

System Overview

Terms and Abbreviations	500
General Information	501
How to Identify the ICU3	502
Main ICU Gauges	503
Remote-Mounted (Satellite) Gauges	504
ICU Self-Test	505
Warning and Indicator Lights	506
Odometer	507
Mode/Reset Switch	508
"+/-" Switch, Steering Wheel	509
Buzzer	510
Friendly Chime	511
Dash Backlighting (panel lamps)	512
Power and Ground Circuits	513
Outside Air Temperature Screens	514
Displaying Faults	515

Components

Component Locations	600
Component Details	601
ICU3 Interface Schematic	602

Troubleshooting

Diagnostic Tools Required	700
ICU3 Troubleshooting Procedures: Start Here	701
ICU Fault Code Display	702
Gauge Diagnosis: Start Here	703
Gauge Diagnosis: Sensor-Driven Gauges	704
Gauge Diagnosis: Air Pressure Gauge	705
Gauge Diagnosis: Fuel Level Gauge	706
Indicator Diagnosis: DEF Level Indicator	707
Gauge Diagnosis: Satellite Gauges	708
Indicator Diagnosis: Lamps in the ICU3	709
Indicator Diagnosis: In-Gauge Warning Lamp	710
Diagnosis: LCD	711
Diagnosis: Backlighting	712
Diagnosis: Mode/Reset Button	713
Diagnosis: Seat Belt Lamp	714

Continued

Table of Contents

Specifications

Roll Call Fault Messages 800

Fault Code Message Display 801

rESEt EE Procedure 802

Sensor Resistance Specifications 803

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

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 parts on the ICU3 are the air pressure gauge module, the nine top center indicator lamps, and the Mode/Reset switch.

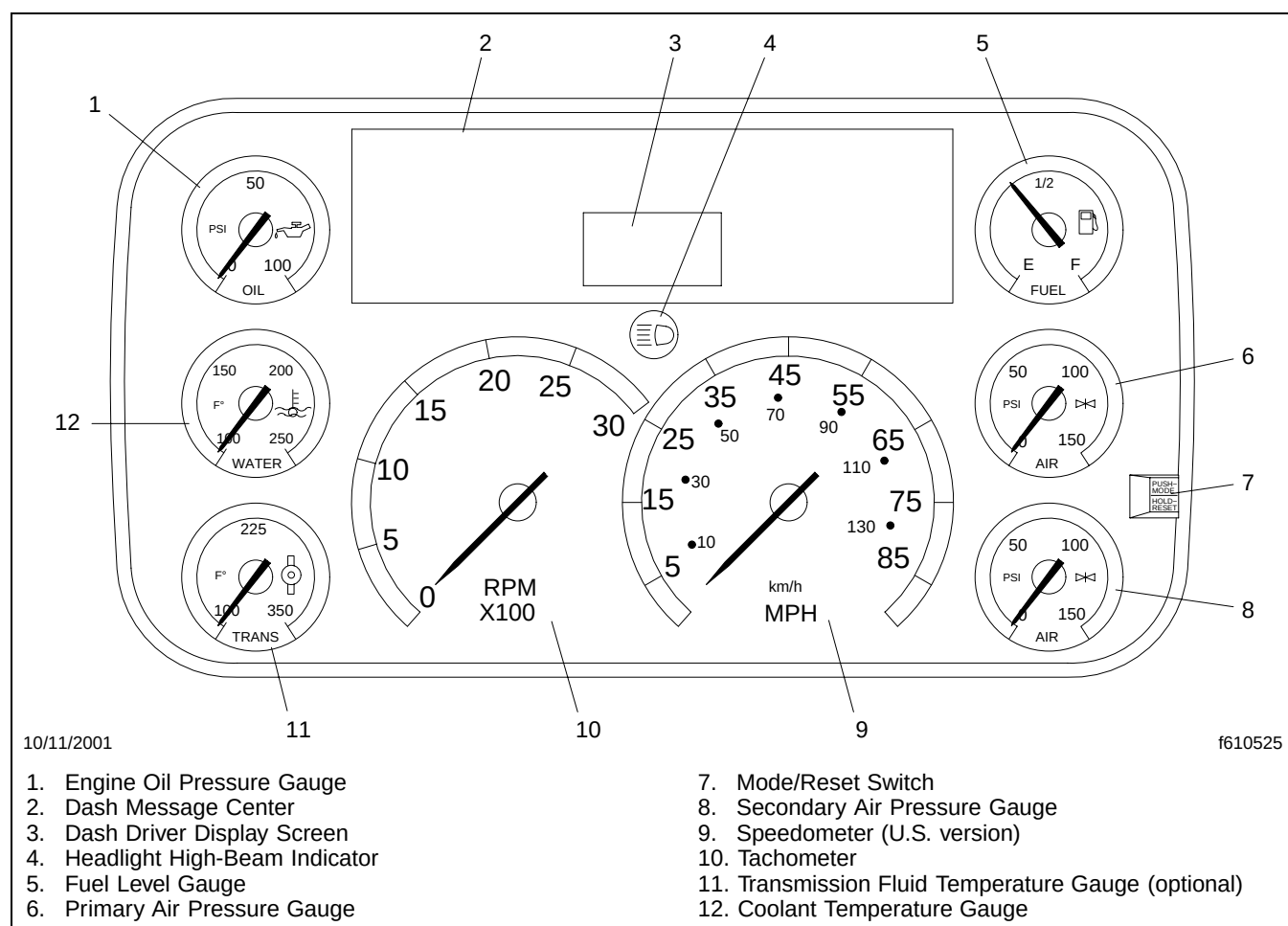


Fig. 1, Typical EPA07 ICU3 Instrument Cluster

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).

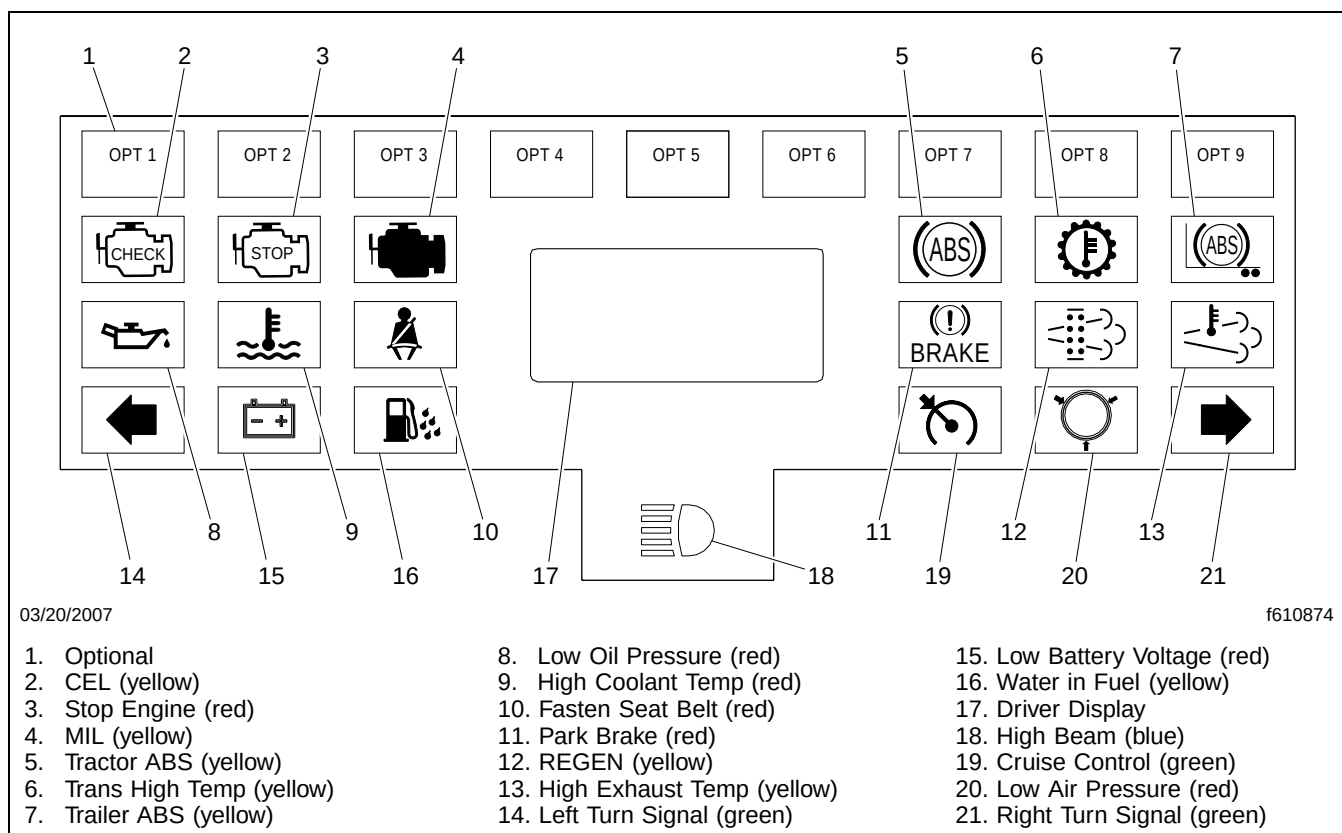


Fig. 2, EPA07 ICU3 Message Center (typical)

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.

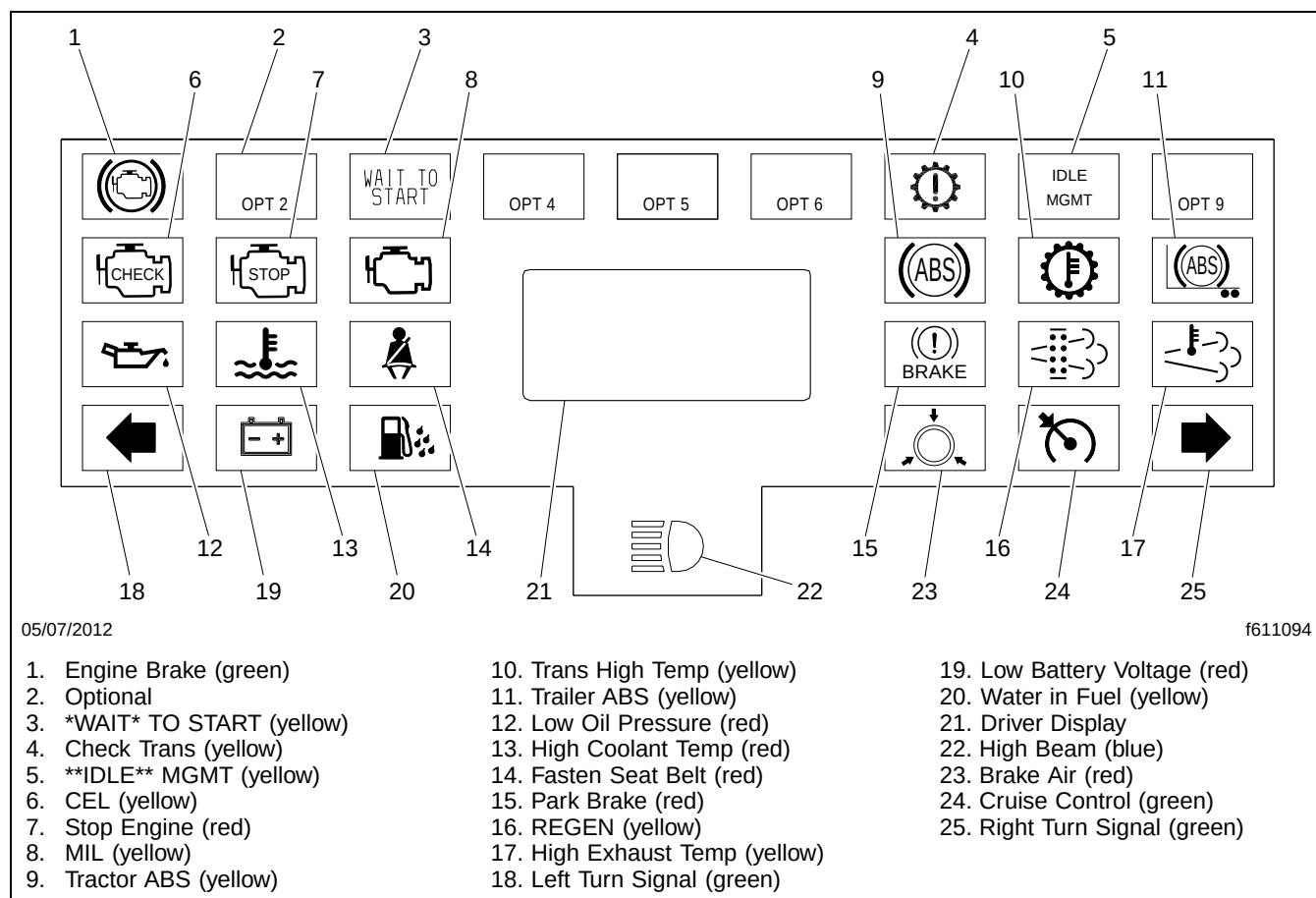


Fig. 3, EPA10 ICU3 Message Center (typical)

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

- 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 12** 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 through 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.

