

Electrical System and Main PDM Overview

G02.01

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500 — Terms and Abbreviations

Backbone—The main J1939 datalink wiring that lies between the two terminating resistors. It does not include the branch circuits to each ECU or to the diagnostic connector.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

MFJB—MEGA® Fuse Junction Block

MGJB—Main Ground Junction Block

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — Electronic Power Distribution

The multiplexed system contains the following power distribution components:

- SAM Cab (relays and fuses), Module 32A
- SAM Chassis (relays and fuses), Module 32K

The SAM Cab and SAM Chassis are electronic control units (ECUs) that have power distribution components such as fuses and relays on them. Refer to **G02.04 — SAM Cab** and **G02.05 — SAM Chassis** for more information.

502 — Electrical Power Distribution

Standard electrical power distribution provides battery power to the electronics system, but it is not controlled by electronics.

The following modules are part of power distribution:

- Main Ground Junction Block (MGJB), Module 280
- MEGA Fuse Junction Block (MFJB), Module 285
- Powertrain PDM, Module 286

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- Load Disconnect Switch, Module 293
- Trailer PDM, Module 296

503 — Main Ground Junction Block (MGJB), Module 280

The MGJB is a main node for connecting a returning ground to the battery. Many of the ground circuits previously on the starter are now on the MGJB.

504 — MEGA Fuse Junction Block (MFJB), Module 285

The MFJB houses up to 5 MEGA fuses, and provides power to the engine harness, SAM Cab, SAM Chassis, chassis-mounted trailer PDM, and an inverter.

The advantage of using an MFJB is that it provides increased robustness in the engine control and cab control electronic systems during cranking. This is because the cab electrical system is fed from the battery through the MFJB, and no longer from the starter. Separate starter cables provide both higher voltage levels and cleaner power during cranking.

Additionally, there are improvements in circuit protection, and starter connection integrity (fewer circuits to connect at the starter stud).

505 — Powertrain PDM, Module 286

The Powertrain Power Distribution Module (PT-PDM) is dedicated to providing battery and ignition power to the engine (ECM), after treatment device (ATD), transmission (TCU), as well as other powertrain-related circuits. It is mounted in the engine compartment, above the quarter fender on the driver side of the vehicle.

506 — Load Disconnect Switch, Module 293

The load disconnect switch is used to disconnect (or open) the connection between the battery and the MFJB. Turning the load disconnect switch to the off position does not disconnect the batteries from the starter.

NOTE: If the engine is running, turning the load disconnect switch to the OFF position will not shut off the engine. The powertrain PDM still gets battery voltage from the emergency power feed on the SAM system.

The load disconnect switch is mounted on one of three locations:

- Inside the cab on the left side of the driver's seat on a left-hand-drive vehicle.
- On the battery box.
- Outboard-mounted on the left frame rail.

507 — Trailer PDM, Module 296

The trailer PDM is used to supply trailer power to the chassis-mounted trailer receptacles. The SAM Chassis supplies control outputs to the remote trailer PDM. The trailer PDM is powered through the vehicle's battery system. The SAM Chassis does not supply battery power to the trailer PDM. See **Fig. 1**.

508 — PDM Diagram

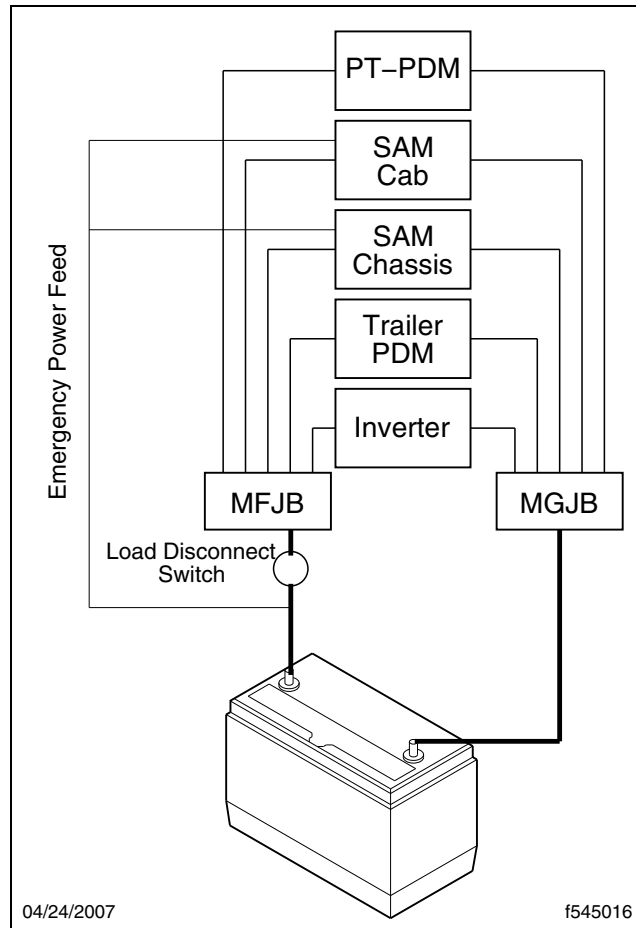


Fig. 1, PDM Diagram

509 — Related Subjects

- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- P01.01 — Starting and Charging

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600 — Component Locations

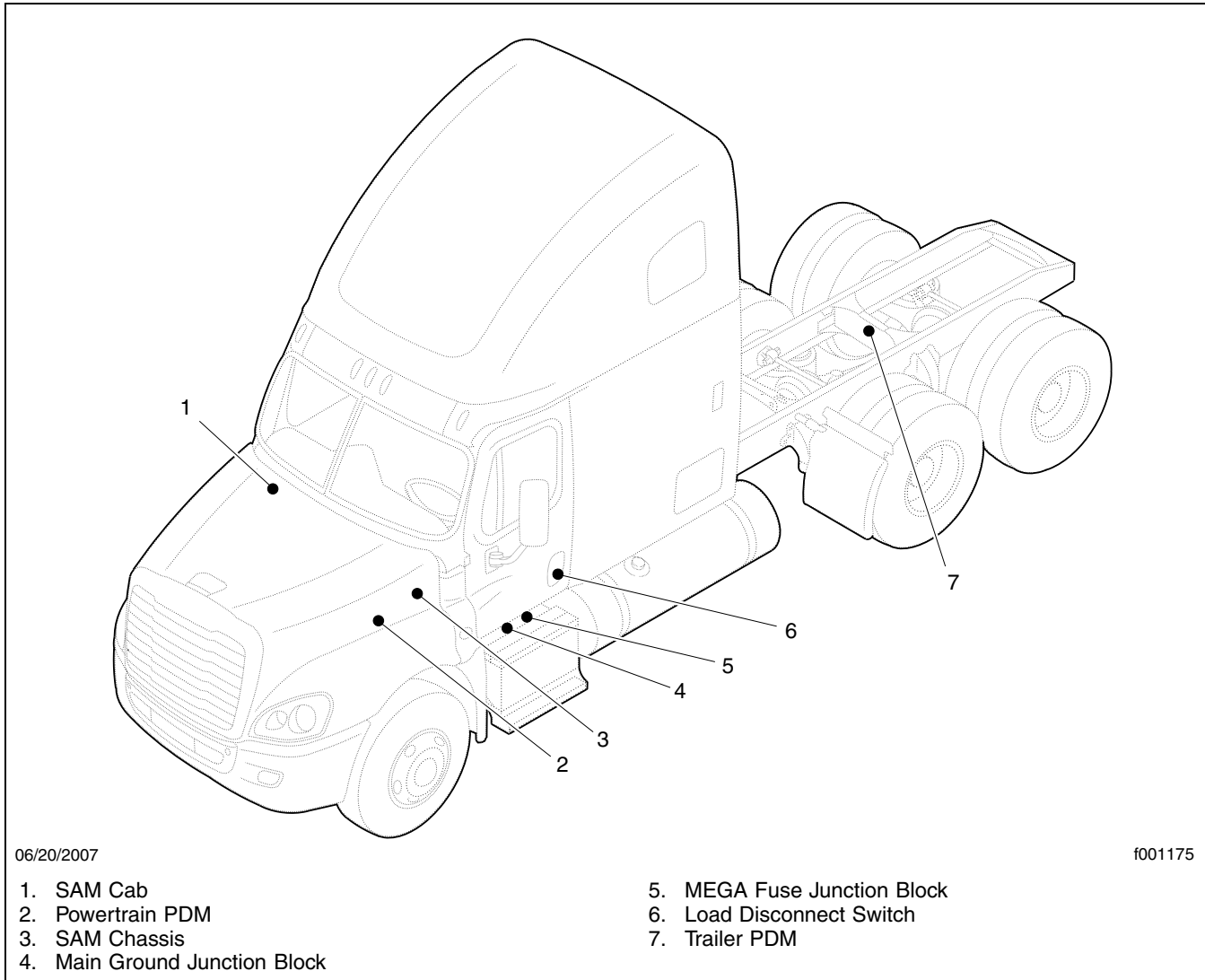


Fig. 2, Component Locations

601 — Component Details

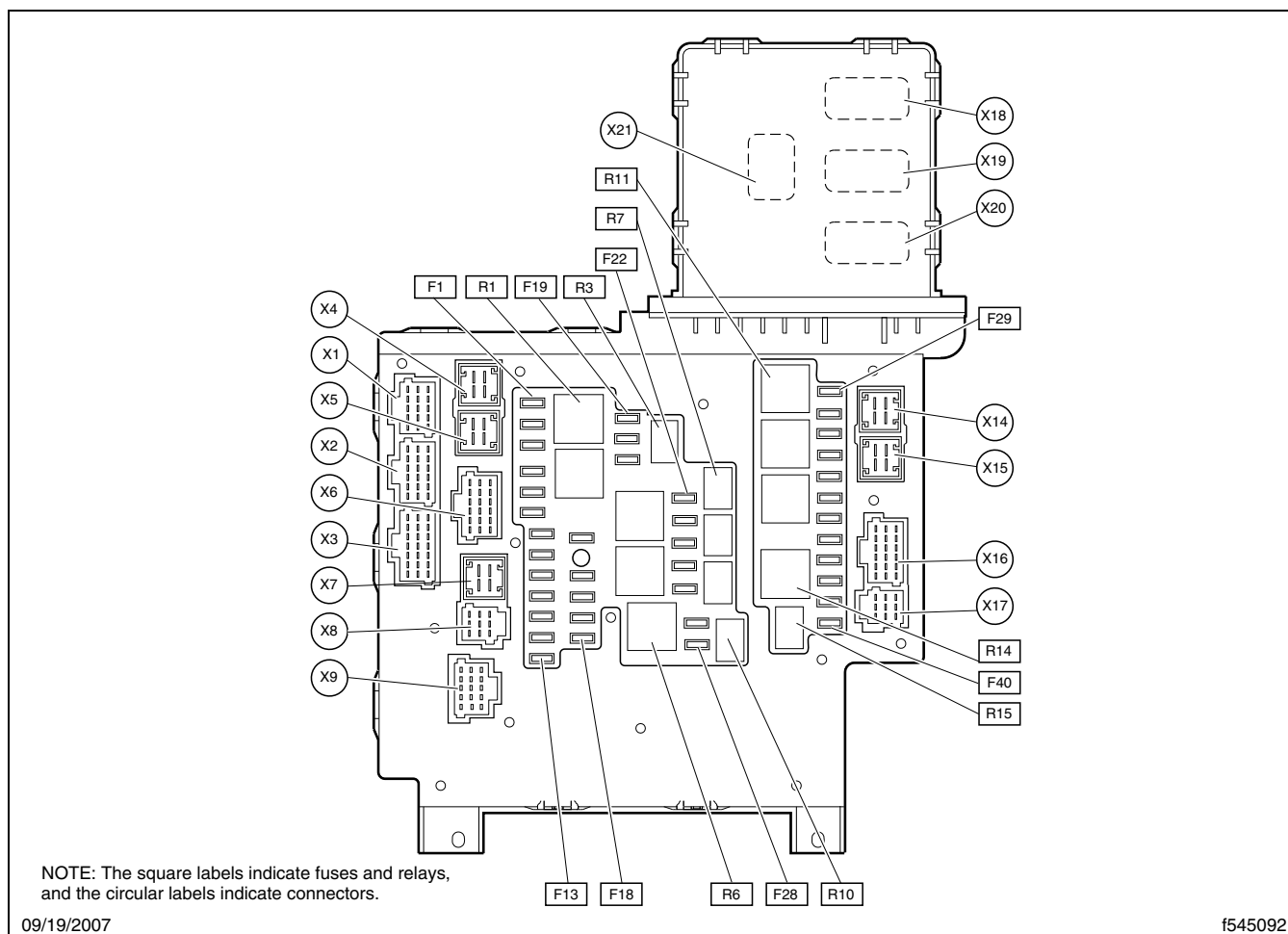


Fig. 3, SAM Cab Fuses and Relays (top)

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Electrical System and Main PDM Overview

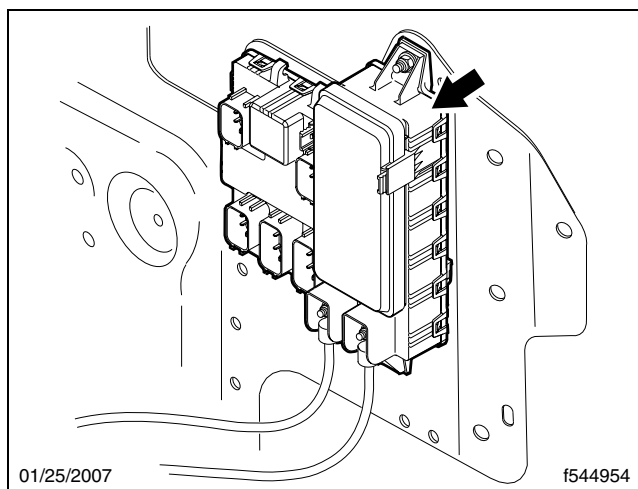


Fig. 4, SAM Chassis

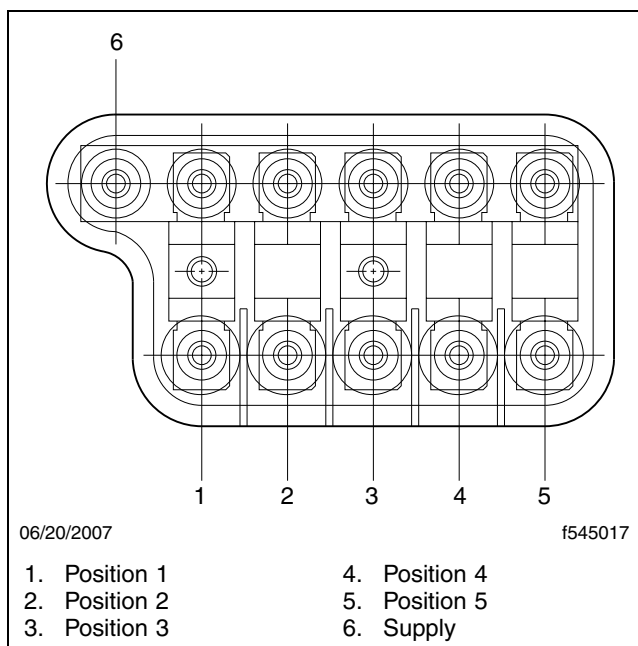


Fig. 5, MEGA Fuse Junction Block

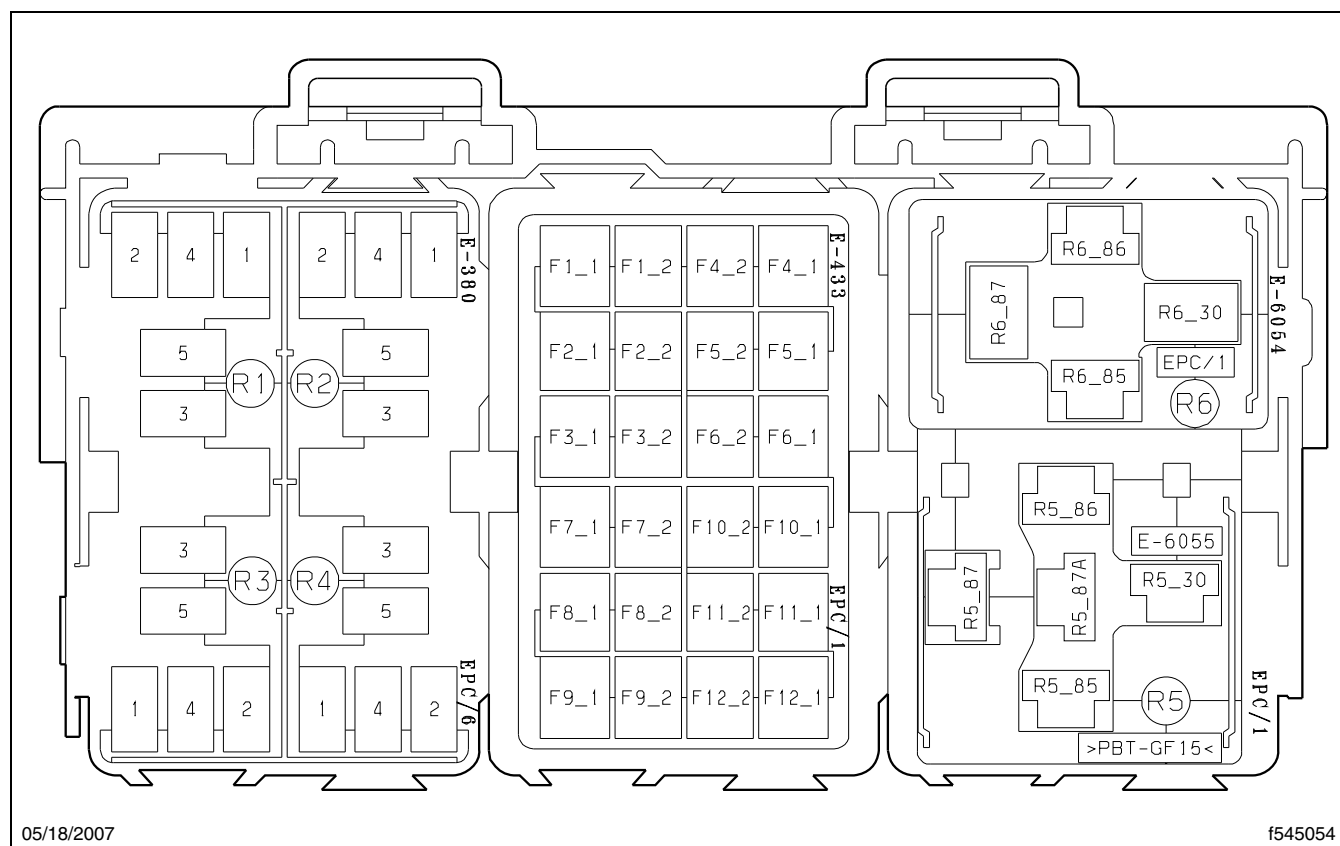


Fig. 6, Powertrain PDM

700 — Possible Causes

- Water Intrusion
- Voltage Spikes
- Short Circuits
- Missing Fuse/Relay
- Incorrect Fuse Rating

701 — Diagnostic Tools Required

- Digital Multimeter

702 — Diagnosis

Refer to the schematic in modules 280 and 285 for an overview of the vehicle power distribution system for troubleshooting. Use **Table 1** to cross reference the individual modules for each subsystem.

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Power Distribution with Module Numbers				
Source	Battery Node	Input/Output Device	Secondary Battery	Module
Battery	Starter Bat Terminal	Starter Motor	—	155
	Alternator Bat Terminal	Alternator	—	125
	Grid Heater	Heater Element	—	12C
	Jump Start Post	—	—	295
	Emergency Power Supply	SAM Cab	—	32A
		SAM Chassis	—	32K
	Load Disconnect Switch	MFJB	Powertrain PDM	286
			SAM Cab	32A
			SAM Chassis	32K
			Trailer PDM	296
			Inverter	337

Table 1, Power Distribution with Module Numbers

800 — SAM Cab Fuses and Relays

SAM Cab Relays	
Part	Name
R1	PWR FD SPARE 1 and 3, BAT
R2	PWR FD SPARE 2 and 4, BAT
R3	HEATED SEAT, IGN
R4	DASH PWR RCPT 1 and 2, BAT
R5	FLT MGM SYS and CB, BAT
R6	PWR RCPT3 and STD HVAC, BAT
R7	DRV INFO/GAUGE, IGN
R8	ICU/VEHICLE SYS, IGN
R9	AMPLIFIER PWR, ACC
R10	MIRROR HEAT
R11	PWR RCPT 6 / FRIG, BAT
R12	PWR RCPT 5, BAT
R13	CAB LIGHTING, BAT
R14	PWR RCPT4/CIR FAN/LAMP, BAT
R15	PWR WINDOW, ACC

Table 2, SAM Cab Relays

Electrical System and Main PDM Overview

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SAM Cab Fuses	
Part	Name
F1	PWR FD SPARE 1 and 3 (30A)
F2	CAB/SLPR HVAC CTRL/SHF PNL (15A)
F3	PWR FD SPARE 2 and 4 (30A)
F4	MSF (15A)
F5	OBD J1939—BAT (10A)
F6	DASH PWR RCPT 1 (15A)
F7	DASH PWR RCPT 2 (15A)
F8	PHONE/RADIO—BAT (15A)
F9	AMPLIFIER PWR (20A)
F10	CAB HVAC MTR (30A)
F11	SLPR HVAC MTR (30A)
F12	DR CTRL L (20A)
F13	DR LOCK/SM CRUISE (20A)
F14	FLT MGM SYS and CB (25A)
F15	SLPR PWR RCPT 3 (20A)
F16	STAND ALONE HVAC (7.5A)
F17	SLPR PWR RCPT 4 (20A)
F18	TELEMATICS/WARNING SYS (15A)
F19	HEATED SEAT (20A)
F20	CGW (2A)
F21	AREA LIGHT (15A)
F22	ICU—BAT (5A)
F23	DR INF /GAUGE (15A)
F24	ICU—IGN (10A)
F25	DASH SPLICE PACK (7.5A)
F26	SRS—AIRBAG (5A)
F27	MIRROR HEAT L (10A)
F28	MIRROR HEAT R (10A)
F29	SAM RELAY COILS (3A)
F30	PWR RCPT 6 / FRIG (20A)
F31	SLPR PWR RCPT 5 (20A)
F32	PWR FD SPARE 5 and 6 (25A)
F33	SPOT LIGHT (20A)
F34	BAGGAGE COMP LAMP (3A)
F35	DOMELAMP CAB (15A)
F36	AUX CIR FAN/RD LAMP (15A)
F37	CLK/DRV INFO/CD/KEYLESS (15A)

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SAM Cab Fuses	
Part	Name
F38	DR CTRL R (20A)
F39	PWR WINDOW R (15A)
F40	PWR WINDOW L (15A)

Table 3, SAM Cab Fuses

801 — SAM Chassis Fuses and Relays

SAM Chassis Relays	
Part	Name
R1	H2O SEP HEAT, IGN
R2	TRLR TRN L
R3	ABS/WIF/CAMERA, IGN
R4	TRLR TRN R
R5	TRLR MARKER
R6	TRLR ABS, IGN
R7	TRLR STOP LAMPS
R8	TRLR POWER
R9	TRLR TAIL LAMPS

Table 4, SAM Chassis Relays

SAM Chassis Fuses	
Part	Name
F1	EAPU (20A)
F2	H2O SEP HEAT (20A)
R3	ABS—BAT1 (20A)
F4	ABS—BAT2 (10A)
F5	TRLR TRN L (20A)
F6	ABS—IGN (15A)
F7	WIF/CAMERA (10A)
F8	TRLR TRN R (20A)
F9	TRLR MKR (30A)
F10	SAM RELAY COILS (5A)
F11	TRLR ABS—IGN (30A)
F12	TRLR STOP (30A)

SAM Chassis Fuses	
Part	Name
F13	TRLR TAIL (20A)
F14	TRLR PWR (30A)

Table 5, SAM Chassis Fuses

802 — MFJB Fuses

MFJB Fuses	
Part	Name
1	Engine Harness (175A)
2	SAM Cab (175A)
3	SAM Chassis (125A)
4	Chassis-Mounted Trailer PDM (125A)
5	Inverter (200A)

Table 6, MFJB Fuses

803 — Powertrain PDM and Trailer PDM Fuses and Relays

Powertrain PDM Fuses and Relays	
Part	Name
F1	N/A
F2	TRANS ECU IGN FUSE
F3	FUEL HEATER FUSE
F4	FUEL HEATER FUSE
F5	ENGINE IGN
F6	SAM CHASS
F7	PLVD/REMOTE SENSE
F8	ENGINE ECU BATT FUSE
F9	CPC/ENG ECU BATT FUSE
F10	TRANS BATT FUSE
F11	TRANS BATT FUSE
F12	TRANS BATT FUSE
R1	TRANS BACKUP RELAY
R2	MEIIR RELAY
R3	NEUTRAL RELAY/START ENABLE
R4	SPARE RELAY/HEAT RELAY

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Powertrain PDM Fuses and Relays	
Part	Name
R5	N/A
R6	70A IGN RELAY

Table 7, Powertrain PDM Fuses and Relays

Datalink Communication Structure

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500 — Terms and Abbreviations

Backbone—The main J1939 datalink wiring that lies between the two terminating resistors. It does not include the branch circuits to each ECU or to the diagnostic connector.

Baud Rate—The rate at which data is transmitted in bits per second.

Branch Circuit—The section of J1939 datalink between the backbone and each ECU that has J1939, and between the backbone and the diagnostic connector.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

J1939 Terminating Resistors—The J1939 datalink has two 120-ohm terminating resistors, one at each end of the backbone. The total datalink parallel resistance is 60 ohms.

MID—Message Identifier

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — Multiplexing Overview

The term "multiplexing" describes the electrical system. Multiplexing is defined as sending multiple electronic messages simultaneously through the same signal path. All the wires used for sending electronic messages make up what is called the "datalink."

Multiplexing allows the electrical system to simultaneously perform tasks and to monitor components. A multiplexed system uses electronic control units (ECUs) to operate the various systems on the vehicle (lighting, braking, and wipers, for example). The electrical system components, such as switches and lamps, are con-

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Datalink Communication Structure

nected to the ECUs, which collect and control all information about the components by communicating on a datalink. See **Fig 1**.

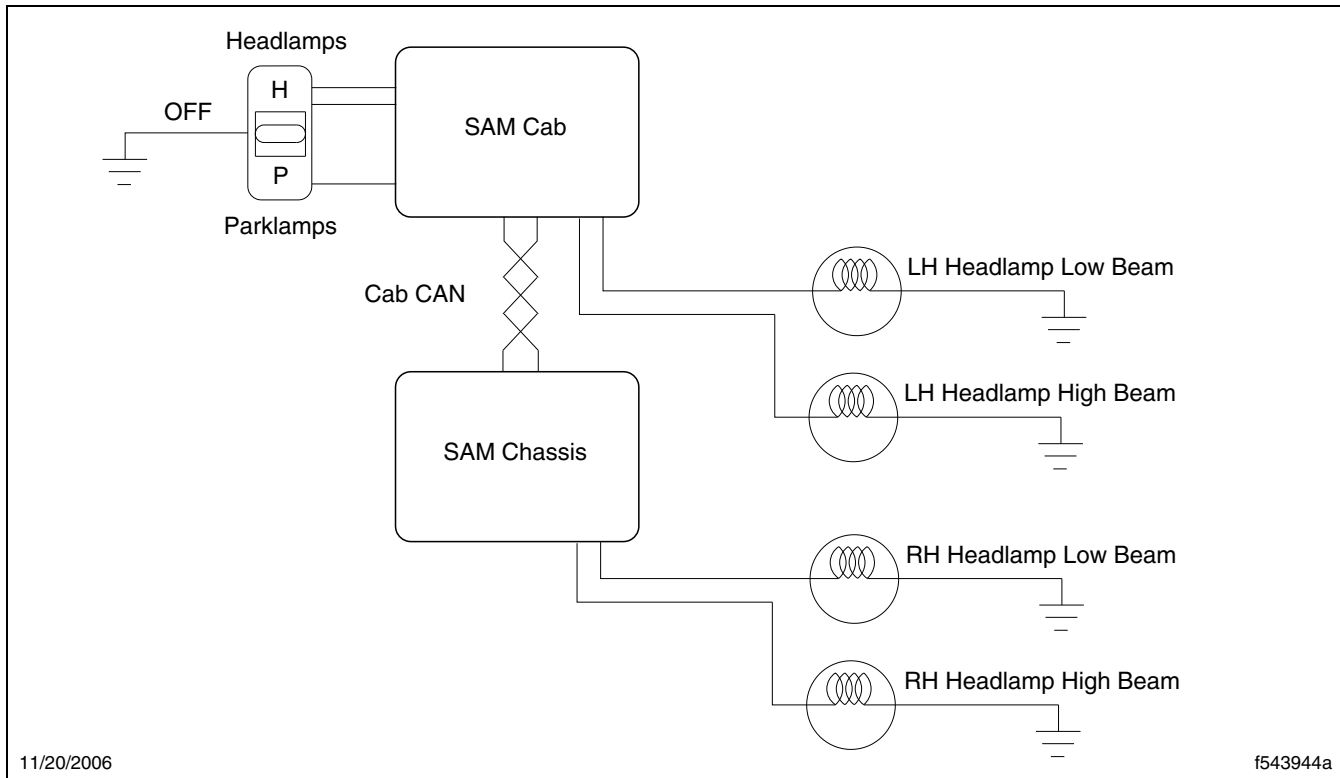


Fig. 1, Example of Multiplexed System with ECUs and Electrical Components

The multiplexed electrical system on this vehicle combines traditional power distribution module (PDM) devices, such as relays and circuit breakers, with electronic devices (ECUs) that communicate over a vehicle datalink. The electronic devices can control power distribution to the electrical loads on the vehicle. This is done by monitoring inputs (from devices such as sensors and switches) and supplying power to outputs (for devices such as lighting, displays, gauges, and indicators). This distributed approach to handling switch inputs and controlling electrical load outputs sharply reduces the number of wires on a vehicle by sharing wires.

502 — Vehicle Datalinks Overview

ECUs on the Cascadia electrical system communicate on four datalinks:

- J1587/J1708 datalink
- J1939 datalink
- Cabin CAN datalink
- Diagnostic CAN datalink (used strictly for off-board tool interaction with Cabin CAN ECUs)

Cabin CAN is the primary datalink for control messaging of most cab and chassis features (interior and exterior lighting, comfort features, and optional features, for example) and has some interaction with control messaging on the J1939 and J1587/J1708 datalinks.

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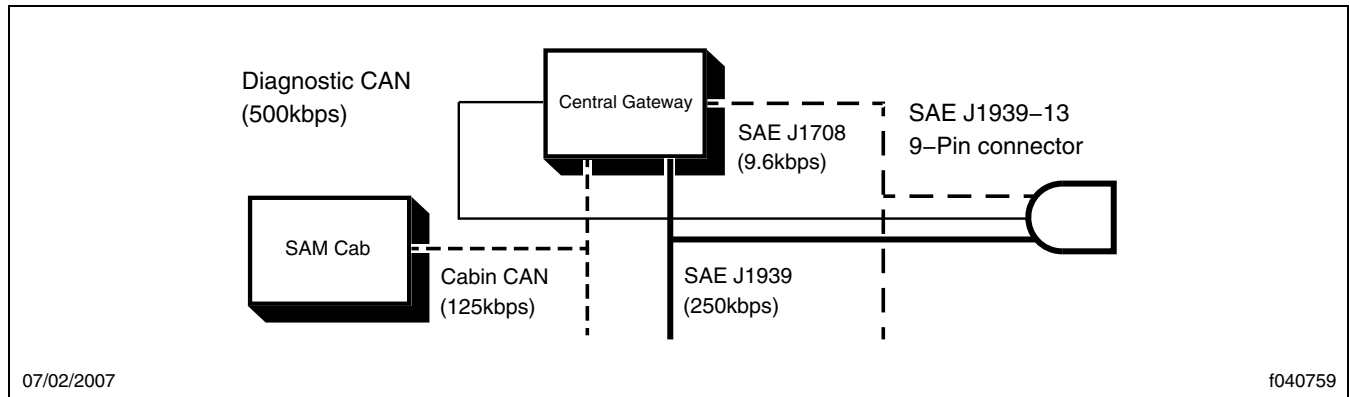


Fig. 2, Central Gateway, Diagnostic Connector, and Vehicle Datalinks

J1939 and J1587/J1708 remain the primary datalinks for powertrain control (engine, transmission, and ABS, for example).

503 — SAE J1587/J1708 Datalink

The J1587 datalink is a low-speed vehicle datalink that communicates information between the electronic control units on the vehicle. The J1587 datalink is also referred to as J1708 or "J1587/J1708."

J1708 refers to the SAE standard for the physical part of the datalink, such as the wiring and electronic components. J1587 refers to the SAE standard for the messaging protocol that communicates on the J1708 network. In the context of vehicle repair, the terms J1708 and J1587 are used interchangeably.

See **G03.01 — Datalink, J1587/J1708** for more information.

504 — SAE J1939 Datalink

The J1939 datalink is a high-speed vehicle datalink that communicates information between electronic control units on the vehicle.

Unlike the J1587 datalink, the J1939 datalink allows an ECU to broadcast requests as well as information. Examples of information that can be communicated on the J1939 datalink are:

- engine rotational speed;
- road speed;
- transmission tailshaft speed;
- engine retarder deactivation request;
- engine torque reduction request.

The "backbone" of the J1939 datalink is the section of the datalink that is between the two terminating resistors. Each ECU is connected to the backbone. The wiring between each ECU and the backbone is referred to as a branch.

See **G03.02 — Datalink, J1939** for more details.

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Datalink Communication Structure

505 — Cabin CAN Datalink

The Cabin CAN datalink does not have a direct connection to the diagnostic connector. Therefore, an off-board tool (such as ServiceLink) must connect to the Diagnostic CAN pins on the diagnostic connector to troubleshoot or configure Cabin CAN ECUs.

The Cabin CAN datalink has the following ECUs directly connected to it:

- SAM Cab
- SAM Chassis
- Modular Switch Field (MSF)
- Central Gateway Module (CGW)

See **G03.03 — Datalink, Cabin CAN** for more information.

506 — Diagnostic CAN

When an off-board tool, such as ServiceLink, is connected to the vehicle, it communicates with the Cabin CAN ECUs via the Diagnostics CAN datalink because there is no accessible service port to the Cabin CAN. The CGW translates messages between the Diagnostic CAN and Cabin CAN datalinks, due to the different speed of the two datalinks.

See **G03.04 — Datalink, Diagnostic CAN** for more information.

507 — ECU Troubleshooting Datalinks

An ECU's "troubleshooting datalink" is the datalink that an off-board tool, such as ServiceLink, uses to communicate and diagnose that ECU. See **Table 1**.

ECU Troubleshooting Datalinks				
ECU is on this Datalink	Direct Connection to Diagnostic Connector?	ECU Troubleshooting Datalink	Direct Connection to Diagnostic Connector?	Diagnostic Communication Protocol
J1708	Yes	J1587/J1708	Yes	J1587/J1708
J1939	Yes	J1939	Yes	J1939
Cabin CAN	No	Diagnostic CAN	Yes	CAN

Table 1, ECU Troubleshooting Datalinks

Fault codes are displayed on the instrument cluster (ICU) display for J1587/J1708 or J1939, depending on the type of ICU installed. Faults from all ECUs can be viewed on ServiceLink.

508 — ECU Configuration

All ECUs connected to the Cabin CAN datalink can have their software "flashed" using ServiceLink.

All ECUs connected to the Cabin CAN datalink, except for the CGW, have parameters that can be configured.

Some J1939 and J1587/J1708 ECUs may be reprogrammed (flashed), or have parameters configured, using ServiceLink or the ECU manufacturer's proprietary off-board tool. For more information, refer to the applicable

Datalink Communication Structure

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subjects in this manual, and the ServiceLink User Documentation (available via the "Help" drop-down menu in ServiceLink).

509 — Datalink Network Topology

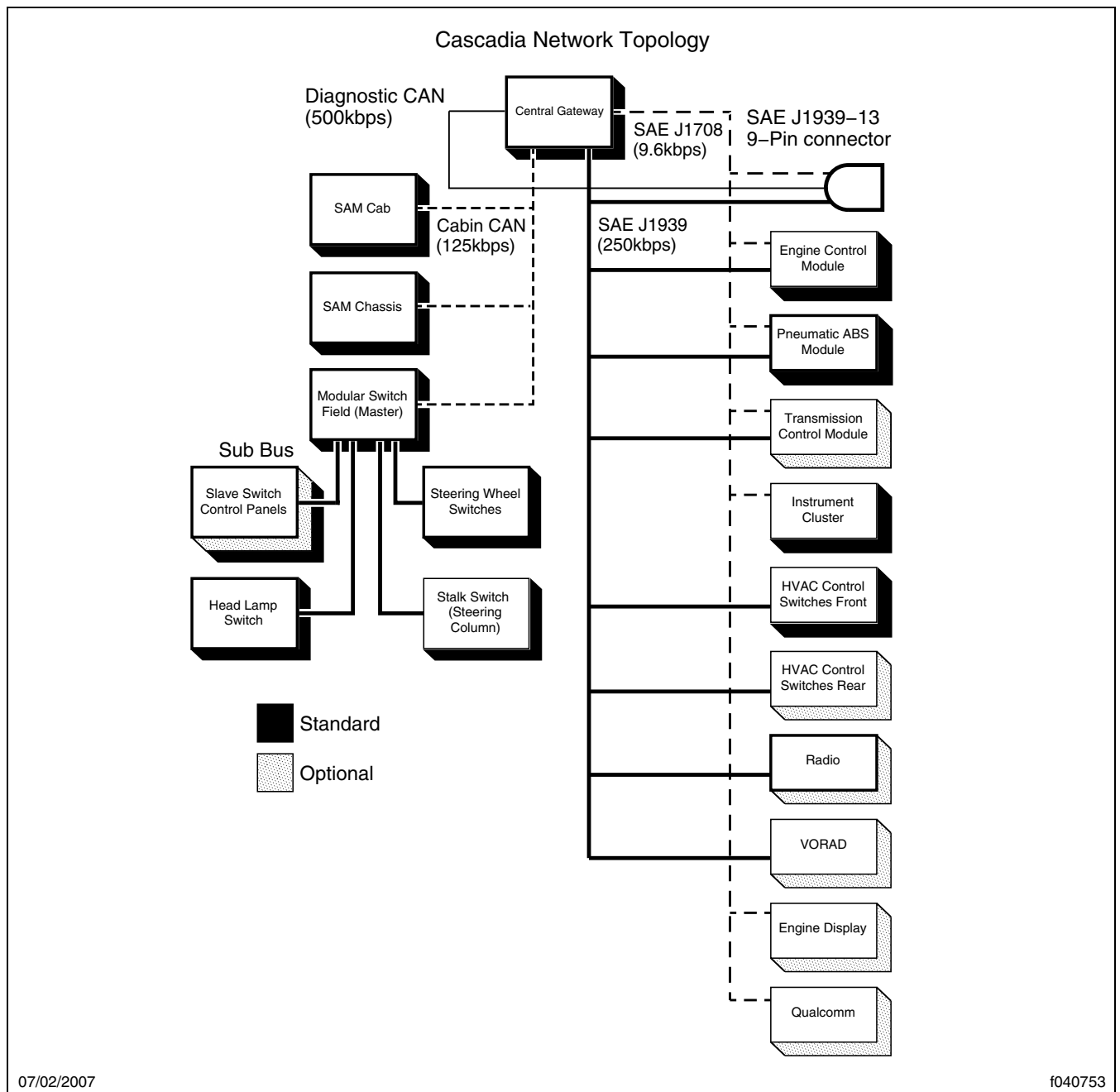


Fig. 3, Datalink Network Topology

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Datalink Communication Structure

510 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.03 — Central Gateway
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.01 — Datalink, J1587/J1708
- G03.02 — Datalink, J1939
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN

600 — Component Locations

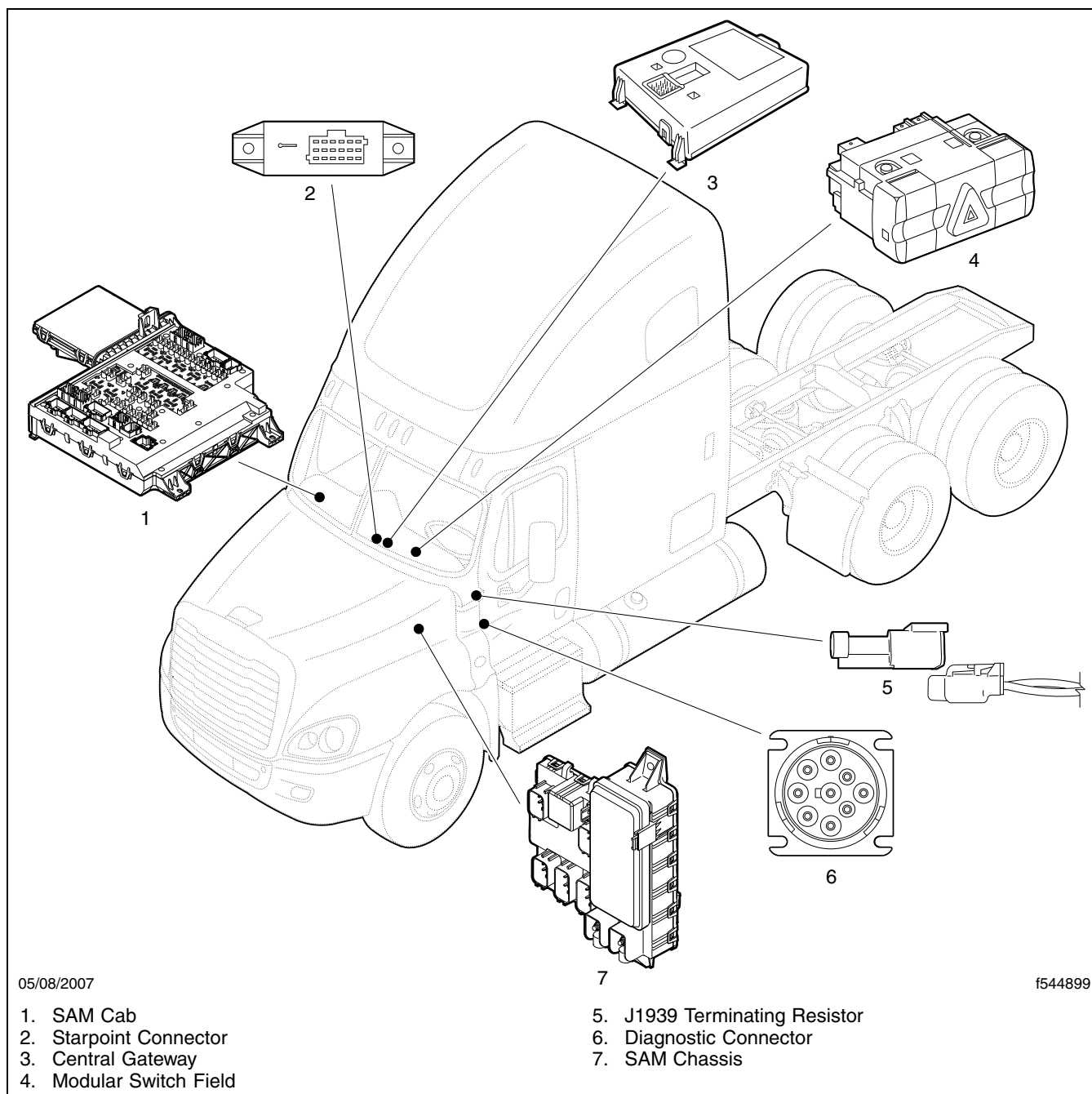


Fig. 4, Component Locations

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Datalink Communication Structure

601 — Component Details

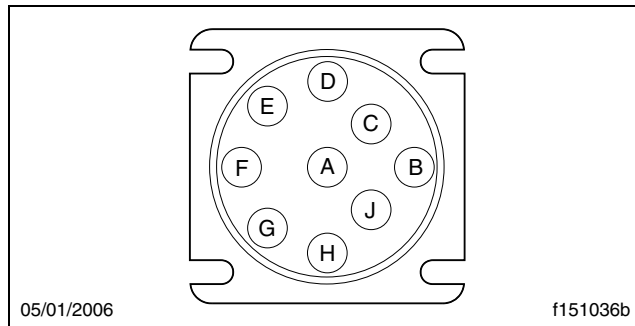


Fig. 5, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	CAN Shield (ground)
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 2, Diagnostic Connector

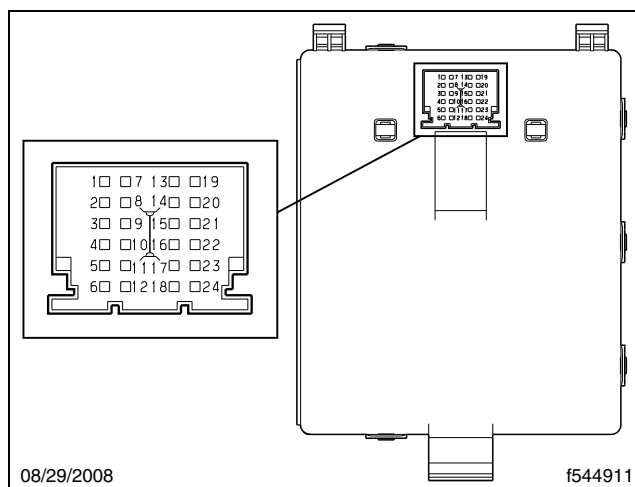


Fig. 6, Central Gateway Module, Cabin CAN Pins

CGW ECU (single connector)	
Pin	Function
1	Battery Power
2	J1708 (+)
3	Not used
4	Not used
5	Not used
6	Not used
7	Ground
8	J1708 (-)
9	Not used
10	Not used
11	Not used
12	Not used
13	Not used
14	Cabin CAN Low
15	Not used
16	J1939 CAN Low
17	Not used
18	Diagnostic CAN Low
19	Cabin CAN High
20	Not used
21	J1939 CAN High
22	Not used
23	Diagnostic CAN High
24	Not used

Table 3, CGW ECU (single connector)

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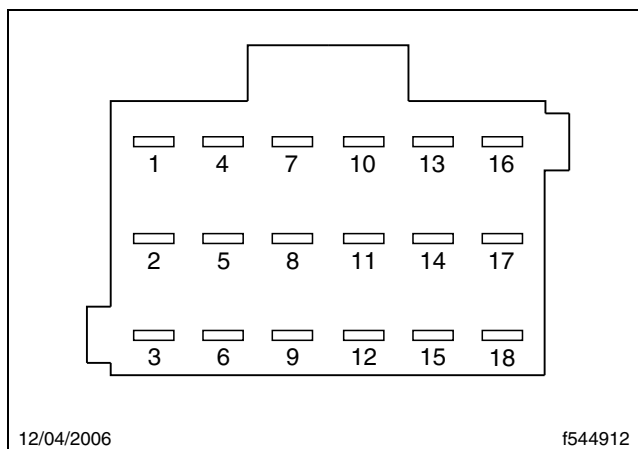


Fig. 7, Starpoint Connector

CGW ECU (single connector)	
Pin	Function
1	Cabin CAN High (to CGW)
2	Not connected
3	Cabin CAN Low (to CGW)
4	Cabin CAN High (to SAM Cab)
5	Not connected
6	Cabin CAN Low (to SAM Cab)
7	Cabin CAN High (to SAM Chassis)
8	Not connected
9	Cabin CAN Low (to SAM Chassis)
10	Cabin CAN High (to MSF)
11	Not connected
12	Cabin CAN Low (to MSF)
13	Not connected
14	Not connected
15	Not connected
16	Not connected
17	Ground
18	Not connected

Table 4, CGW ECU (single connector)

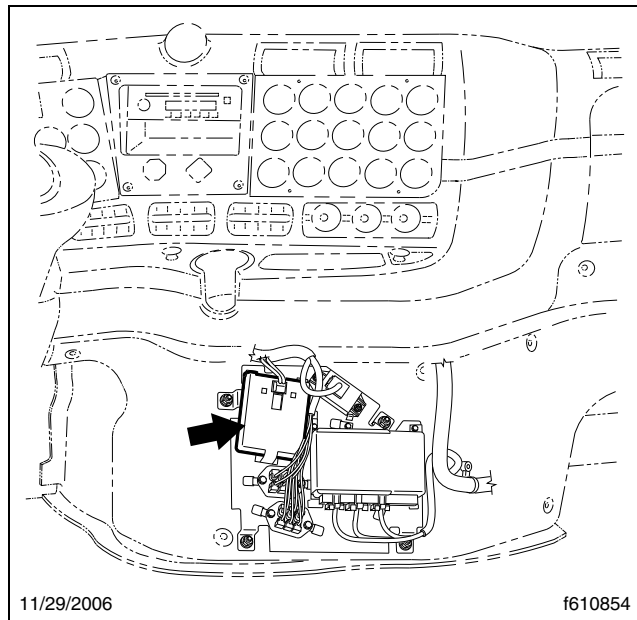


Fig. 8, Central Gateway

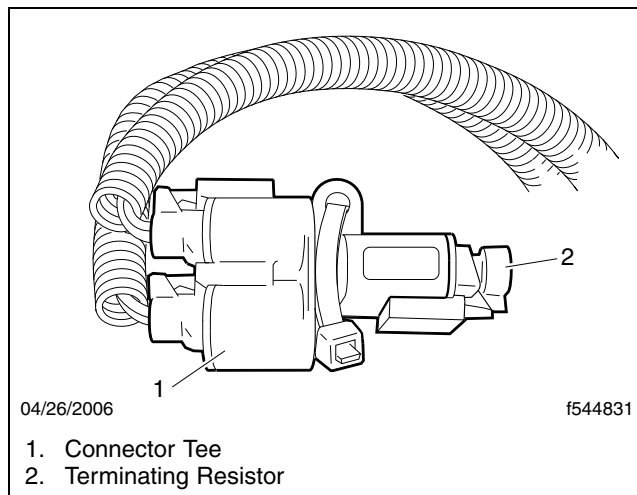


Fig. 9, Connector Tee

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Datalink Communication Structure

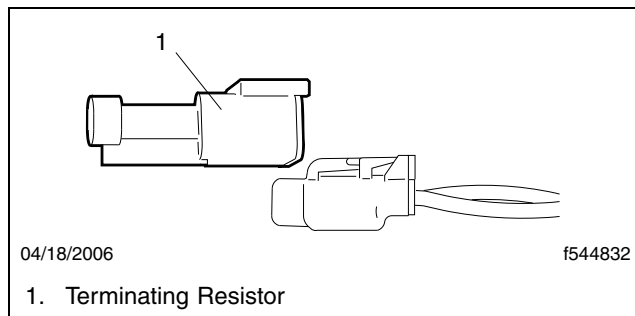


Fig. 10, Terminating Resistor

700 — General Troubleshooting Techniques

Follow the steps below to troubleshoot the datalinks.

1. Identify which datalink has a problem.
2. Perform general electrical troubleshooting for wiring continuity and connections.
3. Refer to individual datalink chapters for more info to troubleshoot the specific datalink.

701 — Diagnostic Tools Required

- ServiceLink

702 — Fault Codes

Refer to **G03.01 — Datalink, J1587/J1708** to troubleshoot the J1587 and J1708 datalink.

Refer to **G03.02 — Datalink, J1939** to troubleshoot the J1939 datalink.

Refer to **G03.03 — Datalink, Cabin CAN** to troubleshoot the Cabin CAN datalink.

Refer to **G03.04 — Datalink, Diagnostic CAN** to troubleshoot the Diagnostic CAN datalink.

703 — References

Refer to **G01.04 — How to Locate a Schematic** for information on wiring.

704 — Possible Causes

Any Datalink:

- wiring
- any ECU connected to the problem datalink

J1939 Datalink:

- terminal resistor value on J1939 datalink

Cabin CAN Datalink:

- starpoint connector resistor value on Cabin CAN datalink

Datalink Communication Structure

G02.02

800 — Wiring

Wiring		
Datalink	Wire Color	
	High	Low
J1939	Yellow	Dark Green
J1587/J1708	Dark Green	Orange
Cabin CAN	Light Blue	White
Diagnostic CAN	Brown with Light Blue Stripe	Brown with White Stripe

Table 5, Wiring

801 — Datalink Communication Rates

Datalink Communication Rates	
Datalink	Kilobits Per Second
J1939	250
J1587/J1708	9600
Cabin CAN	125
Diagnostic CAN	500

Table 6, Datalink Communication Rates

802 — ECU Identification on Datalinks

ECU Identification on Datalinks			
ECU Description	J1587 MID*	J1939 SA†	CAN ID
Engine	128	0	—
Transmission	130	3	—
Antilock Brakes	136	11	—
Instrument Cluster	140	23	—
Vehicle Security Unit (VSU)	163	—	—
Data Logging Unit (DLU)	179	251	—
Collision Avoidance System (headway controller)	219	42	—
SAM Cab	—	—	33
SAM Chassis	—	—	71

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Datalink Communication Structure

ECU Identification on Datalinks			
ECU Description	J1587 MID*	J1939 SA†	CAN ID
Modular Switch Field	—	—	49
Central Gateway	—	—	37

* Message Identifier

† Source Address

Table 7, ECU Identification on Datalinks

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500 — Terms and Abbreviations

Baud Rate—The rate at which data is transmitted in bits per second.

CAN—Controller Area Network

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

ECU—Electronic Control Unit, typically connected to a datalink.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

The Central Gateway is an ECU (Electronic Control Unit), also called the "Central Gateway" (CGW) ECU.

The CGW has the following wiring connections:

- Each datalink on the vehicle: J1708, J1939, Cabin CAN, and Diagnostic CAN.
- On the Diagnostic CAN, the CGW has a direct connection to the diagnostic connector.
- On the Cabin CAN, the CGW is directly connected to the starpoint connector.

G02.03

Central Gateway

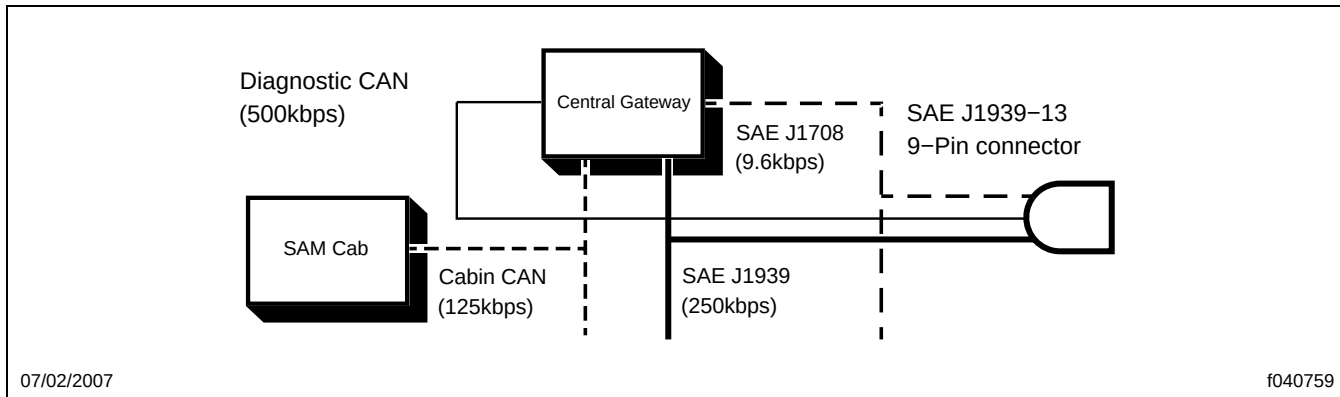


Fig. 1, Central Gateway, Diagnostic Connector, and Vehicle Datalinks

The CGW has the following main functions:

- Routes and translates messages between datalinks.
- Interfaces between off-board tools and Cabin CAN ECUs.
- Provides faults for any missing Cabin CAN ECUs.

The CGW receives battery power and ground from the SAM Cab; power comes through a 2A fuse (F20) on the SAM Cab.

502 — Routing and Translating Messages Between Datalinks

The primary function of the CGW is to connect the four datalinks on the vehicle, and to route and translate the datalink messages between them.

The J1939, J1708, Cabin CAN, and Diagnostic CAN datalinks have different characteristics, but they all work together to control the vehicle. The CGW acts as a translator between the communication protocols used on the various datalinks.

In some instances, the Cabin CAN ECUs need information from J1939 or J1708 ECUs. In these cases, information is sent by the J1939 or J1708 ECU. The CGW picks up the information and passes it to the appropriate Cabin CAN ECU. Similarly, the reverse happens when a J1939 or J1708 ECU needs information from a Cabin CAN ECU.

An example of Cabin CAN and J1939 interaction is the optional cruise control feature. The Engine ECU on the J1939 datalink broadcasts a message containing vehicle speed. The SAM Cab ECU on the Cabin CAN datalink uses the vehicle speed information to perform the cruise control feature. The vehicle speed message flows from the engine ECU to the SAM Cab as follows:

1. The engine ECU broadcasts the vehicle speed message on J1939.
2. The vehicle speed message is picked up by the CGW, from J1939 datalink.
3. The central gateway translates the vehicle speed message from J1939's communication protocol to the Cabin CAN communication protocol.
4. The central gateway routes the vehicle speed message to the Cabin CAN datalink.
5. The vehicle speed message is received by the SAM Cab ECU, and the information is used for cruise control logic.

503 — Interface Between Off-Board Tools and Cabin CAN ECUs

The CGW acts as the interface between ECUs on the Cabin CAN and the outside world. Unlike the J1708 and J1939 datalink, the Cabin CAN datalink does not have its own direct connection to the diagnostic connector. Instead, it is connected to the CGW, which in turn has a direct connection to the diagnostic connector via the Diagnostic CAN datalink.

The CGW separates the Cabin CAN from off-board tools and acts as a firewall, which protects Freightliner's proprietary Cabin CAN datalink from "public" access. This allows for better protection from electrical damage and better control of electrical capabilities, which leads to higher reliability for the ECUs.

504 — ECU Monitoring

The CGW monitors for any missing Cabin CAN ECUs. Each missing Cabin CAN ECU is described in a CAN fault code generated by the CGW.

The CGW monitors all messages on the Cabin CAN datalink to see if an ECU stops sending messages. If this happens, the CGW will report a fault code that a particular ECU is missing. The possible fault codes for missing ECUs are listed in **702 — Fault Codes**.

The ECU monitoring function stops when:

- under or over voltage is detected;
- the Cabin CAN stops communicating.

505 — ECU Configuration

The diagnostic protocol used for troubleshooting or configuring the Central Gateway is the Controller Area Network (CAN).

The Central Gateway does not have any parameters to configure.

The Central Gateway can be flashed using ServiceLink, which will flash to its same version or upgrade, if required.

The software flashing procedure should only be performed on the CGW in the following cases:

- **Feature upgrade:** Adding a new feature to a vehicle may require a newer version of ECU software. ServiceLink will automatically make available any necessary software upgrades.
- **Fixing a software problem in the existing software:** In case a new version of ECU software is needed to fix a problem in the existing ECU software, ServiceLink will automatically make available any necessary software upgrades.
- **Replacement of the Central Gateway:** Flashing ensures that the most recent software is on the installed ECU.
- **As a last resort:** Troubleshooting has narrowed the problem down to being at the Central Gateway itself and no other mechanical or electrical causes for the symptom have been identified. As a last resort before swapping the ECU, flashing the CGW software with the same version may help in the case it became corrupt during the course of normal vehicle operation.

For instructions on how to use ServiceLink to flash the software of a CAN ECU like the Central Gateway, refer to the *ServiceLink User Guide* or *ServiceLink Help* user documentation, available in ServiceLink's "Help" menu.

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Central Gateway

506 — Related Subjects

- G02.02 — Datalink Communication Structure
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.01 — Datalink, J1587/J1708
- G03.02 — Datalink, J1939
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN

507 — Datalink Network Topology

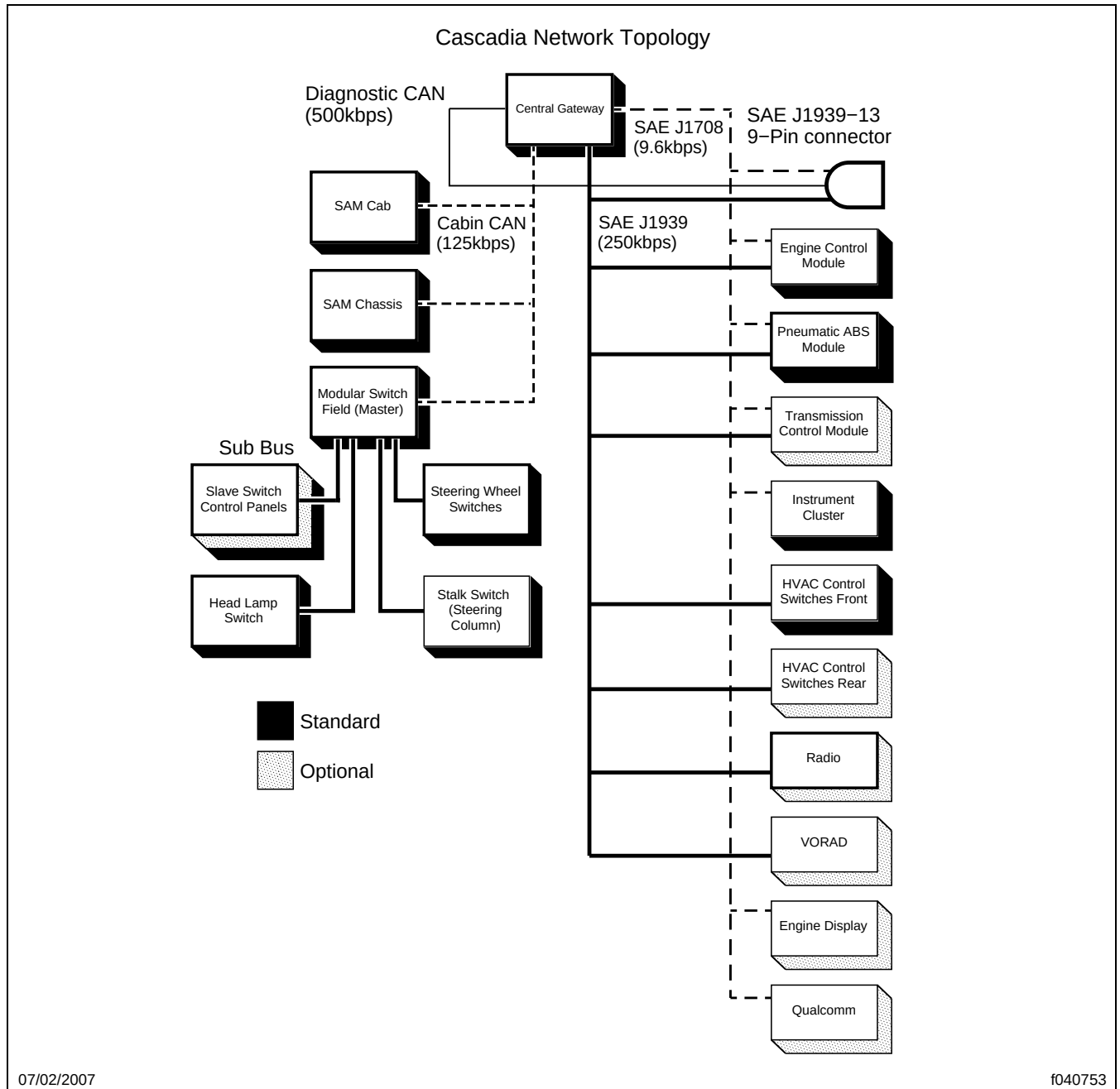


Fig. 2, Datalink Network Topology

G02.03

Central Gateway

600 — Component Locations

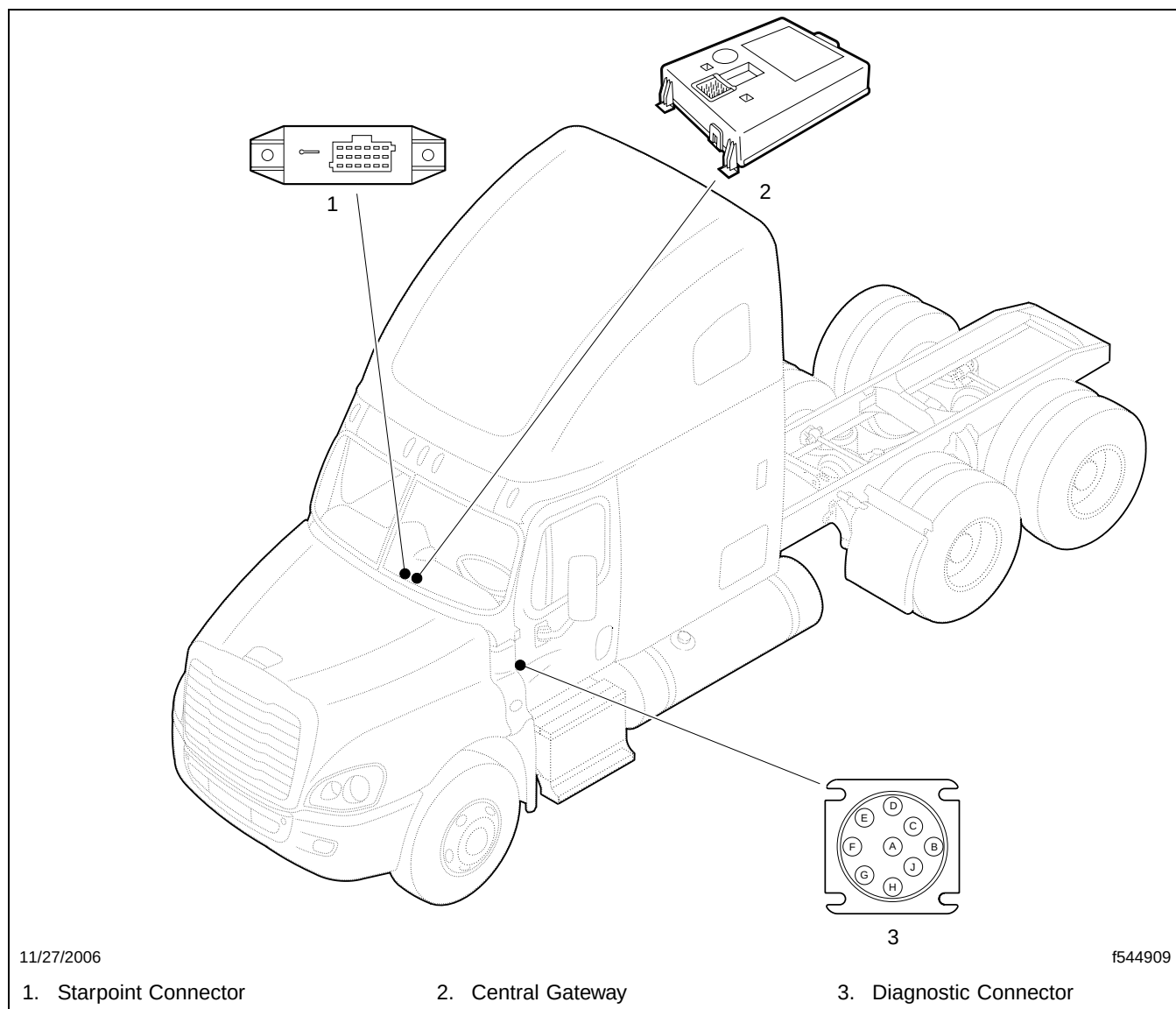


Fig. 3, Component Locations

601 — Component Details

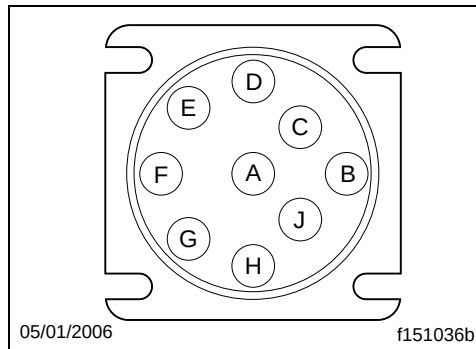


Fig. 4, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (-)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (-)
E	Reserved
F	J1708/J1587 (+)
G	J1708/J1587 (-)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (-)

Table 1, Diagnostic Connector

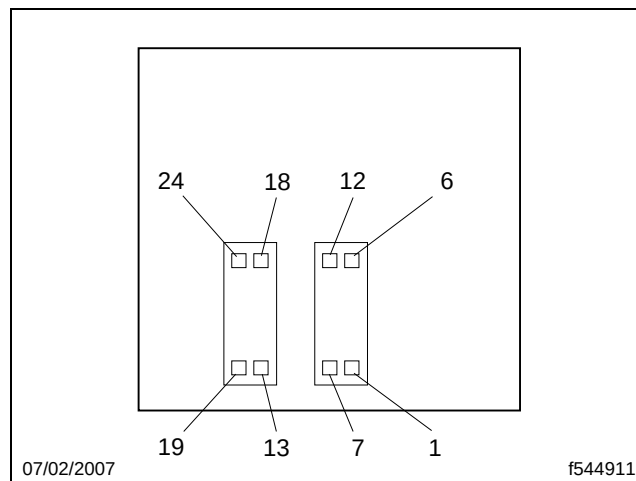


Fig. 5, Central Gateway Module, Cabin CAN Pins

G02.03

Central Gateway

CGW ECU (single connector)	
Pin	Function
1	Battery Power
2	J1708/J1587 (+)
7	Ground
8	J1708/J1587 (-)
14	Cabin CAN Low (-)
16	J1939 Low (-)
18	Diagnostic CAN Low (-)
19	Cabin CAN High (+)
21	J1939 High (+)
23	Diagnostic CAN High (+)

Table 2, CGW ECU (single connector)

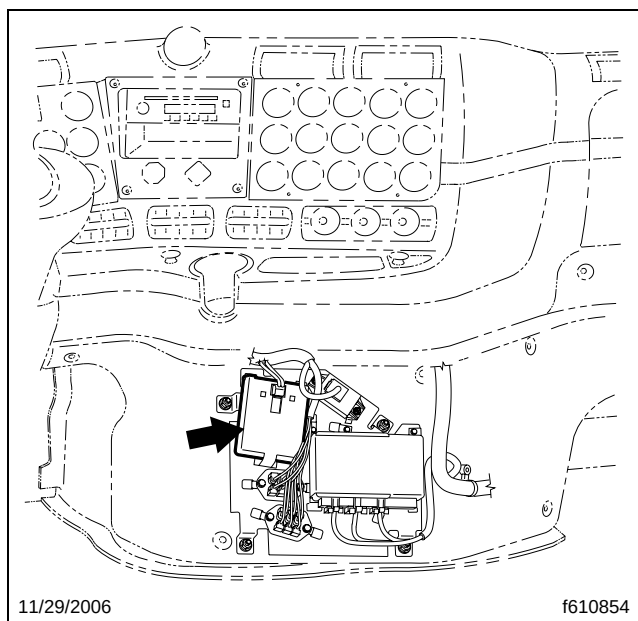


Fig. 6, Central Gateway

700 — Required Tools

- ServiceLink

701 — Possible Causes

- Fuse F20 (CGW power) on the SAM Cab
- Wiring

Central Gateway

G02.03

- Starpoint Connector (Cabin CAN)
- CGW
- J1939 Terminating Resistors
- J1587/J1708 Junction Block
- Diagnostic Connector
- Cabin CAN ECUs

702 — Fault Codes

Fault Codes				
SA	SPN	FMI	Fault Description	Fault Trigger
37	168	4	Battery Power—Voltage below normal or shorted to low	CGW battery power (pin 1) fell below the lower limit of the system voltage range: 9V.
37	168	3	Battery Power—Voltage above normal or shorted to high	CGW battery power (pin 1) exceeded the upper limit of the system voltage range: 16V.
37	628	12	Program Memory—Bad intelligent device or component	The memory in the CGW has a problem.
37	523510	31	Diagnostic CAN Performance	Cabin CAN performance failures (communication is not possible) occur when: • Diagnostic CAN High is shorted to GND • Diagnostic CAN Low is shorted to BAT • Diagnostic CAN Low is shorted to Diagnostic CAN High
37	523511	31	Cabin CAN Performance	Cabin CAN performance failures (communication is not possible) occur when: • Cabin CAN High is shorted to GND • Cabin CAN Low is shorted to BAT • Cabin CAN Low is shorted to Cabin CAN High
37	523512	31	J1939 CAN Performance	J1939 CAN performance failures (communication is not possible) occur when: • J1939 CAN High is shorted to GND • J1939 CAN Low is shorted to BAT • J1939 CAN Low is shorted to J1939 CAN High
37	523513	31	J1708 Performance	J1708 performance errors occur when: • The busload (i.e. amount of data traffic) on J1708 is too high. • The CAN datalinks (Cabin CAN, Diagnostic CAN, J1939 CAN) have extremely high busload.*

G02.03

Central Gateway

Fault Codes				
SA	SPN	FMI	Fault Description	Fault Trigger
37	524033	31	Lost communication with SAM_CAB	Trigger: The fault is triggered when the CGW does not see any messages from the SAM Cab for at least 20 seconds. The fault becomes historic as soon as the CGW sees messages from the SAM Cab. Vehicle Behavior: The SAM Cab and SAM Chassis outputs may be behaving according to "Emergency Power Mode" for a SAM Cab failure. An indication of a SAM Cab failure is that all gauges in the instrumentation control unit (ICU) drop to zero because power to the ICU is lost. Possible Causes: The SAM Cab is not connected to the Cabin CAN datalink, or does not have power. Action: Check wiring from the Cabin CAN to the SAM Cab, and the CGW. Check the SAM Cab power supply cables.
37	524049	31	Lost communication with MSF	Trigger: The fault is triggered when the CGW does not see any messages from the MSF for at least 20 seconds. The fault becomes historic as soon as the CGW sees messages from the MSF. Vehicle Behavior: Headlights automatically turn on for safety. All functions where input switches are controlled by the MSF do not function, such as turn and hazard functions, rotary switch (headlamp) functions, and wiper. Action: Check Cabin CAN wiring, especially connections to the MSF and the CGW. Check MSF power supply.
37	524071	31	Lost communication with SAM_CHAS	Trigger: The fault is triggered when the CGW does not see any messages from the SAM Chassis for at least 20 seconds. The fault becomes historic as soon as the CGW sees messages from the SAM Chassis. Vehicle Behavior: SAM Cab and SAM Chassis outputs may be behaving according to "Emergency Power Mode" for a SAM Chassis failure. An indication of a SAM Chassis failure is that the ICU turn signal indicators flash alternately. Possible Causes: The SAM Chassis is not connected to the Cabin CAN datalink, or does not have power. Action: Check wiring from the Cabin CAN to the SAM Chassis, and the CGW. Check the SAM Chassis power supply cables.

* High bus load on a datalink may be caused by a faulty ECU, which broadcasts erroneous data, clogging up communication on the datalink.

Table 3, Fault Codes

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500 — Terms and Abbreviations

Baud Rate—The rate at which data is transmitted in bits per second.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

CPC—Common Powertrain Controller (for M-B and DDC engines only).

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

HVAC—Heating, Ventilation, and Air Conditioning

ICU—Instrumentation Control Unit

I/O Controls—Input/Output controls allow a technician to activate and deactivate an input or output pin for troubleshooting purposes. I/O controls appear on ServiceLink templates as buttons, typically labeled "ON" and "OFF."

ISS—Ignition Switch Status

MSF—Modular Switch Field

NO—Normally Open

NC—Normally Closed

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

OBD—Onboard Diagnostics

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PDM—Power Distribution Module

PLVD—Progressive Low Voltage Disconnect

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality.

G02.04

SAM Cab

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The SAM Cab is an ECU (Electronic Control Unit). It is also referred to as the "SAM Cabin."

The SAM Cab works closely with the SAM Chassis to control much of the vehicle functionality. The SAM Cab controls most of the cab functions. The SAM Chassis controls most of the chassis functions.

This ECU uses inputs (such as switches, sensors, and datalink messages) and drives outputs (such as lights, motors, and solenoids). See **601 — Component Details** for complete pin information.

IMPORTANT: This subject describes the SAM Cab ECU in general terms. To understand a particular function or system that the SAM Cab is part of, see the appropriate subject in this manual on that function or system. Each subject contains details about the way a function should work, as well as crucial information such as inputs, outputs, interlocks, any related parameters for that particular function, and any other ECUs or components that are a part of that function.

502 — Fuses and Relays

The SAM Cab houses a number of fuses and relays.

See **601 — Component Details** for fuse and relay locations. See **602 — Pinout Mapping**, **603 — Fuse Mapping**, and **604 — Relay Mapping** for the functions associated with each pin, fuse, and relay.

For more information on the power distribution system, see **G02.01 — Electrical System and Main PDM Overview**.

503 — Datalink Connections

The SAM Cab is connected directly to the Cabin CAN datalink. Cabin CAN wires run from the SAM Cab to the starpoint connector, where it joins the rest of the Cabin CAN datalink.

See **G03.03 — Datalink, Cabin CAN** for details.

504 — Diagnostic CAN Datalink

When an off-board tool, such as ServiceLink, is connected to the vehicle, it communicates with the Cabin CAN ECUs via the Diagnostics CAN datalink; there is no accessible service port to the Cabin CAN. The CGW translates between the Diagnostics CAN and Cabin CAN datalink, due to the different speed and message formats of the two datalinks.

505 — Functional Messaging and ECU Troubleshooting

To communicate with the ECU, a different set of messages is used by the off-board tool during troubleshooting than the set of messages used during normal operation.

The set of messages used during normal operation is referred to as functional messages, which are sent cyclically on the Cabin CAN datalink. However, the set of messages (protocol) used during troubleshooting is referred to as Control Area Network (CAN), which operates on a request-and-response basis over the Diagnostic CAN datalink.

Any fault reported on the Cabin CAN is translated to Diagnostics CAN by the CGW, and can be displayed when requested by an off-board tool, such as ServiceLink. Similarly, an off-board tool is able to display input and output pin status information, software interlocks, and allows a user to control inputs or outputs for troubleshooting. This information is displayed in ServiceLink's Datalink Monitor (DLM) templates.

506 — ECU Configuration

The diagnostic protocol used for troubleshooting or configuring the SAM Cab is the Control Area Network (CAN). For more information on CAN, see **G03.04 — Datalink, Diagnostic CAN**.

The SAM Cab has parameters that can be viewed or changed for vehicle configuration.

The SAM Cab software can be flashed using ServiceLink, which will flash to its same version or upgrade, if required.

The software flashing procedure should only be performed on the SAM Cab in the following cases:

- **As a last resort:** Troubleshooting has narrowed the problem down to being at the SAM Cab itself and no other mechanical or electrical causes for the symptom have been identified. As a last resort, flashing the SAM Cab software with the same version may help in the case it became corrupt during the course of normal vehicle operation.
- **For a feature upgrade:** Adding a new feature to a vehicle may require a newer version of ECU software. ServiceLink will automatically make available any necessary software upgrades.
- **Fixing a problem in the existing software:** In case a new version of ECU software is needed to fix a problem in the existing ECU software, ServiceLink will automatically make available any necessary software upgrades.
- **Replacing the SAM Cab:** Flashing ensures that the most recent software is on the installed ECU.

For instructions on how to use ServiceLink to flash the software of a CAN ECU like the SAM Cab, refer to the *ServiceLink User Guide* or *ServiceLink Help* user documentation, available in ServiceLink's "Help" menu.

507 — Datalink Network Topology

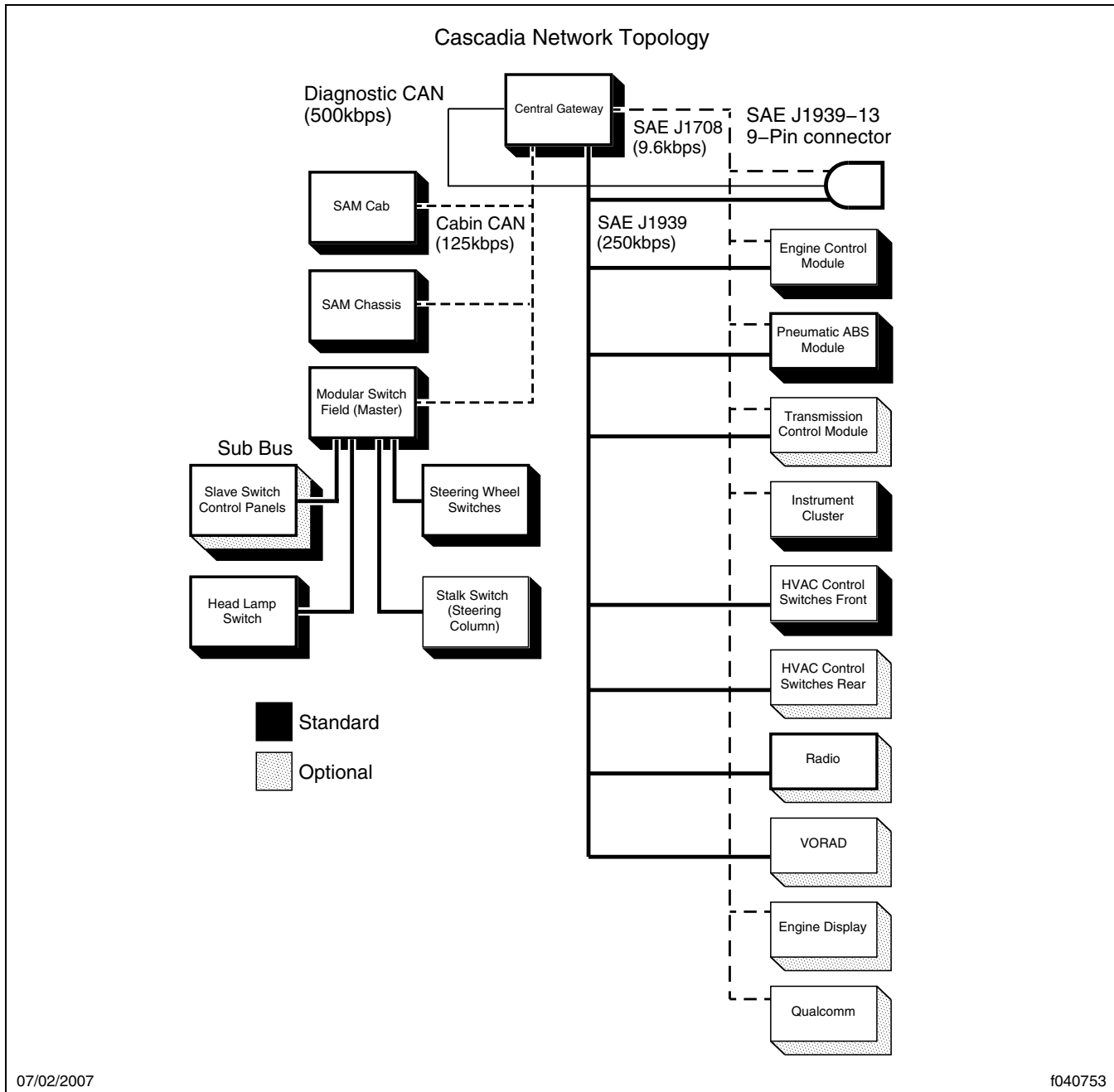


Fig. 1, Datalink Network Topology

600 — Component Locations

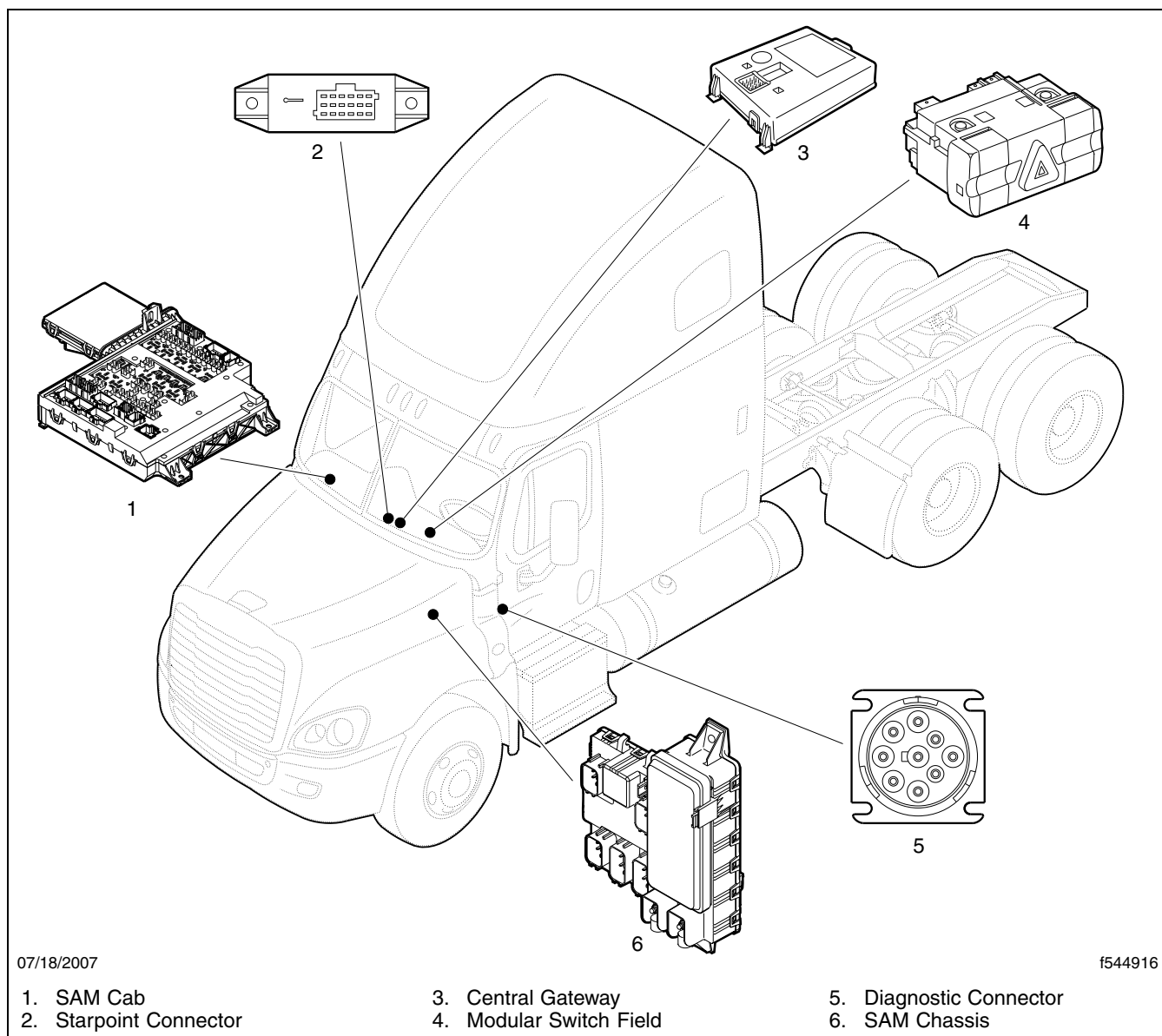


Fig. 2, Component Locations

NOTE: J1939 and J1708 ECUs in this diagram are not intended to represent actual vehicle configuration.

601 — Component Details

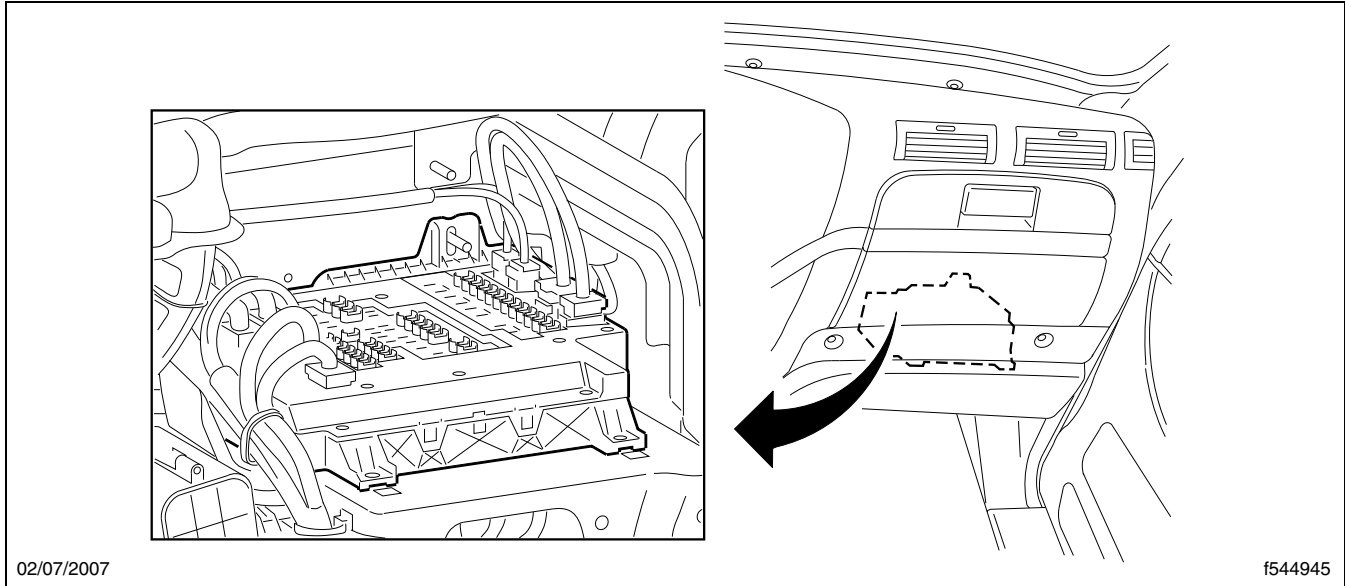


Fig. 3, SAM Cab

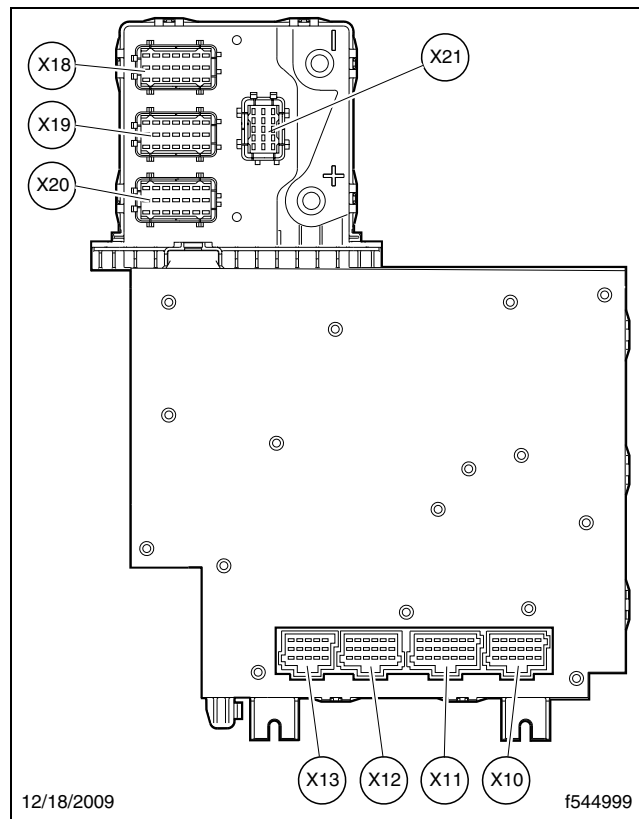


Fig. 4, SAM Cab Connectors (top view)

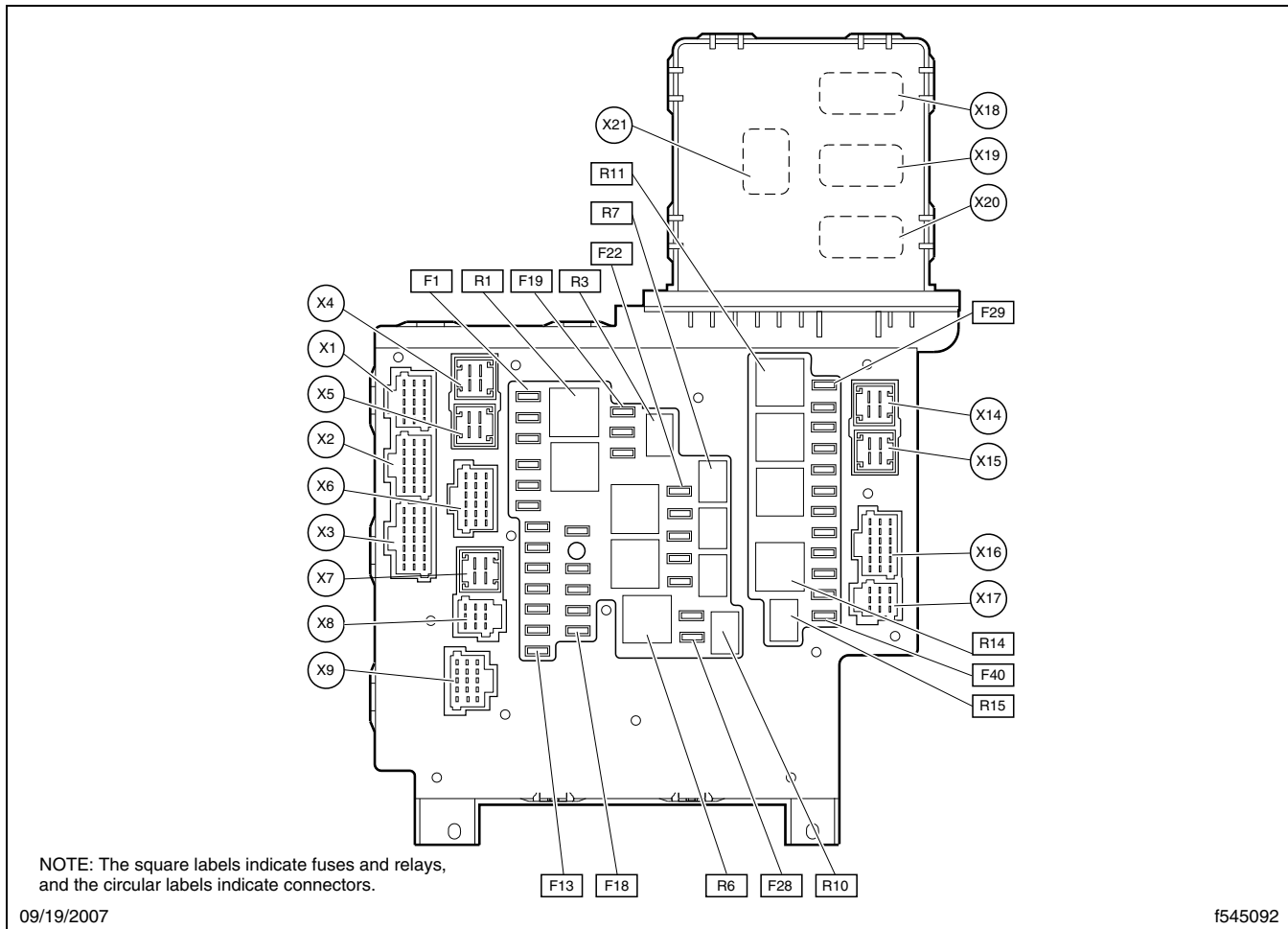


Fig. 5, SAM Cab Fuses and Relays (bottom view)

NOTE: Not all fuse and relay locations are labeled in this image. Locations for fuses and relays in the middle can be determined based on end labels of a row. For example, fuse F17 is one above F18, and R8 is one below R7 and two above R10. All connectors are labeled in this image.

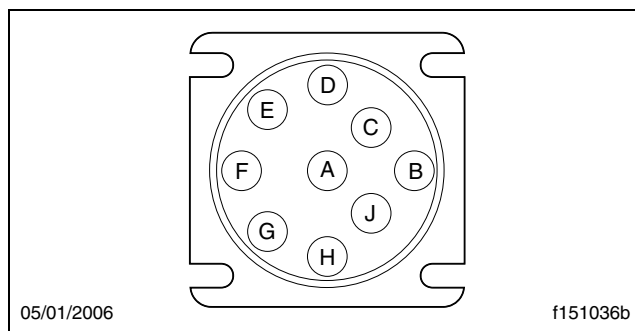


Fig. 6, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	No Connection
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 1, Diagnostic Connector

602 — Pinout Mapping

NOTE: The housing of the SAM Cab contains raised lettering, labeling all connectors, fuses, and relays.

The SAM Cab is available in different hardware models: Highline, Midline, and Baseline. **Table 2** describes any differences in pin functionality between these hardware models

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X1	1	Transmission temperature gauge, Ignition	Transmission temperature gauge, Ignition	—
X1	2	Hands-Free Phone, Ground	Not Connected	—
X1	3	Cabin HVAC Controller, Battery	Cabin HVAC Controller, Battery	—
X1	4	Hands-Free Phone, Ignition	Not Connected	—
X1	5	Heated Seats, Ground	Not Connected	—
X1	6	Sleeper HVAC Controller, Battery	Sleeper HVAC Controller, Battery	—
X1	7	Hands-Free Phone, Battery	Not Connected	—
X1	8	Auxiliary Circulation Fan, Sleeper, Ground	Not Connected	—
X1	9	Transmission Shift Control Panel, Battery	Transmission Shift Control Panel, Battery	—
X1	10	Cabin HVAC Controller, Accessory	Cabin HVAC Controller, Accessory	—
X1	11	Sleeper HVAC Controller, Ground	Sleeper HVAC Controller, Ground	—
X1	12	Heated Seats, Ignition	Not Connected	—
X1	13	Auxiliary Circulation Fan, Sleeper, Battery	Not Connected	—

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SAM Cab

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X1	14	Cabin HVAC Controller, Ground	Cabin HVAC Controller, Ground	—
X1	15	Sleeper HVAC Controller, Accessory	Sleeper HVAC Controller, Accessory	—
X2	1	Auxiliary Heater (ESPAR), Power	Not Connected	—
X2	2	MSF, Ground	MSF, Ground	—
X2	3	OBD J1939, Battery	OBD J1939, Battery	—
X2	4	VCU/CPC, Ignition	VCU/CPC, Ignition	—
X2	5	Area Lighting (Lower Bunk Area and Sleeper Work Surface), Ground	Area Lighting (Lower Bunk Area and Sleeper Work Surface), Ground	—
X2	6	Reserved for future use	Reserved for future use	—
X2	7	Starter relay output from Engine Controller (Optimized Idle)	Starter relay output from Engine Controller (Optimized Idle)	—
X2	8	Diagnostic Connector, Ground 1 (GND1)	Diagnostic Connector, Ground 1 (GND1)	—
X2	9	Diagnostic Connector, Ignition	Diagnostic Connector, Ignition	—
X2	10	Hardwired ISS (Ignition Switch Status), Cab	Hardwired ISS (Ignition Switch Status), Cab	—
X2	11	Diagnostic Connector, Ground 2	Diagnostic Connector, Ground 2	—
X2	12	MSF, Battery	MSF, Battery	—
X2	13	Collision Avoidance System, Battery	Not Connected	—
X2	14	Collision Avoidance System, Ignition	Not Connected	—
X2	15	Area Lighting (Lower Bunk Area and Sleeper Work Surface), Battery	Area Lighting (Lower Bunk Area and Sleeper Work Surface), Battery	—
X2	16	Collision Avoidance System, Ground	Not Connected	—
X2	17	Auxiliary Heater (ESPAR), Ground	Not Connected	—
X2	18	Emergency Battery, Cab	Emergency Battery, Cab	—
X3	1	GPS (Global Positioning System), Battery	Not Connected	—
X3	2	Antitheft Warning System, Battery	Not Connected	—
X3	3	12V Power Receptacle 4 (Sleeper, Cigar), Battery	12V Power Receptacle 4 (Sleeper, Cigar), Battery	—
X3	4	Advertising Light, Accessory	Not Connected	—
X3	5	Standalone HVAC, Battery	Standalone HVAC, Battery	—
X3	6	SRS Airbag, Ignition	Not Connected	—
X3	7	Utility Light	Utility Light	—

SAM Cab

G02.04

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X3	8	Not Connected	Not Connected	—
X3	9	Amplifier Power, Accessory	Not Connected	—
X3	10	GPS (Global Positioning System), Ignition	Not Connected	—
X3	11	Radio, Battery	Radio, Battery	—
X3	12	Not Connected	Not Connected	—
X3	13	Standalone HVAC, Ground	Standalone HVAC, Ground	—
X3	14	SRS Airbag, Ground	Not Connected	—
X3	15	12V Power Receptacle 3 (Sleeper, Cigar), Battery	12V Power Receptacle 3 (Sleeper, Cigar), Battery	—
X3	16	CGW (Central Gateway ECU), Ground	CGW (Central Gateway ECU), Ground	—
X3	17	Amplifier Power, Ground	Not Connected	—
X3	18	CGW (Central Gateway ECU), Battery	CGW (Central Gateway ECU), Battery	—
X3	19	Radio, Ground	Radio, Ground	—
X3	20	Antitheft Warning System, Ground	Not Connected	—
X3	21	Utility Light, Ground	Utility Light, Ground	—
X4	1	Power Feed Spare Output I, Battery	Power Feed Spare Output I, Battery	—
X4	2	Power Feed Spare Output III, Battery	Not Connected	—
X4	3	Power Feed Spare Output I, Ground	Power Feed Spare Output I, Ground	—
X4	4	Power Feed Spare Output III, Ground	Not Connected	—
X5	1	Power Feed Spare Output II, Battery	Power Feed Spare Output II, Battery	—
X5	2	Power Feed Spare Output IV, Battery	Not Connected	—
X5	3	Power Feed Spare Output II, Ground	Power Feed Spare Output II, Ground	—
X5	4	Power Feed Spare Output IV, Ground	Not Connected	—
X6	1	CB Radio, Ground	CB Radio, Ground	—
X6	2	Fleet Management System, Battery	Fleet Management System, Battery	—
X6	3	CB Radio, Battery	CB Radio, Battery	—
X6	4	Instrument Cluster, Ground	Instrument Cluster, Ground	—
X6	5	Power Feed Driver Information System, Ignition	Not Connected	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X6	6	Fleet Management System, Ignition	Fleet Management System, Ignition	—
X6	7	Fleet Management System, Ground	Fleet Management System, Ground	—
X6	8	Power Feed Gauge Pyrometer, Ignition	Not Connected	—
X6	9	12V Power Receptacle 2 (Dash, Phone), Battery	12V Power Receptacle 2 (Dash, Phone), Battery	—
X6	10	Power Feed Gauge Axle Temperature, Ignition	Power Feed Gauge Axle Temperature, Ignition	—
X6	11	Power Feed Gauge Engine Oil Temperature, Ignition	Power Feed Gauge Engine Oil Temperature, Ignition	—
X6	12	Power Feed Clock Cab, Battery	Power Feed Clock Cab, Battery	—
X6	13	Power Feed Driver Information System, Battery	Not Connected	—
X6	14	Power Feed Clock Sleeper, Battery	Power Feed Clock Sleeper, Battery	—
X6	15	12V Power Receptacle 1 (Dash, Cigar), Battery	12V Power Receptacle 1 (Dash, Cigar), Battery	—
X6	16	Instrument Cluster, Ignition	Instrument Cluster, Ignition	—
X6	17	Not Connected	Not Connected	—
X6	18	Instrument Cluster, Battery	Instrument Cluster, Battery	—
X7	1	Sleeper HVAC Fan Motor, Ground	Sleeper HVAC Fan Motor, Ground	—
X7	2	Cabin HVAC Fan Motor, Ground	Cabin HVAC Fan Motor, Ground	—
X7	3	Sleeper HVAC Fan Motor, Battery	Sleeper HVAC Fan Motor, Battery	—
X7	4	Cabin HVAC Fan Motor, Battery	Cabin HVAC Fan Motor, Battery	—
X8	1	Door Open Driver Side Input Pull Down	Door Open Driver Side Input Pull Down	—
X8	2	Mirror Heating Driver, Ground	Mirror Heating Driver, Ground	—
X8	3	Door Control Driver, Ground	Door Control Driver, Ground	—
X8	4	Door Control Driver, Battery	Door Control Driver, Battery	—
X8	5	Door Open Status ICU Input	Door Open Status ICU Input	—
X8	6	Door Lock, Battery	Door Lock, Battery	—
X8	7	Power Window Driver Side, Accessory	Power Window Driver Side, Accessory	—
X8	8	Mirror Heating Driver	Mirror Heating Driver	—
X8	9	Door Sill Lamp Driver	Door Sill Lamp Driver	—
X9	1	Body Builder Connector: Revolution	Not Connected	—

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X9	2	Body Builder Connector: Vehicle Speed	Not Connected	—
X9	3	Function Pin 1	Function Pin 1	—
X9	4	Body Builder Connector: Park Brake	Not Connected	—
X9	5	Function Pin 2	Function Pin 2	—
X9	6	Function Pin 4	Function Pin 4	—
X9	7	Function Pin 3	Function Pin 3	—
X9	8	Body Builder Connector: Ground 1 (GND1)	Not Connected	—
X9	9	Body Builder Connector: Backup Lamp	Not Connected	—
X9	10	Body Builder Connector: Marker Lights	Not Connected	—
X9	11	Body Builder Connector: Ignition	Not Connected	—
X9	12	Body Builder Connector: Tail Lights	Not Connected	—
X9	13	Body Builder Connector: Right Turn	Not Connected	—
X9	14	Body Builder Connector: Left Turn	Not Connected	—
X9	15	Body Builder Connector: Stop Lights	Not Connected	—
X10	1	Tire Pressure Monitoring, Ignition	Not Connected	—
X10	2	Inside Temperature Sensor, Propeller Control, Accessory	Inside Temperature Sensor, Propeller Control, Accessory	—
X10	3	Belt Buckle Contact Signal	Not Connected	—
X10	4	Panel Lamps, Ground	Panel Lamps, Ground	—
X10	5	Tire Pressure Monitoring, Ground	Not Connected	—
X10	6	Vehicle Power Shut Down Signal (Optimized Idle)	Vehicle Power Shut Down Signal (Optimized Idle)	—
X10	7	Service Brake Pressure Switch, Supply	Service Brake Pressure Switch, Supply	—
X10	8	Power Feed Sleeper Thermostat (Optimized Idle), Ground	Power Feed Sleeper Thermostat (Optimized Idle), Ground	—
X10	9	Inside Temperature Sensor, Feedback	Inside Temperature Sensor, Feedback	—
X10	10	Power Feed Sleeper Thermostat (Optimized Idle), Ignition	Power Feed Sleeper Thermostat (Optimized Idle), Ignition	—
X10	11	Inside Temperature Sensor/Propeller, Ground	Inside Temperature Sensor/Propeller, Ground	—
X10	12	Not Connected	Not Connected	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X10	13	Panel Lamps	Panel Lamps	—
X10	14	Inside Temperature Sensor, Ground	Inside Temperature Sensor, Ground	—
X10	15	Belt Buckle Contacts, Ground	Not Connected	—
X10	16	Tire Pressure Monitoring, Battery	Not Connected	—
X10	17	Instrument Cluster, HL Wake Up	Instrument Cluster, HL Wake Up	—
X10	18	Radio, Accessory	Radio, Accessory	—
X11	1	Differential Lock ICU Indicator, RA2	Not Connected	—
X11	2	Washer Level ICU Indicator	Washer Level ICU Indicator	—
X11	3	Electrical Global Fault Indicator (Future Use)	Electrical Global Fault Indicator (Future Use)	—
X11	4	Fuel Water Separator ICU Indicator	Not Connected	—
X11	5	Differential Lock ICU Indicator, RA1	Differential Lock ICU Indicator, RA1	—
X11	6	Low Air Pressure Switch ICU Indicator	Low Air Pressure Switch ICU Indicator	—
X11	7	Lights On Buzzer	Lights On Buzzer	—
X11	8	Air Filter Restriction ICU Indicator	Air Filter Restriction ICU Indicator	—
X11	9	High Beam ICU Indicator	High Beam ICU Indicator	—
X11	10	Rain / Light Sensor, Ground	Not Connected	—
X11	11	Turn Signal Left ICU Indicator	Turn Signal Left ICU Indicator	—
X11	12	Alternator No Charge ICU Indicator	Alternator No Charge ICU Indicator	—
X11	13	Turn Signal Right ICU Indicator	Turn Signal Right ICU Indicator	—
X11	14	Park Brake Switch ICU Indicator	Park Brake Switch ICU Indicator	—
X11	15	Rain / Light Sensor, LIN	Not Connected	—
X11	16	Clutch Switch Return, Ground	Clutch Switch Return, Ground	—
X11	17	Top of Clutch (Cruise Control Disable)	Top of Clutch (Cruise Control Disable)	—
X11	18	Auxiliary Telematic Unit, Ground	Not Connected	—
X11	19	Auxiliary Telematic Unit, Battery	Not Connected	—
X11	20	Bottom of Clutch (Starter Control)	Bottom of Clutch (Starter Control)	—
X11	21	Rain / Light Sensor, Battery	Not Connected	—
X12	1	Rear Baggage Compartment Light Switch Center	Rear Baggage Compartment Light Switch Center	—
X12	2	Rear Baggage Compartment Light Switch Left	Rear Baggage Compartment Light Switch Left	—
X12	3	Footwell Light	Footwell Light	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X12	4	Dome Lamps Sleeper, Ground	Dome Lamps Sleeper, Ground	—
X12	5	Rear Baggage Compartment Light Switch Right	Rear Baggage Compartment Light Switch Right	—
X12	6	Reading Lamp 1 (Dimmable / Theater)	Reading Lamp 1 (Dimmable / Theater)	—
X12	7	Not Connected	Not Connected	—
X12	8	Reading Lamps 1 & 2 (Dimmable / Theater), Ground	Reading Lamps 1 & 2 (Dimmable / Theater), Ground	—
X12	9	General Sleeper Lamp	General Sleeper Lamp	—
X12	10	Footwell Light, Ground	Footwell Light, Ground	—
X12	11	General Sleeper Lamp, Ground	General Sleeper Lamp, Ground	—
X12	12	Rear Baggage Compartment Lights	Rear Baggage Compartment Lights	—
X12	13	Not Connected	Not Connected	—
X12	14	Rear Baggage Compartment Lights, Ground	Rear Baggage Compartment Lights, Ground	—
X12	15	Turn Left Front Side	Turn Left Front Side	—
X12	16	Reading Lamp 2 (Dimmable / Theater)	Reading Lamp 2 (Dimmable / Theater)	—
X12	17	Dome Lamp, Rear	Dome Lamp, Rear	—
X12	18	Turn Right Front Side	Turn Right Front Side	—
X13	1	Not Connected	Not Connected	—
X13	2	SAM Cab, Cabin CAN Low (-)	SAM Cab, Cabin CAN Low (-)	—
X13	3	SAM Cab, Cabin CAN High (+)	SAM Cab, Cabin CAN High (+)	—
X13	4	Ignition Switch - Off	Not Connected	—
X13	5	Ignition Switch - Accessory	Ignition Switch - Accessory	—
X13	6	Ignition Switch - On (Ignition)	Ignition Switch - On (Ignition)	—
X13	7	Ignition Switch - Battery	Ignition Switch - Battery	—
X13	8	Park Brake Switch Feedback	Park Brake Switch Feedback	—
X13	9	Park Brake Switch Supply	Park Brake Switch Supply	—
X13	10	Low Air Pressure Switch Feedback	Low Air Pressure Switch Feedback	—
X13	11	Low Air Pressure Switch Supply	Low Air Pressure Switch Supply	—
X13	12	Service Brake Pressure Switch Feedback	Service Brake Pressure Switch Feedback	—
X13	13	Horn Switch uC (microcontroller) Bypass	Horn Switch uC (microcontroller) Bypass	—
X13	14	Start Enable - Crank Interlock	Not Connected	—
X13	15	Ignition Switch - Crank	Ignition Switch - Crank	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X14	1	12V Power Receptacle 5 (Sleeper, Cigar), Battery	12V Power Receptacle 5 (Sleeper, Cigar), Battery	—
X14	2	12V Power Receptacle 6 (Sleeper, Refrigerator), Battery	12V Power Receptacle 6 (Sleeper, Refrigerator), Battery	—
X14	3	12V Power Receptacles 3 & 4, Ground	12V Power Receptacles 3 & 4, Ground	—
X14	4	12V Power Receptacles 5 & 6, Ground	12V Power Receptacles 5 & 6, Ground	—
X15	1	Power Feed Spare Output V, Battery	Not Connected	—
X15	2	Power Feed Spare Output VI, Battery	Not Connected	—
X15	3	Power Feed Spare Output V, Ground	Not Connected	—
X15	4	12V Power Receptacles 1 & 2, Ground	12V Power Receptacles 1 & 2, Ground	—
X16	1	CD Player, Battery	Not Connected	—
X16	2	Lane Guidance, Ignition	Not Connected	—
X16	3	Lane Guidance, Ground	Not Connected	—
X16	4	Clearance Lamps Front II	Clearance Lamps Front II	—
X16	5	Auxiliary Circulation Fan - Windshield, Accessory	Not Connected	—
X16	6	CD Player, Ground	Not Connected	—
X16	7	Dome Lamp Cab, Battery	Dome Lamp Cab, Battery	—
X16	8	Clearance Lamps Front I	Clearance Lamps Front I	—
X16	9	Clearance Lamps Front, Ground	Clearance Lamps Front, Ground	—
X16	10	Not Connected	Not Connected	—
X16	11	Dome Lamp, Driver / Forward Overhead	Dome Lamp, Driver / Forward Overhead	—
X16	12	Reading Lamps 3 & 4, Ground	Reading Lamps 3 & 4, Ground	—
X16	13	Reading Lamp 4, Battery	Reading Lamp 4, Battery	—
X16	14	Dome Lamp, Passenger	Dome Lamp, Passenger	—
X16	15	Dome Lamps, Forward, Ground	Dome Lamps, Forward, Ground	—
X16	16	Spot Light	Spot Light	—
X16	17	Overhead Compartment Lights, Battery	Overhead Compartment Lights, Battery	—
X16	18	Auxiliary Circulation Fan - Windshield, Ground	Not Connected	—
X17	1	Power Window Passenger Side, Accessory	Power Window Passenger Side, Accessory	—
X17	2	Mirror Heating Passenger	Mirror Heating Passenger	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X17	3	Door Sill Lamp Passenger	Door Sill Lamp Passenger	—
X17	4	Door Control Passenger, Battery	Door Control Passenger, Battery	—
X17	5	Door Open Passenger Side, Input	Door Open Passenger Side, Input	—
X17	6	Keyless Go / Keyless Entry, Ground	Not Connected	—
X17	7	Keyless Go / Keyless Entry, Battery	Not Connected	—
X17	8	Mirror Heating Passenger, Ground	Mirror Heating Passenger, Ground	—
X17	9	Door Control Passenger, Ground	Door Control Passenger, Ground	—
X18	1	Marker Lamps, Front Left, Ground	Marker Lamps, Front Left, Ground	—
X18	2	Headlamp, Turn Lamp Corner Right, Ground	Headlamp, Turn Lamp Corner Right, Ground	—
X18	3	Horn (Electric), Ground	Horn (Electric), Ground	—
X18	4	Marker Lamps, Corner Front Right, Ground	Marker Lamps, Corner Front Right, Ground	—
X18	5	Low Beam, Left	Low Beam, Left	—
X18	6	High Beam, Left	High Beam, Left	—
X18	7	Headlamp, Turn Lamp Corner Left, Ground	Headlamp, Turn Lamp Corner Left, Ground	—
X18	8	Marker Lamps, Corner Front Right	Marker Lamps, Corner Front Right	—
X18	9	Turn Right Front Corner	Turn Right Front Corner	—
X18	10	Marker Lamps, Front Right, Ground	Marker Lights, Front Right, Ground	—
X18	11	Hood Tilt Switch Signal (Optimized Idle)	Hood Tilt Switch Signal (Optimized Idle)	—
X18	12	Marker Lamps, Front Right	Marker Lamps, Front Right	—
X18	13	Marker Lamps, Corner Front Left, Ground	Marker Lamps, Corner Front Left, Ground	—
X18	14	Marker Lamps, Front Left	Marker Lamps, Front Left	—
X18	15	DRL (Daytime Running Lights), Right	DRL (Daytime Running Lights), Right	—
X18	16	Marker Lamps, Corner Front Left	Marker Lamps, Corner Front Left	—
X18	17	High Beam, Right	High Beam, Right	—
X18	18	DRL (Daytime Running Lights), Left	DRL (Daytime Running Lights), Left	—
X18	19	Turn Left Front Corner	Turn Left Front Corner	—
X18	20	Low Beam, Right	Low Beam, Right	—

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X18	21	Horn (Electric), Control	Horn (Electric), Control	—
X19	1	Activate PTO Solenoid, Ground	Not Connected	—
X19	2	Starter Relay, Ground	Starter Relay, Ground	—
X19	3	Starter Relay	Starter Relay	—
X19	4	Not Connected	Not Connected	—
X19	5	Not Connected	Not Connected	—
X19	6	A/C Compressor Clutch	A/C Compressor Clutch	—
X19	7	Not Connected	Not Connected	—
X19	8	Not Connected	Not Connected	—
X19	9	Activate PTO Solenoid, Control	Not Connected	—
X19	10	HVAC Pressure Transducer, Feedback	HVAC Pressure Transducer, Feedback	—
X19	11	Air Intake Warmer / Grid Heater, Ignition	Not Connected	—
X19	12	HVAC Pressure Transducer, Return	HVAC Pressure Transducer, Return	—
X19	13	Air Filter Restriction Sensor, Ignition	Air Filter Restriction Sensor, Ignition	—
X19	14	Hood Tilt Switch Signal Supply	Hood Tilt Switch Signal Supply	—
X19	15	Air Filter Restriction Sensor, Signal	Air Filter Restriction Sensor, Signal	—
X19	16	Hood Tilt & Neutral & Park Brake (Optimized Idle)	Hood Tilt & Neutral & Park Brake (Optimized Idle)	—
X19	17	HVAC Pressure Transducer, Supply (+5V)	HVAC Pressure Transducer, Supply (+5V)	—
X19	18	Engine ECU, Ignition	Engine ECU, Ignition	—
X19	19	PTO Response (Feedback)	Not Connected	—
X19	20	Ether Start Power, Ignition	Ether Start Power, Ignition	—
X19	21	PTO Solenoid Activated	Not Connected	—
X20	1	Fog Lamp, Front Right, Ground	Fog Lamp, Front Right, Ground	—
X20	2	Distance Sensor (Adaptive Cruise Control), Ground	Not Connected	—
X20	3	Fog Lamp, Front Left, Ground	Fog Lamp, Front Left, Ground	—
X20	4	High / Low Beam Auxiliary Right, Ground	High / Low Beam Auxiliary Right, Ground	—
X20	5	High / Low Beam Auxiliary Left, Ground	High / Low Beam Auxiliary Left, Ground	—
X20	6	Not Connected	Not Connected	—
X20	7	Washer Pump, Ground	Washer Pump, Ground	—
X20	8	Fog Lamp, Front Left	Fog Lamp, Front Left	—

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X20	9	Not Connected	Not Connected	—
X20	10	High Beam Auxiliary, Left	Not Connected	—
X20	11	Low Beam Auxiliary, Left	Low Beam Auxiliary, Left	—
X20	12	High Beam Auxiliary, Right	Not Connected	—
X20	13	Temperature Sensor Outside Air Gauge, Ignition	Temperature Sensor Outside Air Gauge, Ignition	—
X20	14	Low Beam Auxiliary, Right	Low Beam Auxiliary, Right	—
X20	15	Turn Right Front Side	Turn Right Front Side	—
X20	16	Temperature Sensor Outside Air, Feedback	Temperature Sensor Outside Air, Feedback	—
X20	17	Fog Lamp, Front Right	Fog Lamp, Front Right	—
X20	18	Temperature Sensor Outside Air, Ground	Temperature Sensor Outside Air, Ground	—
X20	19	Distance Sensor (Adaptive Cruise Control), Battery	Not Connected	—
X20	20	Washer Pump, Control	Washer Pump, Control	—
X20	21	Washer Fluid Level, Feedback	Washer Fluid Level, Feedback	—
X21	1	Horn (Pneumatic), Ground	Not Connected	—
X21	2	Not Connected	Not Connected	—
X21	3	Wiper, Ground	Wiper, Ground	—
X21	4	Not Connected	Not Connected	—
X21	5	Utility Light, Ground	Utility Light, Ground	—
X21	6	LVD Sense, Ground	LVD Sense, Ground	—
X21	7	Not Connected	Not Connected	—
X21	8	Alternator Charging, Feedback	Alternator Charging, Feedback	—
X21	9	Wiper Parked	Wiper Parked	—
X21	10	Horn (Pneumatic), Control	Not Connected	—
X21	11	Turn Left Front Side	Turn Left Front Side	—
X21	12	Wiper Low	Wiper Low	—
X21	13	LVD Sense, Battery / Emergency Supply	LVD Sense, Battery / Emergency Supply	—
X21	14	Utility Light	Utility Light	—
X21	15	Wiper High	Wiper High	—

Table 2, Pinout Mapping

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SAM Cab

603 — Fuse Mapping

Fuse Mapping					
Fuse	Fuse Name	Rating	Connection	Pin	Function
F1	PWR FD SPARE 1&3	30	X4	1	Power Feed Spare Output I, BAT
			X4	2	Power Feed Spare Output III, BAT
F2	CAB/SLPR HVAC CTRL/SHF PNL	15	X1	3	Cabin HVAC controller, BAT
			X1	6	Sleeper HVAC controller, BAT
			X1	9	Transmission shift control panel, BAT
F3	PWR FD SPARE 2&4	30	X5	1	Power Feed Spare Output II, BAT
			X5	2	Power Feed Spare Output IV, BAT
F4	MODULAR SWITCH FIELD	15	X2	12	MSF, BAT
F5	OBD J1939-BAT	10	X2	3	OBD J1939, BAT
			X2	6	OBD DCDI, BAT
F6	DASH PWR RCPT 1	15	X6	15	12V Power Receptacle 1 BAT (Dash, Cigar)
F7	DASH PWR RCPT 2	15	X6	9	12V Power Receptacle 2 BAT (Dash, Phone)
F8	PHONE/RADIO-BAT	15	X1	7	Hands-free phone, BAT
			X3	11	Radio, BAT
F9	AMPLIFIER PWR	20	X3	9	Amplifier Power, ACC
F10	CAB HVAC MTR	30	X7	4	Cabin HVAC fan motor, BAT
F11	SLPR HVAC MTR	30	X7	3	Sleeper HVAC fan motor, BAT
F12	DR CTRL L	20	X8	4	Door control driver, BAT
F13	DR LOCK/SM CRUISE	20	X2	13	Collision avoidance system, BAT
			X8	6	Door lock, BAT
F14	FTL MGM SYS and CB	25	X6	2	Fleet Management System, BAT
			X6	3	CB Radio, BAT
F15	SLPR PWR RCPT 3	20	X3	15	12V Power Receptacle 3 BAT (Sleeper, Cigar)
F16	STAND ALONE HVAC	7.5	X3	5	Stand Alone HVAC, BAT
F17	SLPR PWR RCPT 4	20	X3	3	12V Power Receptacle 4 BAT (Sleeper, Cigar)
F18	TELEMATICS/ WARNING SYS	15	X3	1	GPS, BAT
			X3	2	Antitheft warning system, BAT
			X10	16	Tire Pressure Monitoring, BAT
			X11	19	Auxiliary Telematic Unit, BAT
F19	HEATED SEAT	20	X1	12	Heated Seats, IGN
F20	CENTRAL GATEWAY	2	X3	18	CGW, BAT

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Fuse Mapping					
Fuse	Fuse Name	Rating	Connection	Pin	Function
F21	AREA LIGHT	15	X2	15	Area Lighting BAT (Lwr Bunk and Sleeper Work Surface)
F22	ICU-BAT	5	X6	18	Instrument Cluster / Horn switch supply, BAT
F23	DR INFO/GAUGE	15	X3	10	GPS, IGN
			X6	5	Power Feed Driver Information System, IGN
			X6	6	Fleet Management System, IGN
			X6	8	Power Feed Gauge Pyrometer, IGN
			X6	10	Power Feed Gauge Axle Temp, IGN
			X6	11	Power Feed Gauge Engine Oil Temp, IGN
F24	ICU-IGN	10	X2	9	Diagnostic Connector, IGN
			X6	16	Instrument Cluster, IGN
F25	DASH SPLICE PAK	7.5	X1	1	Trans Temp Gauge, IGN
			X1	4	Dash Splice, IGN
			X2	14	Collision Avoidance System, IGN
F26	SRS-AIRBACK	5	X3	6	SRS Airbag, IGN
F27	MIRROR HEAT L	10	X8	8	Mirror Heat, Driver
F28	MIRROR HEAT R	10	X17	2	Mirror Heat, Passenger
F29	SAM RELAY COILS	3	N/A	N/A	Internal Relay Coil Supply
F30	PWR RCPT 6/FRIG	20	X14	2	12V Pwr Recept 6 BAT (Sleeper, Refrigerator)
F31	SLPR PWR RCPT 5	20	X14	1	12V Power Receptacle 5 BAT (Sleeper, Cigar)
F32	PWR FD SPARE 5&6	25	X15	1	Power feed spare output V, BAT
			X15	2	Power feed spare output VI, BAT
F33	SPOT LIGHT	20	X16	16	Spot Light
F34	BAG COMP LIGHT	3	X16	17	Overhead Compartment Light, BAT
F35	DOMELAMP CAB	15	X16	7	Dome Lamp Cab, BAT
F36	AUX CIR FAN/RD LAMP	15	X1	13	Auxiliary Circulation Fan (Sleeper) BAT
			X16	13	Reading Lamp 4 BAT

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Fuse Mapping					
Fuse	Fuse Name	Rating	Connection	Pin	Function
F37	CLK/DRV INFO/CD/ KEYLESS	15	X6	12	Power Feed Clock Cab, BAT
			X6	13	Power Feed Driver Information System, BAT
			X6	14	Power Feed Clock sleeper, BAT - X6/14
			X16	1	CD-Player, BAT
			X17	7	Keyless Go /Keyless Entry, BAT
F38	DR CTRL R	20	X17	4	Door control passenger, BAT
F39	PWR WINDOW R	15	X17	1	Power Window Passenger Side, ACC
F40	PWR WINDOW L	15	X8	7	Power Window Driver Side, ACC

Table 3, Fuse Mapping

604 — Relay Mapping

Relay Mapping									
Relay	Relay Name	Relay Coil (low current side)		Relay (high current side)			Conn.	Pin	Circuits Supplied
		Control (-) (86)	Control (+) (85)	Common (30)	Type	Suppl. Pwr To			
R1	PWR FD SPARE 1&3, BAT	SAM Micro	F29 (batt power)	Batt	NC	F1	X4	1	Power Feed Spare Output I - BAT
								2	Power Feed Spare Output III - BAT
R2	PWR FD SPARE 2&4, BAT	SAM Micro	F29 (batt power)	Batt	NC	F3	X5	1	Power Feed Spare Output II, BAT
								2	Power Feed Spare Output IV, BAT
R3	HEAT SEAT, IGN	SAM Micro	F29 (batt power)	Batt	NO	F19	X1	12	Heated Seats, IGN
R4	DASH PWR RCPT 1&2, BAT	SAM Micro	F29 (batt power)	Batt	NC	F6	X6	15	12V Power Receptacle 1 BAT (Dash, Cigar)
						F7		9	12V Power Receptacle 2 BAT (Dash, Phone)
R5	FLT MGM SYS & CB, BAT	SAM Micro	F29 (batt power)	Batt	NC	F14	X6	3	CB Radio BAT
								2	Fleet Management System BAT
R6	PWR RCPT 3 & STD HVAC, BAT	SAM Micro	F29 (batt power)	Batt	NC	F15	X3	15	12V Power Receptacle 3 BAT (Sleeper, Cigar)
						F16		5	Stand Alone HVAC

SAM Cab

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Relay Mapping									
Relay	Relay Name	Relay Coil (low current side)		Relay (high current side)			Conn.	Pin	Circuits Supplied
		Control (-) (86)	Control (+) (85)	Common (30)	Type	Suppl. Pwr To			
R7	DRV INFOGAUGE, IGN	SAM Micro	F29 (batt power)	Batt	NO	F23	X3	10	GPS, IGN
							X6	5	Power Feed Driver Information System, IGN
								6	Fleet Management System, IGN
								8	Power Feed Gauge Pyrometer, IGN
								10	Power Feed Gauge Axle Temp, IGN
								11	Power Feed Gauge Engine Oil Temp, IGN
R8	ICU/ VEHICLE SYS, IGN	SAM Micro	F29 (batt power)	Batt	NO	F24	X2	9	Diagnostics Connector, IGN
							X6	16	Instrument Cluster, IGN
						F25	X1	1	Transmission Temp Gauge, IGN
							X1	4	Dash Splice, IGN
							X2	14	Collision Avoidance System, IGN
						F26	X3	6	SRS Airbag, IGN
R9	AMPLIFIER PWR, ACC	SAM Micro	F29 (batt power)	Batt	NO	F9	X3	9	Amplifier Power, ACC
R10	MIRROR HEAT	SAM Micro	F29 (batt power)	Batt	NO	F27	X8	8	Mirror Heat, Driver
						F28	X17	2	Mirror Heat, Passenger
R11	PWR RCPT 6/FRIG, BAT	SAM Micro	F29 (batt power)	Batt	NC	F30	X14	2	12V Power Receptacle 6 BAT (Sleeper, Refrigerator)
R12	PWR RCPT 5, BAT	SAM Micro	F29 (batt power)	Batt	NC	F31	X14	1	12V Power Receptacle 5 BAT (Sleeper, Cigar)
R13	CAB LIGHTING, BAT	SAM Micro	F29 (batt power)	Batt	NC	F21	X2	15	Area Lighting BAT (Lower Bunk Area and Sleeper Work Surface)
						F34	X16	17	Overhead Compartment Light, BAT
						F35	X16	7	Dome Lamp Cab, BAT

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Relay Mapping									
Relay	Relay Name	Relay Coil (low current side)		Relay (high current side)			Conn.	Pin	Circuits Supplied
		Control (-) (86)	Control (+) (85)	Common (30)	Type	Suppl. Pwr To			
R14	PWR RCPT4/ CIR FAN/ LAMP, BAT	SAM Micro	F29 (batt power)	Batt	NC	F17	X3	3	12V Power Receptacle 4 BAT (Sleeper, Cigar)
						F36	X1	13	Auxiliary Circulation Fan, Sleeper, BAT
							X16	13	Reading Lamp 4, BAT
R15	PWR WINDOW, ACC	SAM Micro	F29 (batt power)	Batt	NO	F39	X17	1	Power Window Passenger Side, ACC
						F40	X8	7	Power window Driver Side, ACC

Table 4, Relay Mapping

700 — Troubleshooting Overview

IMPORTANT: If the symptom is specific to a function or system (left low beam headlight does not function, for example), refer to the applicable subject in this manual.

In ServiceLink, use the CAN protocol to troubleshoot or configure the SAM Cabin, via the Diagnostic CAN datalink. See **601 — Component Details** for the Diagnostic CAN pins in the diagnostic connector.

For more information on the Diagnostic CAN datalink or CAN, see **G03.04 — Datalink, Diagnostic CAN**.

701 — Required Tools

- ServiceLink

702 — Possible Causes

- Wiring (bad/loose connection, corrosion, miswiring, etc)
- SAM Cab relays
- SAM Cab fuses
- SAM Cab parameters
- SAM Cab ECU software
- Cabin CAN datalink
- Other ECUs on the Cabin CAN datalink
- Diagnostic CAN datalink

703 — Fault Codes

CAN Fault, SAM Cab				
SA	SPN	FMI	Fault Description	Fault Trigger
33	168	3	Electrical potential (voltage) – voltage above normal or shorted to high.	Trigger: SAM Cab battery voltage sensed to be above normal, or shorted to high. Action: Check power feed wiring to the SAM Cab, and alternator charging wiring.
33	168	4	Electrical potential (voltage) – voltage below normal or shorted to low.	Trigger: SAM Cabin battery voltage sensed to be below normal, or shorted to low. Action: Check power feed wiring to the SAM Cab, and alternator charging wiring.
33	520901	4	Door open driver side, pull down – voltage below normal, or shorted to low source.	Trigger: Driver side door open, pull down pin detected to be shorted to ground, or low source. Action: Check the wiring harness.
33	521109	2	Inside temperature sensor, feedback – data erratic, intermittent, or incorrect.	Trigger: A problem is detected with the inside temperature sensor feedback pin. Vehicle Behavior: Data is erratic, intermittent, or incorrect. Action: Check the wiring harness, especially for loose connections. Check the inside temperature sensor feedback pin.
33	521109	3	Inside temperature sensor feedback – voltage above normal, or shorted to high source.	Trigger: The inside temperature sensor feedback pin is shorted to battery, or high source. Vehicle Behavior: The displayed inside temperature is incorrect. Possible Cause: The feed cable to the inside temperature sensor feedback is shorted to battery. Or, the inside temperature sensor is out of order and shortens to battery. Action: Check the wiring to the inside temperature sensor feedback. Check the inside temperature sensor.
33	521109	4	Inside temperature sensor, feedback – voltage below normal, or shorted to low source.	Trigger: The inside temperature sensor feedback pin is shorted to ground, or low source. Vehicle Behavior: The displayed inside temperature is incorrect. Possible Cause: The feed cable to the inside temperature sensor feedback is shorted to ground. Or, the inside temperature sensor is out of order and shortens pin to ground. Action: Check the wiring to the inside temperature sensor feedback. Check the sensor inside temperature sensor.
33	521217	2	Clutch – data erratic, intermittent, or incorrect.	Trigger: A problem is detected with the clutch. Possible Cause: The switches 'Bottom of clutch (starter control)' and 'Top of clutch (cruise control disable)' are detected to be pressed at the same time. Or, the feed cable to 'Bottom of Clutch' and/or feed cable to 'Top of Clutch' has a short circuit. Action: Check the feed cables to 'Bottom of Clutch switch (starter control)', and 'Top of Clutch switch (cruise control disable)', and check clutch wiring.

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CAN Fault, SAM Cab				
SA	SPN	FMI	Fault Description	Fault Trigger
33	521402	3	CAN low – voltage above normal, or shorted to high source.	Trigger: The Cabin CAN Low (–) pin of SAM Cab is shorted to battery, or high source. Vehicle Behavior: In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check Cabin CAN harness, especially in connection to the SAM Cab. Verify proper connection of the Cabin CAN harness to the SAM Cab.
33	521402	4	CAN low – voltage below normal, or shorted to low source.	Trigger: The Cabin CAN Low (–) pin of SAM Cab is shorted to ground, or low source. Vehicle Behavior: In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check Cabin CAN harness, especially in connection to the SAM Cab. Verify proper connection of the Cabin CAN harness to the SAM Cab.
33	521403	3	CAN high – voltage above normal, or shorted to high source.	Trigger: The Cabin CAN High (+)pin of SAM Cab is shorted to battery, or high source. Vehicle Behavior: In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check Cabin CAN harness, especially in connection to the SAM Cab. Verify proper connection of the Cabin CAN harness to the SAM Cab.
33	521403	4	CAN high – voltage below normal, or shorted to low source.	Trigger: The Cabin CAN High (+)pin of SAM Cab is shorted to ground, or low source. Vehicle Behavior: In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check Cabin CAN harness, especially in connection to the SAM Cab. Verify proper connection of the Cabin CAN harness to the SAM Cab.
33	521805	4	Door open, passenger side, pull down – voltage below normal, or shorted to low source.	Trigger: Door open, passenger side. Pull-down pin detected to be shorted to ground, or low source. Action: Check the wiring harness.
33	521918	4	DRL – voltage below normal, or shorted to low source.	Trigger: DRL pins (for separate DRL lamps only) are detected to be shorted to ground, or low source. One or more of the DRL lamps are off. Action: Check the wiring harness.

SAM Cab

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CAN Fault, SAM Cab				
SA	SPN	FMI	Fault Description	Fault Trigger
33	522003	4	Starter relay 3 – current above normal or grounded circuit.	Trigger: Starter relay 3 pin detected to have above normal current, or shorted to ground. Vehicle Behavior: The vehicle can no longer be started. Possible Cause: A wiring harness problem. Action: Check the starter relay circuit wiring.
33	523511	31	Cabin CAN Bus Performance – condition exists.	Trigger: A problem is detected with Cabin CAN performance. Vehicle Behavior: In the case of a serious problem with the Cabin CAN datalink, the SAM Cab and/or SAM Chassis may be running in emergency power mode. Action: Check Cabin CAN wiring.
33	523541	2	Marker interrupt switch – data erratic, intermittent, or incorrect.	Trigger: A problem is detected with the marker interrupt switch, and may be detected to be pressed for longer than 30 seconds. Vehicle Behavior: The marker interrupt function is not working properly. Action: Check the steering wheel switch unit, and the MSF.
33	523550	7	Park position switch – mechanical system is not responding, or is out of adjustment	Trigger: A problem is detected with the wiper park position switch, causing the wiper to stop. Possible Cause: The wiring harness, a blocked or defective wiper, or the wiper switch is not working.
33	524037	31	Lost communication with CGW	Trigger: The SAM Cab did not receive heartbeat messages from the CGW. Possible Cause: A bad connection between the Cabin CAN datalink and the CGW, or a blown CGW power supply fuse on the SAM Cab. Action: Check the wiring harness, especially the Cabin CAN connection to CGW, and the CGW power supply.

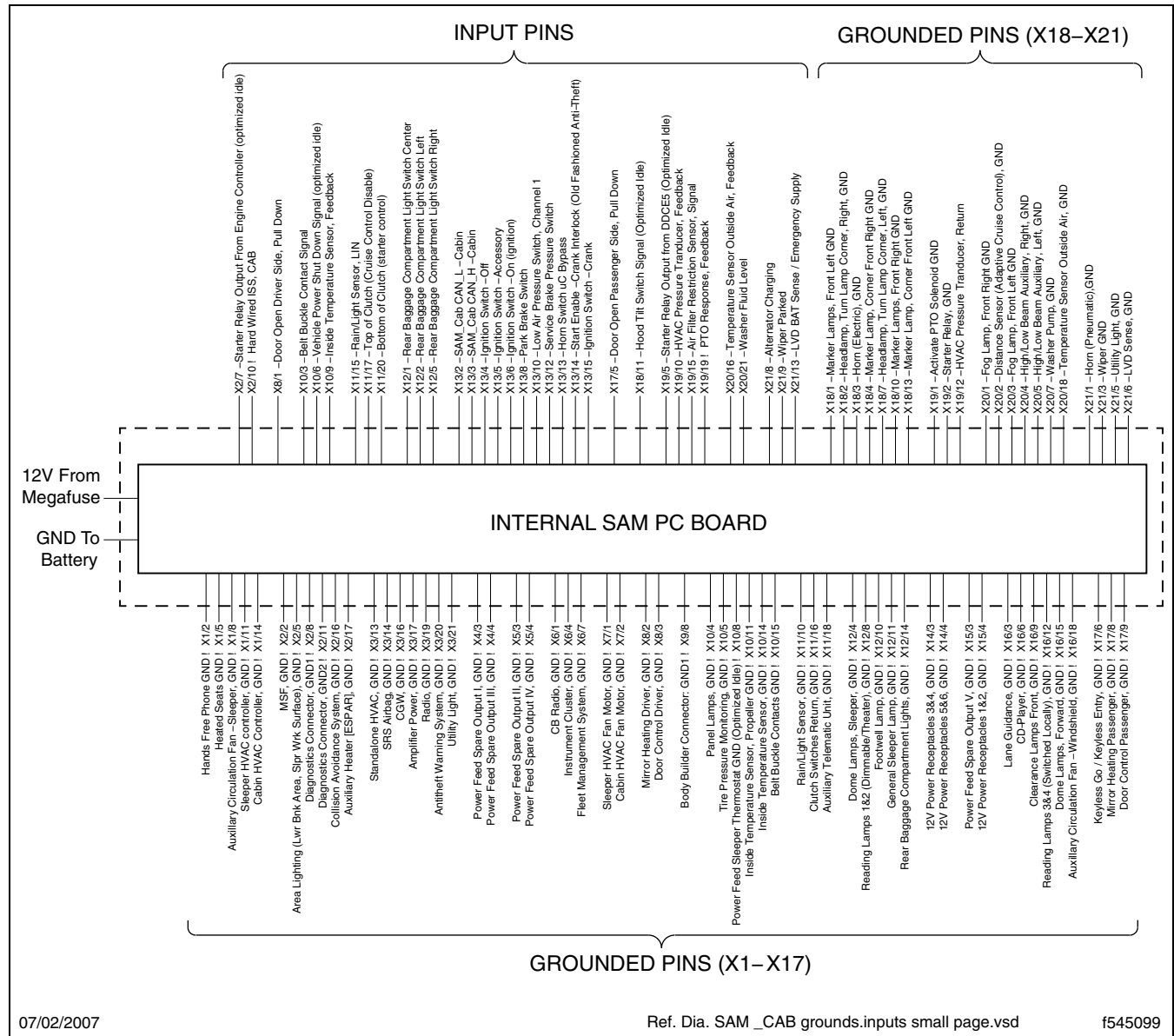
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SAM Cab

CAN Fault, SAM Cab				
SA	SPN	FMI	Fault Description	Fault Trigger
33	524049	31	Lost communication with MSF	Trigger: The SAM Cab did not receive heartbeat messages from the MSF. Vehicle Behavior: Headlights automatically turn on for safety. All functions where input switches are controlled by the MSF do not function, such as Turn and Hazard functions, rotary switch (headlamp) functions and wiper. Possible Cause: A Cabin CAN datalink connection problem to MSF, or the MSF power supply fuse on SAM Cab is blown. Action: Check the wiring harness, especially the Cabin CAN connection to the MSF, and the MSF power supply.
33	524071	31	Lost communication with the SAM Chassis	Trigger: The SAM Cab did not receive heartbeat messages from the SAM Chassis. Vehicle Behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Chassis failure. An indication of a SAM Chassis failure is the ICU turn signal indicators flash alternately. Possible Cause: The Cabin CAN datalink connection to the SAM Chassis, or the power supply to the SAM Chassis. Action: Check the Cabin CAN wiring harness, especially the Cabin CAN connection to the SAM Chassis. Check the SAM Chassis power supply.

Table 5, CAN Fault, SAM Cab

704 — Grounded Pins and Inputs



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Fig. 7, Grounded Pins and Inputs

705 — Fused and FET Controlled Outputs

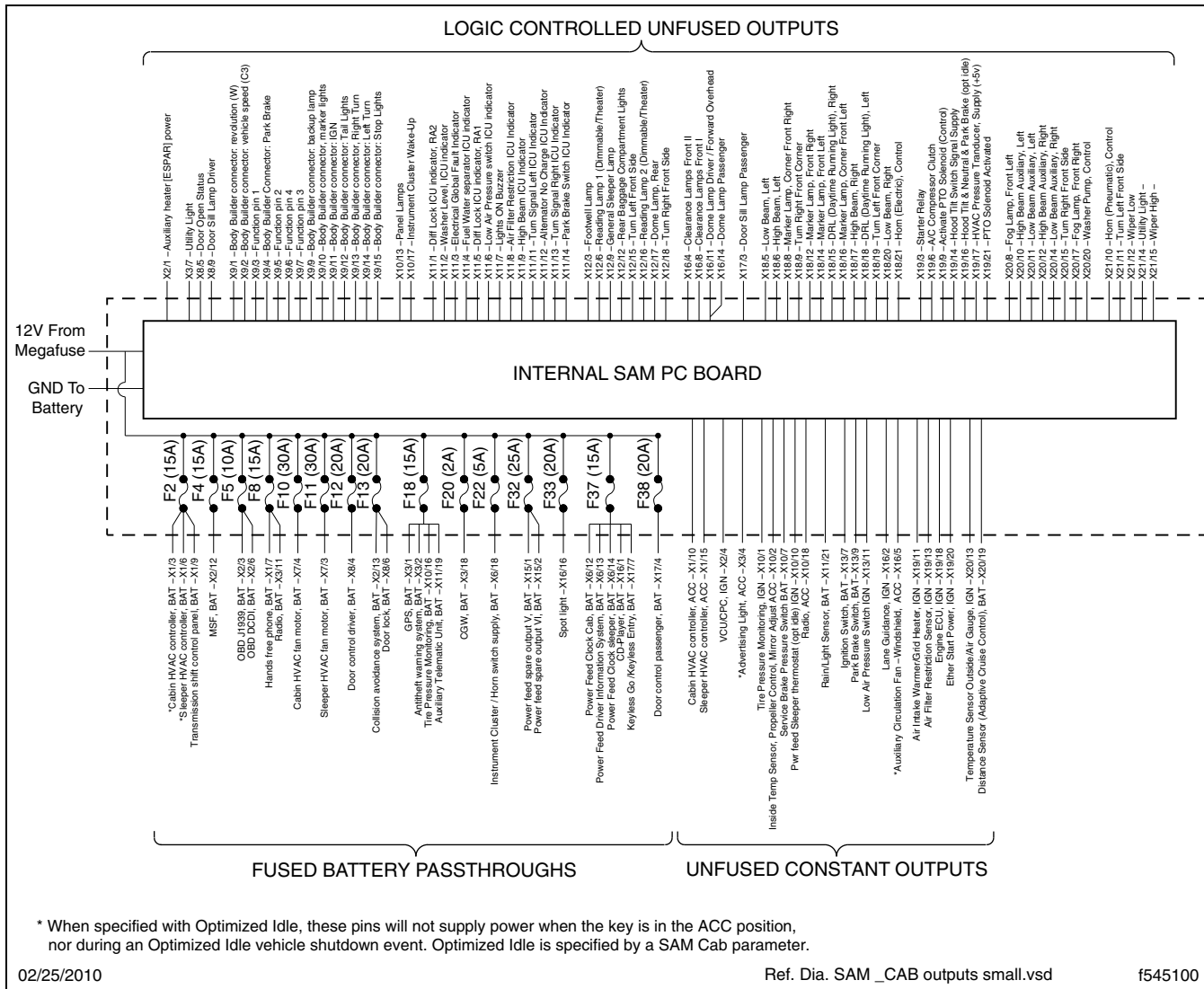


Fig. 8, Fused and FET Controlled Outputs

706 — Relayed Outputs

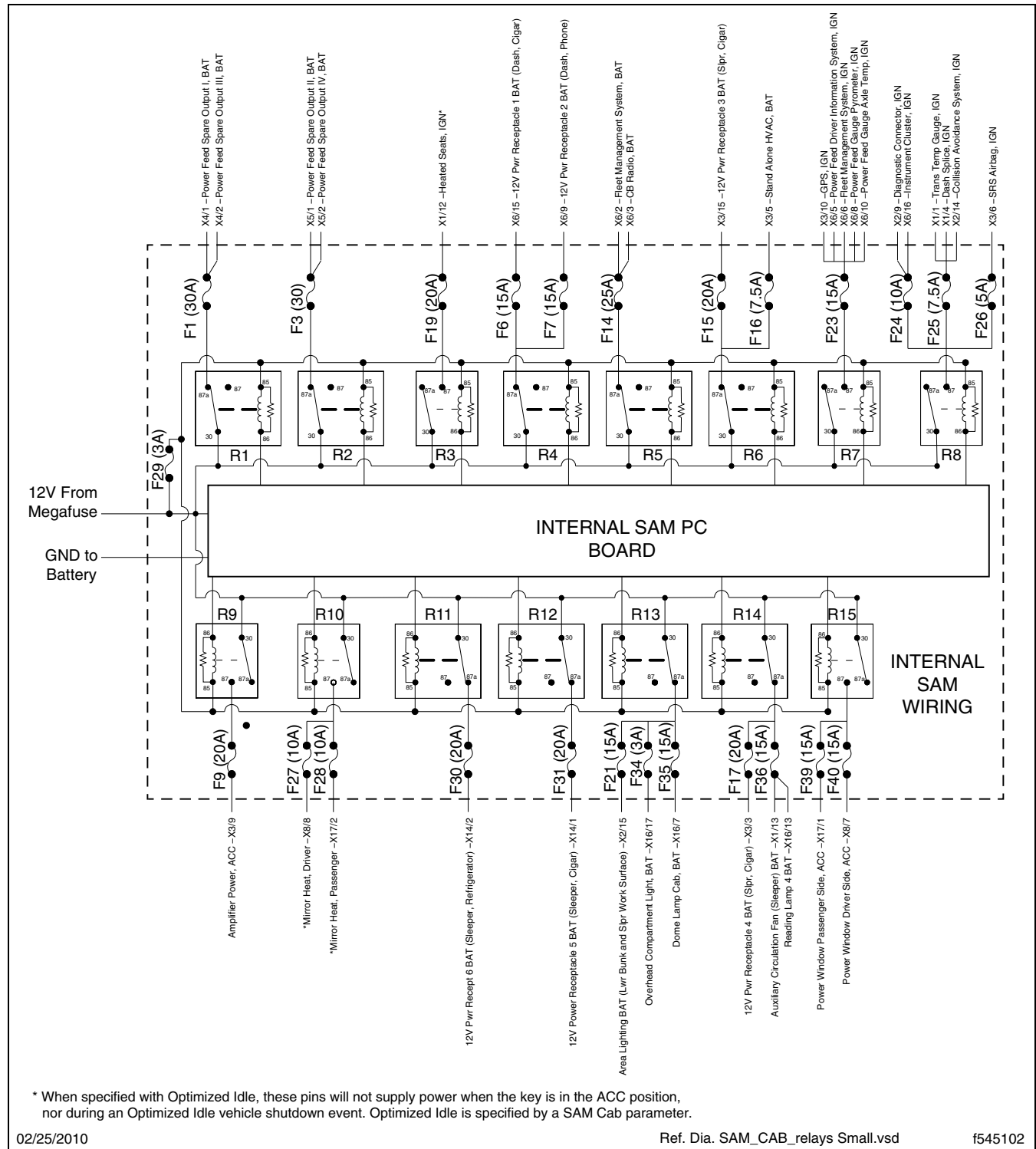


Fig. 9, Relayed Outputs

707 — Logic Controlled Unfused Outputs

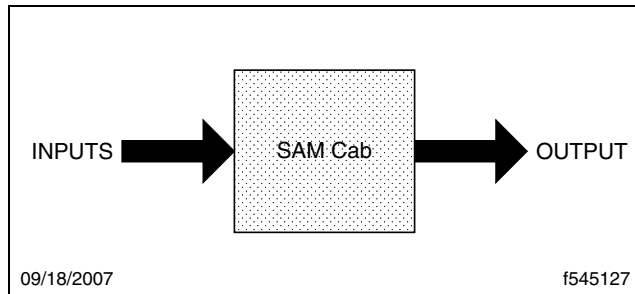


Fig. 10, SAM Unfused Inputs and Outputs

1. **Determine if the template has I/O controls available for the affected function.**

Open the Datalink Monitor template for the function or output that is not functioning.

Are I/O control buttons available for the affected function?

YES → Go to test 2.

NO → Go to test 5.

2. **Use the I/O control feature in Datalink Monitor to test the output circuit.**

Does the function or output work when activated with Datalink Monitor?

YES → Go to test 3.

NO → Go to test 4.

3. **Use Datalink Monitor to determine if input conditions are met for the function or output to operate.**

Are all of the input conditions met?

YES → Check SAM Cab programming and parameters. For additional programming/parameter information specific to this function, refer to the applicable subject in this manual. If programming/parameters are OK, replace the SAM Cab.

NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.

4. **Rule out the output by manually applying fused power and ground.**

Does the function or output work when power and ground are applied manually?

YES → Replace the SAM Cab.

NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

5. **Determine if input conditions are met for the function or output to operate using Datalink Monitor.**

NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

- 5.1 Refer to the function or output in this manual to identify what input conditions have to be met in order for the function or output to operate.
- 5.2 Open the Datalink Monitor template for the applicable function.
- 5.3 While monitoring the template inputs, attempt to activate the function or output using the normal method. Turn on the headlights, for example, if the rotary switch inputs are being tested.

Are all of the input conditions met?

YES → Go to test 6.

NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.

6. Check available voltage at the consumer.

NOTE: Available voltage tests cannot be performed on every SAM Cab function. For example, checking voltage at a turn signal connector will not work. Refer to the applicable subject in this manual for more details about troubleshooting specific outputs. If test 6 cannot be performed, proceed to test 7.

- 6.1 Disconnect the connector at the consumer.
- 6.2 Activate the function by normal means. Turn on the headlights, for example, if the rotary switch inputs are being tested.
- 6.3 Measure voltage between the positive and ground pins on the connector for the function being tested.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 7.

7. Rule out the output by manually applying fused power and ground.

- 7.1 Disconnect the SAM connector(s) containing the circuits for the output (power) and ground for the function being tested.
- 7.2 Apply fused power to the output circuit using jumper wires, and apply ground to the ground circuit.

Does the function or output work when power and ground are applied manually?

YES → Check SAM Cab programming and parameters. For additional programming and parameter information, refer to the applicable subject in this manual. If the programming and parameters are OK, replace the SAM Cab.

NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

708 — Logic Controlled Relayed Fused Outputs

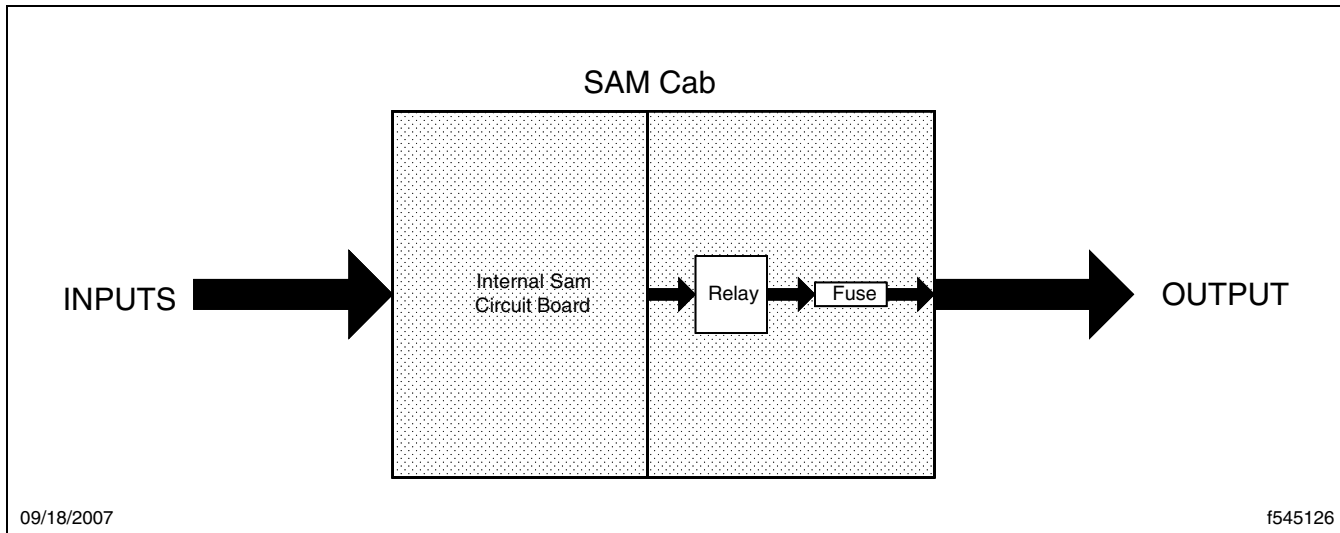


Fig. 11, SAM Fused Inputs and Outputs

1. **Determine if the template has I/O controls available for the affected function.**

Open the Datalink Monitor template for the function or output that is not functioning.

Are I/O control buttons available for the affected function?

YES → Go to test 2.

NO → Go to test 3.

2. **Use Datalink Monitor to determine if the output circuit can be eliminated as the problem.**

NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

2.1 Open the Datalink Monitor template for the applicable function.

2.2 Using the template, attempt to activate the function or output.

Does the function or output work when activated manually in Datalink Monitor?

NOTE: For normally closed relays, activating the SAM output will turn off the relay controls. For normally open relays, activating the SAM output will turn on the relay controls.

YES → Go to test 3.

NO → Go to test 4.

3. **Use Datalink Monitor to determine if input conditions are met for the function or output to operate.**

NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

- 3.1 Refer to the applicable function or output, and identify what input conditions have to be met for normal operation.
- 3.2 Open the applicable Datalink Monitor template.
- 3.3 While monitoring the template inputs, attempt to activate the function or output using the normal method. For example, turn on the headlights if the rotary switch inputs are being tested.

Are all of the input conditions met?

YES → Go to test 4.

NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.

4. Check the available voltage at the consumer.

NOTE: Available voltage tests cannot be performed on every SAM function. For example, checking voltage at a turn signal connector will not work. Refer to the applicable subject for more information about troubleshooting the specific outputs. If test 4 cannot be performed, proceed to test 5.

- 4.1 Disconnect the connector at the consumer.
- 4.2 Activate the function by normal means. For example, turn on the headlights if the rotary switch inputs are being tested.
- 4.3 Measure voltage between the positive and ground pins.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 5.

5. Check for power at the relay coil (low current side).

- 5.1 Remove the relay from the SAM for the function that is not working.
- 5.2 Check for voltage in the SAM relay cavity that corresponds to terminal 85 of the relay.

Is there voltage at relay cavity 85?

YES → Go to test 6.

NO → Check fuse F29 on the SAM Cab.

6. Check for power at the relay common (high current side).

Check for voltage in the SAM relay cavity that corresponds to terminal 30 of the relay.

Is there voltage at relay cavity 30?

YES → Go to test 7.

NO → Check main power to SAM from the MEGA fuse.

7. Check the SAM fuse for the function.

Check the fuse for the function or output.

Is the fuse good?

YES → Go to test 8.

NO → Check for a short to ground in the output circuit. Check the component that the output supplies power to for excessive current draw. Make repairs as necessary, and replace the fuse.

8. **Determine if the function works when power is manually applied.**

Using a fused jumper, apply power to the SAM relay cavity that corresponds to 87 for normally open relay connections, or 87a for normally closed relays.

Does the function work when power is manually applied at the relay?

YES → Go to test 9.

NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

9. **Determine if the output works with a test relay that is operating properly.**

Remove the relay from the SAM and install the known good relay.

Does the function or output work with a known good relay?

YES → Replace the relay.

NO → Check SAM programming and parameters. For additional programming/parameter information, refer to the applicable subject in this manual. If programming and parameters are OK, replace the SAM.

709 — Unfused Constant Outputs

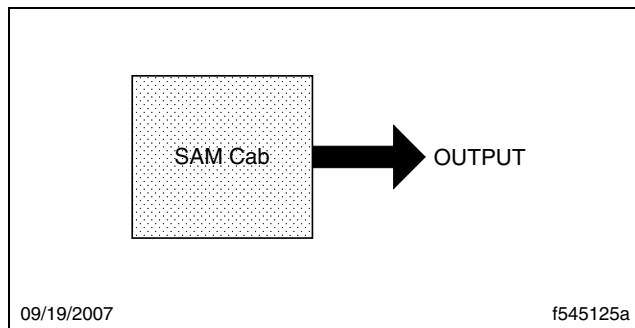


Fig. 12, SAM Unfused Constant Outputs

1. **Check available voltage at the consumer.**

1.1 Disconnect the connector at the consumer.

1.2 Measure the voltage between the positive and ground pins on the connector.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 2.

2. **Check the voltage at output pin.**

2.1 Turn the ignition switch on.

2.2 Check for voltage at the unfused constant output pin.

Is there 12V at the unfused constant output pin?

YES → The problem is in the output power or ground circuits or the load itself. For additional output troubleshooting refer to the applicable subject in this manual.

NO → For IGN and ACC outputs, check for ignition switch function. For all types, check the main power and ground feeds to the SAM. If OK, replace the SAM.

710 — Fused Battery Pass-Through Outputs

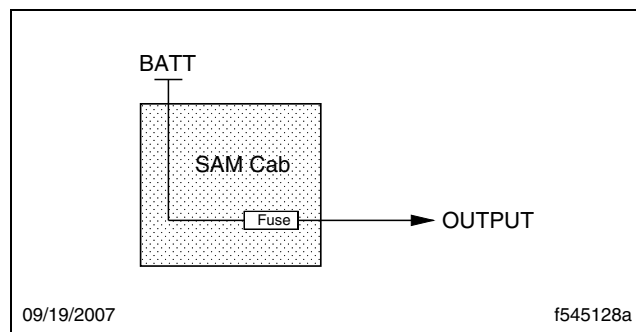


Fig. 13, Fused Battery Pass-Through Outputs

1. Check the fuse in the SAM for the output.

Is the fuse OK?

YES → Go to test 2.

NO → Check for short to ground in the output circuit, repair as necessary, and then replace the fuse. For additional output troubleshooting, refer to the applicable subject in this manual.

2. Check power and ground supply to the SAM.

Is power and ground supply to the SAM OK?

YES → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

NO → Check the MEGA fuse, and the power and ground circuits to the SAM. Repair as necessary.

800 — Maximum Current Pin List

Legend:

NOTE: A dash indicates that information is not available at the time of publication.

• Type:

- "o" Pin: A high-side-driven output (the function activates at higher or near-battery voltage).
- "i" Pin: Input pin.
- "comm" Pin: Used for communication.

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- **Nominal Current (amps):** The expected current under normal operating conditions.
- **Maximum Continuous Current (amps):** The maximum current without shutting the pin off at 77°F (25°C).
- **Maximum Current (amps):** When exceeded the pin will shut off at 185°F (85°C).

Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X1	1	Transmission oil temperature gauge, Ignition	o	0.5	0.675	7.5
X1	3	Cabin HVAC Controller, Battery	o	5	6.75	15
X1	4	Hands-Free Phone, Ignition	o	3	4.05	7.5
X1	6	Sleeper HVAC Controller, Battery	o	3	4.05	15
X1	7	Hands-Free Phone, Battery	o	3	4.05	15
X1	9	Transmission Shift Control Panel, Battery	o	1	1.35	15
X1	10	Cabin HVAC Controller, Accessory	o	0.7	0.945	1.9
X1	12	Heated Seats, Ignition	o	16	21.6	20
X1	13	Auxiliary Circulation Fan, Sleeper, Battery	o	5	6.75	25
X1	15	Sleeper HVAC Controller, Accessory	o	0.7	0.945	1.9
X2	3	OBD J1939, Battery	o	5	6.75	10
X2	6	Reserved for future use.	o	5	6.75	10
X2	7	Starter Relay Output from Engine-ECU (Optimized Idle)	i	0.02	0.027	—
X2	9	Diagnostic Connector, Ignition	o	5	6.75	10
X2	10	Hardwired ISS (Ignition Switch Status), Cab	o	0.02	0.027	—
X2	12	MSF (Modular Switch Field master ECU), Battery	o	10	13.5	15
X2	13	Collision Avoidance System, Battery	o	5	6.75	20
X2	14	Collision Avoidance System, Ignition	o	1.07	1.4445	7.5
X2	15	Area Lighting (lower bunk area and sleeper work surface), Battery	o	9.7	13.095	15
X2	18	Emergency Battery, Cab	o	20	27	—
X3	1	GPS (Global Positioning System), Battery	o	3.21	4.3335	15
X3	2	Antitheft Alarming System, Battery	o	2	2.7	15
X3	3	12V Power Receptacle 4 (sleeper, cigar), Battery	o	20	27	20
X3	4	Advertising Light, Accessory	o	4.8	6.48	9.35
X3	5	Stand Alone HVAC, Battery	o	5	6.75	7.5
X3	6	SRS (Safety Restraint System) Airbag, Ignition	o	3	4.05	5
X3	7	Utility Light	o	12.6	17.01	25
X3	9	Amplifier Power, Accessory	o	20	27	20
X3	10	GPS (Global Positioning System), Ignition	o	1.07	1.4445	15

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Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X3	11	Radio, Battery	o	10	13.5	15
X3	18	CGW (Central Gateway ECU), Battery	o	0.38	0.513	2
X4	1	Power Feed Spare Output I, Battery	o	15	20.25	30
X4	2	Power Feed Spare Output III, Battery	o	15	20.25	30
X5	1	Power feed Spare Output II, Battery	o	15	20.25	30
X5	2	Power Feed Spare Output IV, Battery	o	15	20.25	30
X6	2	Fleet Management System, Battery	o	5	6.75	25
X6	3	CB Radio, Battery	o	20	27	25
X6	5	Power Feed, Driver Information System, Ignition	o	1.07	1.4445	15
X6	6	Fleet Management System, Ignition	o	5	6.75	15
X6	8	Power Feed, Gauge Pyrometer, Ignition	o	0.5	0.675	15
X6	9	12V Power Receptacle 2 (Dash, Phone), Battery	o	15	20.25	15
X6	10	Power Feed, Gauge Axle Temperature, Ignition	o	0.5	0.675	15
X6	11	Power Feed, Gauge Engine Oil Temp, Ignition	o	0.5	0.675	15
X6	12	Power Feed, Clock Cab, Battery	o	0.1	0.135	15
X6	13	Power Feed, Driver Information System, Battery	o	3	4.05	15
X6	14	Power Feed, Clock Sleeper, Battery	o	0.1	0.135	15
X6	15	12V Power Receptacle 1 (dash, cigar), Battery	o	15	20.25	15
X6	15	12V Power Receptacle 3 (sleeper, cigar), Battery	o	20	27	20
X6	16	Instrument Cluster, Ignition	o	4.6	6.21	10
X6	18	Instrument Cluster, Battery	o	3.78	5.103	5
X7	3	Sleeper HVAC Fan Motor, Battery	o	26	35.1	30
X7	4	Cabin HVAC Fan Motor, Battery	o	26	35.1	30
X8	1	Door Open, Driver side, Pull Down	i	0.04	0.054	—
X8	4	Door Control Driver, Battery	o	20	27	20
X8	5	Door Open Status	o	0.04	0.054	0.5
X8	6	Door Lock, Battery	o	12.4	16.74	20
X8	7	Power Window Driver Side, Accessory	o	10	13.5	15
X8	8	Mirror Heating Driver	o	10	13.5	10
X8	9	Door Sill Lamp Driver	o	0.7	0.945	1.9
X9	1	Body Builder Connector: Revolution	o	0.01	0.0135	1
X9	2	Body Builder Connector, Vehicle Speed	o	0.01	0.0135	1
X9	3	Function pin 1	o	0.2	0.27	2
X9	4	Body Builder Connector, Park Brake	o	0.04	0.054	2
X9	5	Function Pin 2	o	0.2	0.27	2

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Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X9	6	Function Pin 4	o	0.2	0.27	2
X9	7	Function Pin 3	o	0.2	0.27	2
X9	9	Body Builder Connector, Backup Lamp	o	0.2	0.27	2
X9	10	Body Builder Connector, Marker Lights	o	0.2	0.27	2
X9	11	Body Builder Connector: Ignition	o	0.2	0.27	2
X9	12	Body Builder Connector: Tail Lights	o	0.2	0.27	2
X9	13	Body Builder Connector: Right Turn	o	0.2	0.27	2
X9	14	Body Builder Connector: Left Turn	o	0.2	0.27	2
X9	15	Body Builder Connector: Stop Lights	o	0.2	0.27	2
X10	1	Tire Pressure Monitoring, Ignition	o	0.1	0.135	2
X10	2	Inside Temperature Sensor, Propeller Control, Accessory	o	0.1	0.135	2
X10	3	Belt Buckle Contact Signal	i	0.04	0.054	—
X10	6	Vehicle Power Shut Down Signal (Optimized Idle)	i	0.02	0.027	—
X10	7	Service Brake Pressure Switch Supply (chopped)	o	0.05	0.0675	2
X10	9	Inside Temperature Sensor, Feedback	i	0.04	0.054	—
X10	10	Power Feed, Sleeper Thermostat (Optimized Idle), Ignition	o	0.04	0.054	1.7
X10	12	Not Connected	i	0.04	0.054	—
X10	13	Panel Lamps	o	4.2	5.67	9.35
X10	16	Tire Pressure Monitoring, Battery	o	2	2.7	15
X10	17	Wake-up, ICU (instrumentation control unit)	o	0.04	0.054	2
X10	18	Radio, Accessory	o	0.7	0.945	2
X11	1	Differential Lock ICU Indicator, RA2	o	0.13	0.1755	2
X11	2	Washer Level ICU Indicator	o	0.13	0.1755	2
X11	3	Electrical Global Fault Indicator (future use)	o	0.13	0.1755	2
X11	5	Differential Lock ICU Indicator, RA1	o	0.13	0.1755	2
X11	6	Low Air Pressure switch ICU Indicator	o	0.13	0.1755	2
X11	7	Lights ON Buzzer	o	0.03	0.0405	2
X11	8	Air Filter Restriction ICU Indicator	o	0.13	0.1755	2
X11	9	High Beam ICU Indicator	o	0.13	0.1755	2
X11	11	Turn Signal Left ICU Indicator	o	0.13	0.1755	2
X11	12	Alternator No Charge ICU Indicator	o	0.13	0.1755	2
X11	13	Turn Signal Right ICU Indicator	o	0.13	0.1755	2
X11	14	Park Brake Switch ICU Indicator	o	0.13	0.1755	2

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Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X11	15	Rain/Light Sensor, LIN	comm	0.2	0.27	—
X11	17	Top of Clutch (cruise control disable)	i	0.02	0.027	—
X11	19	Auxiliary Telematic Unit, Battery	o	3.21	4.3335	20
X11	20	Bottom of Clutch (starter control)	i	0.02	0.027	—
X11	21	Rain/Light Sensor, Battery	o	1	1.35	3.2
X12	1	Rear Baggage Compartment Light Switch Center	i	0.02	0.027	—
X12	2	Rear Baggage Compartment Light Switch Left	i	0.02	0.027	—
X12	3	Footwell Light	o	1.1	1.485	2.8
X12	5	Rear Baggage Compartment Light Switch Right	i	0.02	0.027	—
X12	6	Reading Lamp 1 (dimmable/theater)	o	1.9	2.565	4.3
X12	9	General Sleeper Lamp	o	2.8	3.78	9.3
X12	12	Rear Baggage Compartment Lights	o	1.5	2.025	3.5
X12	15	Turn Left, Front Side	o	2.1	2.835	4.66
X12	16	Reading Lamp 2 (dimmable/theater)	o	1.5	2.025	3.5
X12	17	Dome Lamp, Rear	o	1.9	2.565	4.66
X12	18	Turn Right Front Side	o	2.1	2.835	3.5
X13	2	SAM Cab, Cabin CAN Low (–)	comm	0.2	0.27	0.2
X13	3	SAM Cab, Cabin CAN High (+)	comm	0.2	0.27	0.2
X13	4	Ignition Switch — Off	i	0.02	0.027	—
X13	5	Ignition Switch — Accessory	i	0.02	0.027	—
X13	6	Ignition Switch — On (ignition)	i	0.02	0.027	—
X13	7	Ignition Switch, Battery	o	0.1	0.135	0.2
X13	8	Park Brake Switch Feedback	i	0.05	0.0675	—
X13	9	Park Brake Switch Supply	o	0.05	0.0675	2
X13	10	Low Air Pressure Switch Feedback	i	0.05	0.0675	—
X13	11	Low Air Pressure Switch Supply (chopped)	o	0.05	0.0675	2
X13	12	Service Brake Pressure Switch Feedback	i	0.05	0.0675	—
X13	13	Horn Switch (microcontroller bypass)	i	0.02	0.027	—
X13	14	Start Enable — Crank Interlock	i	0.04	0.054	—
X14	1	12V Power Receptacle 5 (sleeper, cigar), Battery	o	20	27	20
X14	2	12V Power Receptacle 6 (sleeper, refrigerator), Battery	o	20	27	20
X15	1	Power Feed Spare Output V, Battery	o	10	13.5	25
X15	2	Power Feed Spare Output VI, Battery	o	10	13.5	25
X16	1	CD Player, Battery	o	2	2.7	15

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Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X16	2	Lane Guidance, Ignition	o	5	6.75	9.35
X16	5	Auxiliary Circulation Fan — Windshield, Accessory	o	5	6.75	9.35
X16	7	Dome Lamp Cab, Battery	o	10	13.5	15
X16	8	Clearance Lamps front I	o	0.5	0.675	1.9
X16	11	Dome Lamp, Driver (forward overhead)	o	1.9	2.565	9.35
X16	13	Reading Lamp 4, Battery	o	3.5	4.725	15
X16	14	Dome Lamp, Passenger	o	1.9	2.565	9.35
X16	16	Spot Light	o	17	22.95	20
X16	17	Overhead Compartment Lights, Battery	o	1.94	2.619	3
X17	1	Power Window Passenger Side, Accessory	o	10	13.5	15
X17	2	Mirror heating Passenger	o	10	13.5	10
X17	3	Door Sill Lamp Passenger	o	0.7	0.945	1.9
X17	4	Door Control Passenger, Battery	o	20	27	20
X17	5	Door Open Passenger Side, Input	i	0.04	0.054	—
X17	7	Keyless Go/Keyless Entry, Battery	o	5	6.75	15
X18	5	Low Beam, Left	o	4.8	6.48	9.3
X18	6	High Beam, Left	o	4.8	6.48	10.3
X18	8	Marker Lamps, Corner Front Right	o	0.7	0.945	1.7
X18	9	Turn Right Front Corner	o	2.5	3.375	4.66
X18	11	Hood Tilt Switch Signal (Optimized Idle)	i	0.04	0.054	—
X18	12	Marker Lamps, Front Right	o	0.7	0.945	1.7
X18	14	Marker Lamps, Front Left	o	0.7	0.945	1.7
X18	15	DRL (daytime running light), Right	o	2.5	3.375	4.2
X18	16	Marker Lamps, Corner Front Left	o	0.7	0.945	1.7
X18	17	High Beam, Right	o	4.8	6.48	10.3
X18	18	DRL (daytime running light), Left	o	2.5	3.375	4.2
X18	19	Turn Left Front Corner	o	2.5	3.375	4.2
X18	20	Low Beam, Right	o	4.8	6.48	9.3
X18	21	Horn (electric), Ground	o	12.2	16.47	24.2
X19	3	Starter Relay	o	3	4.05	9.35
X19	6	A/C Compressor Clutch	o	5	6.75	9.35
X19	9	Activate PTO Solenoid, Control	o	2	2.7	4.66
X19	10	HVAC Pressure Transducer, Feedback	i	0.05	0.0675	—
X19	11	Air Intake Warmer/Grid Heater, Ignition	o	2.2	2.97	9.35

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Maximum Current Pin List						
Connector	Pin	Function	Type	Nominal Current (Amps)	Maximum Continuous Current (Amps)	Maximum Current (Amps)
X19	13	Air Filter Restriction Sensor, Ignition	o	0.02	0.027	2
X19	14	Hood Tilt Switch Signal Supply (Optimized Idle, Chopped)	o	0.05	0.0675	2
X19	15	Air Filter Restriction Sensor, Signal	i	0.02	0.027	—
X19	16	Hood Tilt and Neutral and Park Brake (Optimized Idle)	o	0.04	0.054	2
X19	17	HVAC Pressure Transducer, Supply (+5V)	o	0.05	0.0675	0.1
X19	18	Engine ECU, Ignition	o	0.8	1.08	1.9
X19	19	PTO Response (Feedback)	i	0.02	0.027	—
X19	20	Ether Start Power, Ignition	o	1.5	2.025	4.66
X19	21	PTO Solenoid Activated	o	2	2.7	4.66
X20	8	Fog Lamp, Front Left	o	4.8	6.48	10.5
X20	10	High Beam Auxiliary, Left	o	4.8	6.48	10.5
X20	11	Low Beam Auxiliary, Left	o	4.8	6.48	10.5
X20	12	High Beam Auxiliary, Right	o	4.8	6.48	10.5
X20	13	Temperature Sensor Outside Air Gauge, Ignition	o	0.5	0.675	1.7
X20	14	Low Beam Auxiliary, Right	o	4.8	6.48	10.2
X20	15	Turn Right, Front Side	o	2.1	2.835	3.5
X20	16	Temperature Sensor Outside Air, Feedback	i	0.04	0.054	—
X20	17	Fog Lamp, Front Right	o	4.8	6.48	10.5
X20	19	Distance Sensor (Adaptive Cruise Control), Battery	o	1	1.35	20
X20	20	Washer Pump, Control	o	4.6	6.21	10.5
X20	21	Washer Fluid Level, Feedback	i	0.04	0.054	—
X21	8	Alternator Charging	i	0.04	0.054	—
X21	9	Wiper Parked	i	0.02	0.027	—
X21	10	Horn (pneumatic), Control	o	0.75	1.0125	1.5
X21	11	Turn Left Front Side	o	2.1	2.835	4.66
X21	12	Wiper Low	o	9	12.15	18.5
X21	13	LVD Sense, Battery/Emergency Supply	i	20	27	—
X21	14	Utility Light	o	12.6	17.01	25
X21	15	Wiper High	o	13	17.55	26.7

Table 6, SAM Cab Maximum Current Pin List

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500 — Terms and Abbreviations

Baud rate—The rate at which data is transmitted in bits per second.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

EAPU—Electric Air Processing Unit

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

I/O Controls—Input/Output controls allow a technician to activate and deactivate an input or output pin for troubleshooting purposes. I/O controls appear on ServiceLink templates as buttons, typically labeled "ON" and "OFF."

MSF—Modular Switch Field

NO—Normally Open

NC—Normally Closed

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PDM—Power Distribution Module

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

WIF—Water In Fuel

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SAM Chassis

501 — General Information

The SAM Chassis is an ECU (Electronic Control Unit). "SAM" stands for "Signal Detect and Actuation Module."

The SAM Chassis works closely with the SAM Cab to control much of the vehicle functionality. The SAM Chassis controls most of the chassis functions, and the SAM Cab controls most of the cab functions.

This ECU uses inputs (such as switches, sensors, and datalink messages), and drives many outputs (such as lights, motors, and solenoids). See **601 — Component Details** for complete pin information.

To understand a particular function or system that the SAM Chassis controls, see the applicable subject in this manual. These subjects contain details about the way the function should work, as well as crucial information such as inputs, outputs, interlocks, any related parameters for that particular function, and any other ECUs or components that are a part of that function.

502 — Fuses and Relays

See **601 — Component Details** for fuse and relay information.

For more information on the power distribution system, see **G02.01 — Electrical System and Main PDM Overview**.

503 — Datalink Connections

The SAM Chassis is connected directly to the Cabin CAN datalink. Cabin CAN wires run from the SAM Chassis to the starpoint connector, where it joins the rest of the Cabin CAN datalink.

See **G03.03 — Datalink, Cabin CAN** for details.

504 — Diagnostic CAN Datalink

When an off-board tool, such as ServiceLink, is connected to the vehicle, it communicates with the Cabin CAN ECUs via the Diagnostics CAN datalink; there is no accessible service port to the Cabin CAN. The CGW translates between the Diagnostics CAN and Cabin CAN datalink, due to the different speed and message formats of the two datalinks.

505 — Functional Messaging and ECU Troubleshooting

To communicate with the ECU, a different set of messages is used by the off-board tool during troubleshooting than the set of messages used during normal operation.

The set of messages used during normal operation is referred to as functional messages, which are sent cyclically on the Cabin CAN datalink. However, the set of messages (protocol) used during troubleshooting is referred to as Control Area Network (CAN), which operates on a request-and-response basis over the Diagnostic CAN datalink.

Any fault reported on the Cabin CAN is translated to Diagnostics CAN by the CGW, and can be displayed when requested by an off-board tool, such as ServiceLink. Similarly, an off-board tool is able to display input and output pin status information, software interlocks, and allows a user to control inputs or outputs for troubleshooting. This information is displayed in ServiceLink's Datalink Monitor (DLM) templates.

506 — ECU Configuration

The diagnostic protocol used for troubleshooting or configuring the SAM Chassis is the Control Area Network (CAN). For more information on CAN, see **G03.04 — Datalink, Diagnostic CAN**.

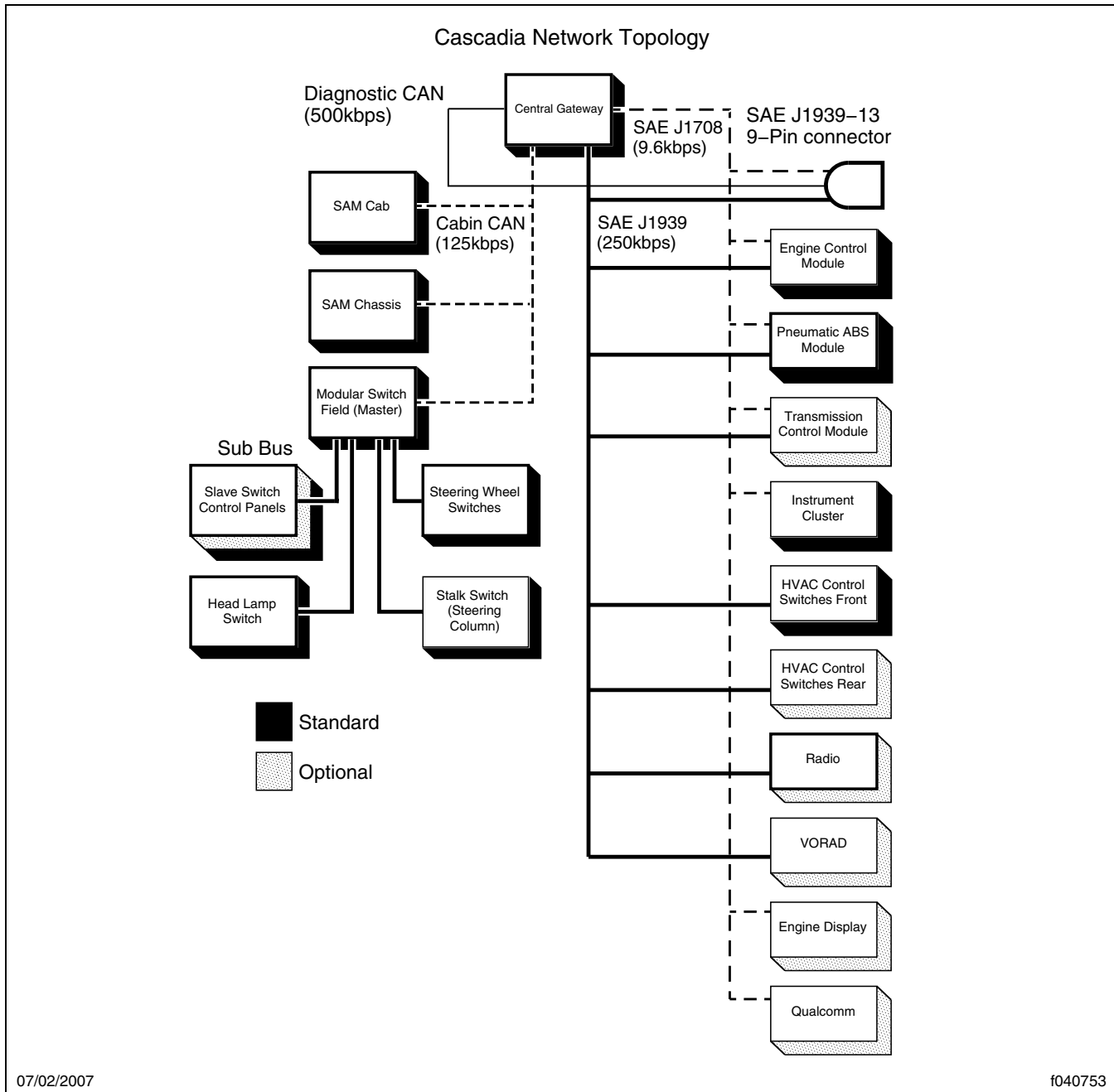
The SAM Chassis has parameters that can be viewed or changed for vehicle configuration.

The SAM Chassis software can be flashed using ServiceLink, which will flash to its same version or upgrade, if required.

The software flashing procedure should only be performed on the SAM Chassis in the following cases:

- **As a last resort:** Troubleshooting has narrowed the problem down to being at the SAM Chassis itself and no other mechanical or electrical causes for the symptom have been identified. As a last resort, flashing the SAM Chassis software with the same version may help in the case it became corrupt during the course of normal vehicle operation.
- **For a feature upgrade:** Adding a new feature to a vehicle may require a newer version of ECU software. ServiceLink will automatically make available any necessary software upgrades.
- **Fixing a problem in the existing software:** In case a new version of ECU software is needed to fix a problem in the existing ECU software, ServiceLink will automatically make available any necessary software upgrades.
- **Replacing the SAM Chassis:** Flashing ensures that the most recent software is on the installed ECU.

For instructions on how to use ServiceLink to flash the software of a CAN ECU like the SAM Chassis, refer to the *ServiceLink User Guide* or *ServiceLink Help* user documentation, available in ServiceLink's "Help" menu.

507 — Datalink Network Topology**Fig. 1, Datalink Network Topology**

600 — Component Locations

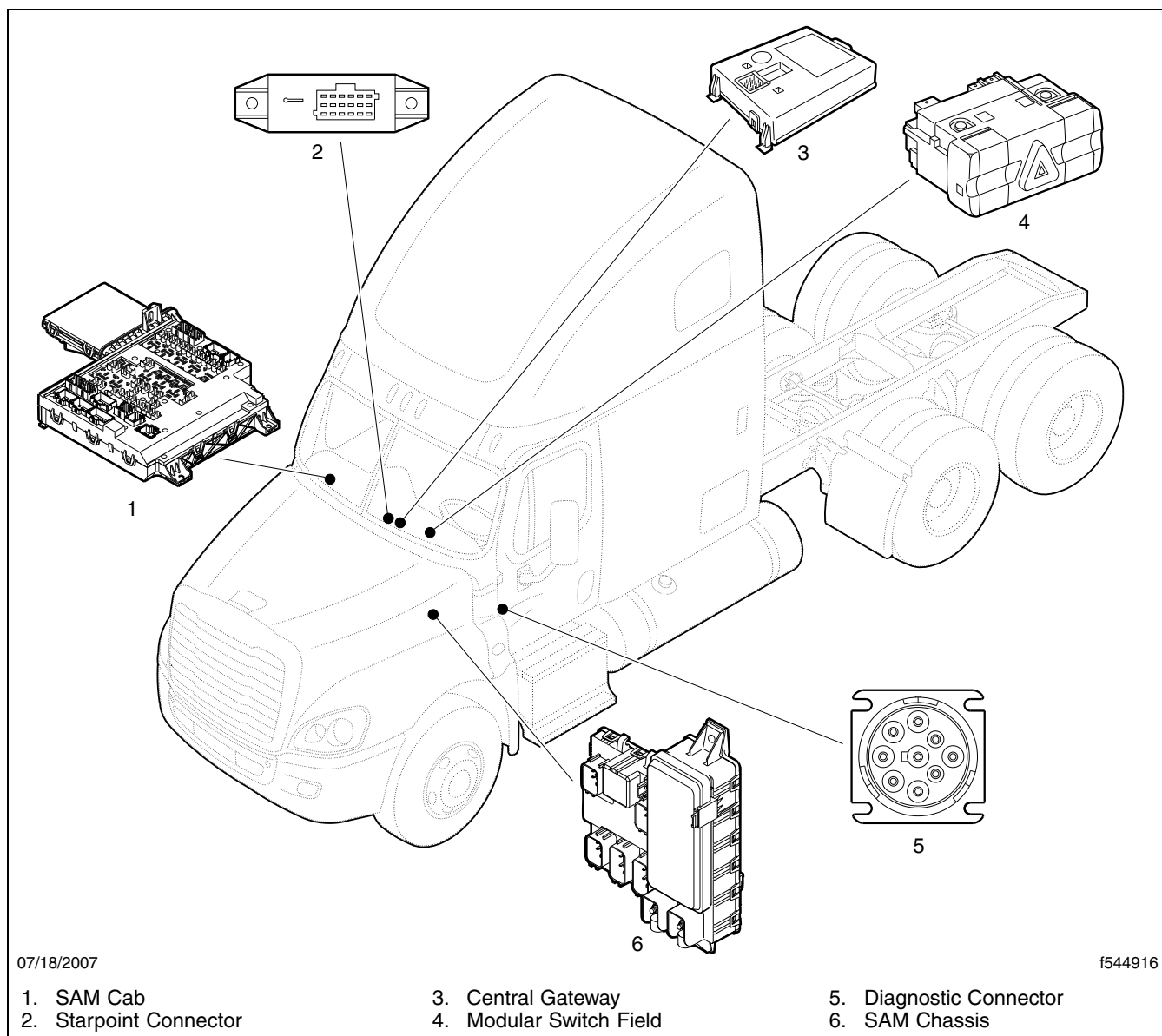


Fig. 2, Component Locations

601 — Component Details

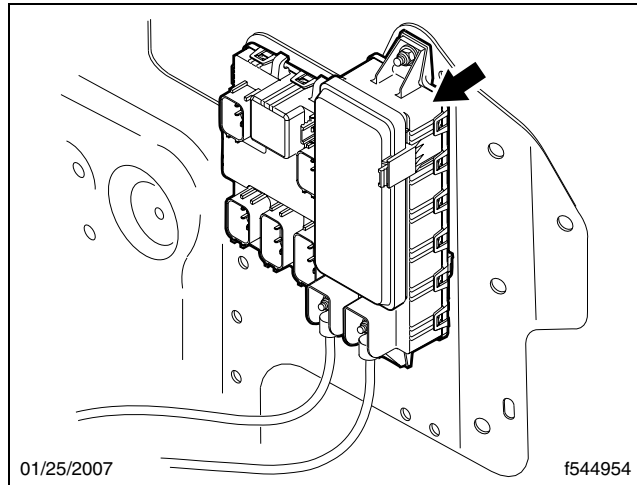


Fig. 3, View of the SAM Chassis on the Frontwall

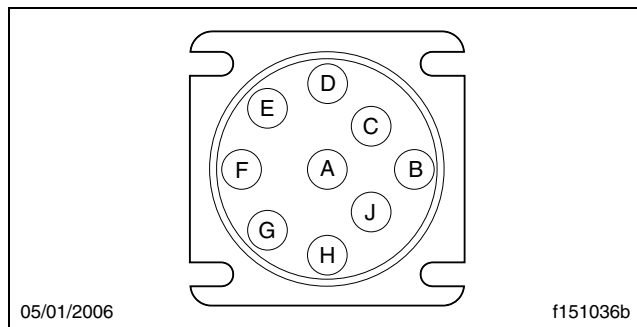


Fig. 4, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	CAN Shield (ground)
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 1, Diagnostic Connector

SAM Chassis

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602 — Pinout Mapping

NOTE: The housing of the SAM Cab contains raised lettering, labeling all connectors, fuses, and relays.

The SAM Chassis is available in different hardware models: Highline, Midline, and Baseline. **Table 2** describes any differences in pin functionality between these hardware models

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X51	1	SAM Chassis, Cabin CAN Low (-)	SAM Chassis, Cabin CAN Low (-)	SAM Chassis, Cabin CAN Low (-)
X51	2	SAM Chassis, Cabin CAN High (+)	SAM Chassis, Cabin CAN High (+)	SAM Chassis, Cabin CAN High (+)
X51	3	Hardwired ISS (Ignition Switch Status), SAM Chassis	Hardwired ISS (Ignition Switch Status), SAM Chassis	Hardwired ISS (Ignition Switch Status), SAM Chassis
X51	4	Not connected	Not connected	Not connected
X51	5	Emergency Battery, SAM Chassis	Emergency Battery, SAM Chassis	Emergency Battery, SAM Chassis
X51	6	Not connected	Not connected	Not connected
X52	1	Marker Lamp, Side Right	Marker Lamp, Side Right	Marker Lamp, Side Right
X52	2	Marker Lamp, Side Right, Ground	Marker Lamp, Side Right, Ground	Marker Lamp, Side Right, Ground
X52	3	Marker Lamp, Corner Rear Right	Marker Lamp, Corner Rear Right	Marker Lamp, Corner Rear Right
X52	4	Power Feed 2, ABS/BS, Battery	Power Feed 2, ABS/BS, Battery	Power Feed 2, ABS/BS, Battery
X52	5	Marker Lamp, Corner Rear Right, Ground	Marker Lamp, Corner Rear Right, Ground	Marker Lamp, Corner Rear Right, Ground
X52	6	Power Feed, ABS/BS, Ignition	Power Feed, ABS/BS, Ignition	Power Feed, ABS/BS, Ignition
X52	7	Power Feed 1, ABS/BS, Battery	Power Feed 1, ABS/BS, Battery	Power Feed 1, ABS/BS, Battery
X52	8	Power Feed 1, ABS/BS, Ground	Power Feed 1, ABS/BS, Ground	Power Feed 1, ABS/BS, Ground
X52	9	Power Feed 2, ABS/BS, Ground	Power Feed 2, ABS/BS, Ground	Power Feed 2, ABS/BS, Ground
X53	1	Marker Lamp, Side Left	Marker Lamp, Side Left	Marker Lamp, Side Left
X53	2	Marker Lamp, Corner Rear Left	Marker Lamp, Corner Rear Left	Marker Lamp, Corner Rear Left
X53	3	Rear View Camera, Ignition	Not connected	Rear View Camera, Ignition
X53	4	Marker Lamp, Corner Rear Left, Ground	Marker Lamp, Corner Rear Left, Ground	Marker Lamp, Corner Rear Left, Ground
X53	5	Trailer ABS Connector (7), ABS Detection	Trailer ABS Connector (7), ABS Detection	Trailer ABS Connector (7), ABS Detection
X53	6	Rear View Camera, Ground	Not connected	Rear View Camera, Ground

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X53	7	Trailer Turn Lamp Right	Trailer Turn Lamp Right	Trailer Turn Lamp Right
X53	8	Marker Lamp, Side Left, Ground	Marker Lamp, Side Left, Ground	Marker Lamp, Side Left, Ground
X53	9	Trailer Turn Lamp Left	Trailer Turn Lamp Left	Trailer Turn Lamp Left
X54	1	Trailer ABS Connector (7), Ignition	Trailer ABS Connector (7), Ignition	Trailer ABS Connector (7), Ignition
X54	2	Not connected	Not connected	Not connected
X54	3	Trailer ABS Connector (7), Ground 1 (GND1)	Trailer ABS Connector (7), Ground 1 (GND1)	Trailer ABS Connector (7), Ground 1 (GND1)
X54	4	Not connected	Not connected	Not connected
X55	1	Trailer Power, Battery or Ignition	Trailer Power, Battery or Ignition	Trailer Power, Battery or Ignition
X55	2	Trailer Marker Lamps	Trailer Marker Lamps	Trailer Marker Lamps
X55	3	Trailer Tail Lamps	Trailer Tail Lamps	Trailer Tail Lamps
X55	4	Trailer Stop Lamps	Trailer Stop Lamps	Trailer Stop Lamps
X56	1	Trailer, Ground 2 (GND2)	Not connected	Not connected
X56	2	End of Frame Primary Trailer Power	Not connected	Not connected
X56	3	Not connected	Not connected	Not connected
X56	4	Differential Lock Solenoid Return, FA1 and FA2	Not connected	Not connected
X56	5	Differential Lock Feedback Switch Return, FA1	Not connected	Not connected
X56	6	Differential Lock Feedback Switch Return, FA2	Not connected	Not connected
X56	7	End of Frame Primary Trailer Turn Lamps Right	Not connected	Not connected
X56	8	Differential Lock Feedback Switch Supply (Chopped), FA2	Not connected	Not connected
X56	9	Not connected	Not connected	Not connected
X56	10	End of Frame Primary Trailer Turn Lamps Left	Not connected	Not connected
X56	11	Differential Lock Feedback Switch Supply (Chopped), FA1	Not connected	Not connected
X56	12	Differential Lock Solenoid Driver, FA1 and FA2	Not connected	Not connected
X56	13	End of Frame Primary Trailer Tail Lamps	Not connected	Not connected
X56	14	End of Frame Primary Trailer Stop Lamps	Not connected	Not connected

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X56	15	End of Frame Primary Trailer Marker Lamps	Not connected	Not connected
X57	1	Power Feed EAPU / WIF Module, Ignition	Not connected	Power Feed EAPU / WIF Module, Ignition
X57	2	Power Feed EAPU (Air Processing Unit), Ground	Not connected	Power Feed EAPU (Air Processing Unit), Ground
X57	3	Air Dryer (Pneumatic, Electrically Heated), Ground	Air Dryer (Pneumatic, Electrically Heated), Ground	Air Dryer (Pneumatic, Electrically Heated), Ground
X57	4	Air Dryer (Pneumatic, Electrically Heated), Accessory	Air Dryer (Pneumatic, Electrically Heated), Accessory	Air Dryer (Pneumatic, Electrically Heated), Accessory
X57	5	Fuel Water Separator Heater Element, Ground	Fuel Water Separator Heater Element, Ground	Fuel Water Separator Heater Element, Ground
X57	6	Not connected	Not connected	Not connected
X57	7	Not connected	Not connected	Not connected
X57	8	Not connected	Not connected	Not connected
X57	9	Not connected	Not connected	Not connected
X57	10	Not connected	Not connected	Not connected
X57	11	Not connected	Not connected	Not connected
X57	12	Not connected	Not connected	Not connected
X57	13	Power Feed EAPU (Air Processing Unit), Battery	Not connected	Power Feed EAPU (Air Processing Unit), Battery
X57	14	Not connected	Not connected	Not connected
X57	15	Fuel Water Separator Heater Element, Ignition	Fuel Water Separator Heater Element, Ignition	Fuel Water Separator Heater Element, Ignition
X58	1	Turn Right Rear Lower	Turn Right Rear Lower	Turn Right Rear Lower
X58	2	Not connected	Not connected	Not connected
X58	3	Tail Lamp Right	Tail Lamp Right	Tail Lamp Right
X58	4	Marker Lamp, Side Left, Ground	Marker Lamp, Side Left, Ground	Marker Lamp, Side Left, Ground
X58	5	Tail Lamps Right, Ground	Tail Lamps Right, Ground	Tail Lamps Right, Ground
X58	6	Not connected	Not connected	Not connected
X58	7	Fuel Level Sensor, Feedback	Fuel Level Sensor, Feedback	Fuel Level Sensor, Feedback
X58	8	Tail Lamps Left, Ground	Tail Lamps Left, Ground	Tail Lamps Left, Ground
X58	9	Not connected	Not connected	Not connected
X58	10	Turn Left Rear Lower	Turn Left Rear Lower	Turn Left Rear Lower
X58	11	Not connected	Not connected	Not connected
X58	12	License Plate Lamp (First)	License Plate Lamp (First)	License Plate Lamp (First)

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SAM Chassis

Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X58	13	Marker Lamp Side Right	Marker Lamp Side Right	Marker Lamp Side Right
X58	14	Marker Lamp Side Right, Ground	Marker Lamp Side Right, Ground	Marker Lamp Side Right, Ground
X58	15	Fuel Level Sensor, Ground	Fuel Level Sensor, Ground	Fuel Level Sensor, Ground
X58	16	Marker Lamp, Side Left	Marker Lamp, Side Left	Marker Lamp, Side Left
X58	17	Not connected	Not connected	Not connected
X58	18	Tail Lamp Left	Tail Lamp Left	Tail Lamp Left
X58	19	Backup Lamp 1	Backup Lamp 1	Backup Lamp 1
X58	20	Stop Lamp, Rear Right Lower	Stop Lamp, Rear Right Lower	Stop Lamp, Rear Right Lower
X58	21	Stop Lamp, Rear Left Lower	Stop Lamp, Rear Left Lower	Stop Lamp, Rear Left Lower
X59	1	Backup Switch, Supply	Backup Switch, Supply	Backup Switch, Supply
X59	2	Transmission Neutral Switch, Supply	Transmission Neutral Switch, Supply	Transmission Neutral Switch, Supply
X59	3	Backup Switch, Return	Backup Switch, Return	Backup Switch, Return
X59	4	Not connected	Not connected	Not connected
X59	5	Not connected	Not connected	Not connected
X59	6	Not connected	Not connected	Not connected
X59	7	Not connected	Not connected	Not connected
X59	8	Not connected	Not connected	Not connected
X59	9	Fuel Water Separator Sensor, Feedback	Not connected	Fuel Water Separator Sensor, Feedback
X59	10	Temperature Sensor Rear Axle 1, Feedback	Temperature Sensor Rear Axle 1, Feedback	Temperature Sensor Rear Axle 1, Feedback
X59	11	Differential Lock Solenoid Driver, RA1 and RA2	Differential Lock Solenoid Driver, RA1 and RA2	Differential Lock Solenoid Driver, RA1 and RA2
X59	12	Not connected	Not connected	Not connected
X59	13	Temperature Sensor Rear Axle 2, Feedback	Temperature Sensor Rear Axle 2, Feedback	Temperature Sensor Rear Axle 2, Feedback
X59	14	Temperature Sensor Rear Axle 2, Ground	Temperature Sensor Rear Axle 2, Ground	Temperature Sensor Rear Axle 2, Ground
X59	15	Differential Lock Feedback Switch Return, RA1	Differential Lock Feedback Switch Return, RA1	Differential Lock Feedback Switch Return, RA1
X59	16	Differential Lock Solenoid Return, RA1 and RA2	Differential Lock Solenoid Return, RA1 and RA2	Differential Lock Solenoid Return, RA1 and RA2
X59	17	Temperature Sensor Rear Axle 1, Ground	Temperature Sensor Rear Axle 1, Ground	Temperature Sensor Rear Axle 1, Ground
X59	18	Transmission Neutral Switch, Return	Transmission Neutral Switch, Return	Transmission Neutral Switch, Return

SAM Chassis

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Pinout Mapping				
Connector	Cavity Number	Function		
		Highline	Baseline	Midline
X59	19	Differential Lock Feedback Switch Supply (Chopped), RA1	Differential Lock Feedback Switch Supply (Chopped), RA1	Differential Lock Feedback Switch Supply (Chopped), RA1
X59	20	Differential Lock Feedback Switch Supply (Chopped), RA2	Differential Lock Feedback Switch Supply (Chopped), RA2	Differential Lock Feedback Switch Supply (Chopped), RA2
X59	21	Differential Lock Feedback Switch Return, RA2	Differential Lock Feedback Switch Return, RA2	Differential Lock Feedback Switch Return, RA2

Table 2, Pinout Mapping

603 — Fuse Mapping

Fuse Mapping					
Fuse	Fuse Name	Rating	Connection	Pin	Function
F1	EAPU	20	X57	13	Power Feed Air Processing Unit, BAT
F2	H2O SEP HEAT	20	X57	15	Fuel Water Heater, IGN
F3	ABS-BAT1	20	X52	7	Power Feed 1 ABS, BAT
F4	ABS-BAT2	10	X52	4	Power Feed 2 ABS, BAT
F5	TRLR TRN L	20	X53	9	Trailer Turn Lamp Left
F6	ABS-IGN	15	X52	6	Power Feed ABS, IGN
F7	WIF/CAMERA	10	X53	3	Rear View Camera
			X57	1	Power Feed EAPU, IGN
F8	TRLR TRN R	20	X53	7	Trailer Turn Lamp Right
F9	TRLR MKR	30	X55	2	Trailer Marker Lamps
F10	SAM RELAY COILS	5	N/A	N/A	Battery Feed for Relay Coils
F11	TRLR ABS-IGN	30	X54	1	Trailer ABS, IGN
F12	TRLR STOP	30	X55	4	Trailer Stop Lamps
F13	TRLR TAIL	20	X55	3	Trailer Tail Lamps
F14	TRLR PWR	30	X55	1	Trailer Power, BAT or IGN

Table 3, Fuse Mapping

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SAM Chassis

604 — Relay Mapping

Relay Mapping									
Relay	Relay Name	Relay Coil (low current side)		Relay (high current side)			Conn.	Pin	Circuits Supplied
		Control (-) (86)	Control (+) (85)	Common (30)	Type	Suppl. Pwr To			
R1	H2O SEP HEAT, IGN	SAM Micro	F10 (batt power)	Batt	NO	F2	X57	15	Fuel Water Heater, IGN
R2	TRLR TRN L	SAM Micro	F10 (batt power)	Batt	NO	F5	X53	9	Trailer Turn Lamp Left
R3	ABS/WIF/ CAMERA, IGN	SAM Micro	F10 (batt power)	Batt	NO	F6	X52	6	Power Feed ABS, IGN
						F7	X53	3	Rear View Camera
							X57	1	Power Feed EAPU, IGN
R4	TRLR TRN R	SAM Micro	F10 (batt power)	Batt	NO	F8	C53	7	Trailer Turn Lamp Right
R5	TRLR MARKER	SAM Micro	F10 (batt power)	Batt	NO	F9	X55	2	Trailer Marker Lamps
R6	TRLR ABS-IGN	SAM Micro	F10 (batt power)	Batt	NO	F11	X54	1	Trailer ABS, IGN
R7	TRLR STOP LAMPS	SAM Micro	F10 (batt power)	Batt	NO	F12	X55	4	Trailer Stop Lamps
R8	TRLR POWER	SAM Micro	F10 (batt power)	Batt	NO*	F14	X55	3	Trailer Power, BAT or IGN
R9	TRLR TAIL LAMPS	SAM Micro	F10 (batt power)	Batt	NO	F13	X55	1	Trailer Tail Lamps

* R8 is a single throw relay, it will only have 4 prongs. Either pin 87 or pin 87a will be missing, depending on the intended functionality of the circuit. If prong 87a is missing the circuit will be normally open, the trailer power circuit is enabled only if the key is in IGN position or enabled through a switch (depending on SAM parameterization). If prong 87 is missing, the circuit is normally closed (BAT). If a 5 prong relay is used, the trailer power will be always on.

Table 4, Relay Mapping

700 — Troubleshooting Overview

If the symptom is function- or system-specific (stop lights do not function, for example), refer to the applicable subject in this manual.

In ServiceLink, use the CAN protocol to troubleshoot or configure the SAM Chassis, via the Diagnostic CAN datalink. See **601 — Component Details** for the Diagnostic CAN pins in the diagnostic connector.

For more information on the Diagnostic CAN datalink, see **G03.04 — Datalink, Diagnostic CAN**.

701 — Required Tools

- ServiceLink

702 — Possible Causes

- Wiring (bad/loose connection, corrosion, miswiring, etc.)
- SAM Chassis relays

SAM Chassis

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- SAM Chassis fuses
- SAM Chassis parameters
- SAM Chassis ECU software
- Cabin CAN datalink
- Other ECUs on the Cabin CAN datalink
- Diagnostic CAN datalink

703 — Fault Codes

CAN Fault, SAM Chassis				
SA	SPN	FMI	Fault Description	Fault Trigger
71	168	3	Electrical Potential (Voltage) – voltage above normal, or shorted to high	Trigger: SAM Chassis battery voltage sensed to be above normal, or shorted to high. Reflects battery voltage datalink value from the SAM Cab ECU. Action: Check power feed wiring to the SAM Cab and the SAM Chassis. Check alternator charging wiring.
71	168	4	Electrical Potential (Voltage) – voltage below normal, or shorted to low	Trigger: SAM Chassis battery voltage sensed to be below normal, or shorted to low. Reflects battery voltage datalink value from the SAM Cab ECU. Action: Check power feed wiring to the SAM Cab and the SAM Chassis. Check alternator charging wiring.
71	520201	3	CAN low – voltage above normal, or shorted to high source	Trigger: The Cabin CAN Low (–) pin is shorted to battery, or high source. Vehicle Behavior: In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check the Cabin CAN harness, especially in connection to the SAM Chassis. Verify proper connection of the Cabin CAN harness to the SAM Chassis.
71	520201	4	CAN low – voltage below normal, or shorted to low source	Trigger: The Cabin CAN Low (–) pin shorted to ground, or low source. Vehicle Behavior: In case of a serious error with the Cabin CAN datalink, SAM Cab, and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check the Cabin CAN harness, especially in connection to the SAM Chassis. Verify proper connection of the Cabin CAN harness to the SAM Chassis.

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SAM Chassis

CAN Fault, SAM Chassis				
SA	SPN	FMI	Fault Description	Fault Trigger
71	520202	3	CAN high – voltage above normal, or shorted to high source	Trigger: The Cabin CAN High (+) pin shorted to battery, or high source. In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check the Cabin CAN harness, especially in connection to the SAM Chassis. Verify proper connection of the Cabin CAN harness to the SAM Chassis.
71	520202	4	CAN high – voltage below normal, or shorted to low source	Trigger: The Cabin CAN High (+) pin shorted to ground, or low source. In the case of a serious error with the Cabin CAN datalink, SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode. Action: Check Cabin CAN harness, especially in connection to the SAM Chassis. Verify proper connection of the Cabin CAN harness to the SAM Chassis.
71	523511	31	Cabin CAN bus performance condition exists	Trigger: A problem is detected with Cabin CAN performance. In the case of a serious problem with the Cabin CAN datalink, the SAM Cab and/or SAM Chassis may be running in Emergency Power Mode. Action: Check Cabin CAN wiring.
71	524033	31	Lost communication with the SAM Cab	Trigger: The SAM Chassis did not receive heartbeat messages from the SAM Cab. Vehicle Behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Cab failure. An indication of a SAM Cab failure is that all gauges in the instrumentation control unit (ICU) drop to zero because power to the ICU is lost. Action: Check Cabin CAN wiring, especially connections to the SAM Cab and SAM Chassis. Check SAM Cab power supply cables.
71	524037	31	Lost communication with the CGW	Trigger: The SAM Chassis did not receive heartbeat messages from the CGW. Action: Check Cabin CAN wiring, especially connections to the CGW and the SAM Chassis. Check CGW power supply fuse and wiring.
71	524049	31	Lost communication with the MSF	Trigger: The SAM Chassis did not receive heartbeat messages from the MSF. Vehicle Behavior: Headlights automatically turn on for safety. All functions where input switches are controlled by the MSF do not function, such as turn and hazard functions, rotary switch (headlamp) functions, and wiper. Action: Check Cabin CAN wiring, especially connections to the MSF and the SAM Chassis.

