way Connector

Description	From	Pin #	To	Pin #	AWG
CAN High	ECA	A	CAN Backbone	A	18
CAN Low	ECA	B	CAN Backbone	B	18
CAN - Pass	ECA	C	Not Used		Plug
Signal	ECA	D	Not Used		Plug
CAN + Pass	ECA	E	Not Used		Plug
Engine Flywheel Speed Sensor Plus	ECA	F	Speed Sensor +	A	18
Engine Flywheel Speed Sensor Minus	ECA	G	Speed Sensor -	B	18
ECA Ignition	ECA	H	HCM	13	18

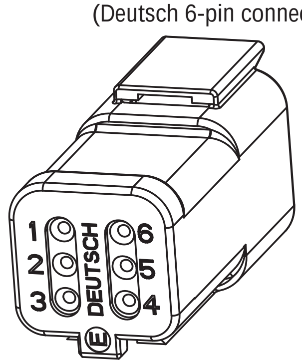
Motor/Generator Connectors



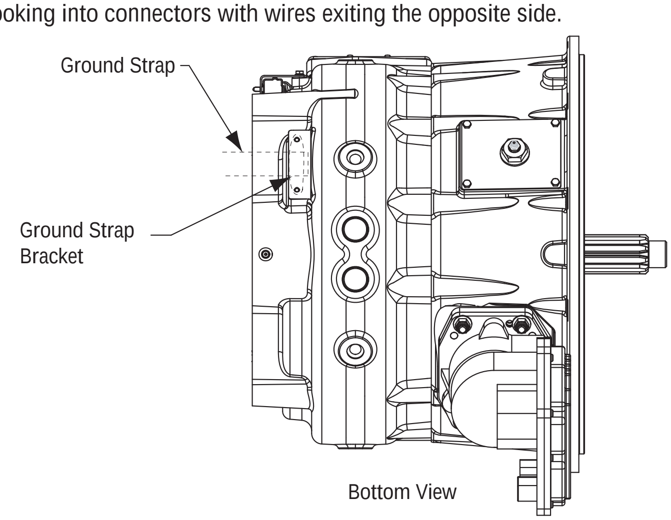
Terminal Side - Harness Connector
Temperature Sensor
(Deutsch 2-pin connector)



Terminal Side - Harness Connector
Resolver
(Deutsch 6-pin connector)



Views looking into connectors with wires exiting the opposite side.



Motor/Generator Resolver Connector

Description	From	Pin #	To	Pin #	AWG
Resolver Signal 3	Motor/Gen	1	EPS Inverter	38	18
Resolver Signal 2	Motor/Gen	2	EPS Inverter	28	18
Resolver Signal 1	Motor/Gen	3	EPS Inverter	40	Plug
Resolver Signal 4	Motor/Gen	4	EPS Inverter	30	Plug
Resolver -	Motor/Gen	5	EPS Inverter	39	Plug
Resolver +	Motor/Gen	6	EPS Inverter	29	18

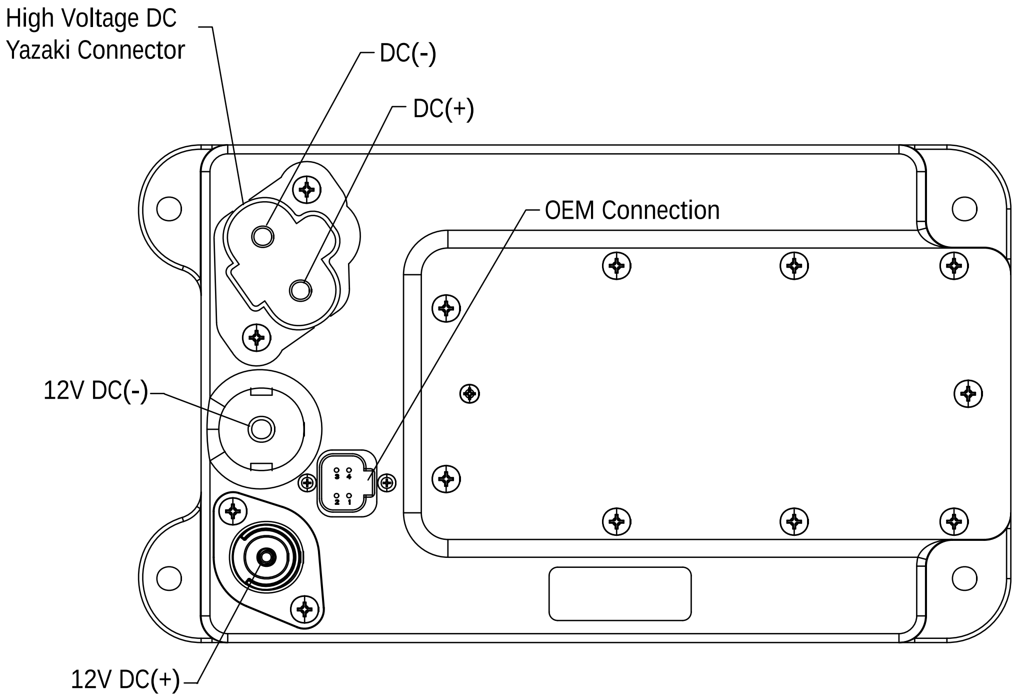
Motor/Generator Temperature Sensor Connector

Description	From	Pin #	To	Pin #	AWG
Motor Temp	Motor/Gen	1	EPS Inverter	37	18
Motor Temp Gnd	Motor/Gen	2	EPS Inverter	36	18

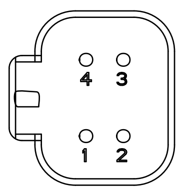
Motor/Generator High-Voltage (AC) Connector

Description	From	Pin #	To	Pin #	AWG
Phase 1	Motor/Gen	U	Inverter	U	4 AWG
Phase 2	Motor/Gen	V	Inverter	V	4 AWG
Phase 3	Motor/Gen	W	Inverter	W	4 AWG

Typical DC/DC Converter Circuit



Deutsch 4-Way OEM Connector



Caution: Remove the 12-volt battery cables prior to working on the DC/DC Converter.

DC/DC Converter 4-Way Deutsch OEM Connector

Description	From	Pin #	To	Pin #	AWG
Ground	DC/DC	4	Ground		18
Thermocouple	DC/DC	3	HCM	11	18
Not Used	DC/DC	2	Not Used		Plug
Voltage Feedback	DC/DC	1	HCM	19	18

Converter High-Voltage (DC) Connector

Description	From	Pin #	To	Pin #	AWG
DC +	DC/DC	A	PEC	A	14
DC -	DC/DC	B	PEC	B	14
Loose Disconnect	DC/DC	1	PEC	1	18
Loose Disconnect	DC/DC	2	PEC	2	18

Converter 12-volt Studs

Description	From	Pin #	To	Pin #	AWG
12volt +	DC/DC	A	Battery Positive Post	A	2
12volt -	DC/DC	B	Battery Negative Post	B	2

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