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 **800 — Roll Call Fault Messages** 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. 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

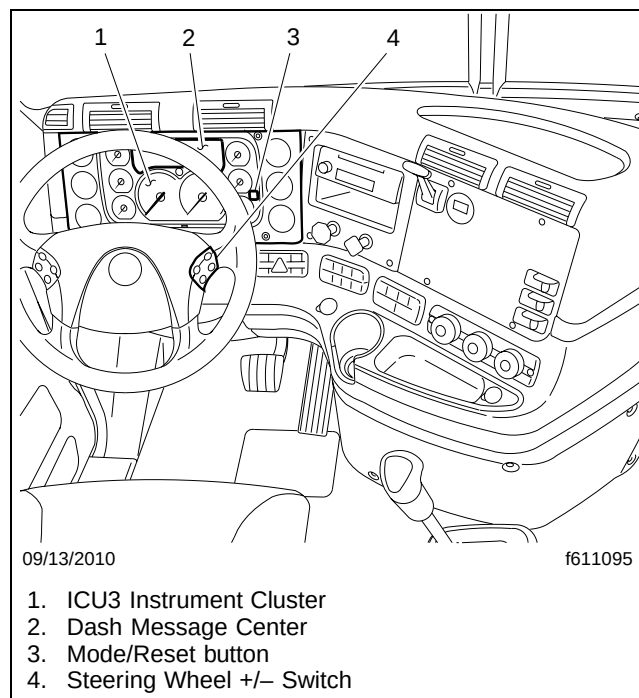


Fig. 4, Component Locations

601 — Component Details

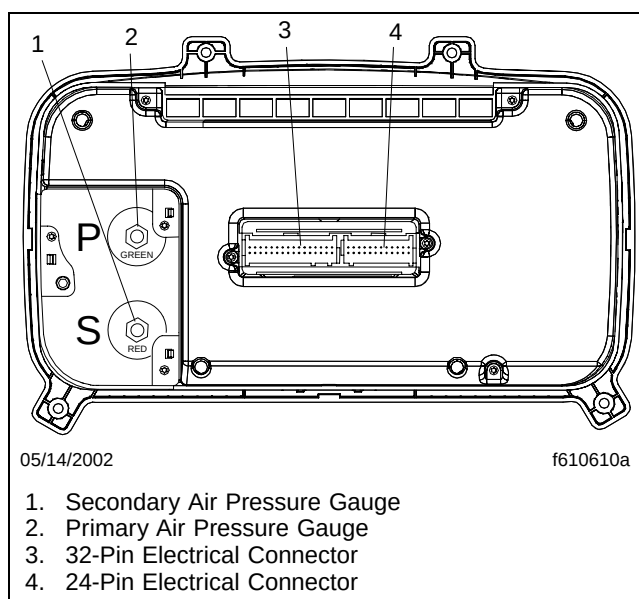


Fig. 5, ICU3 Connector Locations

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

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

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

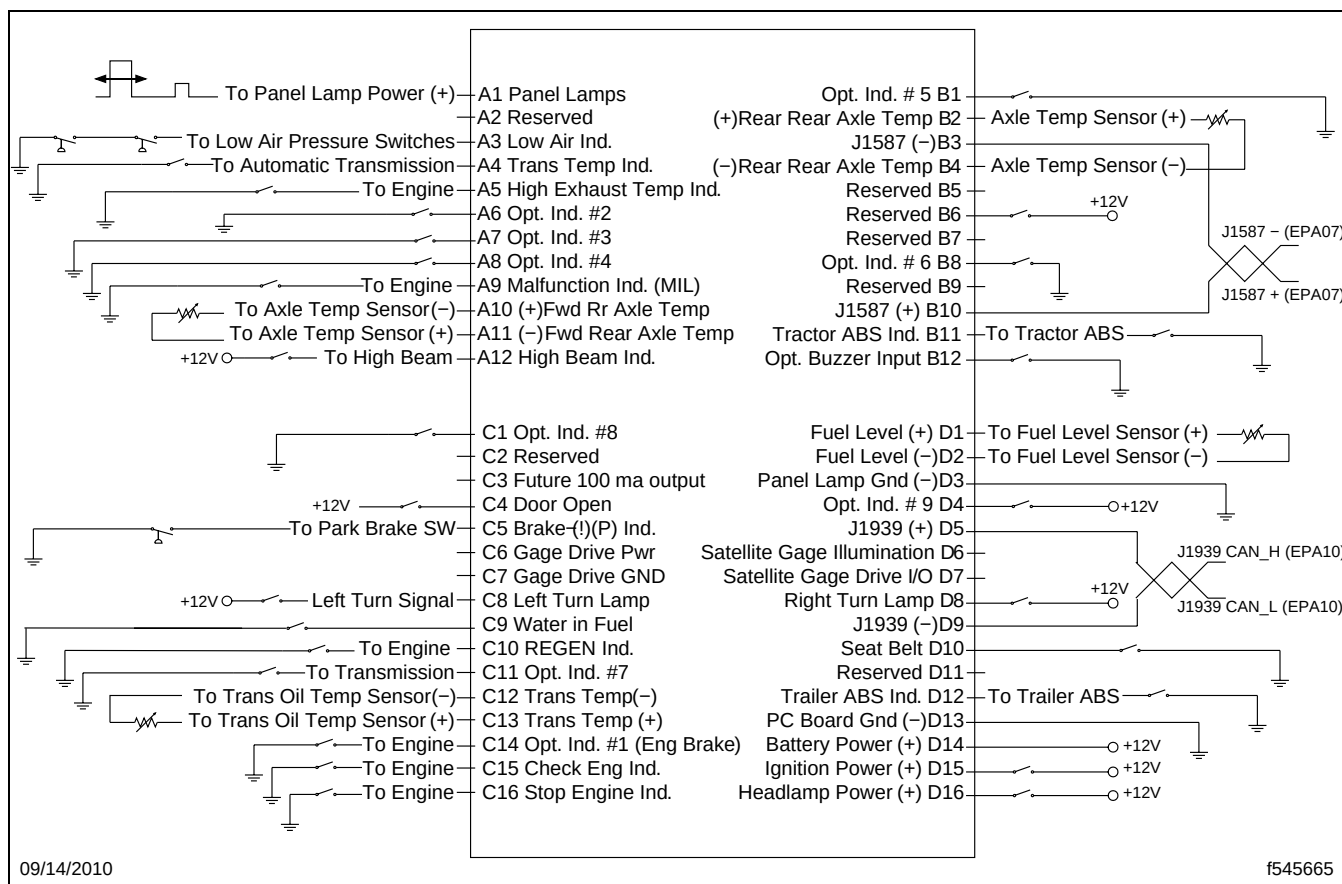


Fig. 6, ICU3 Interface Schematic (2010 shown)

700 — Diagnostic Tools Required

- ServiceLink or DiagnosticLink
- 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 or DiagnosticLink.

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 or DiagnosticLink. 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 **G04.02 — J1939 Fault Codes**. 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 or DiagnosticLink 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 **802 — rESETt EE 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. **800 — Roll Call Fault Messages** 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.				

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: 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)

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 703 — Gauge Diagnosis** to identify the gauge input source.

FUEL LEVEL → Go to **706 — Gauge Diagnosis: Fuel Level Gauge**

DEF LEVEL → Go to **707 — Indicator Diagnosis: DEF Level**

SENSOR DRIVEN → Go to **704 — Gauge Diagnosis: Sensor-Driven Gauges**

AIR PRESSURE → Go to **705 — Gauge Diagnosis: Air Pressure Gauge**

DATALINK DRIVEN → Continue with step 3

3. Confirm gauge accuracy with the applicable ServiceLink template or DiagnosticLink panel.
 - 3.1 Connect ServiceLink or DiagnosticLink. For EPA07 vehicles, open the J1587 ICU3 Instrument Cluster template or panel. For EPA10 vehicles open the J1939 ICU3 Instrument Cluster template or panel.
 - 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 or panel.

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 **703 — Gauge Diagnosis**, 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 **601 — Component Details** 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 **803 — Sensor Resistance Specifications**.
 - 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.

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

Inspect the connector at the fuel level sender at the fuel tank. If the connector is a three-wire type, continue with the three-wire fuel level sender system below. If the connector has two wires, continue with the two-wire fuel level sender troubleshooting procedure. See **Fig. 7** for two-wire sender, or **Fig. 8** for three-wire sender.

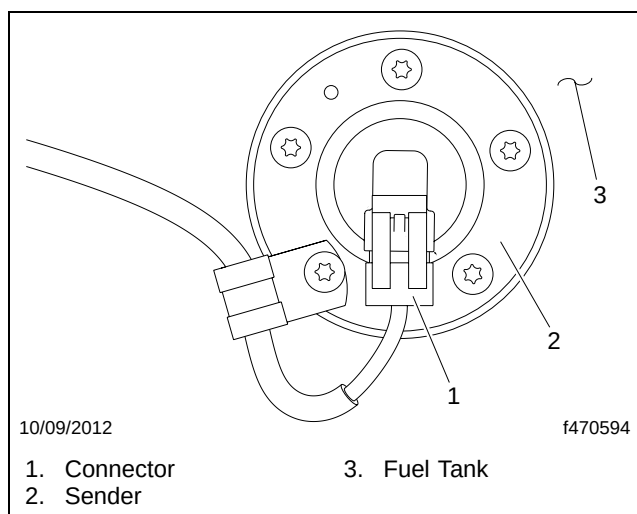


Fig. 7, Two-Wire Sender

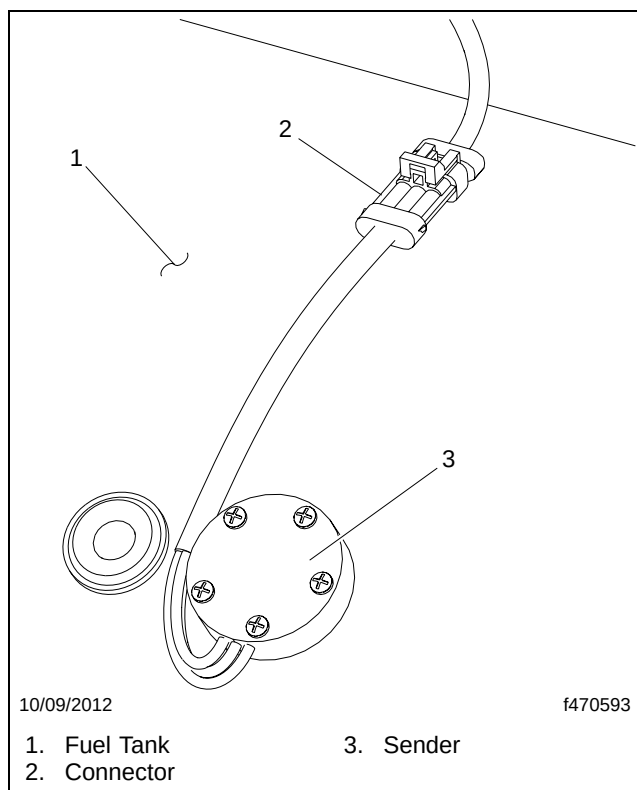


Fig. 8, Three-Wire Sender

Two-Wire Fuel Level Sending Unit

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 increase 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 18** for fuel level sensor resistance specifications.