Table 5, CAN Fault, SAM Chassis

704 — Fused and Relayed Outputs

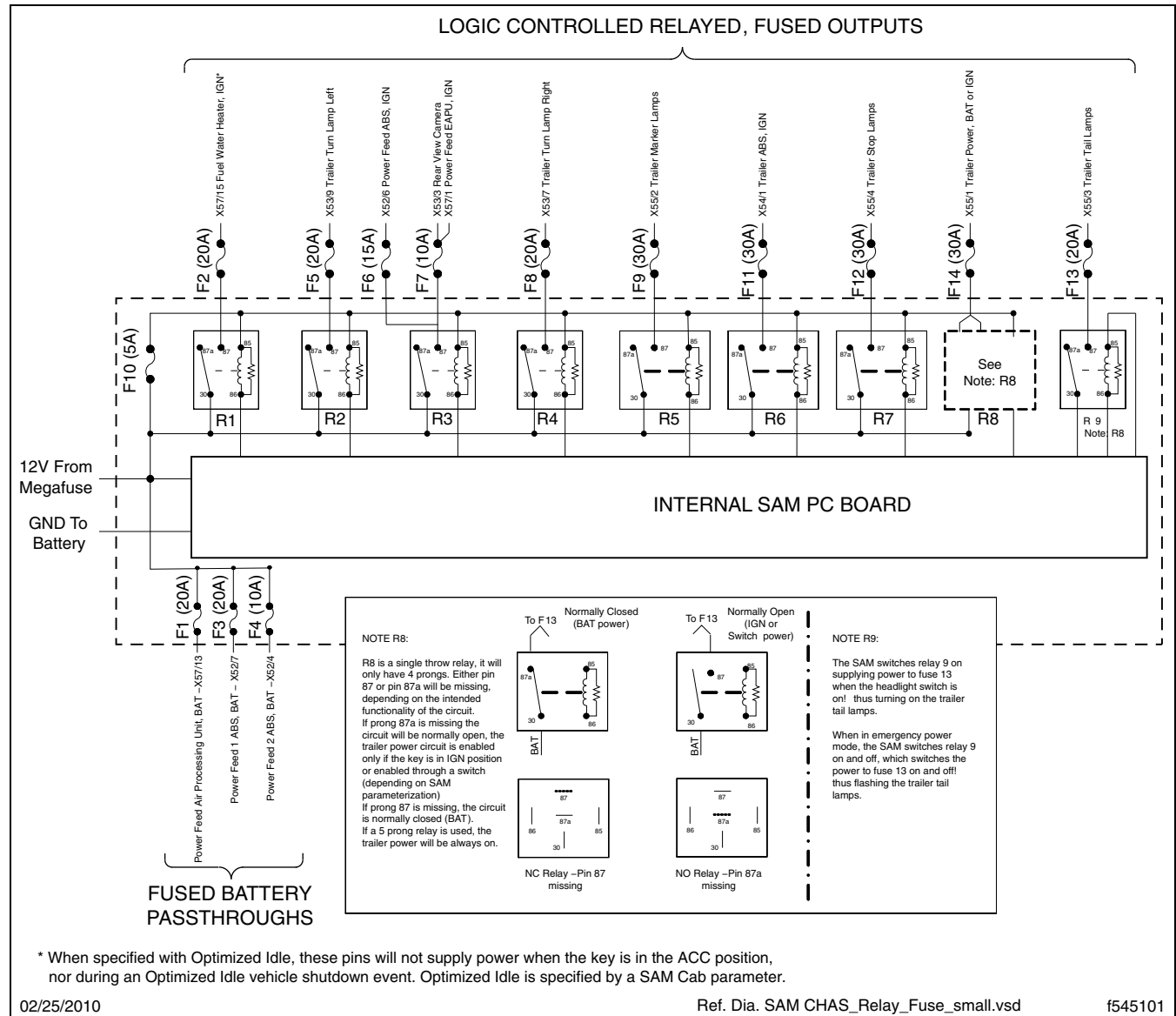
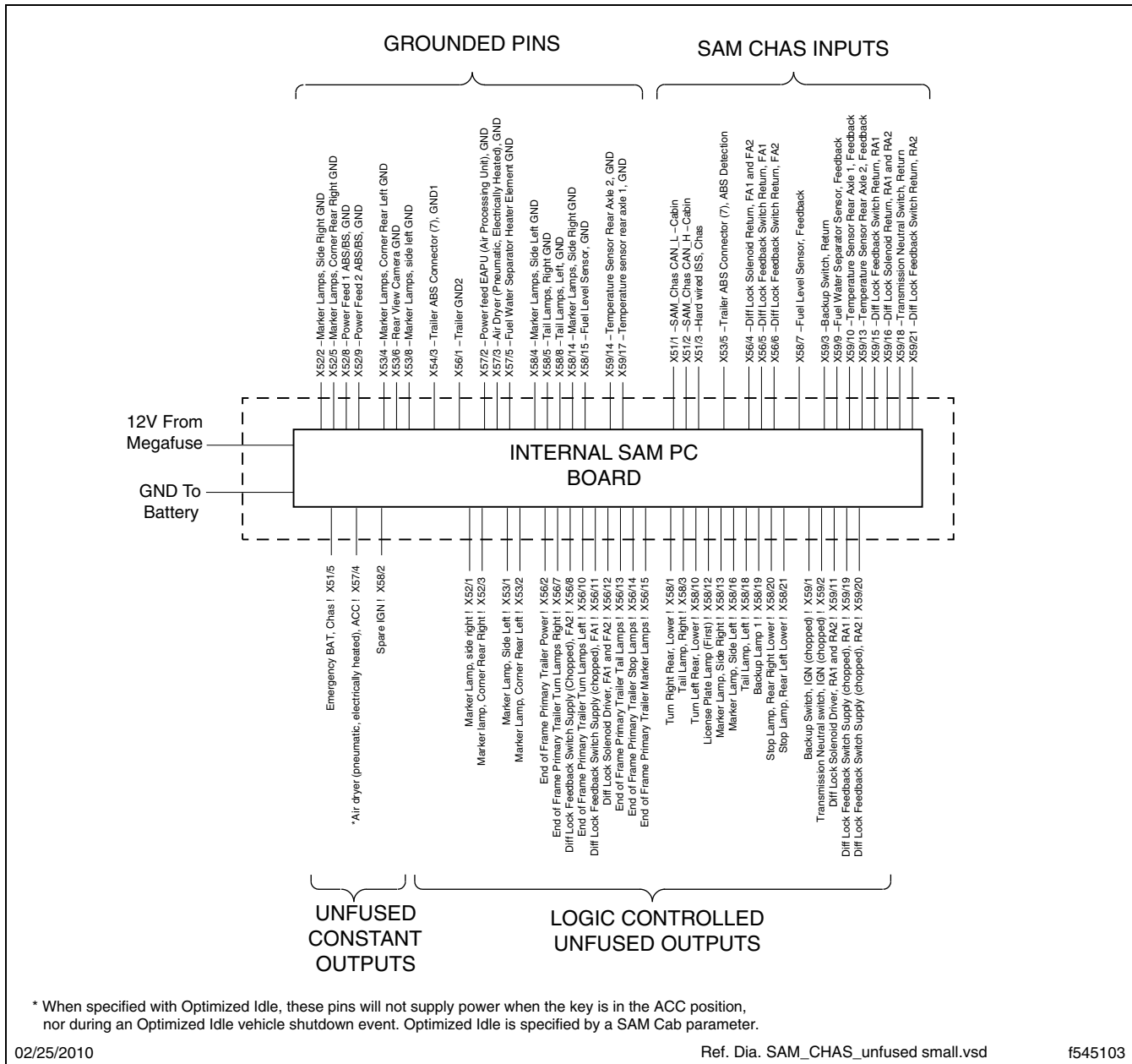


Fig. 5, Fused and Relayed Outputs

705 — Unfused Outputs, Grounded Pins, and Inputs



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Ref. Dia. SAM_CHAS_unfused small.vsd

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Fig. 6, Unfused Outputs, Grounded Pins, and Inputs

706 — Logic Controlled Unfused Outputs

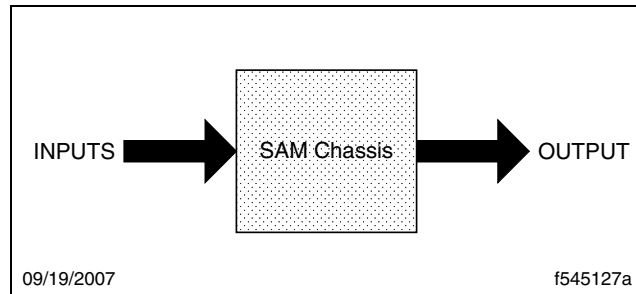


Fig. 7, SAM Unfused Inputs and Outputs

1. **Determine if the template has I/O controls available for the affected function.**
 Open the Datalink Monitor template for the function or output that is not functioning.
 Are I/O control buttons available for the affected function?
YES → Go to test 2.
NO → Go to test 5.
2. **Use the I/O control feature in Datalink Monitor to test the output circuit.**
 Does the function or output work when activated with Datalink Monitor?
YES → Go to test 3.
NO → Go to test 4.
3. **Use Datalink Monitor to determine if input conditions are met for the function or output to operate.**
 Are all of the input conditions met?
YES → Check SAM Chassis programming and parameters. For additional programming/parameter information specific to this function, refer to the applicable subject in this manual. If programming/parameters are OK, replace the SAM Chassis.
NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.
4. **Rule out the output by manually applying fused power and ground.**
 Does the function or output work when power and ground are applied manually?
YES → Replace the SAM Chassis.
NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting specific to this function, refer to the applicable subject in this manual.
5. **Determine if input conditions are met for the function or output to operate using Datalink Monitor.**
 NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

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SAM Chassis

- 5.1 Refer to the function or output in this manual to identify what input conditions have to be met in order for the function or output to operate.
- 5.2 Open the Datalink Monitor template for the applicable function.
- 5.3 While monitoring the template inputs, attempt to activate the function or output using the normal method. For example, turn on the headlights if the rotary switch inputs are being tested.

Are all of the input conditions met?

YES → Go to test 6.

NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.

6. Check available voltage at the consumer.

NOTE: Available voltage tests cannot be performed on every SAM Chassis function. For example, checking voltage at a turn signal connector will not work. Refer to the applicable subject in this manual for more details about troubleshooting specific outputs. If test 6 cannot be performed, proceed to test 7.

- 6.1 Disconnect the connector at the consumer.
- 6.2 Activate the function by normal means. Turn on the headlights, for example, if the rotary switch inputs are being tested.
- 6.3 Measure voltage between the positive and ground pins on the connector.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 7.

7. Rule out the output by manually applying fused power and ground.

- 7.1 Disconnect the SAM connector(s) containing the circuits for the output (power) and ground for the function being tested.
- 7.2 Apply fused power to the output circuit using jumper wires, and apply ground to the ground circuit.

Does the function or output work when power and ground are applied manually?

YES → Check SAM programming and parameters. For additional programming and parameter information, refer to the applicable subject in this manual. If the programming and parameters are OK, replace the SAM Chassis.

NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

707 — Logic Controlled Relayed Fused Outputs

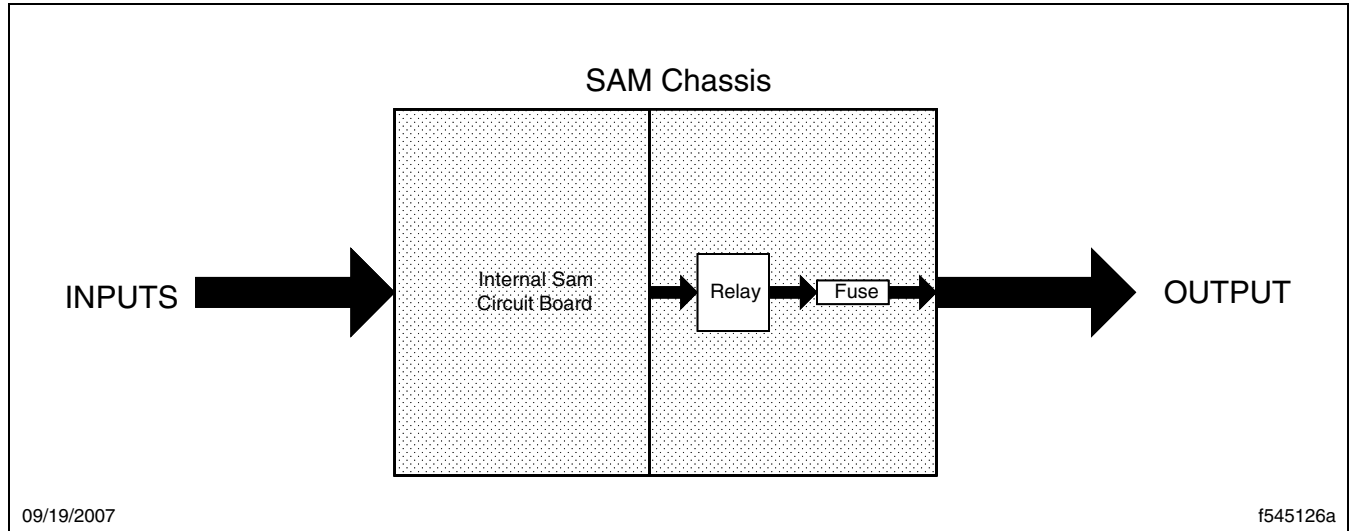


Fig. 8, SAM Fused Inputs and Outputs

1. **Determine if the template has I/O controls available for the affected function.**

Open the Datalink Monitor template for the function or output that is not functioning.

Are I/O control buttons available for the affected function?

YES → Go to test 2.

NO → Go to test 3.

2. **On SAM Chassis with I/O control, use Datalink Monitor to determine if the output circuit can be eliminated as the problem.**

NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

2.1 Open the Datalink Monitor template for the applicable function.

2.2 Using the template, attempt to activate the function or output.

Does the function or output work when activated manually in Datalink Monitor?

NOTE: For normally closed relays, activating the SAM output will turn off the function the relay controls. For normally open relays, activating the SAM output will turn on the function the relay controls.

YES → Go to test 3.

NO → Go to test 4.

3. **Use Datalink Monitor to determine if input conditions are met for function or output to operate.**

NOTE: To determine which Datalink Monitor template to use, refer to the applicable subject in this manual.

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SAM Chassis

- 3.1 Refer to the applicable function or output, and identify what input conditions have to be met for normal operation.
- 3.2 Open the applicable Datalink Monitor template.
- 3.3 While monitoring the template inputs, attempt to activate the function or output using the normal method. Turn on the headlights, for example, if the rotary switch inputs are being tested.

Are all of the input conditions met?

YES → Go to test 4.

NO → For additional input troubleshooting specific to this function, refer to the applicable subject in this manual.

4. Check the available voltage at the consumer.

NOTE: Available voltage tests cannot be performed on every SAM function. For example, checking voltage at a turn signal connector will not work. Refer to the applicable subject for more information about troubleshooting the specific outputs. If test 4 cannot be performed, proceed to test 5.

- 4.1 Disconnect the connector at the consumer.
- 4.2 Activate the function by normal means. Turn on the headlights, for example, if the rotary switch inputs are being tested.
- 4.3 Measure voltage between the positive and ground pins.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 5.

5. Check for power at the relay coil (low current side).

- 5.1 Remove the relay from the SAM for the function that is not working.
- 5.2 Check for voltage in the SAM relay cavity that corresponds to terminal 85 of the relay.

Is there voltage at relay cavity 85?

YES → Go to test 6.

NO → Check fuse F29 on the SAM Chassis.

6. Check for power at the relay common (high current side).

Check for voltage in the SAM relay cavity that corresponds to terminal 30 of the relay.

Is there voltage at relay cavity 30?

YES → Go to test 7.

NO → Check main power to SAM from the MEGA fuse.

7. Check the SAM fuse for the function.

Check the fuse for the function or output.

Is the fuse good?

YES → Go to test 8.

NO → Check for a short to ground in the output circuit. Check the component that the output supplies power to for excessive current draw. Make repairs as necessary, and replace the fuse.

8. **Determine if the function works when power is manually applied.**

Using a fused jumper, apply power to the SAM relay cavity that corresponds to 87 for normally open relay connections, or 87a for normally closed relays.

Does the function work when power is manually applied at the relay?

YES → Go to test 9.

NO → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

9. **Determine if the output works with a test relay that is operating properly.**

Remove the relay from the SAM and install the known good relay.

Does the function or output work with a known good relay?

YES → Replace the relay.

NO → Check SAM programming and parameters. For additional programming/parameter information, refer to the applicable subject in this manual. If programming and parameters are OK, replace the SAM.

708 — Unfused Constant Outputs

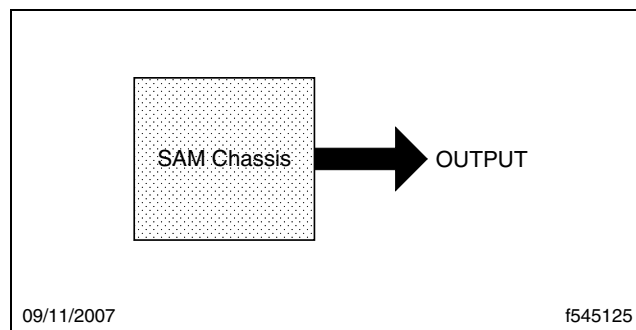


Fig. 9, SAM Unfused Constant Outputs

1. **Check available voltage at the consumer.**

1.1 Disconnect the connector at the consumer.

1.2 Measure the voltage between the positive and ground pins on the connector.

Is there battery voltage across the positive and ground terminals?

YES → Replace the consumer.

NO → Go to test 2.

2. **Check the voltage at output pin.**

2.1 Turn the ignition switch on.

2.2 Check for voltage at the unfused constant output pin.

Is there 12V at the unfused constant output pin?

YES → The problem is in the output power or ground circuits or the load itself. For additional output troubleshooting refer to the applicable subject in this manual.

NO → For IGN and ACC outputs, check for ignition switch function. For all types, check the main power and ground feeds to the SAM. If OK, replace the SAM.

709 — Fused Battery Pass-Through Outputs

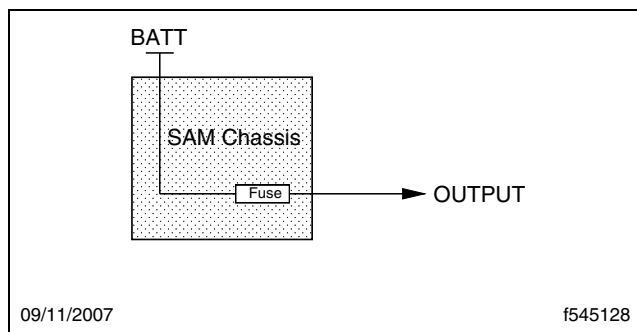


Fig. 10, Fused Battery Pass-Through Outputs

1. **Check the fuse in the SAM for the output.**

Is the fuse OK?

YES → Go to test 2.

NO → Check for short to ground in the output circuit, repair as necessary, and then replace the fuse. For additional output troubleshooting, refer to the applicable subject in this manual.

2. **Check power and ground supply to the SAM.**

Is power and ground supply to the SAM OK?

YES → The problem is in the output power or ground circuits, or the load itself. For additional output troubleshooting, refer to the applicable subject in this manual.

NO → Check the MEGA fuse, and the power and ground circuits to the SAM. Repair as necessary.

Modular Switch Field

G02.06

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier of an ECU communicating on CAN.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PDM—Power Distribution Module

PWM—Pulse-Width Modulation

SA—Source Address; represents the node address of any device that communicates on CAN.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The Modular Switch Field (MSF) includes an MSF Master ECU, MSF slave panels, and various connected switches.

NOTE: This subject describes general operation and troubleshooting for switches in the modular switch field. To troubleshoot a specific switch's function, refer to the applicable troubleshooting subject.

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Modular Switch Field

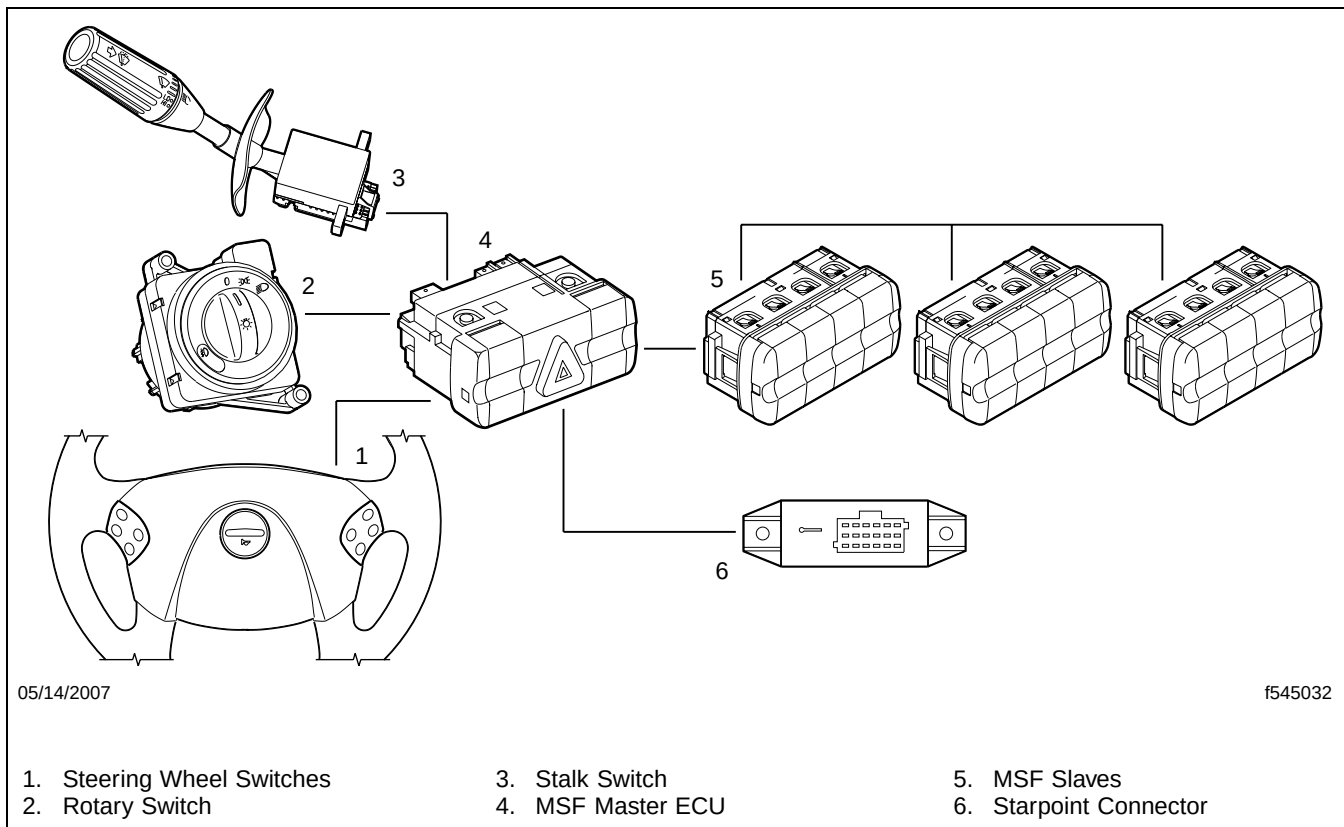


Fig. 1, Modular Switch Field

NOTE: The Starpoint Connector is not a part of the switch field, but is part of the Cabin CAN Datalink. It is included in this illustration because the MSF Master connects to the starpoint connector.

502 — MSF Master ECU

The MSF Master is also referred to as the "Master Control Module" or "Master Control Panel (MCP)."

It is the only component in the modular switch field that is connected to the Cabin CAN datalink. All other components of the switch field are connected to the MSF Master.

The MSF Master houses the hazard switch. It also has housing for two "sub bus switches."

The MSF Master receives battery power and ground from the SAM Cab; power comes through a 15A fuse (F4) on the SAM Cab.

503 — MSF Switches

There are two types of switches in the Modular Switch Field:

- Sub Bus Switches:
 - signal only (multiplexed)
 - hardwired (load-interrupting)

- Other MSF Switches:
 - hazard switch
 - rotary switch (headlamps)
 - stalk switch
 - steering wheel switches

ECU parameters on the MSF Master determine which sub bus switches belong on the vehicle. For more information on ECU parameters for Cabin CAN ECUs, refer to **G03.04 — Datalink, Diagnostic CAN**.

NOTE: The diagnostics, troubleshooting, and configuration in this subject apply only to switches that are a part of the modular switch field. Some switches in the vehicle are not part of the MSF, such as door switches, switches for mirror direction, ABS check, and possibly other aftermarket switches.

504 — Sub Bus Switches

MSF Slaves physically connect switches to the MSF Master via a three-wire proprietary "sub bus." This sub bus consists of one wire that provides power to all connected switches, one wire that provides ground to all connected switches, and one wire that carries a data signal. Off-board tools, such as ServiceLink, do not directly access this sub bus, but can troubleshoot the sub bus pins on the MSF Master and its connected sub bus switches via the MSF Master.

All sub bus switches have a unique ID number that the MSF Master monitors on the sub bus.

Backlighting for all sub bus switches is powered by the sub bus wiring and is controlled by the MSF Master.

There are two types of sub bus switches:

- **Signal-Only (multiplexed):** The MSF Master ECU monitors the sub bus for the presence of a signal switch, as well as its switch position. The switch position is then provided to other ECUs on the Cabin CAN datalink, that use the switch as an input.
- **Hardwired (load-interrupting):** The MSF Master monitors the sub bus for the presence of a hardwired switch only; it does not monitor the switch position of a hardwired switch. Hardwired switches are hardwired to the load for which they are an input. They are also called "load-interrupting," because they often physically interrupt the load for which they are an input. This differs from signal switches, which do not connect to anything except for the sub bus.

The MSF Master provides faults for missing or extra sub bus switches. Missing and extra sub bus switch information can be viewed in the following ServiceLink screens:

- **ECU List icon:** "Faults" screen (CAN protocol)
- **MSF icon:** "Faults" screen (CAN protocol)
- **MSF icon:** "Switches" screen (CAN protocol)

A list of sub bus switches currently connected to the vehicle, as well as the position of any signal switch, is viewable on the "Switches" screen, under the MSF icon on ServiceLink.

Hardwired switches do not have their position status (up, down, middle) available on the sub bus. They must be physically viewed to know their current position. This is because the MSF Master monitors the sub bus for a hardwired switch presence only; it does not monitor the switch position of a hardwired switch due to the way the hardwired switches are designed.

Differences between signal and hardwired switches are:

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- **Connection to external circuits:** hardwired switches are physically connected to the loads for which they are an input, as well as to the sub bus. Signal switches are physically connected to the sub bus only (not to any external circuits).
- **Position information:** signal switches have their position status (up, down, not pressed) viewable in ServiceLink on the MSF icon "Switches" screen. Hardwired switches do not, and must be looked at to know their position status.

Refer to **704 — Diagnostic Tests for Verifying Sub Bus Switch Type** for faults related to missing or extra sub bus switches, as well as diagnostic tests to determine if a sub bus switch is hardwired or signal.

505 — Other MSF Switches

Switches in the MSF include:

- hazard switch
- rotary switch (headlamps)
- stalk switch
- steering wheel switches

All of these switches are physically connected to the MSF Master via wiring, not via the sub bus. An exception is the hazard switch, which is built directly into the MSF Master housing. For troubleshooting information about a switch's specific function, refer to that function's subject in this manual.

Rotary Switch: The rotary switch is also referred to as the "headlamp switch." The rotary switch is the input for marker, clearance, tail, and license plate lamps, and low- and high-beam headlamps. Depending on vehicle options, it may also be the input for fog lamps.

Stalk Switch: The stalk switch is used for left and right turn signals, high-beam activation, performing a flash-to-pass, and activating the wipers and windshield washer. It is wired to the MSF. The stalk switch has three horizontal positions:

- Pushed: high-beam headlights are activated if the low-beam headlights are on (position 2).
- Neutral: no action.
- Pulled: the flash-to-pass function is performed, regardless of the position of the headlight switch.

Steering Wheel Switches: The steering wheel switches are the switch pads on the left and right sides of the steering wheel. They control the following, depending on vehicle options:

- cruise control (on/off, set/resume, accelerate/decelerate, cancel)
- engine brake
- marker interrupt
- menu scroll buttons (+/–) for the driver information center in the instrument cluster

Steering wheel switch inputs to the MSF master are two signal wires, S1 and S2. These are resistive ladder logic inputs for the above functions, however they cannot be measured externally by a voltmeter due to diodes in the steering wheel switch circuitry. To monitor the status of these switches, use the template "MSF Switches: Hazard, Rotary, Stalk, Steering wheel" in ServiceLink.

MSF Master: The MSF Master reports various faults for these switches, such as short-circuits to power or ground.

506 — MSF Slaves

The MSF slaves are simple housings for up to four switches. These connect to the wiring of the proprietary sub bus. The sub bus connects each switch to the MSF Master. MSF Slaves are sometimes also referred to as "Slave Control Panels" (SCP) or as "slaves."

There can be up to 9 slaves installed on a vehicle.

These slave housings can be connected to the MSF Master using the sub bus wiring by either of the following connection methods:

- Daisy chain.
- Direct connection to the MSF Master. The MSF Master has connections for up to six connection's slaves.

Both connection methods may be used at the same time. The maximum length of the sub bus is 40 meters.

See **Fig. 2** for examples of both connection methods.

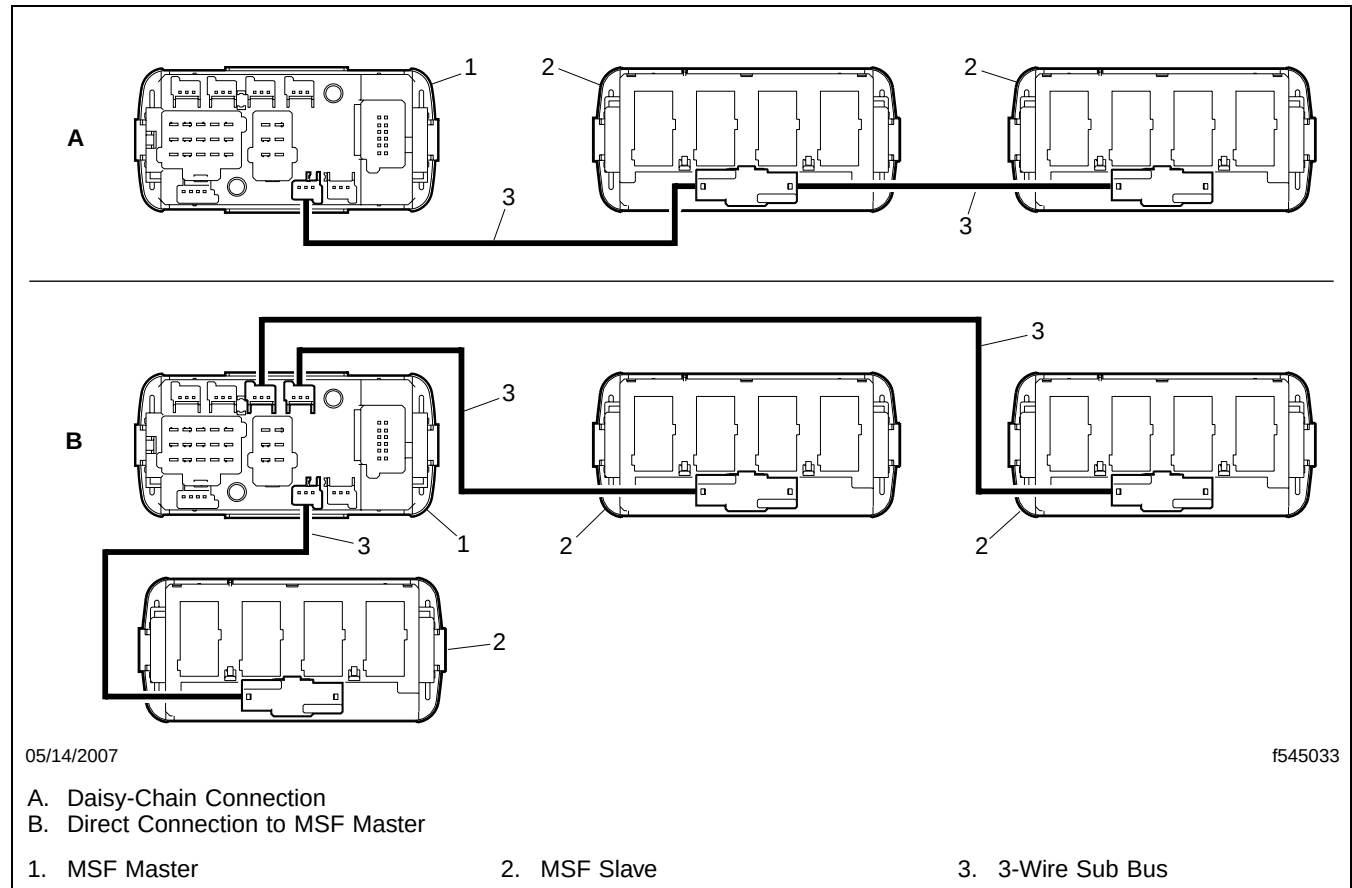


Fig. 2, MSF Slave Connection Methods

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507 — Datalink Network Topology

The MSF Master is the only component of the switch field that is physically connected to the Cabin CAN datalink. All other components of the switch field are not connected to any of the four datalinks. See **G02.02 — Datalink Communication Structure** for details.

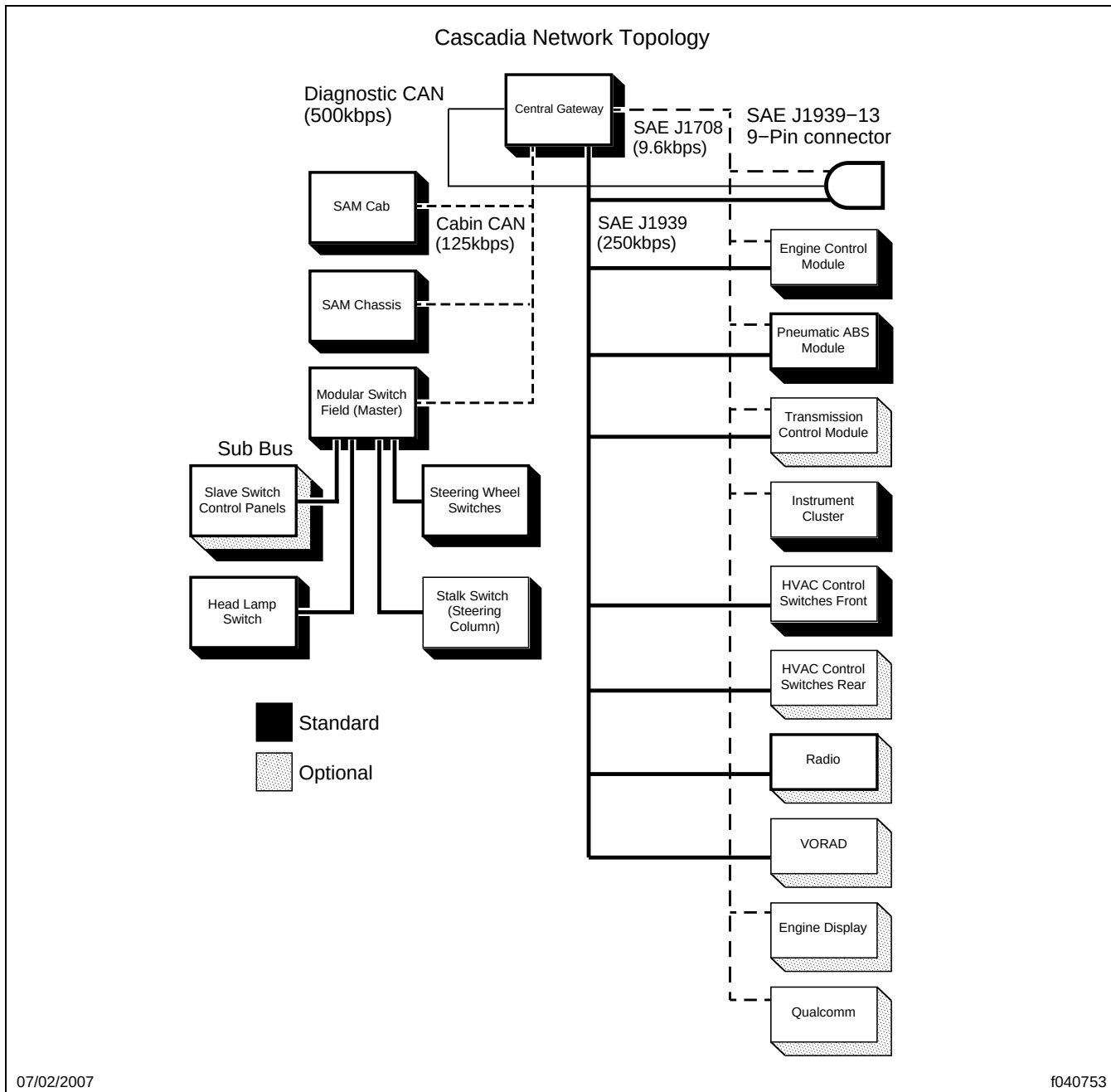


Fig. 3, Datalink Network Topology

The Cabin CAN datalink wires run from the MSF Master to the Starpoint Connector, where it joins the rest of the Cabin CAN datalink.

508 — Datalink, Diagnostic CAN

Since there is no direct connection from the off-board tool to the Cabin CAN datalink, the Diagnostic CAN datalink runs from the diagnostic connector to the Central Gateway ECU (CGW). Its sole purpose is to connect the off-board tool (ServiceLink) to the CGW. In this way, the off-board tool can communicate with all of the Cabin CAN ECUs, such as the MSF Master.

509 — Controller Area Network (CAN)

Off-board tools such as ServiceLink use a communication protocol called CAN to communicate with the Cabin CAN ECUs. This is similar to how J1587 is used to communicate with ECUs connected to the J1708 datalink.

This applies to the SAM Cab, SAM Chassis, Modular Switch Field, and Central Gateway. Sometimes these ECUs are also called "CAN ECUs."

510 — Control Messaging and ECU Troubleshooting

ECU "control messaging" refers to the messages it sends to other ECUs to control the vehicle. This takes place over its connected datalink. However, an ECU's "troubleshooting datalink" refers to the datalink that an off-board tool, such as ServiceLink, uses to communicate and diagnose that ECU. See **Table 1**.

ECU Control Messaging and Troubleshooting Datalinks					
ECU is on this Datalink	Control Messaging Datalink	Direct Connection to Diagnostic Connector?	Troubleshooting Datalink	Direct Connection to Diagnostic Connector?	Diagnostic Communication Protocol
Cabin CAN	Cabin CAN	No	Diagnostic CAN	Yes	CAN

Table 1, ECU Control Messaging and Troubleshooting Datalinks

Faults from all ECUs can be viewed on ServiceLink.

511 — ECU Configuration

The diagnostic protocol used for troubleshooting or configuring the MSF is the Control Area Network (CAN). For more information on CAN, see **G03.04 — Datalink, Diagnostic CAN**.

The MSF Master has parameters that can be viewed or changed for vehicle configuration. The MSF can be flashed using ServiceLink, which will flash to its same version or upgrade, if required.

The software flashing procedure should only be performed on the MSF in the following cases:

- **As a last resort:** Troubleshooting has narrowed the problem down to being at the MSF itself and no other mechanical or electrical causes for the symptom have been identified. As a last resort, flashing the MSF software with the same version may help in the case it became corrupt during the course of normal vehicle operation.
- **For a feature upgrade:** Adding a new feature to a vehicle may require a newer version of ECU software. ServiceLink will automatically make available any necessary software upgrades.

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- **Fixing a problem in the existing software:** In case a new version of ECU software is needed to fix a problem in the existing ECU software, ServiceLink will automatically make available any necessary software upgrades.
- **Replacing the MSF:** Flashing ensures that the most recent software is on the installed ECU.

For instructions on how to use ServiceLink to flash the software of a CAN ECU like the MSF, refer to the *ServiceLink User Guide* or *ServiceLink Help* user documentation, available in ServiceLink's "Help" menu.

512 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.02 — Datalink Communication Structure
- G02.03 — Central Gateway
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN
- G04.03 — CAN Fault Codes

600 — Component Locations

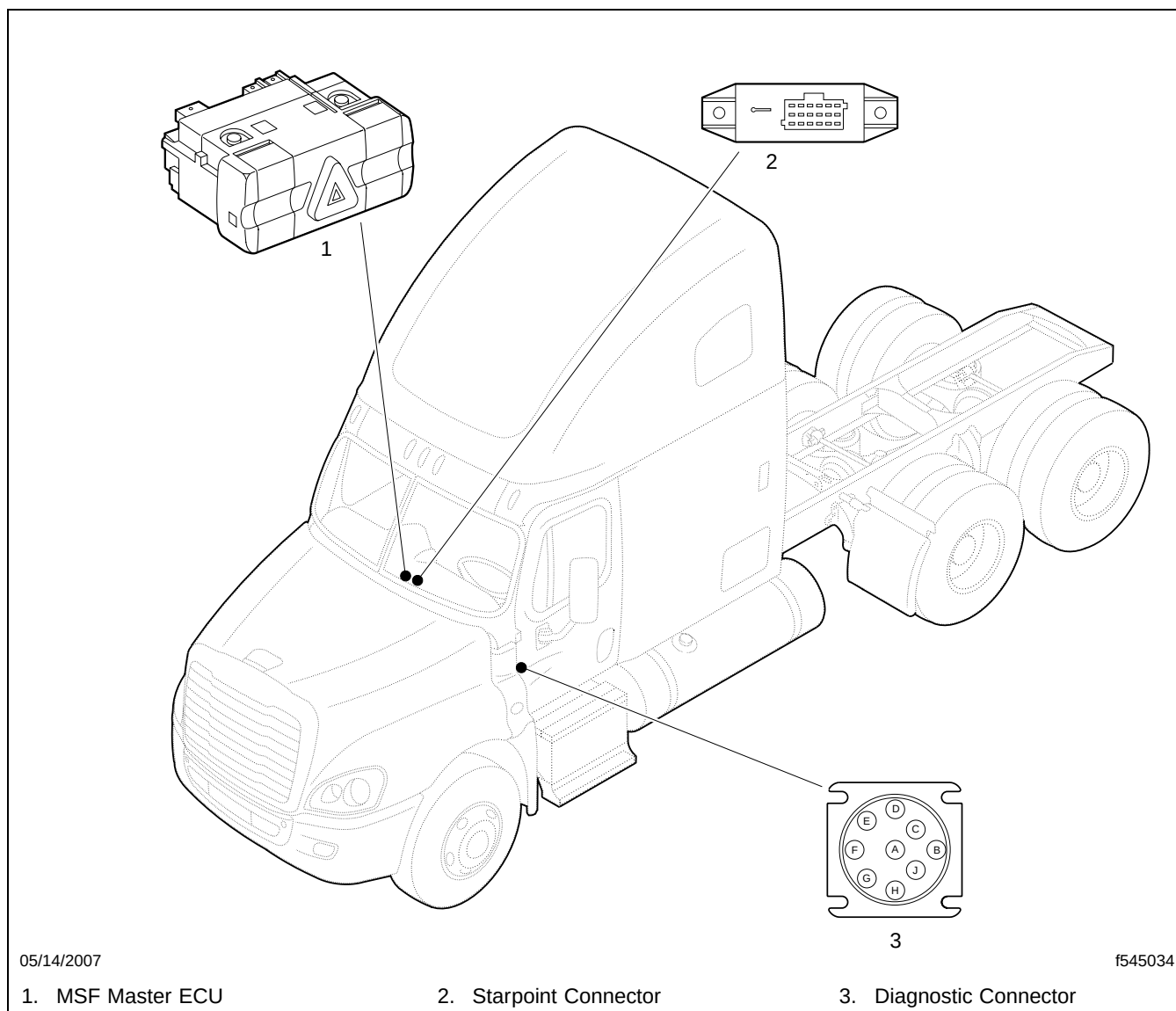


Fig. 4, Component Locations

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Modular Switch Field

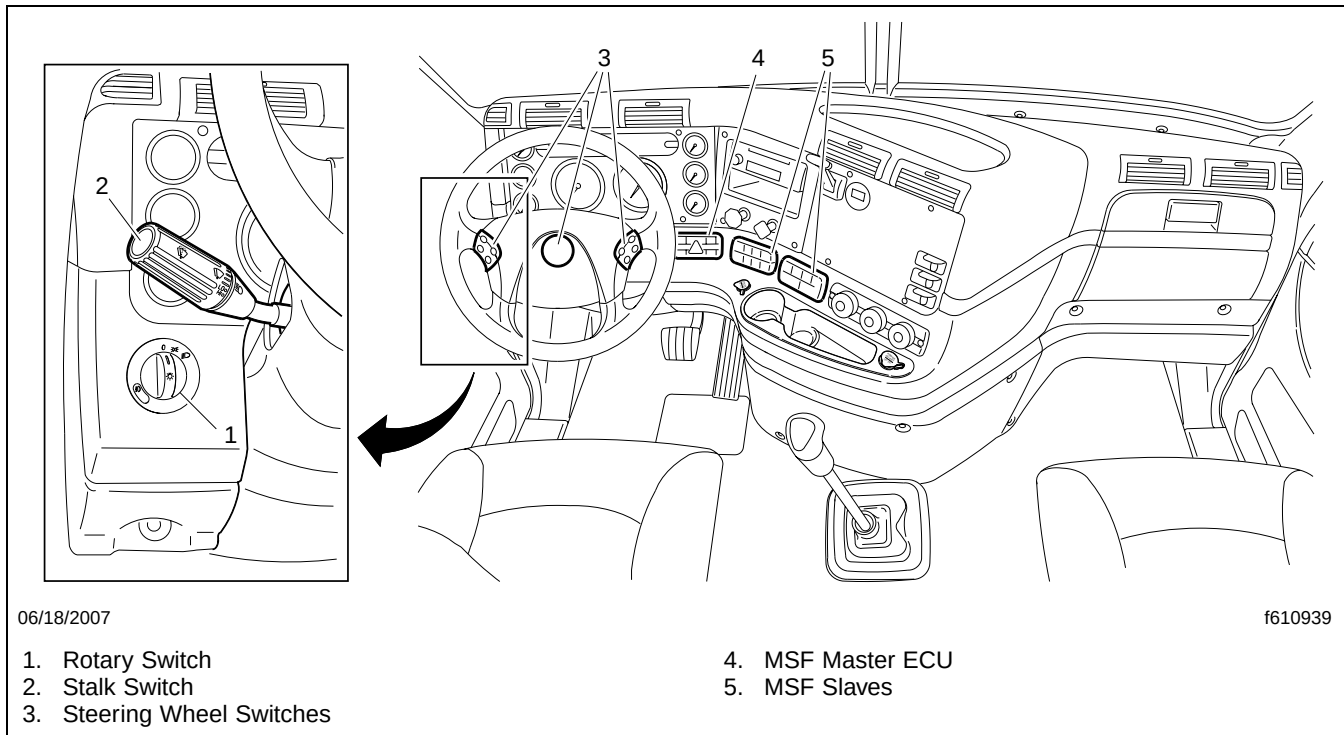


Fig. 5, Component Locations (cab)

601 — MSF Master Connector Pinouts

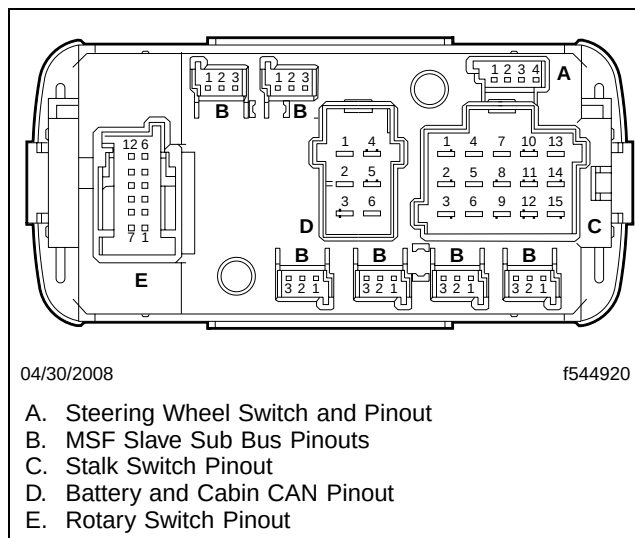


Fig. 6, MSF Master Connection Locations

Connector A Pinout	
Pin	Function
1	Steering wheel, left switch signal (S2)
2	Backlighting PWM
3	Steering wheel, right switch signal (S1)
4	Ground

Table 2, Connector A Pinout

Connector B Pinout: MSF Slave Sub Bus Connector	
Pin	Function
1	Battery Power Supply from MSF Master
2	Sub bus signal from MSF Master
3	Ground from MSF Master

Table 3, Connector B Pinout: MSF Slave Sub Bus Connector

Connector C Pinout: Stalk Switch	
Pin	Function
1	Turn signal switch supply voltage
2	Left turn signal
3	Right turn signal
4	High beam flash signal
5	High beam signal
6	Low beam signal
7	Ignition Power
8	Binary Code Input A
9	Binary Code Input B
10	Not connected
11	Not connected
12	Washer signal
13	Not connected
14	Binary Code Input C
15	+12V ignition

Table 4, Connector C Pinout: Stalk Switch

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Connector D Pinout	
Pin	Function
1	Digital Input #1
2	Battery Power
3	Cabin CAN Low
4	Digital Input #2
5	Cabin CAN High
6	Ground

Table 5, Connector D Pinout

Connector E Pinout: Rotary Switch	
Pin	Function
1	Battery Power
2	Binary Code Input 1 (BC1)
3	Binary Code Input 2 (BC2)
4	Binary Code Input Version
5	Binary Code Common
6	Fog lamp signal
7	Backlighting PWM
8	Backlighting PWM
9	Not connected
10	Ground
11	Ground
12	Ground

Table 6, Connector E Pinout: Rotary Switch

MSF Slaves	
Pin	Function
1	Battery Power
2	Sub bus signal
3	Ground

Table 7, MSF Slaves

602 — Signal-Only Sub Bus Switches

The signal-only sub bus switches are also called "multiplexed" or "MUX" switches.

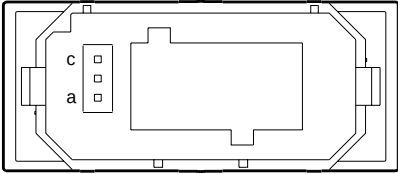
Signal-Only Sub Bus Switches	
	
05/15/2007	f545035
Pin	Function
A	Battery Power
B	Sub bus signal
C	Ground

Table 8, Signal-Only Sub Bus Switches

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603 — Hardwired Sub Bus Switches

For MSF hardwired sub bus switch pin functionality, refer to the MSF hardwired sub bus switch drawing A06–53783. Pin function will vary, based on the individual switch.

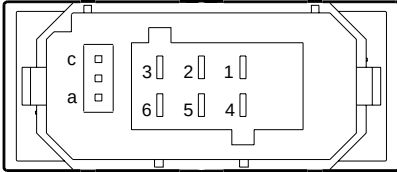
Hardwired Sub Bus Switches	
	
05/15/2007 f545036	
Pin	Function
A	Battery Power
B	Sub bus signal
C	Ground
1	For MSF hardwired switch pin functionality, refer to the MSF hardwired sub bus switch drawing A06–53783. Pin function will vary, based on the individual switch.
2	
3	
4	
5	
6	

Table 9, Hardwired Sub Bus Switches

604 — Rotary Switch

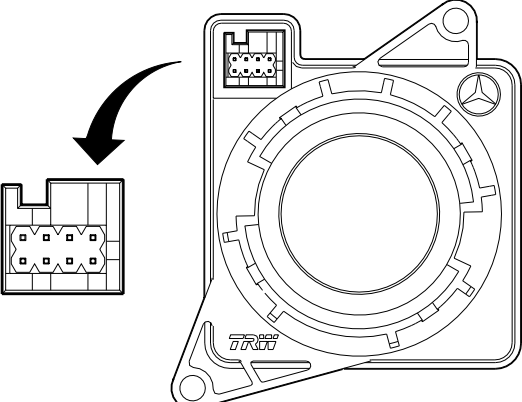
Rotary Switch	
	
05/15/2007	f545037
Pin	Function
1	Binary Code 1
2	Binary Code Common
3	Version
4	Fog Lamps/Road Lamps
5	Binary Code 2
6	Backlighting
7	Ground
8	Battery Power

Table 10, Rotary Switch

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Modular Switch Field

605 — Stalk Switch

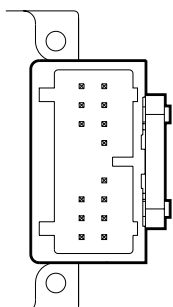
Stalk Switch	
	
05/15/2007	f545038
Pin	Function
1	Wiper switch, ignition power supply
2	Binary Code A
3	Binary Code B
4	Binary Code C
5	Washer signal
6	Not connected
7	Not connected
8	Not connected
9	Headlamp high beam flash signal
10	Headlamp high beam signal
11	Headlamp low beam signal
12	Left turn signal
13	Turn signal switch, power supply
14	Right turn signal

Table 11, Stalk Switch

Modular Switch Field

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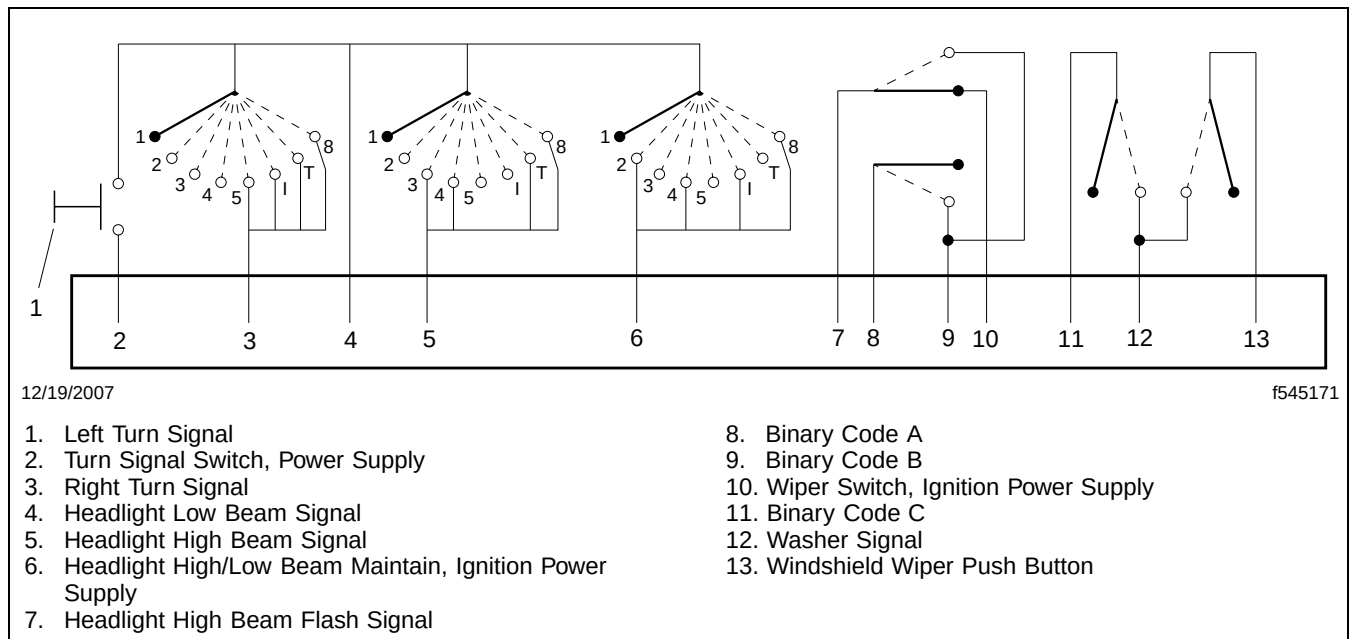


Fig. 7, Stalk Switch Internal Schematic

606 — Steering Wheel Switches

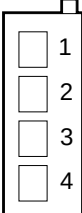
Steering Wheel Switches	
	
05/15/2007	f545039
Pin	Function
1	Steering wheel, left switch signal (S2)
2	Backlighting PWM
3	Steering wheel, right switch signal (S1)
4	Ground

Table 12, Steering Wheel Switches

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Modular Switch Field

607 — Clock Spring Connector

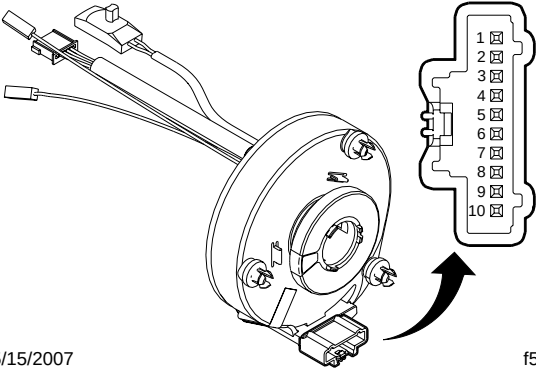
Clock Spring Connector	
	
05/15/2007	f545040
Pin	Function
1	Air bag (+), if used
2	Air bag (-), if used
3	Not used
4	Backlighting Ground
5	Steering wheel, right switch signal (S1)
6	Backlighting PWM
7	Steering wheel, left switch signal (S2)
8	Not used
9	Horn signal
10	Horn

Table 13, Clock Spring Connector

608 — Diagnostic Connector

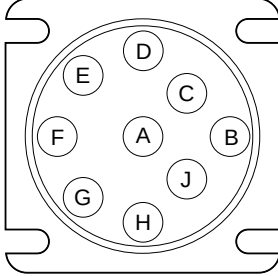
Diagnostic Connector	
	
05/01/2006	f151036b
Pin	Function
A	Ground
B	Battery +12V
C	J1939+
D	J1939–
E	J1939 (only if heavy cable is used)
F	J1587+
G	J1587–
H	Diagnostic CAN+
J	Diagnostic CAN–

Table 14, Diagnostic Connector

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609 — Starpoint Connector

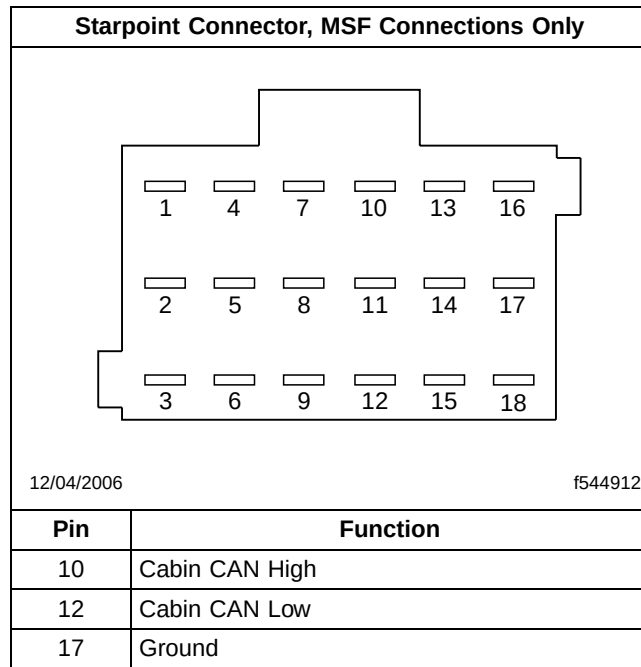


Table 15, Starpoint Connector, MSF Connections Only

700 — Troubleshooting Details

The diagnostic communication protocol used for troubleshooting or configuring the MSF Master and connected switches is CAN, via the Diagnostic CAN datalink. See **608 — Diagnostic Connector** for the Diagnostic CAN pins in the diagnostic connector.

For more information on the Diagnostic CAN datalink or CAN, see **G03.04 — Datalink, Diagnostic CAN**.

701 — Diagnostic Tools Required

- ServiceLink

702 — Possible Causes

- Fuse F4 (MSF power) on the SAM Cab
- Wiring
- Switches
- MSF Master Parameters
- Other ECUs on the Cabin CAN datalink
- Cabin CAN datalink

Modular Switch Field

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703 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	168	3	conn D pin 2	—	—	Electrical Potential (Voltage) — Voltage above normal, or shorted to high source.	Voltage detected at MSF conn D pin 2 (BAT) is greater than expected (16V). While fault is active, MSF may not be responsive (headlamps stay on). There may also be active faults from other CAN ECUs for "Lost communication with MSF." The fault is historic when voltage is detected to be below 15.5V for at least 15 seconds.
Action: With the key on, measure the voltage at MSF master conn D pin 2. If the voltage is greater than proper BAT voltage (10.5 to 15.5V), troubleshoot circuit 14F (mod 860) from the MSF master conn D pin 2 to SAM Cab conn 2 pin 12 for a short to BAT. Check SAM Cab fuse F4 (15A) for MSF power. Repair as required.							
49	168	4	conn D pin 2	—	—	Electrical Potential (Voltage) — Voltage below normal, or shorted to low source.	Voltage detected at MSF conn D pin 2 (BAT) is less than expected (9V). While the fault is active, the MSF may not be responsive (headlamps stay on). There may also be active faults from other CAN ECUs for "Lost communication with MSF." The fault is historic when voltage is detected to be above 10.5V for at least 15 seconds.
Action: With the key on, measure the voltage at MSF master conn D pin 2. If the voltage is lower than 9V, troubleshoot circuit 14F (mod 860) from MSF master conn D pin 2 to SAM Cab conn 2 pin 12 for a short to GND. Check SAM Cab fuse F4 (15A) for MSF power. Repair as required.							
49	520201	4	conn A pin 3	—	—	Steering wheel switch right — Voltage below normal or shorted to low source.	The signal to the steering wheel switches return a "Chopped supply" (squarewave signal) where the amplitude of the signal attenuated is differentiated by which switch is pushed. An unexpectedly small amplitude signal is being detected, or the battery source connector 1 pin 9 may be shorted to ground or fuse F2 might be blown.
Action: Check Fuse F4 for voltage. Use the "SteeringStalkRotaryHazard" template to verify the functionality of the switches. If the switches are not functioning properly, use a multimeter to check the amplitude of the chopped signal from the steering wheel. The signal should be greater than 10.5V amplitude. Push each button on the left side of the steering wheel. If no signal is present, search for short to ground in the applicable harness wires.							

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	520203	3	conn A pin 1	—	—	Steering wheel switch left — Voltage above normal or shorted to high source.	A DC signal causes this fault. The signal to the steering wheel switches return a "Chopped supply" (squarewave signal) where the amplitude of the signal attenuated is differentiated by which switch is pushed.
Action: Use the "SteeringStalkRotaryHazard" template to verify the functionality of the switches. If the switches are not functioning properly, use a multimeter to check for DC offset from ground on connector A pin 1. If DC voltage is present, disconnect the steering wheel switches and retest for DC voltage to determine if the DC source is coming from the steering wheel switches. With DC voltage still present, disconnect the clockspring and retest. With DC voltage still present, trace the short to DC voltage to the short in the wire from connector A pin 1 to the steering wheel clockspring.							
49	520203	4	conn A pin 1	—	—	Steering wheel switch left — Voltage below normal or shorted to low source.	The signal to the steering wheel switches return a "Chopped supply" (squarewave signal) where the amplitude of the signal attenuated is differentiated by which switch is pushed. An unexpectedly small amplitude signal is being detected, or the battery source connector 1 pin 9 may be shorted to ground or fuse F2 might be blown.
Action: Check Fuse F4 for voltage. Use the "SteeringStalkRotaryHazard" template to verify the functionality of the switches. If the switches are not functioning properly, use a multimeter to check the amplitude of the chopped signal from the steering wheel. The signal should be greater than 10.5V amplitude. Push each button on the left side of the steering wheel. If no signal is present, search for short to ground in the applicable harness wires.							
49	520302	3	conn B pin 2	—	—	Sub bus signal — Voltage above normal or shorted to high source.	The fault becomes active when voltage at one of the MSF master's sub bus connectors (conn B) pin 2 (sub bus signal) is detected to be greater than 2V for at least 3 seconds. When fault is active, none of the functions work for multiplexed sub bus switches (A06-53782) connected to the faulty sub bus circuit. Functions for hardwired sub bus switches (A06-53783) may still work. Use ServiceLink's MSF "Switches" screen to see which sub bus switches on the vehicle are hardwired.
Action: The MSF master has multiple sub bus connectors (conn B). With the key ON, measure for voltage > 2V at pin 2 for each sub bus connectors on the MSF master to find the problem connector. At the problem connector, perform a continuity test on circuit 507A from the MSF master conn B pin 2 to the connected MSF slave(s). Repair as required.							
NOTE: The sub bus can connect the MSF master to multiple MSF slaves via daisy chain. It may help to trace and map where all involved MSF slaves are on the vehicle, to find where a possible sub bus signal short may be. For example, the sub bus could connect to an MSF slave in the sleeper compartment where the short may be located.							

Modular Switch Field

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	520302	4	conn B pin 2	—	—	Subbus signal — Voltage below normal or shorted to low source.	The fault becomes active when voltage at one of the MSF master's sub bus connectors (conn B) pin 2 (sub bus signal) is detected to be less than 4V for at least 3 seconds. When fault is active, none of the functions work for multiplexed sub bus switches (A06-53782) connected to the faulty sub bus circuit. Functions for hardwired sub bus switches (A06-53783) may still work. Use ServiceLink's MSF "Switches" screen to see which switches on the vehicle are hardwired.
Action: The MSF master has multiple 3-pin sub bus connectors (conn B). With the key ON, measure for voltage < 4V at pin 2 for each sub bus connectors on the MSF master to find the problem connector. At the problem connector, perform a continuity test on circuit 507A from the MSF master conn B pin 2 to the connected MSF slave(s). Repair as required. NOTE: The sub bus can connect the MSF master to multiple MSF slaves (daisy chained). It may help to trace and map where all involved MSF slaves are on the vehicle, to find where a possible sub bus signal short to GND may be. For example, the sub bus could connect to an MSF slave in the sleeper compartment where the short may be located.							
49	520404	3	conn C pin 4	—	—	Stalk switch flash — Voltage above normal or shorted to high source.	The fault is active when the voltage detected at connector C pin 5 at the MSF is high.
Action: Measure the voltage at MSF conn C pin 5. If the voltage detected is higher than BAT voltage, troubleshoot circuit 465A between MSF conn C pin 5, and stalk switch pin 10 for a short to BAT.							
49	520404	5	conn C pin 4 pin 8, 9, 14	—	—	Stalk switch interrupt — Current below normal, or open circuit.	An interruption is detected between the MSF master and the stalk switch.
Action: Troubleshoot circuit 473C between the MSF Master connector C and the stalk switch connector. Troubleshoot the following connector pairs for continuity: • MSF connector C pin 8 – stalk switch pin 2 • MSF connector C pin 9 – stalk switch pin 3 • MSF connector C pin 14 – stalk switch pin 4 Repair as required.							
49	520405	3	conn C pin 5	—	—	Stalk switch high beam — Voltage above normal or shorted to high source.	Stalk switch low/high beam is not functioning.
Action: Measure the voltage at the MSF conn C pin 5 and pin 6. If the voltage detected is greater than BAT voltage, troubleshoot circuit 465A between the MSF conn C pin 5 and the stalk switch pin 10, or the MSF conn C pin 6 and the stalk switch pin 11 for a short to BAT. Repair as required.							
49	520413	4	conn C pin 15	—	—	Stalk switch wiper common — Voltage below normal or shorted to low source.	Wipers will not function due to invalid stalk switch information.
Action: Troubleshoot for a short in circuit 433A between the MSF and the stalk switch. Test for short to ground on pin 1 in the stalk switch. Disconnect connector C from MSF and test for battery voltage on pin 1, as pin 1 supplies power to the stalk switch. See related information in Wipers Inoperative in All Modes.							

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	520601	4	conn E pin 1	—	—	Headlamp switch +12V Battery — Voltage below normal or shorted to low source.	The fault becomes active when voltage at conn E pin 1 (headlamp/ rotary switch power) is detected to be less than 9V. When fault is active, headlamp switch functions will not work (headlamps, marker lamps, backlighting or fog lamps if equipped). Fault is historic when voltage is detected to be above 10.5V for at least 5 seconds.
Action: With the key ON, measure the voltage at MSF master conn E pin 1 for BAT voltage. Perform a continuity test on circuit 20 (mod 311) from MSF master conn E pin 1 to the headlamp switch pin 8. Repair as required.							
49	520607	4	conn A, pin 2 conn E, pin 7	—	—	Backlighting — Voltage below normal or shorted to low source.	Backlighting on the steering wheel switches and the headlamp switch are not functioning.
Action: Troubleshoot circuit 29A between MSF connector E pin 7 and headlight switch pin 6 or circuit 474BA2 between MSF Steering wheel switches connector pin 2 and steering wheel switches connector pin 6 for a short to GND. Repair as required.							
49	523530	31	—	—	—	Sub bus switch missing.	This fault becomes active when the MSF Master does not sense one or more switches on the sub bus that it expects due to MSF parameter settings.
Action: With the key ON, connect to the vehicle with ServiceLink. Go to the MSF "Switches" screen, and note which switches are marked as missing. For each missing switch, determine whether or not the vehicle should have that switch installed. If it should be installed, install the switch. If it should not be installed, set the appropriate MSF parameter (based on switch ID) to make that switch "not available". If the switch is already installed, the fault indicates the MSF Master is not sensing the switch on the sub bus. Check the connections between the switch, MSF slave and sub bus connections to the MSF master.							
49	523531	31	—	—	—	Extra Sub bus switch.	This fault becomes active when one or more sub bus switches are plugged in that do not have a corresponding MSF parameter set for availability.
Action: With the key ON, connect to the vehicle with ServiceLink. Go to the MSF "Switches" screen and note which switches are marked as extra. For each extra switch, determine whether or not the vehicle should have that switch installed. If it should be installed, set the appropriate MSF parameter (based on switch ID) to make that switch "available". If it should not be installed, find the switch on the vehicle and remove it.							
49	523543	2	conn E, pin 2 conn E, pin 3 conn E, pin 4 conn E, pin 5	—	—	Headlamp switch inputs — Data erratic, intermittent, or incorrect.	The fault becomes active when the MSF master detects invalid signals from the headlamp switch on conn E, pins 2, 3 and 5. The fault is caused by a short to GND, short to BAT, or an open circuit. The fault is historic upon detecting a valid signal from the headlamp/rotary switch.
Action: With the key ON, check the headlamp/rotary switch connection. Check the connections of the wiring harness (mod 311) from the MSF conn E to the headlamp/rotary switch. Perform continuity tests on the involved pins (circuits 474B01, 474B02 and 474B05). Repair as required.							
49	524033	31	—	—	—	Lost communication with the SAM Cab.	Refer to G03.03 — Datalink, Cabin CAN for troubleshooting details on this fault.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	524037	31	—	—	—	Lost communication with CGW.	Refer to G03.03 — Datalink, Cabin CAN for troubleshooting details on this fault.
49	524071	31	—	—	—	Lost communication with SAM Chassis.	Refer to G03.03 — Datalink, Cabin CAN for troubleshooting details on this fault.

Table 16, CAN Fault Codes

704 — Diagnostic Tests for Verifying Sub Bus Switch Type

There are two methods for verifying if a sub bus switch is "hardwired" or "signal":

- Look at the "MSF Switches" screen in ServiceLink.
- Look at the back of the switch.

Determining the Type of Sub Bus Switch (Method 1)

1. Look for the switch on the "MSF Switches" screen in ServiceLink.

- 1.1 Connect ServiceLink to the vehicle.
- 1.2 Navigate to the MSF icon's "Switches" screen.
- 1.3 Look at the "Switch" column and identify the switch in question.
- 1.4 Look at the "Switch ID" column value for that switch.

Is the switch ID between 1 and 150?

YES → It is a signal switch.

NO → It is a hardwired switch. Additionally, the word "Hardwired" will be displayed in this screen's "Position" column for all hardwired switches.

2. If the switch does not appear at all, or if it is marked as "missing" within this screen, the switch may not be connected securely, or may be broken. Repair the problem, then repeat the test.

G02.06

Modular Switch Field

Determining the Type of Sub Bus Switch (Method 2)

1. **Verify whether or not the switch has external circuits attached to it.**

1.1 Remove the switch from its MSF Slave or Master housing.

1.2 Look at the back of the switch.

Does the switch have external circuits (harness) connected to it?

YES → The switch is a Hardwired Switch.

NO → Go to test 2.

2. **Check if the switch has terminals for connecting external circuits.**

Does it have any terminals that are NOT connected to anything?

YES → It is a Hardwired Switch, but is unused. This is an unlikely but possible scenario, which could mean someone installed a hardwired switch instead of a signal switch, or the harness for that switch is not connected. Check against the vehicle specifications, and make repair if necessary.

NO → It is a signal switch.

800 — Sub Bus Switch Specifications

Sub Bus Switch Specifications	
Item	Value
Maximum number switches on the sub bus	38
Maximum sub bus length (in meters)	40
Maximum number of MSF Slaves on a vehicle	9
Maximum current capacity for Hardwired switch (external circuits)	18A

Table 17, Sub Bus Switch Specifications

801 — Stalk Switch Binary Coded Pin Values

The following table shows the expected voltage values for the stalk switch binary coded inputs A, B and C to the MSF master. For binary coded input pin locations at the MSF master, refer to the pinout tables in **601 — MSF Master Connector Pinouts** for connector C, "Stalk Switch." For binary coded pin locations at the stalk switch, refer to **Table 11** in **605 — Stalk Switch**.

Stalk Switch, Binary Coded Pin values			
Stalk Switch Function	Binary Coded Pin values (in Volts)		
	C	B	A
OFF	0	0	0
Intermittent 1	0	0	12
Intermittent 2	0	12	0
Intermittent 3	0	12	12
Intermittent 4	12	0	0

Stalk Switch, Binary Coded Pin values			
Stalk Switch Function	Binary Coded Pin values (in Volts)		
	C	B	A
Intermittent 5	12	0	12
LOW	12	12	0
HIGH	12	12	12

Table 18, Stalk Switch, Binary Coded Pin values

802 — Rotary Switch Binary Coded Pin Values

The following table shows the expected voltage values for the rotary switch binary coded pins 1, 2 and Common, which are inputs to the MSF master. For binary coded input pin locations at the MSF master, refer to the pinout tables in **601 — MSF Master Connector Pinouts** for connector E, "Rotary Switch." For binary coded pin locations at the rotary switch, refer to **Table 10** in **604 — Rotary Switch**.

Rotary Switch, Binary Coded Input Pin Values				
Rotary Switch Position	"Binary Coded Input" Pin Values			Resultant Functionality
	BC1	BC2	BC Common	
Position 0	0	0	12	OFF
Position 1	12	0	12	Marker Lamps
Position 2	12	12	12	Marker and Head Lamps

Table 19, Rotary Switch, Binary Coded Input Pin Values

NOTE: The pin "Binary Coded Input Version" is used to indicate if the Rotary Switch has a position for Fog Lamps.

Common Powertrain Controller

G02.07

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

CPC—Common Powertrain Controller

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

DDDL—Detroit Diesel Diagnostic Link

ECU—Electronic Control Unit, typically connected to a datalink.

MCM—Motor Control Module

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

The Common Powertrain Controller (CPC) is an ECU used with Detroit Diesel and Mercedes-Benz engines. The CPC is the interface between the Motor Control Module (MCM) and the vehicle electronics system, acting as a gateway.

All J1939 and J1587/J1708 datalink communication from the engine to the vehicle electronics occurs with the CPC. The CPC then communicates with the MCM via a proprietary communication protocol (not related to the Cabin CAN).

The CPC has three 18-pin connectors and one 21-pin connector, and is located behind the dash, to the right of the auxiliary panel.

G02.07

Common Powertrain Controller

600 — Component Locations

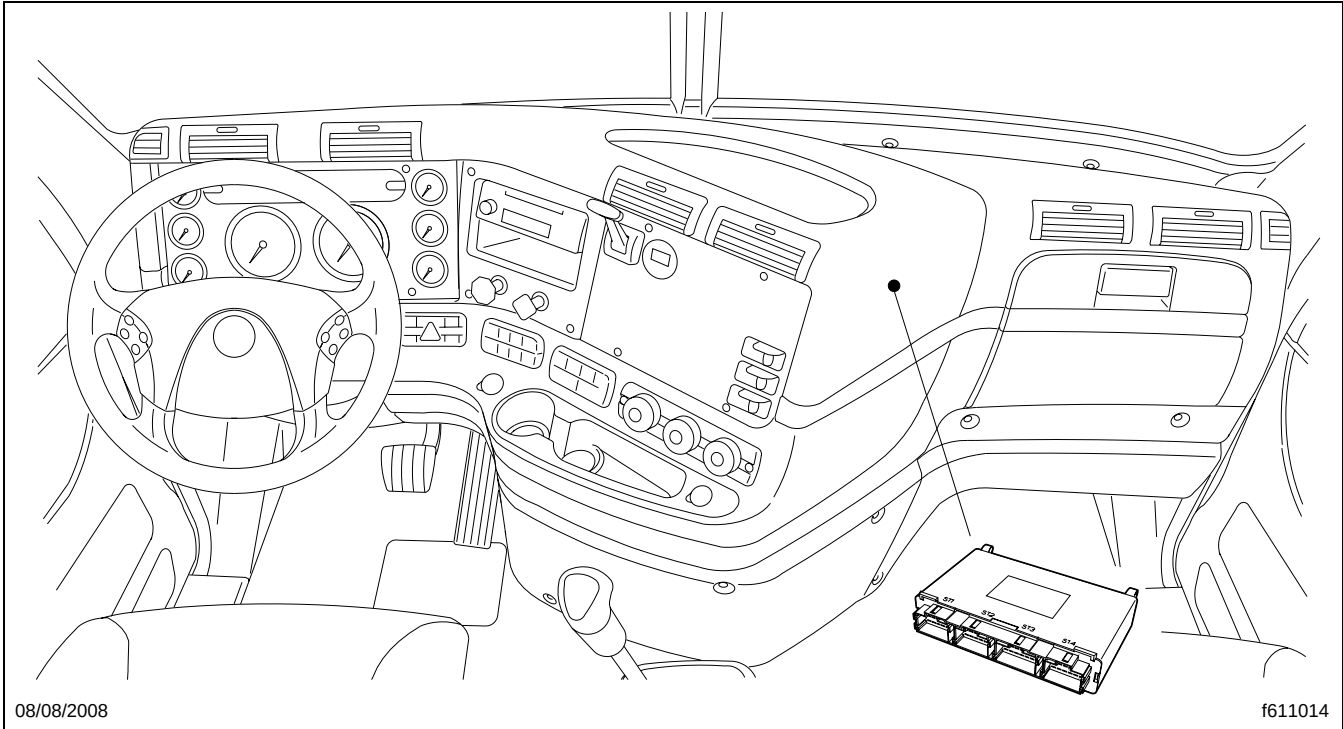


Fig. 1, Common Powertrain Controller

601 — Component Details

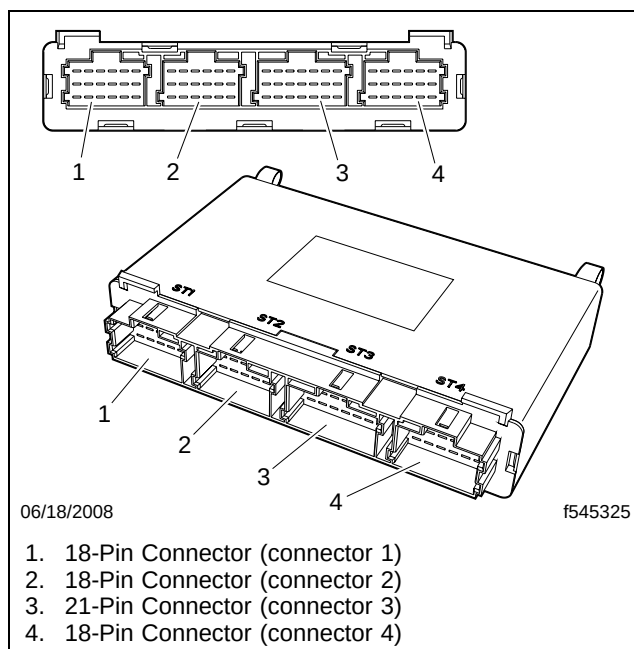


Fig. 2, CPC Connectors

700 — Diagnostic Tools Required

- Detroit Diesel Diagnostic Link (DDDL)

701 — Possible Causes

- Failed programming attempt
- Incorrect parameters
- Faulty wiring
- Low voltage
- Datalink problems
- Powertrain PDM fuses F9 (CPC) or F8 (MCM)

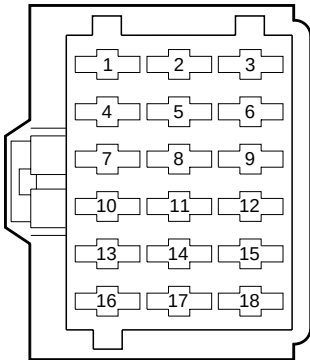
702 — Diagnostic Tests

Refer to Detroit Diesel Power Service Literature for troubleshooting and fault code information. Wiring information for the CPC can be found in PartsPro, under module 283.

G02.07

Common Powertrain Controller

800 — Specifications

Connector 1, 18-Pin			
Pin	Signal Type	Function	Connector
1/1	Digital Input_FLEX_01	Dual-Speed Axle	
1/2	Digital Input_FLEX_02	Park Brake Interlock	
1/3	Digital Input_SFP_05	Idle Validation Switch 2 (throttle active)	
1/4	Digital Output_LP_LS_02	Throttle Position Sensor Ground	
1/5	Digital Output_LP_LS_01	DPF Regeneration Lamp	
1/6	Digital Input _SFP_06	Idle Validation Switch 1 (idle active)	
1/7	SFP_08	Throttle Position Sensor	
1/8	SFP_07	Throttle Position Sensor Supply	
1/9	PWM_FPO_02	Tachometer	
1/10	Digital Input_FLEX_20	Stop Engine/Aux Shutdown #1	
1/11	Digital Input_FLEX_08	Limiter 0	
1/12	Digital Input_FLEX_03	Set/Coast Enable	
1/13	Digital Output_LP_FLEX_01	MIL Lamp	
1/14	Digital Input_FLEX_14	Cruise Control Enable	
1/15	Digital Input_FLEX_15	Stop Engine Override	
1/16	Digital Input_FLEX_16	Resume/Accel Enable	
1/17	Digital Input_FLEX_17	Not Used	
1/18	SFP_01	Run Start	

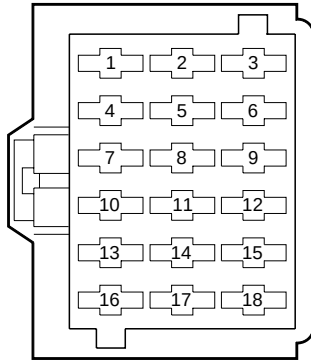
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Table 1, Connector 1, 18-Pin

Common Powertrain Controller

G02.07

Connector 2, 18-Pin			
Pin	Signal Type	Function	Connector
2/1	Battery (+) PSU (KL_30)	Main Battery +12V	
2/2	Battery (-) PSU (KL_31)	Main Battery Ground	
2/3	Battery (+) Switched PSU	Ignition	
2/4	K_DIAG_C	K-line	
2/5	J1708_A_C	J1587 (+)	
2/6	J1708_B_C	J1587 (-)	
2/7	Digital Input_FLEX_15	Service Brake Released Switch	
2/8	Digital Input_FLEX_16	Remote Throttle Select Switch	
2/9	Digital Input_FLEX_09	Remote PTO Switch	
2/10	Digital Output_LP_FLEX_03	Amber Warning Lamp	
2/11	Digital Input_FLEX_10	Limiter 1	
2/12	Digital Input_FLEX_11	A/C Status	
2/13	Digital Input_FLEX_12	Fan Override	
2/14	Digital Input_FLEX_13	Engine Brake Low	
2/15	Digital Input_FLEX_14	Engine Brake Medium	
2/16	VCAN_L_C	J1939 (-)	
2/17	VCAN_GND_C	J1939 Shield	
2/18	VCAN_H_C	J1939 (+)	

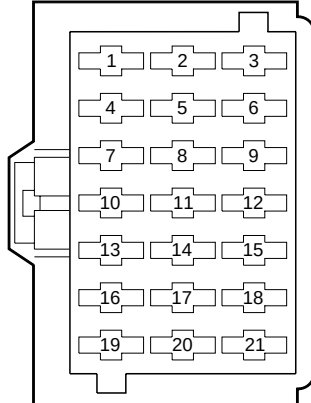
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Table 2, Connector 2, 18-Pin

G02.07

Common Powertrain Controller

Connector 3, 21-Pin			
Pin	Signal Type	Function	Connector
3/1	Analog_In_01	OI Thermostat	
3/2	Analog_GND	Sensor Return	
3/3	Analog_SUP_5V	Sensor Supply	
3/4	Analog_In_02	PTO	
3/5	Analog_Out_01	Not Used	
3/6	Analog_Out_02	Not Used	
3/7	Digital Output_HP_HS_01	Top2 Lockout Solenoid/AGS2 PTO Valve	
3/8	Digital Output_HP_HS_02	Top2 Shift Solenoid/AGS2 PTO Lamp	
3/9	Digital Output_HP_LS_01	AGS2 Backup Lamp/WIF Lamp (DD15)	
3/10	Digital Output_LP_FLEX_02	AGS2 Trans. Temp. Lamp	
3/11	SFP_14	Low Coolant Level Sensor	
3/12	Digital Output_LP_FLEX_04	AGS2 Check Trans. Lamp	
3/13	SFP_09	Vehicle Speed (+)	
3/14	SF_VGND	Vehicle Speed (-)	
3/15	Analog_In_SFP_13	Ambient Air Temp. Sensor	
3/16	Digital Output_LP_FLEX_05	Red Stop Lamp	
3/17	Digital Output_HP_FLEX_02	OI Alarm	
3/18	Digital Input_SFP_02	ABS Active (AGS2 Transmission)	
3/19	Not Used	Not Populated	
3/20	Not Used	Not Populated	
3/21	Not Used	Not Populated	

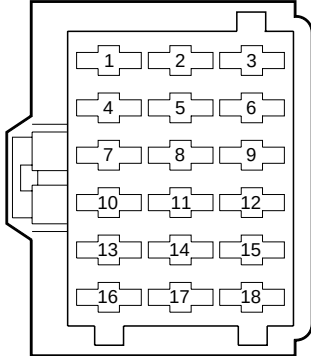
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Table 3, Connector 3, 21-Pin

Common Powertrain Controller

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Connector 4, 18-Pin			
Pin	Signal Type	Function	Connector
4/1	C_ECAN_L	Engine CAN (-)	
4/2	C_ECAN_GND	Engine CAN Shield	
4/3	C_ECAN_H	Engine CAN (+)	
4/4	Digital Input_SFP_11	Not Populated	
4/5	Digital Input_SFP_12	Not Populated	
4/6	Digital Output_LP_FLEX_06	Wait to Start Lamp (Grid Heater)	
4/7	Digital Output_HP_LS_02	High Exhaust Sys. Temp. Lamp	
4/8	Digital Input_FLEX_E1	Clutch Released/PTO Request for AGS2	
4/9	Digital Output_HP_Flex_01	OI Active Lamp/WIF Lamp (MBE 900)	
4/10	Digital Output_HP_HS_04	Vehicle Power Shutdown	
4/11	Frequency_SFP_10	Not Used	
4/12	PWM_FPO_01	Vehicle Speed Output	
4/13	Digital Input_FLEX_16	DPF Inhibit Switch	
4/14	Digital Input_SFP_03	Not Populated	
4/15	Digital Input_SFP_04	Not Populated	
4/16	Digital Input_FLEX_17	Trans. Neutral Switch	
4/17	Digital Input_FLEX_21	DPF Regeneration Switch	
4/18	Digital Input_FLEX_18	Hood Tilt Switch/AGS2 PTO Feedback	

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Table 4, Connector 4, 18-Pin

Datalink, J1587/J1708

G03.01

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Diagnostic Connector—A 9-pin diagnostic connector used for troubleshooting the electrical system.

MSF—Modular Switch Field

Multiplexing—Sending multiple electronic messages through the same signal path at the same time—in this case, through the CAN buses.

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

PDM—Power Distribution Module

SAE—Society of Automotive Engineers

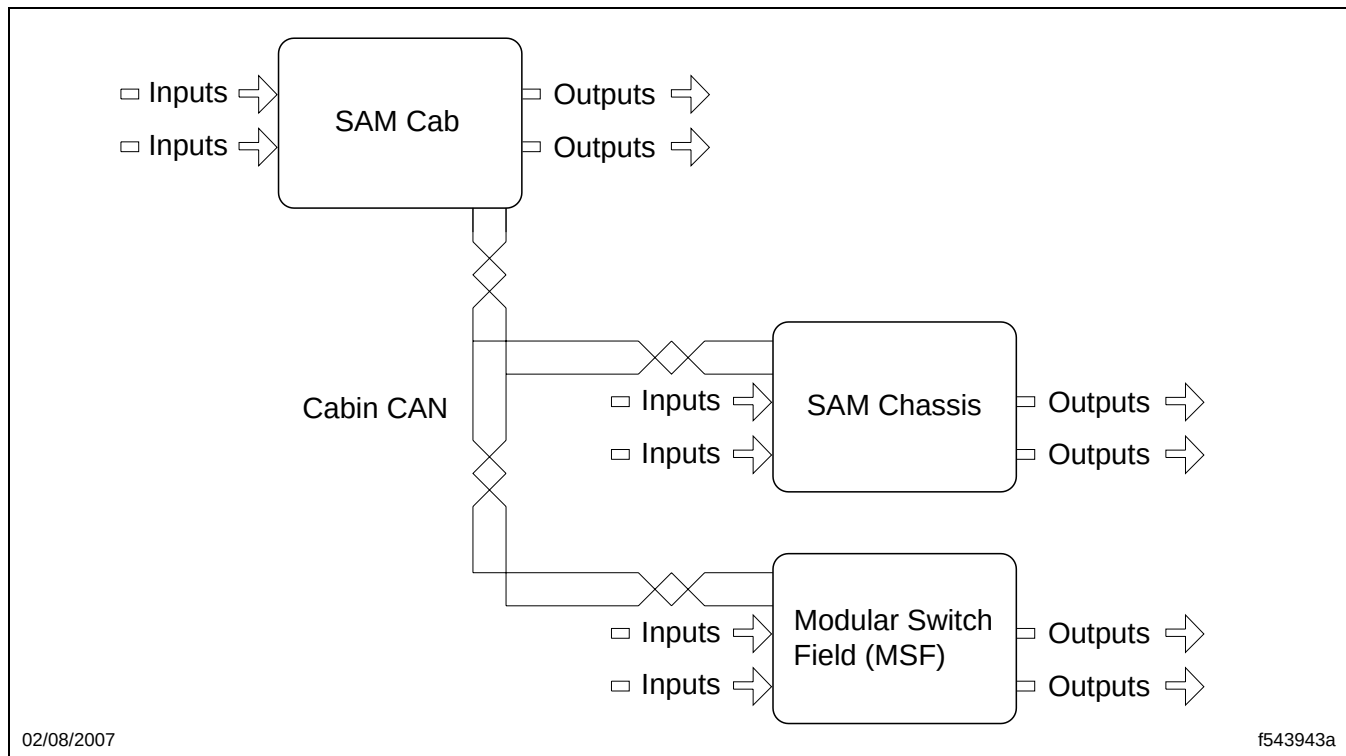
SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — Introduction to Multiplexing

The Cascadia electrical and electronic system is a multiplexing system that replaces traditional power distribution devices with ECUs that communicate over the vehicle datalink. The electronic control units control power distribution to the vehicle electrical loads by monitoring inputs—such as sensors and switches—and supplying power to outputs, such as lighting, displays, gauges, and indicators. Multiplexing reduces the number of interconnecting wires and allows for more precise control of the electrical system by allowing multiple control or diagnostic commands to communicate on a two-wire datalink or network. See **Fig. 1** for a schematic of the multiplexing system.

**Fig. 1, Multiplexing System Controllers**

The multiplexing system serves three main functions:

- Transmits multiple electronic messages through the same wire at the same time;
- Performs tasks and monitors components simultaneously;
- Uses electronic control units (ECU) to operate the system, such as interpreting different messages being transmitted on the same wire.

502 — Vehicle Datalinks

The Cascadia uses the following four datalinks:

- SAE J1587/J1708 datalink
- SAE J1939 datalink
- Cabin CAN datalink
- Diagnostic CAN datalink (mainly used for off-board tool interaction with Cabin CAN ECUs)

On this vehicle, Cabin CAN is the primary datalink for communicating control signals for most cab and chassis features such as interior and exterior lighting, comfort features, and optional features. Some of the Cabin CAN signals are routed to the J1939 and J1587/J1708 datalinks via the central gateway.

J1939 and J1587/J1708 remain the primary datalinks for chassis and powertrain control.

503 — SAE J1587/J1708 Datalink

The J1587 datalink is a low-speed vehicle datalink that communicates information between the electronic control units (ECU) on the vehicle. The J1587 datalink is also referred to as J1708.

J1708 refers to the SAE standard for the physical part of the datalink, such as the wiring and electronic components. J1587 refers to the SAE standard for the messaging protocol that communicates on the J1708 network. In the context of vehicle repair, the terms J1708 and J1587 are used interchangeably.

The J1587 datalink uses a twisted pair of wires to reduce interference from the digital messages being sent on the wires. Wire colors for the J1587 datalink are:

- orange J1587–
- dark green J1587+

504 — Datalink Network Topology

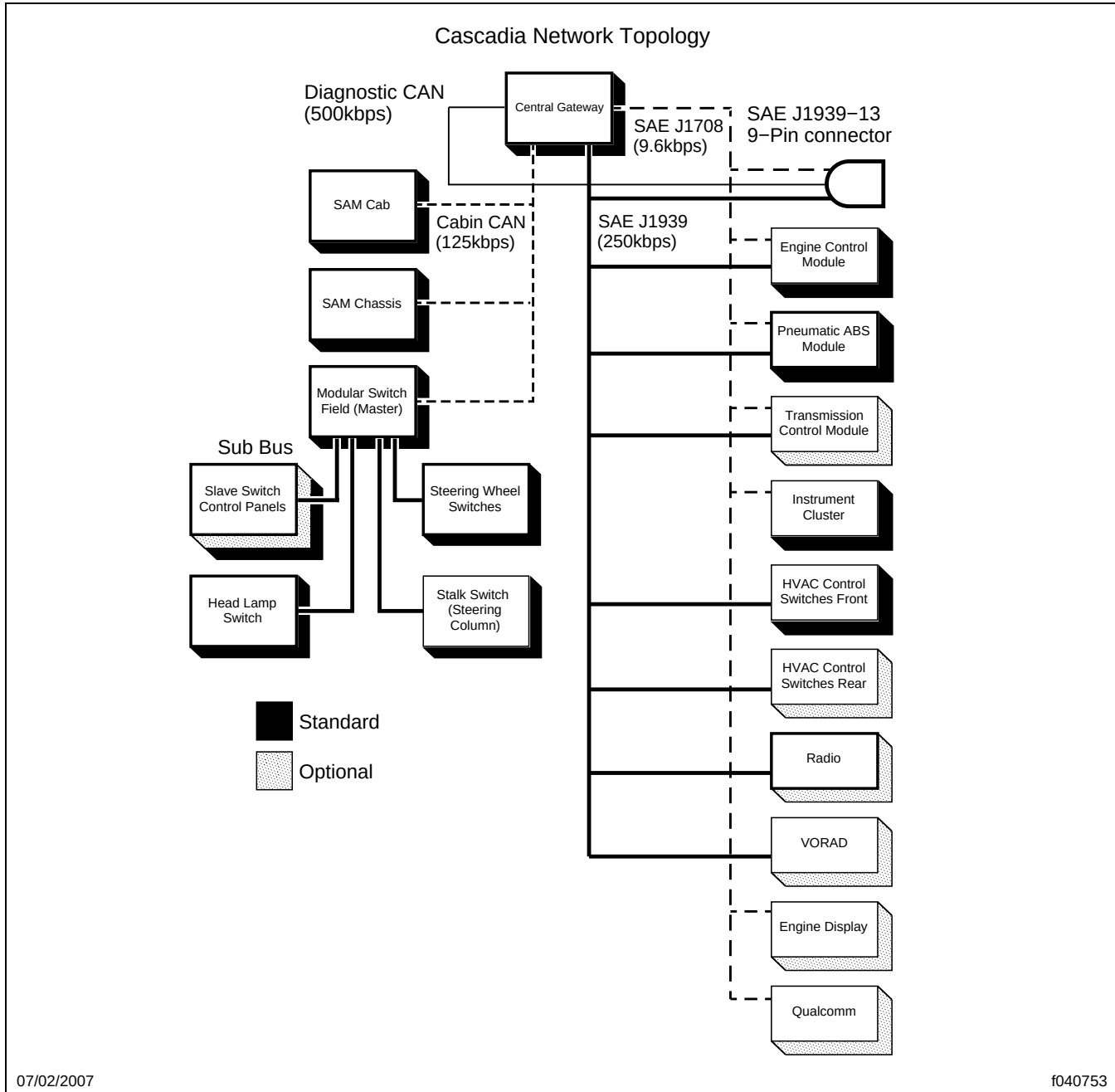


Fig. 2, Datalink Network Topology

600 — Component Locations

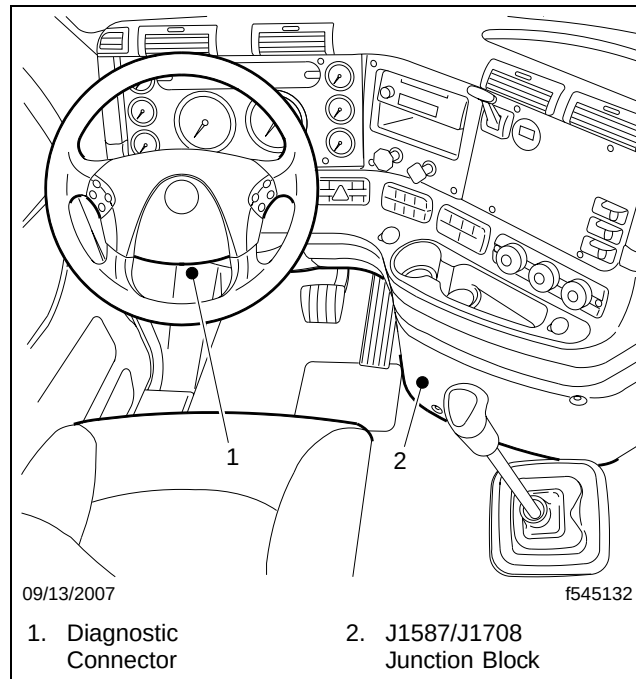


Fig. 3, Component Locations

601 — Component Details

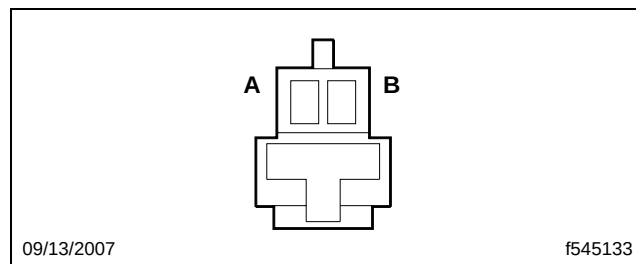
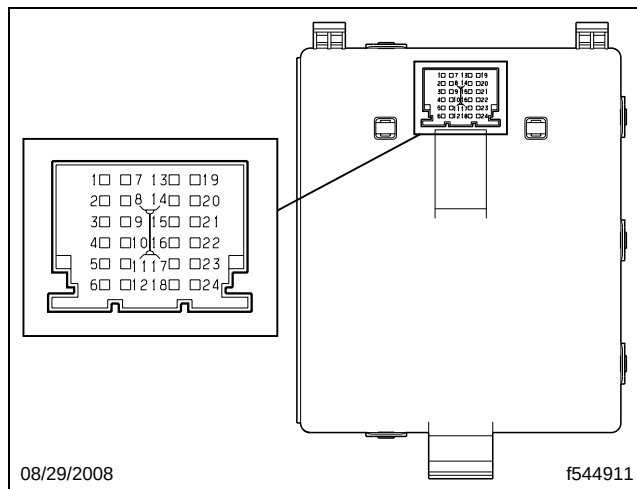


Fig. 4, J1587 Junction Block Connector

J1587 Connector		
Pin	Color	Function
A	Dark Green	J1587 (+)
B	Orange	J1587 (-)

Table 1, J1587 Connector

**Fig. 5, Central Gateway Module, Cabin CAN Pins**

CGW ECU (single connector)	
Pin	Function
1	Battery Power
2	J1708/J1587 (+)
7	Ground
8	J1708/J1587 (-)
14	Cabin CAN Low (-)
16	J1939 Low (-)
18	Diagnostic CAN Low (-)
19	Cabin CAN High (+)
21	J1939 High (+)
23	Diagnostic CAN High (+)

Table 2, CGW ECU (single connector)

700 — Symptoms of a Malfunctioning J1587 Datalink

Symptoms of a malfunctioning J1587 datalink may include the following conditions:

- Gauges are not working.
- ICU displays no J1587, no EnG, or no AbS.
- Warning lamps, such as ABS and CHECK ENGINE, are on.
- Cannot retrieve fault codes from an ECU.
- ServiceLink does not connect to the vehicle.
- One or more ECUs do not show up on the ServiceLink J1587 ECU list.

701 — Diagnosing the J1587/J1708 Datalink

NOTE: Before diagnosing the J1587/J1708 datalink, check the fuses and the battery voltage, and confirm that the ECU connectors are secure on the datalink.

1. Make sure ServiceLink connects to the J1587 Datalink.

- 1.1 Connect ServiceLink to the vehicle.
- 1.2 On the ECU list General Info screen, navigate to the J1708 protocol. Review the ECU list and verify that all ECUs expected on the J1708 datalink are communicating.
- 1.3 Review the Problem ECU list on the bottom of the ECU List General Info Screen.

Does ServiceLink connect to the J1587/J1708 datalink?

YES → Go to test 2.

NO → Check the cables between the computer and vehicle. Check the vehicle interface adapter, and check the PC settings. Repair as necessary, then repeat test 1.

NOTE: ECUs on other protocols may appear as a result of CGW message routing behavior. Routed ECUs are displayed in grey on the ECU list. For more information on CGW message routing behavior, refer to **G02.03 — Central Gateway**.

2. Diagnose the problem ECU.

- 2.1 Check the connector on the problem ECU to verify that it is not loose.
- 2.2 With the key in the OFF position, remove the connector for the problem ECU.
- 2.3 Turn the key to the ON position.
- 2.4 Measure the voltage between the positive (J1587+) and the negative (J1587-) terminals on the connector.
- 2.5 Measure the voltage between the positive post on the battery and the J1587+ terminal.
- 2.6 Measure the voltage between the positive post on the battery and J1587- terminal.
- 2.7 Compare the results to **Table 3**.

J1587 Datalink Voltage Test		
Meter (+) Probe	Meter (-) Probe	Acceptable Voltage Reading
ECU Datalink (+) Terminal	ECU Datalink (-) Terminal	3 to 4 VDC (1 to 3 VAC)
Battery Positive Post	ECU Datalink (+) Terminal	6 to 11 VDC
Battery Positive Post	ECU Datalink (-) Terminal	9 to 13.5 VDC

Table 3, J1587 Datalink Voltage Test

If the voltage is not within the acceptable range, go to test 3.

3. Perform a resistance test.

- 3.1 Turn the key to the OFF position.
- 3.2 Remove the connector from the problem ECU.

G03.01

Datalink, J1587/J1708

- 3.3 Measure the resistance between the J1587+ and J1587– terminals.
- 3.4 Measure the resistance between the J1587+ terminal and the vehicle ground.
- 3.5 Measure the resistance between the J1587– terminal and the vehicle ground.
- 3.6 Compare the values to **Table 4**.

J1587 Datalink Resistance Test		
Meter (+) Probe	Meter (–) Probe	Acceptable Resistance Reading
J1587/J1708 (+)	J1587/J1708 (–)	3k-18k
J1587/J1708 (+)	Vehicle Ground	More than 1k
J1587/J1708 (–)	Vehicle Ground	More than 1k

Table 4, J1587 Datalink Resistance Test

If the resistance is not in the acceptable range, go to test 4.

4. **Test the J1587 junction block.**

- 4.1 Remove the center dash lower trim panel.
- 4.2 Locate the J1587 junction block connector for the ECU.
- 4.3 Connect to the vehicle using ServiceLink.
- 4.4 Navigate to the J1708 tab on the ECU list General Info screen.
- 4.5 Disconnect a J1708 junction block connector. As a connector is removed, its ECU will drop off of the ECU list. If all ECUs drop off from the list, it means that the J1708 connection to the diagnostic connector is lost. If the CGW is disconnected from the junction block, the routed ECUs from other protocols (shared in the grey text) will drop off from the ECU list. When the connector with the datalink interruption is removed, no ECUs will drop off from the General Info screen.
- 4.6 Perform a continuity test to locate the wiring fault.
- 4.7 Repair the affected harness.

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500 — Terms and Abbreviations

Backbone—The main J1939 datalink wiring that lies between the two terminating resistors. It does not include the branch circuits to each ECU or to the diagnostic connector.

Branch Circuit—The section of J1939 datalink between the backbone and each ECU that has J1939, and between the backbone and the diagnostic connector.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

J1939 Terminating Resistors—The J1939 datalink has two 120-ohm terminating resistors, one at each end of the backbone. The total datalink parallel resistance is 60-ohms.

Multiplexing—Sending multiple electronic messages through the same signal path at the same time—in this case, through the CAN buses.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

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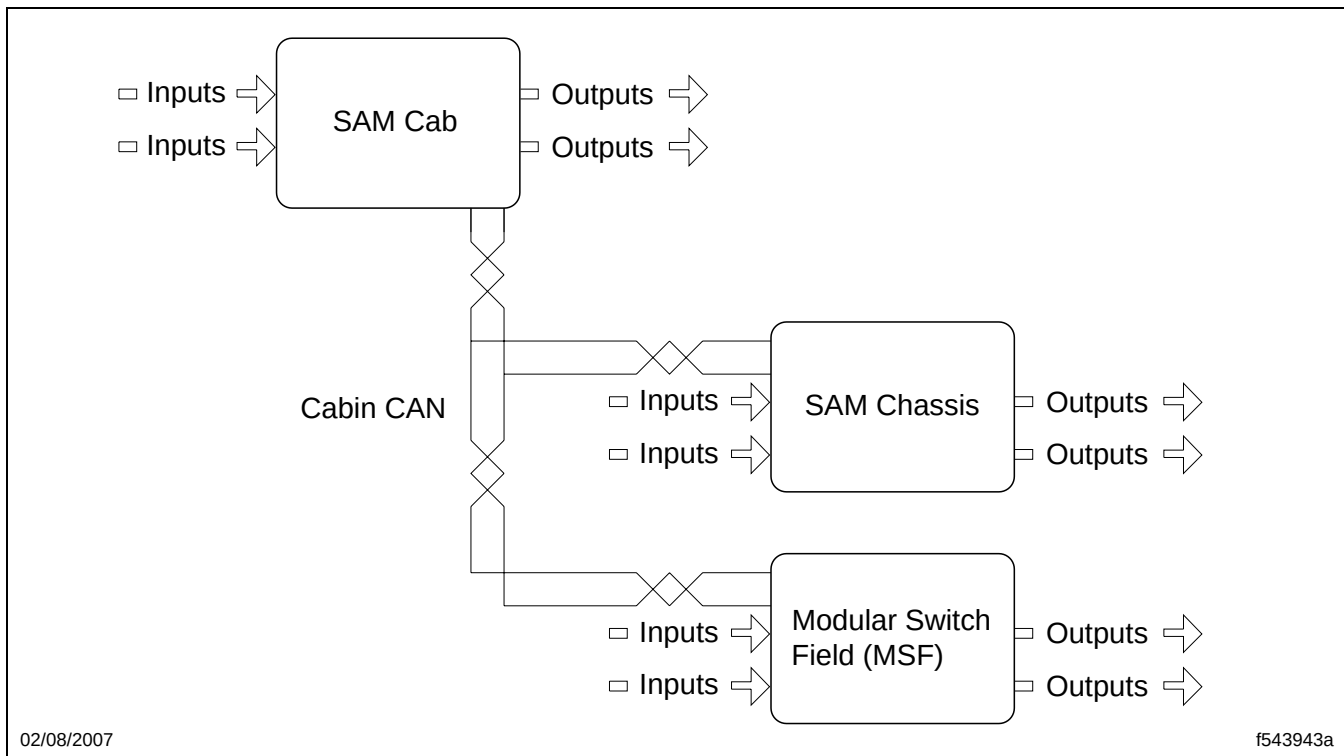


Fig. 1, Multiplexing System Controllers

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Cabin CAN is the primary datalink for communicating control signals for most cab and chassis features such as interior and exterior lighting, comfort features, and optional features. Some of the Cabin CAN signals are routed to the J1939 and J1587/J1708 datalinks via the central gateway.

J1939 and J1587/J1708 remain the primary datalinks for chassis and powertrain control.

503 — SAE J1939 Datalink

The J1939 datalink is a high-speed datalink that communicates information between electronic control units (ECU) on the vehicle. The J1939 communicates at 250,000 bits per second.

Like the J1587 datalink, the J1939 datalink allows an ECU to broadcast requests as well as information. Information that can be communicated on the J1939 datalink includes the following:

- engine rotational speed
- road speed
- transmission tailshaft speed
- engine retarder deactivation request
- engine torque reduction request

The Backbone of the J1939 datalink is the section of the datalink that is between two terminating resistors. Each ECU is connected to the backbone. The wiring between each ECU and the backbone is referred to as a branch.

504 — Terminating Resistors

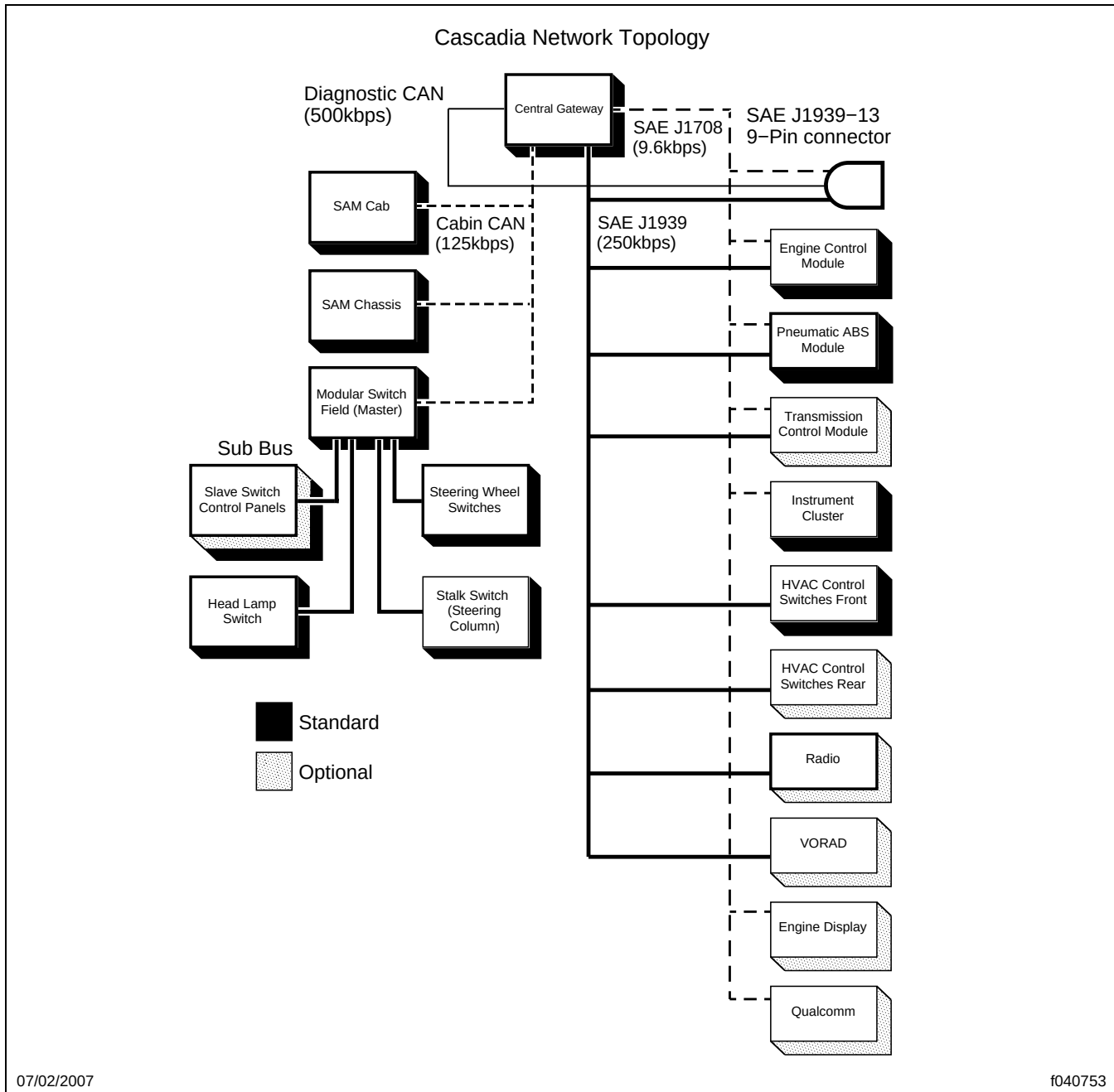
The J1939 datalink consists of twisted yellow and green wires. The yellow wire is J1939+, and the green wire is J1939-. The J1939 datalink has two terminating resistors, one at each end of the backbone.

The purpose of the terminating resistors is to minimize the reflection of data on the datalink. Collision of reflected data can cause J1939 messages to become partially or completely lost. Data collision can also cause the data to be erratic. Terminating resistors prevent this from occurring. Although the J1939 datalink may function with a missing or failed terminating resistor, data collision can occur and cause problems.

Each terminating resistor is 120 ohms, because the resistors are in parallel with one another, their total resistance equals 60 ohms. If a terminating resistor is removed, the circuit resistance should be 120 ohms. With both resistors installed in the circuit, there should be 60 ohms measured at any two points between J1939+ and J1939- in the circuit, such as between pins C and D of the diagnostic connector.

IMPORTANT: It is essential that two terminating resistors are installed in the J1939 datalink. Numerous J1939 problems are attributed to missing terminating resistors.

One of the terminating resistors is located in the driver side lower A pillar panel cover (near the diagnostic connector). The location of the second terminating resistor is behind the center dash lower trim panel near the ABS module.

505 — Datalink Network Topology**Fig. 2, Datalink Network Topology**

600 — Component Locations

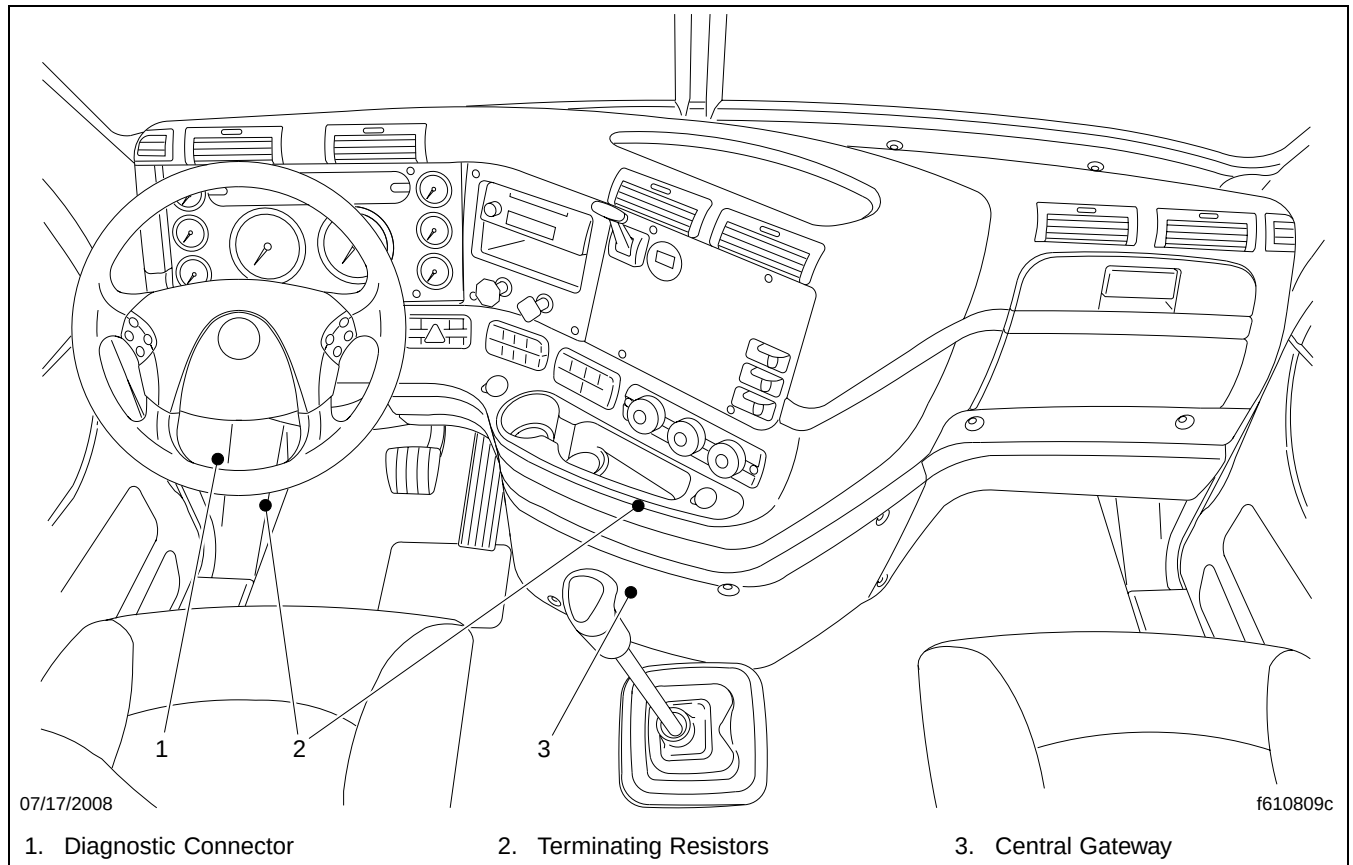


Fig. 3, Component Locations

601 — Component Details

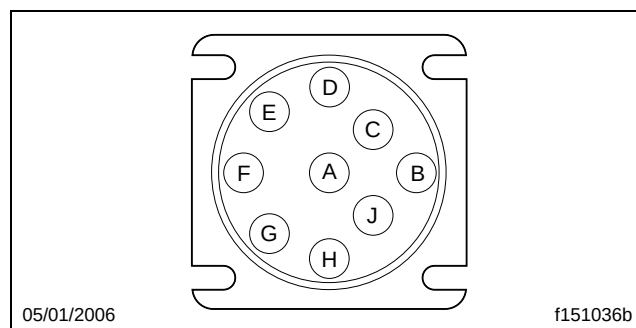


Fig. 4, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	Reserved
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 1, Diagnostic Connector

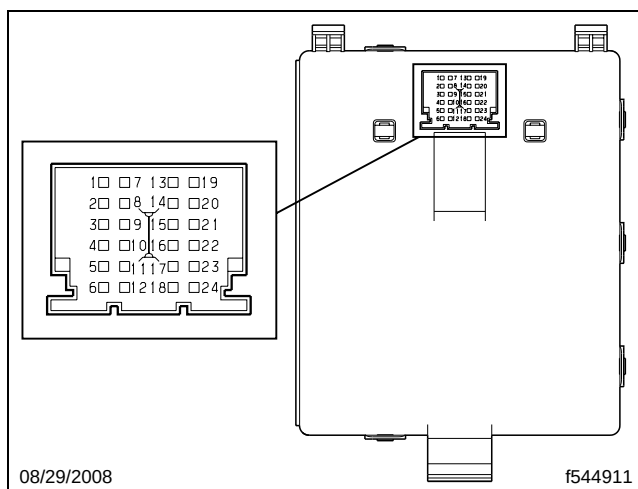


Fig. 5, Central Gateway Module, Cabin CAN Pins

CGW ECU (single connector)	
Pin	Function
1	Battery Power
2	J1708/J1587 (+)
7	Ground
8	J1708/J1587 (–)
14	Cabin CAN Low (–)
16	J1939 Low (–)
18	Diagnostic CAN Low (–)
19	Cabin CAN High (+)

CGW ECU (single connector)	
Pin	Function
21	J1939 High (+)
23	Diagnostic CAN High (+)

Table 2, CGW ECU (single connector)

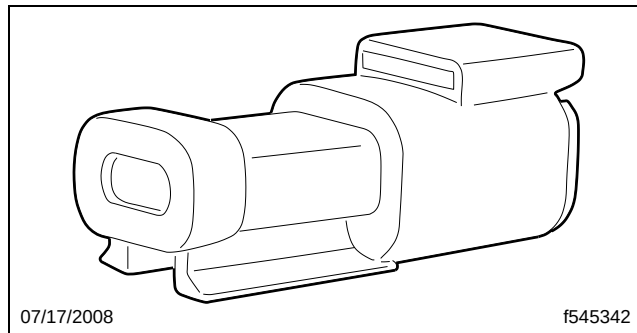


Fig. 6, Terminating Resistor

700 — Diagnostic Tools Required

- ServiceLink
- Datalink Monitor
- Digital Multimeter

701 — Diagnosing the J1939 Datalink

NOTE: Before diagnosing the J1939 datalink, check the fuses and the battery voltage, and confirm that the ECU connectors are secure on the Datalink.

1. Make sure ServiceLink connects to the J1939 Datalink.

- 1.1 Connect ServiceLink to the vehicle.
- 1.2 On the ECU list General Info screen, navigate to the J1939 protocol. Review the ECU list and verify that all ECUs expected on J1939 are communicating.
- 1.3 Review the Problem ECU list on the bottom of the ECU List General Info screen.
- 1.4 Load the Datalink Monitor Template "Cascadia J1939 Test." Review the gauges to verify ECUs communicating on J1939.
- 1.5 Check the cables between the computer and vehicle. Check the vehicle interface adapter and the computer settings. Repair as necessary.

NOTE: ECUs on other protocols may appear as a result of CGW message routing behavior. Routed ECUs are displayed in grey on the ECU list. For more information on CGW message routing behavior, refer to **G02.03 — Central Gateway**.

2. Verify J1939 backbone terminating resistance.

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Datalink, J1939

- 2.1 Test the J1939 backbone terminating resistance to verify that terminating resistors are installed and a complete circuit from the diagnostic connector through the J1939 backbone is established. This does not guarantee that branch circuits to each ECU are OK.
- 2.2 Turn the key to the OFF position.
- 2.3 With the multimeter set to the resistance (Ω) scale, measure the resistance at the diagnostic connector across pin C (J1939+) and pin D (J1939-).

Compare the resistance values:

- **$60 \pm 6 \Omega$** : The J1939 wiring is intact and both terminating resistors are installed.
- **$120 \pm 12 \Omega$** : There is a terminating resistor missing, or a short present. Check the resistance across the terminating resistors.
- **$40 \pm 4 \Omega$** : There is a third terminating resistor installed on the datalink. One terminating resistor must be removed. There should be one terminating resistor on each end of the backbone for a total of two.
- **$0-5 \Omega$** : There is a short between J1939+ and J1939- somewhere on the datalink.
- **Resistance is greater than 1000Ω** : There is an open circuit between the diagnostic connector and the J1939 backbone, or both terminating resistors are missing or open.

3. Test the terminating resistors.

- 3.1 Remove the terminating resistor.
- 3.2 With the multimeter set to the resistance (Ω) scale, measure the resistance across both terminals on the terminating resistor. The acceptable reading value is 110 to 130 ohms. Replace the terminating resistor if it is not within the acceptable range.

4. Verify resistance on the J1939 branch.

- 4.1 If the backbone and terminating resistors on the J1939 datalink have been verified, proceed to testing the J1939 branch wiring at the problem ECU to verify connectivity.
- 4.2 Turn the key to the OFF position.
- 4.3 Remove the connector for the problem ECU.
- 4.4 With the multimeter on the resistance setting, measure the resistance between the J1939+ and J1939- terminals.

Compare the resistance values:

- **The resistance is $60 \pm 6 \Omega$** : The J1939 wiring is intact. Inspect the connector for a loose connection or corrosion. Verify power and ground to the ECU.
- **The resistance is not 60Ω** : There is a problem with J1939 wiring between the ECU connector and the J1939 backbone.

5. Test the J1939 wiring for short to power and ground.

- 5.1 Turn the key to the ON position.
- 5.2 Set the multimeter to read voltage (DC).
- 5.3 Attach the positive probe of the multimeter to the positive terminal of the battery.
- 5.4 With the negative probe, measure the voltage at the J1939+ and J1939- terminals.

Compare the voltage values:

- **0 VDC:** The J1939+ or J1939– wiring is shorted to Power.
- **12 VDC:** The J1939+ or J1939– wiring is shorted to Ground.

6. If the previous tests do not isolate the problem, install a test ECU.

- 6.1 Remove the problem ECU and install a known good ECU.
- 6.2 Connect to ServiceLink and navigate to the ECU list General Info screen.
- 6.3 Verify ECU communication on the J1939 tab.
- 6.4 If the test ECU operates normally, then replace the problem ECU.

Datalink, Cabin CAN

G03.03

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500 — Terms and Abbreviations

Baud Rate—The rate at which data is transmitted in bits per second.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MID—Indicates numeric assignment for a device that communicates on J1587.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

This vehicle has a multiplexed electrical system that uses a mix of traditional power distribution components and electronic control units (ECUs). See **G02.01 — Electrical System and Main PDM Overview** for more details.

502 — Vehicle Datalinks

The Cabin CAN is the primary datalink for control messaging of most cab and chassis features (interior and exterior lighting, comfort features, and optional features, for example), and has some interaction with messaging on the J1939 and J1587/J1708 datalinks.

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Datalink, Cabin CAN

J1939 and J1587/J1708 remain the primary datalinks for chassis and powertrain control (engine, transmission, and ABS, for example).

ECUs on the Cascadia electrical system communicate on four datalinks:

- SAE J1708/J1587 Datalink
- SAE J1939 Datalink
- Cabin CAN Datalink
- Diagnostic CAN Datalink (used strictly for off-board tool interaction with Cabin CAN ECUs)

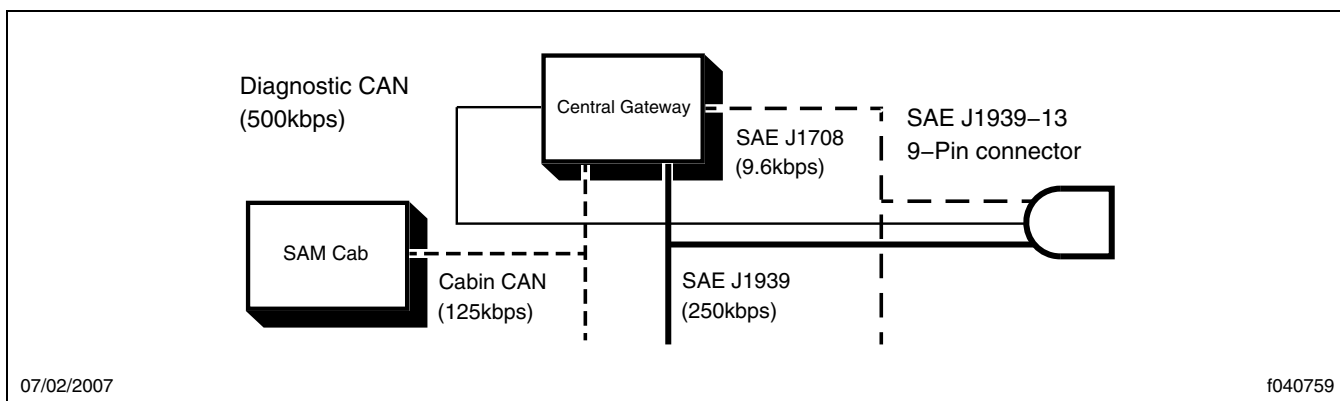


Fig. 1, Vehicle Datalinks, Central Gateway Module and Diagnostic Connector

503 —Cabin CAN Datalink

The Cabin CAN datalink has the following ECUs directly connected to it:

- SAM Cab
- SAM Chassis
- Modular Switch Field (MSF)
- Central Gateway

504 — Cabin CAN Network Topology

The Cabin CAN datalink uses a "star" network topology. The piece of hardware that connects the different components of the Cabin CAN datalink is called the "starpoint connector." Each leg of the Cabin CAN extends from the starpoint connector to an ECU, such as the SAM Cab, and a "star" is formed when multiple legs are connected. This is different from the J1939 datalink networks, which uses a "bus" network topology. See **G03.01 — Datalink, J1587/J1708** and **G03.02 — Datalink, J1939** for more information.

The starpoint connector maintains an internal resistance value of 60 ohms for each leg of the network, similar to the terminating resistors on J1939. See **Fig. 4** and **Fig. 5**.

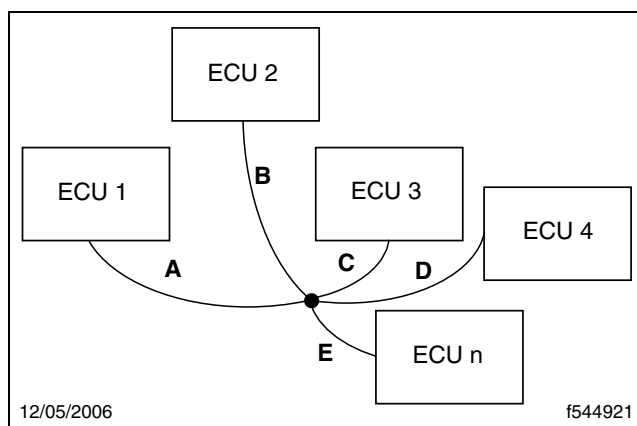


Fig. 2, Generic "Star" Network Topology

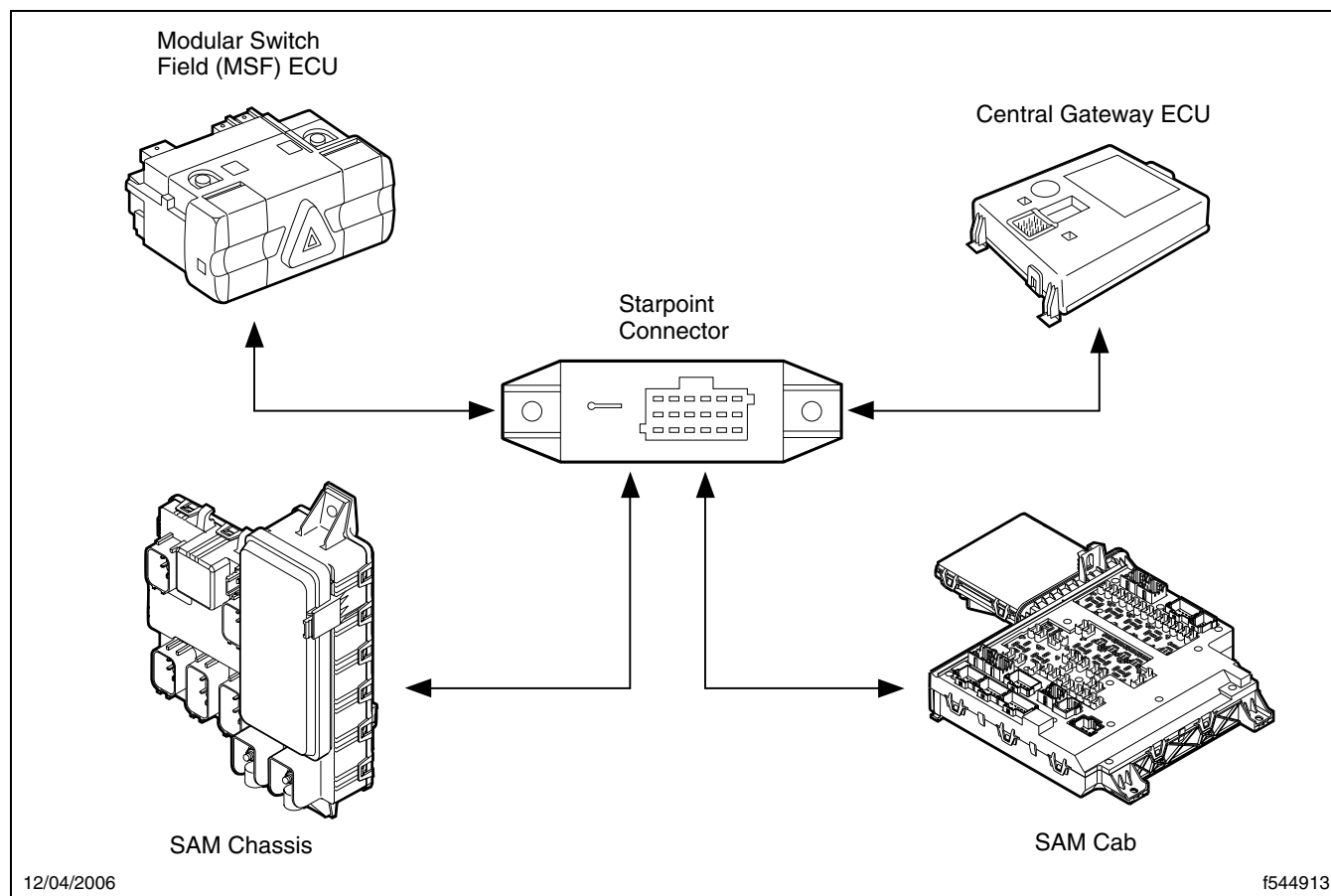


Fig. 3, Cabin CAN Network

For specifications on the starpoint connector, see **800 — Starpoint Connector**.

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Datalink, Cabin CAN

505 — Message Routing by the Central Gateway

Cabin CAN ECUs need information from the J1939 and J1708 datalinks. Information sent by J1939 or J1708 ECUs is obtained by the Central Gateway (CGW), which passes it to the appropriate Cabin CAN ECU. Similarly, the reverse happens when a J1939 or J1708 ECU needs information from a Cabin CAN ECU.

See **G02.03 — Central Gateway** for more information.

506 — Diagnostic CAN

The Cabin CAN datalink does not have a direct connection to the diagnostic connector. In order to troubleshoot or configure Cabin CAN ECUs, an off-board tool (such as ServiceLink) must use the Diagnostic CAN datalink.

The Diagnostic CAN datalink runs from the diagnostic connector to the CGW. Its sole purpose is to connect an off-board tool to the CGW, which routes messages between the tool and the other Cabin CAN ECUs. In this way, an off-board tool communicates with the Cabin CAN ECUs.

See **G03.04 — Datalink, Diagnostic CAN** for more information.

507 — Control Messaging and ECU Troubleshooting

Control messaging includes any datalink message required for vehicle functionality (such as for control of lighting, wipers or optional features).

Cabin CAN ECUs use the Cabin CAN datalink for control messaging, with the CGW sometimes routing information to or from the J1939 and J1708 datalinks.

ECU troubleshooting requires datalink messages that contain information such as fault codes, input or output pin controls, or data that is available specifically for troubleshooting the ECU.

An off-board tool (such as ServiceLink) uses the Diagnostic CAN datalink to access the messages needed for troubleshooting Cabin CAN ECUs.

Refer to **Table 1** for Cabin CAN ECU datalinks for control messaging and troubleshooting.

ECU Control Messaging and Troubleshooting Datalinks				
ECU is on this Datalink	Direct Connection to Diagnostic Connector?	Troubleshooting Datalink	Direct Connection to Diagnostic Connector?	Diagnostic Communication Protocol
Cabin CAN	No	Diagnostic CAN	Yes	CAN

Table 1, ECU Control Messaging and Troubleshooting Datalinks

508 — Controller Area Network

ServiceLink uses a communication protocol called the Controller Area Network (CAN) to communicate with ECUs on the Cabin CAN datalink.

509 — Vehicle Configuration

All Cabin CAN ECUs support flash reprogramming via ServiceLink, which updates the application software running on the ECU. All Cabin CAN ECUs, except for the CGW, have configurable parameters.

For more information on when and how to perform these functions in ServiceLink, see **G03.04 — Datalink, Diagnostic CAN**, the related subjects for the individual Cabin CAN ECUs, and ServiceLink user documentation.

510 — Datalink Network Topology

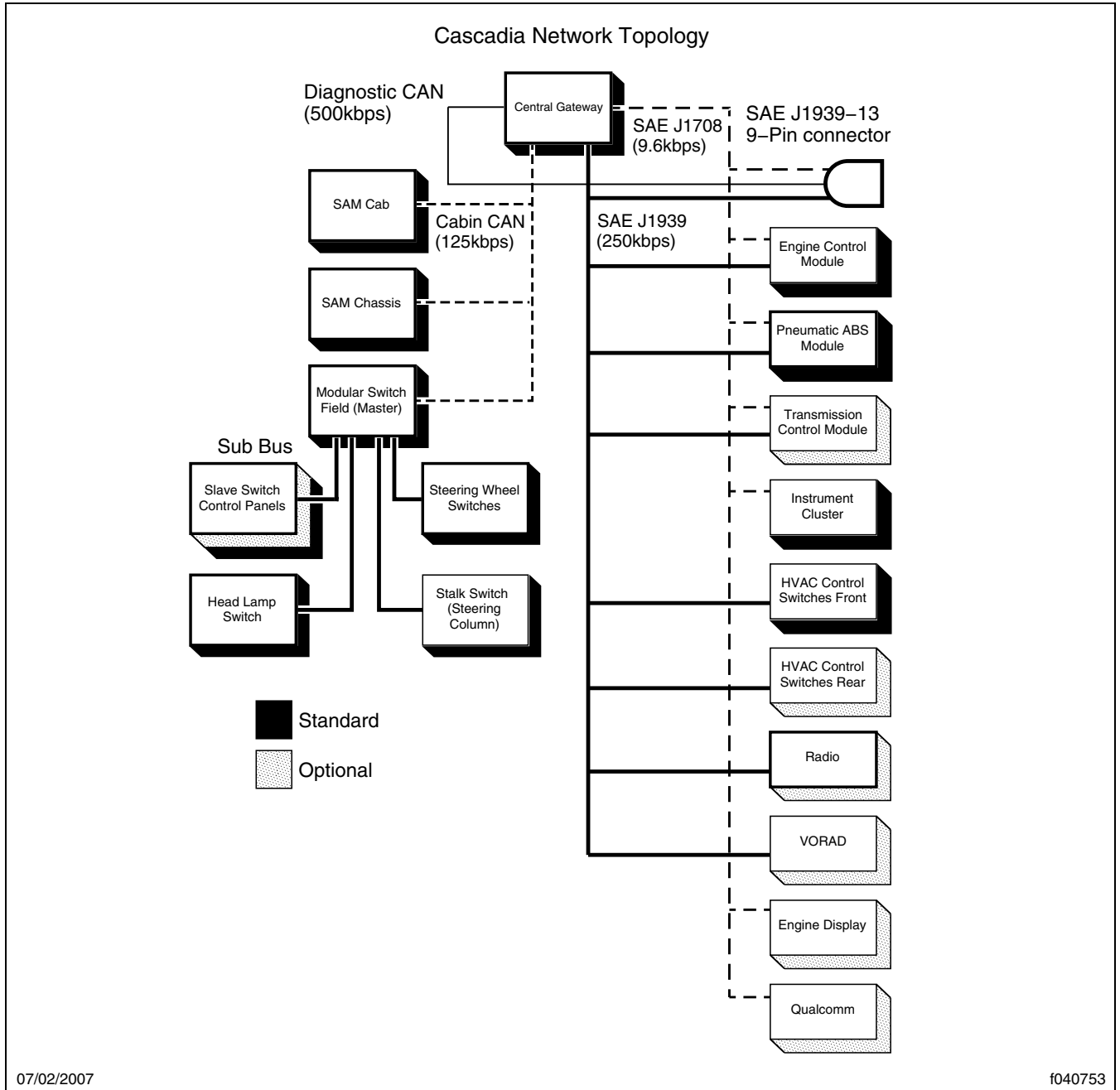


Fig. 4, Datalink Network Topology

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Datalink, Cabin CAN

511 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.02 — Datalink Communication Structure
- G02.03 — Central Gateway
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G04.03 — CAN Fault Codes

600 — Component Locations

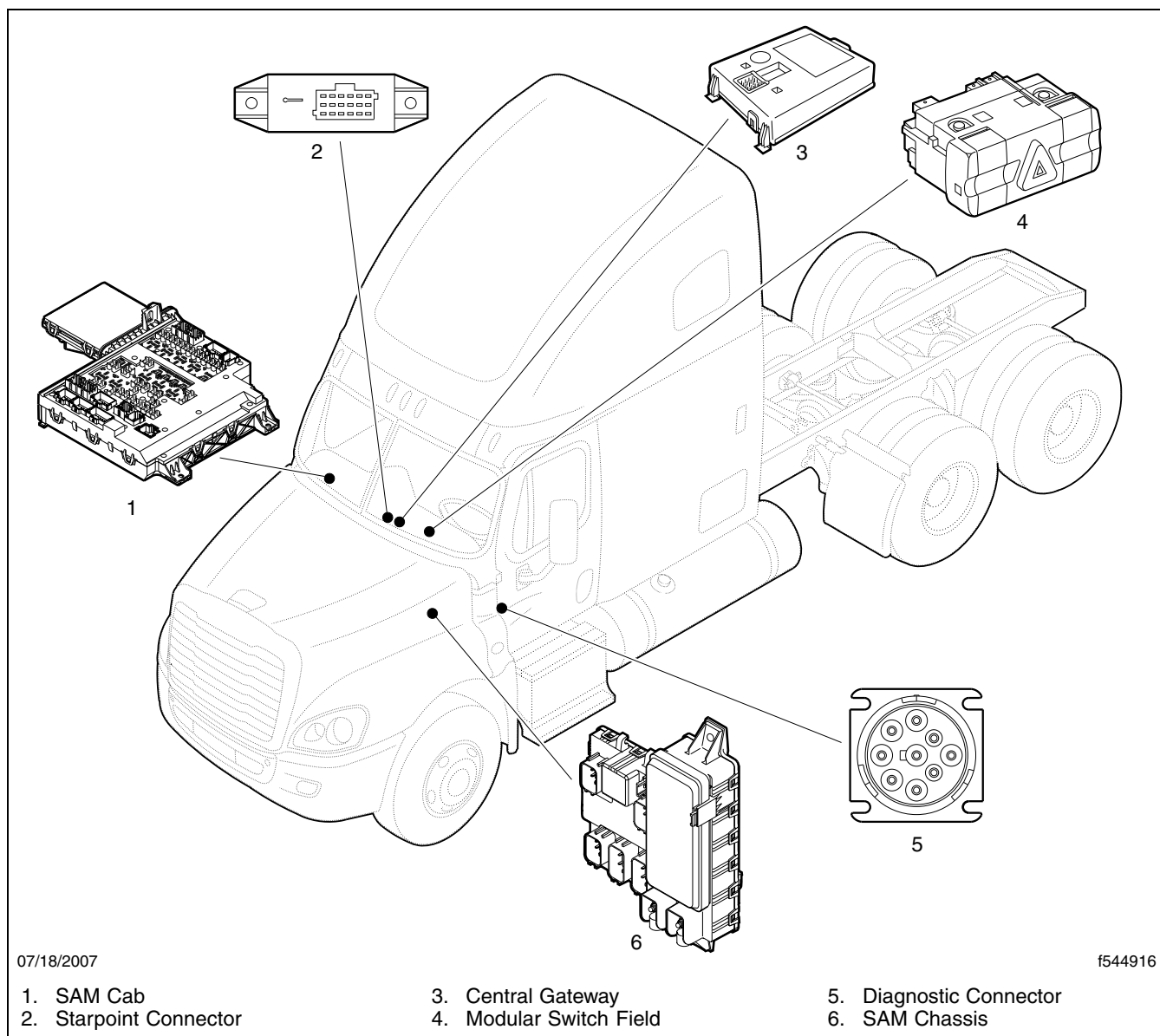


Fig. 5, Component Locations

601 — Component Details

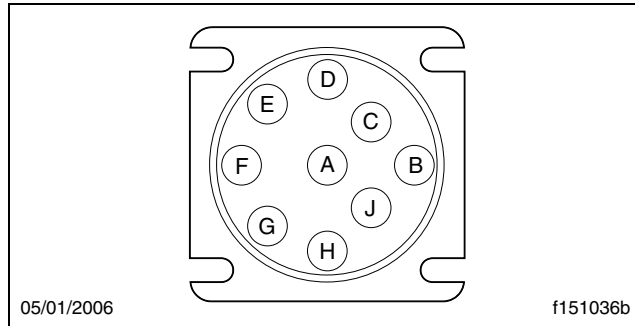


Fig. 6, Diagnostic Connector

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	CAN Shield (ground)
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 2, Diagnostic Connector

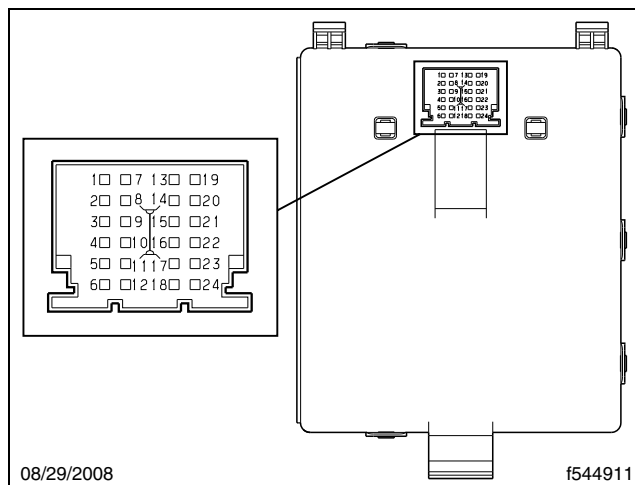


Fig. 7, Central Gateway Module, Cabin CAN Pins

CGW ECU (single connector)	
Pin	Function
1	Battery Power
7	Ground
14	Cabin CAN Low
18	Diagnostic CAN Low
19	Cabin CAN High
23	Diagnostic CAN High

Table 3, CGW ECU (single connector)

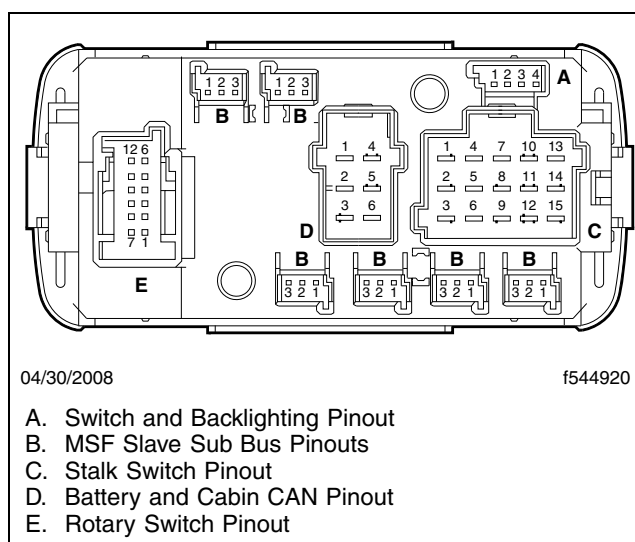


Fig. 8, Modular Switch Field ECU

Modular Switch Field ECU, Cabin CAN pins, Connector D	
Pin	Function
3	Cabin CAN Low
5	Cabin CAN High

Table 4, Modular Switch Field ECU, Connector D

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Datalink, Cabin CAN

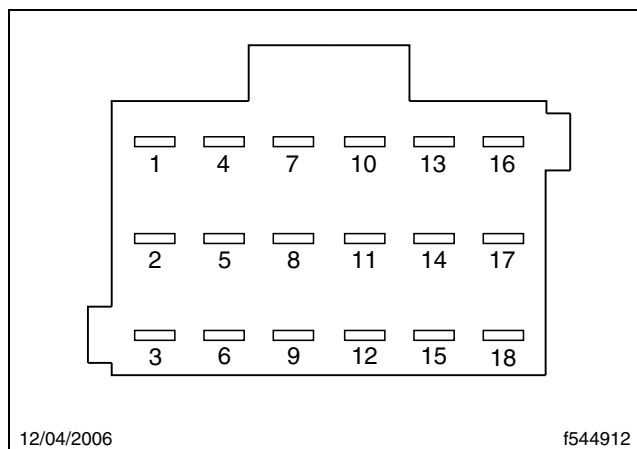


Fig. 9, Starpoint Connector

Starpoint Connector Pin Allocation	
Pin	Function
1	Cabin CAN High (to Central Gateway)
2	Not connected
3	Cabin CAN Low (to Central Gateway)
4	Cabin CAN High (to SAM Cab)
5	Not connected
6	Cabin CAN Low (to SAM Cab)
7	Cabin CAN High (to SAM Chassis)
8	Not connected
9	Cabin CAN Low (to SAM Chassis)
10	Cabin CAN High (to MSF)
11	Not connected
12	Cabin CAN Low (to MSF)
13	Not connected
14	Not connected
15	Not connected
16	Not connected
17	Ground
18	Not connected

Table 5, Starpoint Connector Pin Allocation

700 — Troubleshooting Tips

- Perform general electrical troubleshooting tests first, like checking for wiring continuity and connections.
- Refer to any fault codes reported on CAN in ServiceLink.

701 — Required Tools

- ServiceLink
- Digital Multimeter

702 — Possible Causes

Any Datalink

- Wiring
- Any ECU connected to the problem datalink

Cabin CAN datalink:

- Wiring
- Starpoint Connector resistor value on Cabin CAN datalink connections
- Any Cabin CAN ECU:
 - SAM Cab
 - SAM Chassis
 - Central Gateway
 - Modular Switch Field Master ECU

703 — CAN Fault Codes

NOTE: **Table 6** lists faults for the following ECUs:

- 33 – SAM Cab
- 37 – Central Gateway (CGW)
- 49 – Modular Switch Field (MSF)
- 71 – SAM Chassis

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

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Datalink, Cabin CAN

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521402	3	conn X13 pin 2	—	—	CAN low – Voltage above normal, or shorted to high source.	The Cabin CAN Low (–) pin is shorted to BAT, or high source. Vehicle behavior: SAM Cab and SAM Chassis outputs are behaving according to Emergency Power Mode for a Cabin CAN datalink failure. Indication of such a failure is that the headlamps are active, clearance and marker lamps are flashing, and turn signal ICU indicators are alternating when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X13 pin 2. If the voltage detected is greater than 4.8V, troubleshoot the Cabin CAN Low datalink wiring on the SAM Cab and the other Cabin CAN ECUs for a short to BAT. Refer to G06.09 — Powernet Management for Emergency Power Diagnostics.							
33	521403	4	conn X13 pin 3	—	—	CAN high – Voltage below normal, or shorted to low source.	The Cabin CAN High (+) pin is shorted to GND, or low source. Vehicle behavior: SAM Cab and SAM Chassis outputs are behaving according to Emergency Power Mode for a Cabin CAN datalink failure. Indication of such a failure is that the headlamps are active, clearance and marker lamps are flashing, and turn signal ICU indicators are alternating when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X13 pin 3. If the voltage detected is 0V, troubleshoot the Cabin CAN High datalink wiring on the SAM Cab and the other Cabin CAN ECUs for a short to GND. Refer to G06.09 — Powernet Management for Emergency Power Diagnostics.							
33	524037	31	—	—	—	Lost communication with CGW.	The fault becomes active when the SAM Cab misses 10 consecutive messages from the CGW. The fault becomes historic when the SAM Cab receives at least one message from the CGW.
Action: Verify the connection between the Cabin CAN datalink and the CGW. Disconnect the batteries and measure the resistance at pin 14 and 19 at the CGW. If 60 ohms is not detected, troubleshoot the Cabin CAN connection to the CGW. Measure the voltage on CGW pin 1. If battery voltage is not detected, troubleshoot circuit 443 between CGW pin 1 and SAM Cab conn X3 pin 18. Troubleshoot the GND circuit between CGW pin 7 and SAM Cab conn X3 pin 16. Check fuse F20 (CGW BAT) on the SAM Cab for continuity.							
33	524049	31	—	—	—	Lost communication with MSF.	The fault becomes active when the SAM Cab misses 10 consecutive messages from the MSF. The fault becomes historic when the SAM Cab receives at least one message from the MSF. Vehicle behavior: The headlamps, marker lamps, and clearance lamps will be on when the ignition key is in the "run" position.

Datalink, Cabin CAN

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CAN Fault Codes						
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description
Action: Verify the connection between the Cabin CAN datalink and the MSF. Disconnect the batteries and measure the resistance at connector D, pins 3 and 5 on the MSF. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the MSF. Measure the voltage at conn D pin 2 on the MSF for battery voltage. If battery voltage is not detected, troubleshoot circuit 14F between MSF conn D pin 2 and SAM Cab conn X2 pin 12. Troubleshoot the GND circuit between MSF conn D pin 6 and SAM Cab conn X2 pin 2. Check fuse F4 (MSF BAT) on the SAM Cab for continuity.						
33	524071	31	—	—	—	Lost communication with the SAM Chassis. The fault becomes active when the SAM Cab misses ten consecutive messages from the SAM Chassis. Vehicle Behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Chassis failure. An indication of a SAM Chassis failure is that the ICU turn signal indicators flash alternately when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the SAM Chassis. Disconnect the batteries and measure the resistance at conn X51 pin 1 and conn X51 pin 2 at the SAM Chassis. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Chassis. Measure the battery stud on the SAM Chassis for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Chassis. Refer to G06.09 — Powernet Management to troubleshoot the SAM Chassis for Emergency Power Diagnostics.						
37	523510	31	pin 18 pin 23	—	—	Diagnostic CAN performance. Diagnostic CAN performance failure (communication is not possible) occurs when the Diagnostic CAN High is shorted to GND, the Diagnostic CAN Low is shorted to BAT, or the Diagnostic CAN Low is shorted to Diagnostic CAN High.
Action: Disconnect the batteries and measure the resistance between pins H and J at the diagnostic connector. If 60 ohms is not detected, troubleshoot the Diagnostic CAN datalink wiring for a short to BAT and GND. An open circuit and high shorted to low is also a cause. Troubleshoot the Diagnostic CAN high wiring between diagnostic connector pin H and CGW pin 23. Troubleshoot the Diagnostic CAN low wiring between diagnostic connector pin J and CGW pin 18.						
37	523511	31	pin 14 pin 19	—	—	Cabin CAN performance. Cabin CAN performance failure (communication is not possible) occurs when the Cabin CAN High is shorted to GND, the Cabin CAN Low is shorted to BAT, or the Cabin CAN Low is shorted to Cabin CAN High.
Action: Disconnect the batteries and measure the resistance of the Cabin CAN datalink. If 60 ohms is not detected, troubleshoot the Cabin CAN low datalink for a short to Cabin CAN high. Measure the voltage at Cabin CAN high and Cabin CAN low. If BAT voltage is detected, troubleshoot for a short to GND. If 0V is detected, troubleshoot for a short to BAT. Check the following connector pairs: • SAM Cab conn X13 pin 2 and conn X13 pin 3 • SAM Chassis conn X51 pin 1 and conn X51 pin 2 • MSF conn D, pins 3 and 5						

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Datalink, Cabin CAN

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
37	523512	31	pin 16 pin 21	—	—	J1939 CAN performance.	J1939 performance failure occurs when the J1939 High is shorted to GND, the J1939 Low is shorted to BAT, the J1939 resistance is not equal to 60 ohms, or the J1939 Low is shorted to J1939 High.
Action: Disconnect the batteries and measure the resistance between J1939+ and J1939-. If the resistance is not 60 ohms, refer to G03.02 — Datalink, J1939 to troubleshoot the J1939 datalink. With the key ON, measure the voltage at J1939+ and J1939-. Troubleshoot the J1939 datalink for a short to BAT or short to GND.							
37	523513	31	pin 2 pin 8	—	—	J1708 performance.	J1708 performance failure occurs when the bus load on the J1708 datalink is too high, or when the CGW has an extremely high processor load due to high traffic on Cabin CAN, J1939, or Diagnostic CAN. A short or open circuit between J1708 (+) and J1708 (-) will NOT cause this fault to become active. Fault will become historic once the CGW is able to successfully communicate on the J1708 datalink.
Action: Refer to troubleshooting provided in G03.01 — Datalink, J1587/J1708 .							
37	524033	31	—	—	—	Lost communication with SAM Cab.	The fault is active when the CGW misses 10 consecutive messages from the SAM Cab (on the Cabin CAN datalink). The fault becomes historic when the CGW receives at least one message from the SAM Cab. Vehicle Behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Cab failure. An indication for a SAM Cab failure is the clearance lamps, marker lights, trailer tail lights, and rear stop lights are flashing when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the SAM Cab. Disconnect the batteries and measure the resistance at SAM Cab conn X13 pin 2 and conn X13 pin 3. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Cab. Measure the battery studs for the SAM cab for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Cab. Refer to G06.09 — Powernet Management to troubleshoot the SAM Cab for Emergency Power Diagnostics.							

Datalink, Cabin CAN

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
37	524049	31	—	—	—	Lost communication with MSF.	The fault is active when the CGW misses 10 consecutive messages from the MSF (on the Cabin CAN datalink). The fault becomes historic when the CGW receives at least one message from the MSF. Vehicle behavior: The headlamps, marker lamps, and clearance lamps will be on when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the MSF. Disconnect the batteries and measure the resistance at conn D pins 3 and 5 on the MSF. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the MSF. Measure the voltage at conn D pin 2 on the MSF for battery voltage. If battery voltage is not detected, troubleshoot circuit 14F between MSF conn D pin 2 and SAM Cab conn X2 pin 12. Troubleshoot the GND circuit between MSF conn D pin 6 and SAM Cab conn X2 pin 2. Check fuse F4 (MSF BAT) on the SAM Cab for continuity.							
37	524071	31	—	—	—	Lost communication with the SAM Chassis.	The fault is active when the CGW misses 10 consecutive messages from the SAM Chassis (on the Cabin CAN datalink). The fault becomes historic when the CGW receives at least one message from the SAM Chassis.
Action: Verify the connection between the Cabin CAN datalink and the SAM Chassis. Disconnect the batteries and measure the resistance at conn X51 pin 1 and conn X51 pin 2 at the SAM Chassis. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Chassis. Measure the battery stud for the SAM Chassis for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Chassis. Refer to G06.09 — Power Management to troubleshoot the SAM Chassis for Emergency Power Diagnostics.							
49	524033	31	—	—	—	Lost communication with the SAM Cab.	The fault is active when the MSF misses 10 consecutive messages from the SAM Cab (on the Cabin CAN datalink). The fault becomes historic when the MSF receives at least one message from the SAM Cab. Vehicle behavior: MSF backlighting defaults to 100%. SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Cab failure. An indication for a SAM Cab failure is the clearance lamps, marker lights, trailer tail lights, and rear stop lights are flashing when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the SAM Cab. Disconnect the batteries and measure the resistance at SAM Cab conn X13 pin 2 and conn X13 pin 3. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Cab. Measure the battery stud of the SAM Cab for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Cab. Refer to G06.09 — Power Management to troubleshoot the SAM Cab for Emergency Power Diagnostics.							

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	524037	31	—	—	—	Lost communication with CGW.	The fault is active when the MSF misses 10 consecutive messages from the CGW. The fault becomes historic when the MSF receives at least one message from the CGW.
Action: Verify the connection between the Cabin CAN datalink and the CGW. Disconnect the batteries and measure the resistance at pins 14 and 19 at the CGW. If 60 ohms is not detected, troubleshoot the CGW. Measure the voltage on CGW pins 1 and 7. If battery voltage is not detected, troubleshoot circuit 443 between CGW pin 1 and SAM Cab conn 3 pin 18. Troubleshoot GND circuit between CGW pin 7 and SAM Cab conn 3 pin 16. Check fuse F20 (CGW BAT) on the SAM Cab for continuity.							
49	524071	31	—	—	—	Lost communication with SAM Chassis.	The fault is active when the MSF misses 10 consecutive messages from the SAM Chassis (on the Cabin CAN datalink). The fault becomes historic when the MSF receives at least one message from the SAM Chassis. Vehicle behavior: Indicator light on the Trailer Power sub bus switch is off. The SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Chassis failure. Indication of such a failure is that the turn signal ICU indicators are flashing alternately, rear turn signal lights are flashing, and the stop lights are off when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the SAM Chassis. Disconnect the batteries and measure the resistance at conn 51 pin 1 and conn 51 pin 2 at the SAM Chassis. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Chassis. Measure the battery stud on the SAM Chassis for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Chassis. Refer to G06.09 — Powernet Management to troubleshoot the SAM Chassis for Emergency Power Diagnostics.							
71	520201	3	conn 51 pin 1	—	—	CAN low – Voltage above normal, or shorted to high source.	Cabin CAN Low (–) pin is shorted to BAT, or high source. Vehicle behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a Cabin CAN datalink failure. Indication of such a failure is that the headlamps are active, clearance and marker lamps are flashing, and turn signal ICU indicators are alternating when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X51 pin 1. If the voltage detected is greater than 4.8V, troubleshoot the Cabin CAN Low datalink wiring on the SAM Chassis and the other Cabin CAN ECUs for a short to BAT. Refer to G06.09 — Powernet Management for Emergency Power Diagnostics							

Datalink, Cabin CAN

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
71	520202	4	conn 51 pin 2	—	—	CAN high – Voltage below normal, or shorted to low source.	The Cabin CAN High (+) pin is shorted to GND, or low source. Vehicle behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a Cabin CAN datalink failure. Indication of such a failure is that the headlamps are active, clearance and marker lamps are flashing, and the turn signal ICU indicators are alternating when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X51 pin 2. If the voltage detected is 0V, troubleshoot the Cabin CAN High datalink wiring on the SAM Chassis and the other Cabin CAN ECUs for a short to GND. Refer to G06.09 — Powernet Management for Emergency Power Diagnostics.							
71	524033	31	—	—	—	Lost communication with SAM Cab.	The fault is active when the SAM Chassis misses 10 consecutive messages from the SAM Cab. Vehicle behavior: SAM Cab and SAM Chassis outputs may be behaving according to Emergency Power Mode for a SAM Cab failure. An indication for a SAM Cab failure is the clearance lamps, marker lights, trailer tail lights, and rear stop lights are flashing when the ignition key is in the "run" position.
Action: Verify the connection between the Cabin CAN datalink and the SAM Cab. Disconnect the batteries and measure the resistance at SAM Cab conn X13 pin 2 and conn X13 pin 3. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the SAM Cab. Measure the battery stud on the SAM cab for battery voltage. Check the MEGA fuse and battery cables that supply the SAM Cab. Refer to G06.09 — Power Management to troubleshoot the SAM Cab for Emergency Power Diagnostics.							
71	524037	31	—	—	—	Lost communication with the CGW.	The fault is active when the SAM Chassis misses 10 consecutive messages from the CGW. The fault becomes historic when the SAM Chassis receives at least one message from the CGW.
Action: Verify the connection between the Cabin CAN datalink and the CGW. Disconnect the batteries and measure the resistance at pins 14 and 19 at the CGW. If 60 ohms is not detected, troubleshoot the Cabin CAN connection to the CGW. Measure the voltage on CGW pins 1 and 7. If battery voltage is not detected, troubleshoot circuit 443 between CGW pin 1 and SAM Cab conn X3 pin 18 and GND circuit between CGW pin 7 and SAM Cab conn X3 pin 16. Check fuse F20 (CGW BAT) on the SAM Cab for continuity.							

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Datalink, Cabin CAN

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
71	524049	31	—	—	—	Lost communication with the MSF.	The fault becomes active when the SAM Chassis misses 10 consecutive messages from the MSF. The fault becomes historic when the SAM Chassis receives at least one message from the MSF. Vehicle behavior: Functions for MSF headlamp/rotary, stalk or steering wheel switches cannot be activated or deactivated (headlamps, wipers, and turn signals) when the ignition key is in the "run" position. Headlights stay on.
Action: Verify the connection between the Cabin CAN datalink and the MSF. Disconnect the batteries and measure the resistance at connector D, pins 3 and 5 on the MSF. If 60 ohms is not detected, troubleshoot the Cabin CAN datalink connection to the MSF. Measure the voltages at connector D, pins 2 and 6 on the MSF for battery voltage. If battery voltage is not detected, troubleshoot circuit 14F between MSF conn D pin 2 and SAM Cab conn X2 pin 12. Troubleshoot the GND circuit between MSF conn D pin 6 and SAM Cab conn X2 pin 2. Check fuse F4 (MSF BAT) on the SAM Cab for continuity.							

Table 6, CAN Fault Codes

800 — Starpoint Connector

- The starpoint connector provides 60-ohms of terminating resistance to the Cabin CAN connection of each leg.
- The starpoint connector has capacity to connect up to 6 components.
- All starpoint ground connections are directly connected. A screw connection ties this ground to the chassis ground.

801 — Wiring

Datalink Wire Colors		
Datalink	Wire Color	
	High	Low
Cabin CAN	Light Blue	White
Diagnostic CAN	Brown with Light Blue Stripe	Brown with White Stripe

Table 7, Datalink Wire Colors

802 — Datalink Communication Rates

Datalink Communication Rates	
Datalink	Kilobits Per Second
Cabin CAN	125
Diagnostic CAN	500

Table 8, Datalink Communication Rates**803 — ECU Identification on Datalinks**

NOTE: Parenthesis indicate ECU may appear under these identifiers in the given protocol based on message routing behavior by the CGW.

ECU Identification on Datalinks			
ECU	J1587 MID	J1939 SA	CAN SA
SAM Cab	(249)	(33)	33
SAM Chassis	(216)	(71)	71
Modular Switch Field	(164)	(49)	49
Central Gateway	(206)	(37)	37

Table 9, ECU Identification on Datalinks

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500 — Terms and Abbreviations

Baud Rate—The rate at which data is transmitted in bits per second.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates any device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

This vehicle has a multiplexed electrical system that uses a mix of traditional power distribution components and electronic control units (ECUs). See **G02.01 — Electrical System and Main PDM Overview** for more information.

502 — Vehicle Datalinks

The system communicates on four datalinks:

- SAE J1708/J1587 datalink

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Datalink, Diagnostic CAN

- SAE J1939 datalink
- Cabin CAN datalink
- Diagnostic CAN datalink (strictly used for off-board tool interaction with Cabin CAN ECUs)

The Cabin CAN is the primary datalink used for control messaging (interior and exterior lighting, brakes, and optional features, for example) and has some interaction with control messaging on the J1939 and J1587/J1708 datalinks.

J1939 and J1587/J1708 remain the primary datalinks for chassis and powertrain control (engine, transmission, and ABS, for example).

503 — Diagnostic CAN

The Cabin CAN datalink does not have a direct connection to the diagnostic connector. Therefore, in order to troubleshoot or configure Cabin CAN ECUs, an off-board tool must connect to the Diagnostic CAN datalink in the diagnostic connector. In this way, the off-board tool can communicate with the Cabin CAN ECUs via the CGW.

The Diagnostic CAN datalink runs from the diagnostic connector to the CGW. Its sole purpose is to connect an off-board tool like ServiceLink to the CGW, in order to diagnose or configure ECUs connected to the Diagnostic CAN or the Cabin CAN datalinks.

The CGW separates the Cabin CAN from off-board tools because:

- the CGW acts as a firewall, where Freightliner's proprietary Cabin CAN datalink is protected from "public" access;
- the CGW provides for better protection from electrical damage and better control of electrical capabilities, which leads to more reliable ECUs.

Voltage activity will be seen on the diagnostic connector's Diagnostic CAN datalink pins only while an off-board tool is communicating with the Cabin CAN ECUs. When no off-board tool is communicating, there is no voltage activity on the Diagnostic CAN datalink pins in the diagnostic connector.

504 — Diagnostic CAN Network Topology

The Diagnostic CAN Datalink uses a "point-to-point" network topology where two nodes are connected directly.

This is different from the Cabin CAN, which uses a "star" network topology, and the J1939 datalink network, which uses a "bus" network topology.

The CGW contains an internal resistance of 60 ohms required to terminate the Diagnostic CAN network.

505 — Control Messaging and ECU Troubleshooting

An ECUs "control messaging" refers to the messages it sends to other ECUs to control the vehicle. This takes place over its connected datalink. However, an ECUs "troubleshooting datalink" refers to the datalink that an off-board tool like ServiceLink uses to troubleshoot that ECU.

Cabin CAN is the primary datalink for control messaging of most cab and chassis features, including interior and exterior lighting, comfort features, optional features, and some interaction with control messaging on the J1939 and J1587/J1708 datalinks.

The Cabin CAN datalink does not have a direct connection to the diagnostic connector. Troubleshooting ECUs on the Cabin CAN datalink requires an off-board tool (such as ServiceLink), which connects to the Diagnostic

CAN datalink wires in the diagnostic connector. An off-board tool can communicate with the Cabin CAN ECUs via the CGW. See **Table 1** for a Cabin CAN ECU's datalinks for control messaging and troubleshooting.

ECU Control Messaging and Troubleshooting Datalinks					
ECU is on this Datalink	Control Messaging Datalink	Direct Connection to Diagnostic Connector?	Troubleshooting Datalink	Direct Connection to Diagnostic Connector?	Diagnostic Communication Protocol
Cabin CAN	Cabin CAN	No	Diagnostic CAN	Yes	CAN

Table 1, ECU Control Messaging and Troubleshooting Datalinks

506 — Controller Area Network (CAN)

In general, "CAN" refers to a specific protocol definition of a network's physical layer. By this definition, the J1939, Cabin CAN and Diagnostic CAN datalinks are all CAN networks at the physical layer.

In terms of ServiceLink, "CAN" refers specifically to the device and protocol option used to diagnose and configure ECUs connected to the Diagnostic CAN and Cabin CAN datalinks, including the CGW, SAM Cab, SAM Chassis and MSF. See **Fig. 1**. Cabin CAN ECUs can be viewed in ServiceLink via the CAN protocol. Active and historic faults can be viewed, and historic faults can be cleared. ECU information is available, as is access to Datalink Monitor templates. In addition, ECU configuration functions can be performed, such as flashing ECU software and changing ECU parameters.

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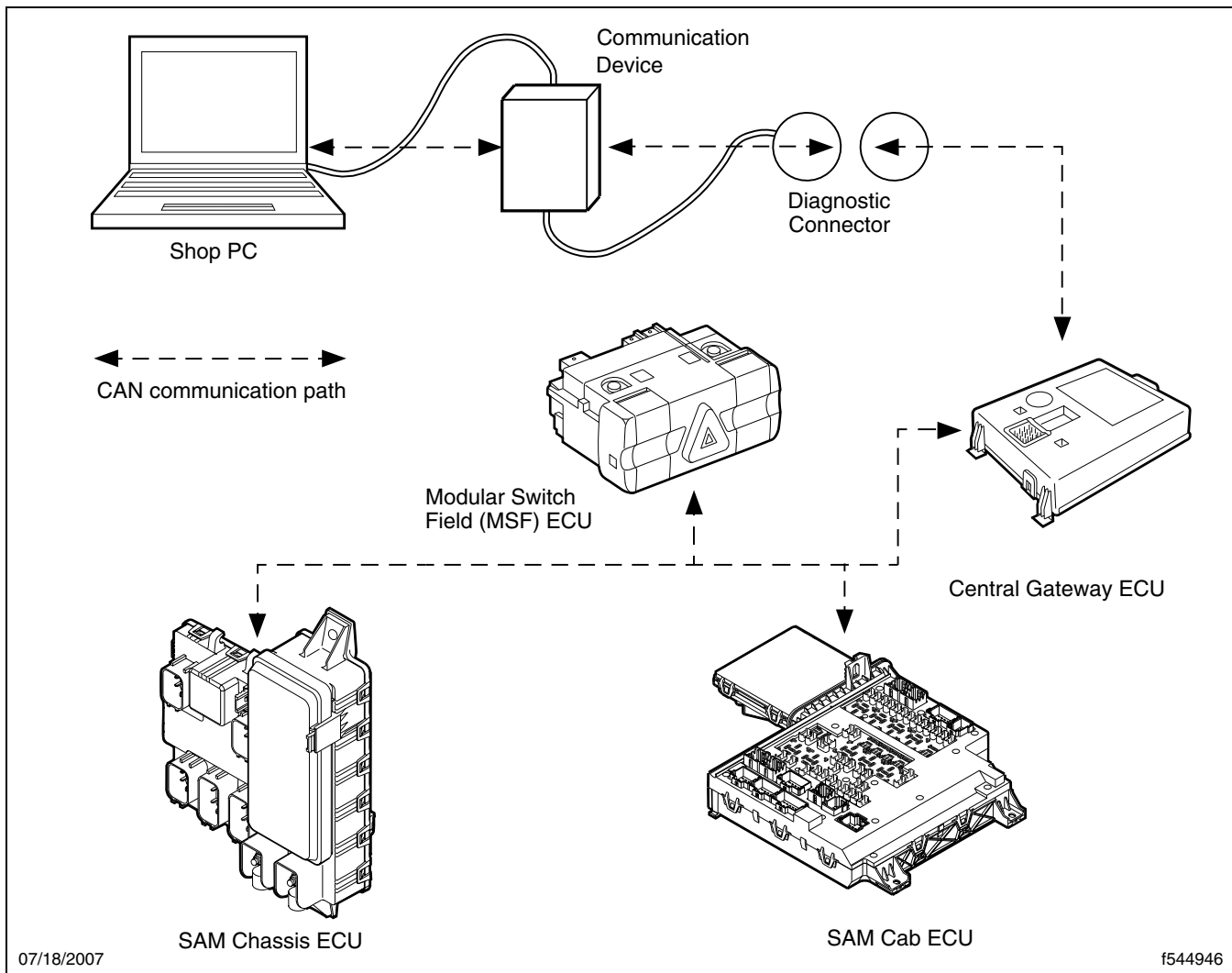


Fig. 1, Diagram of the Cabin CAN ECU Troubleshooting Path

507 — ECU Parameter and Software Configuration

All of the ECUs connected to the Cabin CAN datalink have parameters that can be configured. The only Cabin CAN ECU without parameters is the CGW on EPA07 vehicles. Parameters tell the ECU how to control the vehicle. All Cabin CAN ECUs with parameters have the same parameter structure and behavior described in this subject.

There are two levels of parameters. The higher level is called a "function parameter" in ServiceLink. For each function parameter, there may be one or more detailed parameters describing what the function does. These are called "parameters" in ServiceLink, and include the following:

- hardware or software interlocks
- cut-off speeds
- maximum and minimum limits

In a CAN ECUs "Parameters" screen in ServiceLink, parameters will be either view-only or changeable.

All changeable parameters have a part number associated with them, just like a hardware part. When adding, removing, or changing a feature, the parameters are provided in the form of a part number in the bill of material (BOM).

Viewing, changing, or re-applying parameters may be necessary in the following scenarios:

- Adding an optional feature (daytime running lights, for example).
- Removing an optional feature.
- Changing the functionality of an existing feature, for example, changing the vehicle's daytime running light feature to activate both the marker lights and the low beams, instead of activating only the low beams.

Flashing (or reprogramming) the software is separate from programming the parameters, just as it is in an engine controller.

NOTE: As part of the flashing process in ServiceLink, any parameters that the ECU may have will automatically be reapplied.

For instructions on how to use ServiceLink to change the parameters of a CAN ECU, see the *ServiceLink User Guide* or *ServiceLink Help*.

508 — ECU Configuration

All of the ECUs connected to the Cabin CAN datalink can have their software "flashed" using ServiceLink. This means the ECU's software can be flashed to its same version or upgraded, if required.

The flashing procedure should be performed on an ECU in the following cases only:

- **For a feature upgrade:** Adding a new feature to a vehicle may require a newer version of ECU software. ServiceLink will automatically make available any necessary software upgrades.
- **To fix a problem in the existing software:** In case a new version of ECU software is needed to fix a problem in the existing ECU software, ServiceLink automatically makes available any necessary software upgrades.
- **When replacing the ECU on a vehicle:** Flashing ensures the correct software is on the newly installed ECU.
- **As a last resort:** Troubleshooting has narrowed the problem down to being at the ECU itself and no other mechanical or electrical causes for the symptom have been identified. As a last resort, flashing the ECU's software with the same version may help in the case it became corrupt during the course of normal vehicle operation.

For more information on when and how to perform these processes in ServiceLink, see the ServiceLink user documentation (available via the "Help" drop-down menu in ServiceLink).

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509 — Datalink Network Topology

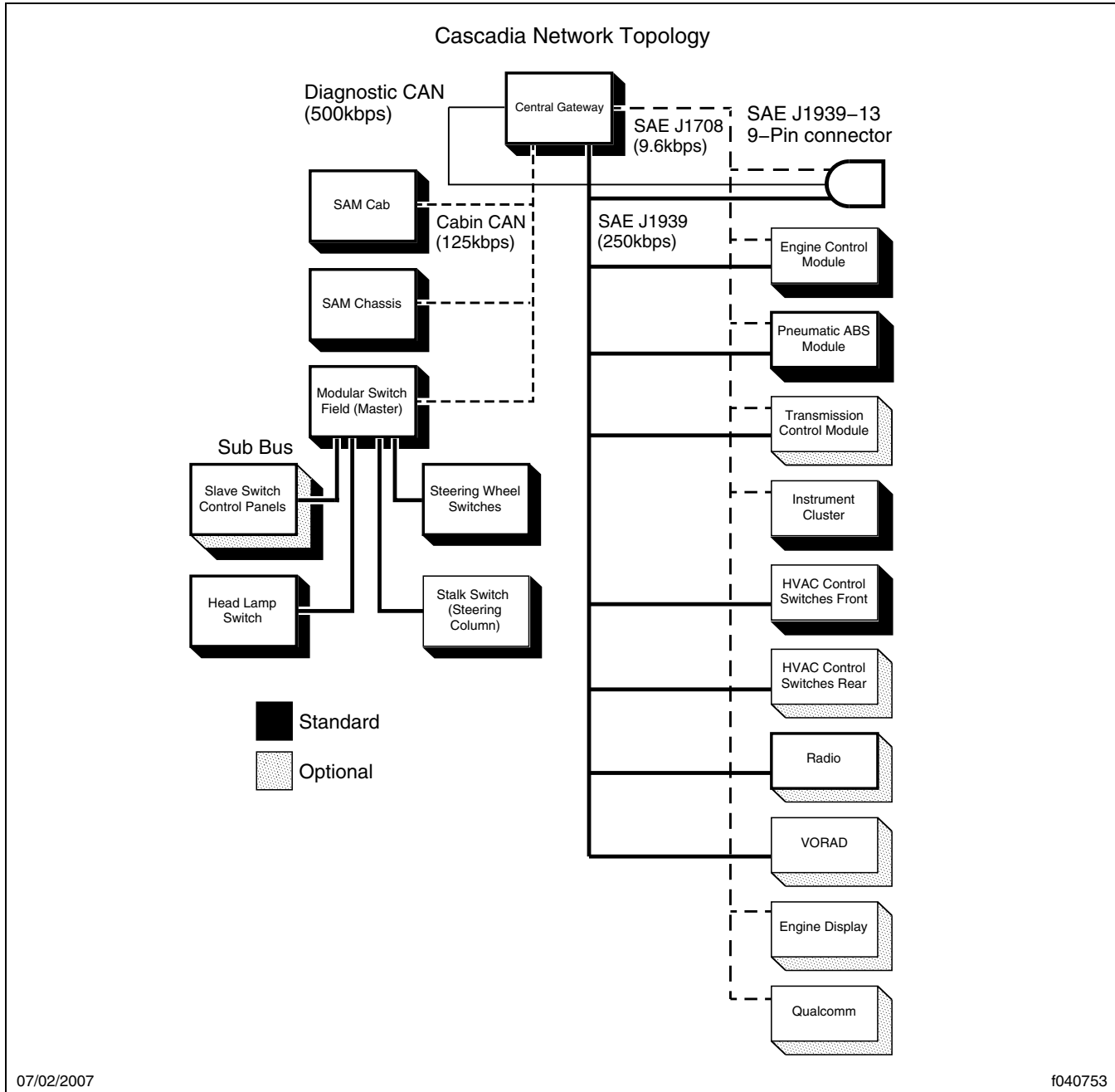


Fig. 2, Datalink Network Topology

510 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.02 — Datalink Communication Structure
- G02.03 — Central Gateway
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.03 — Datalink, Cabin CAN
- G04.03 — CAN Fault Codes

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Datalink, Diagnostic CAN

600 — Component Locations

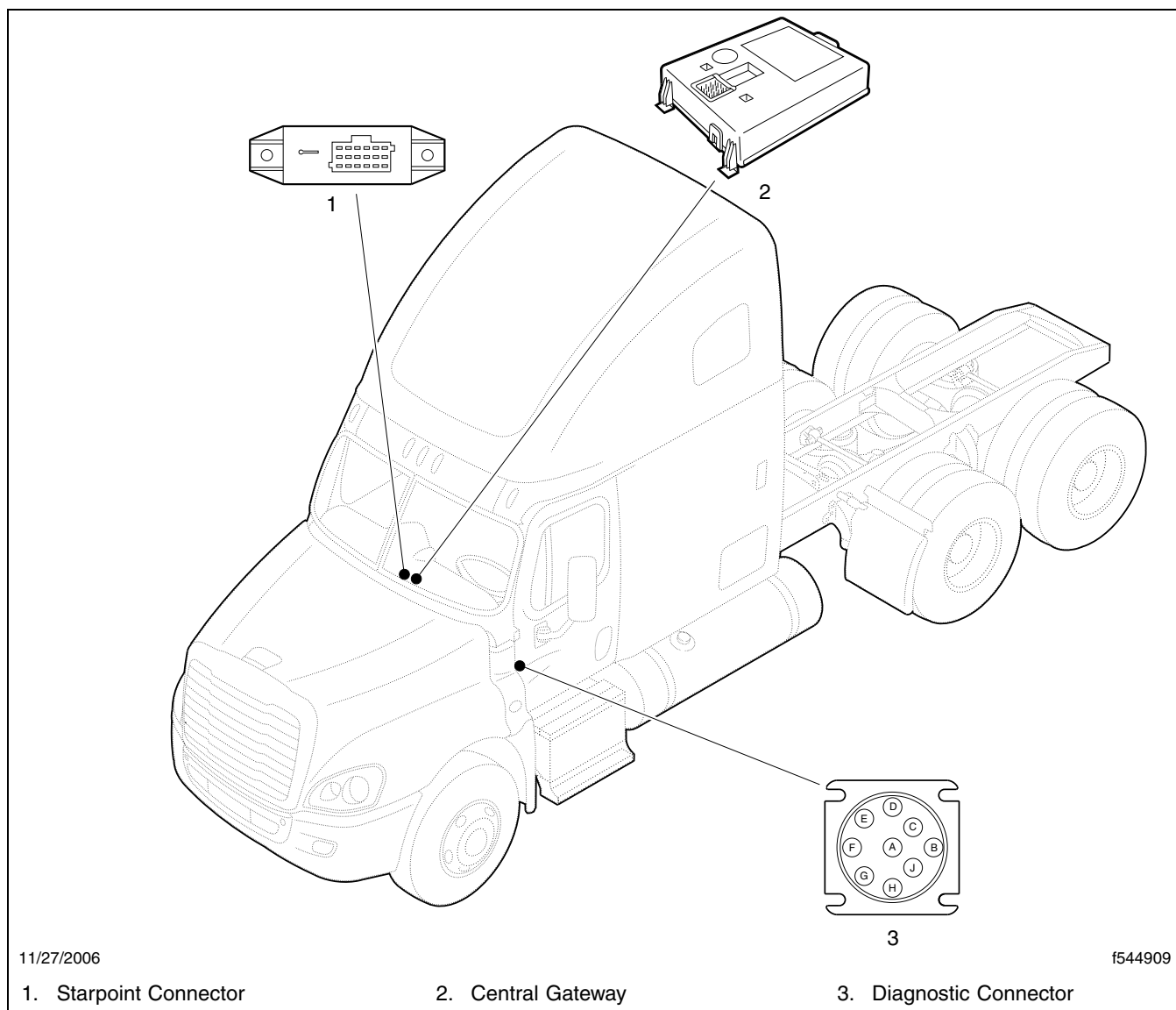
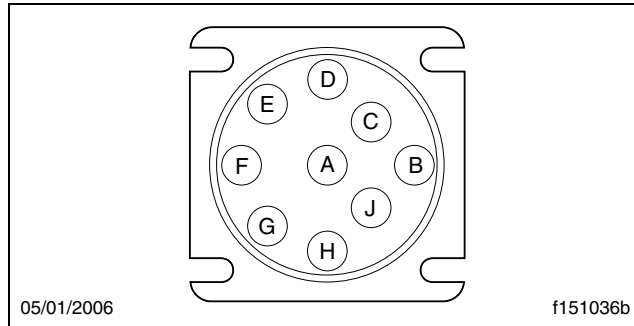
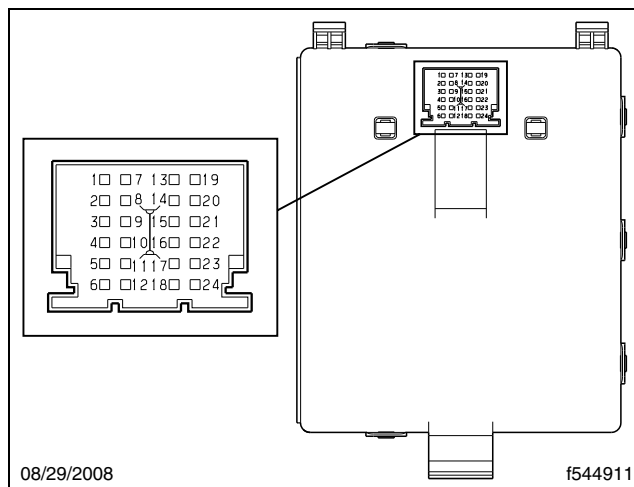


Fig. 3, Component Locations

601 — Component Details**Fig. 5, Diagnostic Connector**

Diagnostic Connector	
Pin	Function
A	Battery (–)
B	Battery (+)
C	J1939 CAN High (+)
D	J1939 CAN Low (–)
E	CAN Shield (ground)
F	J1708/J1587 (+)
G	J1708/J1587 (–)
H	Diagnostic CAN High (+)
J	Diagnostic CAN Low (–)

Table 2, Diagnostic Connector**Fig. 6, Central Gateway Module, Cabin CAN Pins**

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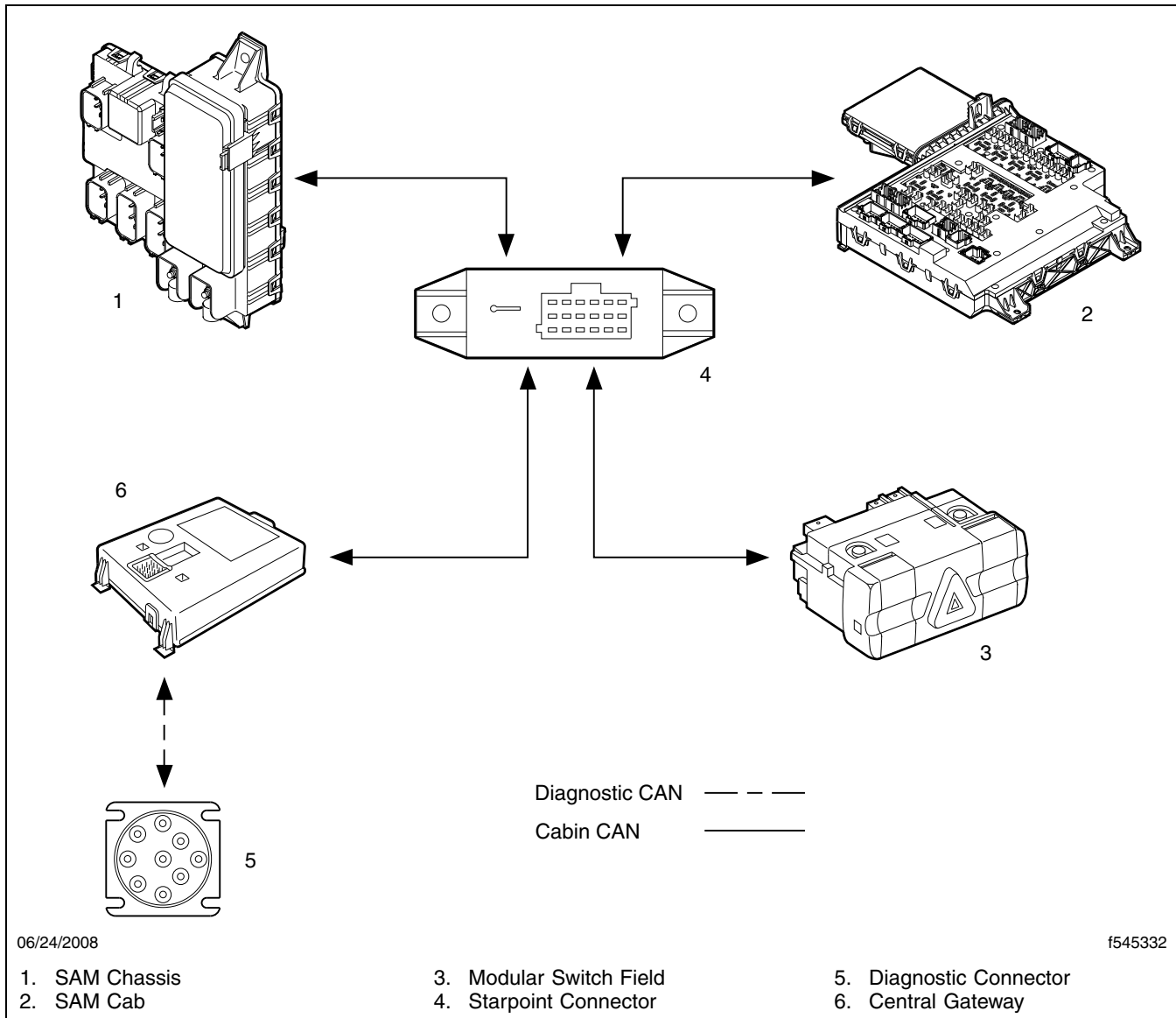


Fig. 4, CAN Datalinks

CGW ECU (single connector)	
Pin	Function
1	Battery Power
7	Ground
18	Diagnostic CAN_L
23	Diagnostic CAN_H

Table 3, CGW ECU (single connector)

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700 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor
- Digital Multimeter

701 — Overview of CAN Datalinks

Diagnostic CAN datalink wiring runs from pins H and J in the diagnostic connector to the Central Gateway (CGW). The CGW maintains an internal resistance of 60 ohms for the Diagnostic CAN datalink wiring, similar to a J1939 terminating resistance.

Cabin CAN datalink wiring runs from each of the connected ECUs to the starpoint connector. The starpoint connector maintains an internal resistance of 60 ohms for each connection to an ECU, similar to a J1939 terminating resistance.

The following ECUs are connected to the Cabin CAN datalink:

- Central Gateway (CGW)
- Modular Switch Field (MSF) Master ECU
- SAM Cab
- SAM Chassis

Applicable Modules

Refer to the **Table 4** for drawings specific to the affected vehicle vehicle.

Component Module Locations	
Component	Location
General Cabin CAN and Diagnostic CAN datalink harness drawings, schematics and installation drawings, including the Starpoint Connector.	Module 160
Central Gateway (CGW)	Module 835
Modular Switch Field (MSF)	Module 860
SAM Cab	Module 32A
SAM Chassis	Module 32K

Table 4, Component Module Locations

702 — Possible Causes

- Wiring
- Diagnostic Connector
- Central Gateway

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Datalink, Diagnostic CAN

703 — Symptoms

Symptoms of a Malfunctioning Diagnostic CAN Datalink:

Cannot connect ServiceLink to any CAN ECUs. See **Table 5** for faults related to Diagnostic CAN wiring failures.

Symptoms of a Malfunctioning Cabin CAN Datalink

- Vehicle systems, especially functions controlled by ECUs on J1939 or J1587, may not operate properly if they are dependent on information coming from the CAN ECUs. For example:
 - Engine controller may report faults due to missing input information expected from the MSF.
 - HVAC system may not work properly and HVAC controller(s) may report faults due to missing input information from the SAM Cab.
- ECU connection behavior seen in ServiceLink:
 - CAN protocol: ServiceLink may connect to the Central Gateway only. The SAM Cab, SAM Chassis, and/or Modular Switch Field may not appear in roll call and would be reported as "MISSING" in the "Problem ECU" table.
 - J1939 and J1708 protocols: Able to connect normally.

Refer to **G03.03 — Datalink, Cabin CAN** for CAN faults related to Cabin CAN wiring or communication failures.

Symptoms of a Missing CAN ECU

NOTE: The below assume these ECUs are detected as missing from the Cabin CAN datalink individually, not at the same time.

Missing SAM Cab

Refer to **C06.09 — Powernet Management** for the "Emergency Power System" information. This subject details the vehicle behavior when a SAM Cab is missing due to a Cabin CAN communication failure.

Refer to **G03.03 — Datalink, Cabin CAN** for possible faults (SPN 524033, FMI 31).

Missing SAM Chassis

Refer to **C06.09 — Powernet Management** for the "Emergency Power System" information. This subject details the vehicle behavior when a SAM Chassis is missing due to a Cabin CAN communication failure.

Refer to **G03.03 — Datalink, Cabin CAN** for possible faults (SPN 524071, FMI 31).

Missing Modular Switch Field (MSF) master ECU

All functions where input switches are controlled by the MSF will not work:

- Stalk Switch functions (Turn Signals, Wiper Motor, Wiper Washer, High Beam, Flash-to-Pass)
- Hazard Lights function
- Rotary (Headlamp) Switch functions (Low and High Beam Headlights, Fog Lamps, Marker/License/Clearance Lamps)
- Steering Wheel Switch functions (Engine Brake, Marker Interrupt, ICU message center toggle +/-, Cruise Control)

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- Sub bus switch functions

As a safety precaution, after about 10 seconds of the MSF being detected as missing from Cabin CAN, the SAM Cab and SAM Chassis will turn ON the following lights:

- Headlight Low Beams
- Marker Lights (tractor and trailer)
- Tail Lights (tractor and trailer)
- Clearance Lights

The check engine light turns ON because the engine controller is missing information from the MSF switch inputs. The engine controller may also report active faults due to this condition.

Refer to **G03.03 — Datalink, Cabin CAN** for possible faults (SPN 524049, FMI 31).

Missing Central Gateway

Vehicle systems may not operate properly due to information not being routed to or from the CAN ECUs. Examples include the following:

- Engine controller may report faults due to missing input information expected from the MSF.
- HVAC system may not work properly and HVAC controller(s) may report faults due to missing input information from the SAM Cab.
- MSF messages not being routed from CAN to J1939 or J1587:
 - Steering wheel switches
 - Engine Brake not working
 - ICU Menu toggle (+/–) not working
 - Engine Brake "Low/Med/High" dash switch (sub bus switch) not working

Refer to **G03.03 — Datalink, Cabin CAN** for possible faults (SPN 524037, FMI 31).

704 — CAN Fault Codes

Refer to **G03.03 — Datalink, Cabin CAN** for additional faults relating to Cabin CAN datalink wiring and ECUs. **IMPORTANT:** The batteries must be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements."

Table 5 lists faults for the following ECUs:

- 37 – Central Gateway (CGW)

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
37	523510	31	pin 18 pin 13	—	—	Diagnostic CAN Performance	Diagnostic CAN performance failure (communication is not possible) occurs when the Diagnostic CAN High is shorted to GND, the Diagnostic CAN Low is shorted to BAT, or the Diagnostic CAN Low is shorted to Diagnostic CAN High.
Action: Disconnect the batteries and measure the resistance between pins H and J at the diagnostic connector. If 60 ohms is not detected, troubleshoot the Diagnostic CAN datalink wiring or a short to BAT and GND. An open circuit and high shorted to low is also a cause. Troubleshoot the Diagnostic CAN high wiring between diagnostic connector pin H and CGW pin 23. Troubleshoot the Diagnostic CAN low wiring between diagnostic connector pin J and CGW pin 18.							

Table 5, CAN Fault Codes

705 — Diagnostic CAN Troubleshooting

1. Refer to **703 — Symptoms** to review ECU behavior to assist in narrowing down the suspect ECU or datalink.
 - 1.1 Connect the vehicle to ServiceLink.
 - 1.2 Verify ServiceLink is communicating with the Central Gateway. The CAN Datalink will show connectivity on the ECU List General Info screen. The Central Gateway will appear under the CAN ECU's detected table.

Is connection to the Central Gateway successful?

YES → The problem is with the Cabin CAN datalink. Refer to **G03.03 – Datalink, Cabin CAN**.

NO → Go to test 2.

2. Troubleshoot Diagnostic CAN wiring
 - 2.1 Turn the key switch to the OFF position and disconnect the batteries.
 - 2.2 Using a multimeter measure the resistance at the diagnostic connector on pin H and J.
 - 2.3 Compare the resistance values to **Table 6**.

Datalink Communication Rates	
Result	Possible Cause
60 Ohms ± 6	The diagnostic CAN datalink is intact, showing proper resistance.
0	Diagnostic CAN (+) and (–) wires are shorted.
"OL" (open load) or very high resistance value.	Open connection between the Diagnostic CAN (+) or (–) wires and the CGW.

Table 6, Datalink Communication Rates

Does the resistance read 60 ohms?

Datalink, Diagnostic CAN

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YES → There is no problem with Diagnostic CAN wiring. The problem is with the interface between the vehicle to diagnostic computer or the Central Gateway. Check datalink, power and ground wires on the Central Gateway.

NO → Go to test 3.

3. Perform a continuity test.

3.1 Perform a continuity test between diagnostic connector Pin H and CGW connector pin 23.

3.2 Perform a continuity test between diagnostic connector Pin J and CGW connector pin 18.

Is continuity (low resistance) detected?

YES → No further testing is necessary.

NO → Repair the affected harness.

800 — Resistors

The Diagnostic CAN datalink uses a 60-ohm load resistor value (similar to the "terminating resistors" on the J1939 datalink), which is built into the central gateway ECU.

801 — Datalink Wire Colors

Datalink Wire Colors		
Datalink	Wire Color	
	High	Low
Cabin CAN	Light Blue	White
Diagnostic CAN	Brown with Light Blue Stripe	Brown with White Stripe

Table 7, Datalink Wire Colors

802 — Datalink Communication Rates

Datalink Communication Rates	
Datalink	Kilobits Per Second
Cabin CAN	125
Diagnostic CAN	500

Table 8, Datalink Communication Rates

803 — ECU Identification on Datalinks

NOTE: Parenthesis indicate ECU may appear under these identifiers in the given protocol based on message routing behavior by the CGW.

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Datalink, Diagnostic CAN

ECU Identification on Datalinks			
ECU Description	J1587 MID*	J1939 SA†	CAN SA†
SAM Cab	(249)	(33)	33
SAM Chassis	(216)	(71)	71
Modular Switch Field	(164)	(49)	49
Central Gateway	(206)	(37)	37

* Message Identifier

† Source Address

Table 9, ECU Identification on Datalinks

J1587 Fault Codes

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J1587 Fault Codes

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500 — Terms and Abbreviations

CAN—Controller Area Network

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

MID—Message Identifier. Indicates numeric assignment for a device that communicates on J1587.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SFU—Switch Field Unit; see MSF.

501 — General Information

This subject contains a master list of all known possible J1587 faults for the Cascadia. For engine faults (MID128), refer to the engine manufacturer's diagnostic tools and documentation.

Fault codes appearing on either the ICU or ServiceLink J1587 fault screens must be verified as faults from a J1587 ECU, and not a "routed fault." A routed fault is a fault that the Central Gateway routed from another protocol to the ICU or the J1587 fault screen.

502 — Routed Faults

The Central Gateway (CGW) routes and translates messages between the J1939, J1708, Cabin CAN, and Diagnostic CAN datalinks.

To verify whether a J1587 fault is routed, perform one of the following steps:

- Use **Table 1** to confirm that the ECU MID is for an ECU that is physically connected to J1587.
- Connect to ServiceLink. In ServiceLink, routed faults appear in grey text. Select a different protocol until ECU faults appear in black text. Seeing a fault in ServiceLink's J1587 fault screen in black text verifies that

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J1587 Fault Codes

the fault is from a J1587 ECU, and verifies that J1587 is the correct protocol to view for troubleshooting that fault or ECU.

The CGW has the following wiring connections:

- Each datalink on the vehicle: J1708, J1939, Cabin CAN, and Diagnostic CAN.
- On the Diagnostic CAN, the CGW has a direct connection to the diagnostic connector.
- On the Cabin CAN, the CGW is directly connected to the starpoint connector.

The CGW has the following main functions:

- Routes and translates messages between datalinks.
- Interfaces between off-board tools and Cabin CAN ECUs.
- Provides faults for any missing Cabin CAN ECUs.

In some cases, the Cabin CAN ECUs need information from J1939 or J1708 ECUs. Information sent by the J1939 or J1708 ECU is picked up by the CGW and passed to the appropriate Cabin CAN ECU. The reverse occurs when a J1939 or J1708 ECU needs information from a CAN ECU.

Routing Active CAN Faults

If a CAN ECU generates an active fault, the CGW will route up to one active fault for that ECU on to J1939 or J1708, for display on the instrument cluster (ICU) message center, which does not have a direct connection to CAN. This is to alert the driver that the ECU has an active fault.

When a CAN ECU generates an active fault:

- J1939 displays up to one active fault for that CAN ECU under the J1939 source address for that CAN ECU. SAM Cab, for example, is SA 33. Accurate SPN and FMI information for that fault is also displayed.
- J1708 displays up to one active fault for that CAN ECU under the MID for that CAN ECU. SAM Cab, for example, is MID 249. Accurate SID/PID or FMI information is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

Routing Active J1939 Faults

If a J1939 ECU generates an active fault, the CGW will route up to one active fault for that ECU on J1708, for display on the instrument cluster (ICU) message center. This alerts the driver that the ECU has an active fault,

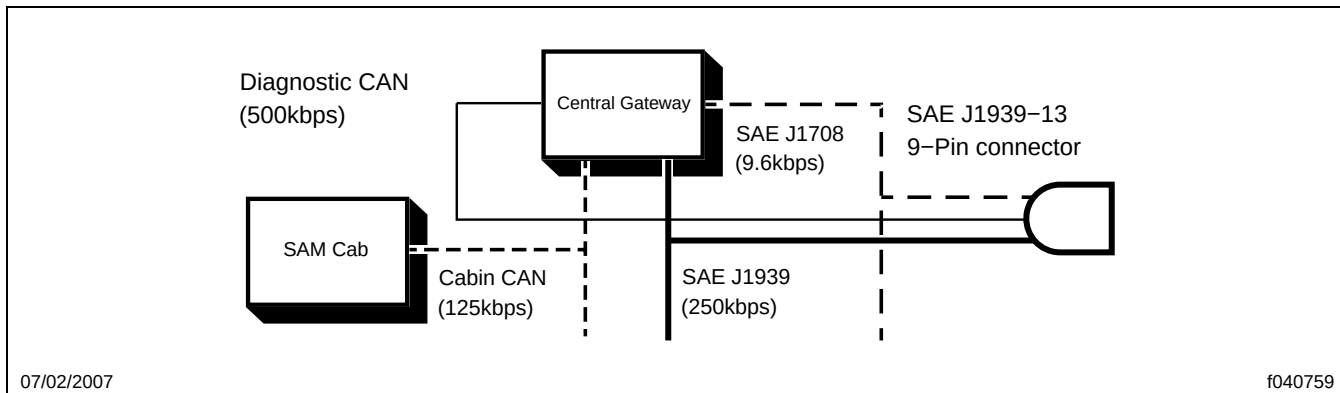


Fig. 1, Central Gateway, Diagnostic Connector, and Vehicle Datalinks

J1587 Fault Codes

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especially if the ICU has a J1708 connection only. When a J1939 ECU generates an active fault, there may be up to one active fault on J1708 for that CAN ECU under the MID for that CAN ECU. The HVAC front control unit, for example, is MID 146. Accurate information for SID/PID or FMI is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

For more information regarding message routing behavior by the CGW, refer to **G02.03 – Central Gateway**.

503 — ECU Identification on Datalinks

The information in **Table 1** identifies which ECU is reporting the fault, and which datalink protocol to load in ServiceLink to get accurate fault information for troubleshooting that ECU.

NOTE: Items in parenthesis indicate a message that is routed through the CGW from an ECU that is not physically connected to the J1587 datalink.

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
SAM Cab	33	(33)	(249)	—
SAM Chassis	71	(71)	(216)	—
Modular Switch Field (MSF)	49	(49)	(164)	—
Central Gateway (CGW)	37	(37)	(206)	—
Engine Control 1	—	0	128	—
Engine Control 2	—	1	175	—
Transmission	—	3	130	—
ABS	—	11	136	—
Retarder, Engine	—	12	173	—
Instrument Cluster	—	23*	140	—
Navigation	—	28	162	—
Engine Display	—	40	171	—
HVAC, Front	—	25	(146)	CGW reporting MID 146; there is no physical J1708 connection.
HVAC, Rear	—	58	(200)	CGW reporting MID 200; there is no physical J1708 connection.
Radio	—	76	(221)	CGW reporting MID 221; there is no physical J1708 connection.
Collision Warning	—	42	(219)	CGW reporting MID 219; there is no physical J1708 connection.
Qualcomm	—	75	181	—
Lane Guidance	—	232	—	—

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J1587 Fault Codes

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
Front Airbag Sensor	—	—	232	—
Roll Sensor Module	—	—	254	—

* ICU4M Only.

Table 1, ECU Identification on Datalinks

The following examples demonstrate how to identify and diagnose faults using **Table 1**.

- J1708 Fault: MID 146, SID 254, FMI 03
 - MID 146 is the Front HVAC.
 - The Front HVAC is diagnosed using J1939.
 - Load the J1939 fault screen in ServiceLink for diagnostic information.
- J1939 Fault: SA 49, SPN 168, FMI 03
 - SA 49 is the Modular Switch Field (MSF).
 - The MSF is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 216, SID 254, FMI 14
 - MID 216 is the SAM Chassis.
 - The SAM Chassis is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 136, SID 123, FMI 02
 - MID 136 is the ABS module.
 - The ABS is diagnosed using the J1708 protocol.
 - Load the J1708 fault screen in ServiceLink for diagnostic information.

504 — J1587 Failure Mode Identifiers

Failure Mode Identifiers (FMIs)	
FMI	Description
00	Data valid but above normal operational range (engine overheating).
01	Data valid but below normal operational range (engine oil pressure too low).
02	Data erratic, intermittent, or incorrect.
03	Voltage above normal, or shorted high.
04	Voltage below normal, or shorted low.
05	Current below normal, or open circuit.
06	Current above normal, or grounded circuit.

J1587 Fault Codes

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Failure Mode Identifiers (FMIs)	
FMI	Description
07	Mechanical system not responding properly.
08	Abnormal frequency, pulse width, or period.
09	Abnormal update rate.
10	Abnormal rate of change.
11	Failure mode not identifiable.
12	Bad intelligent device or component.
13	Out of Calibration.
14	Special Instructions.
15	Reserved for future assignment by SAE.

Table 2, Failure Mode Identifiers (FMIs)

505 — ICU3 Roll Call Faults

On vehicles equipped with the ICU3 instrument cluster, messages from both the engine and ABS on the J1587 datalink are transmitted when the vehicle powers up. If the ICU3 does not receive messages from one or both, it displays "no EnG" and/or "no ABS" faults. If there is no communication between the ICU3 and the J1587 datalink, the ICU displays the message "no DATA". Engine and ABS roll call messages are accompanied by a roll call fault that is only displayed on the ICU driver display screen. Refer to **Table 3** for a list of faults.

NOTE: Roll call faults "ECU 128 SID 254 FAIL 07" and "AbS 136 SID 254 FAIL 07" originate from the ICU, and are only displayed on the ICU driver display screen. The faults will not show up in ServiceLink or any other tool that reads J1587 datalink faults.

If the ICU3 detects an active fault from one of the active faults on the J1587 datalink, it displays a message that contains both an abbreviation of the ECU with the fault, and its MID. Refer to **Table 4** for a list of messages.

For more information, refer to **C01.01 — ICU3**.

506 — ICU4 J1587 Datalink Roll Call Faults

The ICU4 is programmed to detect the engine ECM on the J1587 datalink. Any other ECUs that the ICU detects on the J1587 datalink will be "learned." The ICU will attempt to detect these "learned" ECUs, in addition to the engine ECM on roll call at every subsequent power up. The ICU4M learns and detects up to four components on the J1939 datalink, which includes the front HVAC controller, the rear HVAC controller, the MSF, and the Collision Warning System (VORAD).

If the ICU does not detect an expected ECU on roll call, it will report it on the display. These faults are not displayed in ServiceLink. The ICU4 reports roll call faults with three screens on the display. The first screen shows one of the messages in the "Message" column of **Table 5**. This indicates the J1587 MID of the ECU that is not reporting on roll call. The following two screens report the SID and FMI. Roll call faults have a SID 254 and FMI 07.

NOTE: The ABS and engine ECM do not report the actual MID on the screen, but instead report "no Abs" or "no ENG" to indicate the MIDs of those ECUs.

507 — ICU4M J1587 Datalink Roll Call Faults

The entire roll call fault on the ICU4M is displayed on a single screen. All J1587 datalink roll call faults have a SID 254 and FMI 07. Refer to **Table 6** for more information.

For more information on ICU4/ICU4M roll call faults, refer to **C01.02 — ICU4/ICU4M Instrument Cluster**.

508 — Related Subjects

- **G02.02 — Datalink Communication Structure**
- **G02.04 — SAM Cab**
- **G02.05 — SAM Chassis**
- **G02.06 — Modular Switch Field**
- **G03.01 — Datalink, J1587/J1708**
- **G03.02 — Datalink, J1939**
- **G03.03 — Datalink, Cabin CAN**
- **G03.04 — Datalink, Diagnostic CAN**
- **C01.01 — ICU3**
- **C01.02 — ICU4/ICU4M**

J1587 Fault Codes

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700 — J1587 Fault Codes

J1587 Fault Codes				
MID	SID/PID	FMI	Fault Description	Reference Subjects
136	001-006	01	Incorrect air gap.	H01.01 – ABS and Roll Stability Control System
136	001-006	02	Incorrect tire size.	
136	001-006	03	Sensor shorted to power.	
136	001-006	04	Short to Ground.	
136	001-006	05	Open Circuit.	
136	001-006	06	Short Circuit.	
136	001-006	07	Damaged Tone Ring.	
136	001-006	08	Excessive Wheel Slip.	
136	001-006	09	Wire Mismatch.	
136	001-006	10	Speed Signal Drop Out.	
136	001-006	11	Abnormal Speed.	
136	001-006	12	Frequency Too High.	
136	007-010	03	Short to Power.	
136	007-010	05	Open Circuit.	
136	007-010	06	Short to Ground.	
136	13	03	Retarder Relay Circuit – short to power.	
136	13	05	Retarder Relay Circuit – open circuit.	
136	13	06	Retarder Relay Circuit – short to ground.	
136	14	04	Low voltage or open circuit.	
136	14	05	Ground circuit open or high resistance; verify that the batteries are not disconnected or shut off, otherwise results may be misleading.	
136	14	06	Internal relay does not open.	
136	15	03	ATC Valve ground circuit shorted to power.	
136	15	05	ATC Valve High Impedance.	
136	15	06	ATC Valve ground circuit shorted to ground.	
136	18	03	Short to Power.	
136	18	05	Open Circuit.	
136	18	06	Short to Ground.	
136	231	02	J1939 speed plausibility error; This fault indicates a discrepancy between vehicle speed reported on J1939 and ABS sensed vehicle speed.	
136	231	05	J1939 – open/short.	
136	231	06	J1939 – open/short. Code 136s231 05 may be active as well.	
136	231	07	J1939 time out. Fault occurs if engine retarder sends message incorrectly.	

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J1587 Fault Codes

J1587 Fault Codes				
MID	SID/PID	FMI	Fault Description	Reference Subjects
136	231	08	J1939 time out. Fault occurs if engine retarder sends message incorrectly.	C07.08 — SRS System
136	231	09	J1939 time out. Fault occurs if engine or transmission sends message incorrectly.	
136	231	10	J1939 time out. Fault occurs if exhaust retarder sends a message incorrectly.	
136	231	12	J1939 internal error.	
136	251	03	Overvoltage –Voltage to ECU was too high for more than 5 seconds.	
136	254	05	ABS/ATC ECU, no loads.	
136	254	08	Excessive Wheel Slip.	
136	254	09	Modulator valve actuated too long.	
136	254	07	ABS Missing.	
136	254	02	EEPROM, Wheel parameter incorrect.	
136	254	12	EEPROM, Checksum/internal error.	
136	254	13	Accelerator out of range.	
136	254	14	ECU mounting/accelerometer plausibility.	
140	p168	01	ICU3 voltage is too low (less than 10.5 volts).	C01.01 — ICU3
140	s240	12	ICU3 program memory failure; odometer read/write to EEPROM fails. When this failure occurs, the ICU is unable to display the fault on the LCD, but the fault displays in ServiceLink. When this fault is active, the LCD display shows a series of seven hyphens "- - - - -".	
140	s254	12	ICU3 Controller Failure; ICU self-test "detectschecksum errors".	