Clogged vents or fuel lines will cause a delay on fuel tank equalizing, resulting in inaccurate fuel gauge readings.

Changes with the fuel level will not be indicated by the fuel gauge for 60 seconds. The 60-second delay applies to activation and deactivation unless ignition power is cycled, then it will immediately indicate for the measured value.

1. If the gauge did not initialize correctly as described in **703 — Gauge Diagnosis**, step 1, replace the ICU3.
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. 9**.

Does the resistance increase 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.

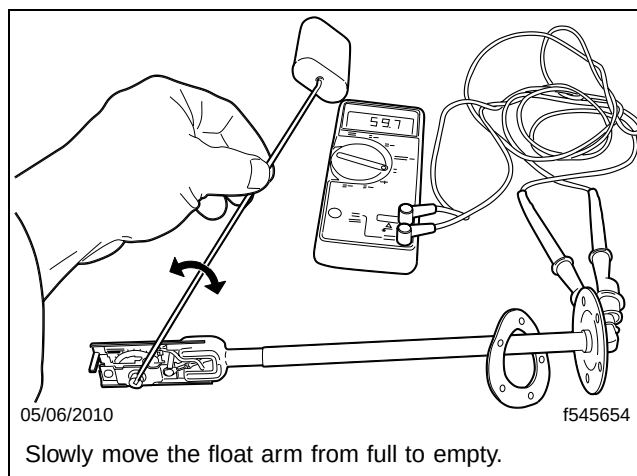


Fig. 9, Testing the Two-Wire Fuel Level Sending Unit

5.4 Does the fuel gauge read as expected?

YES → The fuel gauge is reading correctly.

NO → Check the mechanical integrity of the fuel sender. Is the tank rotated? Is the float arm bent or interfering with the tank wall, return tubes or aux heater line? The fuel tank should be oriented such that the fuel sender is at the top. Repair any defect found.

Three-Wire Fuel Level Sending Unit

The three-wire fuel level sender receives ignition power on circuit 47E. This ignition power circuit is sourced from either the SAM Chassis at connector X57, pin 15, or it is sourced from an under-dash splice pack. Use the actual vehicle schematic that is found in module 847.

There are two different three-wire senders. Use **Table 7** to determine the pin-out for the three-wire sending unit.

Fuel Level Sender Connections			
Vendor	PIN A	PIN B	PIN C
Parker WEBB Sending Unit	Ignition Power In	Signal Out	Ground
SSI Sending Unit	Ground	Signal Out	Ignition Power In

Table 7, Fuel Level Sender Connections

The three-wire sending unit outputs a resistance that the instrument cluster translates into fuel level. **Table 8** displays the three-wire sender voltage values that can be measured with a DMM.

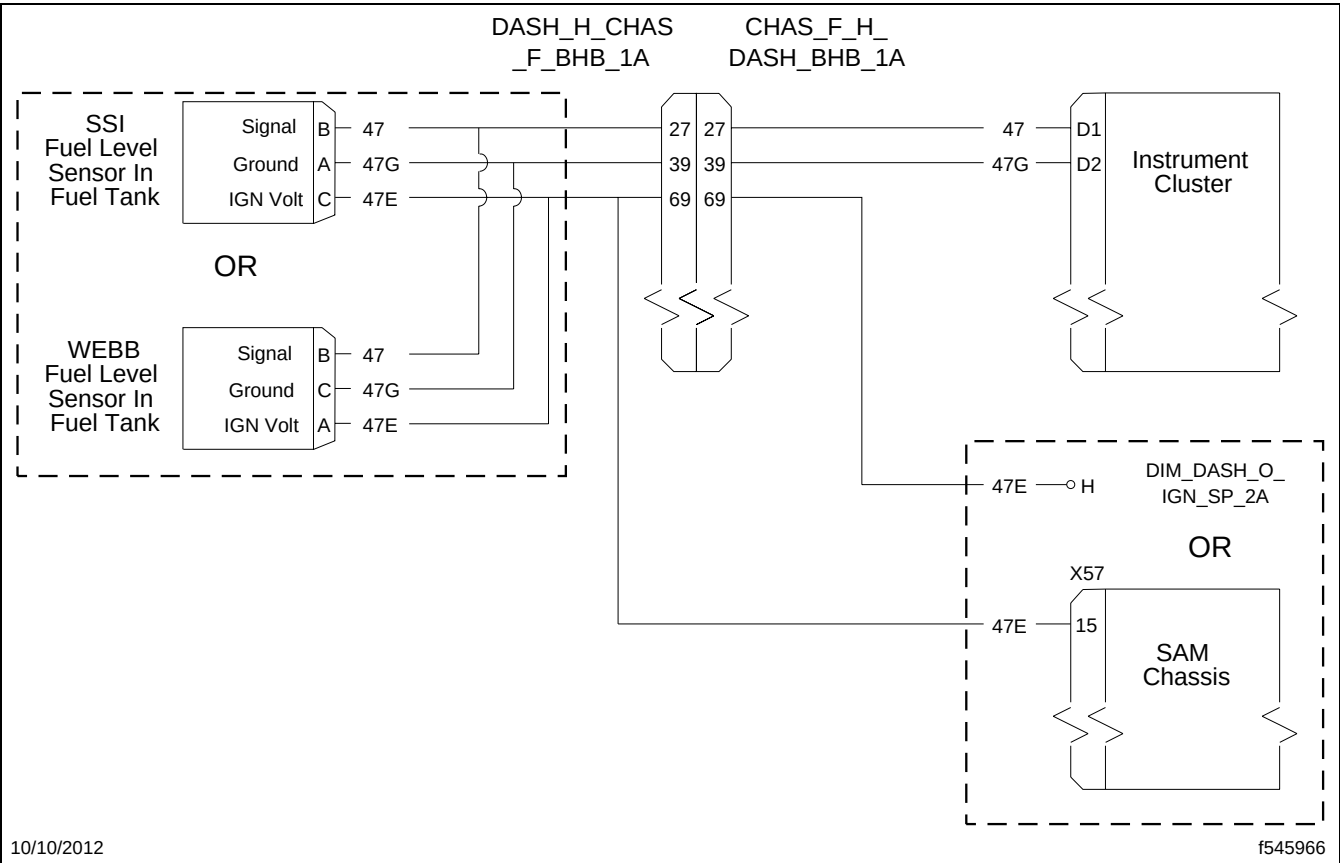


Fig. 10, Three-Wire Fuel Level Sender System Schematic

Approximate Voltage Values From the Three-Wire Sender	
State	Approximate Voltage
Short Low Error	0.2V or less
Full Tank	0.3V
Half Tank	0.9V
Empty Tank	1.7V
Short High Error	1.8 V or more

Table 8, Approximate Voltage Values From the Three-Wire Sender

1. Turn the ignition to ON without starting the engine. If the gauge did not initialize correctly as described in **703 — Gauge Diagnosis**, step 1, replace the ICU3.
2. Determine if the problem is with the wiring of the sending unit.
 - 2.1 With the key in the ON position, backprobe and measure the voltage on all 3 circuits at the fuel level sending unit. Use **Table 8** to reference the expected voltage. Record these measurements; they will be used again later in this procedure.

- 2.2 Are ignition power and ground present on the expected pins?

YES → Go to test 3.

NO → Troubleshoot for an open in circuit 47E or the ground circuit between the fuel level sender and the voltage source. The schematic can be found in module 847.

3. Test for a wiring fault on circuit 47 between the fuel level sender and the ICU.

Connect ServiceLink or DiagnosticLink and check for fault codes from source address 23 (the instrument cluster). Is fault code SPN 96 present?

YES → If the fault has FMI 5, troubleshoot and repair the open circuit wiring fault on circuit 47 between the sending unit and the instrument cluster. If the fault has FMI 6, troubleshoot and repair the short-to-ground wiring fault on circuit 47 between the sending unit and the instrument cluster. If there is no problem with the wiring, replace the sending unit.

NO → Replace the 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.

If the vehicle has been parked for an extended period, it is possible that DEF has crystallized in the sending unit and on the float causing it to stick. Remove the DEF tank and then the float header assembly from the DEF tank. If the failure is a stuck float due to DEF crystallization, the float header assembly and DEF tank can be cleaned and reinstalled. Use warm water to wash the tank, float, and sensor shaft, then use fresh DEF to refill the tank. After cleaning, use an ohm meter to insure the resistance of the DEF level sensor changes according to the values shown in **Table 22** for Cummins engines and **Table 23** for Detroit Diesel engines.

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 **803 — Sensor Resistance Specifications** 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 9** 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 9, DEF Level Faults from SA 0 or SA 61

Diagnose the DEF level indicator as follows.

- 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.
- Use Servicelink or DiagnosticLink 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.
- 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.
- 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 10**.

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 10, Satellite Gauge Daisy Chain Circuits

Table 11 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 11, ICU3 Satellite Gauges

Satellite gauges that are sensor or data driven will initialize at power-on with the same sequence as described in **703 — Gauge Diagnosis**, 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 **703 — Gauge Diagnosis**, step 1?

YES → Go to test 2.

NO → Test the 4 wire satellite gauge circuits for the values shown in **Table 12**. 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 **703 — Gauge Diagnosis** to identify the gauge input source.

SENSOR DRIVEN → Go to **704 — Gauge Diagnosis: Sensor-Driven Gauges**.

AIR PRESSURE → Go to **705 — Gauge Diagnosis: Air Pressure Gauge**.

DATALINK DRIVEN → Continue with step 3.

3. Confirm gauge accuracy with the applicable ServiceLink template or DiagnosticLink panel.
 - 3.1 Connect ServiceLink or DiagnosticLink. For EPA07 vehicles, open the J1587 ICU3 Instrument Cluster template or panel. For EPA10 vehicles open the J1939 ICU3 Instrument Cluster template or panel.
 - 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 or panel.
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 12** 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 12** to determine the optimal troubleshooting method.

For data-driven indicators, use ServiceLink or DiagnosticLink to monitor the data for the indicator. If the ICU3 does not illuminate an indicator when the diagnostic tool 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 12** 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.

ICU3 Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
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.
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.

ICU3 Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
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.
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 12, 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 13, ICU3 In-Gauge Warning Lamps

For data-driven lamps, use ServiceLink or DiagnosticLink to correlate the fault or fluid level condition. For the low-fuel-level lamp, allow for the 60 second delay when troubleshooting.

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).

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. 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 14** for EPA07 J1587/1708 vehicles and **Table 15** 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 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 14, 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 15, EPA10 ICU3 Roll Call Fault Messages Using J1939

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 16** 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 16**, 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 16, 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 17, 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.

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

Fuel Level Sensor Resistance		
Gauge Reading	Sensor Resistance in Ohms	
	Acceptable Range	Nominal
7/8	47.8 to 49.2	48.5
Full	29.4 to 30.6	30.0

Table 18, 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 19, Transmission Oil Temperature Sensor Resistance

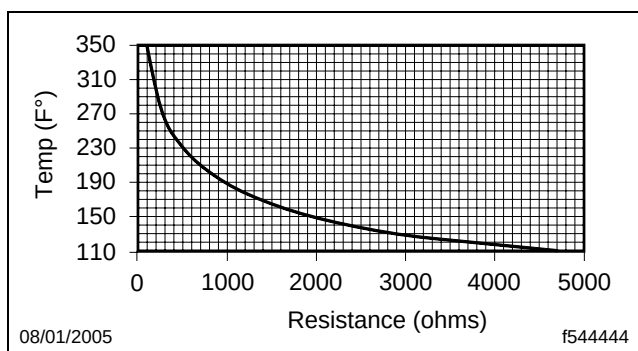


Fig. 11, Transmission Oil Temperature Sensor Resistance (°F)

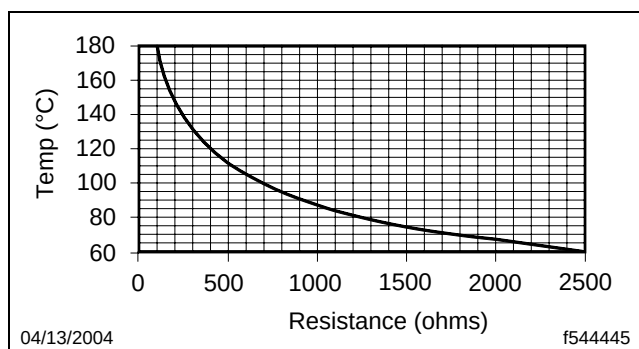


Fig. 12, Transmission Oil Temperature Sensor Resistance (°C)

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 20, Axle Oil Temperature Sensor Resistance—Standard Gauge

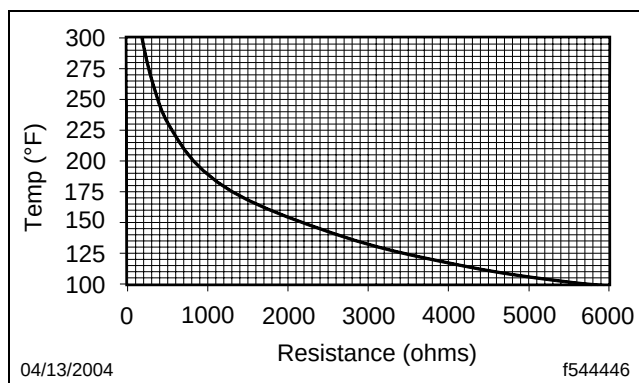


Fig. 13, Axle Oil Temperature Sensor Resistance (°F)

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 21, Axle Oil Temperature Sensor Resistance—Metric Gauge

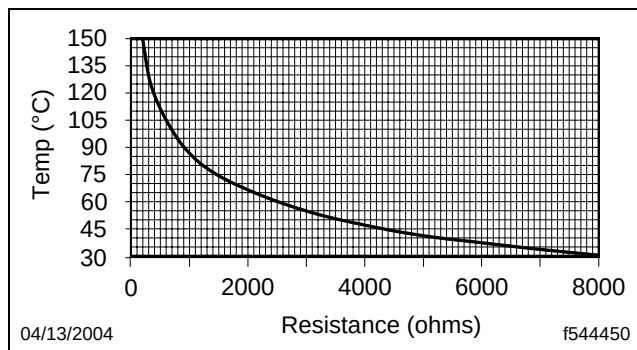


Fig. 14, Axle Oil Temperature Sensor Resistance (°C)

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

Cummins DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
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

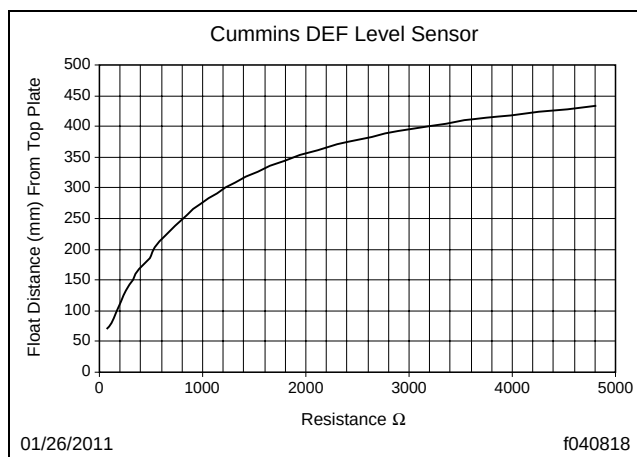


Fig. 15, Cummins DEF Level Sensor Resistance

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

DDC DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
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

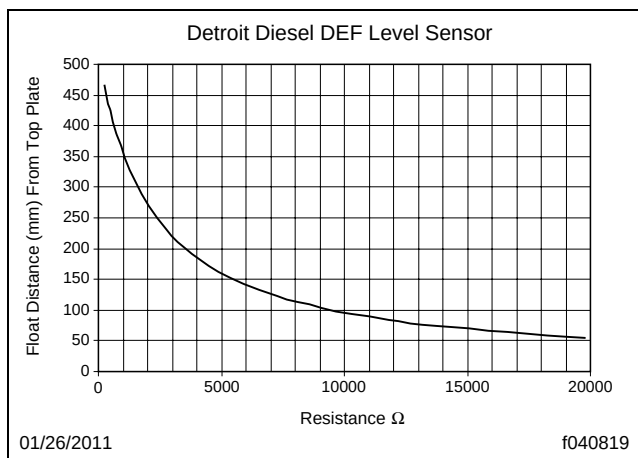


Fig. 16, DDC DEF Level Sensor Resistance

System Overview

Terms and Abbreviations	500
General Information	501
Gauges	502
Warning Lights	503
In-Gauge Warning Lights	504
Standard Warning Lights, Fixed-Position	505
Mode/Reset Switch, ICU4 Only	506
"+/-" Switch, Steering Wheel, ICU4 and ICU4M	507
"My Info/Enter" Switch, ICU4M Only	508
Buzzer and Chime	509
Wake Up	510
Ignition Sequence	511
Outside Air Temperature Screens	512
Automated Manual Transmission	513
Diagnostic Information	514
Vehicle Information, ICU4M Only	515
Odometer	516

Components

Component Locations	600
Component Details	601
Interface Schematic	602

Troubleshooting

Diagnostic Tools Required	700
ICU4/ICU4M Instrumentation Troubleshooting – Start Here	701
Fault Codes, ICU	702
Gauge Diagnosis: Start Here	703
Gauge Diagnosis: Sensor Driven Gauges	704
Gauge Diagnosis: Air Pressure Gauges	705
Gauge Diagnosis: Fuel Level Gauge	706
Indicator Diagnosis: DEF Level Indicator	707
Indicator Diagnosis: Lamps in the ICU4/4M	708
Indicator Diagnosis: Lamps in the Gauges	709
LCD Diagnosis	710
Gauge Diagnosis: Backlighting	711
Mode/Reset Button Diagnosis (ICU4 only)	712
Indicator Diagnosis: Seat Belt Lamp	713

Continued

Table of Contents

Specifications

Roll Call Fault Messages 800

Fault Code Messages 801

Reset EE Procedures 802

Sensor Resistance Specifications 803

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.

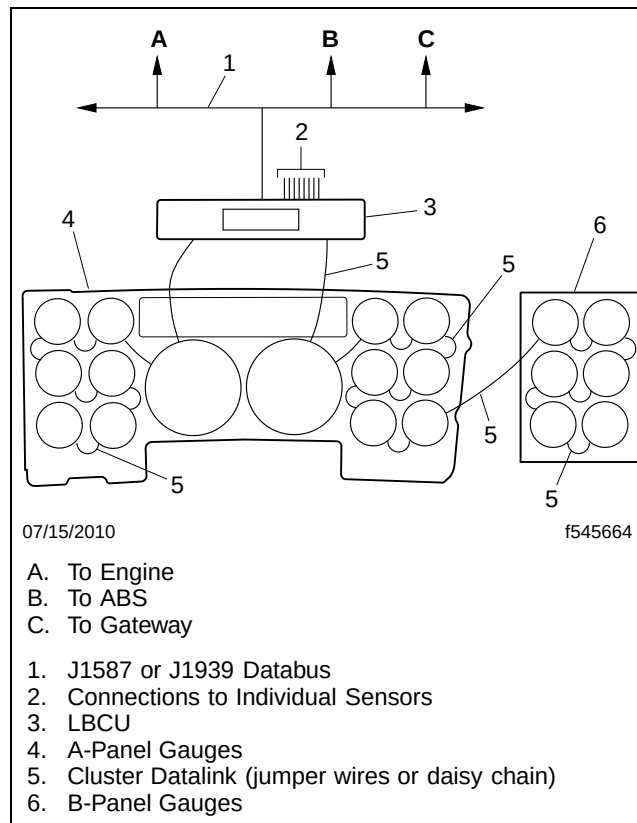


Fig. 1, ICU4/ICU4M Architecture

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.

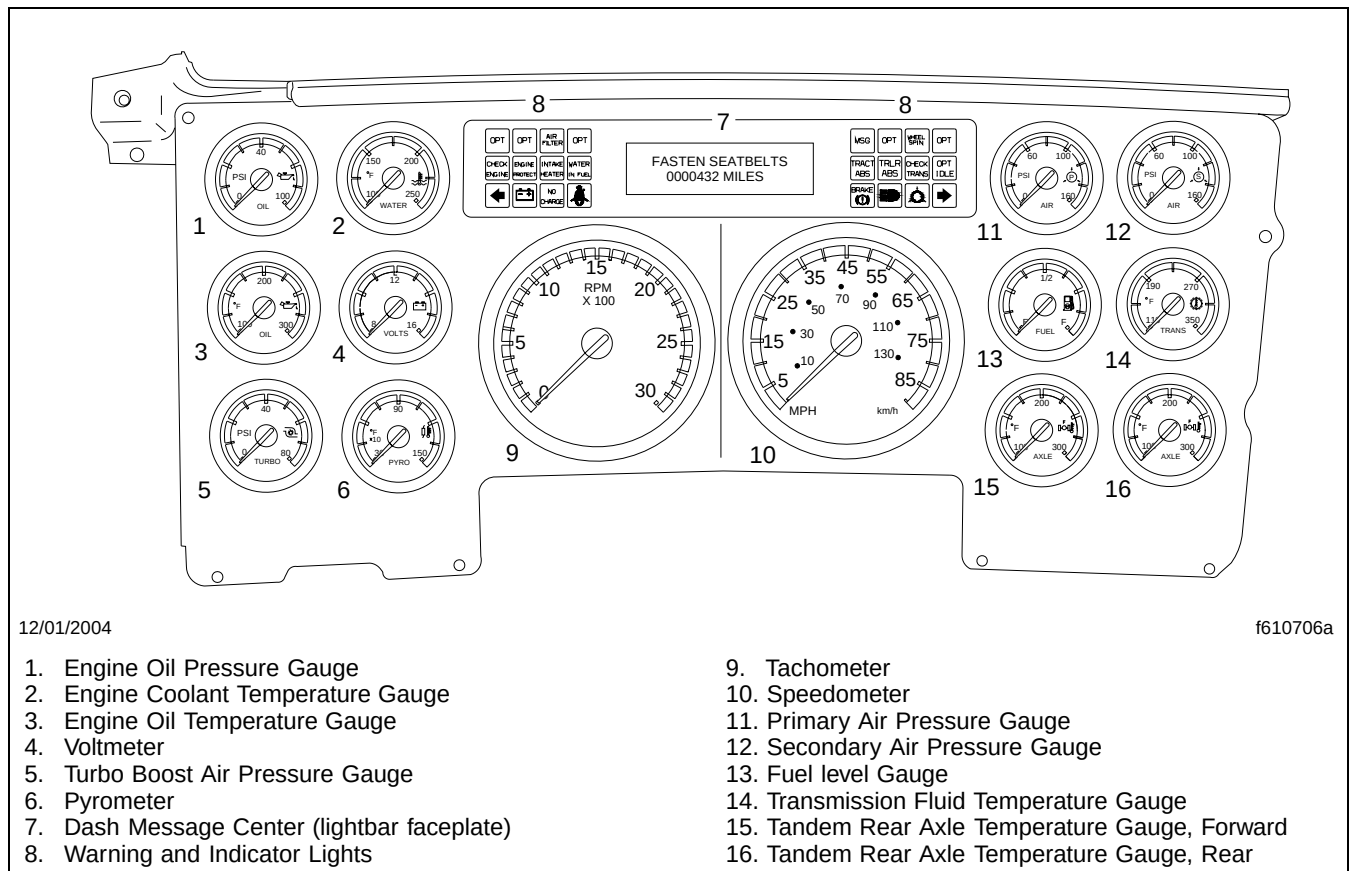


Fig. 2, ICU4M Instrument Cluster (typical)

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 13** 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;

- 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 13** 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.