J1587 Fault Codes

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J1587 Fault Codes				
MID	SID/PID	FMI	Fault Description	Reference Subjects
140	p077	05	Forward rear-axle temperature sensor – open.	C01.02 — ICU4/ICU4M
140	p077	06	Forward rear-axle temperature sensor – shorted.	
140	p078	05	Rear rear-axle temperature sensor – open.	
140	p078	06	Rear rear-axle temperature sensor – shorted.	
140	p96	05	Fuel level sensor – open.	
140	p96	06	Fuel level sensor – shorted.	
140	p168	01	Lightbar voltage too low (less than 10.5 volts).	
140	p177	05	Transmission oil temperature sensor – open.	
140	p177	06	Transmission oil temperature sensor – shorted.	
140	s240	12	LBCU program memory failure.	
140	s254	12	LBCU controller failure.	
232	s001	03	Airbag igniter circuit – shorted to power.	C07.08 — SRS System
232	s001	04	Airbag igniter circuit – shorted to ground.	
232	s001	05	Airbag igniter circuit – open circuit.	
232	s001	06	Airbag igniter circuit – shorted.	
232	s240	14	Frontal collision detected.	
232	s254	07	Frontal Crash Sensor (Safety Restraint System 1); not detected by the ICU on Roll Call.	
254	s001	05	Driver seat igniter loop – open.	
254	s001	06	Driver seat igniter loop – shorted.	
254	s002	05	Driver side airbag igniter loop – open.	
254	s002	06	Driver side airbag igniter loop – shorted.	
254	s003	05	Passenger seat igniter loop – open.	
254	s003	06	Passenger seat igniter loop – shorted.	
254	s004	05	Passenger side airbag igniter loop – open.	
254	s004	06	Passenger side airbag igniter loop – shorted.	
254	s240	14	Rollover or frontal crash detected.	
254	s254	07	Roll Sensor Module (Safety Restraint System 2) – Not Detected by ICU on Roll Call.	
254	s254	12	Rollover module – bad device or component.	

Table 3, J1587 Fault Codes

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J1587 Fault Codes

NOTE: For engine-related faults, refer to the engine manufacturer's diagnostic software.

701 — Displayed Roll Call Messages

Displayed Roll Call Messages	
Displayed Message	Description
no EnG	The ICU is unable to communicate with the engine control module on the J1587 datalink. This is followed by a roll call fault on the driver display. The roll call fault may be displayed as one of the following: no EnG SID 254 FAIL 07 or ECU 128 SID 254 FAIL 07 .
no ABS	The ICU is unable to communicate with the ABS on the J1587 datalink. This is followed by a roll call fault on the driver display. The roll call fault may be displayed as one of the following: no ABS SID 254 FAIL 07 or AbS 136 SID 254 FAIL 07 .
no DATA	The ICU is not communicating with the J1587 datalink.

Table 4, Displayed Roll Call Messages

NOTE: For engine-related faults, refer to the engine manufacturer's diagnostic software.

702 — ICU3 J1587 Fault Messages After Power On Sweep

NOTE: For engine-related faults, refer to the engine manufacturer's diagnostic software.

ICU3 J1587 Fault Messages After Power On Sweep	
Message	System With Active Fault
AbS 136	Antilock Brake System
APU 190	Air Conditioning Protection Unit
Cab 249	SAM Cab
CdU 219	Collision Detection Unit (VORAD)
CEL 231	Cellular Phone
CGU 206	Central Gateway
CHS 216	SAM Chassis
ECU 128	Engine Control Unit (engine control module)
ICU 140	Instrument Cluster Unit (ICU4/4M)
rAd 221	Radio
SAT 181	Satellite Communications (Qualcomm)
Sbu 232	Seat Belt Unit (SPACE/Airbag system)

J1587 Fault Codes

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ICU3 J1587 Fault Messages After Power On Sweep	
Message	System With Active Fault
SdU 236	Step Deployment Unit, Driver Side (not used)
SdU 237	Step Deployment Unit, Passenger Side (not used)
SFU 164	Modular Switch Field
SYS ###	Generic (system not defined in this table)
tCU 130	Transmission Control Unit
tSU 223	Transmission Shift Unit

Table 5, ICU3 J1587 Fault Messages After Power On Sweep

703 — ICU4 J1587 Datalink Roll Call Faults

ICU4 J1587 Datalink Roll Call Faults			
Message	SID	FMI	System Not Responding to Roll Call
No Data	—	—	No ECUs on the J1587 datalink are responding
No ABS	SID 254	FAIL 07	Antilock Brake System (ABS)
No ENG	SID 254	FAIL 07	Engine Control Module 1
ECU 173	SID 254	FAIL 07	Retarder, Engine
ECU 175	SID 254	FAIL 07	Engine Control Module 2
APU 190	SID 254	FAIL 07	Air Conditioning Protection Unit
CAB 249	SID 254	FAIL 07	SAM Cab
CDU 219	SID 254	FAIL 07	Collision Detection Unit (VORAD)
CEL 231	SID 254	FAIL 07	Cellular Phone
CGU 206	SID 254	FAIL 07	Central Gateway
RAD 221	SID 254	FAIL 07	Radio
SAT 181	SID 254	FAIL 07	Satellite Communications
CHS 216	SID 254	FAIL 07	SAM Chassis
SBU 232	SID 254	FAIL 07	Seat Belt Unit (SPACE/Airbag system)
SDU 236	SID 254	FAIL 07	Step Deployment Unit, Driver Side (not used)
SDU 237	SID 254	FAIL 07	Step Deployment Unit, Passenger Side (not used)
SFU 164	SID 254	FAIL 07	Modular Switch Field

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J1587 Fault Codes

ICU4 J1587 Datalink Roll Call Faults			
Message	SID	FMI	System Not Responding to Roll Call
SYS ###	SID 254	FAIL 07	Generic (system not defined in this table)
TCU 130	SID 254	FAIL 07	Transmission Control Unit
TSU 223	SID 254	FAIL 07	Transmission Shift Unit

Table 6, ICU4 J1587 Datalink Roll Call Faults

704 — ICU4M J1587 Datalink Roll Call Faults

ICU4M J1587 Datalink Roll Call Faults	
Fault	System not Responding to Roll Call
128s254 07	Engine Control Module 1
130s254 07	Transmission Control Unit
136s254 07	Antilock Brake System (ABS)
162s254 07	Navigation
171s254 07	Engine Display
173s254 07	Retarder, Engine
175s254 07	Engine Control Module 2
164s254 07	Modular Switch Field (MSF)
181s254 07	Satellite Communications (Qualcomm)
190s254 07	Air Conditioning Protection Unit
206s254 07	Central Gateway
216s254 07	SAM Chassis
219s254 07	Collision Detection Unit (VORAD)
221s254 07	Radio
223s254 07	Transmission Shift Unit
231s254 07	Cellular Phone
232s254 07	Seat Belt Unit (SPACE/Airbag system)
236s254 07	Step Deployment Unit, Driver Side (not used)
237s254 07	Step Deployment Unit, Passenger Side (not used)
249s254 07	SAM Cab

Table 7, ICU4M J1587 Datalink Roll Call Faults

J1939 Fault Codes

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500 — Terms and Abbreviations

CAN—Controller Area Network

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

MID—Message Identifier. Indicates numeric assignment for a device that communicates on J1587.

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

This subject contains a master list of all known possible J1939 faults for the Cascadia. For engine faults (SA 0), refer to the engine manufacturer's diagnostic tools and documentation.

Fault codes appearing on either the ICU or ServiceLink J1587 fault screens must be verified as faults from a J1939 ECU, and not a "routed fault." A routed fault is a fault that the Central Gateway routed from another protocol to the ICU or the J1939 fault screen.

502 — Routed Faults

The Central Gateway (CGW) routes and translates messages between the J1939, J1708, Cabin CAN, and Diagnostic CAN datalinks.

To verify whether a J1939 fault is routed, perform one of the following steps:

- Use **Table 1** to confirm that the ECU MID is for an ECU that is physically connected to J1939.
- Connect to ServiceLink. In ServiceLink, routed faults appear in grey text. Select a different protocol until ECU faults appear in black text. Seeing a fault in ServiceLink's J1939 fault screen in black text verifies that the fault is from a J1939 ECU, and verifies that J1939 is the correct protocol to view for troubleshooting that fault or ECU.

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J1939 Fault Codes

The CGW has the following wiring connections:

- Each datalink on the vehicle: J1708, J1939, Cabin CAN, and Diagnostic CAN.
- On the Diagnostic CAN, the CGW has a direct connection to the diagnostic connector.
- On the Cabin CAN, the CGW is directly connected to the starpoint connector.

The CGW has the following main functions:

- Routes and translates messages between datalinks.
- Interfaces between off-board tools and Cabin CAN ECUs.
- Provides faults for any missing Cabin CAN ECUs.

In some cases, the Cabin CAN ECUs need information from J1939 or J1708 ECUs. Information sent by the J1939 or J1708 ECU is picked up by the CGW and passed to the appropriate Cabin CAN ECU. The reverse occurs when a J1939 or J1708 ECU needs information from a CAN ECU.

Routing Active CAN Faults

If a CAN ECU generates an active fault, the CGW will route up to one active fault for that ECU on to J1939 and J1708 for display on the instrument cluster (ICU) message center, which does not have a direct connection to CAN. This is to alert the driver that the ECU has an active fault.

NOTE: On the Cascadia, the ICU4M simply reads the faults on the datalink and will display 2 messages (a J1708 and a J1939) for the same fault, since the fault is transmitted on both the J1708 and J1939 datalink.

When a CAN ECU generates an active fault:

- J1939 displays up to one active fault for that CAN ECU under the J1939 source address for that CAN ECU. SAM Cab, for example, is SA 33. Accurate SPN and FMI information for that fault is also displayed.
- J1708 displays up to one active fault for that CAN ECU under the MID for that CAN ECU. SAM Cab, for example, is MID 249. Accurate SID/PID or FMI information is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

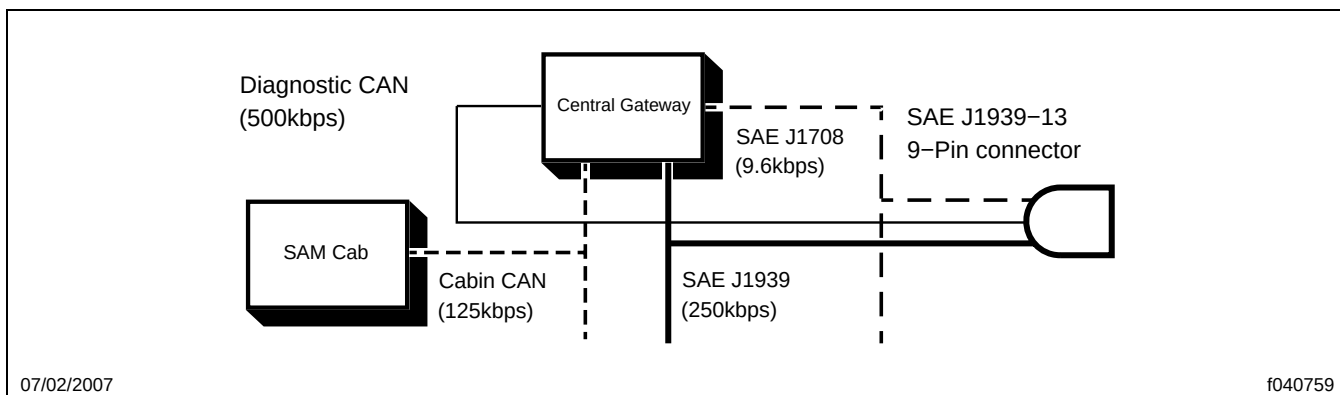


Fig. 1, Central Gateway, Diagnostic Connector, and Vehicle Datalinks

J1939 Fault Codes

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Routing Active J1939 Faults

If a J1939 ECU generates an active fault, the CGW will route up to one active fault for that ECU onto J1708, for display on the instrument cluster (ICU) message center. This is to alert the driver that the ECU has an active fault, especially if the ICU has a J1708 connection only. When a J1939 ECU generates an active fault, there may be up to one active fault on J1708 for that CAN ECU under the MID for that CAN ECU. HVAC Front Control Unit, for example, is MID 146. Accurate information for SID/PID or FMI is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

For more information regarding message routing behavior by the CGW, refer to **G02.03 – Central Gateway**.

503 — ECU Identification on Datalinks

The information in **Table 1** identifies which ECU is reporting the fault, and which datalink protocol to load in ServiceLink to get accurate fault information for troubleshooting that ECU.

NOTE: Items in parenthesis indicate a routed message from an ECU that is not physically connected, but reported by the CGW.

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
SAM Cab	33	(33)	(249)	—
SAM Chassis	71	(71)	(216)	—
Modular Switch Field (MSF)	49	(49)	(164)	—
Central Gateway (CGW)	37	(37)	(206)	—
Engine Control 1	—	0	128	—
Engine Control 2	—	1	175	—
Transmission	—	3	130	—
ABS	—	11	136	—
Retarder, Engine	—	15	173	—
Instrument Cluster	—	23*	140	—
Navigation	—	28	162	—
Engine Display	—	40	171	—
HVAC, Front	—	25	(146)	CGW reporting MID 146; there is no physical J1708 connection.
HVAC, Rear	—	58	(200)	CGW reporting MID 200; there is no physical J1708 connection.
Radio	—	76	(221)	CGW reporting MID 221; there is no physical J1708 connection.
Collision Warning	—	42	(219)	CGW reporting MID 219; there is no physical J1708 connection.
Qualcomm	—	75	181	—

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J1939 Fault Codes

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
Lane Guidance	—	232	—	—
Front Airbag Sensor	—	—	232	—
Roll Sensor Module	—	—	254	—

* ICU4M Only.

Table 1, ECU Identification on Datalinks

The following examples demonstrate how to diagnose faults using **Table 1**.

- J1708 Fault: MID 146, SID 254, FMI 03
 - MID 146 is the Front HVAC.
 - The Front HVAC is diagnosed using J1939.
 - Load the J1939 fault screen in ServiceLink for diagnostic information.
- J1939 Fault: SA 49, SPN 168, FMI 03
 - SA 49 is the Modular Switch Field (MSF).
 - The MSF is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 216, SID 254, FMI 14
 - MID 216 is the SAM Chassis.
 - The SAM Chassis is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 136, SID 123, FMI 02
 - MID 136 is the ABS module.
 - The ABS is diagnosed using the J1708 protocol.
 - Load the J1708 fault screen in ServiceLink for diagnostic information.

504 — J1939 Failure Mode Identifiers

Failure Mode Identifiers (FMIs)	
FMI	Description
00	Data valid but above normal operational range—Most severe level.
01	Data valid but below normal operational range—Most severe level.
02	Data erratic, intermittent, or incorrect.
03	Voltage above normal, or shorted high.
04	Voltage below normal, or shorted low.
05	Current below normal, or open circuit.

J1939 Fault Codes

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Failure Mode Identifiers (FMIs)	
FMI	Description
06	Current above normal, or grounded circuit.
07	Mechanical system not responding, or out of adjustment.
08	Abnormal frequency, pulse width, or period.
09	Abnormal update rate.
10	Abnormal rate of change.
11	Root cause not known.
12	Bad intelligent device or component.
13	Out of Calibration.
14	Special Instructions.
15	Data valid but above normal operational range—Least severe level.
16	Data valid but above normal operational range—Moderately severe level.
17	Data valid but below normal operational range—Least severe level.
18	Data valid but below normal operational range—Moderately severe level.
19	Received network data in error.
20-30	Reserved for future assignment by SAE.
31	Condition exists.

Table 2, Failure Mode Identifiers (FMIs)

505 — ICU4M J1939 Datalink Roll Call Faults

The ICU4M is programmed to learn several ECMs on the J1708 datalink. See **Table 3**. The ICU4M also learns and detects 2 ECUs on the J1939 datalink for roll call. These ECUs are the MSF (SA 49) and the Collision Warning System (VORAD - SA 42). Since the MSF is required to read faults, there is no way of displaying a roll call fault for SA 49.

The ICU4M expects to detect these "learned" ECUs and the engine ECM on roll call at every subsequent power up. If the ICU does not detect an expected ECU on roll call, it reports the fault on the display. These faults are not displayed in ServiceLink. Typical ICU4M J1939 roll call faults are displayed as "SA – SPN 639 FMI 7", and J1708 faults are displayed as "MID s254 FMI 07". As with any fault reported on the ICU4M, the entire fault is shown on a single screen. All J1939 datalink roll call faults have a SPN 639 and FMI 7, and J1708 faults have SID 254 and FMI 07.

For more information on roll call faults, refer to **C01.02 — ICU4/ICU4M**.

J1708 Display Message	
Device	Display Message
Engine	ENG Controller NoRESP 128s254 07
Transmission	Trans Controller NoRESP 130s254 07
ABS	Brake Controller NoRESP 136s254 07

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J1939 Fault Codes

J1708 Display Message	
Device	Display Message
ACPU	A/C Controller NoRESP 190s254 07
SAM Chassis	CHASS Controller NoRESP 216s254 07
Transmission Shift Unit	TSU Controller NoRESP 223s254 07
Cellular	Phone Controller NoRESP 231s254 07
SPACE	SPACE Controller NoRESP 232s254 07
SDU 1	STEP1 Controller NoRESP 236s254 07
SDU 2	STEP2 Controller NoRESP 237s254 07
SAM Cab	SAM Controller NoRESP 249s254 07

Table 3, J1708 Display Message

J1939 Display Message	
Device	Display Message
MSF	SA 49*
Collision Warning System	Radar SA42 SPN000639 J1939 Network 07

* SA 49 roll call error cannot be displayed; a functional J1939 MSF message is required to navigate to the diagnostic errors.

Table 4, J1939 Display Message

506 — Related Subjects

- G02.02 — Datalink Communication Structure
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.01 — Datalink, J1587/J1708
- G03.02 — Datalink, J1939
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN
- C01.02 — ICU4/ICU4M

J1939 Fault Codes

G04.02

700 — J1939 Fault Codes

NOTE: Refer to **C07.09 — Collision Warning System** for more information.

J1939 Fault Codes			
SA	SPN	FMI	Fault Description
25	70	09	Parking brake switch status message – abnormal update rate.
25	84	09	Vehicle speed – abnormal update rate.
25	110	09	Engine coolant temperature message – abnormal update rate.
25	158	03	FCU – voltage above normal.
25	158	04	FCU – voltage below normal.
25	168	09	SAM Cab battery voltage message – abnormal update rate.
25	171	09	Ambient air temperature – abnormal update rate.
25	190	09	Engine speed message – abnormal update rate.
25	629	12	FCU – bad intelligent device or component.
25	639	02	J1939 Datalink, intermittent or incorrect data.
25	876	01	A/C Clutch – protection mode (voltage too low).
25	876	02	A/C Clutch – data erratic, intermittent, or incorrect.
25	876	09	A/C Clutch – abnormal update rate.
25	876	11	A/C Clutch – root cause not known.
25	1547	04	Evaporator sensor-short to ground.
25	1547	05	Evaporator sensor short to battery, or open circuit.
25	1548	04	COTC sensor short to ground.
25	1548	05	COTC Sensor short to battery, or open circuit.
25	522510	0	High pressure sensor – data valid, but above normal operating range.
25	522510	01	High pressure sensor – data valid, but below normal operating range.
25	522510	02	High pressure sensor – data erratic, intermittent, or incorrect.
25	522510	09	High pressure sensor – abnormal update rate.
25	522510	11	High pressure sensor – root cause not known.
25	523307	09	Low air pressure switch status message – abnormal update rate.
25	523315	04	Stepper motor voltage supply driver – voltage below normal, shorted to low source or open circuit.
25	523318	02	Blower motor protection mode (voltage out of range).
25	523318	06	Blower motor protection mode (overcurrent or thermal protection).

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J1939 Fault Codes

J1939 Fault Codes			
SA	SPN	FMI	Fault Description
25	523318	07	Blower motor protection mode (speed mismatch or blocked rotor).
25	523329	02	Defrost door actuator data mismatch.
25	523329	03	Vehicle speed – abnormal update rate.
25	523329	04	Defrost door actuator, voltage below normal, open circuit.
25	523330	02	Blend door actuator, data mismatch.
25	523330	03	Blend door actuator, voltage above normal, or shorted to battery.
25	523330	04	Blend door actuator, voltage below normal, open circuit.
25	523331	02	Recirc door actuator, data mismatch.
25	523331	03	Recirc door actuator, voltage above normal, or shorted to battery.
25	523331	04	Recirc door actuator, voltage below normal, open circuit.
25	523332	02	Floor door actuator, data mismatch.
25	523332	03	Floor door actuator, voltage above normal, or shorted to battery.
25	523332	04	Floor door actuator, voltage below normal, open circuit.
42	639	02	One or more required messages missing from datalink.
42	639	09	No messages being received from the datalink.
42	639	13	Device cannot claim source address on datalink.
42	639	19	Messages received with incorrect data or marked as error.
42	886	07	FLR misaligned.
42	886	12	FLR internally defective.
42	886	13	FLR not configured properly
42	886	14	FLR blocked
42	898	13	Engine not configured for SmartCruise operation.
42	898	14	Engine not supported for SmartCruise operation
42	1563	13	VS-400 component detects incompatibility issue with other VS-400 devices.
58	158	03	ACU – voltage above normal.
58	158	04	ACU – voltage below normal.
58	609	12	ACU – bad intelligent device or component.
58	639	02	J1939 Datalink, intermittent or incorrect data.
58	1548	04	COTC sensor, short to ground.
58	1548	05	COTC sensor, short to battery or open circuit

J1939 Fault Codes

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J1939 Fault Codes			
SA	SPN	FMI	Fault Description
58	523315	04	Stepper motor voltage supply driver – voltage below normal, shorted to low source or open circuit.
58	523318	02	Blower motor, protection mode (voltage out of range).
58	523318	06	Blower motor, protection mode (overcurrent or thermal protection).
58	523318	07	Blower motor, protection mode (speed mismatch or blocked rotor).
58	523330	02	Blend door actuator, data mismatch.
58	523330	03	Blend door actuator, voltage above normal or shorted to battery.
58	523330	04	Blend door actuator, voltage below normal, open circuit.
76	520192	03	Left front speaker – short to BAT.
76	520192	04	Left front speaker – short to GND.
76	520192	05	Left front speaker – open circuit detected.
76	520192	06	Left front speaker – short circuit detected.
76	520193	03	Right front speaker – short to BAT.
76	520193	04	Right front speaker – short to GND.
76	520193	05	Right front speaker – open circuit detected.
76	520193	06	Right front speaker – short circuit detected.
76	520194	03	Left rear speaker – short to BAT.
76	520194	04	Left rear speaker – short to GND.
76	520194	05	Left rear speaker – open circuit detected.
76	520194	06	Left rear speaker – short circuit detected.
76	520195	03	Right rear speaker – short to BAT.
76	520195	04	Right rear speaker – short to GND.
76	520195	05	Right rear speaker – open circuit detected.
76	520195	06	Right rear speaker – short circuit detected.
76	520196	14	Radio Display Fault.
76	520197	14	Stuck Radio Button(s).
76	520199	14	Generic Radio Fault.
76	520200	14	CD Mechanism.
140	639	2	One or more required messages missing from datalink.
140	639	9	No messages being received from the datalink.
140	639	13	Device cannot claim source address on datalink.
140	639	19	Messages received with incorrect data or marked as error.

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J1939 Fault Codes

J1939 Fault Codes			
SA	SPN	FMI	Fault Description
140	893	12	DIU internally defective.
140	1563	13	VS-400 component detects incompatibility issue with other VS-400 devices.
140	1703	03	External right speaker shorted high.
140	1703	04	External right speaker shorted low.
140	1703	05	External right speaker open.
140	1704	03	External left speaker shorted high.
140	1704	04	External left speaker shorted low.
140	1704	05	External left speaker open.

Table 5, J1939 Fault Codes

NOTE: Refer to engine manufacturer documentation or diagnostic software for engine faults.

ICU4M J1939 Roll Call Faults	
Fault	Fault Description
SA25 SPN639 F19	Front HVAC
SA42 SPN639 F19	Collision Warning System (VORAD)
SA49 SPN639 F19	Modular Switch Field (MSF)
SA58 SPN639 F19	Rear HVAC

Table 6, ICU4M J1939 Roll Call Faults

NOTE: Refer to **C01.02 — ICU4/ICU4M** for roll call messages.

CAN Fault Codes

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500 — Terms and Abbreviations

CAN—Controller Area Network

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MID—Message Identifier

MSF—Modular Switch Field

Off-board tool—Typically refers to a PC-based application that communicates with the vehicle datalinks via a connection to the diagnostic connector.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SID—Subsystem Identifier

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

This subject contains a master list of all known CAN faults for the Cascadia. The CAN fault screen on ServiceLink is the only reliable place to find CAN fault information.

Fault codes appearing on either the ICU or ServiceLink J1939/J1708 fault screens must be verified as faults from a J1939 or J1708 ECU, and not a "routed fault". A routed fault is a fault that the Central Gateway routed from another protocol to the ICU or the J1939 and J1708 fault screen.

502 — Routed Faults

The Central Gateway (CGW) routes and translates messages between the J1939, J1708, Cabin CAN, and Diagnostic CAN datalinks.

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CAN Fault Codes

To verify whether a J1939 or J1708 fault is routed, perform one of the following steps:

- Use **Table 1** to confirm that the ECU MID is for an ECU that is physically connected to J1939 or J1708.
- Connect to ServiceLink. In ServiceLink, routed faults appear in grey text. Select a different protocol until ECU faults appear in black text. Seeing a fault in ServiceLink's J1939 or J1708 fault screen in black text verifies that the fault is from a J1939 or J1708 ECU respectively, and verifies that current protocol selected is the correct protocol to view for troubleshooting that fault or ECU.

The CGW has the following wiring connections:

- Each datalink on the vehicle (J1708, J1939, Cabin CAN, and Diagnostic CAN).
- On the Diagnostic CAN, the CGW has a direct connection to the diagnostic connector.
- On the Cabin CAN, the CGW is directly connected to the starpoint connector.

The CGW has the following main functions:

- Routes and translates messages between datalinks.
- Interfaces between off-board tools and Cabin CAN ECUs.
- Provides faults for any missing Cabin CAN ECUs.

In some cases, the Cabin CAN ECUs need information from J1939 or J1708 ECUs. Information sent by the J1939 or J1708 ECU is picked up by the CGW and passed to the appropriate Cabin CAN ECU. The reverse occurs when a J1939 or J1708 ECU needs information from a CAN ECU.

Routing Active CAN Faults

If a CAN ECU generates an active fault, the CGW will route up to one active fault for that ECU on to J1939 or J1708, for display on the instrument cluster (ICU) message center, which does not have a direct connection to CAN. This is to alert the driver that the ECU has an active fault.

When a CAN ECU generates an active fault:

- J1939 displays up to one active fault for that CAN ECU under the J1939 source address for that CAN ECU. SAM Cab, for example, is SA 33. Accurate SPN and FMI information for that fault is also displayed.
- J1708 displays up to one active fault for that CAN ECU under the MID for that CAN ECU. SAM Cab, for example, is MID 249. Accurate SID/PID or FMI information is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

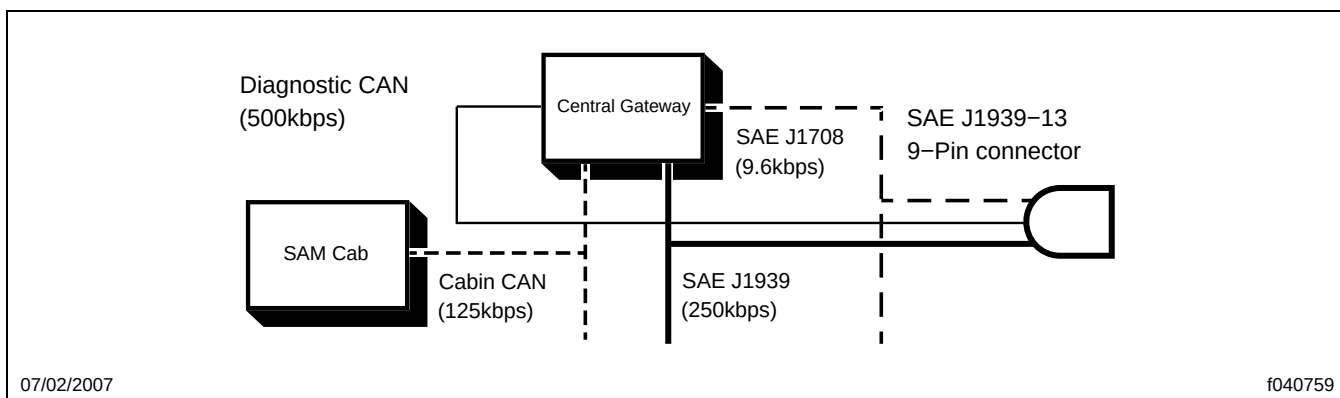


Fig. 1, Central Gateway, Diagnostic Connector, and Vehicle Datalinks

CAN Fault Codes

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Routing Active J1939 Faults

If a J1939 ECU generates an active fault, the CGW will route up to one active fault for that ECU on J1708, for display on the instrument cluster (ICU) message center. This alerts the driver that the ECU has an active fault, especially if the ICU has a J1708 connection only. When a J1939 ECU generates an active fault, there may be up to one active fault on J1708 for that CAN ECU under the MID for that CAN ECU. The HVAC front control unit, for example, is MID 146. Accurate information for SID/PID or FMI is not displayed for that fault. It appears under the generic SID of "254", and the FMI may or may not be accurate.

For more information regarding message routing behavior by the CGW, refer to **G02.03 – Central Gateway**.

503 — ECU Identification on Datalinks

The information in **Table 1** identifies which ECU is reporting the fault, and which datalink protocol to load in ServiceLink to get accurate fault information for troubleshooting that ECU.

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
SAM Cab	33*	(33)	(249)	—
SAM Chassis	71*	(71)	(216)	—
Modular Switch Field (MSF)	49*	(49)	(164)	—
Central Gateway (CGW)	37*	(37)	(206)	—
Engine Control 1	0†	0*	128*	—
Engine Control 2	1†	1*	175*	—
Transmission	3†	3*	130*	—
ABS	11†	11*	136*	—
Retarder, Engine	12†	12*	173	—
Instrument Cluster	23†	23†	140*	—
Navigation	28†	28*	162*	—
Engine Display	40†	40*	171*	—
HVAC, Front	25†	25*	(146)	CGW reporting MID 146; there is no physical J1708 connection.
HVAC, Rear	58†	58*	(200)	CGW reporting MID 200; there is no physical J1708 connection.
Radio	76†	76*	(221)	CGW reporting MID 221; there is no physical J1708 connection.
Collision Warning	42†	42*	(219)	CGW reporting MID 219; there is no physical J1708 connection.
Qualcomm	—	75*	181*	—
Lane Guidance	—	232*	—	—

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CAN Fault Codes

ECU Identification on Datalinks				
ECU Description	CAN ID	J1939 SA	J1587 MID	Comments
Front Airbag Sensor	—	—	232*	—
Roll Sensor Module	—	—	254*	—

* Physically connected to datalink, reported by actual ECU

† Not physically connected, and not reported by the CGW.

‡ ICU4M Only.

Table 1, ECU Identification on Datalinks

NOTE: Items in parenthesis indicate a message that is routed to the CGW from an ECU that is not physically connected to the CGW.

The following examples demonstrate how to identify and diagnose faults using **Table 1**.

- J1708 Fault: MID 146, SID 254, FMI 03
 - MID 146 is the Front HVAC.
 - The Front HVAC is diagnosed using J1939.
 - Load the J1939 fault screen in ServiceLink for diagnostic information.
- J1939 Fault: SA 49, SPN 168, FMI 03
 - SA 49 is the Modular Switch Field (MSF).
 - The MSF is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 216, SID 254, FMI 14
 - MID 216 is the SAM Chassis.
 - The SAM Chassis is diagnosed using the CAN protocol.
 - Load the CAN fault screen in ServiceLink for diagnostic information.
- J1708 Fault: MID 136, SID 123, FMI 02
 - MID 136 is the ABS module.
 - The ABS is diagnosed using the J1708 protocol.
 - Load the J1708 fault screen in ServiceLink for diagnostic information.

504 — ICU4M J1587 Datalink Roll Call Faults

The entire roll call fault on the ICU4M is displayed on a single screen. All J1587 datalink roll call faults have a SID 254 and FMI 07. Refer to **Table 2** for more information.

For more information on ICU4/ICU4M roll call faults, refer to **C01.02 — ICU4/ICU4M**.

CAN Fault Codes

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505 — Related Subjects

- G02.02 — Datalink Communication Structure
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.01 — Datalink, J1587/J1708
- G03.02 — Datalink, J1939
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN

700 — CAN Fault Codes

NOTE: Table 2 lists faults for the following ECUs:

- 33 — SAM Cab
- 37 — Central Gateway (CGW)
- 49 — Modular Switch Field (MSF)
- 71 — SAM Chassis

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	168	3	—	—	—	Electrical Potential (Voltage) – Voltage above normal, or shorted to high source.	P01.01 — Starting and Charging G02.04 — SAM Cab
33	168	4	—	—	—	Electrical Potential (Voltage) – Voltage below normal, or shorted to low source.	P01.01 — Starting and Charging P01.01 — Starting and Charging G02.04 — SAM Cab
33	520201	4	conn X2, pin 14 conn X1, pin 4 conn X1, pin 1	F25	R8	Fuse group 25 – Voltage below normal, or shorted to low source.	C07.09 — Collision Avoidance System G02.04 — SAM Cab
33	520203	4	conn X1, pin 3 conn X1, pin 6 conn X1, pin 9	F2	—	Fuse group 2 – Voltage below normal, or shorted to low source.	C02.01 — HVAC G02.04 — SAM Cab
33	520288	4	conn X2, pin 1	—	—	Auxiliary heater – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	520304	3	conn X2, pin 4	—	—	VCU/CPC, IGN – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab

G04.03

CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	520404	3	conn X3, pin 4	F17	R14	Advertising light, ACC – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	520404	4	conn X3, pin 4	—	—	Advertising light, ACC – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	520406	4	conn X3, pin 6	F26	R8	SRS airbag, IGN_X – Voltage below normal, or shorted to low source.	C07.08 — SRS System G02.04 — SAM Cab
33	520710	3	conn X3, pin 10 conn X6, pin 5 conn X6, pin 6 conn X6, pin 8 conn X6, pin 10 conn X6, pin 11	F23	R7	Fuse group 23 – Voltage above normal, or shorted to high source.	P01.01 — Starting and Charging G02.04 — SAM Cab
33	520710	4	conn X3, pin 10 conn X6, pin 5 conn X6, pin 6 conn X6, pin 8 conn X6, pin 10 conn X6, pin 11	F23	R7	Fuse group 23 – Voltage below normal, or shorted to low source.	P01.01 — Starting and Charging G02.04 — SAM Cab
33	520716	3	conn X1, pin 1 conn X1, pin 4 conn X2, pin 9 conn X2, pin 14 conn X3, pin 6 conn X6, pin 16	F24 ,F25	R8	Relay group 8 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab C01.01 — ICU3 C01.02 — ICU4/ICU4M Instrument Cluster C07.08 — SRS System C07.09 — Collision Warning System
33	520716	4	conn X6 pin 16 conn X2, pin 9	F24	R8	Fuse group 24 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab C01.01 — ICU3 C01.02 — ICU4/ICU4M Instrument Cluster
33	520905	3	conn X8, pin 5	—	—	Door open status – Voltage above normal, or shorted to high source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	520905	4	conn X8, pin 5	—	—	Door open status – Voltage below normal, or shorted to low source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	520908	3	conn X8, pin 8 conn X17, pin 2	F27, F28	R10	Mirror heating, driver and passenger – Voltage above normal, or shorted to high source.	C06.05 — Heated Mirrors G02.04 — SAM Cab
33	520908	4	conn X8, pin 8	F27	R10	Mirror heating, driver – Voltage below normal, or shorted to low source.	C06.05 — Heated Mirrors G02.04 — SAM Cab

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	520909	4	conn X8, pin 9	—	—	Door sill lamp, driver – Voltage below normal, or shorted to low source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	521003	3	conn X9, pin 3	—	—	Function pin 1 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521003	4	conn X9, pin 3	—	—	Function pin 1 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521004	3	conn X9, pin 4	—	—	Body builder connector: park brake – Voltage above normal, or shorted to high source.	H01.05 — Parking Brake Warning System G02.04 — SAM Cab
33	521004	4	conn X9, pin 4	—	—	Body builder connector: park brake – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521005	3	conn X9, pin 5	—	—	Function pin 2 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521005	4	conn X9, pin 5	—	—	Function pin 2 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521006	3	conn X9, pin 6	—	—	Function pin 4 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521006	4	conn X9, pin 6	—	—	Function pin 4 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521007	3	conn X9, pin 7	—	—	Function pin 3 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521007	4	conn X9, pin 7	—	—	Function pin 3 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521009	3	conn X9, pin 9	—	—	Body builder connector: backup lamp – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521010	3	conn X9, pin 10	—	—	Body builder connector: marker lights – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521011	3	conn X9, pin 11	—	—	Body builder connector: IGN_X – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521012	3	conn X9, pin 12	—	—	Body builder connector: tail lights – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521102	3	conn X10, pin 2	—	—	Mirror adjust switch supply, ACC – Voltage above normal, or shorted to high source.	C06.06 — Power Mirrors G02.04 — SAM Cab
33	521102	4	conn X10, pin 2	—	—	Mirror adjust switch supply, ACC – Voltage below normal, or shorted to low source.	C06.06 — Power Mirrors G02.04 — SAM Cab
33	521107	3	conn X10, pin 7	—	—	Service brake pressure switch – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521107	4	conn X10, pin 7	—	—	Service brake pressure switch – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521110	3	conn X20, pin 13	—	—	Ignition group 1 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521110	3	conn X10, pin 10	—	—	Ignition group 1 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521113	4	conn X10, pin 13	—	—	Panel lamps, 12 volt – Voltage below normal, or shorted to low source.	C05.03 — Panel Backlighting G02.04 — SAM Cab
33	521117	4	conn X10, pin 17	—	—	Wake-up (instrument cluster) – Voltage below normal, or shorted to low source.	C05.03 — Panel Backlighting G02.04 — SAM Cab
33	521202	3	conn X11, pin 2	—	—	Washer level, ICU indicator – Voltage above normal, or shorted to high source.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	521204	3	conn X11, pin 4	—	—	Fuel water separator ICU indicator – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521206	3	conn X11, pin 6	—	—	Low air pressure ICU indicator – Voltage above normal, or shorted to high source.	H01.04 — Low Air Pressure Warning G02.04 — SAM Cab

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521207	3	conn X11, pin 7	—	—	Lights ON buzzer – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521208	3	conn X11, pin 8	—	—	Air filter restriction ICU indicator – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521209	4	conn X11, pin 9	—	—	High beam ICU indicator – Voltage below normal, or shorted to low source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521211	4	conn X11, pin 11	—	—	Turn signal, left ICU indicator – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521212	3	conn X11, pin 12	—	—	Alternator, no charge ICU indicator – Voltage above normal, or shorted to high source.	P01.01 — Starting and Charging G02.04 — SAM Cab
33	521213	4	conn X11, pin 13	—	—	Turn signal, right ICU indicator – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521214	3	conn X11, pin 14	—	—	Park brake, ICU indicator – Voltage above normal, or shorted to high source.	H01.05 — Parking Brake Warning System G02.04 — SAM Cab
33	521220	2	conn X11, pin 20 conn X11, pin 17	—	—	Top and bottom-of-clutch switch – Data erratic.	P04.01 — Cruise Control G02.04 — SAM Cab
33	521220	3	conn X11, pin 20 conn X11, pin 17	—	—	Top and bottom-of-clutch switch – Voltage above normal, or shorted to high source.	P04.01 — Cruise Control G02.04 — SAM Cab
33	521303	4	conn X12, pin 3	—	—	Footwell lamp – Voltage below normal, or shorted to low source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	521306	4	conn X12, pin 6	—	—	Reading lamp 1, zone 9 – Voltage below normal, or shorted to low source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab
33	521309	4	conn X12, pin 9	—	—	General sleeper lamp, zone 4b – Voltage below normal, or shorted to low source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521312	3	conn X12, pin 12	—	—	Rear baggage compartment lights – Voltage above normal, or shorted to high source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab
33	521312	4	conn X12, pin 12	—	—	Rear baggage compartment lights – Voltage below normal, or shorted to low source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab
33	521315	3	conn X21, pin 11 conn X12, pin 15	—	—	Turn, left, front side – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521315	4	conn X21, pin 11 conn X12, pin 15	—	—	Turn, left, front side – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521316	4	conn X12, pin 16	—	—	Reading lamp 2, zone 5 – Voltage below normal, or shorted to low source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab
33	521317	4	conn X12, pin 17	—	—	Rear dome lamp, zone 4c – Voltage below normal, or shorted to low source.	C05.02 — Sleeper Lighting G02.04 — SAM Cab
33	521318	3	conn X12, pin 18 conn X20, pin 15	—	—	Turn, right, front side – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521318	4	conn X12, pin 18 conn X20, pin 15	—	—	Turn, right, front side – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521402	3	conn X13, pin 2	—	—	CAN low – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab G02.04 — SAM Cab
33	521403	4	conn X13, pin 3	—	—	CAN high – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521405	2	conn X13, pin 5	—	—	Ignition switch pins (ACC, Off, Ignition On, Crank) – Data erratic, intermittent or incorrect.	G02.04 — SAM Cab
33	521405	2	conn X13, pin 15	—	—	Ignition switch pins (ACC, Off, Ignition On, Crank) – Data erratic, intermittent or incorrect.	G02.04 — SAM Cab

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521405	2	conn X13, pin 4	—	—	Ignition switch pins (ACC, Off, Ignition On, Crank) – Data erratic, intermittent or incorrect.	G02.04 — SAM Cab
33	521405	2	conn X13, pin 6	—	—	Ignition switch pins (ACC, Off, Ignition On, Crank) – Data erratic, intermittent or incorrect.	G02.04 — SAM Cab
33	521407	6	conn X13, pin 7	—	—	Ignition switch, BAT – Current above normal, or grounded circuit.	G02.04 — SAM Cab
33	521411	3	conn X13, pin 10	—	—	Chopped group 5 – Voltage above normal, or shorted to high source.	H01.04 — Low Air Pressure Warning System G02.04 — SAM Cab
33	521411	3	conn X13, pin 11	—	—	Chopped group 5 – Voltage above normal, or shorted to high source.	H01.04 — Low Air Pressure Warning System G02.04 — SAM Cab
33	521411	3	conn X13, pin 8 conn X13, pin 9 conn X13, pin 10 conn X13, pin 11 conn X19, pin 13 conn X18, pin 11 conn X19, pin 14	—	—	Chopped group 5 – Voltage above normal, or shorted to high source.	H01.05 — Parking Brake Warning System H01.04 — Low Air Pressure Warning System G02.04 — SAM Cab
33	521411	4	conn X13, pin 8 conn X13, pin 9 conn X13, pin 10 conn X13, pin 11 conn X19, pin 13 conn X18, pin 11 conn X19, pin 14	—	—	Chopped group 5 – Voltage below normal, or shorted to low source.	H01.04 — Low Air Pressure Warning System H01.05 — Parking Brake Warning System G02.04 — SAM Cab
33	521502	4	conn X14, pin 2	F30	R11	12 V power receptacle 6 – Voltage below normal, or shorted to low source.	C06.08 — Cab Power Receptacles G02.04 — SAM Cab
33	521702	3	conn X16, pin 2	—	—	Lane guidance, IGN – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	521702	4	conn X16, pin 2	—	—	Lane guidance, IGN – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521704	3	conn X16, pin 4	—	—	Clearance lamps II – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521705	4	conn X16, pin 5	—	—	Auxillary circulation fan, windshield, ACC – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	521708	3	conn X16, pin 8	—	—	Clearance lamps I – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab
33	521711	4	conn X16, pin 11 conn X16, pin 14	—	—	Dome lamps, driver and passenger – Voltage below normal, or shorted to low source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	521802	4	conn X17, pin 2	F28	R10	Mirror heating passenger – Voltage below normal, or shorted to low source.	C06.05 — Heated Mirrors G02.04 — SAM Cab
33	521803	4	conn X17, pin 3	—	—	Door sill lamp, passenger – Voltage below normal, or shorted to low source.	C05.01 — Dome Lighting G02.04 — SAM Cab
33	521905	3	conn X18, pin 5	—	—	Low beam, left – Voltage above normal, or shorted to high source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521905	4	conn X18, pin 5	—	—	Low beam, left – Voltage below normal, or shorted to low source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521905	5	conn X18, pin 5	—	—	Low beam, left – Current below normal, or open circuit.	C04.02 — Headlight System G02.04 — SAM Cab
33	521906	3	conn X18, pin 6	—	—	High beam, left – Voltage above normal, or shorted to high source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521906	4	conn X18, pin 6	—	—	High beam, left – Voltage below normal, or shorted to low source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521906	5	conn X18, pin 6	—	—	High beam, left – Current below normal, or open circuit.	C04.02 — Headlight System G02.04 — SAM Cab
33	521908	3	conn X18, pin 8	—	—	Marker lamp, corner, front right – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521909	3	conn X18, pin 9	—	—	Turn, right, front corner – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521909	4	conn X18, pin 9	—	—	Turn, right, front corner – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521909	5	conn X18, pin 9	—	—	Turn, right, front corner – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521912	3	conn X18, pin 12	—	—	Marker lamp, front right – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab
33	521914	3	conn X18, pin 14	—	—	Marker lamp, corner, front left – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab
33	521916	3	conn X18, pin 16	—	—	Marker lamp, corner, front left – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.04 — SAM Cab
33	521917	3	conn X18, pin 17	—	—	High beam, right – Voltage above normal, or shorted to high source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521917	4	conn X18, pin 17	—	—	High beam, right – Voltage below normal, or shorted to low source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521917	5	conn X18, pin 17	—	—	High beam, right – Current below normal, or open circuit.	C04.02 — Headlight System G02.04 — SAM Cab
33	521919	3	conn X18, pin 19	—	—	Turn, left, front corner – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521919	4	conn X18, pin 19	—	—	Turn, left, front corner – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521919	5	conn X18, pin 19	—	—	Turn, left, front corner – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.04 — SAM Cab
33	521920	3	conn X18, pin 20	—	—	Low beam, right – Voltage above normal, or shorted to high source.	C04.02 — Headlight System G02.04 — SAM Cab

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	521920	4	conn X18, pin 20	—	—	Low beam, right – Voltage below normal, or shorted to low source.	C04.02 — Headlight System G02.04 — SAM Cab
33	521920	5	conn X18, pin 20	—	—	Low beam, right – Current below normal, or open circuit.	C04.02 — Headlight System G02.04 — SAM Cab
33	521921	3	conn X18, pin 21	—	—	Horn, electric – Voltage above normal, or shorted to high source.	C06.04 — Horn G02.04 — SAM Cab
33	521921	5	conn X18, pin 21	—	—	Horn, electric – Current below normal, or open circuit.	C06.04 — Horn G02.04 — SAM Cab
33	521921	6	conn X18, pin 21	—	—	Horn, electric – Current above normal, or grounded circuit.	C06.04 — Horn G02.04 — SAM Cab
33	522003	3	conn X19, pin 3	—	—	Starter relay 3 – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522003	4	conn X19, pin 3	—	—	Starter relay 3 – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522006	3	conn X19, pin 6	—	—	A/C Compressor clutch – Voltage above normal, or shorted to high source.	C02.01 — HVAC System G02.04 — SAM Cab
33	522006	4	conn X19, pin 6	—	—	A/C Compressor clutch – Voltage below normal, or shorted to low source.	C02.01 — HVAC System G02.04 — SAM Cab
33	522006	5	conn X19, pin 6	—	—	A/C Compressor clutch – Current below normal, or open circuit.	C02.01 — HVAC System G02.04 — SAM Cab
33	522010	2	conn X19, pin 10	—	—	HVAC pressure transducer, feedback – Data erratic, intermittent or incorrect.	C02.01 — HVAC System G02.04 — SAM Cab
33	522018	3	conn X19, pin 18	—	—	Engine ECU, IGN – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522108	3	conn X20, pin 8	—	—	Fog lamp, front left – Voltage above normal, or shorted to high source.	C04.06 — Fog Lights G02.04 — SAM Cab
33	522108	4	conn X20, pin 8	—	—	Fog lamp, front left – Voltage below normal, or shorted to low source.	C04.06 — Fog Lights G02.04 — SAM Cab

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	522108	5	conn X20, pin 8	—	—	Fog lamp, front left – Current below normal, or open circuit.	C04.06 — Fog Lights G02.04 — SAM Cab
33	522110	3	conn X20, pin 10	—	—	High beam, auxiliary left – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522110	4	conn X20, pin 10	—	—	High beam, auxiliary left – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522111	3	conn X20, pin 11	—	—	Low beam, auxiliary left – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522111	4	conn X20, pin 11	—	—	Low beam, auxiliary left – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522112	3	conn X20, pin 12	—	—	High beam, auxiliary right – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522112	4	conn X20, pin 12	—	—	High beam, auxiliary right – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522114	3	conn X20, pin 14	—	—	Low beam, auxiliary right – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522114	4	conn X20, pin 14	—	—	Low beam, auxiliary right – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522116	2	conn X20, pin 16	—	—	Temperature sensor, outside air, feedback – Data erratic, intermittent or incorrect.	C06.05 — Heated Mirrors G02.04 — SAM Cab
33	522117	3	conn X20, pin 17	—	—	Fog lamp, front right – Voltage above normal, or shorted to high source.	C04.06 — Fog Lights G02.04 — SAM Cab
33	522117	4	conn X20, pin 17	—	—	Fog lamp, front right – Voltage below normal, or shorted to low source.	C04.06 — Fog Lights G02.04 — SAM Cab
33	522117	5	conn X20, pin 17	—	—	Fog lamp, front right – Current below normal, or open circuit.	C04.06 — Fog Lights G02.04 — SAM Cab

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
33	522119	4	conn X20, pin 19	—	—	Distance sensor (adaptive cruise control), BAT – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522120	3	conn X20, pin 20	—	—	Washer pump – Voltage above normal, or shorted to high source.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522120	4	conn X20, pin 20	—	—	Washer pump – Voltage below normal, or shorted to low source.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522120	5	conn X20, pin 20	—	—	Washer pump – Current below normal, or open circuit.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522121	3	conn X20, pin 21	—	—	Washer fluid level sensor – Voltage above normal, or shorted to high source.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522209	2	conn X21, pin 9	—	—	Wiper parked – Data erratic, intermittent or incorrect.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522214	3	conn X21, pin 14 conn X3, pin 7	—	—	Utility light – Voltage above normal, or shorted to high source.	G02.04 — SAM Cab
33	522214	4	conn X21, pin 14 conn X3, pin 7	—	—	Utility light – Voltage below normal, or shorted to low source.	G02.04 — SAM Cab
33	522214	5	conn X21, pin 14 conn X3, pin 7	—	—	Utility light – Current below normal, or open circuit.	G02.04 — SAM Cab
33	522215	3	conn X21, pin 15 conn X21, pin 12	—	—	Wiper high, and wiper low – Voltage above normal, or shorted to high source.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	522215	6	conn X21, pin 15 conn X21, pin 12	—	—	Wiper high, and wiper low – Current above normal, or grounded circuit.	C06.01 — Windshield Wiper/Washer G02.04 — SAM Cab
33	524037	31	—	—	—	Lost communication with CGW.	G03.03 — Datalink, Cabin CAN
33	524049	31	—	—	—	Lost communication with MSF.	G03.03 — Datalink, Cabin CAN
33	524071	31	—	—	—	Lost communication with SAM Chassis.	G03.03 — Datalink, Cabin CAN
37	168	3	pin 1	—	—	Electrical potential (voltage) – voltage shorted above normal or shorted to high.	G02.03 — Central Gateway

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
37	168	4	pin 1	—	—	Electrical potential (voltage) – voltage shorted below normal or shorted to low.	G02.03 — Central Gateway
37	628	12	—	—	—	Program memory – Bad intelligent device or component.	G02.03 — Central Gateway
37	523510	31	pin 18, pin 23	—	—	Diagnostic CAN performance.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	523511	31	pin 14, pin 19	—	—	Cabin CAN performance.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	523512	31	pin 16, pin 21	—	—	J1939 CAN performance.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	523513	31	pin 2, pin 8	—	—	J1708 performance.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	524033	31	—	—	—	Lost communication with SAM Cab.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	524049	31	—	—	—	Lost communication with MSF.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
37	524071	31	—	—	—	Lost communication with SAM Chassis.	G02.03 — Central Gateway G03.03 — Datalink, Cabin CAN
49	168	3	conn D, pin 2	—	—	Electrical Potential (Voltage) – Voltage above normal, or shorted to high source.	C02.06 — Modular Switch Field
49	168	4	conn D, pin 2	—	—	Electrical Potential (Voltage) – Voltage below normal, or shorted to low source.	C02.06 — Modular Switch Field
49	520201	3	conn A, pin 2	—	—	Steering wheel switch, right – Voltage above normal or shorted to high source.	P04.01 — Cruise Control C02.06 — Modular Switch Field
49	520201	4	conn A, pin 2	—	—	Steering wheel switch, right – Voltage below normal or shorted to low source.	P04.01 — Cruise Control C02.06 — Modular Switch Field
49	520203	3	conn A, pin 1	—	—	Steering wheel switch, left – Voltage above normal or shorted to high source.	P04.01 — Cruise Control C02.06 — Modular Switch Field
49	520203	4	conn A, pin 1	—	—	Steering wheel switch, left – Voltage below normal or shorted to low source.	P04.01 — Cruise Control C02.06 — Modular Switch Field
49	520302	3	conn B, pin 2	—	—	Sub bus signal – Voltage above normal or shorted to high source.	C02.06 — Modular Switch Field

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
49	520302	4	conn B, pin 2	—	—	Sub bus signal – Voltage below normal or shorted to low source.	C02.06 — Modular Switch Field
49	520404	3	conn C, pin 4	—	—	Stalk switch flash – Voltage above normal or shorted to high source.	C04.02 — Headlight System C02.06 — Modular Switch Field
49	520404	5	conn C, pin 4 pin 8, 9, 14	—	—	Stalk switch interrupt – Current below normal, or open circuit.	C02.06 — Modular Switch Field
49	520405	3	conn C, pin 5	—	—	Stalk switch, high beam – Voltage above normal or shorted to high source.	C04.02 — Headlight System C02.06 — Modular Switch Field
49	520413	4	conn C, pin 15	—	—	Stalk switch, wiper, common – Voltage below normal or shorted to low source.	C02.06 — Modular Switch Field
49	520601	4	conn E, pin 1	—	—	Headlamp switch +12V Battery – Voltage below normal or shorted to low source.	C02.06 — Modular Switch Field
49	520607	4	conn A, pin 2 conn E, pin 7	—	—	Backlighting – Voltage below normal or shorted to low source.	C05.03 — Panel Backlighting C02.06 — Modular Switch Field
49	523511	31	conn D, pin 3 conn D, pin 5	—	—	Cabin CAN Performance.	C02.06 — Modular Switch Field
49	523530	31	—	—	—	Sub bus switch missing.	C02.06 — Modular Switch Field
49	523531	31	—	—	—	Extra Sub bus switch.	C02.06 — Modular Switch Field
49	523543	2	conn E, pin 2 conn E, pin 3 conn E, pin 4 conn E, pin 5	—	—	Headlamp switch inputs – Data erratic, intermittent, or incorrect.	C04.02 — Headlight System C02.06 — Modular Switch Field
49	524033	31	—	—	—	Lost communication with SAM Cab.	G03.03 — Datalink, Cabin CAN C02.06 — Modular Switch Field
49	524037	31	—	—	—	Lost communication with CGW.	G03.03 — Datalink, Cabin CAN C02.06 — Modular Switch Field
49	524071	31	—	—	—	Lost communication with SAM Chassis.	G03.03 — Datalink, Cabin CAN C02.06 — Modular Switch Field
71	168	3	—	—	—	Electrical potential (voltage) – Voltage above normal or shorted to high source.	P01.01 — Starting and Charging G02.05 — SAM Chassis
71	168	4	—	—	—	Electrical Potential (Voltage) – Voltage below normal, or shorted to low source.	P01.01 — Starting and Charging G02.05 — SAM Chassis

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	520201	3	conn X51, pin 1	—	—	CAN low – Voltage above normal, or shorted to high source.	G02.05 — SAM Chassis
71	520202	4	conn X51, pin 2	—	—	CAN high – Voltage below normal, or shorted to low source.	G02.05 — SAM Chassis
71	520301	3	conn X58, pin 13 conn X52, pin 1	—	—	Marker lamp, side right – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520301	4	conn X58, pin 13 conn X52, pin 1	—	—	Marker lamp, side right – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520301	5	conn X58, pin 13 conn X52, pin 1	—	—	Marker lamp, side right – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520302	4	conn X52, pin 6	F6	R3	Power feed ABS/BS, IGN – Voltage below normal, or shorted to low source.	H01.01 — ABS and Stability Control Systems G02.05 — SAM Chassis
71	520303	3	conn X52, pin 3	—	—	Marker lamp, corner rear, right – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520303	4	conn X52, pin 3	—	—	Marker lamp, corner rear, right – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520303	5	conn X52, pin 3	—	—	Marker lamp, corner rear, right – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520402	3	conn X53, pin 2	—	—	Marker lamp, corner rear, left – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520402	4	conn X53, pin 2	—	—	Marker lamp, corner rear, left – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520402	5	conn X53, pin 2	—	—	Marker lamp, corner rear, left – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520407	3	conn X53, pin 7	F8	R4	Trailer, turn lamp, right – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	520407	4	conn X53, pin 7	F8	R4	Trailer, turn lamp, right – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520409	3	conn X53, pin 9	F5	R2	Trailer, turn lamp, left – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520409	4	conn X53, pin 9	F5	R2	Trailer, turn lamp, left – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520501	3	conn X54, pin 1	F11	R6	Trailer, ABS connector (7), IGN – Voltage above normal, or shorted to high source.	H01.01 — ABS and Stability Control Systems G02.05 — SAM Chassis
71	520501	4	conn X54, pin 1	F11	R6	Trailer, ABS connector (7), IGN – Voltage below normal, or shorted to low source.	H01.01 — ABS and Stability Control Systems G02.05 — SAM Chassis
71	520602	3	conn X55, pin 2	F9	R5	Trailer, marker lamps – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520602	4	conn X55, pin 2	F9	R5	Trailer, marker lamps – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520603	3	conn X55, pin 3	F13	R9	Trailer, tail lamps – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520603	4	conn X55, pin 3	F13	R9	Trailer, tail lamps – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520604	3	conn X55, pin 4	F12	R7	Trailer, stop lamps – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520604	4	conn X55, pin 4	F12	R7	Trailer, stop lamps – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520702	3	conn X56, pin 2	—	—	End-of-frame primary trailer power, IGN – Voltage above normal, or shorted to high source.	C04.07 — Trailer Lights G02.05 — SAM Chassis

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	520707	4	conn X56, pin 7	—	—	End-of-frame primary trailer turn lamps, right – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520707	5	conn X56, pin 7	—	—	End-of-frame primary trailer turn lamps, right – Current below normal, or open circuit.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520710	4	conn X56, pin 10	—	—	End-of-frame primary trailer turn lamps, left – Voltage below normal, or shorted to low source.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520710	5	conn X56, pin 10	—	—	End-of-frame primary trailer turn lamps, left – Current below normal, or open circuit.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520713	5	conn X56, pin 13	—	—	End-of-frame primary trailer tail lamps – Current below normal, or open circuit.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520714	5	conn X56, pin 14	—	—	End-of-frame primary trailer stop lamps – Current below normal, or open circuit.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520715	5	conn X56, pin 15	—	—	End-of-frame primary trailer marker lamps – Current below normal, or open circuit.	C04.07 — Trailer Lights G02.05 — SAM Chassis
71	520801	3	conn X52, pin 6 conn X53, pin 3 conn X57, pin 1	F6, F7	R3	Relay group 3 – Voltage above normal, or shorted to high source.	H01.01 — ABS and Stability Control Systems G02.05 — SAM Chassis
71	520801	4	conn X53, pin 3 conn X57, pin 1	F7	R3	Fuse group 7 – Voltage below normal, or shorted to low source.	G02.05 — SAM Chassis
71	520804	3	conn X57, pin 4	—	—	Air dryer (pneumatic, electrically heated), ACC – Voltage above normal, or shorted to high source.	G02.05 — SAM Chassis
71	520804	4	conn X57, pin 4	—	—	Air dryer (pneumatic, electrically heated), ACC – Voltage below normal, or shorted to low source.	G02.05 — SAM Chassis
71	520815	3	conn X57, pin 15	F2	R1	Fuel water separator heater element – Voltage above normal, or shorted to high source.	G02.05 — SAM Chassis

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	520815	4	conn X57, pin 15	F2	R1	Fuel water separator heater element – Voltage below normal, or shorted to low source.	G02.05 — SAM Chassis
71	520901	3	conn X58, pin 1	—	—	Turn, right, rear lower – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520901	4	conn X58, pin 1	—	—	Turn, right, rear lower – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520901	5	conn X58, pin 1	—	—	Turn, right, rear lower – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520903	3	conn X58, pin 3	—	—	Tail lamp, right – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520903	4	conn X58, pin 3	—	—	Tail lamp, right – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520903	5	conn X58, pin 3	—	—	Tail lamp, right – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520910	3	conn X58, pin 10	—	—	Turn, left, rear lower – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520910	4	conn X58, pin 10	—	—	Turn, left, rear lower – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520910	5	conn X58, pin 10	—	—	Turn, left, rear lower – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520912	3	conn X58, pin 12	—	—	License plate lamp – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520912	4	conn X58, pin 12	—	—	License plate lamp – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520912	5	conn X58, pin 12	—	—	License plate lamp – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis

CAN Fault Codes

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	520916	3	conn X53, pin 1 conn X58, pin 16	—	—	Marker lamp, side, left – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520916	4	conn X53, pin 1 conn X58, pin 16	—	—	Marker lamp, side, left – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520916	5	conn X53, pin 1 conn X58, pin 16	—	—	Marker lamp, side, left – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520918	3	conn X58, pin 18	—	—	Tail lamp, left – Voltage above normal, or shorted to high source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520918	4	conn X58, pin 18	—	—	Tail lamp, left – Voltage below normal, or shorted to low source.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520918	5	conn X58, pin 18	—	—	Tail lamp, left – Current below normal, or open circuit.	C04.05 — Tail and Marker Lights G02.05 — SAM Chassis
71	520919	3	conn X58, pin 19	—	—	Backup lamp – Voltage above normal, or shorted to high source.	C07.01 — Backup Lamps and Alarm G02.05 — SAM Chassis
71	520919	4	conn X58, pin 19	—	—	Backup lamp – Voltage below normal, or shorted to low source.	C07.01 — Backup Lamps and Alarm G02.05 — SAM Chassis
71	520920	3	conn X58, pin 20	—	—	Stop lamp, right – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520920	4	conn X58, pin 20	—	—	Stop lamp, right – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520920	5	conn X58, pin 20	—	—	Stop lamp, right – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520921	3	conn X58, pin 21	—	—	Stop lamp, left – Voltage above normal, or shorted to high source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520921	4	conn X58, pin 21	—	—	Stop lamp, left – Voltage below normal, or shorted to low source.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	520921	5	conn X58, pin 21	—	—	Stop lamp, left – Current below normal, or open circuit.	C04.04 — Stop, Turn, and Hazard Lights G02.05 — SAM Chassis
71	521001	3	conn X59, pin 1 conn X59, pin 3	—	—	Backup switch – Voltage above normal, or shorted to high source.	C07.01 — Backup Lights and Alarm G02.05 — SAM Chassis

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CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Subject
71	521002	3	conn X59, pin 18 conn X59, pin 2	—	—	Transmission, neutral switch – Voltage above normal, or shorted to high source.	P02.02 — Manual Transmission P02.03 — Automatic Manual Transmission with SmartShift G02.05 — SAM Chassis
71	524033	31	—	—	—	Lost communication with SAM Cab.	G03.03 — Datalink, Cabin CAN G02.05 — SAM Chassis
71	524037	31	—	—	—	Lost communication with CGW.	G03.03 — Datalink, Cabin CAN G02.05 — SAM Chassis
71	524049	31	—	—	—	Lost communication with MSF.	G03.03 — Datalink, Cabin CAN G02.05 — SAM Chassis

Table 2, CAN Fault Codes

ICU3 Instrument Cluster

C01.01

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ICU3 Instrument Cluster

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ICU3 Instrument Cluster

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500 — Terms and Abbreviations

CEL—Check Engine Lamp

CGW—Central Gateway

DEF—Diesel Exhaust Fluid

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

LCD—Liquid Crystal Display

LED—Light Emitting Diode

MID—Message Identifier

MIL—Malfunction Indicator Lamp

MSF—Modular Switch Field

PID—Parameter Identifier

PWM—Pulse Width Modulation

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this electronic control unit (ECU) controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SFU—Switch Field Unit; see MSF.

SID—Subsystem Identifier

501 — General Information

The ICU3 instrument cluster is comprised of gauges, warning lights, indicator lights, a buzzer, and a driver display screen built into a single unit to provide the driver with engine and vehicle information. The ICU3 receives data through datalink messages, hard wire inputs, and air pressure inputs.

The ICU3 contains up to 8 individual gauges, and up to 6 additional satellite gauges. See **Fig. 1**. The ICU3 contains a message center with a liquid crystal display (LCD), driver display, and up to 28 warning and indicator lamps.

The ICU3 has no field changeable parameters, with the exception of those functions that can be set using the Mode/Reset button, and the display menus such as service intervals and odometer units.

NOTE: Begin troubleshooting the ICU3 with **701 — ICU3 Troubleshooting Procedures: Start Here** first. Failure to do so may result in an incorrect diagnosis.

502 — How to Identify the ICU3

The ICU3 instrument cluster is distinguished from other ICUs by two distinct features. The ICU3 houses the gauges and display in one integrated assembly. The tachometer dial has a 180 degree sweep while all other

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ICU3 Instrument Cluster

gauges have a 270 degree sweep. Some vehicles may have optional remote mounted gauges that are separate from the main ICU assembly.

503 — Main ICU Gauges

The speedometer, fuel level, engine coolant temperature, tachometer, primary and secondary air pressure, and engine oil pressure gauges are standard on all ICU3 configurations for the Cascadia. Vehicles may have additional optional gauges depending on the configuration.

The ICU3 receives data to drive most gauges from either J1587 datalink messages on vehicles built with EPA07 emissions, and over J1939 on EPA10 and later vehicles, from the engine control module (ECM) or from sensors wired directly to the ICU3. Air pressure gauges are connected directly to the air system they monitor. They are not controlled by the ICU directly, except for backlighting.

The ICU3 gauges sweep 270 degrees, except for the tachometer, which sweeps 180 degrees. ICU3 gauge pointers and backlighting are lit by light emitting diodes (LEDs).

The only serviceable part on the ICU3 is the air pressure gauge module, the nine top center indicator lamps, and the Mode/Reset switch.

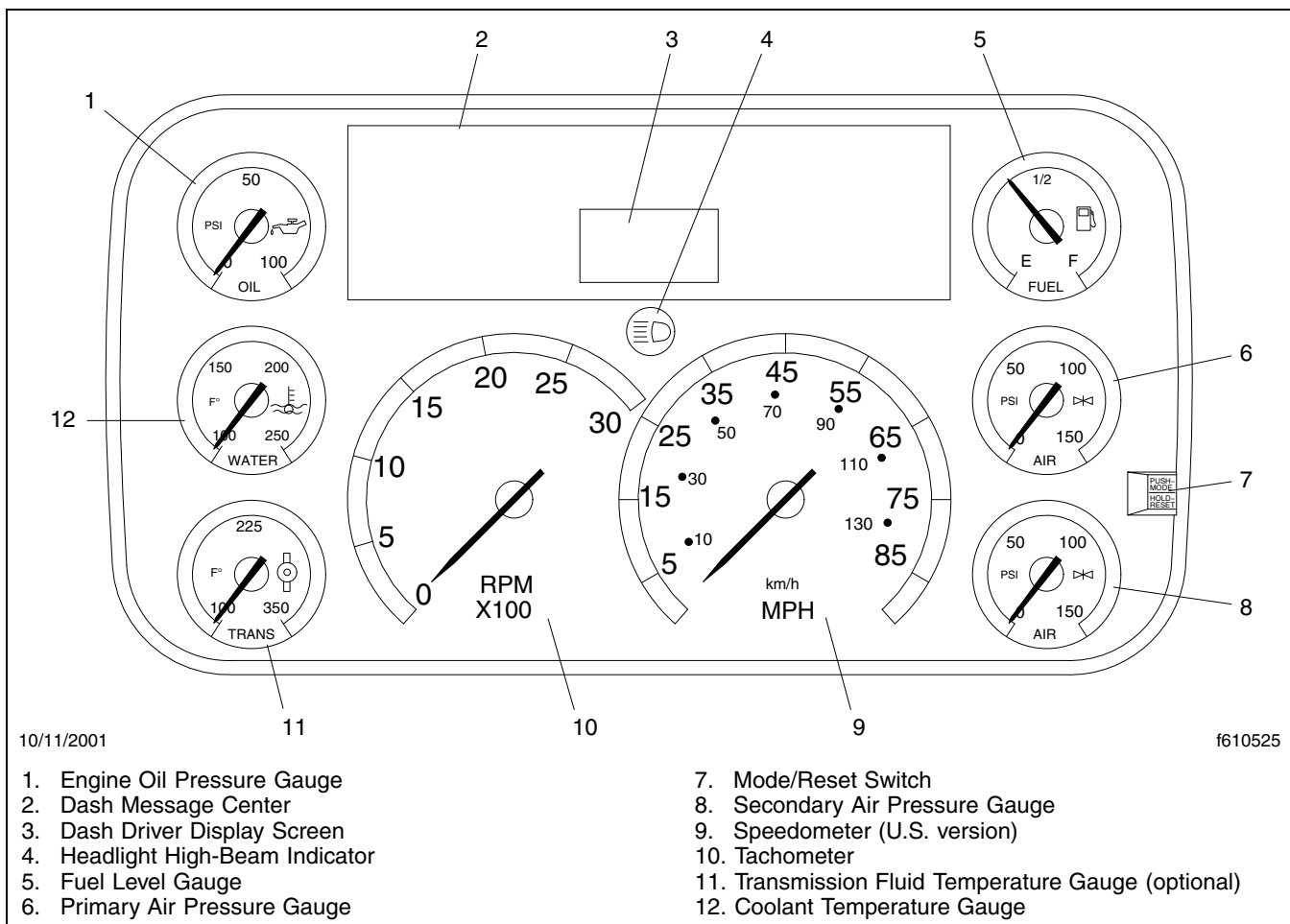


Fig. 1, Typical EPA07 ICU3 Instrument Cluster

504 — Remote-Mounted (Satellite) Gauges

The ICU3 can drive external satellite gauges connected to the proprietary datalink between the ICU3 and the satellite gauges. Four pins are used for this function: gauge power, gauge ground, data, and backlighting. Optional satellite gauges include engine oil temperature, turbo boost, pyrometer, forward-rear axle temperature, rear-rear axle temperature, application air, and suspension air pressure.

505 — ICU Self-Test

When the ignition key is turned on, the ICU3 begins a self-test. The following events occur:

- All ICU3 gauges (except air pressure gauges) sweep to full scale and return to their minimum position;
- The DEF indicator on EPA10 will illuminate all segments then turn them off one at a time before turning the left most segment amber then red;
- All display segments of the driver display screen turn on and then turn off;
- The buzzer sounds for three seconds;
- The battery voltage, low air pressure, low oil pressure, high coolant temperature, low fuel level, and parking brake warning lights come on and then go off (NOTE: others may also self check, but the self-check is not controlled by the ICU, but rather the device it is connected to.);
- The fasten seat belt warning light illuminates for 15 seconds. If the seat belt buckle is hardwired to the ICU, the ICU "learns" this configuration. With a hardwired seat belt buckle switch, the fasten seat belt warning light illuminates for 3 seconds at powerup or until the seat belt is fastened.

Failure of any gauge to sweep during the self-test, except air pressure gauges and the ammeter (satellite mounted), is an indication of a problem. See **701 — ICU3 Troubleshooting Procedures: Start Here** to troubleshoot.

506 — Warning and Indicator Lights

The ICU3 has 28 available warning and indicator light positions on the message center.

The top row of 9 warning and indicator lights are optional, each of which are replaceable. See **Fig. 2** for EPA07 and **Fig. 3** for EPA10 indicator light configurations.

The second, third, and fourth row of 18 standard warning and indicator lights are dedicated to certain fixed functions. There is also a high beam indicator located near the center of the ICU. These fixed-position warning and indicator lights are all non-replaceable LEDs.

See **709 — Indicator Diagnosis: Lamps in the ICU3** for a description of how each warning lamp position is controlled.

507 — Odometer

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either MI or KM, illuminates between the odometer and the volts display when the engine is running or the headlights are turned on. To toggle between MI (miles) or KM (kilometers), press the Mode/Reset button while in the SELECT screen.

The odometer is a seven-digit display with a decimal point until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer rolls over to "1000000" without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

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ICU3 Instrument Cluster

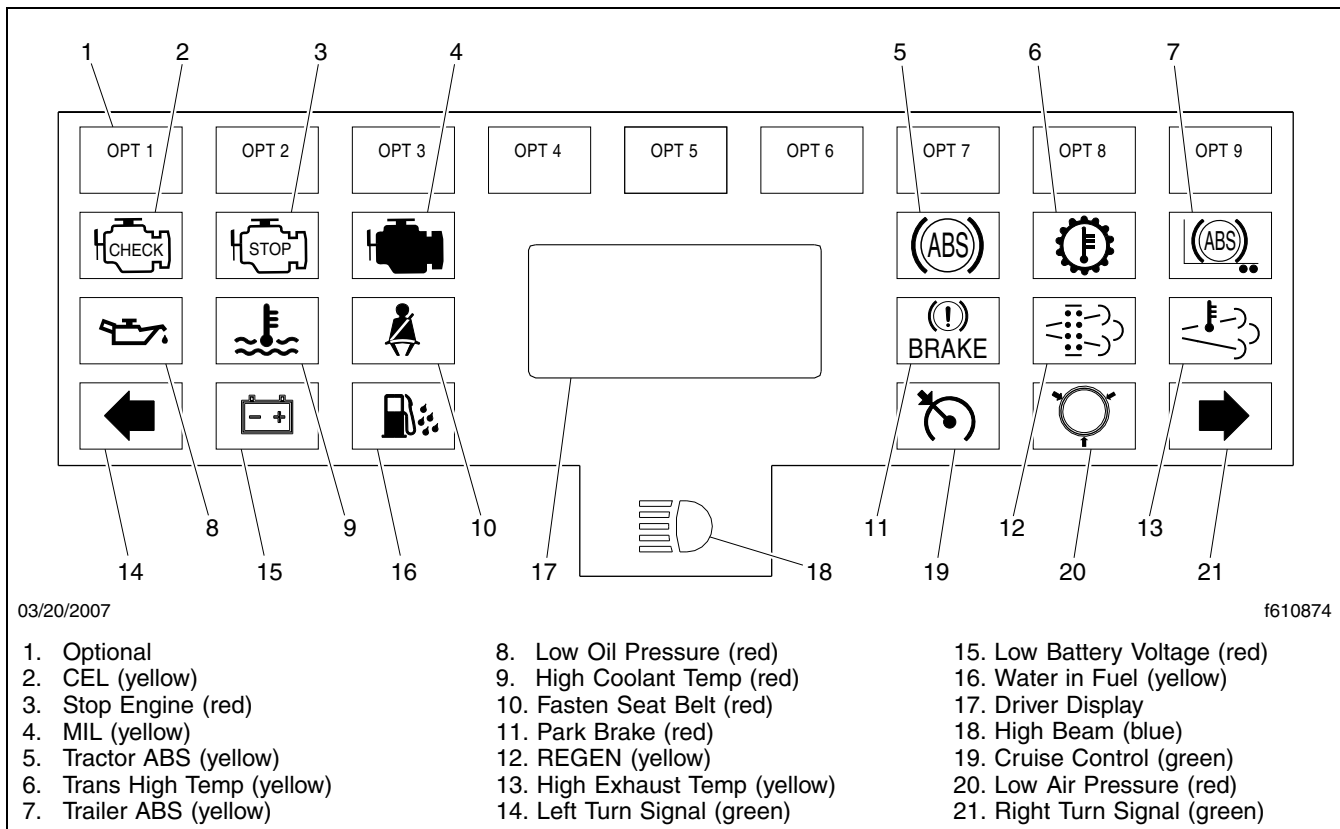


Fig. 2, EPA07 ICU3 Message Center (typical)

The ICU compares odometer data received from the engine controller to its own stored value. It will only alter its stored value if the difference is less than 2 miles. When the ICU is replaced, the odometer display will start from zero even though the engine controller odometer may be a much larger value.

IMPORTANT: Although the odometer uses data supplied by the engine control module (ECM) to update its count, it keeps its own mileage starting from zero, when it was first installed. The ICU odometer may not match the engine ECU odometer. This may occur if the engine has been operated with the ICU disconnected; it also may occur during factory break-in, engine service, or if the ICU has been replaced.

The odometer can be displayed with the ignition off by turning on the headlights.

508 — Mode/Reset Switch

The integral Mode/Reset switch is used to access the display trip screens, miles/kilometers select screens, engine screens, fault code screens, and service interval screens. The switch has two functions: mode switch (momentary push or press), and reset switch (press and hold). The mode reset/switch has the same functionality as the steering wheel "+/-" switch, with the exception that the Mode/Reset switch can only scroll forward through the driver display menus.

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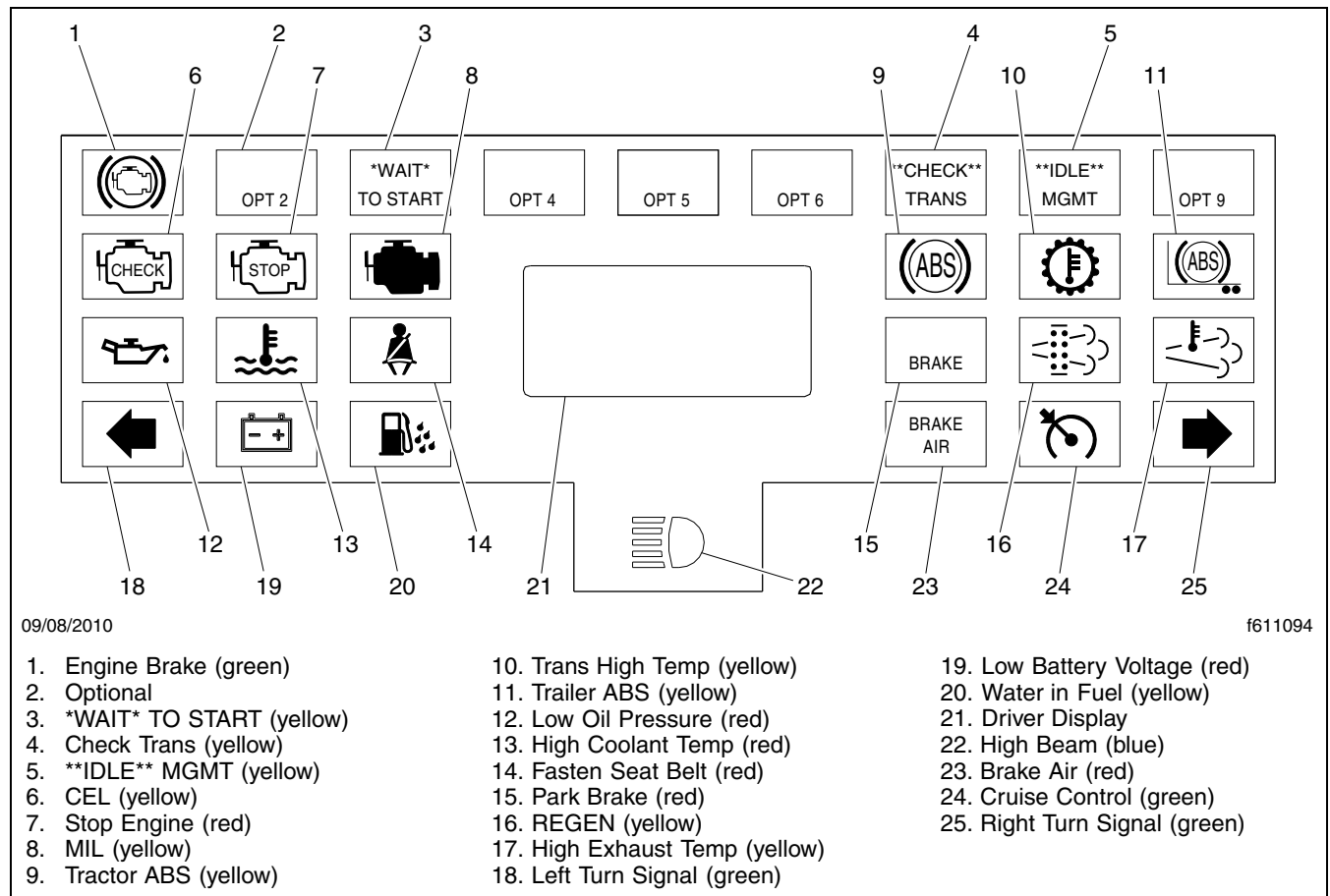


Fig. 3, EPA10 ICU3 Message Center (typical)

509 — "+/-" Switch, Steering Wheel

The steering wheel "+/-" switch is used to access the display trip screens, miles/kilometers select screens, engine screens, fault code screens, and service interval screens. The switch has two functions: mode switch (momentary push or press of the + or – switch), and reset switch (press and hold the + switch). The steering wheel "+/-" switch has the same functionality as the Mode/Reset switch, with the exception that the steering wheel switch can scroll both forward and backward through the driver display screen menus. The Mode/Reset switch only allows forward menu scrolling.

The steering wheel "+/-" switch is wired to the Modular Switch Field (MSF). The MSF transmits the switch status to the Central Gateway (CGW) via CAN datalink. The CGW broadcasts the "+/-" switch status to the ICU3 through the J1587 datalink on EPA07 vehicles, and over J1939 on EPA10 vehicles.

510 — Buzzer

A buzzer sounds during the self-test at start-up, and when the following conditions exist:

- low oil pressure
- high coolant temperature
- low air pressure

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- parking brake is set and the vehicle is moving at a speed greater than 2 mph (3 km/h)
- system voltage is less than 11.9 volts
- an optional circuit connected to pin B12 will activate the buzzer when it is connected to ground.

See **Table 10** in **709 — Indicator Diagnosis: Lamps in the ICU3**, for how the buzzer is controlled in each condition listed above.

511 — Friendly Chime

The friendly chime sounds when the door is open and:

- the parking brake is not set
- the headlights are turned on

On EPA10 vehicles with the hard-wired seat belt switch option, if the seat belt is not latched and the parking brake is released, the chime will sound for 10 seconds.

The friendly chime will sound with the ignition switch either on or off.

512 — Dash Backlighting (panel lamps)

The dash backlighting is controlled by the MSF though the SAM Cab. The SAM Cab provides a pulse width modulation signal to the ICU to control backlighting intensity. This PWM signal is at 400Hz.

513 — Power and Ground Circuits

The battery and ignition inputs must be between 9 and 16V for the ICU to function properly. The ignition circuit draw is 1.6A maximum. The battery input current draw will be less than 3mA with the ignition off.

514 — Outside Air Temperature Screens

Outside air temperature is displayed on the ICU LCD (Driver Display) screen. If miles are selected, the temperature displays in Fahrenheit. If kilometers are selected, the temperature displays in Celsius.

Outside air temperature data is received over the serial data network. If the data is not received by the ICU3 for 60 seconds, it displays three hyphens "- - -" on the driver's display.

When the parking brake is off and the outside air temperature reaches 34°F (1°C) or lower, the ICU LCD warns the driver of possible icy road conditions by sounding the friendly chime and flashing the temperature on the display for 5 seconds, if this warning feature is enabled.

515 — Displaying Faults

The ICU3 will display fault codes that are present in another ECU on the vehicle databus to assist with troubleshooting. If an active fault is received by the ICU3 and the parking brake is set, the diagnostic message screen is displayed on the LCD display. If there are multiple faults, the diagnostic message screen displays the first fault message for three seconds and then the next fault for three seconds. The diagnostic message screen continues to alternate between the active faults until the parking brake is released. If the parking brake is on, then the display can sequence to additional diagnostic screens: "dIAG n", "CLEAR", and "FAULT n". Once the diagnostic message screen is present and the parking brake is set, pushing the Mode/Reset button once displays the "dIAG n" screen.

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If the parking brake is set and the display is sequenced to the "dIAG n" message, the current number of active faults is displayed. The "n" denotes the number of active faults.

The ICU3 can store a maximum of 12 active faults. When there are no active faults present, the display reads "dIAG 0" (n=0). See Subject 800 for additional information on fault code display.

EPA07

When showing the "FAULt n" or "noFAULt n" screen, pressing the Mode/Reset button momentarily displays the MID such as "AbS 136" (Roll Call fault displays "no ABS"). Pressing the button again displays the PID or SID, such as "SID 004". Pressing the button again displays the FMI, such as "FAIL 03".

The ICU3 can clear history faults of all ECUs on the J1587 datalink if the vehicle has less than 254 miles on it. This allows faults generated during manufacturing or aftermarket equipment installation to be cleared without connecting to Servicelink. When the "dIAG n" message is displayed, pressing the Mode/Reset button when the odometer mileage is less than 254 miles will sequence to the "CLEAR" screen. If the mileage is 254 or greater and the Mode/Reset button is pressed, the display returns to the odometer display.

EPA10

When showing the "FAULt n" or "noFAULt n" screen, pressing the button momentarily will display the source controller and address such as "AbS 11" (Roll Call fault displays "no ABS"), pressing the button again will display the SPN such as "SPN 639", and pressing the button again will display the FMI such as "FMI 07". For undefined sources the text will display "SYS XXX" where XXX is the source address.

600 — Component Locations

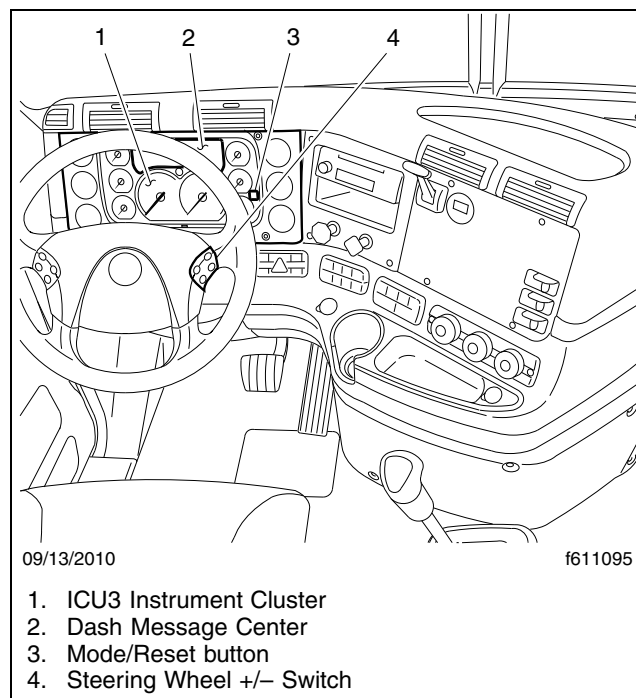


Fig. 4, Component Locations

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601 — Component Details

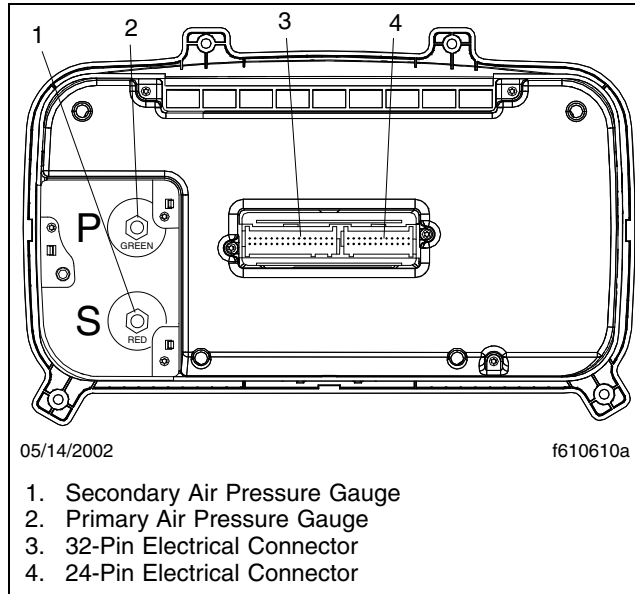


Fig. 5, ICU3 Connector Locations

Table 1 lists the pin locations for the 24-pin connector. **Table 2** lists the pin locations for the 32-pin connector.

24-Pin Connector			
Pin	Circuit Number	Wire Color	Circuit Description
A1	29A	BR	(+) Panel Backlighting (Pulse Width Modulation)
A2	—	—	Reserved
A3	18	R-W	Low Air Pressure Indicator/Buzzer—Ground-Deactivated
A4	—	—	High Trans Temp Indicator (in-gauge)—Ground-Activated
A5	492L	GY	High Exhaust Temperature—Ground-Activated
A6	—	—	Optional Indicator #2—Ground-Activated
A7	—	—	Optional Indicator #3—Ground-Activated
A8	—	—	Optional Indicator #4—Ground-Activated
A9	400	T	MIL Indicator—Ground-Activated
A10	42	LTG-W	(+) Forward Rear Axle Temperature Sensor
A11	42G	LTG-W	(-) Forward Rear Axle Temperature Sensor
A12	222A	LTG	High Beam Indicator—12V activated
B1	—	—	Optional Indicator #5—Ground-Activated
B2	43	LTG-W	(+) Rear Axle Temperature Sensor
B3	1587—	O	(-) J1587 Datalink (EPA07 vehicles)
B4	43G	LTG-W	(-) Rear Axle Temperature Sensor

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24-Pin Connector			
Pin	Circuit Number	Wire Color	Circuit Description
B5	—	—	Reserved
B6	—	—	Reserved
B7	—	—	Reserved
B8	—	—	Optional Indicator #6—Ground-Activated
B9	—	—	Reserved
B10	1587+	DKG	(+) J1587 Datalink (EPA07 vehicles)
B11	376L	O	Tractor ABS Indicator—Ground-Activated
B12	29G	LTG	Optional Buzzer Input—Ground-Activated

Table 1, 24-Pin Connector

32-Pin Connector			
Pin	Circuit Number	Wire Color	Circuit Description
C1	—	—	Optional Indicator #8—Ground-Activated
C2	—	—	Reserved
C3	—	—	Reserved
C4	437W	DKG	Optional 12V Input—Door Open
C5	125	R-W	Park Brake Indicator—Grounded Activated
C6	—	—	Gauge Driver Power (satellite gauges)
C7	—	—	Gauge Driver Ground (satellite gauges)
C8	38J	Y	Left Turn Indicator—12V Activated
C9	—	—	Water in Fuel Indicator—Ground-Activated
C10	492J	GY	Regen Indicator—Ground-Activated
C11	—	—	Optional Indicator #7, Ground-Activated
C12	30G	LTBL-W	(-) Transmission Oil Temperature Sensor
C13	30	LTBL-W	(+) Transmission Oil Temperature Sensor
C14	—	—	Optional Indicator #1—Ground-Activated
C15	440H	GY	Check Engine Light—Ground-Activated
C16	440A	GY	Stop Engine Light—Ground-Activated
D1	47	PK-W	(+) Fuel Level Sensor
D2	47G	PK-W	(-) Fuel Level Sensor
D3	GND	BK	(-) Panel Backlighting
D4	—	Y	Optional Indicator #9—12V-Activated
D5	—	—	J1939 (+) (EPA10 vehicles)
D6	—	—	Satellite Gauge Illumination (EPA10 vehicles)
D7	—	—	Satellite Gauge Drive Data - (EPA10 vehicles)
D8	38K	DKG	Right Turn Indicator—12V-Activated

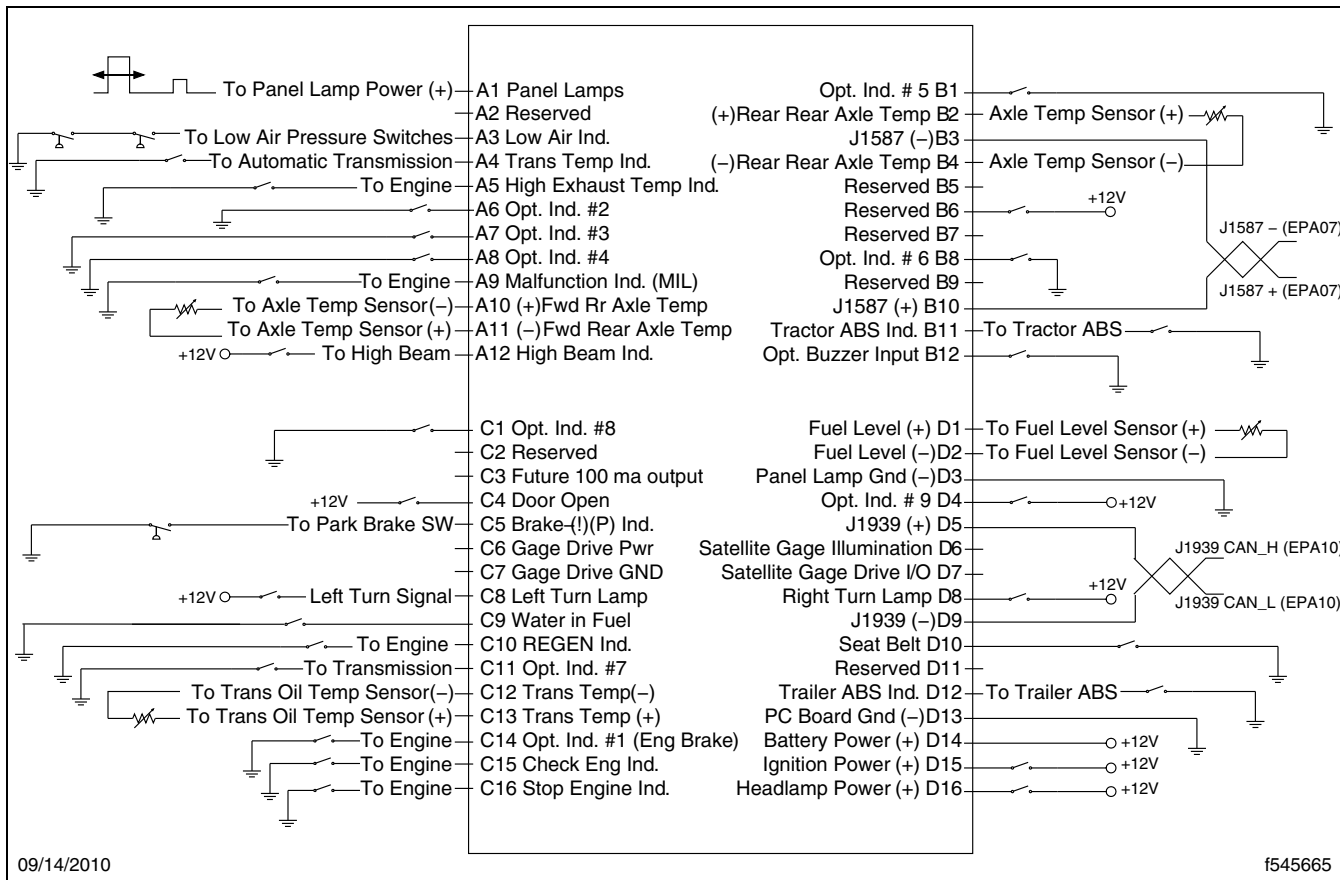
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32-Pin Connector			
Pin	Circuit Number	Wire Color	Circuit Description
D9	—	DKG	J1939 (-) (EPA10 vehicles)
D10	435	—	Optional Seat Belt Input - (EPA10 vehicles)
D11	—	—	Reserved
D12	376F1	O	Trailer ABS Indicator—Ground-Activated
D13	GND	BK-W	(-) ICU Ground
D14	339	DKG	(+) ICU 12V Battery Power
D15	339A	DKG	(+) ICU 12V Ignition Power
D16	359	LTG	(+) ICU 12V Headlight Power Input (ICU Wake Up)

Table 2, 32-Pin Connector

602 — ICU3 Interface Schematic

**Fig. 6, ICU3 Interface Schematic (2010 shown)**

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700 — Diagnostic Tools Required

- ServiceLink/Datalink Monitor
- Digital Multimeter

701 — ICU3 Troubleshooting Procedures: Start Here

Use **Table 3** to determine which procedure to use.

ICU3 Instrumentation Troubleshooting – Start Here		
Problem Type	Symptom	Procedure to Use
Fault Code	A fault code is displayed on the ICU3 display	702
	A Roll Call fault is present – Examples are "no ENG" or "no ABS"	702
	"nO DATA" is displayed on the LCD	702
	"nO J1939" is displayed on the LCD	702
	"- - - - -" (seven dashes) is displayed on the LCD	702
Gauges	Problem with the fuel gauge	706
	Problem with the DEF level indicator	703
	Problem with an air pressure gauge	705
	Problem with any other databus driven gauge	703
	Problem with an optional satellite gauge	708
	Problem with any other sensor driven gauge	704
Backlighting	Problem with backlighting in the ICU3	712
	Problem with backlighting in a remote gauge	712
Warning Indicators	Problem with an in-gauge indicator	710
	Problem with an indicator in the ICU3	709
	Problem with the DEF level indication	703
	Problem with the seat belt indicator	714
LCD Display	A segment of the LCD does not work	711
	The LCD is completely inoperative	711
Mode/Reset Button	The mode/reset button is sticking or does not change the display	713
+/- Steering Wheel Switch	The + or – switch does not interact with the display	See G02.06

Table 3, ICU3 Instrumentation Troubleshooting – Start Here

702 — ICU Fault Code Display

The ICU3 in both EPA07 and EPA10 vehicles will display fault codes that are broadcast from other devices on the databus. Use the following to determine if there is a problem with the ICU3, another device on the databus, a sensor that is connected to a device, or with the databus. Fault codes that are generated by the ICU3 can be read using ServiceLink.

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Some memory errors with the ICU3 will cause the LCD to display "- - - - -" (seven dashes). A fault code may be active and can be read using ServiceLink. This display indicates an electronics failure with the ICU3. Replace the ICU3.

Some errors with the ambient air temperature sensor will cause the LCD to display "- - - F" (or "- - - C"). This indicates an error with the data the ICU3 is receiving from the SAM cab for ambient air temperature. Troubleshoot the sensor using the procedure in Section G04.02, Subject 700. EPA 2010 vehicles can be configured to use ambient air temperature data from the sensor on the front bumper that is connected to the SAM cab or from the engine controller. Use ServiceLink to determine which sensor the SAM cab is configured to broadcast.

Roll call faults occur when the ICU3 is not receiving data from a device that had been on the databus in the past. If a device has been removed from the vehicle (Qualcom for example), perform the resetEE procedure from the ICU3 setup menu. See Subject 802 for the resetEE procedure.

When the display shows "no ENG" or "no ABS" or any other roll call fault, troubleshoot for the cause of the device going off line. Subject 800 provides troubleshooting aids for roll call faults.

EPA07 ICU3 J1587/J1708 Fault Codes MID 140 (ICU)			
SID/PID	FMI	Description	Behavior
P168	1	Low System Voltage	The vehicle voltage measured by the ICU is less than 10.5 volts.
ACTION: Troubleshoot the vehicle charging system. Test the alternator for voltage drop in the alternator cables and battery cables. If the vehicle is equipped with a remote sense circuit to the alternator, check the fuse for circuit 123E.			
S240	12	EEPROM Memory Fault	The ICU has an internal memory fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the ICU.			
S254	12	Internal Electronics Fault	The ICU microprocessor or other internal critical electronics has a fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the ICU.			

Table 4, EPA07 ICU3 J1587/J1708 Fault Codes MID 140 (ICU)

ICU3 J1939 Fault Codes SA 23 (ICU)				
SPN	FMI	Conn/Pin	Description	Behavior
96	5	D1 + D2 -	Fuel Level Circuit Open	The resistance between pins D1 and D2 is greater than 298 ohms. The gauge will point to empty.
ACTION: Use the troubleshooting procedure in 706 beginning at step 4.				
96	6	D1 + D2 -	Fuel Level Circuit Short	The resistance between pins D1 and D2 is less than 23.5 ohms. The gauge will point to empty.
ACTION: Disconnect the fuel level sensor connector at the sending unit. Turn the ignition on and check the fault code display. If the fault code for fuel level circuit short (FMI 6) is still active, locate and repair the short in circuit 47 between the light bar control unit (LBCU) and the fuel level sender. Otherwise use the troubleshooting procedure in 706 beginning at step 5.				
168	1	n/a	Low Voltage	The ICU is measuring a system voltage of less than 12.0 volts.
ACTION: Troubleshoot the charging system and test the battery cables for voltage drop.				
177	6	C12 - C13 +	Transmission Temp Sensor Short	The resistance between pins C12 and C13 is less than 70 ohms. The gauge will point full scale.
ACTION: Troubleshoot for a shorted transmission temperature sensor and for a short to ground in circuit 30.				

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ICU3 J1939 Fault Codes SA 23 (ICU)				
SPN	FMI	Conn/Pin	Description	Behavior
628	12	n/a	ICU Internal Memory Fault	The ICU has an internal memory fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the ICU.				
629	12	n/a	ICU Internal Electronics Fault	The ICU microprocessor or other internal critical electronics has a fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the ICU.				
639	7	n/a	Roll Call Fault	Any other J1939 device that the ICU expects on the network but is not broadcasting will generate a fault code. The source address will be of the device that the ICU is not receiving messages from. Note that this is actually an ICU generated fault code.
ACTION: If a device has been removed from the vehicle or if a used ICU is installed a roll call reset must be performed. Use the "rESEt EE" Screen in the setup menu. If a J1939 device is not broadcasting due to an error, use the troubleshooting procedure for that device to determine the cause of it going off-line.				
2567	0	n/a	Excessive Broadcast Announce Messages (BAM)	Another device on the J1939 databus is transmitting an excessive number of fault messages that are intended for the ICU.
ACTION: Use ServiceLink or scroll through the fault codes that the ICU3 displays to determine which controller has many fault codes. Use the appropriate troubleshooting procedures for that controller to repair its system.				

Table 5, ICU3 J1939 Fault Codes SA 23 (ICU)

703 — Gauge Diagnosis: Start Here

Table 6 defines how each individual gauge, standard or optional, is controlled. Some gauges are J1587 datalink-driven, meaning the information is sent to the instrument cluster from the engine ECM. Other gauges are controlled by a sensor wired directly to the instrument cluster or an air line connected directly to the gauge.

Standard and Optional Gauges: Input Source to ICU3		
Gauge	EPA07 Input	EPA10 J1939 Input
Speedometer	J1587—from engine (MID 128 PID 84)	J1939 from Engine (SA 00 SPN 84)
Engine Coolant Temperature	J1587—from engine (MID 128 PID 110)	J1939 from Engine (SA 00 SPN 110)
Engine Oil Pressure	J1587—from engine (MID 128 PID 100)	J1939 from Engine (SA 00 SPN 100)
Fuel Level	Sensor connected to ICU	Sensor connected to ICU
DEF Level	N/A	J1939 from engine (SA 00 SPN 1761) or J1939 from ACM (SA 61 SPN 1761)
Low DEF Indicator	N/A	J1939 from engine (SA 00 SPN 5245) or J1939 from ACM (SA 61 SPN 5245)
Tachometer	J1587—from engine (MID 128 PID 190)	J1939 from Engine (SA 00 SPN 190)

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Standard and Optional Gauges: Input Source to ICU3		
Gauge	EPA07 Input	EPA10 J1939 Input
Transmission Oil Temperature	Manual, Eaton, and AGS - sensor connected to ICU Allison, and G transmissions - Data from transmission ECU	Manual, Eaton, and AGS - sensor connected to ICU Allison, and G transmissions - Data from transmission ECU SPN 177
Primary Air System Pressure	Air line connected to gauge	Air line connected to gauge
Secondary Air System Pressure	Air line connected to gauge	Air line connected to gauge
Forward Rear Axle Temp	Sensor connected to ICU	Sensor connected to ICU
Rear Axle Temp	Sensor connected to ICU	Sensor connected to ICU
Engine Oil Temperature	J1587—from engine (MID 128 PID 175)	J1939 from Engine (SA 00 SPN 175)
Turbo Boost Pressure	J1587datalink—from engine (MID 128 PID 439)	J1939 from Engine (SA 00 SPN 102)
Pyrometer	J1587—from engine (MID 128 PID 173)	J1939 from Engine (SA 00 SPN 3241)
Application Air Pressure	Air line connected to gauge	Air line connected to gauge
Suspension Air Pressure	Air line connected to gauge	Air line connected to gauge
Ammeter*	Not part of the ICU3	not part of the ICU3

* Ammeter is a stand-alone gauge that is not connected to the ICU3.

Table 6, Standard and Optional Gauges: Input Source to ICU3

1. Test gauge initialization.

- 1.1 Turn the ignition to ON without starting the engine.
- 1.2 Watch the gauge initialization.

All gauges except air pressure gauges should sweep in unison to full scale and back to zero before indicating the actual value.

The DEF indicator on EPA10 vehicles will illuminate all segments then once a second turn off the rightmost segment that is on. The last segment on the left will then turn amber, then red before the actual DEF level is indicated.

The air pressure gauges are mechanical and no initialization is possible except for them to display the actual pressure.

Do the gauges initialize as described above?

YES → Go to step 2.

NO → If the ICU is completely non responsive, troubleshoot for faults with battery power on pin D14, ignition power on pin D15, and the ground on pin D13. If there is no problem with these circuits, replace the ICU. If one or some of the gauges do not initialize as described above, replace the ICU.

2. Is the input source of the gauge with the problem datalink driven, sensor driven, or air pressure driven?

Use **Table 6** in Subject 703 to identify the gauge input source.

FUEL LEVEL → Go to Subject 706 Gauge Diagnosis: Fuel Level Gauge

DEF LEVEL → Go to Subject 707 Indicator Diagnosis: DEF Level

SENSOR DRIVEN → Go to Subject 704 Gauge Diagnosis: Sensor Driven Gauges

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AIR PRESSURE → Go to Subject 705 Gauge Diagnosis: Air Pressure Gauge

DATALINK DRIVEN → Continue with step 3

3. Confirm gauge accuracy with the Datalink monitor template.
 - 3.1 Connect ServiceLink and open the J1587 ICU3 Instrument Cluster template for EPA07 vehicles and the J1939 ICU3 Instrument Cluster template for EPA10 vehicles.
 - 3.2 Start the engine if the data is sourced from the engine.
 - 3.3 Make sure that operating conditions will register a reading on the gauge. For example, the engine temperature is above the minimum level on the gauge.

NOTE: A test drive may be necessary if diagnosing the speedometer.
 - 3.4 Monitor the affected gauge on both the ICU and on the template.

Do the readings closely match?

YES → Go to test 4.

NO → Replace the ICU.
4. Determine the problem with the data that drives the gauge.

The data that the ICU3 receives from the source device is not valid. Refer to the troubleshooting instructions for the source device. For example, if the engine coolant temperature is not indicating, use the troubleshooting material from the engine manufacturer. If the problem is with the speedometer, it may be necessary to drive the vehicle with another vehicle pacing to note the speed, or monitor the ABS wheel speed sensors using Meritor Toolbox. Verify the parameters are correct for axle ratio and tire size.

704 — Gauge Diagnosis: Sensor Driven Gauges

1. If the gauge did not initialize correctly as described in Subject 703 step 1, replace the ICU3.

Is the gauge reading inaccurate or completely at full scale or at zero?

INACCURATE → Go to test 2.

FULL SCALE or ZERO → There may also be an active fault code for the circuit. This may indicate a problem with the wiring or the sensor. Use **Table 1** and **Table 2** in Subject 601 to identify the circuit number and connection for the sensor. Troubleshoot the sensor and wiring for short and open circuits. Repair the wiring or replace the sensor as necessary.
2. Test the accuracy of the sensor using the resistance values shown in Subject 804.
 - 2.1 Measure the resistance of the sensor and compare it with the value shown in appropriate table for the temperature.
 - 2.2 Place the sensor in a container of water with a thermometer and heat to a temperature where the resistance can be accurately measured with an ohm meter.

Does the resistance measurement match the reading for the temperature?

NO → Replace the sensor.

YES → Leaving the sensor disconnected, disconnect the connectors from the ICU and measure the resistance of the circuits to the sensor. Locate and repair a partial shorted or open circuit in the sensor wiring.

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705 — Gauge Diagnosis: Air Pressure Gauge

1. Identify which pressure gauge is not operating properly.

Primary or Secondary → Go to test 2.

Application → Go to test 3.

Suspension or Axle Lift → Go to test 4.

2. **Verify the accuracy of the primary/secondary gauges.**

2.1 Drain the air tanks.

2.2 Connect an accurate pressure gauge to the primary or secondary air tank, depending on which gauge is being diagnosed.

2.3 Start the engine and build air pressure until the compressor cuts out.

Is the air pressure gauge in the cluster within 11 psi (76 kPa) of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks and pinches. If OK, replace the air pressure gauge module.

3. **Verify the accuracy of the application air gauge.**

3.1 Connect an accurate pressure gauge to the delivery port on the foot valve.

3.2 Make a 90 psi brake application while observing the application air pressure gauge and the test gauge.

Is the application air pressure gauge within 11 psi (76 kPa) of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks and pinches. If OK, replace the application air pressure gauge.

4. **Verify the accuracy of the suspension air gauge.**

Connect an accurate pressure gauge to the air suspension. Is the air suspension gauge within 11 psi (76 kPa) of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks and pinches. If OK, replace the suspension air pressure gauge.

706 — Gauge Diagnosis: Fuel Level Gauge

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from $31\pm2\Omega$ with a full tank to $247\pm3\Omega$ when empty.

If the fuel level sender circuit is open or shorted to ground, there would be respectively more than 250 or less than 29Ω between circuit 47 and ground. A fault will be set and the gauge will read empty until the measurement from the sensor is between 250 and 29 ohms. Refer to **Table 16** for fuel level sensor resistance specifications.

1. If the gauge did not initialize correctly as described in Subject 703 step 1, replace the ICU3.

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2. If a 100 ohm resistor is available, disconnect the wiring harness connector at the fuel level sender and place the resistor across circuit 47 and ground in the connector. This will simulate the fuel level sending unit with about 1/2 tank of fuel. Turn the ignition to the ON position and observe the fuel gauge. If the gauge points closely to the 1/2 tank mark, then the wiring and ICU are all operating correctly. Go to step 5 if there is no problem with the wiring and ICU.

3. Check for active fault codes for fuel level circuit.

Is a fuel level fault code active, or does the gauge stay at empty even though there is fuel in the tank?

SHORT LOW → Troubleshoot for a wiring fault in circuit 47 between the fuel level sender and the ICU. Repair as appropriate.

OPEN CIRCUIT → Go to test 4.

NO → Go to test 5.

4. Determine if the problem is with the wiring or the sending unit.

4.1 Turn the ignition to OFF then disconnect the 2-wire connector at the fuel level sender.

4.2 Use a short jumper wire to short the two circuits at the fuel level sender connector together.

4.3 Turn the ignition to ON without starting the engine. Allow the gauges to sweep then check for fault codes.

Does the ICU show an active fault for fuel level sender shorted?

YES → The wiring indicates continuity, go to test 5.

NO → Troubleshoot and repair for an open circuit in the ground or circuit 47 between the fuel level sender and the ICU.

5. Test the sending unit.

5.1 Turn the ignition to OFF and disconnect the batteries.

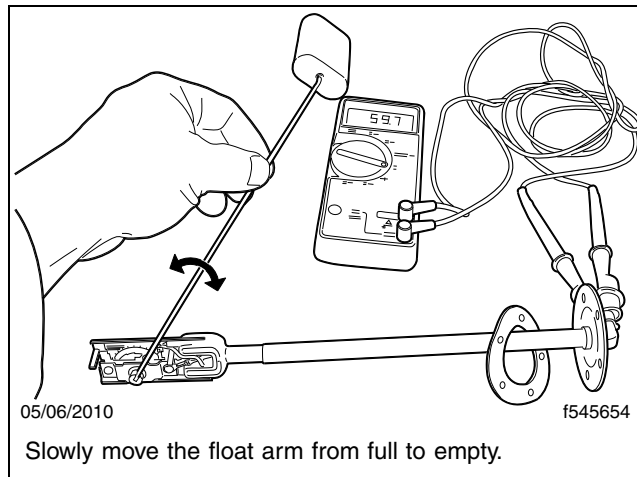
5.2 Remove the fuel sending unit from the fuel tank.

5.3 Connect an ohm meter to the pins at the fuel level sender connector. Slowly change the level of the float arm from full to empty. See **Fig. 7**.

Does the resistance vary linearly from $31\pm2\Omega$ to $247\pm3\Omega$?

YES → Check the connection at the fuel level sender for corrosion. Repair any defect found.

NO → Replace the fuel level sending unit.

**Fig. 7, Testing the Fuel Level Sending Unit**

707 — Indicator Diagnosis: DEF Level Indicator

The DEF level indicator is integrated into the fuel gauge, and uses J1939 data from the ACM. The DEF level is measured by a sealed non-contact variable-resistance sensing assembly located in the DEF tank. The DEF level sensor resistance can be measured at the tank connector. For Detroit Diesel engines, the level sensor signal uses pins 1 and 2. For Cummins engines, the level sensor uses pins 1 and 4.

On Detroit Diesel engines, when the DEF tank is empty, the sensor will measure approximately 240Ω . When full, it will measure approximately $19.8K\Omega$. On Cummins engines, when the DEF tank is empty, the sensor will measure approximately $4.8K\Omega$. When full, it will measure approximately 68Ω . Use the resistance to float height tables in subject 804 to test the resistance for a specific float height.

When there is no DEF in the tank or when there is a fault in the DEF level sensing circuit, the indicator will flash the red segment until the fault is corrected, or a sufficient amount of DEF is added to the tank. Perform the recommended action in **Table 7** to troubleshoot faults with the DEF level sensing circuitry indicated by fault codes with SPN 1761.

DEF Level Faults from SA 0 or SA 61				
SPN	FMI	Description	Behavior	Action
1761	1 17 18 31	DEF level low	The DEF level is low. MIL, CEL, STOP engine lamp, and engine derate may be active.	The DEF tank has run too low. Fill the DEF tank so that it is at least 25% full and idle the engine for 5 minutes. If the problem is still present use the DEF level diagnostic procedure below.
1761	3	DEF level circuit out of range high	The voltage on circuit 532F is greater than the ACM expects.	Troubleshoot circuits 532F and 532F- between the ACM and the temperature level sensor for a wiring fault and also for an open level sensor unit.
1761	4	DEF level circuit out of range low	The voltage on circuit 532F is close to 0 volts.	Troubleshoot circuit 532F between the ACM and the temperature level sensor for a wiring fault and also for a shorted level sensor unit.

Table 7, DEF Level Faults from SA 0 or SA 61

Diagnose the DEF level indicator as follows.

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1. Turn the ignition to on but do not start the engine. Does the DEF level indicator illuminate all segments green then turn them off beginning from the right one at a time until the left one becomes amber then red before either showing a mid range level, or flashing the left segment red?
YES → The DEF level indication display is working properly. Go to Step 2.
NO → Replace the ICU3.
2. Use Servicelink to check for any J1939 faults. Is there a fault for SPN 1761 with FMI 3 or 4 (DEF level sensor out of range) or are any J1939 communications fault codes active? NOTE: SPN 1761 FMI 1, 17, 18, or 31 indicate the DEF level is low. For these FMI's there is no wiring fault but there may be a problem with DEF level indication accuracy.
YES → If the code has FMI 4, troubleshoot for a wiring fault in circuit 532F between the DEF level sensor and the ACM. If the code has FMI 3, go to step 3. If there is a J1939 communications fault, use the troubleshooting information in this manual to locate and repair communications.
NO, or Accuracy Problem → Go to step 4.
3. Turn the ignition off then disconnect the 4 wire connector at the DEF level sender. Use a short jumper wire to short pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) together in the vehicle harness side of the connector. Turn the ignition on without starting the engine. Allow the indicator initialization sequence to complete, then check for fault codes. Is there an active fault for SPN 1761 FMI 4?
YES → The wiring indicates continuity. Go to step 4.
NO → Troubleshoot and repair for an open in circuit 532F and/or circuit 532F- between the DEF level sensor and the ACM.
4. Turn the ignition off and disconnect the batteries. Remove the temperature/level sender unit from the DEF tank. Connect an ohm meter to pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) at the 4 pin connector. Slowly raise the level of the float from empty to full. Record the resistance range measured. Does the vehicle have a Cummins or a DD engine?
Cummins → If the resistance did not vary from approximately 4.8K Ω at empty to 68 Ω at the full position replace the temperature/level sender unit
Detroit Diesel → If the resistance did not vary from approximately 240 Ω at empty to 19.68K Ω at the full position replace the temperature/level sender unit.

708 — Gauge Diagnosis: Satellite Gauges

The ICU3 is capable of controlling up to eight additional gauges located in the dash panels. These gauges are controlled by a databus with backlighting, power, and ground sourced by the ICU3. See **Table 8**.

Satellite Gauge Daisy Chain Circuits		
Connector/Pin	Name	Function
C6	Gauge Power	12 volt source for satellite gauges
C7	Gauge Ground	Ground supply for satellite gauges
D6	Illumination	Backlighting voltage source for satellite gauges
D7	Gauge Data	Databus to satellite gauges

Table 8, Satellite Gauge Daisy Chain Circuits

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Table 9 identifies the satellite gauges that may be used with the ICU3.

ICU3 Satellite Gauges	
Gauge	Input Source
Engine Oil Temperature	Data from the Engine Controller
Turbo Boost Pressure	Data from the Engine Controller
Pyrometer	Data from the Engine Controller
Forward Rear Axle Temperature	Sensor Connected to ICU
Rear Rear Axle Temperature	Sensor Connected to ICU
Application Air Pressure	Air Line Connected to Gauge
Suspension Air Pressure	Air Line Connected to Gauge
Axle Lift Pressure (Up to 4)	Air Line Connected to Gauge

Table 9, ICU3 Satellite Gauges

Satellite gauges that are sensor or data driven will initialize at power-on with the same sequence as described in Subject 703 step 1 for the gauges in the main ICU3. The air pressure gauges only use the backlighting power from the ICU3. If there is a short circuit in any of the satellite gauges of the interconnecting wiring harness, it is possible that none of the gauges will work.

1. Determine if the problem is with the data input to the ICU3 or if the gauge is defective, or if there is a problem with the circuitry driving the satellite gauges.

Turn the ignition to ON and observe the initialization sequence.

Do the gauges initialize as described in Subject 703 step 1?

YES → Go to test 2.

NO → Test the 4 wire satellite gauge circuits for the values shown in **Table 10**. Disconnect the satellite gauges one at a time to troubleshoot for a short in a gauge that could be taking the databus down. Check the 4 wire satellite gauge harness for short or open circuits.

2. Is the input source of the gauge with the problem datalink driven, sensor driven, or air pressure driven?

Use **Table 6** in Subject 703 to identify the gauge input source.

SENSOR DRIVEN → Go to Subject 704 Gauge Diagnosis: Sensor Driven Gauges.

AIR PRESSURE → Go to Subject 705 Gauge Diagnosis: Air Pressure Gauge.

DATALINK DRIVEN → Continue with step 3.

3. Confirm gauge accuracy with the Datalink monitor template.
 - 3.1 Connect ServiceLink and open the J1587 ICU3 Instrument Cluster template for EPA07 vehicles and the J1939 ICU3 Instrument Cluster template for EPA10 vehicles.
 - 3.2 Start the engine.
 - 3.3 Make sure that operating conditions will register a reading on the gauge. For example, the engine oil temperature is above the minimum level on the gauge.
 - 3.4 Monitor the affected gauge on both the ICU and on the template.

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Do the readings closely match?

YES → Go to test 4.

NO → Replace the gauge.

4. Determine the problem with the data that drives the gauge. The data that the ICU3 receives from the source device is not valid. Refer to the troubleshooting instructions for the source device. For example, if the engine oil temperature is not indicating, use the troubleshooting material from the engine manufacturer for the engine oil temperature sensing circuitry.

709 — Indicator Diagnosis: Lamps in the ICU3

Use **Table 10** to determine if an indicator lamp has a power-on bulb check and how it is activated.

The ICU3 does not set fault codes for lamps that are inoperative. If an indicator does not illuminate, use **Table 10** to determine the optimal troubleshooting method.

For data driven indicators, use ServiceLink to monitor the data for the indicator. If the ICU does not illuminate an indicator when ServiceLink shows that it is on, there is a problem with the indicator. The top row lamps are replaceable, for the others the ICU must be replaced.

For indicators that are hardwired, monitor the voltage at the ICU3 input pin. Use **Table 10** to correlate the status of the indicator with the voltage on the input pin. Troubleshoot the vehicle wiring harness or switch as necessary. Indicators with a power-on "bulb check" (even though they are LED's) are confirmed to work.

ICU3 Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
Left Turn Signal		NO	Lamp is ON when 12V is applied to the control pin.	C8	Beep sound when control pin is at 12V.
Right Turn Signal		NO	Lamp is ON when 12V is applied to the control pin.	D8	Beep sound when control pin is at 12V.
High Beam		NO	Lamp is ON when 12V is applied to the control pin.	A12	None.
Park Brake		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded over J1939 from the ABS Controller.	C5	Buzzer active when vehicle speed is greater than 2 MPH (Uses speed data from ABS).
Low Air Pressure		YES	Lamp is ON when the control pin is open circuit. Lamp is OFF when ground is applied to the control pin.	A3	Buzzer active whenever lamp is on.
Battery Voltage		YES	Lamp is ON when system voltage has been less than 12 volts for longer than 40 seconds. The message is broadcast by the engine controller.	Data	Buzzer active whenever lamp is on.

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ICU3 Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
Fasten Seat Belt		YES	If pin D10 is not hardwired to seat belt buckle, lamp is ON for 15 seconds at power up only. If pin D10 is hardwired, the bulb check is three seconds long and the lamp is OFF when ground is applied to the control pin (seat belt latched).	N/A or D10	Friendly Chime for 10 seconds when pin D10 is hardwired if park brake is off and seat belt is not latched.
Check Engine Lamp (CEL)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C15 and Data	None.
Malfunction Indicator Lamp (MIL)		YES	Lamp is ON when ground is applied to the control pin.	A9	None.
Stop Engine		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C16 and Data	None.
Tractor ABS		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the tractor ABS controller. The lamp will also be ON when the ICU3 is not receiving data from the ABS controller.	B11 and Data	None.
Trailer ABS		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the trailer ABS controller.	D12 and Data	None.
Cruise Control		YES	Lamp is ON when commanded by either the MSF (reading the steering wheel switches) or the engine controller. The lamp indicates that cruise control is enabled via the on/off switch and not that the vehicle is driving in cruise control mode.	Data	None.
DPF Regeneration (REGEN)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C10 and Data	None.
High Exhaust Temperature		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	A5 and Data	None.
Water In Fuel		NO	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the engine controller.	C9 and Data	None.
Low Oil Pressure		YES	Lamp is ON when commanded by the engine controller. The lamp will latch on for a minimum of 30 seconds.	Data	Buzzer is active when the lamp is on.
High Coolant Temperature		YES	Lamp is ON when commanded by the engine controller. The lamp will latch on for a minimum of 30 seconds.	Data	Buzzer is active when the lamp is on.

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ICU3 Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
High Transmission Temperature		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the transmission controller or the retarder.	A4 and Data	None.
Option 1 (Engine Brake)		YES	Lamp is ON when ground is applied to the control pin or lamp is ON when commanded by the MSF by reading the steering wheel switches.	C14 and Data	None.
Option 2	—	—	—	A6	None.
Option 3	—	—	—	A7	None.
Option 4	—	—	—	A8	None.
Option 5	—	—	—	B1	None.
Option 6	—	—	—	B8	None.
Option 7 (Check Transmission)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the transmission controller.	C11 and Data	None.
Option 8 (Idle Management)		NO	Lamp is ON when ground is applied to the control pin.	C1	None.
Option 9	—	—	—	D4	None.

Table 10, ICU3 Warning and Indicator Lamps

710 — Indicator Diagnosis: In-Gauge Warning Lamp

In-gauge lamps illuminate during power-on initialization, and when the data to the gauge indicates a fault or an out of normal range condition. An illuminated in-gauge lamp indicates that immediate attention is necessary.

ICU3 In-Gauge Warning Lamps			
Lamp	Bulb Check	Input Source	Activation
Low Fuel Level	YES	Fuel Level Sensor	When the fuel level is less than 1/8th of a tank the lamp will be ON. A 60 second delay applies to activation and deactivation unless ignition power is cycled and it will immediately indicate for the measured value.
Low DEF Level	YES	Data	When the DEF level is less than 15% of tank capacity, the low DEF light will be ON. When DEF level is less than 5% of tank capacity, the low DEF light will flash.

Table 11, ICU3 In-Gauge Warning Lamps

For data driven lamps, use ServiceLink to correlate the fault or fluid level condition. For the low-fuel-level lamp, allow for the 60 second delay when troubleshooting.

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711 — Diagnosis: LCD

1. Check the LCD and the LBCU for any activity. Does the ICU show any activity when the ignition is turned to ON, or is the LCD the only malfunctioning item?

LCD ONLY → Replace the ICU.

NO ACTIVITY FROM THE ENTIRE ICU → Go to test 2.

2. Check the power and ground to the ICU.

Troubleshoot for faults with battery power-on pin D14, ignition power-on pin D15, and the ground on pin D13. If there is no problem with these circuits, replace the ICU.

3. Troubleshoot for the LCD illuminating with ignition turned to OFF and headlamps on.

When the headlamps are on, battery voltage is sourced to the ICU on circuit number 359 pin D16. This voltage will turn the LCD on to display the odometer value. Does the LCD illuminate and display the odometer value with ignition turned to OFF and headlamps on?

YES → Feature is functioning normally.

NO → Test for battery voltage on pin D16. This circuit is sourced from the SAM cab on connector 10, pin 17. Repair any wiring fault that is found with this circuit between the SAM cab and the ICU. If there is no wiring problem, replace the ICU.

712 — Diagnosis: Backlighting

1. **Determine if the primary and/or secondary air pressure gauge backlighting is the only problem.**

Is the primary and/or secondary air pressure gauge backlighting the only problem?

YES → Go to test 2.

NO → Go to test 3.

2. **Inspect the air pressure gauge module ribbon cable.**

2.1 Remove the three air pressure gauge module screws from the back of the ICU.

2.2 Carefully lift the air gauge module off the back of the ICU while leaving the ribbon cable connected.

2.3 Inspect the ribbon cable connection to the ICU PC board. Make sure there is no corrosion, and that it is plugged in all the way.

Is the ribbon cable connection OK?

YES → Replace the air pressure gauge module.

NO → Repair the ribbon cable connection.

3. **Check for voltage on the backlighting circuit.**

3.1 Disconnect the 24-pin and 32-pin connectors from the ICU.

3.2 Turn the headlights on.

3.3 Measure voltage between pin A1 of the 24-pin connector (positive lead) and pin D3 of the 32-pin connector (negative lead).

3.4 Observe the voltage while changing the dimmer switch setting. The voltage should range from approximately 2.5V (full dim) to 11.3V (full bright).

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Is the backlighting voltage OK?

YES → Replace the ICU.

NO → Go to test 4.

4. **Determine if the problem is with the backlighting ground circuit.**

4.1 Disconnect the 24-pin and 32-pin connectors from the ICU.

4.2 Turn the headlights on.

4.3 Measure voltage between pin A1 of the 24-pin connector (positive lead) and a known good ground (negative lead).

4.4 Observe the voltage while changing the dimmer switch setting. The voltage should range from approximately 2.5V (full dim) to 11.3V (full bright).

Is the backlighting voltage OK?

YES → Repair the backlighting ground circuit that connects pin D3 on the 32-pin ICU connector.

NO → Check backlighting circuit 29A.

713 — Diagnosis: Mode/Reset Button

1. **Determine if the Mode/Reset button is sticking or is not springing back.**

Does the Mode/Reset button stick or fail to spring back when released?

YES → Replace the air pressure gauge module.

NO → Go to test 2.

2. **Inspect the air pressure gauge module ribbon cable.**

2.1 Remove the three air pressure gauge module screws from the back of the ICU.

2.2 Carefully lift the air gauge module off the back of the ICU while leaving the ribbon cable connected.

2.3 Inspect the ribbon cable connection to the ICU PC board. Make sure there is no corrosion and that it is plugged in all the way.

Is the ribbon cable connection OK?

YES → If the Mode/Reset button is not working and the ribbon cable connection is OK, replace the air pressure gauge module.

NO → Repair the ribbon cable connection.

714 — Indicator Diagnosis: Seat Belt Lamp

Test the operation of the seat belt lamp.

Turn the ignition to OFF, then turn it to the ON position without starting the engine. Does the lamp always stay on, never illuminate, or only illuminate for 3 to 15 seconds at power-on?

Never ON → The lamp itself is open circuit, replace the ICU3.

Always ON → The ICU has learned that it is in a vehicle that has a seat belt buckle switch hardwired to ICU pin D10. Troubleshoot for an open seat belt buckle switch or open circuit between the seat belt buckle and the ICU.

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If the vehicle does not have a hardwired seat belt buckle switch, perform the ICU3 reset EE procedure as described in **Section 802** of this manual.

Only ON 3 to 15 seconds—A vehicle that does not have a hardwired seat belt buckle switch illuminates the lamp for 15 seconds at power-up. A vehicle that has a hardwired seat belt switch illuminates this lamp for three seconds at power-up and then will turn it off if the seat belt input is at ground (seat belt connected). There is no problem with the lamp circuit if it operates according to this description.

800 — Roll Call Fault Messages

The ICU3 expects to receive messages from the engine and ABS controller at all times. It additionally expects to continue to receive messages from any other controller that it has received messages from in the past. If any of the controllers listed in **Table 12** for EPA07 J1587/1708 vehicles and **Table 13** for EPA10 J1939 vehicles fails to broadcast messages, the ICU3 will display a roll call fault message.

If a device was removed from the vehicle or if an ICU is installed in a vehicle that had previously been a different vehicle, the rESEt EE procedure may be performed. The rESEt EE procedure forces the ICU3 to “forget” then re-learn those devices that it expects to communicate with.

Roll call fault messages are originated by the ICU3 for display only. They are not broadcast over the databus and cannot be read by ServiceLink or any other data analysis tool.

EPA07 ICU3 Roll Call Fault Messages Using J1587/1708		
Displayed Message	SID and Failure	Description
no EnG or ECU 128	SID 254 Fail 07	No data is received from the engine ECU, MID 128.
no AbS or AbS 136	SID 254 Fail 07	No data is received from the antilock brake system ECU, MID 136.
NO dAtA	—	No data is being received from any other device in the vehicle.

Table 12, EPA07 ICU3 Roll Call Fault Messages Using J1587/1708

EPA10 ICU3 Roll Call Fault Messages Using J1939		
Displayed Message	SPN and FMI	Description
0 no EnG	SPN 639 FMI 7	No data is received from the engine ECU, source address 0.
3 no trAn	SPN 639 FMI 7	No data is received from the transmission ECU 3 but it was broadcasting in the past.
11 no AbS	SPN 639 FMI 7	No data is received from the antilock brake system ECU, source address 11.
33 no CAB	SPN 639 FMI 7	No data is received from the SAM cab ECU, source address 33 but it was broadcasting in the past.
49 no SFU	SPN 639 FMI 7	No data is received from the modular switch field master, source address 49 but it was broadcasting in the past.
No dAtA or no J1939	SPN 639 FMI 7	No data is being received from any other device in the vehicle.

Table 13, EPA10 ICU3 Roll Call Fault Messages Using J1939

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801 — Fault Code Message Display

EPA07 Vehicles

If the ICU3 detects an active fault in one of the ECUs on the J1587 datalink, it indicates which ECU has the fault by displaying a message that contains both an abbreviation of the ECU with the fault and its MID. See **Table 14** for a list of possible fault messages.

NOTE: If the ICU detects a fault in an ECU that is not predefined as shown in **Table 14**, it displays the ECU generically as "SYS ###", where ### is the MID of the ECU containing the fault.

EPA07 Displayed Fault Messages			
Message	System With Active Fault	Message	System With Active Fault
ECU 128	Engine Control Unit (engine control module)	CdU 219	Collision Detection Unit (VORAD)
tCU 130	Transmission Control Unit	rAd 221	Radio
AbS 136	Antilock Brake System	tSU 223	Transmission Shift Unit
ICU 140	Instrument Cluster Unit (ICU4/4M)	CEL 231	Cellular Phone
SFU 164	Modular Switch Field	SbU 232	Seat Belt Unit (SPACE/Airbag system)
SAT 181	Satellite Communications (Qualcom)	SdU 236	Step Deployment Unit-Driver Side (not used)
APU 190	Air Conditioning Protection Unit	SdU 237	Step Deployment Unit-Pass Side (not used)
CGU 206	Central Gateway	CAB 249	SAM Cab
CHS 216	SAM Chassis	SYS ###	Generic—system not defined in this table

Table 14, EPA07 Displayed Fault Messages

EPA10 Vehicles

EPA10 Displayed Fault Messages			
Message	System With Active Fault	Message	System With Active Fault
EnG 0	Engine Controller – CPC	CdU 42	Collision Detection Unit
EnG 1	Engine Controller – MCM	SFU 49	Modular Switch Field Master
tCU 3	Transmission Control Unit	EEC 61	Aftertreatment Control Module – ACM
tSU 5	Transmission Shift Unit	CEL 74	Cellular Phone
AbS 11	Antilock Brake Controller	SAT 75	Satellite Communications
ICU 23	Instrumentation Control Unit – ICU3	rAd 76	Radio
CAB 33	SAM Cab	SbU 83	Seat Belt Unit – Space
CGU 37	Central Gateway	SYS ###	Where ### is the source address of any other J1939 controller that is not in this list.

Table 15, EPA10 Displayed Fault Messages

802 — rESet EE Procedure

To reset the EE memory in the ICU3, perform the following procedure. This will reset the memory to "forget" all the devices that have been learned.

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1. Press the mode/reset button until the display shows SEt UP.
2. Hold the button until the display makes a beep and the word service appears. Depending on the options programmed, some other word may also appear.
3. Hold the button until the display shows rESEt.
4. Press the button once quickly so that EE is also displayed. This is the rESEt EE screen.
5. Hold the button until donE is displayed.

803 — Sensor Resistance Specifications

Fuel Level Sensor Resistance		
Gauge Reading	Sensor Resistance in Ohms	
	Acceptable Range	Nominal
Empty Stop	244.0 to 249.0	246.5
Empty	232.0 to 239.2	235.6
1/8	190.8 to 196.9	193.8
1/4	149.6 to 154.5	152.1
3/8	126.1 to 129.0	127.5
1/2	102.5 to 103.5	103.0
5/8	84.4 to 85.7	85.0
3/4	66.2 to 67.8	67.0
7/8	47.8 to 49.2	48.5
Full	29.4 to 30.6	30.0

Table 16, Fuel Level Sensor Resistance

Transmission Oil Temperature Sensor Resistance			
Gauge Temperature in °F	Sensor Resistance in Ohms	Gauge Temperature in °C	Sensor Resistance in Ohms
125	3318	60	2490
163	1626	80	1255
200	837	100	680
238	460	120	390
275	267	140	234
313	162	160	145
350	102	180	95

Table 17, Transmission Oil Temperature Sensor Resistance

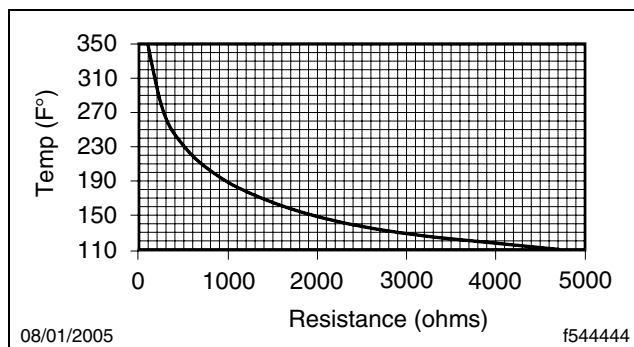


Fig. 8, Transmission Oil Temperature Sensor Resistance (°F)

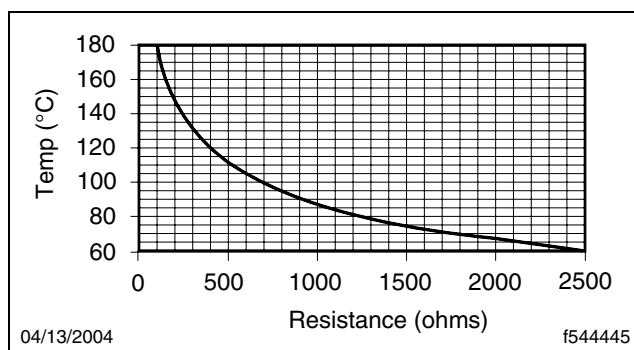


Fig. 9, Transmission Oil Temperature Sensor Resistance (°C)

Axle Oil Temperature Sensor Resistance—Standard Gauge	
Gauge Temperature	Sensor Resistance: ohms
100°F	5933
125°F	3419
150°F	2079
175°F	1283
200°F	837
225°F	557
250°F	380
275°F	267
300°F	190

Table 18, Axle Oil Temperature Sensor Resistance—Standard Gauge

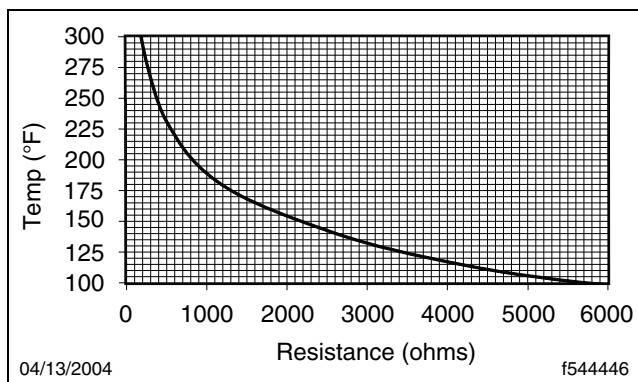


Fig. 10, Axle Oil Temperature Sensor Resistance (°F)

Axle Oil Temperature Sensor Resistance—Metric Gauge	
Gauge Temperature	Sensor Resistance: ohms
30°C	8060
45°C	4465
60°C	2490
75°C	1503
90°C	915
105°C	595
120°C	390
135°C	267
150°C	185

Table 19, Axle Oil Temperature Sensor Resistance—Metric Gauge

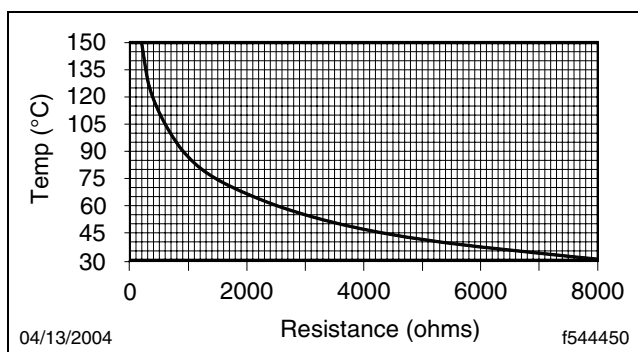


Fig. 11, Axle Oil Temperature Sensor Resistance (°C)

Cummins DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
68	<80
112	80
157	97.6
207	115.2
261	132.8
320	150.4
385	168
485	185.6
539	203.2
629	220.8
731	238.4
847	256
981	273.6
1135	291.2
1316	308.8
1532	326.4
1793	344
2114	361.6
2521	379.2
3052	396.8
3744	414.4
4812	433

Table 20, Cummins DEF Level Sensor Resistance

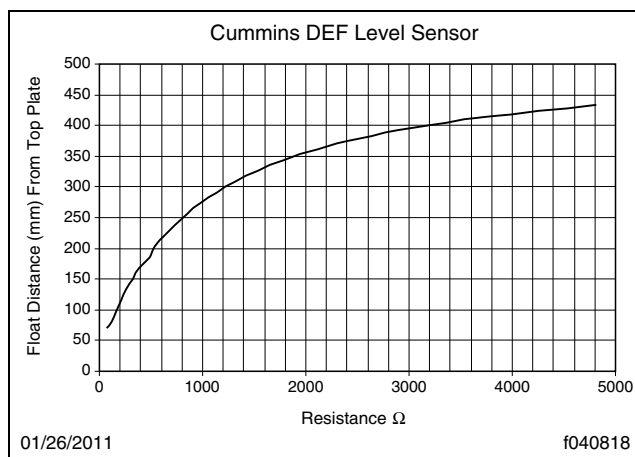


Fig. 12, Cummins DEF Level Sensor Resistance

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DDC DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
19804	54
13764	74
10284	93
8074	113
6534	132
5384	152
4497	172
3799	191
3237	211
2762	230
2375	250
2035	270
1748	289
1493	309
1272	328
1076	348
902	368
744	387
601	407
471	426
353	446
240	<446

Table 21, DDC DEF Level Sensor Resistance

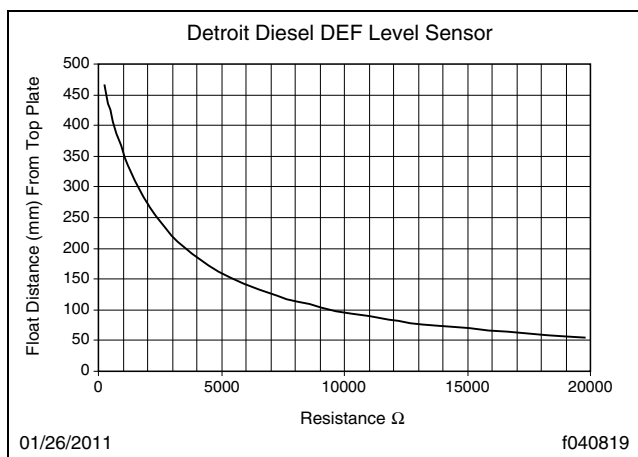


Fig. 13, DDC DEF Level Sensor Resistance

ICU4/ICU4M Instrument Cluster

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500 — Terms and Abbreviations

CAN—Controller Area Network

CEL—Check Engine Lamp

CGW—Central Gateway

DEF—Diesel Exhaust Fluid

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

LBCU—Lightbar Control Unit

LCD—Liquid Crystal Display

LED—Light Emitting Diode

MID—Message Identifier

MIL—Malfunction Indicator Lamp

MSF—Modular Switch Field

PID—Parameter Identifier

PWM—Pulse Width Modulation

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SFU—Switch Field Unit; see MSF.

SID—Subsystem Identifier

501 — General Information

The Ametek ICU4/4M Instrumentation Control Unit (ICU) contains up to 12 individual gauges, a lightbar control unit (LBCU), and a daisy-chain datalink. See **Fig. 1**.

The LBCU drives the electrical gauges, the message center, and some of the indicator lamps. The message center display screen on both the ICU4 and ICU4M is a liquid crystal display (LCD). The ICU4 has a one-line 7 character display. The ICU4M has a two-line 20 character display. The lightbar contains up to 24 warning and indicator lights. See **Table 2**.

502 — Gauges

The lightbar controls all of the individual gauges (**Fig. 2**), except the air pressure gauges and the optional voltmeter, which is a stand-alone gauge. It receives data to drive the electrical gauges from sensors wired directly to the LBCU and over the serial data bus.

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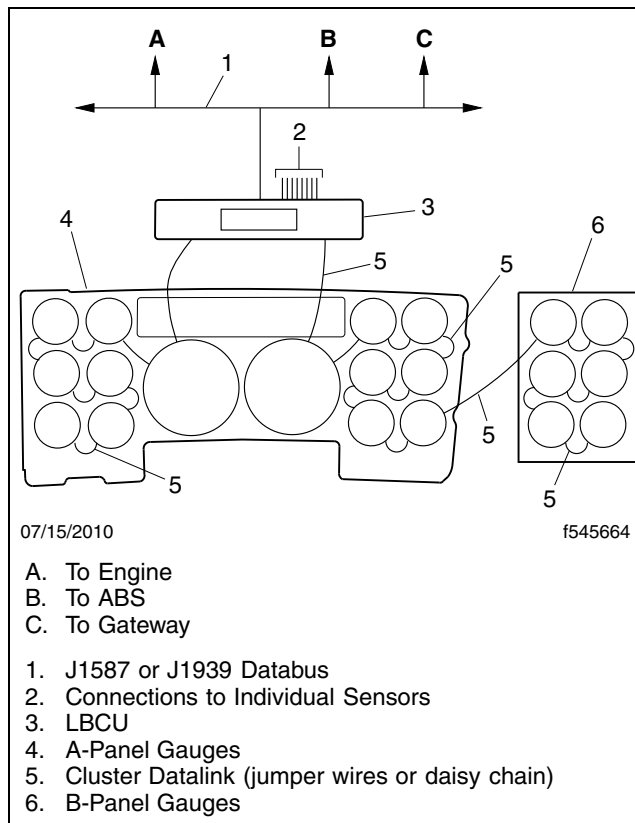


Fig. 1, ICU4/ICU4M Architecture

The LBCU uses its own proprietary databus to transmit gauge information. Each gauge has a unique address that is known to the lightbar. **Table 9** in Subject 703 identifies the input source for gauge data.

Air gauges are connected to the air supply they monitor. They are not controlled by the LBCU, except for back-lighting.

The ICU4/4M gauges sweep 270 degrees and have pointers lit by an LED.

503 — Warning Lights

The LBCU can have up to 24 warning and indicator lights. The top row of 8 warning lamp locations are optionally populated. The second and third row of 16 standard warning lamps have dedicated functions.

504 — In-Gauge Warning Lights

The following four gauges have a small warning LED integrated into the gauge: coolant temperature, engine oil pressure, transmission temperature, and fuel/DEF level.

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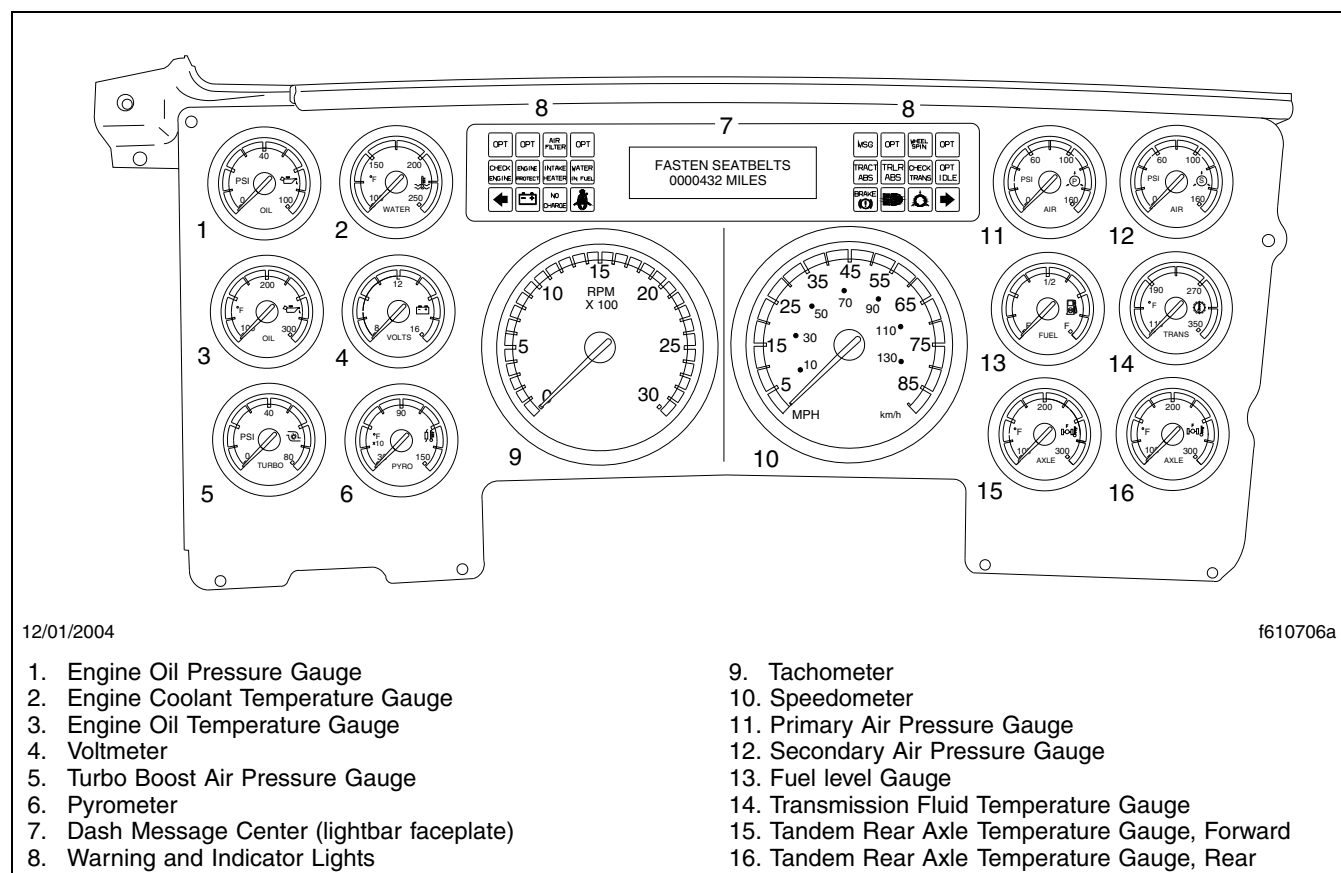


Fig. 2, ICU4M Instrument Cluster (typical)

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505 — Standard Warning Lights, Fixed-Position

EPA07 Standard Warning Lights, Fixed-Position								
09/14/2010	f610886							
Opt. 1	Opt. 2	Opt. 3	Opt. 4		Opt. 5	Opt. 6	Opt. 7	Opt. 8
CEL (yellow)	Stop Engine (red)	High Exh. Temp. (yellow)	REGEN (yellow)		Tractor ABS (yellow)	Trailer ABS (yellow)	Cruise Ctrl. (green)	Opt. Idle (yellow)
Left Turn Sig. (green)	Low Voltage (red)	MIL (yellow)	Fasten Seat belt (red)		Park Brake (red)	High Beam (blue)	Low Air (red)	Right Turn Sig. (green)

Table 1, EPA07 Standard Warning Lights, Fixed-Position

EPA10 Standard Warning Lights, Fixed-Position								
09/14/2010	f611096							
Engine Brake	Water in Fuel	Wait to Start	Opt. 4		Opt. 5	Opt. 6	Check Trans	Opt. 8
CEL (yellow)	Stop Engine (red)	High Exh. Temp. (yellow)	REGEN (yellow)		Tractor ABS (yellow)	Trailer ABS (yellow)	Fasten Seat belt (red)	Opt. Idle (yellow)
Left Turn Sig. (green)	Low Voltage (red)	MIL (yellow)	Cruise Ctrl. (green)		Brake (red)	High Beam (blue)	Brake Air (red)	Right Turn Sig. (green)

Table 2, EPA10 Standard Warning Lights, Fixed-Position

506 — Mode/Reset Switch, ICU4 Only

The integral mode/reset switch is used only on the ICU4 to access the display trip screens, miles/kilometers select screens, engine screens, fault code screens, and service interval screens. The switch has two functions, (1) mode switch (momentary push or press), and (2) reset switch (press and hold). The mode/reset switch has the same functionality as the steering wheel +/- switch.

507 — "+/-" Switch, Steering Wheel, ICU4 and ICU4M

The steering wheel +/- is used on both the ICU4 and ICU4M to access the display trip screens, miles/kilometers select screens, engine screens, fault code screens, and service interval screens. The switch has two functions, (1) mode switch (momentary push or press), and (2) reset switch (press and hold). The ICU4 also has a mode/reset switch which has the same functionality as the steering wheel +/- switch.

The steering wheel +/- switch is connected to the Modular Switch Field (MSF). The MSF transmits the switch status to the Central Gateway (CGW). The CGW broadcasts the +/- switch status to the instrument cluster via J1587 for the EPA07 ICU4, and via J1939 for all others.

508 — "My Info/Enter" Switch, ICU4M Only

The "My Info/Enter" switch, located in one of the MSF switch banks, provides additional menu navigation capabilities on the ICU4M. The MSF transmits the switch status to the Central Gateway (CGW). The CGW broadcasts the switch status to the instrument cluster via J1939.

509 — Buzzer and Chime

The buzzer sounds for three seconds during the self-test at start-up, and when the conditions identified in **Table 11** Subject 708 exist. The buzzer will also sound if an optional circuit connected to pin B12 is connected to ground. The chime sounds when the door is open and either:

- the parking brake is off
- the headlights are on

The chime will also sound on EPA10 vehicles with the hardwired seat belt switch option. The chime will sound for 10 seconds if:

- the seat belt is not latched, and
- the parking brake is released.

510 — Wake Up

The LCBU will wake up to allow reading the odometer without the need to turn the ignition switch on. Wake up mode is activated by the following actions.

- The door is opened supplying battery power to pin C4.
- The headlight switch is turned on supplying battery power to pin D16.

511 — Ignition Sequence

When the ignition key is turned to ON, the ICU4/ICU4M begins a self-test. During the first half of this process—

- all gauges controlled by the message center sweep to full scale and return;

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- all display segments of the message center turn on and then turn off;
- The DEF level indicator initializes;
- the buzzer sounds for three seconds;
- the low battery voltage, low air pressure, high coolant temperature, low oil pressure, and parking brake warning lights come on and then go off. Other lights will also initialize. See **Table 11** in Subject 708 for details on how all the indicators initialize at power on.
- the fasten seat belt warning light illuminates for 15 seconds. If the seat belt buckle is hardwired to the ICU, the ICU "learns" this configuration. With a hardwired seat belt buckle switch, the fasten seat belt warning light illuminates for 3 seconds at powerup or until the seat belt is fastened.

In the second half of the self-test, the software revision level of the ICU4M displays on the message center, followed by the active faults, if any. When the self-test is complete, the fasten seat belt screen displays if the engine is not running. If the engine is running, the idle hours screen displays.

512 — Outside Air Temperature Screens

Outside air temperature is displayed on the lightbar LCD screen. If miles are selected, the temperature will display in degrees Fahrenheit. If kilometers are selected, the temperature will display in degrees Celsius.

Data for the outside air temperature is received from the SAM Cab or from the engine controller. If outside air temperature data is not received for 60 seconds, the LBCU will display three hyphens "- - -" followed by the F or C.

When the parking brake is not set and the outside air temperature reaches 34°F (1°C) or lower, the lightbar LCD will display a message warning of possible icy road conditions. The friendly chime will also sound for 5 seconds. Pressing a steering wheel switch or the my info switch will reset the display to the previous screen.

513 — Automated Manual Transmission

The ICU4M can display selected gear information for vehicles with automated manual transmissions (AMT). The last three digits at the far right on the lower line are reserved for this information. On the diagrams for the stationary access screens, this is indicated by the legend "AMT".

If there is a need to shift, one digit displays an arrow, either up or down depending on the shift direction. The other two digits display the current gear.

On vehicles with conventional manual or automatic transmissions, these three digits do not display.

514 — Diagnostic Information

With the parking brake set, the Diagnostic Information menu on the ICU4/4M can display active fault codes from the ICU and other ECUs in the vehicle. This allows instant review of fault conditions without connecting ServiceLink.

Both the ICU4 and ICU4M have the ability to clear history fault codes for all ECUs on the datalink, if the vehicle has less than 254 miles (409 km). This is to allow a body or equipment manufacturer to clear codes that may be set while the vehicle is incomplete.

515 — Vehicle Information, ICU4M Only

Vehicle information allows you to view datalink activity in a dynamic graph format, datalink usage and error rate (datalink status), and ICU4M data, including ICU4M serial number and software revision level.

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516 — Odometer

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either MI or KM, illuminates between the odometer and the volts display when the engine is running or the headlights are turned on.

To toggle between MI (miles) or KM (kilometers), press the Mode/Reset button while in the SELECT screen.

The odometer is a seven-digit display with a decimal point until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer rolls over to "1000000" without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

The ICU compares odometer data received from the engine controller to its own stored value. It will only alter its stored value if the difference is less than 2 miles (3km). When the ICU is replaced, the odometer display will start from zero even though the engine controller odometer may be a much larger value.

IMPORTANT: Although the odometer uses data supplied by the engine control module (ECM) to update its count, it keeps its own mileage starting from zero, when it was first installed. The ICU odometer may not match the engine ECU odometer. This may occur if the engine has been operated with the ICU disconnected; it may also occur during factory break-in, engine service, or if the ICU has been replaced. The odometer can be displayed with the ignition off by turning on the headlights.

600 — Component Locations

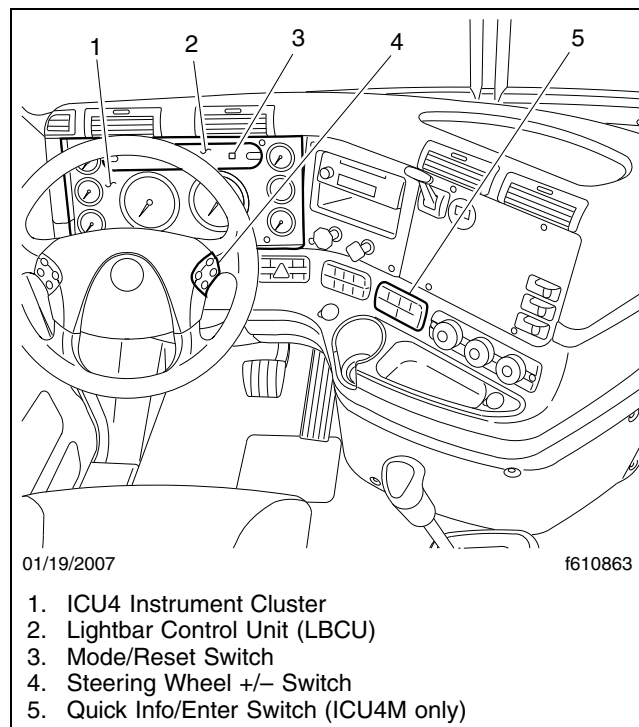


Fig. 3, Component Locations

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601 — Component Details

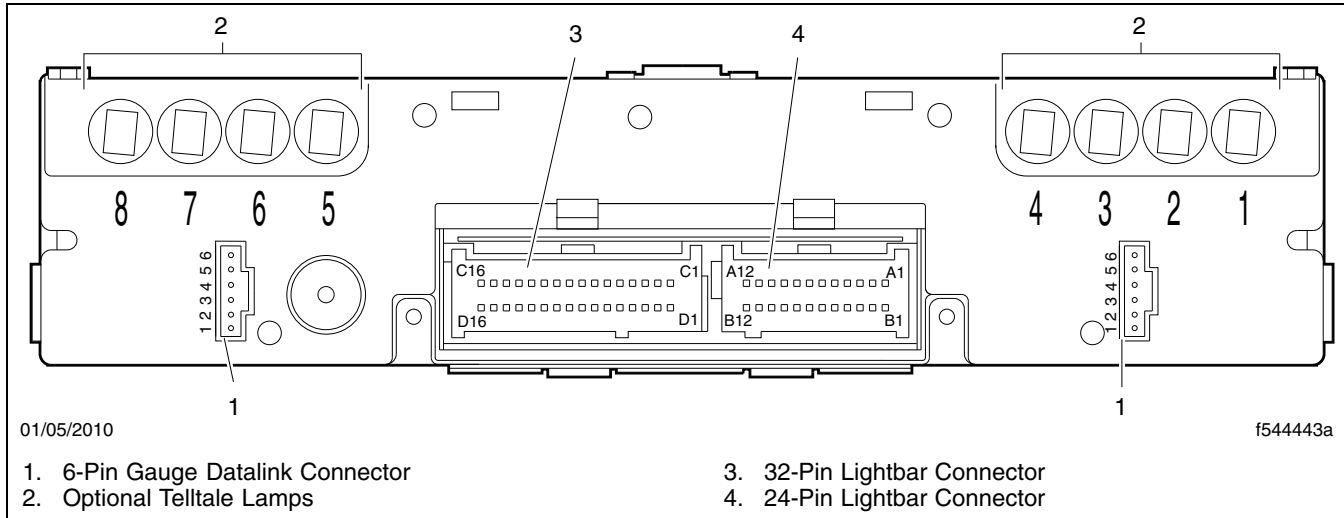


Fig. 4, ICU4/4M Lightbar Connector Pinouts

24-Pin Lightbar Connector			
Pin	Circuit Number	Wire Color	Circuit Description
A1	29A	BR	(+) Panel Backlighting (Pulse Width Modulation)
A2	—	—	EPA07 Reserved EPA10 Optional Indicator #6, Ground-Activated
A3	18	R-W	Low Air Pressure Indicator/Buzzer, Ground-Deactivated
A4	—	—	High Trans Temp Indicator (in-gauge), Ground-Activated
A5	492L	GY	High Exhaust Temperature, Ground-Activated
A6	—	—	Optional Indicator #2, Ground-Activated
A7	—	—	Optional Indicator #3, Ground-Activated
A8	—	—	Optional Indicator #4, Ground-Activated
A9	400	T	MIL Indicator, Ground-Activated
A10	42	LTG-W	(+) Forward Rear Axle Temperature Sensor
A11	42G	LTG-W	(-) Forward Rear Axle Temperature Sensor
A12	222A	LTG	High Beam Indicator, 12V-Activated
B1	—	—	Optional Indicator #5, Ground-Activated
B2	43	LTG-W	(+) Rear Rear Axle Temperature Sensor
B3	1587-	O	(-) J1587 Datalink (ICU4 EPA07 Only)
B4	43G	LTG-W	(-) Rear Rear Axle Temperature Sensor
B5	—	—	Reserved
B6	—	—	Reserved
B7	—	—	Reserved

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24-Pin Lightbar Connector			
Pin	Circuit Number	Wire Color	Circuit Description
B8	—	—	Reserved
B9	—	—	Reserved
B10	1587+	DKG	(+) J1587 Datalink (ICU4 EPA07 Only)
B11	376L	O	Tractor ABS Indicator, Ground-Activated
B12	29G	LTG	Optional Buzzer Input, Ground-Activated

Table 3, 24-Pin Lightbar Connector

32-Pin Lightbar Connector			
Pin	Circuit Number	Wire Color	Circuit Description
C1	472N	GY	Optional Indicator #8, Idle Management Ground-Activated
C2	—	—	Reserved
C3	—	—	Reserved
C4	437W	DKG	Optional 12V Input, Door Open
C5	125	R-W	Park Brake Indicator, Grounded-Activated
C6	—	—	(+) Third Axle Temperature Sensor
C7	—	—	Reserved
C8	38J	Y	Left Turn Indicator, 12V-Activated
C9	—	—	Reserved
C10	492J	GY	Regen Indicator, Ground-Activated
C11	376S	O	Optional Indicator #7, Ground-Activated
C12	30G	LTBL-W	(-) Sensor Ground (Trans Oil Temp)
C13	30	LTBL-W	(+) Transmission Oil Temperature Sensor
C14	—	—	Optional Indicator #1, Ground-Activated
C15	440H	GY	Check Engine Light, Ground-Activated
C16	440A	GY	Stop Engine Light, Ground-Activated
D1	47	PK-W	(+) Fuel Level Sensor
D2	47G	PK-W	(-) Fuel Level Sensor
D3	GND	BK	(-) Panel Backlighting
D4	—	—	Optional Indicator #8, 12V-Activated
D5	1939+	Y	(+) J1939 Datalink (ICU4M and EPA10 ICU4)
D6	—	—	(-) Third Axle Temperature Sensor
D7	—	—	Reserved
D8	38K	DKG	Right Turn Indicator, 12V-Activated
D9	1939—	DKG	(-) J1939 Datalink (ICU4M and EPA10 ICU4)
D10	435	—	Optional Seat Belt Input, EPA10 Vehicles
D11	—	—	Reserved

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32-Pin Lightbar Connector			
Pin	Circuit Number	Wire Color	Circuit Description
D12	376F1	O	Trailer ABS Indicator, Ground-Activated
D13	GND	BK-W	(-) ICU Ground
D14	339	DKG	(+) ICU 12V Battery Power
D15	339A	DKG	(+) ICU 12V Ignition Power
D16	359	LTG	(+) ICU 12V Headlight Power Input (ICU Wake Up)

Table 4, 32-Pin Lightbar Connector

6-Pin Gauge Datalink Connector			
Pin	Circuit Number	Wire Color	Circuit Description
1	—	Blue	(+) Gauge Power, Regulated 7V
2	—	Green	(-) Gauge Ground
3	—	Black	(+) Gauge Datalink
4	—	Violet	(-) Gauge Datalink
5	—	Red	(-) Gauge Backlight Ground
6	—	Yellow	(+) Gauge Backlight Power

Table 5, 6-Pin Gauge Datalink Connector

Fig. 5, Interface Schematic

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701 — ICU4/ICU4M Instrumentation Troubleshooting – Start Here

ICU4 Instrumentation Troubleshooting – Start Here		
Problem Type	Symptom	Procedure to Use
Fault Code	A fault code is displayed from the ICU – SA 23 or MID 140	702
	A fault code is displayed from another device on the databus	702
	A roll call fault is present – Examples are "no ENG" or "no ABS"	702
	"nO DATA" is displayed on the LCD	702
	"nO J1939" is displayed on the LCD	702
	"- - - - -" (seven dashes) is displayed on the LCD	702
Gauges	Problem with the fuel gauge	706
	Problem with the DEF level indicator	703
	Problem with an air pressure gauge	705
	Problem with any other databus driven gauge	703
	Problem with any other sensor driven gauge	704
Backlighting	Problem with backlighting in a gauge or the LCD	711
Warning Indicators	Problem with an in-gauge indicator	709
	Problem with an indicator in the LBCU	708
	Problem with the DEF level indication	703
	Problem with the seat belt indicator	713
LCD Display	A segment of the LCD does not work	710
	The LCD is completely inoperative	710
Mode/Reset Button	The mode/reset button is sticking or does not change the display	712
+/- Steering Wheel Switch	The + or – switch does not interact with the display	See G02.06
My Info or Enter Button	The My Info or Enter button does not interact with the display	See G02.06

Table 6, ICU4 Instrumentation Troubleshooting – Start Here

702 — Fault Codes, ICU

The ICU4/ICU4M in both EPA07 and EPA10 vehicles will display fault codes that are broadcast from other devices on the databus and fault codes generated by the LBCU itself. Use the following to determine if there is a problem with the LBCU, another device on the databus, a sensor that is connected to a device, or with the databus.

Some internal memory errors with the LBCU will cause the LCD to display "- - - - -" (seven dashes). A fault code may be active and could be read using ServiceLink. This display indicates an electronics failure with the ICU4/ICU4M. Replace the LBCU.

Some errors with the ambient air temperature sensor will cause the LCD to display "- - - F" (or "- - - C"). This indicates an error with the data the LBCU is receiving for ambient air temperature. The temperature data is broadcast by the SAM cab. On EPA10 vehicles, the SAM cab may be configured to send temperature data from either the sensor that is located on the bumper or from temperature data received from the engine controller. Troubleshoot the sensor using the procedure in Section G04.02, Subject 700.

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Roll call faults occur when the LBCU is not receiving data from a device that had been on the databus in the past. If a device has been removed from the vehicle (Qualcom for example), or if the ICU had been used temporarily in a different vehicle, perform the resetEE procedure. See Subject 803. When the display shows "no ENG" or "no ABS" or any other roll call fault, troubleshoot for the cause of the device going off-line. Subject 800 provides troubleshooting aids for roll call faults.

The tables referenced under this heading describe fault codes that originate from the ICU4/4M message center. Use **Table 7** to diagnose all MID 140 fault codes on J1587/J1708 vehicles. Use **Table 8** to diagnose all SA 23 fault codes on J1939 vehicles. When the parking brake is on, the ICU will display fault codes that originate from other ECUs on the vehicle. Use **Table 15** and **Table 16** in Subject 801 to identify the controller broadcasting these fault messages.

ICU4/4M J1587/1708 MID 140 (ICU) Fault Codes			
SID/PID	FMI	Description	Behavior
P077	6	Forward Rear Axle Temp Sensor Short	The resistance between pins A10 and A11 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted axle temperature sensor and for a short to ground in circuit 42.			
P078	6	Rear Rear Axle Temp Sensor Short	The resistance between pins B2 and B4 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted axle temperature sensor and for a short to ground in circuit 43.			
P096	5	Fuel Level Circuit Open	The resistance between pins D1 and D2 is greater than 298Ω. The gauge will point to empty.
ACTION: Use the troubleshooting procedure in 706.			
P096	6	Fuel Level Circuit Short	The resistance between pins D1 and D2 is less than 23.5 Ω. The gauge will point to empty.
ACTION: Disconnect the fuel level sensor connector at the sending unit. Turn the ignition to ON and check the fault code display. If the fault code for fuel level circuit short (FMI 6) is still active, locate and repair the short in circuit 47 between the LBCU and the fuel level sender. Otherwise use the troubleshooting procedure in 706.			
P168	1	LBCU Voltage Low	The system voltage measured by the LBCU is less than 10.5 volts.
ACTION: Troubleshoot the vehicle charging system. Test the alternator, then test for voltage drop in the alternator cables and battery cables. If the vehicle is equipped with a remote sense circuit to the alternator, check the fuse for circuit 123E.			
P177	6	Transmission Temp Sensor Short	The resistance between pins C12 and C13 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted transmission temperature sensor and for a short to ground in circuit 30.			
S240	12	LBCU Internal Memory Fault	The LBCU has an internal memory fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the LBCU.			
S254	12	LBCU Internal Electronics Fault	The LBCU microprocessor or other internal critical electronics has a fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the LBCU.			

Table 7, ICU4/4M J1587/1708 MID 140 (ICU) Fault Codes

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ICU4/4M J1939 SA 23 (ICU) Fault Codes				
SPN	FMI	Conn/ Pin	Description	Behavior
77	6	A10 + A11 –	Forward Rear Axle Temp Sensor Short	The resistance between pins A10 and A11 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted axle temperature sensor and for a short to ground in circuit 42.				
78	6	B2 + B4 –	Rear Rear Axle Temp Sensor Short	The resistance between pins B2 and B4 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted axle temperature sensor and for a short to ground in circuit 43.				
96	5	D1 + D2 –	Fuel Level Circuit Open	The resistance between pins D1 and D2 is greater than 298Ω. The gauge will point to empty.
ACTION: Use the troubleshooting procedure in 706.				
96	6	D1 + D2 –	Fuel Level Circuit Short	The resistance between pins D1 and D2 is less than 23.5Ω. The gauge will point to empty.
ACTION: Disconnect the fuel level sensor connector at the sending unit. Turn the ignition to ON and check the fault code display. If the fault code for fuel level circuit short (FMI 6) is still active, locate and repair the short in circuit 47 between the LBCU and the fuel level sender. Otherwise, use the troubleshooting procedure in 706.				
168	1		LBCU Voltage Low	The system voltage measured by the LBCU is less than 10.5 volts.
ACTION: Troubleshoot the vehicle charging system. Test the alternator, then test for voltage drop in the alternator cables and battery cables. If the vehicle is equipped with a remote sense circuit to the alternator, check the fuse for circuit 123E.				
177	6	C12 – C13 +	Transmission Temp Sensor Short	The resistance between pins C12 and C13 is less than 70Ω. The gauge will point full scale.
ACTION: Troubleshoot for a shorted transmission temperature sensor and for a short to ground in circuit 30.				
628	12	n/a	LBCU Internal Memory Fault	The display may show "- - - - -", (seven dashes).
ACTION: Replace the LBCU.				
629	12	n/a	LBCU Internal Electronics Fault	The LBCU microprocessor or other internal critical electronics has a fault. The display may show "- - - - -", (seven dashes).
ACTION: Replace the LBCU.				
639	7	n/a	Roll Call Fault	Any other J1939 device that the LBCU expects on the network but is not broadcasting will generate a fault code. The source address will be of the device that the LBCU is not receiving messages from. Note that this is actually an LBCU generated fault code.
ACTION: If a device has been removed from the vehicle, or if a used LBCU is installed, a roll call reset must be performed. See Subject 802 for the rESet EE procedure. If a J1939 device is not broadcasting due to an error, use the troubleshooting procedure for that device to determine the cause of it going off-line.				

Table 8, ICU4/4M J1939 SA 23 (ICU) Fault Codes

703 — Gauge Diagnosis: Start Here

Table 9 describes where the data is sourced to drive the gauges, identifies each standard and optional gauge, and its method of control. The backlighting for all gauges is controlled by the LBCU using the intensity level data from the MSF.

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ICU4/ICU4M Gauge Input Source		
Gauge	Input Source on J1587/J1708 Systems	Input Source on J1939 Systems
Speedometer	Data from the Engine Controller PID 84	Data from the Engine Controller SPN 84
Tachometer	Data from the Engine Controller PID 190	Data from the Engine Controller SPN 190
Engine Coolant Temperature	Data from the Engine Controller PID 110	Data from the Engine Controller SPN 110
Engine Oil Pressure	Data from the Engine Controller PID 100	Data from the Engine Controller SPN 100
Fuel Level	Sensor Connected to ICU	Sensor connected to ICU
DEF Level	Not Applicable	Data from the Engine Controller, or the ACM, SPN 1761
Primary Air Pressure	Air Line Connected to Gauge	Air Line Connected to Gauge
Secondary Air Pressure	Air Line Connected to Gauge	Air Line Connected to Gauge
Voltmeter	Data from the Engine Controller PID 168	Data from the Engine Controller SPN 168
Engine Oil Temperature	Data from the Engine Controller PID 175	Data from the Engine Controller SPN 175
Turbo Boost Pressure	Data from the Engine Controller PID 439	Data from the Engine Controller SPN 1127
Transmission Temperature	Manual, Eaton, and AGS - sensor connected to ICU Allison, and G transmissions - Data from transmission ECU	Manual, Eaton, and AGS - sensor connected to ICU Allison, and G transmissions - Data from transmission ECU SPN 177
Pyrometer	Data from the Engine Controller PID 173	Data from the Engine Controller SPN 173
Forward Rear Axle Temperature	Sensor Connected to ICU	Sensor connected to ICU
Rear Rear Axle Temperature	Sensor Connected to ICU	Sensor connected to ICU
Application Air Pressure	Air Line Connected to Gauge	Air Line Connected to Gauge
Suspension Air Pressure	Air Line Connected to Gauge	Air Line Connected to Gauge
Axle Lift Pressure	Air Line Connected to Gauge	Air Line Connected to Gauge

Table 9, ICU4/ICU4M Gauge Input Source

1. Test gauge initialization.

- 1.1 Turn the ignition to ON without starting the engine. All gauges except air pressure gauges should sweep in unison to full scale and back to zero before indicating the actual value.
- 1.2 The DEF indicator on EPA10 vehicles will illuminate all segments then once a second turn off the rightmost segment that is on. The last segment on the left will then turn amber, then red before the actual DEF level is indicated
- 1.3 The air pressure gauges are mechanical and no initialization is possible except for them to display the actual pressure. Do the gauges initialize as described above?

YES → Go to step 2.

NO → If the LBCU is completely non responsive, troubleshoot for faults with battery power on pin D14, ignition power on pin D15, and the ground on pin D13. If there is no problem with these circuits, replace the LBCU. If one or some of the gauges do not initialize as described above, troubleshoot for a fault with the daisy chain wiring or for a defective gauge as follows. Disconnect the left

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or the right gauge databus daisy chain circuits from the back of the LBCU one at a time to check if the one that is connected begins working. If one gauge only is not working, check the daisy chain wiring and try substituting a test gauge. A short in any of the gauges can take down all the gauges on the daisy chain. Disconnect one gauge at a time to test. An open circuit in the daisy chain will affect those gauges from that point on.

2. Is the input source of the gauge with the problem datalink driven, sensor driven, or air pressure driven?

Use **Table 12** to identify the gauge input source.

FUEL LEVEL → Go to Subject 706 Gauge Diagnosis: Fuel Level Gauge

DEF LEVEL → Go to Subject 707 Indicator Diagnosis: DEF Level Indicator

SENSOR DRIVEN → Go to Subject 704 Gauge Diagnosis: Sensor Driven Gauges

AIR PRESSURE → Go to Subject 705 Gauge Diagnosis: Air Pressure Gauges

DATALINK DRIVEN → Continue with Step 3.

3. Confirm gauge accuracy with the Datalink monitor template.

- 3.1 Connect ServiceLink and open the J1587 ICU4/ICU4M Instrument Cluster template for EPA07 vehicles and the J1939 ICU4/ICU4M Instrument Cluster template for EPA10 vehicles.

- 3.2 Start the engine if the data is sourced from the engine.

- 3.3 Make sure that operating conditions will register a reading on the gauge. For example, the engine temperature is above the minimum level on the gauge. NOTE: A test drive may be necessary if diagnosing the speedometer.

- 3.4 Monitor the affected gauge on both the ICU and on the template. Do the readings closely match?

YES → Go to test 4.

NO → Replace the gauge.

4. Determine the problem with the data that drives the gauge.

The data that the LBCU receives from the source device is not valid. Refer to the troubleshooting instructions for the source device. For example, if the engine coolant temperature is not indicating, use the troubleshooting material from the engine manufacturer. If the problem is with the speedometer, it may be necessary to drive the vehicle with another vehicle pacing to note the speed, or monitor the ABS wheel speed sensors using Meritor Toolbox. Verify the parameters are correct for axle ratio and tire size.

704 — Gauge Diagnosis: Sensor Driven Gauges

1. If the gauge did not initialize correctly as described in Subject 703 step 1, follow the troubleshooting instructions in 703 step 1.3.

Is the gauge reading inaccurate or completely at full scale or at zero?

INACCURATE → Go to test 2.

FULL SCALE or ZERO → There may also be an active fault code for the circuit which indicates a problem with the wiring or the sensor. Use table 2 and table 3 in Subject 601 to identify the circuit number and connection for the sensor. Troubleshoot the sensor and wiring for short and open circuits. Repair the wiring or replace the sensor as determined.

2. Test the accuracy of the sensor using the resistance values shown in Subject 804.

- 2.1 Measure the resistance of the sensor and compare it with the value shown in the table for the temperature.
- 2.2 Place the sensor in a container of water with a thermometer and heat to a temperature where the resistance can be accurately measured with an ohm meter. Does the resistance measurement match the reading for the temperature?

NO → Replace the sensor.

YES → Leaving the sensor disconnected, disconnect the connectors from the ICU and measure the resistance of the circuits to the sensor. Locate and repair a partial shorted or open circuit in the sensor wiring.

705 — Gauge Diagnosis: Air Pressure Gauges

1. Identify which pressure gauge is not operating properly.

Primary or Secondary → Go to test 2.

Application → Go to test 3.

Suspension or Axle Lift → Go to test 4.

2. **Verify the accuracy of the primary/secondary gauges.**

- 2.1 Drain the air tanks.

- 2.2 Connect an accurate pressure gauge to the primary or secondary air tank, depending on which gauge is being diagnosed.

- 2.3 Start the engine and build air pressure until the compressor cuts out.

Is the air pressure gauge in the cluster within 11 psi (76 kPa) of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks and pinches. If OK, replace the air pressure gauge.

3. **Verify the accuracy of the application air gauge.**

- 3.1 Connect an accurate pressure gauge to the delivery port on the foot valve.

- 3.2 Make a 90 psi (621 kPa) brake application while observing the application air pressure gauge and the test gauge.

Is the application air pressure gauge within 11 psi of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks. If OK, replace the application air pressure gauge.

4. **Verify the accuracy of the suspension air gauge.**

Connect an accurate pressure gauge to the air suspension. Is the air suspension gauge within 11 psi (76 kPa) of the test gauge?

YES → The gauge is OK. No problem found.

NO → Check the air line to the gauge for kinks and pinches. If OK, replace the suspension air pressure gauge.

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706 — Gauge Diagnosis: Fuel Level Gauge

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from $31\pm2\Omega$ with a full tank to $247\pm3\Omega$ when empty.

If the fuel level sender circuit is open or shorted to ground, there would be respectively more than 250 or less than 29Ω between circuit 47 and ground. A fault will be set and the gauge will read empty until the measurement from the sensor is between 250 and 29Ω .

1. If the gauge did not initialize correctly as described in Subject 703 step 1, replace the gauge.
2. If a 100 ohm resistor is available, disconnect the wiring harness connector at the fuel level sender and place the resistor across circuit 47 and ground in the connector. This will simulate the fuel level sending unit with about 1/2 tank of fuel. Turn the ignition to the ON position and observe the fuel gauge. If the gauge points closely to the 1/2 tank mark, then the wiring and ICU are all operating correctly. Go to step 5 if there is no problem with the wiring and ICU.

3. Check for active fault codes for fuel level circuit. Is a fuel level fault code active?

SHORT LOW→Troubleshoot for a wiring fault in circuit 47 between the fuel level sender and the ICU. Repair as appropriate.

OPEN CIRCUIT→Go to test 4.

NO→Go to test 5.

4. Determine if the problem is with the wiring or the sending unit.

- 4.1 Turn the ignition to OFF, then disconnect the 2-wire connector at the fuel level sender.
- 4.2 Use a short jumper wire to short the two circuits at the fuel level sender connector together.
- 4.3 Turn the ignition to ON without starting the engine. Allow the gauges to sweep then check for fault codes. Does the ICU show an active fault for fuel level sender shorted?

YES→The wiring indicates continuity, go to test 5.

NO→Troubleshoot and repair for an open circuit in the ground or circuit 47 between the fuel level sender and the ICU.

5. Test the sending unit.

- 5.1 Turn the ignition to OFF and disconnect the batteries.
- 5.2 Remove the fuel sending unit from the fuel tank.
- 5.3 Connect an ohm meter to the pins at the fuel level sender connector. Slowly change the level of the float arm from full to empty. See **Fig. 6**.

Does the resistance vary linearly from $31\pm2\Omega$ to $247\pm3\Omega$?

YES →Check the connection at the fuel level sender for corrosion. Repair any defect found.

NO →Replace the fuel level sending unit.

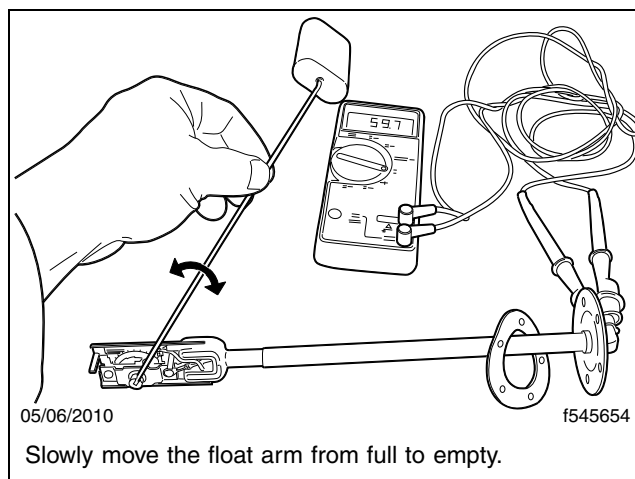


Fig. 6, Testing the Fuel Level Sending Unit

707 — Indicator Diagnosis: DEF Level Indicator

The DEF level indicator is integrated into the fuel gauge, and uses J1939 data from the aftertreatment control module (ACM). The DEF level is measured by a sealed non-contact variable-resistance sensing assembly located in the DEF tank. The DEF level sensor resistance can be measured at the tank connector. For Detroit Diesel engines, the level sensor signal uses pins 1 and 2. For Cummins engines, the level sensor uses pins 1 and 4.

On Detroit Diesel engines, when the DEF tank is empty, the sensor will measure approximately 240Ω . When full, it will measure approximately $19.8K\Omega$. On Cummins engines, when the DEF tank is empty, the sensor will measure approximately $4.8K\Omega$. When full, it will measure approximately 68Ω . Use the resistance to float height table in Subject 400 to test the resistance for a specific float height.

When there is no DEF in the tank or when there is a fault in the DEF level sensing circuit, the indicator will flash the red segment until the fault is corrected, or a sufficient amount of DEF is added to the tank. Perform the recommended action in **Table 10** to troubleshoot faults with the DEF level sensing circuitry indicated by fault codes with SPN 1761.

DEF Level Faults from SA 0 or SA 61				
SPN	FMI	Description	Behavior	Action
1761	1 17 18 31	DEF level low	The DEF level is low. MIL, CEL, STOP engine lamp, and engine derate may be active.	The DEF tank has run too low. Fill the DEF tank so that it is at least 25% full and idle the engine for 5 minutes. If the problem is still present use the DEF level diagnostic procedure that follows.
1761	3	DEF level circuit out of range high	The voltage on circuit 532F is greater than the ACM expects.	Troubleshoot circuits 532F and 532F- between the ACM and the temperature level sensor for a wiring fault and also for an open level sensor unit.
1761	4	DEF level circuit out of range low	The voltage on circuit 532F is close to 0 volts.	Troubleshoot circuit 532F between the ACM and the temperature level sensor for a wiring fault and also for a shorted level sensor unit.

Table 10, DEF Level Faults from SA 0 or SA 61

Diagnose the DEF level indicator as follows.

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1. Turn the ignition to ON but do not start the engine. Does the DEF level indicator illuminate all segments green then turn them off beginning from the right one at a time until the left one becomes amber then red before either showing a mid range level, or flashing the left segment red?
YES → The DEF level indication display is working properly. Go to step 2.
NO → Replace the Fuel/DEF gauge.
2. Use Servicelink to check for any J1939 faults. Is there a fault for SPN 1761 with FMI 3 or 4 (DEF level sensor out of range) or are any J1939 communications fault codes active? NOTE: SPN 1761 FMI 1, 17, 18, or 31 indicate the DEF level is low. For these FMIs, there is no wiring fault but there may be a problem with DEF level indication accuracy.
YES → If the code has FMI 4, troubleshoot for a wiring fault in circuit 532F between the DEF level sensor and the ACM. If the code has FMI 3, go to step 3. If there is a J1939 communications fault, use the troubleshooting information in this manual to locate and repair communications.
NO, or Accuracy Problem → Go to step 4.
3. Turn the ignition to OFF then disconnect the 4 wire connector at the DEF level sender. Use a short jumper wire to short pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) together in the vehicle harness side of the connector. Turn the ignition to ON without starting the engine. Allow the indicator initialization sequence to complete, then check for fault codes. Is there an active fault for SPN 1761 FMI 4?
YES → The wiring indicates continuity. Go to step 4.
NO → Troubleshoot and repair for an open in circuit 532F and/or circuit 532F- between the DEF level sensor and the ACM.
4. Turn the ignition to OFF and disconnect the batteries. Remove the temperature/level sender unit from the DEF tank. Connect an ohm meter to pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) at the 4 pin connector. Slowly raise the level of the float from empty to full. Record the resistance range measured. Does the vehicle have a Cummins or a DD engine?
Cummins → If the resistance did not vary from approximately 4.8K Ω at empty to 68 Ω at the full position replace the temperature/level sender unit.
Detroit Diesel → If the resistance did not vary from approximately 240 Ω at empty to 19.68K Ω at the full position replace the temperature/level sender unit.

708 — Indicator Diagnosis: Lamps in the ICU4/4M

Use **Table 11** to determine if an indicator lamp has a power on bulb check and how it is activated.

The ICU4 does not set fault codes for lamps that are inoperative. If an indicator does not illuminate, use **Table 11** to determine the optimal troubleshooting method.

For data driven indicators, use ServiceLink to monitor the data for the indicator. If the LBCU does not illuminate an indicator when ServiceLink shows that it is on, there is a problem with the indicator. The top row lamps are replaceable for the others, the LBCU must be replaced.

For indicators that are hardwired, monitor the voltage at the LBCU input pin. Use **Table 11** to correlate the status of the indicator with the voltage on the input pin. Troubleshoot the vehicle wiring harness or switch as necessary. Indicators with a power on "bulb check" (even though they are LEDs) are confirmed to work.

Enter the vehicle's VIN in the EZ wiring floating pin dialog box to view a list of the circuit numbers that are used for optional indicator lamps with a "floating position". Use the position of this hardwired circuit to determine if the signal for the lamp is active at the LBCU.

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ICU4/ICU4M Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
Left Turn Signal		None	Lamp is ON when 12V is applied to the control pin.	C8	"Beep" sound when control pin is at 12V
Right Turn Signal		None	Lamp is ON when 12V is applied to the control pin.	D8	"Beep" sound when control pin is at 12V
High Beam		None	Lamp is ON when 12V is applied to the control pin.	A12	None
Brake		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded over J1939 from the ABS Controller.	C5	Buzzer active when vehicle speed is greater than 2 MPH (3 km/h) (Uses speed data from ABS) Chime when park brake is not set and the door is open
Brake Air Pressure		YES	Lamp is ON when the control pin is open circuit. Lamp is OFF when ground is applied to the control pin.	A3	Buzzer active whenever lamp is on
Battery Voltage		YES	Lamp is ON when system voltage has been less than 12 volts for longer than 40 seconds. The message is broadcast by the engine controller.	Data	Buzzer active whenever lamp is on
Fasten Seat Belt		YES	If pin D10 is not hardwired to seat belt buckle, lamp is ON for 15 seconds at power-up only. If pin D10 is hardwired, the bulb check is three seconds long and the lamp is OFF when ground is applied to the control pin (seat belt latched).	N/A or D10	"Friendly" chime for 10 seconds when pin D10 is hardwired if park brake is off and seat belt is not latched
Check Engine Lamp (CEL)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C15 and Data	None
Malfunction Indicator Lamp (MIL)		YES	Lamp is ON when ground is applied to the control pin.	A9	None
Stop Engine		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C16 and Data	None
Tractor ABS		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the tractor ABS controller. The lamp will also be ON when the LBCU is not receiving data from the ABS controller.	B11 and Data	None

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ICU4/ICU4M Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
Trailer ABS		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the trailer ABS controller.	D12 and Data	None
Cruise Control		YES	Lamp is ON when commanded by either the MSF (reading the steering wheel switches) or the engine controller. The lamp indicates that cruise control is enabled via the on/off switch and not that the vehicle is driving in cruise control mode.	Data	None
DPF Regeneration (REGEN)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	C10 and Data	None
High Exhaust Temperature		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the engine controller.	A5 and Data	None
Idle Management		None	Lamp is ON when ground is applied to the control pin.	C1	None
Low Oil Pressure		YES	Lamp is ON when commanded by the engine controller. The lamp will latch on for a minimum of 30 seconds.	Data	Buzzer is active when the lamp is on
High Coolant Temperature		YES	Lamp is ON when commanded by the engine controller. The lamp will latch on for a minimum of 30 seconds.	Data	Buzzer is active when the lamp is on
Option 1 (Engine Brake)		NO*	Lamp is ON when ground is applied to the control pin, or lamp is ON when commanded by the MSF by reading the steering wheel switches.	C14 and Data	None
Option 2 (Water In Fuel)		None	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the engine controller.	A6 and Data	None
Option 3 (Wait to Start)		YES	Lamp is ON when ground is applied to the control pin.	A7	None
Option 4	—	—	—	A8	—
Option 5 (Shore Power)		NO	Lamp is ON when ground is applied to the control pin.	B1	None
Option 6	—	—	—	A2	—

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ICU4/ICU4M Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
Option 7 (Check Transmission) or (Supplemental Restraint System)		YES	Lamp is ON when ground is applied to the control pin or Lamp is ON when commanded by the transmission controller.	C11 and Data	None
					
Option 8	—	—	—	D4	—

Table 11, ICU4/ICU4M Warning and Indicator Lamps

709 — Indicator Diagnosis: Lamps in the Gauges

In-gauge lamps illuminate during power-on initialization, and when the data to the gauge indicates a fault or an out of normal range condition. An illuminated in-gauge lamp indicates that immediate attention is necessary.

ICU4/ICU4M In Gauge Warning Lamps			
Lamp	Bulb Check	Input Source	Activation
Low Fuel Level	YES	Fuel Level Sensor	When the fuel level is less than 1/8th of a tank the lamp will be ON. A 60 second delay applies to activation and deactivation unless ignition power is cycled and it will immediately indicate for the measured value.
Low DEF Level	YES	Data	When the DEF level is less than 15% of tank capacity, the low DEF light will be ON. When DEF level is less than 5% of tank capacity, the low DEF light will flash.
Low Oil Pressure	YES	Data	Lamp is ON when the engine controller sets an active fault with FMI 01 for oil pressure.
High Coolant Temperature	YES	Data	Lamp is ON when the engine controller sets an active fault with FMI 00 for coolant temperature.
High Transmission Temperature	NO*	A4 and Data	Lamp is ON when ground is applied to the control pin or Lamp is ON/FLASHING when commanded by the transmission controller or the retarder

Table 12, ICU4/ICU4M In Gauge Warning Lamps

For data driven lamps, use ServiceLink to correlate the fault or fluid level condition. For the low fuel level lamp, allow for the 60 second delay when troubleshooting.

710 — LCD Diagnosis

1. Check the LCD and the LBCU for any activity. Does the LBCU show any activity when the ignition is turned on or is the LCD the only malfunctioning item?

LCD ONLY → Replace the LBCU.

NO ACTIVITY FROM THE ENTIRE ICU → Go to test 2.

2. Check the power and ground to the LBCU.

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Troubleshoot for faults with battery power on pin D14, ignition power on pin D15, and the ground on pin D13. If there is no problem with these circuits, replace the LBCU.

3. Troubleshoot for the LCD illuminating with ignition off and headlamps on.

When the headlamps are on, battery voltage is sourced to the LBCU on circuit number 359 pin D16. This voltage will turn the LCD on to display the odometer value. Does the LCD illuminate and display the odometer value with ignition off and headlamps on?

YES → Feature is functioning normally.

NO → Test for battery voltage on pin D16. This circuit is sourced from the SAM cab on connector 10, pin 17. Repair any wiring fault that is found with this circuit between the SAM cab and the ICU. If there is no wiring problem, replace the LBCU.

711 — Gauge Diagnosis: Backlighting

1. Determine if the backlighting PWM circuit is operational.

- 1.1 Circuit 29A is sourced from the SAM cab on connector 10, pin 13. It goes to a splice pack and one leg of this circuit feeds the LBCU on pin A1. When the lights are on, this circuit will have some level of voltage that is controlled by repeatedly pressing the backlighting control + and – button on the MSF switch.

- 1.2 Press the backlighting control + button about 10 times. Does pin A1 at the LBCU measure about 12 volts?

YES → Go to test 2.

NO → Troubleshoot for an open circuit or a short to ground in one of the circuit 29A legs. Disconnect them one at a time to determine if there is a short or if the SAM cab is not supplying the PWM signal. Check for communications faults where the SAM may not be able to receive messages from the MSF. The problem is with backlighting power not the LBCU.

2. Check the panel lamp ground to the LBCU. Disconnect the LBCU connectors and measure for continuity on pin D3 of the harness connector to ground. Is there continuity to ground?

YES → Go to test 3.

NO → Repair the open ground circuit.

3. Determine if there is a problem where a gauge or one of the daisy chain circuits is shorting the backlighting circuit, or if the problem is the LBCU.

- 3.1 Disconnect the LBCU daisy chain connectors from the rear of the LBCU but leave the pink 24-pin and 32-pin connectors connected. Turn the ignition and headlights on.

- 3.2 Press the backlighting control + button on the MSF about 10 times, then press the – button about 10 times. Did the LCD change from full brightness after the + button had been pressed to very dim after the – button was pressed?

YES → Go to test 4.

NO → Replace the LBCU.

4. Determine which gauge or daisy chain circuit is open or shorted.

- 4.1 Reconnect one of the daisy chain circuits to the LBCU.

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- 4.2 Turn the ignition and headlights on and press the backlighting control + button on the MSF about 10 times. Does the backlighting in the gauge chain function?

YES → Locate the short or open in the other daisy chain circuit and/or gauges.

NO → Locate the short or open in a gauge or a daisy chain jumper in this circuit.

712 — Mode/Reset Button Diagnosis (ICU4 only)

Check the Mode/Reset button for physical binding.

1. Remove the ICU4 bezel by carefully prying it from the face of the instrument panel. For instructions, see **Section 54.04 Subject 130** of the *Cascadia Workshop Manual*.
2. Remove the rubber button from the LBCU. Is there debris or some other substance that may cause the button to bind and stick?

YES → Clean the substance from the button and bezel. Use care to keep all cleaning solution and debris from entering the LBCU.

NO → If there is an alignment problem with the LBCU and/or the bezel, determine if it can be adjusted or repaired. If no repair is possible, replace the LBCU.

713 — Indicator Diagnosis: Seat Belt Lamp

Test the operation of the seat belt lamp.

Turn the ignition to OFF, then turn it to the ON position without starting the engine. Does the lamp always stay on, never illuminate, or only illuminate for 3 to 15 seconds at power on?

Never ON → The lamp itself is open circuit, replace the LBCU.

Always ON → The ICU has learned that it is in a vehicle that has a seat belt buckle switch hardwired to LBCU pin D10. Troubleshoot for an open seat belt buckle switch or open circuit between the seat belt buckle and the LBCU. If the vehicle does not have a hardwired seat belt buckle switch, perform the ICU4 or ICU4M reset EE procedure as described in **Section 803** of this manual.

Only ON 3 to 15 seconds → A vehicle that does not have a hardwired seat belt buckle switch illuminates the lamp for 15 seconds at power-up. A vehicle that has a hardwired seat belt switch illuminates this lamp for three seconds at power-up and then will turn it off if the seat belt input is at ground (seat belt connected). There is no problem with the lamp circuit if it operates according to this description.

800 — Roll Call Fault Messages

The ICU4/4M expects to receive messages from the engine and ABS controller at all times. It additionally expects to continue to receive messages from any other controller that it has received messages from in the past. If any of the controllers listed in **Table 13** for J1587/1708 vehicles and **Table 14** for J1939 vehicles fails to broadcast messages, the ICU4/4M will display a roll call fault message.

If a device was removed from the vehicle or if an ICU is installed in a vehicle that had previously been a different vehicle, the rESET EE procedure may be performed. The rESET EE procedure forces the ICU to "forget" then re-learn those devices that it expects to communicate with. See Subject 802 for instructions to perform the rESET EE procedure.

Roll call fault messages are originated by the ICU4/4M for display only. They are not broadcast over the databus and cannot be read by ServiceLink or any other data analysis tool.

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J1587/J1708 ICU4/ICU4M Roll Call Fault Messages		
Displayed Message	SID and FMI	Description
no EnG	SID 254 Fail 7	The ICU is unable to exchange data with the engine controller (CPC).
ECU 128	SID 254 Fail 7	The ICU is unable to exchange data with the engine controller (CPC).
no AbS	SID 254 Fail 7	The ICU is unable to exchange data with the antilock brake controller.
AbS 136	SID 254 Fail 7	The ICU is unable to exchange data with the anti lock brake controller.
nO dATa	—	The ICU is unable to exchange data with any device in the vehicle.
130	SID 254 Fail 7	No data is received from the transmission controller but it had been in the past.
164	SID 254 Fail 7	No data is received from the modular switch field controller but it had been in the past.
181	SID 254 Fail 7	No data is received from the satellite controller but it had been in the past.
190	SID 254 Fail 7	No data is received from the air conditioning protection unit but it had been in the past.
206	SID 254 Fail 7	No data is received from the central gateway controller but it had been in the past.
216	SID 254 Fail 7	No data is received from the SAM chassis controller but it had been in the past.
219	SID 254 Fail 7	No data is received from the collision detection unit (VORAD) controller but it had been in the past.
221	SID 254 Fail 7	No data is received from the radio but it had been in the past.
223	SID 254 Fail 7	No data is received from the transmission shift unit but it had been in the past.
231	SID 254 Fail 7	No data is received from the cellular communications unit but it had been in the past.
232	SID 254 Fail 7	No data is received from the air bag/seat belt controller (SPACE) but it had been in the past.
249	SID 254 Fail 7	No data is received from the SAM cab but it had been in the past.

Table 13, J1587/J1708 ICU4/ICU4M Roll Call Fault Messages

J1939 ICU4/ICU4M Roll Call Fault Messages		
Displayed Message	SPN and MI	Description
nO J1939	SPN 639 FMI 7	No data is received from any device in the vehicle.
ENG 0	SPN 639 FMI 7	No data is received from the engine controller (CPC), source address 0.
ENG2 1	SPN 639 FMI 7	No data is received from the engine controller (MCM), source address 1 but it was broadcasting in the past.

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J1939 ICU4/ICU4M Roll Call Fault Messages		
Displayed Message	SPN and MI	Description
Trans 3	SPN 639 FMI 7	No data is received from the transmission controller, source address 3 but it was broadcasting in the past.
TSU 5	SPN 639 FMI 7	No data is received from the transmission shift unit, source address 5 but it was broadcasting in the past.
Brake 11	SPN 639 FMI 7	No data is received from the antilock brake controller, source address 11 but it was broadcasting in the past.
MUX 49	SPN 639 FMI 7	No data is received from the modular switch field, source address 49 but it was broadcasting in the past.
EEC 61	SPN 639 FMI 7	No data is received from the aftertreatment control module, source address 61 but it was broadcasting in the past.
CEL 74	SPN 639 FMI 7	No data is received from the cellular communications device, source address 74 but it was broadcasting in the past.
SATI 75	SPN 639 FMI 7	No data is received from the satellite communications unit, source address 75 but it was broadcasting in the past.
SRS 83	SPN 639 FMI 7	No data is received from the air bag/SPACE controller, source address 3 but it was broadcasting in the past.

Table 14, J1939 ICU4/ICU4M Roll Call Fault Messages

801 — Fault Code Messages

Table 15 shows J1587/1708 Fault Display Messages, and **Table 16** shows J1939 Fault Display Messages.

J1587/1708 Fault Display Messages			
Displayed Message	System Broadcasting Fault	Displayed Message	System Broadcasting Fault
ECU 128	Engine Controller (CPC)	CDU 219	Collision Detection Unit (VORAD)
TCU 130	Transmission Controller	RAD 221	Radio
ICU 140	Instrumentation Control Unit (ICU4/ICU4M)	TSU 223	Transmission Shift Controller
SFU 164	Modular Switch Field	CEL 231	Cellular Phone
SAT 181	Satellite Communications (Qualcom)	SBU 232	Seat Belt Unit (SPACE/Airbag System)
APU 190	Air Conditioning Protection Unit	CAB 249	SAM Cab
CGU 206	Central Gateway	SYS ###	Where ### is the MID for a device other than the ones listed above

Table 15, J1587/1708 Fault Display Messages

J1939 Fault Display Messages			
Displayed Message	System Broadcasting Fault	Displayed Message	System Broadcasting Fault
ECU 0	Engine Control Unit 1 (CPC)	SFU 49	Modular Switch Field
ECU 1	Engine Control Unit 2 (MCM)	EEC 61	Aftertreatment Control Module (ACM)
TCU 3	Transmission Control Unit	CHS 71	Sam Chassis

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J1939 Fault Display Messages			
Displayed Message	System Broadcasting Fault	Displayed Message	System Broadcasting Fault
TSU 5	Transmission Shift Unit	CEL 74	Cellular Phone
ABS 11	Antilock Brake Controller	SAT 75	Satellite Communications (Qualcom)
ICU 23	Instrumentation Control Unit (ICU4/ICU4M)	RAD 76	Radio
CAB 33	SAM Cab	SRS 83	Safety Restraint System (SPACE/Airbag system)
CGU 37	Central Gateway	SYS ###	Where ### is the source address for a device other than the ones listed above
CDU 42	Collision Detection Unit (VORAD)	—	—

Table 16, J1939 Fault Display Messages

802 — Reset EE Procedures

ICU4 Reset EE Procedure

1. Apply the parking brake and turn the ignition to ON without starting the engine.
2. Press the Mode/Reset button until the SETUP message appears on the display.
3. Press and hold the Mode/Reset button until the SELECT message appears on the display.
4. Press the Mode/Reset button until the RESET EE message appears on the display.
5. Press and hold the Mode/Reset button until the word DONE is displayed.

ICU4M Reset EE Procedure

1. Apply the parking brake and turn the ignition to ON without starting the engine.
2. Press the – button on the steering wheel several times until the SETUP INFORMATION message appears on the display.
3. Press My Info button one time.
4. Press the – button on the steering wheel several times until the display shows: PUSH → KEY TO RESET PARAMETERS.
5. Press the My Info button one time. The display will show "RESET PARAMETERS NO YES".
6. Press the + or – button on the steering wheel so that YES is highlighted.
7. Press the My Info button one time.
8. The ICU will now relearn all connected ECUs.

803 — Sensor Resistance Specifications

Fuel Level Sensor Resistance		
Gauge Reading	Sensor Resistance (ohms)	
	Acceptable Range	Nominal
Empty Stop	244.0 to 249.0	246.5
Empty	232.0 to 239.2	235.6
1/8	190.8 to 196.9	193.8
1/4	149.6 to 154.5	152.1
3/8	126.1 to 129.0	127.5
1/2	102.5 to 103.5	103.0
5/8	84.4 to 85.7	85.0
3/4	66.2 to 67.8	67.0
7/8	47.8 to 49.2	48.5
Full	29.4 to 30.6	30.0

Table 17, Fuel Level Sensor Resistance

Transmission Oil Temperature Sensor Resistance, Standard Gauge	
Gauge Temperature (°F)	Sensor Resistance (ohms)
110	4752
150	2079
190	991
230	510
270	285
310	167
350	102

Table 18, Transmission Oil Temperature Sensor Resistance, Standard Gauge

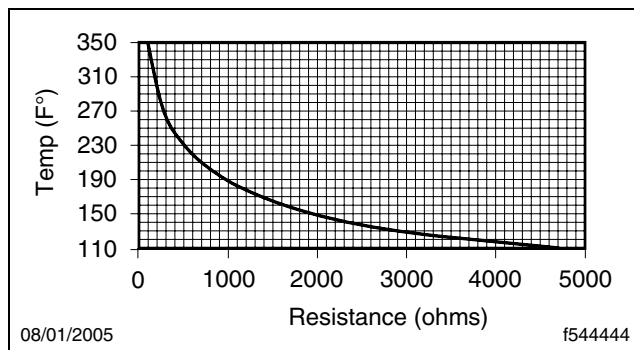


Fig. 7, Transmission Oil Temperature Sensor Resistance, Fahrenheit

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ICU4/ICU4M Instrument Cluster

Transmission Oil Temperature Sensor Resistance, Metric Gauge	
Gauge Temperature (°C)	Sensor Resistance (ohms)
60	2490
80	1255
100	680
120	390
140	234
160	145
180	95

Table 19, Transmission Oil Temperature Sensor Resistance, Metric Gauge

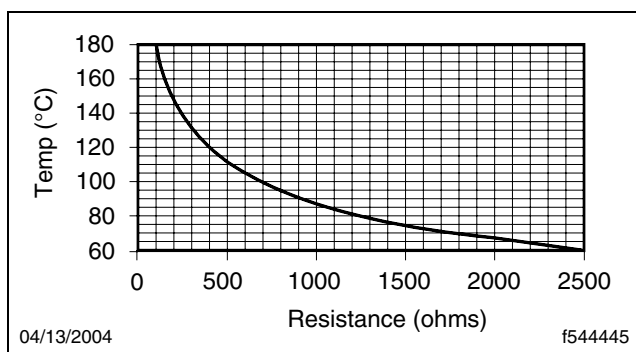


Fig. 8, Transmission Oil Temperature Sensor Resistance, Celsius

Axle Oil Temperature Sensor Resistance, Standard Gauge	
Gauge Temperature (°F)	Sensor Resistance (ohms)
100	5933
125	3419
150	2079
175	1283
200	837
225	557
250	380
275	267
300	190

Table 20, Axle Oil Temperature Sensor Resistance, Standard Gauge

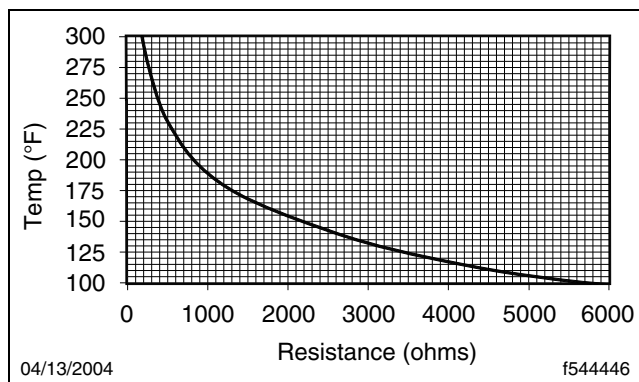


Fig. 9, Transmission Oil Temperature Sensor Resistance, Fahrenheit

Axle Oil Temperature Sensor Resistance, Metric Gauge	
Gauge Temperature (°C)	Sensor Resistance (ohms)
30	8060
45	4465
60	2490
75	1503
90	915
105	595
120	390
135	267
150	185

Table 21, Axle Oil Temperature Sensor Resistance, Metric Gauge

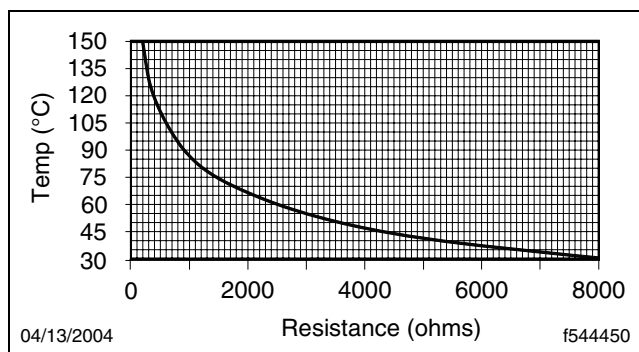


Fig. 10, Transmission Oil Temperature Sensor Resistance, Celsius

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ICU4/ICU4M Instrument Cluster

Cummins DEF Level Sensor Resistance	
Sensor Resistance (ohms)	Float Distance (mm) From Top Plate
68	<80
112	80
157	97.6
207	115.2
261	132.8
320	150.4
385	168
485	185.6
539	203.2
629	220.8
731	238.4
847	256
981	273.6
1135	291.2
1316	308.8
1532	326.4
1793	344
2114	361.6
2521	379.2
3052	396.8
3744	414.4
4812	433

Table 22, Cummins DEF Level Sensor Resistance

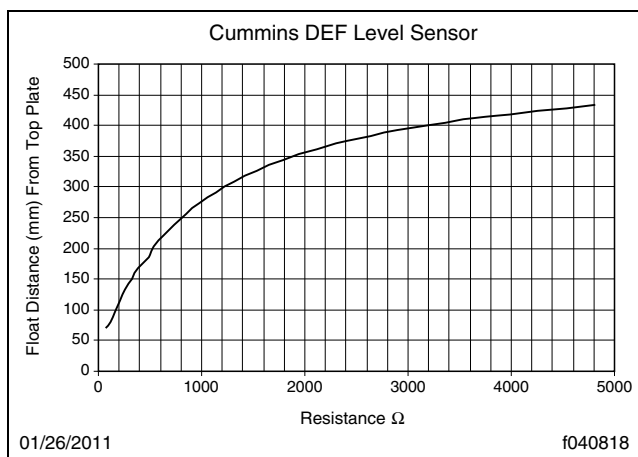


Fig. 11, Cummins DEF Level Sensor Resistance

DDC DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
19804	54
13764	74
10284	93
8074	113
6534	132
5384	152
4497	172
3799	191
3237	211
2762	230
2375	250
2035	270
1748	289
1493	309
1272	328
1076	348
902	368
744	387
601	407
471	426
353	446
240	<446

Table 23, DDC DEF Level Sensor Resistance

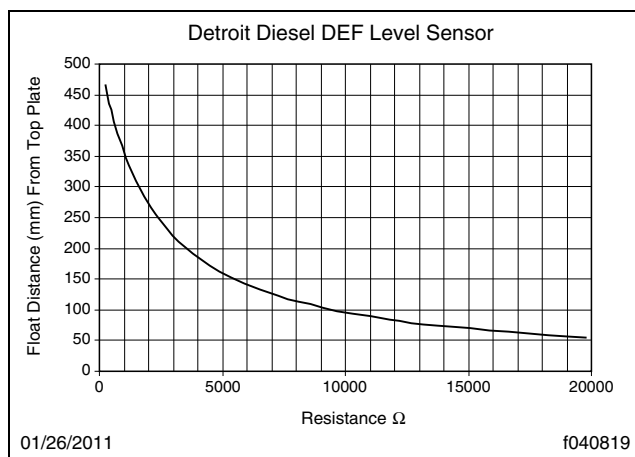


Fig. 12, DDC DEF Level Sensor Resistance

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500 — Terms and Abbreviations

ACU—Auxiliary Control Unit. This is the module that controls the rear HVAC system on vehicles with a sleeper that contains a rear HVAC unit (non-parked HVAC systems).