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

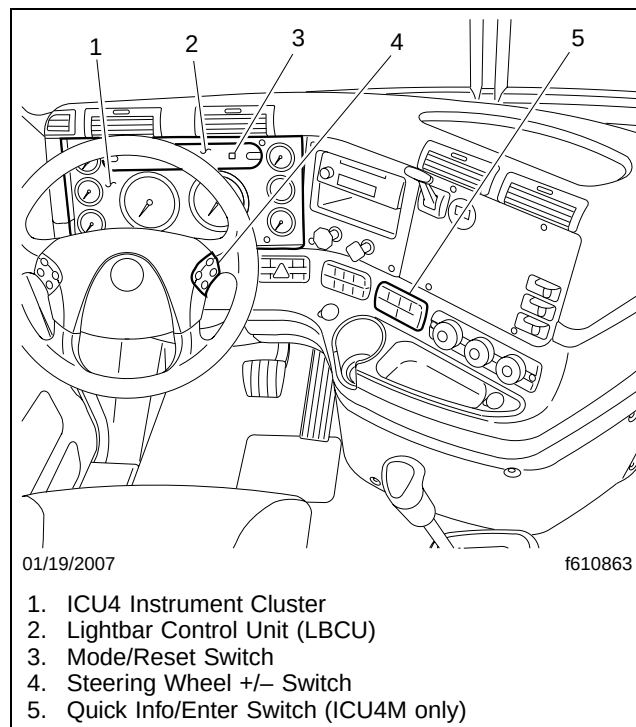


Fig. 3, Component Locations

601 — Component Details

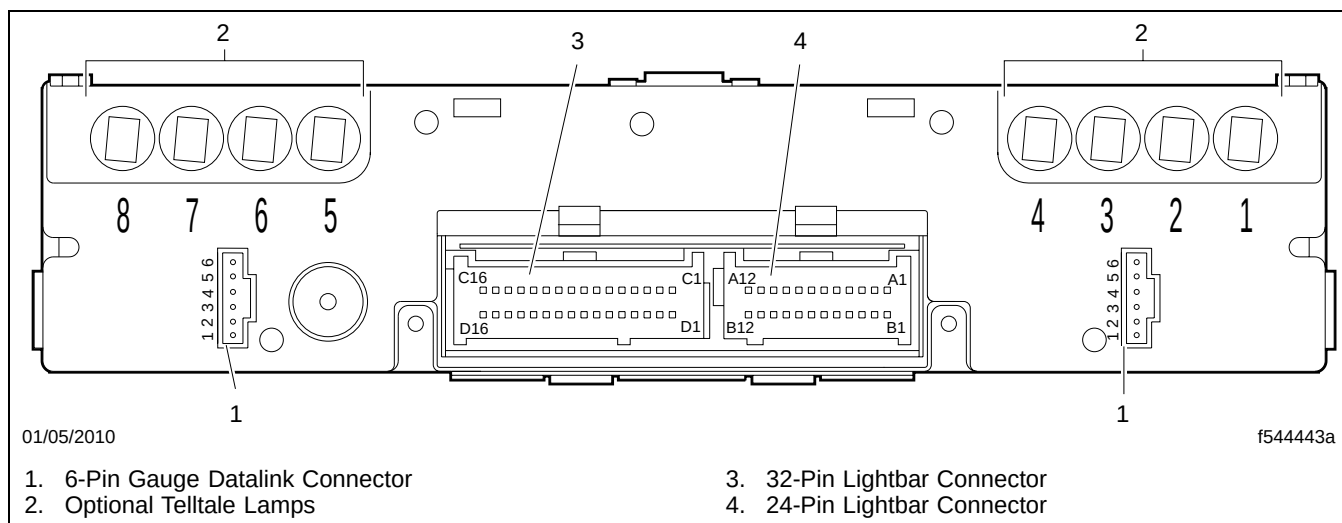


Fig. 4, ICU4/4M Lightbar Connector Pinouts

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

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

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

602 — Interface Schematic

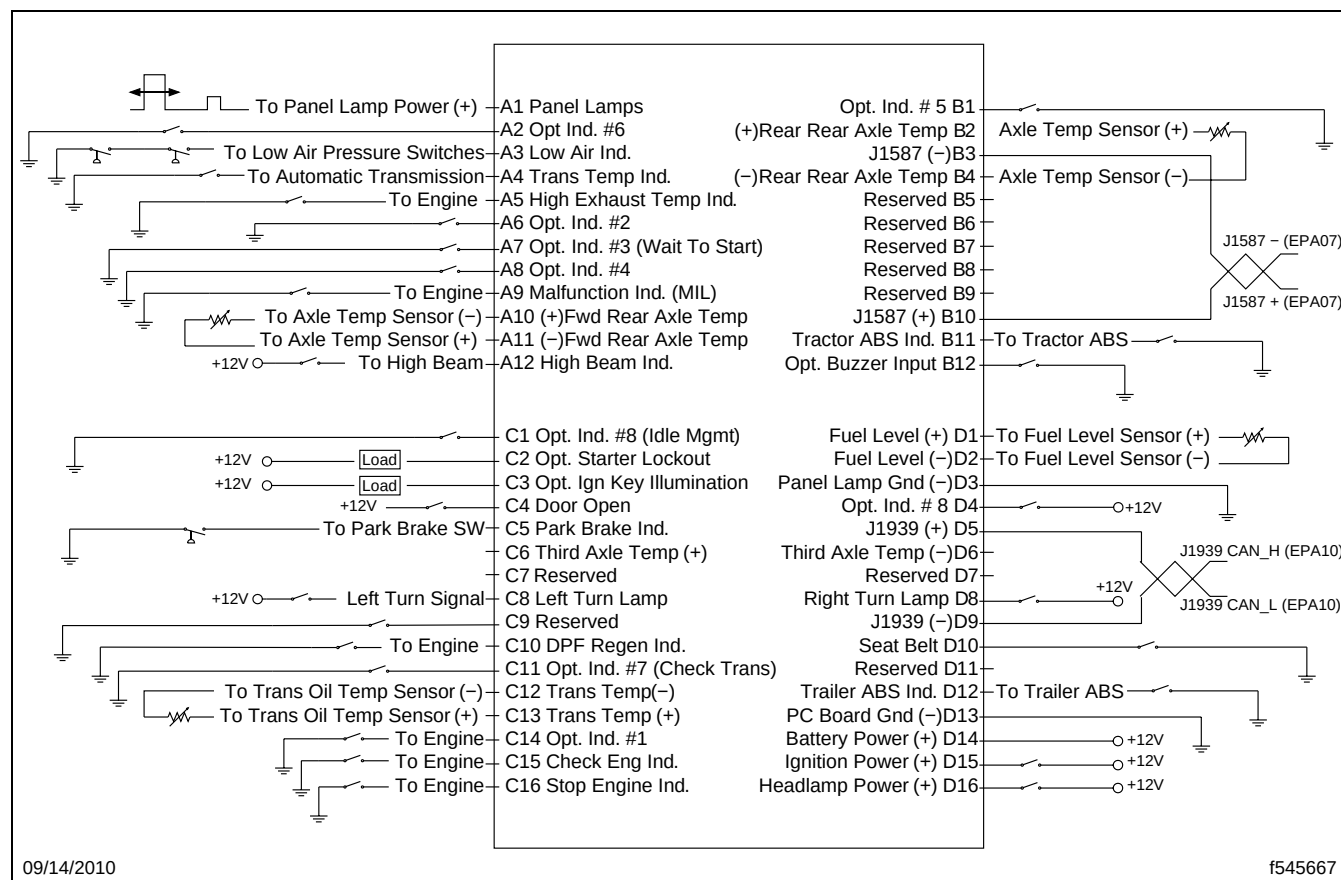


Fig. 5, Interface Schematic

700 — Diagnostic Tools Required

- ServiceLink/Datalink Monitor
- Digital Multimeter

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.

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 17** and **Table 18** 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

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.

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

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 14** 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.

706 — Gauge Diagnosis: Fuel Level Gauge

Inspect the connector at the fuel level sender at the fuel tank. If the connector is a three-wire type, continue with the three-wire fuel level sender system below. If the connector has two wires, continue with the two-wire fuel level sender troubleshooting procedure. See **Fig. 6** for two-wire sender, or **Fig. 7** for three-wire sender.

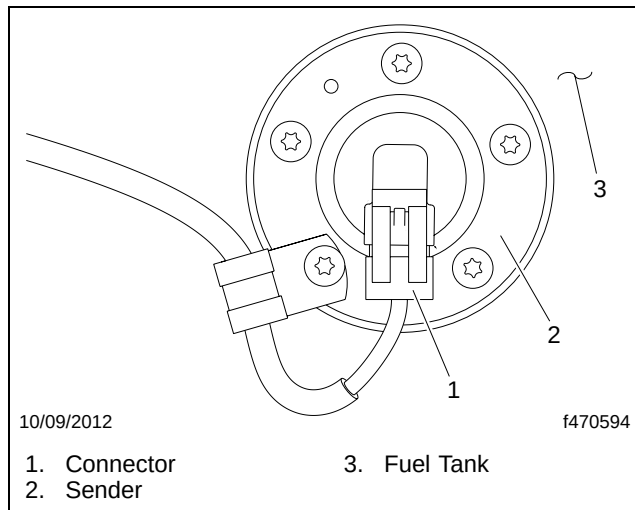
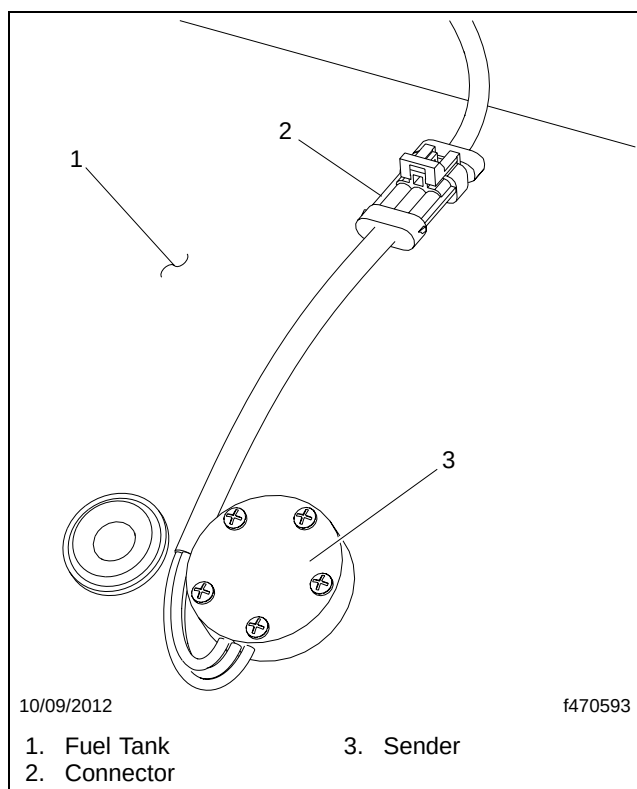


Fig. 6, Two-Wire Sender

**Fig. 7, Three-Wire Sender**

Two-Wire Fuel Level Sending Unit

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 increases 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 .

Clogged vents or fuel lines will cause a delay on fuel tank equalizing, resulting in inaccurate fuel gauge readings.

Changes with the fuel level will not be indicated by the fuel gauge for 60 seconds. The 60-second delay applies to activation and deactivation unless ignition power is cycled, then it will immediately indicate for the measured value.

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. 8**.

Does the resistance increase 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.

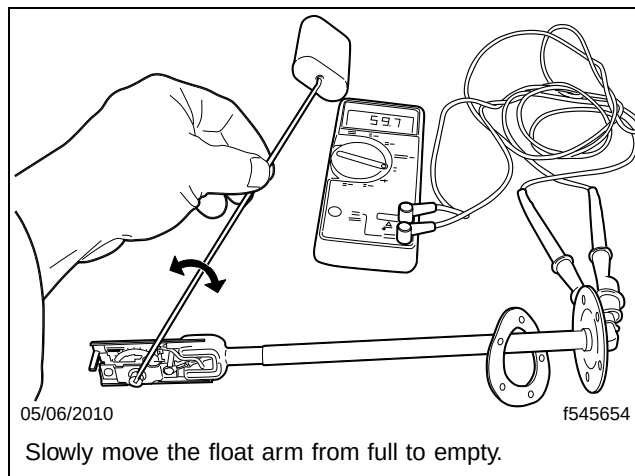


Fig. 8, Testing the Two-Wire Fuel Level Sending Unit

- 5.4 Does the fuel gauge read as expected?

YES →The fuel gauge is reading correctly.

NO →Check the mechanical integrity of the fuel sender. Is the tank rotated? Is the float arm bent or interfering with the tank wall, return tubes or aux heater line? The fuel tank should be oriented such that the fuel sender is at the top. Repair any defect found.

Three-Wire Fuel Level Sending Unit

The Three-wire fuel level sender receives ignition power on circuit 47E. This ignition power circuit is sourced from either the SAM Chassis at connector X57, pin 15, or it is sourced from an under-dash splice pack. Use the actual vehicle schematic that is found in module 847.

There are two different three-wire senders. Use **Table 10** to determine the pin-out for the three-wire sending unit.

Fuel Level Sender Connections			
Vendor	PIN A	PIN B	PIN C
Parker WEBB Sending Unit	Ignition Power In	Signal Out	Ground
SSI Sending Unit	Ground	Signal Out	Ignition Power In

Table 10, Fuel Level Sender Connections

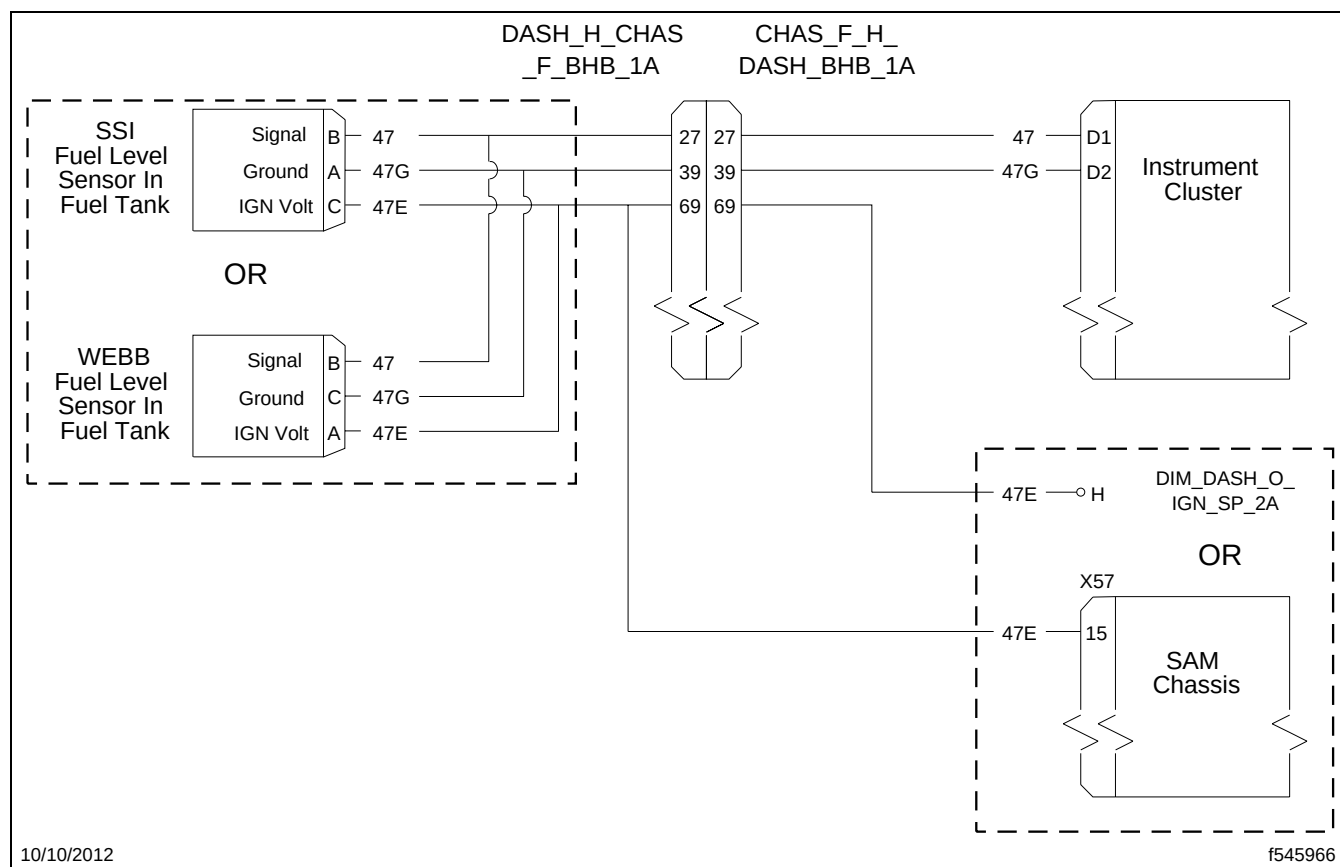


Fig. 9, Three-Wire Fuel Level Sender System Schematic

The three-wire sending unit outputs a resistance that the instrument cluster translates into fuel level. **Table 11** displays the three-wire sender voltage values that can be measured with a DMM.

Approximate Voltage Values From the Three-Wire Sender	
State	Approximate Voltage
Short Low Error	0.2V or less
Full Tank	0.3V
Half Tank	0.9V
Empty Tank	1.7V
Short High Error	1.8 V or more

Table 11, Approximate Voltage Values From the Three-Wire Sender

1. Turn the ignition to ON without starting the engine. If the gauge did not initialize correctly as described in subject 703, step 1, replace the gauge.
2. Determine if the problem is with the wiring of the sending unit.
 - 2.1 With the key in the ON position, backprobe and measure the voltage on all 3 circuits at the fuel level sending unit. Use table 1 to reference the expected voltage. Record these measurements; they will be used again later in this procedure.
 - 2.2 Are ignition power and ground present on the expected pins?

YES → Go to test 3.

NO → Troubleshoot for an open in circuit 47E or the ground circuit between the fuel level sender and the voltage source. The schematic can be found in module 847.
3. Test for a wiring fault on circuit 47 between the fuel level sender and the ICU.

Connect ServiceLink and check for fault codes from source address 23 (the instrument cluster). Is fault code SPN 96 present?

YES → If the fault has FMI 5, troubleshoot and repair the open circuit wiring fault on circuit 47 between the sending unit and the instrument cluster. If the fault has FMI 6, troubleshoot and repair the short-to-ground wiring fault on circuit 47 between the sending unit and the instrument cluster. If there is no problem with the wiring, replace the sending unit.

NO → Replace the 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.

If the vehicle has been parked for an extended period, it is possible that DEF has crystallized in the sending unit and on the float causing it to stick. Remove the DEF tank and then the float header assembly from the DEF tank. If the failure is a stuck float due to DEF crystallization, the float header assembly and DEF tank can be cleaned and reinstalled. Use warm water to wash the tank, float, and sensor shaft, then use fresh DEF to refill

the tank. After cleaning, use an ohm meter to insure the resistance of the DEF level sensor changes according to the values shown in **Table 24** for Cummins engines and **Table 25** for Detroit Diesel engines.

On Detroit Diesel engines, when the DEF tank is empty, the sensor will measure approximately 240Ω. When full, it will measure approximately 19.8KΩ. On Cummins engines, when the DEF tank is empty, the sensor will measure approximately 4.8KΩ. 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 12** 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 12, DEF Level Faults from SA 0 or SA 61

Diagnose the DEF level indicator as follows.

- 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.
- 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.
- 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.

- 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 13** 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 13** 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 13** 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.

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

ICU4/ICU4M Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
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
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

ICU4/ICU4M Warning and Indicator Lamps					
Lamp	Symbol	Bulb Check	Activation	Control Pin	Buzzer Operation
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	—
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 13, 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 14, 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.

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.

- 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 15** for J1587/1708 vehicles and **Table 16** 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.

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.

J1587/J1708 ICU4/ICU4M Roll Call Fault Messages		
Displayed Message	SID and FMI	Description
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 15, 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.
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.

J1939 ICU4/ICU4M Roll Call Fault Messages		
Displayed Message	SPN and MI	Description
SATI 75	SPN 639 FMI 7	No data us 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 16, J1939 ICU4/ICU4M Roll Call Fault Messages

801 — Fault Code Messages

Table 17 shows J1587/1708 Fault Display Messages, and Table 18 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 17, 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
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 18, 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 19, 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 20, Transmission Oil Temperature Sensor Resistance, Standard Gauge

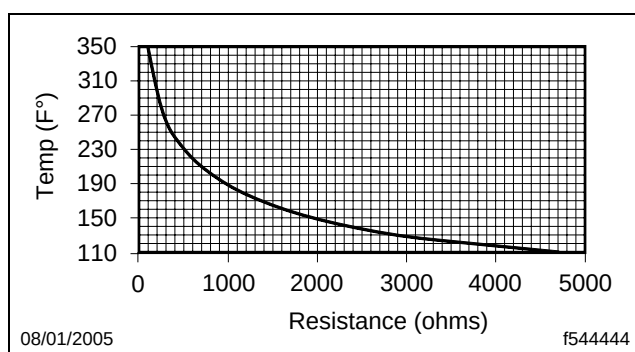


Fig. 10, Transmission Oil Temperature Sensor Resistance, Fahrenheit

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 21, Transmission Oil Temperature Sensor Resistance, Metric Gauge

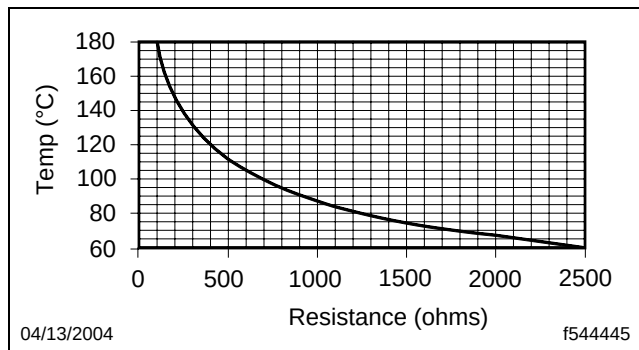


Fig. 11, Transmission Oil Temperature Sensor Resistance, Celsius

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 22, Axle Oil Temperature Sensor Resistance, Standard Gauge

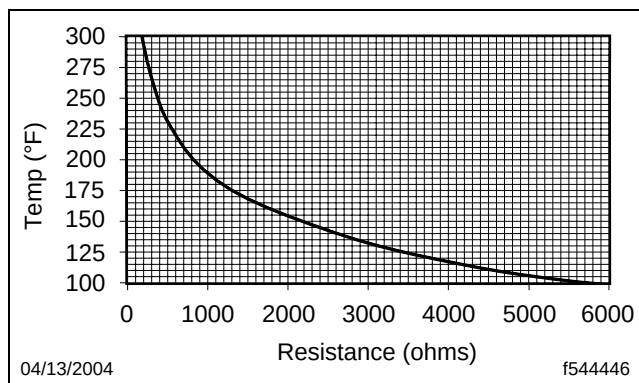


Fig. 12, Transmission Oil Temperature Sensor Resistance, Fahrenheit

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 23, Axle Oil Temperature Sensor Resistance, Metric Gauge