CGW—Central Gateway (a.k.a. Gateway Module)

Datalink— A collection of wires, connecting system components, through which data is transmitted.

ECU— Electronic Control Unit; typically connected to a datalink.

FCU—Front Control Unit. This is the module that controls the front HVAC system, including A/C compressor operation.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

HVAC—Heating, Ventilation, and Air Conditioning

OSA—Outside Air; means that the air entering the HVAC unit comes from outside the vehicle (fresh air)

Parameter—A parameter is a predetermined variable in a set, each of which restricts or defines the specific capabilities of the system as a whole. Parameters are used to customize the configuration of the system.

RECIRC—Recirculation mode; means that the air entering the HVAC unit comes from within the Cabin space.

ROM—Rear Override Mode; allows the driver to override the sleeper HVAC settings from the front control panel.

SA—Source Address; indicates any device that communicates on J1939.

SAM—Signal detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM-Cabin"); this ECU controls mainly Cab-related functionality. See **G02.04—SAM Cab** for more information.

501 — General Information

The main heating, ventilation, and air conditioning (HVAC) system consists of the following major components and subcomponents:

- Brushless direct current (BLDC) blower motor
- Evaporator core
- Heater core
- Recirculation filter
- Outside air filter
- Four electric actuators
- Evaporator temperature sensor
- Blend air temperature sensor
- Thermostatic expansion valve (TXV)
- Front climate control panel—also called Front Control Unit (FCU)

The auxiliary HVAC system consists of the following major components and subcomponents:

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- Brushless direct current (BLDC) blower motor
- Evaporator core
- Heater core
- One electric actuator
- Blend air temperature sensor
- Rear climate control panel—also called Auxiliary Control Unit (ACU)
- Thermostatic expansion valve (TXV)

The following components are shared by both the main and the auxiliary HVAC systems:

- Refrigerant compressor
- Condenser
- High-side pressure transducer
- Receiver-drier

System Overview

The Cascadia heating, ventilation, and air conditioning (HVAC) system is designed to deliver air at a temperature to maintain driver comfort. It is also designed to defrost the cab windows to maintain visibility.

The system uses constant outlet temperature control (COTC) to provide discharge air temperature out the ducts that has a stable temperature based on a reference point for each temperature knob detent position. The control head will modulate the temperature door in order to reach and maintain the reference temperature. Conditioning of the air itself is accomplished by drawing air into the front HVAC unit by the blower from either outside the cab (fresh air), inside the cab (recirc air), or a mixture of the two. See "Controlled Partial Recirc" for more information. This incoming air is then directed through the evaporator coil. If the system is in air conditioning or defrost mode, the evaporator will both cool and dehumidify the incoming air. If heating is desired, some or all of the air leaving the evaporator will be routed through the heater core to reheat the air. Engine coolant is continually circulated through the heater core, which transfers engine heat to the air flowing through the heater core. The amount of air routed through the heater core depends on the position of the mix door, which is controlled by both the temperature setting on the HVAC panel as well as the heater core temperature sensor. The HVAC controller will continually adjust the temperature mix door to maintain the temperature selected by the driver. Air is then directed to the vents per the mode selection on the HVAC controller. The front HVAC unit has two air filters: one that filters outside air, and another that filters recirculated air drawn into the unit. The air conditioning system uses a brushless blower motor to circulate temperature-controlled air through the cab. The rate of airflow is controlled by a multispeed fan switch.

Electrical and Control

Figure 1 shows the electrical control topology of the HVAC system. **Figure 2** is a block diagram of the front control panel system architecture. **Figure 3** is a block diagram of the rear control panel system architecture.

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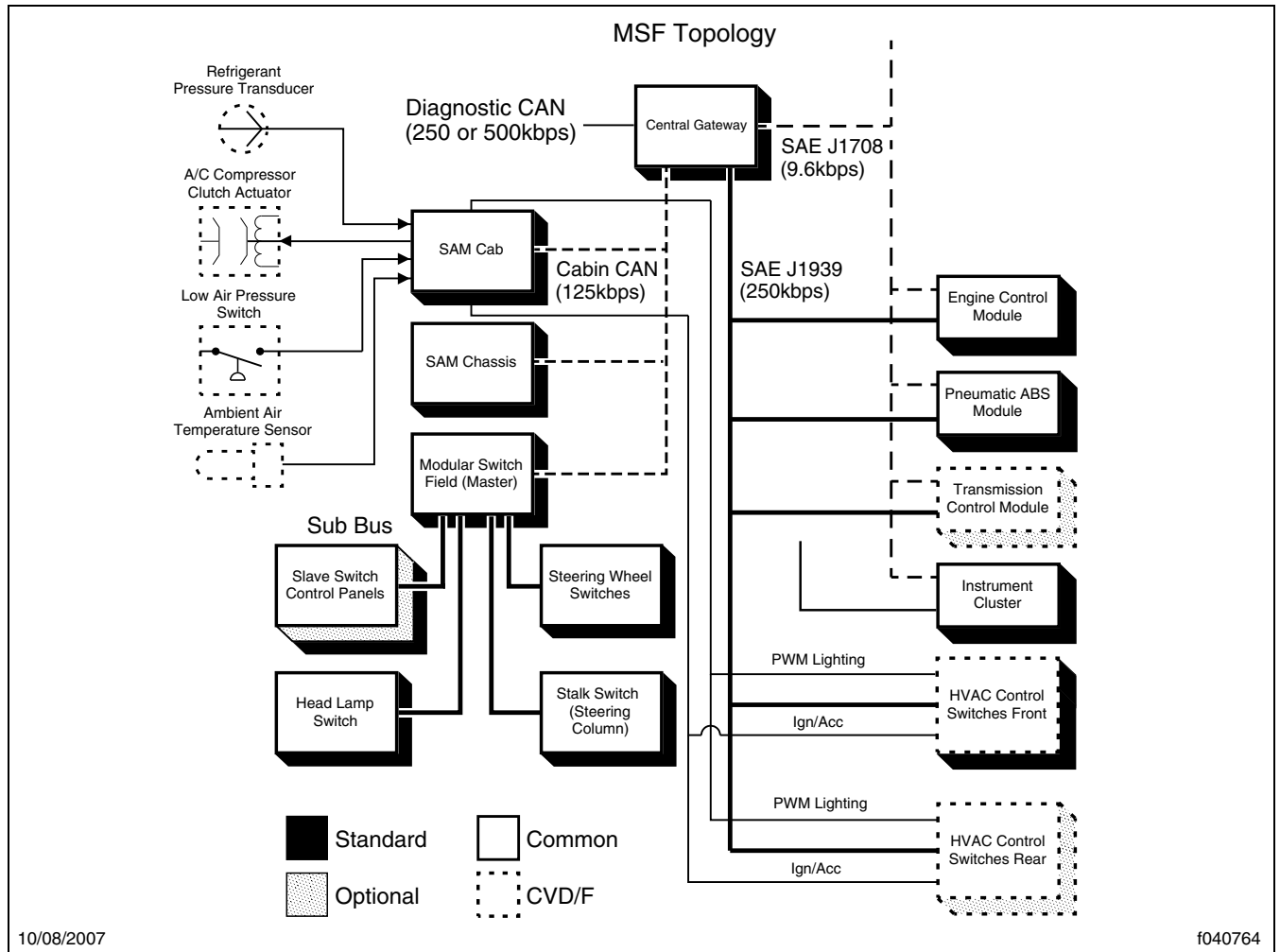


Fig. 1, HVAC System Electrical Control Topology

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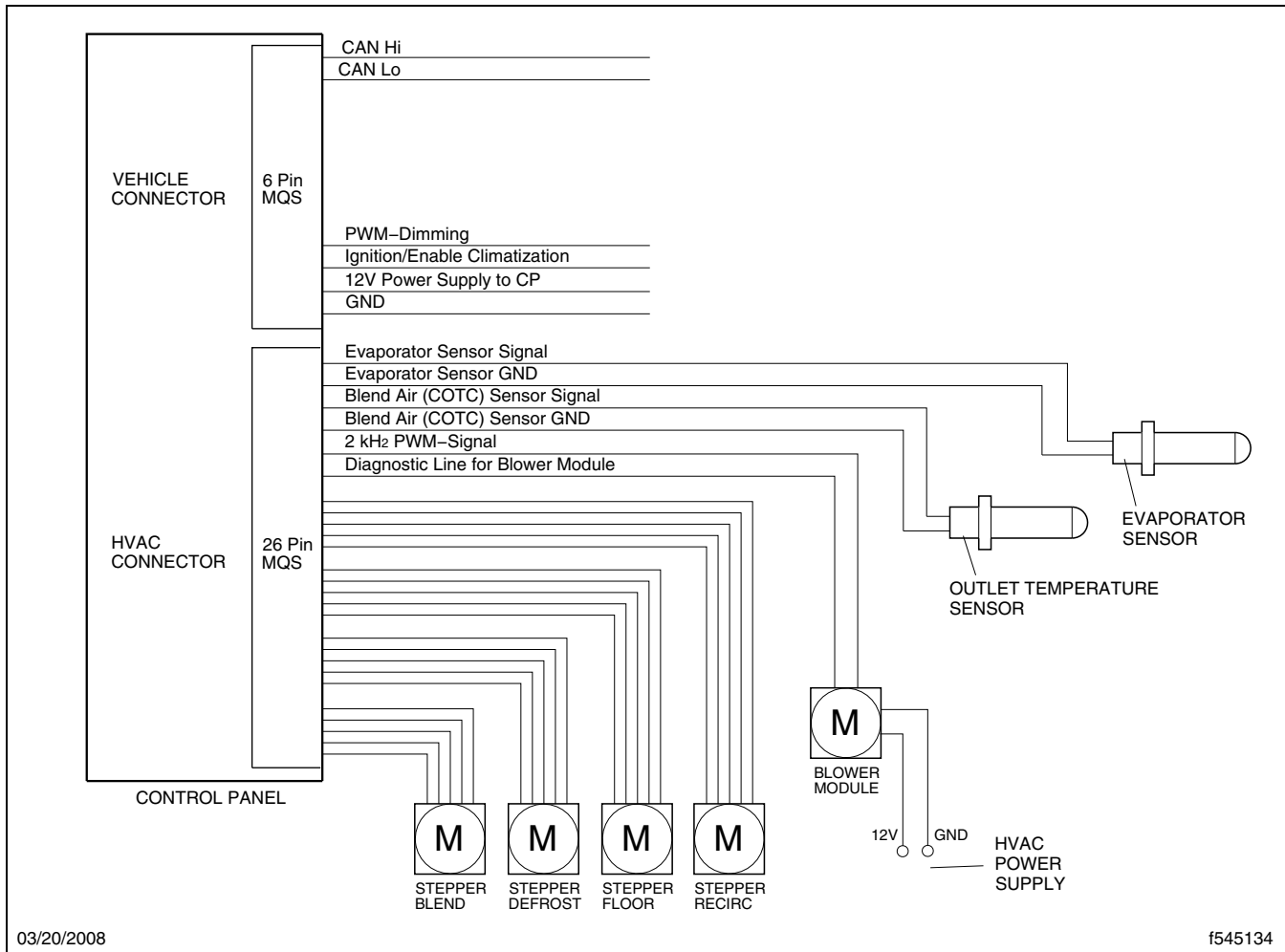


Fig. 2, Front Control Panel System Architecture

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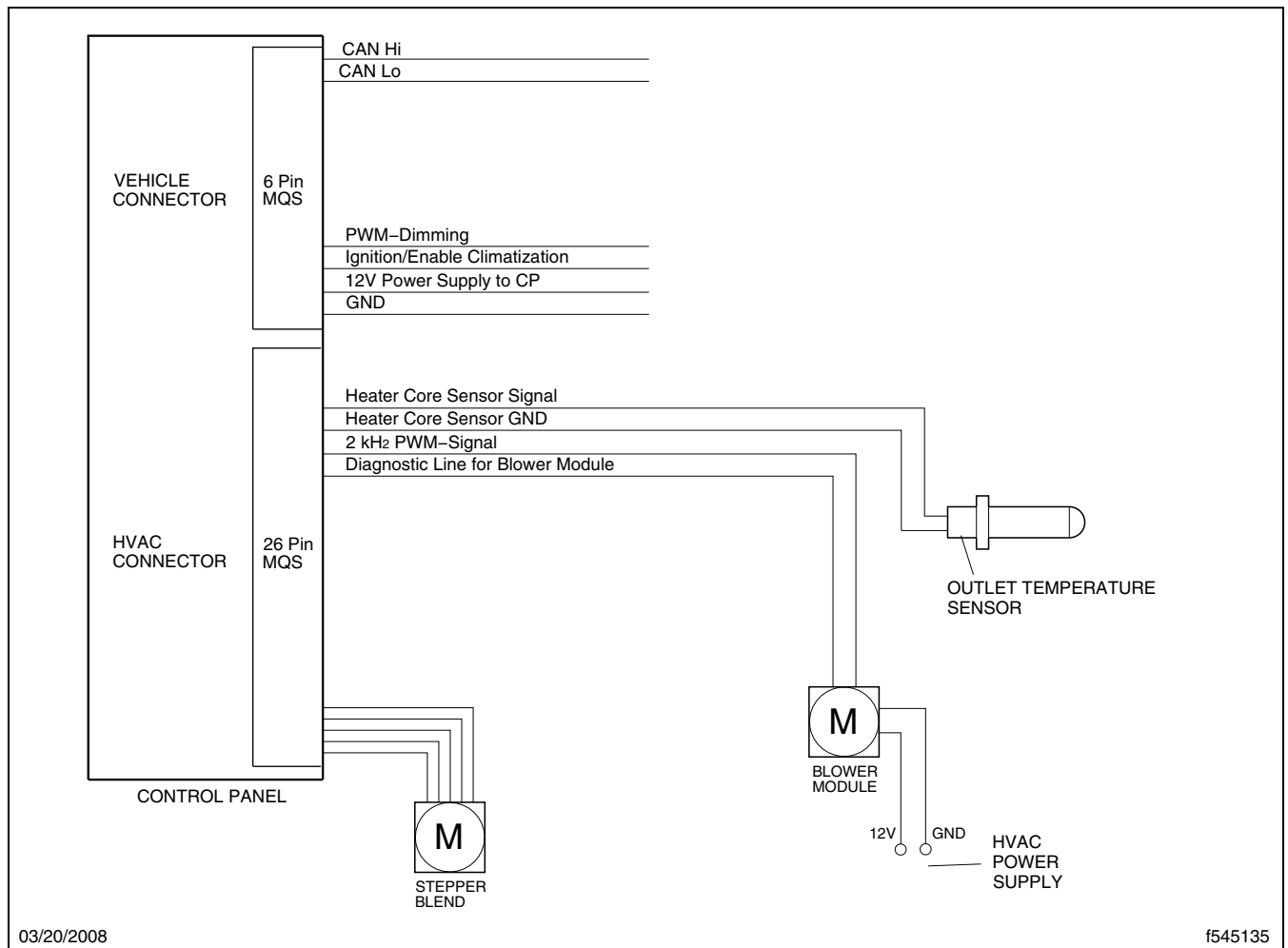


Fig. 3, Rear Control Panel System Architecture

Power Management

Battery power is supplied to the FCU and ACU from the SAM Cab through separate 15A fuses. Battery power is supplied to the front and rear blower motors from the SAM Cab through separate 30A fuses. The FCU and ACU operate normally within a range of 9 to 16 VDC. After the ignition has been off for at least 2 seconds, the FCU and ACU will turn off and go into a sleep, drawing less than 1 mA of current. The FCU will not request A/C compressor clutch engagement if the voltage message from the SAM is less than 12V. If the SAM voltage is not available, the FCU will use the voltage it senses directly.

Backlighting

The backlighting for the FCU and ACU is controlled by a pulse width modulated signal from the SAM Cab. This signal is a constant 400Hz. The duty cycle of the signal determines the illumination intensity—10% or less duty cycle (full dim) to 90% or higher duty cycle (full bright). The SAM Cab sends a message on the J1939 datalink, which is used by the FCU and ACU to control dimming for daylight and nighttime conditions.

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Communication

The FCU and ACU communicate over the J1939 datalink. The FCU uses source address (SA) 25 and the ACU uses SA 58. The messaging communicated is used for operation, diagnostics, and data used to monitor the system with a Datalink Monitor.

A/C Clutch Engagement Rules

When all of the conditions in **Table 1** are met, the FCU will send a message to the SAM Cab commanding it to engage the A/C compressor clutch. Under normal operation, the A/C compressor cycles on/off based on the evaporator temperature sensor input to the FCU. See **Table 1** for the required conditions for the FCU to send an A/C clutch engagement command to SAM Cab.

Conditions for FCU To Send A/C Clutch Engagement Command to SAM Cab		
Input	Input Type	Condition
Blower switch position*	Internal to FCU	Any speed EXCEPT off
A/C switch pressed* OR Mode knob in one of the defrost positions	Internal to FCU	A/C switch LED is on (blower must be on too)
Countdown timers preventing A/C clutch engagement more than 4 times per minute.	Internal to FCU	Timers must be expired (when clutch is turned on, a 15-second timer starts, when it is turned off, a 3-second timer starts—minimum cycle time = 18 seconds)
Vehicle air pressure status	J1939 message from SAM Cab via CGW	Air pressure greater than 60 psi (415 kPa)
Engine rpm	J1939 message from ECM	rpm = 450 or higher for at least 5 seconds
Refrigerant pressure (high side)	J1939 message from SAM Cab via CGW	Refrigerant pressure = above 34 psi (234 kPa)†
Battery voltage	J1939 message from SAM Cab via CGW‡	12.5V or higher§
Evaporator temperature	Sensor	38.5°F (3.5°C) or higher

* If the front unit is off (blower off), the A/C can be turned on from the rear unit (minimum A/C support). When this happens, the front unit's blower speed will turn on to low, and the A/C switch LED will illuminate—all other conditions must be met in order for the A/C compressor to engage.

† See table in Section 800 for high and low pressure cut in/cut out specifications. The value of 34 psi (234 kPa) is the minimum pressure for compressor engagement under normal conditions.

‡ If SAM Cab battery voltage is not available, the FCU will use voltage sensed on its circuit board.

§ If the compressor is engaged and the voltage drops below 12V, the FCU will command that it be disengaged.

Table 1, Conditions for FCU To Send A/C Clutch Engagement Command to SAM Cab

Controlled Partial Recirc

RECIRC allows the driver to choose whether air drawn into the unit comes from outside the cab (outside air) or from inside the cab (recirculated air). The HVAC controller controls an electric actuator, or stepper motor, which moves a door inside the unit, which controls the source of air entering the unit. Recirculated air will provide maximum cooling when the air conditioner is used, and it also allows the driver to prevent outside air from entering the cab under conditions when the air outside is undesirable (dust, smoke, etc.). Recirculated air is not available when the HVAC unit is in defrost mode. When the unit is in DEFROST mode, the unit will automatically disable RECIRC (if enabled) allowing 100% of the air entering the unit to come from outside of the vehicle. Outside air helps maximize defrost performance. If the driver chooses RECIRC mode, 100% of the air entering the unit will come from inside the vehicle for 20 minutes. After 20 minutes has elapsed, the unit will enter partial RECIRC.

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mode, allowing some outside air to enter and mix with the recirculated air entering the unit from the cab, if the blower setting is on the third setting or higher as shown in **Table 2**.

The driver can press the RECIRC button and enter full RECIRC again at any time—except in defrost mode (where recirc is not available).

Controlled Partial Recirc Rules			
Blower Speed	Recirculation OFF	Recirculation ON (first 20 minutes)	Recirculation ON (after first 20 minutes)
OFF	100% Recirculated Air	100% Recirculated Air	100% Recirculated Air
1	100% Fresh Air		100% Fresh Air
2			
3–8			90% Recirculated Air (Partial Recirc)

Table 2, Controlled Partial Recirculation Rules

ACU Override Mode

The ACU override feature allows the user to override the settings of the bunk HVAC system from the front HVAC control panel. If the prerequisite conditions are met, when the driver presses the AUX button on the front control panel, the FCU sends a J1939 message to the ACU requesting it to enter ACU override mode. If there are no conditions preventing it from entering override mode, the ACU will enter the override mode and send the FCU a J1939 message indicating that it has entered the ACU override mode. The FCU then sends a J1939 message to the ACU containing its current temperature and blower settings. The ACU will control the bunk HVAC unit to attain the temperature and blower motor set points as received in the J1939 blower motor and temperature set points message from the FCU. If the user then selects a different temperature or blower speed setting on the front control panel, the front unit's settings will change without changing the settings previously sent to the ACU, unless the driver presses the AUX button off, then on again. Conditions that must be met in order to enter the ACU override mode are:

- FCU must be active (powered up and on the J1939 datalink)
- No active faults, in the front or auxiliary HVAC systems, that would prevent engagement
- "AUX" switch must be pressed on the front control panel

The ACU override will be disabled if any of the following occurs:

- The "AUX" button is turned off
- The FCU detects an active fault in the front system that would prevent engagement
- The FCU receives an active fault message from the ACU that would prevent engagement
- The blower speed or temperature knob settings on the bunk unit are changed (the FCU will detect this change through a J1939 message)
- Setting the parking brake

The above conditions will cause the FCU to send a J1939 message to the ACU requesting that the override mode be turned off. The ACU will respond to the FCU with a message indicating that it has turned the override mode off.

The indicator LED on the "AUX" switch will be steady ON when the FCU senses the "AUX" switch in the ON position. It will be OFF when the FCU senses the "AUX" switch in the OFF position.

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FCU Override Mode

The ACU has the capability to override the FCU temperature and blower settings once the vehicle parking brake has been engaged. This is determined by a J1939 message from the SAM Cab. Once the parking brake is set, and either the blower or temperature control setting on the bunk HVAC has been changed, the FCU will then mimic the settings of the ACU temperature and blower. Both the FCU and ACU control settings will remain as they are if the ACU control settings are not changed. The FCU override can be deactivated by modifying any of the FCU functions or releasing the parking brake. The ACU override mode is still available by depressing the "AUX" switch. Once the parking brake is disengaged, the FCU override mode is disabled, and the FCU will function based on the control settings on the FCU.

Minimum A/C Support

The FCU minimum A/C support feature is intended to assist the bunk HVAC system in maintaining its temperature setting by turning on the FCU to a minimum operating mode for A/C support. This feature is only implemented when:

- the front blower motor control is turned OFF, or the A/C switch is OFF, and
- the system is not in front override mode.

If the above conditions are met, and the ACU determines that it needs the A/C compressor to operate in order for it to maintain temperature, the ACU will request the FCU to engage the A/C compressor clutch.

Mode Control

Table 3 lists the mode control settings for the different positions of the mode control knob.

Figure 4 shows the airflow through the front HVAC unit with the mode setting in the DEF/FLOOR position, and the temperature set to medium heat.

Figure 5 shows the airflow through the front HVAC unit with the mode setting in the full DEFROST position, and the temperature set to full HOT.

Figure 6 shows the airflow through the front HVAC unit with the mode setting in the full FLOOR position, and the temperature set to full HOT.

Figure 7 shows the airflow through the front HVAC unit with the mode setting in full FACE position, and the temperature set to full COLD (MAX A/C Mode).

Mode Control Settings			
Knob Position	Mode	Mode Door Position	A/C Request and A/C Indicator Lit (automatically)
1	FACE	100% FACE	No
2	Minor detent	75% FACE + 25% FLOOR	No
3	BI-LEVEL	50% FACE + 50% FLOOR	No
4	Minor detent	25% FACE + 75% FLOOR	No
5	FLOOR	100% FLOOR	No
6	Minor detent	75% FLOOR + 25% DEFROST	Yes
7	DEF/FLOOR	50% FLOOR + 50% DEFROST	Yes

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Mode Control Settings			
Knob Position	Mode	Mode Door Position	A/C Request and A/C Indicator Lit (automatically)
8	Minor detent	25% FLOOR + 75% DEFROST	Yes
9	DEFROST	100% DEFROST	Yes

Table 3, Mode Control Settings

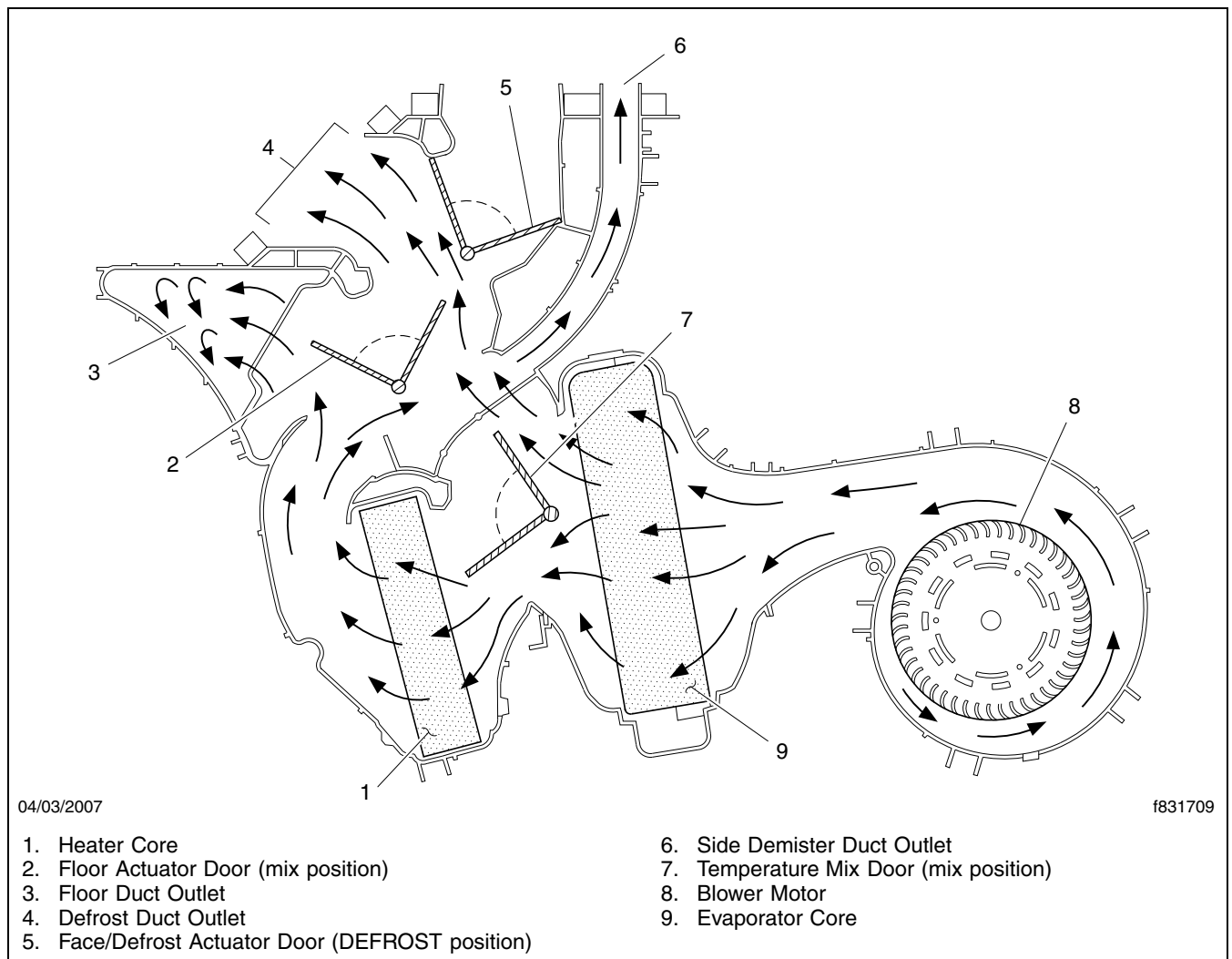


Fig. 4, Airflow Through Front HVAC Unit—Mode in DEF/FLOOR Position, Temperature Set to Medium Heat

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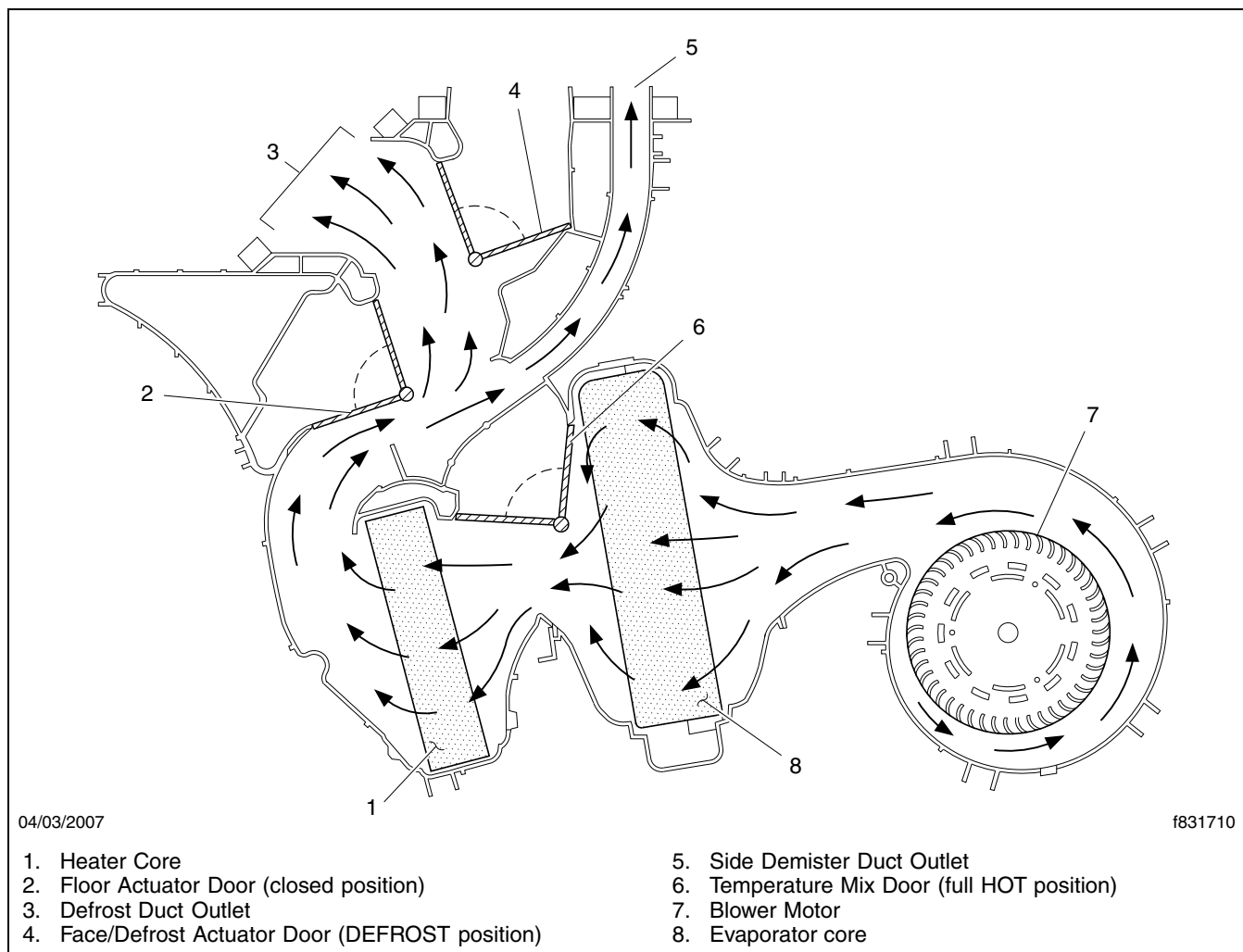


Fig. 5, Airflow Through Front HVAC Unit—Mode in Full DEFROST Position, Temperature Set to Full HOT

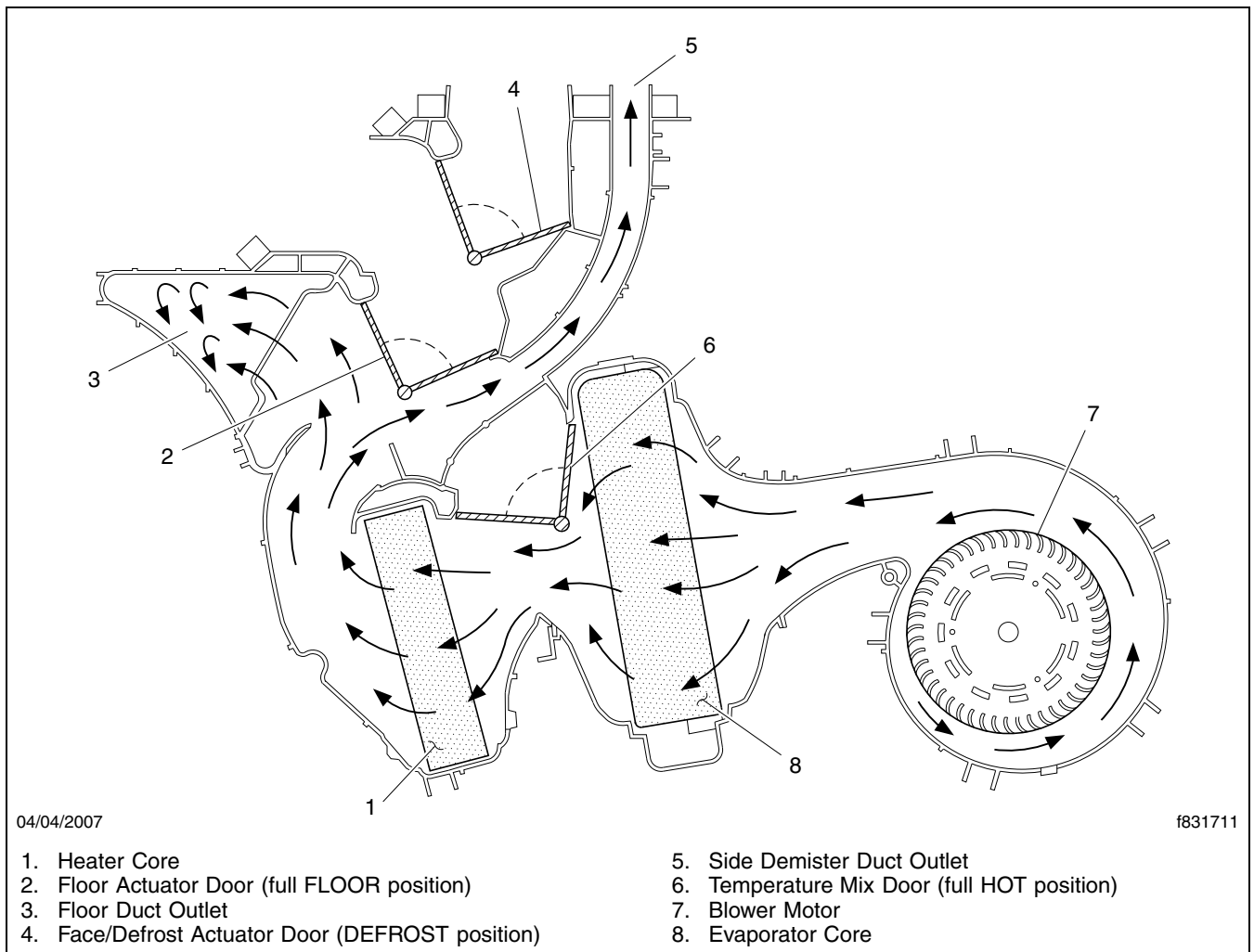


Fig. 6, Airflow Through Front HVAC Unit—Mode in Full FLOOR Position, Temperature Set to Full HOT

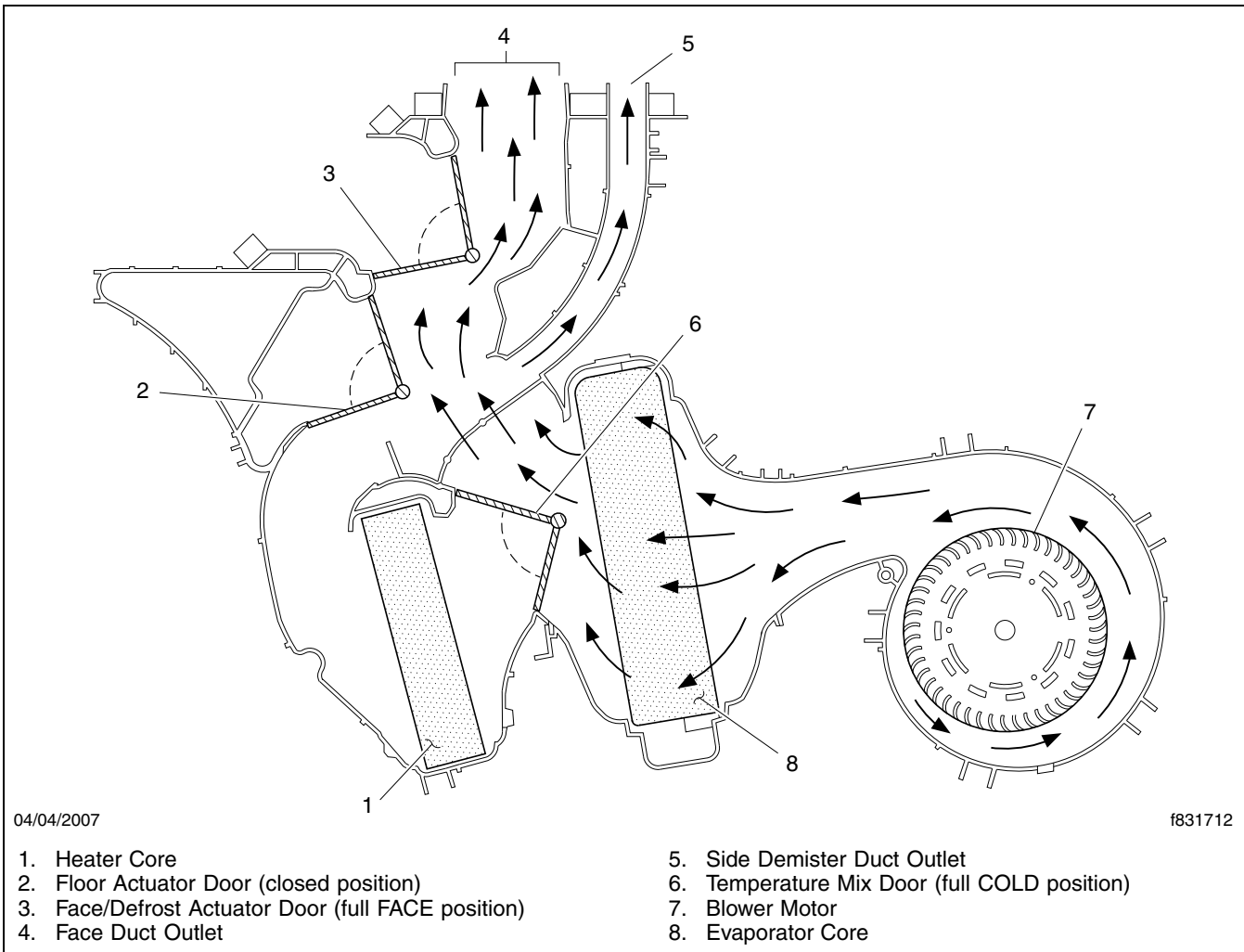


Fig. 7, Airflow Through Front HVAC Unit—Mode in Full FACE Position, Temperature Set to Full COLD (MAX A/C mode)

Manual Calibration Mode

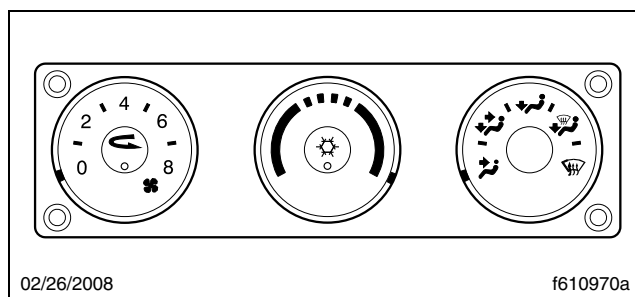


Fig. 8, Manual Calibration Mode Knob Positions

It is necessary to calibrate the actuators if they are removed or replaced. To enter calibration mode, perform the following steps:

1. Turn the ignition ON (engine OFF).
2. Set the blower speed control to OFF (full counterclockwise position).
3. Set the temperature control knob to the full clockwise position (HOT).
4. Set the mode control knob to the full counterclockwise position (FACE).
5. Press the A/C and RECIRC buttons simultaneously until the A/C and RECIRC indicators begin flashing simultaneously.

The calibration process will begin and will continue until the A/C and RECIRC indicators stop flashing.

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600 — Component Locations

HVAC Component Locations (general)

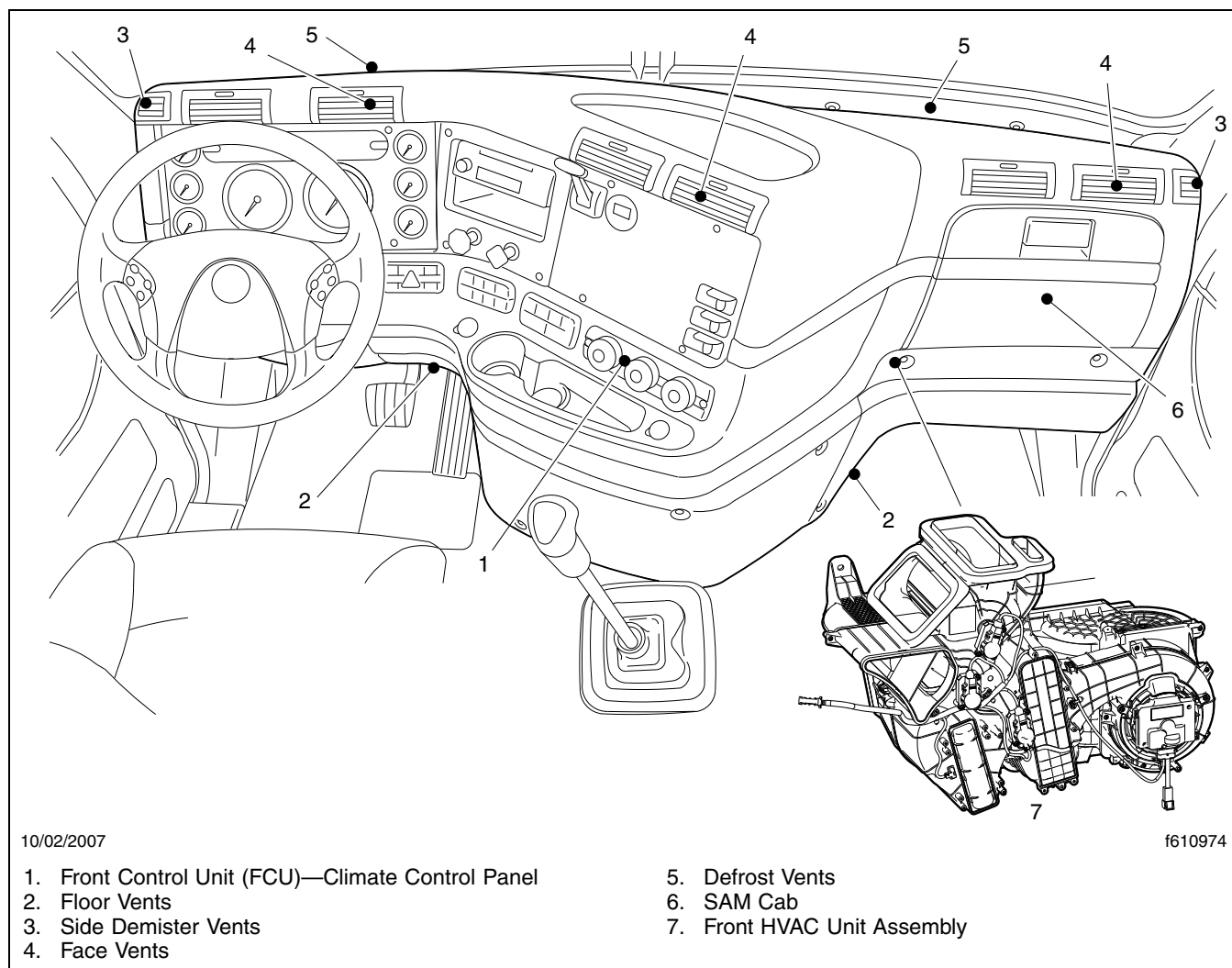


Fig. 9, HVAC Component Locations (general)

Component Locations—Front HVAC

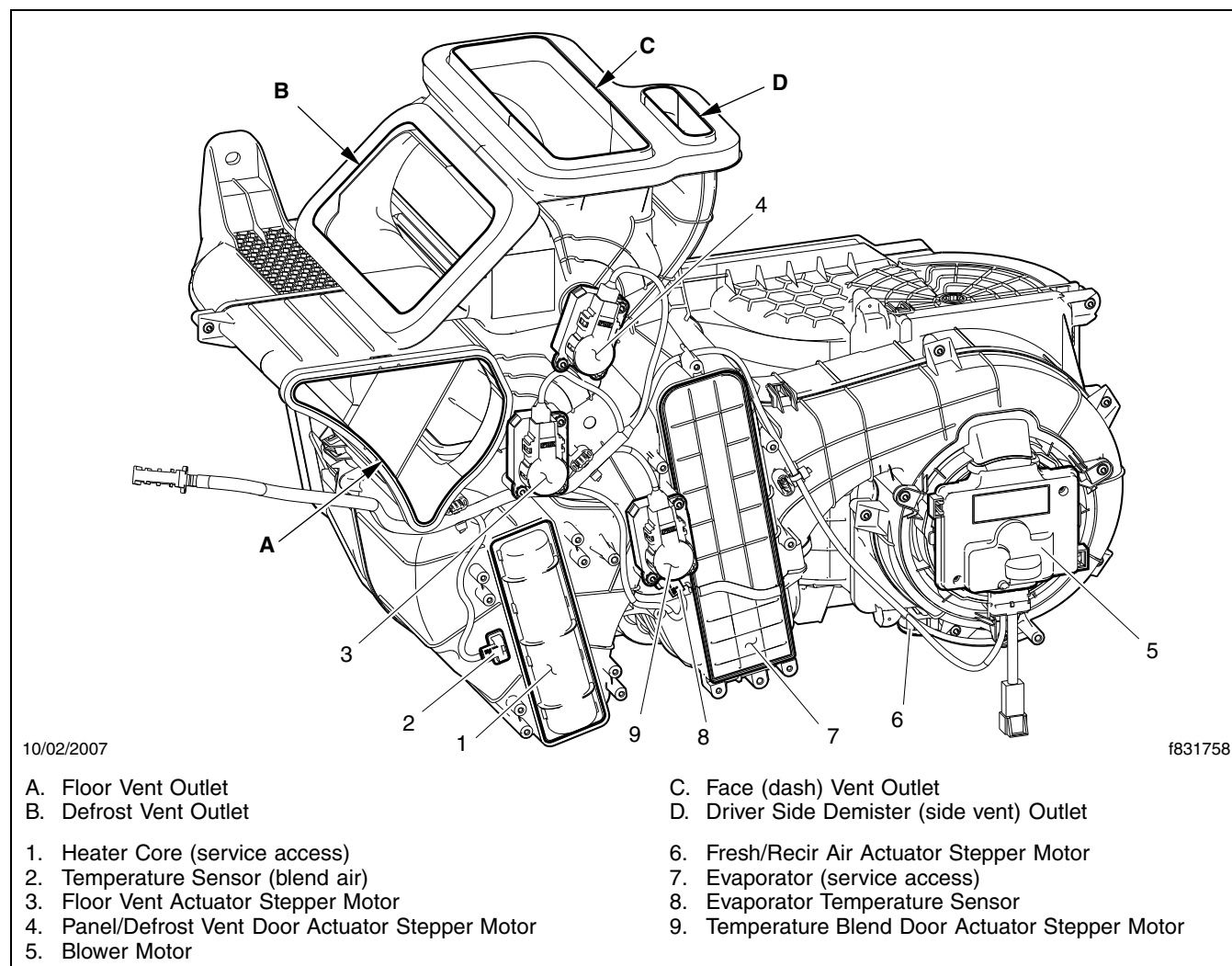


Fig. 10, Component Locations, Front HVAC

Component Locations—Sleeper HVAC

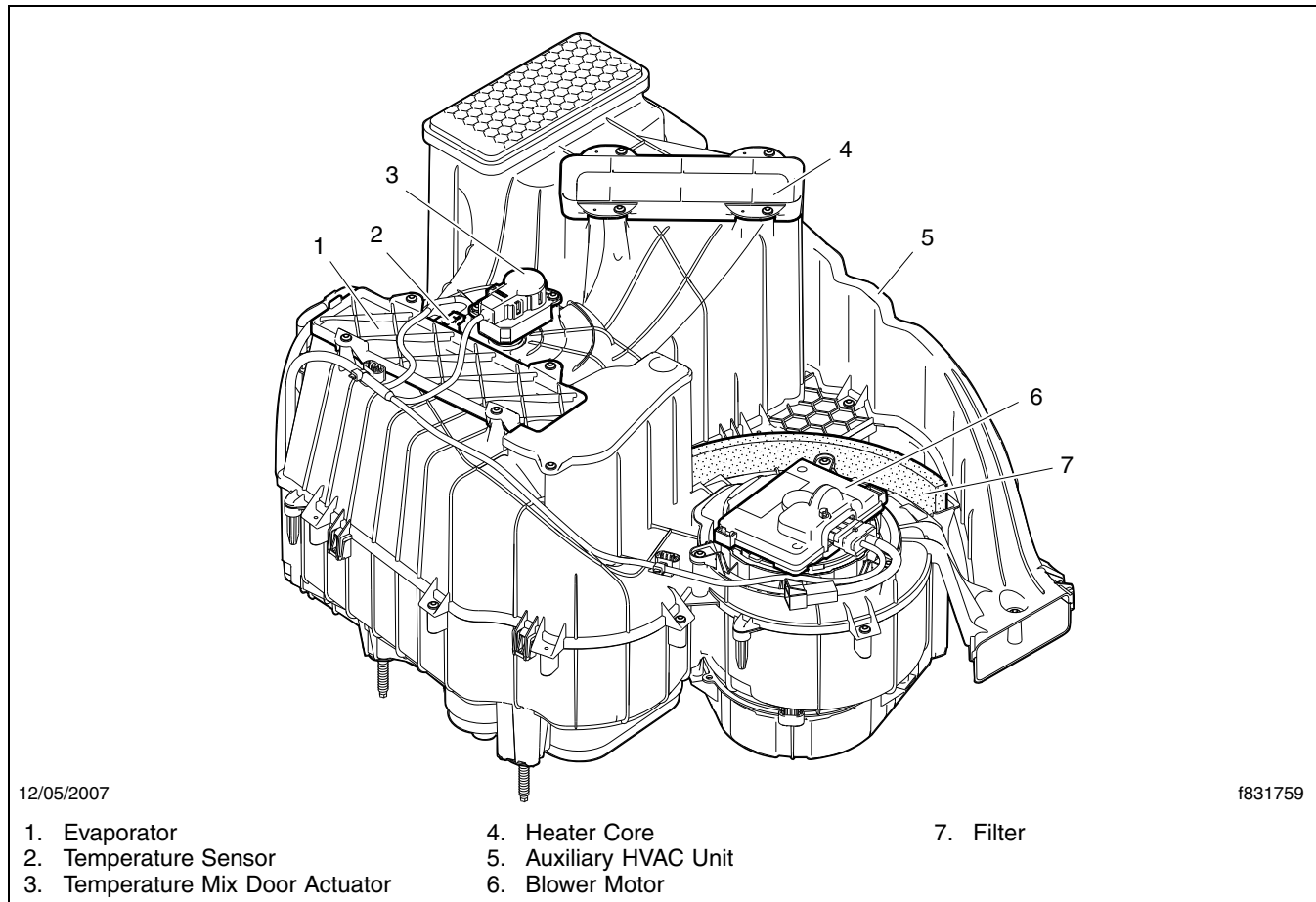


Fig. 11, Component Locations, Sleeper HVAC

601 — Component Details

Front Control Unit (FCU)

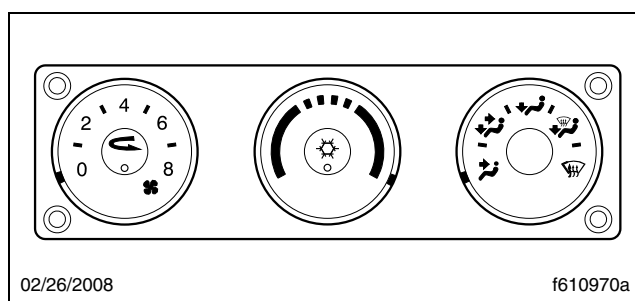


Fig. 12, Day Cab FCU

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The front control unit (FCU), also known as the climate control panel, is the brain of the front HVAC system. It also houses the knobs and switches that allow the driver to select various modes of operation, such as temperature, blower speed, air conditioning, etc. The SAM Cab provides the FCU with battery power, ignition power, and ground. It also supplies the signal to control backlighting. The FCU communicates with other ECUs on the J1939 datalink. The FCU controls all of the HVAC unit's four actuator stepper motors. Two of these are used to control airflow out of the vents (see "Mode Control"), one is used to control temperature by directing how much air flows through the heater core, and one is used to control whether recirculated or fresh air enters the unit (see "Controlled Partial Recirculation Rules"). The FCU controls the blower motor by providing a pulse width modulated signal to indicate set speed. It also monitors the blower motor feedback for actual blower speed and blower motor faults. The FCU determines when the A/C compressor should operate, and sends a request to the SAM Cab. The FCU can remotely control the bunk HVAC unit.

Auxiliary Control Unit (ACU)

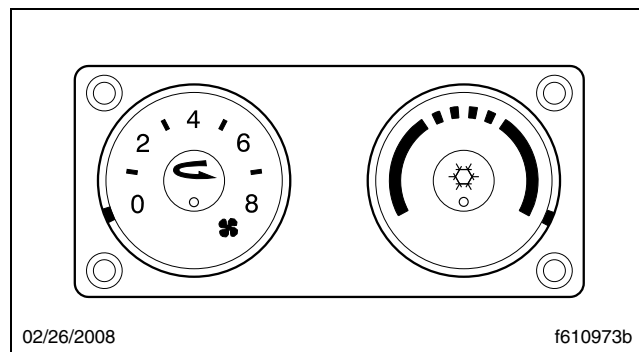


Fig. 14, Auxiliary Control Unit

The auxiliary control unit (ACU), is the brain of the bunk HVAC system. It is also known as the bunk climate control panel. It also houses the knobs and switches that allow the bunk occupant to select various modes of operation such as temperature, blower speed, air conditioning, etc. The SAM Cab provides the ACU with battery power, ignition power, and ground. It also supplies the signal to control backlighting. The ACU communicates with other ECUs on the J1939 datalink. The ACU controls an actuator stepper motor in the bunk HVAC unit, which operates a temperature mix door that directs how much air flows through the bunk heater core. The ACU controls the bunk unit blower motor by providing a pulse width modulated signal to indicate set speed. It also monitors the blower motor feedback for actual blower speed, and blower motor faults. The ACU can remotely control the front HVAC unit when the parking brake is set. See "FCU Override Mode".

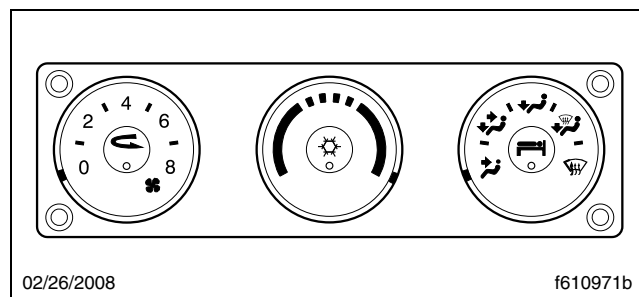


Fig. 13, Sleeper Cab FCU

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Compressor

The primary purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and compress it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. The secondary purpose of the compressor is to move refrigerant through the air conditioning system.

Pressure Transducer

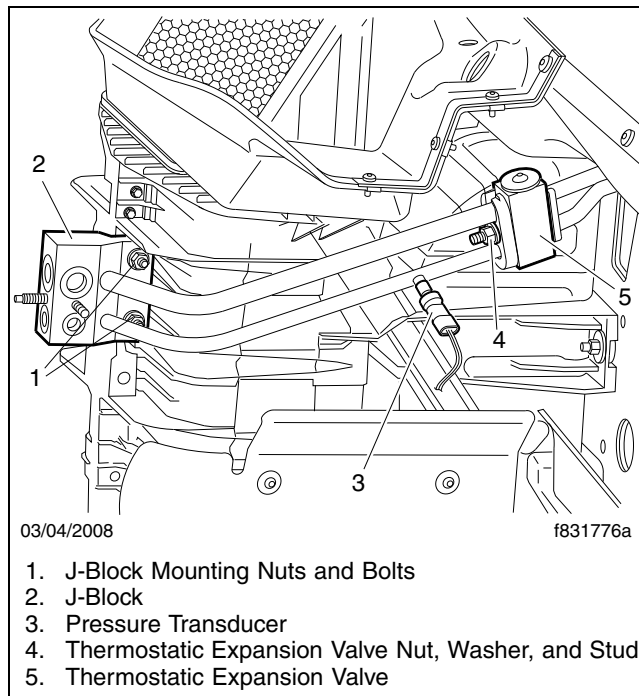


Fig. 15, Pressure Transducer

A pressure transducer, located in the high side of the refrigerant system close to the TXV, is used in place of the conventional binary and fan cycling switches. The transducer is connected to the SAM Cab.

Actuators

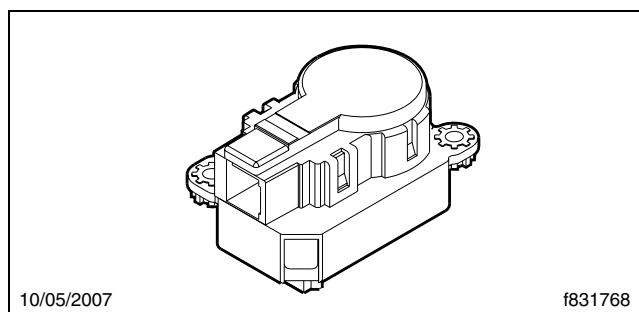


Fig. 16, Actuator

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Each actuator has a stepper motor in it that operates by switching 4 wires (the other two pins, 2 and 5, are tied to ignition level) in a proper sequence to cause rotation. The four wires are each switched on and off at 50Hz rate by the control panel, resulting in 200 "steps" per second. There is essentially 10 degrees of door rotation per second. There is no feedback to the FCU or ACU because the actuator moves a fixed angle for each step.

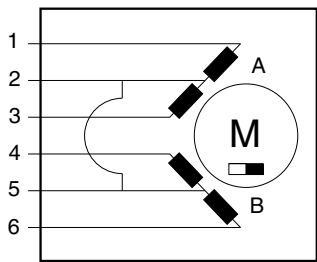
Actuator Connection and Drive Sequence					
Connecting Diagram		0	I	II	III
	1			—	—
	3	—	—		
	4		—	—	
	6	—			—
	2+5	+	+	+	+
	1		—	—	
	3	—			—
	4			—	—
	6	—	—		
	2+5	+	+	+	+

Table 4, Actuator Connection and Drive Sequence

Evaporator Sensor

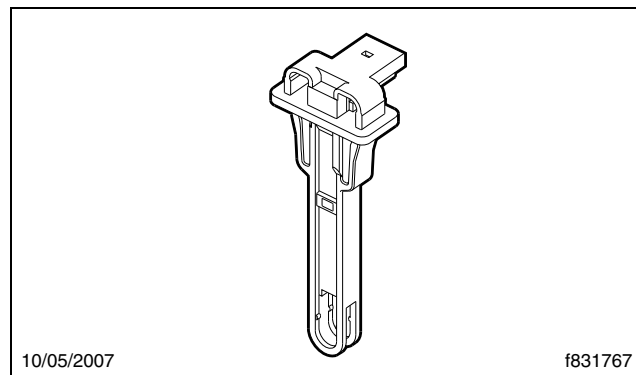


Fig. 17, Evaporator Temperature Sensor

The evaporator temperature sensor is used by the FCU to control the refrigerant compressor, to maintain temperature within its set-points, and to prevent evaporator freezing. It is a negative temperature coefficient (NTC), meaning that its resistance decreases as temperature increases. The FCU turns the compressor on when the temperature sensed by the evaporator temperature sensor is at or above 38.5°F (3.5°C). The FCU cycles the compressor off when the temperature sensed by the evaporator temperature sensor is at or below 38.0°F (3°C).

NOTE: There are other things that can prevent the compressor from engaging, regardless of whether the temperature sensed by the evaporator temperature sensor is within the range in which the compressor should engage. See "A/C Clutch Engagement".

Blower Motor

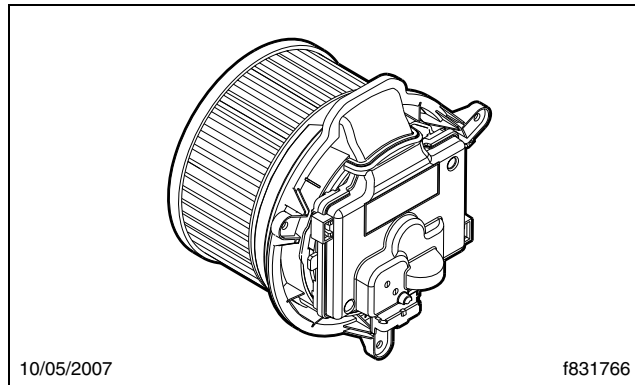


Fig. 18, Blower Motor

The Cascadia uses a brushless direct current (BLDC) blower motor in both the front and rear HVAC units. Both the front and rear BLDC blower motors have four circuits connected to them as follows:

- Battery power supplied directly from the SAM Cab through separate 30A fused circuits
- Ground supplied directly from the SAM Cab
- Pulse Width Modulated (PWM) speed control signal from the FCU and ACU
- Feedback signal to the FCU and ACU indicating rotational speed and fault diagnostics

The blower speed is controlled by the fan switches on the front and rear climate control panels (FCU and ACU). The control head sends a PWM signal to the blower motor at a frequency of 2000 Hz. The pulse width varies with the fan switch speed selection. The blower operates from within a speed ranging from approximately 400 to 3850 rpm.

Under normal operation, the feedback signal to the FCU and ACU indicates blower speed by varying the frequency. **$\text{rpm} = 20 \times \text{Frequency}$** . The BLDC blower motor has built-in protections that will cause the motor to operate at reduced speed or shut down to prevent damage. Any of the following conditions will cause the blower to enter protection mode:

- Over/Under Voltage—If the voltage supply to the blower motor is less than 8.5V or more than 17V, the blower motor will enter protection mode and shut down. The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- Reverse Voltage Protection—The motor will not operate if the polarity of the motor power and ground leads are reversed.
- Current Protection—If the motor exceeds the maximum current, the speed will be reduced until the current is within the normal range (under 23.5A). The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- Temperature Protection—If the motor's internal temperature sensor senses that the temperature is too high, the blower speed is reduced to 1000 rpm to reduce the load on the motor, and a comparison is made

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between the sensor reading and the maximum limit. If the temperature is still too high, the blower speed is further reduced to the minimum value of approximately 500 rpm, and a temperature comparison is made to the maximum. If after the second comparison, the temperature is still too high, the motor will shut down until it has cooled sufficiently. The blower feed-back circuit will indicate a fault, and a fault will be logged in the FCU or ACU.

If the BLDC blower motor has entered protection mode due to one of the conditions listed above, the blower speed feedback signal becomes a diagnostic signal to the FCU and ACU by setting its frequency at 10Hz and varying the duty cycle of the signal to indicate the cause of the protection mode. Refer to **Table 27**. A fault will be logged by the FCU or ACU.

Thermostatic Expansion Valve

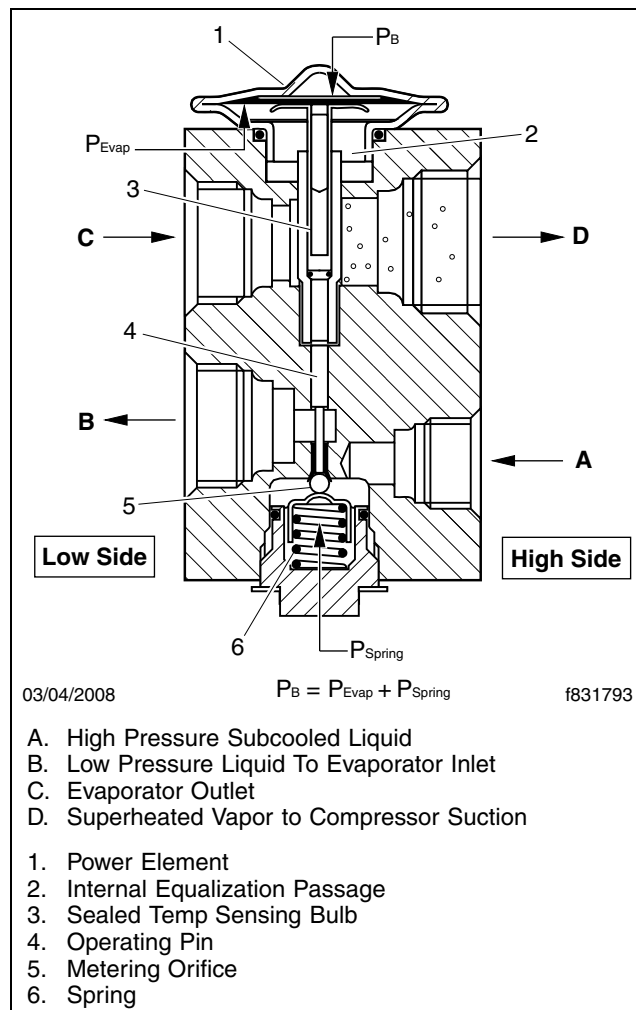


Fig. 19, Thermostatic Expansion Valve (cutaway)

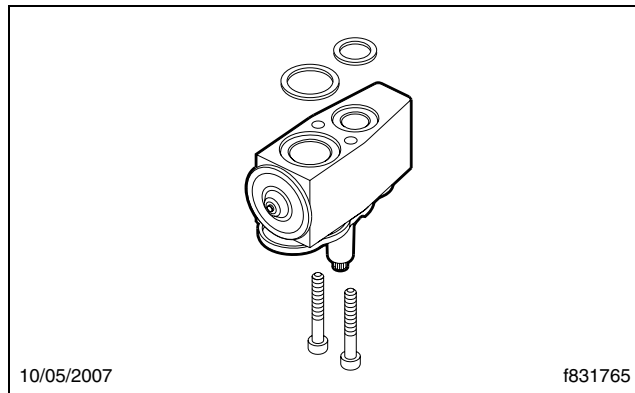


Fig. 20, Thermostatic Expansion Valve

The Thermostatic Expansion Valve (TXV) is a controlling device that regulates the flow of refrigerant into the evaporator. It is actuated by changes in evaporator pressure and the superheat of the refrigerant gas leaving the evaporator. Superheat is defined as any temperature of a gas above the boiling point for that liquid. For example, when a refrigerant liquid boils at a low temperature of 40°F (4.5°C) in the evaporator and then the refrigerant gas increases in temperature, superheat has been added. If this refrigerant changed from a liquid to a gas or vapor at 40°F (4.5°C) and then the refrigerant vapor increased in temperature to 50°F (10°C), then it has been superheated by 10°F (6.5°C). The refrigerant entering the evaporator is metered at a rate that matches the amount of refrigerant being boiled off in the evaporator. In addition to metering refrigerant, the TXV also provides a pressure drop in the system, separating the high-pressure side of the system from the low-pressure side.

To operate properly, the TXV must have a steady flow of liquid refrigerant supplied to it by the high side of the system. Issues such as an excessively low refrigerant charge, or contaminants in the system can interrupt this flow of liquid to the valve. In these cases, symptoms may surface making it seem as if the valve is inoperative or plugged. These symptoms can include poor performance, low low-side pressures (even a vacuum), etc. Before replacing a TXV, it is important to verify that there are no contaminants in the system and that the refrigerant charge is correct, by performing a refrigerant identification and thorough leak check of the entire system.

The TXV is often incorrectly replaced as the primary failed part, but is rarely the cause of a performance issue. In rare instances the power element of the TXV can lose its charge causing the valve to close, but there is no other situation that can be considered a failure of the TXV. Due to the similarity of symptoms that these root causes have on A/C performance, proper diagnosis is essential to making the correct repairs to the A/C system. It is for this reason that Freightliner requires refrigerant identification and leak checking prior to replacement of any TXV.

Receiver-Drier

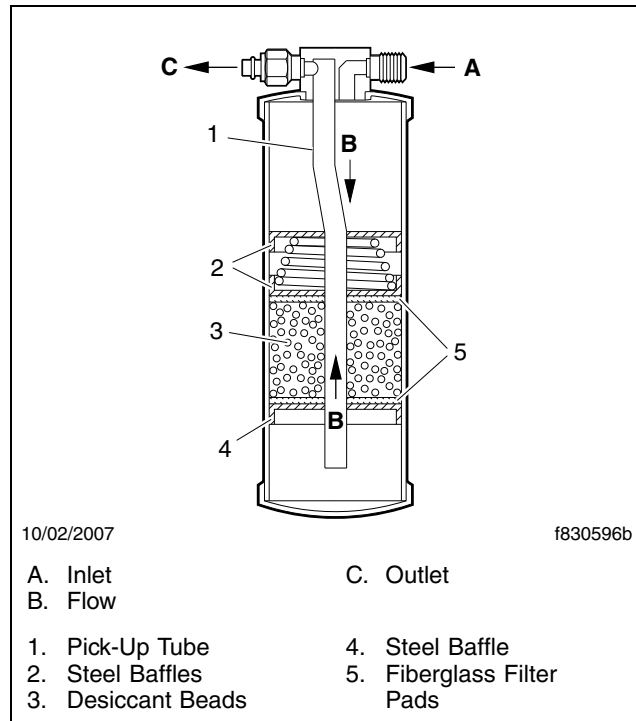
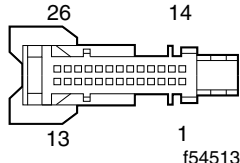


Fig. 21, Receiver-Drier

The receiver-drier is used as a reservoir and filter for liquid refrigerant from the condenser. A receiver-drier also removes moisture from the refrigerant. The moisture absorbing material, or desiccant, in the unit helps prevent ice blockages from forming in the expansion valve and in other parts of the system.

602 — Electrical Connectors

Electrical Connectors—Front HVAC

FCU 26-Pin Connector			 f545136
Pin	Circuit #	Wire Color	Circuit Description
1	338A1-4	Light Blue	Blend actuator-ground (-) #4
2	338A1-2	Light Blue	Blend actuator-ground (-) #2
3	338A2-3	Light Blue	Defrost actuator-ground (-) #3
4	338A2-1	Light Blue	Defrost actuator-ground (-) #1

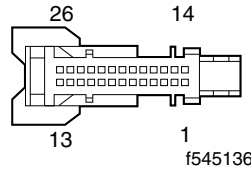
FCU 26-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
5	338A3-3	Light Blue	Floor actuator-ground (-) #3
6	338A3-1	Light Blue	Floor actuator-ground (-) #1
7	338A1-2	Light Blue	Recirc actuator-ground (-) #3
8	338A4-1	Light Blue	Recirc actuator-ground (-) #1
9	338K	Light Blue	Evaporator sensor signal
10	338L	Light Blue	Heater core sensor signal
11	338G2	Light Blue	Sensor ground (-)
12	338A1+	Light Blue	Blend actuator-supply (+)
13	338A2+	Light Blue	Defrost actuator-supply (+)
14	338A1-3	Light Blue	Blend actuator-ground (-) #3
15	338A1-1	Light Blue	Blend actuator-ground (-) #1
16	338A2-4	Light Blue	Defrost actuator-ground (-) #4
17	338A2-2	Light Blue	Defrost actuator-ground (-) #2
18	338A3-4	Light Blue	Floor actuator-ground (-) #4
19	338A3-2	Light Blue	Floor actuator-ground (-) #2
20	338A4-4	Light Blue	Recirc actuator-ground (-) #4
21	338A4-2	Light Blue	Recirc actuator-ground (-) #2
22	—	—	Not Used
23	338M	Light Blue	Blower motor diagnostic (PWM)
24	338H	Light Blue	Blower motor control (PWM)
25	338A3+	Light Blue	Floor actuator-supply (+)
26	338A4+	Light Blue	Recirc actuator-supply (+)

Table 5, FCU 26-Pin Connector

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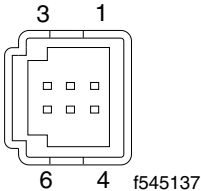
FCU 6-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(-) datalink
3	29A	Brown	Backlighting input (PWM)
4	98	Light Blue	+12V battery
5	GND	Black	Ground
6	81C	Pink	+12V ignition/acc

Table 6, FCU 6-Pin Connector

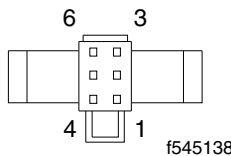
Actuator Stepper Motor 6-Pin Connector (Front Unit Actuators)						
Pin	Circuit No.				Wire Color	Circuit Description
	Fresh/Recirc	Temperature Blend	Floor	Defrost/Face		
1	338A4-1	338A1-1	338A3-1	38A2-1	Light Blue	Ground #1
2	338A4+	338A1+	338A3+	338A2+	Light Blue	Supply (+)
3	338A4-3	338A1-3	338A3-3	338A2-3	Light Blue	Ground #3
4	338A4-4	338A1-4	338A3-4	338A2-4	Light Blue	Ground #4
5	—	—	—	—	—	Not used
6	338A4-2	338A1-2	338A3-2	338A2-2	Light Blue	Ground #2

Table 7, Actuator Stepper Motor 6-Pin Connector (front unit actuators)

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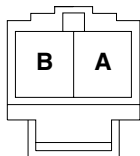
Blower Motor 2-Pin Connector (Front Unit)			 f545139
Pin	Circuit #	Wire Color	Circuit Description
A	98F	Light Blue	+12V battery
B	GND	Black	Ground

Table 8, Blower Motor 2-Pin Connector (Front Unit)

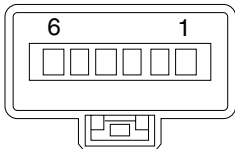
Blower Motor 6-Pin Connector (Front Unit)			 f545140
Pin	Circuit #	Wire Color	Circuit Description
1	338M	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDH	Black	Ground
4	98F	Light Blue	+12V battery
5	338H	Light Blue	Blower motor speed control signal
6	—	—	Not used

Table 9, Blower Motor 6-Pin Connector (Front Unit)

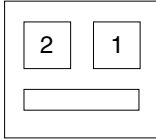
Heater Core Temperature Sensor, CDTC (Front Unit)			 f545141
Pin	Circuit #	Wire Color	Circuit Description
1	338L	Light Blue	—
2	338G1	Light Blue	—

Table 10, Heater Core Temperature Sensor, CDTC (Front Unit)

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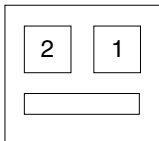
Evaporator Temperature Sensor (Front Unit)			 f545141
Pin	Circuit #	Wire Color	Circuit Description
1	338K	Light Blue	Evaporator Sensor Signal
2	338G	Light Blue	Ground

Table 11, Evaporator Temperature Sensor (Front Unit)

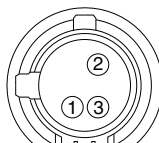
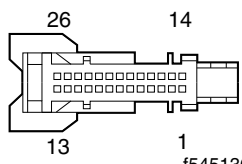
High-Side Pressure Transducer Connector			 f545142
Pin	Circuit #	Wire Color	Circuit Description
1	440	Gray	Sensor +5V supply
2	440Y	Gray	Sensor feedback
3	440G	Black	Sensor ground

Table 12, High-Side Pressure Transducer Connector

Electrical Connectors—Sleeper HVAC

Auxiliary HVAC to Control Panel 26-Pin Connector			 f545136
Pin	Circuit #	Wire Color	Circuit Description
1	338SA1-4	Light Blue	Blend actuator-ground (-) #4
2	338SA1-2	Light Blue	Blend actuator-ground (-) #2
3-9	—	Light Blue	Not used
10	338SK	Light Blue	Heater core sensor signal
11	338SG	Light Blue	Sensor ground (-)
12	338SA1+	Light Blue	Blend actuator-supply (+)

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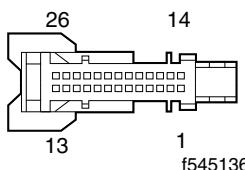
Auxiliary HVAC to Control Panel 26-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
13	—	Light Blue	Not used
14	338SA1-3	Light Blue	Blend actuator-ground (-) #3
15	338SA1-1	Light Blue	Blend actuator-ground (-) #1
16-22	—	Light Blue	Not used
23	338SM	Light Blue	Blower motor diagnostic (PWM)
24	338SH	Light Blue	Blower motor control (PWM)
25-26	—	Light Blue	Not used

Table 13, Auxiliary HVAC to Control Panel 26-Pin Connector

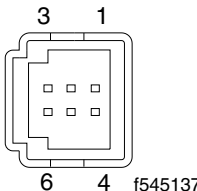
Auxiliary HVAC to Control Panel 6-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(-) datalink
3	29A	Brown	Backlighting input (PWM)
4	98G	Light Blue	+12V battery
5	GND	Black	Ground
6	220	Pink	+12V ignition/acc

Table 14, Auxiliary HVAC to Control Panel 6-Pin Connector

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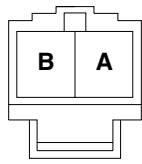
Blower Motor 2-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
A	98G	Light Blue	+12V battery
B	GNDF	Black	Ground

Table 15, Blower Motor 2-Pin Connector (Sleeper Unit)

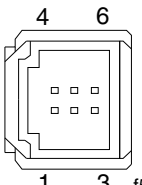
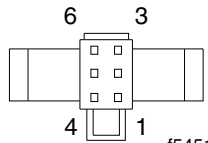
Blower Motor 6-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
1	338SM	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDF	Black	Ground
4	98G	Light Blue	+12V battery
5	338SH	Light Blue	Blower motor speed control signal
6	—	—	Not used

Table 16, Blower Motor 6-Pin Connector (Sleeper Unit)

Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
1	338SA1-1	Light Blue	Blend actuator-ground (-) #1
2	338SA1+	Light Blue	Blend actuator-supply (+)
3	338SA1-3	Light Blue	Blend actuator-ground (-) #3
4	338SA1-4	Light Blue	Blend actuator-ground (-) #4

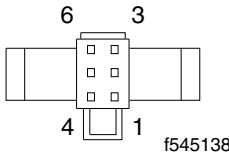
Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
5	—	—	Not used
6	338SA1-2	Light Blue	Blend actuator-ground (-) #2

Table 17, Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)

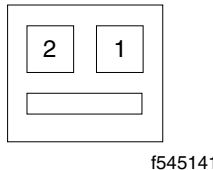
Heater Core Temperature Sensor, CDTC (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
1	338SK	Light Blue	—
2	338SG	Light Blue	—

Table 18, Heater Core Temperature Sensor, CDTC (Sleeper Unit)

700 — Troubleshooting

Diagnostic Overview

For system performance testing, ambient temperature must be above 70°F (21°C) to produce reliable results. In order to quickly determine if the symptoms are related to refrigerant or electrical, two main tools should be utilized by the technician: ServiceLink and a refrigerant gauge set.

General Diagnostic Procedure

1. Perform the preliminary checks.
2. Perform an initial system inspection.
3. Make a determination about which system is suspected (refrigerant or electrical), and follow the symptoms through to a suspected part.
4. Repair the problem.
5. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
6. Verify that the problem has been resolved.

701 — Diagnostic Process

Preliminary Checks

NOTE: Pay attention to the refrigerant system components for evidence of oil seepage and other potential leaks that will be checked during subsequent diagnostic steps.

Before testing the operation of the air conditioning system, check the following items:

1. Inspect the drive belt and mounting fasteners for signs of wear or looseness.
2. Visually inspect the clutch for signs of overheating, damage, or wear. If necessary, check the clutch gap. For instructions, see **Section 83.04**, Subject 140.
3. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
4. Inspect the fresh and recirculation air filter elements, and inspect the intake-air ducting for debris.
5. With the engine off, and Optimized Idle (if applicable) disabled, turn the compressor drive plate by hand to feel for grinding or harshness inside the compressor.

Initial Inspection

1. Connect the refrigerant pressure gauges and ServiceLink to the vehicle.
2. Start the vehicle and select A/C mode and a cold temp setting to request compressor engagement. If the following conditions are met, the clutch should engage.
 - The engine is running at or above 450 RPM for at least five seconds.
 - Refrigerant system high side pressure is above 20 psi (140 kPa). Pressure reading is taken at the pressure transducer.
 - Refrigerant system high side pressure is below 450 psi (3100 kPa). Pressure reading is taken at the pressure transducer.
 - Vehicle compressed air system is above 60 psi (414 kPa). Pressure is taken at the dash ECU, and transmitted on the J1587 databus.
 - Evaporator core temperature sensor is above 44°F (6.5°C). Temperature is taken in the main heater box, as a direct input to the front control unit (FCU).
 - The blower feedback from the main HVAC unit is connected, and the signal is meeting the minimum RPM requirements for each knob position.

At this point you should be seeing some indication of a problem, either electrical or refrigerant.

Electrical—If there are any faults that affect the FCU or any of the parallel systems that provide input information to the FCU, or if the system requirements are being met, but the clutch is still not engaging, there may be an electrical problem related to the FCU, or the voltage signal to the compressor.

Refrigerant—If the low side pressure is drawing down far below 20 psi (140 kPa), or if the high side pressure is rising above 450 psi (3100 kPa), there is a refrigerant-related problem.

Post-Repair Procedures

After repair work is completed, verify that the repair resolved the problem.

1. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
2. Check for fault codes. There should be no active fault codes that indicate the problem still exists.
3. If there is still a problem, repeat the appropriate tests, and make repairs as needed.
4. Verify again.

702 — Refrigerant System Tests

Test Procedure

Use the following procedure to evaluate the performance of the air conditioning system. If the system does not perform as stated below, further diagnosis and repair may be necessary.

NOTE: The dash outlet temperature will fluctuate during each clutch cycle, and the temperature reading should be taken at the lowest value.

1. Park the vehicle out of direct sunlight, shut down the engine, and set the parking brakes. Chock the tires.
2. Open the hood and leave the hood open for the entire test.
3. Open the driver and passenger doors and leave the doors open for the entire test.
4. Note the current ambient air temperature.

NOTE: High relative humidity reduces cooling and could increase the dash outlet temperatures, and high-side system pressures.

5. Using the ambient air temperature readings noted in the previous step, find the temperature/pressure specifications in **Table 22** that best match your ambient conditions.
6. Connect the test gauges to the high and low side service ports.
7. Place a thermometer in the center dash outlet. If the vehicle is a SleeperCab, place another thermometer in the lower sleeper outlet.

NOTE: EPA10 and owner-set idle limits may prevent the warm-up run from continuing without occasional throttle inputs.

8. Start the engine and run the A/C for 15 minutes.
9. Set the engine speed to 1500 rpm and engage the engine fan.
10. Set the cab climate control panel to the following settings:
 - air selection switch to face mode
 - air conditioning on
 - blower speed switch to high
 - temperature control switch to full cold
 - recirculation switch off
11. On SleeperCabs, set the sleeper climate control panel to the following settings (or initiate "bunk override" mode):

- blower speed switch to high
 - temperature control switch to full cold
12. Allow the system to stabilize at least five minutes or until the dash and sleeper outlet temperatures have reached a minimum, then compare the system values to the information in **Table 22** in **800—Specifications**. The results should be close to those listed, but minor discrepancies are not a guarantee that the system has a refrigerant system problem.

Possible causes of refrigerant system complaints:

- Too much oil - High high-side pressure, poor heat rejection at the condenser
- Too much refrigerant - High high-side pressure, good cooling
- Not enough refrigerant - Low high-side pressure, low low-side pressure, poor cooling
- Debris in the system - TXV plugged or uncontrollable, compressor turns hard, receiver/drier is icing
- Contaminated or incorrect refrigerant - Very inconsistent system pressures and duct temps

Thermal Expansion Valve (TXV) Testing

To determine if the TXV is functioning, watch the low-side pressure while the compressor is engaged. The influence from the TXV modulating can be seen as the low-side gauge needle "wags." As the load on the system changes from ambient conditions, the TXV may not wag as much, and care must be taken to prevent false diagnosis. The function of the individual TXVs in a dual evaporator system will be combined to produce the total pressure needle wagging that is observed. If a TXV failure is suspected, connect the gauge set to the properly charged refrigerant loop, and run the compressor. Watch for the low-side gauge needle to wag, indicating that the TXV is working. Depending on the load, the low-side pressure may progress from moderate to high, but the needle will simultaneously wag as the average pressure changes.

Sanden A/C Compressor Testing, Pressure or Pumping Test

NOTE: This test is meant to be performed after a failure has been repaired, which may have caused damage to the compressor due to low refrigerant or oil levels.

Compressors cause refrigerant to flow through the system by creating a pressure differential, high and low pressures. If the compressor can be forced to produce a high pressure in excess of 350 psi (2415 kPa), it is a good compressor.

IMPORTANT: The compressor pumping test must be performed with the refrigerant system charged to the factory specifications, and functioning properly. This test should only be run for a short time period. Shut the system down immediately once 350 psi (2415 kPa) is achieved.

1. Confirm the system is charged per the OEM requirement before proceeding.
2. Disable the engine cooling fan. The condenser can also be blocked with a sheet of cardboard. The purpose is to limit heat removal from the system and build compressor discharge pressure.

3. Start the engine and engage the compressor clutch.

Compressors operating within specification should be capable of reaching 350 psi (2415 kPa).

4. Shut the system down immediately, once 350 psi (2415 kPa) is achieved.

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Denso A/C Compressor Pressure Test

NOTE: This test can be performed after a failure has been repaired, or on compressors experiencing a low "high side" pressure, or a high "low side" symptoms, when properly charged. The compressor pressure test must be performed with the refrigerant system discharged and the refrigerant lines disconnected.

Test the performance of the compressor as follows.

1. Place your thumb over the suction port of the compressor and slowly rotate the compressor. An even suction should be felt as the compressor is turned.
2. Place your thumb over the discharge port and slowly rotate the compressor. An even pressure should be felt as the compressor is turned.
3. If an uneven pressure is felt on either the suction or discharge port while turning the compressor, internal damage has occurred, and the compressor will not perform properly.

703 —Fault Code Driven Diagnostics

Fault Codes—HVAC

J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	SPN	FMI	Fault Description	Fault Trigger
25	70	9	Parking Brake Switch Status Message—abnormal update rate	FCU does not receive J1939 parking brake switch status from SAM Cab.
25	84	9	Vehicle Speed—abnormal update rate	FCU does not receive J1939 vehicle speed message from engine ECM.
25	110	9	Engine Coolant Temperature Message—abnormal update rate	FCU does not receive J1939 engine coolant temperature message from engine ECM.
25	158	3	FCU—voltage above normal	FCU voltage is too high or voltage is applied when it should not be.
		4	FCU—voltage below normal	FCU voltage is too low.
25	168	9	SAM Cab Battery Voltage Message—abnormal update rate	FCU does not receive J1939 battery voltage message from SAM Cab.
25	171	9	Ambient Air Temperature—abnormal update rate	Data from SAM?
25	190	9	Engine Speed Message—abnormal update rate	FCU does not receive J1939 engine speed message from engine ECM.
25	629	12	FCU—bad intelligent device or component	—
25	639	2	J1939 Datalink—intermittent or incorrect data	FCU attempts to broadcast this fault if all J1939 receive messages are corrupt continuously for a period of 1.5 seconds.
25	876	1	A/C Clutch—protection mode (voltage too low)	Based on battery volt message from SAM allowing for line loss to clutch (11.5V minimum).
		2	A/C Clutch—data erratic, intermittent, or incorrect	—
		9	A/C Clutch—abnormal update rate	—
		10	A/C Clutch—root cause not known	—

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J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	SPN	FMI	Fault Description	Fault Trigger
25	1547	4	Evaporator Sensor—short to ground	—
		5	Evaporator Sensor—short to battery or open circuit	—
25	1548	4	COTC Sensor—short to ground	—
		5	COTC Sensor—short to battery or open circuit	—
25	522510	0	High Pressure Sensor—data valid, but above normal operating range.	Pressure above 530 psi.
		1	High Pressure Sensor—data valid, but below normal operating range.	Pressure 18–30 inHg (vac).
		2	High Pressure Sensor—data erratic, intermittent, or incorrect	—
		9	High Pressure Sensor—abnormal update rate	—
		11	High Pressure Sensor—root cause not known	—
25	523307	9	Low Air Pressure Switch Status Message—abnormal update rate	FCU does not receive J1939 low air pressure switch status message from SAM Cab.
25	523318	2	Blower Motor—protection mode (voltage out of range)	—
		6	Blower Motor—protection mode (overcurrent or thermal protection)	—
		7	Blower Motor—protection mode (speed mismatch or blocked rotor)	—
25	523329	2	Defrost Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Defrost Door Actuator—voltage above normal or shorted to battery	—
		4	Defrost Door Actuator—voltage below normal, open circuit	—
25	523330	2	Blend Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Blend Door Actuator—voltage above normal or shorted to battery	—
		4	Blend Door Actuator—voltage below normal, open circuit	—
25	523331	2	Recirc Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Recirc Door Actuator—voltage above normal or shorted to battery	—
		4	Recirc Door Actuator—voltage below normal, open circuit	—

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J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	SPN	FMI	Fault Description	Fault Trigger
25	523332	2	Floor Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Floor Door Actuator—voltage above normal or shorted to battery	—
		4	Floor Door Actuator—voltage below normal, open circuit	—

Table 19, J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 25

J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 58				
SA	SPN	FMI	Fault Description	Fault Trigger
58	158	3	ACU—voltage above normal	—
		4	ACU—voltage below normal	—
58	609	12	ACU—bad intelligent device or component	Replace ACU.
58	639	2	J1939 Datalink—intermittent or incorrect data	ACU attempts to broadcast this fault if all J1939 receive messages are corrupt continuously for a period of 1.5 seconds.
58	1548	4	COTC Sensor—short to ground	—
		5	COTC Sensor— short to battery or open circuit	—
58	523318	2	Blower Motor—protection mode (voltage out of range)	—
		6	Blower Motor—protection mode (overcurrent or thermal protection)	—
		7	Blower Motor—protection mode (speed mismatch or blocked rotor)	—
58	523330	2	Blend Door Actuator—data mismatch	All output data is read high not matching low input from microprocessor.
		3	Blend Door Actuator—voltage above normal or shorted to battery	—
		4	Blend Door Actuator—voltage below normal, open circuit	—

Table 20, J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 58

SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33				
SA	SPN	FMI	Fault Description	Fault Trigger
33	170	2	Interior Ambient Air Temperature Sensor—data erratic	—
		3	Interior Ambient Air Temperature Sensor—short to battery	—
		4	Interior Ambient Air Temperature Sensor—short to ground	—
33	876	3	A/C Compressor Output—short to battery	—
		4	A/C Compressor Output—short to ground	—

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SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33				
SA	SPN	FMI	Fault Description	Fault Trigger
33	521510	3	High-Side Pressure Transducer Feedback—short to battery	SAM Cab detects above normal voltage on pressure feedback circuit.
		4	High-Side Pressure Transducer Feedback—short to ground	SAM Cab detects below normal voltage on pressure feedback circuit.
33	521515	4	Cabin HVAC Power—short to ground	—

Table 21, SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33

704 — Approved Leak Detection Methods

General Information

The information in this section is intended to convey a general method of leak detecting that should be used to enhance the usefulness of a leak detector being used in accordance with operator's instructions provided by the manufacturer. No technician should attempt to perform leak detection without reading and understanding the owner's manuals for the tools being used, and should expect to review those instructions from time to time, to ensure the proper care was developed using the published list of recommended tools and warranty evaluation guides as a basis for the expectations for repair competence. The only way to confirm that a refrigerant leak exists is by finding a failed or damaged component. A UV flashlight and goggles can be used to provide an indication of a leak, but an approved electronic leak detector must be used to confirm the existence of a leak, and to approximate the leak rate. The connections used for A/C refrigerant are intended to seal properly, but given the high level of sensitivity provided by current leak detecting equipment, the detector may indicate a leak even though the connection meets the design specifications. To balance this, the "Acceptable Leak Rates by Component", **Table 34**, in Specifications contains the qualifying leak rates for the components used on Cascadia vehicles. The leak rates, in oz/yr, correspond to the sensitivity values required for all detectors that meet the SAE J2791 functional specifications. By switching between the sensitivity levels, it is possible to discern between leaks of varying sizes and qualify each potential leak. It is expected that a leak rate relates to each component, as it arrives at the factory, but the Mini-Statoseals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multi-port connection, the leak rate for two Mini-Statoseals should be considered a condemning value if it is not completely clear which seal is leaking.

Method

IMPORTANT: The refrigerant system should be warmed up from completion of the initial inspection, but the engine is off.

1. Shut down the engine.
2. Before testing for compressor leaks, blow shop air near the compressor shaft seal to clear any refrigerant that may have collected.
3. Install caps before testing the service ports.
4. Minimize the amount of wind blowing through the test area, as wind will make small leaks harder to find.
5. Set the detector on the most sensitive setting.
6. Start at a point along the refrigerant loop, and methodically follow the refrigerant path. Test all around O-ring connections and crimped ends until you reach the starting point.

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7. When the detector indicates a suspected leak, move the detector away from the suspect area, then recheck to the location after the detector has cleared. If the detector continues to indicate a leak, adjust the sensitivity of the detector to match the designed leak specifications shown in "Acceptable Leak Rates by Component", **Table 34**, in **800—Specifications**, and retest the suspected area to confirm the leak. Mark any confirmed leaks, then change the sensitivity back to high and continue checking the system.
8. After the entire system has been checked, recover the refrigerant, investigate each leak point to determine what component failed, and how, then repair the leak.
9. Recharge the refrigerant system, then use the electronic leak detector to confirm that each connection opened during the repair is sealed within the design specifications provided in the "Acceptable Leak Rates by Component," **Table 34**, in **800—Specifications**.

Diagnostic Tools Required

The following diagnostic tools are required to perform troubleshooting procedures on Cascadia vehicles.

- Servicelink
- Digital multimeter
- Approved refrigerant leak detector

800 — Specifications

The following test conditions should be established prior to checking the A/C temperature and pressure.

- engine @ 1500 rpm
- engine fan locked on
- normal A/C mode – Outside air (not recirc mode)
- blower speed set to high
- driver and passenger doors open
- hood open
- not in direct sunlight
- no wind speed
- allow conditions to stabilize

See **Table 22** for temperature and pressure specifications for a day cab with a HD-1 condenser.

See **Table 23** for temperature and pressure specifications for a SleeperCab with a HD-2 condenser.

A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	Low	25	40–54 (4–12)	78–118 (540–815)	9–43 (62–300)	Cycling—On 5 sec; Off 11 sec
70 (21)	Med	50	44–54 (7–12)	77–120 (530–825)	10–46 (70–315)	Cycling—On 6 sec; Off 10 sec

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A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	High	70	46–56 (8–13)	75–120 (515–825)	10–50 (70–345)	Cycling—On 6 sec; Off 9 sec
80 (27)	Low	25	42–56 (8–14)	94–139 (650–960)	11–48 (75–330)	Cycling—On 7 sec; Off 9 sec
80 (27)	Med	50	46–58 (8–14)	97–148 (670–1020)	13–51 (90–350)	Cycling—On 9 sec; Off 6–9 sec
80 (27)	High	70	45–63 (7–17)	99–147 (685–1015)	9–55 (60–380)	Cycling—On 7–27 sec; Off 4–8 sec
90 (32)	Low	25	46–58 (8–14)	109–159 (750–1095)	13–51 (90–350)	Cycling—On 9 sec; Off 6 sec
90 (32)	Med	50	47 (8)	165 (1140)	19 (130)	On steady
90 (32)	High	70	53 (12)	171 (1180)	23 (160)	On steady
100 (38)	Low	10	44–62 (7–17)	129–177 (890–1220)	14–49 (95–340)	Cycling—On 8–15 sec; Off 4–8 sec
100 (38)	Med	25	46 (8)	174 (1200)	18 (125)	On steady
100 (38)	High	40	53 (12)	180 (1240)	22 (150)	On steady

Table 22, A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser

A/C Temperature/Pressure Specifications—SleeperCab With HD-2 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	Low	25	43–55 (6–13)	73–130 (505–895)	16–48 (110–330)	Cycling—On 7 sec; Off 8sec
70 (21)	Med	50	46–54 (8–12)	73–131 (505–905)	19–48 (130–330)	Cycling—On 8 sec; Off 8 sec
70 (21)	High	70	46–55 (8–13)	74–133 (510–915)	17–48 (115–330)	Cycling—On 10 sec; Off 6 sec
80 (27)	Low	25	45–53 (7–12)	95–147 (655–1015)	19–46 (130–315)	Cycling—On 9 sec; Off 6 sec
80 (27)	Med	50	45–55 (7–13)	95–150 (655–1035)	20–47 (140–325)	Cycling—On 40–180 sec; Off 3–6 sec
80 (27)	High	70	50 (10)	149 (1025)	25 (170)	On steady
90 (32)	Low	25	46 (8)	165 (1140)	23 (160)	On steady
90 (32)	Med	50	53 (12)	171 (1180)	28 (195)	On steady
90 (32)	High	70	59 (15)	177 (1170)	32 (220)	On steady
100 (38)	Low	10	46 (8)	185 (1275)	24 (165)	On steady
100 (38)	Med	25	52 (11)	192 (1325)	28 (195)	On steady
100 (38)	High	40	57 (14)	194 (1340)	32 (220)	On steady

Table 23, A/C Temperature/Pressure Specifications—SleeperCab With HD-2 Condenser

FCU/ACU Electrical Specifications	
Specification	Value
Normal operating voltage range	9–16V
FCU/ACU max parasitic draw (ignition off)	1mA
FCU/ACU maximum current draw (battery input)	1.5A
FCU/ACU maximum current draw (ignition input)	50mA
Blower Motor maximum current draw	23A

Table 24, FCU/ACU Electrical Specifications

Default Datalink Values If the FCU does not receive some or all of the necessary parameters from other ECUs, the default values in this table are used.	
Parameter	Default Value
Vehicle Speed (from engine)	60 mph
Ambient Temperature (from SAM Cab)	70°F (21°C)
High-Side Refrigerant Pressure (from SAM Cab)	10 psig
Low Air Pressure (from ICU)	OK (<60 psig)
Engine rpm (from engine)	0 rpm
Override Message (from ACU)	none
Vehicle voltage (SAM Cab)	Same as FCU voltage
Engine Coolant Temp (from engine)	170°F (58°C)

Table 25, Default Datalink Values

Pressure Relief Valve	
Specification	Value: psi (kPa)
Opening Pressure	508–595 (3505–4100)
Minimum Closing Pressure*	439 (3025)

* Minimum closing pressure is the minimum pressure at which the valve will close after it has been opened by high pressure.

Table 26, Pressure Relief Valve

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Blower Motor Protection Modes (as Indicated On Speed/Diagnostics Circuit)			
Protection Mode	Frequency	Duty Cycle	Notes
Voltage too low	10 Hz	50%	If the blower is in protection mode, it communicates this via the speed feedback/diagnostic circuit to the control head, by varying the duty cycle of a 10 Hz signal. The duty cycle will correspond to the protection mode entered. Use the Datalink Monitor template to monitor for protection mode. Protection mode may generate a fault code.
Voltage too high	10 Hz	50%	
Locked rotor	10 Hz	75%	
Overcurrent or thermal protection	10 Hz	25%	

Table 27, Blower Motor Protection Modes

Engine Fan Engagement Request Specifications Based on High-Side Pressure (as measured by high-side pressure transducer)			
Engine Fan State	Nominal Pressure: psi (kPa)	Pressure Range: psi (kPa)	Notes
ON	300 (2070)	281–318 (1940–2190)	If the high-side pressure reaches this range, engine fan engagement will be requested.
OFF	250 (1725)	231–268 (1590–1850)	Once engine fan engagement has been requested, it will remain on until the high-side pressure drops to within this range.*

* Although an engine fan request is made by the HVAC controller, based on high-side pressure, the fan is controlled by the engine ECU, which considers a number of other factors and parameters that are specific to each engine.

Table 28, Engine Fan Engagement Request Specifications Based on High-Side Pressure

Minimum Time HVAC Sends Engine Fan Request Based on High-Side Pressure (as measured by high-side pressure transducer)			
Vehicle Speed: mph	Parking Brake Status	Minimum Time Engine Fan Request Is Active	Notes
0	ON	Continuously	HVAC sends engine fan request continuously as long as A/C compressor engagement has been initiated in the last 90 seconds. NOTE: It is normal for the engine fan to run continuously when the vehicle is parked, with the parking brake set, and the A/C on.
0–20	OFF	180 sec	Minimum time HVAC sends engine fan request.
20–40	OFF	90 sec	
Above 40	OFF	30 sec	

Table 29, Minimum Time HVAC Sends Engine Fan Request Based on High-Side Pressure

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Compressor High and Low Pressure Cut-Out (as measured by high-side pressure transducer)			
—	Nominal Pressure: psi (kPa)	Pressure Range: psi (kPa)	Notes
High Pressure Cut-Out	437 (3015)	418–455 (2880–3140)	If high side pressure rises to within this range, the compressor will disengage and not re-engage until within the high pressure cut-in range.
High Pressure Cut-In*	288 (1985)	270–306 (1860–2110)	High side pressure range that compressor will re-engage after high pressure cut-out.
Low Pressure Cut-Out	34 (235)	26–41 (180–285)	If high side pressure drops to within this range, the compressor will disengage or be prevented from engaging if not previously engaged. Compressor will not re-engage until pressure is above the low pressure cut-in.
Low Pressure Cut-In*	36 (250)	28–43 (195–295)	High side pressure at which the compressor will re-engage after low pressure cut-out.

* Assumes all other A/C compressor clutch engagement rules have been met to allow compressor engagement.

Table 30, Compressor High and Low Pressure Cut-out

Evaporator Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	19721	20485
23	-5	11512	11816
32	0	8910	9090
68	20	3374	3512
77	25	2694	2820
86	30	2165	2277
95	35	1751	1849
104	40	1425	1511

Table 31, Evaporator Temperature Sensor Resistance

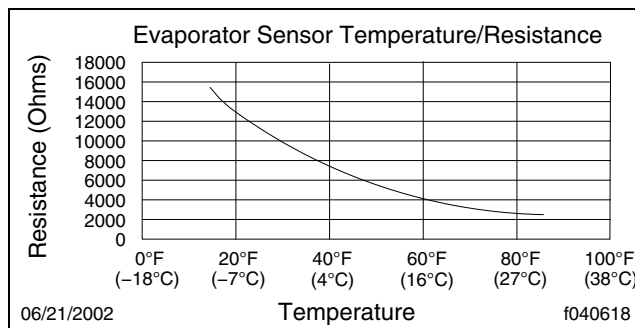


Fig. 22, Evaporator Sensor Resistance Specifications

COTC Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	69193	76665
32	0	31254	34046
59	15	15156	16260
68	20	12081	12899
77	25	9700	10300
86	30	7793	8321
95	35	6304	6759
104	40	5130	5524

Table 32, COTC Temperature Sensor Resistance

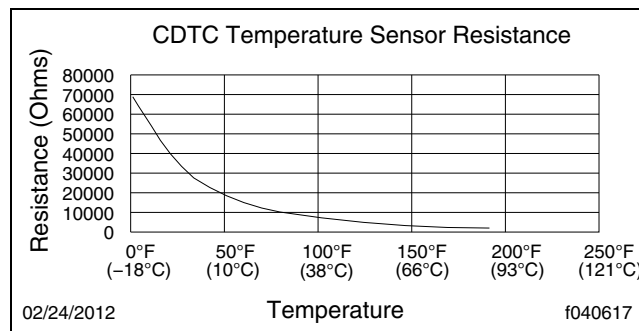


Fig. 23, COTC Sensor Resistance Specifications

Outside Air Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
-40	-40	97894	103950
14	-10	16285	16849
23	-5	12485	12839
32	0	9656	9890
41	5	7480	7708
50	10	5852	6054
68	20	3659	3815
77	25	2922	3060
95	35	1905	2003
104	40	1551	1637
113	45	1270	1344

Table 33, Outside Air Temperature Sensor Resistance

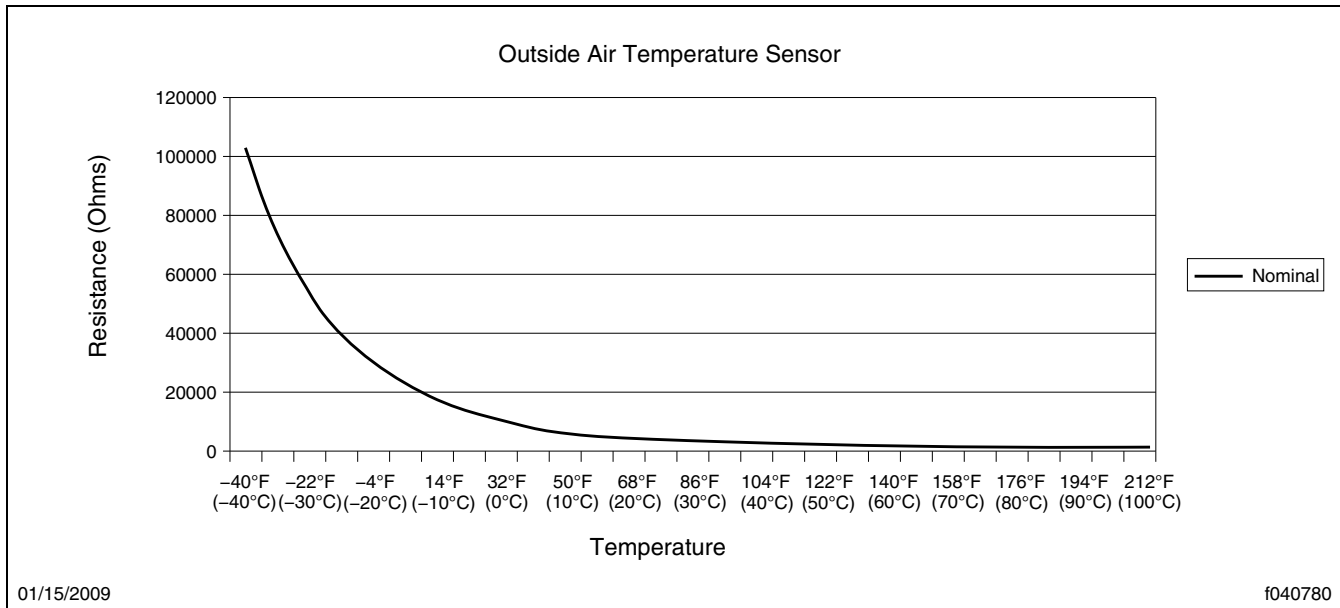


Fig. 24, Outside Air Temperature Sensor Resistance Specifications

Acceptable Leak Rates by Component	
Component	Acceptable Leak Rates
J-Block Body	0.25 oz/yr and greater condemns these components
Evaporators (main and auxiliary)	
Condenser	
Receiver-Drier (body)	
Lines/Hoses	
Capped Charge Ports	
Mini-Statoseal (1 - when the leak can be tied to a single seal)	0.50 oz/yr and greater condemns these components
Mini-Statoseals (2 - when the leak cannot be tied to a single seal)	
Compressor (shaft seal, housing, etc.)	
TXV (Power Valve and Super Heat Cap)	
Sensor/Switches (O-ring and crimped body connections)	

Table 34, Acceptable Leak Rates by Component

ParkSmart™ Auxiliary HVAC System

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500 — Terms and Abbreviations

ACU—Auxiliary Control Unit. This is the module that controls the rear HVAC system on vehicles with a sleeper that contains a rear HVAC unit (Unique parts for ParkSmart and standard auxiliary systems).

CGW—Central Gateway (a.k.a. Gateway Module)

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit; typically connected to a datalink.

FCU—Front Control Unit. This is the module that controls the front HVAC system, including A/C compressor operation.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

FOH—Fuel-Operated Heater

HVAC—Heating, Ventilation, and Air Conditioning

Parameter—A parameter is a predetermined variable in a set, each of which restricts or defines the specific capabilities of the system as a whole. Parameters are used to customize the configuration of the system.

PDM—Power Distribution Module

ROM—Rear Override Mode; allows the driver to override the sleeper HVAC settings from the front control panel.

SA—Source Address; indicates any device that communicates on J1939.

SAM—Signal detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM-Cabin"); this ECU controls mainly Cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The ParkSmart Auxiliary HVAC unit replaces the standard bunk heating, ventilation, and air conditioning (HVAC) system. It consists of the following major components and subcomponents:

- Brushless direct current (BLDC) blower motor
- Stand alone refrigerant system
- Heater core
- Recirculation filter
- Ambient air temperature sensor
- Electric blend door actuator
- Evaporator temperature sensor
- Bunk temperature sensor
- Fuel-operated heater (FOH)
- Auxiliary control unit (ACU)
- Power distribution module

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- Internal unit controller (PCB on Bergstrom print)
- Condenser fan
- Dedicated bank of AGM batteries

The following components are unique and separate from the main refrigerant system:

- Refrigerant compressor
- Condenser
- High-side pressure switch
- Receiver-drier
- Evaporator

The ParkSmart system is designed to deliver heating and cooling to maintain driver comfort while the vehicle is parked, as well as when the vehicle is driving down the road. This system was designed to maintain an established temperature while the engine is off. The system does not have enough capacity to significantly raise or lower the cabin temperature without the help of the front HVAC system. The ParkSmart air conditioning unit contains a stand-alone refrigerant loop separate from the main HVAC system, and as such, is not affected by the front HVAC refrigerant system.

On units built prior to July 2011, the refrigerant, oil, and system charge cannot be adjusted in the field. If the refrigerant loop has been discharged in a unit manufactured prior to July of 2011, the unit must be replaced. Units manufactured after July of 2011 are capable of being recovered and charged in the field, and some parts in the refrigerant loop are serviceable.

The ParkSmart A/C system uses a unique temperature control system to provide a stable bunk temperature. It achieves this based on a reference point for each temperature knob detent position, a bunk temperature sensor, and modulating the condenser fan speed and the compressor speed. Air is drawn into the ParkSmart HVAC unit by the blower from inside the cab, recirculating the air. This incoming air is cooled and dehumidified as it passes through the evaporator coil. In A/C mode, the blend door is always closed. If heating is desired, some or all of the air drawn into the unit will be routed through the heater core. Engine coolant is continually circulated through the fuel-operated heater, and then through the heater core, which transfers engine heat to the air. The amount of air routed through the heater core depends on the position of the blend door, which is determined from the setting on the ACU, and the bunk and evaporator temperature sensors feedback. The HVAC controller will continually adjust the blend door to maintain the temperature selected by the driver. The ParkSmart HVAC unit has an air filter that filters recirculated air drawn into the unit.

502 — ParkSmart Auxiliary HVAC Operation

The ACU temperature settings are 60°F (15°C) to 85°F (29°C), with the center setting being 74°F (23°C). Turning the temperature knob all the way to the left or to the right will set it at "full cold" or "full hot" and the A/C or heater will run at full capacity. The fan speed is manually selected; 0 is off, and 8 is maximum. See **Fig. 1**, and **Table 1**.

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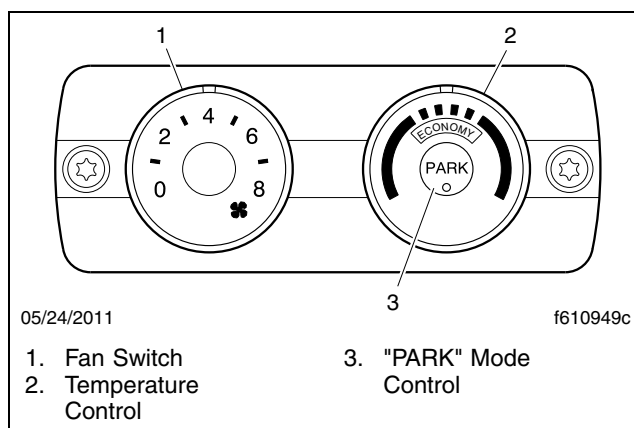


Fig. 1, ParkSmart Auxiliary Control Unit

Temperature Control Knob Position to Requested Output Temperature	
Temperature Control Knob Position (Clicks)	Requested Sleeper Temperature Degrees F (C)
1	60 (16)
2	60 (16)
3	62 (17)
4	64 (18)
5	66 (19)
6	68 (20)
7	70 (21)
8	71 (22)
9	72 (22)
10	73 (23)
11	74 (23)
12	75 (24)
13	76 (24)
14	77 (25)
15	78 (25)
16	79 (26)
17	80 (27)
18	82 (28)
19	84 (29)
20	85 (29)
21	Full Hot

Table 1, Temperature Control Knob Position to Requested Output Temperature

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Before operating the ParkSmart HVAC unit, the sleeper interior temperature should first be brought to the desired temperature with the engine running, and the bunk curtain open. The ParkSmart HVAC unit is designed to maintain an established comfortable bunk temperature for up to 12 hours, with the bunk curtain closed. See **Table 2** for recommended settings for comfort while the vehicle is parked.

IMPORTANT: Battery condition and charge status have a significant impact on the ParkSmart run time. If the batteries have not had enough time to charge, are damaged, or have additional loads applied, the expected run time will be reduced.

Parked HVAC Comfort Guide				
Rest Hours Desired	Weather		Setting Guide	
	Outdoor Temperature less than or equal to: °F (°C)	Sunshine less than or equal to	Maximum Blower Speed	Minimum Temperature Knob Setting
4	105 (40)	Light Sun	8	Full Cold
6	95 (35)	Full Sun	8	Mid
	90 (32)	Light Sun	8	Full Cold
	100 (38)	Night Time	8	Full Cold
	110 (43)	Full Sun	6	3 O'clock
8	75 (24)	Night Time	6-8	Full Cold
	95 (35)	Light Sun	6	10 O'clock
10	85 (30)	Light Sun	6	10 O'clock
	100 (38)	Light Sun	6	Mid
	95 (35)	Night Time	6	10 O'clock
	105 (40)	Night Time	6	Mid
12	90 (32)	Night Time	6	10 O'clock
	100 (38)	Night Time	6	Mid

Table 2, Parked HVAC Comfort Guide

There are three operating modes for the ParkSmart HVAC unit:

- Engine ON
- Engine OFF (ignition ON)
- Parked (engine OFF, ignition OFF)

When the unit is turned on initially, regardless of the mode or temperature setting (heat or A/C), the condenser fan will run for up to 30 seconds.

Engine ON Mode—If the engine is ON, the ParkSmart HVAC unit runs on the power supplied by the alternator, and either uses its internal air conditioner for cooling, or the engine coolant for heating (similar to the standard auxiliary HVAC unit). While the engine is running, the fuel-operated heater is not allowed to operate. In engine on mode, the ParkSmart unit, if set on full cold, will run at maximum available output. In this cooling level, the A/C will run at maximum potential output, lengthening the time needed to recharge the batteries.

In this cooling mode:

- Condenser fan is ON

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- Compressor is ON (as needed)
- Blower is ON (at selected speed)
- The blend door should be fully closed
- Temperature controlled with compressor and condenser fan speed

NOTE: The system turns off when the key is turned to the "OFF" position, and the system must be restarted if continued operation is desired.

Engine OFF Mode (ignition ON)—If the engine is OFF and the key is in "ACC" or "ON" position, the ParkSmart unit runs in ventilation mode, running the blower, but not the compressor. If you want cooling in this mode, you can press the "PARK" button to put the system in parked mode. When the "PARK" button is depressed the air conditioning portion of the unit will operate until the disconnect voltage is reached.

Parked Mode (engine OFF, ignition OFF)—If the engine is OFF, the ignition key is in the "OFF" position, and the fan knob is in any position other than 0, pressing the "PARK" button on the auxiliary HVAC control puts the ParkSmart HVAC system in the parked mode. It draws power from all eight batteries until the separator disconnect voltage is sensed in the main batteries. When separator voltage is reached, the unit will run only on the auxiliary batteries until the battery bank reaches the units internal disconnect voltage of 11.3 volts, at which time the system shuts down. In this mode the system runs either the internal air conditioner for cooling or a fuel-operated heater.

600 — Component Locations

The ParkSmart HVAC system on the Cascadia has several unique components from the standard sleeper HVAC. These components replace those of the standard unit and although the role is similar, the function is different.

The ParkSmart auxiliary HVAC replaces the standard sleeper auxiliary HVAC unit. It is located in the left hand cabinet stack. The heater core, blend door stepper motor, bunk temperature sensor, ambient temperature sensor (same as bunk), evaporator temperature sensor (units built prior to July 2011), and blower motor are common parts with those used in the main, and standard, HVAC units. Beginning in July 2011 the condenser and fan assembly are located outside on the backwall of the sleeper, and the system utilizes a different evaporator sensor.

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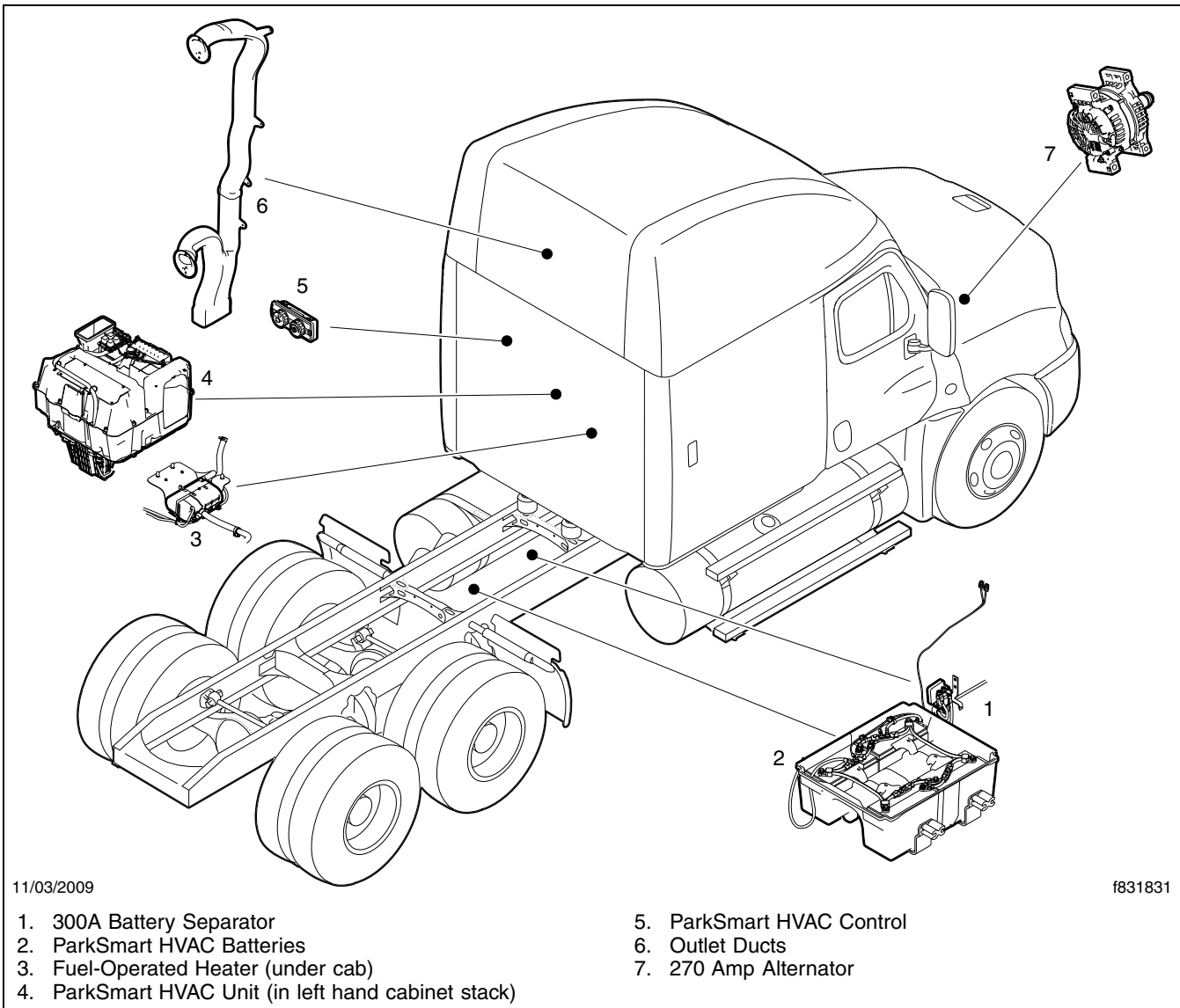


Fig. 2, Component Locations (units built before July 2011)

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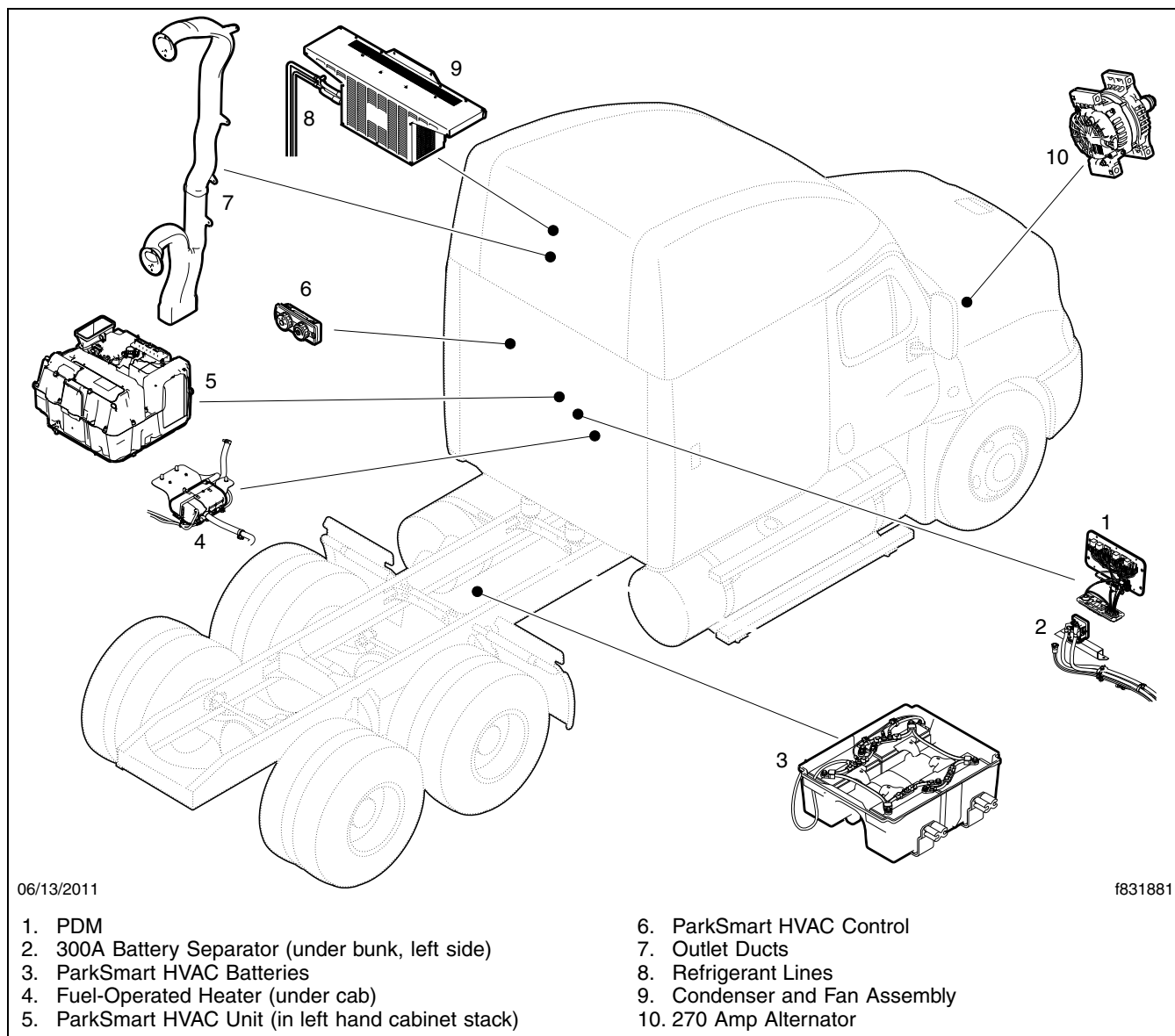


Fig. 3, Component Locations (units built from July 2011)

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601 — Component Details

Auxiliary Control Unit (ACU)

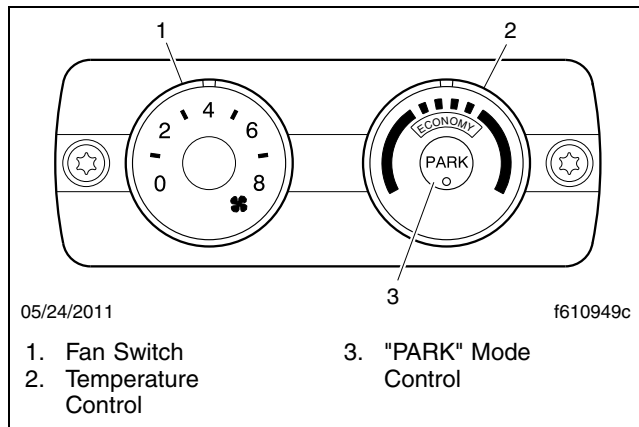


Fig. 4, ParkSmart Auxiliary Control Unit

The ACU contains the knobs and switches that allow the bunk occupant to select various modes of operation such as temperature and blower speed. The ACU interfaces with the main HVAC control unit similarly to the standard ACU. The SAM Cabin provides the ACU with battery power. Ignition power and ground are also routed through the SAM Cab. The ACU communicates with the front HVAC, and internal ParkSmart control units on the J1939 datalink. The "PARK" button replaces the snowflake (air conditioning) button of the standard auxiliary unit. This "PARK" button enables control of the system when the engine is off.

When the vehicle is running, the ParkSmart HVAC unit functions similarly to the standard auxiliary unit. The controller exits parked mode when the engine is started, the unit is shut off, or if the ParkSmart batteries are drained to the ParkSmart internal low voltage disconnect (LVD) setting (11.3 Volts). The "PARK" lamp illuminates for eight seconds when touched in "PARK" mode, but remains illuminated if communication with the parked unit responds to the "wake-up" request.

ACU Pin-Out (from MOD 689 and 70C)			
PIN	Description	Typical Value	Connects To
1/6	CAN (+)	60 ohms (between + and -)	J1939 backbone
2/6	CAN (-)	60 ohms (between + and -)	J1939 backbone
3/6	Backlighting (unused)	PWM signal	Main backlighting circuit
4/6	Power	12-14 VDC	SAM cab
5/6	Ground	0 VDC	SAM cab
6/6	Ignition signal	12-14 VDC	SAM cab
23/26	Backlighting signal	PWM	Internal controller
24/26	Wake up circuit	12-14 VDC ("PARK" button off) less than 1 VDC ("PARK" button on)	Internal controller

Table 3, ACU Pin-Out (from MOD 689 and 70C)

Internal Controller

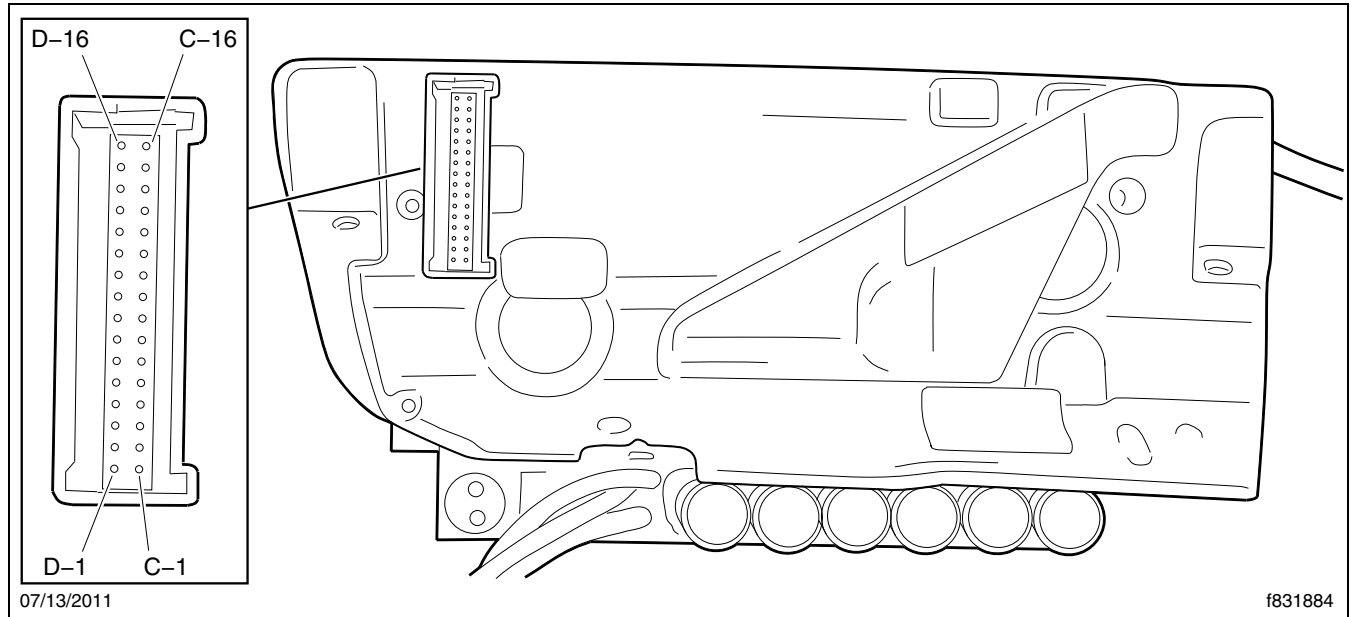


Fig. 5, Internal Controller

This device stores the operating program and controls the ParkSmart unit. It controls the output voltage to the variable speed compressor and condenser fan, interfaces with the ACU, and communicates on the J1939 databus. In units manufactured before July 2011, it is located in the lower section of the unit under the evaporator blower and fuse center. In units manufactured from July 2011, it is located on top of the unit.

The low voltage dropout setting protects the ParkSmart system from damage due to excessively low voltage. This control system is completely separate from the Cascadia's low voltage disconnect and only applies to the ParkSmart internal controller.

- If the voltage of the auxiliary batteries is less than 11.3V for 10 seconds, the unit shuts off.
- Following a battery disconnect the operator will need to press the "PARK" button to re-start the unit, once the available voltage has been increased.

To access the wiring diagram for the internal harness of the ParkSmart unit, refer to module 689 in PartsPro. For units built before July 2011, the wiring diagram is part of the detail drawing of the main unit (A22-64736). Select the part from the list and click the EZWiring button. For units built from July 2011, the wiring diagram is listed as a reference item in the BOM. Additional wiring information for the system can be found in modules 70C and 29J. Use PartsPro to obtain the most current versions of all wiring diagrams.

Table 4 shows the ParkSmart control module connector pinout.

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ParkSmart Control Module Connector Pinout					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
C1	12V_CTL_FUSED	Red	12V power from main batteries for controls	12–14V	Control fuse F2
C2	GND	Black	Ground for controls	0V	Black bulkhead connector
C3	12V_AUX_BATT	Red	Sense wire for auxiliary battery voltage	12–14V	Blue bulkhead connector
C4	PARK_SW	White	Input from parking brake switch	11.5–14V with parking brake released, less than 0.5V with parking brake engaged. This signal is 12V supplied by the SAM through a normally open air pressure switch on the parking brake manifold.	4-way connector near PDM
C5	CANH	Yellow	J1939 Can bus HI	2.5V bus idle, 3.5V active	4-way connector near PDM
C6	CANL	Green	J1939 Can bus LO	2.5V bus idle, 1.5V active	4-way connector near PDM
C7	COND_FAN	White	PWM ground switched output to control condenser fan speed	0V fan off, 1.6–4.5V cooling mode. 2 KHz switch-to-ground PWM signal	Condenser fan (3-way connector)
C8	ACT_COMMON	Lt. Green	12V power for blend door actuator	11-14V	Blend door actuator (top of unit)
C9	ACT_PHASEA	Pink	Ground switched output to blend door motor phase	11-14V, pulses to less than 0.5V when motor running	Blend door actuator (top of unit)
C10	ACT_PHASEB	Blue	Ground switched output to blend door motor phase	11-14V, pulses to less than 0.5V when motor running	Blend door actuator (top of unit)
C11	ACT_PHASEC	Purple	Ground switched output to blend door motor phase	11-14V, pulses to less than 0.5V when motor running	Blend door actuator (top of unit)
C12	ACT_PHASED	Red/Black	Ground switched output to blend door motor phase	11-14V, pulses to less than 0.5V when motor running	Blend door actuator (top of unit)
C13	BLWR_CTL	Tan	PWM ground switched output to control blower speed	10V low speed, 6V high speed. 2 KHz switch - to - ground PWM signal	Blower motor
C14	N/C		Not connected	—	—
C15	HTR_ENABLE	Yellow	12V output to enable FOH operation	11-14V in heat mode and parking brake engaged	4-way bulkhead connector
C16	SLPR_TEMP	White	0 -5V input from sleeper temperature sensor	5V with sensor open or unplugged, 2V-3.3V with sensor plugged in	Sleeper temp sensor—near ACU on cabinet
D1	COND_IN_TEMP	White	0-5V input from outside air temperature sensor	5V with sensor open or unplugged, 2V-3.3V with sensor plugged in	Outside air temperature sensor - under control module cover

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ParkSmart Control Module Connector Pinout					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
D2	PRESS_SW	Lt. Blue	Pressure switch input	11-14V if open and unit on, less than 1V if switch closed or unit off	High pressure switch
D3	EVAP_TEMP	Lt. Green	0-5V input from evaporator temperature sensor	5V with sensor open or unplugged, 1V-2.5V with sensor plugged in	Evaporator temperature sensor - top of unit just inside cabinet base
D4	N/C		Not connected	—	—
D5	SENSOR_GND	White/Black	Ground from control module for sensors, pressure switch	Ground	Temperature sensors, high pressure switch
D6	WAKEUP	Orange	Switch to ground input from ACU - turns on ParkSmart unit	11-14V with control off, less than 1V when unit on ("PARK" button pressed or key on) The control panel switches this signal to ground when the "PARK" button is pushed, or the key is turned to "ON". It wakes up the Parked unit, which begins broadcasting its J1939 message. If the panel does not receive a message in 3 seconds, it releases the signal, which goes back to 12V.	Yellow 26 way connector on back of ACU
D7	HTR_FAULT	Green	Fault input from FOH - not currently implemented Pre-July 2011 units only	Used for software upgrades - no normal function (0 VDC)	4-way bulkhead connector
D8	BLWR_FAULT	Gray	Fault input from blower - switched to ground	N/A	Blower motor
D9	DIMMER	White/Red	PWM power output to dimmer when control changed	2-3V for 8-10 sec. after changing settings	Yellow 26-way connector on back of ACU
D10	RELAY1	White	Switch to Ground output to relay 1 - Compressor power from main batteries	Less than 0.5V in Engine On mode, otherwise 11-14V	Relay in PDM
D11	RELAY2	White	Switch to Ground output to relay 2 - Blower/Fan power from main batteries	Less than 0.5V in Engine On mode, otherwise 11-14V	Relay in PDM
D12	RELAY3	White	Switch to Ground output to relay 3 - compressor power from auxiliary batteries	Less than 0.5V in Parked, Engine Off modes, otherwise 11-14V	Relay in PDM
D13	RELAY4	White	Switch to Ground output to relay 4 - Blower/Fan power from auxiliary batteries	Less than 0.5V in Parked, Engine Off modes, otherwise 11-14V	Relay in PDM

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ParkSmart Control Module Connector Pinout					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
D14	PROG_ENABLE	White	Ground input to go into reprogramming mode Pre-July 2011 units only	Not normally used	Loose blade connector or unused socket in PDM
D15	N/C		Not connected	—	—
D16	N/C		Not connected	—	—

Table 4, ParkSmart Control Module Pinout

Separator (interconnect controller)

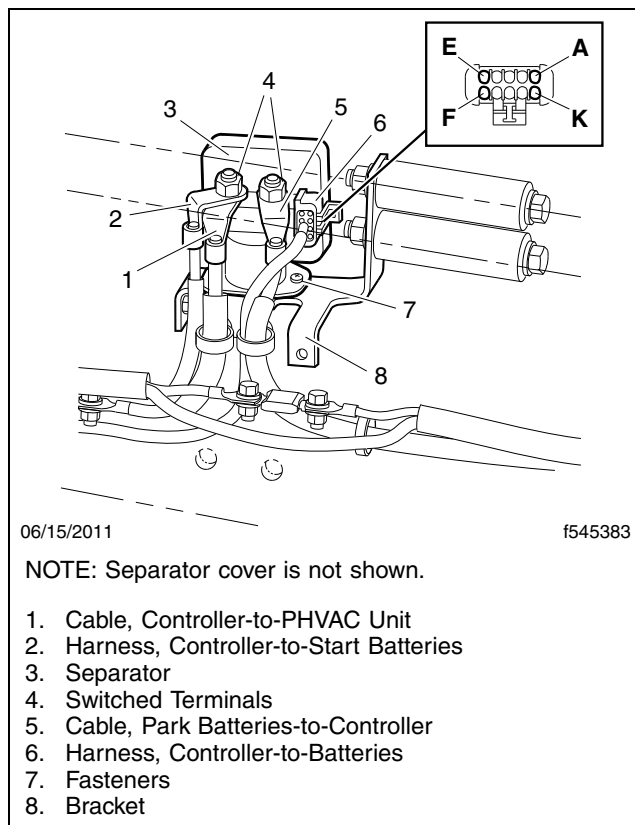
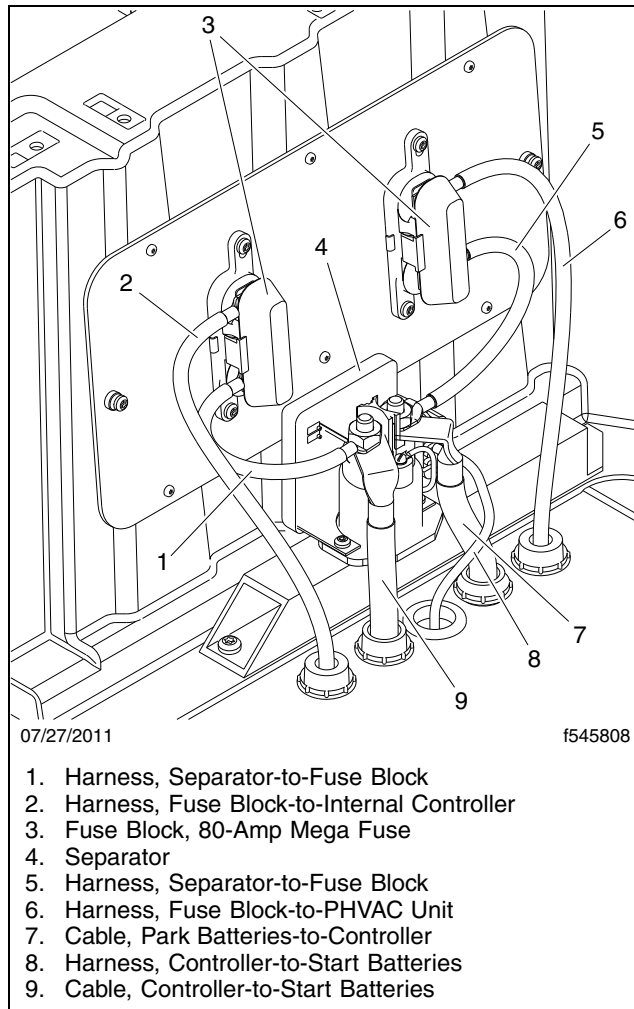


Fig. 6, Separator (interconnect controller)
Frame-Mounted Installation (pre-July 2011)



**Fig. 7, Separator (interconnect controller)
Under-Bunk Installation (pre-July 2011)**

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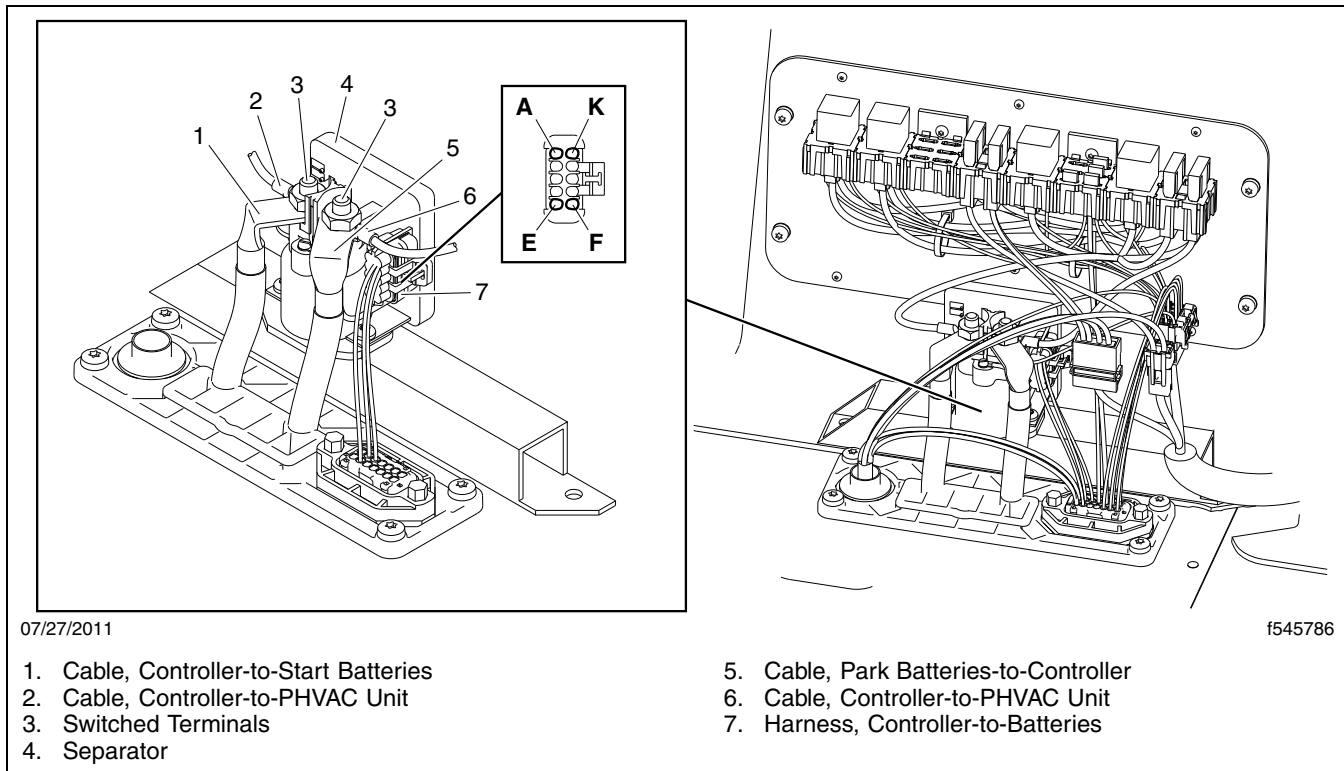


Fig. 8, Separator (interconnect controller) Installation (from July 2011)

The ParkSmart system uses a 300A integrated solenoid and control module to separate the main batteries from the auxiliary batteries. The unit features a bi-stable solenoid that can remain open or closed without a coil current draw. The disconnect voltage of 12.5V (nominal) is near the full charge resting voltage of the batteries. This will allow the solenoid to remain closed for some time after the engine is stopped. This was designed to preserve starting battery capacity for engine cranking. On vehicles produced after July 2011 there is a separator disconnect feature that opens the separator during cranking via a wire leading to the ignition switch. See **Table 6** for separator operating specifications.

Separator Pin-Out (from MOD 29J for pre-July 2011) (from MOD 29J, 156, and 160 for July 2011 to date)			
PIN	Description	Typical Value	Connects To
1	Main Battery	12 VDC	Start Batteries
2	Auxiliary Battery	12 VDC	Parked Batteries
A	NA	—	—
B	Start Interrupt (post-July 2011 only)	12 VDC (ignition switch in "START" position)	Ignition switch
C	NA	—	—
D	Reconnect/Ground	0 VDC	Start Batteries
E	NA	—	—
F	NA	—	—

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Separator Pin-Out (from MOD 29J for pre-July 2011) (from MOD 29J, 156, and 160 for July 2011 to date)			
PIN	Description	Typical Value	Connects To
G	NA	—	—
H	Ground	0 VDC	Start Batteries
J	NA	—	—
K	Remote Sense	12 VDC	Start Batteries

Table 5, Separator Pin-Out (from MOD 29J for pre-July 2011) (from MOD 29J, 156, and 160 for July 2011 to date)

Separator Operating Specifications						
Characteristic	Symbol	Minimum	Typical	Maximum	Unit	Notes:
Normal Input Voltage	Vin	9	—	16	V	Voltage range in unit is guaranteed to function within specification.
Minimum Input Voltage	Vinmin	—	8.5	9	V	Proper solenoid operation is not guaranteed below 9V, but typically operates to 8.5V.
Connect Voltage	Vcon	13	13.2	13.5	V	—
Disconnect Voltage	Vdcon	12.3	12.5	12.7	V	—
Connect Delay	Tco	2	2.5	3	s	—
Disconnect Delay (Short)	Tdd	9	10	11	s	Delay mode jumper input open
Disconnect Delay (Long)	Tddl	270	300	330	s	Delay mode jumper input grounded

Table 6, Separator Operating Specifications

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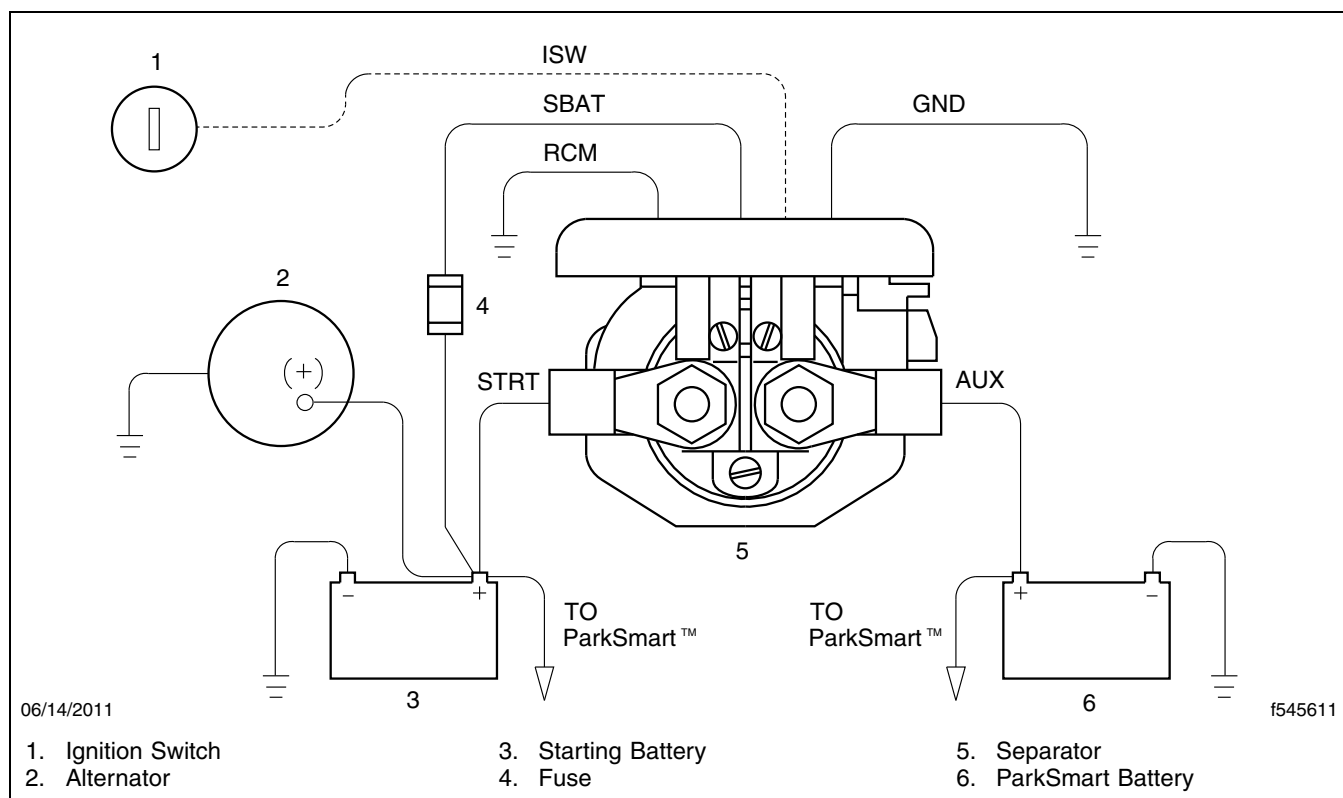


Fig. 9, Separator Wiring Diagram

As shown in the separator wiring diagram, the separator voltage sense wire (SBAT) attaches to the start batteries within six inches of the positive terminal, via a 5 amp ATO fuse.

Condenser Fan

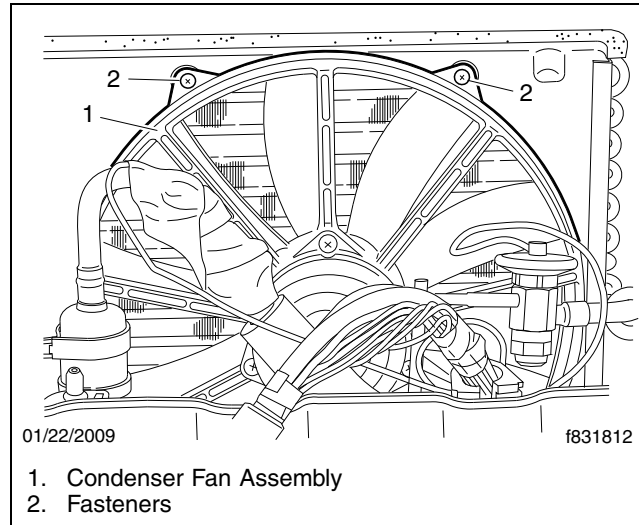


Fig. 10, Condenser Fan Installation (pre-July 2011 shown)

The fan is connected to the system with a three-wire connector containing a signal wire, as well as power and ground. If the fan has power and ground, but the signal wire is broken, the fan will run at full speed.

Condenser Fan Pin-Out (from MOD 689)			
PIN	Description	Typical Value	Connects To
A	Power	12–14 VDC	F5 ParkSmart PDM
B	Ground	0 VDC	ParkSmart consolidated ground cable
C	Signal	PWM	Internal controller

Table 7, Condenser Fan Pin-Out (from MOD 689)

Power Distribution Module (PDM)

On systems manufactured before July 2011, the PDM is located on top of the ParkSmart unit. See **Fig. 11**. On systems manufactured from July 2011, the PDM is located on the forward panel of the storage compartment under the lower bunk near the driver's side outside access door. See **Fig. 12**.

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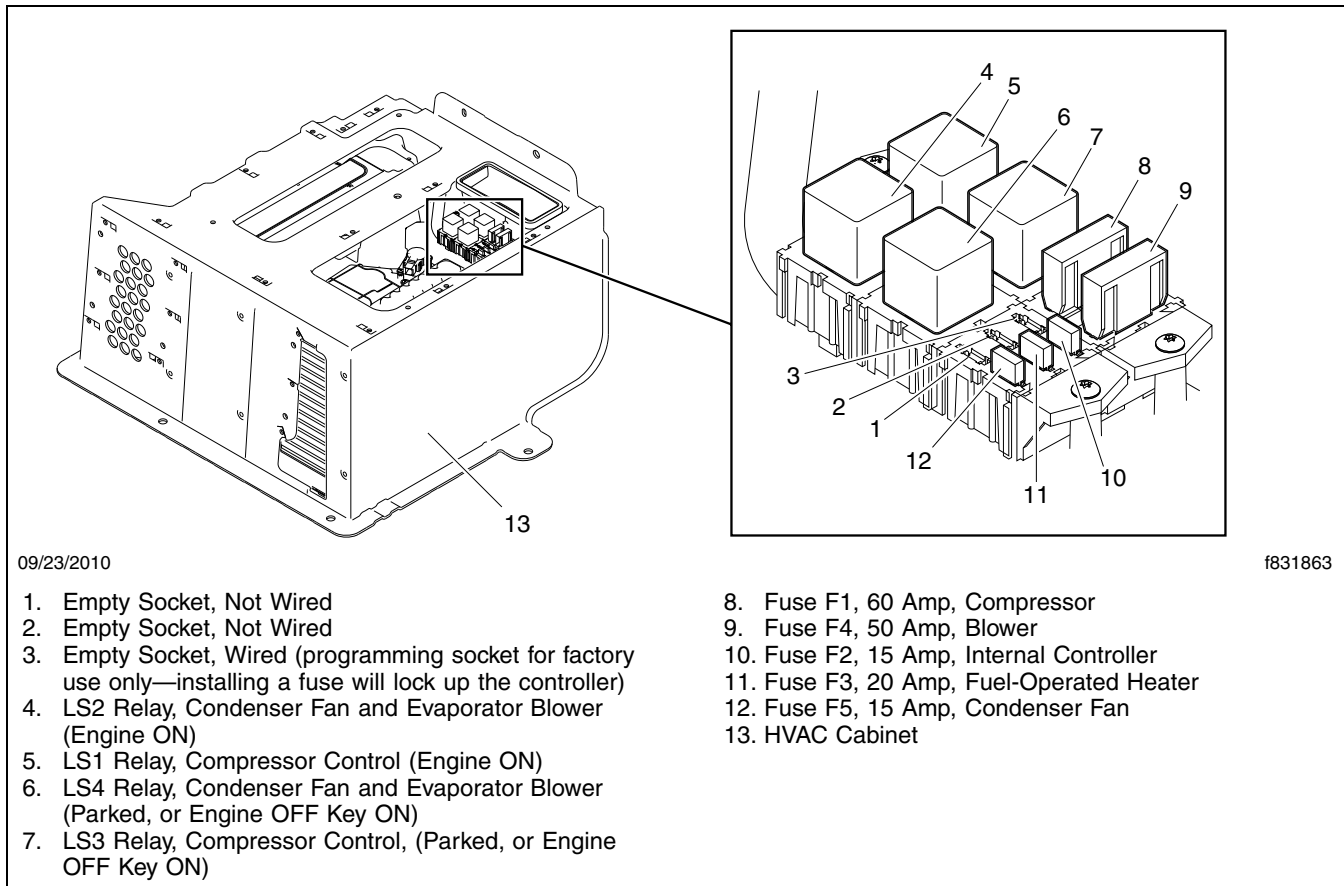


Fig. 11, ParkSmart PDM (pre-July 2011)

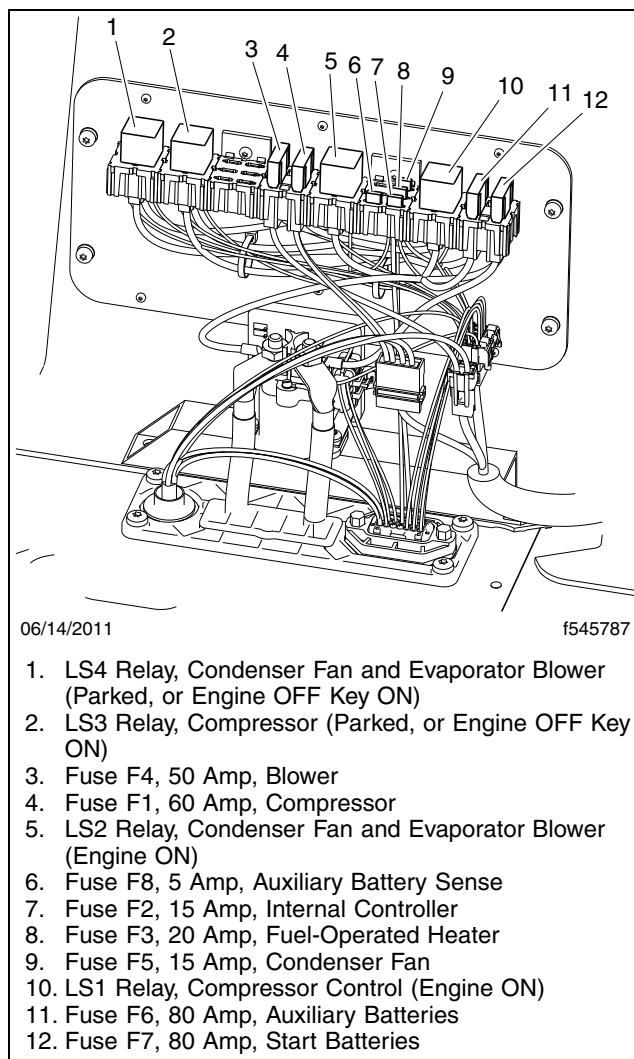


Fig. 12, ParkSmart PDM (from July 2011)

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Battery System

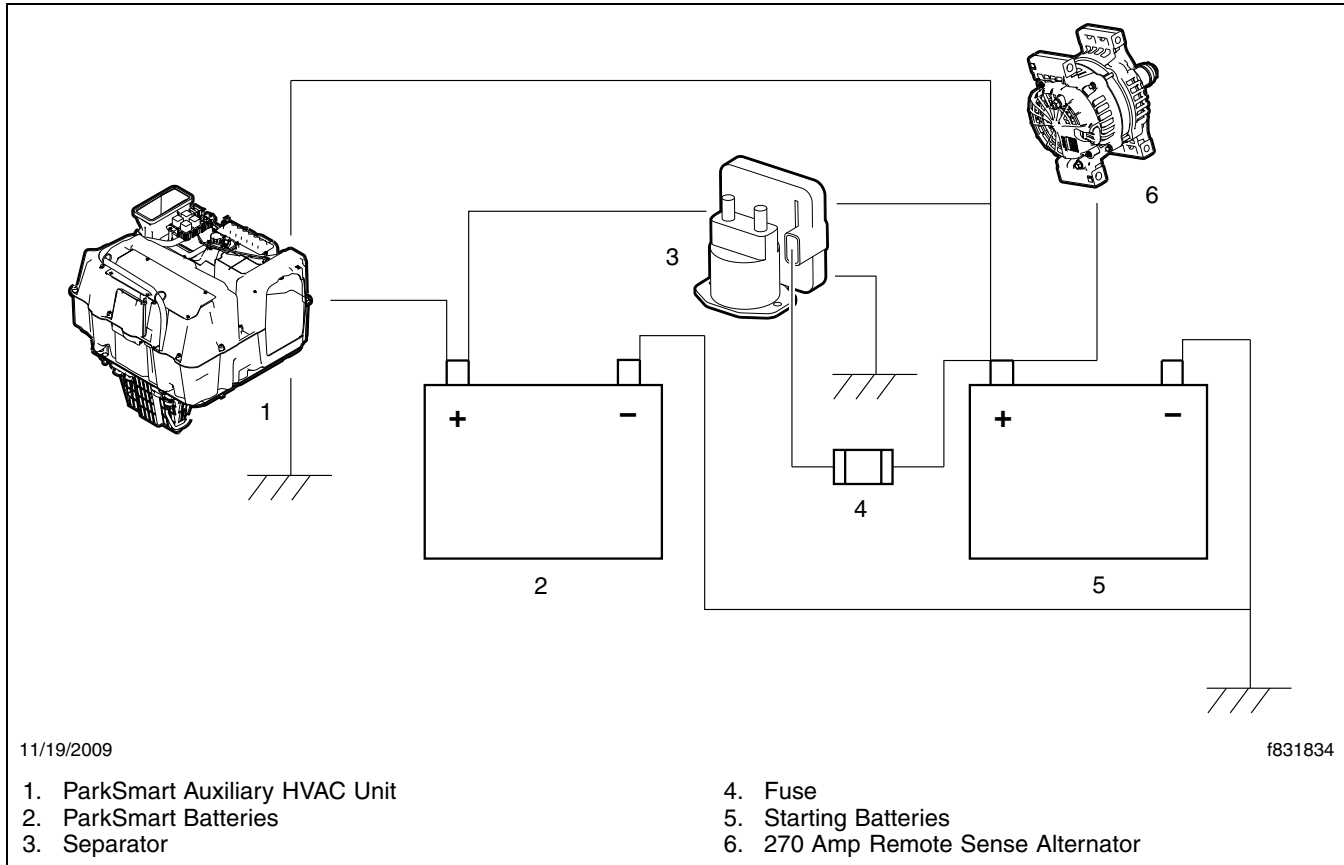


Fig. 13, Battery System

The ParkSmart unit relies on the alternator to charge the additional 4 AGM batteries to power the system. The ParkSmart auxiliary unit operates in two electrical modes: high power mode when the engine is running, and low power mode when in Parked mode at ambient temps below 105°F (41°C).

IMPORTANT: Any additional loads placed on either set of batteries will affect the total run time in parked mode, the ability to start the truck and/or the amount of time required to completely recharge the batteries for the next parked rest cycle.

IMPORTANT: Jump starting at the ParkSmart batteries will not help to start a truck with low starting battery voltage, but removing the sense wire fuse may reduce the load on the boost system, if both banks of batteries are low.

NOTE: The batteries for the ParkSmart HVAC are located either on the drivers side frame rail, or between the frame rails behind the cab. The auxiliary (parked) batteries can be distinguished from the start batteries by determining which set is closest to the front of the vehicle. The start batteries will always be closest to the front of the cab.

Blower Motor

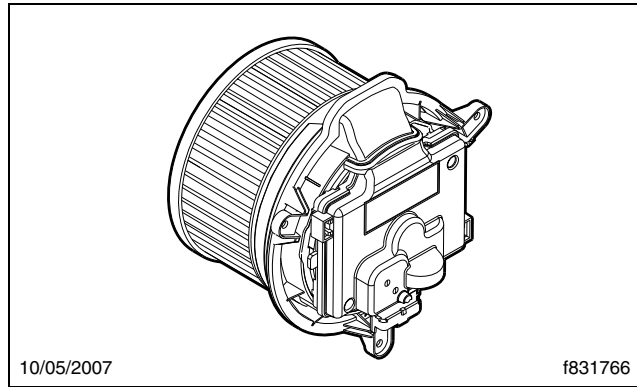


Fig. 14, Blower Motor

The blower speed is adjusted by the fan switches on the main and auxiliary climate control panels (FCU and/or ACU depending on operational mode). The ACU broadcasts a blower speed request on J1939, and the internal controller sends a PWM signal to the blower motor at a frequency of 2000 Hz. The pulse width varies with the fan switch speed selection. The blower operates within a speed ranging of approximately 400 to 3850 rpm. Under normal operation, the feedback signal indicates blower speed by varying the frequency ($\text{rpm} = 20 \times \text{frequency}$). The BLDC blower motor has built-in protections that will cause the motor to operate at reduced speed, or shut down, to prevent damage. Any of the following conditions will cause the blower to enter protection mode:

- **Over/Under Voltage**—If the voltage supply to the blower motor is less than 8.5V or more than 17V, the blower motor will enter protection mode. The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- **Reverse Voltage Protection**—The motor will not operate if the polarity of the motor power and ground leads are reversed.
- **Current Protection**—If the motor exceeds the maximum current, the speed will be reduced until the current is within the normal range (under 23.5A). The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- **Temperature Protection**—If the motor's internal temperature is too high, the blower speed is reduced to 1000 rpm to reduce the load on the motor, and a comparison is made between the sensor reading and the maximum limit. If the temperature is still too high, the blower speed is further reduced to the minimum value of approximately 500 rpm, and a temperature comparison is made to the maximum. If after the second comparison, the temperature is still too high, the motor will shut down until it has cooled sufficiently. The blower feed-back circuit will indicate a fault, and a fault will be logged in the FCU or ACU.

If the blower motor has entered protection mode due to one of the conditions listed above, the blower speed feedback signal becomes a diagnostic signal to the FCU and ACU by setting its frequency at 10Hz and varying the duty cycle of the signal to indicate the current protection mode. Refer to **Table 8**. A fault will be logged by the FCU or ACU.

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Blower Motor Protection Modes (As Indicated On Speed/Diagnostics Circuit)			
Protection Mode	Frequency	Duty Cycle	Notes
Voltage too low	10 Hz	50%	If the blower is in protection mode, it communicates this via the speed feedback/diagnostic circuit to the ACU, by varying the duty cycle of a 10 Hz signal. The duty cycle will correspond to the protection mode entered. Use the Datalink Monitor template to monitor for protection mode. Protection mode may generate a fault code.
Voltage too high	10 Hz	50%	
Locked rotor	10 Hz	75%	
Overcurrent or thermal protection	10 Hz	25%	

Table 8, Blower Motor Protection Modes (As Indicated On Speed/Diagnostics Circuit)

Blower Motor Pin-Out (from MOD 689)			
PIN	Description	Typical Value	Connects To
1	Blower fault	Variable frequency signal (RPM/20)	Internal controller
2	Not used	—	—
3	Battery voltage	12 VDC	ParkSmart PDM
4	Ground	0 VDC	Common ParkSmart ground cable
5	Blower control	PWM signal (2000 Hz)	Internal controller
6	Not used	—	—

Table 9, Blower Motor Pin-Out (from MOD 689)

Actuator

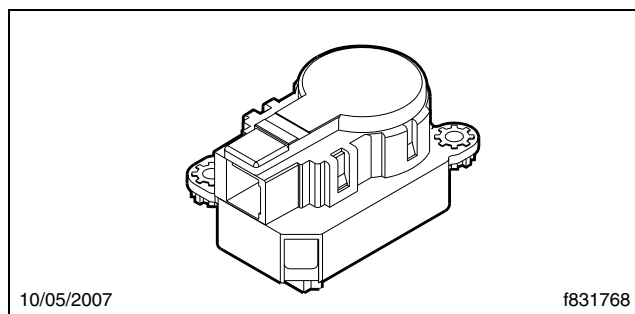


Fig. 15, Actuator

The blend door actuator has a stepper motor in it that operates by switching 4 wires (the other two pins, 2 and 5, are tied to ignition level) in a proper sequence to cause rotation. The four wires are each switched on and off at 50Hz rate by the control panel, resulting in 200 "steps" per second. There is essentially 10 degrees of door rotation per second. There is no feedback to the FCU or ACU because the actuator moves a fixed angle for each step. See **Table 10**.

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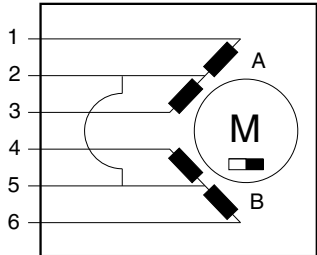
Actuator Connection and Drive Sequence					
		0	I	II	III
Connecting Diagram  10/03/2007 f545144	1			—	—
	3	—	—		
	4		—	—	
	6	—			—
	2+5	+	+	+	+
	1		—	—	
	3	—			—
	4			—	—
	6	—	—		
	2+5	+	+	+	+

Table 10, Actuator Connection and Drive Sequence

Bunk and Ambient Air Temperature Sensors

These sensors monitor the sleeper compartment temperature and outside temperature. The bunk temperature sensor is located near the ACU. For units built before July 2011, the ambient temperature sensor is in the unit housing under the internal controller. For units built from July 2011 the ambient air temperature sensor is located in the condenser housing on the backwall of the sleeper. In units built before July 2011, both sensor positions use the same part. Units built from July 2011 use a different ambient air temperature sensor, but the resistance values are in the same range. If the bunk sensor provides an unexpected value, the unit will default to a target of 72°F (23°C). If the ambient air temperature sensor provides an unexpected value, the power management system stops and the unit will operate at maximum output. This will reduce the run time of the unit.

Bunk and Ambient Air Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	69193	76665
32	0	31254	34046
59	15	15156	16260
68	20	12081	12899
77	25	9700	10300
86	30	7793	8321
95	35	6304	6759
104	40	5130	5524

Table 11, Bunk and Ambient Air Temperature Sensor Resistance

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Bunk Temperature Sensor Pin-Out (from MOD 689)			
PIN	Description	Typical Value	Connects To
1	Sensor Power	5 VDC (without sensor connected)	Internal Controller
2	Common sensor ground circuit	0 VDC	Internal Controller

Table 12, Bunk Temperature Sensor Pin-Out (from MOD 689)

Ambient Air Temperature Sensor Pin-Out (from MOD 689)			
PIN	Description	Typical Value	Connects To
A	Sensor Power	5 VDC (without sensor connected)	Internal Controller
B	Common sensor ground circuit	0 VDC	Internal Controller

Table 13, Ambient Air Temperature Sensor Pin-Out (from MOD 689)

Evaporator Temperature Sensor

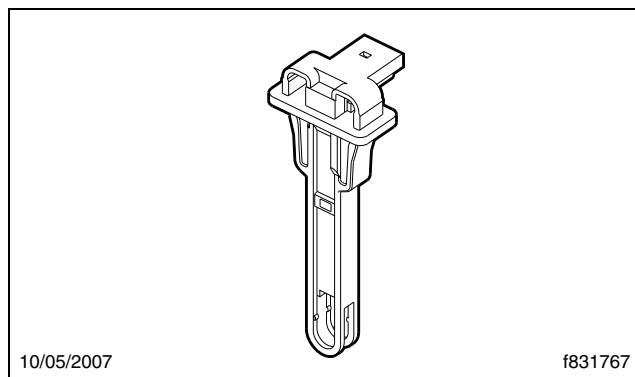


Fig. 16, Evaporator Temperature Sensor

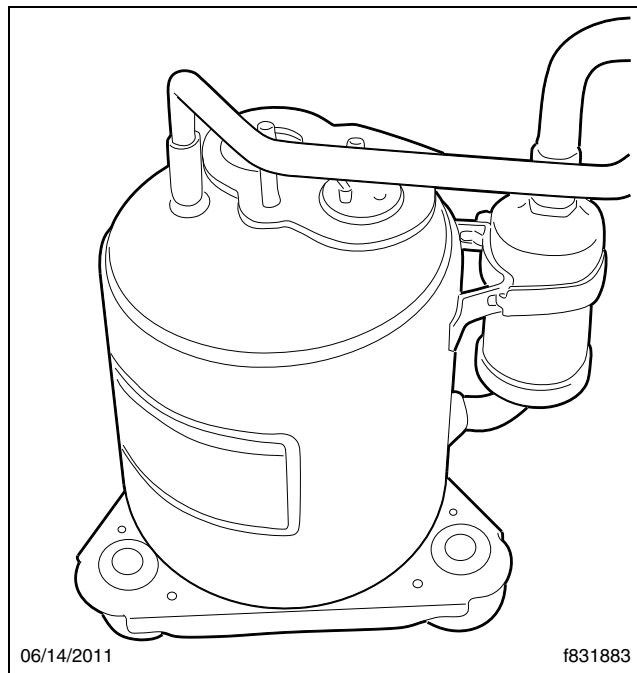
The evaporator temperature sensor is used by the ACU to control the refrigerant compressor, to maintain temperature within its set-points, and to prevent evaporator freezing. It is a negative temperature coefficient (NTC), meaning that its resistance decreases as temperature increases. The internal controller turns the compressor on when the temperature sensed by the evaporator temperature sensor is at or above 43°F (6.1°C). The internal controller cycles the compressor off when the temperature sensed by the evaporator temperature sensor is at or below 38°F (3°C).

Evaporator Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	19721	20485
23	-5	11512	11816
32	0	8910	9090

Evaporator Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
68	20	3374	3512
77	25	2694	2820
86	30	2165	2277
95	35	1751	1849
104	40	1425	1511

Table 14, Evaporator Temperature Sensor Resistance

Compressor

**Fig. 17, Compressor**

The compressor is a rotary valve type, and has no provisions for checking oil level. The internal controller varies the speed to control the output, and therefore power consumption. The compressor runs on three timed signals, in specific order from the internal controller. The power wires must be connected to specific pins to make the compressor operate. The rubber seal on the top of the compressor indicates the pin name (A, B, and C). The pins, in alphabetical order, and the first initial of the wire color, align to spell BOY (A=Blue, B=Orange, C=Yellow). Installing the wires incorrectly will damage the compressor.

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CAUTION

Do not touch the compressor supply wires and chassis ground at the same time. Doing so may cause minor electrical shock and possible personal injury.

After removing the cabinet and top of the ParkSmart case, as shown in *Cascadia Workshop Manual*, safely re-connect the wiring and batteries. Independently check the voltage (VDC) and frequency (Hz) from the internal controller at the compressor. Remove the power wires from the compressor and keep them from shorting together or to the chassis. Use the "max" or "record" mode on DC Volts to capture the peak voltage on each wire (this could take up to 30 seconds). Perform the voltage test, then the frequency test, at each of the three compressor power wires with the negative probe connected to vehicle ground.

The internal controller will make ten separate attempts to start the compressor, and the test must coincide with one of the start attempts. After the ten start attempts are made, no more starts will be attempted until the "PARK" button has been cycled off for ten seconds and back on. If the signal is correct, and the compressor will not run, the compressor is faulty. If the signal is not correct, there is a problem with the inputs to the controller, or the controller itself.

NOTE: A fault with the thermo switch, high pressure switch, or evaporator sensor will cause the internal controller to provide un-pulsed voltage to the compressor.

Compressor Pin-Out (from MOD 689)			
PIN	Description	Typical Value	Connects To
A, B, and C	Pulsed Signal	6 VDC (at 230-11000 HZ)	Internal Controller

Table 15, Compressor Pin-Out (from MOD 689)

High Pressure Switch

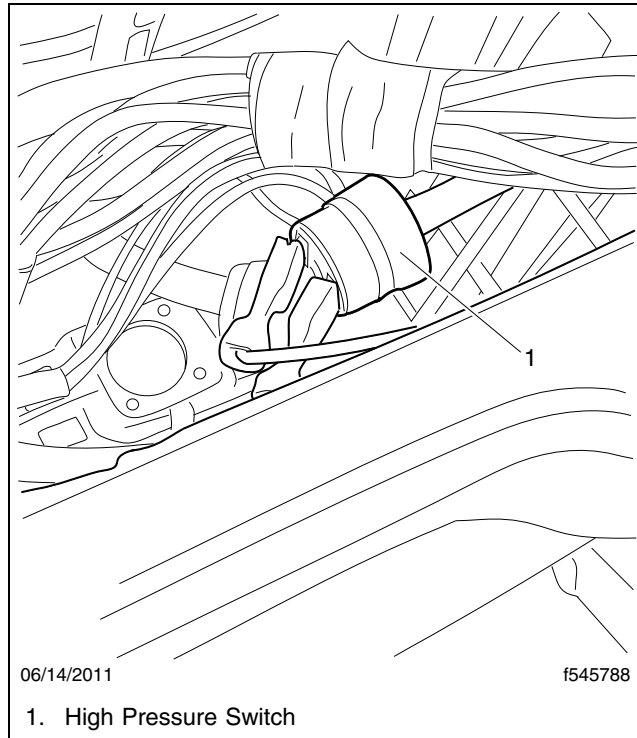


Fig. 18, High Pressure Switch

This is a normally closed, brazed-in pressure switch that opens to prevent the operation of the compressor if the high-side refrigerant pressure exceeds 380 ± 10 psi (2620 ± 70 kPa) and closes at 240 ± 10 psi (1655 ± 70 kPa). It is not serviceable. If the switch fails, replace the refrigerant circuit.

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Compressor Temperature Sensor

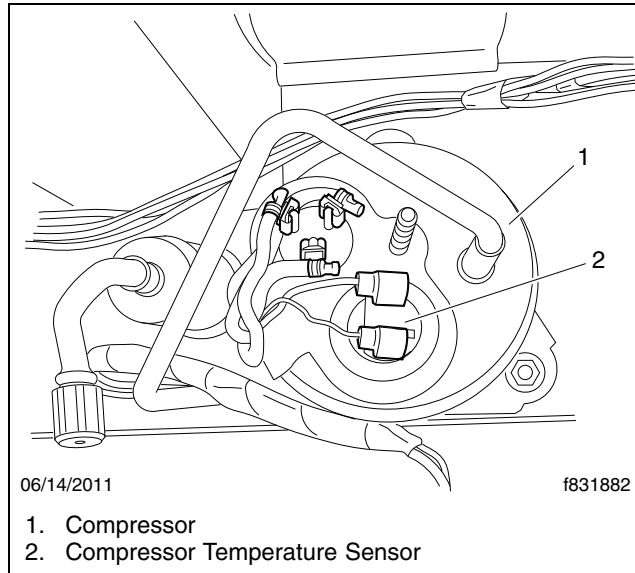


Fig. 19, Compressor Temperature Sensor

This is a normally-closed bi-metal switch that protects the compressor from high-temperature running conditions.

Fuel-Operated Heater

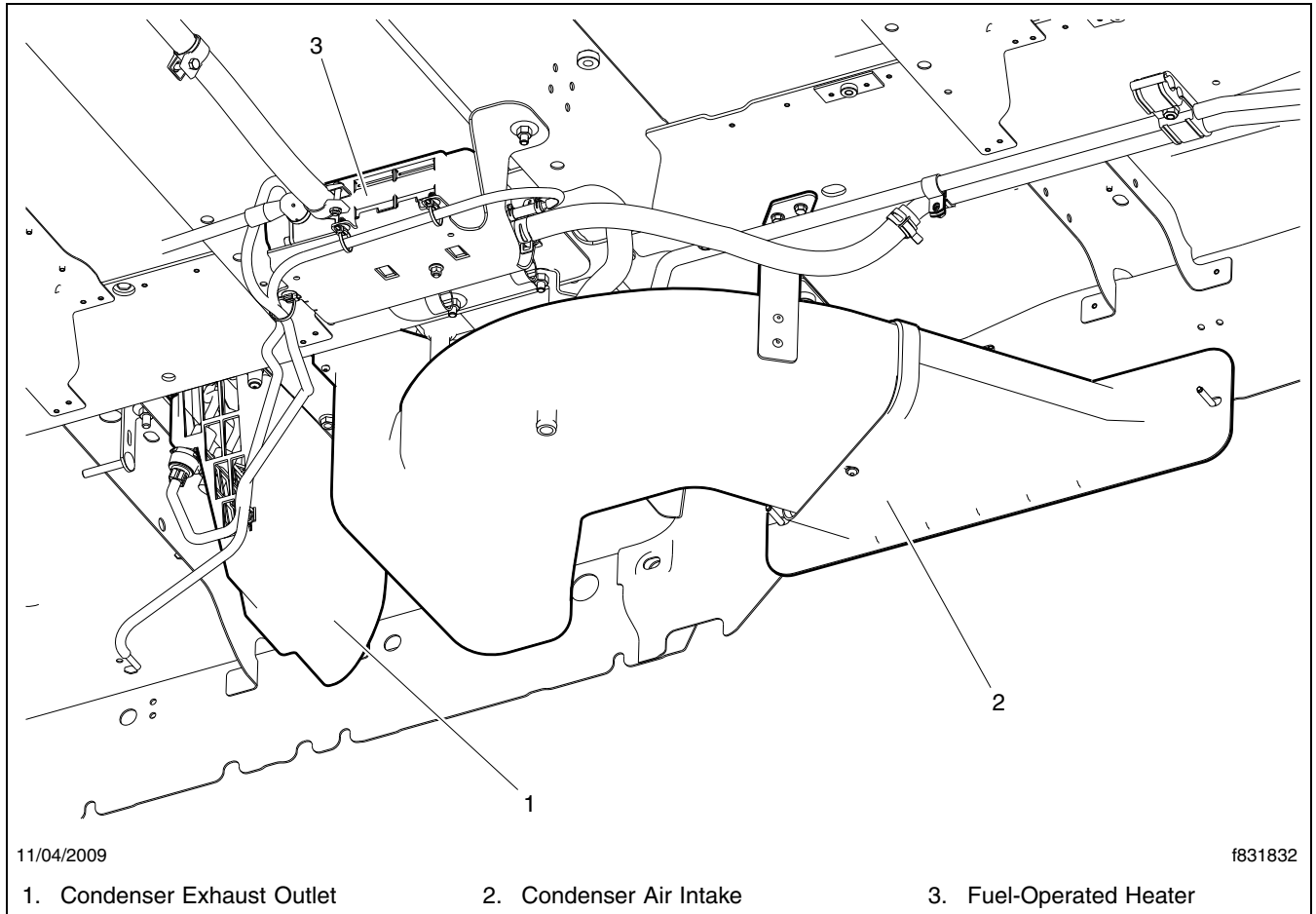


Fig. 20, Fuel-Operated Heater Location (pre-July 2011 shown)

An Espar Hydronic 5 fuel-operated heater is an integral component of the ParkSmart HVAC system. This unit is used to heat engine coolant which then passes through the auxiliary heater core and warms the bunk.

The fuel-operated heater is plumbed in series with the engine coolant system. When the engine is running, heat to the ParkSmart unit is supplied by the engine coolant system, and the fuel-operated heater is not operational. When the engine is not running, coolant is drawn from the engine coolant system, heated by the fuel-operated heater, and passes through a heater core in the ParkSmart unit to heat the bunk. The heated coolant flows through the rest of the vehicle's coolant system and returns to the fuel-operated heater through the internal water pump. The fuel-operated heater exhausts through a tube located at the rear of the sleeper.

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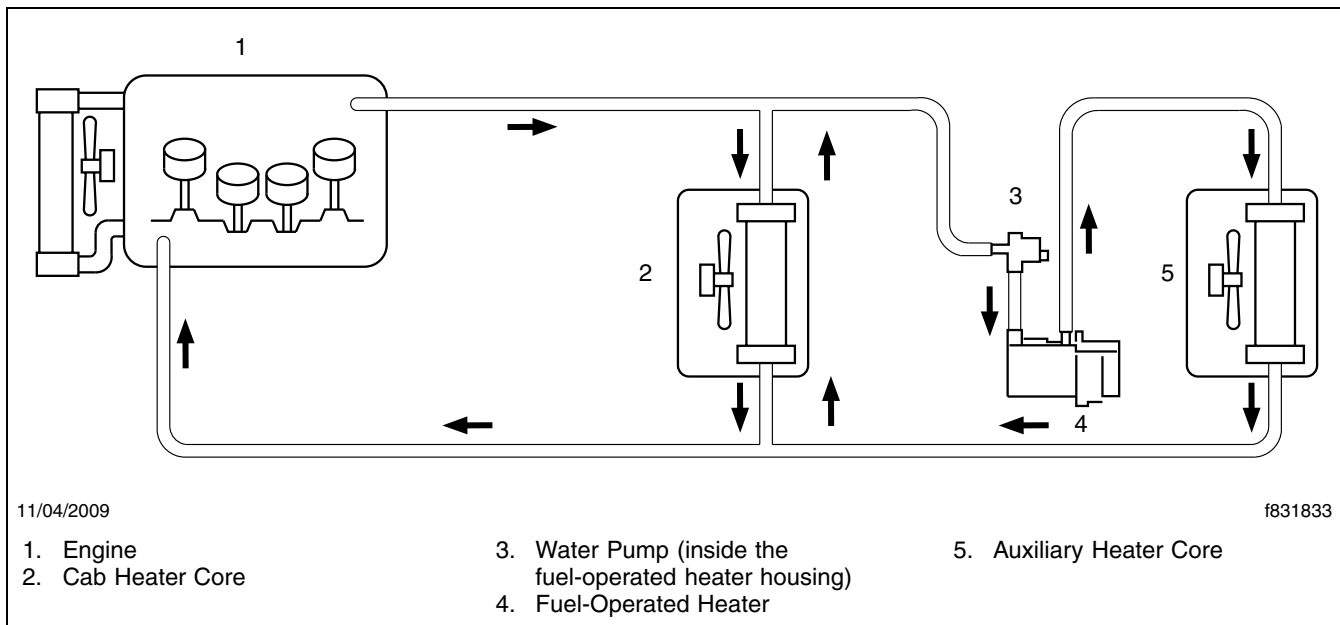


Fig. 21, Fuel-Operated Heater System

Refer to **Table 16** for fuel-operated heater operation modes.

Fuel-Operated Heater Operation									
Component	Operating Mode								
	Starting Phase					Running Phase	Shutdown Phase		
	Initial Attempt			2nd Attempt (if required)		Controlled Heating	After Glow	Cool Down	OFF or Stand-By
	System Check	Pre-Heat	Ignition	Pre-Heat	Ignition				
Water Pump	Off	On	On	On	On	On	On	On	Off (On if in Stand-By)
Blower	On Momentarily	On	On	On	On	On	On	On	Off
Glow Pin	Off	On	On	On	On		On	Off	Off
Fuel Pump	Off	Off	On	Off	On	On	Off	Off	Off
Time	1–3 Sec	40 Sec	Up to 80 Sec	40 Sec	Up to 80 Sec	Continuous	20 Sec	2.5 Min	—
	High/Low Operation (until switched off manually or automatically)								

Table 16, Fuel-Operated Heater Operation

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Fuel-Operated Heater Pin-Out (from MOD 689) (to July 2011)			
PIN	Description	Typical Value	Connects To
1	Power	12 VDC	Fuse F3 in ParkSmart PDM
2	Heat Enable	12 VDC	Internal controller
3	Ground	0 VDC	Common ground cable
4	Heater Diagnostics	Only used by Espar Diagnostic tool	Internal controller

Table 17, Fuel-Operated Heater Pin-Out (from MOD 689) (to July 2011)

Fuel-Operated Heater Pin-Out (from MOD 689) (from July 2011)			
PIN	Description	Typical Value	Connects To
1	Power	12 VDC	Fuse F3 in ParkSmart PDM
2	Ground	0 VDC	ParkSmart common ground cable
3	Not used	—	—
4	Fuel pump signal	12 VDC	Fuel-operated heater fuel pump
5	Heater diagnostics	Only used by Espar tool	—
6	Not used	—	—
7	Heater enable	12 VDC	Internal controller
8	Not used	—	—

Table 18, Fuel-Operated Heater Pin-Out (from MOD 689) (from July 2011)

Park Brake Switch

The parking brake switch used on ParkSmart is a normally-closed air switch installed in the air manifold above the throttle pedal. When the parking brake is applied, air pressure in the circuit opens the switch. There can be up to three similar air switches installed in this location, but they are not identical. If the wrong switch is connected to the ParkSmart system, the fuel-operated heater will not be requested in parked mode, but all the other features will function as designed.

Park Brake Switch Pin-Out (from MOD 70C)			
PIN	Description	Typical Value	Connects To
A	Power	12 VDC	Fuse F16 SAM Cab
B	Signal	0 VDC (w/parking brake applied)	Internal controller

Table 19, Park Brake Switch Pin-Out (from MOD 70C)

700 — Troubleshooting

Use the ParkSmart Troubleshooting Checklist (**Table 20**) to categorize the failure, and confirm all the system requirements are being met. Then go to the specific diagnostic subject as directed. Refer to the *Cascadia Workshop Manual* for specific repair procedures.

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Table 20 lists common ParkSmart HVAC system problems and solutions. To diagnose fuel-operated heater problems, use the recommendations in **Table 20** in conjunction with the fault code list in **Table 26**, and the heater manufacturer's service manual.

ParkSmart Troubleshooting Checklist				
Step	Preset Conditions	Test Results (record in blank column)		Next step
Vehicle parked, key off, parking brake set. Bunk temperature must be above 60°F (15°C) to test ParkSmart A/C system.				
1	Check resting voltage on both battery banks	Front voltage		If less than 12.4V, see Diagnostic Subject 6.
		Rear voltage		
2	Start ParkSmart. Full cold, blower on 1, push "PARK" button.	Light illuminates and stays on		If no, see Diagnostic Subject 1.
		Blower comes on		If no, see Diagnostic Subject 4.
		Compressor comes on		If no, see Diagnostic Subject 2.
		Condenser fan comes on		If no, see Diagnostic Subject 3.
3	Switch to heat. Full hot, blower still on 1, ("PARK" button still illuminated)	Heater comes on (hear or feel heater exhaust)		If no, see Diagnostic Subject 5.
Vehicle Running. Bunk temperature must be above 60°F (15°C) to test the ParkSmart A/C system.				
4	Start vehicle. Check battery bank voltages.	Front voltage		Battery voltage should come up above 13.7V. If not, diagnose battery, cable, and/or charging issue.
		Rear voltage		Battery voltage should rise above 12.5V. If not, see Diagnostic Subject 6.
5	Start ParkSmart unit. Blower on 1, temp full cold.	Blower comes on		If no, see Diagnostic Subject 4.
		Compressor comes on		If no, see Diagnostic Subject 2.
		Condenser fan comes on		If no, see Diagnostic Subject 3.
6	Run time complaint	Tests 1 - 5 check good		If yes, see Diagnostic Subject 6.
7	A/C lack of cooling complaint	Tests 1 - 5 check good		If yes, see Diagnostic Subject 7.

Table 20, ParkSmart Troubleshooting Checklist

ParkSmart Diagnostic Subjects

Diagnostic Subject 1 – J1939 and ACU Function

If the unit does not turn on in any mode there are several components to check.

If the "PARK" indicator light does not illuminate on the ACU when the blower is set to anything but 0, and the "PARK" button is pushed, check the power and ground on the back of the ACU. Power (12 Volts) and ground, supplied by the vehicle harness, must be available at the ACU for the indicator light to work. If power is available and the light does not illuminate when "PARK" button is pushed, replace the ACU.

If when the blower is set to anything but 0, and the "PARK" button is pushed, the "PARK" indicator light illuminates for several seconds before turning off, this is an indication that the ACU is making a request, but the internal controller is not waking up. Check the following:

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- On vehicles manufactured before July 2011, disconnect both battery positive power cables from the condenser air outlet basket pass-through, wait 5 minutes, connect the power cables, and recheck if the park indicator light stays on.
On vehicles manufactured from July 2011, remove fuses F6 and F7, wait 5 minutes, install the fuses, and recheck if the "PARK" indicator light stays on.
- On vehicles manufactured before July 2011, disconnect the fuel-operated heater control harness from the pass-through connection, and recheck if the "PARK" indicator light stays on.
On vehicles manufactured from July 2011, disconnect the fuel-operated heater control harness at the eight-pin connector near the heater, and recheck if the "PARK" indicator light stays on.
- Start the engine, set the FCU to blower on anything but zero, press bunk override. Check to see if the ParkSmart is functioning in over-the-road mode.
- The J1939 Databus must be connected at both the internal ParkSmart control board and at the ParkSmart ACU for the ParkSmart to run properly. The resistance check across the databus connectors leading into the ACU and the internal controller should be 60Ω (ignition key in the "OFF" position). If not, trace the wire to find the problem with the databus.
- SAM Cabin fuse 2.

Diagnostic Subject 2 – Compressor Operation

If the internal controller is waking up, but the compressor does not run, check the following:

- Power at fuse F1.
- Power at relays 1 (on road) and 3 (parked), and they are switching.
- The compressor is being requested by the internal controller, as seen from the ParkSmart ServiceLink template.
- The over-pressure switch in the refrigerant loop is closed (fault codes available).
- Cabin temperature sensor must read above 60°F (15°C) for A/C to function.
- Evaporator temperature sensor reading is below 38°F (3°C) (fault codes available).
- The thermal switch on the compressor has opened or failed.
- The correct power from the internal controller is reaching the compressor.

Diagnostic Subject 3 – Condenser Fan Operation

The condenser fan should start up and run every time the unit is started. If not, check the following:

- Power at fuse F5.
- Power at relays 2 (on road) and 4 (parked), and they are switching.
- Signal voltage (from internal controller).
- The internal controller is making a request for the condenser fan, as seen from the ParkSmart ServiceLink template.
- Power and ground at the fan connector.

Diagnostic Subject 4 – Blower Operation

If the blower motor is not responding as expected, check the following:

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- Power at fuse F4.
- Power at relays 2 (on road) and 4 (parked), and they are switching.
- Blower motor request, as seen from the ParkSmart template in ServiceLink.
- Blower motor fault codes.
- Power and ground at blower connector.

Diagnostic Subject 5 – Fuel-Operated Heater Operation

If everything else in the ParkSmart system is working, but the fuel-operated heater does not start, check the following:

- Power at fuse F3.
- Power and ground at the connector pass-through in the condenser air outlet basket.
- Back probe for voltage on the yellow "heat request" wire (at the pass-through connector).
- Fault or Lock-out codes in the fuel-operated heater's internal controller (Espar special tools required).

Diagnostic Subject 6 – System Charging, Batteries, Separator, and Run Time Complaints

If it is determined that the unit is running properly, and lack of run time is the only complaint: a lack of expected run time can be caused by several different and distinct issues.

Batteries are not Properly Charged

Battery charge level should exceed 12.3V prior to analysis of the system for other issues. Charge the batteries if needed. Low voltage in the parked batteries (11.8 to 11.2V) is expected with the main batteries in the 12.05V range. This does not indicate separator malfunction. Examine driving habits; it will take six to eight hours of driving before a discharged battery bank will fully charge under normal driving conditions. Consult the ParkSmart operating instructions in the *Cascadia Driver's Manual* for estimated run times given temperature and sun load. These estimates are all based on completely charged batteries. If the driver had not been driving for 8 hours to recharge from the previous rest period, the batteries may not have fully recovered yet. Follow standard warranty practices for the evaluation and replacement of AGM batteries as needed. See Freightliner Service Bulletins 54-250 and 54-228.

Battery Separator is not Functioning Properly

To perform the on-vehicle test of the separator, check the resting voltage of both sets of batteries, start the engine and observe the main battery set charge to be within 1 volt of the alternator output, then within 15 seconds of the main battery set reaching 13.2 VDC, the separator will close and raise the auxiliary battery set, confirming the separator has closed and the auxiliary batteries are being charged. (On vehicles manufactured after July 2011, the start interrupt will keep the separator open for 75 seconds after the start.) Find the 5 amp fuse on the sense wire (located in the main battery box), and remove it to force the separator to open. Within 15 seconds, the separator will re-open and the auxiliary battery set will show a reduction in voltage.

Bench testing the separator function requires that power be provided to the "START" or "AUX" battery post on the separator, as either of these is the source for the large current required to make the switch occur.

Proper separator function:

1. Remove the covers from both battery boxes, and note the resting voltage of both sets of batteries.

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Resting Voltage		
Start:	Auxiliary:	Voltages should be different at each bank after ParkSmart operation.

Table 21, Resting Voltage

2. Start the engine. After waiting for one minute, recheck voltage at both banks of batteries.

Engine Running Voltage		
Start:	Auxiliary:	Voltage at both banks must rise to 13–14V.

Table 22, Engine Running Voltage

3. Pull the sense wire fuse (located within six inches of the positive "start" battery posts), and record the voltage at the auxiliary batteries.

Sense Wire Fuse Removed Voltage		
Start:	Auxiliary:	Auxiliary batteries will drop to resting voltage.

Table 23, Sense Wire Fuse Removed Voltage

The separator is designed to connect both battery banks together while the vehicle is charging (above 13.2 volts) and disconnect them when the voltage drops below 12.5 volts as measured at the main battery bank. This system is dependent on a fused sense wire that connects the separator to the positive side of the main batteries. When the vehicle is not running the voltages of the battery banks can be different. This is normal, it is not an indication of separator malfunction. When the vehicle starts the alternator will increase the voltage of the system. The battery voltage seen at the main batteries rapidly increases to 13.5-14.0 volts. When the battery sense wire for the separator achieves a voltage of 13.2 volts the separator will close, this closure allows power to flow from the alternator to the auxiliary batteries. The closure can create a momentary voltage drop in the system (as four discharged batteries become connected) which may cause the separator to open and close repeatedly (this is not a failure.) Once connected, the separator will not open again until the voltage of the sense wire is below 12.5 Volts for a period of 20 seconds or more. The separator will not function properly if the fuse or sense wire is compromised in any way. Corrosion at the sense line fuse is a common reason for the separator not functioning. Always check sense line integrity (voltage drop test between line ends) prior to replacing the separator. The ground to the separator is also vitally important to proper system operation.

Ambient Temperature Sensor Failure

The failure of this sensor results in the unit reverting to full power even when parked, lessening run time. Use the template in ServicePro to see the requested compressor duty cycle, and compare the displayed value to **Table 11**. The normal compressor duty cycle in parked mode with moderate ambient conditions is 32%, but full output in over the road mode will be 54%. **Table 11** shows the sensor temperature/resistance relationship.

Improper Use of the Unit

Proper operation of the unit, as described in the *Cascadia Driver's Manual*, is necessary for achieving advertised run times. Refer to *Cascadia Driver's Manual* for proper operation instructions.

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Diagnostic Subject 7 – Cooling Performance

If the unit is operating but a lack of cooling is the issue: Run the ParkSmart unit on full cold, blower speed 8, for at least 20 minutes, then check the following. Ambient temperature must be above 60°F (15°C) to test the ParkSmart system.

Temperature Check	
Location	Temperature
Outside ambient temperature	
Inside cabin temperature	
Duct outlet temperature	

Table 24, Temperature Check

To test for low refrigerant in an otherwise operating system, the following conditions are met:

- Duct outlet temperature is within five degrees of inside cabin temperature.
- Auxiliary batteries must be charged to in excess of 12.3V.
- The blend door is completely closed.

Set the unit to full cold, blower speed 8, make sure that both air vents are fully opened. Press the "PARK" button. With the engine off (key in the OFF position), use a current clamp (See **Fig. 22** or **Fig. 23**) to determine the number of amps that the ParkSmart unit is drawing from the auxiliary batteries:

- If the duct outlet temperature is 15°F (8°C) or more cooler than the inside cabin temperature, the A/C system is operating correctly.
- If the system is full of refrigerant, the current draw should be in the range of 45 to 70 amps, measured on the main ground cable coming from the ParkSmart unit.
- If the current draw is lower than 40 amps with the compressor running (as well as the condenser and blower fans), the refrigerant charge in the system is suspect.
- One check of the refrigerant level is to touch the A/C line leading to the evaporator (it can be accessed from the filter opening without removing the unit). See **Fig. 24**. When the compressor is running this line should be cold and covered in condensation. If this line is not cold, the unit is likely low on refrigerant, or experiencing another refrigerant loop problem. On systems built after July 2011, also check the high side line going to the evaporator to see if it is hot.
- If the fan, blower, and compressor are running in parked mode and the air is not cold at the louvers, and the evaporator inlet tube is not cold, then there may be a refrigerant leak. If there is a leak, units built before July 2011 will need to be replaced. Units built after July 2011 will need to be checked for leaks using an approved refrigerant leak detector, and repaired (or replaced depending on the failure mode, location, and progressive damage).
- A plugged inlet filter will decrease performance. The filter can be removed, and cleaned by hand washing it in water.

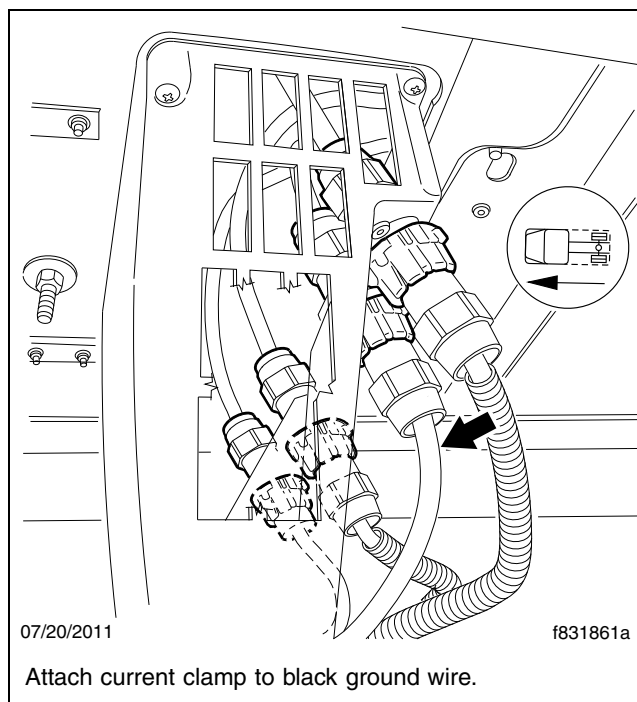


Fig. 22, Checking the Amp Draw (pre-July 2011 shown, under cab installation)

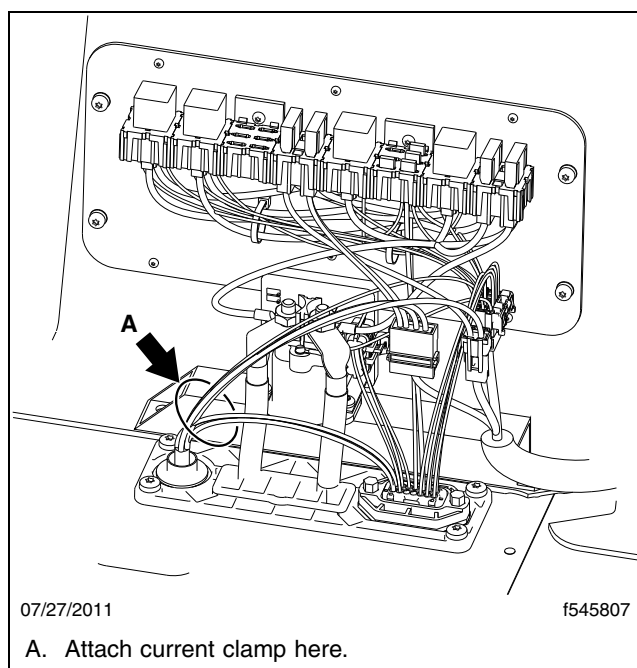


Fig. 23, Checking the Amp Draw (pre-July 2011 under bunk installation)

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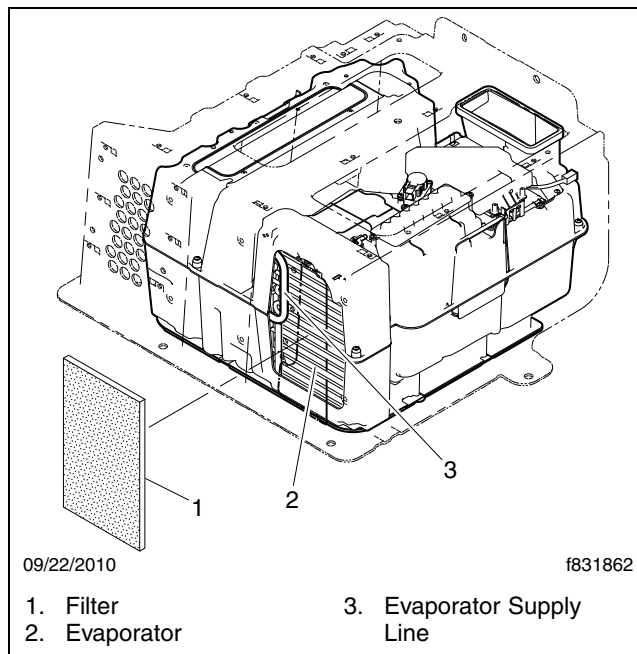


Fig. 24, Evaporator Line Check (cabinet not shown for clarity)

Component Specific Tests

Electrical Quick-Test

This test will help determine if there is a problem, and where it is located in relation to the fuses.

First test the fuses with the engine running, then test them in parked mode. A positive result will be near battery voltage in all cases.

Setup 1 - Engine running, blower on.

Setup 2 - Parked mode. Engine off, key set to OFF, blower on, press the "PARK" button.

1. Test for voltage at fuses 2 and 3.
2. Test for voltage at the remaining fuses (1, 4, and 5).

After completing this test, you will know:

- the voltage coming into the ParkSmart PDM from both battery connectors.
- if the relays are working, and what their voltage drop is.
- if the relays have power on the positive coil circuit.
- if the internal controller is providing ground to the relay coils.

Fuel-Operated Heater Test

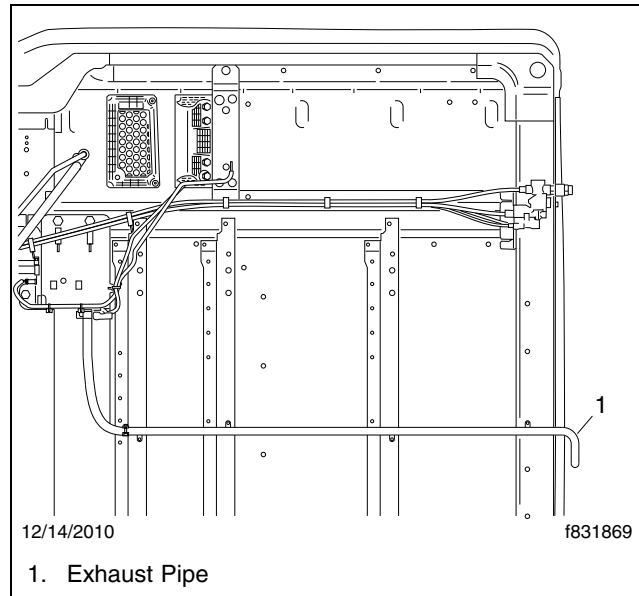


Fig. 25, Exhaust Pipe Installation

The fuel-operated heater requires three conditions to work:

- Power and ground at the connector on the condenser exhaust basket
- 12V on the yellow signal wire at the connector
- Fuel in the tank
- No internal fault codes that activate a "lock out" mode

Test the fuel-operated heater function as follows.

1. Verify that there is power and ground at the connector.
2. Jump the power from the red wire to the yellow wire (so that both supply 12V to the heater). See **Fig. 26**.

If the fuel-operated heater powers up and begins to run, the ParkSmart system is not providing the request signal. The fuel-operated heater is not faulty; continue diagnosis using the ParkSmart Controls Test that follows.

If the fuel-operated heater does not turn on, refer to the *Espar Hydronic 4-5* manual, and use the Espar diagnostic tool to diagnose the issue. See **Table 25** for common problems with the system.

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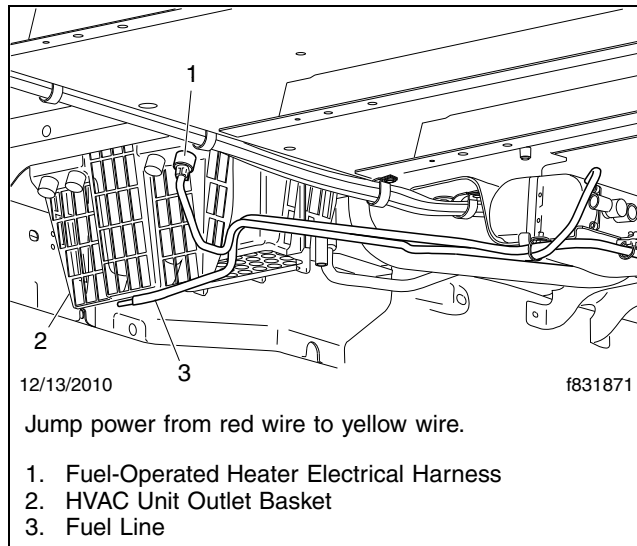


Fig. 26, Testing the Fuel-Operated Heater Function

Fuel-Operated Heater Troubleshooting: "No Start" and "Heater Stops" Conditions		
Problem	Description of the Problem	Possible Reason and Method of Repair
1	Nothing happens when the heater is turned on. Coolant pump is not pumping.	1. Check the voltage at the heater harness connector pins 1 and 2. Turn the heater on and make sure that the voltage is still OK. Repair the harness and connections if necessary.
		2. If the voltage is OK, then try to start the heater by connecting the red and yellow wires together using a jumper wire.
		3. If the heater still does not start, then most likely the ECU is locked or the start-up self test fails. NOTE: Use the 7-Day Timer, EDiTH, or diagnostic tool, to retrieve fault codes from the heater's memory and to unlock the ECU if it is locked. Follow the heater manufacturer's service manual for the fault code's description and repair methods.
2	When turned on, heater just pumps coolant, never stops and never performs a start attempt. No fault codes found in memory.	1. Check and replace the temperature sensor.
		2. If the sensor is good, replace the ECU.
3	Heater switches into shutdown phase 20 seconds after being turned on (the most likely, fault code 11 found in memory).	Check the voltage at the heater harness connector pins 1 and 2. Turn the heater on and make sure that the voltage is still OK. Repair the harness and connections if necessary.
4	Heater makes two attempts to start with no success, and then stops completely. No smoke comes from the exhaust pipe, some smoke can be seen between the exhaust pipe and heater.	1. Check if the exhaust pipe is plugged.
		2. Check the combustion air intake pipe. If the exhaust and combustion air intake pipes are OK, see problem 5 below.
5	Heater makes two attempts to start, may smoke for awhile and then it stops.	1. Do the fuel quantity check, and if the amount of fuel is sufficient, then check the fuel pick-up pipe, fuel lines and connections, and the fuel filter on the pump. Replace the filter or pump if necessary.
		2. Check the glow pin, and replace the atomizing screen. Clean the combustion tube (including all its airways) and the heat exchanger.

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Fuel-Operated Heater Troubleshooting: "No Start" and "Heater Stops" Conditions		
Problem	Description of the Problem	Possible Reason and Method of Repair
6	Heater starts and runs, but smokes excessively. NOTE: Minor smoking at startup is normal, but large amounts of continued smoke indicates combustion problem.	1. The heater needs to have the combustion screen/chamber serviced. 2. There is a combustion air flow restriction causing a rich running condition.
7	Heater makes two attempts to start, then stops. Both times it sounds like the ignition takes place and then combustion process stops together with the fuel metering pump. Usually no smoke comes from the exhaust pipe.	1. The heater ignited but the flame was not detected. Check the flame sensor. 2. Replace the ECU if the flame sensor is good.
8	Heater ignites normally, but often stops. (codes 52-56 found in memory)	Check for gaps in the fuel lines inside the rubber hose connections (see the installation instructions for details).
9	Heater overheats and stops soon after being turned on. The temperature of the heat exchanger raises quickly after the start.	1. Bleed the coolant lines and heat exchanger. Check the plumbing to ensure there are no air pockets or other restrictions to coolant flow. 2. Check to see if the coolant pump spins. Unblock and clean it if necessary.
10	Heater does not provide enough power. Mostly working on low power level, which can be detected by measuring electrical current draw.	1. Check the coolant pump for a blockage. 2. Check the heater plumbing for a blockage or damage.
11	Ground wire burned out.	A short circuit happened in the vehicle power circuits while the vehicle power switch in the battery ground wire was turned off. Fix the wire or replace the ECU.

Table 25, Fuel-Operated Heater Troubleshooting: "No Start" and "Heater Stops" Conditions

ParkSmart Controls Test

If the fuel-operated heater worked during the "Fuel-Operated Heater Test" but does not power up with the ParkSmart controls, check for the following:

- The park brake switch is operating correctly and parking brake is set. See the "Park Brake Pressure Switch Test" below.
- The engine must be off (J1939 reporting zero (0) engine rpm).
- The internal controller must be waking up. The light must stay illuminated on the ACU when and the "PARK" button is pressed.
- The fan is set to anything but zero, temperature knob set to maximum heat, and the ambient temperature sensor reading below 85°F (29°C).

If the above conditions are met, test for 12V on the yellow wire when heat request is initiated. If the yellow wire does not show 12V, but the fuel-operated heater will function when the yellow wire is jumped to 12V, there may be an internal problem with the ParkSmart. Use the internal wiring and pin-out details in the "Internal Controller" section of "Component Details" to confirm all the system circuits are providing the proper signals to the controller.