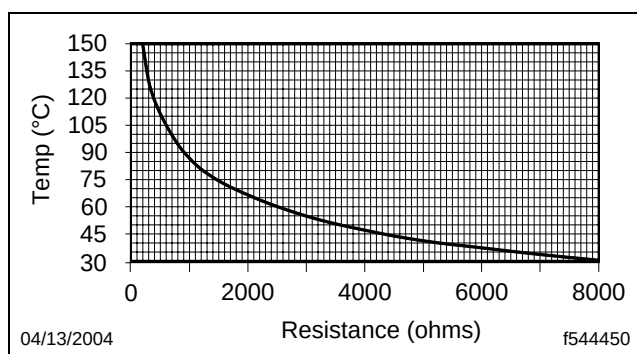


Fig. 13, Transmission Oil Temperature Sensor Resistance, Celsius

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

Cummins DEF Level Sensor Resistance	
Sensor Resistance (ohms)	Float Distance (mm) From Top Plate
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 24, Cummins DEF Level Sensor Resistance

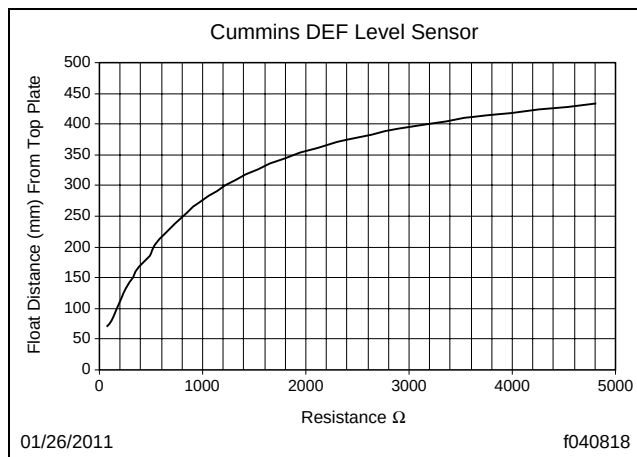


Fig. 14, Cummins DEF Level Sensor Resistance

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

DDC DEF Level Sensor Resistance	
Sensor Resistance (Ohms)	Float Distance (mm) From Top Plate
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 25, DDC DEF Level Sensor Resistance

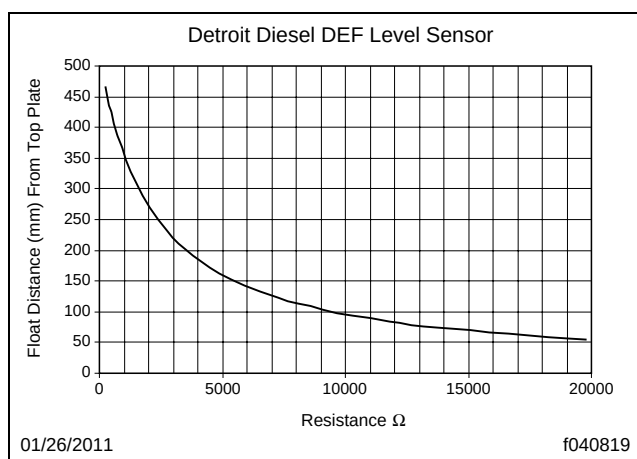


Fig. 15, DDC DEF Level Sensor Resistance

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600
Component Details	601
Electrical Connectors	602

Troubleshooting

Troubleshooting	700
Diagnostic Process	701
Refrigerant System Tests	702
Fault Code Driven Diagnostics	703
Approved Leak Detection Methods	704

Specifications

Specification	800

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 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:

- 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 filter outside air, and another that filter 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.