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ParkSmart™ Auxiliary HVAC System

Park Brake Pressure Switch Test

When the fuel-operated heater will not start it is possible that the parking brake switch (see **Fig. 27**) is not operating correctly. This switch is normally open (infinite resistance across the terminals) when the parking brake is set. The fuel-operated heater will not operate if this circuit is closed. In order to test the circuit and switch when the fuel-operated heater is not otherwise operational:

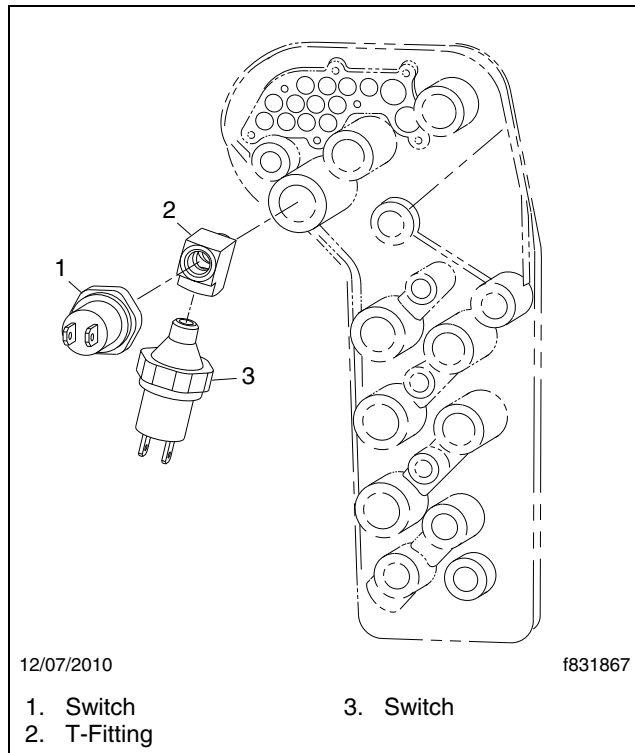


Fig. 27, Park Brake Pressure Switch Location (typical)

1. Turn the engine off.
2. Set the parking brake.
3. Remove the covers in the driver footwell that cover the air brake distribution panel.

NOTE: The wiring to the switches is labeled. The ParkSmart switch has the number of the harness on it (this can be found in PartsPro if necessary). This switch does not report on the J1939 databus, thus the value on the databus is not indicative of the status of this switch.

4. Disconnect one of the wires from the switch.
5. Set the ParkSmart unit on full heat, blower set at 4. Press the "PARK" button.

At this point you should hear the blower start. After approximately 2 minutes you will be able to hear and feel the fuel-operated heater exhaust at the pipe. If the fuel-operated heater does not operate at this time, the switch is not the problem.

ParkSmart™ Auxiliary HVAC System

C02.03

To verify that the switch is operating correctly:

- 5.1 Disconnect both wires from the switch.
- 5.2 With the parking brake set, place a multimeter across the terminals. You should see infinite resistance.
- 5.3 Verify that the wheels are securely chocked, then release the parking brake. You should now see 0 resistance.

Condenser Fan Test

The condenser fan should start every time the unit is powered up regardless of the temperature setting. To verify that the condenser fan is operating correctly at start-up, perform the following.

1. Ensure that the ignition key is in the "OFF" position.
2. The fan knob on ParkSmart controller should be set to any value other than 0. It will be easier to hear the condenser fan if the blower is set to a lower speed.
3. Press the "PARK" button. The condenser fan should power up and be heard running. If the condenser fan is not heard at start-up continue by troubleshooting the fuses and wiring, then test the speed signal from the controller.

ParkSmart Fault Codes

There are no fault codes for low system pressure or an improperly functioning compressor. If the compressor is not functioning, a determination will have to be made based on available voltage, and wiring integrity in the system. **Table 26** shows the fault codes that exist for the ParkSmart.

ParkSmart Fault Codes					
SPN	FMI	Name	Description	Transmitting Module	Limitations
171	4	Ambient Air Temperature Sensor	Shorted to ground	FCU/ACU/ACU	—
171	5	Ambient Air Temperature Sensor	Shorted to battery or open circuit	FCU/ACU/ACU	—
605	5	Refrigerant Pressure Switch	Refrigerant pressure open circuit (over- or underpressure)	FCU/ACU/ACU	—
1547	4	Evaporator Temperature Sensor	Shorted to ground	FCU/ACU	—
1547	5	Evaporator Temperature Sensor	Shorted to battery or open circuit	FCU/ACU	—
1548	4	Sleeper Temperature Sensor	Shorted to ground	FCU/ACU/ACU	—
1548	5	Sleeper Temperature Sensor	Shorted to battery or open circuit	FCU/ACU/ACU	—
523318	2	Blower Motor	Protection Mode: Voltage out of range	FCU/ACU/ACU	Diagnostic feedback PWM signal is 10Hz at 50% duty cycle.
523318	6	Blower Motor	Protection Mode: Overcurrent or thermal protection	FCU/ACU/ACU	Diagnostic feedback PWM signal is 10Hz at 25% duty cycle.

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ParkSmart™ Auxiliary HVAC System

ParkSmart Fault Codes					
SPN	FMI	Name	Description	Transmitting Module	Limitations
523318	7	Blower Motor	Protection Mode: Speed mismatch or blocked rotor	FCU/ACU/ACU	Diagnostic feedback PWM signal is 10Hz at 75% duty cycle. Use of this FMI assumes a mechanical problem.
523330	3	Blend Door Actuator Position	Voltage above normal or shorted to high source	FCU/ACU/ACU	—
523330	4	Blend Door Actuator Position	Voltage below normal, shorted to low source, or open circuit	FCU/ACU/ACU	—

Table 26, ParkSmart Fault Codes

Communication

The front HVAC control unit, auxiliary control unit, and the ParkSmart internal control unit communicate over the J1939 datalink. The front HVAC control unit uses source address (SA) 25 and the auxiliary control unit uses SA 58. The internal ParkSmart controller uses SA 68. The messaging communicated is used for operation, diagnostics, and data used to monitor the system with Datalink Monitor.

701 — Approved Leak Detection Methods

NOTICE

The ParkSmart system uses a non-conductive compressor oil. Use only polyvinylether (PVE) refrigerant oil in this system. The system should never be recovered to check AC charge. The ParkSmart system does not need any oil added unless refrigerant loop components have been replaced, or the system has been recovered in excess of 4 times. Addition of improper oil types, or too much oil, will cause damage to the compressor.

In units built from start of production through June of 2011, the ParkSmart refrigerant loop is not serviceable. When a performance complaint is coupled with evidence of a refrigerant leak, standard leak detecting methods may be employed to confirm the unit is losing refrigerant. The refrigerant type is R-134a. Follow the manufacturers' operating instructions and use the leak detectors from the approved tool list to confirm suspected leaks. If a leak is confirmed on an under performing unit, the refrigerant loop will need to be replaced with a new one.

Beginning in July of 2011 an R-134 A/C service port has been added to the high pressure side of the ParkSmart system for charging and recovery of refrigerant. Charging and recovery of this system should not be done until after the other troubleshooting methods have pointed to low or no refrigerant in the system.

Lighting System Overview

C04.01

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Lighting System Overview

C04.01

500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Multiplexing—Sending multiple electronic messages through the same signal path at the same time—in this case, through the CAN buses.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

This subject provides an overview of the exterior lighting system. Each lighting component is detailed individually in **C04 — Exterior Lighting**.

The external lighting system is multiplexed using a combination of wiring, CAN messages, and the following electronic components:

- Modular Switch Field (MSF)
 - MSF Master ECU
 - MSF Slaves Switch Housing
 - Sub-bus Switches
 - Rotary (Headlight) Switch
 - Steering Wheel Switches

C04.01

Lighting System Overview

– Stalk Switch

- SAM Cab
- SAM Chassis

External lighting functions, such as low-beam headlights, fog lamps, and marker lamps, operate in a similar fashion. The driver uses switches that are connected to the Modular Switch Field (MSF) Master ECU. The MSF Master continuously monitors the position of the switches and communicates the position to the SAM Cab and SAM Chassis, via the Cabin CAN datalink. The SAM Cab and SAM Chassis directly control the lighting circuits.

If the MSF becomes disabled, the SAM Cab and SAM Chassis will turn on the exterior lights. The MSF can become disabled if, for example, it loses its Cabin CAN connection. This is the fail-safe behavior when the MSF is disabled, because under normal circumstances the MSF provides the status of the headlamp switch to the SAMs. If the MSF is missing, the SAMs must default to the safest behavior, which is to turn on all exterior lights to guarantee the truck remains conspicuous.

The datalink used for troubleshooting or configuring the SAM Cab, SAM Chassis, MSF Master and connected switches is the Diagnostic CAN.

For more information on the Diagnostic CAN datalink, see **G03.04 — Datalink, Diagnostic CAN**.

502 — System Diagrams

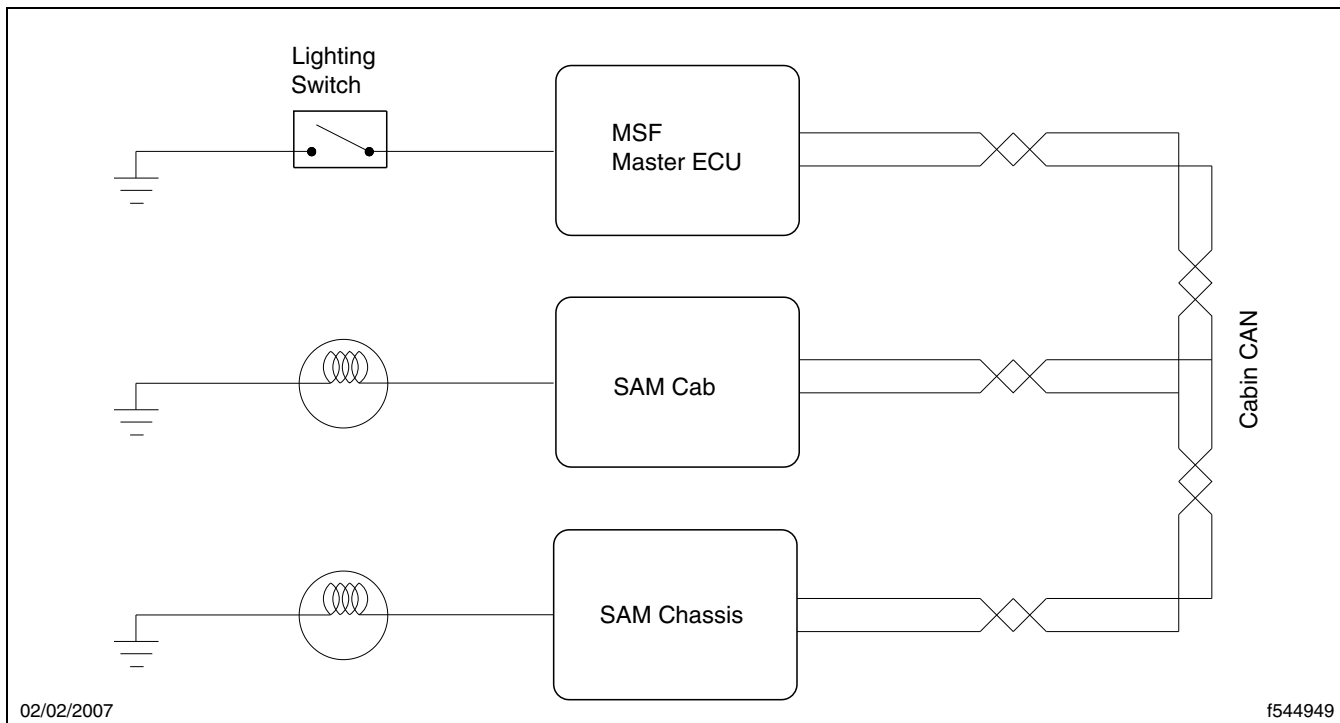


Fig. 1, Generic Diagram of the Exterior Lighting System

503 — Datalink Network Topology

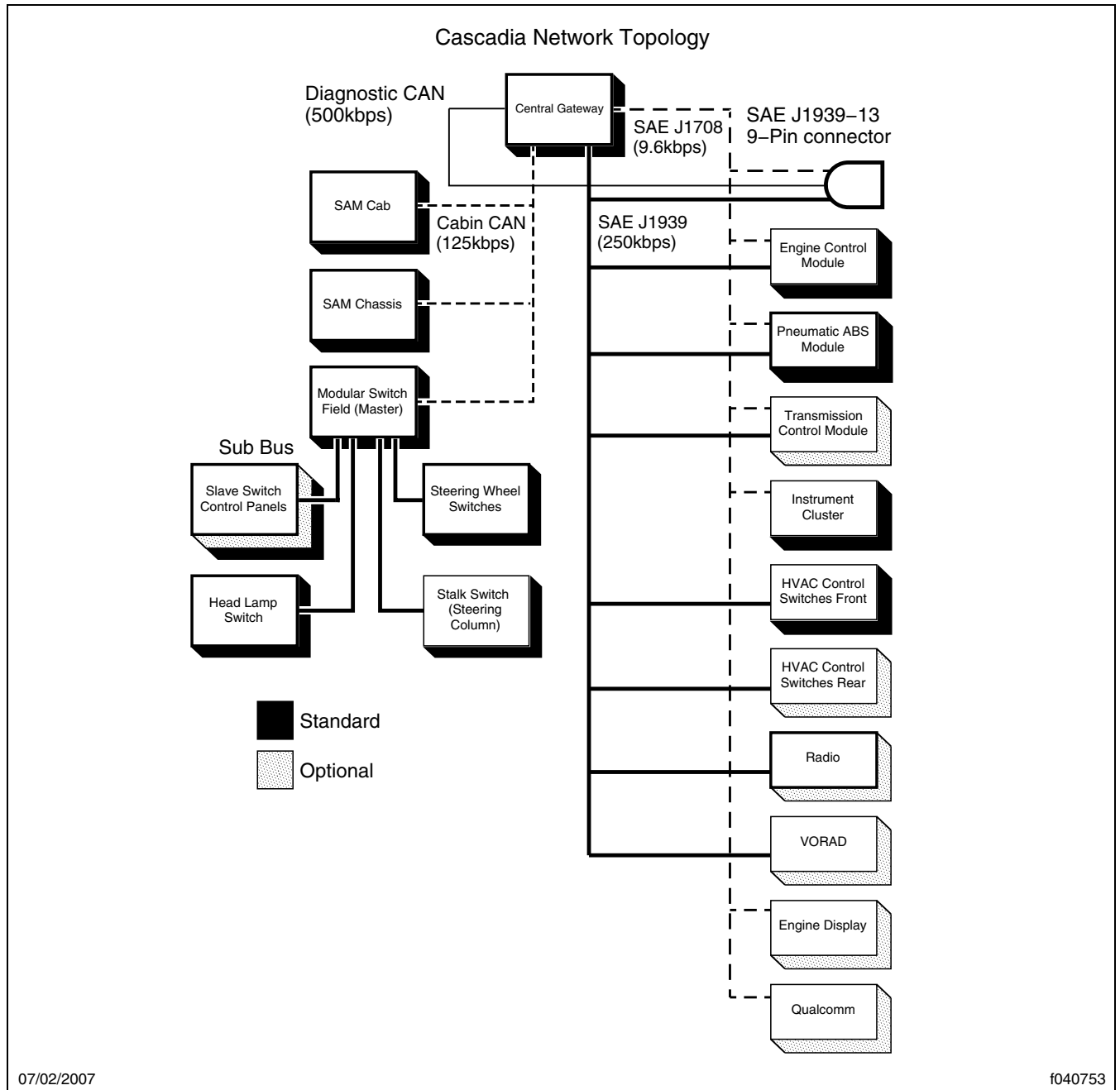


Fig. 2, Datalink Network Topology

C04.01

Lighting System Overview

504 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G02.06 — Modular Switch Field
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN

See **C04 — Exterior Lighting** for specific exterior lighting functions.

Lighting System Overview

C04.01

600 — Component Locations

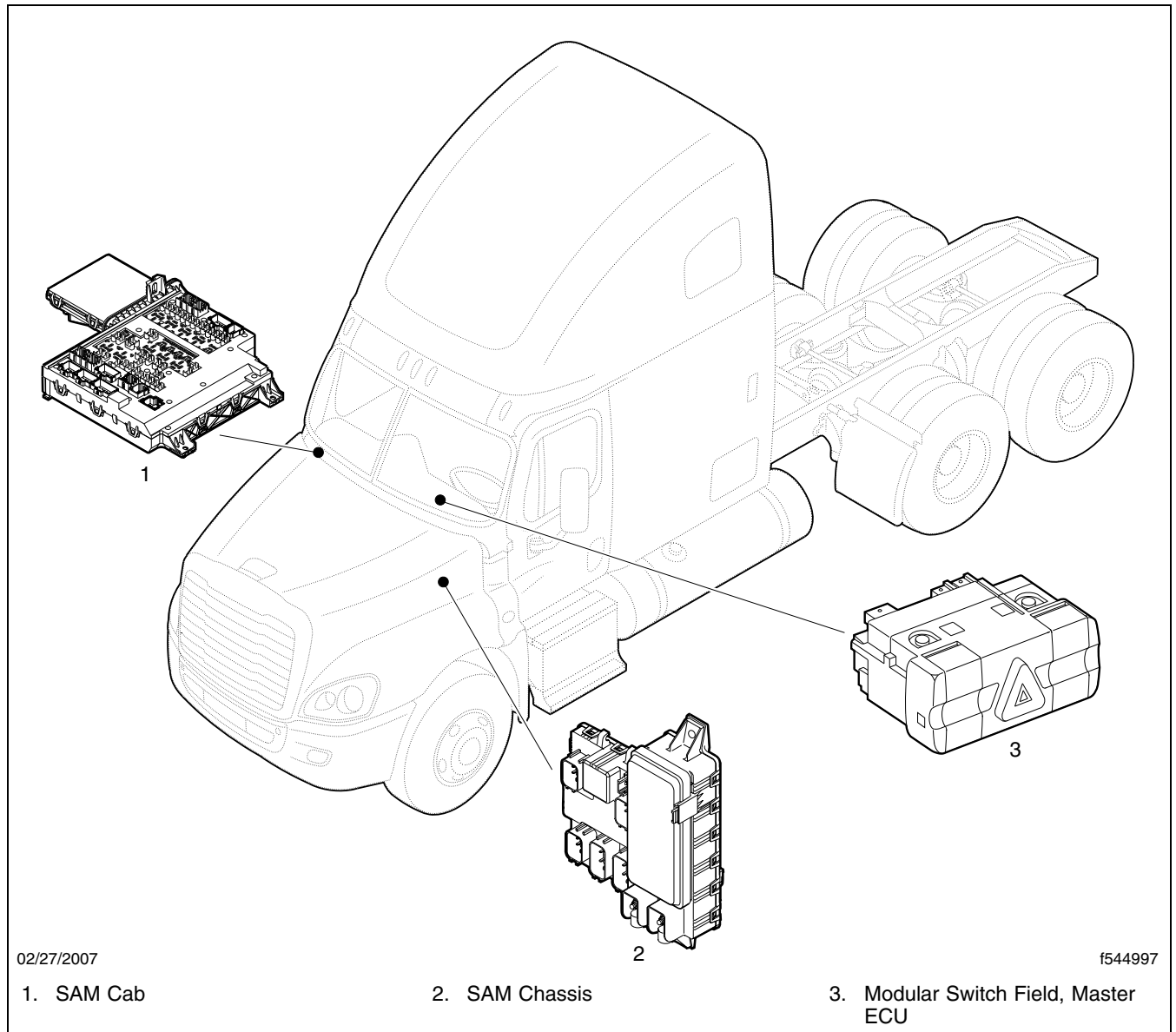


Fig. 3, Component Locations

Headlight System

C04.02

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Headlight System

C04.02

500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector used for troubleshooting the electrical system.

ECU—Electronic Control Unit, typically connected to a datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Multiplexing—Sending multiple electronic messages through the same signal path at the same time—in this case, through the CAN buses.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The headlights are activated by the headlight switch (also called the rotary switch), which is wired to the modular switch field (MSF) Master ECU. See **Fig. 1**.

C04.02

Headlight System

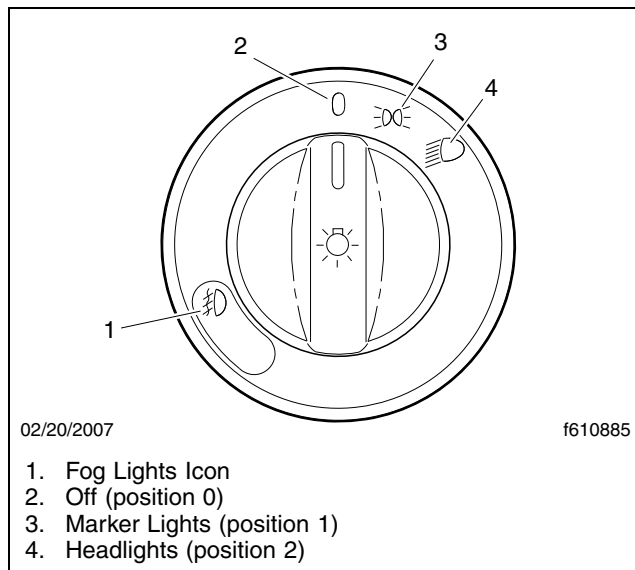


Fig. 1, Headlight Switch

The headlight switch has the following positions:

- Position 0: off
- Position 1: activates the marker/clearance/tail/license plate lamps.
- Position 2: activates all marker and clearance lamps, and low or high beam headlights (depending on the position of the stalk switch).

The stalk switch is used for high beam activation, and performing a flash-to-pass. It is wired to the MSF.

The stalk switch has three horizontal positions:

- Pushed: high beam headlights are activated if the headlight switch is in position 2.
- Neutral: no action.
- Pulled: the flash-to-pass function is performed, regardless of the position of the headlight switch.

The MSF monitors both the headlight and stalk switches, and communicates their position to the SAM Cab through messaging on the Cabin CAN datalink. The SAM Cab controls the headlamp circuits directly. See **Fig. 2** for system block diagram.

Headlight System

C04.02

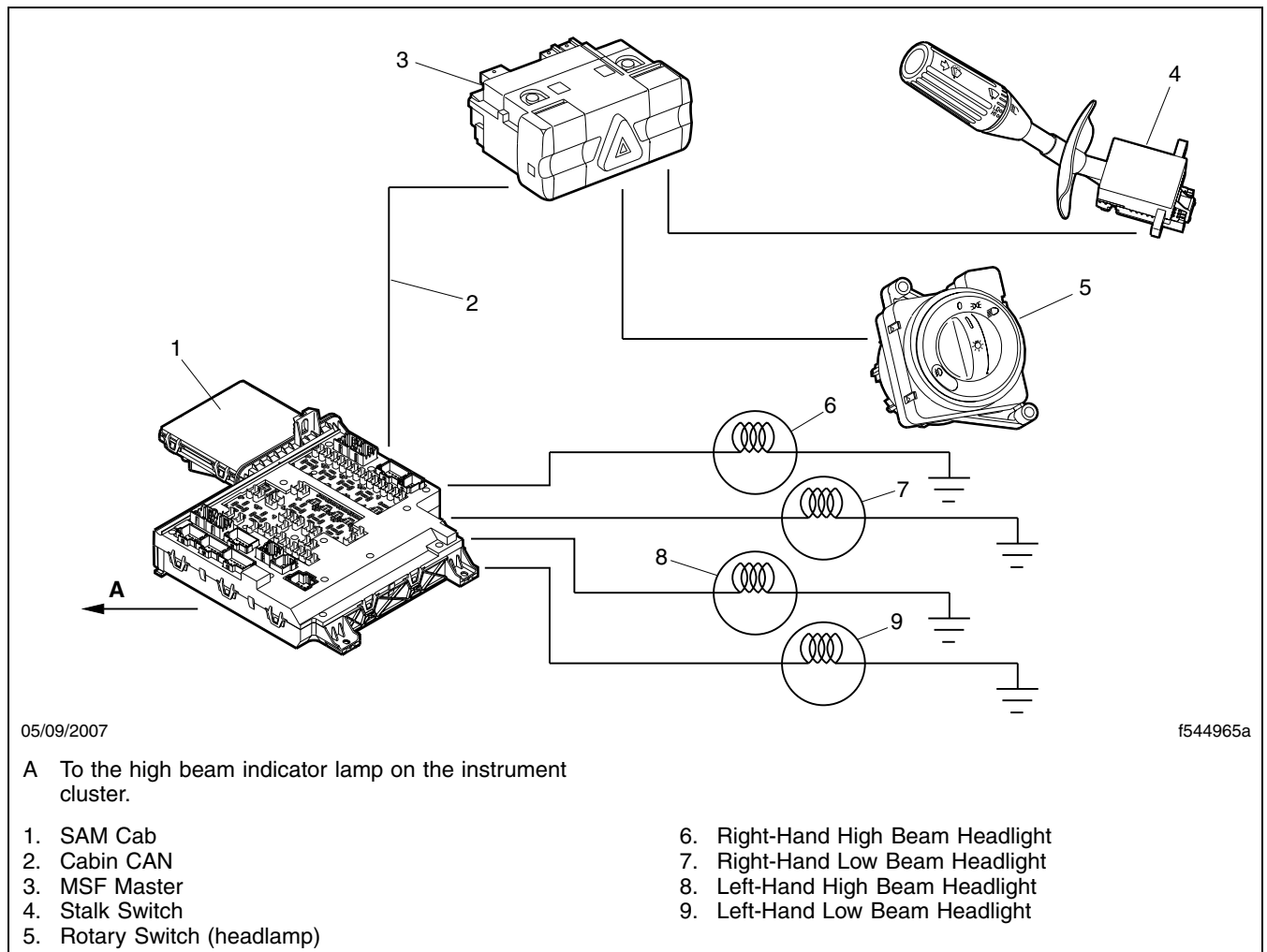


Fig. 2, Headlight System Diagram

502 — Low Beam Headlights

The low beam headlights are activated when the headlamp switch is in position 2.

Activation of the low beam headlights affects the daytime running lights. See **C04.03 – Daytime Running Lights** for details.

The low beam headlights also have a behavior called "soft start", which is intended to help extend bulb life. When activated, low beam output pins will ramp up from off to full brightness over a 2.5 second period. The soft start feature does not affect high beams or fog lamps.

See **801 — Parameters** for a list of parameters affecting headlights.

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Headlight System

503 — High Beam Headlights

The high beam headlights are activated when the headlamp switch is in Position 2, and the stalk switch is in the "pushed", horizontal position (high beams are activated).

Activation of the high beam headlights will turn on the high beam indicator lamp in the ICU. The high beam indicator lamp is hardwired to the ICU from the SAM Cab.

For information on the high beam indicator lamp, see the applicable subject in **C01 — Instrument Cluster**.

See **801 — Parameters** for a list of parameters affecting the headlamps.

NOTE: The ignition switch must be on to activate the high beams.

504 — Flash-to-Pass

The flash-to-pass feature is a momentary activation of high beams, by pulling the stalk switch.

The SAM Cab's High Beam outputs are used for the Flash-to-Pass feature. The input from the stalk switch will turn on the High Beam outputs for the duration that the stalk switch is held in the Flash-to-Pass position, regardless of headlamp/rotary switch position.

Activation of the High Beams for either the High Beam or Flash-to-Pass functions will activate the High Beam Indicator Lamp in the Instrument Cluster Unit (ICU). The High Beam Indicator Lamp is hard-wired to the ICU from the SAM Cab.

If the fog lights are activated when the flash-to-pass request is made, they will be deactivated during flash-to-pass activation. The fog lights activate again after flash-to-pass terminates. For more information, see **C04.06 — Fog Lights**. This function can be parameterized.

505 — Follow Me Home

The follow me home feature temporarily activates the low-beam headlights after the engine is turned off. This feature provides temporary lighting in the path of the headlights while walking away from the vehicle.

The condition for activation of this feature is that the headlight switch has been turned from the on position to the off position, and the ignition switch is turned off within 30 seconds of turning the headlight switch off.

Once the follow me home feature is activated and there is no change to the position of the door—it remains closed or open—the headlights stay on for 10 seconds. When a change is made to the position of the door within the 10-second period, the 10-second timer stops and the headlights stay on for an additional 15 seconds.

The follow me home feature can be temporarily disabled by turning the ignition switch on, or by cycling the headlight switch from the off position to one of the other two positions.

See **801 — Parameters** for a list of parameters affecting the follow me home function

506 — Datalink Network Topology

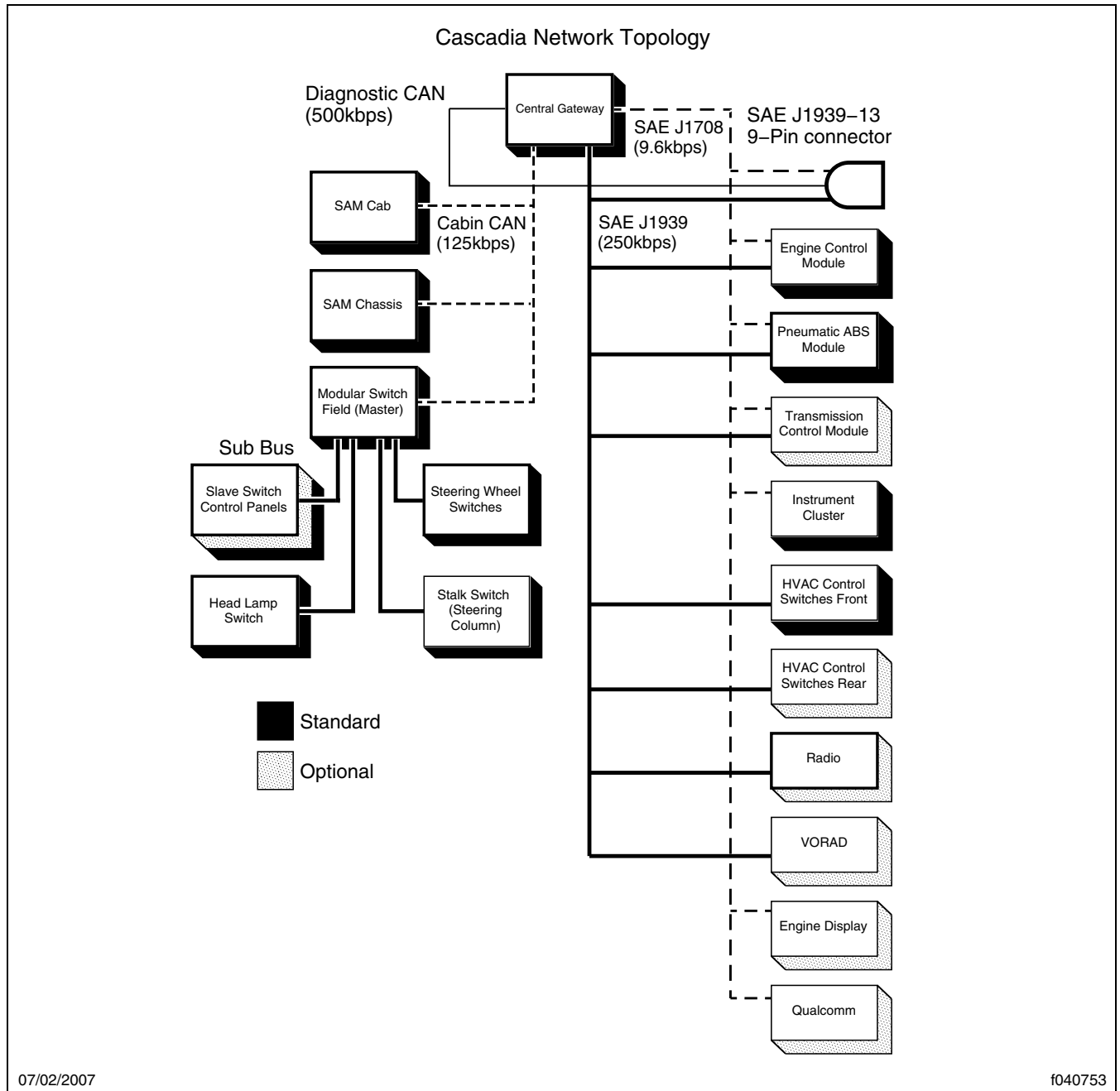


Fig. 3, Datalink Network Topology

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Headlight System

507 — Related Subjects

- G02.01 — Electrical System and Main PDM Overview
- G02.04 — SAM Cab
- G02.06 — Modular Switch Field
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN
- C04.01 — Lighting System Overview
- C04.03 — Daytime Running Lights
- C04.06 — Fog Lights
- Individual Instrument Cluster subjects in **C01 — Instrument Cluster**

600 — Component Locations

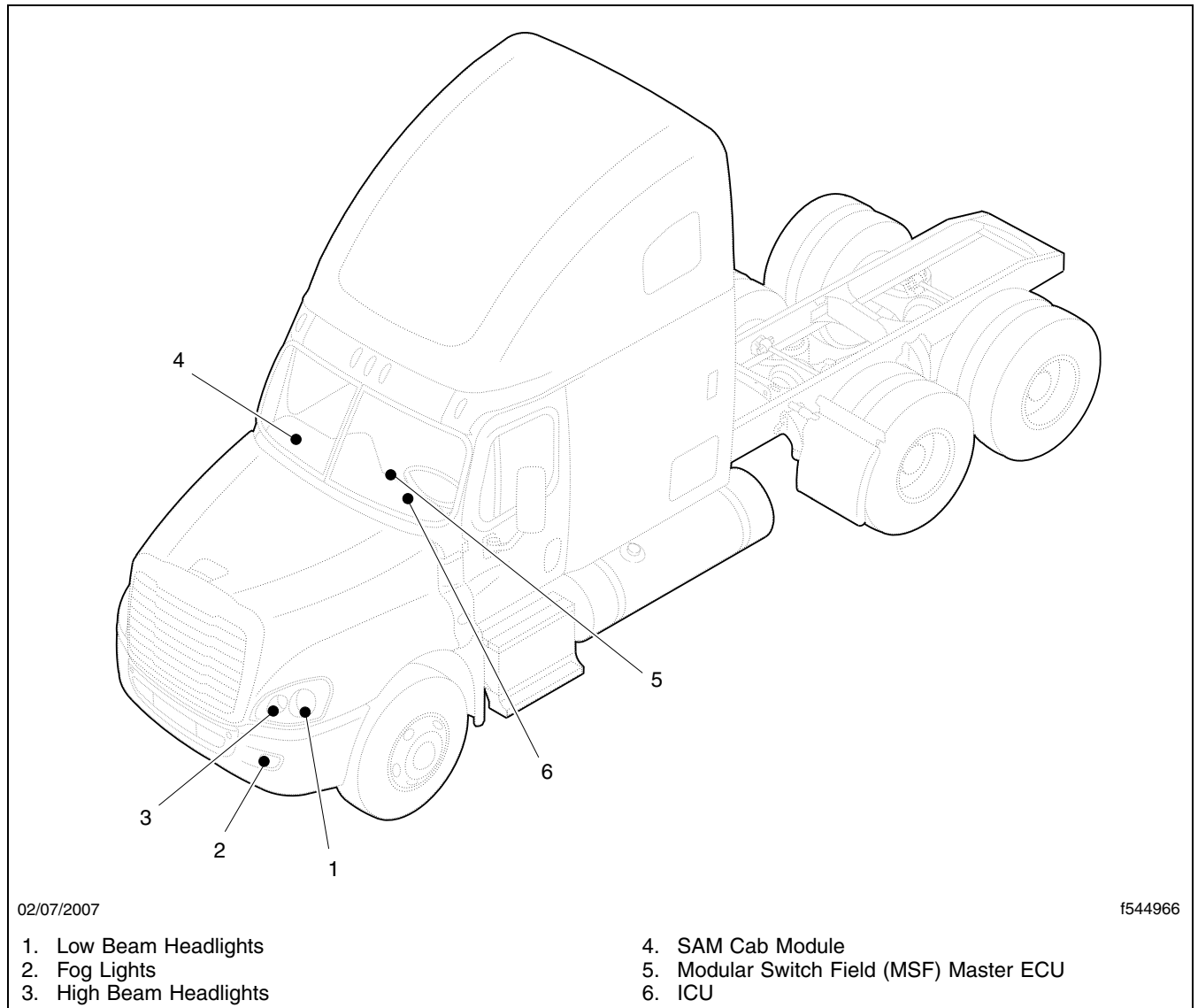


Fig. 4, Component Locations (exterior)

C04.02

Headlight System

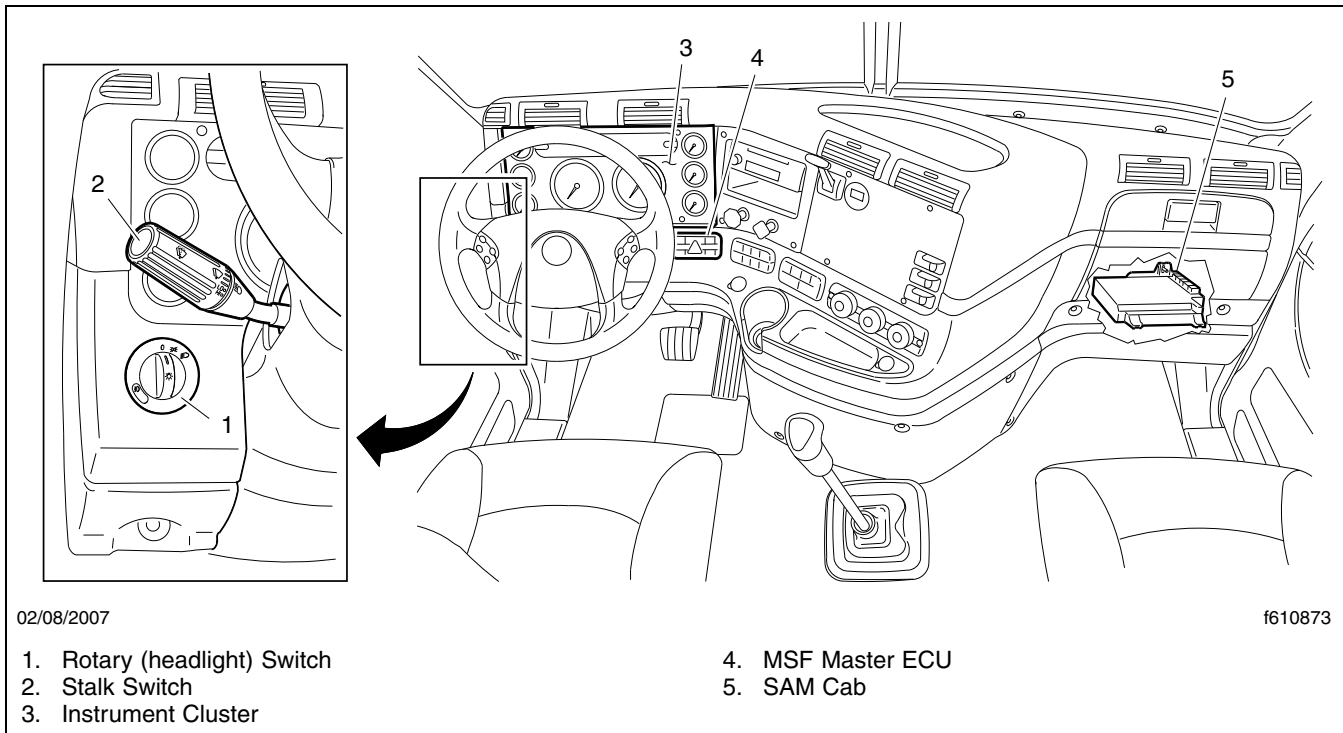


Fig. 5, Component Locations (interior)

601 — Component Details

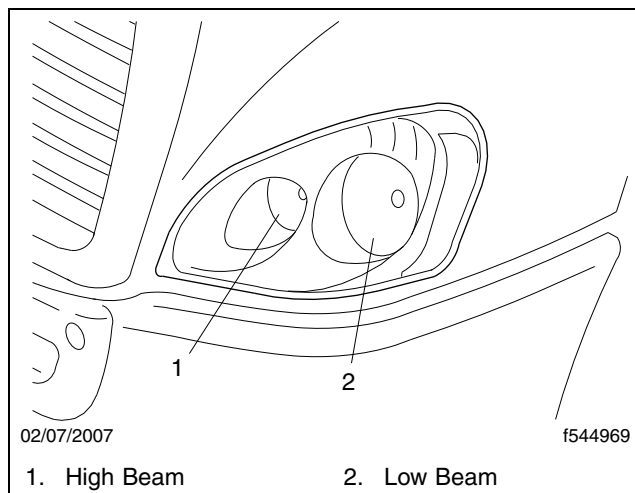


Fig. 6, Headlight (front view)

Headlight System

C04.02

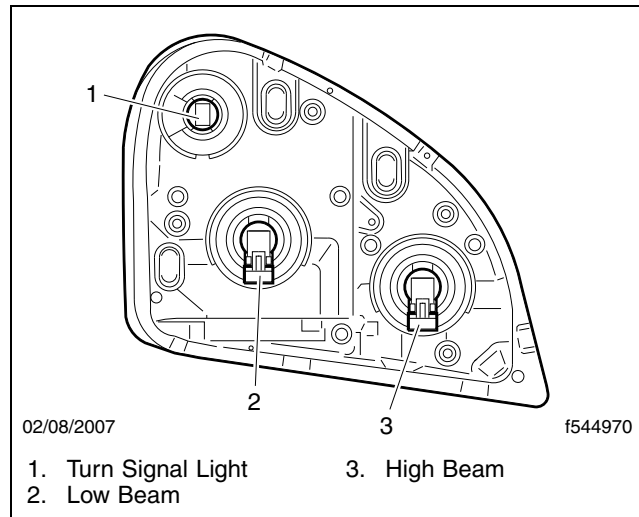


Fig. 7, Headlight (rear view)

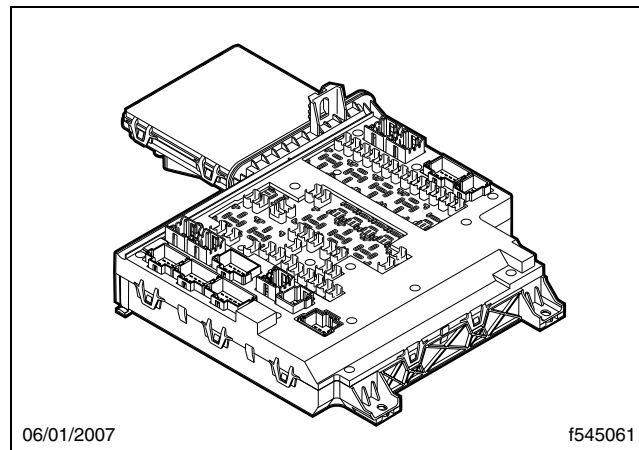


Fig. 8, SAM Cab

NOTE: Pinout included for convenience. For additional Component Details, please see **G02.04 — SAM Cab**.

SAM Cab Pinout Locations		
Connector	Pin	Description
X11	9	High Beam ICU indicator
X18	5	Low Beam, left
X18	6	High Beam, left
X18	17	High Beam, right
X18	20	Low Beam, right
X20	4	High/Low Beam auxiliary, right, GND

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Headlight System

SAM Cab Pinout Locations		
Connector	Pin	Description
X20	5	High/Low Beam auxiliary, left, GND
X20	10	High Beam auxiliary, left

Table 1, SAM Cab Pinout Locations

700 — Possible Causes

- Wiring, including switches and lighting components
- SAM Cab
- Modular Switch Field, Master ECU

701 — Pin Inputs and Datalink Messages

Datalink Messages				
Message	Datalink	From	To	Description
Main Light Switch Request	Cabin CAN	MSF	SAM Cab	Indicates the state of the headlight switch.
High Beam Switch Request	Cabin CAN	MSF	SAM Cab	Indicates the state of the high beam switch.
High Beam Flash Switch Request	Cabin CAN	MSF	SAM Cab	Indicates the state of the high beam flash switch.

Table 2, Datalink Messages

702 — CAN Fault Codes

NOTE: **Table 3** lists faults for the following ECUs:

- 33 – SAM Cab
- 37 – Central Gateway (CGW)
- 49 – Modular Switch Field (MSF)
- 71 – SAM Chassis

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

Headlight System

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521209	4	conn X11 pin 9	—	—	High beam ICU indicator – Voltage below normal, or shorted to low source.	The fault is active when the high beams are on and the current detected at conn X11 pin 9 is below 2A. This fault becomes historic when the current detected is greater than 0.2A.
Action: With the ignition on, turn the high beams ON and measure the voltage at conn X11 pin 9. If BAT voltage is not detected, troubleshoot circuit 222A for a short to GND.							
33	521905	3	conn X18 pin 5	—	—	Low beam left – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 5 is higher than 8V when the low beams are off. The fault becomes historic when the voltage detected is below 1.2V
Action: With the headlight switch in the OFF position, measure the voltage at SAM Cab conn X18 pin 5. Troubleshoot circuit 20L for a short to BAT.							
33	521905	4	conn X18 pin 5	—	—	Low beam left – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 5 is greater than 9.3A. The fault becomes historic when the current detected is below 6.7A.
Action: Turn the headlight switch to the ON 2 position. Measure the voltage at SAM Cab conn X18 pin 5. If BAT voltage is not detected, troubleshoot circuit 20L for a short to GND.							
33	521905	5	conn X18 pin 5	—	—	Low beam left – Current below normal, or open circuit.	The fault is active when current is not detected at conn X18 pin 5. The fault becomes historic when current detected greater than 0.5A
Action: Turn the headlights to position 2 and check if low beam headlamp is active. If not, turn the headlight switch to the OFF position. Measure the voltage at SAM Cab conn X18 pin 5. If BAT voltage is not detected, troubleshoot circuit 20L for an open circuit. Troubleshoot the lamp for continuity.							
33	521906	3	conn X18 pin 6	—	—	High beam left – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 6 is higher than 8V when the high beams are off. The fault becomes historic when the voltage detected is below 1.2V.
Action: With the high beams off, measure the voltage at SAM Cab conn X18 pin 6. Troubleshoot circuit 20H for a short to BAT if the voltage detected is above 8V.							
33	521906	4	conn X18 pin 6	—	—	High beam left – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 6 is greater than 10.3A. The fault becomes historic when the current detected is below 7.4A.
Action: Turn on the high beams. Measure the voltage at SAM Cab conn X18 pin 6. If BAT voltage is not detected, troubleshoot circuit 20H for a short to GND.							
33	521906	5	conn X18 pin 6	—	—	High beam left – Current below normal, or open circuit.	The fault is active when current is not detected at conn X18 pin 6. The fault becomes historic when current detected greater than 0.5A.
Action: Set the ignition to "run", headlights to position 2, activate the high beam switch, and check if high beam headlamp is active. If not, turn off the high beams. Measure the voltage at SAM Cab conn X18 pin 6. If BAT voltage is not detected, troubleshoot circuit 20H for an open circuit. Troubleshoot the lamp for continuity.							

C04.02

Headlight System

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521917	3	conn X18 pin 17	—	—	High beam right – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 7 is higher than 8V when the high beams are off. The fault becomes historic when the voltage detected is below 1.2V.
Action: With the high beams off, measure the voltage at SAM Cab conn X18 pin 17. Troubleshoot circuit 21H for a short to BAT if the voltage detected is above 8V.							
33	521917	4	conn X18 pin 17	—	—	High beam right – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 7 is greater than 10.3A. The fault becomes historic when the current detected is below 7.4A.
Action: Turn on the high beams. Measure the voltage at SAM Cab conn X18 pin 17. If BAT voltage is not detected, troubleshoot circuit 21H for a short to GND.							
33	521917	5	conn X18 pin 17	—	—	High beam right – Current below normal, or open circuit.	The fault is active when current is not detected at conn X18 pin 7. The fault becomes historic when current detected greater than 0.5A.
Action: Set the ignition to "run", headlights to position 2, activate the high beam switch, and check if high beam headlamp is active. If not, turn off the high beams. Measure the voltage at SAM Cab conn X18 pin 17. If BAT voltage is not detected, troubleshoot circuit 21H for an open circuit. Troubleshoot the lamp for continuity.							
33	521920	3	conn X18 pin 20	—	—	Low beam right – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 20 is higher than 8V when the low beams are off. The fault becomes historic when the voltage detected is below 1.2V.
Action: With headlight switch in the OFF position, measure the voltage at SAM Cab conn X18 pin 20. Troubleshoot circuit 21L for a short to BAT if the voltage detected is greater than 8V.							
33	521920	4	conn X18 pin 20	—	—	Low beam right – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 20 is greater than 9.3A. The fault becomes historic when the current detected is below 6.7A.
Action: Turn the headlight switch to the ON 2 position. Measure the voltage at SAM Cab conn X18 pin 20. If BAT voltage is not detected, troubleshoot circuit 21L for a short to GND.							
33	521920	5	conn X18 pin 20	—	—	Low beam right – Current below normal, or open circuit.	The fault is active when current is not detected at conn X18 pin 20. The fault becomes historic when current detected greater than 0.5A.
Action: Set the ignition to "run", headlights to position 2 and check if low beam headlamp is active. If not, turn the headlight switch to the OFF position. Measure the voltage at SAM Cab conn X18 pin 20. If BAT voltage is not detected, troubleshoot circuit 21L for an open circuit. Troubleshoot the lamp for continuity.							
49	520404	3	conn C pin 4	—	—	Stalk switch flash – Voltage above normal or shorted to high source.	The fault is active when the voltage detected at conn C pin 4 at the MSF is high.
Action: Measure the voltage at the MSF conn C pin 4. If the voltage detected is higher than BAT voltage, troubleshoot circuit 465A between MSF conn C pin 4 and stalk switch pin 10 for a short to BAT.							

Table 3, CAN Fault Codes

Headlight System

C04.02

800 — Interlocks

Depending on the parameter configuration, the SAM Cab may consider the following as interlock information:

- If the daytime running lights (DRL) are activated.
- If the Follow Me Home feature has activated the low beam headlights.

See **801 — Parameters** for more details.

801 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
311	001 447 84 58	Headlamps, with no follow me home and no DRL.	PARM-CAB, HDLP, NO CNT	SAM Cab
311	001 447 85 58	Headlamps, with Follow Me Home.	PARM-CAB, HDLP, FMH	SAM Cab
311	001 447 86 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps.	PARM-CAB, HDLP, DRL, TUS	SAM Cab
311	001 447 87 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, with Follow Me Home.	PARM-CAB, HDLP, DRL, TUS, FMH	SAM Cab
311	001 447 88 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps.	PARM-CAB, HDLP, DRL, TUS, MKR	SAM Cab
311	001 447 89 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, with Follow Me Home.	PARM-CAB, HL, DRL, TUS, MKR, FMH	SAM Cab
311	001 447 90 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph.	PARM-CAB, HL, DRL, TUS, 10MPH	SAM Cab
311	001 447 91 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, with Follow Me Home.	PARM-CAB, HL, DRL, TUS, 10MP, FMH	SAM Cab
311	001 447 92 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph.	PARM-CAB, HL, DRL, TUS, MKR, 10MPH	SAM Cab
311	001 447 93 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, with Follow Me Home.	PARM-CAB, HL, DRL, TS, MKR, 10M, FMH	SAM Cab
311	003 447 08 58	Headlamps, 5.2 software only.	PARM-CAB, HDLP, ND, NO CNT	SAM Cab
311	003 447 09 58	Headlamps, with Follow Me Home, 5.2 software only.	PARM-CAB, HDLP, FMH, ND	SAM Cab
311	003 447 10 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, 5.2 software only.	PARM-CAB, HDLP, DRL, TUS, ND	SAM Cab

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Headlight System

Parameters				
Module	Part Number	Description	Parameter	ECU
311	003 447 11 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, with Follow Me Home, 5.2 software only.	PARM-CAB, HDLP, DRL, TUS, FMH, ND	SAM Cab
311	003 447 12 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, 5.2 software only.	PARM-CAB, HDLP, DRL, TUS, MKR, ND	SAM Cab
311	003 447 13 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, with Follow Me Home, 5.2 software only.	PARM-CAB, HL,DRL, TS, MK, FMH, ND	SAM Cab
311	003 447 14 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, 5.2 software only.	PARM-CAB, HL, DRL, TS, 10MPH, ND	SAM Cab
311	003 447 15 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, with Follow Me Home, 5.2 software only.	PARM-CAB, HL, DRL, TS, 10M, FMH, ND	SAM Cab
311	003 447 16 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, 5.2 software only.	PARM-CAB, HL, DRL, TS, MK, 10M, ND	SAM Cab
311	003 447 17 58	Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, with Follow Me Home, 5.2 software only.	PARM-CAB, HL, DRL10, TS, MK, FMH, ND	SAM Cab
311	000 447 80 23	Vehicle is equipped with DRL override switch, ID062, multiplexed sub bus switch.	PARM-MSF, MUX, DRL OVERRIDE	MSF
311	000 447 81 23	Vehicle is not equipped with DRL override switch, ID062, multiplexed sub bus switch.	PARM-MSF, MUX, DRL OVERRIDE, NC	MSF

Table 4, Parameters

Daytime Running Lights

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Daytime Running Lights

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

ECU—Electronic Control Unit, typically connected to a datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

Daytime Running Lights (DRL) are external lights that automatically activate to indicate that the vehicle is in use.

The lamps used for DRL are set by parameter. DRL can be any of the following configurations, depending on vehicle parameter settings:

A function of certain existing exterior lighting lamps serving a dual purpose. The pinouts for these lamps can be found in the applicable subject in section **C04 — Exterior Lighting**. Possible lamps include front corner turn signal lamps.

In order for the SAM modules to activate the lamps for DRL, several conditions need to be met. Activation of the DRL function is based on various parameter settings. Refer to **800 — Inputs and Interlocks** for inputs and interlocks that activate DRL. Refer to **C04.02 — Headlight System** for parameters related to DRL functionality.

If front corner turn signal lamps are used for DRL, they will be continuously illuminated until the driver activates the turn signals. When either the left or right turn signal is activated, the corresponding front corner turn signal

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Daytime Running Lights

lamp will flash according to the turn signal function. The front corner turn signal lamp on the opposite side remains illuminated according to the DRL function. When the hazard light switch is activated, both front corner turn signal lamps flash according to the hazard lights function. The hazard lights function takes precedence over the DRL function. See **Fig. 1**.

Refer to **C04.04 — Stop, Turn, and Hazard Lights** for more information.

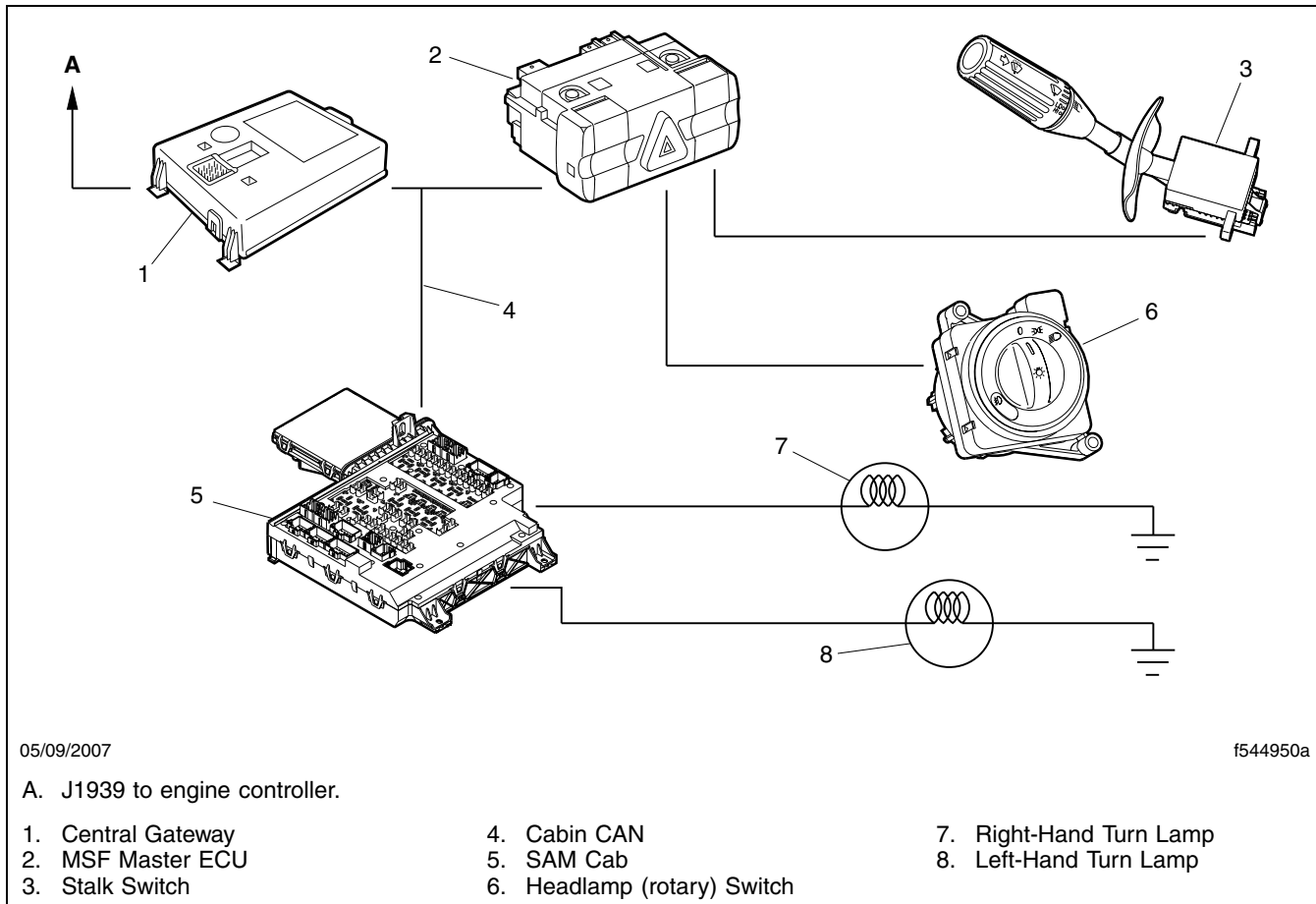


Fig. 1, System Diagram for Daytime Running Lights using Turn Lamps

The DRL feature is controlled by the headlamp switch, also called the rotary switch. The headlamp switch must be in the off position in order for the daytime running lights to activate. The headlamp switch is directly connected to the Modular Switch Field (MSF).

The headlamp switch has the following positions:

- Headlamp Switch Position 0: Headlamp switch is off. If interlocks are met, daytime running lights are activated.
- Headlamp Switch Position 1: DRL functionality is deactivated. Marker, clearance, tail, and license plate lamps are activated.

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- Headlamp Switch Position 2: DRL functionality remains deactivated. All lamps listed for position 1, as well as low-beam and high-beam headlights (depending on the position of the stalk switch), are activated.

The MSF monitors the headlamp (rotary) switch, and broadcasts its state to the SAM Cab via a message on the Cabin CAN datalink.

In addition to the headlamp switch being in position 0 (or in the off position), the DRL feature will not activate until the engine is running at 400 rpm or higher, or the parking brake is released.

The vehicle may be configured for a DRL override switch. In this case, the operator can deactivate (override) the DRL by pressing the DRL override switch. The switch would be connected to the MSF via the sub bus. The MSF monitors this switch and broadcasts its state to the SAM Cab via a message on the Cabin CAN datalink. See **G02.06 — Modular Switch Field** for more information on the MSF system.

If DRL is activated, the high beam lamps can still be used to perform flash-to-pass.

If DRL is activated, a slight delay of approximately 0.5 seconds may occur when the headlamp switch is turned from the OFF position (headlamp switch position 0) to either headlamp switch position 1 or 2. This delay is normal. The purpose of the delay is to help extend the life cycle of the headlights.

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Daytime Running Lights

502 — Vehicle Network Topology

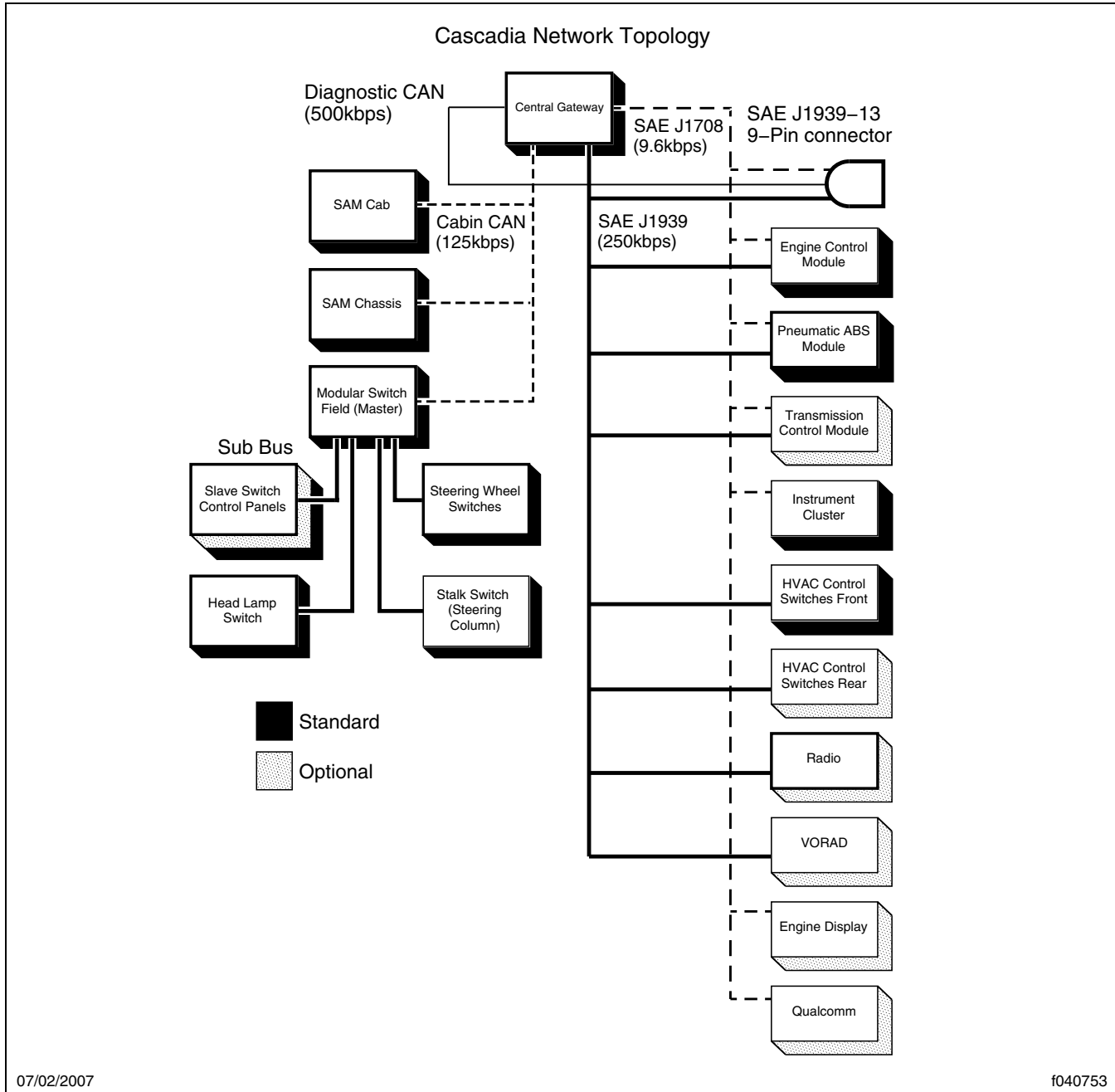


Fig. 2, Vehicle Network Topology

503 — Related Subjects

- G02.02 — Datalink Communication Structure
- G02.04 — SAM Cab
- G02.05 — SAM Chassis
- G03.03 — Datalink, Cabin CAN
- G03.04 — Datalink, Diagnostic CAN
- C04.01 — Lighting System Overview
- C04.02 — Headlight System
- C04.04 — Stop, Turn, and Hazard Lights
- C04.05 — Tail and Marker Lights

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Daytime Running Lights

600 — Component Locations

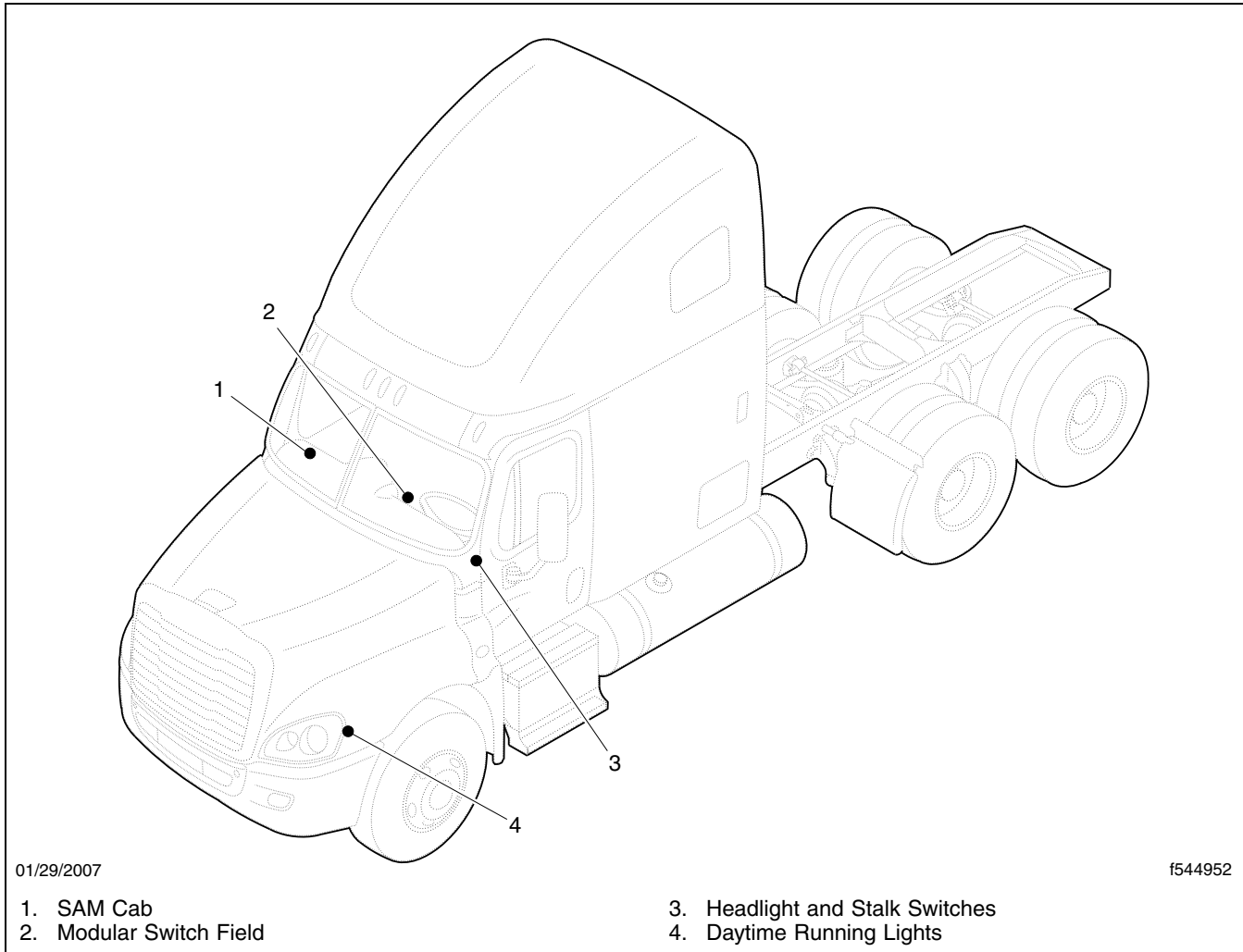


Fig. 3, Component Locations

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601 — Component Details

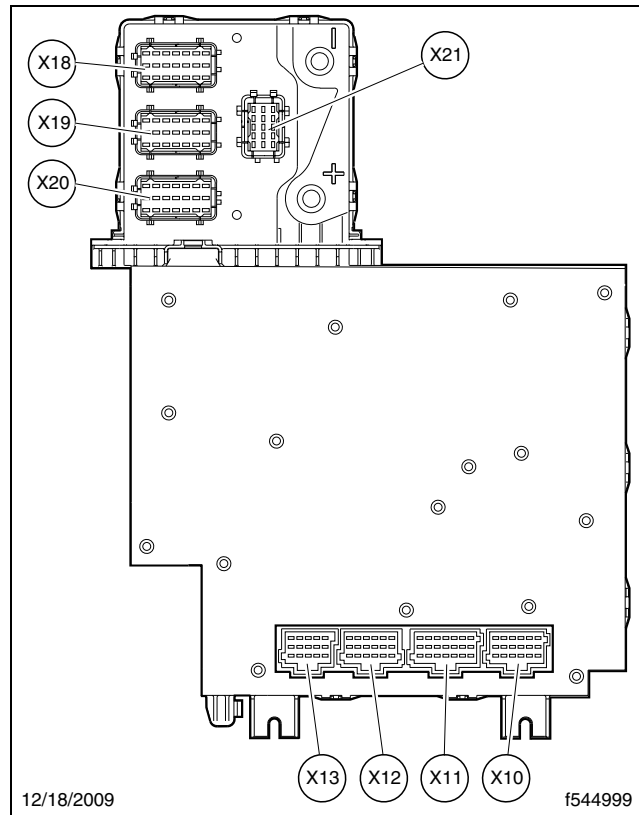


Fig. 4, SAM Cab Pin Locations (bottom)

SAM Cab Pinout Locations		
Connector	Pin	Description
X18	15	DRL, right
X18	18	DRL, left

Table 1, SAM Cab Pinout Locations

700 — Troubleshooting Overview

NOTE: For daytime running lights configured to use existing lamps (high beam headlights, for example), refer to the applicable subject for more information. For example, if high/low-beam headlights are used for DRL functionality, see **C04.02 — Headlight System** for pinout information.

The protocol used for troubleshooting or configuring the SAM Cab, the MSF, and connected switches is CAN, via the Diagnostic CAN datalink pins in the 9-pin diagnostic connector. For more information on the Diagnostic CAN datalink, see subject **G03.04 — Datalink, Diagnostic CAN**.

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Daytime Running Lights

701 — CAN Fault Codes

CAN Fault Codes					
SA	SPN	FMI	Fault Description	Fault Trigger	Vehicle Behavior
33	521918	4	DRL, voltage below normal, or shorted to low source.	DRL pins (separate DRL) are detected to be shorted to ground or low source.	One or more of the DRL lamps are off. Check wiring harness.

Table 2, CAN Fault Codes

NOTE: For CAN faults associated with the headlamp (rotary) switch, or DRL override switch, you can also see the fault code list in **G02.06 — Modular Switch Field**.

702 — Possible Causes

- wiring (including switches, and lighting components, such as bulbs)
- SAM Cab
- Modular Switch Field, Master ECU

800 — Inputs and Interlocks

Switches

- Headlamp Switch
- DRL Override Switch (optional)

Interlocks

- Engine is running at 400 rpm, or greater
- Parking brake is released
- Refer to DRL-related parameters in subject **C04.02 — Headlight System** for more interlock information. An example of an additional parameter-based interlock is wheel-based vehicle speed, when vehicle parameters are configured to use a DRL cut-out speed.

Pins

There are no input pins for this feature.

Datalink Messages

Depending on vehicle parameters, certain datalink messages may be used as inputs or interlocks for the DRL feature. See **Table 3** for a list of possible datalink messages.

NOTE: DRL Parameters are listed in **C04.02 — Headlight System**.

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Possible Datalink Messages				
Message	Datalink	From	To	Description
DRL Override Request	Cabin CAN	MSF	SAM Cab	Indicates that the operator has pressed the DRL override switch.
Headlight Switch Request	Cabin CAN	MSF	SAM Cab	Indicates the state of the headlamp (rotary) switch.
Wheel Based Vehicle Speed	J1939, Cabin CAN	Engine Controller	SAM Cab	Current wheel-based vehicle speed, used when DRL is configured to use cutout speed.
Engine RPM	J1939, Cabin CAN	Engine Controller	SAM Cab	Engine RPM, used as an interlock.

Table 3, Possible Datalink Messages

801 — Outputs

Pins

For the pin-out locations when the DRL lamps are configured for dual purpose lamps (front turn signal lamps, for example), either:

- Refer to **G02.04 — SAM Cab** for specific pin-out locations
- Refer to the specific pin-outs by component:
 - **C04.02 — Headlight System**
 - **C04.04 — Stop, Turn, and Hazard Lights**
 - **C04.05 — Tail and Marker Lights**

802 — Parameters

In order for the daytime running lights to be activated, several conditions may need to be met based on parameter settings. Refer to subject **C04.02 — Headlight System** for all parameters related to the daytime running lights.

Stop, Turn, and Hazard Lights

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Stop, Turn, and Hazard Lights

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — Stop Lamps

The stop lamps are actuated by the SAM Chassis when service brakes are applied. The lamps are located in the back of the chassis, and indicate that the vehicle is decelerating. The vehicle uses either the same lamp for the combo stop/turn signal, or it can use separate lamps.

The stop lamp lighting configuration for combo stop/rear-turn-signal or separate stop/rear-turn-signal is controlled by parameter. The stop lamp request input may be either a message from the Datalink to the SAM Chassis or a hardwired service brake switch input to the SAM Cab.

Activation of the stop lamps influences the following features:

- trailer lighting
- turn signals (if the combo stop/rear-turn-signal option is present)
- hazard lights (if the combo stop/rear-turn-signal option is present)

Activation of the stop lamps is influenced by the following features:

- service brake switch
- turn signals (if the combo stop/rear-turn-signal signal option is present)
- hazard lights (if the combo stop/rear-turn-signal option is present)

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Stop, Turn, and Hazard Lights

502 — Turn Signal

Input from the stalk switch to the MSF Master is sent on Datalink to the SAM Cab. The SAM Cab actuates the corresponding front left or right turn signal lamps. The SAM Cab sends a command message on Datalink to the SAM Chassis to actuate corresponding rear left or right turn signal lamps.

Activation of the turn signals influences the following features:

- hazard lights
- daytime running lights
- stop lamp (brake lights)

Activation of the turn signals is influenced by the following features:

- hazard, turn signal, and stop lamps
- daytime running lights

503 — Hazard Lights

Hazard lights consist of both turn signal lamps, used to warn other drivers that the vehicle may be a traffic hazard. The MSF input is sent on Datalink to the SAM Cab to flash the turn signal lamps and turn signal indicator lamps in the ICU.

Hazard Request is fulfilled when the hazard switch is requested by MSF Master.

Activation of hazard lights influences the following features:

- trailer lighting
- daytime running lights
- turn signals
- stop lamps (if the combo stop/rear turn signal option is present)

Activation of the hazard lights is influenced by the following features:

- Turn signals
- Stop lamps (if the combo stop/rear-turn-signal option is present)

Stop, Turn, and Hazard Lights

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600 — Component Locations

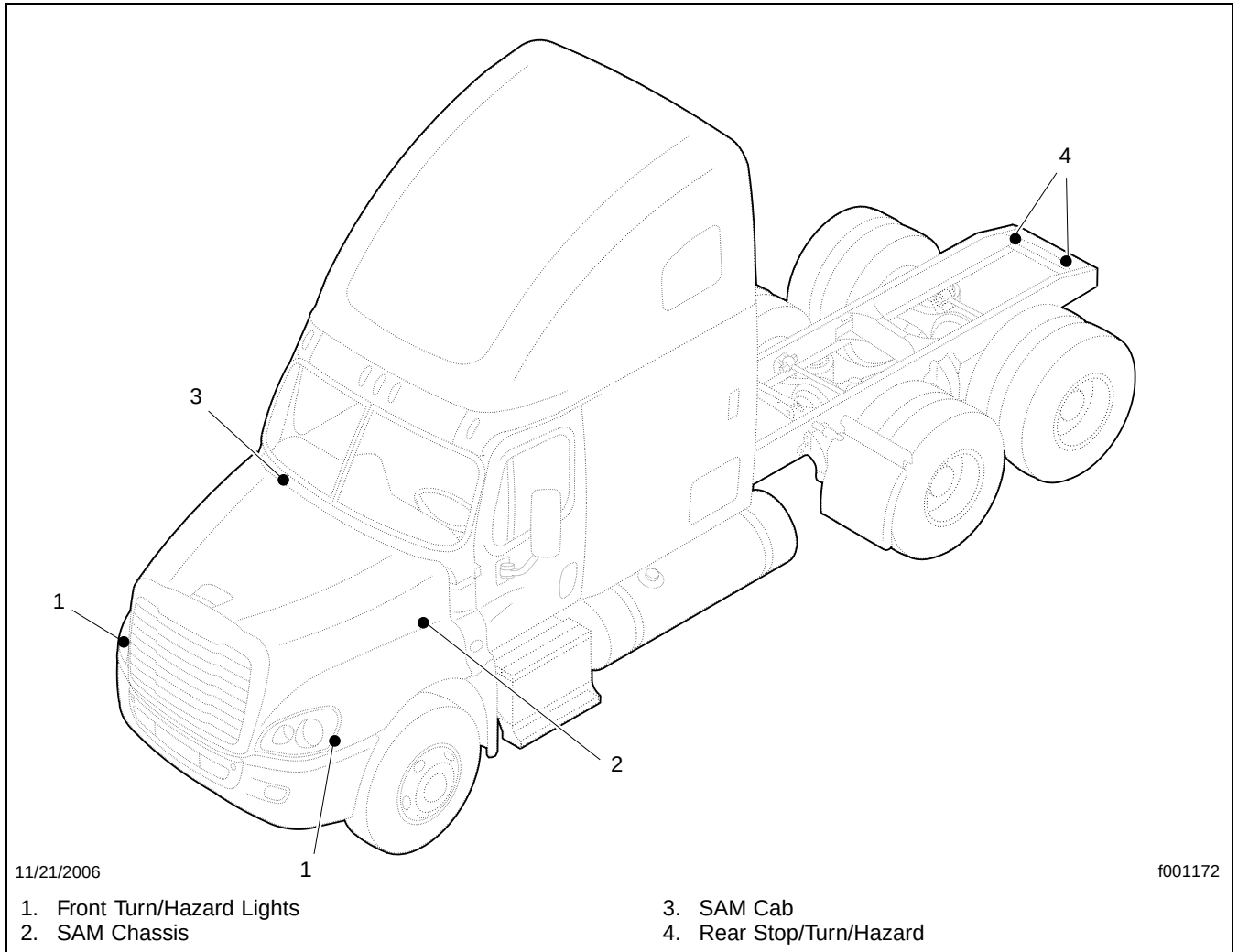


Fig. 1, Component Locations

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Stop, Turn, and Hazard Lights

601 — Component Details

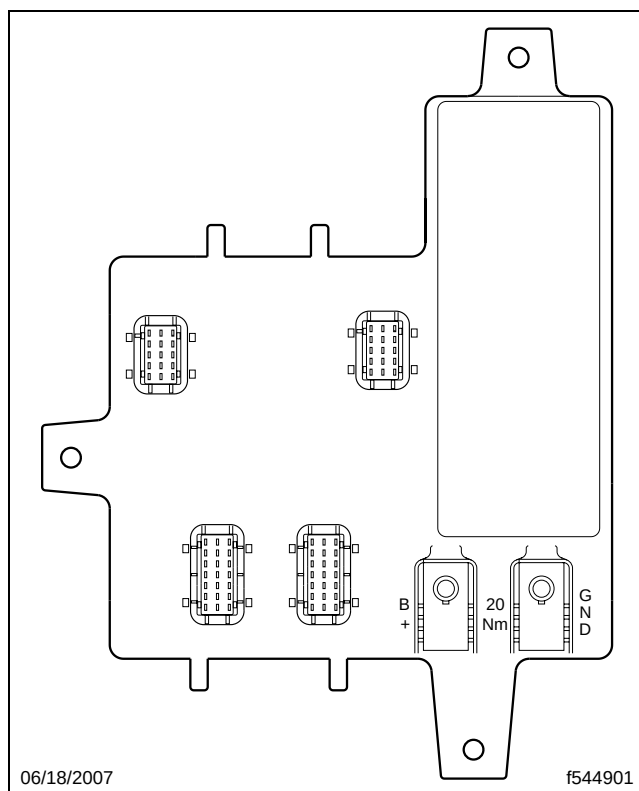


Fig. 2, SAM Chassis

SAM Chassis Connector, X58			
Function	Connector	Pin	Circuit
Turn Right, Rear	X58	1	38H
Turn Left, Rear	X58	10	38G
Tail Lamp, Right	X58	3	23H
Tail Lamp, Left	X58	18	23G
Stop Lamp, Right	X58	20	39R
Stop Lamp, Left	X58	21	39L
Tail Lamp, Right, GND	X58	5	GND
Tail Lamp, Left, GND	X58	8	GND1

Table 1, SAM Chassis Connector, X58

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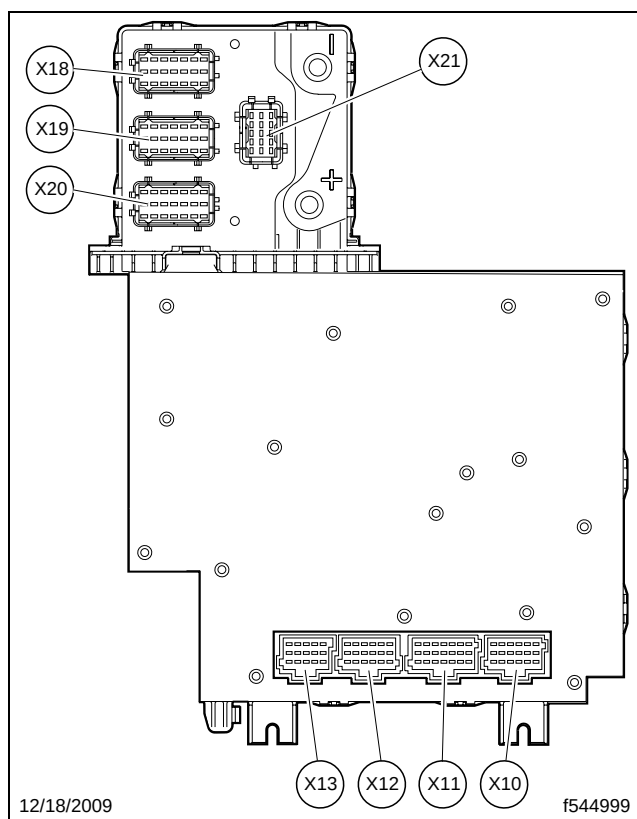


Fig. 3, SAM Cab Connectors (top view)

SAM Cab Connector X18, X20, X21			
Function	Connector	Pin	Circuit
Turn/Marker Side Left GND	X18	1	GND
Turn/Marker Side Right GND	X18	10	GND
Turn Corner Front Right	X18	9	38RC
Turn/Marker Corner Front Right GND	X18	4	GND
Turn Corner Front Left	X18	19	38LC
Turn/Marker Corner Front Left GND	X18	13	GND
Turn Right Side Lamp	X20	15	38F
Turn Left Side Lamp	X21	11	38E

Table 2, SAM Cab Connector X18, X20, X21

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Stop, Turn, and Hazard Lights

SAM Cab Connector X13, X10			
Function	Connector	Pin	Circuit
Service Brake Pressure Switch	X13	12	36R
Service Brake Pressure SW, BAT	X10	7	36

Table 3, SAM Cab Connector X13, X10

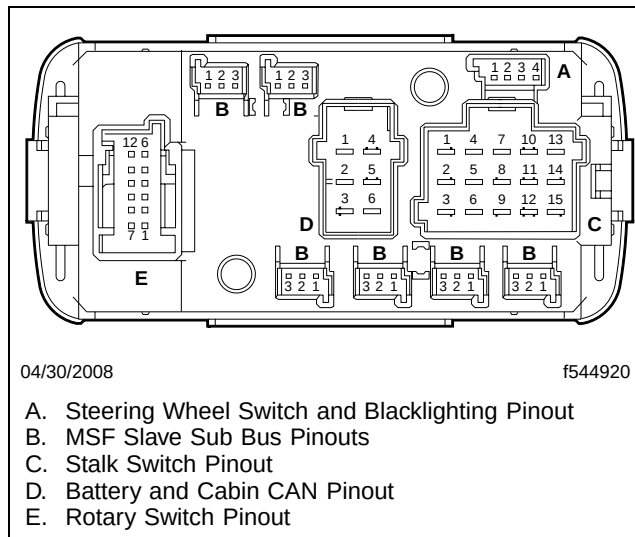


Fig. 4, MSF Master Connection Locations

Steering Column Stalk Switch		
Function	Pin	Circuit
Turn Signal Supply Voltage	1	38A
Left Turn Signal	2	38C
Right Turn Signal	3	38D

Table 4, Steering Column Stalk Switch

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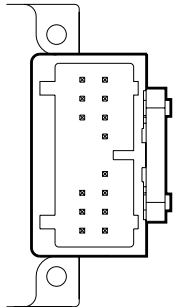
Stalk Switch Connector C		
		
Function	Pin	Circuit
Left Turn	12	38C
Turn Signal Common	13	38A
Right Turn	14	38D

Table 5, Stalk Switch Connector C

700 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor Template – Stop Turn Hazard Lamps
- Digital Multimeter

701 — CAN Fault Codes

NOTE: **Table 6** lists faults for the following ECUs:

- 33 – SAM Cab
- 37 – Central Gateway (CGW)
- 49 – Modular Switch Field (MSF)
- 71 – SAM Chassis

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

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Stop, Turn, and Hazard Lights

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521315	3	conn X21, pin 11 conn X12, pin 15	—	—	Turn, Left, front side – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at SAM Cab conn X21 pin 11 and conn X12 pin 15 is higher than 4.5V when the left turn signal lights are off. The fault becomes historic when the voltage detected is below 1.5V. Vehicle behavior: The left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at SAM Cab conn X21 pin 11. If the voltage detected is greater than 4.5V, troubleshoot circuit 38E for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521315	4	conn X21, pin 11 conn X12, pin 15	—	—	Turn, Left, front side – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X21 pin 11 and conn X12 pin 15 is lower than 3.5A when the front left turn signal is on. The fault becomes historic when the current detected is less than 2.8A. Vehicle behavior: left turn signal lights are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at SAM Cab conn X21 pin 11 and conn X12 pin 15. If the voltage detected is less than BAT voltage, troubleshoot circuit 38E for a short to GND and open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521318	3	conn X12, pin 18 conn X20, pin 15	—	—	Turn, Right, front side – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at SAM Cab conn X12 pin 18 and conn X20 pin 15 is higher than 4.5V when the left turn signals are off. The fault becomes historic when the voltage detected is below 1.5V. Vehicle behavior: right turn signal lights are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at SAM Cab conn X20 pin 15. If the voltage detected is greater than 4.5V, troubleshoot circuit 38F for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521318	4	conn X12, pin 18 conn X20, pin 15	—	—	Turn, Right, front side – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X20 pin 18 and conn X12 pin 18 is lower than 3.5A when the front left turn signal is on. The fault becomes historic when the current detected is less than 2.8A. Vehicle behavior: right turn signal lights are flashing at twice the normal frequency when the ignition key is in the "run" position.

Stop, Turn, and Hazard Lights

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
Action: Disconnect the batteries and measure the voltage at SAM Cab conn X20 pin 15. If the voltage detected is less than BAT voltage, troubleshoot circuit 38F for a short to GND or open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521107	3	conn X10 pin 7	—	—	Service brake pressure switch – Voltage above normal, or shorted to high source.	conn X10 pin 7 is the chopped supply, and conn X13 pin 12 is the return (destination of the chopped supply). This fault indicates that a DC voltage is present due to a shorted high to a DC source. Vehicle behavior: stop lights are active due to a fail-safe reaction when the ignition key is in the "run" position.
Action: Remove the wire from SAM Cab conn X10 pin 7. Test for DC voltage with a DMM on the removed wire, and trace the problem back to the DC source. Refer to G02.04 — SAM Cab, 709 — Unfused Constant Outputs for a generic troubleshooting procedure for that pin type.							
33	521107	4	conn X10 pin 7	—	—	Service brake pressure switch – Voltage below normal, or shorted to low source.	conn X10 pin 7 is the chopped supply, and conn X13 pin 12 is the return (destination of the chopped supply). This fault indicates that the chopped supply is being shorted to a low source or to ground. Vehicle behavior: stop lights are active due to a fail-safe reaction when the ignition key is in the "run" position.
Action: Disconnect SAM Cab conn X10 and conn X13 from the ECU. Test conn X10 pin 7 for a short circuit to ground using an ohm meter. Refer to G02.04 — SAM Cab, 709 — Unfused Constant Outputs for a generic troubleshooting procedure for that pin type.							
33	521909	3	conn X18 pin 9	—	—	Turn, Right, front corner – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 9 is greater than 4.5V when the right turn signal is off. The fault becomes historic when the voltage detected is less than 1.5V. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X18 pin 9. If the voltage detected is greater than 4.5V, troubleshoot circuit 38RC for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521909	4	conn X18 pin 9	—	—	Turn, Right, front corner – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 9 is greater than 4.2A. The fault becomes historic when the current detected is less than 3.3A. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.

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Stop, Turn, and Hazard Lights

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
Action: Turn on the right front corner light. Measure the voltage at conn X18 pin 9. If the voltage detected is less than BAT voltage, troubleshoot circuit 38RC for a short to GND. Check the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521909	5	conn X18 pin 9	—	—	Turn, Right, front corner – Current below normal, or open circuit.	The fault is active when an open circuit between conn X18 pin 9 and ground has been detected. The fault becomes historic when continuity in the circuit is established. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Troubleshoot circuit 38RC and GND between the SAM Cab and the lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521919	3	conn X18 pin 19	—	—	Turn, Left, front corner – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18 pin 19 is greater than 4.5V when the right turn signal is off. The fault becomes historic when the voltage detected is less than 1.5V. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X18 pin 19. If the voltage detected is greater than 4.5V, troubleshoot circuit 38LC for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521919	4	conn X18 pin 19	—	—	Turn, Left, front corner – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X18 pin 19 is greater than 4.2A. The fault becomes historic when the current detected is less than 3.3A. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Turn on the right front corner light. Measure the voltage at conn X18 pin 19. If the voltage detected is less than BAT voltage, troubleshoot circuit 38LC for a short to GND. Check the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521919	5	conn X18 pin 19	—	—	Turn, Left, front corner – Current below normal, or open circuit.	The fault is active when an open circuit between conn X18 pin 19 and ground has been detected. The fault becomes historic when continuity in the circuit is established. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Troubleshoot circuit 38LC and GND between the SAM Cab and the lower left turn lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521211	4	conn X11 pin 11	—	—	Turn signal, Left, ICU indicator – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X11 pin 11 is above 2A when the left turn signal is on. The fault becomes historic when the current detected is less than 0.2A.
Action: Turn the left turn signal on. Measure the voltage at conn X11 pin 11. If BAT voltage is not detected, troubleshoot circuit 38J for a short to GND. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521213	4	conn X11 pin 13	—	—	Turn signal, Right, ICU indicator – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X11 pin 13 is above 2A when the right turn signal is on. The fault becomes historic when the current detected is less than 0.2A.
Action: Turn the right turn signal on. Measure the voltage at conn X11 pin 13. If BAT voltage is not detected, troubleshoot circuit 38K for a short to GND. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520901	3	conn X58 pin 1	—	—	Turn, Right, rear lower – Voltage above normal, or shorted to high source.	The tail lamps are currently off. The fault is active when the voltage detected at conn X58 pin 3 is greater than 8.1V. The fault becomes historic when the voltage detected is less than 6.8V.
Action: Disconnect the batteries and measure the voltage at conn X58 pin 3. If the voltage detected is greater than 8.1V, troubleshoot circuit 23H for a short to BAT. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520901	4	conn X58 pin 1	—	—	Turn, Right, rear lower – Voltage below normal, or shorted to low source.	The fault is active when the right tail lamps are on and the current detected is greater than 14.5A. The fault becomes historic when the current detected is less than 1.8A.
Action: Disconnect the batteries and measure the voltage at conn X58 pin 3. If the the voltage detected is not BAT voltage, troubleshoot circuit 23H for a short to GND. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520901	5	conn X58 pin 1	—	—	Turn, Right, rear lower – Current below normal, or open circuit.	An open circuit has been detected at conn X58 pin 3.
Action: Troubleshoot circuit 23H between the SAM Chassis and GND to the right tail lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520910	3	conn X58 pin 10	—	—	Turn, Left, rear lower – Voltage above normal, or shorted to high source.	The voltage detected on conn X58 pin 12 is higher than 4.2V. The fault becomes historic when the voltage detected is lower than 1.5V.
Action: Disconnect the batteries and measure the voltage at conn X58 pin 12. Troubleshoot circuit 23C for a short to BAT. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520910	4	conn X58 pin 10	—	—	Turn, Left, rear lower – Voltage below normal, or shorted to low source.	The license plate light is not functioning when the headlight switch is turned on.

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Stop, Turn, and Hazard Lights

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
Action: Disconnect the batteries and measure the voltage at conn X58 pin 12. If BAT voltage is not detected, troubleshoot circuit 23C for a short to GND. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520910	5	conn X58 pin 10	—	—	Turn, Left, rear lower – Current below normal, or open circuit.	An open circuit has been detected on conn X58 pin 12.
Action: Remove connector conn X58 pin 12. Troubleshoot circuit and GND between the SAM Chassis and license plate lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520920	3	conn X58 pin 20	—	—	Stop lamp, right – Voltage above normal, or shorted to high source.	The vehicle will be equipped with combination stop and turn signal lights. The fault is active when the voltage detected at conn X58 pin 20 is greater than 8.1V when the rear right stop lamp is off. The fault becomes historic when the voltage detected is less than 6.8V. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X58 pin 20. If the voltage detected is greater than 8.1V, troubleshoot circuit 39R for a short to BAT. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520920	4	conn X58 pin 20	—	—	Stop lamp, right – Voltage below normal, or shorted to low source.	The vehicle is equipped with combination stop and turn signal lights. The fault is active when the right stop lamps are on and the current detected at conn X58 pin 20 is greater than 35A. The fault becomes historic when the current detected is less than 3.9A. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at SAM Chassis conn X58 pin 20. If BAT voltage is not detected, troubleshoot circuit 39R for a short to GND. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520920	5	conn X58 pin 20	—	—	Stop lamp, right – Current below normal, or open circuit.	The vehicle is equipped with combination stop and turn signal lights. The fault is active when the right stop lamp is off and there is an open circuit detected at conn X58 pin 20. Vehicle behavior: right turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
Action: Troubleshoot circuit 39R and GND between the SAM Chassis and right stop lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520921	3	conn X58 pin 21	—	—	Stop lamp, left – Voltage above normal, or shorted to high source.	The vehicle will be equipped with combination stop and turn signal lights. The fault is active when the voltage detected at conn X58 pin 21 is greater than 8.1V when the rear left stop lamp is off. The fault becomes historic when the voltage detected is less than 6.8V. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at conn X58 pin 21. If the voltage detected is greater than 8.1V, troubleshoot circuit 39L for a short to BAT. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520921	4	conn X58 pin 21	—	—	Stop lamp, left – Voltage below normal, or shorted to low source.	The vehicle is equipped with combination stop and turn signal lights. The fault is active when the left stop lamps are on and current detected at conn X58 pin 21 is greater than 35A. The fault becomes historic when the current detected is less than 3.9A. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Disconnect the batteries and measure the voltage at SAM Chassis conn X58 pin 21. If BAT voltage is not detected, troubleshoot circuit 39L for a short to GND. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
71	520921	5	conn X58 pin 21	—	—	Stop lamp, left – Current below normal, or open circuit.	The vehicle is equipped with combination stop and turn signal lights. The fault is active when the left stop lamp is off and there is an open circuit detected at conn X58 pin 21. Vehicle behavior: left turn signals are flashing at twice the normal frequency when the ignition key is in the "run" position.
Action: Troubleshoot circuit 39L and GND1 between the SAM Chassis and left stop lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.05 — SAM Chassis, 706 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

Table 6, CAN Fault Codes

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Stop, Turn, and Hazard Lights

702 — Input Troubleshooting

Service Brake Switch

NOTE: The service brake switch supply voltage is a chopped signal with 20% duty cycle. When measuring the switch supply from the SAM Cab, measure the duty cycle. Refer to the applicable G06 drawing in module 877 for wiring information.

1. **Jump the two terminals to the brake switch to bypass the switch.**

1.1 Disconnect the two terminals on the brake switch.

1.2 Insert a jumper wire from terminal A to terminal B at the brake switch wires.

Did the stop lights turn on after the brake switch was bypassed?

YES → The brake switch is likely the problem; replace the switch.

NO → Go to test 2.

2. **Measure the service brake switch supply duty cycle at the switch.**

2.1 Disconnect the two terminals on the brake switch.

2.2 Measure the duty cycle at the supply side to the switch.

Is there 20% duty cycle at the service brake supply?

YES → Go to test 3.

NO → Access the SAM Cab, and measure the chopped signal duty cycle at connector X10 pin 7. Also inspect pin 7 ensuring proper seating in the connector. Check for bent pins, corrosion, or other types of damage to this connector/terminal. Check for continuity in the brake switch harness from the SAM Cab connector, repair as needed. If the chopped signal is not available at pin X10.7, and no other damage was found to that connector/pin, then refer to **G02.04 — SAM Cab** for more information about this ECU.

3. **Measure duty cycle of the service brake switch return to the SAM Cab with the service brake applied.**

3.1 Reconnect the terminals to the service brake switch that were removed in the previous step.

3.2 Disconnect the SAM Cab connector X13.

3.3 Measure duty cycle at connector/terminal X13.12 with the service brake applied.

Is there 20% duty cycle at the SAM Cab connector/terminal X13.12 with the service brake applied?

YES → The service brake switch circuit is intact and functioning normally. If there is no damage to the SAM Cab pin X13.12, then the problem is likely with the output side of the service brake system.

NO → The problem is likely in the harness between the service brake switch and the SAM Cab terminal X13.12. Repair as necessary.

Stalk Switch, Turn Signals

1. **Measure for continuity in the turn signal input circuit between the stalk switch and the MSF.**

1.1 Pull the MSF from the dash to expose the connector side.

1.2 Remove connector C from the MSF.

1.3 Put the stalk switch in the left or right turn position.

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- 1.4 Measure for continuity between the common terminal on the MSF, C.1 and the appropriate left or right turn signal input terminals C.2/C.3.

- Left Turn: Pins 1 to 2
- Right Turn: Pins 1 to 3

Is there continuity between the turn signal MSF connector, terminal C.2/C.3, and the common terminal C.1 with the stalk switch turned to the appropriate left or right turn position?

YES → The turn signal input to the MSF is normal. The problem may be with the output side of the turn signal system.

NO → Go to test 2.

2. **Remove the stalk switch and repeat the continuity checks directly at the stalk switch.**

- 2.1 Remove the steering wheel cover to access the stalk switch.
- 2.2 Remove the stalk switch and the connector.
- 2.3 Turn the stalk switch to the left or right turn position.
- 2.4 Measure continuity between the appropriate stalk switch pins.
 - Left Turn: Pins 13 to 12
 - Right Turn: Pins 13 to 14

Is there continuity on both the left and right turn positions when measured directly at the stalk switch?

YES → The stalk switch is good. The problem is likely in the harness between the stalk switch, and the MSF connector C. Troubleshoot this harness and repair as needed.

NO → The stalk switch is likely the problem. Replace the stalk switch.

Hazard Switch

The hazard switch is an integrated part of the MSF controller. There are no serviceable parts to the MSF controller aside from the two flanking switches. If the hazard switch fails a simple functional check, the MSF controller needs to be replaced. See **G02.06 — Modular Switch Field** for more information.

703 — Output Troubleshooting

Stop Lights

A common cause of the stop lights not functioning is that the SAM Chassis parameter for combination or separate stop/turn lights is set incorrectly. Use ServiceLink to verify that the correct parameter is set for the SAM Chassis. Continue troubleshooting if necessary.

NOTE: For vehicles with combination stop/turn lights, refer the "Rear Turn Lights" troubleshooting section.

1. **Check for continuity in the affected stop lamp circuit. Check both sides, if necessary.**

- 1.1 Disconnect SAM Chassis connector X58.
- 1.2 Measure for continuity in the appropriate left/right (or both) stop lamp circuit:
 - Left Stop Lamp: X58.21 to X58.8

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- Right Stop Lamp: X58.20 to X58.5

Is there an open circuit in the affected left and/or right stop lamp output circuit?

YES → Go to test 2.

NO → Go to test 3.

2. Isolate the open circuit.

- 2.1 Disconnect SAM Chassis connector X58.
- 2.2 Disconnect the affected left and/or right stop/tail lamp connector.
- 2.3 Measure resistance in the harness:
 - X58.21 to terminal C of the left tail lamp for circuit 36L
 - X58.8 to terminal E of the tail lamp for circuit GND1
 - X58.20 to terminal C of the right tail lamp for circuit 36R
 - X58.5 to terminal E of the right tail lamp for circuit GND

Is there low resistance in the circuits tested?

YES → Install the tail lamp connectors on both the tail lamp(s), and on the SAM Chassis. Perform a functional test of the stop lamps to determine if the problem is intermittent. If the problem still exists, go back to the "Stop Turn Hazard Datalink Monitor" template and evaluate the stop lamp functionality.

NO → Repair the harness with the affected circuit or replace the bulb.

3. Determine if a short exists in the stop lamp circuitry.

NOTE: A short condition for the stop lamp circuit occurs when greater than 9.5 amps are detected by the SAM Chassis stop lamp circuitry.

- 3.1 Disconnect the stop/tail lamp connector at the rear of the vehicle.
- 3.2 Measure for continuity between terminal C and ground.

Is there continuity between terminal C of the stop/tail lamp connector, and ground?

YES → There is a short in this harness. Isolate the short, and repair/replace the affected harness.

NO → The problem may be intermittent. Install the tail lamp connectors and attempt to recreate the problem. Continue troubleshooting as needed.

Rear Turn Lights

1. Check for continuity in the affected turn lamp circuit.

- 1.1 Disconnect the SAM Chassis connector X58.
- 1.2 Measure for continuity in the appropriate left/right (or both) turn lamp circuit:
 - Left turn Lamp: X58.10 to X58.8
 - Right turn Lamp: X58.1 to X58.5

Is there an open circuit in the affected left and/or right turn lamp output circuit?

YES → Go to test 2.

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NO → Go to test 3.

2. Isolate the open circuit.

2.1 Disconnect the SAM Chassis connector X58.

2.2 Disconnect the affected left and/or right tail lamp connector.

2.3 Measure resistance in the harness:

- X58.21 to terminal B of the left tail lamp for circuit 39L
- X58.8 to terminal E of the tail lamp for circuit GND1
- X58.20 to terminal B of the right tail lamp for circuit 39R
- X58.5 to terminal E of the right tail lamp for circuit GND

Is there low resistance in the circuits tested?

YES → Install the tail lamp connectors on both the tail lamp(s), and on the SAM Chassis. Perform a functional test of the stop lamps to determine if the problem is intermittent. If the problem still exists, go back to the "Stop Turn Hazard Datalink Monitor" template and evaluate the rear turn lamp(s) functionality.

NO → Repair the harness with the affected circuit or replace the bulb.

3. Determine if a short exists in the rear turn lamp circuitry.

NOTE: A short condition for the rear turn lamp circuit occurs when greater than 9.5 amps are detected by the SAM Chassis turn lamp circuitry.

3.1 Disconnect the tail lamp connector at the rear of the vehicle.

3.2 Measure for continuity between terminal C and ground.

Is there continuity between terminal C of the tail lamp connector, and ground?

YES → There is a short in this harness. Isolate the short, and repair/replace the affected harness.

NO → The problem may be intermittent. Install the tail lamp connectors and attempt to recreate the problem. Continue troubleshooting as needed.

Front and Side Turn Light

1. Check for continuity in the affected front/side turn lamp circuit.

1.1 Disconnect the SAM Cab connector X18, X20, and/or X21.

1.2 Measure for continuity in the appropriate left/right (or both) turn lamp circuit:

- Turn left front corner lamp: X18.19 to X18.7
- Turn right front corner lamp: X18.9 to X18.2
- Turn left front side lamp: X21.11 to X18.1
- Turn right front side lamp: X20.15 to X18.10

Is there an open circuit in the affected left and/or right turn lamp output circuit(s)?

YES → Go to test 2.

NO → Go to test 3.

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2. Isolate the open circuit.

- 2.1 Disconnect the SAM Cab connector(s) X18, X20, and/or X21.
- 2.2 Disconnect the affected left and/or right turn lamp connector(s).
- 2.3 Measure resistance in the harness:
 - X18.19 to terminal C of the turn left front corner lamp for circuit 38LC
 - X18.7 to terminal A of the turn left front corner lamp for circuit GND
 - X18.9 to terminal C of the turn right front corner lamp for circuit 38RC
 - X18.2 to terminal A of the turn right front corner lamp for circuit GND
 - X21.11 to terminal 3 of the turn left side lamp for circuit 38E
 - X18.1 to terminal 1 of the turn left side lamp for circuit GND
 - X20.15 to terminal 3 of the turn right side lamp for circuit 38F
 - X18.10 to terminal 1 of the turn right side lamp for circuit GND

Is there low resistance in the circuits tested?

YES → Install the turn lamp connectors and the SAM Cab connectors. Perform a functional test of the affected turn lamp(s) to determine if the problem is intermittent. If the problem still exists, go back to the "Stop Turn Hazard Datalink Monitor" template and evaluate the turn lamp(s) functionality.

NO → Repair the harness with the affected circuit or replace the bulb.

3. Determine if a short exists in the turn lamp circuitry.

NOTE: A short condition for the turn lamp circuit occurs when greater than 3.5-4.2 amps are detected by the SAM Cab turn lamp circuitry.

- 3.1 Disconnect the turn lamp connector at the affected output.
- 3.2 Measure for continuity between the output source (either terminal C or 3) and ground.

Is there continuity between terminal C or 3 of the turn lamp connector, and ground?

YES → There is a short in this harness. Isolate the short, and repair/replace the affected harness.

NO → The problem may be intermittent, reinstall the turn lamp connector(s) and attempt to recreate the problem. Continue troubleshooting as needed.

Hazard Lights

Hazard light outputs are the same as the turn signal outputs. For diagnostics, refer to the "Turn Lights" troubleshooting section.

Stop, Turn, and Hazard Lights

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800 — Parameters

Parameters				
Module Number	Part Number	Description	Parameter	ECU
301	000 447 35 61	Combination stop and turn signal lights, 5.1 software only.	PARM-CHAS, STL, TUS, CMB	SAM Chassis
301	000 447 36 61	Separate stop and turn signal lights, 5.1 software only.	PARM-CHAS, STL, TUS, SEP	SAM Chassis
301	000 447 38 61	Combination stop and turn signal lights, 5.2 software only.	PARM-CHAS, STL, TUS, CMB, ND	SAM Chassis
301	000 447 39 61	Separate stop and turn signal lights, 5.2 software only.	PARM-CHAS, STL, TUS, SEP, ND	SAM Chassis
301	000 447 46 61	Combination stop and turn signal lights, 5.4 software only.	PARM-CHAS, STL, TUS, CMB, TLFD	SAM Chassis
301	000 447 47 61	Separate stop and turn signal lights, 5.4 software only.	PARM-CHAS, STL, TUS, SEP, TLFD	SAM Chassis
301	002 447 02 58	Turn tip not present.	PARM-CAB, TUS, NO CNT	SAM Cab
301	002 447 03 58	Turn tip present, with 5 flashes.	PARM-CAB, TUS, TUT, X5	SAM Cab
301	002 447 85 58	Turn tip present, with 3 flashes.	PARM-CAB, TUS, TUT, X3	SAM Cab
311	001 447 84 58	Headlamps.	PARM-CAB, HDLP, NO CNT	SAM Cab
311	001 447 85 58	Headlamps, with Follow Me Home.	PARM-CAB, HDLP, FMH	SAM Cab
311	001 447 86 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps.	PARM-CAB, HDLP, DRL, TUS	SAM Cab
311	001 447 87 58	"Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, with Follow Me Home."	PARM-CAB, HDLP, DRL, TUS, FMH	SAM Cab
311	001 447 88 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps."	PARM-CAB, HDLP, DRL, TUS, MKR	SAM Cab
311	001 447 89 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, with Follow Me Home."	PARM-CAB, HL, DRL, TUS, MKR, FMH	SAM Cab

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Parameters				
Module Number	Part Number	Description	Parameter	ECU
311	001 447 90 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph.	PARM-CAB, HL, DRL, TUS, 10MPH	SAM Cab
311	001 447 91 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, with Follow Me Home.	PARM-CAB, HL, DRL, TUS, 10MP, FMH	SAM Cab
311	001 447 92 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph."	PARM-CAB, HL, DRL, TUS, MKR, 10MPH	SAM Cab
311	001 447 93 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, with Follow Me Home."	PARM-CAB, HL, DRL, TS, MKR, 10M, FMH	SAM Cab
311	003 447 08 58	Headlamps, 5.2 software only.	PARM-CAB, HDLP, ND, NO CNT	SAM Cab
311	003 447 09 58	Headlamps, with Follow Me Home, 5.2 software only.	PARM-CAB, HDLP, FMH, ND	SAM Cab
311	003 447 10 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, 5.2 software only.	PARM-CAB, HDLP, DRL, TUS, ND	SAM Cab
311	003 447 11 58	"Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, with Follow Me Home, 5.2 software only."	PARM-CAB, HDLP, DRL, TUS, FMH, ND	SAM Cab
311	003 447 12 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, 5.2 software only."	PARM-CAB, HDLP, DRL, TUS, MKR, ND	SAM Cab

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Parameters				
Module Number	Part Number	Description	Parameter	ECU
311	003 447 13 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, with Follow Me Home, 5.2 software only."	PARM-CAB, HL, DRL, TS, MK, FMH, ND	SAM Cab
311	003 447 14 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, 5.2 software only.	PARM-CAB, HL, DRL, TS, 10MPH, ND	SAM Cab
311	003 447 15 58	Headlamps, with Daytime Running Lights (DRL) using front turn signal lamps, DRL cutout speed = 10 mph, with Follow Me Home, 5.2 software only.	PARM-CAB, HL, DRL, TS, 10M, FMH, ND	SAM Cab
311	003 447 16 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, 5.2 software only."	PARM-CAB, HL, DRL, TS, MK, 10M, ND	SAM Cab
311	003 447 17 58	"Headlamps, with Daytime Running Lights (DRL) using turn signal, marker, tail and license plate lamps, DRL cutout speed = 10 mph, with Follow Me Home, 5.2 software only."	PARM-CAB, HL, DRL10, TS, MK, FMH, ND	SAM Cab

Table 7, Parameters

Tail and Marker Lights

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The tail and marker lights are controlled by the headlight switch, and are activated when the headlight switch is in position 1 (parking lights), and will remain active when the headlight switch is in position 2 (headlights). This function encompasses the marker lights, the clearance lights, the taillights, and the license plate light. See **Fig. 1**.

When the headlight switch is turned to the first position (parking lights), a hard-wired signal is sent from the headlight switch to the MSF Master to request that the tail and marker lights be activated. The MSF Master then sends a message over the Cabin CAN to the SAM system to activate the appropriate outputs. See **Fig. 2** for a system diagram.

For more information about how the modular switch field (MSF) operates, see subject **G02.06 — Modular Switch Field**.

C04.05

Tail and Marker Lights

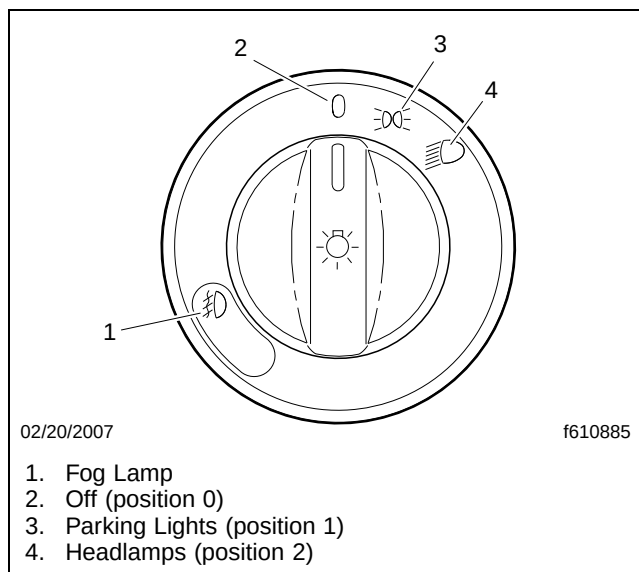


Fig. 1, Headlight Switch

502 — Marker Interrupt Switch

The marker interrupt switch is located on the steering wheel, and is used to temporarily cycle the marker lights. The marker interrupt switch will either energize the marker lights when the headlight switch is off, or de-energize the marker lights when the headlight switch is turned on.

Since the headlight switch controls the marker lights, the marker interrupt switch does not control outputs directly. Instead, the marker interrupt switch sends an internal signal to the MSF Master to cycle the tail and marker lights. The marker interrupt switch is ignored while cycling the marker lights.

503 — Controls

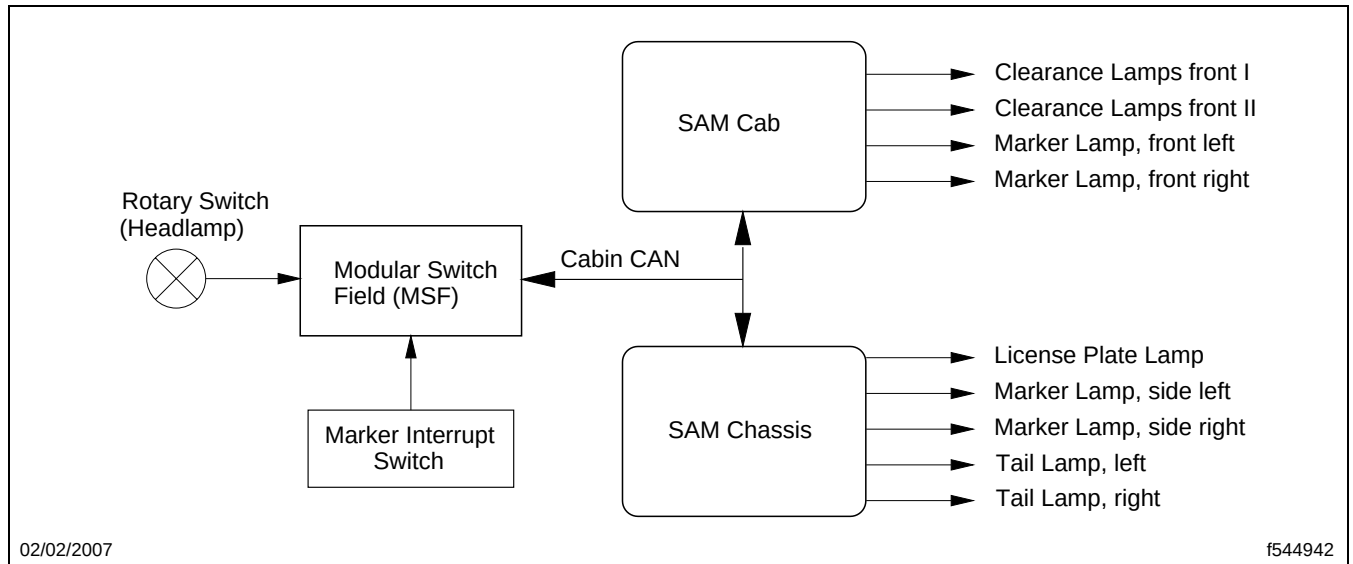


Fig. 2, Tail and Marker Light System Diagram

C04.05

Tail and Marker Lights

600 — Component Locations

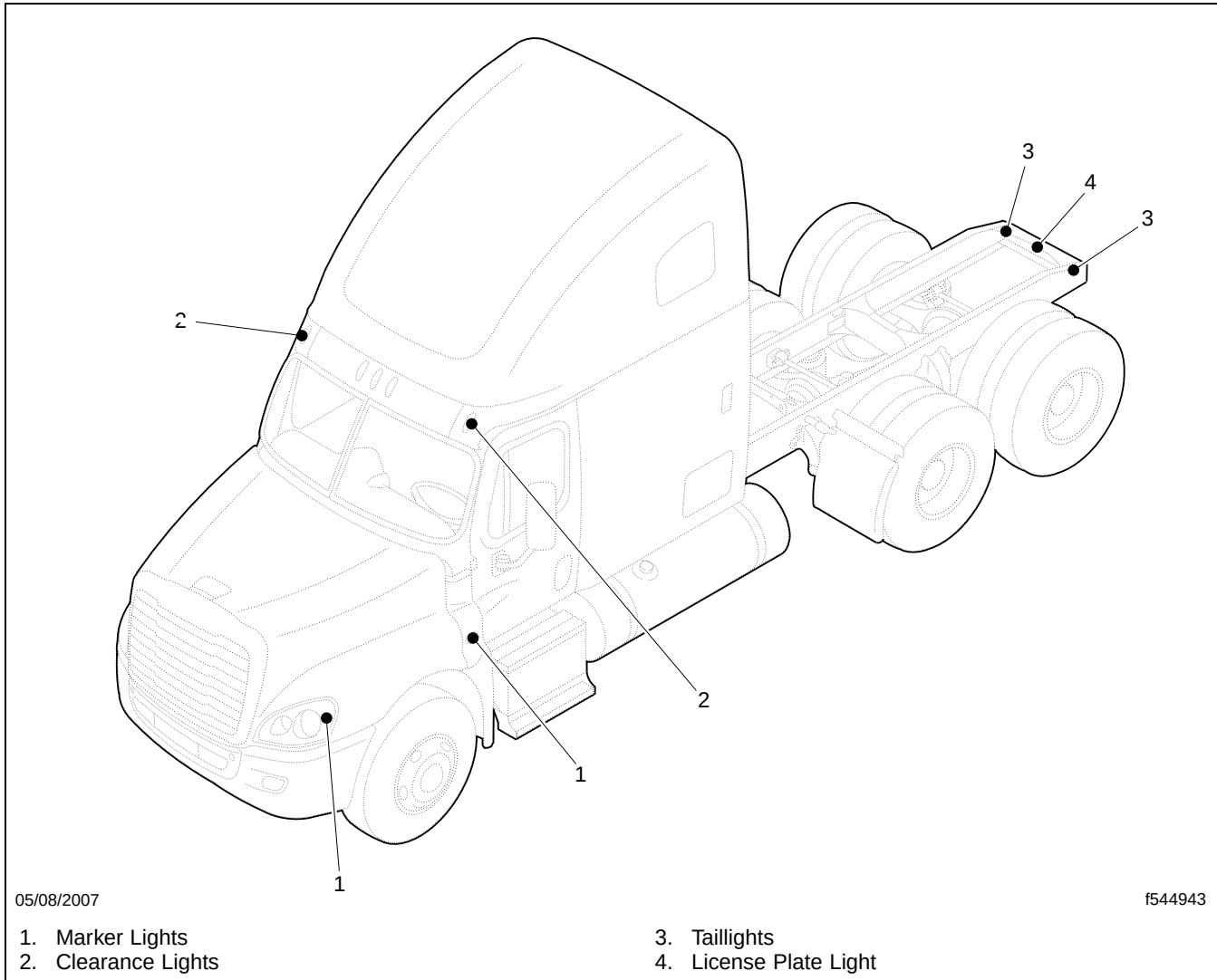


Fig. 3, Component Locations

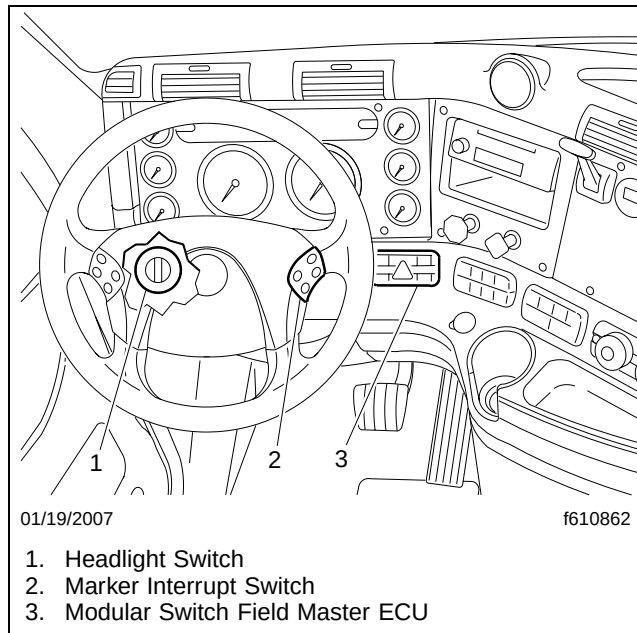


Fig. 4, Light Switches

601 — Component Details

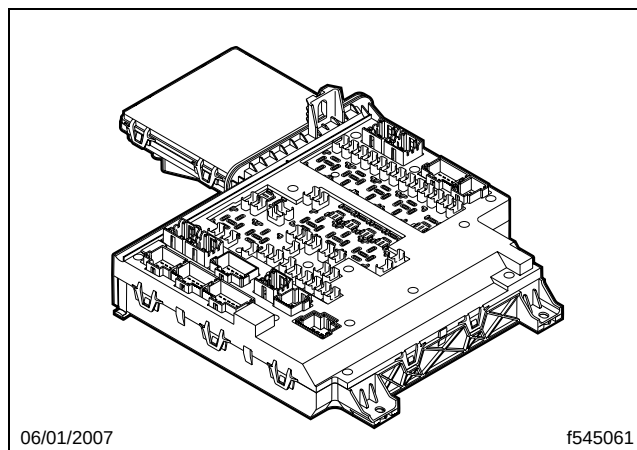


Fig. 5, SAM Cab

C04.05

Tail and Marker Lights

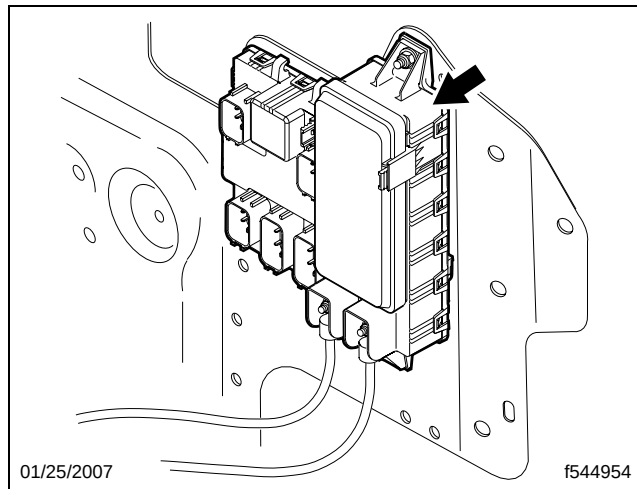


Fig. 6, SAM Chassis

700 — Diagnostic Tools Required

- High Impedance Multimeter
- ServiceLink

800 — Marker, Tail, Clearance, and License Plate Light Output

Marker, Tail, Clearance, and License Plate Light Output				
Description	Connector	PIN	SAM Cab	SAM Chassis
Marker lights, corner rear left GND	X53	4	—	X
Marker lights, side right GND	X52	2	—	X
Marker lights, corner rear right GND	X52	5	—	X
Marker light, corner rear left	X53	2	—	X
Marker light, corner rear right	X52	3	—	X
Marker light, side left	X53	1	—	X
Marker light, side right	X52	1	—	X
Marker lights, side left GND	X53	8	—	X
License plate light	X58	12	—	X
Taillight, left	X58	18	—	X
Taillight, right	X58	3	—	X
Taillights, left, GND	X58	8	—	X
Taillights, right GND	X58	5	—	X
Clearance lights, front I	X16	8	X	—
Clearance lights, front II	X16	4	X	—
Clearance lights, front GND	X16	9	X	—

Tail and Marker Lights

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Marker, Tail, Clearance, and License Plate Light Output				
Description	Connector	PIN	SAM Cab	SAM Chassis
Marker light, corner front left GND	X18	13	X	—
Marker lights, front right GND	X18	10	X	—
Marker light, corner front right GND	X18	4	X	—
Marker light, front left	X18	14	X	—
Marker light, front right	X18	12	X	—
Marker light, corner front left	X18	16	X	—
Marker light, corner front right	X18	8	X	—
Marker lights, front left GND	X18	1	X	—

Table 1, Marker, Tail, Clearance, and License Plate Light Output

801 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
30A	002 447 64 58	Marker interrupt switch present with one momentary interrupt.	PARM-CAB, MIS	SAM Cab
	002 447 86 58	Marker interrupt switch present with two momentary interrupts.	PARM-CAB, MIS, X2	
	000 447 32 61	Marker light fault detection.	PARM-CHAS, MKR, DET	SAM Chassis

Table 2, Parameters

Fog Lights

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500 — Terms and Abbreviations

CAN—Controller Area Network

Datalink—A collection of wires, connecting system components, through which data is transmitted.

DLM—Datalink Monitor

ECU—Electronic Control Unit, typically connected to a datalink.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The fog light switch is part of the headlight switch. The fog lights are only available when the headlight switch is in position 1 (parking lights) or position 2 (headlights). The fog lights are activated when the headlight switch is pulled out. See **Fig. 1**.

The availability of the fog lights is controlled by parameter. When the headlight switch is pulled out, the switch is read by the MSF Master and is sent on datalink to the SAM cab, which activates the fog lights. The fog lights are disabled when the high beams are on.

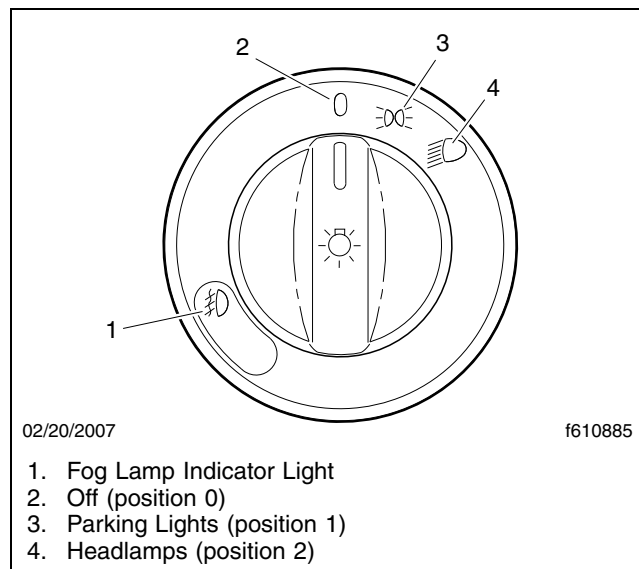


Fig. 1, Headlight Switch

Activation of the fog lights is influenced by the following features:

- Headlight Switch, Position 1

C04.06

Fog Lights

- Headlight Switch, Position 2
- High Beams/Flash-to-Pass

502 — Controls

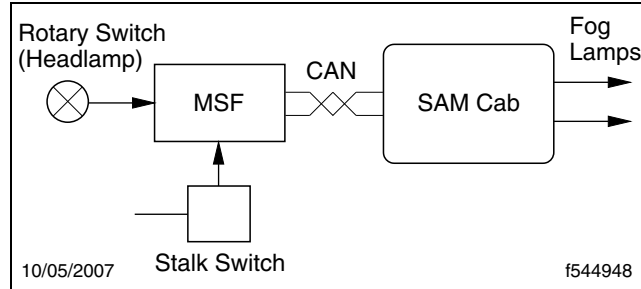


Fig. 2, Controls

600 — Component Locations

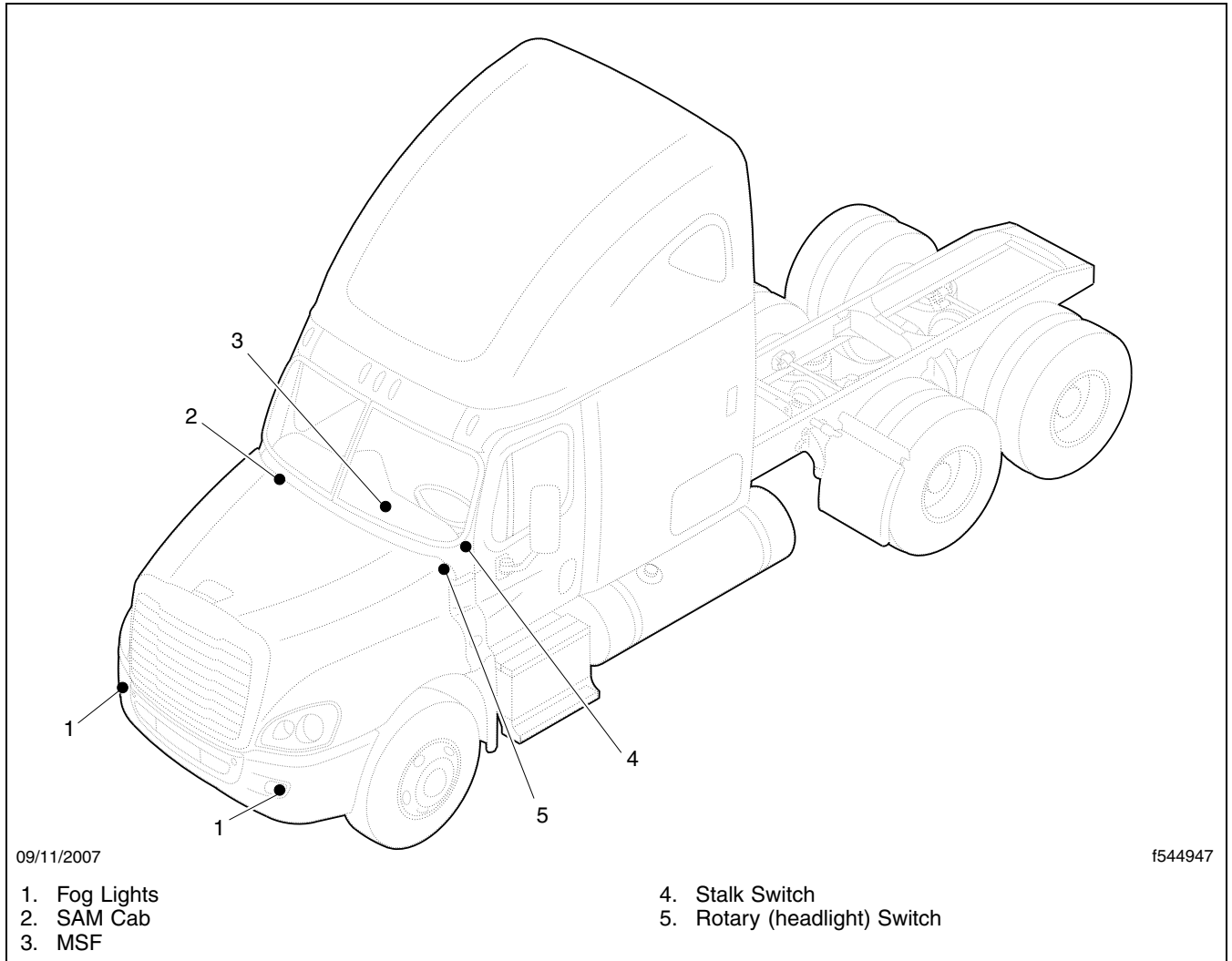


Fig. 3, Component Locations

601 — Component Details

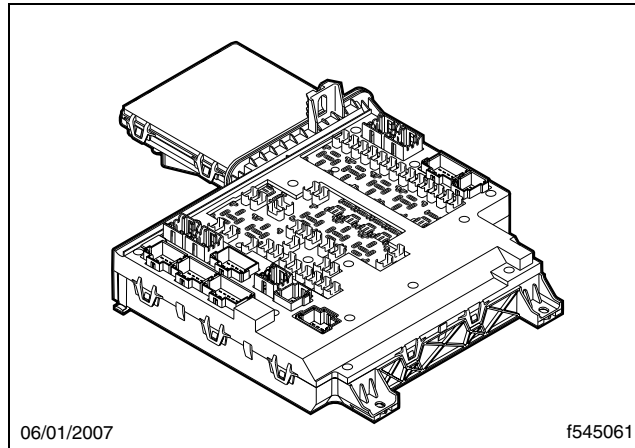


Fig. 4, SAM Cab

SAM Cab Connector X20			
09/12/2007 f545131			
Function	Connector	Pin	Circuit
Fog Light, Left	X20	8	28L
Fog Light, Left, Ground	X20	3	GND1
Fog Light, Right	X20	17	28R
Fog Light, Right, Ground	X20	1	GND2

Table 1, SAM Cab Connector X20

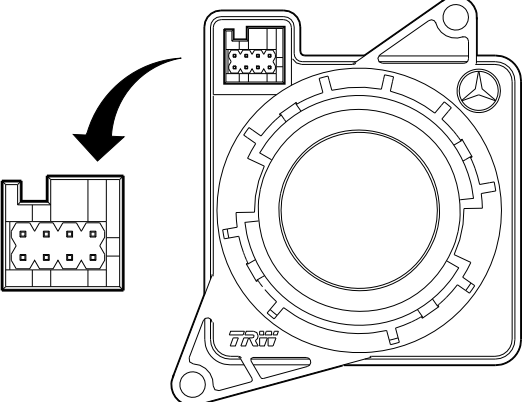
Rotary Switch Pinout	
	
05/15/2007	f545037
Pin	Function
1	Binary Code 1
2	Binary Code Common
3	Version
4	Fog Lamps/Road Lamps
5	Binary Code 2
6	Backlighting
7	Ground
8	Battery Power

Table 2, Rotary Switch Pinout

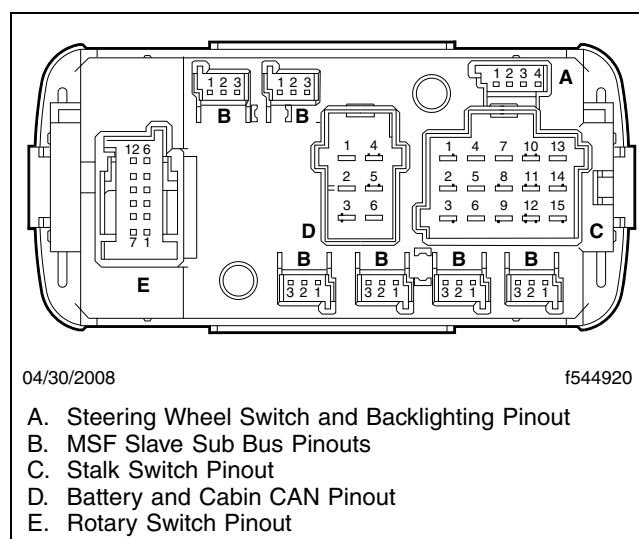


Fig. 5, MSF (connector side)

Connector E Pinout: Rotary Switch	
Pin	Function
1	Battery Power
2	Binary Code Input 1 (BC1)
3	Binary Code Input 2 (BC2)
4	Binary Code Input Version
5	Binary Code Common
6	Fog lamp signal
7	Backlighting PWM
8	Backlighting PWM
9	Not connected
10	Ground
11	Ground
12	Ground

Table 3, Connector E Pinout: Rotary Switch

700 — Troubleshooting Overview

The Fog Lights are a function controlled by the SAM system. Begin troubleshooting this SAM function in **G02.04** — **SAM Cab**, logic controlled unfused outputs.

701 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor Template "Fog Lights."
- Digital Multimeter

702 — CAN Fault Codes

NOTE: **Table 4** lists faults for the following ECUs:

- 33 – SAM Cab
- 37 – Central Gateway (CGW)
- 49 – Modular Switch Field (MSF)
- 71 – SAM Chassis

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

Fog Lights

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	522108	3	conn X20 pin 8	—	—	Fog lamp, front left – Voltage above normal, or shorted to high source.	While the left fog lamp is off, the fault becomes active when the voltage detected at conn X20 pin 8 is greater than 8V. The fault becomes historic when the voltage detected is less than 1.2V.
Action: Disconnect the batteries and measure the voltage at conn X20 pin 8. If the voltage detected is greater than 8V, troubleshoot circuit 28L for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522108	4	conn X20 pin 8	—	—	Fog lamp, front left – Voltage below normal, or shorted to low source.	The fault is active when the left fog lamp is activated but it does not turn on. The current detected on conn X20 pin 8 is greater than 10.5A. The fault becomes historic when the current detected is less than 6.7A.
Action: Disconnect the batteries and measure the voltage at conn X20 pin 8. If BAT voltage is not detected, troubleshoot circuit 28L for a short to GND. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522108	5	conn X20 pin 8	—	—	Fog lamp, front left – Current below normal, or open circuit.	An open circuit has been detected at conn X20 pin 8.
Action: Troubleshoot circuit 28L and GND1 between the SAM Cab and left fog lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522117	3	conn X20 pin 17	—	—	Fog lamp, front right – Voltage above normal, or shorted to high source.	While the right fog lamp is off, the fault becomes active when the voltage detected at conn X20 pin 17 is greater than 8V. The fault becomes historic when the voltage detected is less than 1.2V.
Action: Disconnect the batteries and measure the voltage at conn X20 pin 17. If the voltage detected is greater than 8V, troubleshoot circuit 28R for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522117	4	conn X20 pin 17	—	—	Fog lamp, front right – Voltage below normal, or shorted to low source.	The fault is active when the right fog lamp is activated but it does not turn on. The current detected on conn X20 pin 17 is greater than 10.5A. The fault becomes historic when the current detected is less than 6.7A.
Action: Disconnect the batteries and measure the voltage at conn X20 pin 17. If BAT voltage is not detected, troubleshoot circuit 28R for a short to GND. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522117	5	conn X20 pin 17	—	—	Fog lamp, front right – Current below normal, or open circuit.	An open circuit has been detected at conn X20 pin 17.
Action: Troubleshoot circuit 28R and GND2 between the SAM Cab and right fog lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

Table 4, CAN Fault Codes

703 — Inputs and Interlocks

Interlocks depend on which parameters are set. Double check the fog lamp parameters using ServiceLink, and **Table 4** in **800 — Parameters** to ensure which interlocks are implemented.

I/O and Interlock	
Pin	Function
Inputs	Rotary (headlamp) SW – Pull position 1 and 2
Interlocks	High Beams / Flash to Pass
SAM Output/Type	X20.8 (Left), Logic-Controlled, Unfused X20.17 (Right), Logic-Controlled, Unfused

Table 5, I/O and Interlock

704 — Input Troubleshooting

The primary input for the fog lights is the headlamp switch. Refer to the appropriate G06 drawing in module 311, headlamp switch wiring.

1. Measure the fog light MSF input voltage.

- 1.1 Remove the MSF from the dash.
- 1.2 Disconnect connector E from the MSF.
- 1.3 Remove the lock from the connector to expose the back of the connector.
- 1.4 Plug the connector (with lock removed) back into the MSF.
- 1.5 Insert conducting probes into the back of connector E terminals 6 and 12.
- 1.6 Put the headlight switch in the fog light position.
- 1.7 Measure the voltage between terminals 6 and 12. See **Fig. 6**.

Is the voltage between pins 6 and 12 roughly 3.5 to 4.5 volts when the headlight switch is in the pulled out (fog light) position?

YES → The MSF is getting the correct signal for the fog light ON request. Check the terminals and pin at the MSF for damage.

NO → Go to test 2.

2. Check for continuity between the headlight switch connector (terminal 4), and the MSF connector E (terminal 6).

- 2.1 Access the headlight switch, and disconnect the harness.
- 2.2 Inspect the pins on the headlight switch, pins 4 and 8. Repair or replace the switch, if necessary.
- 2.3 Inspect the terminals on the harness, and ensure that they are seated properly in the connector.
- 2.4 Measure continuity in the harness.

Is there an open circuit?

YES → Repair the harness.

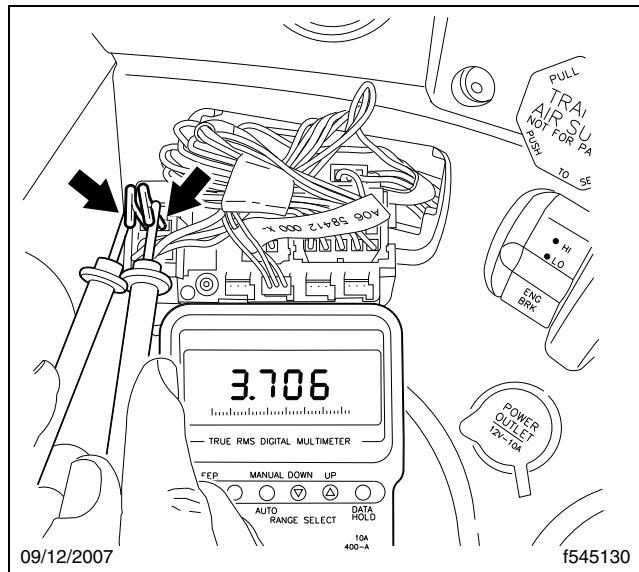


Fig. 6, Measuring Voltage Between Terminals 6 and 12

NO → Go to test 3.

3. Check resistance in the headlight switch between pins 4 and 8.

NOTE: There is high resistance when checking this circuit, due to the diode in series with R3. R3 is only 1500Ω , but the diode in an inactive circuit makes the resistance closer to $600K\Omega$.

- 3.1 Pull the headlight switch out to the fog light position.
- 3.2 Measure the resistance between pins 4 and 8 on the switch.
- 3.3 Push the headlight switch back to the off position.
- 3.4 Measure resistance again between pins 4 and 8. See **Fig. 7**.

Is there a high (but not open circuit) resistance in the switch circuit when in the fog light ON position, and open circuit when in the OFF position?

YES → The switch appears to be working properly. Install the headlight switch connector and the MSF connector, and perform a functional check of the fog lights. Continue troubleshooting inputs as needed.

NO → Replace the headlight switch.

705 — Output Troubleshooting

There are no fuses or relays associated with SAM Cab outputs for the fog lights. Refer to appropriate G06 drawing in module 313 to troubleshoot circuits 28L and 28R.

NOTE: Refer to SAM output troubleshooting in **G02.04 — SAM Cab** as a first step before following the troubleshooting steps in this subject.

NOTE: For better access to the engine side of the SAM Cab, remove the passenger side cowl.

1. Check for continuity in all fog lamp circuit(s).

C04.06

Fog Lights

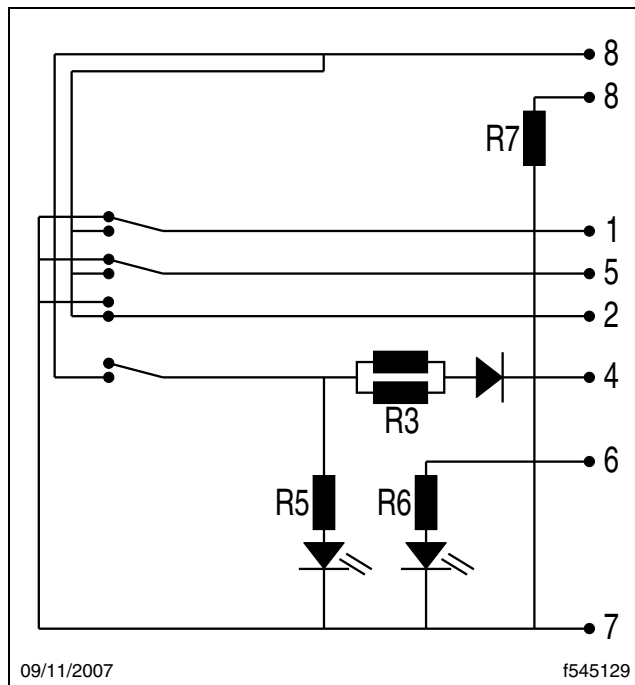


Fig. 7, Headlight Switch Pins

- 1.1 Remove connector X20 from the SAM Cab.
- 1.2 Measure resistance between terminals:
 - X20.8 and X20.3 for the left fog light circuit.
 - X20.17 and X20.1 for the right fog light circuit.

Is there an open circuit in the fog light output circuit(s)?

YES → Go to test 2.

NO → Go to test 3.

2. Isolate the open circuit.

- 2.1 Remove connector X20 from the SAM Cab.
- 2.2 Remove the connector from the fog light.
- 2.3 Measure resistance in the harness:
 - X20.8 to terminal B for circuit 28L
 - X20.3 to terminal A for circuit GND1
 - X20.17 to terminal B for circuit 28R
 - X20.1 to terminal A for circuit GND2
 - Between the two pins of the fog lamp itself.

Is there low resistance (less than one ohm) in the circuits tested?

Fog Lights

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YES → Install the fog light connectors on both the lamps, and the SAM Cab. Perform a functional test of the fog lights to determine if the problem is intermittent. If the problem still exists, go back to the fog light Datalink monitor template and evaluate the fog light functionality.

NO → Repair the harness with the affected circuit or replace the bulb.

3. Determine if a short exists in the fog light circuitry, using the Datalink monitor.

NOTE: A short condition for the fog light circuit occurs when greater than 10.4 amps are detected by the SAM Cab fog light circuitry.

- 3.1 Reset the SAM Cab by cycling battery power, either with a load disconnect switch, or by momentarily removing the negative lead to the batteries.
- 3.2 Connect to the vehicle using the Datalink monitor template "Fog Lights."
- 3.3 Turn the ignition ON, and the fog lights ON. Both output indicators on the fog light DLM template should turn ON, even with a short.
- 3.4 Turn the fog lights OFF. If a short exists, the output indicator(s) on the Datalink monitor template will remain ON.

Did the fog light indicator(s) on the Datalink monitor template remain ON after turning the fog lights OFF?

YES → This is a short circuit condition. Troubleshoot the affected fog light circuit(s) as indicated by the Datalink monitor template, and repair the harness as needed. Be sure to reset the SAM Cab after the short is corrected.

NO → Perform a functional test of the fog lights to determine if the problem is intermittent. If the problem still exists, continue with the fog light Datalink monitor template, and evaluate the fog light functionality. Refer to **G02.04 — SAM Cab** for more information.

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
313	002 447 35 58	No fog lights, no auxiliary high-beam lights.	PARM-CAB, ALA, NO CNT	SAM Cab
	002 447 37 58	No fog lights, auxiliary high-beam lights present.	PARM-CAB, ALA, AHL	
	002 447 41 58	Fog lights disabled with high-beam lights, no auxiliary high-beam lights.	PARM-CAB, ALA, FGD	
	003 447 20 58	Fog lights disabled with high-beam lights, no auxiliary high-beam lights, 5.2 software only.	PARM-CAB, ALA, FGD, ND	
	000 447 78 23	Vehicle is equipped with auxiliary headlight switch, ID015, multiplexed sub bus switch.	PARM-MSF, MUX, AUX HD LIGHT, NC	MSF
	000 447 79 23	Vehicle is not equipped with auxiliary headlight switch, ID015, multiplexed sub bus switch.	PARM-MSF, MUX, AUX HD LIGHT, NC	

Table 6, Parameters

Trailer Lights

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500 — Terms and Abbreviations

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit, typically connected to a datalink.

EOF—End of Frame

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

Trailers equipped with pneumatic brakes and used in North and South America are generally equipped with an electrical cable that terminates in a 7-way connector. In some cases, trailers used in North America are equipped with two electrical cables; one is an SAE J560 connector, and the other is an ISO 3731 connector.

Power for the trailer lights is passed from the vehicle to the trailer by the primary receptacle. This is either the end of frame (EOF) primary receptacle, or the standard primary receptacle located at the back of the cab.

502 — End of Frame Primary Receptacle

The SAM Chassis supplies control outputs to a remote trailer-power distribution module. The remote trailer-power distribution module is powered through the battery system; the SAM Chassis does not supply the power. The interface between the vehicle and the trailer is made through a chassis-mounted primary receptacle. The use of the EOF primary receptacle feature is controllable by parameter.

503 — Primary Receptacle

The SAM Chassis supplies outputs for trailer functions. The interface between the vehicle and the trailer is made through a 7-pin primary receptacle. The use of the primary receptacle feature is controlled by parameter. The configuration of the trailer power source (BAT or IGN) is also controlled by parameter.

Trailer power can also be controlled by a dash switch. The dash switch is read by the MSF Master and a datalink message is transmitted to the SAM Chassis. If the switch is configured as present, the trailer power source configuration is set to IGN. The presence of the dash switch is controlled by parameter.

C04.07

Trailer Lights

600 — Component Locations

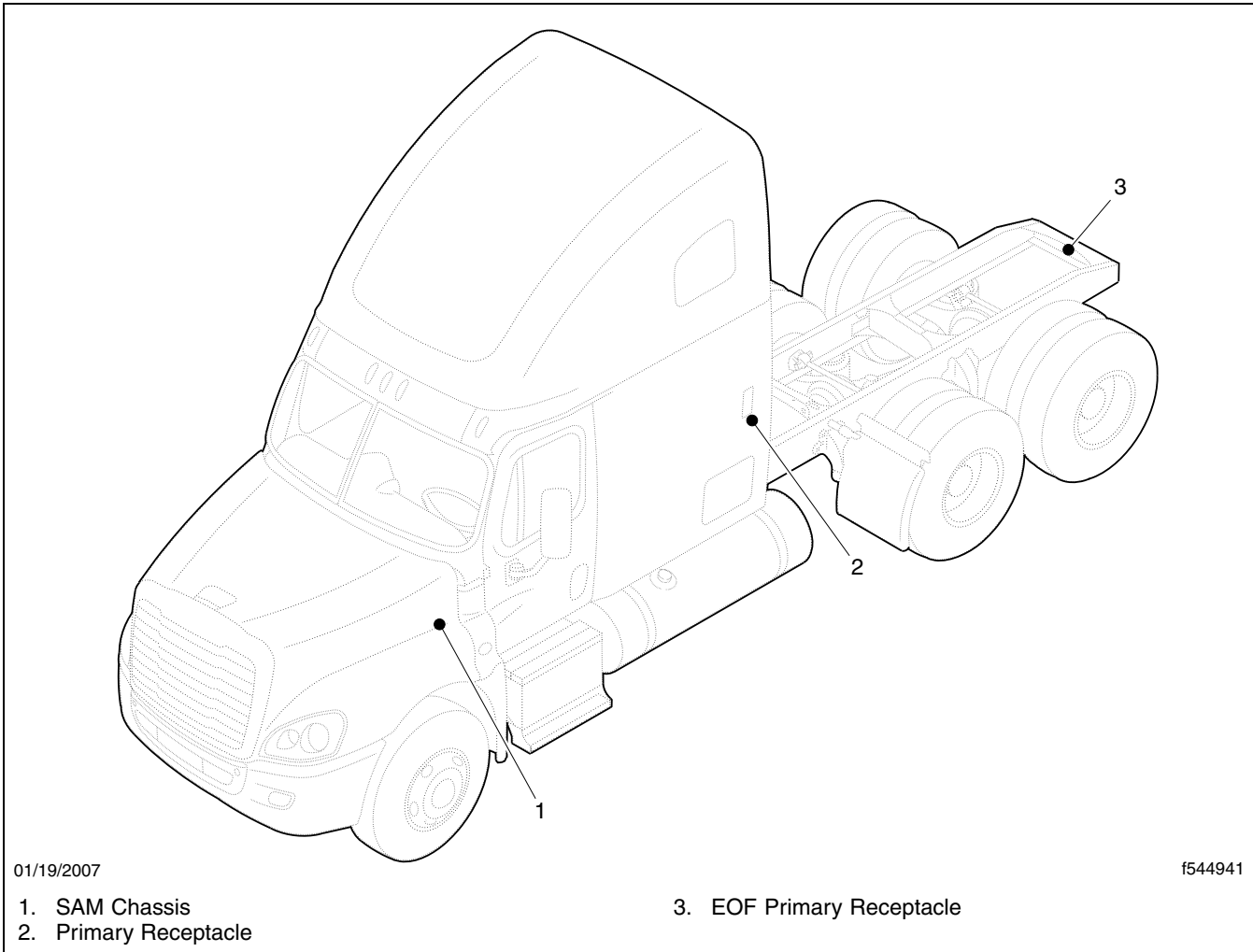


Fig. 1, Component Locations

601 — Component Details

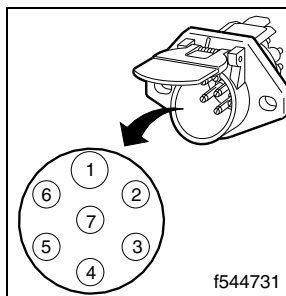


Fig. 2, Primary Receptacle 7-Pin Connector

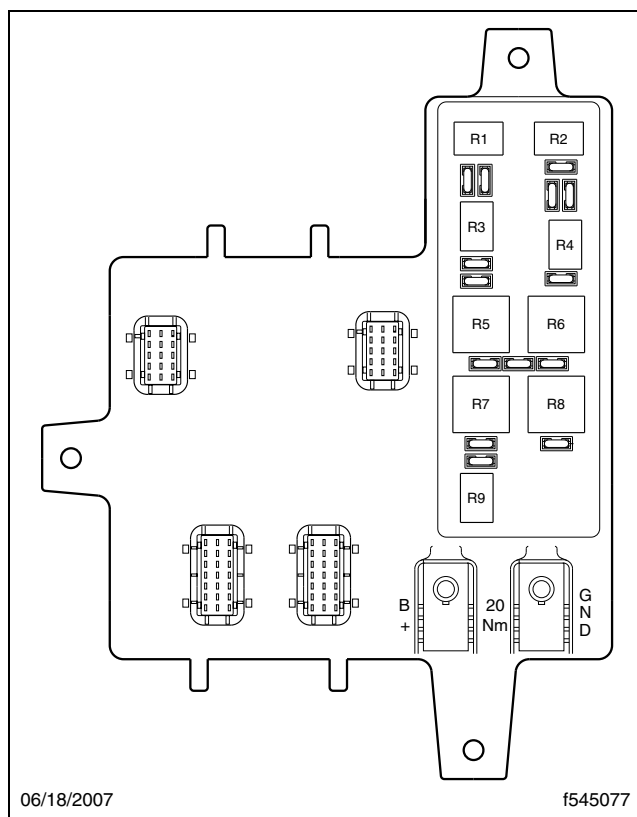


Fig. 3, SAM Chassis

C04.07

Trailer Lights

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
296	000 447 23 61	Mounted, left side, back of cab, trailer auxiliary switch present.	PARM-CHAS, TRA, SWP	SAM Chassis
	000 447 24 61	Mounted, left side, back of cab, ignition powered.	PARM-CHAS, TRA, IGN	
	000 447 25 61	Mounted, left side, back of cab, battery powered.	PARM-CHAS, TRA, BATT	
	000 447 29 61	Mounted, left side, back of cab and end of frame, trailer auxiliary switch present.	PARM-CHAS, TRA, SWP, BOC, EOF	
	000 447 30 61	Mounted, left side, back of cab and end of frame, ignition powered.	PARM-CHAS, TRA, IGN, BOC, EOF	
	000 447 31 61	Mounted, left side, back of cab and end of frame, battery powered.	PARM-CHAS, TRA, BATT, BOC, EOF	
	001 447 26 23	Vehicle is equipped with trailer power switch, ID122 multiplexed sub bus switch.	PARM-MSF, MUX, TRAILER POWER	
	001 447 27 23	Vehicle is not equipped with trailer power switch, ID122 multiplexed sub bus switch.	PARM-MSF, MUX, TRAILER POWER, NC	MSF
	000 447 68 23	Vehicle is equipped with auxiliary trailer switch, ID157 hardwired sub bus switch.	PARM-MSF, HWD, TRAILER AUX	
	000 447 69 23	Vehicle is equipped with auxiliary trailer switch, ID157 hardwired sub bus switch.	PARM-MSF, HWD, TRAILER AUX, NC	

Table 1, Parameters

Dome Lighting

C05.01

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500 — Terms and Abbreviations

CAN—Controller Area Network

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Momentary Switch—A switch that returns to neutral position after being pushed.

Maintained/Latching Switch—A switch that remains in position after being pushed.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PLVD—Progressive Low Voltage Disconnect

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

Dome Lights

Day cabs and sleeper cabs have two combination dome/reading lights at the front of the vehicle. Day cabs have one rear dome lamp centered in the ceiling of the cab when the premium lighting option is chosen.

When either the driver or passenger door is opened, the SAM Cab activates the dome lamps. In day cabs with the premium lighting option, the dome lamps can be activated with the front dome lamp switch.

Reading/Map Lights

The reading and map lights are in the same housing as the dome lamps. These lamps are not multiplexed and are activated and deactivated by pressing on the light fixture.

Footwell Lights

The footwell lights light the floor and lower dash directly in front of the driver and passenger seats. When either the driver or passenger door is opened, the SAM Cab activates the footwell lights. The SAM Cab receives a message from the MSF to activate the footwell lighting when the footwell MSF switch is pressed.

Driver- and Passenger-Side Door Switches

The dome and footwell lamps are activated by opening the driver or passenger door. Opening and closing the door actuates a switch that is part of the door latch assembly in each door.

- Continuity across door switch (switch closed) = door open
- No continuity across door switch (switch open) = door closed

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There is continuity across the door switch when the door latch is in the open or primary latch position. There is no continuity across the switch when the latch is fully closed on the secondary latch position. To open the switch (interrupt the current path) the latch must be in the secondary latched position. Constant battery power is supplied to each door switch from SAM Cab fuse F13, pin X8.6. When the door switch is open, a 12V signal is returned to the SAM Cab (pin X8.1 for the driver side and pin X17.5 for the passenger side).

502 — Dimming Conditions and Timer Logic

If the vehicle speed exceeds 18 mph (29 km/h), the dome lamps reduce illumination to 40% to reduce glare inside the cab, otherwise the illumination values will remain at their current level.

Timer logic varies as described below.

NOTE: The following conditions apply to both the driver and passenger dome light.

Instantly Off , or turned to ON

If the ignition is on and the doors are closed (door switches open) the dome lights over the driver and passenger instantly begin dimming to fully off (theater lighting timer shut down), approximately 2 seconds.

Off After 15 Seconds

If the ignition is off and the doors are closed (door switches open) the dome lights above the driver and passenger turn off after 15 seconds.

Off After 15 Minutes

If the doors are left open (one or both door switches closed), the dome lights above the driver and passenger turn off after 15 minutes. The door must be open or not latched in the secondary latch. If one of the door switches changes state (is opened or closed) the 15 minute timer will restart.

503 — Lamp Control Modes

Three types of controls are used for the interior lights.

Locally switched lights can be turned on or off using a switch that is connected in series with the light bulb. The SAM Cab provides battery power to the switch.

SAM-Switched lights can be turned on or off by the SAM Cab. The SAM Cab receives input from a hardwired input or a datalink message. There are two steady state levels, on or off. Some SAM-switched lights are timed, so after a prescribed period of time, the lights will shut off. Others are under PLVD control and are switched off if the battery voltage becomes too low.

Theater lighting can be turned on or off by the SAM Cab. The SAM Cab receives an input from a remote momentary switch or a datalink message. There are two steady state levels, on or off.

Lights controlled by theater lighting are ramped on or off as they are switched on or off. Ramped lighting means that the lights gradually come on to their full illumination when turned on and gradually lose their illumination when turned off.

504 — Dimmable Lighting

Dimmable lighting allows the driver to dim the brightness of some interior lights. On a day cab with premium lighting, the dome lights in the overhead console and the rear dome lamp can be dimmed. To dim the lights, the driver presses and holds the switch that activates the light. While the switch is being pressed, the light decreases

and increases in brightness until the switch is released. The amount of illumination at the time the switch is released is stored as a value. If the illumination is less than 30% of the maximum illumination when the switch is released, it will be set at the default level 100%. Press the switch to turn the light off. When the switch is pressed again, the lights will illuminate to the amount of brightness they were set to.

600 — Component Locations

NOTE: Lamps 2 and 3 are controlled by the same switch.

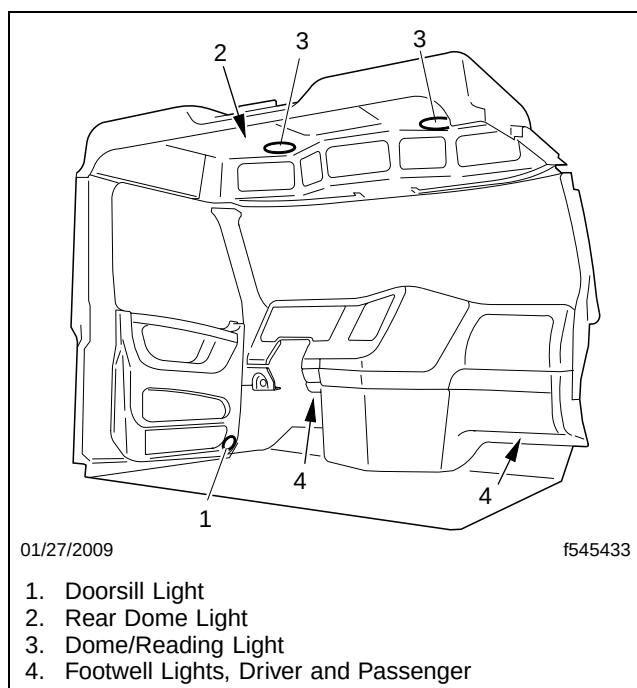


Fig. 1, Component Locations

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Dome Lighting

601 — Component Details

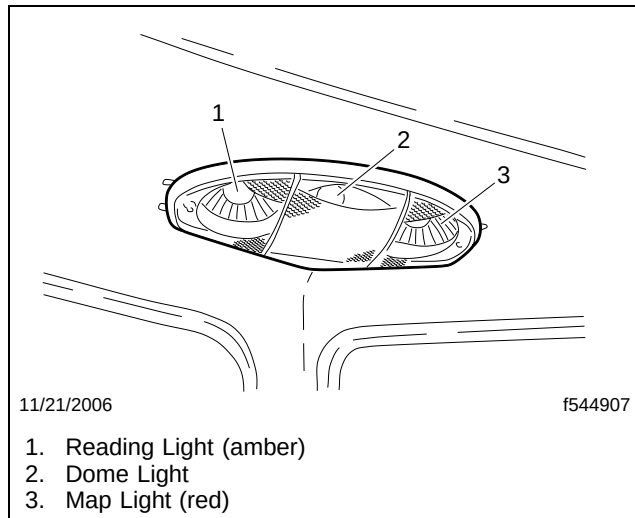


Fig. 2, Dome Light (driver-side)

NOTE: The reading light and the map light are reversed on the passenger-side of the vehicle.

SAM Cab Connector 8		
01/09/2008 f545187		
Pin	Circuit	Description
1	108T	Door Open Driver Side
6	443	Door Lock, BAT

Table 1, SAM Cab Connector 8

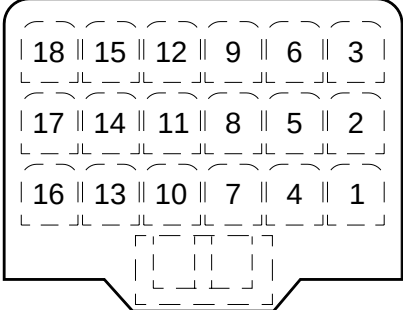
SAM Cab Connector X12		
		
06/21/2007 f545093		
Pin	Circuit	Description
3	108A	Footwell Lamp
10	GND	Footwell Lamp, GND

Table 2, SAM Cab Connector X12

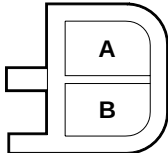
Footwell Lamp Connector		
		
06/21/2007 f545095		
Pin	Circuit	Description
A	108A	Footwell Lamp
B	GND	Footwell Lamp, GND

Table 3, Footwell Lamp Connector

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Dome Lighting

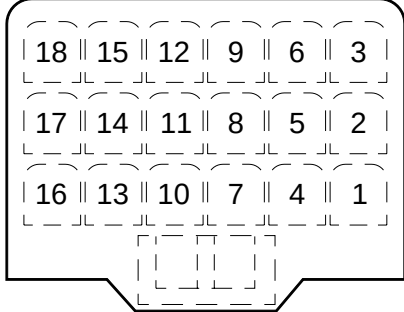
SAM Cab Connector X16		
		
06/21/2007 f545093		
Pin	Circuit	Description
7	41	Dome Lamp, Cab, Battery
11	108D	Dome Lamp, Driver, Forward, Overhead
14	108D	Dome Lamp, Passenger (rear dome lamp)
15	GND	GND, General Cab (forward dome lamp)

Table 4, SAM Cab Connector X16

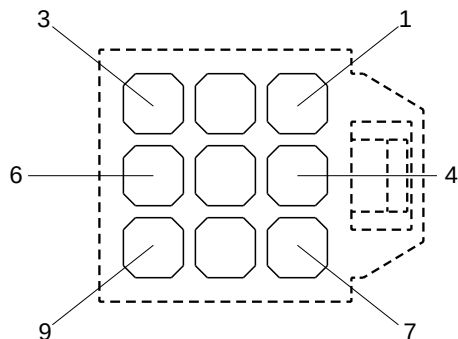
SAM Cab Connector 17		
		
01/09/2008 f545187		
Pin	Circuit	Description
5	108U	Door Open, Passenger Side

Table 5, SAM Cab Connector 17

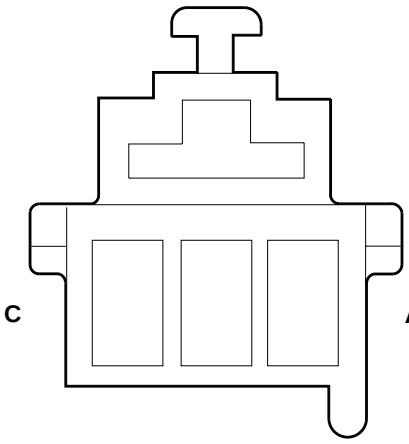
Front Dome Lamp Connector		
		
05/10/2007 f545031		
Front Dome Lamp Connector, Driver Side		
Pin	Circuit	Description
A	41	Reading/Dome/Map Light, Battery Power
B	GND	Dome Lamp, GND
C	108D	Dome Lamp, Door Activated
Front Dome Lamp Connector, Passenger Side		
Pin	Circuit	Description
A	108D	Dome Lamp, Door Activated
B	GND	Dome Lamp, GND
C	41	Reading/Dome/Map light, Battery Power

Table 6, Front Dome Lamp Connector

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Dome Lighting

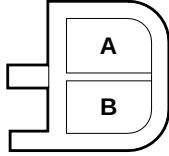
Vanity Mirror Light Connector			
			
06/21/2007		f545095	
Vanity Mirror Light Connector, Driver Side			
Pin	Circuit	Color	Description
A	GND	Black	GND, General Cab/Chassis
B	41	Purple/White	Dome Lamp constant 12V supply
Vanity Mirror Light Connector, Passenger Side			
A	GND	Black	GND, General Cab/Chassis
B	41	Purple/White	Dome Lamp constant 12V supply

Table 7, Vanity Mirror Light Connector

700 — Troubleshooting Overview

The dome lamps are controlled by the SAM system. Begin troubleshooting this SAM function in **G02.04 — SAM Cab**, section **707 — Logic Controlled Unfused Outputs**.

Check vehicle battery voltage and fuses, check the ECU connectors to ensure they are securely attached. This troubleshooting assumes the vehicle has charged batteries.

701 — CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	520905	3	conn X8 pin 5	—	—	Door open status – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X8, pin 5 is greater than 3.4V and the driver-side door is closed. The fault becomes historic when the voltage detected is less than 1V.
Action: Close the driver-side door. Measure the voltage at conn X8, pin 5. If the voltage detected is not 0V, troubleshoot circuit 437W for a short to BAT.							
33	520905	4	conn X8 pin 5	—	—	Door open status – Voltage below normal, or shorted to low source.	The current detected at conn X8, pin 5 is greater than 2A. The fault is historic when the current is below 0.2A.
Action: With the door open, measure the voltage at conn X8, pin 5. If the voltage detected is not BAT voltage, troubleshoot circuit 437W for a short to GND.							

Dome Lighting

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	520909	4	conn X8 pin 9	—	—	Door sill lamp driver – Voltage below normal, or shorted to low source.	This fault may be caused either by a short circuit to ground or by a burned out door sill lamp (open circuit). In the case of a short to ground, when the door sill lamp is active, the current detected is above 1.9A. The fault becomes historic when the current detected is below 1.3A.
Action: With the driver door open measure the voltage at conn X8, pin 9. If the voltage detected is not BAT voltage, troubleshoot circuit 108V for a short to GND. Troubleshoot circuits 108V and GND between the SAM Cab and driver door sill lamp for an open circuit. Troubleshoot the lamp for continuity.							
33	521303	4	conn X12 pin 3	—	—	Footwell lamp – Voltage below normal, or shorted to low source.	This fault may be caused either by a short circuit to ground or by a burned out footwell lamp (open circuit). Additionally, if one footwell lamp is open, both footwell lamps will not work due to circuit protection behavior by the SAM Cab. In the case of a short to ground, when the footwell lamps are active, the current detected is above 2.8A. The fault becomes historic when the current detected is below 2A.
Action: Open the door or press the footwell switch to activate the footwell lamps. Measure the voltage at conn X12, pin 3 for BAT voltage if the voltage detected is not BAT voltage. If the voltage detected is not BAT voltage, troubleshoot circuit 108A for a short to GND. Perform a continuity test on circuit 108A and GND between the footwell lamps for an open circuit. Troubleshoot the lamp for continuity.							
33	521711	4	conn X16, pin 11 conn X16, pin 14	—	—	Dome lamps driver and passenger – Voltage below normal, or shorted to low source.	When the Dome lamps are active, the current detected at conn X16, pin 11 and conn X16, pin 14 (day cab with premium lighting only) is greater than 9.3A. The fault becomes historic when the current detected is below 6.7A.
Action: Measure the voltage at conn X16, pin 11 and X16, pin 14 when the dome lamps are activated. If the voltage detected is not BAT voltage, troubleshoot circuit 108D for a short to ground. Troubleshoot the lamp for continuity.							
33	521803	4	conn X17 pin 3	—	—	Door sill lamp passenger – Voltage below normal, or shorted to low source.	This fault may be caused either by a short circuit to ground or by a burned out door sill lamp (open circuit). In the case of a short to ground, when the door sill lamp is active, the current detected is above 1.9A. The fault becomes historic when the current detected is below 1.3A.
Action: With the passenger door open measure the voltage at conn X17, pin 3. If the voltage detected is BAT voltage, troubleshoot circuit 108W for a short to GND. Troubleshoot circuits 108W and GND1 between the SAM Cab and passenger door sill lamp for an open circuit. Troubleshoot the lamp for continuity.							

Table 8, CAN Fault Codes

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Dome Lighting

702 — Diagnostic Tools Required

- ServiceLink
- Datalink Monitor Template "Interior Lighting - Dome, Entrance and Footwell"
- Digital Multimeter

703 — Input Troubleshooting

The primary input for the dome lamps are the driver and passenger door actuators. The front dome lamp switch is a secondary input in Cascadia Day Cabs with premium lighting.

NOTE: Use the Datalink Monitor template "Interior Lighting - Dome, Entrance and Footwell" to monitor the status of the door latches. The door latches may need adjustment if they cannot be put in the secondary latch position.

1. Insert conducting probes into the following terminal pairs on the SAM Cab:
 - X8.1(–) and X8.6(+), driver door
 - X17.5(–) and X8.6(+), passenger door
2. Measure the voltage across the terminal pairs with the door closed and open.
3. Compare the results in **Table 9**.

Dome Lamp Input Values		
Function	Door Status	Acceptable Value
Door Open, Driver-Side	Open	0V
	Closed	BAT Voltage
Door Open, Passenger-Side	Open	0V
	Closed	BAT Voltage

Table 9, Dome Lamp Input Values

4. If one of the doors does not go to 0V with the door open, measure the other door circuit to verify the output from the SAM Cab. Check fuse F13 if the door closed voltage is 0V for both doors.
5. Remove connectors X8 and X17. Perform a continuity test with the door open on the following terminal pairs to check for continuity:
 - X8.6 and X8.1 for circuits 108T and 443
 - X8.6 and X17.5 for circuits 108U and 443
6. If no continuity is found, measure for continuity from the door lock actuator to the SAM Cab.
 - 6.1 Remove the interior door panel.
 - 6.2 Remove the door module.
 - 6.3 Remove the door lock actuator connector.
 - 6.4 Measure for continuity across the following connector pairs:
 - X8.6 and left door lock actuator pin 2, circuit 443

- X8.1 and left door lock actuator pin 1, circuit 108T
- X8.6 and right door lock actuator pin 2, circuit 443
- X17.5 and left door actuator, pin 1, circuit 108U

6.5 If continuity is found for both circuits connected to the door lock actuator, replace the door lock actuator.

704 — MSF Input Troubleshooting

1. Visually confirm the correct MSF switch is installed and is securely fastened.
2. Load ServiceLink.
3. Load the Modular Switch Field ECU screen; navigate to the "Switches" tab.
4. Review the list and confirm the problem switch is present.
5. Press the problem switch and verify the state value changes.
6. Replace as required.

705 — Output Troubleshooting

Dome Lamps

1. Remove the glove box to access the SAM Cab.
2. Insert conducting probes to the problem lamp and measure the voltage
 - X16.11 and X16.15, driver and passenger dome lamp
 - X16.14 and X16.15, rear dome lamp (day cab only)

The driver and passenger dome lamps and rear dome lamp should read BAT voltage when either door is open.

3. Check the door actuator circuit to ensure it is intact.
4. Remove the connector at the problem lamp and measure for voltage at pins B and C on the driver side lamp, A and B on the passenger side lamp, or B and C on the rear dome lamp (day cab only).
5. If BAT voltage is not measured at the lamp connector, remove connector X16 and dome lamp connector to measure for continuity.
6. Isolate the open circuit. Measure for continuity at the following connector pairs:
 - On the driver dome lamp:
 - X16.11 and connector C, circuit 108D
 - X16.15 and connector B, GND
 - On the passenger dome lamp:
 - X16.11 and connector A, circuit 108D
 - X16.15 and connector B, GND
 - On the rear dome lamp:

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- X16.14 and connector C, circuit 108D
- X16.15 and connector B, GND

NOTE: There are interconnects for all of the above circuits. If one of these tests fail, the interconnect should be checked to further isolate the problem. Repair as required.

7. Repair as required.

Reading/Map Lamp

1. Remove the glove box to access the SAM Cab.
2. Insert conducting probes into X16.7 and X16.15 for the map/reading lights and measure the voltage. The voltage measured should be BAT voltage.
3. Make sure the voltage across fuse F35 is measured to be the same as system ground.
4. Remove the connector at the problem lamp and measure the voltage across pins A and B on the driver side, or B and C on the passenger side.
5. If BAT voltage is not measured at the lamp connector, remove connector X16 and the Reading/Map lamp connector to measure for continuity.
6. Isolate the open circuit:
 - Driver side Reading/Map lamp:
 - X16.7 and connector A for circuit 41
 - X16.15 and connector B for circuit GND
 - Passenger-Side Reading/Map Lamp:
 - X16.7 and connector C for circuit 41
 - X16.15 and connector B for circuit GND
 - Rear Dome lamp (premium lighting in day cabs only):
 - X16.7 and connector A for circuit 41
 - X16.15 and connector B for circuit GND

NOTE: There are interconnects for all of the above circuits. If one of these tests fail, the interconnect should be checked to further isolate the problem.

7. Repair as required.

Footwell Lamps

1. Remove the glove box to access the SAM Cab.
2. Insert conducting probes into X12.3 and X12.10 and measure the voltage.
3. The voltage measured for the footwell lights should be BAT voltage when the doors are open.
4. Ensure the footwell lamps are being activated by the door actuator circuits and, with the ignition on, by the footwell lamp switch.
5. Remove the problem lamp.

Dome Lighting

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6. Measure the voltage at the footwell light connector for BAT voltage.
7. If BAT voltage is not seen, remove connector X12 and check the following connector pairs for continuity:
 - X12.3 – Left footwell lamp pin A, circuit 108A
 - X12.10 – Left footwell lamp pin B, GND
 - X12.3 – Right footwell lamp pin A, circuit 108A
 - X12.10 – Right footwell lamp pin B, GND
8. Repair as required.

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
32B	002 447 08 58	SAM Cab Parameter, Standard, Footwell Lighting – Driver/Passenger, Interior Lighting	PARM-CAB, LI, FWL, STD	SAM Cab
	002 447 13 58	SAM Cab Parameter, Premium, Footwell Lighting – Driver/Passenger, Interior Lighting	PARM-CAB, LI, FWL, PRM	
	002 447 87 58	SAM Cab Parameter, Standard, Dome Lamps, Interior Lighting	PARM-CAB, LI, DOL, STD, CL100	
	002 447 88 58	SAM Cab Parameter, Premium, Dome Lamps, Interior Lighting, Theater Lighting	PARM-CAB, LI, DOL, PRM, TH, CL100	
	002 447 89 58	SAM Cab Parameter, Premium, Dome Lamps, Interior Lighting, Dimmable Lighting	PARM-CAB, LI, DOL, PRM, DM, CL100	
67E	002 447 92 58	SAM Cab Parameter, Standard, Entrance Lighting, Interior Lighting	PARM-CAB, LI, ENL, NO DWS, STD	
	002 447 93 58	SAM Cab Parameter, Premium, Entrance Lighting, Interior Lighting	PARM-CAB, LI, ENL, NO DWS, PRM	

Table 10, Parameters

Sleeper Lighting

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500 — Terms and Abbreviations

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

Sleeper lighting includes the group of lamps that provide lighting for the sleeper section when the upper bunk is in the down position, for the lower bunk when the upper bunk is stowed, and inside the cabinets when the doors are opened.

Sleeper lighting includes:

- sleeper roof; overhead lighting
- lower bunk reading light
- writing surface lamp
- baggage compartment lights
- sleeper footwell lights

Sleeper lighting uses three lighting control modes: theater lamps, ECU switched lamps, and locally switched lamps. When a light is activated in the theater lamp control mode, the illumination gradually ramps up from OFF to 100%. When the light is deactivated, the illumination ramps down from 100% to OFF. ECU-switched lamps are switched off and on by the SAM Cab. The SAM Cab receives its input from the sub bus switch to turn the lamp ON or OFF. Locally switched lamps have bulbs and switches that are contained in a single assembly. Locally switched lamps are not multiplexed; the SAM Cab only provides power to the circuit.

The sleeper roof overhead lighting and lower bunk reading lights are activated by multiplexed sub bus switches, and the sleeper footwell lamps use hardwired sub bus switches. The three baggage compartment lights are illuminated when one of the baggage compartment doors are opened or the lower bunk is raised. If either of the baggage compartment doors are open or the lower bunk is raised for longer than 30 minutes, the baggage compartment lights will shut off. The writing surface lamp is switched on and off by pressing the lens assembly of the light.

502 — Sub Bus Switches

There are two types of sub bus switches:

- **Signal-only (multiplexed)**: The MSF Master monitors the sub bus for a signal switch presence, as well as its switch position. That switch position is then provided to other ECUs on the Cabin CAN datalink that use that switch as an input.

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Sleeper Lighting

- **Hardwired (load-interrupting):** The MSF Master monitors the sub bus for a hardwired switch presence only; it does not monitor the switch position of a hardwired switch. Hardwired switches are physically hardwired to the load they are an input for. They are also called "load-interrupting" because they often physically interrupt the load for which they are an input. Compare this to signal switches, which do not connect to anything except for the sub bus.

Differences between signal and hardwired switches:

- **Connection to external circuits:** Hardwired switches are physically connected to the loads they are an input for, as well as to the sub bus. Whereas, Signal Switches are only physically connected to the sub bus (not to any external circuits).
- **Position Information:** Signal switches have their position status (up, down, and middle) viewable in ServiceLink on the MSF icon "Switches" screen. Hardwired switches do not, and must be looked at to know their position status.

For more information on sub bus switches, refer to **G02.06 — Modular Switch Field**.

503 — Lamp Control Modes

Sleeper lighting uses three lamp control modes, locally switched lamps, theater lighting, and ECU switched lamps.

504 — ECU Switched Lamps

ECU-Switched lamps are switched on and off by the SAM Cab. The SAM Cab receives an input from a sub bus switch or a data link message. Lamps controlled by the ECU switched lamps control mode do not ramp on and off like theater lighting.

505 — Locally Switched Lamps

Locally switched lamps are lamps that can be turned on and off through a switch connected in series with the bulb. The switch and bulb are in an integrated assembly. Pressing on the lighting assembly switches the lamp on and off. The SAM Cab only supplies power to the circuit; it does not send any multiplexed signals.

506 — Theater Lighting

Theater lamps are lights that are turned on and off by the SAM Cab. The SAM Cab receives an input from a momentary switch or a datalink message. When the lamp is activated, the lamp's illumination is gradually increased from off to 100% over a short period of time. When the lamp is deactivated, the lamp gradually decreases in illumination from 100% to off, over a short period of time. The parameter "par_reading_lights_ramp_time" stores the value of how long the ramp up and down periods take. For driver comfort, the maximum illumination value of the lamp may be adjusted through the parameter "Par_reading_lights_max_level."

507 — Dimmable Lighting

Dimmable lighting allows the driver to dim the brightness of some interior lights. On a sleeper cab with premium lighting, the lower left and right side reading lamp can be dimmed. To dim the lights, the driver presses and holds the switch that activates the light. While the switch is being pressed, the light decreases and increases in brightness until the switch is released.

The amount of illumination at the time the switch is released is stored as a value by the SAM Cab. If the illumination is less than 30% of the maximum illumination when the switch is released, it will be set at the default level 100%. Press the switch to turn the light off. When the switch is pressed again, the lights will display the amount of brightness they were set to.

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600 — Component Locations

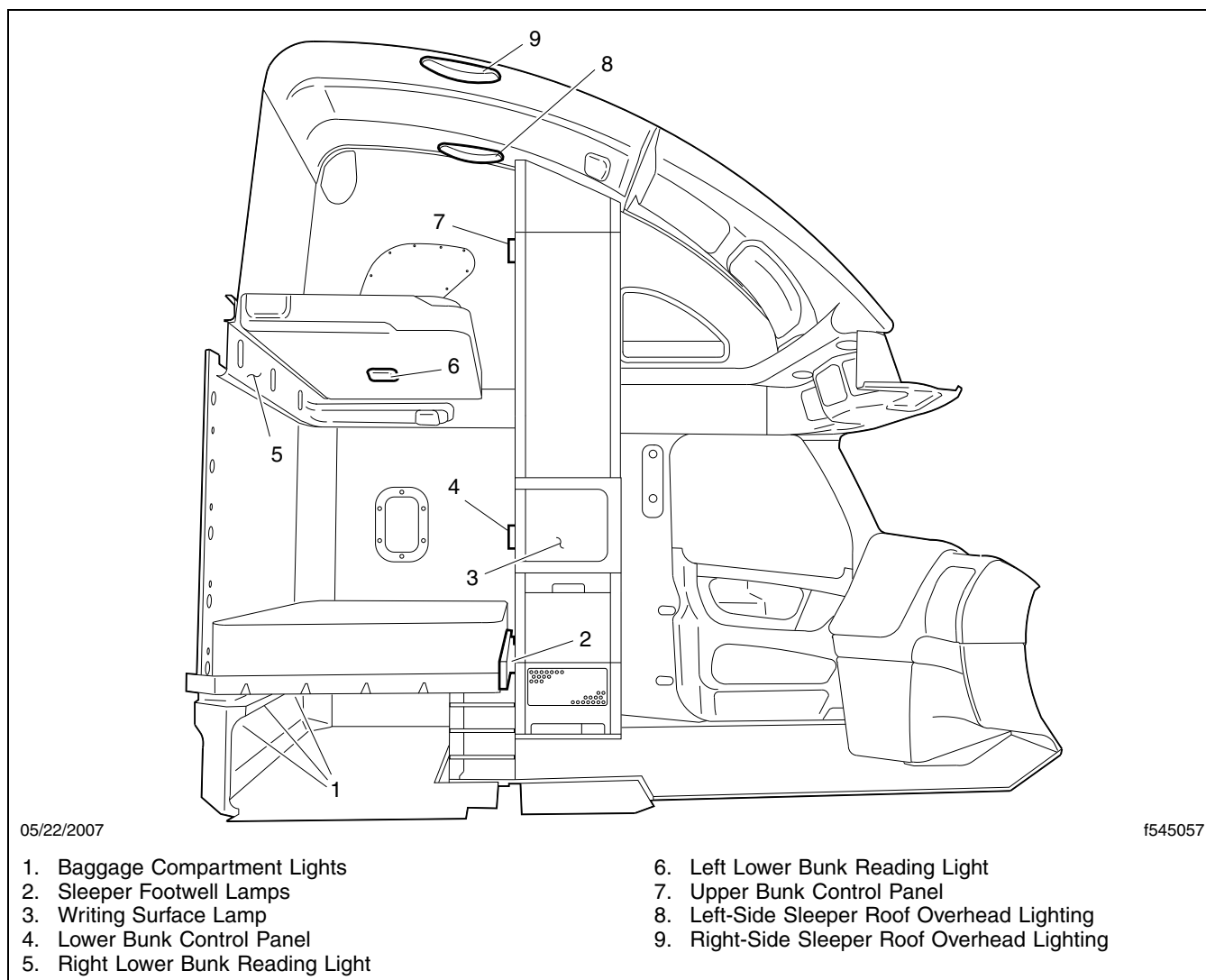


Fig. 1, Component Locations

700 — Troubleshooting Overview

Sleeper lighting is a function controlled by the SAM system. Begin troubleshooting the SAM function in **G02.04 — SAM Cab**.

Before troubleshooting, check battery voltage, fuses, and ECU connectors.

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Sleeper Lighting

701 — Diagnostic Tools Required

- ServiceLink
- Datalink Monitor
- Digital Multimeter

702 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521306	4	conn X12 pin 6	—	—	Reading lamp 1, zone 9 – Voltage below normal, or shorted to low source.	The current detected at conn X12 pin 6 is higher than 4.3A when reading light 1 is active. The fault becomes historic when the current is below 3.3A.
Action: Measure the voltage at conn X12 pin 6. Troubleshoot circuit 504E for a short to GND. Troubleshoot circuit 504E and GND3 between the SAM Cab and lamp for an open circuit. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521309	4	conn X12 pin 9	—	—	General sleeper lamp, zone 4b – Voltage below normal, or shorted to low source.	The current detected at conn X12 pin 9 is higher than 9.3A when general sleeper lighting is active. The fault becomes historic when the current is below 5.2A.
Action: Measure the voltage at conn X12 pin 9. If the voltage detected is 0V, troubleshoot circuit 504B for a short to GND. Check the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521312	3	conn X12 pin 12	—	—	Rear baggage compartment lights – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X12 pin 12 is higher than 4.5V. The fault becomes historic when the voltage detected is lower than 1.5V.
Action: Measure the voltage at conn X12 pin 12. If BAT voltage is detected, troubleshoot circuit 113A for a short to BAT. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521312	4	conn X12 pin 12	—	—	Rear baggage compartment lights – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X12 pin 12 is greater than 3.5A and the rear baggage compartment lights are active. The fault becomes historic when the current detected is below 2.8A.
Action: Activate the baggage compartment lights, measure the voltage across conn X12 pin 12. If BAT voltage is not detected, troubleshoot circuit 113A for a short to GND. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

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CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521316	4	conn X12 pin 16	—	—	Reading lamp 2, zone 5 – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X12 pin 16 is greater than 3.5A. The fault becomes historic when the current detected is below 2.8A.
Action: Activate reading lamp 2, measure the voltage across conn X12 pin 16. If BAT voltage is not detected, troubleshoot circuit 504D for a short to GND. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521317	4	conn X12 pin 17	—	—	Rear dome lamp, zone 4c – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X12 pin 17 is higher than 4.2A. The fault becomes historic when the current detected is below 3.3A.
Action: Activate the rear dome lamp. Measure the voltage across conn X12 pin 17. If BAT voltage is not detected troubleshoot circuit 504C. Repair as required. Troubleshoot the lamp for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

Table 1, CAN Fault Codes

703 — Input Troubleshooting

General Sleeper Switches

1. Verify the operation of the switches using ServiceLink.

- 1.1 Visually verify the correct switches are present on the MSF.
- 1.2 Load ServiceLink.
- 1.3 Navigate to the MSF "Switches" screen.
- 1.4 Review the list and identify the suspect switch. If the switch is not communicating with the MSF, it will be marked as "missing." If this is the case, the switch may be damaged, or not be connected securely.

Are any switches missing from the list?

YES → Remove the switch and install a test switch (a known good switch). Retest substeps 1.2 through 1.4. If the test switch reports in ServiceLink, replace the faulty switch.

NO → Test the switch to verify it is functional.

Go to test 2 if the switch is a multiplexed switch.

Go to test 3 if the switch is a hardwired switch.

To determine if the switch is hardwired or multiplexed, refer to the "Switches" screen in ServiceLink. Switch IDs 1–150 are multiplexed, all others are hardwired. The word "Hardwired" will be displayed in the "Switches" screen "Position" column for all hardwired switches.

2. Test the multiplexed switches.

For multiplexed switches, press and hold the switch. The switch will change state from "not pressed" to "up" on the Switches screen.

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Does the switch change state?

YES → Install all switches and perform a functional test to confirm operation. Continue troubleshooting as needed.

NO → Remove the switch and install a known good switch and retest. If the switch state changes in ServiceLink, replace the faulty switch. Verify functionality using Datalink Monitor Template "Sleeper lighting." Continue troubleshooting as needed.

3. Test the hardwired switches.

3.1 Load ServiceLink.

3.2 Navigate to the MSF "Switches" screen.

3.3 Remove the switch from the MSF Slave.

3.4 Press the switch to the "on" position.

3.5 Using a multimeter on the resistance setting, measure for continuity (under 1k ohms) across pins 1 and 3.

Is there continuity on the hardwired switch in the ON position?

YES → Replace the switch with a known good test switch and retest. If the test switch functions, replace the faulty switch.

NO → Replace the switch and perform a functional test to confirm operation. Verify functionality with Datalink Monitor template "Sleeper Lighting." Refer to **703 — Output Troubleshooting** for additional troubleshooting steps.

For more information on MSF switch troubleshooting, refer to **G02.06 — Modular Switch Field**.

Baggage Compartment Switches

This coverage applies to the baggage compartment and the writing surface light. The inputs for the baggage compartment are the bunk switch or the baggage compartment door switches.

1. Measure the voltage across the input pins for the baggage compartment.

1.1 Insert conducting probes into the input pins for the baggage compartment switches:

- X16.17 and X12.2 for circuit 113F
- X16.17 and X12.1 for circuit 113G
- X16.17 and X12.5 for circuit 113H

1.2 Measure the voltage across the pins.

Does the voltage read BAT voltage?

YES → Go to test 2.

NO → Check fuse F34. Replace as needed.

2. Verify switch operation.

2.1 Insert conducting probes into the terminals.

2.2 Switch the light on by lifting the bunk and opening the baggage compartment door.

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- 2.3 Measure the voltage.

Did the voltage change from BAT voltage to 0V?

YES → Inspect connector terminals for corrosion. Retest circuit for an intermittent problem. Continue testing as needed.

NO → Go to test 3.

3. Check switch circuits for open circuits.

- 3.1 Remove the SAM Cab connector for the affected light.

- 3.2 Remove the connector for the light switch and measure for continuity. See **Table 2** for the applicable circuit.

Is there a low resistance?

YES → Connect all connectors to the switches and lights, and perform functional tests to determine if it is intermittent. Troubleshoot the baggage compartment switches and the writing surface light switch.

NO → Repair the open circuit or replace the bulb as necessary.

Switch Name and Terminal Location	
Switch	Location
Right baggage compartment switch	Terminal A to X16.17 for circuit 113
	Terminal B to X12.5 for circuit 113H
Center baggage compartment switch	Terminal A to X16.17 for circuit 113
	Terminal B to X12.1 for circuit 113G
Left baggage compartment switch	Terminal A to X16.17 for circuit 113
	Terminal B to X12.2 for circuit 113F

Table 2, Switch Name and Terminal Location

704 — Output Troubleshooting

1. Measure the voltage from the suspected light.

- 1.1 Turn the affected light on.
- 1.2 Insert a conducting probe into the SAM Cab for the circuit being tested.
- Rear Dome Light: X12.6, X12.8
 - Lower Bunk Light (driver side): X12.16, X12.8
 - General Sleeper Light (passenger side): X12.9, X12.11
 - General Sleeper Light (Driver Side): X2.5, X12.17
 - Writing Surface Light: X2.15, X2.5
 - Sleeper Footwell Light: X2.15, X2.5
 - Rear Baggage Compartment Light: X12.12, X12.14
- 1.3 Measure the voltage across the connectors when the light is switched on.

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Sleeper Lighting

Are any switches missing from the list?

YES → Go to test 2.

NO → The output signal is not available. Check the SAM Cab parameters and verify that the correct sleeper lighting parameters are applied to the vehicle. Verify that the fuses for the circuit are still functional.

2. Isolate the open circuit.

2.1 Remove the SAM Cab connector to the suspected light circuit.

2.2 Remove the connector to the suspected light.

2.3 Measure the resistance in the harness. See **Table 3** for the applicable circuit.

YES → Attach all the terminals and connectors. Perform a functional test to verify it is not an intermittent problem. If the problem still exists, check with Datalink Monitor template "Sleeper Lighting" and evaluate functionality.

NO → Repair the harness with the affected circuit or replace the bulb as necessary.

Switch Name and Terminal Location	
Switch	Location
Forward dome light	X12.6 to terminal A for circuit 504A
	X12.8 to terminal B for circuit GND3
Lower bunk reading light (driver side)	X12.16 to terminal A for circuit 504D
	X12.8 to terminal B for circuit GND3
Lower bunk reading light (passenger side)	Terminal A to back of lower bunk switch pin 3 for circuit 504E
	X2.15 to Lower bunk switch harness terminal 1 for circuit 504F
	Lower bunk switch harness terminal 1 – X2.15 for circuit 504F
	X2.5 – terminal B – circuit GND4
Rear dome light/upper bunk reading light (driver side)	X12.9 to terminal A for circuit 504B
	X12.11 to terminal B for circuit GND5
Rear dome light (passenger side)	X2.5 to terminal A for circuit 504C
	X12.17 to terminal B for circuit GND4
Writing surface light	X2.15 to terminal A for circuit 504F
	X2.5 to terminal B for circuit GND4
Sleeper footwell light, left	X2.15 to Footwell switch harness terminal 3 for circuit 504F
	Footwell switch harness terminal 1 to terminal A for circuit 108A
	X2.5 to terminal B for circuit GND4
Sleeper footwell light, right	X2.15 to foot well switch harness terminal 3 for circuit 504F
	Footwell switch harness terminal 1 to terminal A for circuit 108A
	X2.5 – terminal B for circuit GND4

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Switch Name and Terminal Location	
Switch	Location
Right baggage compartment light	X12.12 – terminal A for circuit 113A
	X12.14 – terminal B for circuit GND
Center baggage compartment light	X12.12 to terminal A for circuit 113A
	X12.14 to terminal B for circuit GND
Left baggage compartment light	X12.12 to terminal A for circuit 113A
	X12.14 to terminal B for circuit GND

Table 3, Switch Name and Terminal Location

800 — Parameters

Parameters				
Module	Part	Description	Parameter	ECU
32C	000 447 58 23	The vehicle is equipped with Rear footwell Lamp, ID196, hardwired sub bus switch.	PARM-MSF, HWD, REAR FTWELL LP	MSF
32C	000 447 92 23	The vehicle is equipped with Reading Lamp Lower Right, ID074, multiplexed sub bus switch.	PARM-MSF, MUX, LOW SLPR LMP, BNK	MSF
32C	001 447 20 23	The vehicle is equipped with Lower Bunk Reading Lamp, ID123, multiplexed sub bus switch.	PARM-MSF, MUX, READ LMP BUNK LOW	MSF
32C	001 447 22 23	The vehicle is equipped with Dome Lamp, Dash, ID199, Hardwired sub bus switch.	PARM-MSF, MUX, RR DOME LMP, BUNK	MSF
32C	001 447 28 23	The vehicle is equipped with Upper sleeper lamp, bunk, ID111, multiplexed sub bus switch.	PARM-MSF, MUX, UP SLPR LMP, BUNK	MSF
32C	001 447 97 23	The vehicle is equipped with Dome Lamp, Bunk, ID195, Hardwired sub bus switch.	PARM-MSF, HWD, RR DM LMP, DASH	MSF
32C	003 447 54 58	SAM Cab Parameter, Dimmable, Interior Lighting, Step Sleeper Lighting, Sleeper.	PARM-CAB, LI, SPR, STP, DM	SAM Cab
32C	002 447 15 58	SAM Cab Parameter, Interior Lighting, Sleeper.	PARM-CAB, LI, SPR	SAM Cab
32C	002 447 17 58	SAM Cab Parameter, Dimmable Interior Lighting, Sleeper.	PARM-CAB, LI, SPR, DM	SAM Cab

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Sleeper Lighting

Parameters				
Module	Part	Description	Parameter	ECU
32C	002 447 84 58	SAM Cab Parameter, Interior Lighting, Step Sleeper Lighting, Sleeper, Theater.	PARM-CAB, LI, SPR, STP, TH	SAM Cab
32C	002 447 94 58	SAM Cab Parameter, Baggage Compartment Lamps, Day Cab, Interior Lighting.	PARM-CAB, LI, BCL, LS, DYCB	SAM Cab

Table 4, Parameters

Panel Backlighting

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500 — Terms and Abbreviations

ECU—Electronic Control Unit, typically connected to a datalink.

Maintained/Latching Switch—A switch that remains in the depressed position after being pushed.

Momentary Switch—A switch that returns to the neutral position after being pushed.

MSF—Modular Switch Field

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

Panel Backlighting is the illumination of the ICU and various switch legends on the vehicle instrument panel, and auxiliary control panels in the sleeper section. The following panels are backlit:

- Instrumentation Control Unit
- Front and Rear HVAC Control Panel
- MSF Switches
- Headlight Controls
- Lower and Upper Bunk Control Panels

Backlighting is controlled by a pulse width modulated signal from the SAM Cab. The signal is a constant 125Hz. The duty cycle of the signal determines the illumination intensity from 10% (lowest intensity) to 90% (brightest intensity).

There are four lighting modes for backlighting:

- Daytime
- Nighttime
- Accessory
- Marker Interrupt

Each lighting mode has an independent illumination value, which is stored in the SAM Cab. When the lighting mode transitions from inactive to active, the SAM Cab broadcasts the illumination value of that lighting mode on the datalink to determine the level of brightness. For more information on lighting modes, refer to **Table 1**.

All lighting modes use either hardwired pins or the sub bus message.

NOTE: When the driver or passenger door is open, panel backlighting illumination increases to 100%. It will remain at this value regardless of what lighting mode is active, until the doors are closed. Once the doors are closed, the active lighting mode will take priority and illuminate the panel backlighting accordingly.

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Panel Backlighting

Backlighting Modes		
Lighting Mode	Active Conditions	Illumination Value
Daytime	Active when the headlamp switch position is OFF.	The illumination value of the panel backlighting is controlled by the increment/decrement rocker switch.
Nighttime	Active when the headlamp switch is not OFF.	The illumination value of the panel backlighting is controlled by the increment/decrement rocker switch.
Accessory	This mode is active when the ignition switch is in the ACC position.	The illumination value is at a brightness set by parameter "par_backlighting_acc_mode_dim_value".
Marker Interrupt	This mode is active when pressing the marker interrupt switch.	If the panel lamps are ON when the marker interrupt mode becomes active, they will be de-energized. If the Panel lamps are OFF when the marker interrupt mode becomes active, they will be energized.

Table 1, Backlighting Modes

The following modes take priority in the order shown when more than one lighting mode is active:

1. Marker Interrupt Mode
2. Accessory Mode
3. Daytime/Nighttime Mode

502 — Lamp Control Modes

Panel backlighting uses two lamp control modes: ECU switched lamps and theater lighting.

503 — ECU Switched Lamps

ECU switched lamps can be switched on and off by an ECU. The ECU receives an input from a remote momentary switch or a datalink message. There are only two levels of operation, on or off.

504 — Theater Lighting

Theater lighting is switched on and off by the SAM Cab. The SAM Cab receives an input from a momentary sub bus switch or a datalink message. When the lamp is activated, illumination is gradually increased from OFF to 100% over a period of time set by a parameter. When the lamp is deactivated, illumination gradually decreases from 100% to OFF over a period of time set by a parameter. The parameter "par_backlighting_ramp_time" stores the value of the length of the ramp up and ramp down periods. The maximum illumination value of the panel lamps in accessory mode may be adjusted through the parameter "par_backlighting_ramp_time."

600 — Component Locations

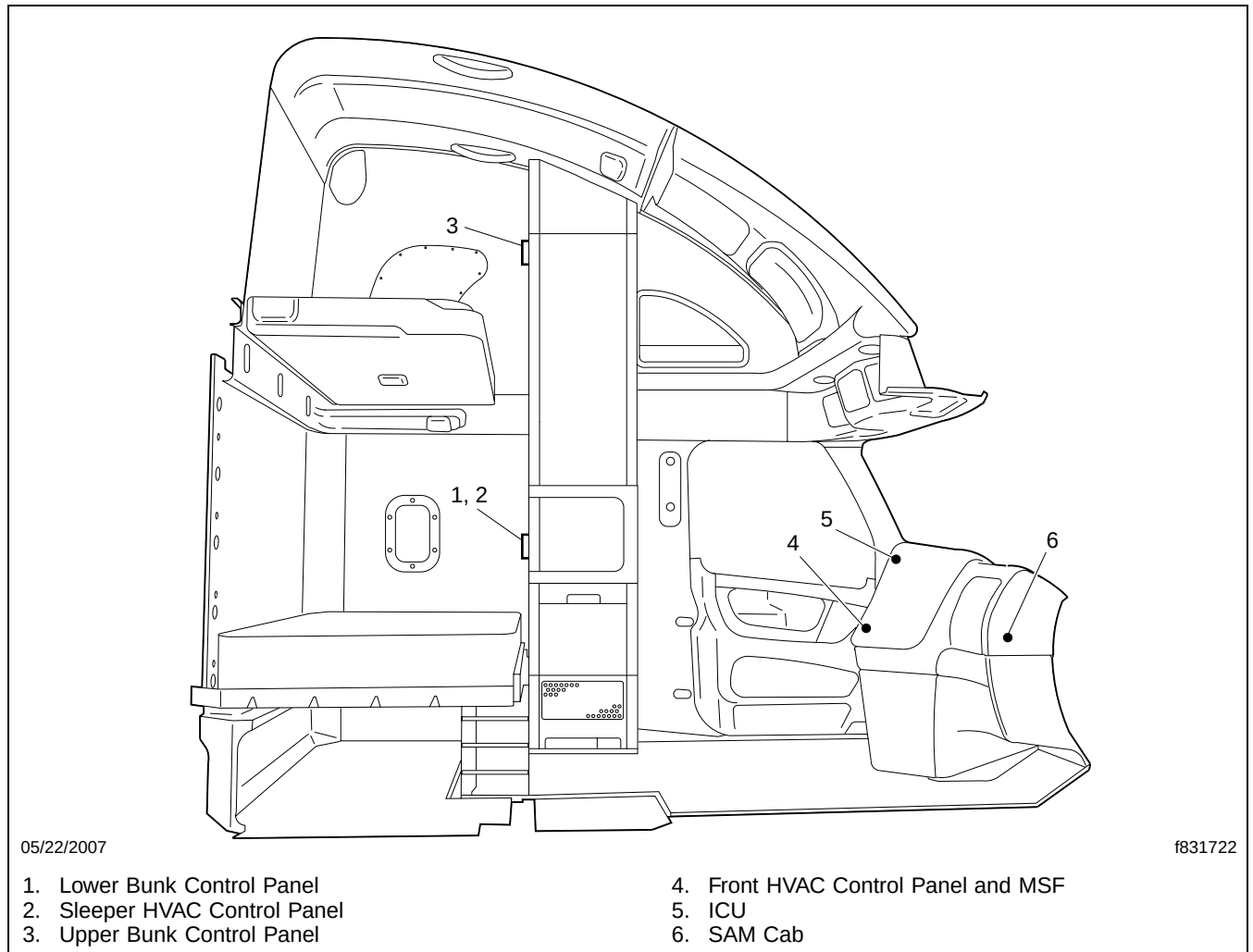


Fig. 1, Component Locations

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601 — Component Details

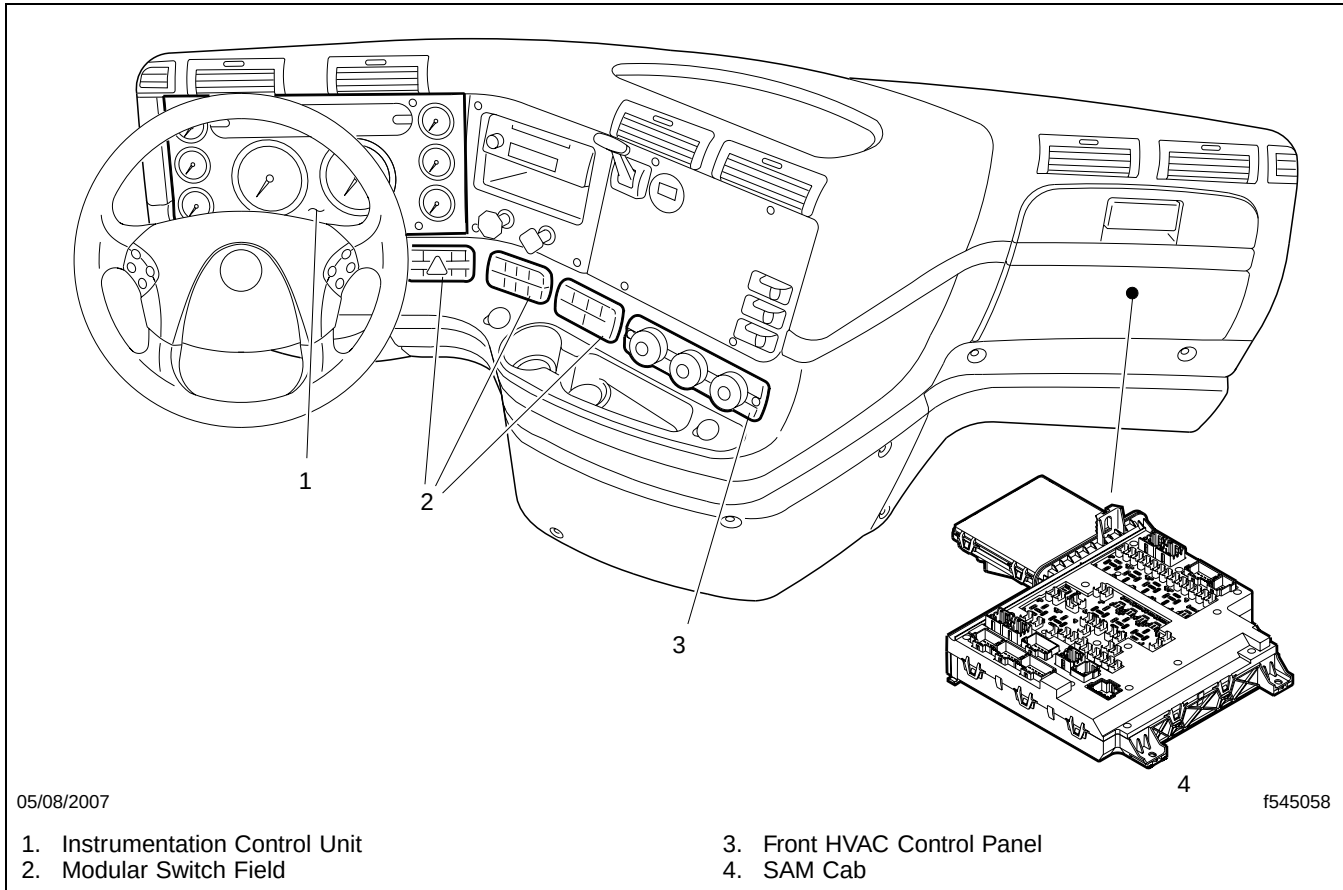


Fig. 2, Component Details

Panel Backlighting

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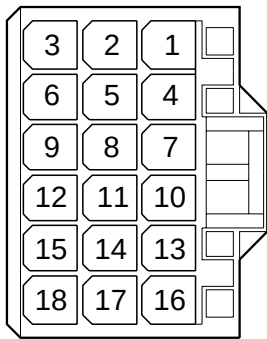
SAM Cab Connector X10		
 04/15/2009 f545507		
Pin	Circuit	Description
4	GND	Panel Lamps,GND
13	29A	Panel Lamps, 12V

Table 2, SAM Cab Connector X10

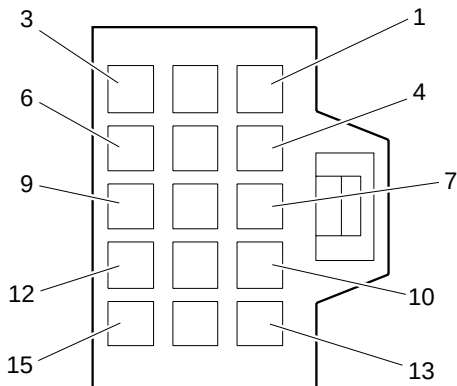
SAM Cab Connector X13		
 05/10/2007 f545030		
Pin	Circuit	Description
5	52B	Ignition Switch, Accessory
6	52D	Ignition Switch, ON (ignition)
7	52	Ignition Switch, BAT

Table 3, SAM Cab Connector X13

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Panel Backlighting

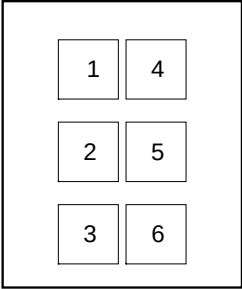
HVAC and Auxiliary HVAC Connectors		
 01/23/2009 f545435		
Pin	Circuit	Description
3	29A	Panel Lamps, BAT

Table 4, HVAC and Auxiliary HVAC Connectors

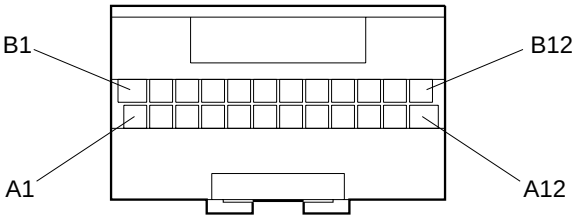
ICU 24-Pin Connector		
 01/23/2009 f545436		
Pin	Circuit	Description
A1	29A	Panel Lamps, BAT

Table 5, ICU 24-Pin Connector

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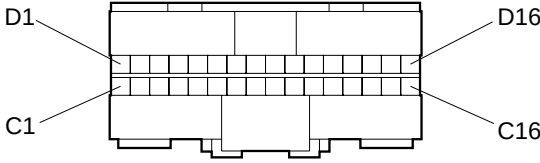
ICU 32-Pin Connector		
 Diagram of the ICU 32-Pin Connector. The connector is shown from a top-down perspective. Pins are labeled D1, D16, C1, and C16. D1 and D16 are on the top row, while C1 and C16 are on the bottom row. The connector has a central block and two side blocks.		
01/23/2009 f545437		
Pin	Circuit	Description
D3	GND	Panel Lamps, GND

Table 6, ICU 32-Pin Connector

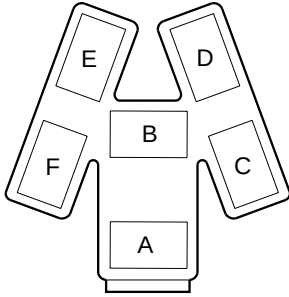
Ignition Switch		
 Diagram of the Ignition Switch. The switch is shown from a top-down perspective. Terminals are labeled A, B, C, D, E, and F. A is at the bottom, B is in the center, C is on the right, D is on the top right, E is on the top left, and F is on the left. The switch has a central block and two side blocks.		
01/23/2009 f545434		
Pin	Circuit	Description
A	52	Ignition Switch, BAT
D	52D	Ignition Switch, ON
E	52B	Ignition Switch, Accessory

Table 7, Ignition Switch

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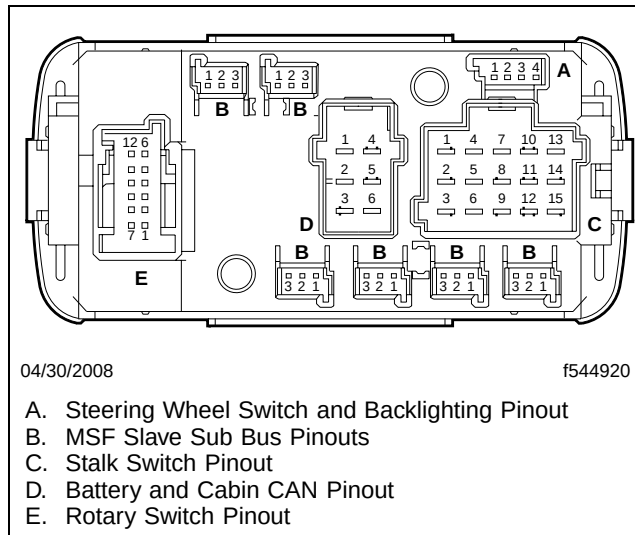


Fig. 3, MSF Master Connection Locations

MSF Connector A Pinout	
Pin	Function
2	Backlighting PWM
4	Ground

Table 8, MSF onnector A Pinout

MSF Connector B Pinout	
Pin	Function
1	Battery Supply from MSF Master
2	Sub Bus Signal from MSF Master
3	Ground from MSF Master

Table 9, MSF Connector B Pinout

Connector D Pinout	
Pin	Function
1	—
2	Battery Power
3	Cabin CAN Low
4	—
5	Cabin CAN High
6	Ground

Table 10, Connector D Pinout

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Connector E Pinout	
Pin	Function
1	Battery Power
2	Binary Code Input 1 (BC1)
3	Binary Code Input 2 (BC2)
7	Backlighting PWM
12	Ground

Table 11, Connector E Pinout

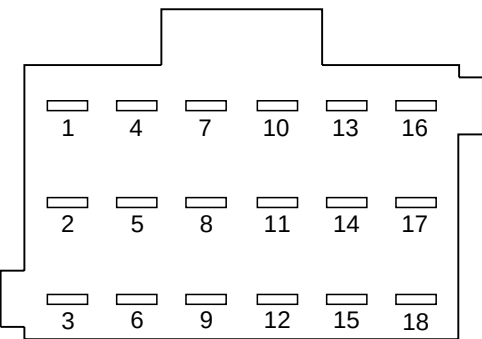
Starpoint Connector	
	
12/04/2006 f544912	
Pin	Function
10	Cabin CAN High
12	Cabin CAN Low
17	Ground

Table 12, Starpoint Connector

Rotary Switch Pinout	
Pin	Function
1	Binary Code 1
2	Binary Code Common
3	Version
4	Fog Lamps/Road Lamps
5	Binary Code 2
6	Backlighting
7	Ground
8	Battery Power

Table 13, Rotary Switch Pinout

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MSF Slaves	
Pin	Function
1	Battery Power
2	Sub Bus Signal
3	Ground

Table 14, MSF Slaves

700 — Troubleshooting Overview

Check all harness connectors before troubleshooting.

Panel backlighting is a function controlled by the SAM system. Begin troubleshooting this SAM function in section **G02.04 — SAM Cab, 700 — Logic Controlled Unfused Outputs**.

701 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor
- Digital Multimeter

702 — CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521113	4	conn X10 pin 13	—	—	Panel lamps 12 volt – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X10 pin 13 is higher than 9.3A. The fault becomes historic when the current detected is less than 5.2A.
Action: With the panel lamps active, measure the voltage at conn X10 pin 13. If BAT voltage is not detected, troubleshoot circuit 29A for a short to GND. Check circuit 29A between conn X10 pin 13 and ICU pin A1 for continuity. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	521117	4	conn X10 pin 17	—	—	Wake-up (instrument cluster) – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X10 pin 17 is higher than 2A. The fault becomes historic when the current detected is less than 0.2A.
Action: Turn the headlamp switch to the ON 2 position. Measure the voltage at conn X10 pin 17. If the voltage detected is not BAT voltage, troubleshoot circuit 359 between conn X10 pin 17 and ICU pin D16 for a short to GND. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
49	520607	4	conn A pin 2 conn E pin 7	—	—	Backlighting – Voltage below normal or shorted to low source.	Backlighting on the steering wheel switches and the headlamp switch are not functioning
Action: Troubleshoot for a short to GND in circuit 29A between MSF connector E, pin 7, and headlight switch pin 6. Troubleshoot for a short to GND in circuit 474BA2 between MSF connector A (steering wheel switches connector) pin 2 and the steering wheel switch pin 6. Repair as required.							

Table 15, CAN Fault Codes

703 — Input Troubleshooting

Panel Backlighting is influenced by entrance lighting, ignition switch position, the headlight switch position, the marker interrupt switch, and the driver/passenger door.

Daytime Mode

Conditions:

- Ignition switch – ON
- Headlight switch – OFF position

Nighttime Mode (door closed)

Conditions:

- Ignition Switch – ON position
- Headlight Switch – ON

Accessory Mode (door closed)

Conditions:

- Ignition Switch – Transitions from OFF to ACCESSORY
- Headlight switch – Position does not affect accessory mode

Marker Interrupt Mode (door closed)

Conditions:

- Marker interrupt switch is pressed

NOTE: The illumination level of the panel lamps remains at 100% while the doors are open, regardless of what lighting mode is currently active.

1. Identify the lighting mode and verify that it is functioning correctly.

- 1.1 Load Datalink Monitor template "Panel Backlighting" and connect to the vehicle.
- 1.2 Cycle through each lighting mode to see if it activates with the MSF increment/decrement switch.
- 1.3 Increase and/or decrease the panel lamp illumination and verify the values change. The illumination value of each lighting mode should be stored in SAM Cab memory, so the value should be present when that lighting mode is active again.

NOTE: The illumination value for "Accessory Mode" does not change when the panel lamps increment/decrement sub bus switch is pressed.

Are any lighting modes inactive?

YES → Go to test 2.

NO → Check all ECU connectors and verify that the ignition switch is functioning. Determine if the error was an intermittent problem.

2. Check the lighting mode and verify that the interlocks are met.

- 2.1 With Datalink Monitor template "Panel Backlighting" loaded, activate the affected lighting mode.
- 2.2 Verify that the lighting mode becomes active on the template.

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2.3 Measure the voltage on the SAM Cab and MSF terminals indicated in **Table 16**. Compare with values shown in **Table 16**.

- **MSF connector E (headlight switch):**

- Remove the MSF from the dash.
- Disconnect connector E from the MSF.
- Remove the lock from the connector to expose the back of the connector.
- Depending on the lighting mode being tested, measure the voltage in the following terminals and compare with the values given.

- **MSF connector A (marker interrupt switch):**

- Remove the MSF from the dash.
- Insert a conducting probe into terminal 2 (+) and 4 (–).
- Measure the voltage of the terminals given in the table below.

- **SAM Cab connector X13 (ignition switch):**

- Using a long battery cable, connect the negative probe of the multimeter to the negative post on the vehicle battery.
- Insert a conducting probe into the terminal specified in **Table 16** and measure this with the positive probe on the multimeter.

Input Measurements								
Lighting Mode	Headlight Switch Position	Ignition Switch Position	MSF Connector A	MSF Connector E		SAM Cab		
			Terminal 2 (+) Terminal 4 (–)	Terminal 2 (+) Terminal 12 (–)	Terminal 3 (+) Terminal 12 (–)	X13.5	X13.6	X13.7
Daytime	OFF	ON	—	0V	0V	BAT	BAT	BAT
Nighttime	1	ON	—	12V	0V	BAT	BAT	BAT
	2	ON	—	12V	12V	BAT	BAT	BAT
Accessory	—	ACC	—	—	—	BAT	BAT	BAT
Marker Interrupt	—	ON	12V	—	—	BAT	BAT	BAT

Table 16, Input Measurements

Are there any measurements outside of the ranges?

YES → Go to test 3 for the ignition switch. Go to test 4 for the headlight switch. Go to test 5 for the marker interrupt switch .

NO → Connect all connectors and verify functional operation to determine if it is an intermittent problem. Test the lighting mode with Datalink Monitor template "Sleeper Lighting." Load "MSF Switches: Hazard, Rotary, Stalk, Steering Wheel" to troubleshoot the headlight and steering wheel switches. Continue troubleshooting inputs as necessary.

3. Locate open circuit in the ignition switch.

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- 3.1 Remove connector X13 from the SAM Cab.
- 3.2 Remove the connector from the back of the ignition switch.
- 3.3 Measure the resistance between the following terminal pairs:
 - Ignition switch terminal A – X13.7 (ignition switch BAT)
 - Ignition switch terminal D – X13.6 (ignition on)
 - Ignition switch terminal E – X13.5 (accessory)

Is low resistance detected?

YES → Connect the connectors and perform a functional test to determine whether the problem is intermittent. If the problem still exists, go back to the Datalink Monitor template and evaluate the operation of the panel backlighting.

NO → Repair the harness with the open circuit.

4. Locate open circuit in the headlight switch.

- 4.1 Remove the MSF from the dash.
- 4.2 Disconnect connector E from the MSF.
- 4.3 Remove the lock from the connector to expose the back of the connector.
- 4.4 Insert the connector into the MSF.
- 4.5 Measure the resistance between the terminal pairs below.
 - Headlamp Switch Terminal 1; MSF Connector E, Terminal 2
 - Headlamp Switch, Terminal 5; MSF Connector E, Terminal 3
 - Headlamp Switch, Terminal 6; MSF Connector E, Terminal 7
 - Headlamp Switch, Terminal 7; MSF Connector E, Terminal 12
 - Headlamp Switch, Terminal 8; MSF Connector E, Terminal 1

Is there a low resistance detected?

YES → Install the connectors and perform a functional test to determine whether the problem is intermittent. If the trouble still exists replace the headlight switch.

NO → Repair the harness with the open circuit.

5. Locate open circuit in the marker interrupt switch.

- 5.1 Remove the MSF from the dash.
- 5.2 Disconnect Connector A from the MSF.
- 5.3 Remove the connector from the clock spring.
- 5.4 Measure the resistance between the terminals:
 - MSF connector A, terminal 2; Clock spring connector terminal 6
 - MSF connector A, terminal 4; Clock spring connector terminal 4

Is there a low resistance detected?

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Panel Backlighting

YES → Install the connectors and perform a functional test to determine whether the problem is intermittent. Load DataLink Monitor Template "MSF Switches: Hazard, Rotary, Stalk, Steering wheel" for additional troubleshooting for the marker interrupt switch.

NO → Repair the harness with the open circuit.

704 — Output Troubleshooting

Backlighting illumination for the MSF Master and slaves is separate from the ICU, air switches, and HVAC units.

The output for MSF backlighting is through a datalink message. The output for the ICU, dash switches, and HVAC controls is through SAM Cab pins X10.13 and X10.4.

705 — Dash Light Troubleshooting (not MSF related)

1. Measure the voltage from the SAM Cab output.

- 1.1 Insert a conducting probe into terminals X10.13 (+) and X10.4 (–)
- 1.2 Activate the panel lamps.
- 1.3 Measure the voltage between terminals X10.13 and X10.4

Is panel backlighting voltage between 3.6 and 12.4 volts when the illumination is between 10 and 100% brightness?

YES → Go to test 2.

NO → Using Datalink Monitor template "Panel Backlighting" and Input Troubleshooting, determine if the input interlocks are met to activate the panel backlighting output.

2. Perform a continuity test.

Select the appropriate circuit and measure the resistance:

- X10.13 to ICU, connector A1
- X10.4 to ICU, connector D3
- X10.13 to HVAC, terminal 3
- X10.13 to right door, terminal 6
- X10.13 to left door, terminal 8
- X10.13 to Auxillary HVAC, terminal 3
- X10.13 to back panel illumination splice pack 1, terminal A
- Back panel illumination splice pack 1, terminal B to back panel illumination splice pack 2, terminal A
- X10.4 to switch and gauge ground splice pack 1, terminal A
- X10.4 to switch and gauge ground splice pack 2, terminal A

Is there a low resistance?

YES → Go to test 3.

NO → Repair the open circuit. Connect all connectors and perform a functional test. Continue troubleshooting as needed.

3. **Test the illuminating device.**

Remove the component that is not illuminating. Install a known good one and test again.

Does the test component illuminate?

YES → Replace the device.

NO → Perform a functional test of the panel lamps to determine whether the problem is intermittent. Check all connectors and make they are secure.

706 — MSF Panel Lamp Incremental/Decremental Sub Bus Switch Troubleshooting

Perform MSF switch troubleshooting if the panel backlighting sub bus switch does not increase or decrease the illumination.

1. **Test the affected switch.**

2. Make sure the doors are closed and that the panel lamps are not in ACCESSORY mode.

2.1 Load ServiceLink and connect to the vehicle.

2.2 Navigate to the MSF "Switches" screen.

2.3 Locate the affected switch on the list. If the switch is not communicating with the MSF, it will be listed as "missing."

Are any switches missing from the list?

YES → With the vehicle powered down, remove the switch and install a known good switch. Power up the vehicle and repeat the test. If the test switch reports, replace the affected switch.

NO → Make sure that the switch is properly seated. Press and hold the switch in the "up" and "down" positions to see if it changes the state on the "Switches" screen. If the switch does not change state, replace it.

707 — MSF Backlighting Troubleshooting

The backlighting for the MSF Master, slaves, and headlight switch is provided by a datalink message from the SAM Cab to the MSF Master. If the input conditions are met, the SAM Cab broadcasts the state of the panel lamps.

1. Turn on the panel lamps by selecting any lighting mode.

2. Observe the panel lamps on all MSF slave control panels and the headlight switch.

Go to **708 — MSF Sub Bus Switch Illumination Troubleshooting** if the panel lamps are not illuminating some of the controls on the MSF slaves.

Go to **709 — Headlight Switch Illumination Troubleshooting** if the headlight switch is not illuminating.

Go to **710 — CAN Wiring Troubleshooting** if ALL of the panel lamps on the MSF are not illuminating.

708 — MSF Sub Bus Switch Illumination Troubleshooting

Troubleshoot the sub bus components if some of the switches on the slave control panels are not illuminating. If the sub bus switches are not illuminating, make sure the switch is communicating on datalink.

1. **Make sure the sub bus switch is connected.**

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Panel Backlighting

1.1 Load ServiceLink and connect to the vehicle.

1.2 Navigate to the MSF "Switches" screen.

1.3 Find the affected switches on the list.

Is the suspect switch being reported as "available" on the switches screen (does it appear as a white row)?

YES → Check the switch to see if it is properly seated in the control panel. If the problem continues, replace the switch.

NO → Go to test 2.

2. Test the switch with a known good slave control panel.

2.1 Disconnect ServiceLink from the vehicle. Power down the vehicle then disconnect the batteries.

2.2 Remove the affected slave control panel from the dash.

2.3 Remove all of the sub bus switches from the affected slave control panel.

2.4 Install the test slave control panel and install all switches from the affected control panel.

2.5 Connect the batteries and power up the vehicle.

2.6 Connect ServiceLink to the vehicle.

2.7 Navigate to the MSF "Switches" screen."

Is the affected switch being reported as "available" on the switches screen (does it appear as a white row)?

YES → Replace the affected control panel.

NO → Go to test 3.

3. Check the sub bus wiring.

3.1 Disconnect ServiceLink from the vehicle.

3.2 Power down the vehicle then disconnect the batteries.

3.3 Remove the affected slave control panel from the dash.

3.4 Connect the batteries and power up the vehicle.

3.5 Turn the ignition to the ON position.

3.6 Insert conducting probes and measure the voltage for the following terminal pairs:

- Sub bus wiring, terminal 1 and 3
- Sub bus wiring, terminal 2 and 3

Is the voltage for terminal 1 and 3 12 volts, and the voltage for terminal 1 and 2 5 volts?

YES → Connect all Slave control panels and switches. Perform a functional test to determine whether the problem is intermittent.

NO → Go to test 4.

4. Test sub bus wiring.

Perform a continuity test between the sub bus harness connected to the affected control panel.

Is there a low resistance?

YES → Refer to DataLink Monitor template "Panel Backlighting" to verify that the interlocks for the panel backlighting system are being met for the panel lamps to illuminate.

NO → Replace the sub bus wiring. Connect all switches and slave control panels and perform a functional test. Continue troubleshooting as needed.

709 — Headlight Switch Illumination Troubleshooting

1. Test the headlight switch.

- 1.1 Remove the MSF from the dash.
- 1.2 Disconnect connector E from the MSF.
- 1.3 Remove the lock from the connector to expose the back of the connector.
- 1.4 Attach the connector to the MSF.
- 1.5 Insert conducting probes to terminals 12 and 7.
- 1.6 Activate any lighting mode.
- 1.7 Measure the voltage between terminals 12 and 7.

Is the voltage between 3.5V and 12V when the panel lamps are turned on?

YES → Go to test 2.

NO → Check all connectors and verify they are securely fastened. Refer to Datalink Monitor template "Panel Backlighting" to verify that all interlocks are met for the panel lamps to illuminate. Continue troubleshooting as needed.

2. Test the headlight switch harness.

- 2.1 Remove connector E from the MSF.
- 2.2 Remove the connector from the headlight switch.
- 2.3 Perform a continuity test between the following terminal pairs:
 - MSF connector E, terminal 7; headlight switch, terminal 6
 - MSF connector E, terminal 12; headlight switch, terminal 7

Is there a low resistance?

YES → Connect all connectors and perform a functional test of the system to determine if the problem is intermittent. If the problem continues, install a test headlight switch. If the test headlight switch illuminates, replace the headlight switch.

NO → Repair the harness.

710 — CAN Wiring Troubleshooting

1. Check the SAM Cab output.

- 1.1 Load Datalink Monitor template "Panel Backlighting."
- 1.2 Activate the panel lamps.

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Panel Backlighting

1.3 Observe the panel backlighting status annunciator.

Is the panel backlighting status ON?

YES → The SAM Cab is broadcasting the panel lamps message. Go to test 2 to troubleshoot Cabin CAN wiring.

NO → Make sure that the input interlocks are met to turn on the panel lamps. Refer to **703 — Input Troubleshooting** for more information.

2. Troubleshoot the Cabin CAN datalink.

2.1 Load Datalink Monitor Template "CAN Datalinks Communication Test" and check the ECU Hardware boxes for the CAN ECUs.

2.2 Make a note of which ECUs are not communicating.

Is the hardware part number displayed for the MSF and SAM Cab?

YES → The MSF and SAM Cab are communicating on the Cabin CAN datalink. Perform a functional test to determine whether the problem is intermittent. Continue troubleshooting as needed.

NO → Go to test 3.

3. Troubleshoot Cabin CAN datalink connection to ECU.

3.1 Turn the key to the OFF position.

3.2 Turn the load disconnect switch to the OFF position, or remove the negative cable from the batteries.

3.3 Remove the MSF from the dash.

3.4 Remove connector D.

3.5 Insert conducting probes into terminals 3 and 5.

3.6 Measure the resistance between terminals 3 and 5.

Does the multimeter read 60 ohms?

YES → The Cabin CAN wiring is intact. Check all connectors and make sure they are secure. Make sure that the interlocks are met to turn on the panel lamps.

NO → Go to test 4.

4. Troubleshoot Cabin CAN wiring to the MSF.

With the ignition in the OFF position, measure the resistance between the following terminal pairs:

- MSF connector D, terminal 3; Starpoint connector, terminal 12
- MSF connector D, terminal 5; Starpoint connector, terminal 10

Is there low resistance?

YES → Install all connectors and perform a functional test to determine whether there is an intermittent problem.

NO → Repair the open circuit.

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
81B	003 447 39 58	ICU ON delay with door open and OFF delay with door closed, standard .	PARM-CAB, ICU, DDO, DDC, STD, 30DM	SAM Cab
	003 447 43 58	ICU ON delay with door open and OFF delay with door closed, premium.	PARM-CAB, ICU, DDO, DDC, PRM, 30DM	SAM Cab

Table 17, Parameters

Windshield Washer/Wiper

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500 — Terms and Abbreviations

CGW—Central Gateway

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

MID—Message Identifier. Indicates numeric assignment for a device that communicates on J1587.

MSF—Modular Switch Field

PID—Parameter Identifier

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SID—Subsystem Identifier

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The windshield wiper/washer system is comprised of the following components:

- Wiper motor
- Washer pump
- Washer level switch (optional)
- Rain sensor
- ICU (low washer fluid indicator)
- SAM Cab
- Wiper/Washer switch

The windshield wipers and windshield washer pump are controlled by selecting the function on the stalk switch mounted to the steering column. Wiper speed can be set to variable intermittent, low, and high speed.

The stalk switch is connected to the modular switch field (MSF). The MSF sends the switch status to the SAM Cab via the Cabin CAN datalink.

The wiper and washer are functional if the ignition is in the ON or CRANK position.

502 — Wiper Motor

The wiper motor is controlled by the SAM Cab. The SAM Cab provides ground to the wiper motor as well as power to the low and high speed windings. The wiper motor also provides an input to the SAM Cab indicating its parked position. It does this by grounding the wiper park circuit when the wiper motor is in the park position.

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Windshield Washer/Wiper

503 — Washer Fluid Pump and Reservoir

The washer fluid pump is mounted to the back side of the washer fluid reservoir. The washer fluid reservoir is mounted under the passenger side floor/door jam. The washer pump is controlled by the driver by depressing the stalk switch.

The washer pump will pump windshield washer fluid onto the windshield for as long as the washer button is pressed. The windshield wipers will turn on low speed while the wash button is pressed. When the button is pressed, there will be a short delay before the washer pump runs.

After the wash button is released, the wipers will continue to operate for one to several wipe cycles—called "after wiping"—depending on how long the wash button was pressed initially and whether the after wipe cycle is interrupted by another press of the wash button.

504 — Washer Fluid Reservoir Float Switch (optional)

Some vehicles are equipped with an optional washer fluid level float switch connected to the SAM Cab. When the fluid is low, the float switch closes and grounds the input to the SAM Cab. If the fluid is low, the SAM Cab will ground the ICU input to activate the washer fluid level warning lamp.

505 — Wiper Controls (momentary wiping)

When the windshield washer button is pressed momentarily, the wipers will operate one full cycle and return to the parked position. If the button is held on, the washer pump will operate after a short delay. The driver can momentarily press the windshield washer button anytime a single wipe is desired without operating the washer pump. If the wiper switch was previously set to intermittent wipe, the momentary wipe will have priority.

600 — Component Locations

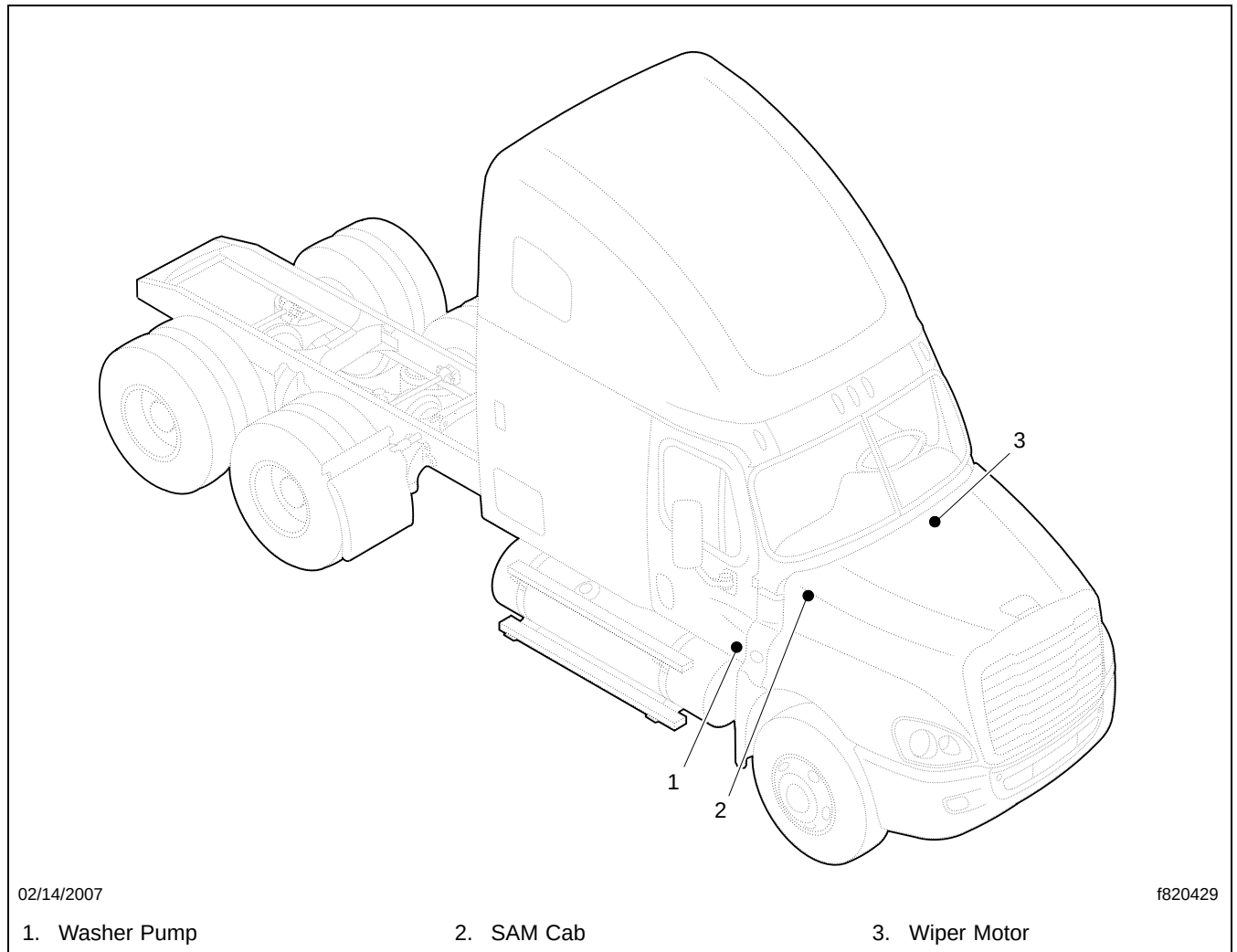


Fig. 1, Component Locations

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Windshield Washer/Wiper

601 — Component Details

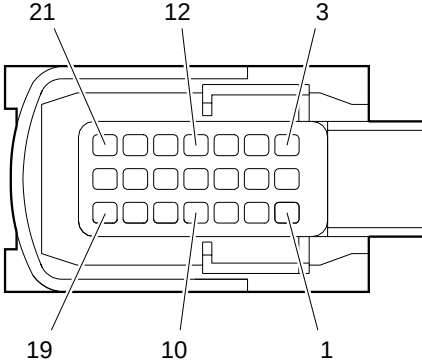
SAM Cab connector X20 Pins			
 04/14/2009 f545498			
Pin	Circuit Number	Wire Color	Circuit Description
7	GND	Black	Washer Pump Ground
20	320	Dark Blue	Washer Pump Control
21	320A	Dark Blue	Wiper Fluid Level

Table 1, SAM Cab connector X20 Pins

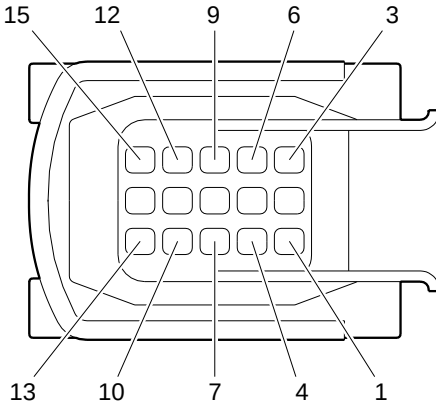
SAM Cab connector X21 pins			
 04/14/2009 f545499			
Pin	Circuit Number	Wire Color	Circuit Description
3	GND	Black	Wiper Motor Ground
9	315P	Dark Blue	Wiper Motor Park Mode Supply
12	315L	Dark Blue	Wiper Motor Low Supply
15	315H	Dark Blue	Wiper Motor High Supply

Table 2, SAM Cab connector X21 pins

Windshield Washer/Wiper

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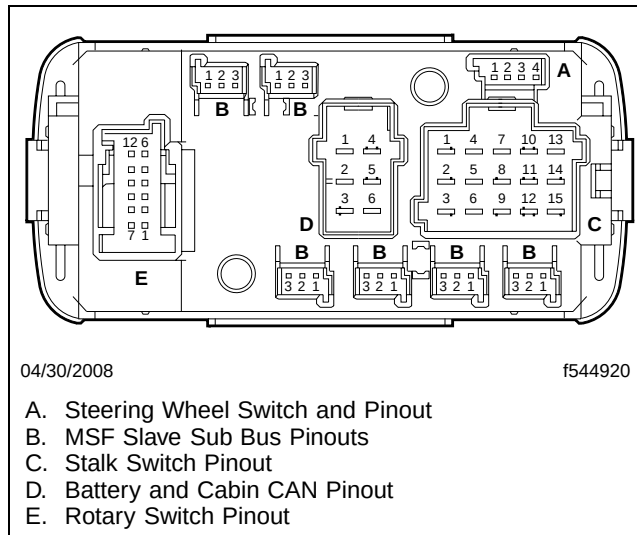


Fig. 2, MSF Master Connection Locations

Connector C Pinout: Stalk Switch	
Pin	Circuit Number
1	Wiper Switch, Ignition Power Supply
2	Left Turn Signal
3	Right Turn Signal
4	High Beam Flash Signal
5	High Beam Signal
6	Low Beam Signal
7	Ignition Power
8	Binary Code Input A
9	Binary Code Input B
10	Not Connected
11	Not Connected
12	Washer Signal
13	Not Connected
14	Binary Code Input C
15	Not Connected

Table 3, Connector C Pinout: Stalk Switch

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Windshield Washer/Wiper

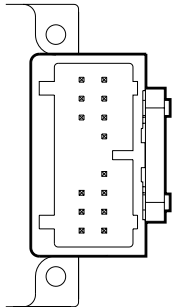
Stalk Switch Connector	
	
Pin	Circuit Number
1	Turn Signal Switch Supply Voltage
2	Binary Code A
3	Binary Code B
4	Binary Code C
5	Washer Signal
6	Not Connected
7	Not Connected
8	Not Connected
9	Headlamp High Beam Flash Signal
10	Headlamp High Beam Signal
11	Headlamp Low Beam Signal
12	Left Turn Signal
13	Turn Signal Switch, Power Supply
14	Right Turn Signal

Table 4, Stalk Switch Connector

700 — Diagnostic Tools Required

- ServiceLink
- Multimeter
- Conducting Probes

Windshield Washer/Wiper

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701 — CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521202	3	conn X11 pin 2	—	—	Washer level, ICU indicator – Voltage above normal, or shorted to high source.	There is a high voltage detected on conn X11, pin 4 when the washer fluid level indicator is active.
Action: Measure the voltage on conn X11, pin 4. If the voltage detected is greater than 0V, make sure the washer fluid level is low or that the washer fluid level ICU indicator is activated using the ON button in the Windshield Wiper/Washer template. Troubleshoot the circuit for a short to BAT. If the voltage detected is 0V, troubleshoot the indicator lamp on the ICU for continuity.							
33	522120	3	conn X20 pin 20	—	—	Washer pump – Voltage above normal, or shorted to high source.	The washer pump is not commanded on but battery voltage is detected on circuit 320.
Action: Troubleshoot for a short to battery in circuit 320. An issue with wiring may be activating this output unexpectedly. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522120	4	conn X20 pin 20	—	—	Washer pump – Voltage below normal, or shorted to low source.	The washer pump does not function; the circuit is detected at ground when it is commanded on.
Action: Troubleshoot for a short to ground in circuit 320. Test the washer pump for a direct short. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522120	5	conn X20 pin 20	—	—	Washer pump – Current below normal, or open circuit.	The washer pump does not function; no current is detected through the circuit.
Action: Test for an open circuit internal to the washer pump and its connector. Test for an open in circuits 320 and GND between the SAM cab and the washer pump. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522121	3	conn X20 pin 21	—	—	Washer fluid level sensor – Voltage above normal, or shorted to high source.	The circuit from the washer fluid level sensor is detected at a voltage above 7 volts.
Action: Troubleshoot for circuit 320A shorted to battery voltage between washer fluid level sensor and the SAM cab.							
33	522209	2	conn X21 pin 9	—	—	Wiper parked – Data erratic, intermittent or incorrect.	Wiper motor park switch signal is erratic. The wipers may be running even after they are turned off.
Action: Troubleshoot for an open circuit 315P between the wiper motor and the SAM cab. The wiper motor may have a park switch fault.							
33	522215	3	conn X21, pin 15 pin X21, pin 12	—	—	Wiper high and wiper low – Voltage above normal, or shorted to high source.	Wipers are running on high and/or low speed when they are not commanded on.
Action: Troubleshoot for a short to battery in circuit 315L and 315H. An issue with wiring may be activating these outputs unexpectedly. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							
33	522215	6	conn X21, pin 15 pin X21, pin 12	—	—	Wiper high and wiper low – Current above normal, or grounded circuit.	The wipers do not function on low or high speed. The circuit is at ground when commanded on.
Action: Troubleshoot for a short to ground in circuit 315L and 315H. Test the wiper motor for a direct short. Refer to G02.04 — SAM Cab, 707 — Logic Controlled Unfused Outputs for a generic troubleshooting procedure for that pin type.							

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Windshield Washer/Wiper

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	520404	5	conn C, pin 4 pin 8, 9, 14	—	—	Stalk switch interrupt – Current below normal, or open circuit.	An interruption has been detected between the MSF master and the stalk switch.
Action: Troubleshoot circuit 473C between the MSF Master connector C and the stalk switch connector. Troubleshoot the following connector pairs for continuity: • MSF connector C pin 8, stalk switch pin 2 • MSF connector C pin 9, stalk switch pin 3 • MSF connector C pin 14, stalk switch pin 4 Repair as required.							
49	520413	4	conn C pin 15	—	—	Stalk switch wiper common – Voltage below normal or shorted to low source.	Wipers will not function due to invalid stalk switch information.
Action: Troubleshoot for short in circuit 433A between MSF and stalk switch. Test for short to ground on pin 1 in stalk switch. Disconnect connector C from MSF and test for battery voltage on pin 1, as pin 1 supplies power to the stalk switch. Refer 702 — Wipers Inoperative in All Modes for additional troubleshooting.							

Table 5, CAN Fault Codes

702 — Wipers Inoperative in All Modes

1. Measure the voltage and pins D and E.

1.1 Turn the key switch to the ON position and the stalk switch to the LOW position.

1.2 Using conducting probes, measure the voltage at pins D and E.

Does pin D and pin E measure 12V?

YES → Verify the linkage is not loose or slipping. Remove the suspect wiper motor and replace with a test wiper motor and retest. If the failure does not duplicate, replace the wiper motor.

NO → Go to test 2.

2. Measure the voltage at SAM Cab connectors X21.12 and X21.15.

With the stalk switch set to LOW and the ignition in the ON position, measure the voltage at SAM Cab connectors X21.12 and X21.15.

Does SAM Cab connector X21.12 and X21.15 read 12V?

YES → Go to test 3.

NO → Go to **708 — Stalk Switch Troubleshooting**.

3. Perform a continuity test.

Perform a continuity test between the following connector pairs:

SAM Cab X21.12 – Wiper Motor Pin E

SAM Cab X21.15 – Wiper Motor Pin D

Is there a low resistance?

YES → Reconnect all connectors and retest to determine whether the problem is intermittent.

NO → Repair the affected harness.

703 — High Speed Inoperative

1. Measure the voltage on pin D of the wiper motor.

1.1 Set the stalk switch to HIGH, and turn the key switch to the ON position.

1.2 Insert a conducting probe and measure the voltage across pin D on the wiper motor.

Does the pin read system BAT voltage?

YES → Verify that the linkage is not loose or slipping. Remove the suspect wiper motor and replace with a test wiper motor and retest. If the failure does not duplicate, replace the wiper motor.

NO → Go to test 2.

2. Measure the voltage at SAM Cab pin X21.15.

With the stalk switch set to the HIGH setting and the ignition in the ON position, measure the voltage at SAM Cab pin X21.15.

Does the meter read system BAT voltage?

YES → Perform a continuity test between SAM Cab connector X21.15 and wiper motor pin D, and repair any open circuits.

NO → Go to **708 — Stalk Switch Troubleshooting**.

704 — Low Speed and Intermittent Settings Inoperative, High Speed OK

1. Measure the voltage across pin E at the wiper motor.

1.1 Turn the key switch to the ON position, and set the stalk switch to the LOW position.

1.2 Using a conducting probe measure the voltage across pin E at the wiper motor.

Does the meter read system BAT voltage?

YES → Verify the linkage is not loose or slipping. Remove the suspect wiper motor and replace with a test wiper motor and retest. If the failure does not duplicate, replace the wiper motor.

NO → Go to test 2.

2. Measure the voltage at SAM CAB pin X21.12.

With the stalk switch set to the LOW position and the ignition in the ON position, measure the voltage at SAM CAB pin X21.12.

Does the meter read system BAT voltage?

YES → Perform a continuity test between SAM Cab connector X21.15 and wiper motor pin E and repair any open circuits.

NO → Go to **708 — Stalk Switch Troubleshooting**.

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Windshield Washer/Wiper

705 — Wipers Do Not Park

1. **Measure the voltage at pin B on the wiper motor.**

- 1.1 Turn the key switch to the "ON" position. Leave the wiper switch in the OFF position.
- 1.2 Measure the voltage at pin B on the wiper motor. If the key switch is turned off while the wipers are mid swipe, they will stop in that position.

Does pin B read system BAT voltage?

YES → Go to test 2.

NO → Go to test 3.

2. **Measure the voltage across pin B of the wiper motor to test the internal park switch.**

- 2.1 Set the stalk switch to the LOW position.
- 2.2 Measure the voltage across pin B of the wiper motor to test the internal park switch. When the wipers are running, pin B is 12V except when they are momentarily in the parked position. When momentarily in the parked position, pin B is 0V. If pin B is always at 12V, the wipers remain on until the key switch is turned OFF; it will then stop in the position it was at when the key was shut off.

Does the meter read system BAT voltage at wiper motor pin B?

YES → Replace the wiper motor.

NO → Go to test 3.

3. **Perform a continuity test at SAM Cab connector X21.9.**

Does the meter read system BAT voltage?

YES → Perform a continuity test between SAM Cab connector X21.9 and wiper motor pin B. Repair as necessary.

NO → Reconnect all connectors and perform a functional test to determine whether the problem is intermittent.

706 — Wipers Stay On or Wipe Intermittently Until Ignition is Turned Off

1. **Test the wiper motor with the ignition in ON position.**

2. Turn the key switch to the ON position. Leave the wiper switch in the OFF position.
3. If the wipers remain on continuously, measure the voltage across pin B of the wiper motor to check the internal park switch. When the wipers are running, pin B will be 12V except when they are momentary in the parked position. When momentarily in the parked position pin B is 0V.

Does the multimeter momentarily go to 0v when the wiper is in the parked position?

YES → Go to **708 — Stalk Switch Troubleshooting.**

NO → Replace the wiper motor.

707 — Washers Inoperative

1. **Test the operation of the wipers and washer system.**

Windshield Washer/Wiper

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- 1.1 Turn the key switch to the ON position and the wiper switch to LOW. If the wipers do not function, troubleshoot for inoperative wipers in **702 — Wipers Inoperative in All Models**.
- 1.2 If the wipers operate normally, turn them off and verify there is adequate fluid in the washer fluid reservoir.
- 1.3 Test wiper operation again.
- 1.4 Hold the washer switch in the ON position for at least 5 seconds in case the hoses are leaking, or the system has lost its prime.

Did the washer fluid spray the windshield?

YES → Check all connectors and perform a functional test to determine if the problem is intermittent.

NO → Go to test 2.

2. Check the system for fluid leaks.

With the ignition in the ON position, hold the washer switch and measure the voltage at pin 1 of the washer pump. This step may require a long extension cable connected at the washer pump.

Does the meter read system BAT voltage?

YES → Replace the washer pump.

NO → Go to test 3.

3. Measure the voltage at SAM Cab connector X20.20.

Hold the washer switch down and measure the voltage at SAM Cab connector X20.20.

Does the meter read system BAT voltage?

YES → Perform a continuity test between the following connector pairs:

- SAM Cab connector X20.20 – washer pump pin 1
- SAM Cab connector X20.7 – washer pump pin 2

Repair as necessary.

NO → Go to test 4.

4. Measure the voltage across MSF connector C pin 5.

While holding the washer switch, measure the voltage across MSF connector C pin 5.

Does the meter read system BAT voltage?

YES → Reconnect all connectors and perform a functional test to determine whether the problem is intermittent. Retest as necessary.

NO → Check the stalk switch harness for continuity. If no issue is found, replace the stalk switch.

708 — Stalk Switch Troubleshooting

1. Verify the operation of the stalk switch.

- 1.1 Remove the MSF from the dash.
- 1.2 Insert conducting probes into MSF connector C, pins 8, 9, and 14.

C06.01

Windshield Washer/Wiper

1.3 Set the stalk switch to each suspect wiper mode and measure the voltage across each pin.

1.4 Compare the values shown in **Table** .

Do any wiper modes fail the test?

YES → Go to test 2.

NO → Reconnect all connectors and perform a functional test to determine whether the problem is intermittent. Repeat troubleshooting as necessary.

2. Test the wipers using a known good stalk switch.

Remove the stalk switch and install a test stalk switch and repeat the steps from test 1.

Do any of the wiper modes fail the test?

YES → Remove the stalk switch harness and perform a continuity test and replace as necessary.

NO → Replace the stalk switch.

800 — Wiper Motor Specifications

Wiper Motor Specifications	
Condition	Typical Current Draw (load dependent)
Low Speed	3-8 Amps
High Speed	4-8 Amps
Locked/Stalled	28-30 Amps Maximum

Table 6, Wiper Motor Specifications

Stalk Switch, Binary Coded Pin Values			
Stalk Switch Function	Binary Coded Pin Values (volts)		
	C	B	A
OFF	0	0	0
Intermittent 1	0	0	BAT
Intermittent 2	0	BAT	0
Intermittent 3	0	BAT	BAT
Intermittent 4	BAT	0	0
Intermittent 5	BAT	0	BAT
LOW	BAT	BAT	0
HIGH	BAT	BAT	BAT

Table 7, Stalk Switch, Binary Coded Pin Values

Door Locks

C06.03

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500 — Terms and Abbreviations

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The door lock system consists of lock mechanisms, activated either manually or electronically.

The door can be locked manually by:

- the door lock knob;
- the key in the lock cylinder.

The door can be unlocked manually by:

- opening the door using the interior door latch handle;
- the key in the lock cylinder.

The electric door lock consists of two door-mounted switches and two solenoids, one each for the driver and passenger doors. Battery power and a ground wire is provided from the SAM Cab to each switch. Both switches have three positions: lock doors, open circuit, and unlock doors. The switch is spring-loaded to be in the open-circuit position. The solenoids are tied together electrically and are controlled by two wires: A and B. The wires move the solenoids to lock or unlock the mechanical door mechanism depending on which of the two wires receives the battery power.

The power locks are fused by fuse 13 (20 amp) on the SAM Cab, and provided power from pin 6 on connector X8. The ground is shared with the heated mirrors system, pin 2 on connector X8 on the driver side, and pin 2 on connector X17 for the passenger side.

When the switch is pressed to lock the doors:

- the switch completes the circuit to the solenoids, applying battery power on wire A;
- the solenoids move the mechanical lock mechanisms to the lock position.

When the switch is pressed to unlock the door:

- the switch reverses the circuit to the solenoids, applying battery power on wire B;
- the solenoids move the mechanical lock mechanisms to the unlock position.

When operated manually, the locks operate independently. When operated electronically, both locks operate together.

C06.03

Door Locks

600 — Component Locations

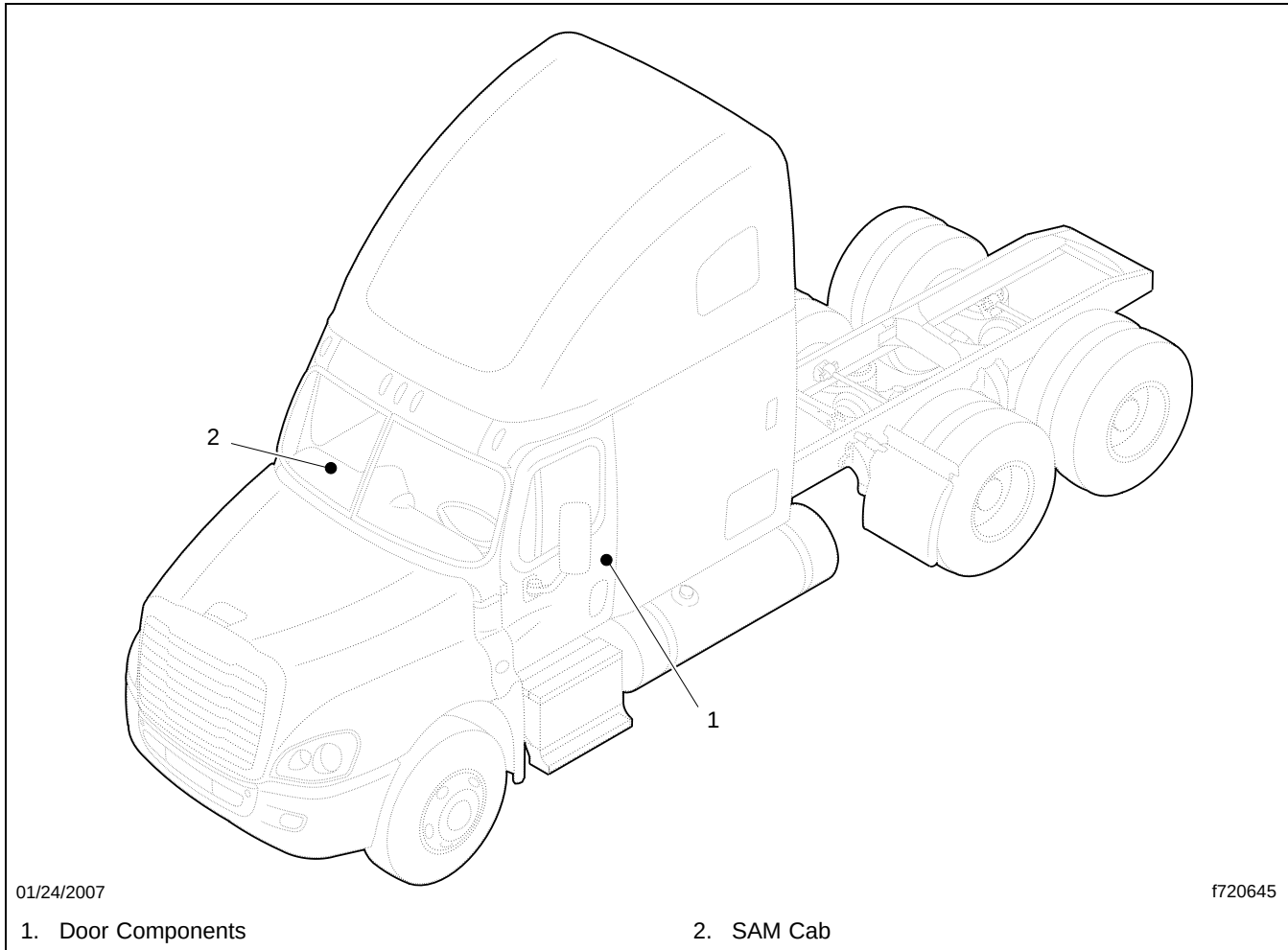


Fig. 1, Component Locations

601 — Component Details

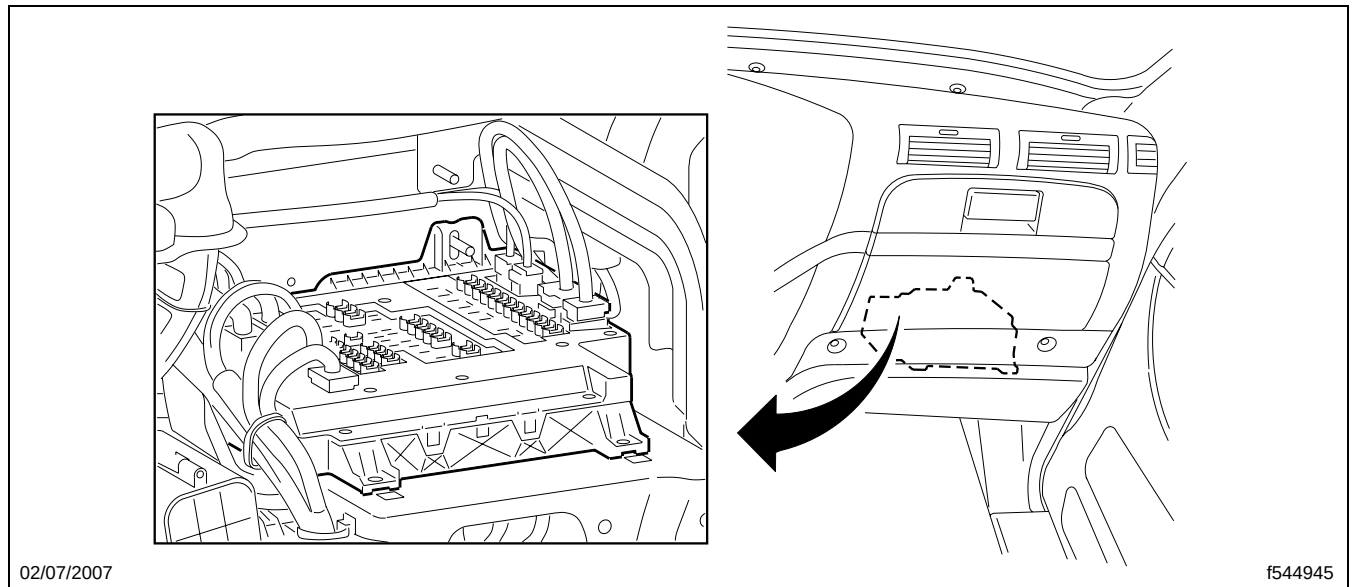


Fig. 2, SAM Cab

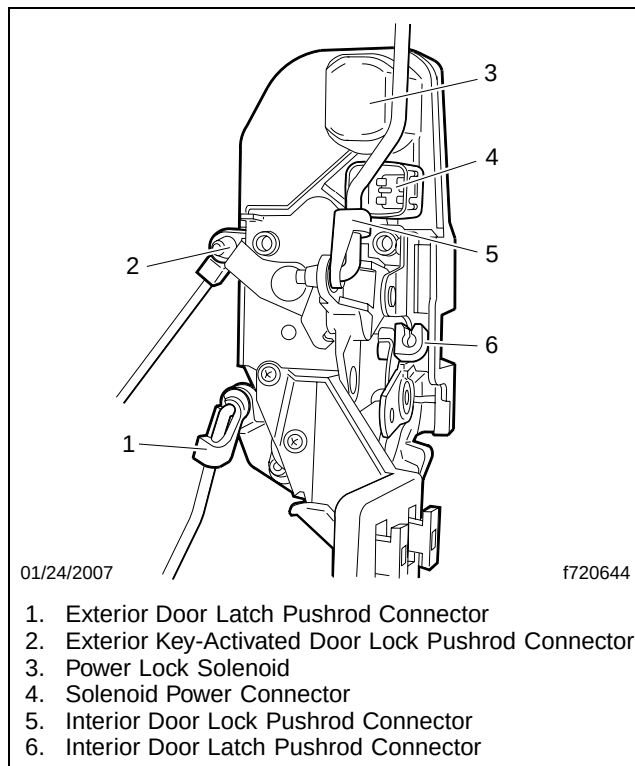


Fig. 3, Door Lock/Latch and Solenoid Mechanism Detail

System Overview

Terms and Abbreviations	500
Air Horn	501
Electric Horn	502

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Parameters	800
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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

ECU—Electronic Control Unit, typically connected to a datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — Air Horn

The air horn is operated by an overhead lanyard. Pulling the lanyard opens a valve to feed air to the horn. The air horn remains activated for the duration of the pull. The valve is spring-loaded and closes once the lanyard is released. See **Fig. 1**.

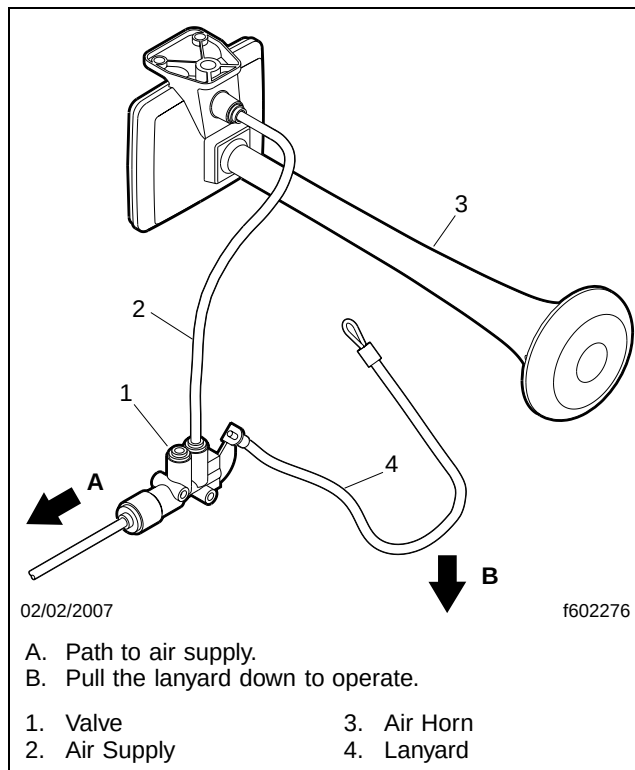


Fig. 1, Air Horn

502 — Electric Horn

The electric horn is operated by pressing the horn switch, located in the center of the steering wheel. The horn switch is wired directly to the SAM Cab. Pressing the horn switch activates the horn for the duration that the switch is pressed, however the horn will terminate after 60 seconds of continuous activation.

The electric horn is powered by a pin on the SAM Cab ECU. There is no change in functionality between single and dual electric horn systems.

The electric horn operates regardless of the position of the ignition key. See Fig. 2.

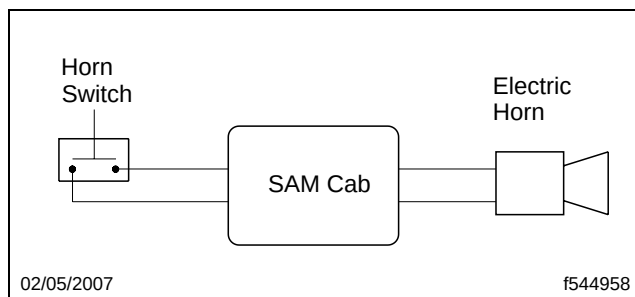


Fig. 2, Electric Horn Wiring

600 — Component Locations

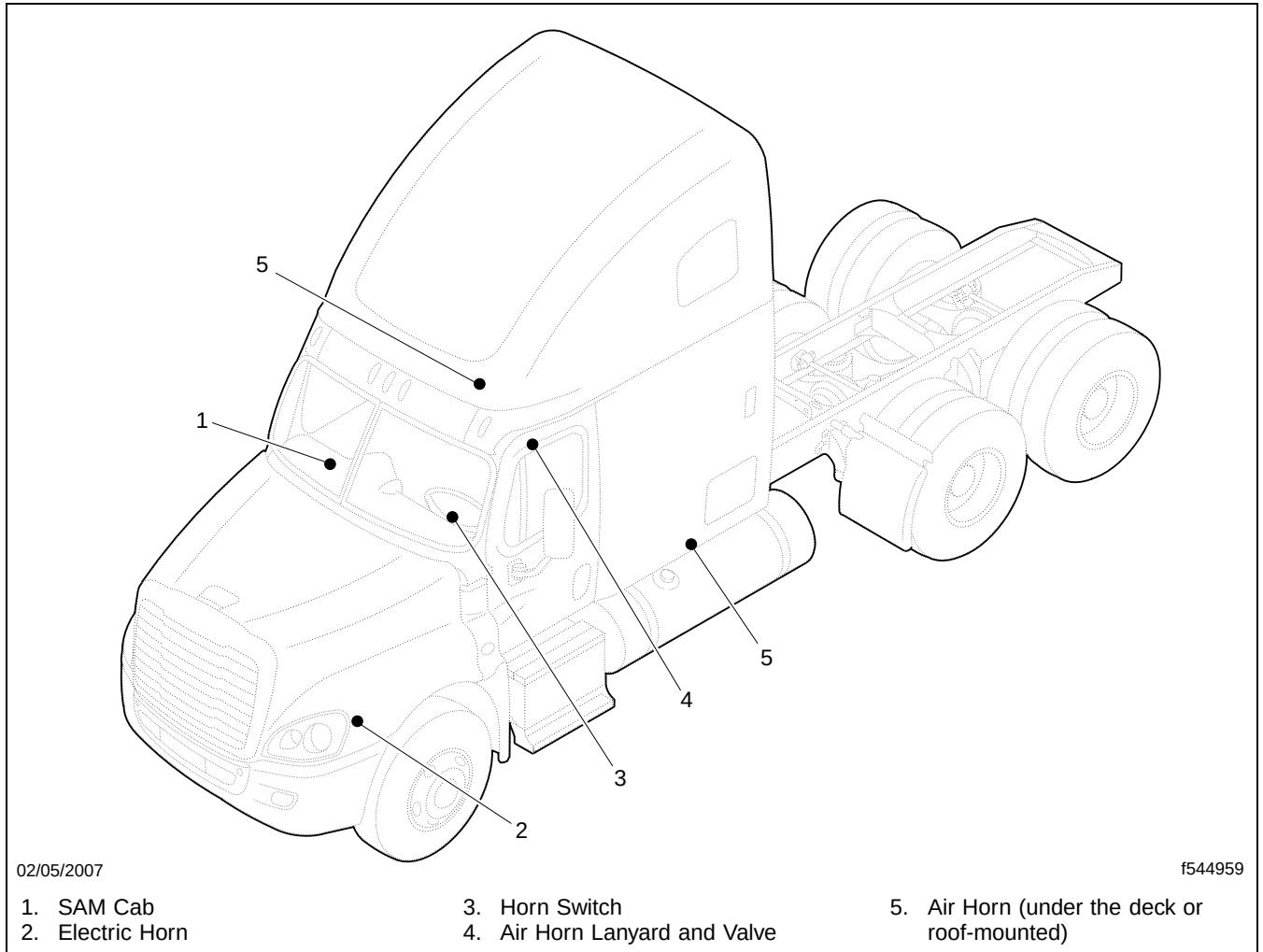


Fig. 3, Component Locations

601 — Component Details

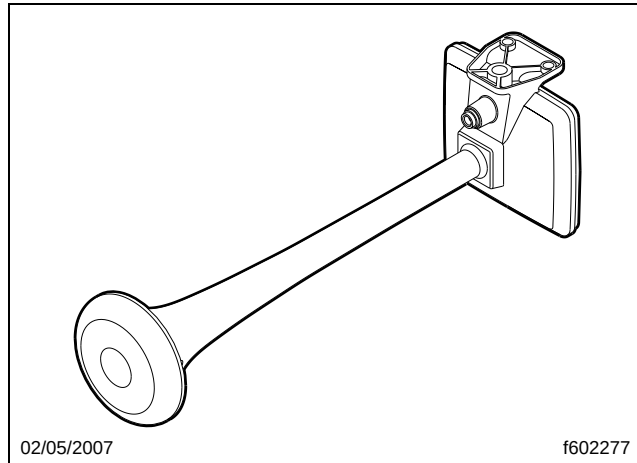


Fig. 4, Air Horn

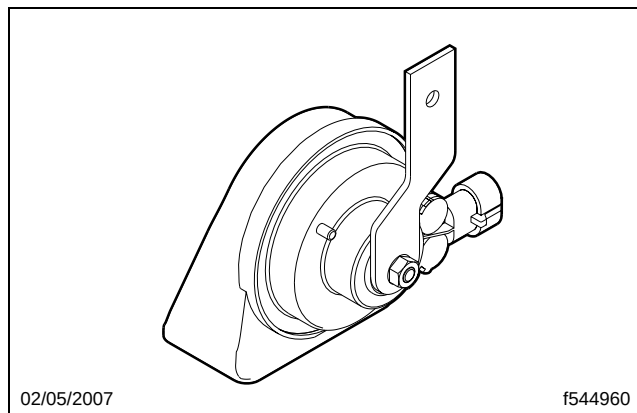


Fig. 5, Electric Horn

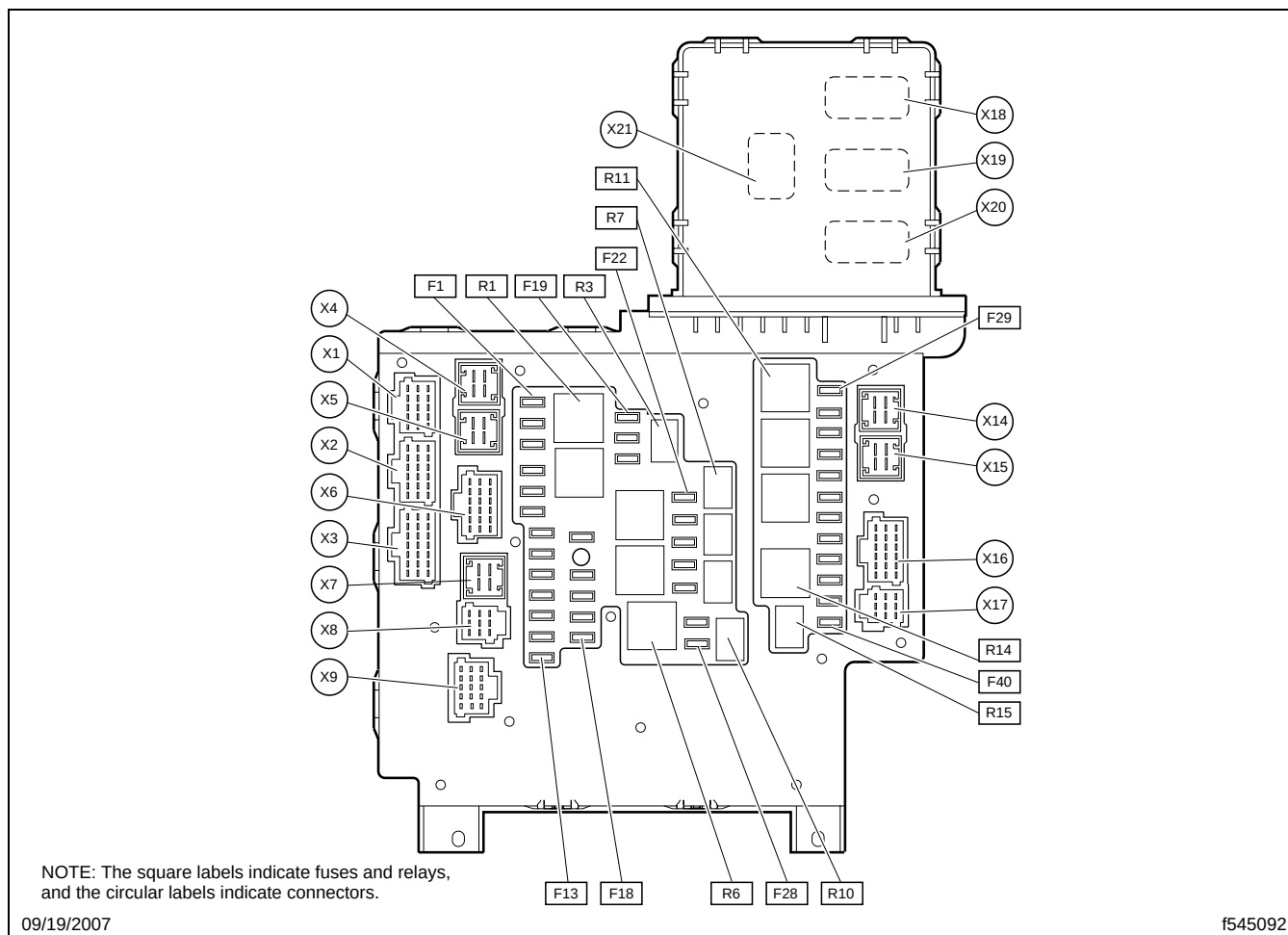


Fig. 6, SAM Cab Pin Locations (top)

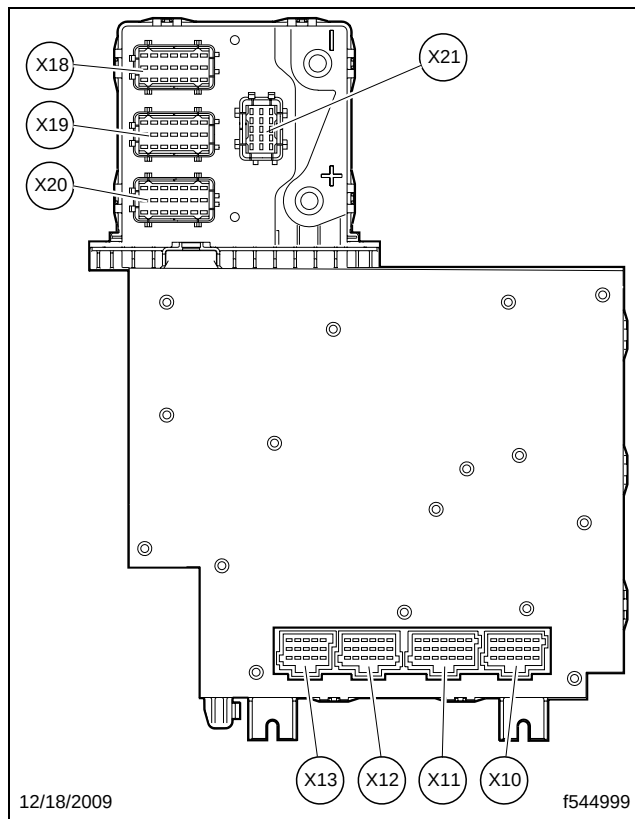


Fig. 7, SAM Cab Pin Locations (bottom)

SAM Cab Pinout Locations					
Connector	Pin	Description	ECU Model	Relay	Fuse (rating in volts)
X6	18	Horn Switch and Instrument Cluster, Battery power	Baseline	—	F22 (5)
X13	13	Horn switch uC bypass	Baseline	—	—
X18	3	Horn (electric), Ground	Baseline	—	—
X18	21	Horn (electric), Control	Baseline	—	—

Table 1, SAM Cab Pinout Locations

700 — Troubleshooting Overview

The diagnostic communication protocol used for troubleshooting or configuring the SAM Cab is the CAN protocol, via the Diagnostic CAN datalink. For more information on the Diagnostic CAN datalink, see **G03.04 — Datalink, Diagnostic CAN**.

Horn

C06.04

701 — Possible Causes

Air Horn

- Air supply, hoses
- Lanyard and Valve

Electric Horn

- Wiring (including the switch/horn component)
- SAM Cab

702 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Connector/Pin	Fuse	Relay	Description	Details
33	521921	3	conn X18 pin 21	—	—	Horn, Electric – Voltage above normal, or shorted to high source.	The fault is active when the voltage detected at conn X18, pin 21 is greater than 8V. The fault becomes historic when the voltage detected is less than 1.2V.
Action: With the horn inactive, measure the voltage at conn X18, pin 21. If BAT voltage is detected, troubleshoot circuit 24B for a short to BAT. Refer to G02.04 — SAM Cab , 707 — <i>Logic Controlled Unfused Outputs</i> for a generic troubleshooting procedure for that pin type.							
33	521921	5	conn X18 pin 21	—	—	Horn, Electric – Current below normal, or open circuit.	The fault is active when the current detected at conn X18, pin 21 is less than .01A. The fault becomes historic when the current detected is greater than 0.5A.
Action: While the horn is active, measure the voltage at pin A at the horn. If the voltage detected is 0V, troubleshoot circuit 24B and GND between the horn and the SAM Cab for an open circuit. Remove the horn, measure the resistance across pin A and B for continuity. Refer to G02.04 — SAM Cab , 707 — <i>Logic Controlled Unfused Outputs</i> for a generic troubleshooting procedure for that pin type.							
33	521921	6	conn X18 pin 21	—	—	Horn, Electric – Current above normal, or grounded circuit.	The fault is active when the current detected at conn X18, pin 21 is higher than 24.2A. The fault becomes historic when the current detected is less than 17.5A.
Action: With the horn active, measure the voltage at conn X18, pin 21. If the voltage detected is 0V, troubleshoot circuit 24B for a short to GND. Refer to G02.04 — SAM Cab , 707 — <i>Logic Controlled Unfused Outputs</i> for a generic troubleshooting procedure for that pin type.							

Table 2, CAN Fault Codes

C06.04

Horn

800 — Parameters

Parameters				
Module	Part	Description	Parameter	ECU
264	001 447 75 58	The vehicle is equipped with an electric horn. The foot switch is not present. The horn selection switch is not needed.	PARM-CAB, ASG, NO CNT	SAM Cab
264	001 447 76 58	The vehicle is equipped with a pneumatic air horn and an electric horn. The foot switch is present. The electric horn can be activated with either the steering wheel switch or the foot switch. The horn selection switch is not needed.	PARM-CAB, ASG, NAH, E/E, FS, MOM	SAM Cab
264	001 447 77 58	The vehicle is equipped with a pneumatic air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn can be activated with either the steering wheel switch or the foot switch. When the horn selection switch is active, it disables activation of the electric horn via the foot switch.	PARM-CAB, ASG, NAH, E/X, FS, MOM	SAM Cab
264	001 447 78 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is not present. When the horn selection switch is not active, the steering wheel switch activates the electric horn. When the horn selection switch is activated, the steering wheel switch activates the air horn.	PARM-CAB, ASG, A/A, MOM	SAM Cab
264	001 447 79 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn will activate with the steering wheel switch and the air horn will activate with the foot switch. When the horn selection switch is active, the air horn is activated with the steering wheel switch or the foot switch.	PARM-CAB, ASG, A/A, FS, MOM	SAM Cab

Horn

C06.04

Parameters				
Module	Part	Description	Parameter	ECU
264	001 447 80 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn will activate with the steering wheel switch, and the air horn will activate with the foot switch. When the horn selection switch is active, the air horn is activated with the steering wheel switch and the electric horn is activated with the foot switch.	PARM-CAB, ASG, A/E, FS, MOM	SAM Cab
264	001 447 81 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn will activate with the steering wheel switch and the air horn will activate with the foot switch. When the horn selection switch is active, the electric horn is activated with the steering wheel switch or the foot switch.	PARM-CAB, ASG, FS, MOM	SAM Cab
264	001 447 82 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn will activate with the steering wheel switch and the air horn will activate with the foot switch. When the horn selection switch is active, the air horn will activate with the steering wheel switch and nothing will activate with the foot switch.	PARM-CAB, ASG, A/X, FS, MOM	SAM Cab
264	001 447 83 58	The vehicle is equipped with an electrically-controlled air horn and an electric horn. The foot switch is present. When the horn selection switch is not active, the electric horn will activate with the steering wheel switch and the air horn will activate with the foot switch. When the horn selection switch is active, the electric horn will activate with the steering wheel switch and nothing will activate with the foot switch.	PARM-CAB, ASG, E/X, FS, MOM	SAM Cab
264	001 447 94 58	The vehicle is equipped with a pneumatic air horn and an electric horn. The foot switch is not present. The electric horn is activated with the steering wheel switch. The horn selection switch is not needed.	PARM-CAB, ASG, NAH, E/X, MOM	SAM Cab

C06.04

Horn

Parameters				
Module	Part	Description	Parameter	ECU
264	001 447 90 23	The vehicle is equipped with the horn selection switch, ID017, multiplexed sub bus switch.	PARM-MSF, MUX, HORN SELELEC/AIR	MSF
264	001 447 90 23	The vehicle is not equipped with the horn selection switch, ID017, multiplexed sub bus switch.	PARM-MSF, MUX, HRN SEL EL/AIR, NC	MSF

Table 3, Parameters

Heated Mirrors

C06.05

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500 — Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

MSF—Modular Switch Field

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

The heated mirror system is used to clear ice and frost from the side mirrors. The heated mirrors are activated by pressing the multiplexed mirror heat switch button connected to the MSF. When pressed, the smart switch sends a momentary signal to the MSF master, which broadcasts the switch state on the Cabin CAN. The ON switch state is received by the SAM Cab where the heated mirror circuit is enabled. A FET on the SAM Cab is turned on, grounding pin 86 of relay R10, allowing current for the control side of the relay to flow through fuse F29 (3 amp, violet) to pin 85. This activates the relay, and allows current from the SAM to flow through pin 30 of the relay to output pin 87. The circuit then splits to the individual mirrors.

The left mirror is fused through F27 (10 amp, red) to SAM Cab connector X8, pin 8, to the mirrors, then grounded on the same connector, pin 2.

The right mirror is fused through F28 (10 amp, red) to SAM Cab connector X17, pin 8, to the mirrors, then grounded on the same connector, pin 2.

The SAM Cab sends a status feedback signal back to the MSF master, which broadcasts it to the mirror heat smart switch to drive the indicator light on the switch.

In order for the heated mirrors to operate, the key must be turned to IGN. The heated mirror will remain on for 30 minutes. After 30 minutes, the heated mirrors will disengage only if the outside air temperature is greater than 60°F (16°C). The outside air temp is monitored by a sensor. The sensor is powered by pin 16 on connector X20, and grounded on pin 18 on X20.

For more information regarding the MSF, see **G02.06—Modular Switch Field**.

C06.05

Heated Mirrors

600 — Component Locations

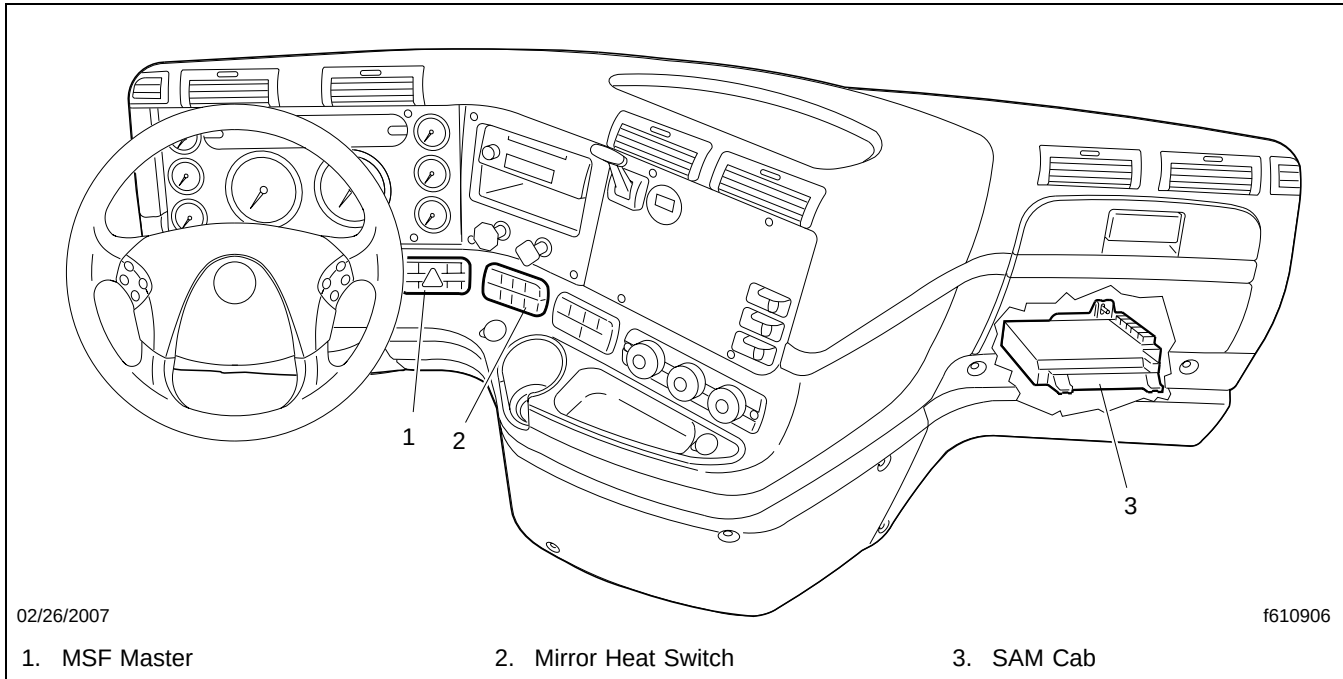


Fig. 1, Component Locations

Heated Mirrors

C06.05

601 — Component Details

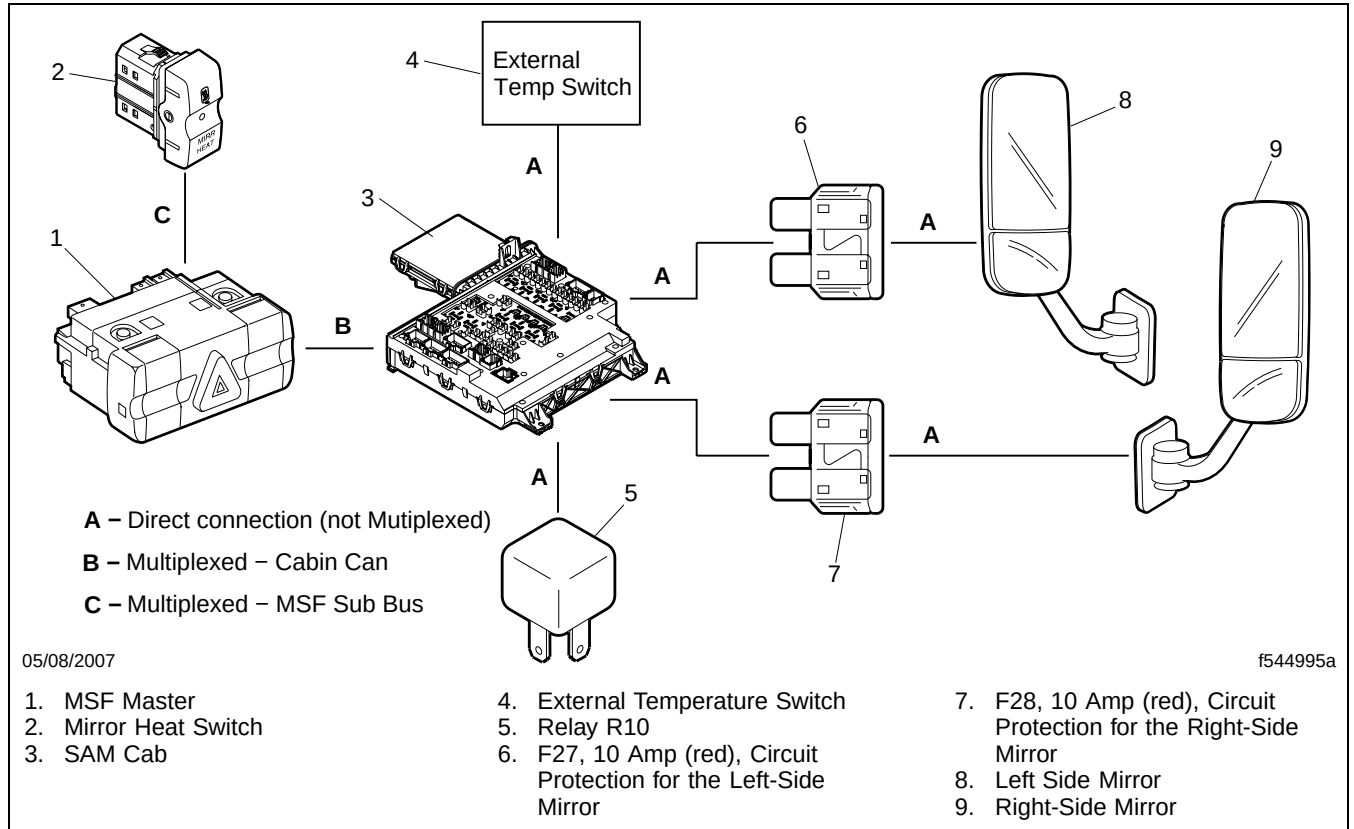


Fig. 2, Heated Mirror Wiring

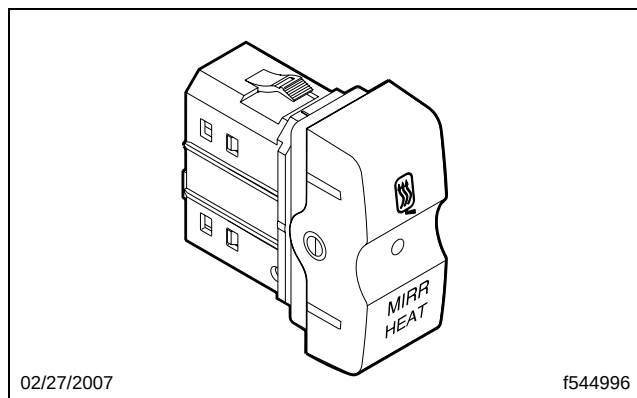


Fig. 3, Mirror Heat Switch Detail

Power Mirrors

C06.06

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500 — Terms and Abbreviations

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The power mirror adjustment system allows the driver to electrically control the adjustment of the side mirrors. The mirror to be adjusted is selected by pushing "L" or "R" on the mirror selector switch. The position of the selected mirror can be adjusted using the circular 4-position switch, while the ignition is in the ACC or IGN position.

The mirror selector rocker switch and the mirror adjustment switch work together to route power to the correct wires, which power motors inside of the mirror assemblies. To move the mirror in the opposite direction, the polarity of the wires is reversed. Power is routed to the switch from cavity X10/2 on the SAM Cab, and grounded in common with the heated mirrors system on pin X8/2. The power mirror adjustment system is protected against shorts-to-ground by a self-protected FET driver. After a short-to-ground has occurred and been removed, the output is reactivated on the next ignition switch transition to ACC. The back of the switch has a 10-pin connector; the wiring is detailed in **601 — Component Details**. There are no multiplexed messages in the power mirror adjustment system.

C06.06

Power Mirrors

600 — Component Locations

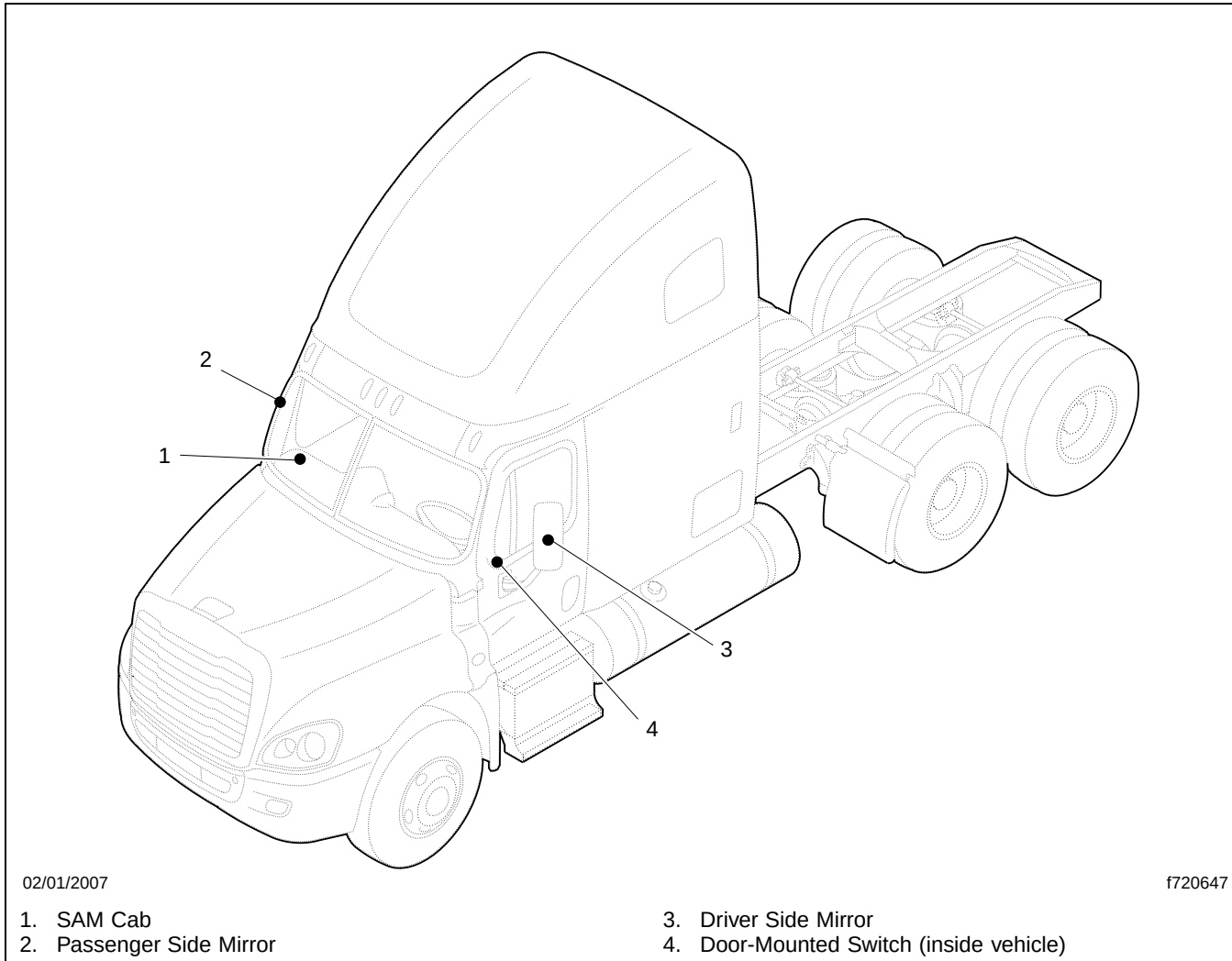


Fig. 1, Component Locations

601 — Component Details

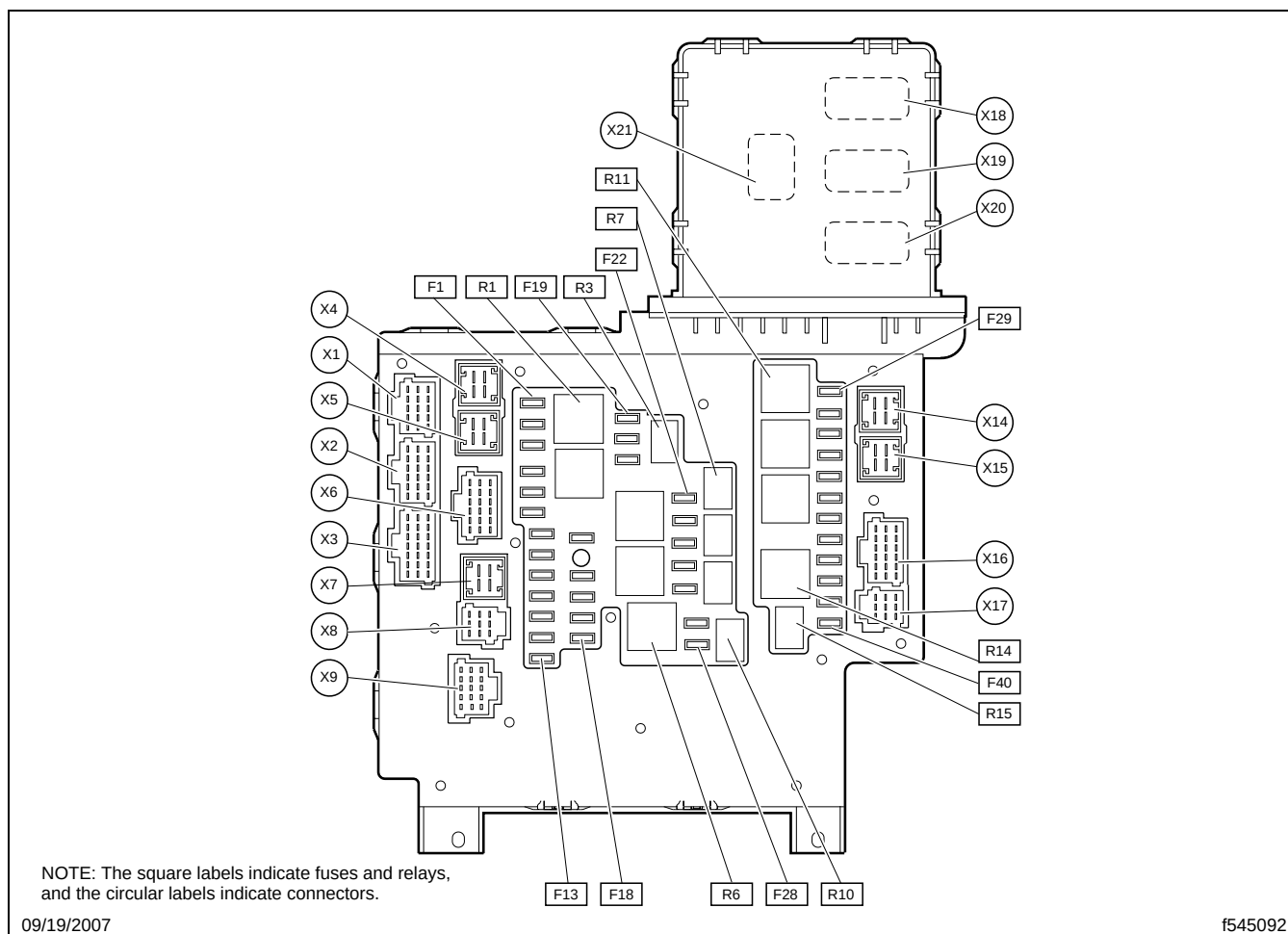


Fig. 2, SAM Cab Fuses and Relays

C06.06

Power Mirrors

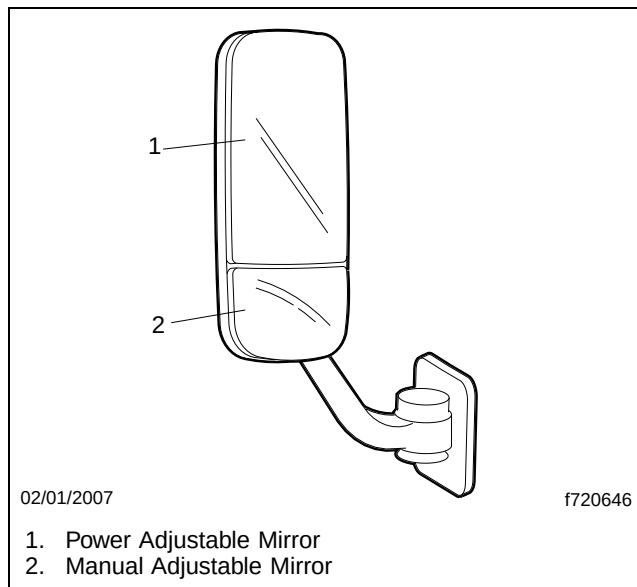


Fig. 3, Mirror Detail

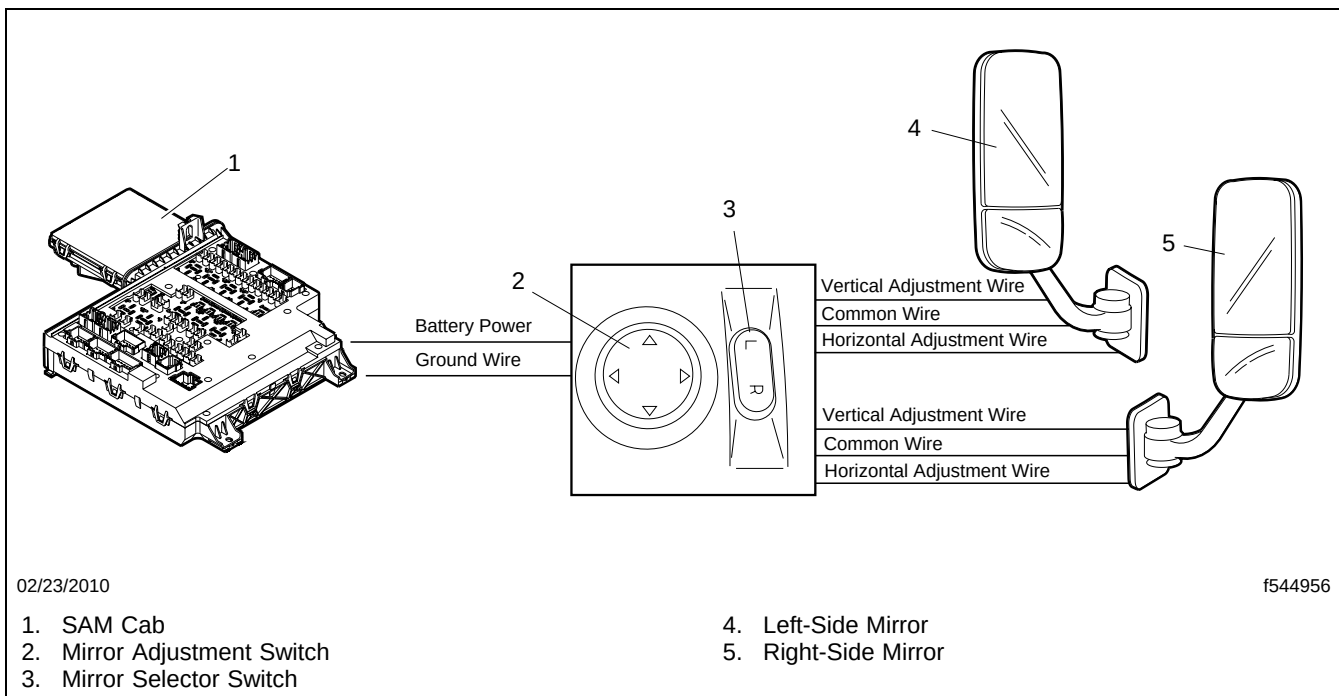


Fig. 4, Power Mirror Adjustment Wiring

Power Mirrors

C06.06

700 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521102	3	conn X10 pin 2	—	—	Mirror adjust switch supply, ACC – Voltage above normal, or shorted to high source.	BAT voltage has been detected while the mirror adjust switch is inactive.
Action: With the key in the OFF position, measure the voltage at conn X10 pin 2. If the voltage detected is greater than 0V, troubleshoot circuit 157 for a short to BAT. This pin is an unfused constant output. Refer to G02.04 — SAM Cab, 710 — Fused Battery Pass-Through Outputs for a generic troubleshooting procedure for that pin type.							
33	521102	4	conn X10 pin 2	—	—	Mirror adjust switch supply, ACC – Voltage below normal, or shorted to low source.	The fault is active when the current detected at conn X10 pin 2 is greater than 2A. The fault becomes historic when the current detected is less than 0.2A.
Action: Measure the voltage at conn X10 pin 2. If the voltage detected is not BAT voltage, troubleshoot circuit 157 for a short to GND. Troubleshoot the mirror adjust switch to ensure it is functioning. Refer to G02.04 — SAM Cab, 710 — Fused Battery Pass-Through Outputs for a generic troubleshooting procedure for that pin type.							

Table 1, CAN Fault Codes

Power Windows

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500 — Terms and Abbreviations

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

Power (and non-power) windows exist in three configurations:

- Standard: driver and passenger door power windows
- Optional: manual windows for both driver and passenger windows
- Optional: manual window for the driver side, and power window for the passenger side

Power windows are electronically controlled by a switch mounted on the door. The switch has three positions: roll down window, neutral, and roll up window. The switch is spring-loaded, and normally in the neutral position. On vehicles equipped with power windows on the driver and passenger side, both sides will have switches to control the passenger-side window.

Power windows can only be activated when the ignition switch is in the "ACC" or "IGN" position.

The driver-side door switch operates by pressing:

- backward to activate the window up;
- forward to roll the window down;
- forward and holding for about one second ("express down").

The passenger-side window switches operate the same as the driver-side window, without the express down function. The express down function is controlled by a module that's mounted near the torsion spring.

The power for the windows is provided by the SAM Cab. Power is provided on the following pins:

- Driver Side: connector X8; power is on pin 7, ground is on pin 3.
- Passenger Side: connector X17; power is on pin 1, ground is on pin 9.

If a switch is activated, it completes a circuit to the regulator motor that moves the regulator arm and lower window glass holder either up or down. As the window is rolled down, the torsion spring is tightened. As the window is rolled up, the torsion spring helps the motor push the window glass up.

When a switch is pressed to roll down the window:

- the switch completes the circuit to the regulator motor, applying battery power to wire A, and wire B becomes the ground wire;
- the motor moves the regulator arm down;
- the torsion spring is wound up tighter as the regulator arm is lowered.

When a switch is pressed to roll the window up:

- the switch reverses the circuit to the regulator motor, applying battery power to wire B, and wire A becomes the ground wire;
- the motor moves the regulator arm up;
- the force of the torsion spring assists the motor in rotating the regulator arm.

C06.07

Power Windows

When the driver-side window switch is held down for more than 1 second:

- the "express down" module is activated;
- the "express down" module continues to send current to the window motor, even after the switch is released, until the window is completely lowered;
- the torsion spring is wound as the regulator arm goes down.

600 — Component Locations

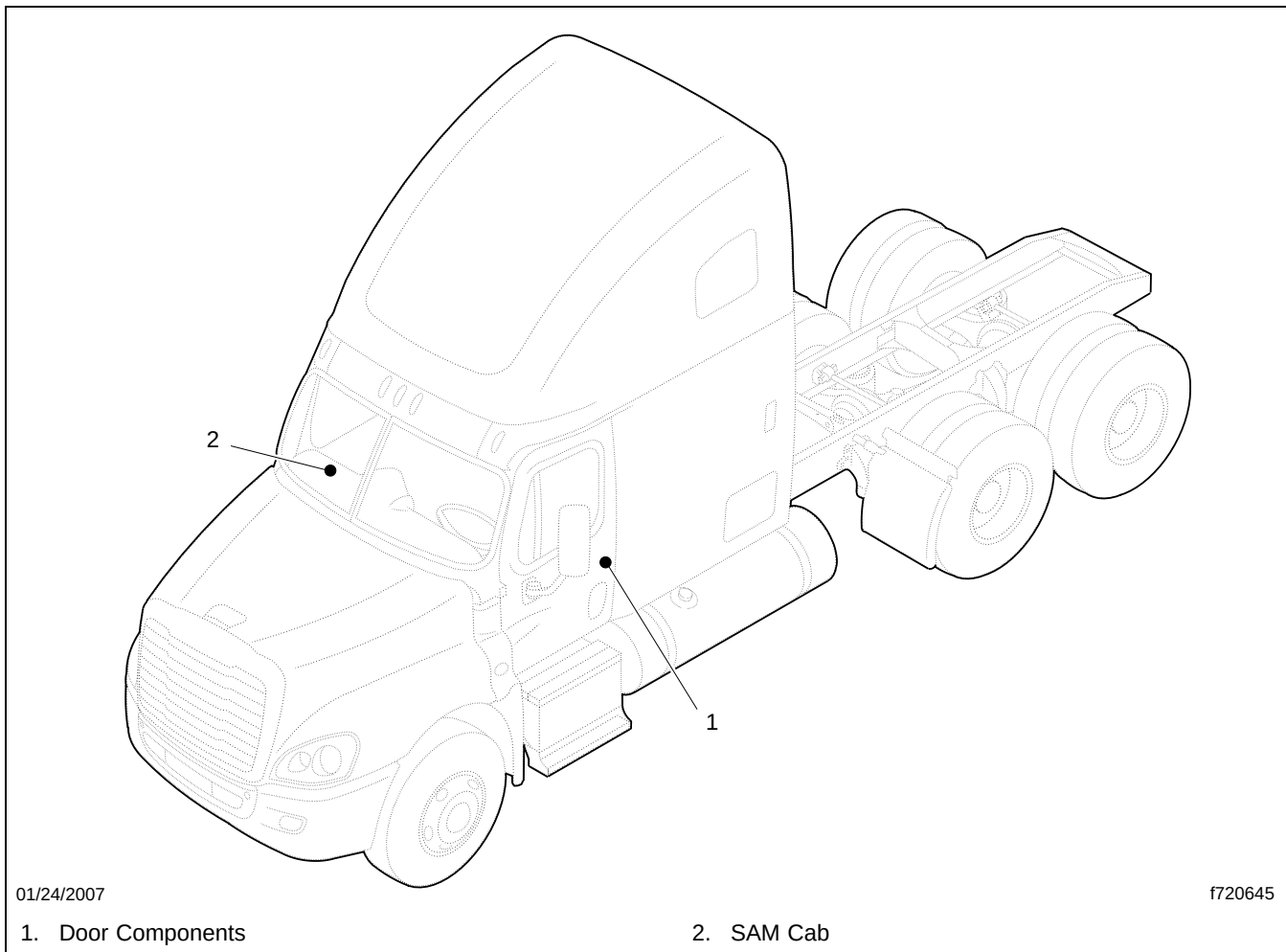


Fig. 1, Component Locations

Power Windows

C06.07

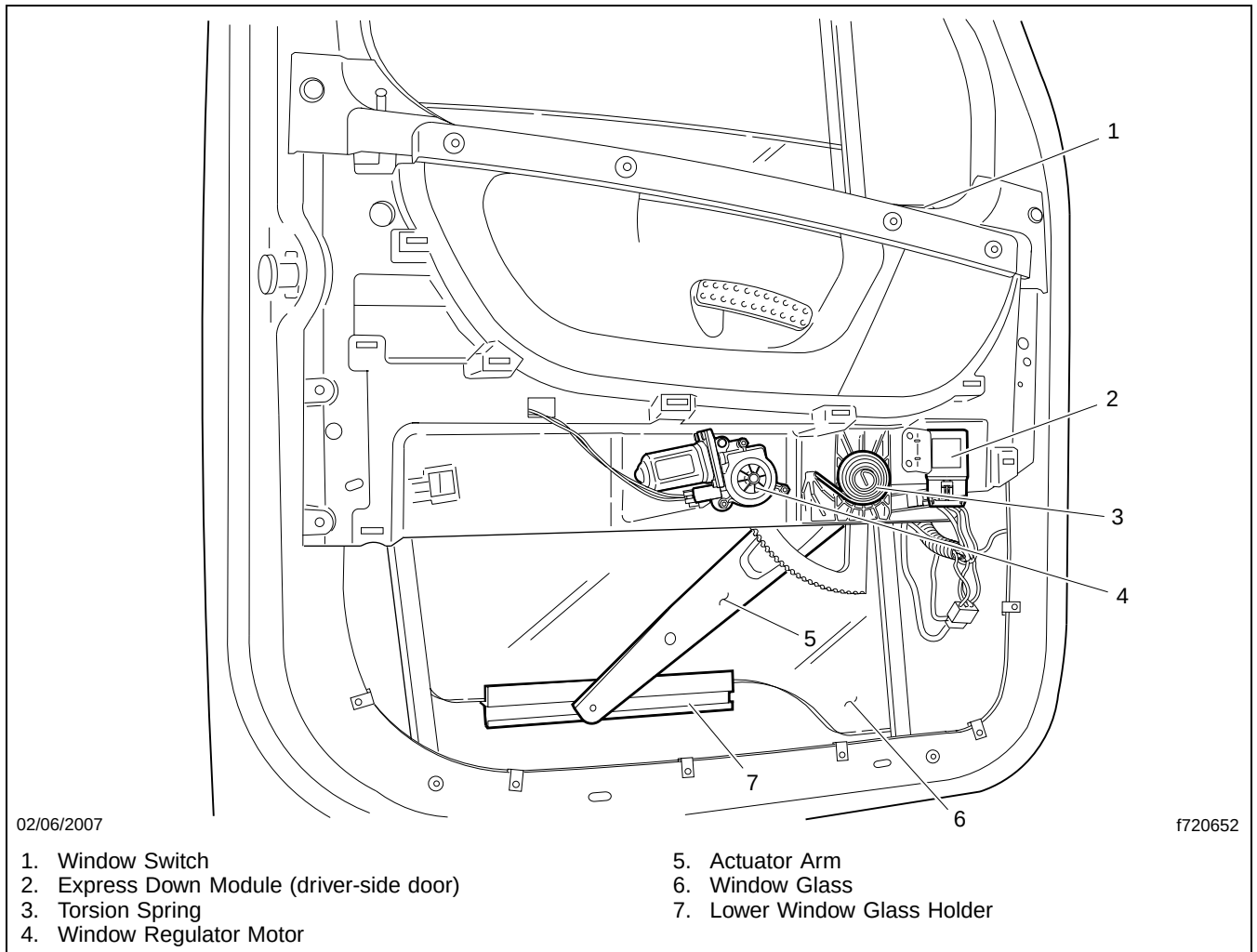


Fig. 2, Door Component Locations (driver-side shown)

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Power Windows

601 — Component Details

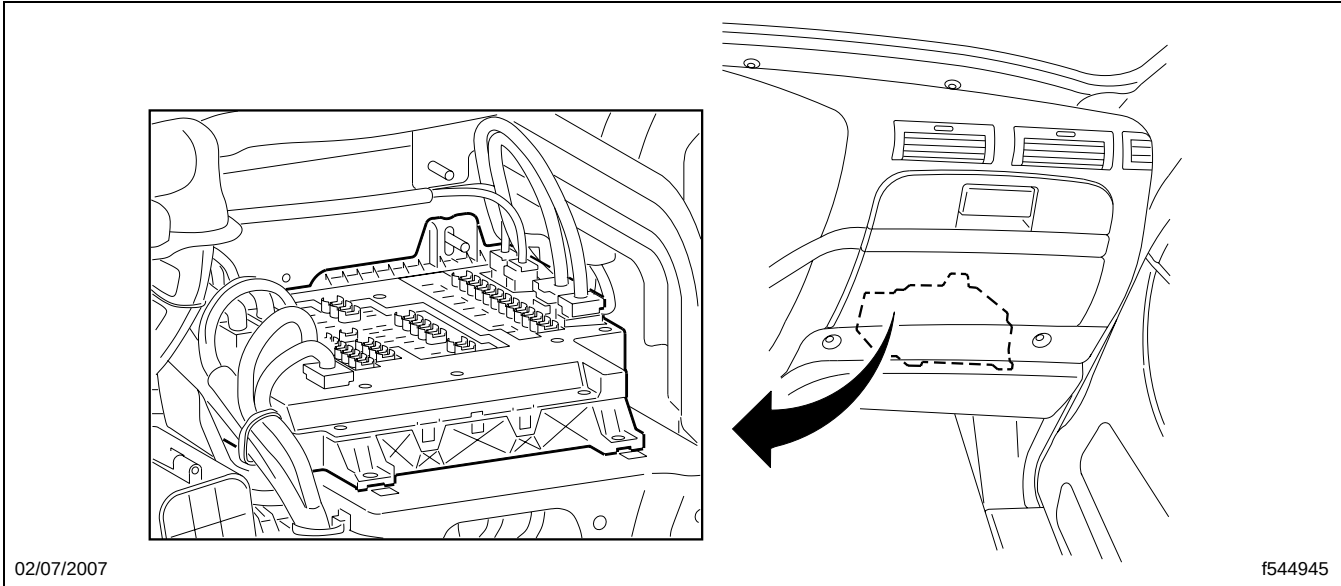


Fig. 3, SAM Cab

700 — Troubleshooting Overview

The power window system is powered through SAM cab relay R15 and fuse F40 for the driver side, and fuse F39 for the passenger side. There are no fault codes for the power window system. The power windows operate when the key is in the accessory or ignition position.

Power Windows

C06.07

701 — Wiring Schematic

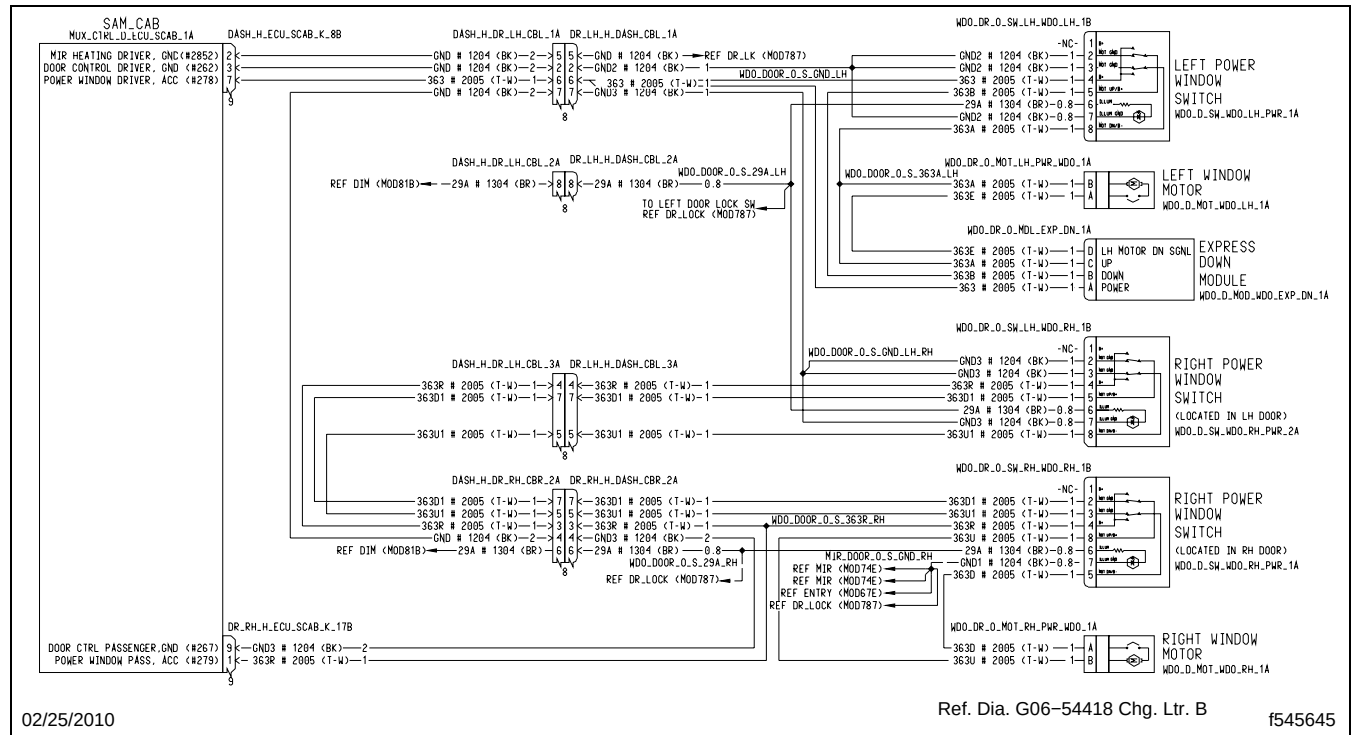


Fig. 4, Wiring Schematic, Power Windows

702 — Diagnostic Tools Required

- Digital Multimeter

703 — Power Window Diagnostics—Driver Side

Perform the following steps if the driver-side power window does not operate properly.

NOTE: Power window regulators are equipped with automatic reset internal thermal protection to prevent motor damage from electrical failure or overuse. Depending on the air temperature, window load, and amount of use, the protection may trip after two or three window cycles. This is normal and is not considered to be a defect. Allow the motor to cool at least 10 minutes to reset the thermal protection before testing.

1. Check the operation of the power window.

Is the window totally inoperative?

YES → Test relay R15 and fuse F40 in the SAM cab. If fuse F40 is open, replace the fuse and go to test 3. If the relay is open, replace it. Otherwise, go to test 2.

NO → Loosen the window guide channels, then check that there is lubricant in the channel along the bottom of the window. Operate the window. If the window operates freely, tighten the guide channels in a position where they are not binding the window. Otherwise go to test 2.

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Power Windows

2. Check for battery voltage at the power window motor.

- 2.1 Remove the driver-side door interior trim panel. See **Section 72.00, Subject 110** of the *Cascadia™ Workshop Manual*.
- 2.2 Measure the voltage across the power window motor, with the switch in both the up and down positions.

Is battery voltage or negative battery voltage present in both UP and DOWN positions, one position only, or in neither position?

BOTH POSITIONS → Battery voltage at the motor indicates either an open circuit breaker or an open motor. The internal circuit protection in the motor may have tripped. Allow the motor to cool for about 10 minutes, then check the voltage again. If the motor keeps binding and tripping the circuit breaker, follow the NO instructions of test 1. If the motor is always open circuit, follow the YES instructions of test 5.

ONE POSITION ONLY → Replace the power window switch.

NEITHER POSITION → Go to test 3.

3. Check the voltage on circuit 363.

Measure the voltage on circuit 363 at the power window switch and at the express down module.

Is battery voltage present?

YES → Go to test 4.

NO → Locate the wiring fault in circuit 363 between the SAM cab connector X8, pin 7, and the switch/module. Repair as needed.

4. Check for voltage between circuits 363A and 363B at the power window switch.

With the power window switch in both the UP and DOWN positions, measure the voltage between pin 8 (circuit 363A) and pin 5 (circuit 363B) at the power window switch.

Is battery voltage (UP position) and negative battery voltage (DOWN position) present?

YES → Go to test 5.

NO → Troubleshoot for a wiring fault in the ground circuit between the SAM cab connector X8, pin 3, and the switch pins 2 and 3. If a fault is found, repair as appropriate. Otherwise, replace the power window switch.

5. Check for voltage at the power window motor across circuits 363A and 363E.

With the power window switch in both the UP and DOWN positions, measure the voltage at the power window motor across circuits 363A and 363E.

As both positions of the switch are tested, are positive and negative battery voltage present?

YES → Replace the power window motor. Note that the spring in the window regulator places a significant pre-load on the arm and motor.

NO → Repeat the measurement between circuits 363A and 363B at the express down module (test 4). If battery voltage and negative battery voltage is present, replace the express down module. Otherwise, repair the wiring fault in the door harness.

704 — Power Window Diagnostics—Passenger Side

Perform the following steps if the passenger-side power window does not operate properly.

NOTE: Power window regulators are equipped with automatic reset internal thermal protection to prevent motor damage from electrical failure or overuse. Depending on the air temperature, window load, and amount of use, the protection may trip after two or three window cycles. This is normal and is not considered to be a defect. Allow the motor to cool at least 10 minutes to reset the thermal protection before testing.

1. Check the operation of the power window.

Is the window totally inoperative?

YES → Test relay R15 and fuse F39 in the SAM cab. If fuse F39 is open, replace the fuse and go to test 3. If the relay is open, replace it. Otherwise, go to test 2.

NO → Loosen the window guide channels, then check that there is lubricant in the channel along the bottom of the window. Operate the window. If the window operates freely, tighten the guide channels in a position where they are not binding the window. Otherwise go to test 2.

2. Check for battery voltage at the power window motor.

2.1 Remove the passenger-side door interior trim panel. See **Section 72.00, Subject 110** of the *Cascadia™ Workshop Manual*.

2.2 Measure the voltage across the power window motor, with the switch in the up or down position.

Is battery voltage or negative battery voltage present in both UP and DOWN positions, one position only, or in neither position?

BOTH POSITIONS → Battery voltage at the motor indicates either an open circuit breaker or an open motor. The internal circuit protection in the motor may have tripped. Allow the motor to cool for about 10 minutes, then check the voltage again. If the motor keeps binding and tripping the circuit breaker, follow the NO instructions of test 1. If the motor is always open circuit, follow the YES instructions of test 6.

ONE POSITION ONLY → Replace the power window switch.

NEITHER POSITION → Go to test 3.

3. Check the voltage on circuit 363R.

Measure the voltage on circuit 363R at both the driver-side and passenger-side power window switches.

Is battery voltage present?

YES → Go to test 4.

NO → Locate the wiring fault in circuit 363R between the SAM cab connector X17, pin 1, and either of the switches. Repair as needed.

4. Check for voltage between circuits 363D1 and 363U1 at the driver-side passenger-window switch.

With the power window switch in both the UP and DOWN positions, measure the voltage between pin 8 (circuit 363D1) and pin 5 (circuit 363U1) at the driver-side passenger-window switch.

Is battery voltage (UP position) and negative battery voltage (DOWN position) present?

YES → Go to test 5.

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Power Windows

NO → Troubleshoot for a wiring fault in the ground circuit between the SAM cab connector X17, pin 9, and the driver-side passenger-window switch, pins 2 and 3. If a fault is found, repair as appropriate. Otherwise, replace the driver-side passenger-window switch.

5. **Check for voltage between circuits 363U and 363D at the passenger-side power window switch.**

With the power window switch in both the UP and DOWN positions, measure the voltage between pin 8 (circuit 363U) and pin 5 (circuit 363D) at the passenger-side power window switch.

Is battery voltage (UP position) and negative battery voltage (DOWN position) present?

YES → Go to test 6.

NO → Troubleshoot for a wiring fault in circuits 363D1 and 363U1, between the driver-side passenger-window switch and the passenger-side switch. If a fault is found, repair as appropriate. Otherwise, replace the passenger-side power window switch.

6. **Check for voltage at the power window motor across circuits 363D and 363U.**

With the power window switch in both the UP and DOWN positions, measure the voltage at the power window motor across circuits 363D and 363U.

As both positions of the switch are tested, are positive and negative battery voltage present?

YES → Replace the power window motor. Note that the spring in the window regulator places a significant pre-load on the arm and motor.

NO → Troubleshoot for a wiring fault in the passenger-side door harness. Repair as needed.

Cab Power Receptacles

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500 — Terms and Abbreviations

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The cigar lighter outlet provides 12V power to any device connected to it. The SAM Cab provides 12V power to six power receptacles. Two 12V power receptacles (called power receptacle 1 and 2) are located in the dash. Power receptacle 1 is the cigar power receptacle, and power receptacle 2 is the phone power receptacle. These receptacles are fused and receive their power from the batteries. The ignition switch position has no effect on the power output.

Four more power receptacles (3 through 6) are offered as optional 12V power output in the sleeper section of the cab. Power receptacles 3 through 5 are identical in functionality to power receptacles 1 and 2.

NOTE: Power receptacles 3 through 5 are controlled by the powernet management feature.

502 — Powernet Management

The powernet management feature protects the batteries from discharging too much by temporarily shutting down loads from the power supply. This ensures that in the event of a drop in voltage, the battery draining process is slowed.

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Cab Power Receptacles

600 — Component Locations

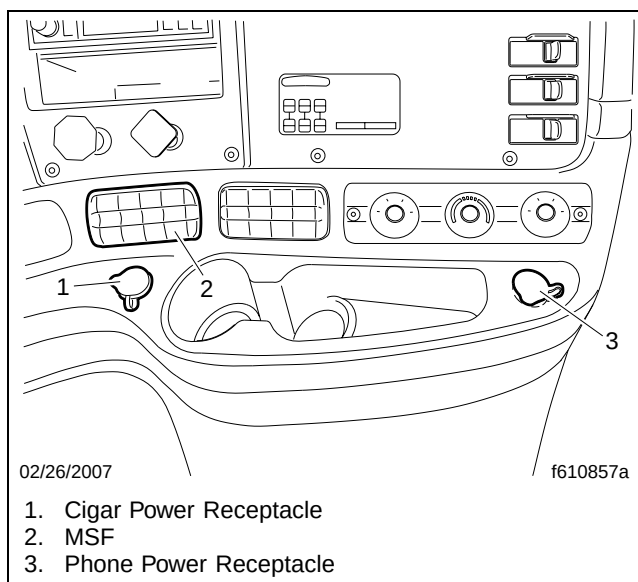


Fig. 1, Power Receptacle Locations

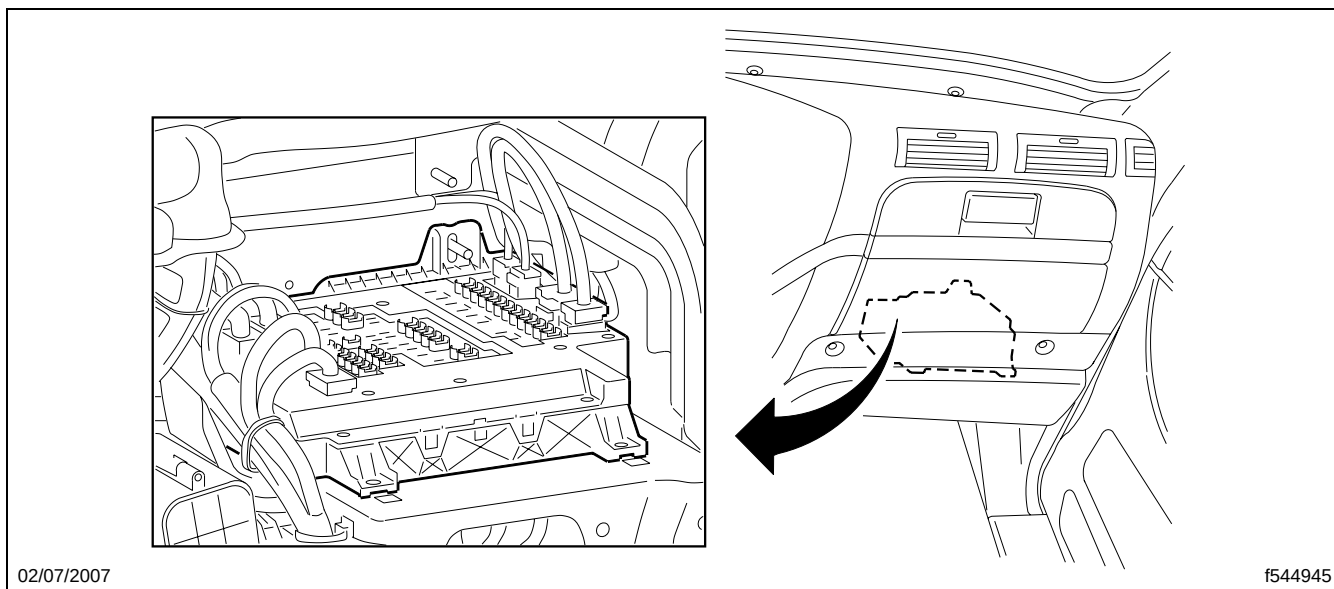


Fig. 2, SAM Cab

Cab Power Receptacles

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700 — Fuse and Relay Distribution

Fuse and Relay Distribution			
Name	Description	Value/Range	Default Value
SAM_CAB BASELINE	A06-60968-004	06-62395-001	06-62982-001
SAM_CAB HIGHLINE	A06-60969-004	06-62395-000	06-62982-000
SAM_CHAS BASELINE	A06-60970-004	06-62396-001	06-62983-001
SAM_CHAS MIDLINE w/o X56	A06-65601-004	06-62396-002	06-62983-002
SAM_CHAS HIGHLINE	A06-60971-004	06-62396-000	06-62983-000

Table 1, Fuse and Relay Distribution

Powernet Management

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500 — Terms and Abbreviations

Datalink—A collection of wires, connecting system components, through which data is transmitted.

DLM—Datalink Monitor

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MFJB—MEGA® Fuse Junction Block

MGJB—Main Ground Junction Block

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PDM—Power Distribution Module

PLVD—Progressive Low Voltage Disconnect

PNM—Powernet Management

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

The powernet management feature protects the batteries from discharging too much by temporarily shutting down loads from the power supply. This ensures that in the event of a drop in voltage, the battery draining process is slowed.

Progressive low voltage disconnect (PLVD) is used to implement the powernet management feature. When the battery voltage drops below a predetermined value, loads designated as comfort loads (priority level I) are shut down first. Then loads designated as house loads (priority level II) are shut down. If necessary, basic loads (priority level III) are shut down last.

The progressive shutdown of loads from comfort loads, to house loads, to basic loads allows the driver to continue using critical loads, while noncritical loads are temporarily unavailable. Calculations for disconnecting loads are based on battery voltage, ignition switch status, and engine RPM. Also, a time delay is implemented for the shutdown and reactivation of loads to avoid unnecessary cycling of loads when battery voltage is close to the shutdown thresholds.

The SAM Cab reads the battery voltage via a dedicated sense pin that is fused in the powertrain PDM and not at the MFJB.

One minute before the comfort loads and house loads are shut down, an alarm sounds for 10 seconds. No alarm sounds before the basic loads shut down.

If the interior lights have been shut down by PLVD, pressing one of the interior light switches (if equipped) brings the interior lights back on.

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See **Table 1** for the type of loads shut down under specific conditions.

See **Table 2** for the loads that are designated comfort, house, and basic load status.

Type of Loads Shut Down Under Specific Conditions			
Key Switch Position	Engine On and Voltage Less Than 12.5 Volts	Engine Off and Voltage Less Than 12.3 Volts	Engine Off and Voltage Less Than 12.1 Volts
Off	N/A	Priority level I, II loads	Priority level I, II, and III loads
Accessory	N/A	Priority Level I loads	Priority level I, II loads
On	Priority level I loads	Priority Level I loads	Priority level I, II loads
Crank	N/A	N/A	N/A

Table 1, Type of Loads Shut Down Under Specific Conditions

Designated Loads	
Type of Load	Function
Priority Level I Loads	12V power receptacle 6 (sleeper, refrigerator)
	Amplifier power, accessory
	General sleeper light
	Footwell light
	Reading light 1 (dimmable/theater)
	Reading light 2 (dimmable/theater)
	Rear baggage compartment light
	12V power receptacle 5 (sleeper, cigar), battery
	Auxiliary circulation fan-sleeper, battery
	12V power receptacle 4 (sleeper, cigar), battery
	Reading light 4 (switched locally), battery
	Heated seats, ignition

Designated Loads	
Type of Load	Function
Priority Level II Loads	12V power receptacle 2 (dash, phone), battery
	12V power receptacle 1 (dash, cigar), battery
	Sleeper HVAC controller, accessory
	Cabin HVAC controller, accessory
	Radio, accessory (clamp 15R)
	Power feed spare output I, battery
	Power feed spare output III, battery
	Mirror heating, passenger
	Mirror heating, driver
	Power feed spare output IV, battery
	Power feed spare output II, battery
	Fuel water separator heater element, ignition
	Air dryer (pneumatic, electrically heated), accessory
	Auxiliary circulation fan-windshield, accessory
	Auxiliary heater (ESPAR) power
	Utility light
	Utility light
	Dome light rear
	Area lighting (lower bunk and sleeper work surface), battery
	Dome light cab, battery
	Overhead compartment lights, battery
	12V power receptacle 3 (sleeper, cigar), battery
	Stand-alone HVAC, battery
	Advertising light, accessory
	Dome light passenger (second pin, uses same output driver as 532)
	Dome light driver/forward overhead (first pin, uses same output driver as 534)
Priority Level III Loads	CB radio, battery
	Fleet management system, battery
	Trailer power, battery or ignition

Table 2, Designated Loads

502 — Emergency Power System Overview

The emergency power feature ensures that in the event of a SAM failure, the vehicle can be driven off the highway and kept conspicuous until help arrives. The driver has control of this feature in that, when the ignition is in

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Powernet Management

the ON position, the emergency outputs remain on in their current state. When the ignition is turned OFF, the emergency outputs are shut off.

The emergency power feature provides basic functionality to the SAM during the following failure modes:

- **Power Failure:** Loss of main power supply to SAM Cab or SAM Chassis.
- **SAM Microprocessor Failure:** Loss of function of the main microprocessor due to microprocessor component failure, memory damage, or crystal damage.
- **CAN Communication Failure:** Cabin CAN communication failure between the SAM Cab and SAM Chassis due to a damaged cable, loose connections, application failure, or damage to a transceiver.

When the SAM Cab fails, all gauges in the ICU drop to zero, and the engine cannot be restarted.

When the SAM Chassis fails, the turn signal indicators flash alternately. The engine can still be restarted when the SAM Chassis fails.

503 — Output Responses to a SAM Failure

The SAM Cab and SAM Chassis have specific output responses to each type of failure mode.

See **Table 3** for the SAM Cab and SAM Chassis output responses when:

- the ignition is in the ON position, and the SAM Cab has lost main power supply; **OR**
- the ignition is in the ON position, and the SAM Cab is not working due to a loss of CAN communication with the SAM Chassis; **OR**
- a SAM microprocessor failure with the SAM Cab.

See **Table 4** for the SAM Cab and SAM Chassis output responses when:

- the ignition is in the ON position, and the SAM Chassis has lost main power supply; **OR**
- the ignition is in the ON position, and the SAM Chassis is not working due to a loss of CAN communication with the SAM Cab; **OR**
- a SAM microprocessor failure with the SAM Chassis.

See **Table 5** for the SAM Cab and SAM Chassis output responses when the SAMs are functioning normally and:

- the ignition is in the ON position, and the SAM Chassis has lost main power supply; **OR**
- the ignition is in the ON position; **AND**
- loss of power to both SAMs (the load disconnect switch is open, for example).

See **Table 6** for the SAM Cab and SAM Chassis output responses when the ignition is in the OFF position. Regardless of the previous failure mode, the emergency power feature is deactivated when the ignition is in the OFF position.

SAM Output Responses to a SAM Cab Failure		
Description	Connector	Pin
SAM Cab	Dash panel lights, 12 Volts	Flashing
	Low-beam headlights	On
	Clearance lights	Flashing
	Identification lights	Off
	Front marker lights	Flashing
	Engine ECU (powertrain PDM), Ignition	On
	Starter relay	Cannot start vehicle
	Turn signal indicators, ICU	Off
	Side marker lights	Flashing
SAM Chassis	Rear turn signal lights	Off
	Trailer tail lights	Flashing
	Rear stop lights	Flashing

Table 3, SAM Output Responses to a SAM Cab Failure

SAM Output Responses to a SAM Chassis Failure		
Description	Connector	Pin
SAM Cab	Dash panel lights, 12 Volts	Flashing
	Low-beam headlights	On
	Clearance lights	Flashing
	Identification lights	Flashing
	Front marker lights	Flashing
	Engine ECU (powertrain PDM), Ignition	On
	Starter relay	Can start vehicle
	Turn signal indicators, ICU	Flashing alternately
	Side marker lights	Flashing
SAM Chassis	Rear turn signal lights	Flashing
	Trailer tail lights	Flashing
	Rear stop lights	Off

Table 4, SAM Output Responses to a SAM Chassis Failure

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SAM Output Responses When the Load Disconnect Switch is Open		
Description	Connector	Pin
SAM Cab	Dash panel lights, 12 Volts	Flashing
	Low-beam headlights	On
	Clearance lights	Flashing
	Identification lights	Flashing
	Front marker lights	Flashing
	Engine ECU (powertrain PDM), Ignition	On
	Starter relay	Cannot start vehicle
	Turn signal indicators, ICU3	Off
	Side marker lights	Off
SAM Chassis	Rear turn signal lights	Off
	Trailer tail lights	Off
	Rear stop lights	Off

Table 5, SAM Output Responses When the Load Disconnect Switch is Open

SAM Output Responses When the Ignition is in the Off Position		
Description	Connector	Pin
SAM Cab	Dash panel lights, 12 Volts	Off
	Low-beam headlights	Off
	Clearance lights	Off
	Identification lights	Off
	Front marker lights	Off
	Engine ECU (powertrain PDM), Ignition	Off
	Starter relay	Off
	Turn signal indicators, ICU3	Off
	Side marker lights	Off
SAM Chassis	Rear turn signal lights	Off
	Trailer tail lights	Off
	Rear stop lights	Off

Table 6, SAM Output Responses When the Ignition is in the Off Position

600 — Component Locations

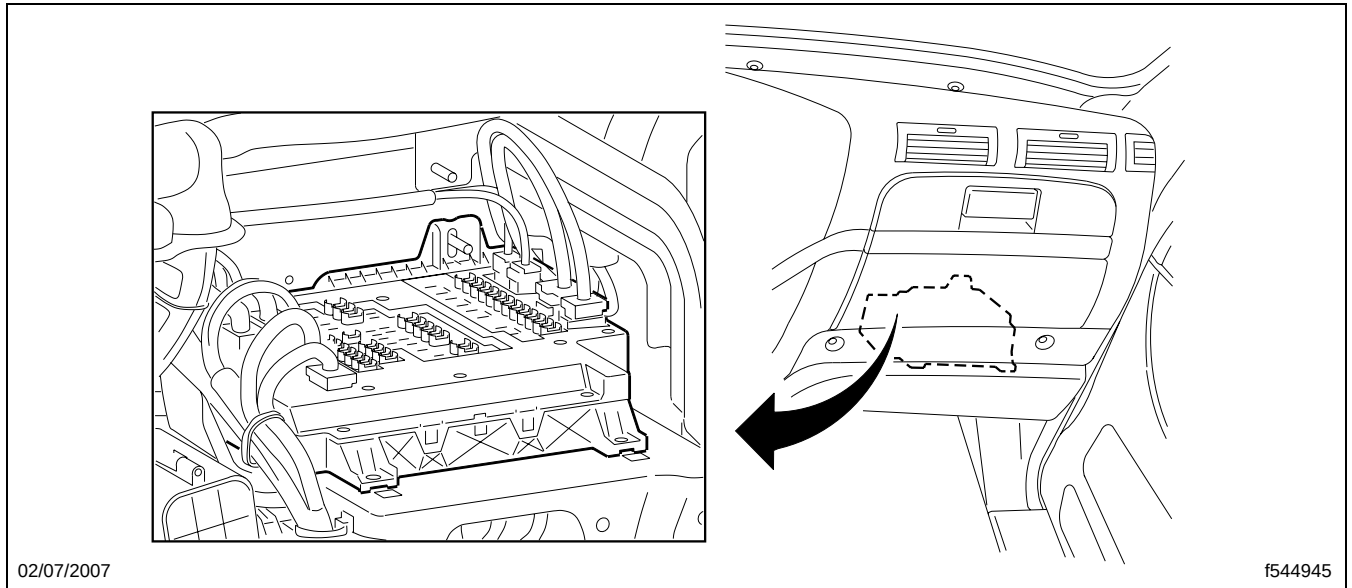


Fig. 1, SAM Cab

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601 — Component Details

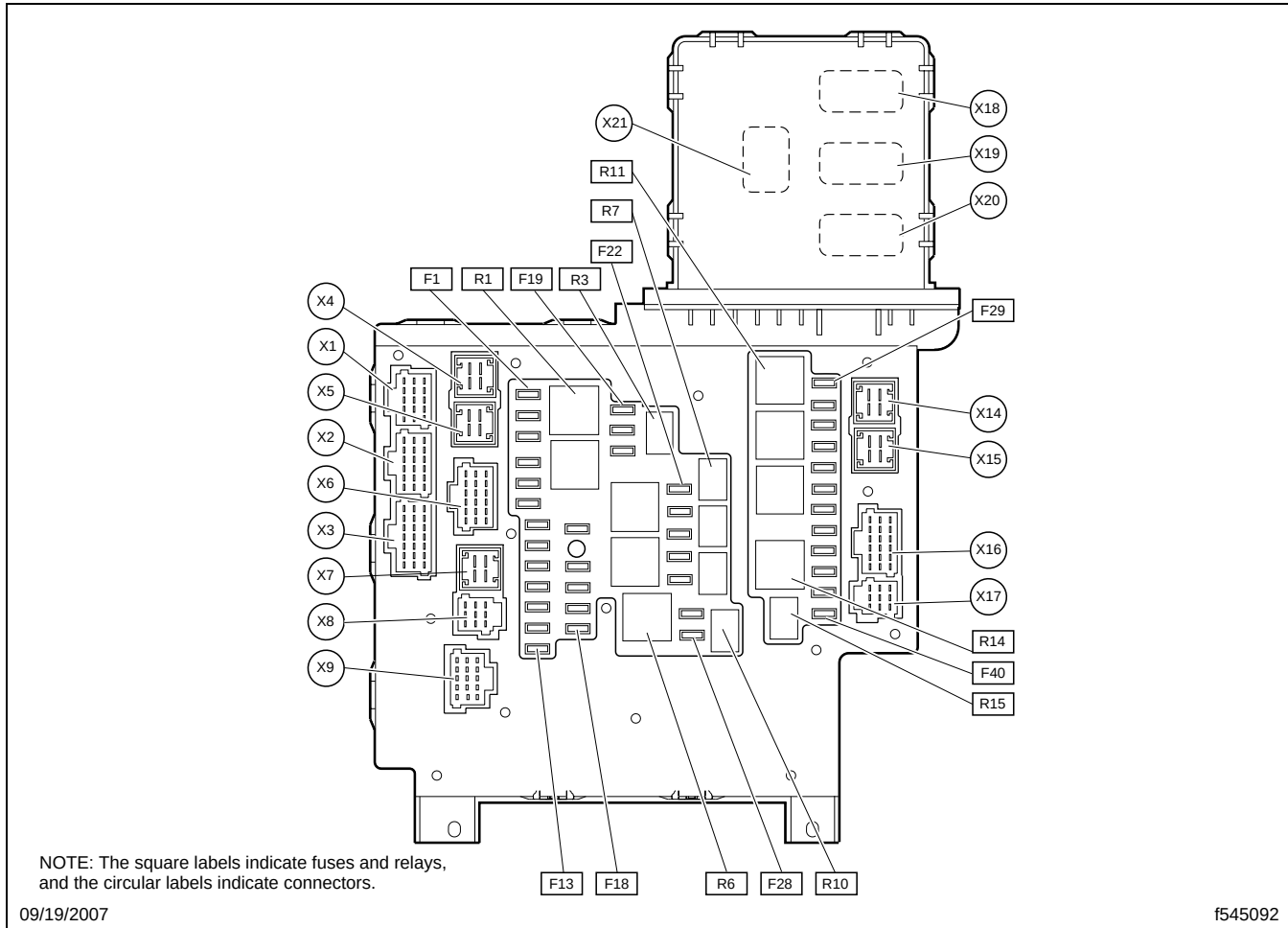


Fig. 2, SAM Cab Fuses and Relays

700 — Troubleshooting Overview

When loads are shut off by a PLVD event, the effected loads are turned off by design, therefore no diagnostic fault code(s) is logged. When large groups of loads are not working, first use the DLM Template to establish whether the system is in a PLVD event by reading the powernet performance level (PPL) of the system. If PPL is normal, then look for diagnostic fault code(s) for other system failures that may have caused the load(s) to be turned off.

701 — Diagnostic Tools Required

- ServiceLink
- DLM Template, "Powernet Management, PLVD"
- Digital Multimeter

702 — Progressive Low Voltage Disconnect Diagnostics

The low voltage disconnect is primarily a software-controlled feature of the SAM system.

Perform the following steps if a problem with the PLVD feature is suspected.

1. **Check the PLVD remote sense fuse.**

1.1 Access the powertrain PDM.

1.2 Check fuse F7, PLVD remote sense.

Is the PLVD remote sense fuse blown?

YES → Replace fuse F7, and determine if there is a short in this circuit.

NO → Go to test 2.

2. **Check that the PLVD parameter is enabled.**

2.1 Open ServiceLink, and connect to the vehicle.

2.2 Check the parameters in both the SAM Cab, and SAM Chassis.

Are PLVD parameters 002 447 54 58 (for the SAM Cab) and 000 447 21 61 (for the SAM Chassis) set?

YES → Go to test 3.

NO → Set the above parameters to enable the PLVD feature.

3. **Observe the PLVD operation using the Datalink Monitor.**

3.1 Open ServiceLink, and connect to the vehicle (if not already done).

3.2 Launch the Datalink Monitor template "Powernet Management, PLVD" for 3.2.

3.3 Using the Datalink Monitor, check for CAN faults that may help in isolating any related failures.

NOTE: When loads are turned off by the PLVD feature, no fault codes are reported. However fault codes for related systems associated with the SAMs may help in determining where a problem exists.

3.4 Observe the PLVD loads with the DLM template.

Do the PLVD loads appear to be switching at the appropriate voltages, and there are no related fault codes?

YES → The PLVD feature is likely working properly.

NO → Troubleshoot the SAM system. Begin with the SAM Cab, since most of the PLVD loads are powered by this ECU. Refer to G02.04 — SAM Cab.

703 — Emergency Power Diagnostics

NOTE: Refer to the symptoms in **Table 7** when the ignition switch is in the ON position. If the key is in the OFF or ACC position, these symptoms do not apply.

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Emergency Power Symptoms	
Emergency Power Symptom	Remedy
All gauges in the ICU drop to zero, engine cannot be restarted	Refer to 704 — All Gauges in the ICU Drop to Zero, Engine Cannot Be Restarted.
Turn signal indicators flash alternately, engine can be restarted	Refer to 705 — Turn Signal Indicators Flash Alternately, Engine Can Be Restarted.
Turn signal indicators flash alternately, engine cannot be restarted	Refer to 706 — Turn Signal Indicators Flash Alternately, Engine Cannot Be Restarted.

Table 7, Emergency Power Symptoms

704 — All Gauges in the ICU Drop to Zero, Engine Cannot Be Restarted

This symptom usually implies a problem with the SAM Cab, typically a loss of main power, loss of Cabin CAN, or an internal electronics failure with the SAM Cab.

1. Check for battery voltage at the SAM Cab.

- 1.1 Access the battery studs for the SAM Cab in the engine compartment.
- 1.2 Measure voltage across the positive and negative studs at the SAM cab.

NOTE: It may be difficult to get both hands behind the cabin air filter to access both the positive and negative studs of the SAM Cab. Try accessing the positive stud of the SAM Cab with one lead, and the ground stud of the alternator with the other.

Is battery voltage available at the SAM Cab?

YES → Battery voltage is good, check for loss of the CAN. Go to test 3.

NO → Go to test 2.

2. Check the MEGA Fuse and battery cables that supply power to the SAM Cab.

- 2.1 Disconnect negative leads at the battery.
- 2.2 Disconnect the positive lead to the MFJB.
- 2.3 Measure resistance across each MEGA Fuse.
- 2.4 Measure resistance in both positive and negative battery cables that feed the SAM Cab.

NOTE: When measuring resistance in the SAM Cab battery circuits, try measuring from the SAM Cab BAT to the alternator BAT studs, then from the SAM Cab GND stud to the alternator GND stud. They both share common nodes at either the MGJB or MFJB.

Are there any open circuits in the MEGA Fuses, or battery cables, feeding the SAM Cab?

YES → Repair any open circuits in the battery cables feeding the SAM Cab. If one or more MEGA Fuses are blown, you will need to first determine the cause of the high amp spike that blew the MEGA Fuse.

NO → Go to test 3.

3. Check for a loss of CAN communication between the SAM Cab and SAM Chassis.

- 3.1 Connect a service computer to the vehicle, and run ServiceLink.
- 3.2 Note if there are any Cabin CAN faults for loss of communication for either SAM?

3.3 Troubleshoot the Cabin CAN. Refer to **G03.03 — Datalink, Cabin CAN**.

Are the SAMs communicating on Cabin CAN?

YES → Go to test 4.

NO → Repair the Cabin CAN. Refer to **G03.03 — Datalink, Cabin CAN**.

4. Check for internal failure of the SAM Cab.

4.1 With the service computer still connected and running ServiceLink, look at the "General ECU" list, for any "Problem ECUs."

4.2 Note if there are any Cabin CAN faults for the SAMs.

4.3 Troubleshoot the SAM Cab. Refer to **G02.04 — SAM Cab**.

Is the SAM Cab functioning normally?

YES → The vehicle may not be in emergency power mode. Re-evaluate the symptoms to determine where the problem exists.

NO → Contact the Freightliner Customer Assistance Center.

705 — Turn Signal Indicators Flash Alternately, Engine Can Be Restarted

This symptom usually implies a problem with the SAM Chassis, typically a loss of main power, loss of Cabin CAN, or an internal electronics failure with the SAM Chassis.

1. Check for battery voltage at the SAM Chassis.

1.1 Access the battery studs for the SAM Chassis.

1.2 Measure voltage across the positive and negative studs at the SAM Chassis.

Do you get battery voltage across the positive and negative studs of the SAM Chassis?

YES → Battery voltage is good, check for loss of CAN. Go to test 3.

NO → Go to test 2.

2. Check the MEGA Fuse and battery cables that supply the SAM Chassis.

2.1 Disconnect negative leads at the battery.

2.2 Disconnect the battery positive lead to the MFJB.

2.3 Measure resistance across each MEGA Fuse.

2.4 Measure resistance in both positive and negative battery cables that feed the SAM Chassis.

Are there any open circuits in the MEGA Fuses, or battery cables feeding the SAM Chassis?

YES → Repair any open circuits in the battery cables feeding the SAM Chassis. If one or more MEGA Fuses are blown, first determine the cause of the high amp spike that blew the MEGA Fuse.

NO → Go to test 3.

3. Check for a loss of CAN communication between the SAM Chassis, and SAM Cab.

3.1 Connect a service computer to the vehicle, and run ServiceLink.

3.2 Note if there are any Cabin CAN faults for loss of communication for either SAM?

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3.3 Troubleshoot the Cabin CAN. Refer to **G03.03 — Datalink, Cabin CAN**.

Are the SAMs communicating on Cabin CAN?

YES → Go to test 4.

NO → Repair the Cabin CAN. Refer to **G03.03 — Datalink, Cabin CAN**.

4. Check for internal failure of the SAM Chassis.

4.1 With the service computer still connected and running ServiceLink, look at the General ECU list, for any "Problem ECUs."

4.2 Note if there are any Cabin CAN faults for the SAMs.

4.3 Troubleshoot the SAMs. Refer to **G02.05 — SAM Chassis**.

Is the SAM Chassis functioning normally?

YES → The vehicle may not be in emergency power mode. Re-evaluate the symptoms to determine where the problem exists.

NO → Contact the Freightliner Customer Assistance Center.

706 — Turn Signal Indicators Flash Alternately, Engine Cannot Be Restarted

This symptom usually implies a problem with both SAMs, typically a loss of main power to both SAMs. The most common cause of this symptom is that the ignition is in the ON position, but the load disconnect switch is in the OFF position.

1. Check if the load disconnect switch is OFF.

Is the load disconnect switch OFF, while the ignition was in the ON position?

YES → Turn the load disconnect to the on position.

NO → Go to test 2.

2. Check the battery cables from the battery to the MFJB.

Is there battery voltage at the MFJB stud?

YES → Go to test 3.

NO → Repair the open circuit between the battery and the MFJB.

3. Check the battery voltage across all MEGA Fuses.

Is there battery voltage across all MEGA Fuses on the MFJB?

YES → Continue checking for battery voltage to each of the SAM battery and ground studs until the open circuit is found.

NO → Replace any blown MEGA Fuses once the cause if the blown MEGA Fuse is discovered. Do not simply replace a blown MEGA Fuse without determining why it opened.

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
306	000 447 20 61	Progressive low voltage disconnect not present.	PARM-CHAS, PNM, NO CNT	SAM Chassis
	000 447 21 61	Progressive low voltage disconnect present.	PARM-CHAS, PNM, LVD	
	002 447 53 58	Progressive low voltage disconnect not present.	PARM-CAB, PNM, NO CNT	SAM Cab
	002 447 54 58	Progressive low voltage disconnect present.	PARM-CAB, PNM, LVD	

Table 8, Parameters

801 — Designated Loads with Connector and Cavity Locations

Designated Loads with Connector and Cavity Locations			
Type of Load	Function	Connector ID	Cavity Number
Priority Level I Loads	Amplifier power, accessory	X3	9
	General sleeper light	X2	9
	Footwell light	X12	3
	Reading light 1 (dimnable/theater)		6
	Reading light 2 (dimnable/theater)		16
	Rear baggage compartment light		12
	12 V power receptacle 5 (sleeper, cigar), battery	X14	1
	Auxiliary circulation fan-sleeper, battery	X1	13
	12 V power receptacle 4 (sleeper, cigar), battery	X3	3
	Reading light 4 (switched locally), battery	X16	13
	Heated seats, ignition	X1	12

C06.09

Powernet Management

Designated Loads with Connector and Cavity Locations			
Type of Load	Function	Connector ID	Cavity Number
Priority Level II Loads	12 V power receptacle 2 (dash, phone), battery	X6	9
	12 V power receptacle 1 (dash, cigar), battery		15
	Sleeper HVAC controller, accessory	X1	15
	Cabin HVAC controller, accessory		10
	Radio, accessory (clamp 15R)	X10	18
	Power feed spare output I, battery	X4	1
	Power feed spare output III, battery		2
	12 V power receptacle 6 (sleeper, refrigerator)	X14	2
	Mirror heating, passenger	X17	2
	Mirror heating, driver	X8	8
	Power feed spare output IV, battery	X5	2
	Power feed spare output II, battery		1
	Fuel water separator heater element, ignition	X57	15
	Air dryer (pneumatic, electrically heated), accessory		4
	Auxiliary circulation fan-windshield, accessory	X16	5
	Auxiliary heater (ESPAR) power	X2	1
	Utility light 1	X3	7
	Utility light 2	X21	14
	Dome light rear	X12	17
	Area lighting (lower bunk and sleeper work surface), battery	X2	15
	Dome light cab, battery	X16	7
	Overhead compartment lights, battery		17
	12 V power receptacle 3 (sleeper, cigar), battery	X3	
	Stand-alone HVAC, battery		15
	Advertising light, accessory		5
	Dome light passenger (second pin, uses same output driver as 532)	X16	4
	Dome light driver/forward overhead (first pin, uses same output driver as 534)		14
Priority Level III Loads	CB radio, battery	X6	3
	Fleet management system, battery		2
	Trailer power, battery or ignition	X55	1

Table 9, Designated Loads with Connector and Cavity Locations

Backup Lights and Alarm

C07.01

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Backup Lights and Alarm

C07.01

500 — Terms and Abbreviations

CAN—Controller Area Network

CGW—Central Gateway

Chopped Signal—A signal with a fixed duty cycle.

Communication Protocol—A set of rules governing communication between electronic devices.

Datalink—A collection of wires, connecting system components, through which data is transmitted.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAE—Society of Automotive Engineers

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

The backup lighting and alarm provides both visual and audible warning and aft lighting when the transmission is in reverse gear. The input, depending on the transmission type, is either a datalink signal from transmission controller or a hardwired switch that is read by the SAM Chassis. The backup alarm is externally spliced with the backup lamp.

The backup lighting feature reads the CAN-converted J1939 message (via the CGW) from the electronic transmission, and the backup switch status message created from the backup switch. The SAM Chassis reads the message from the SAM Cab indicating that the reverse gear is engaged or, for transmissions without datalink capability, the SAM Chassis reads a hardwired backup switch input and sends the status via a CAN message.

The pin "backup switch," from the SAM Chassis provides 12V to the backup switch, with a chopped IGN signal. If the switch is closed, the fixed duty cycle (chopped) signal is also applied to "backup switch return." This means a valid switch closure, and the switch is good.

If the backup switch return is shorted to GND, there will be no fixed duty cycle signal applied to the backup switch return, indicating a fault condition.

If the backup switch return is shorted to BAT, there will not be a fixed duty cycle signal applied to the backup switch return, indicating a fault condition.

C07.01

Backup Lights and Alarm

502 — Controls

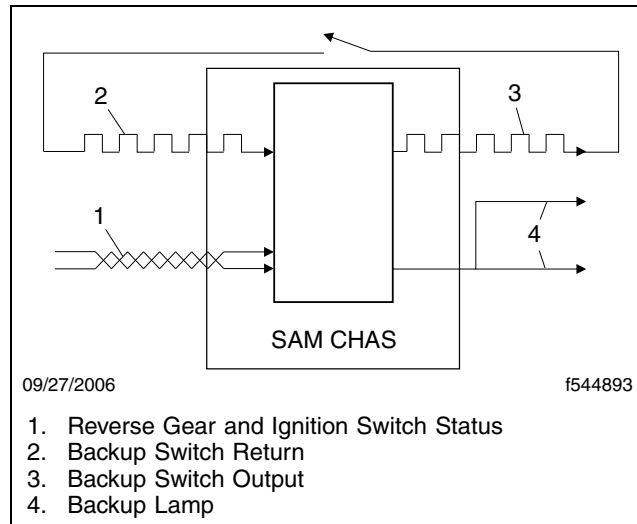


Fig. 1, Controls

Backup Lights and Alarm

C07.01

600 — Component Locations

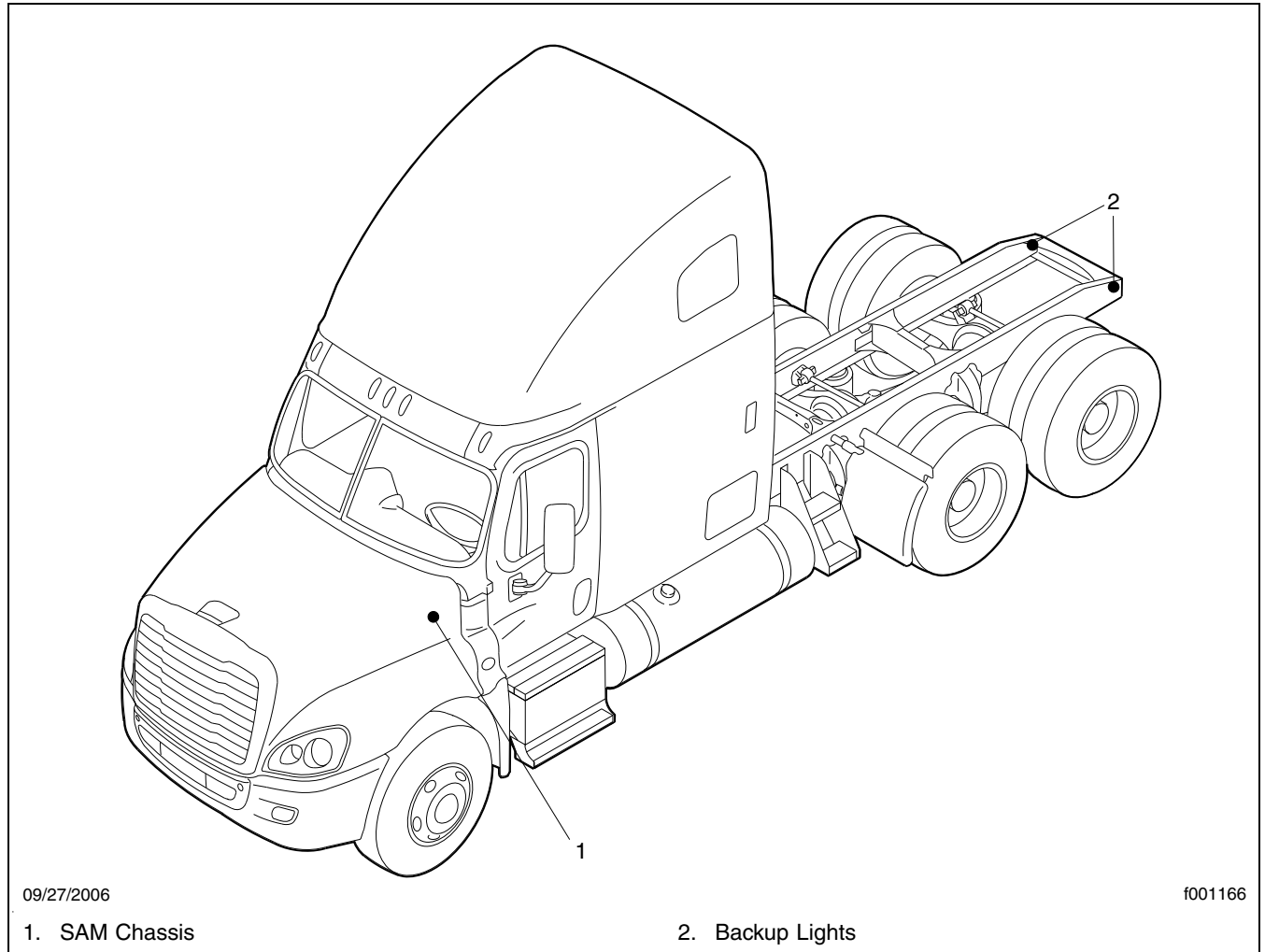


Fig. 2, Component Locations

C07.01

Backup Lights and Alarm

601 — Component Details

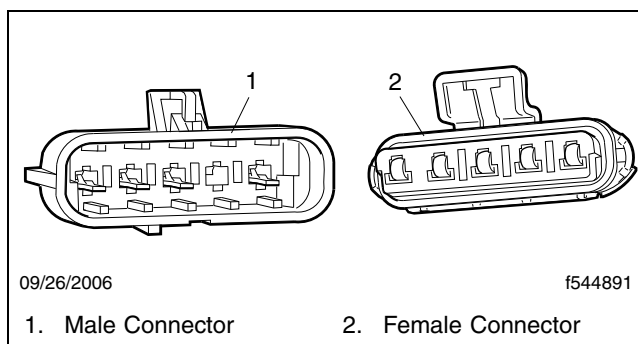


Fig. 3, Backup Light Connector

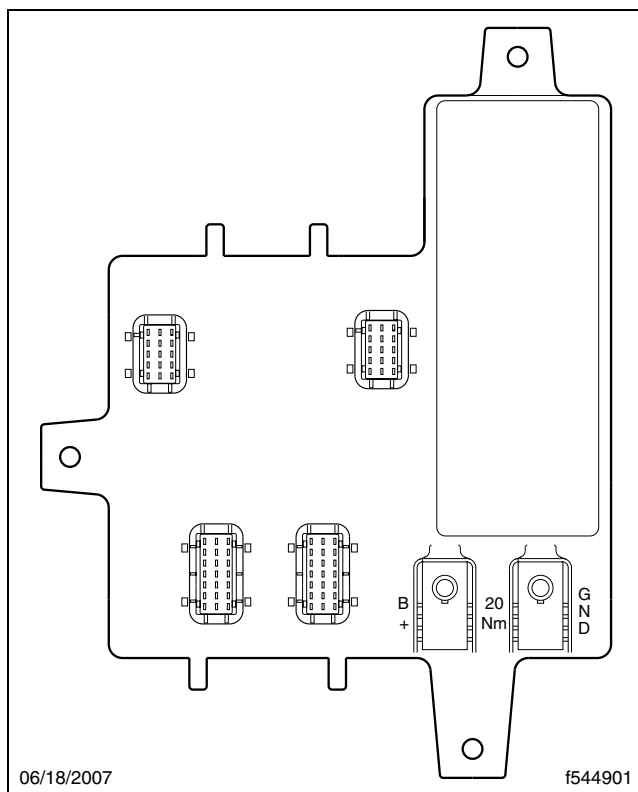


Fig. 4, SAM Chassis

700 — Troubleshooting Overview

The backup lights are controlled by the SAM system. Begin troubleshooting in **G02.05 — SAM Chassis**, section **706 — Logic Controlled Unfused Outputs**.

Backup Lights and Alarm

C07.01

701 — Diagnostic Tools Required

- ServiceLink/DataLink Monitor
- Digital Multimeter
- ServiceLink
- DataLink Monitor template "Backup Lamp"

702 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
71	520919	3	conn X58 pin 19	—	—	Backup lamp – Voltage above normal, or shorted to high source.	The fault is active if the voltage detected at conn X58 pin 19 is higher than 8.1V when the backup lamps are off. The fault becomes historic when the voltage detected is less than 6.8V.
Action: With the backup lamp inactive, measure the voltage at conn X58 pin 19. Troubleshoot circuit 120B for a short to BAT if 0V is not detected.							
71	520919	4	conn X58 pin 19	—	—	Backup lamp – Voltage below normal, or shorted to low source.	The fault is active if the current detected at conn X58 pin 19 is greater than 17.2A when the backup lamps are active. The fault becomes historic when the current is less than 8A.
Action: With the backup lamps active, measure the voltage at conn X58 pin 19. If the voltage detected is not BAT voltage, troubleshoot circuit 120B for a short to GND.							
71	521001	3	conn X59, pin 1 conn X59, pin 3	—	—	Backup switch – Voltage above normal, or shorted to high source.	The backup switch does not reflect the actual transmission reverse status. The backup switch is not receiving the transmission reverse status from the electronic transmission.
Action: Check the parameter to ensure it has an automated manual transmission, and not an automatic transmission. Measure the voltage at conn X59 pin 1 and conn X59 pin 3. With the vehicle not in reverse, if the voltage detected at conn X59 pin 1 is not 3 to 7V and conn X59 pin 3 is not 0V, troubleshoot circuits 120 and 120H for a short to BAT.							

Table 1, CAN Fault Codes

703 — Input Troubleshooting, Manual and Automated Transmissions

Perform the following tests with the engine OFF and the ignition switch in the ON position. There are variations of the backup lamp configurations, such as using an adapter harness without integral tail lamps. Or, for automatic transmissions, there is a J1939 message indicating to the SAM Chassis that the transmission is in reverse.

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Backup Lights and Alarm

This symptom usually implies a problem with the SAM Chassis, typically a loss of main power, loss of Cabin CAN, or an internal electronics failure with the SAM Chassis.

1. Measure the backup lamp switch chopped supply voltage.

- 1.1 Remove connector X59 from the SAM Chassis.
- 1.2 Set the multimeter to read AC voltage, and measure voltage between pin X59.1 and the SAM Chassis ground terminal.

Is the voltage between 3 and 7 VAC between pin X59.1 and the SAM Chassis ground terminal?

YES → The chopped signal supply is normal, go to step 2.

NO → The chopped signal is not available. This signal should be present whether or not the transmission is in reverse. Check the SAM Chassis parameters, and ensure that it is configured for a manual/automated transmission, and not an automatic transmission.

2. Check the backup lamp switch return voltage, with the transmission in reverse.

- 2.1 Remove connector X59 from the SAM Chassis, and take the back cover of the connector off exposing the back of the wires.
- 2.2 Insert a conducting metal probe in the back of terminal 3 on connector X59 (to back-probe the terminal).
- 2.3 Install connector X59 to the SAM Chassis.
- 2.4 Put the transmission in reverse gear. It may be necessary to start the engine to get it in reverse..
- 2.5 Set the multimeter to read AC voltage, and measure voltage between terminal X59.3 and the SAM Chassis ground terminal.

Is the voltage between 3 and 7 VAC at terminal X59.3 with the transmission in reverse?

YES → The chopped return signal is normal. If problem persists, reevaluate the backup lamp function using the DataLink Monitor template, and determine if there is a problem with the outputs, or with the SAM Chassis.

NO → The problem is with the backup switch and/or harness. Troubleshoot as required. Refer to drawings in module 35H for more information about this switch input circuit.

704 Output Troubleshooting

The output can be tested by jumping connector/pins X59.1 to X59.3. This simulates a backup switch closure, and should turn the backup lamp ON (manual and automatic transmissions only).

There are different configurations for the tail lamp assemblies. However, troubleshooting the backup lamp output circuit should be very similar. Use the appropriate instructions that would apply to the configuration for either integral tail lamp assemblies or a jumper harness for the backup lamp.

1. Check for continuity in the backup lamp circuit(s).

- 1.1 Remove connector X58 from the SAM Chassis.
- 1.2 Measure resistance between the terminals:
 - X58.19 and X58.8 left tail lamp assembly.
 - X58.19 and X58.5 right tail lamp assembly

Backup Lights and Alarm

C07.01

Is there an open circuit in the backup/tail lamp output circuit(s)?

YES → Go to test 2.

NO → Go to test 3.

2. Isolate the open circuit.

2.1 Remove connector X58 from the SAM Chassis.

2.2 Remove the connector to the backup/tail lamp(s) (depending on configuration).

2.3 Measure resistance in the harness:

- X58.19 to terminal(s) A for circuit 120B.
- X58.8 to terminal E for circuit GND1 (left tail lamp assembly).
- X58.5 to terminal E for circuit GND (right tail lamp assembly).
- Between pins A and E of the backup/tail lamp(s).

Is there low resistance (less than one ohm) in the circuits tested?

YES → Install the backup/tail lamp connector(s) to their assemblies, and connector X58 to the SAM Chassis. Perform a functional test of the backup lamps to determine if the problem is intermittent. If the problem still exists, go back to the backup lamp DataLink Monitor template and evaluate the backup lamp functionality.

NO → Check the intermediate connector for an open circuit (see the appropriate G06 drawings in module 35H). Repair the harness with the affected open circuit or replace the bulb.

3. Determine if a short exists in the backup lamp circuit(s).

NOTE: A short circuit condition for the backup lamp circuit occurs when greater than 9.9 amps is detected at the SAM Chassis. When a short circuit is cleared, an ignition cycle is required to turn the backup lamps on again.

3.1 Remove connector X58 from the SAM Chassis.

3.2 Measure resistance between terminal X58.19 on the connector, and the ground stud on the SAM Chassis.

Is there continuity between terminal X58.19 and ground, indicating a short circuit?

YES → Repair the short circuit in circuit 120B.

NO → Perform a functional test of the backup lamp(s) to determine if the problem is intermittent. If the problem still exists, continue with the "Backup Lamp" Datalink monitor template, and evaluate the backup lamp functionality. Refer to **G02.05 — SAM Chassis** for more information.

C07.01

Backup Lights and Alarm

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
35H	000 447 13 61	Backup Lamps, backup switch present, for Automated Manual transmissions without support of J1939 electronic transmission controller 2 (ETC2) message.	PARM-CHAS, BKL, BKS, MAN, AUT	SAM Chassis
	000 447 14 61	Backup Lamps, backup switch not present, for Automatic or Automated Manual transmissions with support for J1939 electronic transmission controller 2 (ETC2) message.	PARM-CHAS, BKL, AT, ETC2	

Table 2, Parameters

Heated Seats

C07.02

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500 — Terms and Abbreviations

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The heated seats system is an option to provide heating for the driver seat or the driver and passenger seats.

The heated seats system includes the following components:

- Driver seat
- Passenger seat
- Driver-side seat module
- Passenger-side seat module
- Seat heating element

Heated seats are activated by switches located on the driver-side and passenger-side seat module. The SAM Cab provides power (pin 12) and ground (pin 5) to the system from connector X1. There is no multiplexing supplied to the heated seats.

The heater system in the seat is a closed loop, wire heating element. When the switch on the seat module is set to the "ON" position, power passes through a thermostat to the heating wire. When the thermostat reaches the upper limit, between 115 and 118°F (46 and 48°C), the circuit in the thermostat opens and causes the elements to cool. When the thermostat reaches its lower limit, between 81 and 114°F (27 and 46°C), the circuit closes and power to the the elements is restored, causing the elements to heat up. This cycle repeats until the switch on the seat module is turned to the "OFF" position.

C07.02

Heated Seats

600 — Component Locations

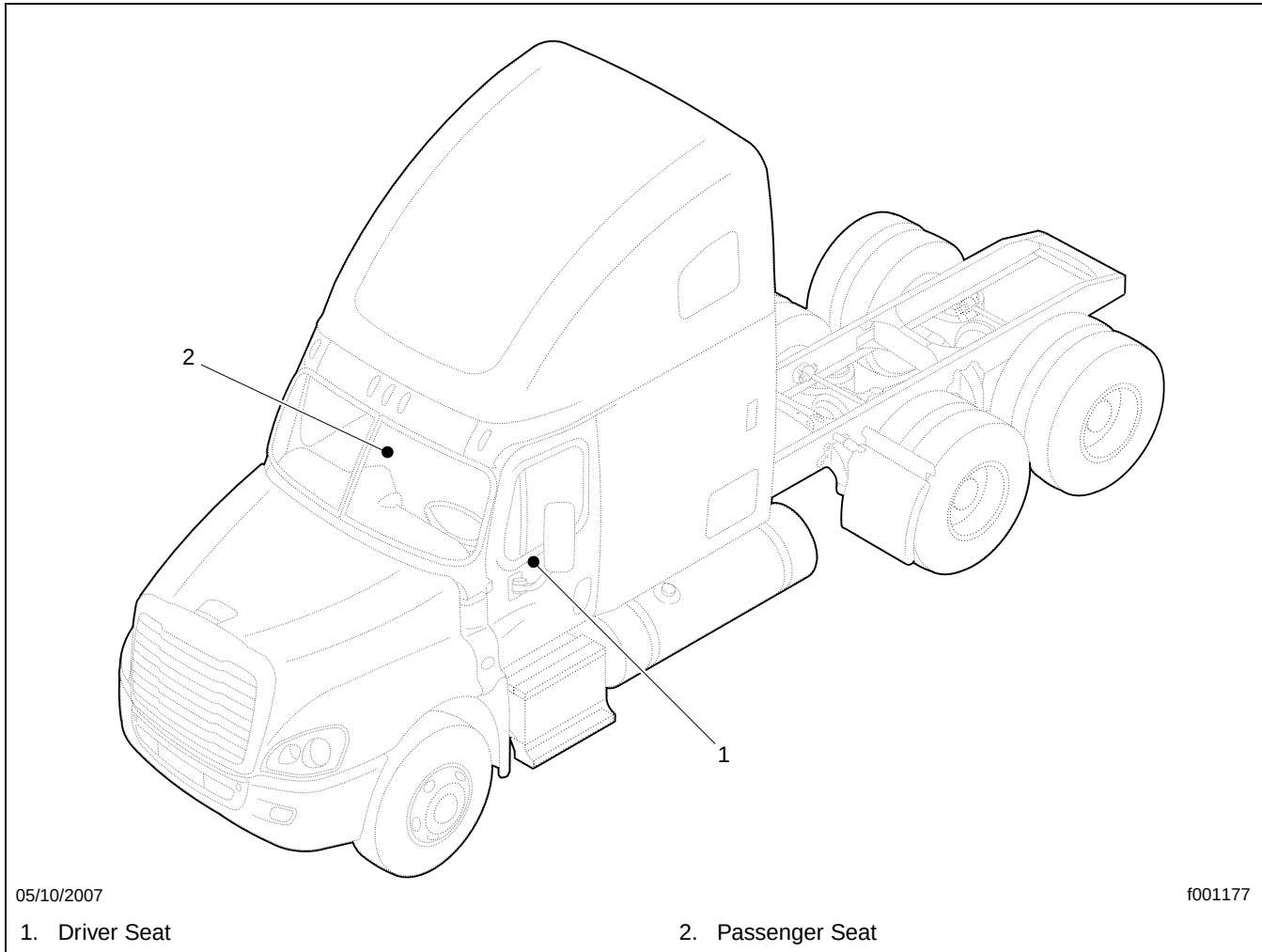


Fig. 1, Component Locations

Heated Seats

C07.02

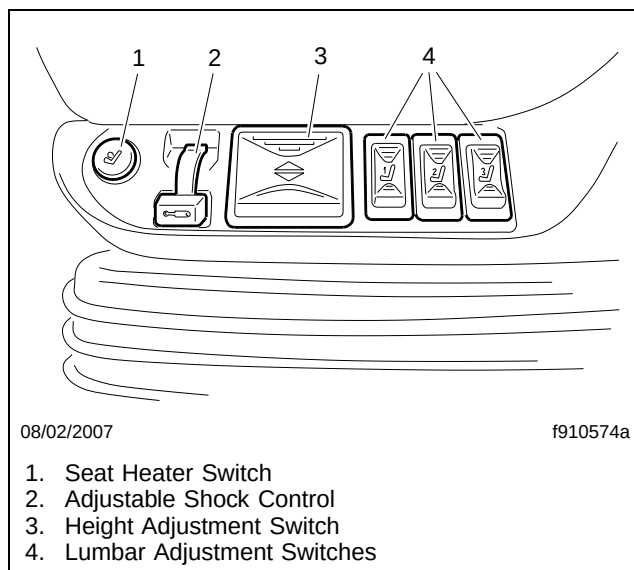


Fig. 2, Seat Module

SAM Cab Connector, X1			
05/10/2007 f545030			
Pin	Circuit	Color	Description
5	242A	White	Heated Seats, IGN
12	GND	Black	Heated Seats, GND

Table 1, SAM Cab Connector, X1

C07.02

Heated Seats

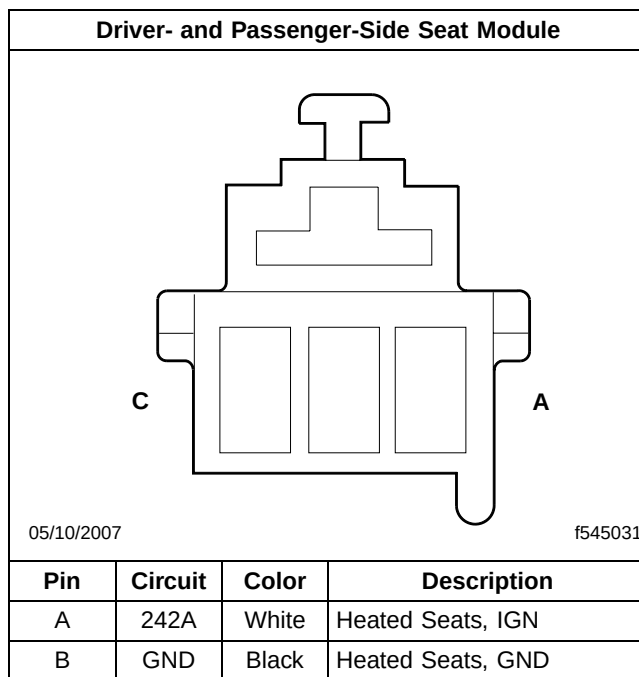


Table 2, Driver- and Passenger-Side Seat Module

Spare Power Feed Outputs

C07.03

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Spare Power Feed Outputs

C07.03

500 — Terms and Abbreviations

CAN—Controller Area Network

ECU—Electronic Control Unit, typically connected to a datalink.

LVD—Low Voltage Disconnect

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

"Spare power feed outputs" are pins that provide battery power and ground as spare outputs on the SAM Cab ECU. These pins are not controlled by software. Some of the battery outputs are controlled by low voltage disconnect (LVD) functionality.

There are two different groups of battery output pins in this feature:

- Pins that are directly connected to the battery by fuse, and therefore are not controlled by the SAM Cab.
- Pins that depend on power management. These pins are grouped on relays and are controlled by LVD. See **C06.09 — Powernet Management** for more information on LVD.

IMPORTANT: The pins provide spare battery and ground connections. The circuits and functions connected to them are not pre-defined.

600 — Component Locations

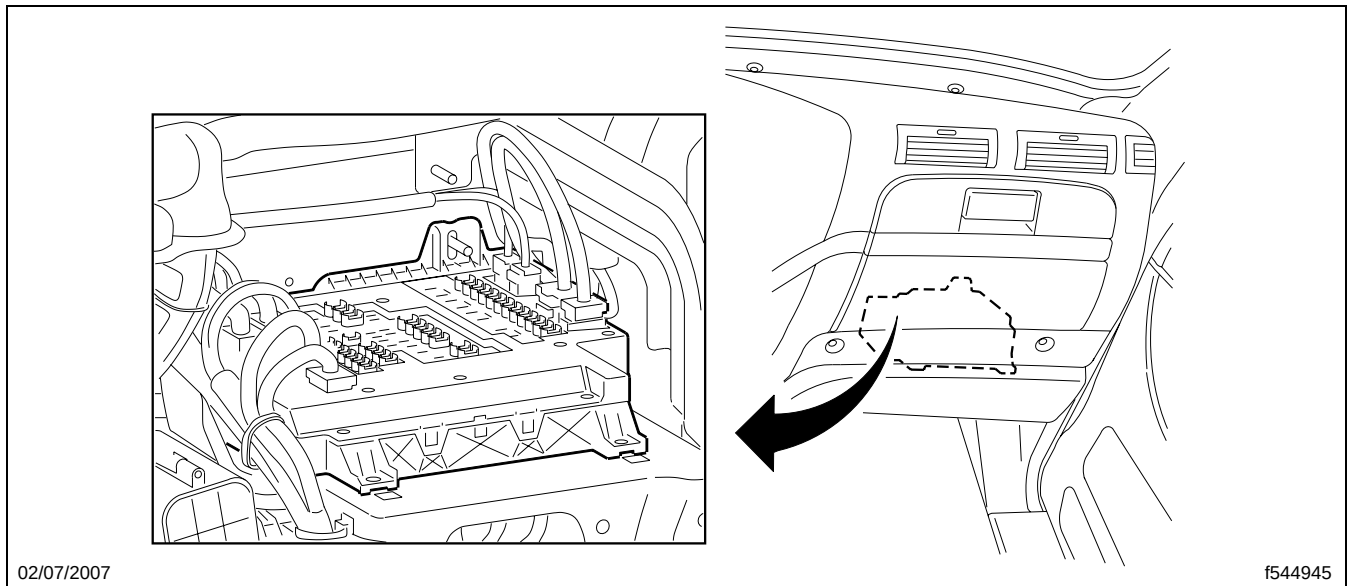


Fig. 1, SAM Cab

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Spare Power Feed Outputs

601 — Component Details

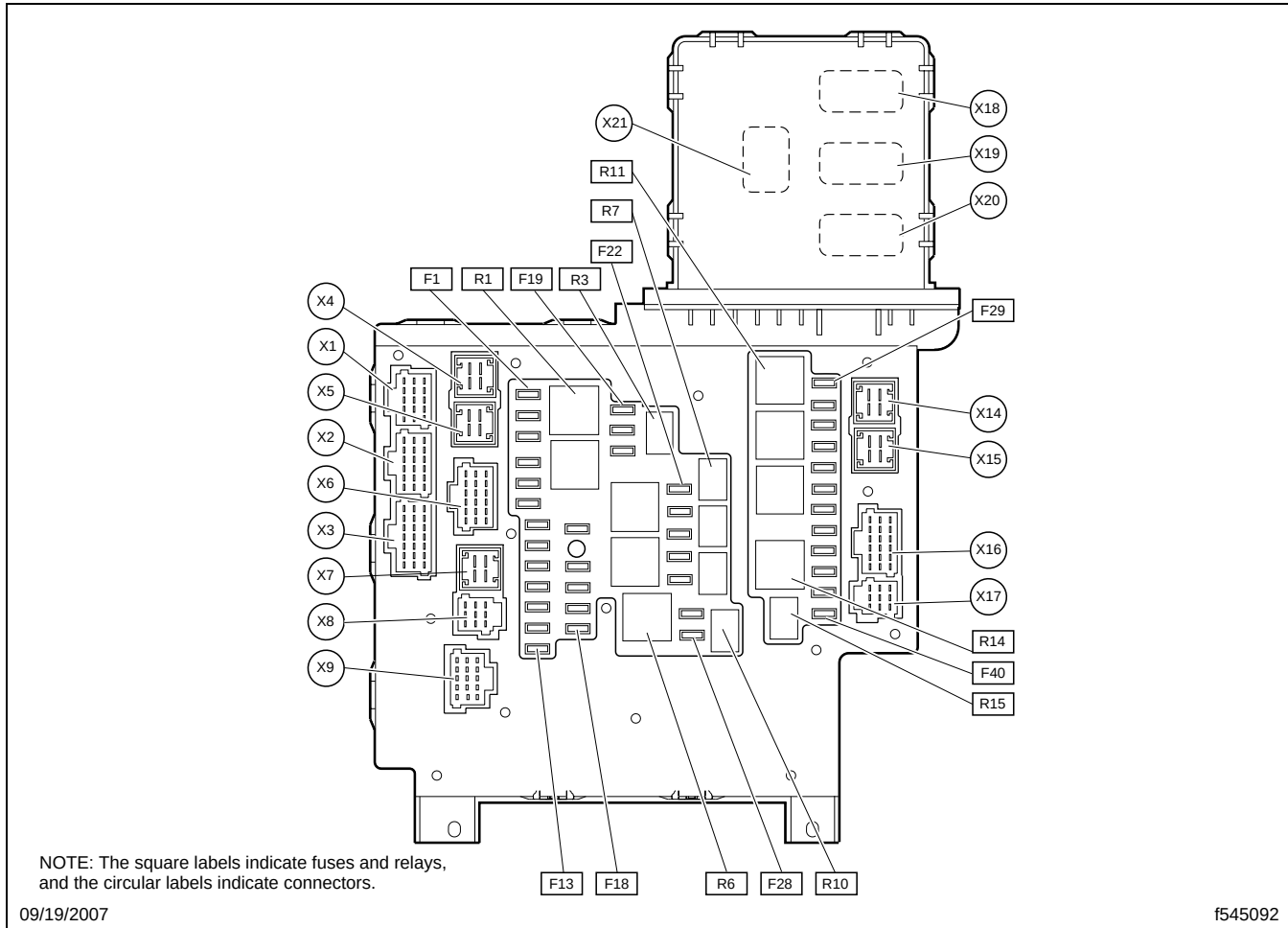


Fig. 2, SAM Cab Fuses and Relays

SAM Cab Fuses and Relays							
Description	SAM Cabin Connector	Terminal Cavity Number	Relay	Fuse	Hardware level	Nominal Load in A & 25C	LVD Level
Power feed spare output I, battery	X4	1	R1 (n/c LVD)	F1 (30)	Low	30	4
Power feed spare output I, ground	X4	3	—	—	Low	—	—
Power feed spare output II, battery	X5	1	R1 (n/c LVD)	F3 (30)	Low	30	4
Power feed spare output II, ground	X5	3	—	—	Low	—	—

Spare Power Feed Outputs

C07.03

SAM Cab Fuses and Relays							
Description	SAM Cabin Connector	Terminal Cavity Number	Relay	Fuse	Hardware level	Nominal Load in A & 25C	LVD Level
Power feed spare output III, battery	X4	2	R1 (n/c LVD)	F1 (30)	High	30	4
Power feed spare output III, ground	X4	4	—	—	High	—	—
Power feed spare output IV, battery	X5	2	R2 (n/c LVD)	F3 (30)	High	30	4
Power feed spare output IV, ground	X5	4	—	—	High	—	—
Power feed spare output V, battery	X15	1	—	F32 (25)	High	30	0
Power feed spare output V, ground	X15	3	—	—	High	—	—
Power feed spare output VI, battery	X15	2	—	F32 (25)	High	30	0

Table 1, SAM Cab Fuses and Relays

700 — Troubleshooting Overview

Spare power feed outputs are on the SAM Cab ECU. All of the battery output pins involve a fuse, and some battery output pins involve a relay. Refer to **601 — Component Details** for fuse and relay numbers associated with each pin. Since no CAN fault codes are available for this feature, troubleshooting should begin with verifying that the associated fuse and relay (if present) is functioning.

Predictive Cruise Control

C07.05

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Predictive Cruise Control

C07.05

500 — Terms and Abbreviations

CPC—Common Powertrain Controller (for MBE and DDC engines only).

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit, typically connected to a datalink.

GPS—Global Positioning System

J1939 Terminating Resistors—The J1939 datalink has two 120-ohm terminating resistors, one at each end of the backbone. The total datalink parallel resistance is 60 ohms.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

PCC—Predictive Cruise Control

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

Predictive Cruise Control (PCC) is an optional fuel savings application that adjusts the vehicle speed based on the approaching road profile. The system allows the vehicle to vary from the set cruise speed by up to 6% depending on the approaching road grade. The vehicle automatically engages the engine brakes to slow the vehicle down when the actual vehicle speed exceeds the cruise set speed by 6%.

Using 3D digital map technology and GPS, Predictive Cruise Control evaluates the upcoming road grade 2000 meters in advance to determine the most fuel efficient vehicle speed. The 3D digital map database contains road profile information for over 200,000 highway miles in the 48 contiguous United States, including all Interstate and many major US highways.

Driver interaction of Predictive Cruise Control is the same as conventional cruise control using existing cruise control switches. It runs in the background with no input from the driver or information displayed to the driver during operation. In the event of a Predictive Cruise Control fault or when driving on a road with no profile information available in the 3D digital map database, the system reverts to conventional cruise control. The cruise control operation will continue "normally" with the cruise control speed going smoothly back to the driver's set speed.

The Predictive Cruise Control system consists of an electronic controller with GPS and a digital map database and a GPS sensor. The controller interacts with the CPC using proprietary J1939 messages to control vehicle speed and monitor parameter information.

C07.05

Predictive Cruise Control

600 — Component Locations

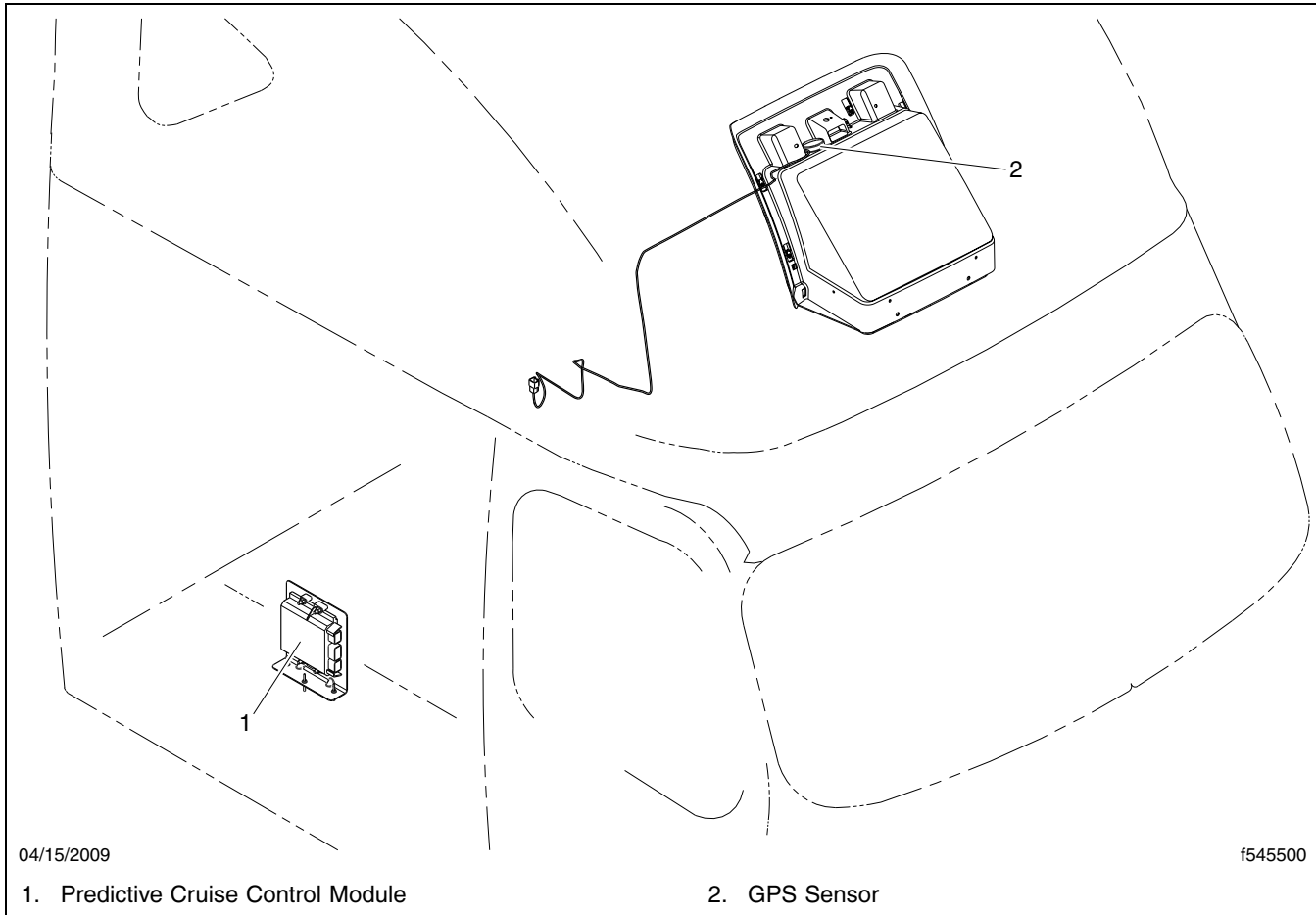


Fig. 1, Component Locations

601 — Component Details

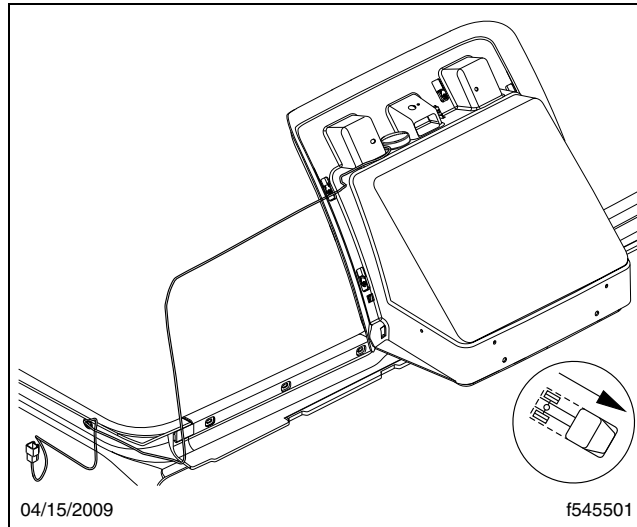


Fig. 2, GPS Sensor

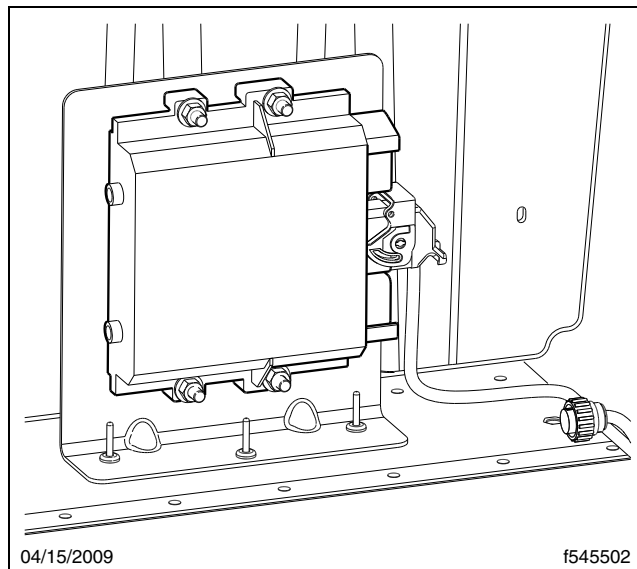


Fig. 3, Predictive Cruise Control Module

C07.05

Predictive Cruise Control

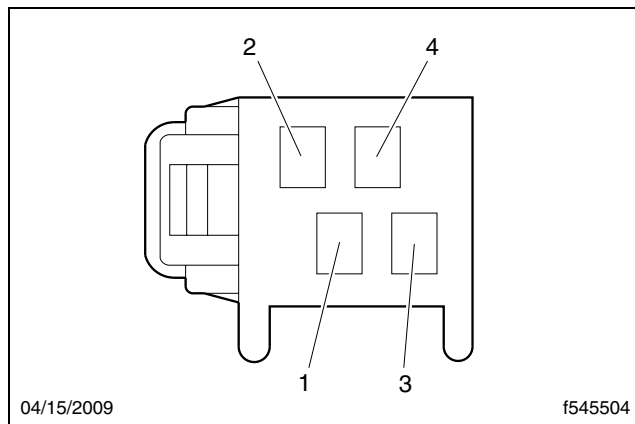


Fig. 4, GPS Connector

GPS Connector		
Pin	Circuit	Description
1	250XV	PCC, 5V Sensor
2	250XG	PCC, Sensor Ground
3	250XT	PCC, Sensor TX
4	250XR	PCC, Sensor RX

Table 1, GPS Connector

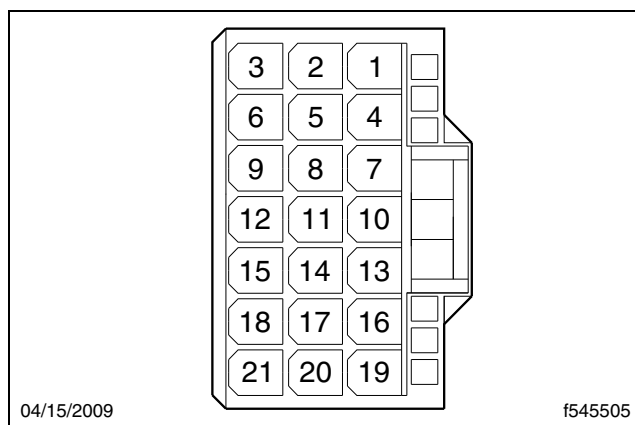


Fig. 5, SAM Cab, X11

SAM Cab, X11		
Pin	Circuit	Description
18	GND	Ground, general, cab/chassis
19	250XS	PCC, Power

Table 2, SAM Cab, X11

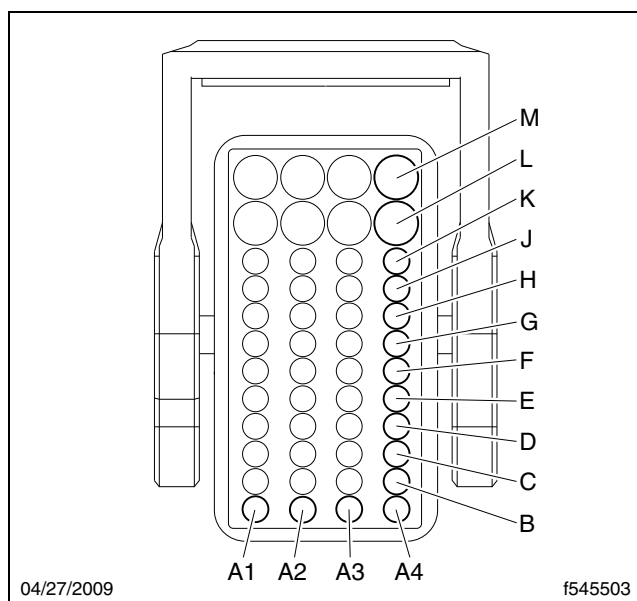


Fig. 6, Predictive Cruise Control, Connector J2

Predictive Cruise Control, Connector J2		
Pin	Circuit	Description
A3	250XR	PCC, Sensor RX
B3	250XT	PCC, Sensor TX
H1	1939+	J1939 datalink (+)
H2	1939–	J1939 datalink (–)
L1	81C	Ignition
L3	250XG	PCC, Sensor GND
M1	GND	Ground, general, cab/chassis
M2	250XS	PCC, power
M4	250XV	PCC, 5V power

Table 3, Predictive Cruise Control, Connector J2

The Run Smart Predictive Cruise sticker is displayed on the dash of Cascadia vehicles equipped with PCC.

700 — Diagnostic Tools required

- Digital Multimeter
- ServiceLink
- Detroit Diesel Diagnostic Link

Refer to module 149 for applicable wiring drawings.



Fig. 7, PCC Sticker

701 — Diagnostic Tests

Verify that the batteries are fully charged, all ECU connectors are securely fastened, and fuse F18 has continuity.

1. Connect the communication adaptor to the vehicle diagnostic adaptor.
2. Connect to the vehicle with ServiceLink.
3. Review the General Info screen for missing ECUs.
4. Load the Fault screen, and review the list for active faults.

702 — CPC Timeout (SA 17, SPN 639, FMI 2)

1. Remove connector J2 from the PCC module.
2. With the key in the ON position measure the voltage at the following connector pair for BAT voltage.
 - PCC J2-M1 (-) — PCC J2-M2 (+)
 - PCC J2-M1 (-) — PCC J2-L1 (+)
3. If the BAT voltage is not measured in step 1, perform a continuity test between the following connector pairs.
 - PCC J2-M2 – SAM Cab X11.19
 - PCC J2-M1 – SAM Cab X11.18
 - PCC J2-L1 – Ignition switch pin B
4. With the key in the OFF position, measure the resistance at PCC connector J2-H1 and J2-H2. Compare results.
 - $60 \pm 6 \Omega$: The J1939 wiring is intact and both terminating resistors are installed.
 - $120 \pm 12 \Omega$: There is a terminating resistor missing or a short present. Check the resistance across the terminating resistors.
 - $40 \pm 4 \Omega$: There is a third terminating resistor installed on the datalink. One terminating must be removed. There should be one terminating resistor on each end of the backbone for a total of two.
 - $0-5 \pm$: There is a short between J1939+ and J1939- somewhere on the datalink.
 - Resistance is greater than 1000Ω : There is an open circuit between the J1939 connector and the J1939 backbone or both terminating resistors are missing or open.
5. Refer to **G03.02 — Datalink, J1939** for additional steps to troubleshoot the J1939 datalink.
6. Repair as required.

Predictive Cruise Control

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7. Check ServiceLink for active fault codes. If any are active correct them. If there are no active faults, clear the historic faults and restart the system.

703 — No GPS Data (SA 17, SPN 841 FMI 2)

1. Remove the connector from the GPS Sensor.
2. With the key in the ON position, measure the voltage at terminals 1 and 2 at the GPS harness.
3. If 5V is not measured, check the following connector pairs for continuity.
 - PCC J2-M4 – GPS terminal 1 for circuit 250XV
 - PCC J2-L3 – GPS terminal 2 for circuit 250 XG
4. Measure the voltage at terminal J2-M4 at the PCC module, If 5V is not measured, replace the PCC module.
5. If 5V is measured at the PCC module, perform a continuity test on the serial connection for the GPS sensor at the following terminal pairs.
 - PCC J2-A3 – GPS terminal 3 for circuit 250XR
 - PCC J2-B3 – GPS terminal 4 for circuit 250XT
6. Repair as required.
7. Check ServiceLink for active fault codes. If any are active correct them. If there are no active faults, clear the historic faults and restart the system.

800 — Fault Codes

J1587 Fault Codes					
MID	SID	FMI	Fault Description	Fault Trigger	Action
128	216	14	Predictive Cruise Control Device Reporting Error.	The fault will be active in the event that: • The "PCC state" is reported as ERROR or NOT AVAILABLE, • The PCC status 1 message is not received within 300ms, or • The last 3 messages received within a 300ms period are not contiguous.	Refer to Detroit Diesel Diagnostic Link for troubleshooting.
128	216	9	Predictive Cruise Control Message Not Received.	Whenever PCC is configured, the PCC status 1 message is monitored after the engine is in RUN mode. If the message is not received by the CPC2, the fault becomes active.	Refer to Detroit Diesel Diagnostic Link for troubleshooting.

Table 4, J1587 Fault Codes

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Predictive Cruise Control

J1939 Fault Codes					
SA	SPN	FMI	Fault Description	Fault Trigger	Action
0	841	14	Predictive Cruise Control Device Reporting Error.	The fault will be active in the event that: • The "PCC state" is reported as ERROR or NOT AVAILABLE, • The PCC status 1 message is not received within 300ms, or • The last 3 messages received within a 300ms period are not contiguous.	Refer to the Detroit Diesel Diagnostic Link for troubleshooting.
0	841	9	Predictive Cruise Control Message Not Received.	Whenever PCC is configured, the PCC status 1 message is monitored after the engine is in RUN mode. If the message is not received by the CPC2, the fault becomes active.	Refer to the Detroit Diesel Diagnostic Link for troubleshooting.
17	639	2	CPC Timeout (no connection to CPC or J1939 fault).	If CPC communication is not detected after 20s, an active fault is set.	See 702 — CPC Timeout (SA 17, SPN 639, FMI 2)
17	841	2	No GPS data (bad receiver or serial connection).	If GPS communication is not detected after 100s, an active fault is set.	See 703 — No GPS Data (SA 17, SPN 841 FMI 2)

Table 5, J1939 Fault Codes

801 — Parameters

Parameters		
ECU	Parameter	Value
CPC2	PCC_Feature_Enable	0-Disable 1-Enable
CPC2	PCC_Eng_Brake_Mode	0=OVS with standard thresh 1=OVS with alternate thresh
CPC2	PCC_RSL_Mode	0=RSL limit only, PCC offset ignored 1=RSL limit add PCC offset
CPC2	PCC_Lower_Veh_Spd_Limit	-20 - 0%
CPC2	PCC_Upper_Veh_Spd_Limit	0 - 20%

Table 6, Parameters

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500 — Terms and Abbreviations**CGW**—Central Gateway**FMI**—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.**ICU**—Instrumentation Control Unit**MID**—Message Identifier**PID**—Parameter Identifier**SAM**—Signal Detect and Actuation Module**SID**—Subsystem Identifier**501 — General Information**

There are two distinct safety restraint systems (SRS) available as options on the Cascadia: a driver-side front airbag system, and a driver and passenger rollover protection system. There are several combinations of these systems available, see **Table 1**.

Air Bag Data Codes			
Databook Code	Front Air Bag (steering wheel)	Rollover Protection with Side Air Bag (driver-side)	Rollover Protection with Side Air Bag (passenger-side)
725-001	X	—	—
725-010	—	X	—
725-011	—	X	X
725-012	X	X	—
725-013	X	X	X

Table 1, Air Bag Data Codes

The driver-side airbag system protects the driver in a frontal collision. This system consists of an airbag mounted to the steering wheel, a frontal crash sensor module mounted under the driver's seat, a clockspring in the steering column, a warning lamp in the instrument cluster, and wiring harnesses. If the crash sensor module detects a frontal collision, it sends an electrical signal to the airbag causing it to deploy. If the vehicle is also equipped with a rollover protection system, the frontal crash sensor is part of the rollover protection module.

The rollover protection system protects the driver, and the passenger if the vehicle is equipped with passenger-side rollover protection. This system consists of two pyrotechnic cylinders attached to the seat and seatbelt, a side airbag, a roll sensor module mounted under the driver's seat, a warning lamp, and wiring harnesses. If the rollover protection system module detects the vehicle is in an unrecoverable rollover situation, the two pyrotechnic cylinders will deploy causing the seat to be pulled as close to the floor as possible and to tighten the seatbelt on the occupant. The side airbag will deploy to protect the occupant from neck injuries as the vehicle rolls on its side.

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J1587/J1708 Air Bag and Rollover Protection System

502 — Safety Precautions

WARNING

Before performing any work on the RollTek system, review all service literature and comply with the following warnings and precautions. Unintentional or improper deployment of the RollTek system can result in injury or death.

Damaged or deployed RollTek systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

- Do not attempt to modify the RollTek system. Doing so could change the effectiveness of the system. The RollTek system must be replaced after being activated.
- Do not attempt to service or to disassemble the RollTek module. The RollTek module cannot be serviced.
- Do not attempt to deploy an undeployed pyrotechnic inflator device, such as the RollTek Rollover Protection module. For disposition of an undeployed pyrotechnic inflator device, please contact LifeGuard Technologies (1-866-765-5835) for handling and forwarding instructions.
- Do not cut, drill, braze, solder, weld, strike, or probe any part of the RollTek system. Air bags and seat cylinders contain explosives and pressurized gas that can be dangerous if punctured, damaged, or cut.
- Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the RollTek system.
- Do not remove the RollTek sensors from the mounted locations if connected. Movement from a connected sensor can deploy the devices. The sensors should not be removed except for replacement.
- Do not connect electrical power to the RollTek module or sensors unless they are securely mounted in their designated locations.
- Do not attempt to adapt, reuse, or install a RollTek system in any vehicle other than the specific vehicle for which it is designed.
- Keep hands and tools away from the scissor points under the seats.
- Do not cut wires or tamper with the connectors between the vehicle wiring harness and the RollTek system. Cutting or removing the electrical connectors could cause unintentional deployment.
- Do not expose the RollTek system to electricity. Never probe a circuit.
- Store, transport, dispose, and recycle deployed RollTek system components in accordance with all applicable federal, state, and local regulations.
- Replace damaged seat belts, or seat belts that were worn in an accident, and check all anchoring points.
- The RollTek system requires a special seat belt. Care must be taken to ensure the correct seat belt is used.
- The seat must be attached to the RollTek module and seat riser with the capscrews and spacers provided with the module.
- Always disconnect the SRS system when welding on the vehicle.

- **Before connecting or disconnecting the SRS sensors, always turn the battery switch to OFF and disconnect the batteries, then wait one minute before connecting or disconnecting the sensors.**

The RollTek system contains components with pyrotechnic inflator devices, which use combustible chemicals. The RollTek module and the air bags have inflators. Use care when replacing or handling these system components.

For disposition of a deployed pyrotechnic inflator device, follow and comply with any current and applicable state laws.

600 — Component Locations

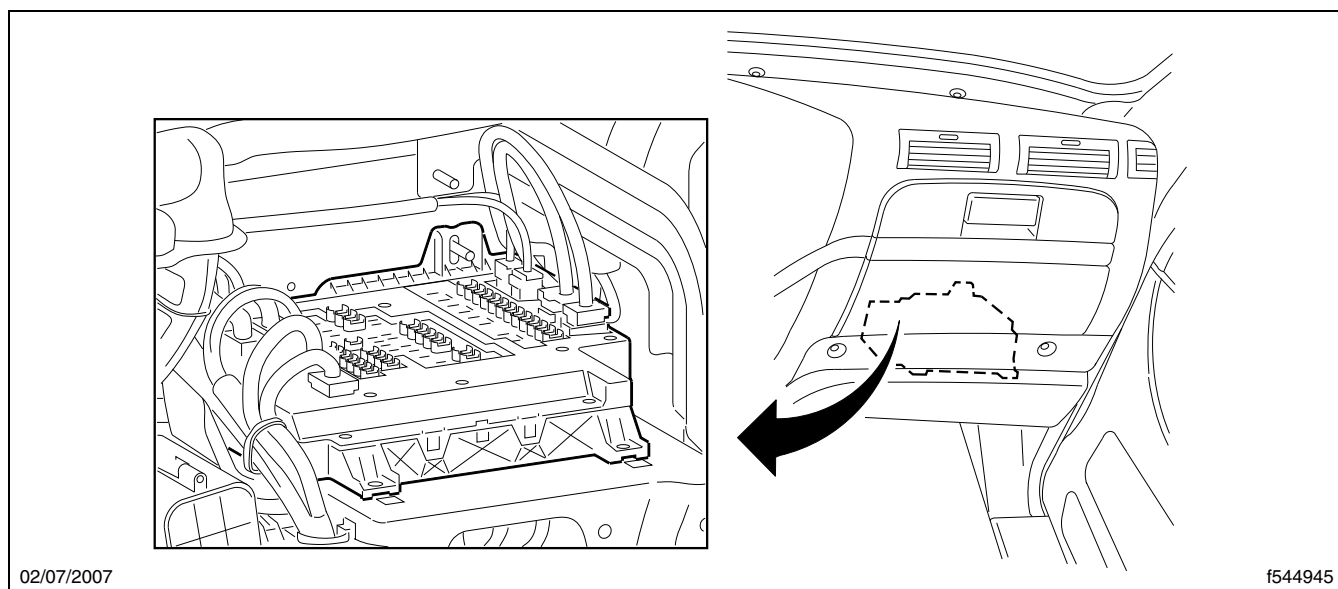


Fig. 1, SAM Cab

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J1587/J1708 Air Bag and Rollover Protection System

601 — Component Details

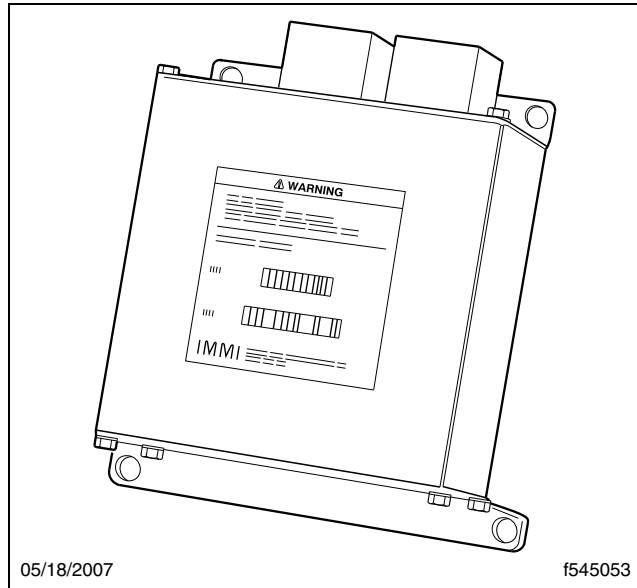


Fig. 2, SRS Module

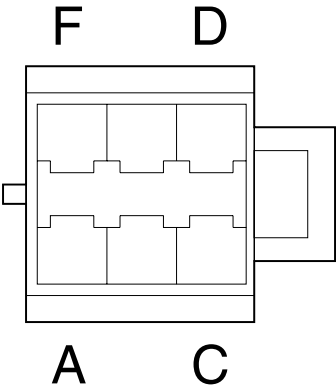
6-Pin Driver-Side SRS Module (systems with a front airbag)			
			
05/17/2007		f545042	
Pin	Circuit Number	Wire Color	Description
A	81C	PK	+12V Ignition Power
B	GND	BK	Ground
C	1587+	DKG	(+) J1587 Datalink
D	1587–	O	(–) J1587 Datalink
E	454L	Y-W	SRS Warning Lamp
F	—	—	Not Used

Table 2, 6-Pin Driver-Side SRS Module (systems with a front airbag)

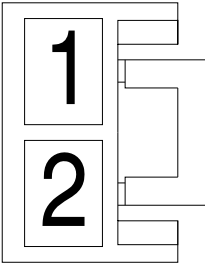
2-Pin Driver-Side SRS Module (systems with a front airbag)			
			
05/17/2007		f545043	
Pin	Circuit Number	Wire Color	Description
1	454A+	Y-W	(+) Front Airbag Signal
2	454A–	Y-W	(–) Front Airbag Signal

Table 3, 2-Pin Driver-Side SRS Module (systems with a front airbag)

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J1587/J1708 Air Bag and Rollover Protection System

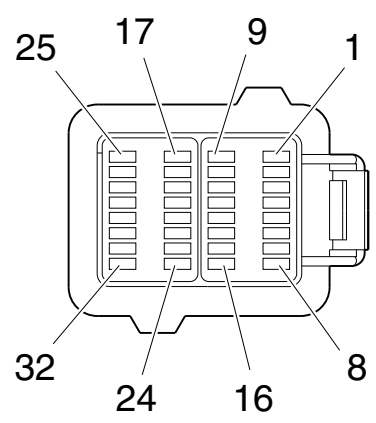
32-Pin Driver-Side SRS Module (systems without a front airbag, RollTek Only)			
 05/17/2007 f545045			
Pin	Circuit Number	Wire Color	Description
1-2	—	—	Not Used
3	454L	Y-W	SRS Warning Lamp
4	GND	BK	Ground
5	—	—	Not Used
6	81C	PK	+12V Ignition Power
7	GND	BK	Ground
8	—	—	Not Used
9	1587+	DKG	(+) J1587 Datalink
10	1587–	O	(–) J1587 Datalink
11-32	—	—	Not Used

Table 4, 32-Pin Driver-Side SRS Module (systems without a front airbag, RollTek only)

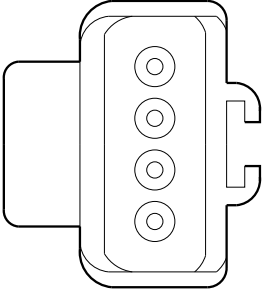
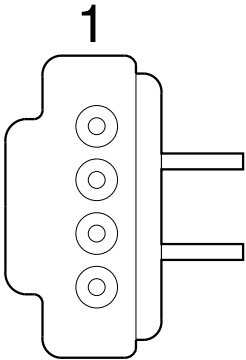
4-Pin Driver-Side SRS Module (systems with passenger RollTek)			
 05/17/2007 f545046			
Pin	Circuit Number	Wire Color	Description
1	454C+	Y-W	(+) Passenger-Side Suspension Seat Safety System Signal
2	454C–	Y-W	(–) Passenger-Side Suspension Seat Safety System Signal
3	454B+	Y-W	(+) Passenger-Side Airbag Signal
4	454B–	Y-W	(–) Passenger-Side Airbag Signal

Table 5, 4-Pin Driver-Side SRS Module (systems with passenger RollTek)

4-Pin Passenger-Side SRS Module (systems with passenger RollTek)			
 05/17/2007 f545047			
Pin	Circuit Number	Wire Color	Description
1	454C+	Y-W	(+) Passenger-Side Suspension Seat Safety System Signal
2	454C–	Y-W	(–) Passenger-Side Suspension Seat Safety System Signal

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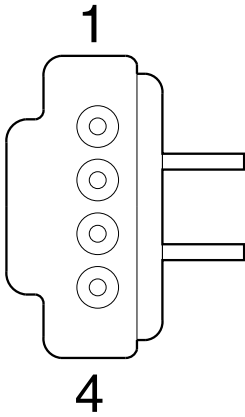
4-Pin Passenger-Side SRS Module (systems with passenger RollTek)			
 05/17/2007 f545047			
Pin	Circuit Number	Wire Color	Description
3	454B+	Y-W	(+) Passenger-Side Airbag Signal
4	454B-	Y-W	(-) Passenger-Side Airbag Signal

Table 6, 4-Pin Passenger-Side SRS Module (systems with passenger RollTek)

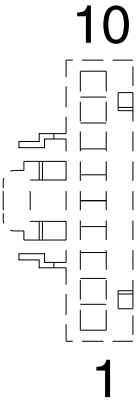
10-Pin Clockspring Connector (systems with front airbag)			
 05/17/2007 f545044			
Pin	Circuit Number	Wire Color	Description
1	454A+	Y-W	(+) Front Airbag Signal
2	454A-	Y-W	(-) Front Airbag Signal
3-10	—	—	Not Part of the Airbag System

Table 7, 10-Pin Clockspring Connector (systems with front airbag)

700 — Diagnostics

Use ServiceLink connected to the J1708 databus to monitor for RollTek fault codes. The RollTek system communicates over the J1708 data bus using message identifier (MID) 254.

The RollTek system is powered by circuit 81C from SAM cab connector X3, pin 6. The circuit is connected through relay R8 and fused through the 5-amp fuse F26.

The operational readiness of the RollTek system is indicated by the supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on for approximately 10 seconds when the engine is started and then goes off. The indicator will remain on if there is a problem with the air bag or RollTek system. Service is required if the SRS indicator does not come on when the ignition is turned ON, or if the SRS indicator remains on.

WARNING

Before performing any service on the RollTek system, deactivate the system by turning off the ignition and battery switch. Do NOT service a live RollTek system. Accidental deployment could cause serious injury and property damage.

Prior to performing any service work on the RollTek Rollover Protection System, it is necessary to determine the nature and exact cause of the problem, using the diagnostic procedure in this subject.

701 — RollTek Diagnostic Procedure

1. Connect the ServiceLink PC to the vehicle diagnostic port.
2. Turn the ignition to the ON position. The RollTek fault light should illuminate for 4 to 10 seconds before turning off. If the light does not turn off, continue to Step 3.
3. Verify that ServiceLink finds MID 254. If ServiceLink does not read MID 254, check the wiring from the diagnostic port to the roll sensors, and the power wiring to the roll sensors.
4. Read the active and inactive faults.
 - 4.1 If the fault lamp is off, there should be no J1708 faults reported.
 - 4.2 If the fault lamp is on and faults are reported, locate the source of the fault and repair as necessary. Once the fault status changes from active to inactive, the fault can be cleared and the fault lamp should turn off.
5. Create a fault on the roll sensor by unplugging the connection to the Driver SRA. Disconnect only one device at a time to verify safety device connections.
 - 5.1 Verify that the fault lamp turns on after about 10 seconds.
 - 5.2 Verify that the diagnostic code on ServiceLink matches the code for "Driver SRA Open Circuit." Refer to **Table 8**. If the diagnostic code does not match the safety device location, check the wiring and repair if necessary.
 - 5.3 Once the correct diagnostic code is verified, reconnect the safety device. Verify that the diagnostic code changes from active to inactive.
 - 5.4 Clear the fault. Verify that the fault lamp turns off.
 - 5.5 If the vehicle has a passenger side RollTek seat installed, repeat step 5 to verify wiring to the passenger SRA. Refer to the diagnostic code table for "Passenger SRA Open Circuit."

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J1587/J1708 Air Bag and Rollover Protection System

- 5.6 If the vehicle includes frontal airbag protection, repeat Steps 3 through 5 to verify the presence of MID 232 and the connection to the driver airbag.

702 — Fault Codes

Fault Codes for Atlas RollTek			
SID	FMI	MID	Description
1	5	254	Driver S4 Open Circuit
1	6	254	Driver S4 Short Circuit
2	5	254	Driver SRA Open Circuit
2	6	254	Driver SRA Short Circuit
3	5	254	Passenger S4 Open Circuit
3	6	254	Passenger S4 Short Circuit
4	5	254	Passenger SRA Open Circuit
4	6	254	Passenger SRA Short Circuit
240	14	254	A roll event is stored
254	12	254	Bad Intelligent Device (internal error)

Table 8, Fault Codes for Atlas RollTek

Fault Codes for Atlas Frontal Air Bag			
SID	FMI	MID	Description
1	3	232	Driver Airbag Circuit Shorted High
1	4	232	Driver Airbag Circuit Shorted Low
1	5	232	Driver Airbag Open Circuit
1	6	232	Driver Airbag Short Circuit
240	14	232	A crash is stored
254	12	232	Bad Intelligent Device (Internal Error)

Table 9, Fault Codes for Atlas Frontal Air Bag

800 — SRS Wiring Schematics

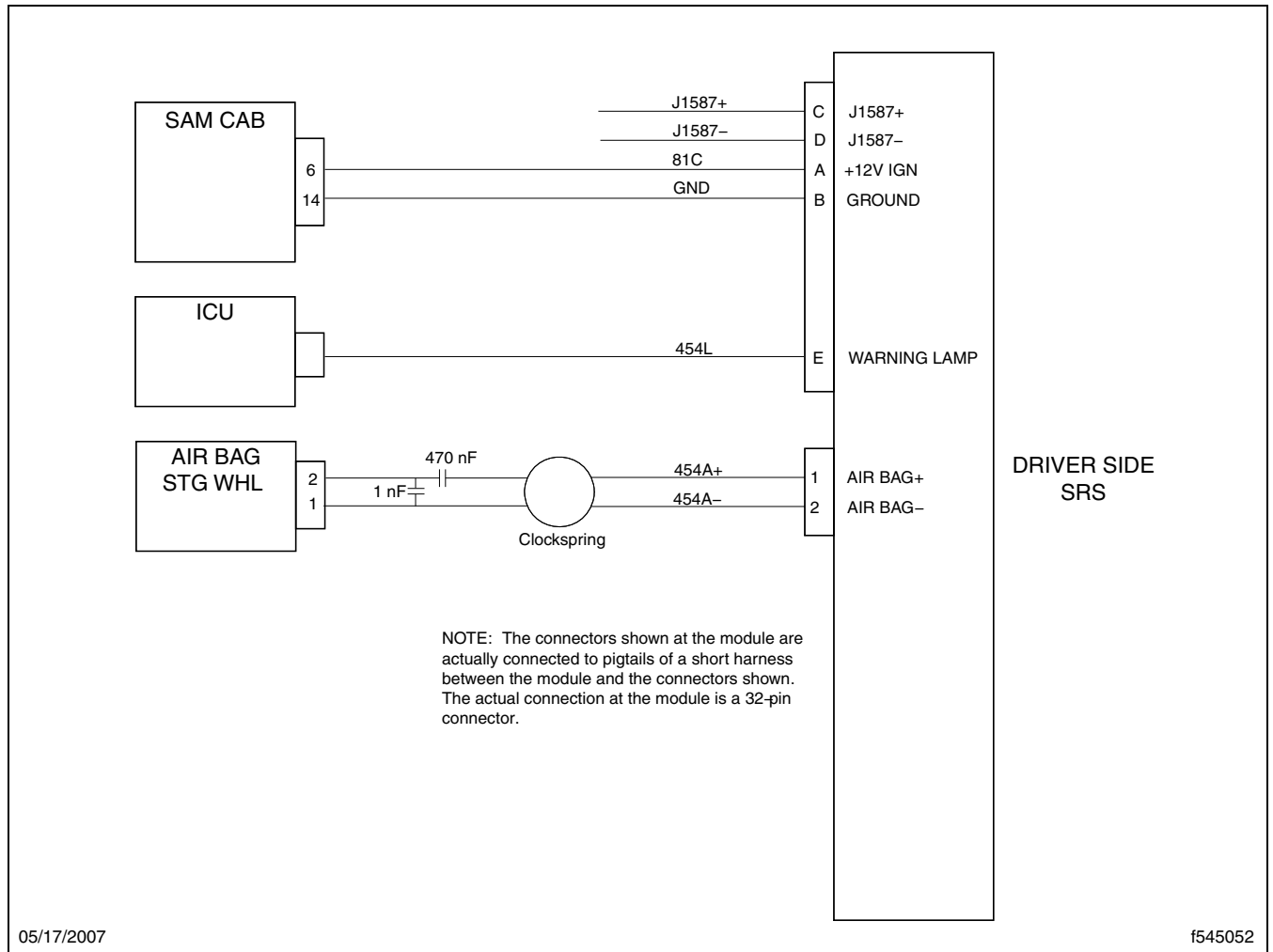


Fig. 3, SRS Wiring Schematic (air bag only)

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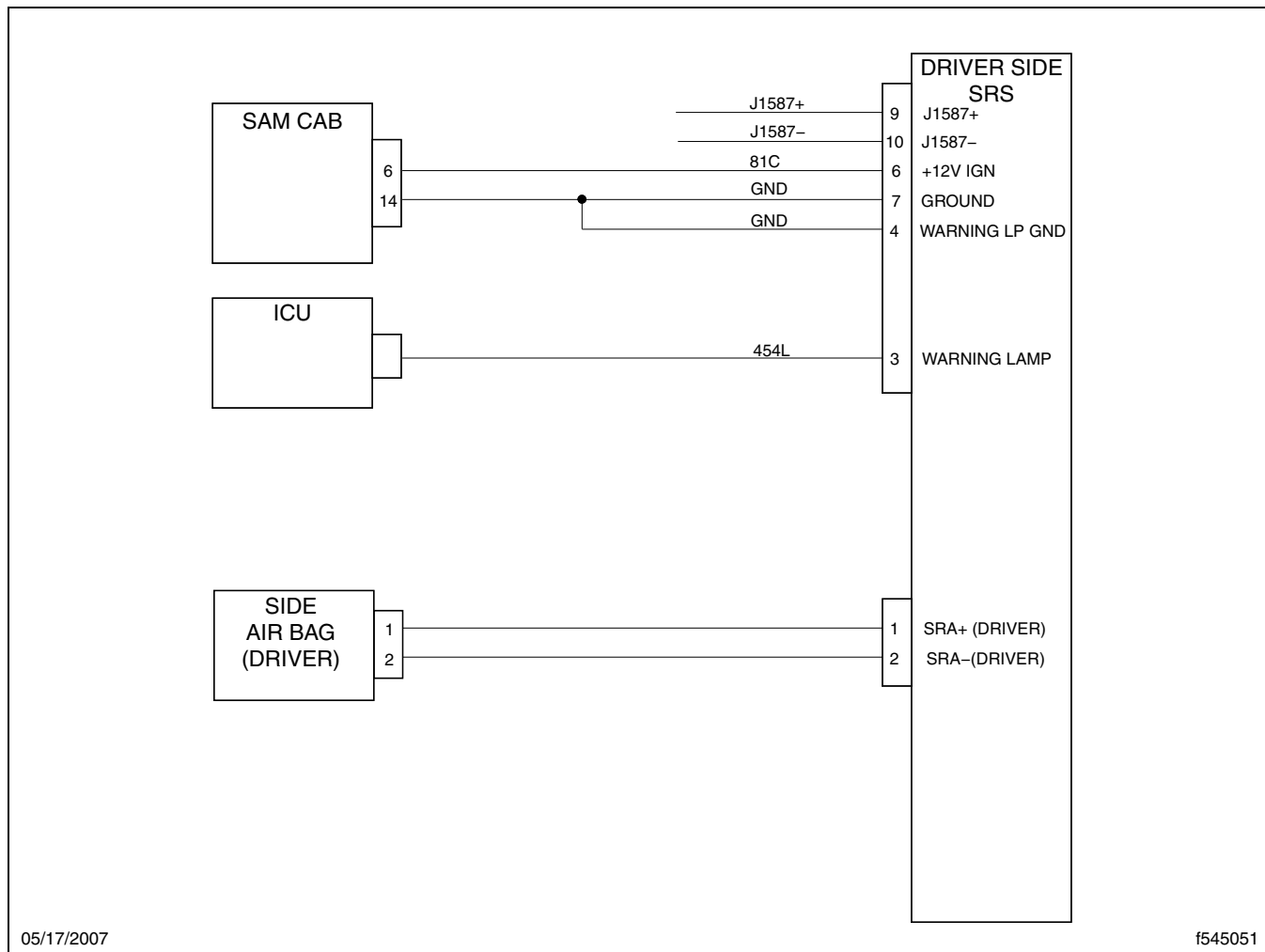


Fig. 4, Wiring Schematic, Driver-Side (rollover protection only)

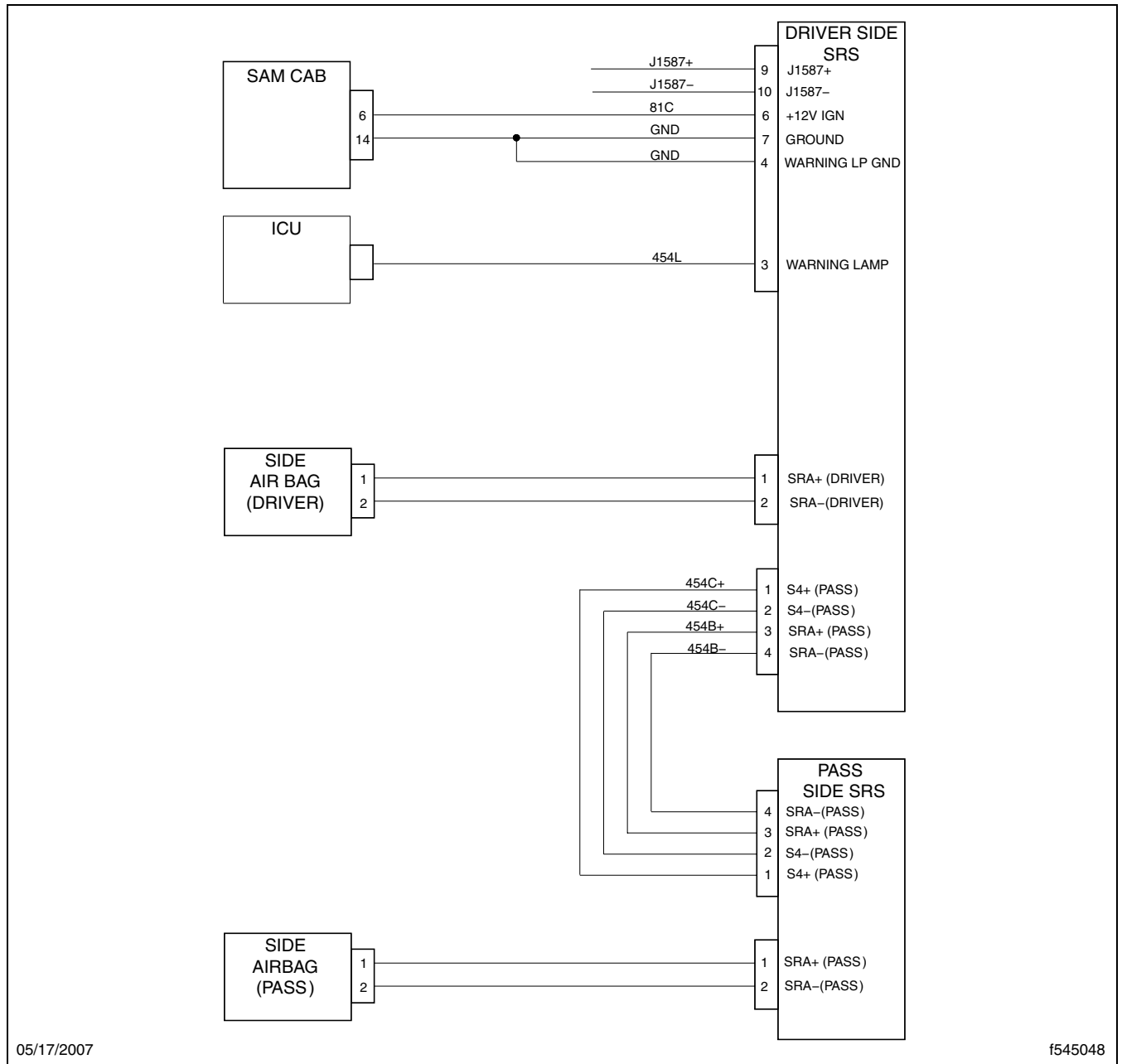


Fig. 5, SRS Wiring Schematic, Driver- and Passenger-Side (rollover protection only)

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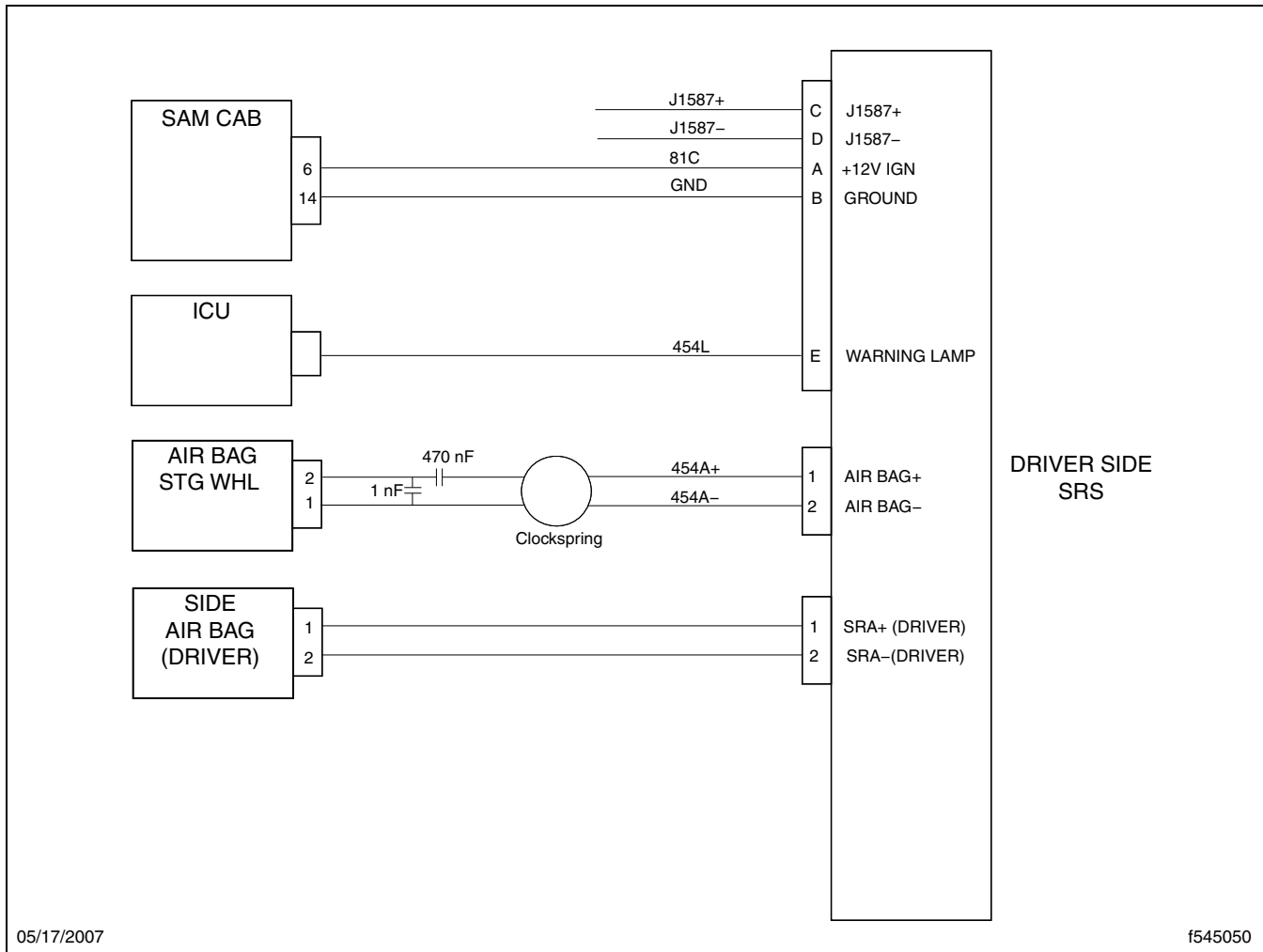


Fig. 6, SRS Wiring Schematic, Driver-Side (rollover protection and front airbag)

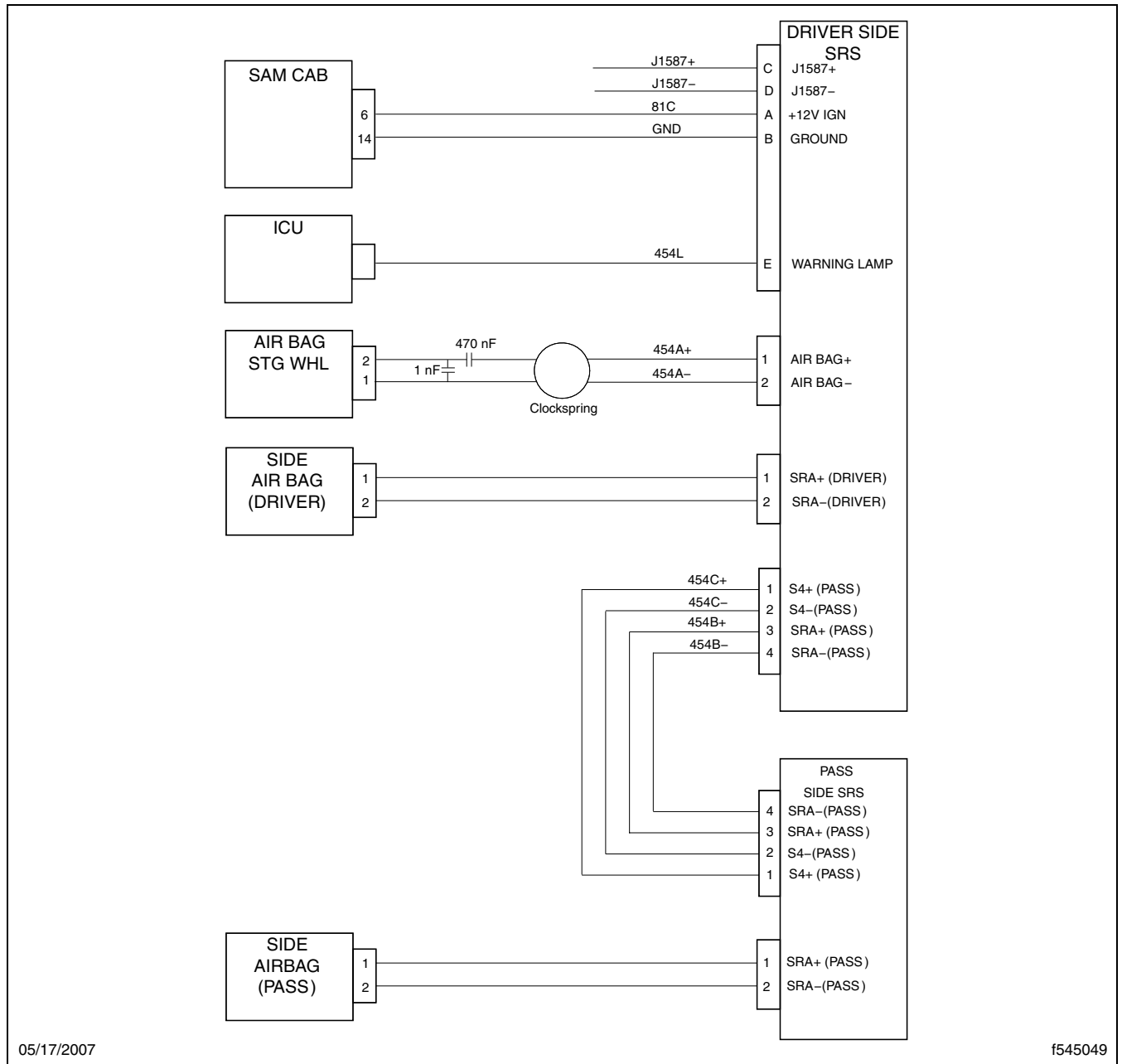


Fig. 7, SRS Wiring Schematic, Driver- and Passenger-Side (rollover protection and front airbag)

Collision Warning System

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Collision Warning System

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500 — Terms and Abbreviations

ACC—Adaptive Cruise Control

CAN—Controller Area Network

CWS—Collision Warning System

DIU—Driver Interface Unit

ECU—Electronic Control Unit, typically connected to a datalink.

FLR—Forward Looking Radar

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939 or CAN.

SAM—Signal Detect and Actuation Module

SOD—Side Object Detection

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

SmartCruise®—Eaton trademark name for adaptive cruise control.

SSD—Side Sensor Display

VORAD—Vehicle On-Board Radar

501 — General Information

The Eaton VORAD VS-400 is an Adaptive Cruise Control and Collision Warning System. It consists of a Forward Looking Radar (FLR), Driver Interface Unit (DIU), and optional Side Object Detection (SOD) with Side Sensor Display (SSD). The VS-400 provides warning information to the driver using auditory and visual alerts about objects ahead of the host vehicle that are potential collision hazards.

The SAM Cab provides ignition power to the collision avoidance system via connector X2 pin 14. See **702 — CAN Fault Codes** for details.

502 — Forward Looking Radar

The Forward Looking Radar (FLR) determines the distance, lane position, relative speed, and direction of vehicles in front of the host vehicle. The FLR includes a Doppler radar that transmits at a 77 GHz frequency. It has an 11-degree wide and 5-degree high field of view. A built-in yaw rate sensor (gyro) provides a reference point for lane positioning in turns. The J1939 interface allows the FLR to be installed as a SmartCruise-only stand-alone unit, or as a component of the complete Eaton VORAD VS-400 system. The FLR can track multiple objects simultaneously in relative motion within the radar's effective range of view. Relative motion is defined as an object's movement towards, or away from, the radar transceiver.

Located on the forward-most position of the vehicle, the FLR transmits and receives low-power, high-frequency signals. Transmitted signals that are reflected off objects in front of the vehicle are received and processed by the radar's internal microprocessor to determine the object(s) relative distance, position, speed, and direction of travel.

NOTE: The Forward Looking Radar is only activated while the vehicle is in motion.

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Collision Warning System

503 — Driver Interface Unit

The Driver Interface Unit (DIU) is the CWS central information center. The DIU provides the driver with visual and audio alerts as well as system configuration, status, and diagnostic information. The DIU uses the J1939 datalink to communicate with the FLR and other vehicle system devices.

The DIU contains:

- an internal speaker;
- a yellow LED array that illuminates with headway alert displays;
- a red LED array that illuminates with the collision alert display;
- an orange LED that illuminates when a system failure occurs;
- a blue LED that illuminates when information is available;
- a display LCD screen that shows warnings, menus, and other information;
- three user selection buttons for scrolling up, scrolling down, and selection;
- a light sensor to support daytime or nighttime modes of illumination.

The DIU supports Driver ID with PIN support; this is optional at display start up. The ID is a numerical value entered through the keypad.

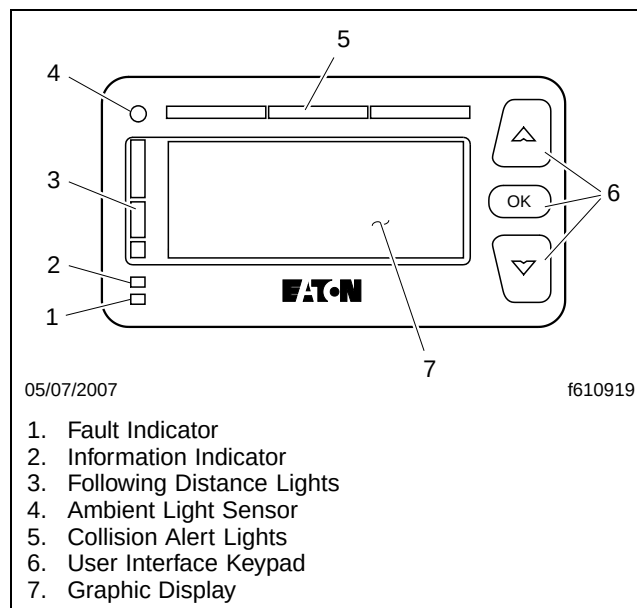


Fig. 1, Driver Interface Unit

504 — Forward Looking Collision Warning System

The VS-400 FLR identifies and tracks the nearest object in the host vehicle's lane of travel. This object is classified into one of the following areas and assigned one of the following driver information messages and driver warning tone sequences.

Collision Warning System

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Object Detected

When an object is in the host vehicle's lane of travel, the VS-400 system displays the following message and tone:

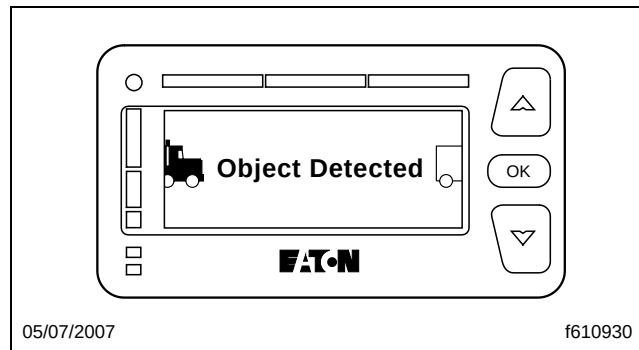


Fig. 2, Object Detected Message

Tone Sequence: none.

Headway Alert Operation

The alerts given by the VS-400 system are based on the "headway" to the object ahead whenever the host vehicle speed is 10 mph (16 km) or greater. The DIU displays and sounds warnings for objects detected by the FLR in the lane of travel.

Alert 1 (3 Second Headway)

When a moving object is in the lane of travel and its headway is between 2 and 3 seconds, the DIU displays the following message:

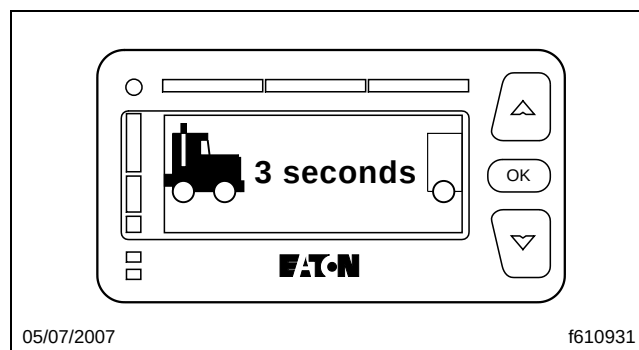


Fig. 3, Three Seconds Message

Tone Sequence: no tone is sounded.

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Alert 2 (2 second headway)

When a moving object is in the lane of travel and its headway is greater than 1 second up to, and including, 2 seconds, the DIU displays the following message and tones:

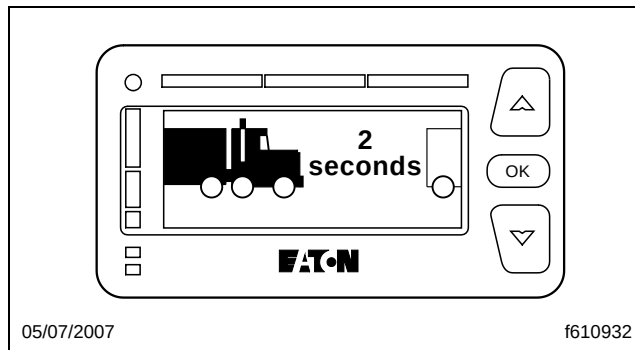


Fig. 4, Two Seconds Message

Tone Sequence: 2-Second closing headway alert.

This tone sequence is not sounded if the distance between the object and the FLR is increasing or the host vehicle's brakes are applied.

Alert 3 (1-Second Headway)

When the host vehicle is closing on a moving object in its lane of travel and its headway is greater than 0.5 seconds up to, and including, 1 second, or the object is between 0 and 1 second and moving away, the DIU displays the following message and sound tones.

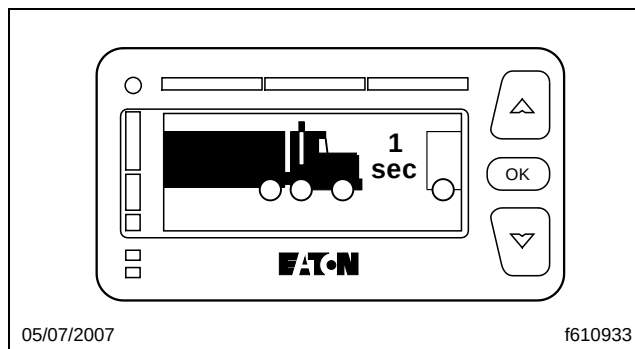


Fig. 5, One Second Message

Tone Sequence: 1-Second closing headway alert.

This tone sequence is not sounded if the distance between the object and the FLR is increasing or the host vehicle's brakes are applied.

Collision Warning System

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Collision Alerts: Alert 4 (1/2-Second Headway)

When an object is in the lane of travel and its headway is 0.5 second or less, the host vehicle speed is at least 10 mph, and the host vehicle is closing on the object, then the DIU displays the COLLISION ALERT message, and sound tones.

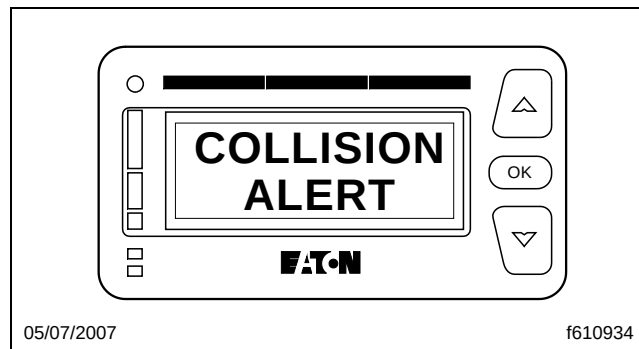


Fig. 6, 1/2 Second Message

Tone Sequence: 1/2-Second collision alert tones are sounded continuously.

Slow Moving Object Alert

If the headway to a slow moving object is 3 seconds or less and the host vehicle's turn radius is 750 feet or more, the Collision Alert message is displayed and the "slow moving alert" is sounded if:

- the host vehicle's speed is greater than 35 mph;
- the speed of the object is greater than 5 feet per second;
- the object is in the host vehicle's lane of travel and within 220 feet from the FLR;
- the objects speed is less than 80% of the host vehicle speed.

Stationary Object Alert

If the headway to a slow moving object is 3 seconds or less and the host vehicle's turn radius is 750 feet or more, the Collision Alert message is displayed and the "stationary alert" is sounded when:

- the host vehicle's speed is greater than 10 mph;
- an object is detected in the host vehicle's lane of travel within 220 feet from the FLR;
- the object is moving less than or equal to 5 feet per second (3.4 mph).

505 — Side Object Detection

Side object detection consists of two components, a Side Sensor Display unit and a Side Sensor. It is an optional feature and can work completely independent from the VS-400. The side sensor display is mounted on the A-pillar at a position easily viewed by the driver when scanning the mirrors. The side sensor should be mounted on the side of the vehicle 22 to 36 inches off the ground. The sensor face should be perpendicular to the ground with an unobstructed view of the area of coverage. The sensor detects objects within 2 to 10 feet away with a 110 degree field of view. The side sensor and side sensor display communicate over a proprietary datalink and communicate messages to the side sensor display with the following:

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- The red LED illuminates when an object is detected.
- The red LED illuminates and a triple tone is given off when objects are detected and the turn signal is activated.
- The light sensor determines if the side sensor display is in daytime or nighttime mode; the display brightness is automatically adjusted for daytime or nighttime operation.
- The yellow LED illuminates when no objects are detected.
- The red and yellow LED illuminate when there is a fault condition.

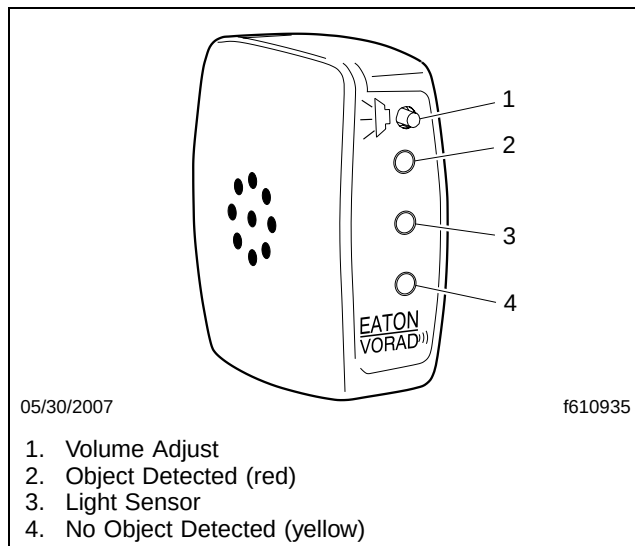


Fig. 7, Side Object Detection Module

506 — SmartCruise

The VS-400 SmartCruise is an Eaton VORAD proprietary system capable of controlling the vehicle's headway. SmartCruise is enabled in the VS-400 system, if the VS-400 system is configured for CWS.

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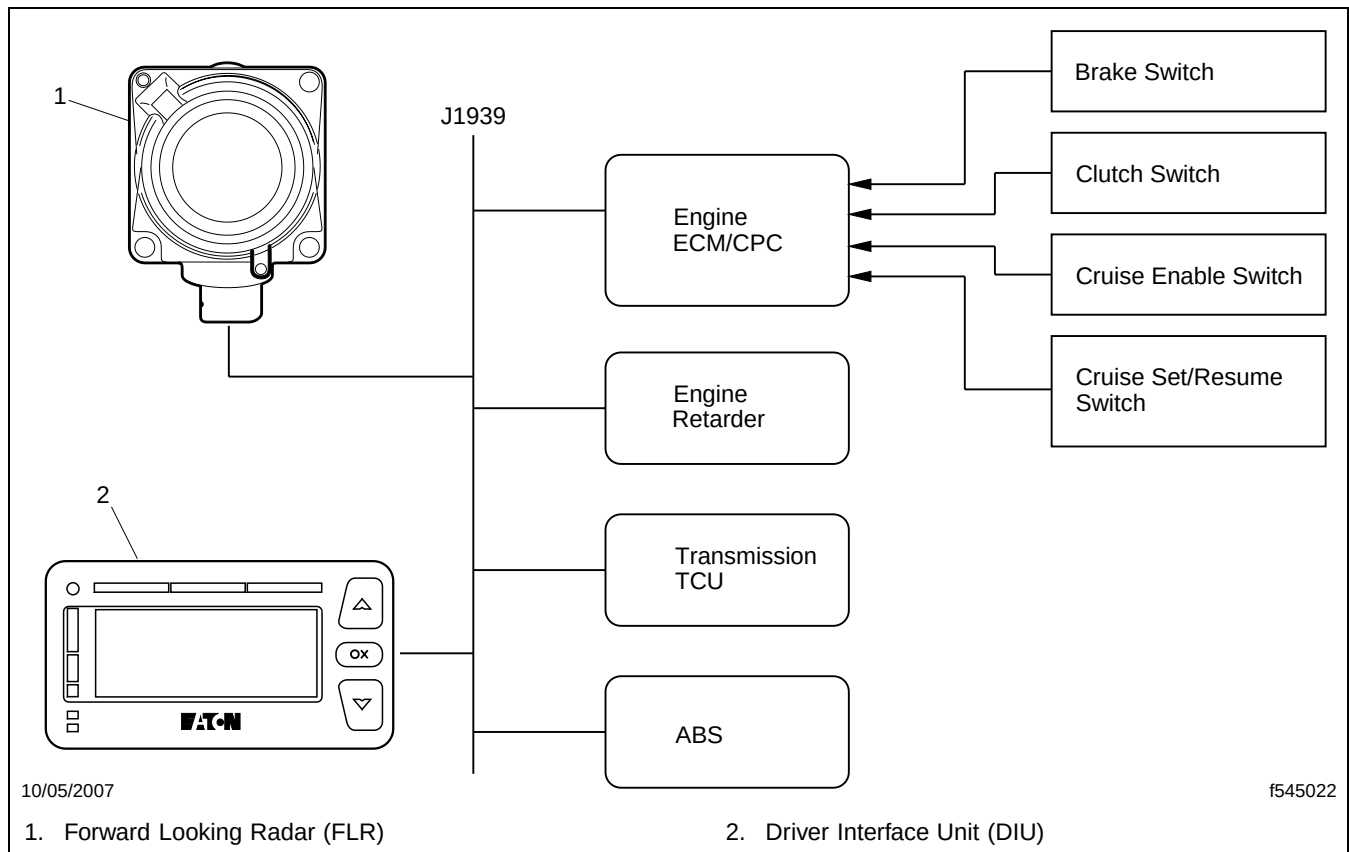


Fig. 8, SmartCruise Wiring

SmartCruise is an Adaptive Cruise Control (ACC) system. It uses the VS-400 hardware and SmartCruise software to maintain the host vehicle's headway by interacting with the engine and requesting that the engine de-fuel, or de-fuel and apply the engine brake. Since SmartCruise does not apply the service brake or steer the vehicle, the driver needs to be in control of the vehicle at all times. Because of the limitations of the VS-400 system in distinguishing real objects from false objects when these objects are stationary and present in or near the vehicle's lane of travel (road signs in a curve or near the lane of travel, overpasses, parked vehicles on the side of the road, center dividers, retaining walls, etc.), SmartCruise may ignore stationary objects when maintaining the host vehicle's headway. However, the VS-400 Collision Warning System (CWS) will alert the driver of an object in the host vehicle's lane of travel.

SmartCruise works in conjunction with the engine cruise control functions so that all the cruise control functions operate as usual when no objects are present in the lane of travel. This feature is called "conventional cruise control," and it is managed by the Engine Control Unit (ECU).

Using the data gathered by the FLR sensor, SmartCruise is capable of controlling the headway of the host vehicle if a valid object is identified. This is accomplished by communicating with the Engine Control Module (ECM) over the J1939 Datalink. When the driver activates conventional cruise control, vehicle speed is controlled by the engine cruise control system until SmartCruise determines that an object is being approached. SmartCruise sends a message over the J1939 Datalink to the engine to de-fuel, and, depending on conditions, apply the engine brake. Once the correct headway is achieved, then SmartCruise attempts to maintain that headway until the speed exceeds the driver's set speed. Once this condition is met, SmartCruise allows the engine to continue with conventional cruise control functions.

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Eaton VORAD Requirements

If the VS-400 is configured with the SmartCruise option, the system sends the SAE J1939 "heartbeat" message ACC1 every 100ms. Once the self-check is successfully completed and no system faults occur, the VS-400 starts transmitting the SAE J1939 "heartbeat" message every 100ms until Power Off to indicate to the engine that the VS-400 is operating properly. If the "SmartCruise Enable" configuration is not enabled, no ACC1 messages are transmitted.

SmartCruise is always in one of the following 8 states, and will transmit its current state in the ACC1 message:

000—Off (stand by, enabled, ready for activation): Indicates SmartCruise is configured and there are no VS-400 faults that prevent SmartCruise from operating. Conventional Cruise Control is not active in this state.

001—Speed Control Active: SmartCruise is ON, but not currently sending control messages. In other words, no object ahead and the Conventional Cruise Control is controlling road speed to the driver's set speed.

010—Distance Control Active: SmartCruise is ON actively sending control messages to maintain headway with an object detected in the lane of travel.

011—Overtake Mode: SmartCruise is ON, but temporarily disabled, because the driver is manually overriding cruise control by using either the throttle pedal or the cruise control "ACCEL" switch.

100—Not Defined: Not used.

101—Finish Mode: SmartCruise is on, no object ahead, and SmartCruise is sending control messages to return to driver's set speed. This occurs when the object SmartCruise was tracking moves out of the way and SmartCruise returns the vehicle to the driver's set speed.

110—Disabled or Error: SmartCruise is in an error state and cannot operate.

111—Not Available: SmartCruise is not available for some other reason than listed above.

If a fault occurs when SmartCruise operation is not allowed, the fault will remain active until the ignition power is cycled (Off/On) or the fault is cleared using a service tool (Service Ranger or ServiceLink). An active fault will cause the "110 Disabled or error" state to be sent in the ACC1 message. The DIU will display a screen stating "ACC unavailable" and activate the fault lamp. The VS-400 system will also transmit a DTC in DM1 on the J1939 datalink.

SmartCruise can function as specified only when the engine is programmed for Adaptive Cruise Control (ACC). An FLR configured with SmartCruise will look for this indication from the ECM or CPC. The ECM or CPC will transmit the state of this option in the ACC state field of the ACC1 message. The field is set to 111 (not available) if the engine does not support ACC, and 010 if there is an error. Any other state indicates that the engine does not support ACC. If the engine reports that it is not configured for ACC, then the following screen is displayed:

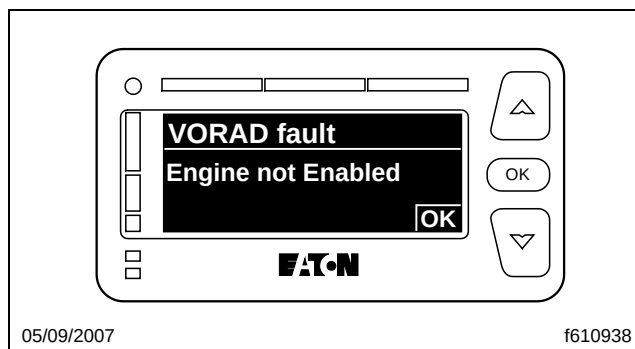


Fig. 9, Engine Not Detected

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600 — Component Locations

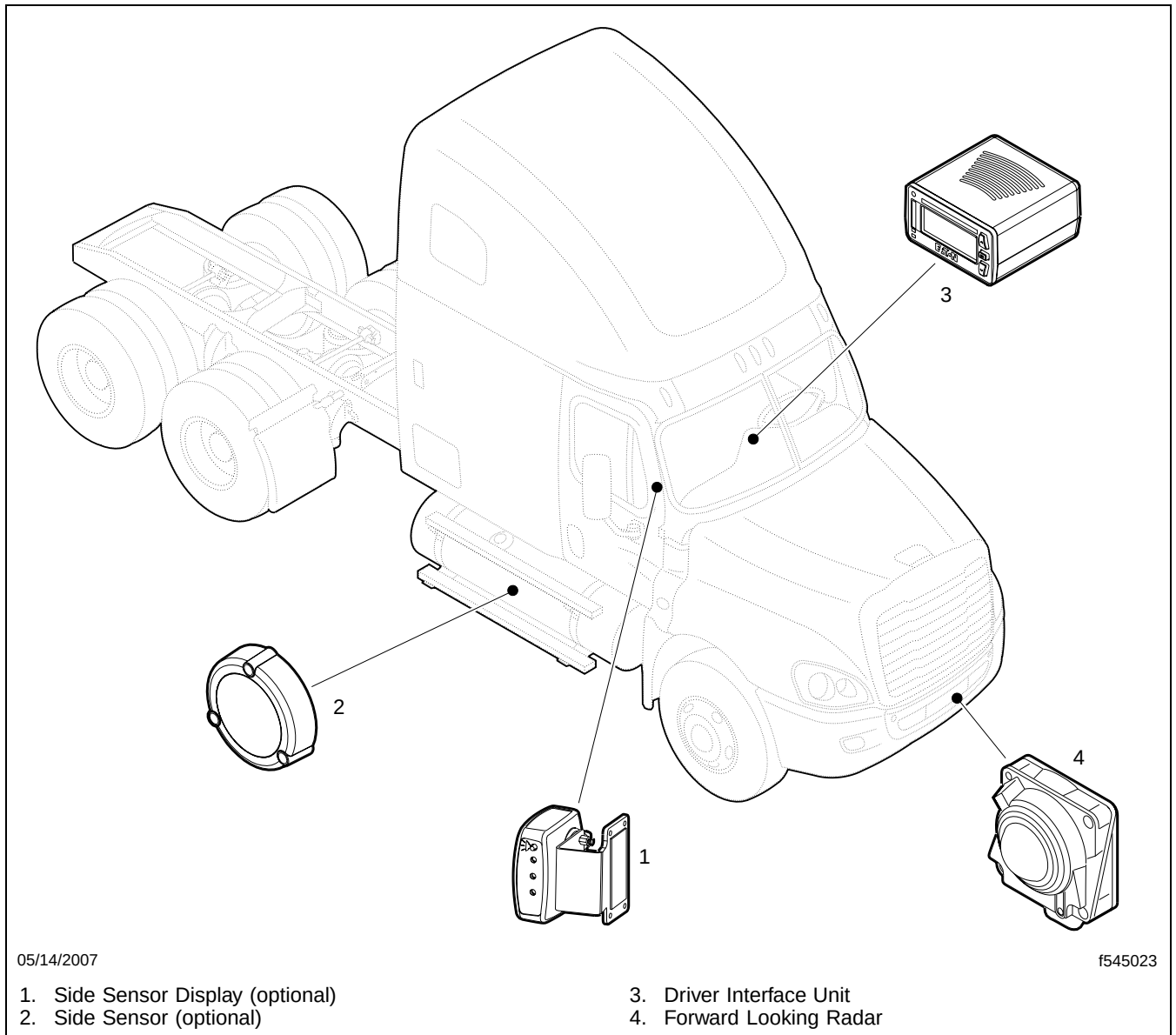


Fig. 10, Component Locations (exterior)

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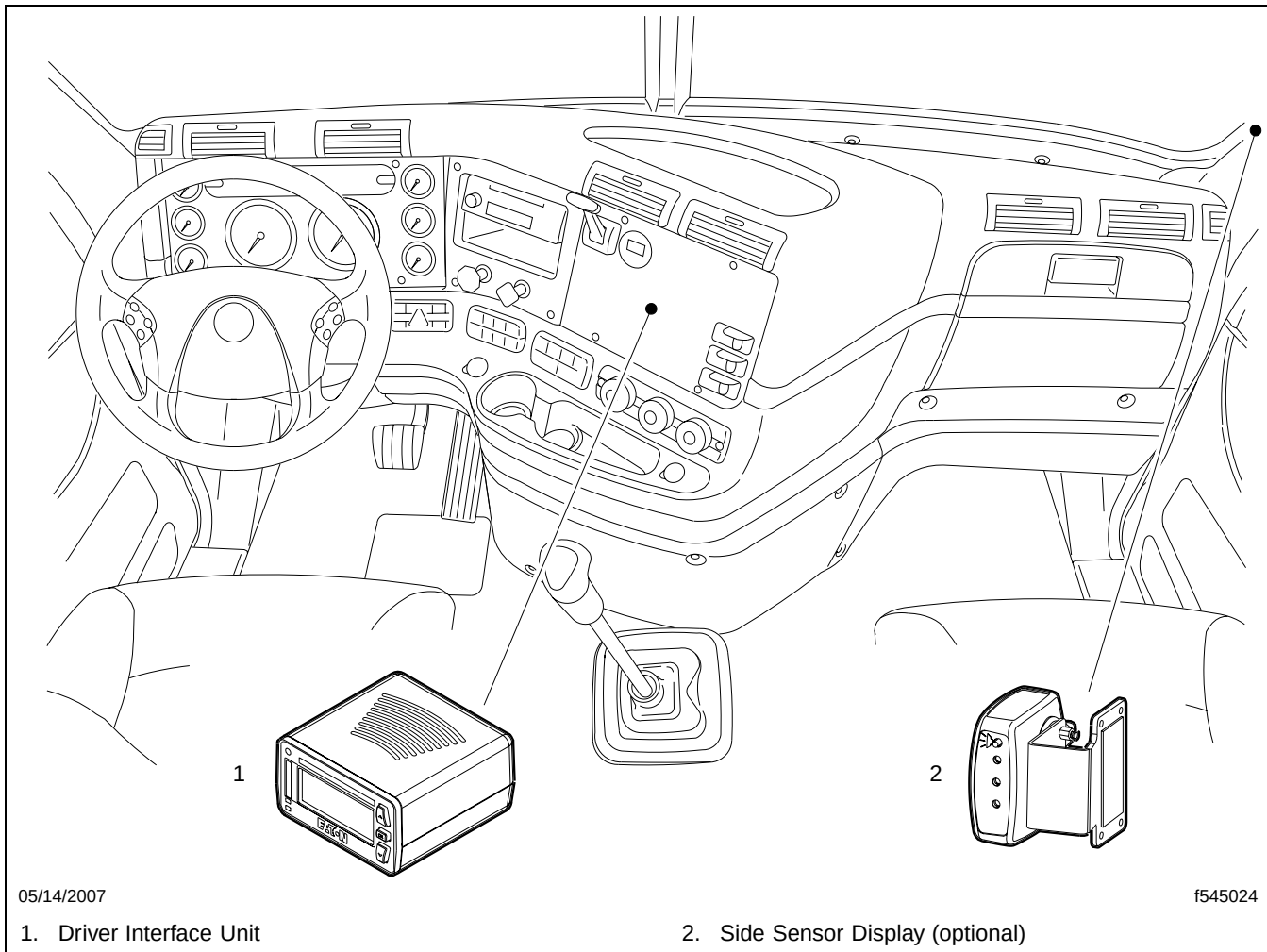


Fig. 11, Component Locations (interior)

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601 — Component Details

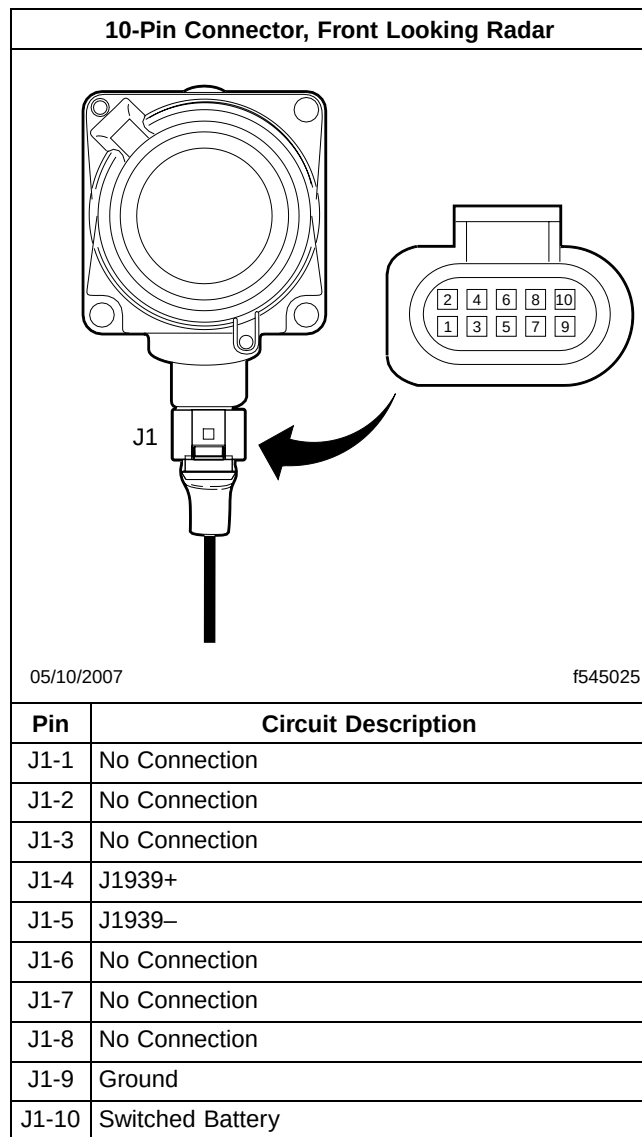


Table 1, 10-Pin Connector, Front Looking Radar

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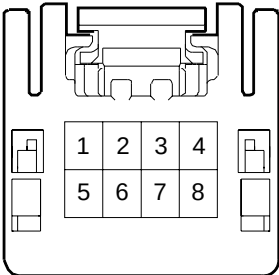
DIU 8-Pin Connector	
	
05/10/2007	f545027
Pin	Circuit Description
J1-1	Right Speaker (optional)
J1-2	Left Speaker (optional)
J1-3	Not Used
J1-4	Switched Battery
J1-5	Ground
J1-6	J1939+
J1-7	J1939-
J1-8	Not Used

Table 2, DIU 8-Pin Connector

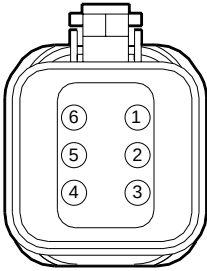
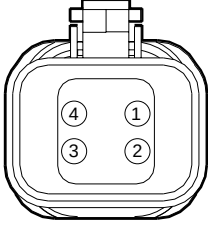
6-Pin Connector, Side Sensor	
	
05/10/2007	f545028
Pin	Circuit Description
J2-1	Ignition (12V switched)
J2-2	Ground
J2-3	Communication (to side sensor display)
J2-4	Power (to side sensor display unit)
J2-5	Side Object Detector Display Unit Signal Ground
J2-6	No Connection

Table 3, 6-Pin Connector, Side Sensor

Collision Warning System

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Side Sensor Display Unit Connector	
	
05/10/2007 f545029	
Pin	Circuit Description
J1-1	Power (from side sensor)
J1-2	Ground
J1-3	Communication (from side sensor)
J1-4	Turn Signal*

* The right turn signal is used for a side sensor mounted on the right side of the vehicle. The same can be done for the left-side sensor.

Table 4, Side Sensor Display Unit Connector

700 — J1939 Fault Codes

Source Addresses:

- Forward Looking Radar (FLR) – 42
- Driver Interface Unit (DIU) – 140
- SAM Cab – 33

NOTE: These J1939 fault codes are proprietary to the Eaton VORAD VS-400. ServiceLink will NOT provide full fault descriptions. Refer to Eaton Service Ranger for more detailed information.

J1939 Fault Codes				
SPN	SA	FMI	Fault Description	Fault Trigger
639	140/42	2	One or more required messages missing from datalink.	—
639	140/42	9	No messages being received from the datalink.	
639	140/42	13	Device cannot claim source address on datalink.	
639	140/42	19	Messages received with incorrect data or marked as error.	
886	42	7	FLR misaligned.	
886	42	12	FLR internally defective.	
886	42	13	FLR not configured properly.	
886	42	14	FLR blocked.	
893	140	12	DIU internally defective.	

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J1939 Fault Codes				
SPN	SA	FMI	Fault Description	Fault Trigger
898	42	13	Engine not configured for SmartCruise operation.	Tested only if SC configured
898	42	14	Engine not supported for SmartCruise operation.	
1563	140/42	13	VS-400 component detects incompatibility issue with other VS-400 devices.	—
1703	140	3	External right speaker shorted high.	Tested only if external right speaker configured
1703	140	4	External right speaker shorted low.	
1703	140	5	External right speaker open.	
1704	140	3	External left speaker shorted high.	
1704	140	4	External left speaker shorted low.	
1704	140	5	External left speaker open.	

Table 5, J1939 Fault Codes

701 — CAN Fault Codes

NOTE: Unless otherwise specified, all voltage measurements reference system ground.

IMPORTANT: The batteries **must** be disconnected prior to any resistance tests being performed. Failure to do so may result in inconclusive resistance measurements.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	520201	4	conn X2 pin 14	F25	R8	Fuse group 25 – Voltage below normal, or shorted to low source.	The voltage detected at conn X2 pin 14 is lower than expected.
Action: Measure the voltage at conn X2 pin 14. If BAT voltage is not detected, troubleshoot circuit 444 for a short to GND. Check fuse F25 for continuity. Repair as required.							

Table 6, CAN Fault Codes

800 — Parameters

The following table contains parameters that can be modified with Eaton Service Ranger software.

Parameters	
Description	Comments
Minimum volume	Minimum speaker volume that the DIU will allow the user to set.
Retain volume setting	Retains the volume setting across ignition cycles. Otherwise, volume setting defaults to 100% on each new ignition cycle.
Sound power-up tone	Plays tone at power-up as a speaker-check function.

Collision Warning System

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Parameters	
Description	Comments
SmartCruise range enable	Allows SmartCruise range (following distance) to be adjusted.
Two-second alert tone	Allows a tone to be played during a 2 second headway alert.
One-second alert tone	Allows a tone to be played during a 1 second headway alert.
Suppress headway alert tones on brake	Suppresses all headway alert tones (yellow LED) when brake is applied.
Suppress collision alert tones on brake	Suppresses all collision alert tones (red LED) when brake is applied.
Standby mode allowed	Allows the DIU to be put into Standby Mode by the user.
Left speaker output	Enables left external speaker and diagnostics.
Right speaker output	Enables right external speaker and diagnostics.
SmartCruise	Enables SmartCruise operation. This option cannot be set by Service Ranger; it must be purchased.
Collision warning	Enables Collision Warning operation. This option cannot be set by Service Ranger; it must be purchased.

Table 7, Parameters

J1939 Air Bag and Rollover Protection System

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J1939 Air Bag and Rollover Protection System

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500 — Terms and Abbreviations

CGW—Central Gateway

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

SAM—Signal Detect and Actuation Module

SPN—Suspect Parameter Number

501 — General Information

The J1939 RollTek system uses the AB10 sensor, with sensing elements that detect both frontal impact and side roll events. Even if battery power is lost during an event, deployment of restraint devices will still be possible through its energy reserve capacitors. Upon deployment, crash-relevant parameters are saved in the AB10 sensor.

System diagnostics continuously monitor internal AB10 functions and external circuits. Fault conditions are indicated using the SRS fault lamp and communicated over the SAE J1939 data bus.

When the ignition is turned on, the AB10 performs an initialization that takes approximately six seconds. The SRS fault lamp is on during this time.

The number of igniter circuits the AB10 controls is parameterized, based on vehicle content. There are five different configurations for the AB10 system:

- Driver Frontal Impact Protection—controls a driver frontal air bag and only uses the AB10 sensor.
- Driver Side Roll Protection—controls the driver's seat belt pretensioner and side air bag. The AB10 is internal to the RollTek Module.
- Driver Frontal and Side Roll Protection—controls the drivers seat belt pretensioner, frontal, and side air bag. The AB10 is internal to the RollTek module.
- Driver and Passenger Side Roll Protection—controls the driver's and passenger's seat belt pretensioners. The AB10 is internal to the RollTek module under the driver's seat. The RollTek module under the passenger's seat is used only for deploying the passenger-side seat belt pretensioner.
- Driver and Passenger Frontal and Side Roll Protection—controls the driver's and passenger's seat belt pretensioners, and the frontal and side air bags. The AB10 is internal to the RollTek module under the driver's seat. The RollTek module under the passengers seat is used only for deploying the passenger-side seat belt pretensioner and the passenger-side air bag.

The RollTek/AB10 system communicates over the J1939 data bus and is assigned the source address 83 (0x53).

502 — Safety Precautions



Before performing any work on the RollTek system, review all service literature and comply with the following warnings and precautions. Unintentional or improper deployment of the RollTek system can result in injury or death.

C07.11 J1939 Air Bag and Rollover Protection System

Damaged or deployed RollTek systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

- Do not attempt to modify the RollTek system. Doing so could change the effectiveness of the system. The RollTek system must be replaced after being activated.
- Do not attempt to service or to disassemble the RollTek module. The RollTek module cannot be serviced.
- Do not attempt to deploy an undeployed pyrotechnic inflator device, such as the RollTek Rollover Protection module. For disposition of an undeployed pyrotechnic inflator device, please contact LifeGuard Technologies (1-866-765-5835) for handling and forwarding instructions.
- Do not cut, drill, braze, solder, weld, strike, or probe any part of the RollTek system. Air bags and seat cylinders contain explosives and pressurized gas that can be dangerous if punctured, damaged, or cut.
- Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the RollTek system.
- Do not remove the RollTek sensors from the mounted locations if connected. Movement from a connected sensor can deploy the devices. The sensors should not be removed except for replacement.
- Do not connect electrical power to the RollTek module or sensors unless they are securely mounted in their designated locations.
- Do not attempt to adapt, reuse, or install a RollTek system in any vehicle other than the specific vehicle for which it is designed.
- Keep hands and tools away from the scissor points under the seats.
- Do not cut wires or tamper with the connectors between the vehicle wiring harness and the RollTek system. Cutting or removing the electrical connectors could cause unintentional deployment.
- Do not expose the RollTek system to electricity. Never probe a circuit.
- Store, transport, dispose, and recycle deployed RollTek system components in accordance with all applicable federal, state, and local regulations.
- Replace damaged seat belts, or seat belts that were worn in an accident, and check all anchoring points.
- The RollTek system requires a special seat belt. Care must be taken to ensure the correct seat belt is used.
- The seat must be attached to the RollTek module and seat riser with the capscrews and spacers provided with the module.
- Always disconnect the SRS system when welding on the vehicle.
- Before connecting or disconnecting the SRS sensors, always turn the battery switch to OFF and disconnect the batteries, then wait one minute before connecting or disconnecting the sensors.

The RollTek system contains components with pyrotechnic inflator devices, which use combustible chemicals. The RollTek module and the air bags have inflators. Use care when replacing or handling these system components.

For disposition of a deployed pyrotechnic inflator device, follow and comply with any current and applicable state laws.

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600 — Component Locations

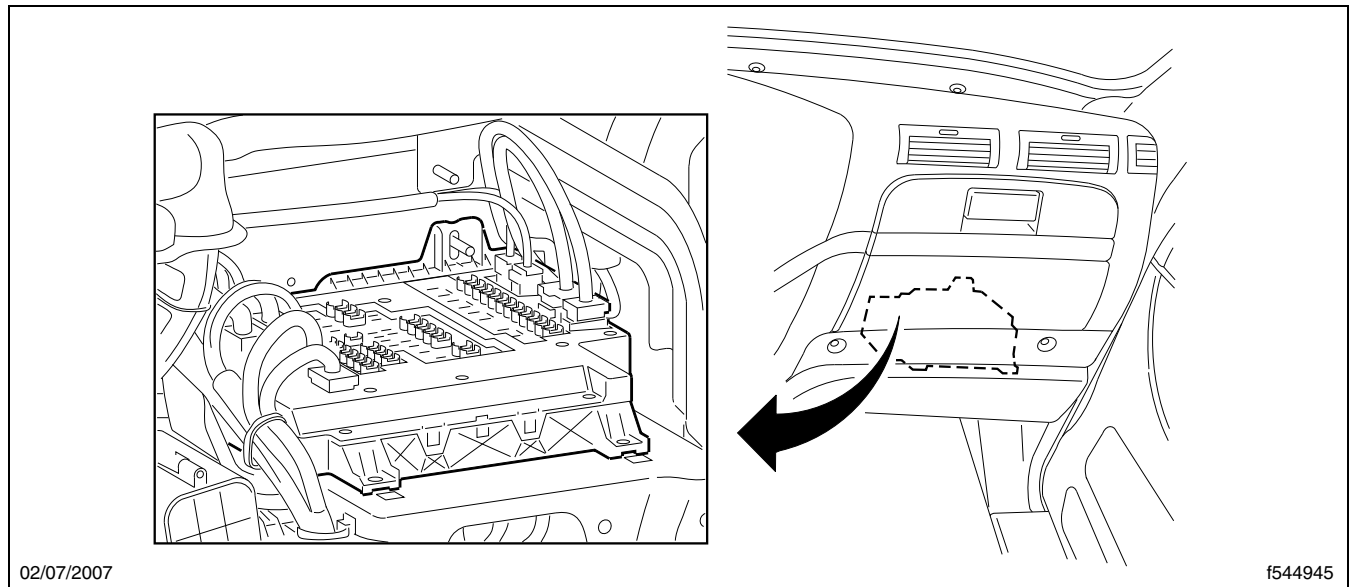


Fig. 1, SAM Cab

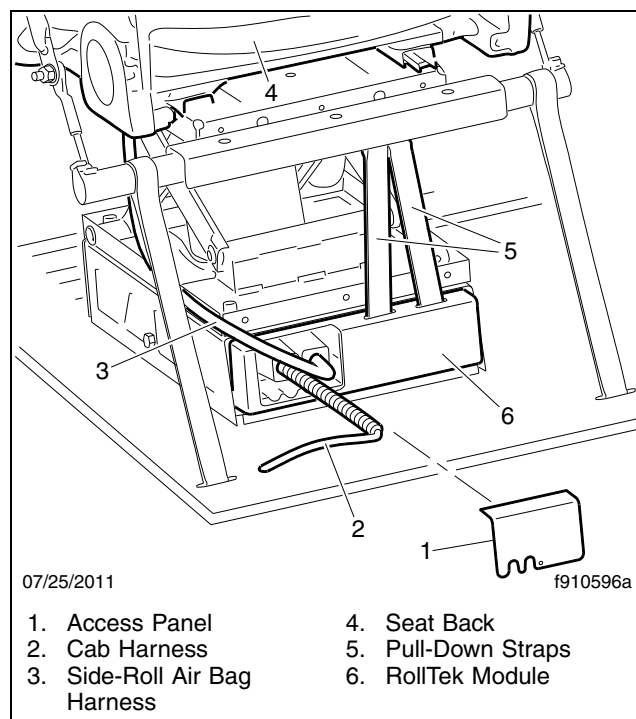


Fig. 2, RollTek Module

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J1939 Air Bag and Rollover Protection System

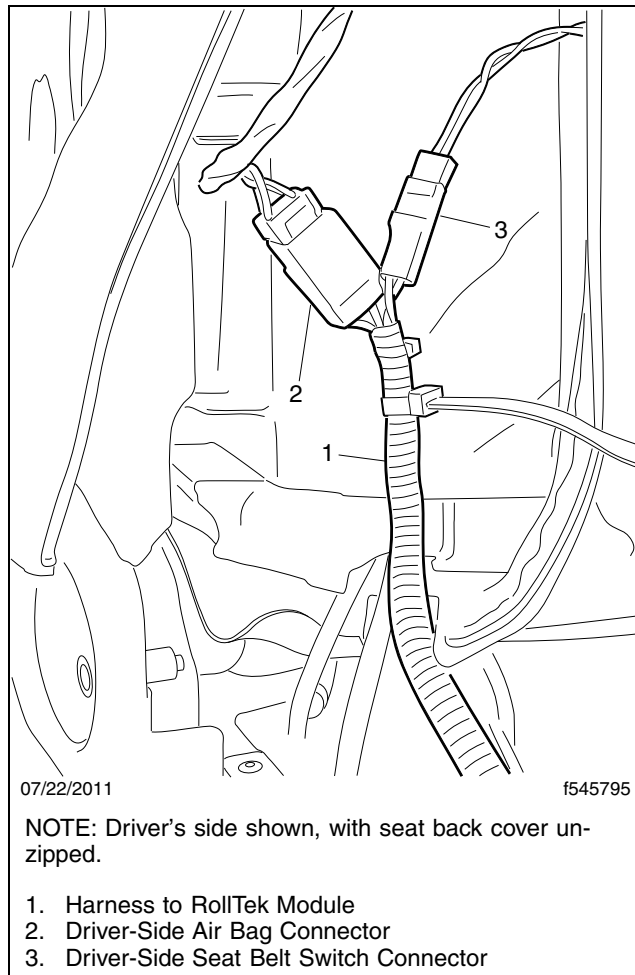


Fig. 3, Seat Back Connectors

J1939 Air Bag and Rollover Protection System

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601 — Component Details

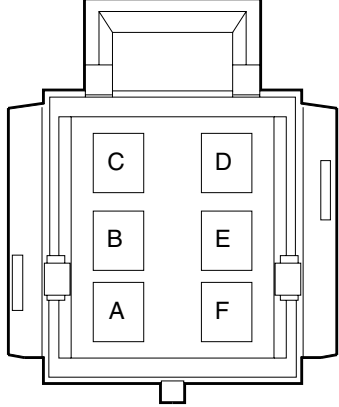
6-Pin Communication and Power Connector Pin Destination				
Connector Manufacturer: Packard Housing Part Number: 12064754 Secondary Lock Part Number: 12064755 Terminal Part Number: 12034047 Color: Black				
 f545796				
Connector Front View				
Connector Name	Location	Pin	Wire Color	Description
A	B-Pillar (frontal only) or on RollTek Module	A	Red	+12V
		B	Black	Ground
		C	Yellow	J1939 (+)
		D	Green	J1939 (-)
		E	White	Warning Lamp

Table 1, 6-Pin Communication and Power Connector Pin Destination

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J1939 Air Bag and Rollover Protection System

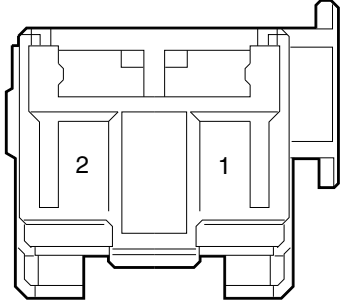
2-Pin Front Air Bag Connector Pin				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
				
Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
B	On RollTek Module	1	Yellow/White	Driver Front Air Bag (+)
		2	Yellow/White	Driver Front Air Bag (-)

Table 2, 2-Pin Front Air Bag Connector Pin

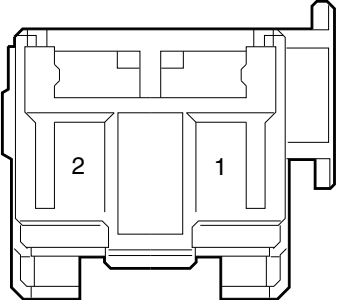
2-Pin Driver-Side Air Bag Connection				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
				
Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
C	Back of Driver Seat	1	Blue	Driver SRA (+)
		2	White	Driver SRA (-)

Table 3, 2-Pin Driver-Side Air Bag Connection

J1939 Air Bag and Rollover Protection System

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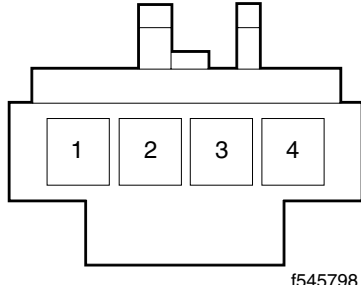
4-Pin Signal to Deploy Passenger-Side Pyrotechnics				
Connector Manufacturer: FCI Housing Part Number: 54550400 Terminal Part Number: 54001803 Color: Yellow				
				
Connector Name	Location	Pin	Wire Color	Description
D	Inside Driver-Side Component Box	1	Yellow/White	Passenger S4 (+)
		2	Yellow/White	Passenger S4 (-)
		3	Yellow/White	Passenger SRA (+)
		4	Yellow/White	Passenger SRA (-)

Table 4, 4-Pin Signal to Deploy Passenger-Side Pyrotechnics

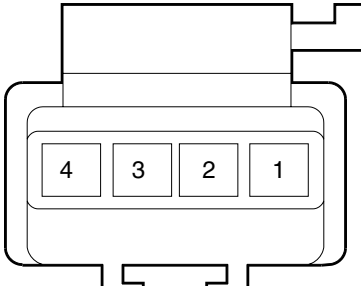
4-Pin Passenger-Side Pyrotechnics				
Connector Manufacturer: FCI Housing Part Number: 54550402 Terminal Part Number: 54001819 Color: Yellow				
				
Connector Name	Location	Pin	Wire Color	Description
E	Inside Passenger-Side Component Box	1	Yellow/White	Passenger S4 (+)
		2	Yellow/White	Passenger S4 (-)
		3	Yellow/White	Passenger SRA (+)
		4	Yellow/White	Passenger SRA (-)

Table 5, 4-Pin Passenger-Side Pyrotechnics

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J1939 Air Bag and Rollover Protection System

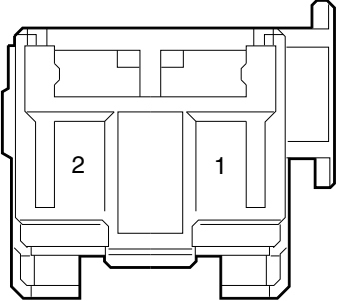
2-Pin Passenger-Side Air Bag				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
				
Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
F	Back of Driver Seat	1	Blue	Passenger SRA (+)
		2	White	Passenger SRA (-)

Table 6, 2-Pin Passenger-Side Air Bag

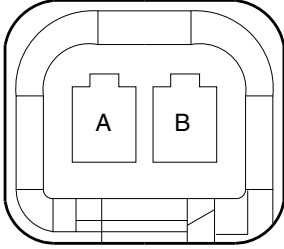
Driver's Buckle Connector				
Connector Manufacturer: Packard Housing Part Number: 12047663 Lock Part Number: 12047665 Terminal Part Number: 12047581 Color: Black				
				
Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
G	Back of Driver Seat from AB10-ECU	A	Gray	Driver's Buckle (+)
		B	White	Driver's Buckle (-)

Table 7, Driver's Buckle Connector

J1939 Air Bag and Rollover Protection System

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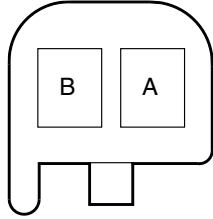
Passenger Buckle Switch From AB10-ECU				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				
				
Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
H	Inside Driver's Component Box	A	Tan/White	Driver's Buckle (+)
		B	Tan/White	Driver's Buckle (-)

Table 8, Passenger Buckle Switch From AB10-ECU

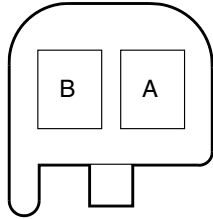
Buckle Connector Passenger and Driver				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				
				
Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
I	End of Buckle Harness (driver and passenger)	A	Tan/White	Driver's Buckle (+)
		B	Tan/White	Driver's Buckle (-)

Table 9, Buckle Connector Passenger and Driver

700 — Diagnostics

Use ServiceLink connected to the J1939 databus to monitor for RollTek fault codes. The RollTek/AB10 system communicates over the J1939 data bus and is assigned the source address 83 (0x53).

The RollTek system is powered by circuit 81C from SAM cab connector X3, pin 6. The circuit is connected through relay R8 and fused through the 5-amp fuse F26.

The operational readiness of the RollTek system is indicated by the supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on for approximately 10 seconds when the engine is started and then goes off. The indicator will remain on if there is a problem with the air bag or RollTek system. Service is required if the SRS indicator does not come on when the ignition is turned ON, or if the SRS indicator remains on.

C07.11 J1939 Air Bag and Rollover Protection System

WARNING

Before performing any service on the RollTek system, deactivate the system by turning off the ignition and battery switch. Do NOT service a live RollTek system. Accidental deployment could cause serious injury and property damage.

Prior to performing any service work on the RollTek Rollover Protection System, it is necessary to determine the nature and exact cause of the problem, using the applicable diagnostic procedure in this subject.

1. Determine the appropriate service procedure based on the information provided by the active fault code(s).
2. Complete the service procedure, then clear fault codes following specific fault clearing instructions, if identified in the procedure.
3. Turn the ignition OFF. After 5 seconds, turn it back ON, and verify that no RollTek faults are active.

701 — Fault Codes

RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
624	03	Warning Lamp Circuit Out of Range High	A-E	Troubleshoot for a wiring fault on circuit 454L between the RollTek module and the ICU. This fault can also be set if the lamp in the ICU has been replaced with one that does not draw the amperage that the RollTek module expects.
	04	Warning Lamp Circuit Out of Range Low		
	05	Warning Lamp Circuit Current Low or Open		
	06	Warning Lamp Circuit Current High or Short to Battery		
	31	Warning Lamp Circuit Cross Coupling		
	14	Warning Lamp Circuit Configuration		

J1939 Air Bag and Rollover Protection System

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RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
4818	03	Driver Front Air Bag Circuit Out of Range High	B-1 B-2	Follow the disconnect sequence: 1. Disconnect the batteries and wait one minute. 2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. 3. Disconnect all RollTek module connectors. 4. Disconnect the driver's front air bag connector at the steering column. With the air bag disconnected and placed aside, troubleshoot for a wiring fault with the clockspring and on circuits 454A+ and 454A– between the RollTek module and the driver's front air bag connector at the clockspring. If no wiring fault is found, place a 2.2Ω +/-5% 1/4-watt resistor across the 454A+ and 454A– circuits in the vehicle side of the harness. Reconnect the RollTek module but leave the driver's front air bag disconnected. Connect the batteries, then turn on the ignition without starting the engine. If the fault does not reset as active, replace the air bag. If the fault is still active, replace the RollTek module from under the driver's seat. See the <i>Cascadia Workshop Manual</i>, Section 91.03.
	04	Driver Front Air Bag Circuit Out of Range Low		
	05	Driver Front Air Bag Circuit Current Low or Open		
	06	Driver Front Air Bag Circuit Current High		
	31	Driver Front Air Bag Circuit Cross Coupling		
	14	Driver Front Air Bag Circuit Configuration		
4822	03	Driver Buckle Pretensioner Circuit Out of Range High	Internal	Internal circuit fault with the driver-side buckle pretensioner. Replace the RollTek module. See the <i>Cascadia Workshop Manual</i>, Section 91.03.
	04	Driver Buckle Pretensioner Circuit Out of Range Low		
	05	Driver Buckle Pretensioner Circuit Current Low or Open		
	06	Driver Buckle Pretensioner Circuit Current High		
	31	Driver Buckle Pretensioner Circuit Cross Coupling		
	14	Driver Buckle Pretensioner Circuit Configuration		

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RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
4823	03	Passenger Buckle Tension Interconnect Circuit Out of Range High	D-1 D-2 E-1 E-2	Follow the disconnect sequence: 1. Disconnect the batteries and wait one minute. 2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. 3. Disconnect all Rolltek module connectors from all Rolltek modules. Troubleshoot for a wiring fault on circuits 454C+ and 454C– between the driver-side Rolltek module connector D, pins 1 and 2, and the passenger-side Rolltek module connector E, pins 1 and 2. Repair any wiring fault that is found.
	04	Passenger Buckle Tension Interconnect Circuit Out of Range Low		
	05	Passenger Buckle Tension Interconnect Circuit Current Low or Open		
	06	Passenger Buckle Tension Interconnect Circuit Current High		
	31	Passenger Buckle Tension Interconnect Circuit Cross Coupling		
	14	Passenger Buckle Tension Interconnect Circuit Configuration		
4824	03	Driver Side Air Bag Circuit Out of Range High	C-1 C-2	1. Turn off the ignition and wait one minute. 2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. 3. Unzip the driver-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 3. Disconnect the yellow connector that connects to the Rolltek module to the driver-side air bag. 4. Place a 2.2Ω $\pm$ 5% 1/4-watt resistor in the connector on the side of the harness from the Rolltek module. This resistor will simulate the air bag that will remain disconnected. 5. Turn the ignition on without starting the engine. If the fault does not reset as active, replace the air bag. If the fault remains active, troubleshoot for and repair a fault in the wiring to the Rolltek module. If no wiring fault is found, replace the Rolltek module. See the <i>Cascadia Workshop Manual</i>, Section 91.03.
	04	Driver Side Air Bag Circuit Out of Range Low		
	05	Driver Side Air Bag Circuit Current Low or Open		
	06	Driver Side Air Bag Circuit Current High		
	31	Driver Side Air Bag Circuit Cross Coupling		
	14	Driver Side Air Bag Circuit Configuration		

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RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
4826	03	Passenger Side Air Bag Circuit Out of Range High	D-3 D-4 E-3 E-4 F-1 F-2	Follow the disconnect sequence:
	04	Passenger Side Air Bag Circuit Out of Range Low		1. Disconnect the batteries and wait one minute.
	05	Passenger Side Air Bag Circuit Current Low or Open		2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
	06	Passenger Side Air Bag Circuit Current High		3. Disconnect all Rolltek module connectors from all Rolltek modules.
	31	Passenger Side Air Bag Circuit Cross Coupling		Troubleshoot for and repair a wiring fault on circuits 454C+ and 454C- between the driver-side Rolltek module connector D, pins 3 and 4, and the passenger-side Rolltek module connector E, pins 3 and 4.
	14	Passenger Side Air Bag Circuit Configuration		If there is no wiring fault, unzip the passenger-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 3 . Disconnect the yellow connector for the wiring from the Rolltek module to the side air bag.
				1. Place a 2.2Ω +/- 5% 1/4-watt resistor in the yellow connector on the side of the harness from the passenger-side Rolltek module. This resistor will simulate the air bag that will remain disconnected.
				2. While wearing the ground strap, reconnect all the other Rolltek module connectors.
				3. Turn the ignition on without starting the engine. If the fault does not reset as active, replace the air bag. If the fault remains active, troubleshoot for and repair a fault in the wiring to the Rolltek module. If no wiring fault is found, replace the Rolltek module. See the <i>Cascadia Workshop Manual</i> , Section 91.03 .

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RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
4952	03	Driver Side Seat Belt Buckle Circuit Out of Range High	G-1 G-2 I-1 I-2	1. Turn off the ignition and wait one minute. 2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. 3. Unzip the driver-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 3. Disconnect the smaller white connector that connects to the Rolltek module to the driver-side seat belt buckle. 4. Measure resistance across the seat belt buckle (white) connector with the seat belt latched and unlatched. The latch circuit should measure 100Ω when the seat belt is latched and 400Ω when the seat belt is unlatched. If the resistance measurement is significantly different than these values, replace the seat belt buckle assembly. 5. If the seat belt buckle side of the circuit passes all testing, troubleshoot for and repair a wiring fault in the harness between the Rolltek module and the connector. 6. If there is no wiring fault, replace the Rolltek module. See the <i>Cascadia Workshop Manual</i>, Section 91.03.
	04	Driver Side Seat Belt Buckle Circuit Out of Range Low		
	05	Driver Side Seat Belt Buckle Circuit Current Low or Open		
	06	Driver Side Seat Belt Buckle Circuit Current High		
	31	Driver Side Seat Belt Buckle Circuit Cross Coupling		
4953	03	Passenger Side Seat Belt Buckle Circuit Out of Range High	H-1 H-2 I-1 I-2	1. Turn off the ignition and wait one minute. 2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. 3. Unzip the passenger-side seat back and locate the connectors in the lower outboard area of the seat back. See Fig. 2. Disconnect the smaller white connector that connects the Rolltek module to the passenger-side seat belt buckle. 4. Measure resistance across the seat belt buckle (white) connector with the seat belt latched and unlatched. The latch circuit should measure 100Ω when the seat belt is latched and 400Ω when the seat belt is unlatched. If the resistance measurement is significantly different than these values, replace the seat belt buckle assembly. 5. If the seat belt buckle side of the circuit passes all testing, troubleshoot for and repair a wiring fault in the harness between the Rolltek module and the connector. 6. If there is no wiring fault, replace the Rolltek module. See the <i>Cascadia Workshop Manual</i>, Section 91.03.
	04	Passenger Side Seat Belt Buckle Circuit Out of Range Low		
	05	Passenger Side Seat Belt Buckle Circuit Current Low or Open		
	06	Passenger Side Seat Belt Buckle Circuit Current High		
	31	Passenger Side Seat Belt Buckle Circuit Cross Coupling		
4973	14	Deployment Event	—	The Rolltek controller has deployed an air bag or seat belt pretensioner. Contact the Customer Assistance Center at 1-800-385-4357 or 1-800-FTL-HELP.
32512	14	Not Programmed—Container 1	—	The Rolltek ECU is not programmed/configured with application parameters. Replace the Rolltek module. See the <i>Cascadia Workshop Manual</i> , Section 91.03 .
32513	14	Not Programmed—Container 2	—	The Rolltek ECU is not programmed/configured with application parameters. Replace the Rolltek module. See the <i>Cascadia Workshop Manual</i> , Section 91.03 .

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RollTek J1939 Fault Codes				
SPN	FMI	Description	Connector/ Pin	Action
36590	12	Internal Fault	—	The Rolltek module has an internal fault. Do not issue a Clear Fault (DM3) message. Replace the Rolltek module. See the <i>Cascadia Workshop Manual</i> , Section 91.03 .
49267	11	CAN Bus Off	A-C A-D	Fault with CAN communications. Troubleshoot for a circuitry fault with CAN-H and CAN-L.
61696	03	Vbat Out of Range High	A-A	The operating voltage range is 8–16 volts. Troubleshoot for a fault with the vehicle charging system. See P01.01—Starting and Charging .
	04	Vbat Out of Range Low	A-B	

Table 10, RollTek J1939 Fault Codes

800 — SRS Wiring Schematics

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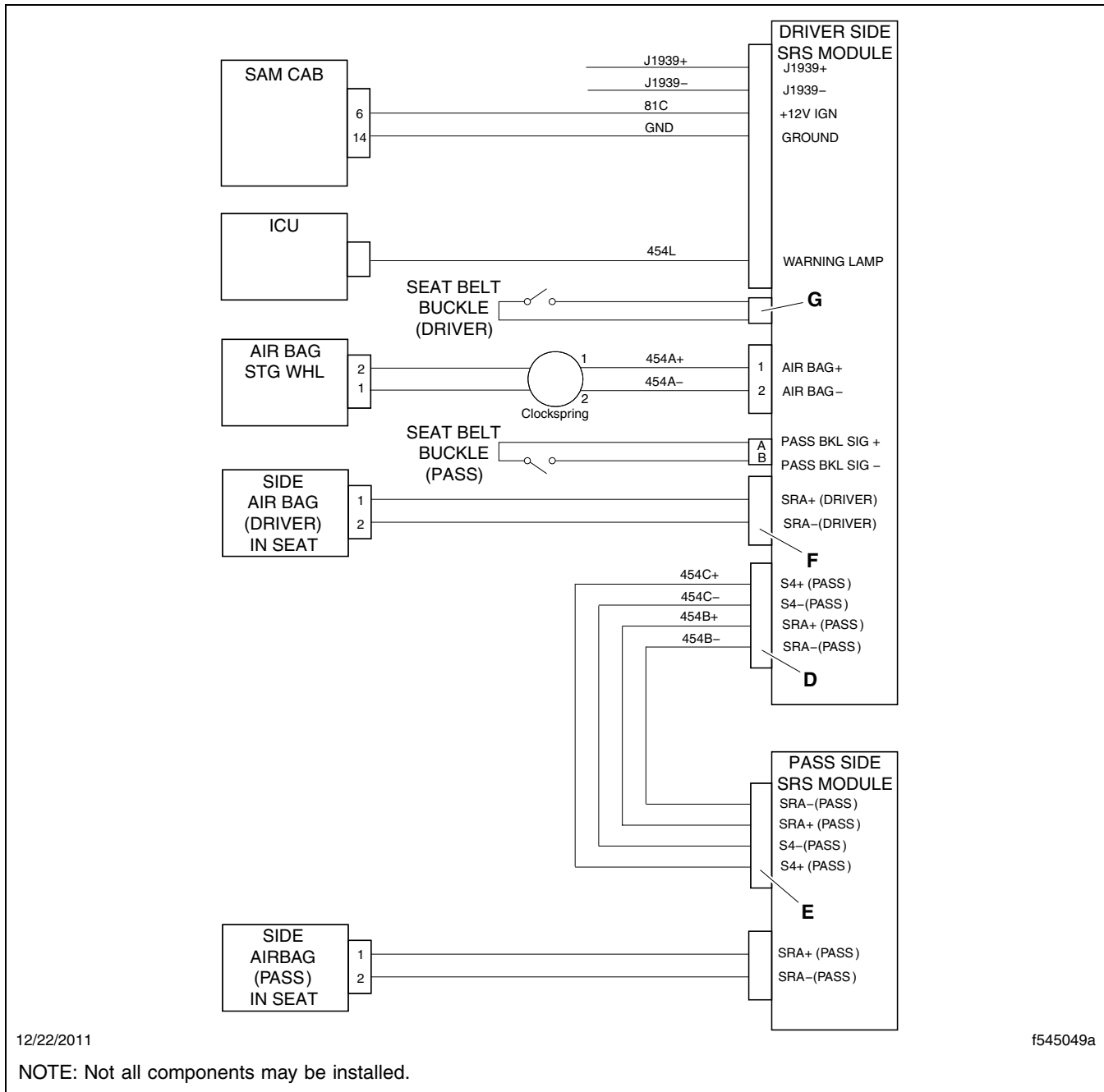


Fig. 4, SRS Wiring Schematic

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500 — Terms and Abbreviations

ABS—Antilock Braking System

ATC—Automatic Traction Control

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit, typically connected to a datalink.

ESC—Electronic Stability Control

ESC Module—Electronic Stability Control System Electronic Control Unit

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

ICU—Instrumentation Control Unit

LBCU—Light Bar Control Unit

MSF—Modular Switch Field

RSA—Roll Stability Advisor

RSC—Roll Stability Control

SAE—Society of Automotive Engineers

SAS—Steering Angle Sensor

501 — General Information

Freightliner Cascadia™ vehicles are equipped with a Meritor WABCO E-Version Antilock Braking System (ABS) with a cab-mounted electronic control unit. The ABS is an electronic wheel speed monitoring and control system that works with the standard air brake system. It passively monitors vehicle wheel speed at all times, then controls wheel speed during emergency stops. As a result, the driver has full control of braking until the ECU senses that a lockup is about to occur.

CAUTION

The size of the tires installed at the factory is programmed into the Antilock Braking System Electronic Control Unit (ABS ECU). Installing different size tires could result in a reduced braking force, leading to longer stopping distances and possibly resulting in personal injury or property damage.

The ABS includes signal-generating sensors activated by tone (tooth) wheels located on the hubs of the monitored wheels. See **Fig. 1**. The sensors transmit vehicle wheel speed information to the ECU. According to programmed specifications, the control unit signals the appropriate modulator valve to increase, reduce, or maintain air pressure in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

Freightliner Cascadia™ vehicles come standard with four-channel ABS; four wheel speed sensors, and four modulator valves (4S/4M). Optional ABS systems are also available; 6S/4M and 6S/6M ABS. Automatic Traction Control (ATC) is optional with any of the standard or optional configurations.

During normal braking conditions, the standard air brake system is in effect. If the vehicle is equipped with ATC, wheel spin is controlled during reduced-traction startup and acceleration.

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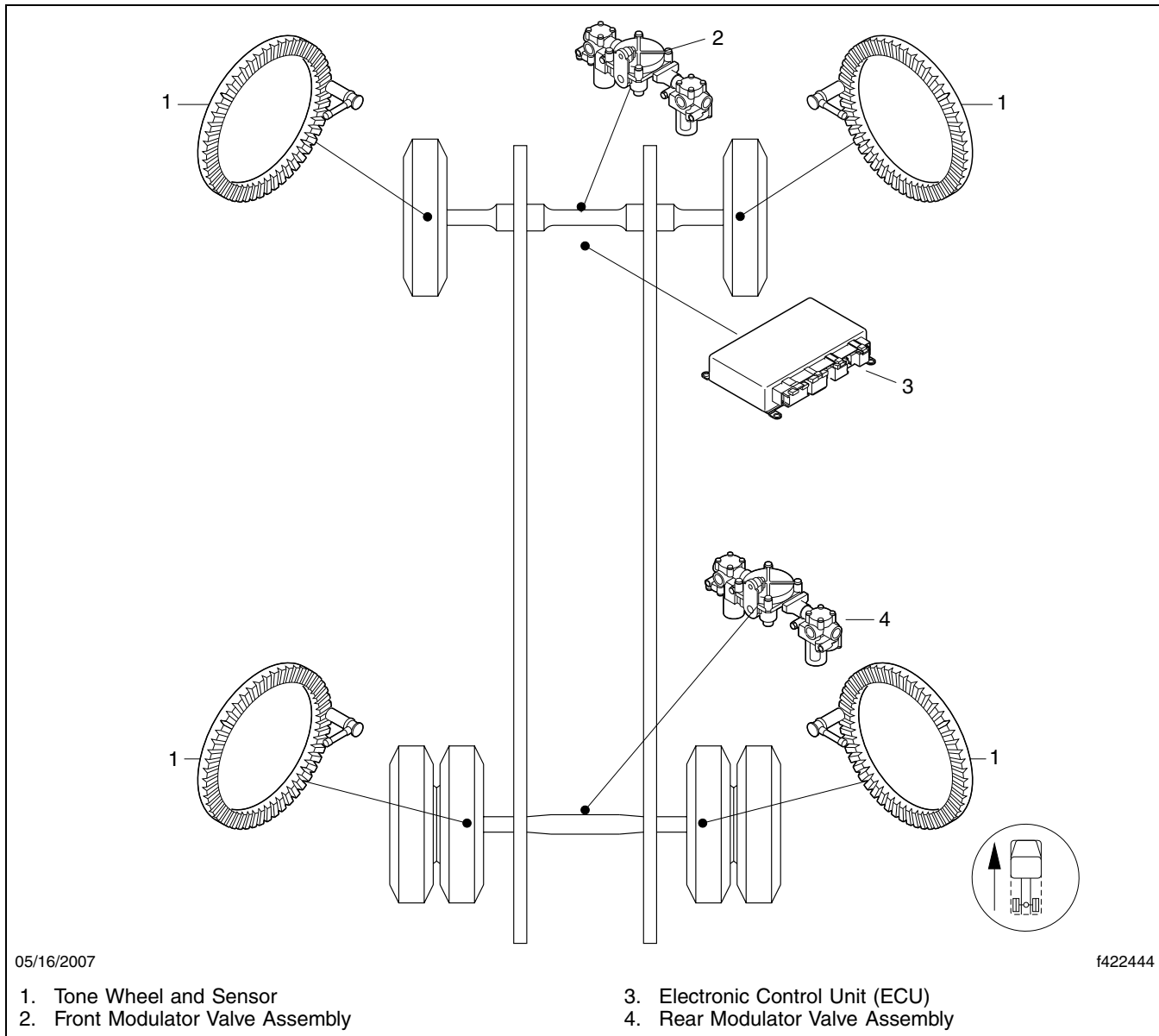


Fig. 1, ABS Component Location (4-channel, 4S/4M system shown)

502 — Principles of Operation

The ABS has an electronic control unit (ECU) that serves as the information processing and command center for the antilock braking system. The ECU is a digital microcomputer that receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the modulator valves.

The major components of the Meritor WABCO pneumatic ABS system include the following:

- Wheel speed sensors

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- An electronic control unit (ECU)
- Modulator valves (solenoid control valves)
- Automatic Traction Control (ATC) valve (optional)
- ABS warning and wheel-spin indicator lights

503 — Wheel Speed Sensors

The wheel speed sensor assembly is a signal generating device. The assembly includes a sensor (coil wrapped around a magnet), a tone wheel, and a sensor clip that holds the sensor in position near the tone wheel. See **Fig. 2**. Each ABS-controlled wheel has a wheel speed sensor assembly with its tone wheel mounted on the hub. When the vehicle is moving, the teeth on the tone wheel cause interruptions in the magnetic field created by the sensor. The interruptions create electrical pulses that are sent to the electronic control unit where they are used to determine the wheel speed.

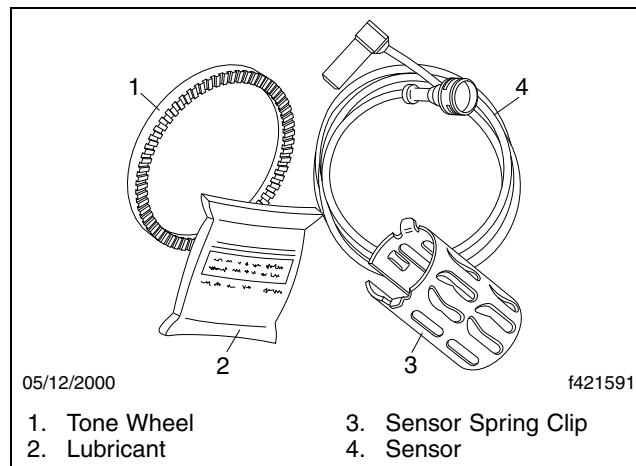


Fig. 2, Wheel Speed Sensor Components

504 — ABS Electronic Control Unit (ECU)

The ECU is mounted inside the cab behind the lower center dash panel.

The ECU receives signals from the wheel speed sensors and uses them to calculate wheel speed and a vehicle reference speed. The unit is programmed to determine whether the wheels are slowing at a normal braking rate or at a higher rate, requiring ABS braking control. If the ECU senses wheel slip or lockup, the appropriate control circuit signals the modulator valve(s) to release, hold, or reapply braking pressure.

The ECU also shuts down the engine brake and the exhaust brake, if equipped, when a wheel approaches a slip or lockup condition. When the wheels return to a normal rate of speed, the engine and exhaust brakes are reactivated automatically.

The ECU constantly monitors the wheel sensors, modulator valves, automatic traction control valve (if equipped), and the electrical circuitry.

The ABS performs a self-test when the ignition is turned on. During the self-test, the modulator valves and the ATC valve cycle on and off, creating clicking noises that may be heard inside the cab. These clicking noises are

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normal and do not indicate an ABS problem. If a problem is detected, the ECU will log a fault code and illuminate the warning lamp.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (such as a sensor, modulator valve, wiring connection, or short circuit), the ABS warning light comes on, a fault code is stored in ECU memory, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit retains the ABS effect.

Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a modulator valve or valve assembly is damaged and inoperative. These components are an integral part of the air brake system, so normal braking may be impaired or inoperative.

For troubleshooting purposes, the ECU can communicate with the Meritor WABCO PC Diagnostics (recommended), ServiceLink, or other tool capable of reading J1587 fault codes through the diagnostic connector.

IMPORTANT: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

505 — Modulator Valves

Modulator valves control the air pressure in each affected brake chamber during an ABS operation. Depending on the signal received from the ECU, modulator valves prevent wheel lockup by reducing, maintaining, or increasing brake pressure.

During normal braking applications, the ABS system is inactive and compressed air flows freely through the modulator valves to the brake chambers. Each ABS-monitored wheel has its own modulator valve. The front and rear modulator valve assemblies are mounted on a crossmember near the brake chambers. See **Fig. 1**. The assembly includes two modulator valves, one mounted on each side of a service relay valve.

If the vehicle has an ATC system, the ATC valve is mounted on the control port of the service relay valve. Vehicles with tandem rear axles and a 4S/4M ABS share modulator valves. One wheel is sensed but the modulator valve controls both wheels on a side.

Each modulator valve assembly includes two solenoid control valves (one supply and one exhaust) and two diaphragms. See **Fig. 3**.

- The supply diaphragm opens and closes an air passage between the supply port and delivery port. It is controlled by the supply solenoid valve.
- The exhaust diaphragm opens and closes an air passage between the exhaust port and the delivery port. It is controlled by the exhaust solenoid valve.

The ECU energizes different combinations of these solenoid valves to perform four functions: normal braking (without ABS control), ABS brake release (exhaust), ABS brake hold, and normal brake reapply.

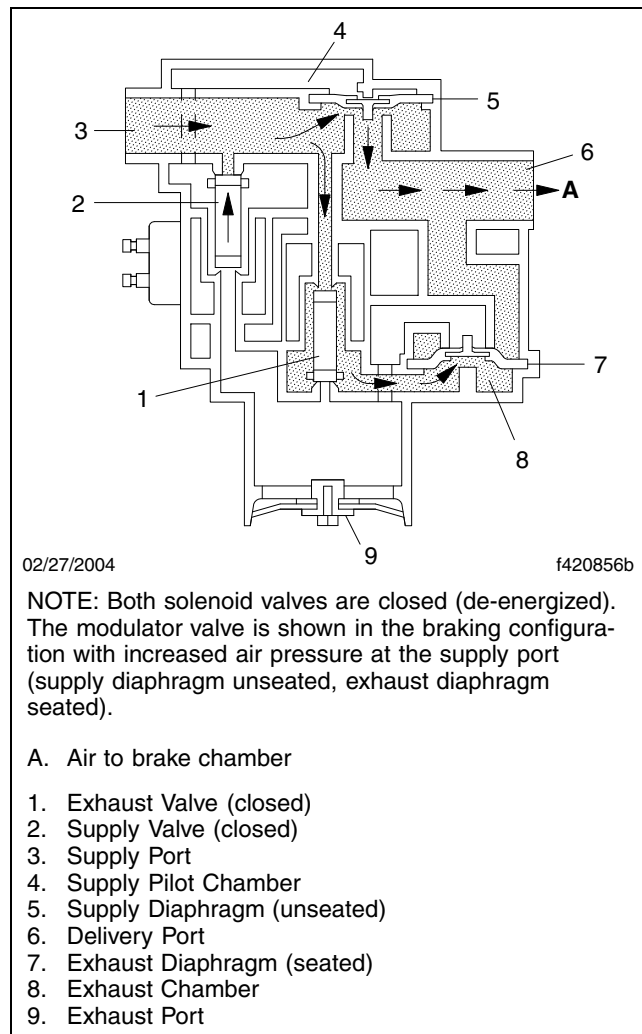


Fig. 3, Modulator Valve, Normal Brake Control (brake applied)

506 — Normal Brake Control

The normal brake function (without ABS control) operates as follows:

- Before braking, the supply pilot chamber is open to the atmosphere through the exhaust port.
- When the brakes are applied, both solenoid valves in the ABS modulator valve are closed (de-energized).
- Increased air pressure entering the supply port unseats the supply diaphragm by increasing the pressure under the diaphragm. This opens the passage to the delivery port and allows air to flow directly through the valve and into the brake chamber.
- Air also flows through the exhaust valve. The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port.

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- When the brake pedal is released, air pressure at the supply port decreases and the higher pressure in the brake chamber reverses the flow of air in the modulator valve. Air now flows from the delivery port to the supply port until the pressure is balanced. This releases the supply diaphragm and closes the passage between the two ports.
- The reduced pressure unseats the exhaust diaphragm and air is vented through the exhaust port to the atmosphere.

507 — Brake Release (ABS Active)

The ABS brake release (exhaust) function is triggered when the ECU determines that the brakes are about to lock. It operates as follows:

- When a wheel is going to lock, the ECU opens (energizes) both solenoid valves in the ABS modulator valve. See **Fig. 4**.
- The open supply valve allows compressed air to enter the supply pilot chamber above the supply diaphragm. The increased pressure seats the diaphragm and stops air from entering the brake chamber.
- The open exhaust valve shuts off the supply of air entering the exhaust pilot chamber. It also creates an opening between the pilot and exhaust chambers.
- Air from the brake chamber enters through the delivery port. The pressure unseats the exhaust diaphragm, creating an opening between the delivery and exhaust chambers. Brake chamber air is then released through the exhaust port.

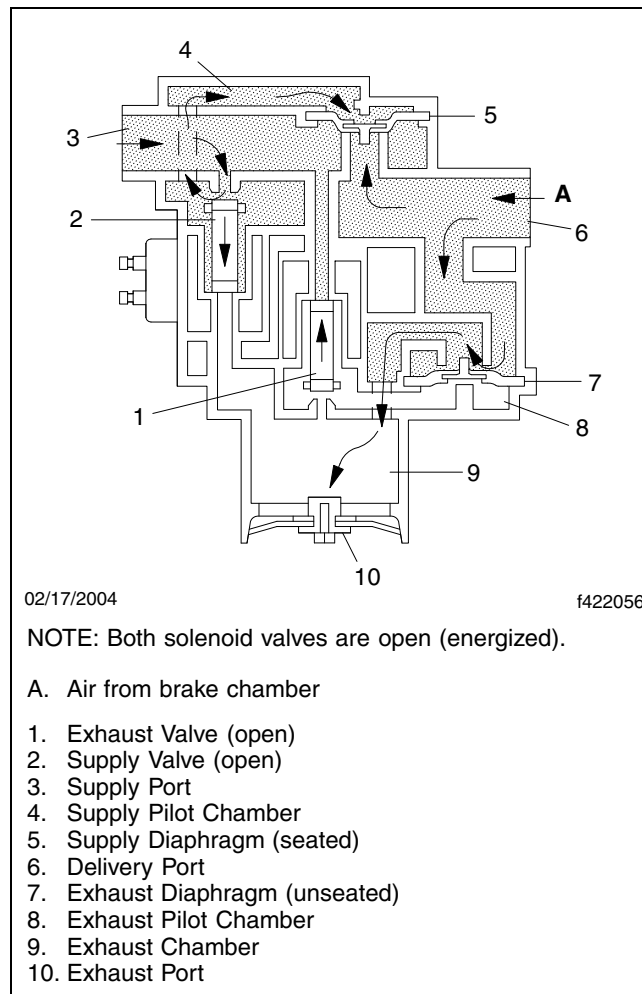


Fig. 4, Modulator Valve, Brake Release (exhaust)

508 — Brake Hold Control (ABS Active)

The ABS brake hold function takes control during an emergency stop when the pedal control valve delivers more air than the brakes can handle without locking.

- The hold function occurs after the ABS has started to control the pressure in the brake chamber by releasing some of the air.
- When enough air is released through the exhaust port to stop the wheel from locking (ABS brake release), the exhaust valve is closed and air pressure is allowed to flow into the exhaust pilot chamber. See **Fig. 5**.
- The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port. This stops the flow of air from the brake chamber to the exhaust port.
- The supply valve stays open to maintain pressure in the supply pilot chamber and keep the supply diaphragm seated. This prevents further buildup of pressure in the brake chamber.

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- The remaining air pressure in the brake chamber is held and remains constant for stopping the vehicle in the minimum distance.

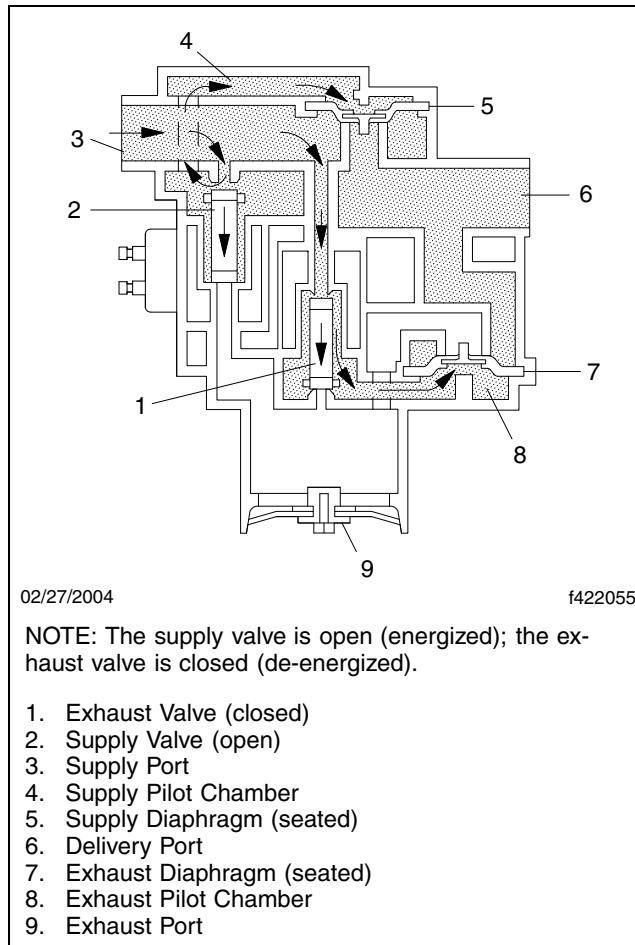


Fig. 5, Modulator Valve, Brake Hold Control

509 — Reapply Brake Control (ABS Active)

The last ABS function is the reapply brake control. To achieve maximum braking, the ECU determines when to reapply the air pressure that the pedal control valve is delivering. When appropriate, both ABS solenoid valves are closed, which returns the system to the normal brake control state shown in **Fig. 11**.

During an ABS event, the ECU cycles the modulator valve(s) through the sequence of ABS valve states (brake release, hold, and reapply) very rapidly in order to control wheel speed. The effect is similar to manually pumping the brakes on a vehicle without an ABS.

NOTE: The driver always controls the maximum amount of pressure applied to the brakes. Pressure to the brake chamber can never be more than the driver applies with the foot pedal. The ABS can override the pedal pressure to provide less brake pressure, but not more.

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510 — Automatic Traction Control (ATC)

If the vehicle is equipped with Automatic Traction Control (ATC), the ABS/ATC system automatically reduces wheel spin during low-traction startup or acceleration. If a drive wheel starts to spin faster than the steer axle wheels, the ATC system applies air pressure to brake that drive wheel. This transfers engine torque to the wheel or wheels that have better traction (differential braking).

If two or more drive wheels spin, the ATC reduces the engine torque to provide improved traction, overriding the throttle pressure from the driver.

The ATC valve controls only the brake chambers for the drive wheels. It is mounted on the service relay valve (rear modulator valve assembly).

The solenoid in the ATC valve controls an on/off air valve, which allows or prevents air flow to the control side of the service relay valve. If a wheel spin from one side of the vehicle is detected, the ECU signals the ATC valve to open. This allows compressed air to enter the service relay valve and the normal ABS control system determines which brake to apply.

The ATC function turns on and off automatically; drivers do not have to select this feature. If a drive wheel spins during startup or acceleration, the ATC indicator lamp comes on, indicating the ATC is active. It goes out when the drive wheel stops spinning.

511 — Roll Stability Advisor (RSA)

The roll stability advisor warns the driver when the risk of a rollover is moderate to high. These warnings come in the form of audible alerts as well as messages displayed on the ICU. The ABS ECU contains a sensor that measures lateral acceleration, and the ECU calculates an estimated load. The ABS ECU estimates turn severity relative to rollover limit. The ABS ECU then conveys the risk and severity of the maneuver information to the ICU display. No messages or audible alerts occur if the system determines the vehicle is being driven safely. RSA is not active below 13 mph or when there is a fault in the ABS.

If the vehicle operation reaches the initial threshold of rollover risk, the following message will display briefly, and self-extinguish. See **Fig. 6**.

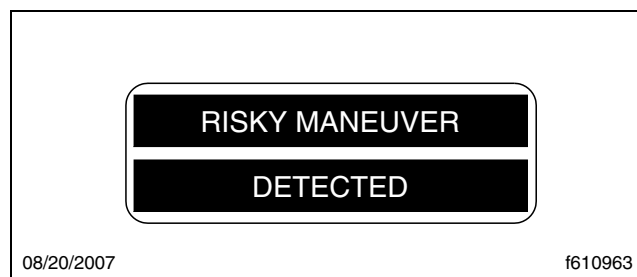


Fig. 6, Risky Maneuver Detected Warning

This is considered the "training point", with the goal to train drivers to avoid getting this message by operating the vehicle below this threshold. Beyond the initial rollover risk threshold, RSA has three levels of rollover-risk alert screens and sounds that can occur.

Level 1: Moderate Rollover Risk— A Level 1 alert includes a 2 second tone along with the alternating screens shown below. See **Fig. 7**. The screens will display for 8 seconds unless the driver acknowledges them sooner.

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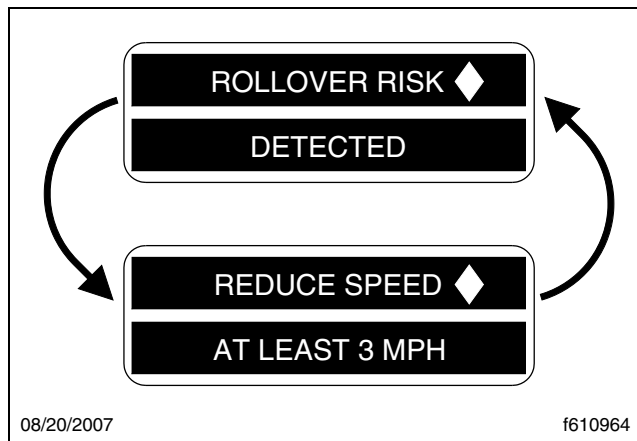


Fig. 7, Rollover Risk Detected Warning

Level 2: High Risk of Rollover— A Level 2 alert includes a 5 second tone along with the alternating screens shown below. See **Fig. 8**. The screens will display for 14 seconds unless the driver acknowledges them sooner.

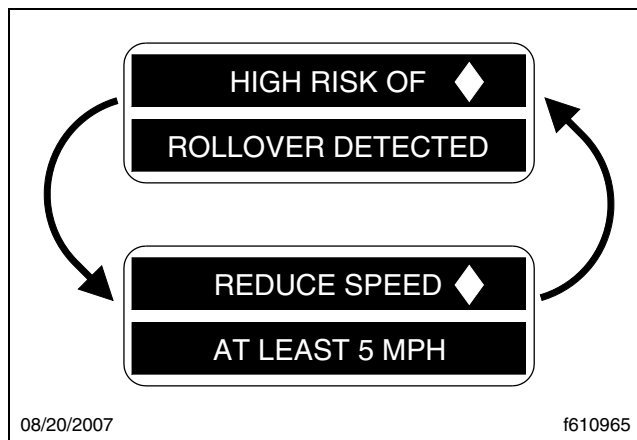


Fig. 8, High Risk of Rollover Warning

Level 3: Very High Risk of Rollover— A Level 3 alert includes a 10 second tone along with the alternating screens shown below. See **Fig. 9**. The screens will display for 20 seconds unless the driver acknowledges them sooner.

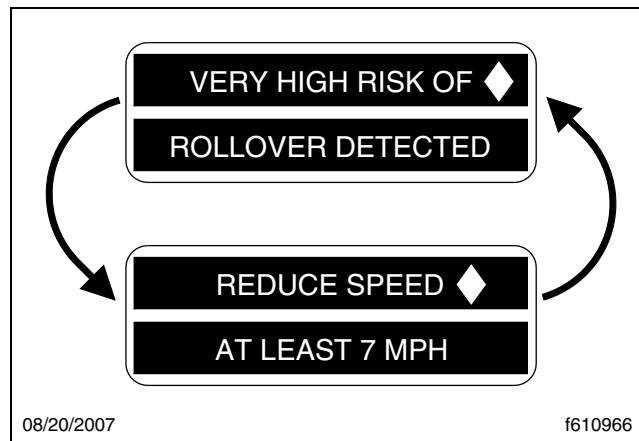


Fig. 9, Very High Risk of Rollover Warning

512 — Roll Stability Control (RSC)

Cascadia vehicles can be equipped with a Meritor WABCO Roll Stability Control (RSC) system in order to help prevent a roll over incident from occurring. The RSC system is an electronic system that passively monitors wheel speed and lateral acceleration, then controls drive axle and trailer axle braking, while decreasing engine torque and applying engine retarder (if equipped) in emergency roll over situations. As a result, the driver has full control over the vehicle until the ABS Electronic Control Unit (ECU) detects a potential roll over and intervenes accordingly.

By combining information on calculated load and turn severity with wheel speed differences (side to side) RSC sends a signal over the J1939 datalink to the engine controller causing the following:

- power to be reduced
- engine brake application and/or tractor rear axle service brake and trailer service brake application

When active, tractor rear brakes are applied using the ATC solenoid valve, while the trailer brakes are applied by the Roll Stability Control solenoid valve, which is the same type used for ATC, that is connected between the pneumatic brake system foot valve and the tractor protection valve. It has an independent air supply from the secondary air tank. In normal operation, the roll stability control valve does nothing and allows control of the trailer brakes from the foot valve. If a rollover is about to happen, the valve opens the air supply from the secondary air tank to the tractor protection valve, which causes the trailer brakes to apply.

The RSC system is automatic; it becomes active when it senses imminent rollover. Indicator lamps, chimes, and/or messages on the instrument cluster will notify the driver if the system became active.

The major components of the Meritor WABCO RSC system include the following:

- Accelerometer integrated into the ABS ECU
- ATC solenoid valve for full drive axle braking
- RSC solenoid valve for full trailer axle braking

513 — Roll Stability Advisor and Control (RAC) Fault Message

If a failure is detected in the roll stability advisor and control system, the following fault message will be displayed in the ICU until the problem is corrected. See Fig. 10. Check the ABS system for fault codes.

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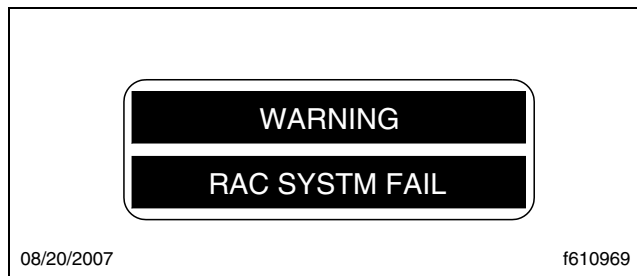


Fig. 10, RAC System Fail Warning

514 — Electronic Stability Control

The Electronic Stability Control (ESC) system is a roll stability control system which offers the additional capability of complete directional stability (yaw control) in oversteer and understeer conditions, such as the ability to reduce the likelihood of drift-out or jackknife. The ESC system includes an additional solenoid valve for front axle braking, a brake pressure sensor, a steering angle sensor (SAS), and an Electronic Stability Control ECU (ESC module) with an integrated yaw rate sensor. The additional sensors allow the ECU to determine where the driver is attempting to steer the vehicle and how much brake demand they are requiring in order to more precisely control the vehicle in an emergency situation. The additional front solenoid valve allows for individual wheel braking on the steering axle to provide yaw control.

The ESC system includes the following:

- ATC solenoid valve for full drive axle braking
- RSC solenoid valve for full trailer braking
- Front solenoid valve for full steer axle braking
- Pressure sensor for driver brake demand
- Steering Angle Sensor (SAS)
- ESC module (with integrated yaw rate and accelerometer sensors)

On vehicles equipped with ESC, the ABS module does not house the accelerometer. The accelerometer is located in the ESC module. The ESC system becomes active when a potential rollover or loss of yaw stability is detected.

During a transition from a high to low traction surface, the ESC system may possibly activate if the vehicle is not responding to the drivers input. See **Fig. 11**.

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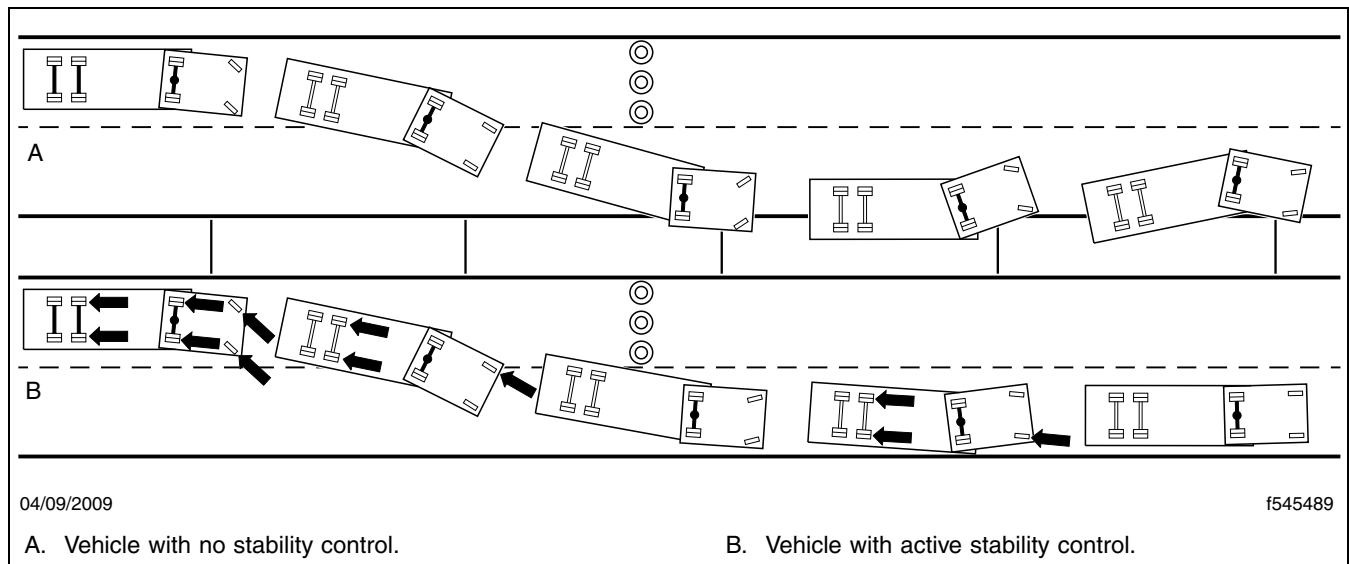


Fig. 11, Vehicle Traction with Stability Control

Electronic Stability Control Module

The Electronic Stability Control (ESC) ECU is mounted on the chassis, as close to the vehicle horizontal center of gravity as possible.

The ESC module has two sensors, an accelerometer, and a yaw rate sensor. The accelerometer is used to measure lateral acceleration only. When cornering, lateral acceleration causes a force directed at the vehicle's center of gravity, and, if high enough, may cause a vehicle to roll. The yaw rate sensor provides rotational sensing, which is used to detect and help prevent understeer, vehicle spinout, or a jackknife. The ESC module has one 4-pin connector that communicates with the ABS ECU.

IMPORTANT: The ESC Module must be mounted exactly as it was installed in production. The WABCO label must be right-side up. The ECU will be perpendicular to the frame rails, and the 4-pin connector on the ESC module will be facing towards the rear of the tractor. Make sure that the ESC Module is securely mounted and cannot move.

515 — ATC Switch (Deep Mud/Snow Switch)

An ATC function switch on the dash allows the driver to select from two levels of drive-axle traction control. In the default position, the ATC reduces drive-axle wheel spin on icy, wet, or sand-covered roads. Pressing the ATC switch increases the available traction on extra soft surfaces like snow, mud, or gravel by slightly increasing the permissible wheel spin. The greater wheel spin may also be used to help burn through a thin layer of ice.

The ATC switch overrides the ATC function. It must be manually selected by pressing the ATC spring-loaded switch briefly after the vehicle is started. The ECU indicates the activation by a constant flashing of the WHEEL SPIN lamp. This mode is disengaged by pressing the ATC switch again or turning the ignition switch off.

The ATC switch is located in a slave Modular Switch Field (MSF). It is hardwired to the tractor ABS ECU—it is not a multiplexed switch.

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516 — Tractor ABS Warning Lamp

The tractor ABS warning light (TRACTOR ABS) receives power whenever the ignition switch is turned on. The ground path for this indicator is through the tractor ABS ECU. For the first three seconds after the ignition is turned on, the ABS performs a bulb check during the self test. The bulb will go out if no malfunctions are detected during the self test.

If a fault is detected in the ABS, it will illuminate the tractor ABS warning lamp as long as the fault remains active.

NOTE: If the stored faults are cleared, the tractor ABS warning light remains on until the vehicle is driven above a speed of 4 mph (6 km/h).

517 — ATC/RSC/ESC Indicator Lamp

The ATC/RSC indicator light also receives power whenever the ignition switch is on. If the drive-axle wheels spin or if RSC is active, the ATC/RSC indicator light turns on. See **Fig. 12**.

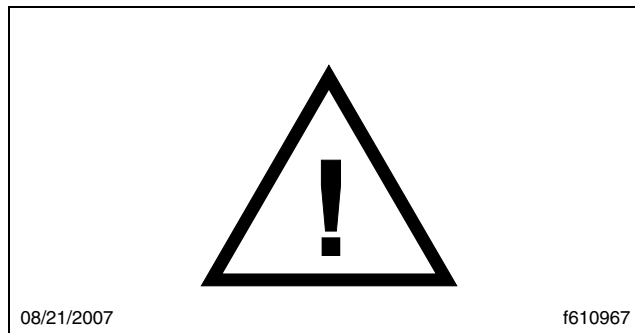


Fig. 12, ATC/RSC/ESC Indicator Light

If the ATC switch is activated, the ABS allows more wheel spin than normal and the ATC/RSC/ESC indicator blinks continuously until the switch is deactivated.

If the ATC/RSC/ESC indicator light stays on during normal vehicle operation, there is a malfunction in the system.

If the vehicle is equipped with ATC and not RSC/ESC, both the ABS and ATC lamps turn on for approximately 3 seconds when the ignition is turned to the ON position, then turn off simultaneously.

If the vehicle is equipped with both ATC and RSC/ESC, both the ABS and ATC/RSC/ESC lights turn on for approximately 3 seconds when the ignition is turned to the ON position, but the ATC/RSC/ESC light will stay lit longer than the ABS light.

518 — Trailer ABS Warning Light

The trailer ABS can be turned on one of two ways depending on whether the vehicle is towing a trailer with ABS capable of Powerline Carrier Communications (PLC).

- A. Trailers ABS capable of PLC—When the trailer ABS detects a fault, it sends a message to command the warning light on through PLC to the tractor ABS. The tractor ABS then turns on the lamp by hardwire between the tractor ABS and the trailer ABS warning lamp in the ICU. For more information on PLC, see "Powerline Carrier Communications (PLC) and Trailer ABS Warning Light " below.
- B. Trailer ABS not equipped with PLC—When the trailer ABS detects a fault, it turns the trailer ABS warning light on directly by hardwire between the trailer ABS and the ICU.

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NOTE: For doubles and triples, the lamp does not distinguish between trailers. A system fault in any of the trailers will activate the trailer ABS warning light.

When the ignition is turned on, a three second bulb check will occur. If no faults are detected, the warning lamp should turn off.

NOTE: When a PLC equipped tractor is connected to a trailer without ABS, at start-up, the lamp will not come on for a bulb check.

519 — Powerline Carrier Communications (PLC) and Trailer ABS Warning Light

Truck and trailer ABS systems built since March 2001 are equipped with special internal electronics that can transmit and receive messages through the power line to each ECU. This method of communication is called powerline carrier communications or PLC.

Each ECU has a separate power supply that passes through a PLC filter. PLC messages are in the form of a frequency modulated signal superimposed over the direct current (DC) power supply. The PLC filter allows the DC power supplies to be separate, while allowing the PLC messages to pass from the trailer power line to the tractor ABS power line. It does this through a series of inductor coils and capacitors. The coils pass DC power while blocking the frequency modulated signal. The capacitors pass the frequency modulated signal from one powerline to the other while blocking the DC power. The filter shares the PLC signal on the separate power lines, while keeping the actual power supplies to the ECUs separate. The filter also prevents interference throughout the rest of the vehicle's electrical system.

If the trailer ABS ECU detects a fault in the trailer's ABS system, the trailer ABS ECU transmits a message over the power line via PLC, which is received by the tractor ABS. The tractor ABS turns on the trailer ABS lamp on the dash.

When a PLC equipped tractor connects to a PLC equipped trailer, at start-up, the lamp should come on for a few seconds, then turn off if no trailer ABS faults exist.

520 — PLC Filter

As mentioned in the previous paragraphs, the PLC filter allows messages to transmit between the tractor ABS power line and the trailer ABS power line, while remaining separate. All Cascadia™ trucks are equipped with a PLC filter.

Trucks with trailer receptacles mounted directly to the back of the cab have a toroidal style PLC in the harness, on the back wall of the cab or sleeper, below and to the left of the receptacles. See **Fig. 13**. Trucks with trailer receptacles mounted on the chassis use a PLC filter contained in a module mounted to a bracket on the frame crossmember near the receptacles.

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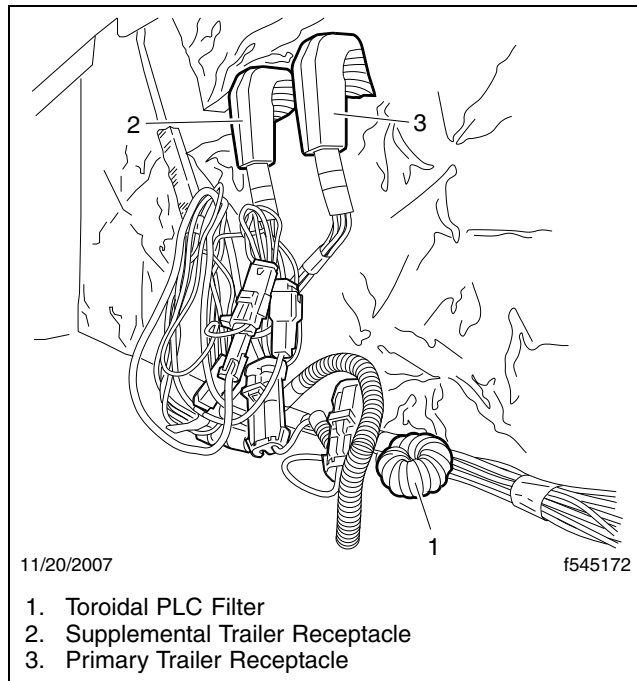


Fig. 13, PLC Filter Location

521 — Tire Size

For proper ABS/ATC operation with the standard ECU, the front and rear tire sizes must be within 14 percent of each other. When the tire-size range is exceeded, system performance can be affected and the warning lamp may come on. Call Meritor WABCO at 1-800-535-5560 if you plan a tire-size difference greater than 14 percent. Calculate the percentage difference of the tire sizes with the following equation:

Percentage Difference = $\{(\text{steer-axle tire RPM} \div \text{drive-axle tire RPM}) - 1\} \times 100$,

where RPM equals tire revolutions per mile.

522 — Reconfiguration

E-version ECUs memorize the following components if they are connected at power-up:

- ESC Module
- RSC Valve
- Front Solenoid Valve
- Pressure Sensor
- Steering Angle Sensor
- ATC Valve
- Retarder Valve
- Datalink SAE J1939

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Once these components have been memorized, the ECU will look for them at each power-up. If a memorized component is not present, the ECU will record a fault. For example, if an ATC valve is memorized, but is not present at the next power-up, the ECU records a fault. This can occur if an ECU is moved from one vehicle to another, and one or more of the memorized components are not available on the new vehicle. If this occurs, use Meritor Toolbox software to re-configure the ECU.

Refer to the Meritor WABCO End of Line (EOL) procedure for the initialization process when replacing major components such as an ECU. In addition, when the Steering Angle Sensor is replaced, or if work was performed on the steering system, it is important that the Steering Angle Sensor is re-calibrated. These procedures can be found in the latest version of the Meritor WABCO Maintenance Manual (MM-0112). This document is available at the Meritor WABCO website.

NOTE: For complete instructions for using TOOLBOX software, refer to the ArvinMeritor "TOOLBOX User's Manual, TP-99102."

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ABS and Stability Control Systems

523 — Electronic Stability Control Topology

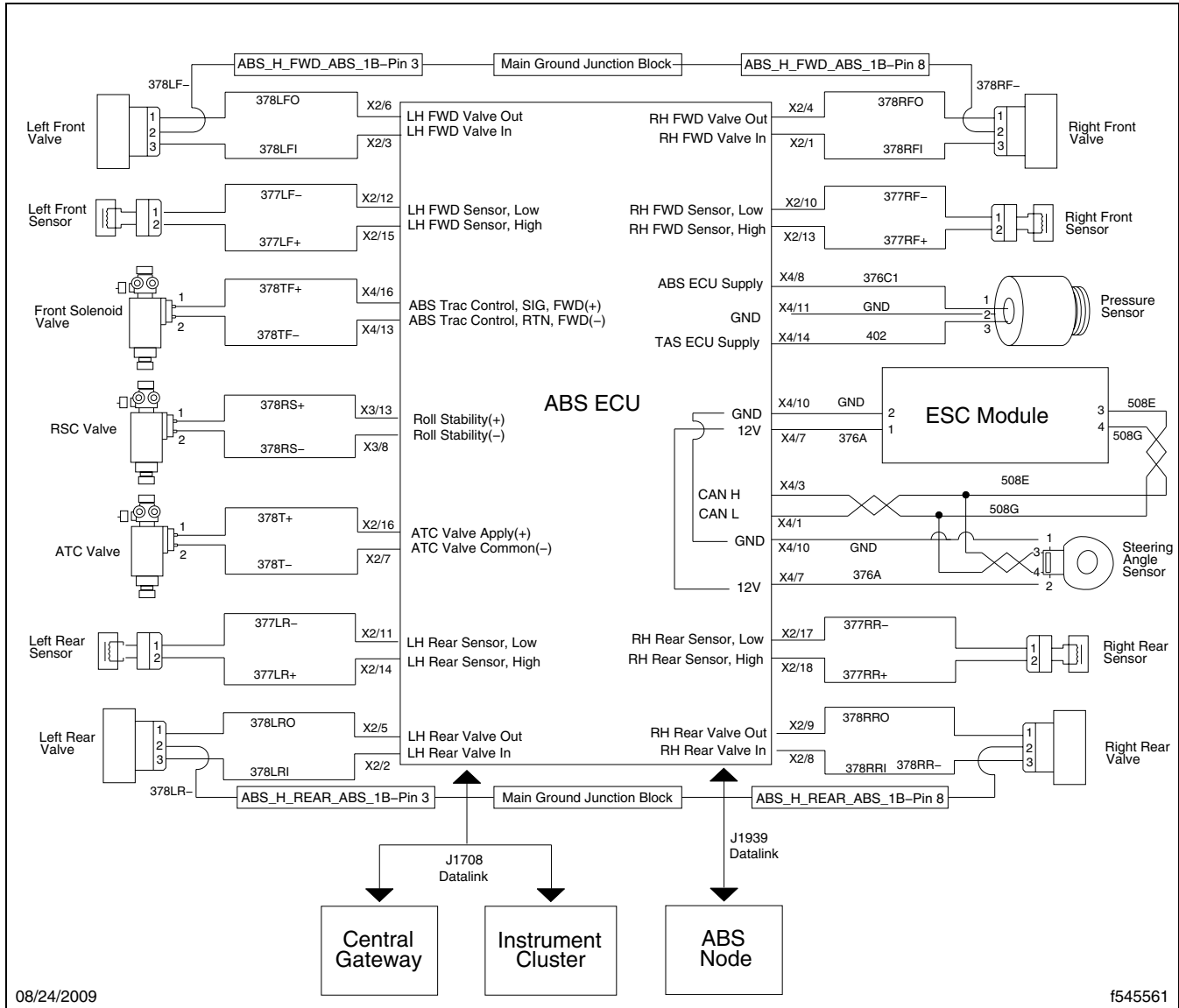


Fig. 14, Electronic Stability Control Topology

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600 — Component Locations

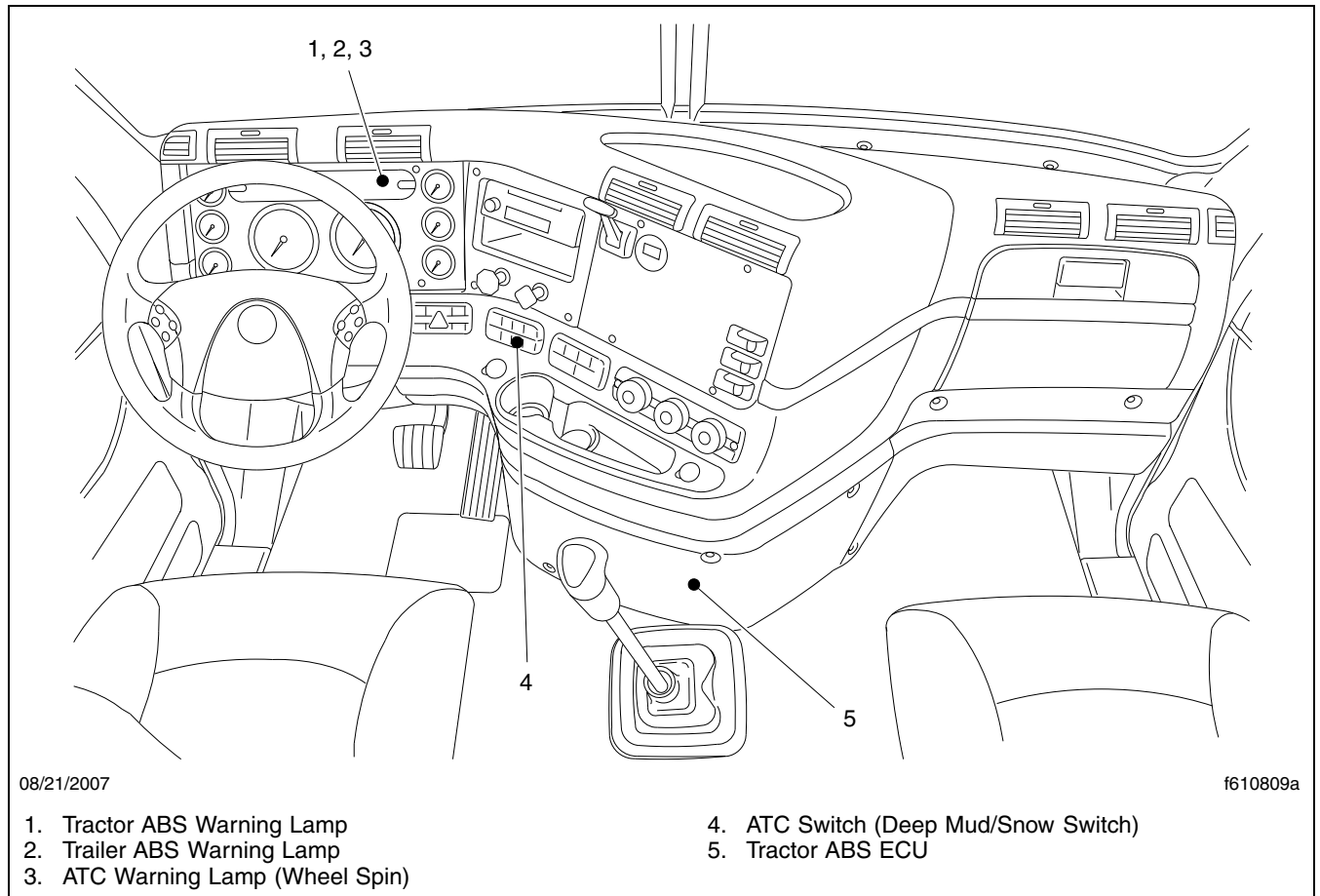


Fig. 15, Component Locations

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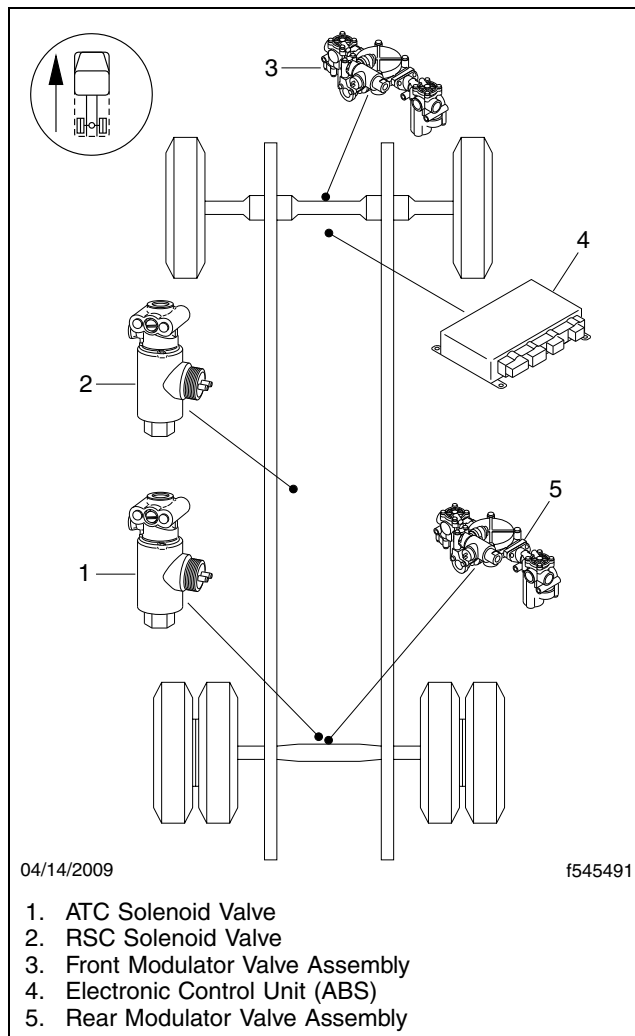


Fig. 16, Roll Stability Control Component Locations

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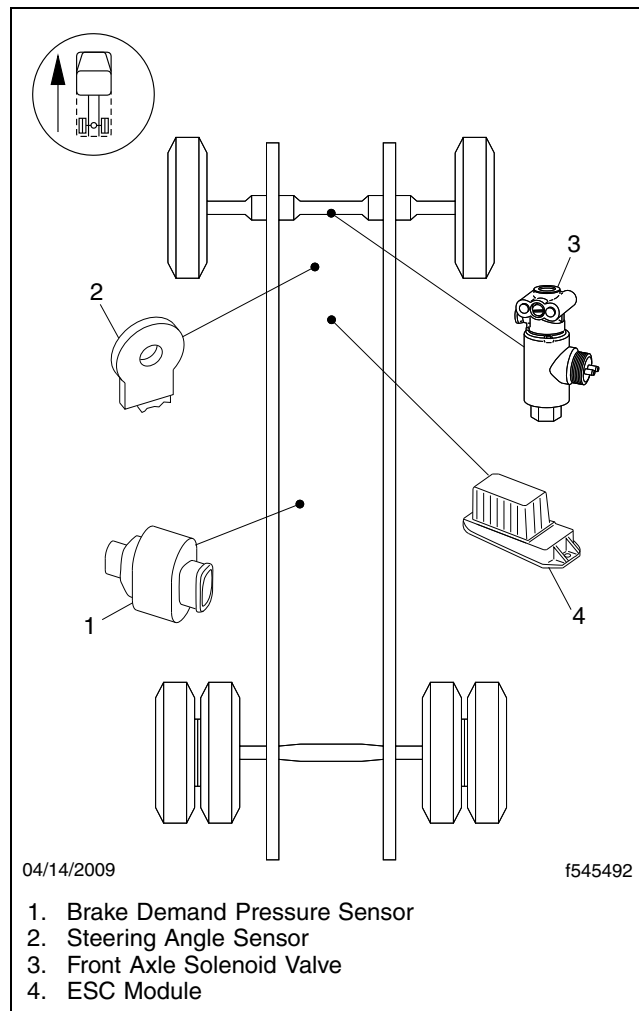


Fig. 17, Electronic Stability Control Component Locations

NOTE: The components in **Fig. 17** are needed in addition to the ones used in the RSC system

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601 — Component Details

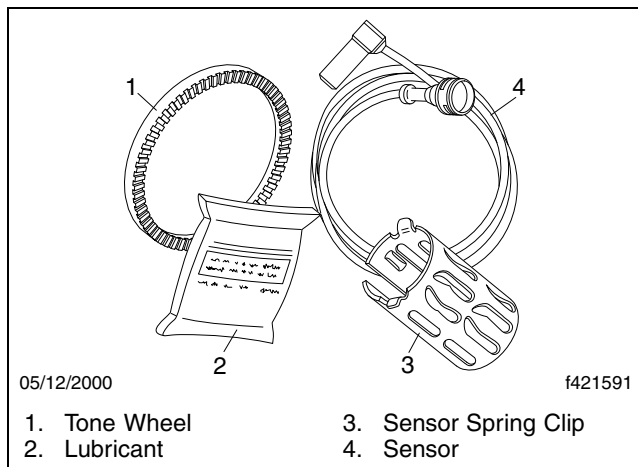


Fig. 18, Wheel Speed Sensor Components

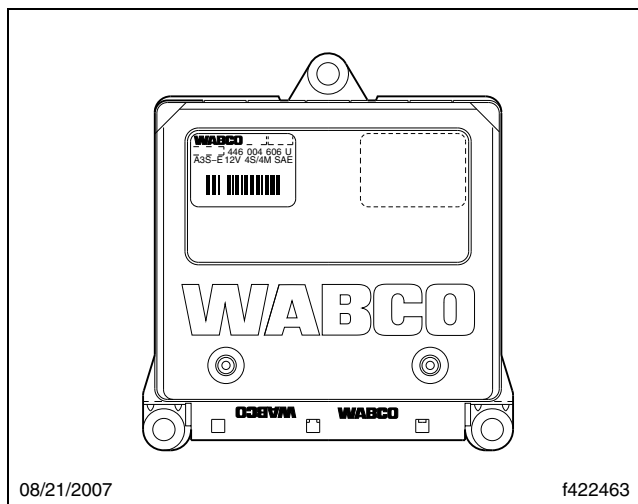


Fig. 19, ECU

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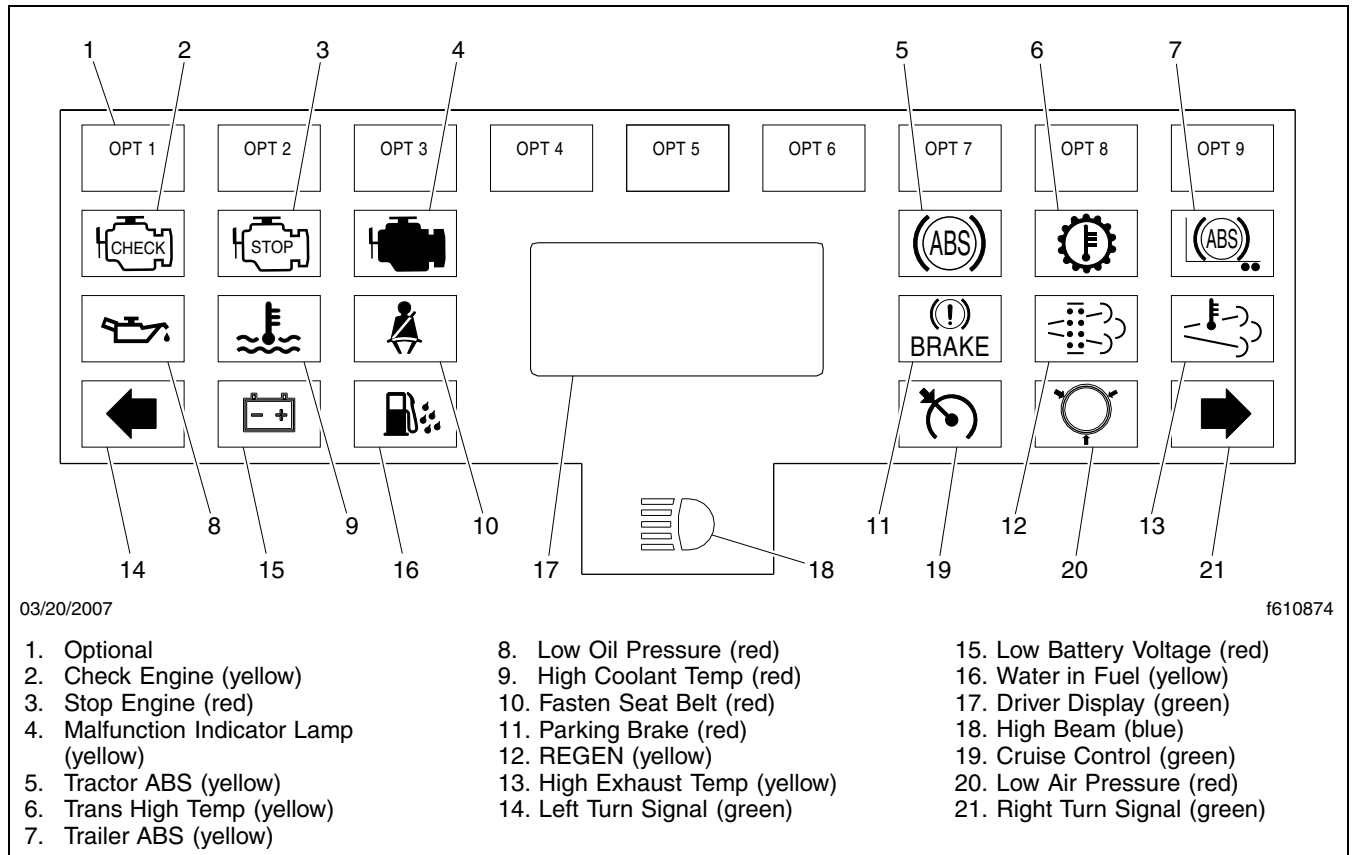


Fig. 20, LBCU

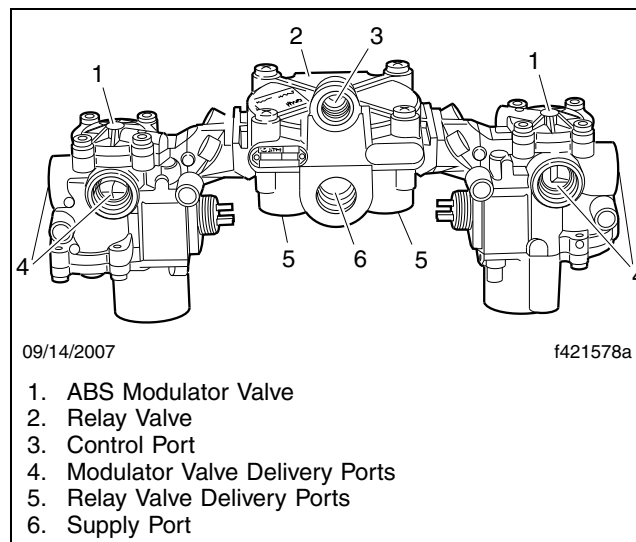


Fig. 21, Modulator Valve Assembly

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ABS and Stability Control Systems

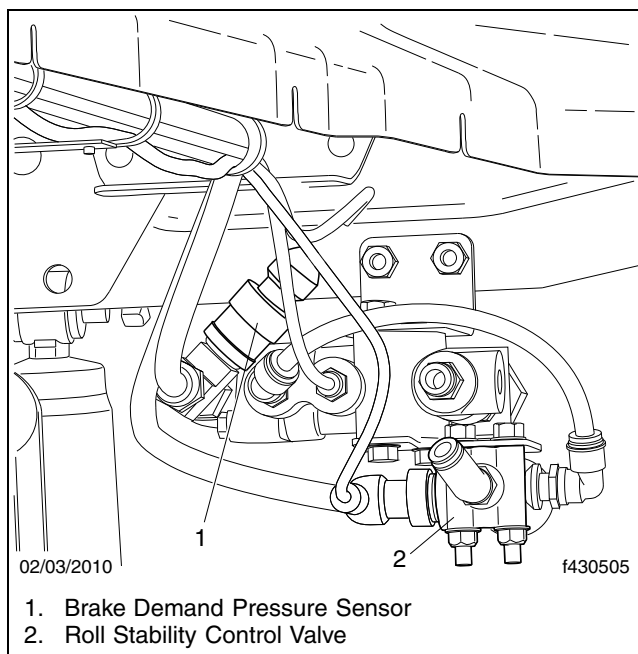


Fig. 22, Pressure Sensor (mounted on trailer protection valve)

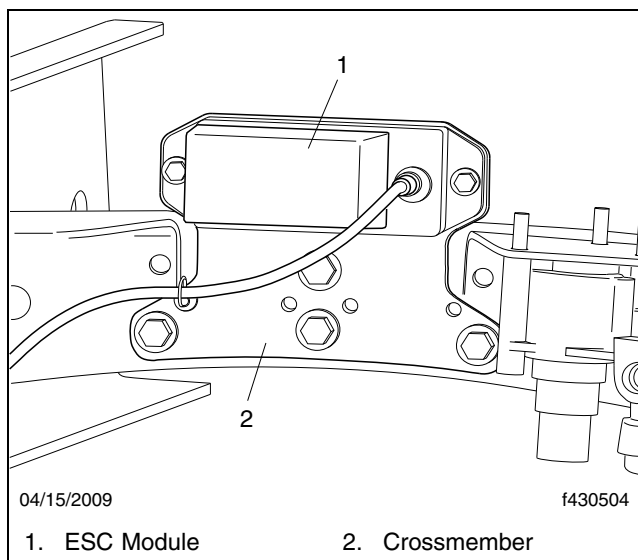


Fig. 23, Electronic Stability Control Module

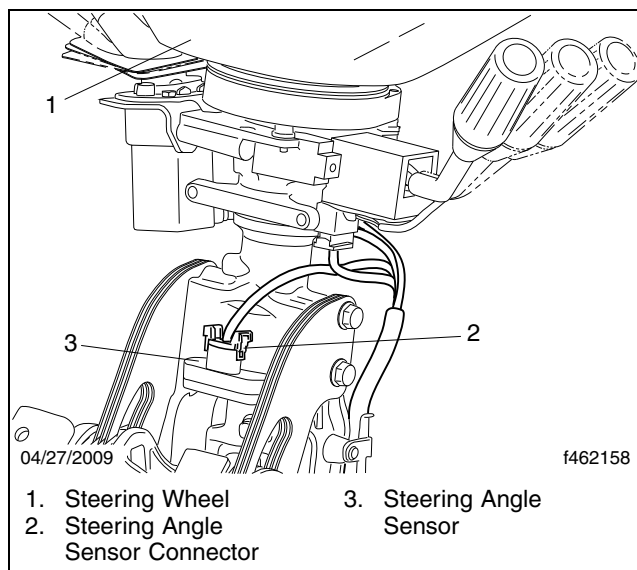


Fig. 24, Steering Angle Sensor

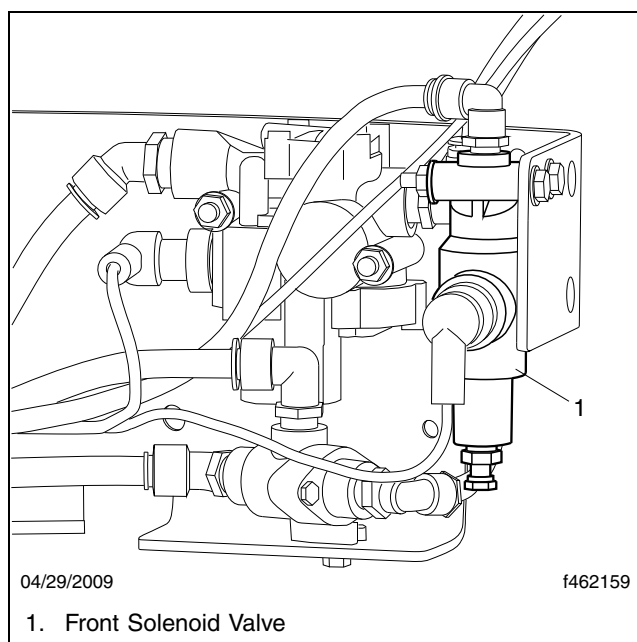


Fig. 25, Front Modulator Valve Assembly

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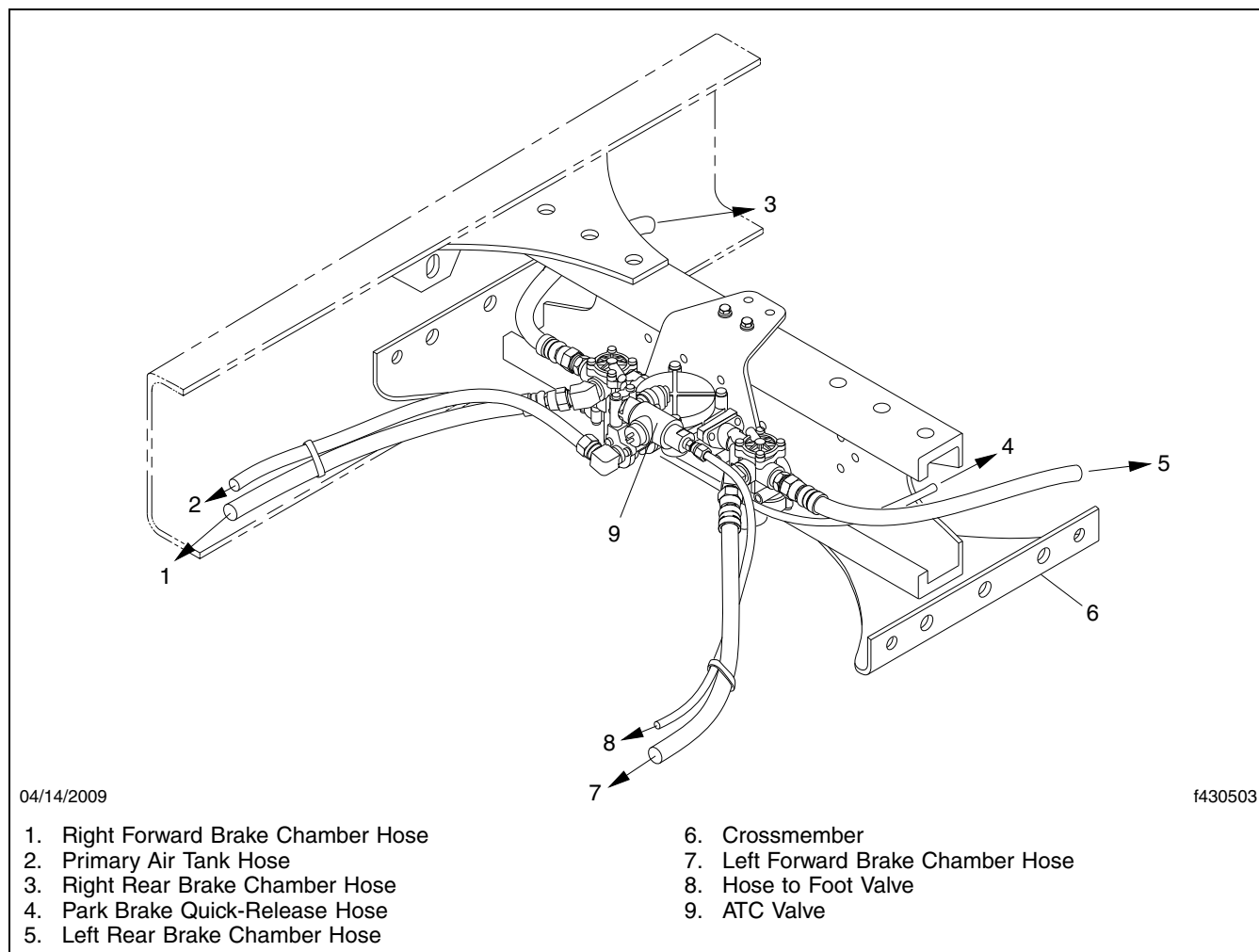
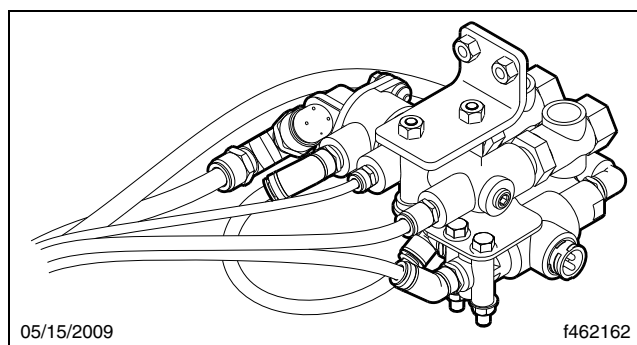


Fig. 26, Rear Modulator Valve Assembly with ATC Valve



**Fig. 27, Roll Stability Control Solenoid Valve
mounted to Trailer Protection Valve**

ABS and Stability Control Systems

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602 — Connector Pinout Details

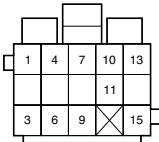
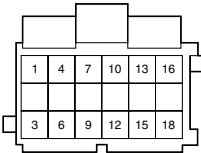
15-Pin X1 ABS ECU Connector			
			
Pin	Circuit #	Wire Color	Circuit Description
1	1939-A	Dark Green	J1939 datalink (-)
2	376F	Orange	Trailer ABS
3	1939+A	Yellow	J1939 datalink (+)
4	GND1	Black	Ground
5	—	—	Not used
6	376T	Orange	ATC switch input
7	376C or 376C4	Orange	+12V ignition
8	376A	Orange	+12V battery
9	GND	Black	Ground
10	1587-A	Orange	J1587 datalink (-)
11	1587+A	Dark Green	J1587 datalink (+)
12	—	—	Ground jumper between pins 9 and 15
13	376S	Orange	ATC/RSC lamp signal
14	—	—	Not used (retarder relay)
15	376L	Orange	Tractor ABS lamp signal (to ICU)

Table 1, 15-Pin X1 ABS ECU Connector

18-Pin X2 ABS ECU Connector			
			
Pin	Circuit #	Wire Color	Circuit Description
1	378RFI	Orange	Right front modulator valve in
2	378LRI	Orange	Left rear modulator valve in
3	378LFI	Orange	Left front modulator valve in

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ABS and Stability Control Systems

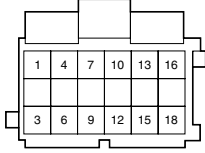
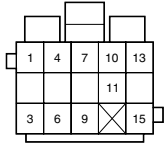
18-Pin X2 ABS ECU Connector			
			
Pin	Circuit #	Wire Color	Circuit Description
4	378RFO	Orange	Right front modulator valve out
5	378LRO	Orange	Left rear modulator valve out
6	378LFO	Orange	Left front modulator valve out
7	378T-	Orange	ATC valve common
8	378RRI	Orange	Right rear modulator valve in
9	378RRO	Orange	Right rear modulator valve out
10	377RF-	Black	Right front wheel speed sensor (-)
11	377LR-	Black	Left rear wheel speed sensor (-)
12	377LF-	Black	Left front wheel speed sensor (-)
13	377RF+	Brown	Right front wheel speed sensor (+)
14	377LR+	Brown	Left rear wheel speed sensor (+)
15	377LF+	Brown	Left front wheel speed sensor (+)
16	378T+	Orange	ATC valve apply
17	377RR-	Black	Right rear wheel speed sensor (-)
18	377RR+	Brown	Right rear wheel speed sensor (+)

Table 2, 18-Pin X2 ABS ECU Connector

15-Pin X3 ABS ECU Connector			
			
Pin	Circuit #	Wire Color	Circuit Description
1	—	—	Not used
2	377LA-	Black	Left third wheel speed sensor (-)
3	378LAI	Orange	Left third modulator valve in
4	—	—	Not used

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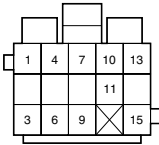
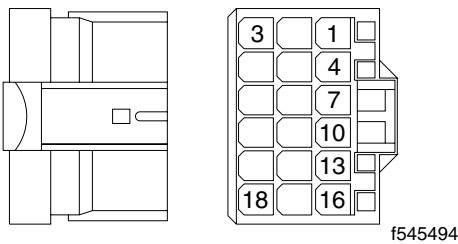
15-Pin X3 ABS ECU Connector			
			
Pin	Circuit #	Wire Color	Circuit Description
5	377LA+	Brown	Left third wheel speed sensor (+)
6	378LAO	Orange	Left third modulator valve out
7	—	—	Not used
8	378RS—	Orange	Roll stability control valve (—)
9	—	—	Not used
10	—	—	Not used
11	377RA—	Black	Right third wheel speed sensor (—)
12	378RAI	Orange	Right third modulator valve in
13	378RS+	Orange	Roll stability control valve (+)
14	377RA+	Brown	Right third wheel speed sensor (+)
15	378RAO	Orange	Right third modulator valve out

Table 3, 15-Pin X3 ABS ECU Connector

18-Pin X4 ABS ECU Connector			
			
Pin	Circuit	Wire Color	Description
1	50G	Brown/White	ESC CAN-Low
2	—	—	Not Used
3	50E	Brown/ Light Blue	ESC CAN-High
4	—	—	Not Used
5	—	—	Not Used
6	—	—	Not Used
7	376A	Orange	+12V Ignition
8	376C1	Orange	ABS ECU Ignition Supply

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ABS and Stability Control Systems

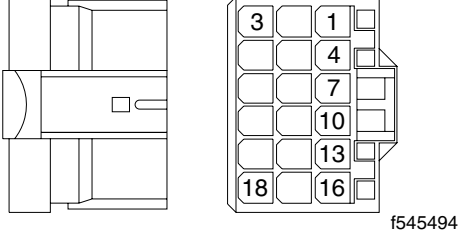
18-Pin X4 ABS ECU Connector			
			
Pin	Circuit	Wire Color	Description
9	—	—	Not Used
10	GND	Black	Ground
11	GND	Black	Ground
12	—	—	Not Used
13	378TF-	Orange	ABS, ESC Front Solenoid Return
14	402	Pink/White	TAS ECU Supply
15	—	—	Not Used
16	378TF+	Orange	ABS, ESC Front Solenoid Signal
17	—	—	Not Used
18	—	—	Not Used

Table 4, 18-Pin X4 ABS ECU Connector

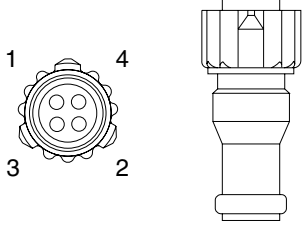
ESC Module Connector			
			
Pin	Circuit	Wire Color	Description
1	376A	Orange	+12V Ignition
2	GND	Black	Ground
3	508E	Brown/Light Blue	ESC CAN-High
4	508G	Brown/White	ESC CAN-Low

Table 5, ESC Module Connector

ABS and Stability Control Systems

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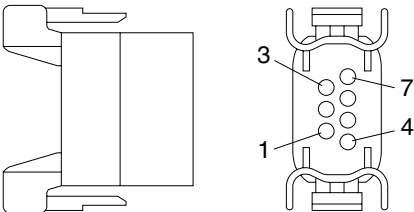
Steering Angle Sensor Connector			
 04/21/2009 f545517			
Pin	Circuit	Wire Color	Description
1	GND	Black	Ground
2	576A	Orange	+12V Ignition
3	508E	Brown/Light Blue	J1939 Datalink (+) Proprietary
4	508G	Brown/White	J1939 Datalink (-) Proprietary
5	—	—	Not Used
6	—	—	Not Used
7	—	—	Not Used

Table 6, Steering Angle Sensor Connector

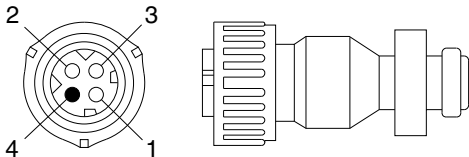
Driver Demand Brake Pressure Sensor Connector			
 04/21/2009 f545515			
Pin	Circuit	Wire Color	Description
1	376C1	Orange	ABS ECU Ignition Supply
2	GND	Black	Ground
3	402	Pink/White	Pressure Signal
4	—	—	Not Used

Table 7, Driver Demand Brake Pressure Sensor Connector

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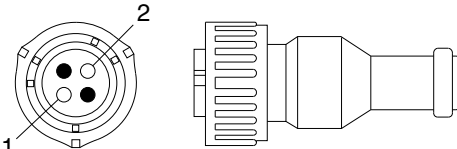
ATC Valve Connector			
 04/21/2009 f545516			
Pin	Circuit	Wire Color	Description
1	378T+	Black	ABS Traction Control Solenoid Signal (+)
2	378T-	Brown	ABS Traction Control Solenoid Signal (-)
3	—	—	Not Used
4	—	—	Not Used

Table 8, ATC Valve Connector

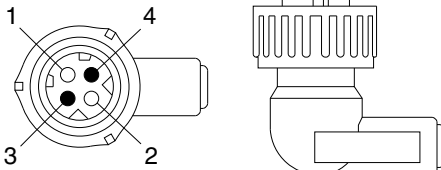
RSC Valve Connector			
 04/21/2009 f545495			
Pin	Circuit	Wire Color	Description
1	378RS+	Black	Roll Stability Control Valve Signal (+)
2	378RS-	Brown	Roll Stability Control Valve Return (-)
3	—	—	Not Used
4	—	—	Not Used

Table 9, RSC Valve Connector

ABS and Stability Control Systems

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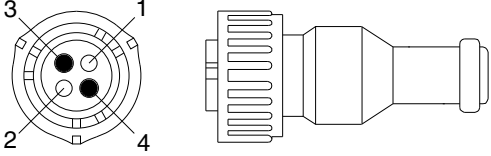
Front Solenoid Valve Connector			
			
04/21/2009		f545518	
Pin	Circuit	Wire Color	Description
1	378TF+	Orange	Front Solenoid Valve Signal (+)
2	378TF-	Orange	Front Solenoid Valve Return (-)
3	—	—	Not Used
4	—	—	Not Used

Table 10, Front Solenoid Valve Connector

603 — Brake System Modules

ABS, RSC, and ESC System Modules	
Description	Module
ABS Control Unit	49A
Vehicle Stability Control	49b
Wiring, Vehicle Stability Control	49e
MGJB, Electrical System	280
Wiring, Dash Harness, SAS	320
Wiring, ABS/RSC/ESC	330
Wiring, Chassis, ABS/RSC/ESC	332
Valve, Front Brakes, ESC	413
Trailer Protection Valve, RSC	482
Steering Column	532
ABS Sensor, Front	414
Rear Modulator Valve Assembly	490
Instrument Panel	732
Miscellaneous Module References	
Description	Module
Wiring, Chassis, Modulator Valve	333
Front Brakes, Disc	402
Front Brakes, Rotors	419
Rear Brakes	423

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ABS and Stability Control Systems

ABS, RSC, and ESC System Modules	
Description	Module
Air Line Overview	871
Wiring, Service/Park Brake	877
Air Piping Pass Through	880
Front, Brake Hardware	43E

Table 11, ABS, RSC, and ESC System Modules

Before electrical troubleshooting, read all active fault codes through Service Link. This could verify an intermittent problem, such as a loose connection, that is accidentally fixed by shifting and moving wires while troubleshooting.

- Perform general electrical troubleshooting tests first, like checking for wiring continuity and connections.
- Refer to any fault codes reported on CAN in ServiceLink.

700 — Troubleshooting Tips

Before electrical troubleshooting, read all active fault codes through Service Link. This could verify an intermittent problem, such as a loose connection, that is accidentally fixed by shifting and moving wires while troubleshooting.

- Perform general electrical troubleshooting tests first, like checking for wiring continuity and connections.
- Refer to any fault codes reported on CAN in ServiceLink.

701 — Diagnostic Tools Required

The following tools are required to perform troubleshooting procedures.

- Servicelink or Meritor Toolbox
- Digital Multimeter

702 — Wheel Sensor Troubleshooting (SIDs 001 through 006)

J1587 Wheel Speed Sensor Fault Codes—Identifying SIDs With Specific Sensors			
MID	PID	Description	FMI's
136	001	Left front wheel speed sensor	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12
	002	Right front wheel speed sensor	
	003	Left rear wheel speed sensor	
	004	Right rear wheel speed sensor	
	005	Left 3rd wheel speed sensor	
	006	Right 3rd wheel speed sensor	

Table 12, J1587 Wheel Speed Sensor Fault Codes

ABS and Stability Control Systems

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J1587 Wheel Speed Sensor Fault Codes – Troubleshooting					
MID	SIDs	FMI	Fault Description	Fault Trigger	Action
136	001–006	01	Incorrect air gap	Sensor output voltage too low but just exceeds trigger level.	Perform WHEEL SPEED SENSOR OUTPUT VOLTAGE TEST.
136	001–006	02	Incorrect tire size	Wheel speed difference within front axle >10% or difference within wheels of different axles is >19%.	Check for correct tire size and mixed tire sizes. Check for correct number of tone wheel teeth. Repair as necessary.
136	001–006	03	Sensor shorted to power	DC voltage detected.	Perform WHEEL SPEED SENSOR CIRCUIT SHORT TO POWER TEST.
136	001–006	04	Short to ground	Short to ground detected.	Perform WHEEL SPEED SENSOR CIRCUIT RESISTANCE TEST.
136	001–006	05	Open circuit	Open circuit detected.	Perform WHEEL SPEED SENSOR CIRCUIT RESISTANCE TEST.
136	001–006	06	Short circuit	Short between sensor wires detected.	Perform WHEEL SPEED SENSOR CIRCUIT RESISTANCE TEST.
136	001–006	07	Damaged tone ring	Cyclic drop out detected at speed higher than 10 km/h. Several wheel revolutions necessary to trigger.	Inspect tone ring for damage and missing teeth. Make sure correct tone ring is installed (100-tooth is normal application). Repair as necessary.
136	001–006	08	Excessive wheel slip	Excessive tire spin for more than 16 seconds detected.	Check sensor adjustment.
136	001–006	09	Wire mismatch	Wire from another sensor detected.	Check sensor wiring.
136	001–006	10	Speed signal drop out	Temporary loss of wheel speed signal.	Perform WHEEL SPEED SENSOR SIGNAL TEST.
136	001–006	11	Abnormal speed	Brake squeezes or chatters.	Perform WHEEL SPEED SENSOR SIGNAL TEST.
136	001–006	12	Frequency too high	Non-plausible sensor frequency measured.	Check sensor wiring and connections. If OK, replace ECU.

Table 13, J1587 Wheel Speed Sensor Fault Codes-Troubleshooting

703 — Wheel Speed Sensor Tests

NOTE: Meritor WABCO PC Diagnostics can be used for this test to compare speed signal output of all sensors. A problem will be indicated by low or erratic output.

1. Measure the sensor output voltage.

- 1.1 Park the vehicle on a level surface and set the parking brake.
- 1.2 Chock the tires of the axle not being tested. Raise the vehicle and put jack stands under the axle so the wheels can rotate.
- 1.3 Disconnect the applicable connector from the ABS ECU for the sensor being tested.
- 1.4 Set a digital multimeter to the AC voltmeter mode. Connect the probes to the cable connector terminals for the sensor being tested.
- 1.5 Rotate the wheel by hand at a speed of 30 rpm (one-half revolution per second) and read the voltage output.

Is the AC voltage greater than 0.2V?

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YES → Voltage output is within normal range. No problem found.

NO → Push the sensor into its holder until it touches the tone ring, then repeat this test. If voltage is still below 0.2V, replace the sensor.

2. **Check sensor circuit for short to ground.**

2.1 Disconnect the ECU connector that contains the sensor wires for the sensor being tested.

2.2 Check the resistance between each of the two sensor circuits (at the ECU connector) and ground. If the reading for either circuit is less than 10,000 Ohms, a short to ground is detected.

Is a short to ground detected?

YES → Sensor wiring is shorted to ground. Repair as necessary.

NO → Go to Test 3

3. **Check the sensor circuit resistance.**

3.1 Disconnect the ECU connector that contains the sensor wires for the sensor being tested.

3.2 Measure the resistance between the two circuits for the sensor being tested.

Is the resistance 900 to 2000 Ohms?

YES → Sensor circuit resistance is within specifications. Verify fault and repeat tests. If problem persists, ECU may be faulty.

NO → Go to Test 4.

4. **Check the sensor resistance.**

4.1 Disconnect the sensor being tested.

4.2 Measure the resistance between the sensor terminals.

Is the resistance 900 to 2000 Ohms?

YES → Sensor wiring is shorted or open, depending on results of Test 2 above. Repair as necessary.

NO → Replace wheel speed sensor.

5. **Check for voltage in sensor wiring.**

5.1 Disconnect the ECU connector that contains the sensor wires for the sensor being tested.

5.2 Check for voltage between each of the two sensor circuits (at the ECU connector) and ground. If the reading for either circuit is more than 0.2V, a short to power is detected.

Is a short to power detected?

YES → Sensor wiring is shorted to power. Repair as necessary.

NO → Verify fault and repeat test. If problem persists, ECU may be faulty.

6. **Check the sensor output signal.**

6.1 Adjust the wheel speed sensor.

6.2 Connect Meritor WABCO PC Diagnostics to the vehicle.

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- 6.3 Observe the sensor output graph in PC Diagnostics while spinning the wheel or driving the vehicle. Observe if the signal drops out or is erratic.

Is the signal erratic or does it drop out?

YES → Check sensor and harness wiring. Also, check brakes—the cause could be from brake chatter.

NO → Sensor adjustment corrected the problem.

704 — Modulator Valve Troubleshooting (SIDs 007 through 010)

J1587 Modulator Valve Fault Codes—Identifying SIDs With Specific Valves			
MID	SID	Description	FMI
136	007	Left front modulator valve	03, 05, 06
	008	Right front modulator valve	
	009	Left rear modulator valve	
	010	Right rear modulator valve	

Table 14, J1587 Modulator Valve Fault Codes

J1587 Modulator Valve Fault Codes—Troubleshooting					
MID	SID	FMI	Fault Description	Fault Trigger	Action
136	007–010	03	Short to power	Short to power detected in Inlet or outlet solenoid circuit.	Perform Modulator Valve Voltage Test
		05	Open circuit	Open detected in inlet or outlet solenoid circuit.	Perform Modulator Valve Test
		06	Short to ground	Short to ground detected in inlet or outlet solenoid circuits.	

Table 15, J1587 Modulator Valve Fault Codes

705 — Modulator Valve Tests

1. Check for voltage in the modulator valve circuit wiring for a short to power.

- 1.1 Disconnect the ECU connector that contains the modulator valve wires for the modulator being tested.
- 1.2 Check for voltage between each of the three valve circuits (at the ECU connector) and ground. If the reading for any circuit is more than 0.2V, a short to power is detected.

Is a short to power detected?

YES → Modulator valve wiring is shorted to power. Repair as necessary.

NO → Verify fault and repeat test. If problem persists, ECU may be faulty.

2. Check the modulator valve inlet and outlet coil resistance.

- 2.1 Disconnect the connector at the modulator valve.
- 2.2 Measure resistance between modulator "in" and "ground" pins.
Measure resistance between modulator "out" and "ground" pins. See **Fig. 28**.

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Is there between 4 and 8 Ohms?

YES → The modulator is good. Check the modulator valve circuit wiring.

NO → Clean the terminals on the modulator valve and check the resistance again. If the resistance is still not correct, replace the valve.

706 — Retarder Relay Faults (SID 013)

J1587 Retarder Relay Fault Codes (SID 013)—Troubleshooting					
MID	SID	FMI	Fault Description	Fault Trigger	Action
136	013	03	Retarder relay circuit—short to power	This vehicle does not use the retarder relay circuit.	Check if a circuit has been connected to pin X1/14 by mistake. Re-configure the ECU.
		05	Retarder relay circuit—open circuit		
		06	Retarder relay circuit—short to ground		

Table 16, J1587 Retarder Relay Fault Codes (SID 013)

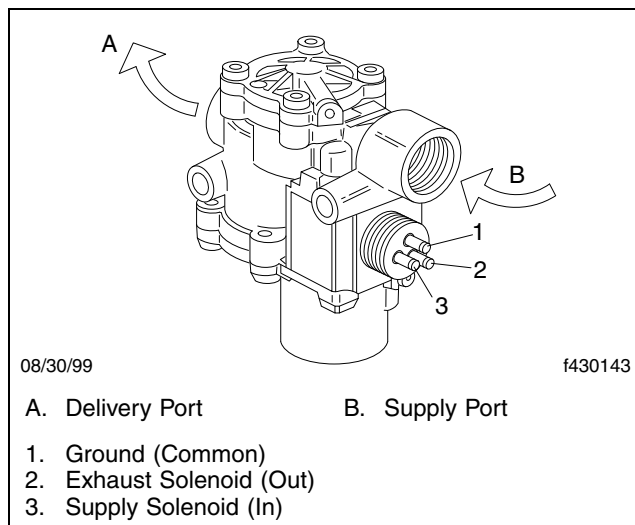


Fig. 28, Modulator Valve Terminals

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707 — ECU Power and Ground Faults (SID 014)

Power and Ground Faults Troubleshooting (SID 014) (Cab Mounted ECU)							
MID	SID	FMI	Problem	Test	Test Result	Action	Blink Code
136	014	04	Low voltage or open circuit.	1. Disconnect the 15-pin X1 connector from the ABS ECU. With the ignition ON, measure the voltage between pins 8 and 9.	Voltage is 9.5 to 14 volts.	System voltage is acceptable. Check for intermittent low voltage. Check the batteries and charging system. Voltage may have been temporarily too low. Repair as necessary.	8-1
					Voltage is less than 9.5 volts.	Check vehicle batteries and charging system. Check ABS ECU power and ground circuits for open or high resistance. Repair as necessary.	
136	014	05	Ground circuit open or high resistance. <i>NOTE: Make sure the batteries are disconnected or shut off, otherwise results may be misleading.</i>	2. Disconnect the 15-pin X1 connector from the ABS ECU. Measure the resistance in the ground circuit between pin 9 and the negative battery terminal.	Ground is okay.	Verify fault. Check ground circuit for open or high resistance. Repair as necessary.	8-5
					Ground is open or has high resistance.	Repair ground circuit as necessary.	
136	014	06	Internal relay does not open.			If fault repeats, replace the ABS ECU.	8-3

Table 17, Power and Ground Faults Troubleshooting (SID 014) (Cab-Mounted ECU)

708 — J1587 Fault Codes

J1587 Fault Codes						
MID	SID	FMI	Fault Description	Test	Result	Action
136	88	1	ESC – Initialization Not Complete	—	—	Important: Refer to Meritor WABCO's End of Line (EOL) procedure for the initialization process. This procedure can be found in Meritor WABCO's Maintenance Manual MM-0112. This document is available through Meritor WABCO or their website.
136	88	2	ESC – System Configuration	—	—	The ESC module is not compatible with the ABS ECU. Contact OEM or Meritor WABCO for ECU combinations.

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J1587 Fault Codes						
MID	SID	FMI	Fault Description	Test	Result	Action
136	88	5	ESC – CAN Datalink Loss	Remove the 4-pin connector from the ESC Module. Turn the ignition ON. Measure the voltage between pins 1 and 2 of the 4-pin connector.	Voltage	Verify fault. Check ESC Module wiring for intermittent connection. Check for open connection on ESC Module and insure it is tight and clear of debris/corrosion. Repair as necessary. If fault persists, ESC module or ABS ECU may be faulty.
					No Voltage.	Check wiring in circuit 376A from ESC Module to ABS ECU unit. Repair as necessary.
136	88	9	ESC – CAN Datalink Incorrect or Missing	Remove the 4-pin connector from the ESC Module. Measure the resistance between pins 3 and 4 on the 4-pin connector.	Resistance is approximately 90 ohms.	Verify fault. Check ESC Module wiring for intermittent connection and insure it is tight and clear of debris/corrosion. Repair as necessary. Measure the resistance from the ABS ECU X4 18-pin connector and insure approximate 90 ohms is measured. If fault persists, ESC module or ABS ECU may be faulty.
					Resistance is much less or much greater than 90 ohms.	Check wiring between the ESC Module and ABS ECU. Repair as necessary. If fault persists, the ESC Module or ABS ECU may be faulty.
136	88	12	ESC – Internal Fault	Check the ESC Module and its mounting location. Verify that the ESC module is mounted horizontally and properly secured to the cross member. Check the 4-pin connector on the ESC Module and insure it is tight and clear of debris and corrosion. Check the wiring between the ESC module and the ABS ECU.	—	Verify fault. Clear code from ECU memory. Check for other fault codes that may have occurred with this fault, as this could indicate faulty wiring or poor connection at ESC module. If fault persists, the ESC module may be faulty.
136	88	13	ESC – Initialization Required	—	—	Important: Refer to Meritor WABCO's End of Line (EOL) procedure for the initialization process. This procedure can be found in Meritor WABCO's Maintenance Manual MM-0112. This document is available through Meritor WABCO or their website.

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J1587 Fault Codes						
MID	SID	FMI	Fault Description	Test	Result	Action
136	88	14	ESC – Module Mounting Fault	Check the ESC Module and its mounting location. Verify the ESC module is mounted horizontally and properly secured to the crossmember. Check the 4-pin connector on the ESC Module and insure it is tight and clear of debris and corrosion. Check wiring between the ESC module and the ABS ECU.	—	Verify fault. Clear code from ECU memory. If fault persists, the ESC module may be faulty.
136	89	1, 2, 7 or 8	SAS – Steering Angle Sensor various faults	—	—	Visually check the installation of the steering sensor and mount to ensure it is properly seated. If any vehicle work related to the steering system has been performed, the SAS must be calibrated and the ESC module initialized. Refer to Meritor WABCO's End of Line (EOL) procedure for the initialization process. This procedure can be found in Meritor WABCO's Maintenance Manual MM-0112. This document is available through Meritor WABCO or their website.
136	89	9	SAS – Commutation Fault	Remove the 7-pin connector from the Steering Angle Sensor. Measure the resistance between pins 3 and 4 of the 7-pin connector.	Resistance is approximately 90 ohms.	Verify fault. Check Steering Angle Sensor wiring. Check for open connection between the ABS ECU and Steering angle sensor. Ensure connection is tight and clear of debris/corrosion. Repair as necessary. If fault persists, the SAS or ABS ECU may be faulty.
					Resistance is much less or much greater than 90 ohms.	Check wiring between the SAS and ABS ECU. Repair as necessary. If fault persists, the SAS Sensor or ABS ECU may be faulty.

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J1587 Fault Codes						
MID	SID	FMI	Fault Description	Test	Result	Action
136	89	12	SAS – Sensor Defective	Disconnect the 7-pin connector from the steering angle sensor. Turn ignition ON. Measure the voltage between pins 1 and 2 of the 7-pin connector.	Voltage	Check Steering Angle Sensor wiring. Check for intermittent connection between the ABS ECU and Steering angle sensor. Ensure connection is tight and clear of debris/corrosion. If fault persists, the ABS ECU may be faulty.
					No Voltage.	Check the wiring in circuit 576A between the SAS and the ABS ECU. Repair as necessary.
136	89	13	SAS – Not Calibrated	—	—	Refer to Meritor WABCO's SAS calibration procedure. This procedure can be found in Meritor WABCO's Maintenance Manual MM-0112. This document is available through Meritor WABCO or their website.
136	89	14	SAS – Internal Fault	—	—	Check SAS and its mounting location. Verify the SAS is securely mounted and the connector is free of debris and corrosion. SAS may be faulty.
136	16	5	BLS/Pressure Sensor	Disconnect the 18-pin X4 connector from the ABS ECU. Measure the voltage between pin 8 of the 18-pin (X4) connector and ground.	Voltage.	Wire shorted to power, check wiring and repair as necessary.
					No voltage.	Open circuit or shorted to ground. Check wiring and repair as necessary.
136	19	2	Front Axle Brake Valve – Open	Disconnect connector X4 from the ABS ECU. Measure the resistance between pins 16 and 13 of the 18-pin (X4) connector.	Open circuit, or high resistance.	Check Front solenoid valve wiring for corrosion or open connection. Repair as necessary. See 709 — Solenoid Valve Tests . If fault persists, replace the front solenoid valve.
					Resistance is 7-14 ohms.	Correct resistance is measured. Check wiring for intermittent connection. Repair as necessary. If fault persists, see 709 — Solenoid Valve Tests . If Front valve passes test, ABS ECU may be faulty.

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J1587 Fault Codes						
MID	SID	FMI	Fault Description	Test	Result	Action
136	19	5	Trailer Brake Valve (RSC) Open	Disconnect connector X3 from the ABS ECU. Measure the resistance between pins 13 and 8 of the 15-pin (X3) connector.	Open circuit, or high resistance.	Check RSC valve wiring for corrosion or open connection. Repair as necessary. See 709 — Solenoid Valve Tests . If fault persists, replace the RSC valve.
					Resistance is 7-14 ohms.	Correct resistance is measured. Check wiring for intermittent connection. Repair as necessary. If fault persists, see 709 — Solenoid Valve Tests . If RSC valve passes test, ABS ECU may be faulty.
136	19	12	SAS and ESC Module – Shorted to Ground	Disconnect connector X4 from the ABS ECU. Measure the resistance between pin 7 of the 18-pin (X4) connector and ground.	Low Resistance	Wire shorted to ground, check wiring and repair as necessary.
					High Resistance	Verify fault. Check for intermittent fault in circuit 376A or open circuit. If fault persists, ABS ECU may be faulty.
136	55	3	Brake Pressure Sensor – Shorted to Battery	Disconnect the 4-pin connector from the Brake Pressure Sensor. Measure the resistance between pin 3 of the 4-pin connector and power.	Low Resistance	Wire shorted to power, check wiring and repair as necessary.
					High Resistance	Verify fault. Check for intermittent fault in circuit 402. If fault persists, sensor may be faulty.
136	55	5	Brake Pressure Sensor – Open or shorted to ground.	Disconnect the 4-pin connector from the Brake Pressure Sensor. Measure the resistance between pin 2 of the 4-pin connector and ground.	Low Resistance	Wire shorted to ground, check wiring and repair as necessary.
					High Resistance	Verify fault. Check for intermittent fault in ground circuit or open circuit. If fault persists, sensor may be faulty.

Table 18, J1587 Fault Codes

709 — Solenoid Valve Tests

1. **Test the voltage on the affected solenoid valve connector.**
 - 1.1 Disconnect the 4-pin connector from the solenoid valve.
 - 1.2 Switch the ignition to the ON position
 - 1.3 Measure the voltage between all pins in the solenoid connector and a good ground.

Is voltage present on any pin?

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YES → Check the wiring for a short to power. Repair as necessary.

NO → Go to test 2.

2. **Measure the voltage between all pins in the solenoid connector and +12V power.**

Is voltage present on any pin?

YES → The wire shorted to ground. Repair as necessary.

NO → Go to test 3.

3. **Measure the resistance between pins 1 and 2 on the solenoid valve.**

Is the resistance between 7 and 14 ohms?

YES → Go to test 4.

NO → Clean the electrical contacts on the solenoid and test again. If the resistance is still not correct, replace the solenoid valve.

4. **Measure the resistance of the solenoid valve through the wiring to the ABS ECU.**

Refer to **601 — Component Details** for the solenoid valve being tested.

Is the resistance between 7 and 14 ohms?

YES → Check for other electrical faults. The ABS ECU or the solenoid valve may be faulty.

NO → Clean the electrical contacts and check wiring between the ABS ECU and solenoid valve. Repair as necessary. If the resistance is still not correct, replace the solenoid valve.

710 — ATC Power and Ground Faults (SID 015)

ATC Valve Ground Circuit Faults Troubleshooting (SID 015) (Cab-Mounted ECU)							
MID	SID	FMI	Problem	Test	Test Result	Action	Blink Code
136	015	03	ATC valve ground circuit shorted to power.	1. Disconnect the 18-pin X2 connector from the ABS ECU. With the ignition ON, check for voltage between pin 7 and ground.	Voltage at pin 7.	Circuit 378T— is shorted to power. Locate fault and repair as necessary.	8-5
					No voltage at pin 7.	Verify fault. Check for intermittent fault in circuit 378T—and repair as necessary.	
136	015	05	ATC Valve—High Impedance.			Replace ABS ECU if fault persists.	
136	018	06	ATC Valve ground circuit shorted to ground.	2. Disconnect the 18-pin X2 connector. Check resistance between pin 7 and a good ground.	Resistance is less than 10,000 Ohms.	Circuit 378T— is shorted to ground. Locate fault and repair as necessary.	
					Resistance is greater than 10,000 Ohms.	Verify fault. Check for intermittent fault in circuit 378T—and repair as necessary.	

Table 19, ATC Valve Ground Circuit Faults Troubleshooting (SID 015) (Cab-Mounted ECU)

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711 — ATC Valve Faults (SID 018)

ATC Valve Power Circuit Faults Troubleshooting (SID 018) (Cab Mounted ECU)							
MID	SID	FMI	Problem	Test	Test Result	Action	Blink Code
136	018	03	Short to power.	1. Disconnect the 18-pin (X2) connector from the ABS ECU. Measure the voltage between pin 16 of the 18-pin (X2) connector and a good chassis ground.	Voltage.	Circuit 378T+ is shorted to power. Repair as necessary.	7-2
					No voltage.	Verify fault. Check for intermittent fault in circuit 378T+. If fault persists, replace ABS ECU.	
136	018	05	Open circuit.	2. Disconnect the ATC Valve connector. Measure the resistance across the two pins of the ATC valve. <i>NOTE: If the vehicle does not have an ATC valve, re-configure the ECU.</i>	Resistance is 7 to 14 Ohms.	Perform Test 3.	7-2
					Resistance is not 7 to 14 Ohms.	Replace ATC Valve.	
				3. Reconnect the ATC valve connector. Disconnect the 18-pin X2 connector from the ECU. Measure the resistance across pins 7 and 16 of the 18-pin X2 connector.	Resistance is 7 to 14 Ohms.	Verify fault. Check for intermittent open circuit in 378T+ and 378T-. Repair as necessary.	
					Resistance is not 7 to 14 Ohms.	Repair circuit 378T+ or 378T-.	7-2
136	018	06	Short to ground.	4. Disconnect the 18-pin X2 connector, check continuity between pin 16 and a good ground.	Continuity.	Circuit 378T+ is shorted to ground. Repair as necessary.	7-2
					No continuity.	Verify fault. Check circuit 378T+ for intermittent short to ground. Repair as necessary.	

Table 20, ATC Valve Power Circuit Faults Troubleshooting (SID 018) (Cab Mounted ECU)

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712 — J1939 Datalink Faults (SID 231)

J1939 Datalink Troubleshooting (SID 231)						
MID	SID	FMI	Problem	Test	Test Result	Action
136	231	02	J1939 speed plausibility error. NOTE: This fault indicates a discrepancy between vehicle speed reported on J1939 and ABS sensed vehicle speed.	—	—	Check speedometer calibration. Check for a tire size mismatch. The vehicle speed reported on the J1939 datalink does not agree with the wheel sensor speeds.
136	231	05	J1939 open/short.	Refer to Section G03.02 for troubleshooting J1939.	—	Repair J1939 datalink as necessary.
136	231	06	J1939 open/short. Code 13s231 05 may be active as well.	Check the driveline retarder ECU and wires. Check the J1939 Datalink. Refer to Section G03.02	—	Repair J1939 datalink as necessary.
136	231	07	J1939 time out. NOTE: Fault occurs if engine retarder sends message incorrectly.	Check the driveline retarder ECU and wires. Refer to Section G03.02	—	Check J1939 datalink and driveline retarder ECU. Repair as necessary.
136	231	08	J1939 time out. NOTE: Fault occurs if engine retarder sends message incorrectly.	Check engine ECU and wires. Check J1939 datalink. Refer to Section G03.02	—	Check J1939 datalink and engine ECU. Repair as necessary.
136	231	09	J1939 time out. NOTE: Fault occurs if engine retarder sends message incorrectly.	Check engine and transmission ECUs and wires. Check J1939 datalink. Refer to Section G03.02	—	Check J1939 datalink, engine ECU, transmission ECU, and wiring. Repair as necessary.
136	231	10	J1939 time out. NOTE: Fault occurs if the exhaust retarder sends a message incorrectly.	Check the engine ECU and wires. Check the J1939 datalink. Refer to Section G03.02	—	Check J1939 datalink and engine ECU. Repair as necessary.
136	231	12	J1939 internal error.	—	—	Verify fault. Clear code from the ECU memory. If fault persists, replace the ABS ECU.

Table 21, J1939 Datalink Troubleshooting (SID 231)

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713 — Voltage Faults (SID 251)

Voltage Troubleshooting (SID 251)						
MID	SID	FMI	Problem	Test	Test Result	Action
136	251	03	Overvoltage. Voltage to ECU was too high for more than 5 seconds.	Using Meritor PC Diagnostics, check the diagonal voltages with the engine running at governed speed, or measure the voltage at the batteries with the engine running at governed speed.	Voltage is 9.5 to 14 volts.	Check for intermittent sources of high voltage. Check condition of charging system and batteries. Verify fault.
					Voltage is greater than 14 volts.	Check charging system. Repair as necessary.

Table 22, Voltage Troubleshooting (SID 251)

714 — Miscellaneous Faults (SID 254)

Miscellaneous Faults Troubleshooting (SID 254)						
MID	SID	FMI	Problem	Fault Trigger	Action	
136	254	02	EEPROM, Wheel parameter incorrect.	Wheel parameters are out of tolerance.	Check wheel size and tire mismatch. If OK, replace ECU.	
136	254	05	ABS/ATC ECU, no loads.	No modulator valve connected. Fault may have resulted from end of line test at factory.	Check modulator valve connections.	
136	254	07	ABS missing.	This is a roll call fault generated by the ICU. It means the ICU does not detect the ABS on the J1587 datalink. Fault does not show up on datalink, only on ICU display.	Check power/ground to ABS, check ABS J1587 datalink wiring.	
136	254	08	Excessive wheel slip.	One wheel was much faster than the other. May have been caused by testing vehicle on a dynamometer.	Check wheel speed sensor air gaps.	
136	254	09	Modulator valve actuated too long.	Modulator valve was activated too long (more than 75% of 5 minutes).	After a delay, function will return to normal.	
136	254	12	EEPROM Checksum/internal error.	—	If fault persists, replace the ABS ECU.	
136	254	13	Accelerometer out of range.	Measured acceleration out of range.	If fault persists, replace the ABS ECU.	
136	254	14	ECU Mounting/ accelerometer plausibility.	ECU not mounted correctly, or acceleration not plausible. Extreme banked road (measured acceleration not plausible). Accelerometer linearity (measured acceleration not plausible).	Check ECU mounting. Replace the ECU if fault persists.	

Table 23, Miscellaneous Faults Troubleshooting (SID 254)

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800 — Specifications

ABS and RSC Component Specifications			
Component	Measurement	Normal Range	Notes
Wheel Speed Sensor	Resistance	900–2000 Ohms	Measured across the two sensor terminals.
	Output voltage	0.2V AC (minimum)	Measured across the two sensor terminals while rotating the wheel 30 rpm.
Modulator Valve	Resistance	4–9 Ohms	Resistance between each coil pin and ground pin.
ATC/RSC/Front Solenoid Valve	Resistance	7–14 Ohms	Measured across the two valve terminals.
Accelerometer	Voltage	2.21 to 2.78 V	Measured with Meritor WABCO Toolbox software.

Table 24, ABS and RSC Component Specifications

Low Air Pressure Warning System

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Low Air Pressure Warning System

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500 Terms and Abbreviations

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CGW—Central Gateway

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit, typically connected to a datalink.

ICU—Instrumentation Control Unit

LBCU—Lightbar Control Unit

Multiplexing—Sending multiple electronic messages through the same signal path at the same time—in this case, through the wiring.

MSF—Modular Switch Field

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SAM Chassis—Signal Detect and Actuation Module Chassis; this ECU controls mainly chassis-related functionality. See **G02.05 — SAM Chassis** for more information.

501 — General Information

Federal regulations require that the driver be alerted if the brake system air pressure drops below 60 psi (414 kPa). The low air pressure warning system uses a loud tone, and an indicator light on the lightbar, to alert the driver that the primary or secondary air system is below 65 psi (448 kPa). The system is activated when the key is in the ignition switch, and turned to the ON position. System components include the following:

- two pneumatically actuated, normally open, electrical switches, wired in series
- Lightbar Control Unit (LBCU) indicator light
- LBCU Speaker
- SAM Cab

The SAM Cab monitors the status of the switches via pin 10 and 11 on connector X13, where 11 is the output and 10 is the input. Unless both pneumatic switches register greater than 65 psi (448 kPa), the circuit will not be complete. If the circuit is not complete, SAM Cab activates the LBCU indicator and warning tone by applying high impedance to pin 6 of connector X11, which is connected directly to Pin A-3 on the instrument cluster. The LBCU also broadcasts the state of the low air warning system on the J1587 datalink.

NOTE: The ICU3, ICU4, and ICU4M all function in the same manner in this system.

When the vehicle key is turned to the ON position, a test of the ICU will occur, which will illuminate several indicator lights on the LBCU and activate the buzzer for 3 seconds. If the pneumatic switch circuit is not complete, SAM Cab will activate the low air pressure warning system, and the LBCU indicator light and buzzer will remain on after the LBCU self-test. For more information on individual components, see the following subjects:

- **C01.01 — ICU3 Instrument Cluster**
- **C01.02 — ICU4/ICU4M Instrument Cluster**

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Low Air Pressure Warning System

- G02.03 — Central Gateway
- G02.04 — SAM Cab

600 — Component Locations

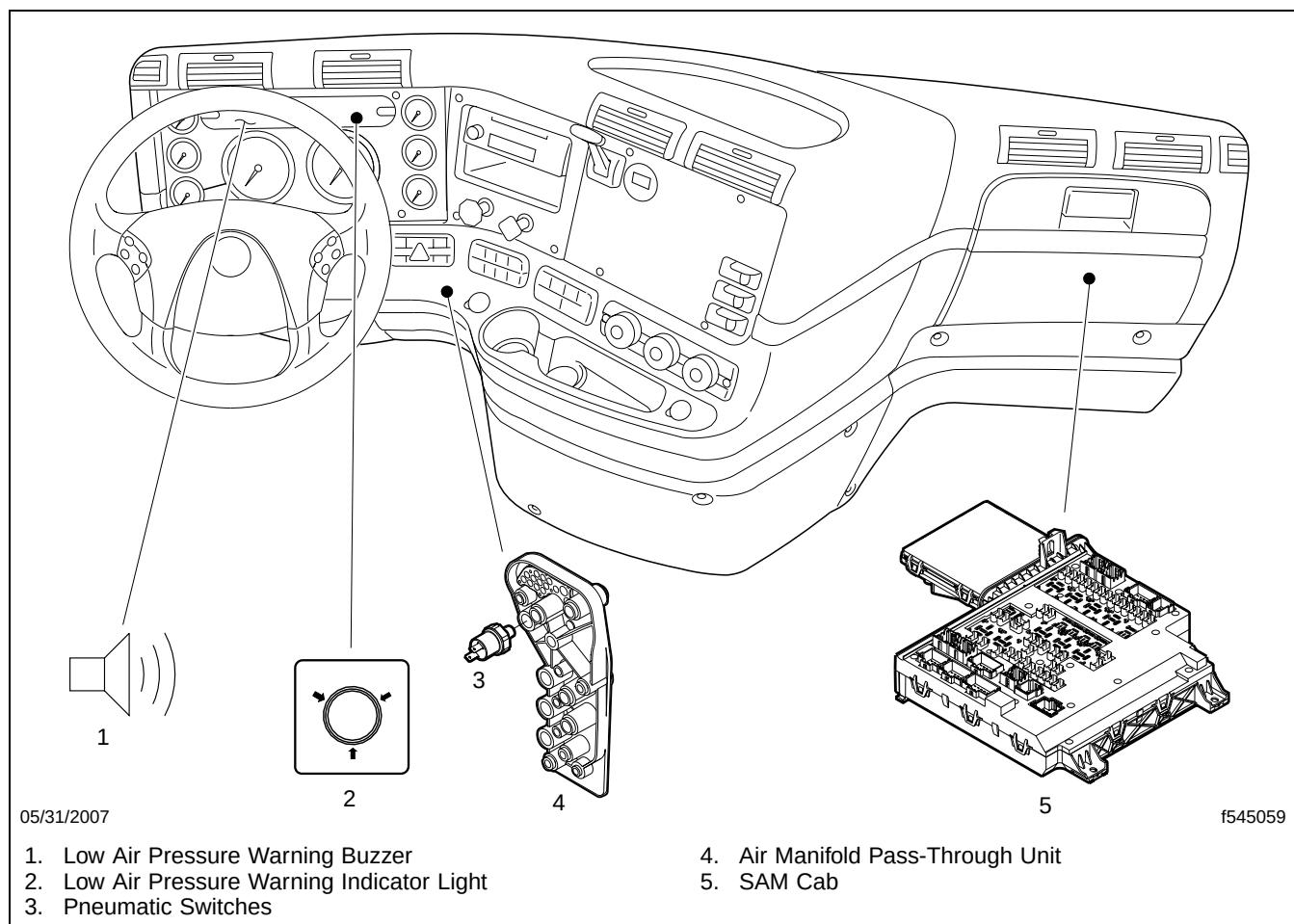


Fig. 1, Low Air Pressure Warning System Components

Low Air Pressure Warning System

H01.04

601 — Component Details

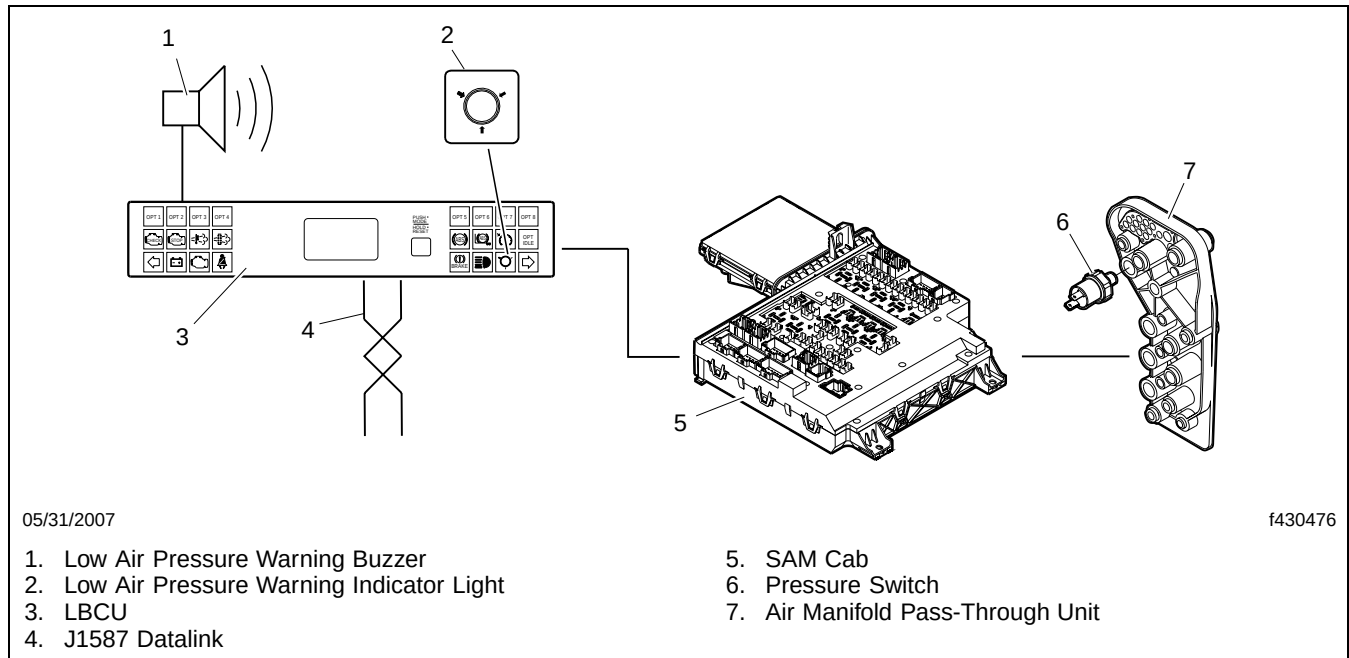


Fig. 2, Low Air Pressure Warning System Components (ICU4 shown)

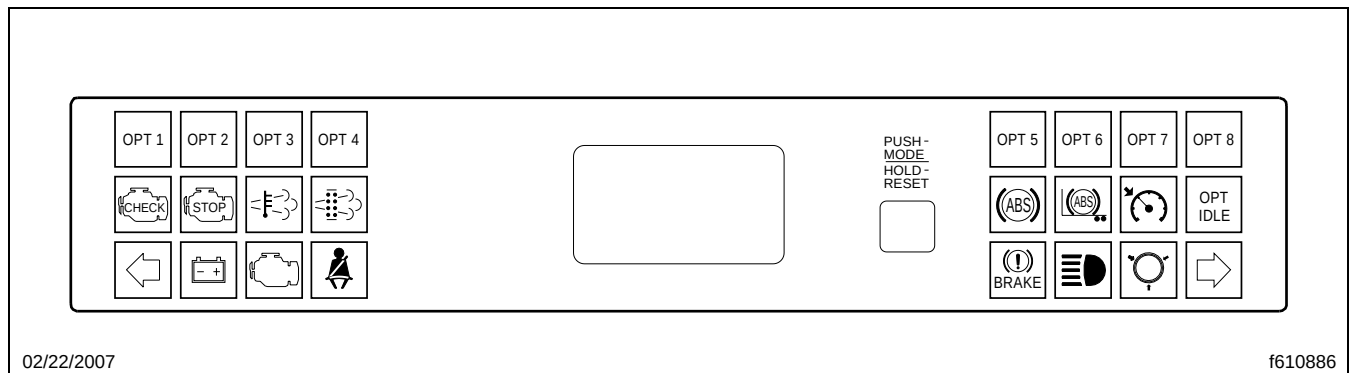


Fig. 3, Lightbar Control Unit (ICU4 shown)

Part of the Instrumentation Control Unit, the LBCU communicates over the J1587/J1708 datalink. The buzzer is activated for 3 seconds during the ICU self-test, and when there is low air pressure, low oil pressure, high coolant temperature, or the parking brake is set and the vehicle is moving at a speed of at least 2 mph (4 km/h).

H01.04

Low Air Pressure Warning System

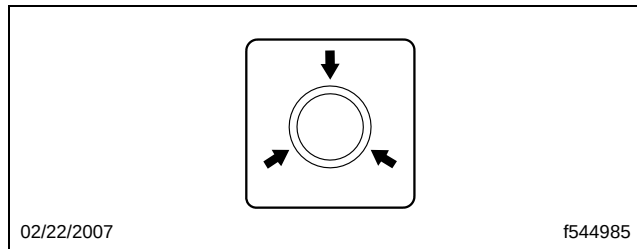


Fig. 4, Low Air Pressure Warning Indicator Light

The low air pressure warning indicator light is located next to the right turn indicator light on the bottom row of the LBCU; it is illuminated for 3 seconds during the ICU self-test, and any time the low air pressure warning system is activated. It is a nonreplacable red LED.

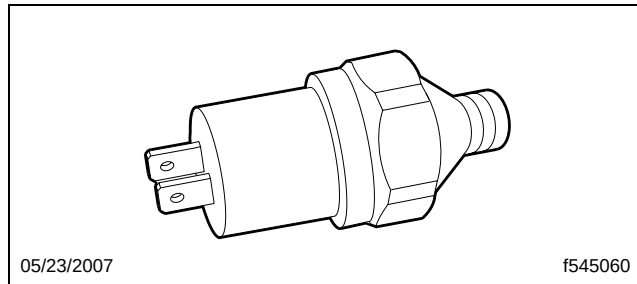


Fig. 5, Pneumatic Switches

The pneumatic switches are pneumatically actuated, normally open, electrical switches, with a 65 to 75 psi (448 to 517 kPa) trigger. The two switches are mounted on the air manifold pass-through unit, on the cab side of the frontwall, just above the throttle pedal. They are connected to the primary air system and are wired in series. Both switches must be closed for the circuit to be complete.

The SAM Cab monitors the status of the pneumatic switches, and broadcasts it over the Cabin CAN.

Parking Brake Warning

H01.05

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Parking Brake Warning

H01.05

500 — Terms and Abbreviations

ECU—Electronic Control Unit, typically connected to a datalink.

ICU—Instrumentation Control Unit

LBCU—Light Bar Control Unit

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

501 — General Information

The parking brake warning system activates a warning light on the dash if the parking brake is engaged, and activates an audible alarm if the vehicle speed is greater than 2 mph (3.2 km/h) with the parking brake engaged. For more information on the parking brake system, see **H01.09 — Park Brake System**.

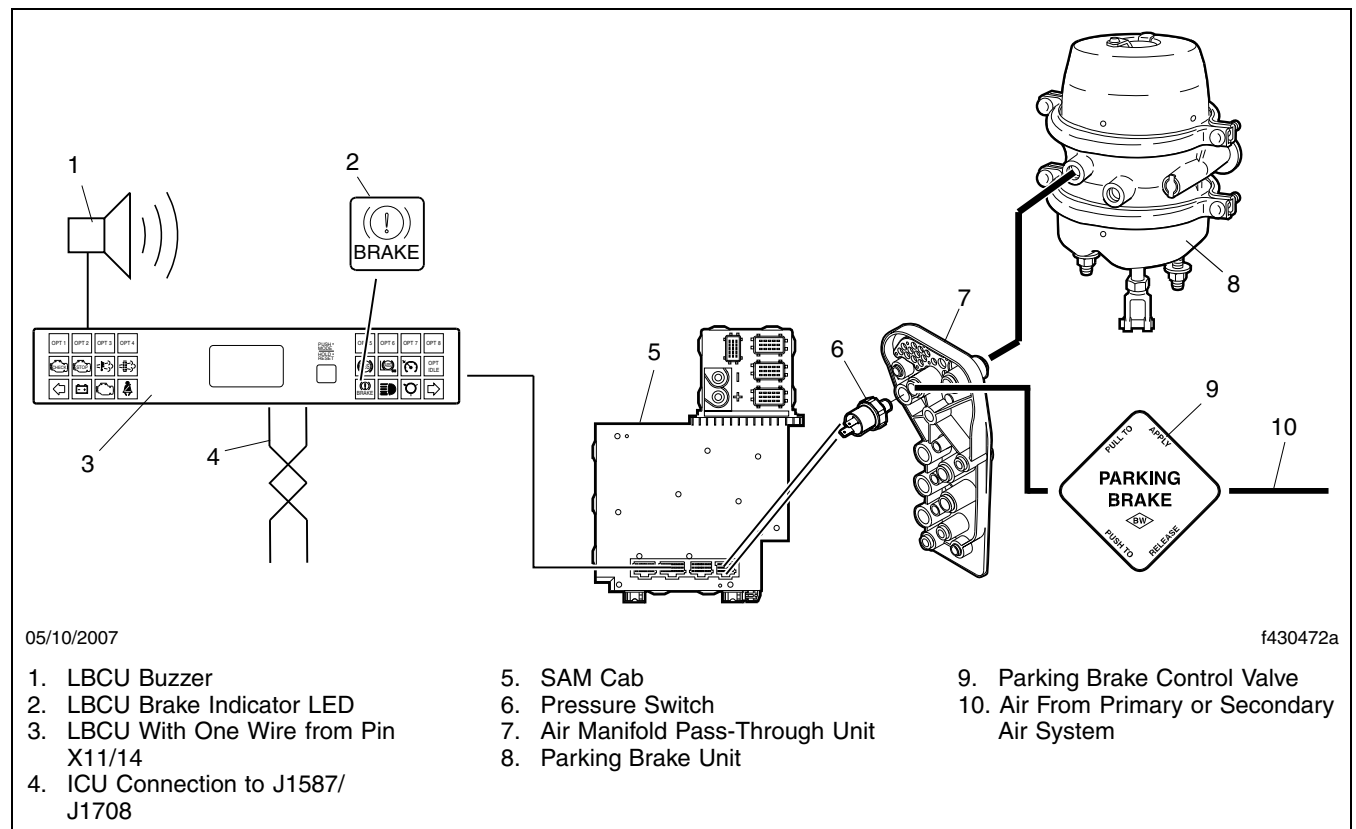


Fig. 1, Parking Brake Warning System

The SAM Cab monitors the status of the parking brake control valve by a small electrical switch integrated into the valve. A 0.04 amp current sent from pin 9 on connector X13 is monitored by pin 8 on the same connector. If the parking brake is set and the switch is closed, the SAM Cab grounds pin 14 on connector X11 and illuminates

H01.05

Parking Brake Warning

the park brake warning LED, which is powered by the LBCU. If the vehicle speed is greater than 2 mph (3.2 km/h), the LBCU warning buzzer is also activated by the ICU.

502 — Related Subjects

- C01.01 — ICU3 Instrument Cluster
- C01.02 — ICU4/4M Instrument Cluster
- G02.04 — SAM Cab
- H01.04 — Low Air Pressure Warning System

600 — Component Locations

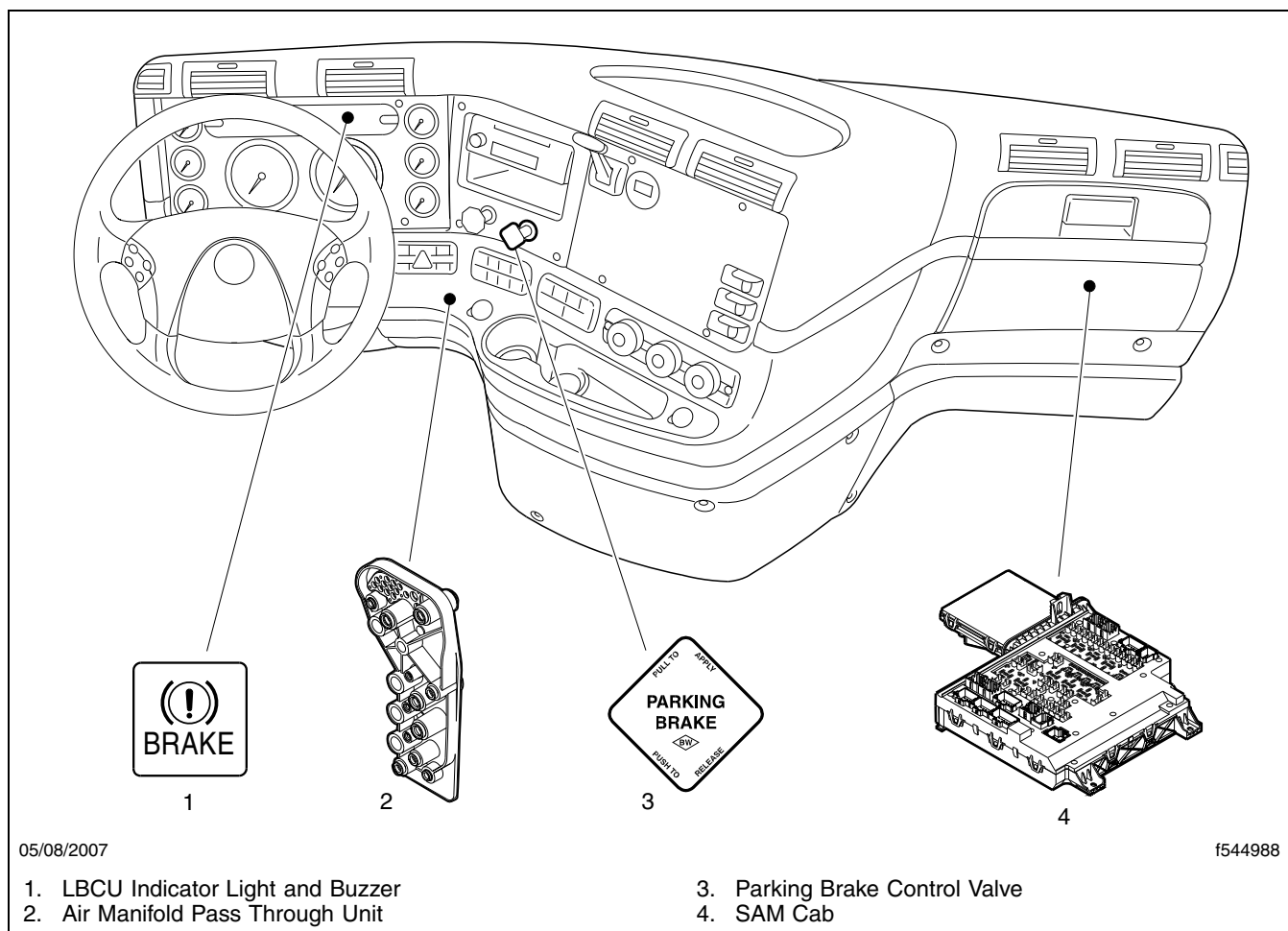


Fig. 2, Component Locations

Parking Brake Warning

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601 — Component Details

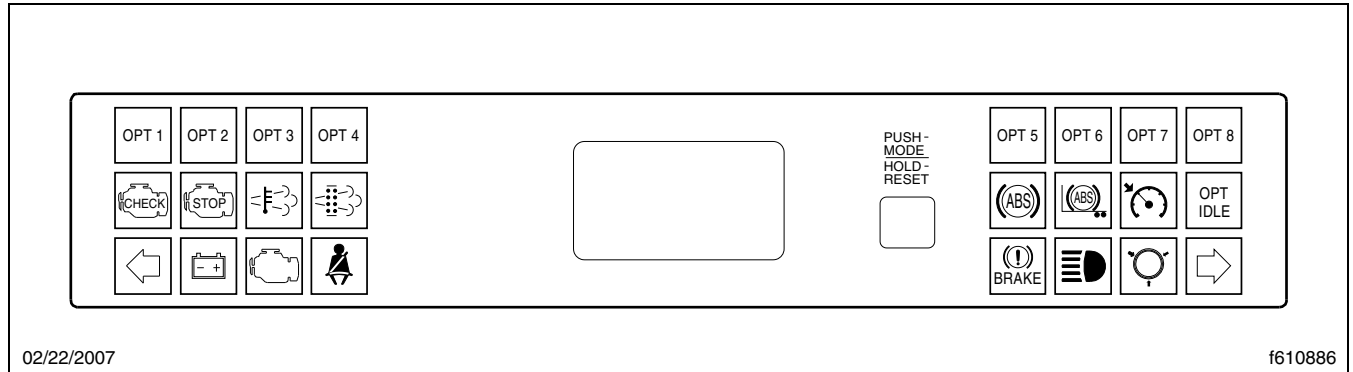


Fig. 3, Light Bar Control Unit

The LBCU is part of the instrumentation control unit. It communicates over the J1587/J1708 datalink. A buzzer is activated for 3 seconds during the ICU self-test, and when there is low air pressure, low oil pressure, high coolant temperature, or the parking brake is set and the vehicle is moving at a speed of at least 2 mph (3.2 km/h).

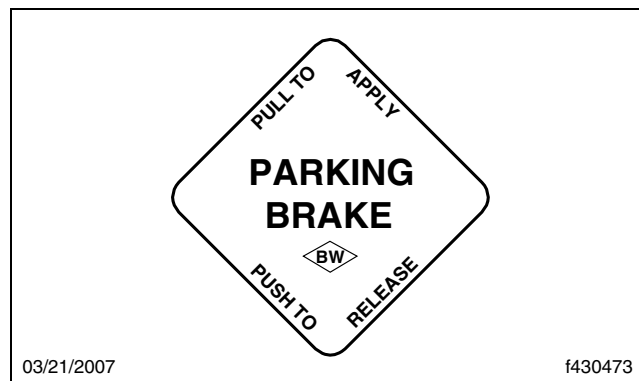


Fig. 4, Parking Brake Control Valve

The parking brake control valve engages the brake when pulled, and releases the brake when pushed.

H01.05

Parking Brake Warning

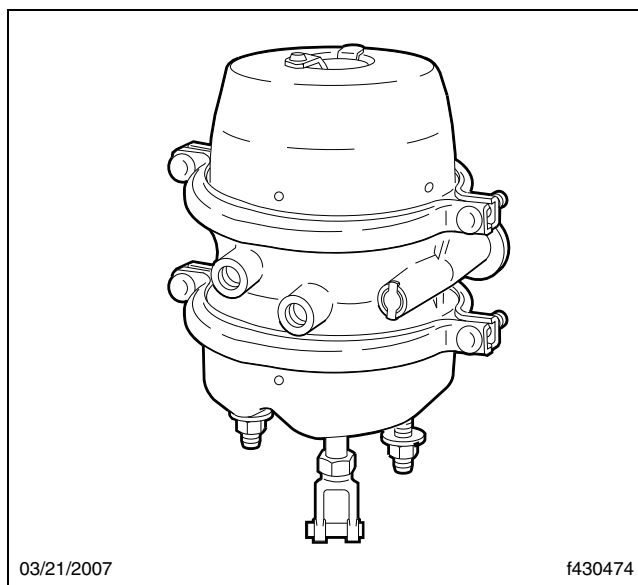


Fig. 5, Parking Brake

The parking brake is a spring powered brake and a pneumatically powered release.

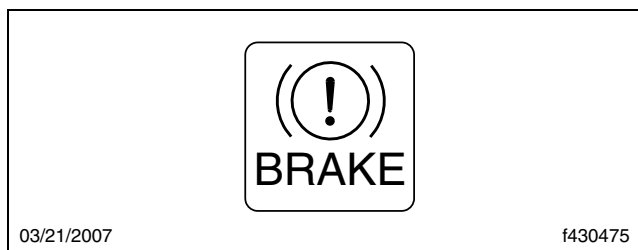


Fig. 6, LBCU Parking Brake Indicator Light

The parking brake indicator light is located immediately to the right of the LBCU LCD screen on the bottom row. It is illuminated when the parking brake is set and the key is in IGN position. It is a non-replaceable red LED.

Air Supply System

H01.06

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501 — General Information

The air supply system generates pressurized, dried, air to be used by various systems of the vehicle, including the air brakes, suspension, and trailer air supply system. **Figure 2** shows a basic schematic of the air supply system components, and how they are connected. The diagram is only a general representation of the components. In most cases the governor is attached directly to the compressor and there is an air passage between the two, eliminating the need for an air line.

H01.06

Air Supply System

600 — Component Locations

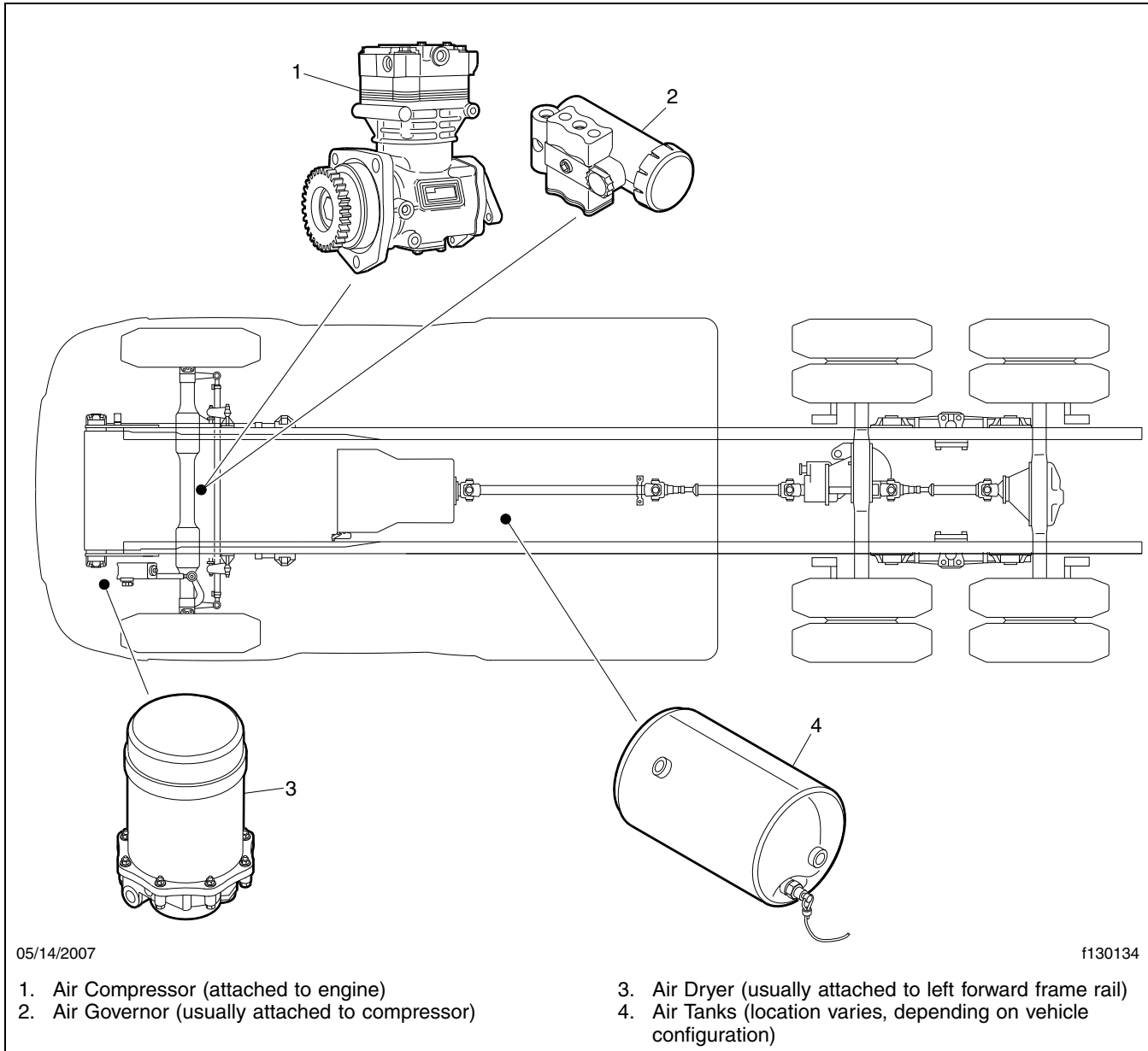


Fig. 1, Component Locations

Air Supply System

H01.06

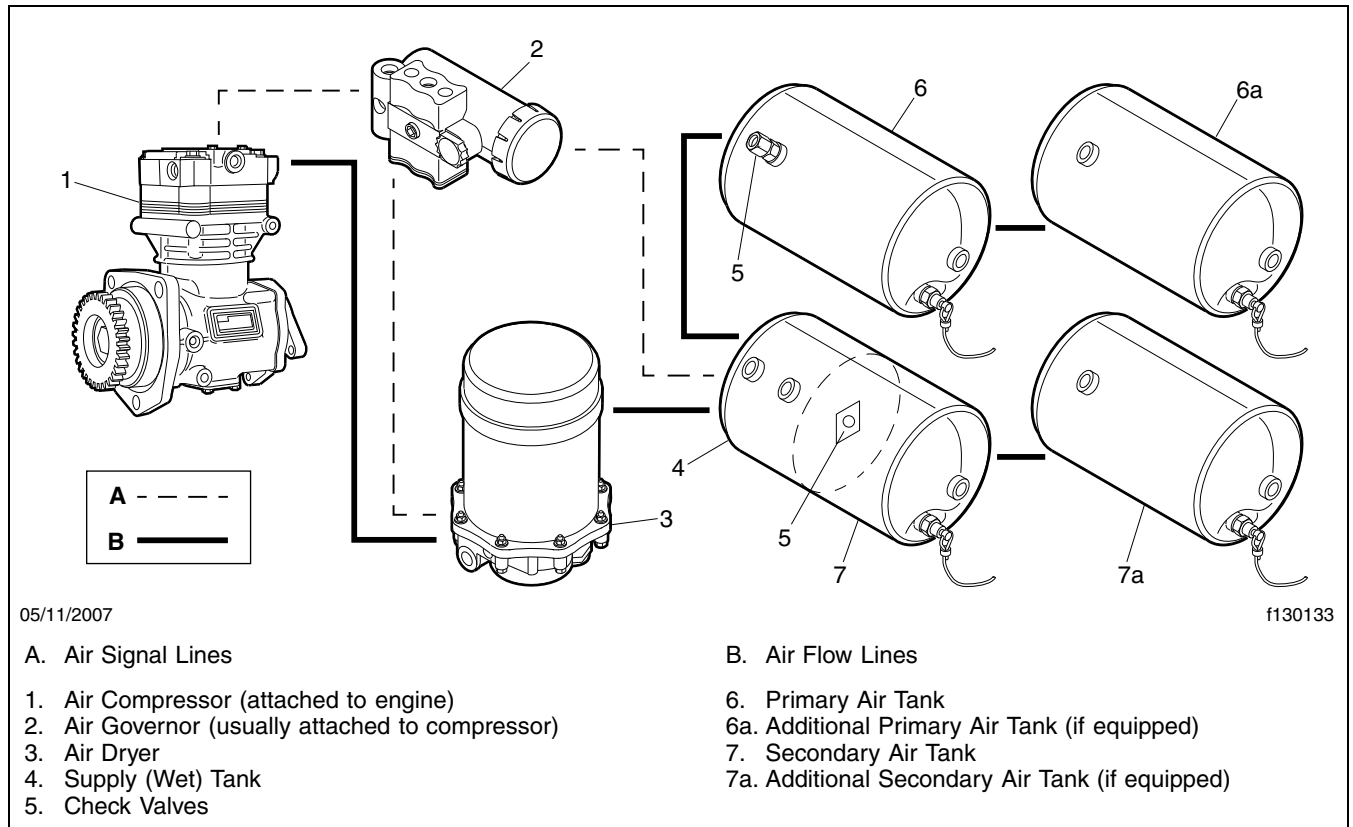


Fig. 2, Air Supply System Components

601 — Component Details

Air Intake

The air is captured through the air intake system of the vehicle. It passes through the air filter to remove water and debris. The air compressor on the Cascadia™ is naturally aspirated; the air passes from the vehicle air filter directly to the air compressor intake.

H01.06

Air Supply System

Air Compressor

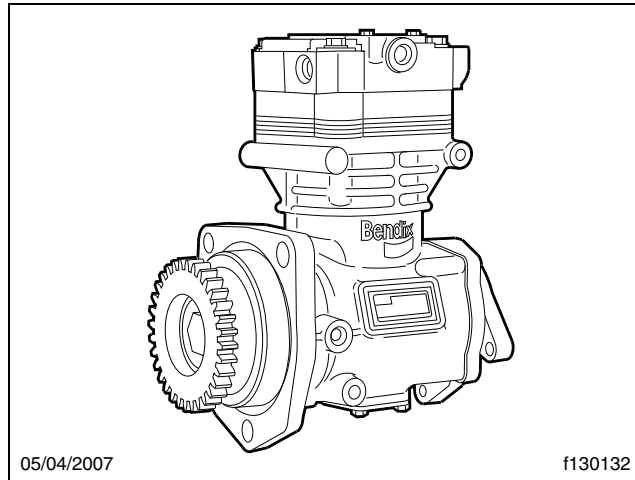


Fig. 3, Air Compressor

The air compressor is attached directly to the engine. The compressor operates in either the loaded or unloaded condition, which is controlled by a pneumatic signal from the governor. In the loaded condition, the compressor is actively compressing air. In the unloaded condition, the compressor's valves stay closed, and the compressor does not work to compress air for the air system. The air compressor is gear-driven by the engine, and is lubricated with engine oil. The piston rings will always pass small amounts of oil into the air system, and as the piston ring seals degrade, more oil will pass through. For air compressor applications for the engines offered in the Cascadia, see **Table 1**. From the compressor, the compressed air goes through a braided hose to the air dryer.

Cascadia Air Compressors		
Engine	Standard Compressor	High-Flow Compressor
Detroit Diesel Series 60	Bendix BA-921	Bendix BA-922
Caterpillar C-15	CAT 270	
Mercedes-Benz MBE4000	WABCO 15.5	WABCO 28.1

Table 1, Cascadia Air Compressors

Air Dryer

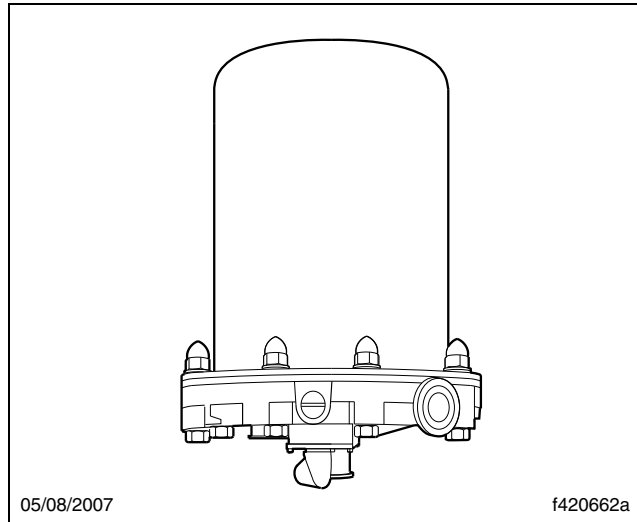


Fig. 4, Air Dryer

The air dryer is usually located on the front left frame rail. Most air dryers have some kind of oil filter before a bed of moisture-absorbing desiccant. The air dryer removes water that has condensed as a by-product of the compression process, and also removes oil that gets passed through from the compressor. When the compressor reaches the high-pressure limit, and the governor signals for the compressor to turn OFF (cutout), the dryer also momentarily purges the desiccant bed of any collected moisture. The air dryers used are the Bendix models AD-9, AD-IP, AD-IS, and a WABCO System Saver 1200. The Bendix AD-IS, is attached directly to the supply tank. From the air dryer, the air goes through a black air hose into the wet tank (also called the supply tank).

Supply or Wet Tank

The purpose of the supply (wet) tank is to collect moisture, so that it does not easily pass on to the other tanks, or the rest of the air system. A small black hose connects the wet tank to the air governor, so the governor can monitor system pressure. From the wet tank, the air goes through a check valve into another air tank, either the primary or secondary air tank, depending on the vehicle configuration. In many cases, the wet tank will be a small compartment of one of the other tanks. In these cases a weld line is visible on the exterior of the tank. Each tank is protected by a check valve that prevents flow back into the wet tank.

H01.06

Air Supply System

Air Governor

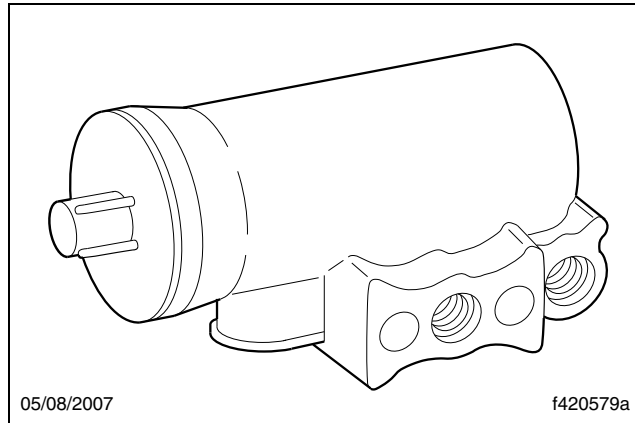


Fig. 5, Air Governor

The air governor is attached directly on the compressor on all engines except for the Mercedes-Benz MBE4000, where it is located on the engine block. The air governor cut-in pressure is 110 psi (758 kPa), and the cutout pressure is 130 psi (896 kPa). When the governor senses that the pressure in the wet tank has reached the cut-out level (130 ± 5 psi [896 ± 34 kPa]), the compressor turns OFF (unloaded). As air is used, or depleted, from the tanks, the pressure in the supply/wet tank falls. When it reaches the cut-in pressure level (110 ± 5 psi [758 ± 34 kPa]), the compressor turns ON (loaded), and starts pumping air again. Once the cutout pressure has been reached, the governor sends a signal (through a direct connection if the governor is attached directly to the compressor) to the compressor to move to the unloaded condition. The governor also sends a pressure signal, through a small silver hose, to the air dryer to purge. The model used is a Bendix D-2A.

Dual Air System

The air in the supply or wet tank passes through single check valves to fill the two separate air tank systems known as the primary and secondary air systems. The check valves, or in some cases pressure protection valves, are used to isolate these two independent air systems from each other. If there is a leak in one system, which may drain it down to zero pressure, the other air system will remain unaffected.

Air Brake System

Normally, the steering axle service brakes are plumbed into the secondary air system, and the drive axle service brakes are plumbed into the primary air system. The trailer service brakes, and parking brakes, receive air from either the primary or secondary air system, depending on which system has the higher pressure. The truck/tractor parking brake control is also supplied by the higher of either the primary or secondary system. Neither the service brakes nor the parking brakes are pressure-protected. The total air reservoir volume, of all the air tanks on the vehicle (including the wet/supply tank) available for use by the brake system, must exceed a volume of 12 times the total brake chamber volume, at maximum brake chamber stroke.

Air Accessories

The vehicle air accessories are generally the non-service/parking-brake related, air-powered features, that are required to be pressure-protected from the rest of the air systems. Air accessories include, but are not limited to: engine fan control, engine brake control, engine performance control, interaxle lock control, differential lock control, front axle air suspension, rear axle air suspension, cab suspension, air seats, air horns, transmission

Air Supply System

H01.06

control, rear air suspension dump, fifth wheel slide, fifth wheel kingpin lock, and PTO control. Generally, all air accessories are plumbed to the secondary air system.

Pressure Protection

Pressure protection valves (PPV) are installed between the secondary air tank(s) and all air accessory devices. The PPV "protects" the air reservoir from being completely drained if there is a leak in an air accessory device(s). In an emergency, when there is a leak or the pressure is falling, the PPV reserves the air tank pressure for the higher priority brake system, and shuts off the lower priority air accessory device(s). The PPV is a simple spring-piston device. If the pressure in the air tank is rising from 0 psi (0 kPa), at a designated opening pressure, the PPV opens and delivers air to the air accessory device(s). If there is a leak in the air accessory device(s), as the pressure is falling, the PPV will close at a designed pressure level, and let the air accessory device go to 0 psi (0 kPa), while retaining air pressure in the air tanks. The rear suspension is typically supplied through an 85 psi (586 kPa) (open) PPV, which closes at about 67 psi (462 kPa). All the other air accessory devices are typically supplied through a 55 psi (379 kPa) (open) PPV, that closes at about 45 psi (310 kPa). The 55 psi (379 kPa) PPV often feeds a junction block, from which several air accessory devices are plumbed. Although the purpose of pressure protection is to protect the brake air from a leak in an air accessory, there is also a kind of protection for the air accessory in the event that there is a leak in the air tank or brake system. In that case, the tank pressure (and air accessory pressure) will fall until it reaches the closing point of the valve, and then it will trap or hold that pressure in the air accessory device.

For more information on individual components, see the following:

- C01.02 — ICU4/4M Instrument Cluster
- G02.03 — Central Gateway
- G02.04 — SAM Cab Module
- G02.05 — SAM Chassis Module

Service Brakes, Air System

H01.08

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Service Brakes, Air System

H01.08

500 — General Information

The service brake system uses pressurized air to actuate the service brakes. The service brake system applies gradual pressure to the brake chambers proportional to the pressure applied to the brake foot pedal. For more information on the service brakes, refer to *Service Brakes, Mechanical System*, H01.07. For vehicle specific air system plumbing diagrams, refer to EZWiring™.

The service brake air system includes the following components:

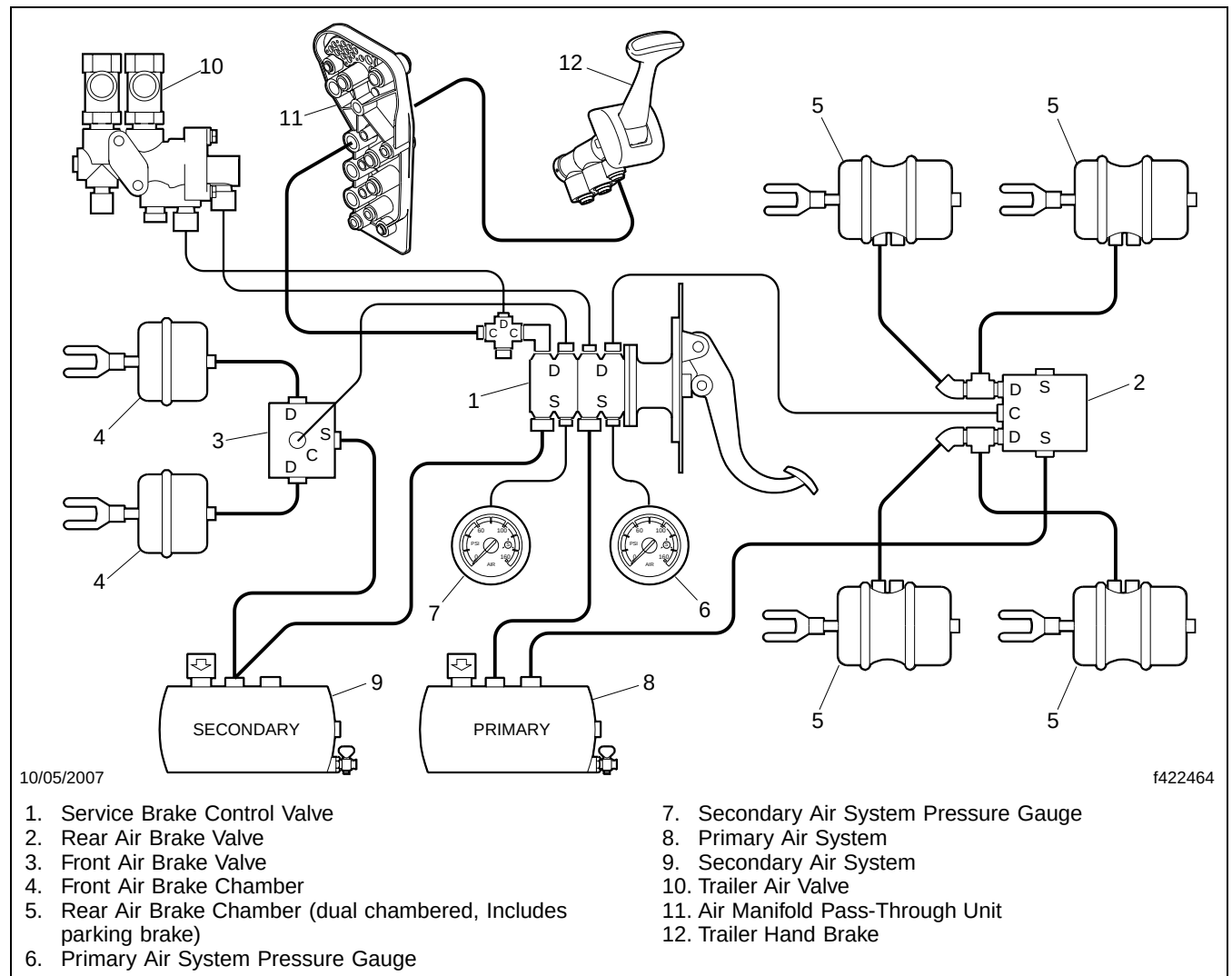


Fig. 1, Service Brake System Components (typical)

When the brake pedal is pressed, air from the secondary air system pressurizes the line to the control port of the front brake valve. The front brake valve opens proportionally to the pressure in the control line, and air from the secondary air system connected to the supply port of the valve is routed to the delivery port, where it pressurizes the brake canisters and applies the brakes. This same process occurs for the rear brakes, except the rear brakes use air from the primary air system. Additionally the trailer brake is actuated in the same way, but the

H01.08

Service Brakes, Air System

trailer brake can also be operated independently of the tractor brakes, using the trailer hand brake located on the dash. The air pressure gauges located in the ICU are connected to the supply port of the service brake control valve through the air manifold pass-through unit. For more information on individual components see the following subjects:

- H01.06 – Air Supply System
- H01.07 – Service Brakes, Mechanical System
- H01.09 – Parking Brake System

600 — Component Locations

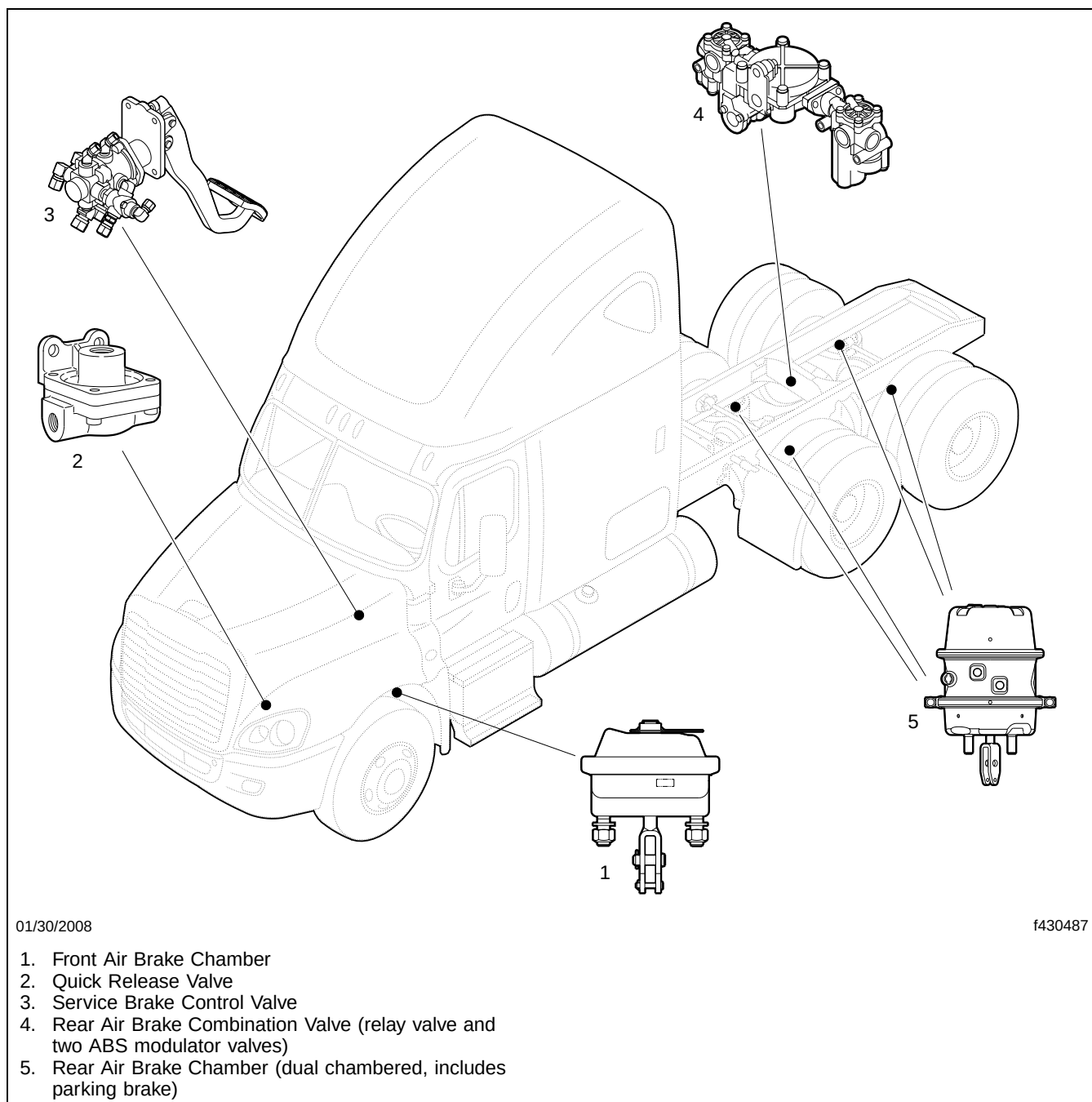


Fig. 2, Component Locations

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Service Brakes, Air System

610 — Component Details

Service Brake Control Valve

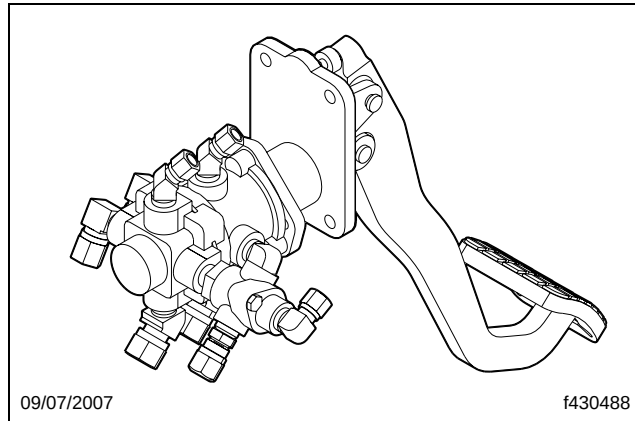


Fig. 3, Service Brake Control Valve

The service brake control valve is actually two separate valves, the half closer to the front wall is supplied by the primary air system (port is indicated with "SUP 11"). The delivery ports go to the rear brakes and trailer brakes (both horizontal unmarked ports). The top port is directly linked to the supply port, and the Primary air gauge is connected here. The second half of the brake control valve is supplied by the secondary air system, and the delivery ports (with the marks "DEL 21") lead to the front brakes, with an additional double check valve that allows for either the trailer hand valve, or brake control valve, air application to the trailer air valve. The top port is directly linked to the supply port, and the secondary air gauge is connected here.

Rear Air Brake Combination Valve

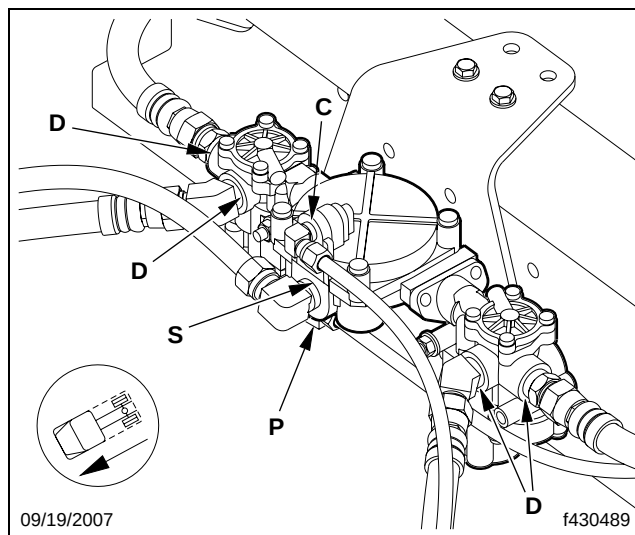


Fig. 4, Rear Air Brake Combination Valve

Service Brakes, Air System

H01.08

The rear air brake combination valve is mounted on the crossmember beneath the fifth wheel (if equipped). The combination valve consists of a relay valve, and two ABS modulation valves. The combination valve is labeled with an "S" indicating supply port for the relay valve, "C" indicating the control port for the relay valve and "D" indicating the delivery ports of the modulator valves. The "P" indicates a delivery port from the relay valve and leads to the parking brake control valve.

Front Brake Air Valve

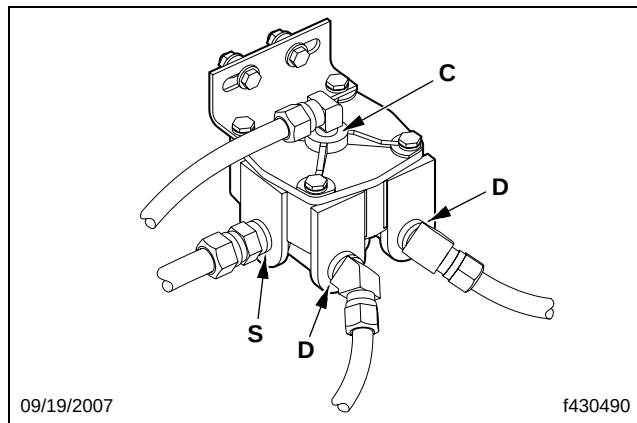


Fig. 5, Front Brake Relay Valve

The front brake air valve is mounted on the front of the left frame rail. "S" indicates the supply port, "C" indicates the control port, "D" indicates delivery ports. "E" indicates the exhaust port. Depending on vehicle configuration, it will be either a quick release valve (>90%) or a relay valve.

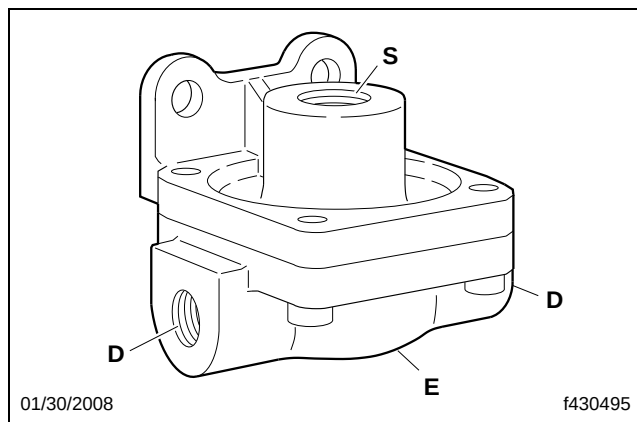


Fig. 6, Front Brake Quick Release Valve

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Service Brakes, Air System

Front Air Brake Chamber

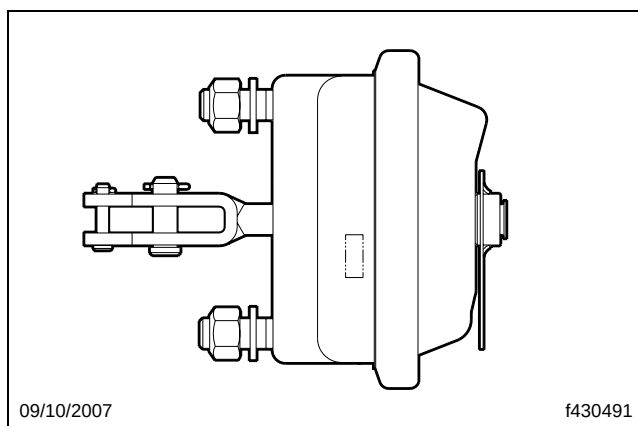


Fig. 7, Front Air Brake Chamber

The front air brake chambers are single chamber units. They only apply the vehicle service brakes.

Rear Air Brake Chamber

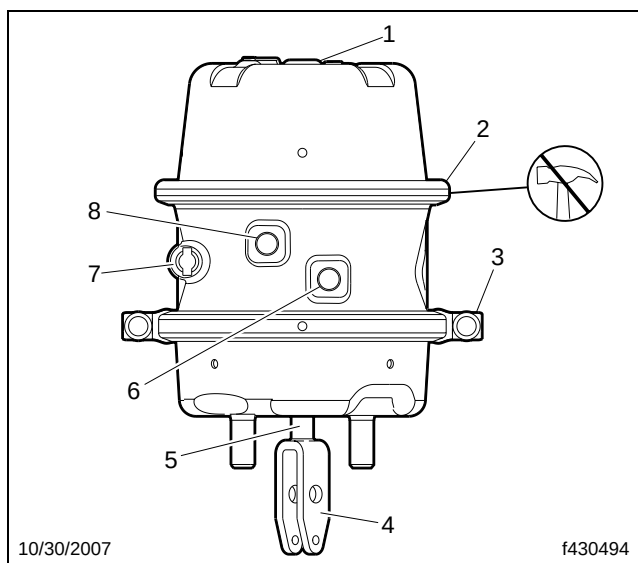


Fig. 8, Rear Air Brake Chamber

The rear air brake chambers, on at least one of the rear axles, are a two-chambered design, with a service brake chamber, and a parking brake chamber. "P" indicates the parking brake port, and "S" indicates the service brake port. Normally, the forward rear axle will have the parking brakes, and the rear rear axle will have single chamber brake chambers similar to those on the front brakes. In some applications, both rear axles will have parking brake chambers installed.

700 — Quick Release Valve Operation and Leakage Tests

The following tests should be performed after repairing or replacing the quick release valve to ensure that it is functioning properly.

1. Park the vehicle on a level surface and set the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. On QR-1C valves, remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of no greater than a 1-inch (2.5-cm) bubble in 5 seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the valve should exhaust air at the exhaust port when the foot brake is released.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of no greater than a 1-inch (2.5-cm) bubble in 5 seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

Parking Brake System

H01.09

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Parking Brake System

H01.09

502 — System Overview

DANGER

Do not attempt to remove the factory-sealed clamp ring of a dual chamber brake chamber for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

The parking brake system uses powerful springs to apply the rear brake chambers when parking. The parking brake can only be released if there is air pressure greater than the pressure of the parking brake spring (approximately 65 psi [448 kPa]). If the primary air system loses pressure, the parking brakes will gradually start applying pressure at about 65 psi (448 kPa), and will be fully applied when there is no longer any pressure in the primary air system. For more information on the parking brake system, see the following:

- H01.05 — Parking Brake Warning System
- H01.08 — Service Brake, Air System

The parking brake system includes the following components:

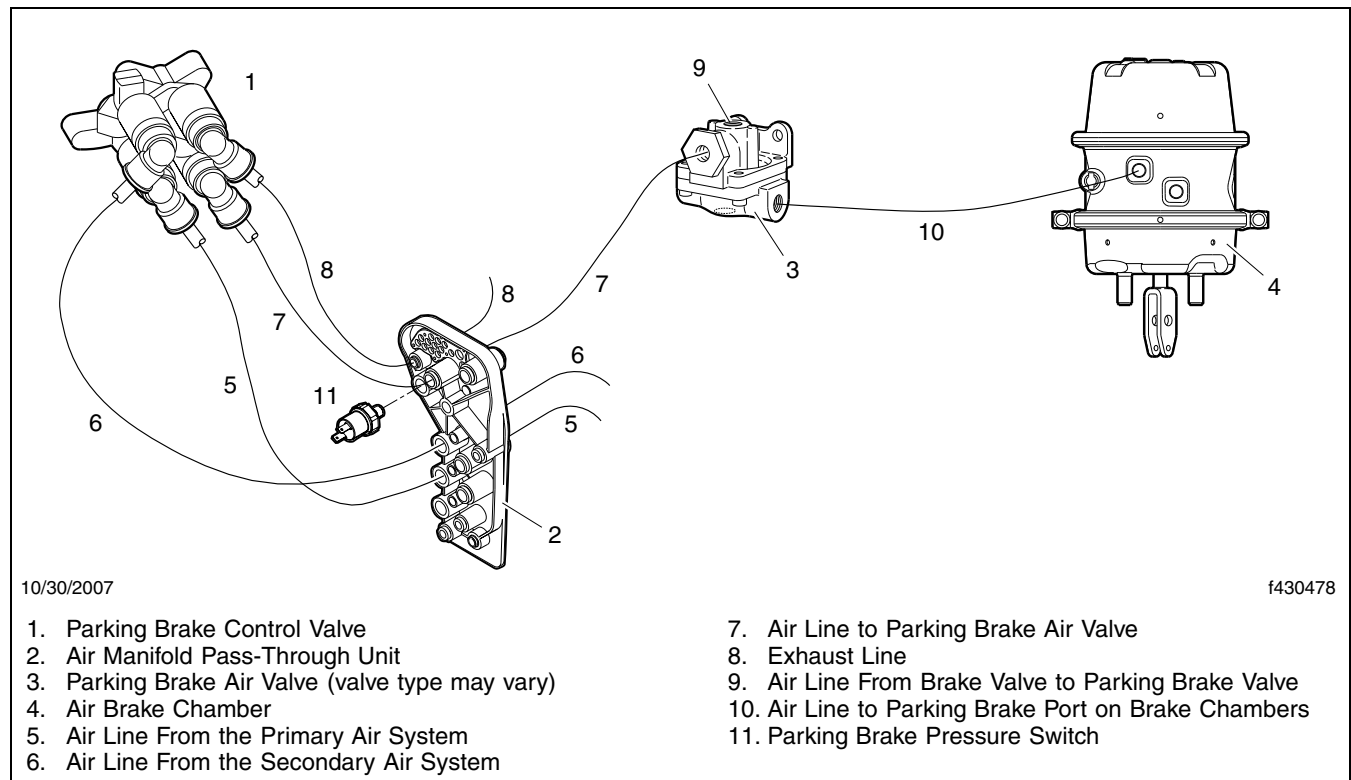


Fig. 1, Parking Brake System Components

When the parking brake knob is pushed to release the parking brake, air from either the primary or secondary air system (whichever is greater) pressurizes the black delivery line that runs back through the air manifold pass-through unit to the control port on the parking brake air valve. When the control port is pressurized, it allows air

H01.09

Parking Brake System

to flow from the supply port to the delivery ports, which lead to the parking brake port on the air brake chambers. The supply air to the parking brake air valve is supplied by the air brake valve, which in turn is supplied by the primary air system.

For more information on individual components, see the following chapters:

- H01.05 — Parking Brake Warning System
- H01.06 — Air Supply System
- H01.08 — Service Brakes, Air System

Parking Brake System

H01.09

600 — Component Locations

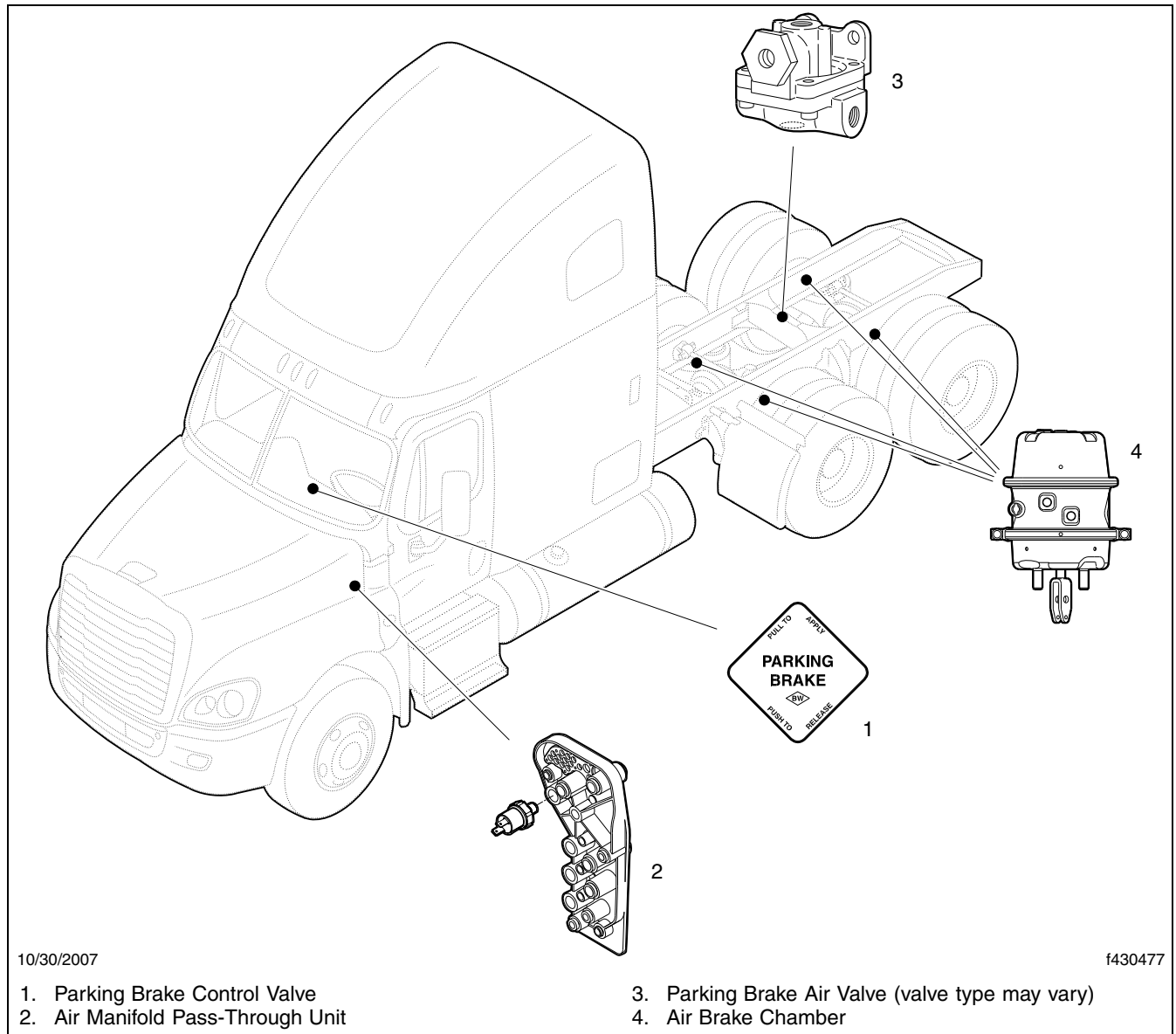


Fig. 2, Component Locations

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Parking Brake System

601 — Component Details

Parking Brake Control Valve

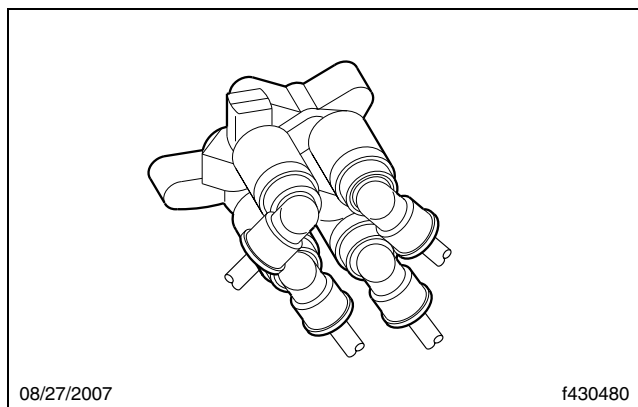


Fig. 3, Parking Brake Control Valve

The parking brake control valve has four air hoses connected to the back of it. The green line is primary air supply, the red line is secondary air supply, the black line is for the control signal to the parking brake air valve, and the yellow line is the exhaust port, which leads to the engine side of the front wall to eliminate the control valve from exhausting into the dash area.

Air Manifold Pass-Through Unit

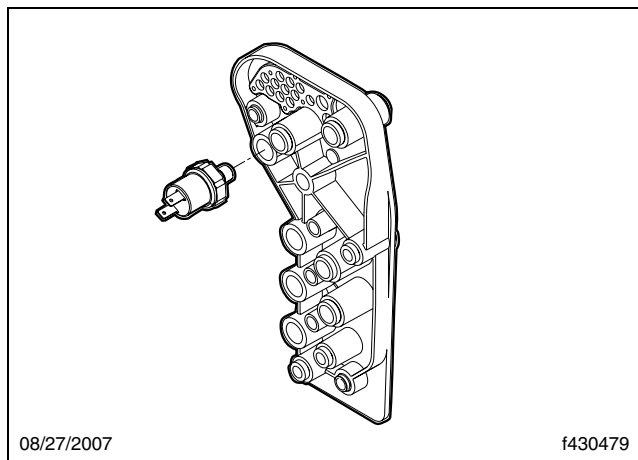


Fig. 4, Air Manifold Pass-Through Unit

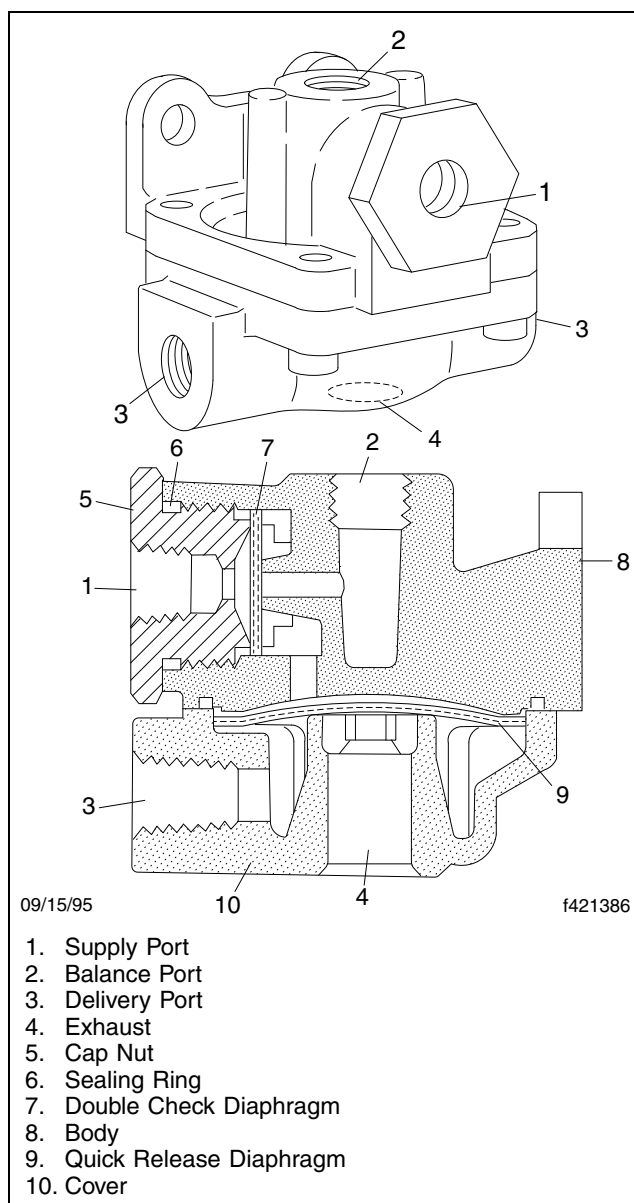
The air manifold pass-through unit is located on the front wall above the throttle pedal. The pressure switch shown is part of the Parking Brake Warning System (H01.05).

Parking Brake System

H01.09

Parking Brake Air Valve

Tractor Applications



**Fig. 5, Parking Brake Air Valve (QR-1C
cross-section shown)**

On a tractor application, the parking brake air valve is mounted near the rear axle, generally on the fifth wheel rear horizontal crossmember. This quick release valve is a dual function valve. Its primary function is to speed up the release of air pressure from the parking brake chambers. Additionally, the valve works as an anticom pound

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Parking Brake System

device. The double check valve feature prevents a service and parking brake application from occurring at the same time. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on the quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.

Straight Truck Applications

On straight truck applications, the parking brake air valve is mounted near the rear axle, generally on a horizontal crossmember. The Bendix SR-7™ spring brake modulating valve is used in conjunction with a dual air brake system and spring brake actuator, and performs the following functions:

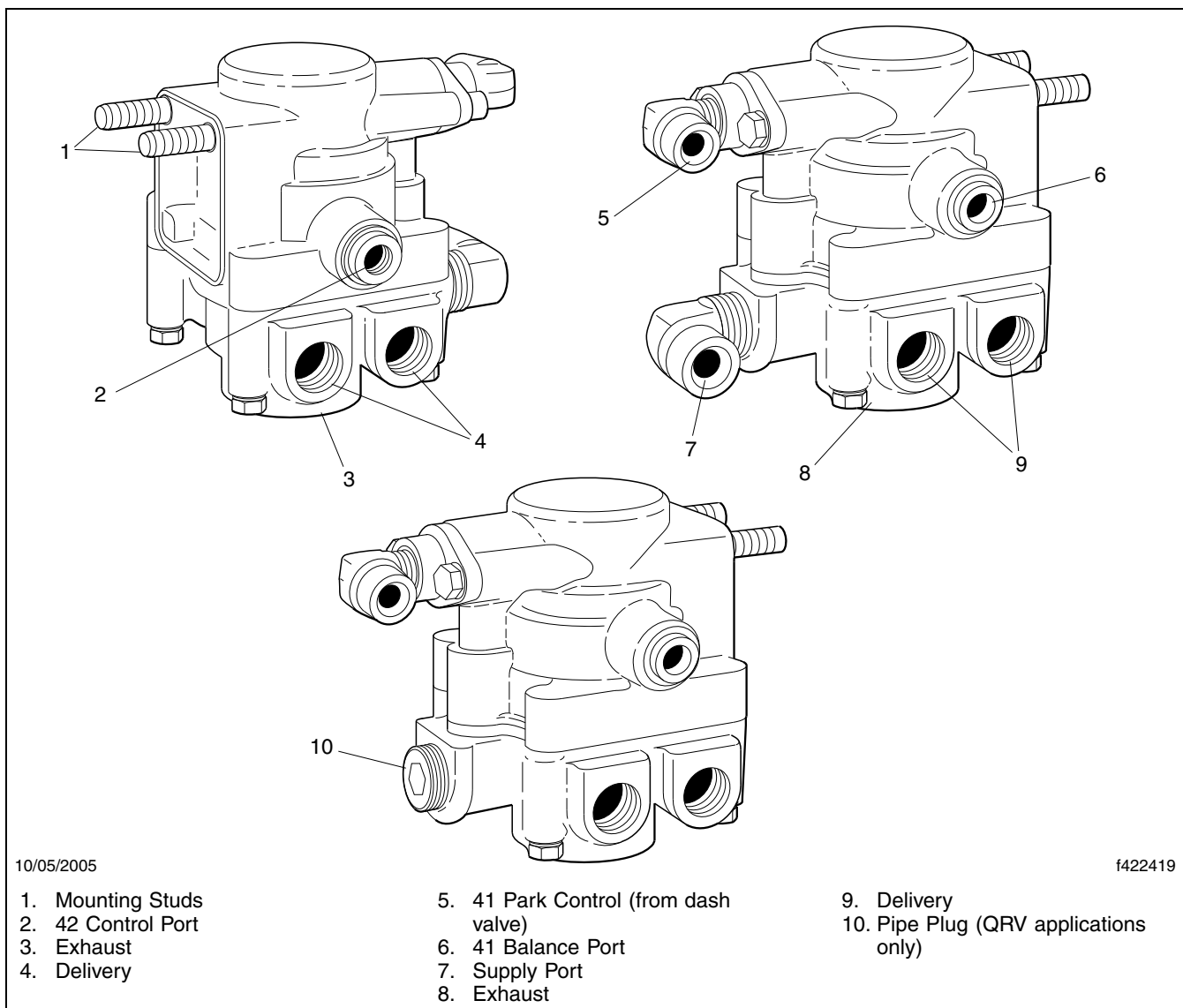


Fig. 6, SR-7 Spring Brake Modulating Valve (exterior views)

Parking Brake System

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- Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
- Prevents compounding of service and spring brake forces.

The SR-7 valve has one park control, one service control, one supply, one balance, four delivery NPT ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.

Dual Air Brake Chamber

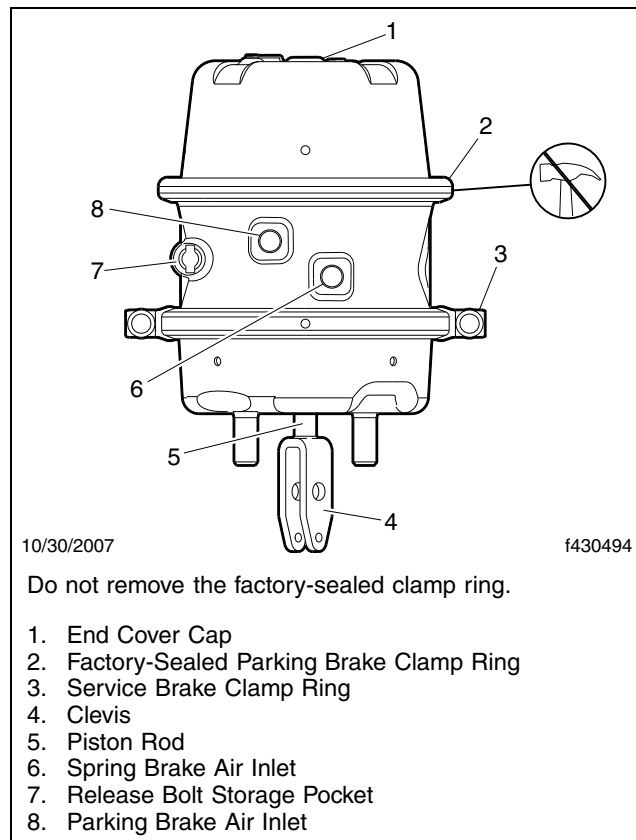


Fig. 7, Dual Air Brake Chamber

The air brake chambers are a standard 2 chambered design.

700 — Operating and Leakage Tests

The following tests should be performed if the parking brake system is not operating properly, and/or after repairing or replacing the valve, to ensure that it is functioning properly.

Quick Release Valve, Bendix QR-1C

1. Make sure the tires are properly chocked.

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2. Build system air pressure to 120 psi (827 kPa).
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Coat the exhaust and balance ports with a soap solution; leakage of a 1-inch (25-mm) bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes; the valve should exhaust air at the exhaust port.
6. Build system air pressure to 120 psi (827 kPa).
7. Remove the air line from the valve supply port. With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a 1-inch (25-mm) bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in **Group 42** of the *Cascadia™ Workshop Manual*.

Modulating Valve, Bendix SR-7



Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, or if leakage is excessive, replace it following the instructions in **Group 42** of the *Cascadia™ Workshop Manual*.

Operational Check

1. Make sure the tires are properly chocked.
2. Charge the air brake system to governor cut-out pressure.
3. Place the parking control valve in the PARK position. Observe that the spring brake actuators apply promptly.
4. Remove one line from a delivery port of the SR-7 valve and install a test gauge that is known to be accurate. See **Fig. 6** for the port locations.
5. Place the parking control valve in the RELEASE position. Observe that the spring brake actuators fully release.
6. With the parking control valve still in the RELEASE position, note the gauge pressure reading. Correct spring brake actuator hold-off pressure is 107 psi (737 kPa) nominal.
7. Place the parking control valve in the PARK position. The gauge reading should drop to zero promptly. A lag (more than 3 seconds) in the drop of pressure would indicate faulty operation.
8. With the parking control valve still in the PARK position, gradually apply the foot brake valve and note a pressure reading increase on the gauge installed in the SR-7 valve delivery port.
9. Place the parking control valve in the RELEASE position.
10. Drain the reservoir that supplies the rear service brake circuit; apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied (spring

Parking Brake System

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brake modulation). After the foot brake valve has been applied several times, the pressure reading on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

Leakage Test

Place the parking control valve in the RELEASE position; using a soap solution, coat all ports including the exhaust port. A 1-inch (25-mm) bubble in three seconds is permitted.

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500 — Terms and Abbreviations

Bellow—A rubber or polypropylene "boot" that is clamped over the ends of the rack and inner tie rods on the rack and pinion steering gear

I-Shaft—Intermediate Steering Shaft.

Poppet—A rising and falling valve consisting of a disk at the end of a vertically set stem. The poppet reduces power steering hydraulic pressure just before full right or left turns.

PSSA—Power Steering System Analyzer

501 — General Information

The power steering pump converts the rotational energy of the engine into hydraulic energy, flow, and pressure. The steering gear then uses this hydraulic energy to steer the vehicle.

The power steering pump creates a partial vacuum at the inlet, which causes atmospheric pressure to force the fluid into the pump from the reservoir. The pump then pushes the fluid into the system for use by the steering gear.

Pump output flow relates to steering gear speed, and the pump output pressure relates to steering gear force.

600 — Component Locations

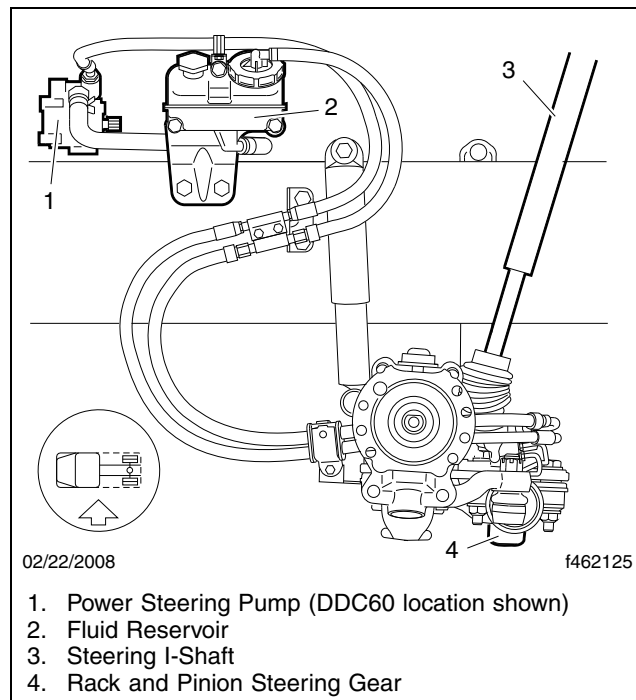


Fig. 1, Rack and Pinion Steering System

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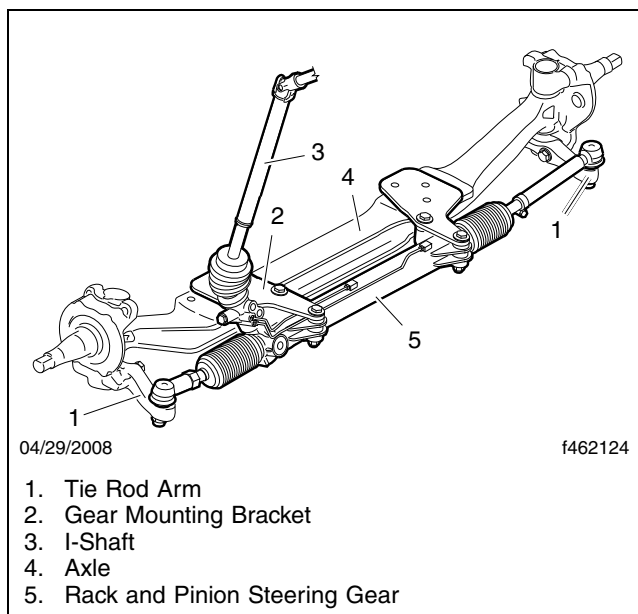


Fig. 2, Rack and Pinion Steering Gear

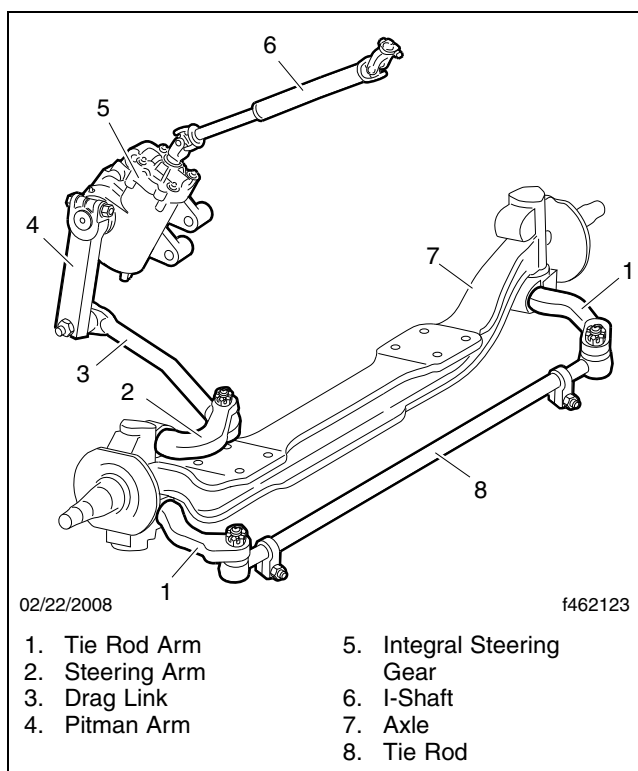


Fig. 3, Integral Steering Gear

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700 — Possible Causes

- Excessive Heat
- Contaminated Fluid
- External Damage
- Misaligned or Improperly Adjusted Components
- Excessive System Restriction

701 — Diagnostic Tools Required

- Power Steering System Analyzer (PSSA)
- Low Pressure Gauge, 200–300 psi (1380–2070 kPa) maximum
- Temperature Gauge
- Steering Stop Spacer, 1-inch

702 — Checklist for Troubleshooting Power Steering Problems

A Checklist for Troubleshooting Power Steering Problems, form STI-492, has been developed to accompany the procedure in **703 — Steering System Troubleshooting**. To access Form STI-492, follow the steps below.

1. Log into www.AccessFreightliner.com.
2. Under Applications, click on **WarrantyLit**.
3. Click on **Forms**.
4. Select "**Checklist for Troubleshooting Power Steering Problems (STI492)**."
5. Save or print form STI-492.

Each test in **703 — Steering System Troubleshooting** corresponds to a step on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with test 1 and finish with test 6.

Steering Complaint and Troubleshooting Steps Checklist												
LH	RH	Both	Complaint	Troubleshooting Steps								
				1	2	3	4	5	6	7	8	9
			Hard or heavy steering									
			Low assist									
			Binding	•	•		•	•	•	•	•	•
			Locking									
			Occasional loss of assist									
			Reduced wheel cut								•	

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Steering Complaint and Troubleshooting Steps Checklist												
LH	RH	Both	Complaint	Troubleshooting Steps								
				1	2	3	4	5	6	7	8	9
			Pulling to one side*	•		•			•			
			Darting/oversteering	•	•	•	•		•			
			Wandering									
			Noisy steering				•	•	•			
			External seals leaking					•	•			•
			Excessive heat									

* If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in the *Cascadia Workshop Manual* to ensure the brake system is functioning properly.

Table 1, Steering Complaint and Troubleshooting Steps Checklist

703 — Steering System Troubleshooting

Tests 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

1. Check the tire pressure and load.

- 1.1 Check the tires for damage.
- 1.2 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides.
- 1.3 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides.
- 1.4 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.
- 1.5 Make sure the vehicle is being operated within rated capacities.

Were any problems found with tire pressure and load?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

2. Check fifth wheel condition.

- 2.1 Check fifth wheel lubrication.
- 2.2 Check the plate surface for burrs, gouges, and irregularities.

Were any problems found with the fifth wheel?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

3. Check vehicle alignment and wheel bearing adjustment.

- 3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.

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- 3.2 Check front axle caster and camber measurements.
- 3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.
- 3.4 Ensure the rear axle is properly aligned.

Were any problems found with vehicle alignment and wheel bearing adjustment?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

4. **Check for loose and binding components. Check whether any steering components need maintenance or adjustment.**

- 4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Lubricate as needed.
- 4.2 Check the steering driveline U-joints for looseness or binding. Lubricate as needed.
- 4.3 Check the sector shaft adjustment.
 - With the vehicle on the ground, the engine idling, and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
 - Align a reference mark on the steering wheel to a rule, then, with the engine running, slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
 - Measure the lash (free play) at the rim of the steering wheel. Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.
- 4.4 Check that the front wheels self-return without binding.
 - With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
 - Disconnect the drag link from the steering arm.
 - By hand, pull one tire to the axle stop and release. The tire should self-return to almost straight ahead. Repeat with the opposite tire.
 - If a tire does not return to near straight ahead, check for binding or lack of lubrication in the steering axle kingpin bushings or tie rod linkage.
 - Connect the drag link and tighten the castle nut, then install a new cotter pin.

- 4.5 Inspect all suspension fasteners and components for wear or looseness.

Were any problems found with loose or binding components?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

5. **Check the steering system for leaks or restrictions, and test the system back pressure.**

- 5.1 Inspect hoses, fittings, and seals for damage or leaks.
 - With the engine idling, inspect for kinked or collapsed hoses. Ensure the steering system is filled with the correct automatic transmission fluid.
 - Inspect fittings for leaks.

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- Inspect all external seals.
- Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
- If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in test 6.

5.2 Inspect the steering gear for external leakage.

- Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
- Inspect the sector shaft for signs of leakage.
- Inspect the vent plug in the trunion housing for signs of leakage.

NOTICE

Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could occur.

5.3 Check total steering system back pressure.

- Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
- Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
- With the engine idling, read the total system back pressure on the pressure gauge.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system. If the system back pressure is still excessive, go to the next substep.
- If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to test 6.

5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See **Fig. 4** for a plumbing diagram.

- Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See **Fig. 5** for an example. If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the gear input and output lines to the gear and continue with this substep.
- If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together. If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.
- Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped. If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

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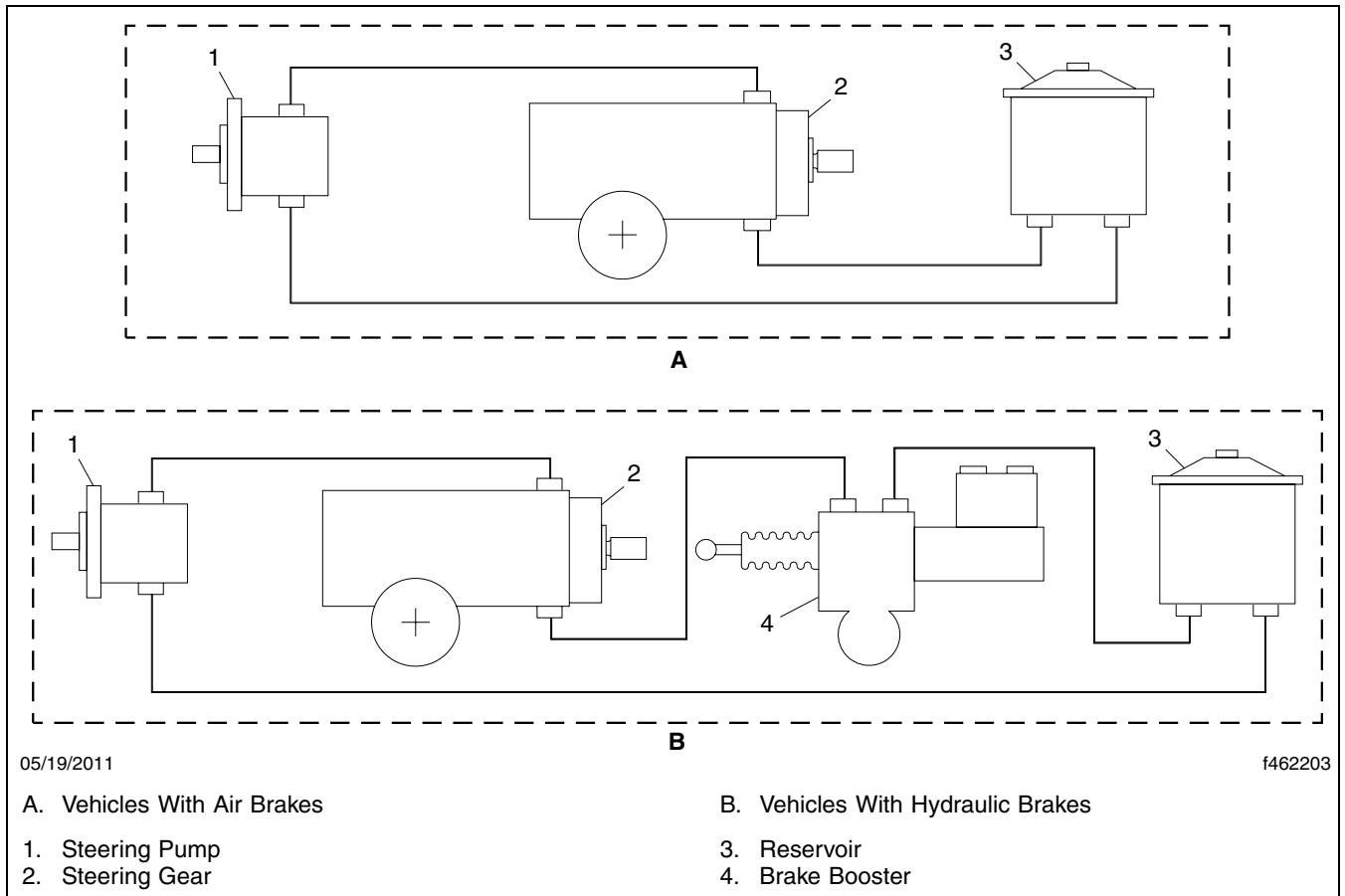


Fig. 4, Plumbing Diagrams

Were any problems found with leaks or system restriction?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

6. Check steering pump performance.

If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests again. If the system fails again, replace the pump.

Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions. Install the PSSA between the steering pump and the gear for the following substeps.

NOTICE

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

6.1 Check for erratic pump response.

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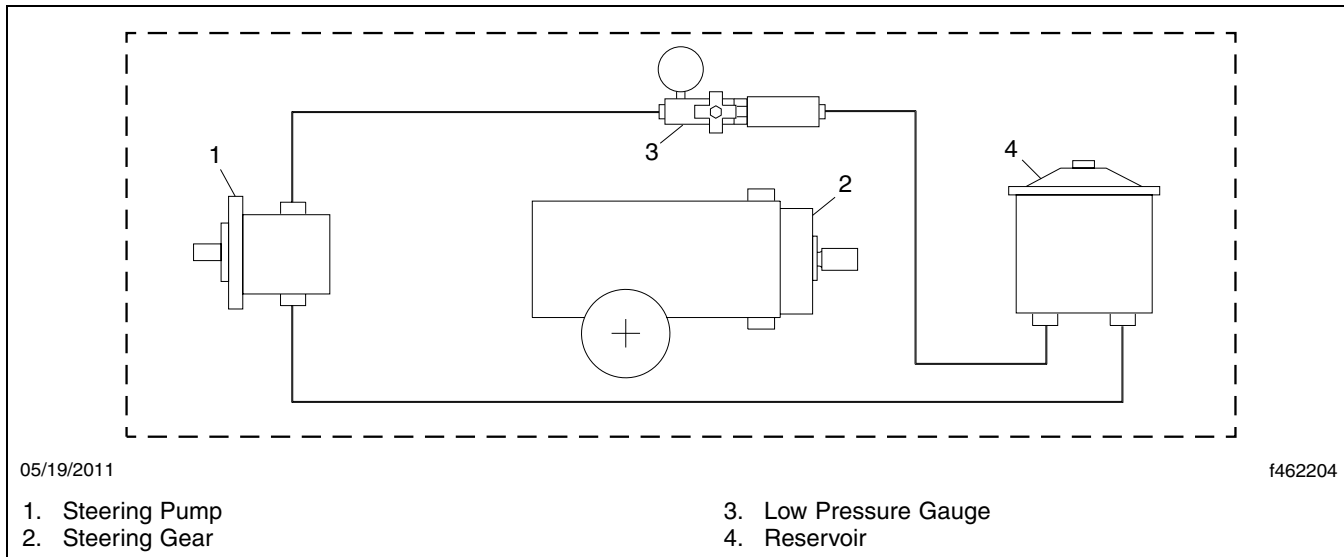


Fig. 5, Testing Steering Gear Restriction

- Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
- If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
- If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

6.2 Check the pump relief pressure.

- Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
- If the pump relief pressure does not exceed the typical relief pressure listed in **801 — Steering Gear Relief Pressures**, replace the PRV or pump, as required.
- If the pump relief pressure exceeds the typical relief pressure listed in **801 — Steering Gear Relief Pressures**, it is acceptable. Go to the next substep.

6.3 Test the pump relief valve reaction at idle.

- Run the engine at idle and note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.4 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm and note the flow rate with the load valve open.

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- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

IMPORTANT: For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the testload pressures.

6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **800 — Minimum Steering Pump Flow Rates**.

6.6 Test the flow of the pump with no load applied.

- Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
- If the flow rate is below the minimum indicated in **800 — Minimum Steering Pump Flow Rates**, replace the PRV or pump, as required.
- If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.

Were any problems found with pump performance?

YES → Replace the pump or PRV and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

7. Test the steering gear internal leakage.

Select TRW integral steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, **Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV**, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

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WARNING

Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.

- 7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

NOTICE

While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.

- 7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve. Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in sub-step 6.2).
- 7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.
- 7.5 Repeat the previous substeps for the opposite turn.

The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system using the substeps that follow.

- 7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.
- 7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.
- 7.8 Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder. If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

Were any problems found with steering gear internal leakage?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

8. Check the steering gear poppet relief valve and stop bolt adjustment.

- 8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is $\frac{1}{2}$ -inch (13-mm) clearance from all stationary components, and $\frac{3}{4}$ -inch (19-mm) clearance from all moving components.

- 8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

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NOTICE

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

8.3 Check the poppet relief pressure.

- Install the PSSA between the steering pump and the steering gear.
- Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
- The pressure should drop slightly before the stop bolts are contacted. If the pressure increases (from contact with the stop bolts), reset the poppets.
If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the *Cascadia Workshop Manual* for gear-specific information.

8.4 Check for normal hissing sound at full turn.

8.5 Check for abnormal power steering noise. See **Table 2** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

Power Steering System Noise	
Noise	Remedy
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
A change from the usual pump sound	Check the steering fluid reservoir for air bubbles and foam. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
Clicking noise during a turn	Check for loose steering components. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed.
Hissing when the steering wheel is at or near full turn	This is normal; no action is needed.
Steering Pump intake line is plugged	Drain the system. Clear the intake line if needed. Fill the system.
Air leak at the pump or reservoir connections, fittings, or shaft seal	Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed.
Pump input shaft is misaligned	Replace the pump.

Table 2, Power Steering System Noise

Were any problems found with the poppet valves?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

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NOTICE

If the system temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.

9. Test the system operating temperature.

- 9.1 Run the engine at governed speed.
- 9.2 Observe the power steering fluid temperature until it stabilizes.
- 9.3 Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- 9.4 If the temperature does not exceed 250°F (121°C) during the test, excessive heat is probably not the cause of the complaint.

If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem.

If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete test 5 again. If steering pump flow and relief pressures found in test 6 above were close to the maximum allowable, complete test 6 again.

Did system temperature exceed 250°F (121°C)?

YES → Fix the problem and re-evaluate the steering system complaint.

NO → Go to the next appropriate test.

Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 3** for a list of recommended leakage test components.

Internal Leakage Test Components			
Part	Available From	Part Number (Vendor P/N)	Item #, Fig. 6
Power Steering System Analyzer (PSSA)	SPX Kent-Moore	J-26487	5
PSSA Adaptor Kit	SPX Kent-Moore	J-28593	—
Relief Valve Plug	SPX Kent-Moore	J-37130	—
Connector, Straight Thread with O-Ring	Daimler Trucks PDC	23-11470-088	6
Power Steering Hose, 42"	Daimler Trucks PDC	14-12694-042	8
Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb	Daimler Trucks PDC	23-11321-001	9
Pipe Coupling, 3/8" NPT	Parker Hannifin	PH 3/8 GG S (3/8 GG-S)	10

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Internal Leakage Test Components			
Part	Available From	Part Number (Vendor P/N)	Item #, Fig. 6
Tee, Male JIC with Male NPT Branch *	Parker Hannifin	PH 8STXS (8 STX-S)	11
Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2)	Weatherhead	WH 9100X8X6 (9100x8x6)	12
Swivel Nut Run Tee	Parker Hannifin	PH 8 R6X S (8 R6X-S)	13
3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body	Parker Hannifin	B10-2-A6P (PH B102A6P)	14
Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob	Parker Hannifin	PH RAH101K30 (RAH101K30)	15

* Use steel 37 degree JIC fittings only.

Table 3, Internal Leakage Test Components

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

1. Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See **Fig. 6**.
2. Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in **Fig. 6**.
4. Install the PSSA and other test components as shown in **Fig. 6**.
5. Open the external relief valve on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
7. Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

NOTICE

Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.

8. With the engine on, close the shutoff valve on the PSSA.
9. Set the system relief pressure by closing the external relief valve until the gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
10. Continue with the steering gear internal leakage test (test 7 above).

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Power Steering System

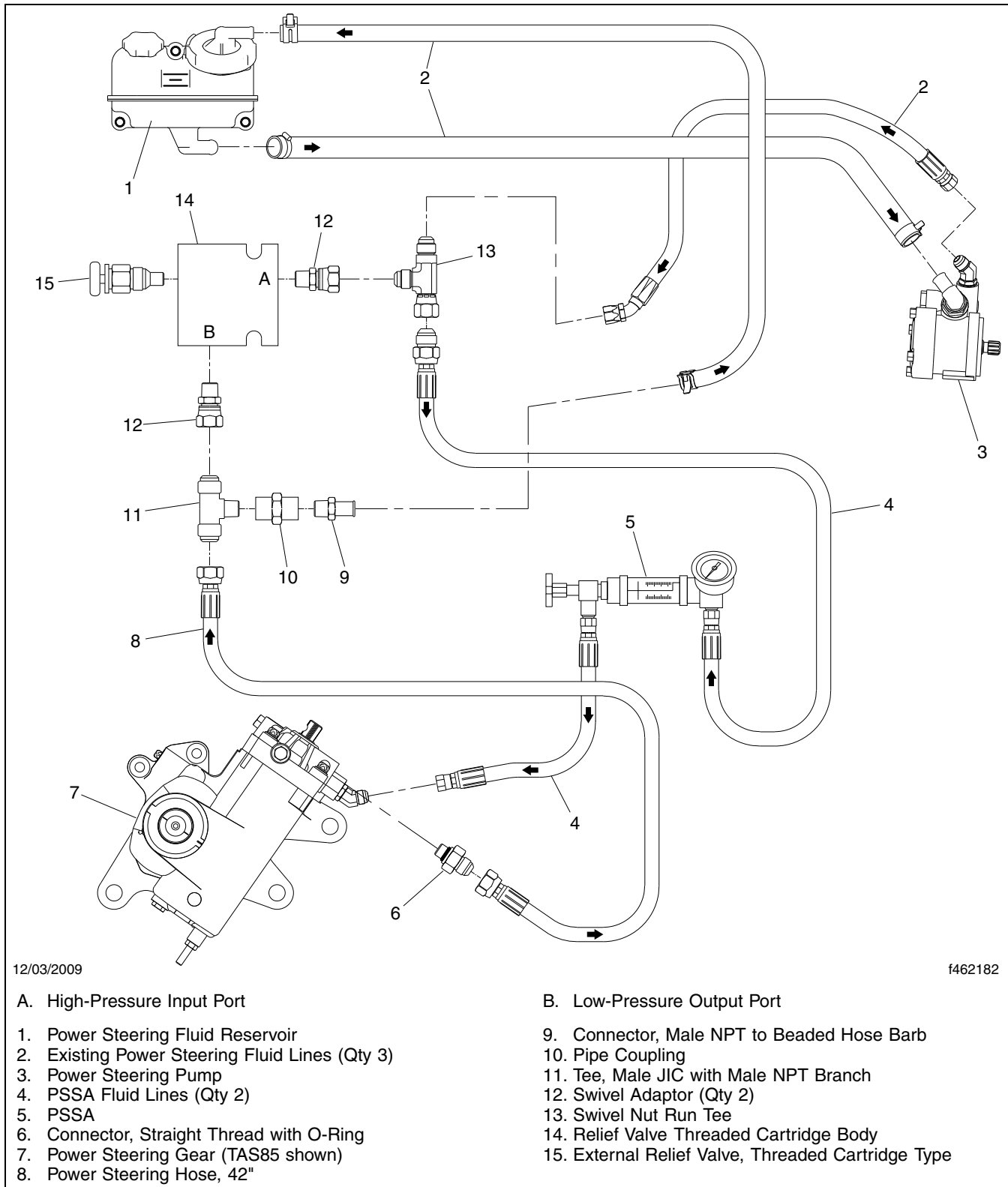


Fig. 6, Internal Leakage Test Component Installation

Power Steering System

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800 — Minimum Steering Pump Flow Rates

Minimum Measured Pump Flow Rates			
Steering Gear	Flow at 1500 rpm, No Load: gpm (L/min)	Flow at 1000 psi (6900 kPa): gpm (L/min)	Flow at 1800 psi (12 400 kPa): gpm (L/min)
Sheppard HD94	3.7 (14.0)	2.6 (9.8)	1.8 (6.8)
Sheppard M100		2.8 (10.6)	2.3 (8.7)
ThyssenKrupp LZS5 Rack and Pinion		3.3 (12.5)	2.8 (10.6)
TRW TAS40		2.1 (7.9)*	1.6 (6.1)
TRW TAS55		2.4 (9.1)*	1.9 (7.2)
TRW TAS65		2.8 (10.6)*	2.3 (8.7)
TRW TAS65 With C28 or C32 Linear Cylinder	5.8 (22.0)	4.9 (18.5)	4.4 (16.7)
TRW TAS65 With RCS65			
TRW TAS85	3.7 (14.0)	3.3 (12.5)	2.8 (10.6)
TRW TAS85 With C28 or C32 Linear Cylinder	5.8 (22.0)	5.4 (20.4)*	4.9 (18.5)
TRW TAS85 With RCS65			
TRW THP45	3.7 (14.0)	2.2 (8.3)	1.4 (5.3)
TRW THP60 or PCF60		2.6 (9.8)	1.8 (6.8)
TRW THP60 With Linear Cylinder	5.8 (22.0)	4.1 (15.5)	3.3 (12.5)
TRW THP60 With RCH45			

* Approximate value based on flow at 1800 psi (12 400 kPa).

Table 4, Minimum Measured Pump Flow Rates

801 — Steering Gear Relief Pressures

Typical Steering Gear Relief Pressure at Engine Idle	
Steering Gear	Typical Relief Pressure: psi (kPa)
Sheppard HD94	2683 ± 100 (18 500 ± 700)
Sheppard M100	2175 ± 100 (15 000 ± 700)
ThyssenKrupp LZS5 Rack and Pinion	2300 ± 116 (15 500 ± 800)
TRW TAS40	2175 ± 100 (15 000 ± 700)*
TRW TAS55	
TRW TAS65	
TRW TAS85	
TRW TAS65 With C28 or C32 Linear Cylinder	
TRW TAS65 With RCS65	
TRW TAS85 With C28 or C32 Linear Cylinder	
TRW TAS85 With RCS65	

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Power Steering System

Typical Steering Gear Relief Pressure at Engine Idle	
Steering Gear	Typical Relief Pressure: psi (kPa)
TRW THP45	2683 ± 100 (18 500 ± 700)
TRW THP60 or PCF60	
TRW THP60 With Linear Cylinder	
TRW THP60 With RCH45	

* On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

Table 5, Typical Steering Gear Relief Pressure at Engine Idle

Starting and Charging

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500 — Terms and Abbreviations

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

ETPDM—Engine Transmission Power Distribution Module; also referred to as the power train power distribution module.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

IMS—Integrated Magnetic Switch

MFJB—MEGA[®] Fuse Junction Block

MGJB—Main Ground Junction Block

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address; indicates numeric assignment for a device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SOC—State of Charge

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The starting and charging system consists of three main elements: the battery system, the charging system, and the starting system. These systems provide the starting capability of the vehicle, and supply power to all of the electrical and electronic systems.

It is important that all three elements are well maintained for the overall health of the system. Poorly charged batteries, or bad connections, can cause premature failure to any or all of the elements of the starting and charging system.

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600 — Component Locations

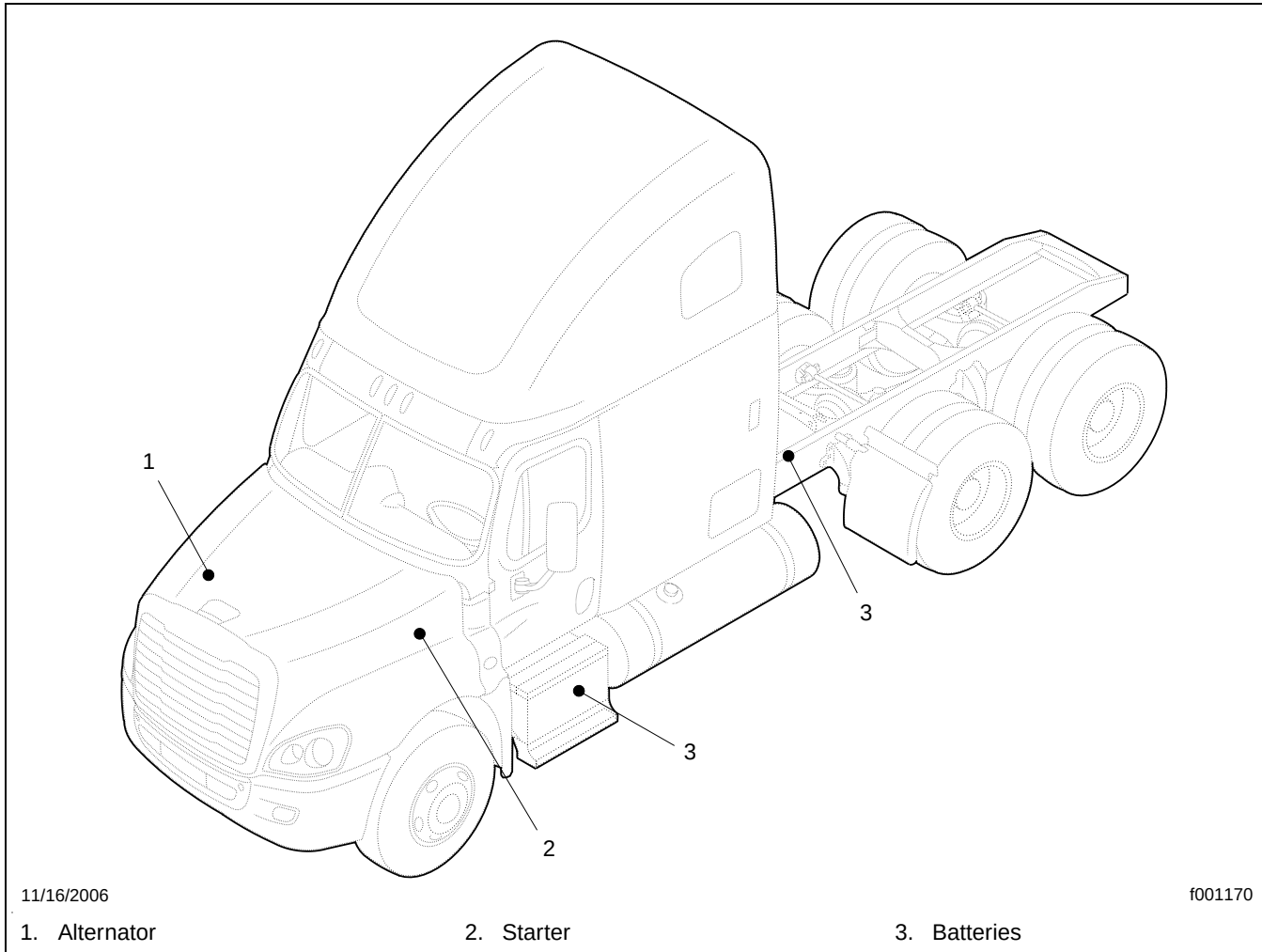


Fig. 1, Component Locations

601 — Component Details

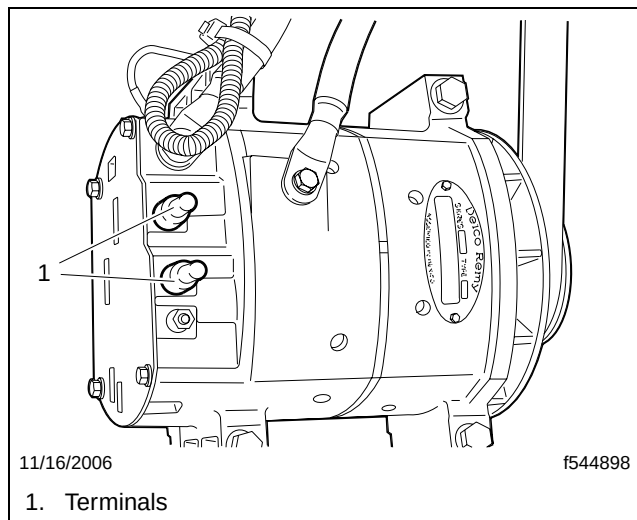


Fig. 2, Alternator

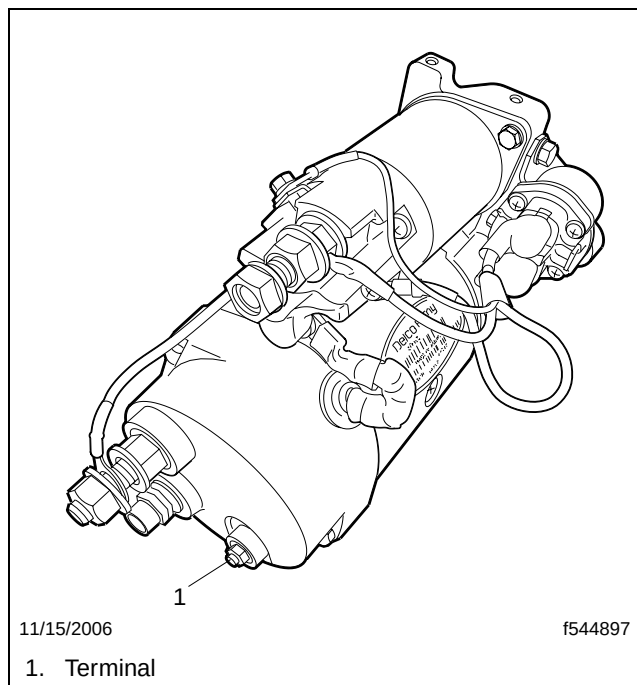


Fig. 3, Planetary Gear Reduction Starter

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700 — Battery System Diagnostics

Diagnostic Tools Required

- Approved Battery Tester

Possible Causes

Age—Batteries are perishable components, eventually wearing out through a process of sulfating.

Excessive Heat—If batteries are subjected to excessive temperatures, the positive plates quickly become corroded.

Cold Weather—The viscosity of engine oils decreases in cold temperatures, making engines harder to crank. This places a heavier and longer-lasting drain on the battery.

Vibration—If a battery is not securely fastened to the vehicle frame, the resulting vibration can shed the active material from the battery plate grids.

Fast Charging—Using a high charging rate to quickly charge batteries can be damaging, if the battery becomes overheated and begins gassing.

Deep Cycling—Repeated deep cycling eventually causes a battery to lose its ability to accept a charge.

Diagnostic Tests

1. **Check the battery pack state of charge (SOC).**

- 1.1 Remove the surface charge from the battery pack.
- 1.2 Shut down the engine.
- 1.3 Turn on the headlights for 2 to 3 minutes or until the battery voltage is down to 12.6 volts.

Is the battery pack at 75% SOC (12.4 volts) or higher? Refer to **800 — Battery State of Charge** to verify the voltage.

YES → Go to test 2.

NO → Charge the batteries until they are at least at 12.4 volts with the surface charge removed, then proceed to test 3.

2. **Check the condition of the batteries.**

- 2.1 Disconnect the battery pack.
- 2.2 Test the batteries individually using an approved tester.

Do all of the batteries pass the battery test?

YES → Go to test 4.

NO → Replace the batteries.

3. **Reconnect the battery pack.**

Were any of the batteries replaced, or corroded terminals repaired?

YES → Re-evaluate the starting and charging system symptoms.

NO → Go to test 4.

Starting and Charging

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4. Attempt to start the engine.

Does the engine start normally using only the onboard batteries?

YES → Go to **701 — Charging System Diagnostics**.

NO → Go to **702 — Starting System Diagnostics**.

701 — Charging System Diagnostics

Theory of Operation

The charging system consists of the alternator, drive belt, charging circuits, and sometimes sensing circuits. A current is sent through the slip rings on the alternator rotor, creating a magnetic field around the rotor. The drive belt then spins the rotor creating a rotating magnetic field that crosses the alternator stator. This creates a current that gets sent through the batteries to charge and maintain the battery system.

NOTE: Perform battery tests prior to testing the charging system. Defective or discharged batteries will cause invalid test results for the charging system.

Diagnostic Tools Required

- Approved alternator tester
- Volt/ohmmeter
- Clamp-on induction ammeter
- Carbon pile load tester
- Long test leads

Possible Causes

Excessive Heat: Alternators may become damaged if operated at excessive temperatures for an extended period of time. Modern heavy-duty alternators are designed to operate under the hood, where temperatures are high, however the alternator cooling capabilities need to be maintained. This means the alternator needs to be clean, and have adequate air flow.

Dirt or Oil Buildup: Charging system components operate less efficiently when a buildup of dirt or oil form around wire and cable connection points. Dirty connection points impair the flow of electrical current.

Vibration: If charging system components are poorly or loosely mounted, the resulting vibration can damage sensitive internal components. A loosely mounted component will also diminish the performance of the belt drives. This is very important on high-powered engines.

Diagnostic Tests

1. Measure the voltage at the alternator output terminal.

- 1.1 Shut down the engine.
- 1.2 Connect the alternator tester or voltmeter to the output and ground terminals of the alternator.
- 1.3 Check for battery voltage at the alternator output.

Is there battery voltage between the alternator output and ground terminals?

YES → Go to test 2.

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NO → Troubleshoot the alternator charging circuit. Inspect for loose, missing, or corroded connections between the alternator output to the un-fused side of the MFJB, then from the MFJB to the batteries. Continue checking the ground side from the alternator to the MGJB, then to the batteries.

2. **Measure the alternator's no load output voltage at 1500 rpm.**

2.1 Start the engine and turn off all electrical loads.

2.2 Run the engine at 1500 rpm for a few minutes to stabilize the charging system.

2.3 Measure the alternator output voltage at 1500 rpm with no electrical loads on.

Is the "no load" output voltage between 13.8 and 14.2 volts?

YES → Go to test 3.

NO → If undercharging, replace the alternator.

If overcharging, check the remote sense fuse in the battery box (if equipped), and the remote sense circuit (123E). If overcharging continues, replace the alternator.

3. **Measure the alternator output voltage with loads applied.**

3.1 Clamp the induction ammeter onto the alternator output cable, at least 6 inches (152 mm) from the alternator.

3.2 With the engine running at 1500 rpm, turn on electrical loads (front and rear blower motors, headlights, road lamps) until the ammeter reads between 60 and 75 amps.

3.3 Measure the output voltage of the alternator.

Is the alternator output voltage 13.6 volts or above?

YES → Go to test 4.

NO → Replace the alternator.

4. **Perform an alternator amperage output test.**

4.1 Connect a carbon pile load tester to the batteries.

4.2 Run the engine at 1500 rpm.

4.3 Adjust the carbon pile tester until the induction ammeter reads its maximum output current.

4.4 Remove the carbon pile load tester from the batteries, and return the engine to idle.

Is the maximum alternator output current at least 85% of its rated value?

YES → Go to test 5.

NO → Replace the alternator.

5. **Check for voltage drop from the alternator output to the batteries.**

5.1 Connect a voltmeter between the alternator output terminal, and the battery positive terminal.

5.2 With the engine running at 1500 rpm, turn on electrical loads (front and rear blower motors, headlights, road lamps).

5.3 Measure the voltage drop from the alternator to the batteries.

Is the voltage drop 0.5 volts or less?

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YES → The charging system is working properly.

NO → Go to test 6.

6. Check the charging system connections, cables, and terminals.

- 6.1 Check all connections between the batteries, MFJB, and alternator for tightness and signs of corrosion. Correct as necessary.
- 6.2 Check all cables for breaks or partial breaks. Repair as necessary.
- 6.3 Check each ring terminal for breakage at the point where it attaches to the cable or wire. Repair as necessary.
- 6.4 Repeat test 5 after repairs are made to check for adequate voltage drop (less than 0.5 volt).

702 — Starting System Diagnostics

Fault Codes

CAN Fault — Starter Relay				
SA	SPN	FMI	Fault Description	Fault Trigger
33	522003	4	Starter relay — current above normal or grounded circuit.	This Fault is triggered when the ignition switch is in the "CRANK" position, and pin X19.3 senses greater than 7.0 amps. The fault becomes inactive when pin X19.3 senses less than 4.0 amps.

Theory of Operation

The starting system converts electrical energy from the batteries into mechanical energy to start the engine. The starter motor is a small but powerful electric motor that delivers a large amount of power in a short period of time. When the starter motor is energized, it engages the ring gear and produces torque, which turns the flywheel and cranks the engine.

When the ignition switch is released from the start position to the run position, the solenoid is deactivated. Its internal return springs cause the drive pinion to be pulled out of mesh with the flywheel, and the starter motor stops.

The starter relay control is a function of the SAM Cab. It is parameterized for transmission type, engine speed settings, and several time delay settings.

Starter Relay

On the Cascadia, the ignition switch is de-coupled from the starter relay. The SAM Cab activates an output to drive the starter relay. There may be other interlocks and control mechanisms between the SAM Cab and the starter relay depending on the make of the engine and transmission. On a vehicle with an Eaton automated transmission, a safety interlock relay is provided between the SAM Cab starter relay output and the starter relay.

Three criteria determine when the starter motor can be turned on:

- **Safety:** One of three conditions must be met before the starter motor can be activated. The bottom-of-clutch switch must be closed, the neutral switch must be closed, or a CAN message from the transmission

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ECU indicates that it is safe to activate the starter motor. The safety condition depends on which parameters are programmed on the vehicle.

- **User Control:** The driver requests an engine start by turning the ignition switch.
- **Reliability:** The SAM cab provides anti-grinding protection and thermal protection to the starter motor. When certain conditions exist that may damage the starter motor, the SAM Cab prevents cranking for a set period of time to protect the starter motor.

Anti-grinding Protection Rules:

- The engine speed must be less than 100 rpm to initiate a crank cycle.
- The crank cycle is terminated when the engine speed exceeds 300 rpm.

Thermal Protection Rules:

If the engine speed does not exceed 100 rpm during the crank cycle, cranking is terminated after a maximum of 5 seconds, even if the driver continues to hold the ignition key in the start (crank) position. Cranking can be initiated again after a 30-second cool-down period. This situation occurs when the engine is stalled due to a mechanical failure and excessive heat builds up in the starter motor.

When the engine speed exceeds 150 rpm but does not exceed 300 rpm during the crank cycle, cranking is terminated after a maximum of 10 seconds, even if the driver holds the the ignition key in the start (crank) position. Cranking can be initiated again after a 30-second cool-down period. This situation occurs when the engine is running and turning properly but cranking is still initiated. The termination of cranking protects the starter after the engine is fired.

Diagnostic Tools Required

- Approved alternator tester
- volt/ohmmeter
- carbon pile load tester
- long test leads

Possible Causes

Battery Charge: A battery having a low/poor SOC places abnormal stress on the starting system.

Operator Abuse: Engaging the starter into a running ring gear, starter overrun, and cranking the starter for too long are all extremely damaging to the starting system.

Excessive Heat: Excessive heat is generally due to continuous engagement of the starter. The starter should operate for 30 seconds maximum, then let it cool down for 2 minutes.

Excessive Vibration: If starting system components are poorly or loosely mounted to the vehicle's engine, the resulting vibration can damage sensitive internal components.

Corrosion, Dirt, and Dust: Starting system components operate less efficiently when corrosion forms or dirt particles build up around wire and cable connection points. Corroded and dirty connection points impair the flow of electrical current.

Diagnostic Tests

NOTE: While performing these tests, do not crank the starter for more than 30 seconds. Allow 2 minutes between each cranking of the starter to allow the starter to cool.

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NOTE: Perform battery tests prior to testing the starting system. Inoperable or discharged batteries will cause invalid test results for the starting system.

1. **Verify complaint, and note symptoms.**

1.1 Crank the engine using only onboard starting batteries.

1.2 Note any symptoms related to the starting system.

Does the starter crank normally?

YES → Interview driver to determine the complaint. If the complaint involves the starting system, but the symptoms were intermittent, try allowing the engine to cool before testing the complaint again.

NO → Go to step 2.

2. **Perform a visual inspection of the starting system cables, wires, and components.**

2.1 Verify all connections to the magnetic switch, starter BAT, GND, and 'S' terminals.

2.2 Inspect the starter, solenoid, and the magnetic switch for physical damage.

Were any loose or missing connections found, or damaged starting system components found?

YES → Repair as needed, and reevaluate the starting system complaint.

NO → Go to appropriate tests based on the symptoms you experienced.

Starter Cranks Slowly

1. **Disable the engine ECM to allow cranking without starting the engine.**

1.1 Locate the Engine Transmission Power Distribution Module (ETPDM) in the driver's side of the engine compartment.

1.2 Remove the fuse(s) for the engine ECM.

2. **Check available cranking voltage at the starter.**

2.1 Attach a long jumper lead from the battery negative post, to the negative lead of the voltmeter.

2.2 Connect the positive lead of the voltmeter to the three locations listed below, measuring voltage at each point, one at a time while the starter is cranking.

- starter solenoid battery terminal
- starter solenoid motor terminal
- starter ground terminal

3. **Check available cranking voltage at the battery pack.**

3.1 Connect the positive lead of the voltmeter to the positive battery post.

3.2 Have an assistant crank the starter.

3.3 Measure the voltage at the battery pack while cranking the starter.

4. **Compare voltages from tests 2 and 3.**

Is there more than one volt difference between the starter solenoid battery terminal voltage and battery voltage?

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YES → There is a bad connection between the batteries and the starter. Refer to **703 — Battery Cable Voltage Drop Tests** to troubleshoot the connection.

NO → Go to the next question.

Is there more than one volt difference between solenoid motor terminal voltage and battery voltage?

YES → Replace the starter. The solenoid has failed.

NO → Go to the next question.

Is there more than one volt reading when measuring between the starter ground terminal and the battery ground terminal while cranking?

YES → There is a bad connection between the starter and battery negative terminal. Refer to **703 — Battery Cable Voltage Drop Tests** to troubleshoot the connection.

NO → The problem may be with the starter. Rule out other conditions such as cold start (thick oil) or engine problems prior to replacing the starter.

5. Install the engine ECM fuse(s) in the ETPDM.

Starter Will Not Turn, Starter Solenoid and Magnetic Switch Click

NOTE: If the engine is locked, the starter will be drawing a large amount of current even though the starter is not turning. If the starter solenoid makes a loud clunk and the starter cables become warm quickly or jump when the key is turned to the start position, check for a mechanical problem with the engine before continuing.

1. **Check available cranking voltage at the starter.**

- 1.1 Attach a long jumper lead from the battery negative post, to the negative lead of the voltmeter.
- 1.2 Connect the positive lead of the voltmeter to the three locations listed below, measuring voltage at each point, one at a time while the key is being held in the start position.
 - starter solenoid battery terminal
 - starter solenoid motor terminal
 - starter ground terminal

2. **Check available cranking voltage at the battery pack.**

- 2.1 Connect the positive lead of the voltmeter to the positive battery post.
- 2.2 Have an assistant turn the key to the start position.
- 2.3 Measure the voltage at the battery pack while holding the key in the start position.

3. **Compare voltages from tests 1 and 2.**

Is there more than one volt difference between the starter solenoid battery terminal voltage and battery voltage?

YES → There is a bad connection between the batteries and the starter; conduct voltage drop tests. Refer to **703 — Battery Cable Voltage Drop Tests** to troubleshoot the connection.

NO → Go to the next question.

Is there more than one volt difference between solenoid motor terminal voltage and battery voltage?

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YES → Replace the starter. The solenoid has failed.

NO → Go to the next question.

Is there more than one volt reading when measuring between the starter ground terminal and the battery ground terminal while the key is being held in the start position?

YES → There is a bad connection between the starter and battery negative terminal; conduct voltage drop tests. Refer to **703 — Battery Cable Voltage Drop Tests** to troubleshoot the connection.

NO → The problem may be with the starter. Rule out other conditions, such as engine problems, prior to replacing the starter.

Starter Will Not Turn, but the Magnetic Switch Clicks.

1. Check available cranking voltage at the starter.

- 1.1 Attach a long jumper lead from the battery negative post, to the negative lead of the voltmeter.
- 1.2 Connect the positive lead of the voltmeter to the three locations listed below, measuring voltage at each point, one at a time while the key is being held in the start position.
 - starter solenoid 'S' terminal
 - magnetic switch starter terminal
 - magnetic switch battery terminal

2. Check available cranking voltage at the battery pack.

- 2.1 Connect the positive lead of the voltmeter to the positive battery post.
- 2.2 Have an assistant turn the key to the start position.
- 2.3 Measure the voltage at the battery pack while holding the key in the start position.

3. Compare voltages from tests 1 and 2.

Is there more than one volt difference between the starter solenoid 'S' terminal voltage and battery voltage?

YES → Go to the next question.

NO → Move the lead to the starter ground terminal.

Is there less than one volt while the key is in the start position?

YES → Replace the starter.

NO → Repair the starter ground circuit

Is there more than one volt difference between magnetic switch starter terminal voltage and battery voltage?

YES → Go to the next question.

NO → There is a problem between the magnetic switch and the starter solenoid 'S' terminal. Repair the solenoid. Refer to the *Cascadia Workshop Manual* for instructions.

Is there more than one volt difference between magnetic switch battery terminal voltage and battery voltage?

YES → There is a bad connection between the battery supply and the magnetic switch. Check the connection from the magnetic switch battery terminal to the MFJB, and repair as required.

NO → Replace the magnetic switch. Refer to the *Cascadia Workshop Manual* for instructions.

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Starter Will Not Turn, No Clicking Noise

1. **Check voltage at the magnetic switch ignition and ground terminal.**

- 1.1 Attach a long jumper lead from the battery negative post, to the negative lead of a voltmeter.
- 1.2 Connect the positive lead of the voltmeter to the two locations listed below, measuring voltage at each point, one at a time while the key is being held in the start position.
 - magnetic switch ignition terminal
 - magnetic switch ground terminal

2. **Check available cranking voltage at the battery pack.**

- 2.1 Connect the positive lead of the voltmeter to the positive battery post.
- 2.2 Have an assistant turn the key to the start position.
- 2.3 Measure the voltage at the battery pack while the key is being held in the start position.

3. **Compare voltages from tests 1 and 2.**

Is there more than one volt difference between the magnetic switch ignition terminal voltage and battery voltage?

YES → There is a problem in the ignition input circuit to the magnetic switch, or the starter interlocks. This signal comes from the SAM Cab. See **801 — Starter Crank Interlocks** for details about crank enable conditions. Use the "Starter Relay/Crank Enable" Datalink Monitor template to view the interlock signals to the SAM Cab.

NO → Continue to the ground terminal.

Is there more than 0.5 volts at the magnetic switch ground terminal?

YES → The ground circuit has high resistance.

NO → Replace the magnetic switch.

Starter Makes Clicking Noise, But Does Not Crank (or cranks intermittently)

1. **Check voltage at the starter solenoid 'S' terminal.**

- 1.1 Attach a long jumper lead from the battery negative post, to the negative lead of the voltmeter.
- 1.2 Connect the positive lead of the voltmeter to the solenoid "S" terminal.
- 1.3 Have an assistant turn the key to the start position.
- 1.4 Measure the voltage.

Is there more than 6 volts at the solenoid 'S' terminal?

YES → Go to test 2.

NO → Troubleshoot the magnetic switch and circuitry.

2. **Inspect the pinion and ring gear.**

- 2.1 Remove the starter.
- 2.2 Visually inspect the pinion gear.

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2.3 Visually inspect the ring gear.

NOTE: If a milled ring and/or pinion gear is the cause of the starting system problems, evaluate the root cause of this condition. Interview the driver to ensure proper starting procedures are being followed.

Is the pinion or ring gear milled or chipped?

YES → Replace the starter and/or ring gear as required.

NO → Install the starter, and reevaluate the starting system symptoms.

703 — Battery Cable Voltage Drop Tests

1. Set-up the carbon pile tester.

1.1 Connect the positive lead of the carbon pile tester to the starter solenoid 'B' terminal.

1.2 Connect the negative lead of the carbon pile tester to the starter 'G' terminal.

2. Measure V1.

2.1 Connect the positive lead of the voltmeter to the battery positive terminal.

2.2 Connect the negative lead of the voltmeter to the starter 'B' terminal.

2.3 Turn the carbon pile tester to 500 amp load.

2.4 Measure the voltage; record as V1.

2.5 Turn off the carbon pile tester.

3. Measure V2.

3.1 Connect the negative lead of the voltmeter to the battery negative terminal.

3.2 Connect the positive lead of the voltmeter to the starter 'G' terminal.

3.3 Turn the carbon pile tester to 500 amp load.

3.4 Measure the voltage; record as V2.

3.5 Turn off the carbon pile tester.

4. Add voltage losses.

Is $V1 + V2$ greater than 0.50 volts?

YES → Isolate the defective cables, and repair or replace.

NO → Go to test 5.

5. Measure voltages at each battery terminal.

5.1 Have one person turn the carbon pile tester to 500 amp load.

5.2 A second person measures voltage across each battery.

5.3 Turn the carbon pile tester off after voltages are measured.

Is there a difference of more than 0.50 volts between any of the batteries?

YES → Repair or replace defective interconnecting battery cables.

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NO → Voltage loss on the battery cables is not the cause of the problem.

800 — Battery State of Charge

Open Circuit Voltage	State of Charge
12.6V	100%
12.4V	75%
12.2V	50%
12.0V	25%
11.8V	0%

Table 1, Battery State of Charge

801 — Starter Crank Interlocks

There are five different crank enable configurations depending on how the vehicle is programmed. These are all inputs to the SAM Cab, where the output is to the magnetic switch.

Starter Crank Interlocks					
Configuration	Ignition	Bottom of Clutch Switch	Neutral Switch	J1939 Neutral Message	Engine rpm
1	Crank	Closed	—	—	<= set parameter value
2	Crank	—	Closed	—	<= set parameter value
3	Crank	Closed	Closed	—	<= set parameter value
4	Crank	—	—	N	<= set parameter value
5	Crank	—	—	—	<= set parameter value

Table 2, Starter Crank Interlocks

802 — Parameters

Parameters				
Module Number	Part Number	Description	Parameter	ECU
12C	002 447 49 58	Alternator charging disabled.	PARM-CAB, ALC, NO CNT	SAM Cab
	002 447 50 58	Alternator charging enabled.	PARM-CAB, ALC, ENABLE	
156	002 447 24 58	Manual and Eaton AS transmission with bottom-of-clutch switch.	PARM-CAB, STR, MAN, BCS	
	002 447 27 58	Allison Automatic transmission with J1939 ETC7.	PARM-CAB, STR, AUT, ETC7	
	002 447 28 58	Eaton DM automatic transmission with transmission ECU interlock.	PARM-CAB, STR, AUT, DG	

Table 3, Parameters

Clutch

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500 — Hydraulic Clutch Control System

The hydraulic clutch control system consists of a pedal unit and a slave cylinder, connected by a hydraulic hose and fastened with quick-disconnect clip. The components of the system have been specially designed to use DOT 4 brake fluid.

The pedal unit includes a hydraulic subassembly, composed of the master cylinder and reservoir, which can be removed from the pedal unit for service purposes.

When the clutch pedal is depressed, the fluid in the master cylinder is forced through a hydraulic line to the slave cylinder. The fluid pressure moves the slave cylinder piston, pushing the plunger rod and clutch release lever, which disengages the clutch.

The hydraulic system is self-adjusting.

501 — Clutches

The primary purpose of the clutch is to transfer the power of the engine from the engine flywheel to the transmission. At the point where the clutch engagement begins (clutch pedal partially released), the transmission input shaft may be stationary, as when the vehicle is not moving, or it may be rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. Once the clutch is fully engaged (clutch pedal fully released), both the engine flywheel and the transmission input shaft will be rotating at the same speed.

The secondary purpose of the clutch is to dampen unwanted vibrations that normally exist in the driveline system. The springs within each driven disc provide a flexible link between the friction surface and the disc hubs. Dampened clutch discs are specifically designed to prolong the life of the drivetrain components by reducing vibrations from the engine, non-uniform U-joint angles, and road dips and bumps.

When the vehicle is stationary, the clutch brake permits shifting into first gear or reverse gear without severe gear clash. The clutch brake is between the release bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release bearing housing transmission bearing cap, stopping the rotation of the main drive gear. The clutch brake may be a disc type or a torque-limiting type. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 24 N·m) are reached. The clutch brakes are not designed for upshifting.

502 — Eaton Solo 15.5-Inch Clutch

Eaton Fuller Solo clutches are adjustment-free. As the clutch wears, its wear-adjusting technology monitors clutch components and makes any necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam's movement, indicating when it's time to replace the clutch and showing how much clutch life remains.

P02.01

Clutch

600 — Component Locations

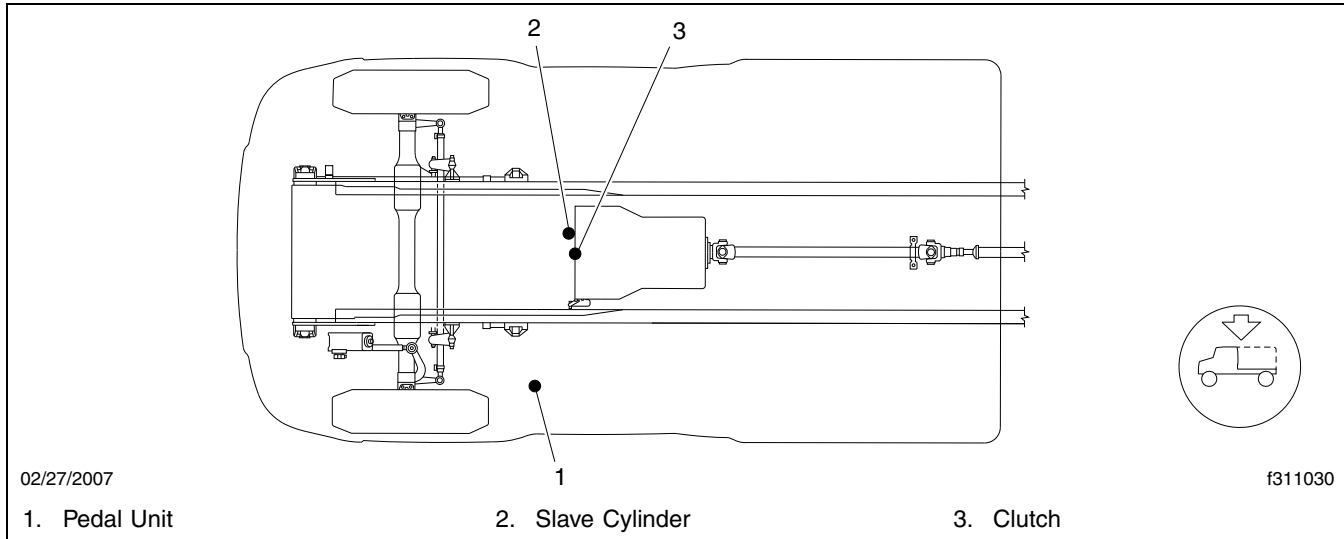


Fig. 1, Component Locations

601 — Component Details

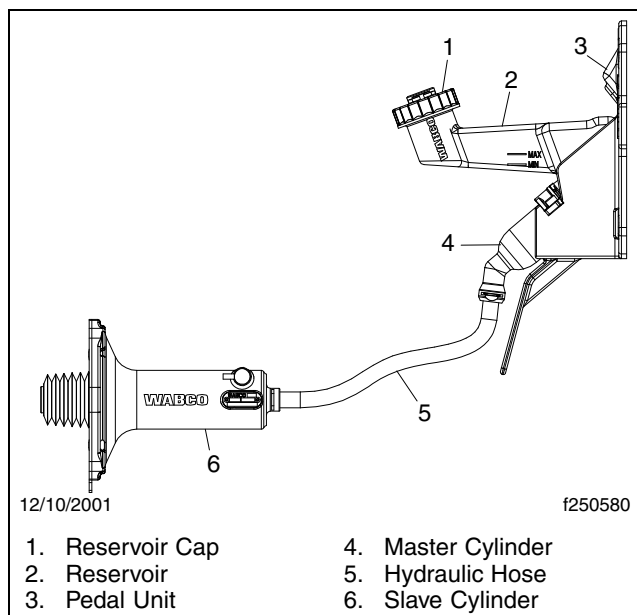


Fig. 2, Hydraulic Clutch Control Components

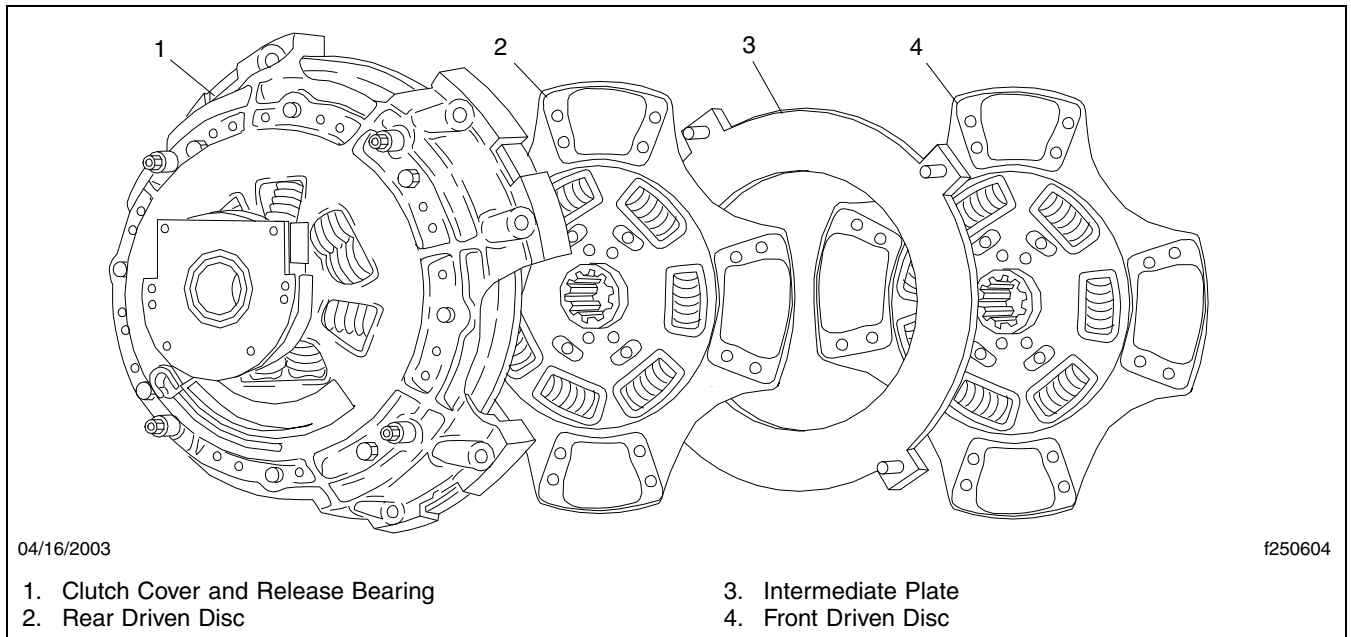


Fig. 3, Solo Clutch

700 — Clutch Troubleshooting

References

www.roadranger.com

701 — Clutch Control Switch Check

1. Check the condition of the clutch control switch connector, as follows.
 - 1.1 Disconnect the clutch control switch connector located under the dash just above the clutch pedal.
 - 1.2 Visually inspect the connector for bent or corroded pins.

Are the clutch control switch pins in good condition and free from corrosion?

YES → Go to Test 2.

NO → Repair or replace damaged components as needed.
2. Check the upper position (top of clutch) on pins B and C, as follows.
 - 2.1 Perform a continuity test between pins B and C, with the clutch pedal not depressed.
 - 2.2 Perform a continuity test between pins B and C, with the clutch pedal depressed about 4 inches (10 cm).

Is there continuity when the clutch pedal is not depressed (switch closed), and no continuity when the clutch pedal is depressed (switch open) about 4 inches (10 cm)?

YES → Go to Test 3.

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Clutch

NO → Replace the clutch control switch.

3. Check the lower position (bottom of clutch) on pins A and C, as follows.

- 3.1 Perform a continuity test between pins A and C, with the clutch pedal not depressed.
- 3.2 Perform a continuity test between pins A and C, with the clutch pedal depressed all the way.

Is there no continuity when the clutch pedal is not depressed (switch open), and continuity when the clutch pedal is depressed (switch closed)?

YES → There are no problems with the clutch control switch, reconnect the clutch control switch connector, and re-evaluate the symptoms. Continue troubleshooting.

NO → Replace the clutch control switch.

702 — Clutch Actuation System Leak Check

Shut down the engine, if not already done. Then, have an assistant press down on the clutch pedal while you check the clutch hydraulic system for signs of leaks.

Were any hydraulic leaks discovered in the clutch actuation system?

YES → Repair any hydraulic leaks as needed.

NO → Continue to “Clutch Actuation System Check.”

703 — Clutch Actuation System Check

1. Check the action of the clutch pedal, as follows.

- 1.1 Shut down the engine, if not already done.
- 1.2 Press the pedal all the way to the floor several times, and check the action of the pedal.

The pedal should be easy to operate, and should return without difficulty to its original position. It should feel firm and responsive, not soft or spongy.

Does the clutch pedal feel firm and responsive, and not soft or spongy?

YES → Go to Test 2.

NO → There may be air in the hydraulic system, or possibly a hydraulic fluid leak. Fill and bleed the hydraulic system. Check for fluid leaks, and repair or replace any leaking components.

2. Check the operation of the clutch, as follows.

- 2.1 With both the clutch and brake pedals depressed, attempt to start the engine.

IMPORTANT: If the starter will not operate, follow the “Clutch Control Switch Check” instructions above.

- 2.2 Test drive the vehicle.
- 2.3 Check for proper clutch function while shifting gears.

IMPORTANT: If cruise control does not deactivate when the clutch pedal is depressed, follow the “Clutch Control Switch Check” instructions above.

- 2.4 With cruise control on, press the clutch pedal down.

Clutch

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Does the clutch operate properly?

YES → There are no detectable problems with the clutch, re-evaluate the complaint or possibly interview the driver to determine where the problem may be.

NO → Locate the description of the problem in the following tables to correct the defect.

Problem: The Clutch Pedal is Unusually Hard to Operate	
Possible Cause	Remedy
The clutch is damaged.	Remove the clutch and inspect if for damage. Replace the clutch if damaged, or make any necessary repairs.
The return or assist spring is broken.	Replace the pedal unit.
The pedal assembly is worn or jammed.	Replace the pedal unit.
The master cylinder has components that are jammed or broken.	Replace the hydraulic subassembly.

Table 1, The Clutch Pedal is Unusually Hard to Operate

Problem: The Clutch Does Not Completely Disengage; Shifting is Difficult and Noisy	
Possible Cause	Remedy
There is air in the hydraulic system.	Bleed the hydraulic system.
There is a hydraulic fluid leak.	Check the fluid level. Check for leakage and replace any components found to be leaking. Fill and bleed the hydraulic system.
Components of the pedal unit are defective.	Replace the pedal unit.
The slave cylinder is defective.	Replace the slave cylinder.
The slave cylinder is loose.	Tighten the M8 slave cylinder mounting capscrews.
The wrong type of brake fluid was used.	Replace the complete hydraulic system. Fill only with approved DOT 4 brake fluid.

Table 2, The Clutch Does Not Completely Disengage; Shifting is Difficult and Noisy

Problem: The Clutch is Slipping	
Possible Cause	Remedy
The clutch is worn.	Replace the clutch.
Contamination (e.g. oil, grease).	Replace the clutch.

Table 3, The Clutch is Slipping

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Clutch

800 — Clutch Control Switch

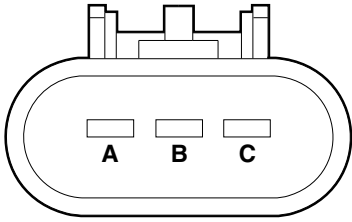
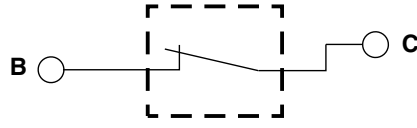
Connector	Clutch Control Switch Diagram	A	B	C
 03/19/2007 f545004	 03/19/2007 f545005	—	Yellow	Black

Table 4, Clutch Control Switch, Top of Clutch Control

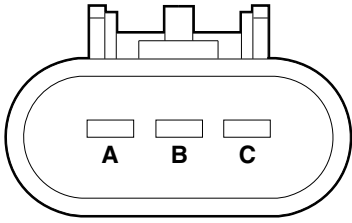
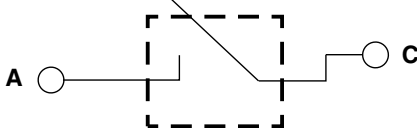
Connector	Clutch Control Switch Diagram	A	B	C
 03/19/2007 f545004	 03/19/2007 f545006	Blue	—	Black

Table 5, Clutch Control Switch, Bottom of Clutch Control

801 — Hydraulic Slave Cylinder

Hydraulic Slave Cylinder Specifications	
Hydraulic Fluid	DOT 4 (SAE J1703)
Temperature Range	–40 to 212°F (–40 to 100°C)

Table 6, Hydraulic Slave Cylinder Specifications

Manual Transmission

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Manual Transmission

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500 — General Information

The transmission must efficiently transfer the engine's power, in terms of torque, to the vehicle's drive wheels. Torque is the twisting force delivered by the engine's flywheel. The transmission's gear ratio increases or decreases torque depending on the requirements needed to move or start the load. Gearing also increases or decreases speed. The gear ratios are correctly spaced so that the engine will operate in its most efficient rpm range with progressive speed changes.

To meet the vehicle's requirements, the transmission must have ratios low enough to start the vehicle moving, maintain movement up grades, and keep the engine operating in its peak efficiency range. The transmission must also provide an easy method for gear selection.

Refer to the transmission vendor for specific troubleshooting and service information. Look for the serial tag on the transmission to identify which specific model transmission you have, then use this model number to reference the appropriate troubleshooting and service information. See **Fig. 1**.

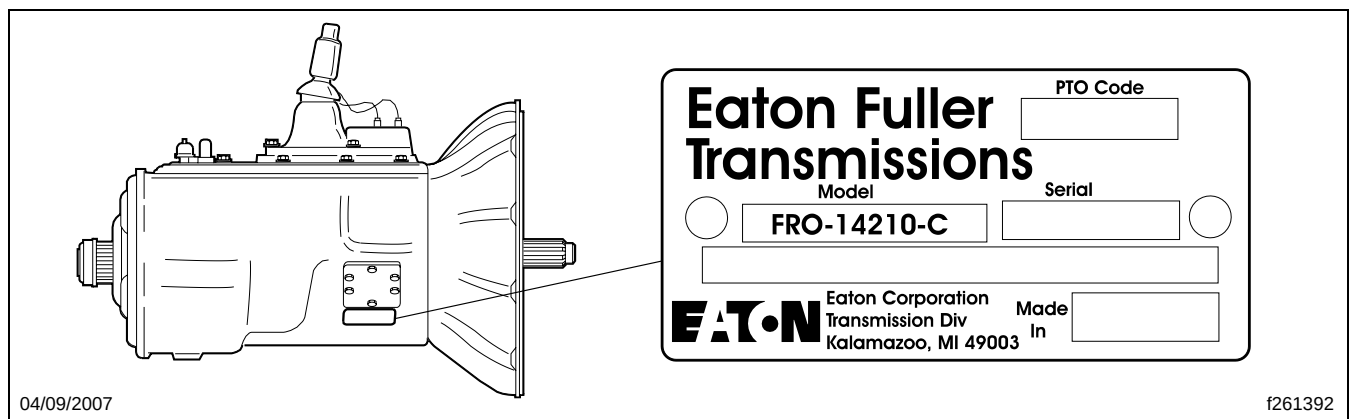


Fig. 1, Transmission Serial Tag

600 — Component Locations

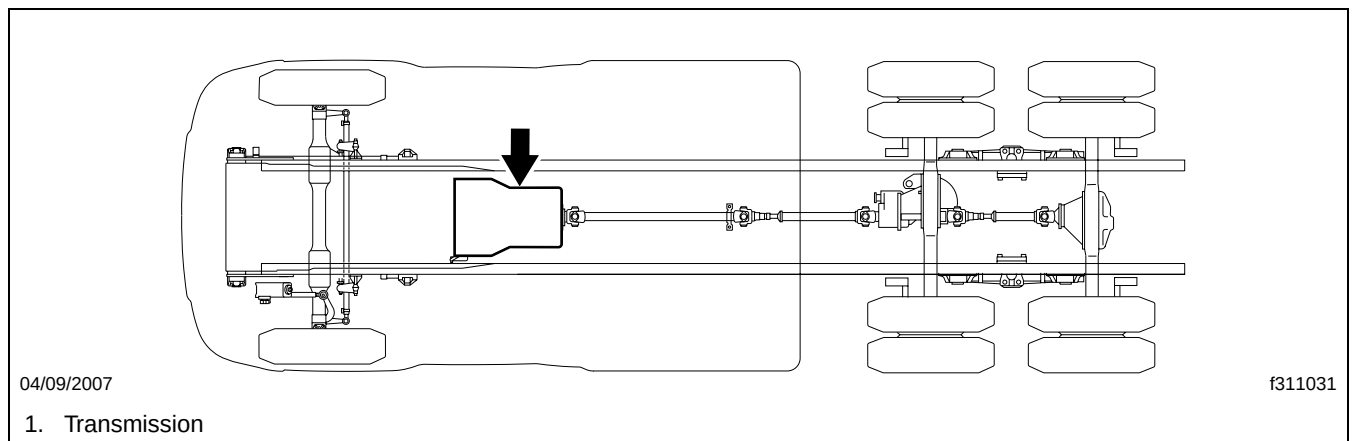


Fig. 2, Transmission

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Manual Transmission

601 — Component Details

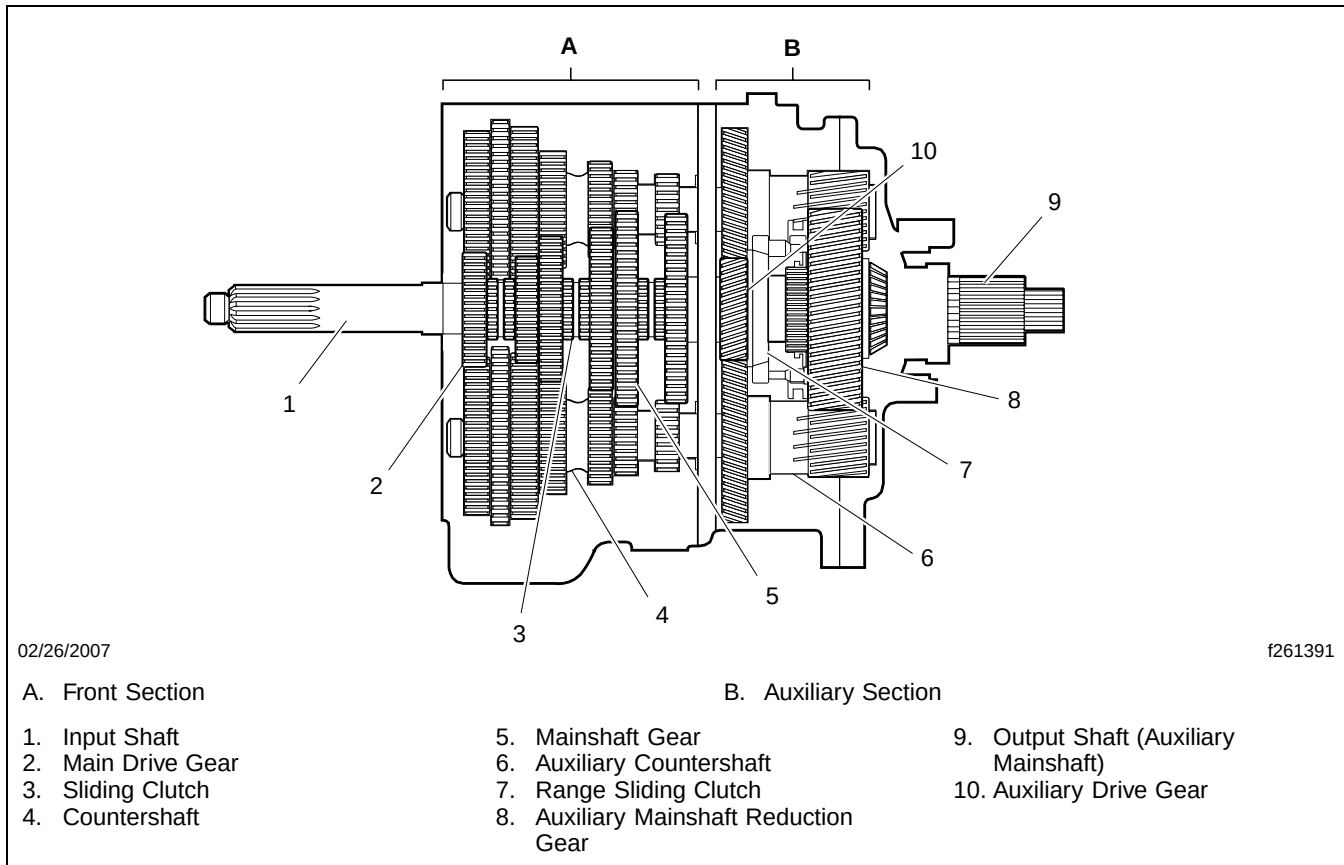


Fig. 3, Transmission Components

700 — Diagnosis

Refer to the transmission vendor's literature for specific troubleshooting and service information. This information can be viewed or downloaded from the internet, or paper manuals can be ordered from the vendor.

Possible Causes / General Complaints

Gear Jumpout— Jumpout usually occurs with the splitter gear set. If torque is not sufficiently broken during splitter shifts, the sliding clutch gear may not have enough time to complete the shift before torque is reapplied to the gears. As torque is reapplied, the partially engaged clutch gear "jumps" out of the splitter gear. Since the gears have torque applied to them, damage will be done to the clutching teeth of the mating gears.

Gear Slipout— When a sliding clutch is moved to engage with a main shaft gear, the mating teeth must be parallel. Tapered or worn clutching teeth will try to "walk" apart as the gears rotate.

Hard Shifting— Shift linkage is a common cause of hard shifting complaints. Another common cause is the splines of a sliding clutch gear binding on the main shaft as a result of a twisted main shaft key, bent shift yoke, or bowed main shaft key. Also, yoke bars binding in the bar housing as a result of cracked housing,

Manual Transmission

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over-torqued shift block lock-screw, sprung yoke bar, or swelled areas of the yoke bar may cause hard shifting.

Heat— Excessive heat may be caused by improper lubrication, operating consistently under 20 mph, high engine rpm, high horsepower, overdrive operation, or coasting downhill with the clutch depressed.

Transmission Noise, Growling— A growling noise may be audible if there is an error in tooth spacing, which can be caused by improper timing of the transmission during reassembly, or improper timing due to gear turning on the countershaft.

Transmission Noise, High Pitched Whine or Squeal— High-pitched whining or squealing can be caused by normal gear wear, including gear tooth pitting from excessive use (in advanced deterioration, a howl will result), mismatched gear sets (identifiable by an uneven wear pattern on the face of the gear teeth), or pinched bearings (insufficient axial or radial clearance).

Transmission Noise, Knocking, or Thudding— Bumps or swells are present on gear teeth. Generally this noise is more predominant when the gear is loaded; thus, the problem can be located as the noise occurs in a specific gear position. Bumps or swells are caused by improper handling of gears before or during assembly. Also, a gear cracked or broken by shock loading or by pressing on the shaft during installation will produce this sound at low speeds (at high speeds a howl may be audible). Bearing noise comes in at low shaft speeds in any position. It is caused by bearings with damaged balls or rollers, or with pitted and spalled raceways.

Vibration— Although the effects of vibration will show up in the transmission, vibration usually originates somewhere else in the drivetrain. Vibration can usually be felt or heard by the driver; however, in some cases, transmission damage caused by vibration will occur without the driver's knowledge.

Diagnostic Tests

Refer to vendor literature for diagnostic tests.

References

See the following for additional diagnostic information:

- **G05.01 — Vibration**
- **C01.06 — Air Supply System**
- Eaton's website, www.roadranger.com
- Meritor's website, www.meritorhvs.com

Automated Manual Transmission with SmartShift **P02.03**

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500 — Terms and Abbreviations

AMT—Automated Manual Transmission

Databus—No longer used; replaced by "datalink."

Datalink—A collection of wires, connecting system components, through which data is transmitted.

ECU—Electronic Control Unit, typically connected to a datalink.

ICU—Instrumentation Control Unit

TCU—Transmission Control Unit

501 — Automated Transmission

An automated manual transmission (AMT) combines the best features of manual and automatic transmissions. Manual transmissions are lighter than conventional automatic transmissions and suffer fewer energy losses. However, many drivers prefer the convenience of an automatic.

An automated transmission operates similarly to a manual transmission except that it does not require clutch actuation or shifting by the driver. Shifting can either be performed automatically, or the driver may shift manually using the slide switch on the Freightliner SmartShift control.

502 — Freightliner SmartShift Transmission Shift Control

The following information is provided to help determine whether a problem is the transmission or the Freightliner SmartShift Transmission Shift Control.

Resistance checks at the SmartShift connector can help determine connection problems. DataLink Software can be used to test the SmartShift control. Some of these tests require a ServiceLink computer connected to the vehicle.

The ICU will display current gear information for vehicles with automated transmissions. This information is sent to the ICU through the datalink from the TCU. The last three digits at the far right on the lower line of the ICU message center is reserved for this display information. If there is a need to shift, one digit displays an arrow, either up or down depending on the shift direction. The other two digits display the current gear.

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600 — Component Details

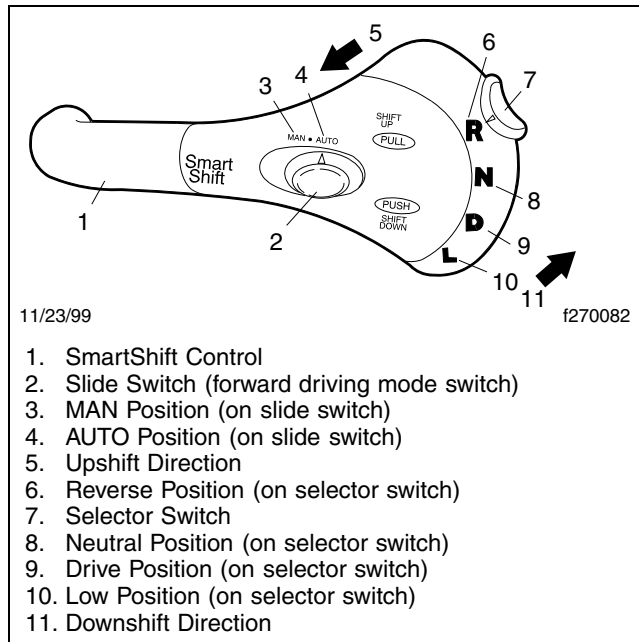


Fig. 1, SmartShift Control

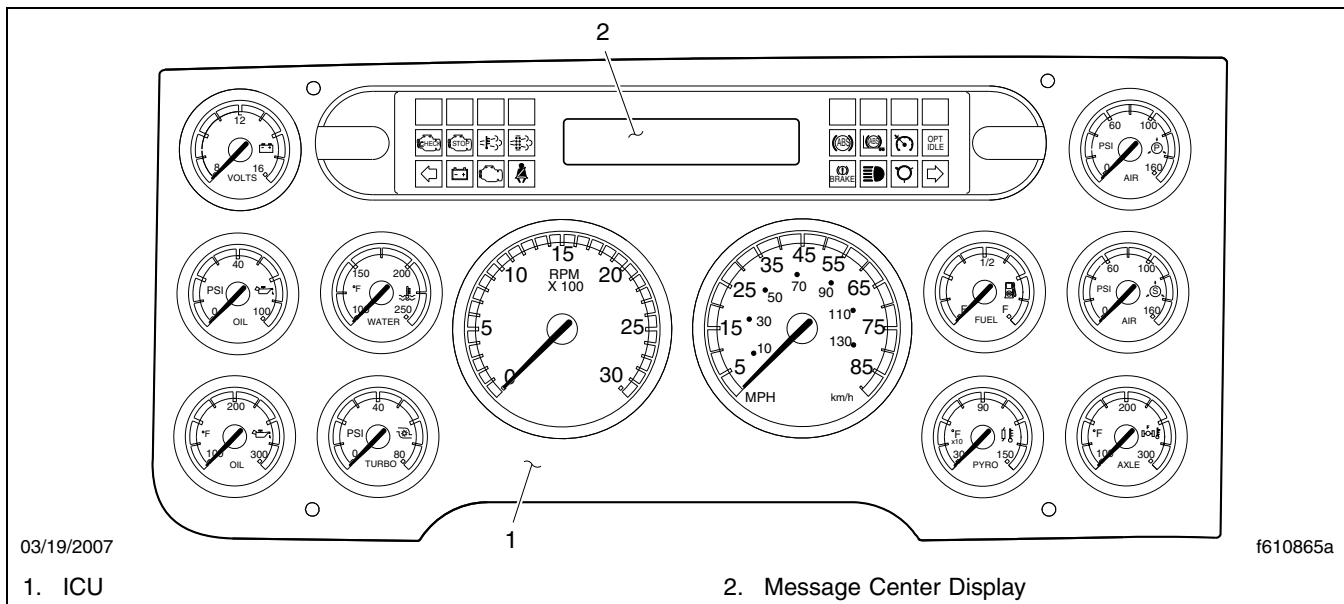


Fig. 2, ICU Message Center

700 — Troubleshooting an Automated Transmission

Refer to the vendor's literature for specific troubleshooting of the automated transmission. This information can be viewed or downloaded from the internet, and paper manuals can be ordered from the vendor.

Fault Codes

Refer to the vendor's literature for a detailed fault code list.

References

See the following for additional diagnostic information:

- **G05.01 — Vibration**
- **H01.06 — Air Supply System**
- **C01.02 — ICU4M**
- Eaton's website, www.roadranger.com

Diagnostic Tools

Use the following diagnostic tools when troubleshooting an automated transmission:

- ServiceLink
- digital multimeter
- wire extension (assembly instructions are provided later in this subject)
- diagnostic software supplied by transmission OEM
- DataLink Monitor Template (SmartShift with Eaton Fuller automated transmissions only)

701 — Shift Control Resistance Test

1. Inspect the SmartShift electrical connector.
 - 1.1 Remove the screws that secure the steering column trim panels. See **Fig. 3**.

P02.03 Automated Manual Transmission with SmartShift

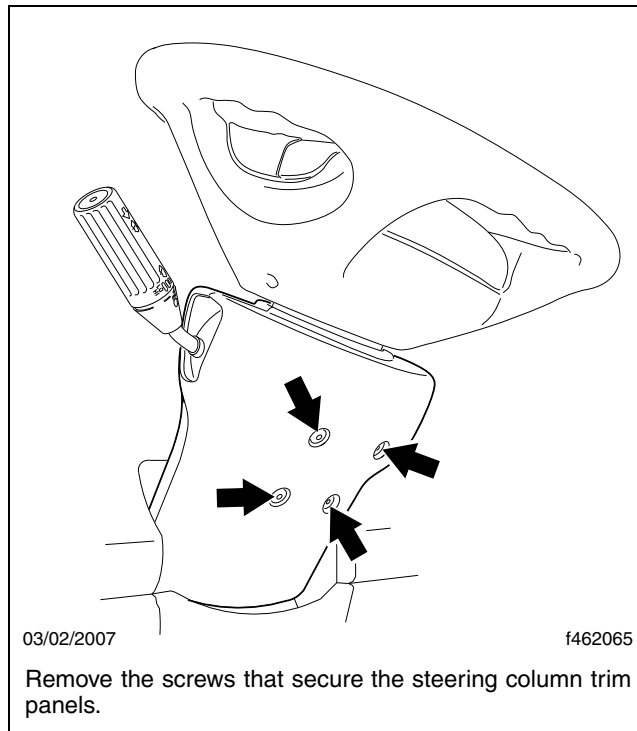


Fig. 3, Steering Column Screws

- 1.2 Separate the forward and rear panels to access the shift control.
- 1.3 Disconnect the electrical connector from the plug on the shift control unit.
- 1.4 Visually inspect the connector and pins for damage and corrosion, and, if needed, add a dielectric grease.

Are the connector and pins free from damage?

YES → Go to test 2.

NO → Repair any damaged pins or connectors as needed. Then, if needed, go to test 2.

2. Assemble and install a wire extension kit, then use it to check the resistance on the SmartShift control. See **Table 1** for a list of parts for a wire extension kit.

Parts for Wire Extension*		
Part Number	Description	Qty.
PAC 12110847 L	Metri-Pack Terminal	3
PAC 12047767 L	Connector Terminal	3
48-02493-184	18GA GTX Wire, Yellow	3 ft x 3
PAC 12047781 B	3-Pin Connector	1
PAC 12047783 B	Connector Lock	1

* Parts are available through the PDCs.

Table 1, Parts for Wire Extension

Automated Manual Transmission with SmartShift

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NOTE: Using a wire extension prevents needing to remove the shift control.

- 2.1 Crimp the connector terminals at the end of each 3-foot (1-meter) wire.
- 2.2 Assemble the 3-pin connector with the connector terminals and connector lock.
- 2.3 Crimp the Metri-Pack terminals on the other end of the wires.
- 2.4 Plug the wire extension into the plug on the shift control unit. See **Fig. 4**.

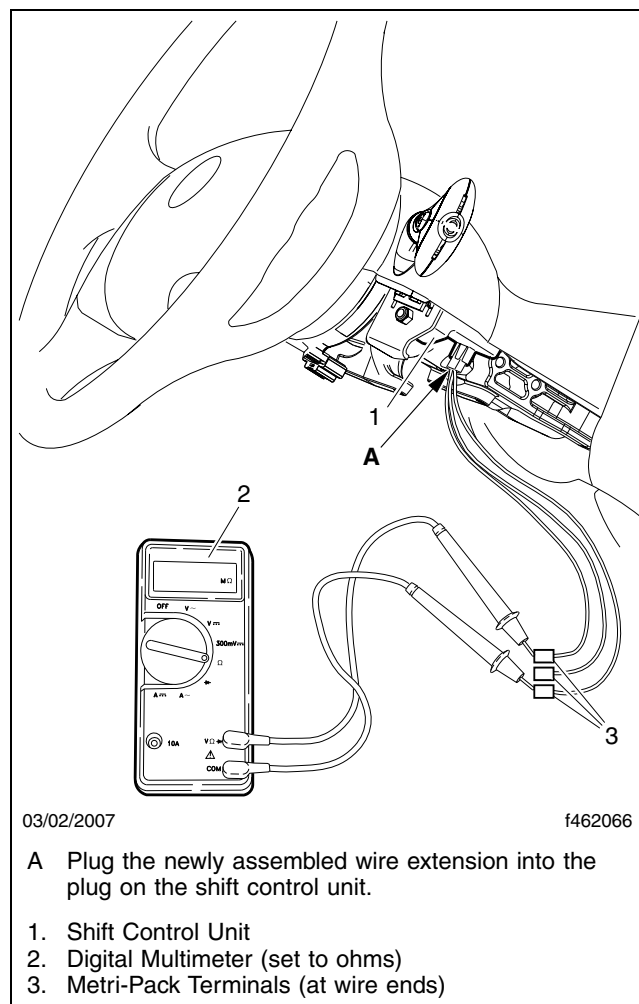


Fig. 4, Resistance Checking at Shift Control

- 2.5 If the wire extension fits snugly into the SmartShift control, proceed to the next step. If not, ensure the extension terminals are fully seated in the plug; reseat the terminals as needed. If a connector is not available, you may plug the terminals into the individual pins on the shift control—just be sure the terminals do not touch one another when performing the resistance checks.

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- 2.6 Check the resistance at the end of the wires. See **Fig. 4**. To identify terminal positions, see **Fig. 5**. For resistance values, see **Table 2** and **Table 3**.

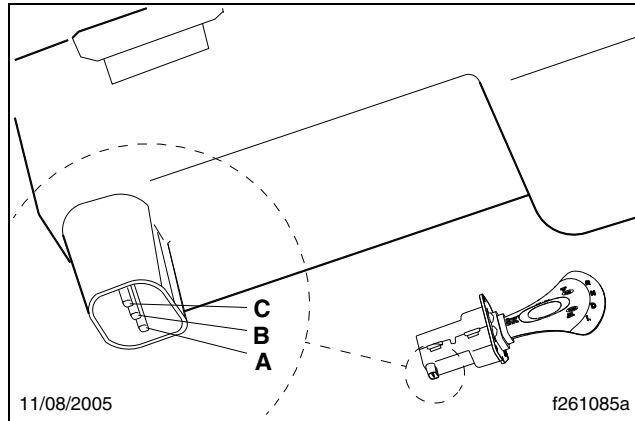


Fig. 5, SmartShift Terminal Positions

Resistance on SmartShift Controls at B and C	
Selector Switch Position	Reading: kOhm
R	2.947–3.067
N	0.347–0.361
D	0.606–0.630
L*	1.65–1.72

* Applies to four-position (R-N-D-L) controls only.

Table 2, Resistance on SmartShift Controls at B and C

Resistance on SmartShift Controls at A and C	
Slide Switch + Lever Position	Reading: kOhm
Manual	2.865–2.981
Manual + Up	0.531–0.553
Manual + Down	1.150–1.197
Auto	11.27–11.73

Table 3, Resistance on SmartShift Controls at A and C

- 2.7 Are the resistance values within the correct ranges specified in **Table 2** and **Table 3**?

YES → The Freightliner SmartShift control is working properly. Continue with this troubleshooting subject.

NO → Replace the Freightliner SmartShift control.

702 — SmartShift Control Testing for Eaton Fuller Automated Transmissions

The DataLink Monitor Template for Eaton Fuller automated transmissions (with SmartShift control) displays the current vehicle status and will reflect changes in status. Vehicle information is retrieved from the transmission ECU on the datalink. This DataLink Monitor Template can also be used to verify readings on the instrument panel.

To test the shift control using the datalink, place the vehicle into a mode that allows the gears to be shifted without the engine running. Using ServiceLink, open the DataLink Monitor Template (SmartShift with Eaton Fuller automated transmissions), and put the TCU in "Engine ON" mode.

Diagnostic Tests

1. Verify whether the transmission will shift gears.
 - 1.1 Start the engine.
 - 1.2 Turn the ignition *off*, and then, without starting the engine again, turn the ignition back *on*.
 - 1.3 Using the SmartShift control, verify whether the TCU will allow shifting.

Will the transmission shift gears?

YES → Go to test 2.

NO → There may be a problem with the transmission. Refer to vendor literature for specific troubleshooting information.
2. Using the SmartShift control, try shifting the transmission. Does information on the DataLink Monitor Template correspond to commands input at the SmartShift control and the dash display?

YES → The SmartShift control is providing the correct input to the TCU. The problem is likely with the automated transmission. Refer to vendor literature for specific troubleshooting information for the automated transmission.

NO → There may be a problem with the harness between the SmartShift control and the TCU. Check for common wiring problems. If there are no problems with this harness, refer to the vendor literature for specific troubleshooting information for the automated transmission.

Automatic Transmission

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500 — Terms and Abbreviations

Datalink—A collection of wires connecting system components through which data is transmitted.

Planetary Gear—An outer gear that revolves around an inner sun gear.

Parameter—A parameter is a predetermined variable in a set, each of which restricts or defines the specific capabilities of the system as a whole. Parameters are used to customize the configuration of the system.

TCU—Transmission Control Unit

501 — Automatic Transmission

The primary purpose of the transmission is to allow the engine to operate in a limited speed range, while allowing the output speeds to vary greatly. The transmission uses gears to make effective use of the engines torque while keeping the engine at optimal speeds.

The key difference between manual and automatic transmissions is that manual transmissions lock and unlock different sets of gears to the output shaft, and automatic transmissions use the same gear sets to produce the various gear ratios. This is accomplished by use of a planetary gear set.

The transmission fluid is an important aspect to maintain in automatic transmissions. The fluid cools, lubricates, and transmits hydraulic power between the engine and transmission. The fluid needs to be maintained at proper levels, if it's too low, the torque converter and clutches do not receive an adequate supply of fluid, causing the transmission to overheat. If the level is too high, the fluid aerates, causing the transmission to shift erratically and overheat. The fluid may also be expelled through the dipstick tube, or breather. Damage due to excessive heat may be key to diagnosing transmission related issues.

For detailed diagnostics information of the Allison Automatic transmission, including troubleshooting transmission fault codes, refer to Allison's own publications and use Allison approved diagnostic service tools. This will ensure you are using the most up to date and accurate information available.

For datalink related issues, refer to section **G02.02 — Datalink Communication Structure**.

600 — Component Locations

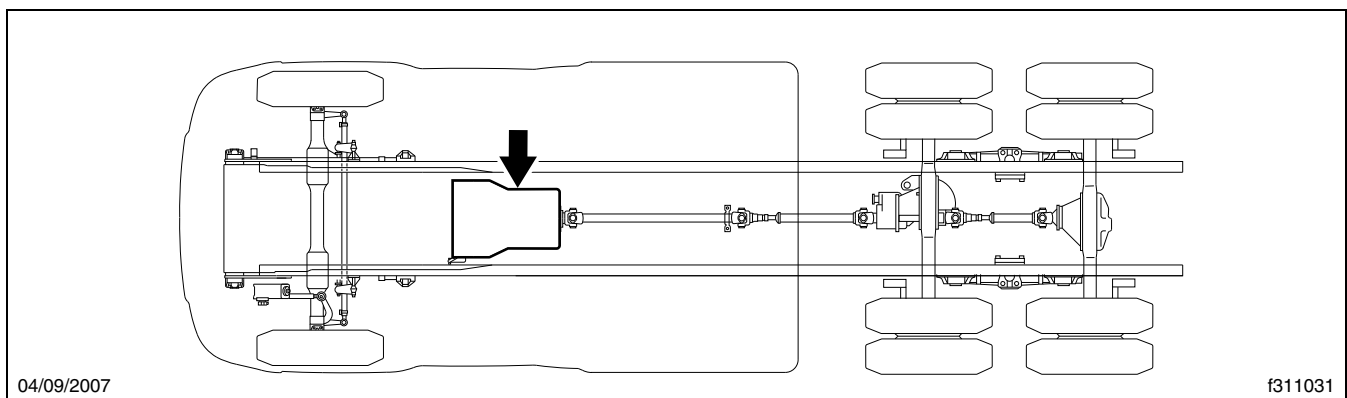


Fig. 1, Transmission

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Automatic Transmission

700 — Automatic Transmission Troubleshooting

Reference: www.allisontransmission.com

Diagnostic Tools Required:

- Allison DOC™
- Other diagnostic tools specified by the transmission OEM

701 — Fluid Leak Diagnosis

- Find the source of the leak.
 - Identify the fluid (engine oil, automatic transmission fluid, hydraulic fluid from the power steering system, etc.).
 - Operate the vehicle to reach normal operating temperature.
 - Inspect the vehicle to identify the source of the leak. See **Table 1** for possible points of transmission fluid leak and their causes.

Transmission Fluid Leaks, Locations and Causes	
Leak Location	Possible Causes
Transmission mating surfaces	Attaching bolts not correctly aligned.
	Improperly installed/damaged gasket.
	Mating surface(s) damaged or dirty.
Housing	Fill tube or plug seal damaged or missing.
	Fill tube bracket dislocated.
	Oil cooler connector fittings loose or damaged.
	Output shaft seal worn-out or damaged.
	Pressure port plugs loose.
	Porous casting.
At the converter end	Converter seal damaged.
	Seal lip cut (check converter hub for damage).
	Garter spring missing from seal.
	Converter leak in weld area or O-ring seal.
	Porous casting.
Fluid comes out of the fill tube	Overfilled.
	Incorrect dipstick.
	Plugged vent.
	Coolant in the fluid.
	Incorrect electronic fluid indication.
	Drain-back holes plugged.

Table 1, Transmission Fluid Leaks, Locations and Causes

Automatic Transmission

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- 1.4 Inspect both the suspected area and the gasket mating surfaces for leaks.
- 1.5 Clean the suspected area if the leak still cannot be identified. Dry the area when finished.
- 1.6 Operate the vehicle for several miles at varying speeds, and inspect for leaks.

Has the source of the leak been found?

YES → Go to step 4 for repairs.

NO → Go to either step 2 to use the power method of leak detection, or step 3 for the dye and black light method, depending on your shop practices.

2. Leak Detection, Power Method

- 2.1 Clean the suspected area.
- 2.2 Apply an aerosol-type white power to the suspected area.
- 2.3 Operate the vehicle under normal conditions.
- 2.4 Inspect the area and trace the leak path over the white power.

Has the source of the leak been found?

YES → Go to step 4 for repairs.

NO → Repeat step 2 until the source is found.

3. Leak Detection, Black Light and Dye Method

NOTE: If a black light and dye kit are available, use the kit instructions.

- 3.1 Pour the specified amount of dye into the transmission fill tube.
- 3.2 Operate the vehicle under normal conditions.
- 3.3 Shine the black light toward the suspected area. The dyed fluid will appear as a brightly colored trace leading to the leak.

Has the source of the leak been found?

YES → Go to step 4 for repairs.

NO → Repeat step 3 until the source is found.

4. Once the leak has been traced back to its source, inspect the leaking part for the conditions listed in **Table 2**, and repair as needed.

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Automatic Transmission

Transmission Fluid Leaks, Components	
Component	Possible Causes
Gaskets	Fluid level or pressure is too high.
	Plugged vent or drain-back holes.
	Improperly tightened fasteners or damaged threads.
	Warped flanges or seals surfaces.
	Scratches, burrs, or other damage to sealing surfaces.
	Damaged or worn-out gasket.
	Cracked or porous casting.
	Improper sealant used, where applicable.
Seals	Fluid level or pressure is too high.
	Plugged vent or drain-back hole.
	Damaged seal bore.
	Damaged or worn-out seal.
	Improper seal installation.
	Cracks in components.
	Output shaft surface scratched, nicked, or damaged.
	Loose or worn-out bearing causes excessive seal wear.
Sealing Flange	Bent sealing flange. Replace sealing flange if bent.

Table 2, Transmission Fluid Leaks, Components

702 — Automatic Transmission Diagnostics

Refer to the vendor literature for detailed transmission diagnostics.

800 — Specifications

Transmission Fluid Contamination	
Contaminant	Limit
Water	0.2% Maximum
Glycol	No trace allowed.
Unapproved Fluids*	If detected, change transmission fluids.

* Any fluid not on an Allison-approved fluid list must not be used. A list of approved automatic transmission fluids can be found at the Allison website, www.allisontransmission.com.

Table 3, Transmission Fluid Contamination

Cruise Control

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500 — Terms and Abbreviations

Baud Rate—The rate at which data is transmitted in bits per second.

Cabin CAN—A proprietary datalink connecting certain ECUs on the vehicle, specifically the CGW, MSF, SAM Cab, and SAM Chassis.

CAN—Controller Area Network

CAN ID—The identifier for a specific message, which also contains the source address of the sending ECU communicating on the J1939 datalink.

CGW—Central Gateway

Communication Protocol—A set of rules governing communication between electronic devices.

CPC—Common Powertrain Controller

Datalink—A collection of wires, connecting system components, through which data is transmitted.

Datalink Topology—The arrangement in which the nodes (ECUs) of a datalink are connected to each other.

Diagnostic CAN—Datalink that runs from the diagnostic connector to the CGW.

Diagnostic Connector—A 9-pin diagnostic connector is used for troubleshooting the electrical system.

ECM—Engine Control Module

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

MSF—Modular Switch Field

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address, indicates any device that communicates on J1939.

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM Cabin"); this ECU controls mainly cab-related functionality. See **G02.04 — SAM Cab** for more information.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

501 — General Information

The cruise control system manages the throttle of the vehicle in order to maintain the speed that the driver sets without throttle input from the driver.

The cruise control system works in cooperation with several components including the engine control module (ECM), the central gateway (CGW), the SAM Cab, and the modular switch field (MSF). The cruise control system is engaged by pressing the "On/Off" button on the left-hand side of steering wheel. See **Fig. 2**. Pressing the "On/Off" button changes a resistive ladder that the MSF Master reads from the steering wheel buttons. The MSF Master broadcasts the Cruise Control Enable Switch Request on Cabin CAN to the CGW. The CGW routes the request message to the engine controller, and if all the prerequisites are met, enables the cruise control. The "Set/Accel" and "Resume/Coast" buttons, as well as the "On/Off" button (when pressed a second time to deactivate cruise control) operate the same way using different messaging.

P04.01

Cruise Control

The ECM monitors the position of the throttle pedal via datalink, and uses an algorithm to adjust the throttle to keep the speed of the vehicle constant while the cruise control is engaged. The cruise control sets the throttle to the minimum required to maintain the vehicle speed.

The SAM Cab constantly broadcasts on the Cabin CAN the position of several switches that the cruise control system uses. The CGW routes these broadcast signals to the J1939 datalink, where they are received by the ECM. These switches include:

- Service brake
- Top-of-clutch switch
- Parking brake switch

If any of these switches are engaged, cruise control will pause. The ECM also monitors the vehicle speed, which must be greater than 35 mph (56 Km/h) for the cruise control to engage.

In addition to the cruise control being deactivated by the use of the service brake or the clutch, there are optional parameters that may disengage cruise control with any one of the following conditions:

- The hazard lights are enabled.
- Windshield wipers are at any setting other than off.
- The headlight switch is at any setting other than off.

The steering wheel switches, hazard lights, stalk switch, and headlight switches are all connected to the MSF, which is constantly monitoring the status of the switches and transmitting the switch status on the Cabin CAN.

The cruise control remains on unless turned off by the steering wheel "On/Off" switch, or the ignition is turned off. If it is paused by the service brake, clutch, or via parameter, the speed that the cruise control was set at before the pause is resumed by pressing the steering wheel "Resume/Coast" button.

502 — Related Subjects

- **G02.01 — Electrical System and Main PDM Overview**
- **G02.02 — Datalink Communication Structure**
- **G02.03 — Central Gateway**
- **G02.04 — SAM Cab**
- **G02.06 — Modular Switch Field**
- **G03.03 — Datalink, Cabin CAN**

600 — Component Locations

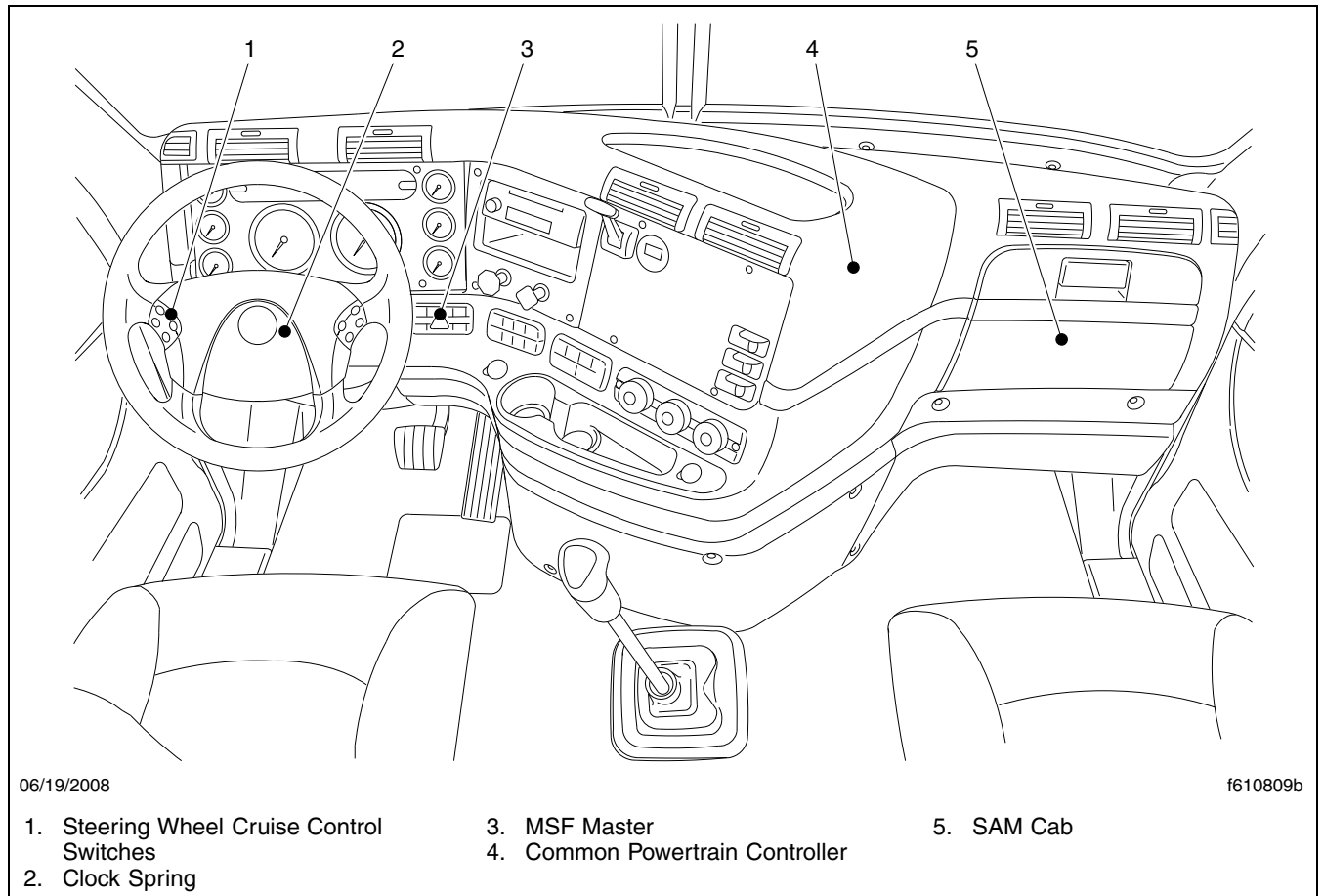
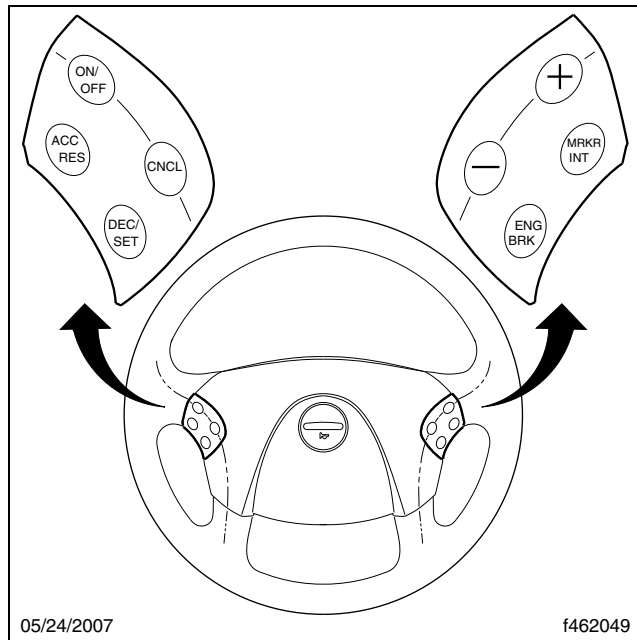


Fig. 1, Component Locations

601 — Component Details**Fig. 2, Steering Wheel Switches**

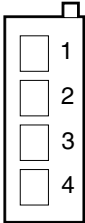
Steering Wheel Switches	
	
05/15/2007	f545039
Pin	Function
1	Steering Wheel, Left Switch Signal (S2)
2	Backlighting PWM
3	Steering Wheel, Right Switch Signal (S1)
4	Ground

Table 1, Steering Wheel Switches

Cruise Control

P04.01

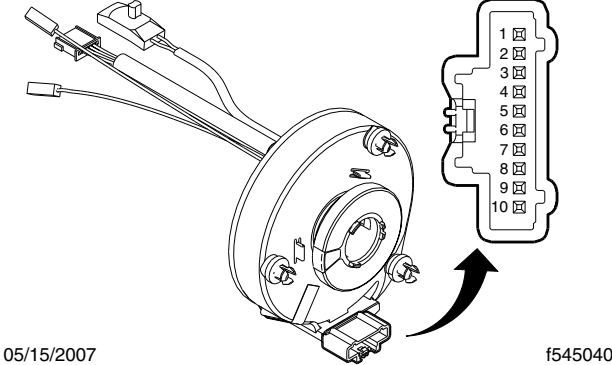
Clock Spring Connector	
	
Pin	Function
1	Air Bag (+), if used
2	Air Bag (-), if used
3	Not Used
4	Backlighting Ground
5	Steering Wheel, Right Switch Signal (S1)
6	Backlighting PWM
7	Steering Wheel, Left Switch Signal (S2)
8	Not Used
9	Horn Signal
10	Horn

Table 2, Clock Spring Connector

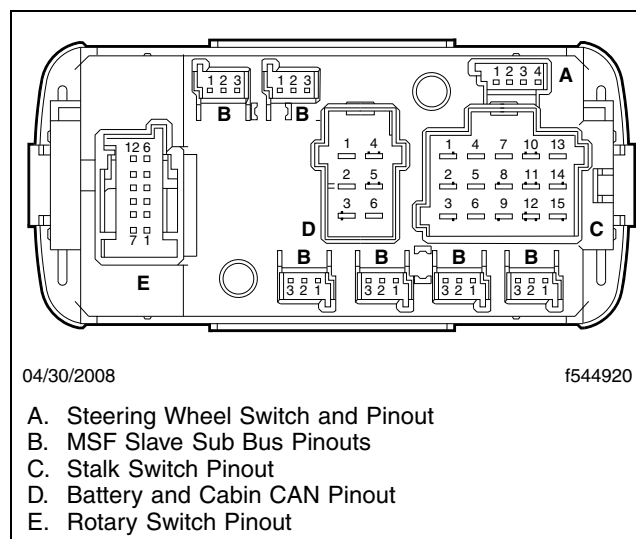


Fig. 3, MSF Master

P04.01

Cruise Control

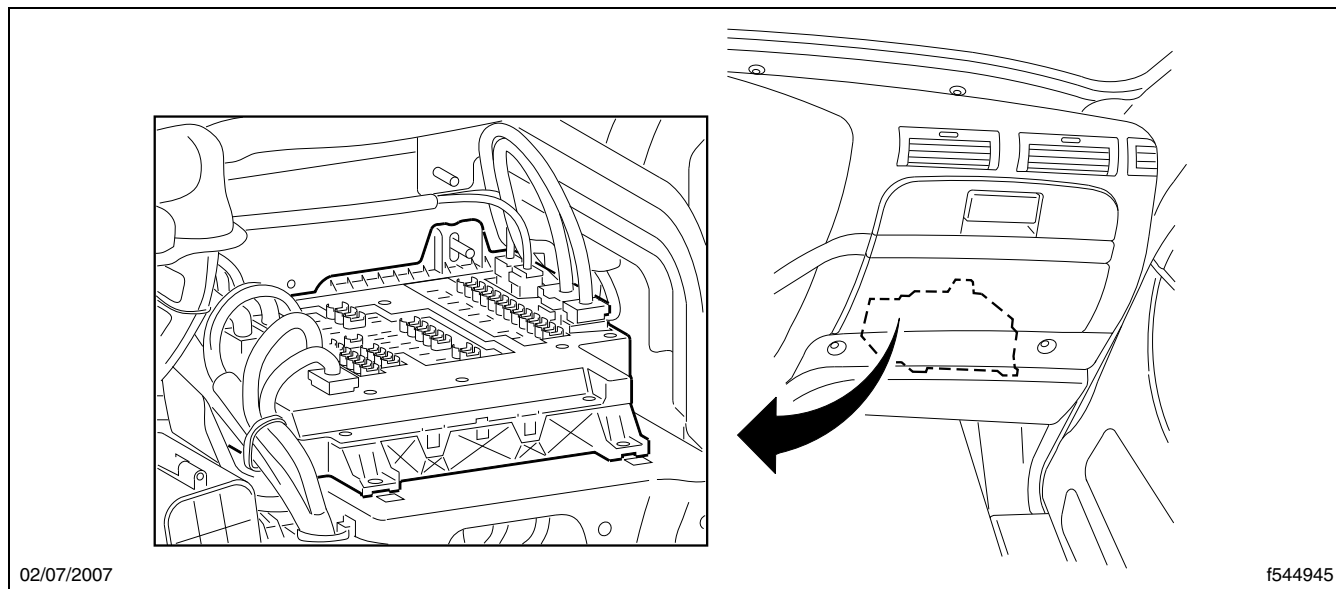


Fig. 4, SAM Cab

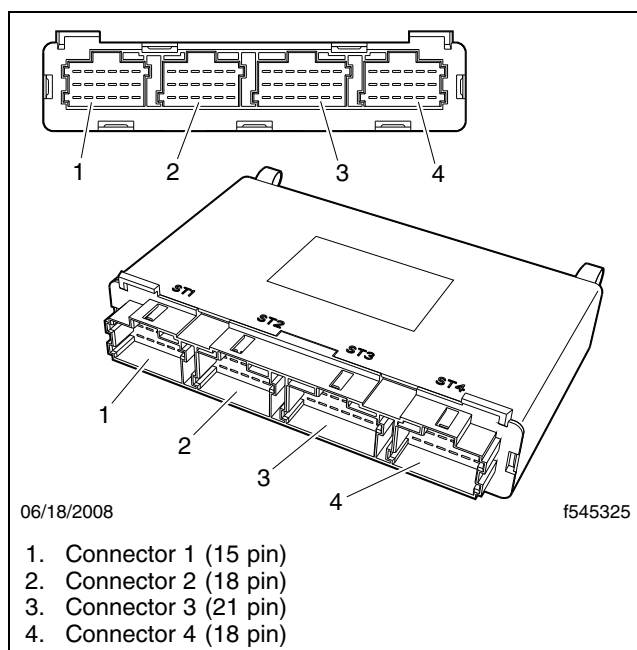


Fig. 5, Common Powertrain Controller

700 — Required Tools

- ServiceLink
- DDDL (Detroit Diesel and Mercedes engines)

Cruise Control

P04.01

701 — Possible Causes

- Incorrect parameter for the SAM Cab
- Incorrect parameter for the CPC
- Wiring, connections
- Switches

702 — Fault Codes

CAN Faults, MSF				
SA	SPN	FMI	Fault Description	Fault Trigger
49	520203	3	Steering wheel switch pin S1 — Voltage above normal, or shorted to high.	Trigger: Open or short circuit to battery power on the steering wheel switch pin S1. The two conditions cannot be differentiated by the ECU. Vehicle Behavior: The steering wheel switch is without function. Action: Check the wiring and connector.
49	520203	4	Steering wheel switch pin S1 — Voltage below normal, or shorted to low.	Trigger: Short circuit to ground on steering wheel switch pin S1. Vehicle Behavior: The steering wheel switch is without function. Action: Check the wiring and connector.

Table 3, CAN Faults, MSF

703 — Diagnostic Tests

1. **Verify the SAM Cab and CPC (where applicable) parameters are configured correctly.**

NOTE: Some Cruise Control Disengage parameters from the SAM Cab may be dropping cruise control unexpectedly, even though it is working as programmed. For example, the cruise control drops off when the wipers are ON.

Are the parameters set correctly?

YES → Go to test 2.

NO → Update the parameters as needed.

2. **Open Datalink Monitor template "Cascadia Cruise Control" in ServiceLink, and verify the operation of the switch inputs and interlocks.**

Are the inputs and interlocks functioning correctly?

YES → Go to test 3.

NO → Troubleshoot the switch inputs and/or interlocks. Refer to **G02.04 — SAM Cab** and **G02.06 — Modular Switch Field** for more information.

3. **Use Datalink Monitor template "Cascadia Cruise Control" to troubleshoot the status messages from the engine controller.**

Are the control messages from the engine reflecting the state change when the input switches are operated?

P04.01

Cruise Control

YES → Perform a functional check of the cruise control. Be sure to double check the possible interlocks (hazard lights, headlights, and wipers).

NO → Use the engine OEM diagnostic software for troubleshooting the engine controller.

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
149	002 447 18 58	Cruise control disengage input not present.	PARM-CAB, CRC, NO CNT	SAM Cab
	002 447 19 58	Disengage with hazard lights, headlights, or wipers on.	PARM-CAB, CRC, DIS, HDL, WW	
	002 447 20 58	Disengage with hazard lights or wipers on.	PARM-CAB, CRC, DIS, WW	
	002 447 21 58	Disengage with hazard lights or headlights on.	PARM-CAB, CRC, DIS, HDL	

Table 4, Parameters

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500 — Terms and Abbreviations

CSC—Customer Support Center

ECM—Engine Control Module

ECU—Electronic Control Unit

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

GPS—Global Positioning System

GSM—Global System for Mobile Communications; the cellular telephone network.

LED—Light-Emitting Diode

OTA—Over the Air; OTA refers to software updates made to the Virtual Technician system over the GPS system.

Parameter—A parameter is a specific value that is assigned to a feature or function of the vehicle, and allows the customer to choose how that particular feature or function will work on the vehicle.

SA—Source Address, indicates any device that communicates on J1939.

SPN—Suspect Parameter Number. The part of a J1939 or CAN fault code that identifies how part of a device, or item on a device, failed.

VT—Virtual Technician

501 — General Information

The Virtual Technician (VT) ECU generates diagnostic information to aid Detroit Diesel and the technician in diagnosing complex engine control issues. The system creates sensor log files, captures fault codes, and sends alert messages and other advanced diagnostic information to the Detroit Diesel Customer Support Center. The ECU utilizes GPS navigation, GSM (cellular telephone) communication, and a J1939 connection for databus monitoring. Virtual Technician does not require any driver input to function. The ECU is located behind the sunglass holder on the passenger side of the overhead console, and is mounted to a bracket via hook and loop tape. See **Fig. 1**. The ECU can safely be removed from the mount while remaining wired into the vehicle for visual diagnostic purposes.

502 — Modes of Operation

There are three modes of operation for the Virtual Technician ECU:

- **Registration Mode:** The vehicle identification number (VIN), engine serial number, and GPS ID are gathered at the manufacturing facility in this mode. Registration mode also occurs when a new unit is installed at the dealership.
- **Normal Operation Mode:** This mode occurs after electronic registration of the unit. In this mode, the ECU gathers fault codes, ring buffer files, and GPS data. This mode monitors the databus for general information and fault codes. Transmission of this information to Detroit Diesel generally occurs within 4 minutes of collection depending on GSM network availability. Normal mode also allows for over-the-air updates of VT firmware.
- **Dormant Mode:** In dormant mode, activity and data usage is minimized or eliminated. This mode is activated only by remote modification of the firmware settings by the CSC. This may occur if the VT subscription ends.

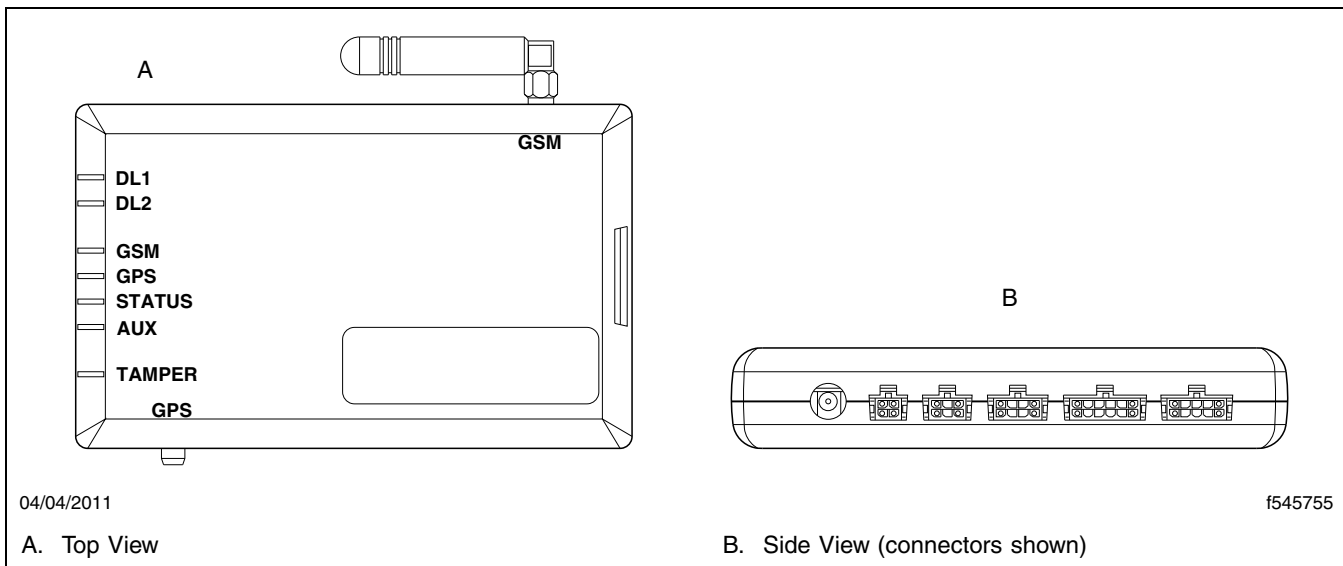


Fig. 1, Virtual Technician ECU

600 — Component Locations

NOTE: The Virtual Technician is located in the overhead console, behind the sunglass holder.

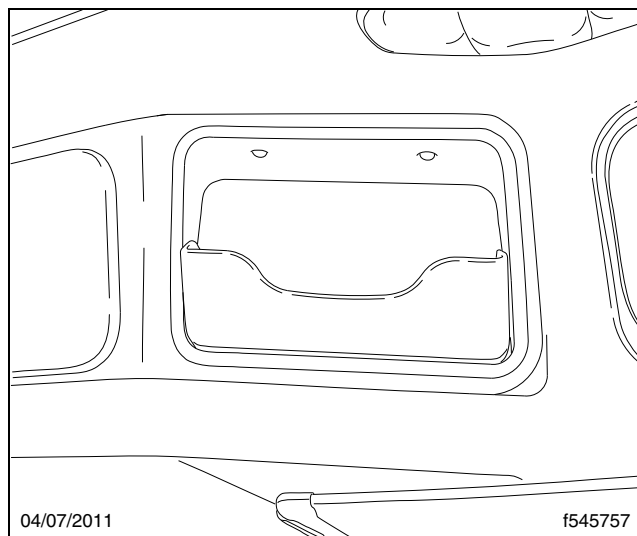


Fig. 2, Sunglass Holder

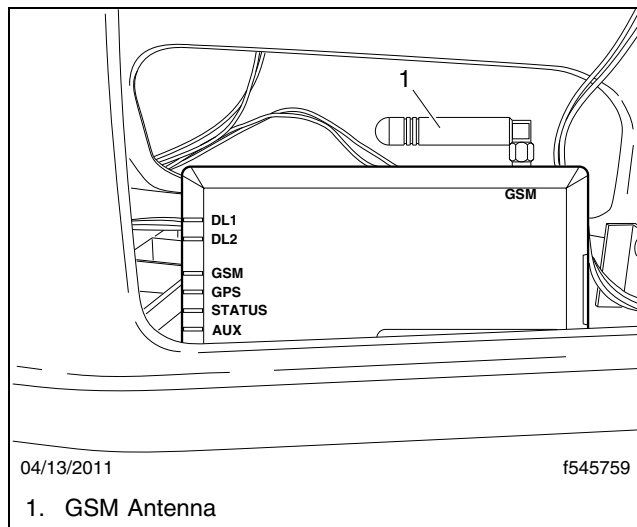


Fig. 3, Virtual Technician ECU, Installed

601 — Component Details

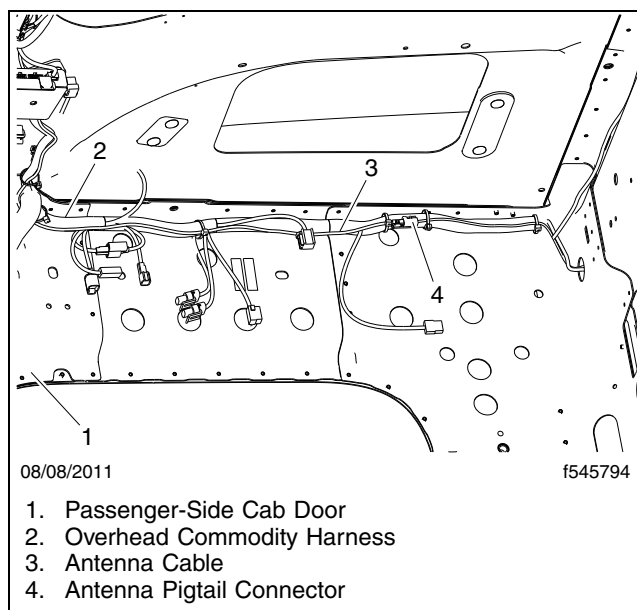


Fig. 4, Antenna Connector (daycab)

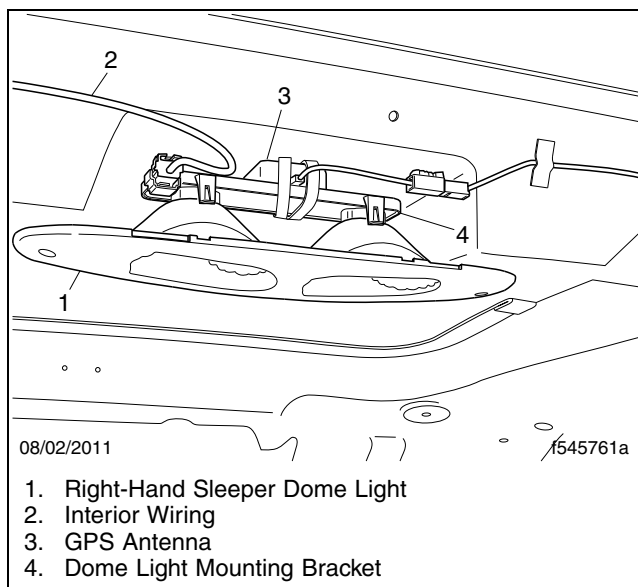


Fig. 5, Dome Light Connections

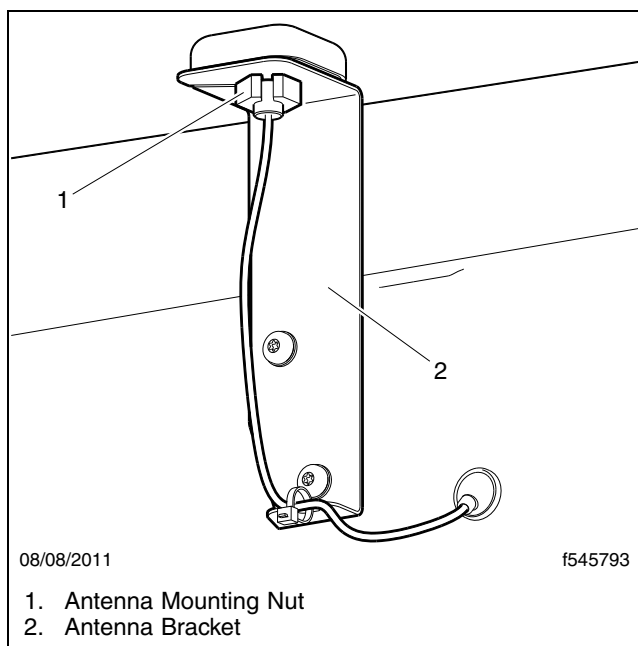


Fig. 6, External Antenna (daycab)

700 — Diagnostic Overview

All testing of the GPS and cellular reception must be done outside, and at a distance of at least 40 feet (12 meters) from any buildings. This ensures adequate GPS signal strength and good cellular reception.

Diagnosing Virtual Technician requires access to the ECU to view the LEDs on the unit. The LEDs provide diagnostic information needed by the technician and the CSC (Customer Support Center). To access the unit, remove the sunglass holder from the passenger side of the overhead console and detach the VT box from the hook and loop tape mounting. To diagnose the unit, turn the ignition to the ON position.

There are seven LEDs visible on the VT ECU module. If no LEDs light up with the ignition ON, diagnose supplied power and ground to the unit. See **Table 1**.

Diagnostic LEDs			
Name	Color	Function	Action
DL1	Red	Red Blink (1Hz): J1708 connectivity (disabled). No J1708 activity detected (device is awake). Device is not wired for J1708 connectivity.	Red is the normal and Expected state.
DL2	Red and Green	Red Blink (1Hz): J1939 connectivity. No J1939 activity detected (device is awake). Green Blink (1Hz): J1939 activity detected (device is awake) .	Green blink is expected, if LED is blinking red diagnose J1939 connectivity issue at the terminals.
GSM	Green	Solid: GPS connection successful. One Blink: Initializing. Two Blinks: Acquiring time zone information. Three Blinks: Attempting to make a GPS connection.	Solid is expected – if otherwise call the CSC for further instruction.
GPS	Green	Solid: Satellites acquired. One Blink: Acquiring satellites.	Refer to J1939 Fault codes if problem is suspected.
Status	Green	Solid: Engine running. One Blink: Engine not running; no data to send. Two Blinks: Data is available to be sent. Four Blinks: GPS storage log is full.	Refer to J1939 Fault codes if problem is suspected.
AUX	Red	Solid: GSM Modem Comm. Error, or panic line is active. Two Blinks: Not Used. Three Blinks: GSM modem is not starting up. Four Blinks: SIM Card read error. Five Blinks: GSM CTS (clear-to-send) line is active.	Refer to J1939 Fault codes if problem is suspected.
Tamper	Red	Disabled	N/A

Table 1, Diagnostic LEDs

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Virtual Technician

701 — Fault Codes

NOTE: The VT ECU source address (SA) is usually 74. Due to the addition of other telematics devices, SA 74 may be taken by another ECU. In this case the VT ECU will be assigned another source address. This has no effect on the operation of the ECU or the vehicle.

Fault Codes				
Fault	SPN	FMI	Details	Action
Sim Card Error	524283	11	Installed SIM Card cannot be read.	Contact CSC/ Replace ECU
GPS Shorted	524286	4	Center lead shorted to ground or cable ground.	Check the antenna cable; replace GPS Antenna if necessary
GPS Not Connected	524286	5	Antenna open or cut.	Attach GPS Antenna. Replace Antenna if wiring damaged
NAND Full	524285	0	Full	Contact CSC/ Replace ECU
NAND ++Checksum Error	524285	2	Error	Contact CSC/ Replace ECU
NAND I/O Error	524285	11	Cannot read/write.	Contact CSC/ Replace ECU
uSD Full	524284	0	Full	Contact CSC/ Replace ECU
uSD Checksum Error	524284	2	Read/write error	Contact CSC/ Replace ECU
uSD I/O Error (micro SD)	524284	11	Cannot read/write – not present	Contact CSC/ Replace ECU
RTC Error (real time clock)	524282	11	VTECU RTC out of range	Contact CSC/ Replace ECU

Table 2, Fault Codes

702 — DL1 and DL2 Alternate Functionality

These LEDs indicate other behavior than those indicated at startup:

- **Fast alternating red DL1 and DL2 blinks:** indicates that the device is booting.
- **Fast-alternating green DL1 and DL2 blinks:** indicates that a new firmware file is detected and is being loaded.
- **Solid red DL1 and OFF (dark) DL2:** indicates that the device is updating the vehicle interface firmware.

703 — External Antennas

There are two SMA connectors on the VT ECU module. One connector is for an external GPS antenna, and the other is for an external GSM antenna. The GSM antenna is mounted directly to the ECU

704 — Updating Firmware

The approved method for updating the VT ECU firmware is through an over-the-air (OTA) update. OTA updates occur when VT is sent a firmware file over the GSM connection. This allows remote programming of modules in the field. If a software issue is suspected, contact the Detroit Diesel Customer Support Center for further diagnostics.

The OTA process begins by scheduling the device to update to Zonar and Daimler approved firmware. Once the OTA update is scheduled the device uploads the necessary data. The download occurs when the ignition wire is powered off and the device is no longer seeing engine RPM data. The OTA process is underway when the Tamper, Aux, Status, GSM and GPS LEDs all blink together at a 1hz rate.

The device must stay powered on while the OTA update is downloading. Cycling the ignition will not interrupt an OTA update. The module will stop downloading only if power is removed from the unit. Data is not collected during an OTA update.

705 — Vehicle Fault Monitoring

When the VT ECU receives a new fault code, it compares the received message to a list stored internally. If the fault code is already on the list, it will be ignored. New fault codes are added to the list and the appropriate information is uploaded to the Zonar server. If the fault code is a ring buffer trigger, a ring buffer will be created and uploaded along with the normal fault data.

706 — Ring Buffer Files

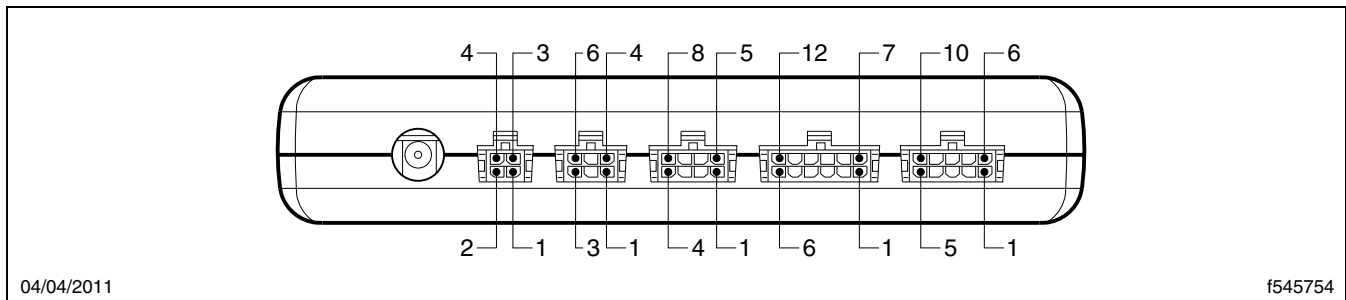
The VT ECU is capable of generating diagnostic ring buffer files. A ring buffer file is a recording of J1939 databus activity over a predefined period. This information is sent directly to the CSC for analysis.

800 — Virtual Technician ECU Connector Reference

Power Connector						
Connector	Pin	Name	Type	Minimum	Maximum	Notes
4-Pin	1	Power	Input	8 VDC	30 VDC	Requires External Fuse
	2	Ignition	Input	0 VDC	30 VDC	Requires External Fuse 0 VDC = Logic 0 1.8 VDC = Logic 1
	3	Ground	—	0 VDC	0 VDC	—
	4	Panic Switch	Input	0 VDC	5 VDC	Ground Closure Switch Only

Table 3, Power Connector

Expansion and Diagnostics Connector						
Connector	Pin	Name	Type	Minimum	Maximum	Notes
6-Pin	1	RS-232 TX	Output	-15 VDC	15 VDC	Proprietary
	2	Ground	—	0 VDC	0 VDC	—
	3	5V Supply	Output	5 VDC	5 VDC	—
	4	RS-232 RX	Input	-15 VDC	15 VDC	Proprietary
	5	DSR-IN	Input	-15 VDC	15 VDC	—
	6	Panic Switch	Input	0 VDC	5 VDC	Ground Closure Switch Only

Table 4, Expansion and Diagnostics Connector**Fig. 7, ECU Connector Reference**

EVIR Connector						
Connector	Pin	Name	Type	Minimum	Maximum	Notes
8-Pin	1	RS-232 TX	Output	-15 VDC	15 VDC	Proprietary
	2	CTS IN	Input	-15 VDC	15 VDC	—
	3	DSR OUT	Output	-15 VDC	15 VDC	—
	4	Power Out	Output	—	—	System Supply Voltage, Unregulated
	5	NC	—	—	—	—
	6	Ground	—	—	—	—
	7	NC	—	—	—	—
	8	RS-232 RX	Input	-15 VDC	15 VDC	Proprietary

Table 5, EVIR Connector

General Purpose I/O Connector						
Connector	Pin	Name	Type	Minimum	Maximum	Notes
12-Pin	1	GPIO 1	Input	0 VDC	30 VDC	0 VDC = Logic 0 1.8 VDC = Logic 1
	2	GPIO 3	Input	0 VDC	30 VDC	0 VDC = Logic 0 1.8 VDC = Logic 1
	3	GPIO 5	Input	0 VDC	30 VDC	0 VDC = Logic 0 1.8 VDC = Logic 1
	4	SPI-IN	Input	0	3.3 VDC	Proprietary
	5	SPI-OUT	Output	0	3.3 VDC	Proprietary
	6	SPI-CLK	Output	0	3.3 VDC	Proprietary
	7	GPIO 2	Input	0 VDC	30 VDC	0 VDC = Logic 0 1.8 VDC = Logic 1
	8	GPIO 4	Input	0 VDC	30 VDC	0 VDC = Logic 0 1.8 VDC = Logic 1
	9	SPI-CS	Output	0	3.3 VDC	Proprietary
	10	Relay	Output	—	2 A	Open Drain Output
	11	Ground	—	—	—	—
	12	3.3V Supply	Output	3.3 VDC	3.3 VDC	—

Table 6, General Purpose I/O Connector

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Virtual Technician

Vehicle Communication Connector						
Connector	Pin	Name	Type	Minimum	Maximum	Notes
10-Pin	1	J1939 –H	—	–27 VDC	40 VDC	—
	2	CAN-Shield	—	0 VDC	0 VDC	J1939, –11 Only
	3	J1708 (–)	—	—	—	
	4	NC	—	—	—	—
	5	NC	—	—	—	—
	6	J1939 –L	—	–27 VDC	40 VDC	—
	7	J1708 (+)	—	—	—	Disabled
	8	NC	—	—	—	—
	9	NC	—	—	—	—
	10	Ground	—	0 VDC	0 VDC	—

Table 7, Vehicle Communication Connector