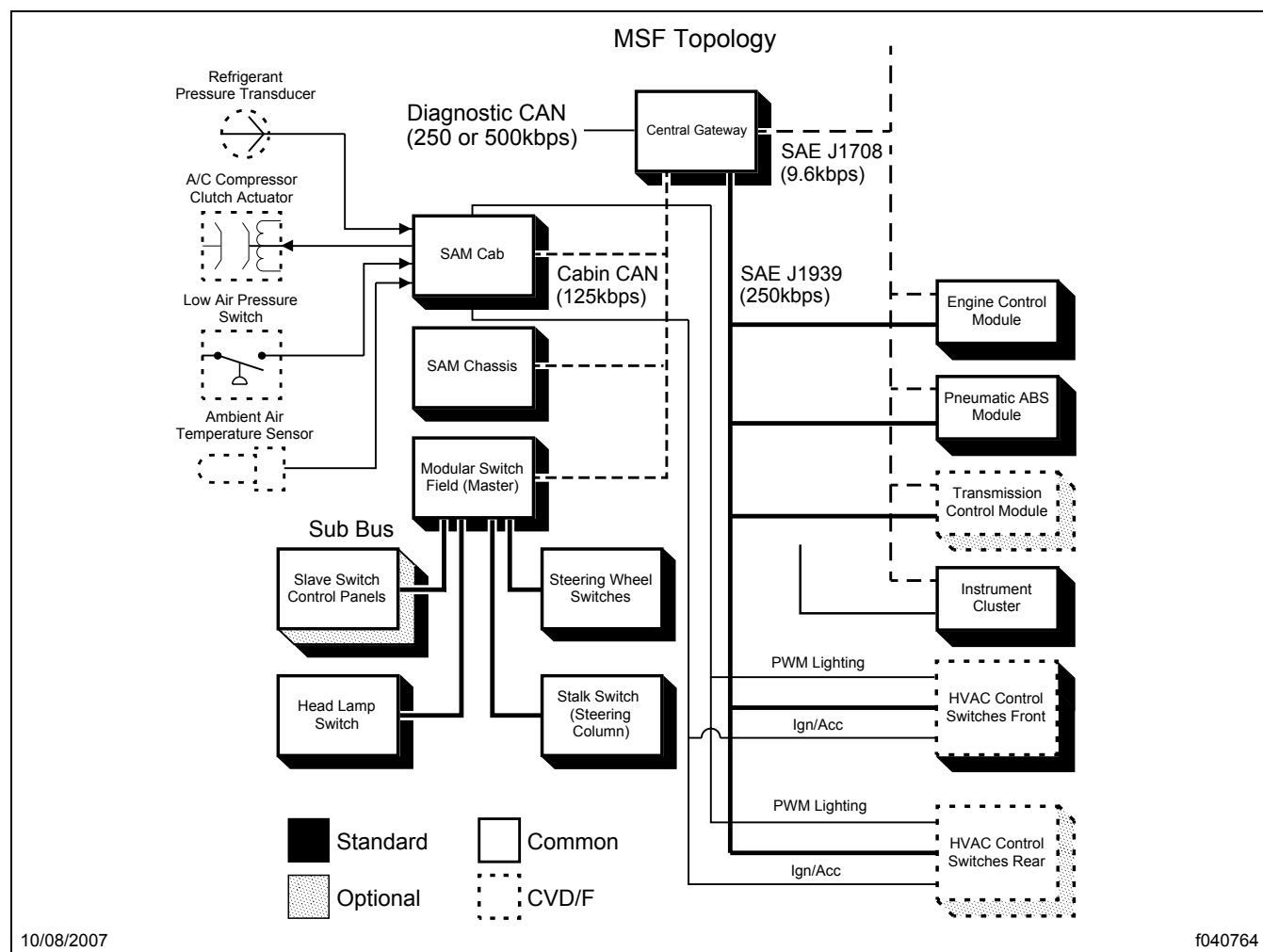


Fig. 1, HVAC System Electrical Control Topology

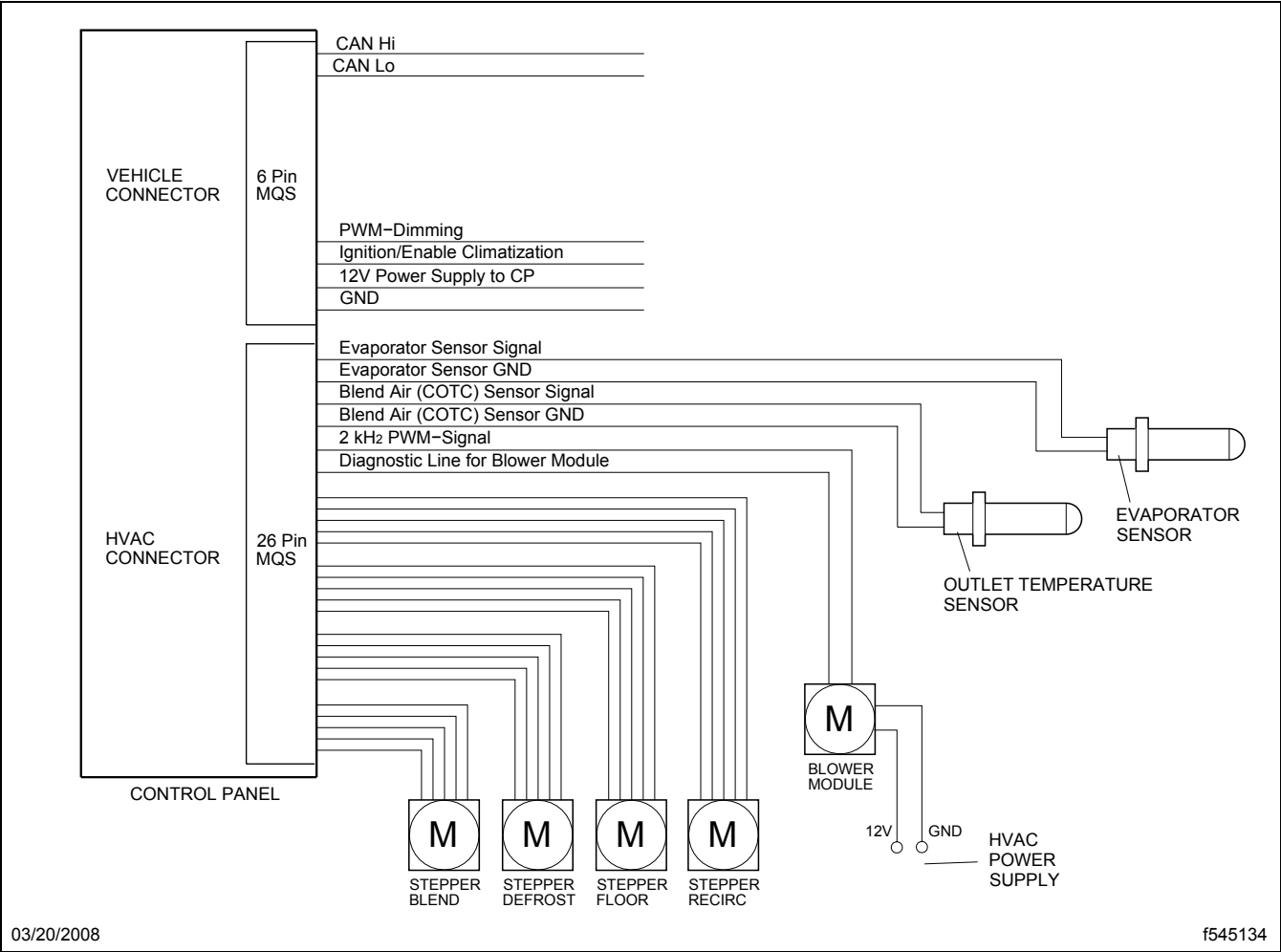


Fig. 2, Front Control Panel System Architecture

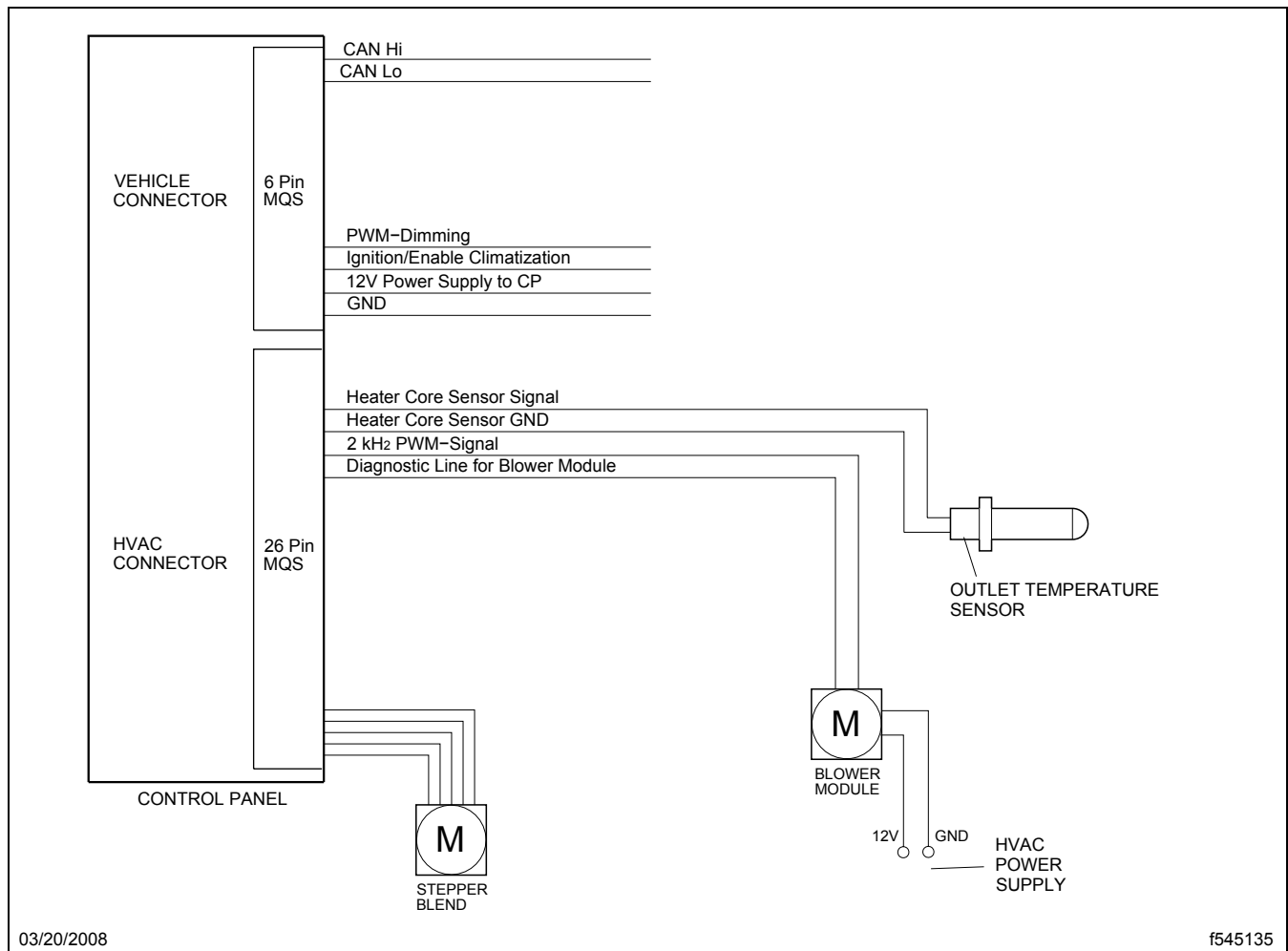


Fig. 3, Rear Control Panel System Architecture

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.

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
Ambient temperature†	J1939 message from SAM Cab via CGW	Ambient = 40°F to 200°F (4.5°C to 93°C)
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.

† Ambient temperature is not used as a condition for A/C clutch engagement on vehicles built after 6/15/2009, or prior vehicles that have previously had the front HVAC control unit replaced with an updated part. Updated parts would be the following or newer: A22-60645-101, A22-60645-501, or A22-60669-002.

‡ 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 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			

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.

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

Mode Control Settings			
Knob Position	Mode	Mode Door Position	A/C Request and A/C Indicator Lit (automatically)
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
8	Minor detent	25% FLOOR + 75% DEFROST	Yes
9	DEFROST	100% DEFROST	Yes

Table 3, Mode Control Settings

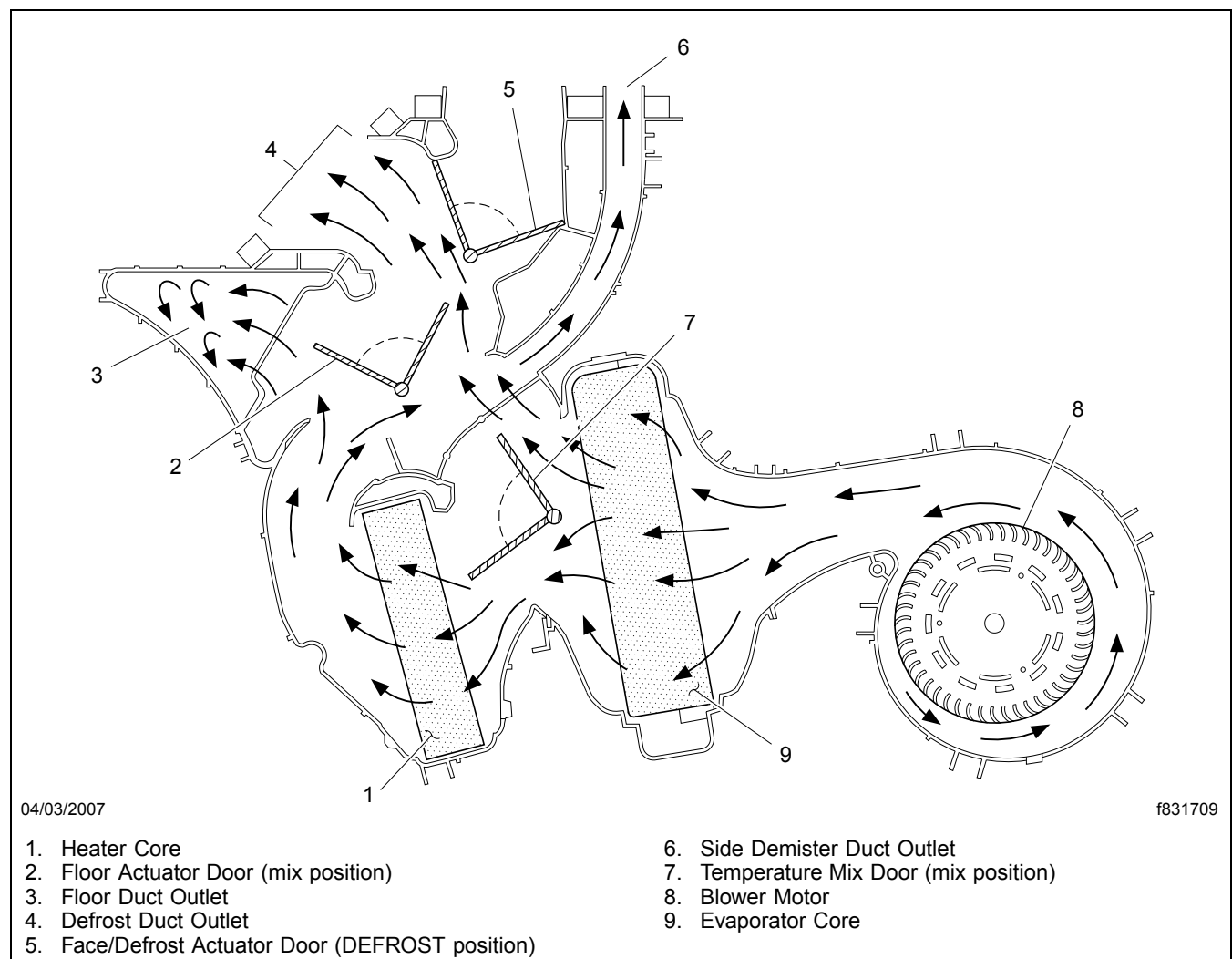


Fig. 4, Airflow Through Front HVAC Unit—Mode in DEF/FLOOR Position, Temperature Set to Medium Heat

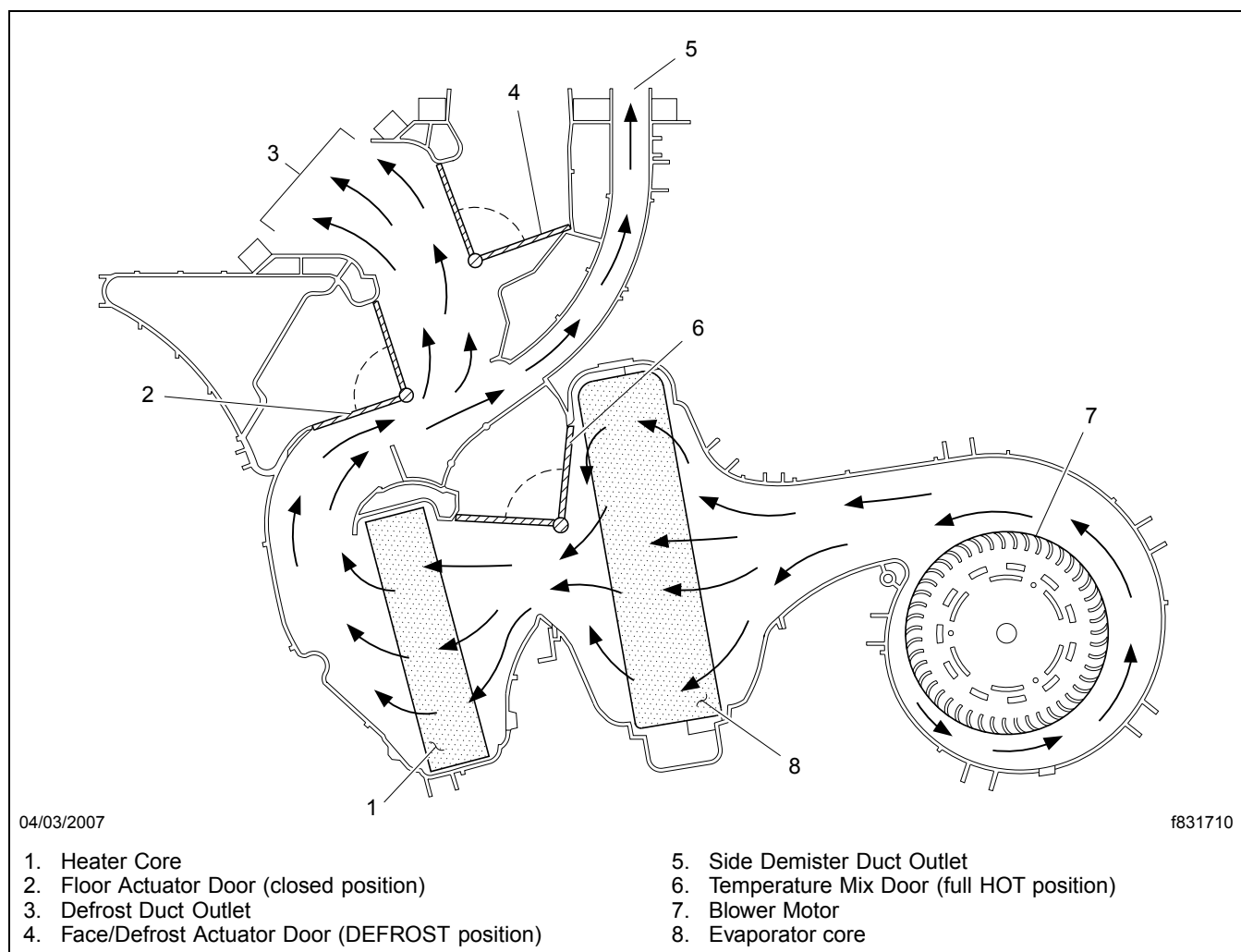


Fig. 5, Airflow Through Front HVAC Unit—Mode in Full DEFROST Position, Temperature Set to Full HOT

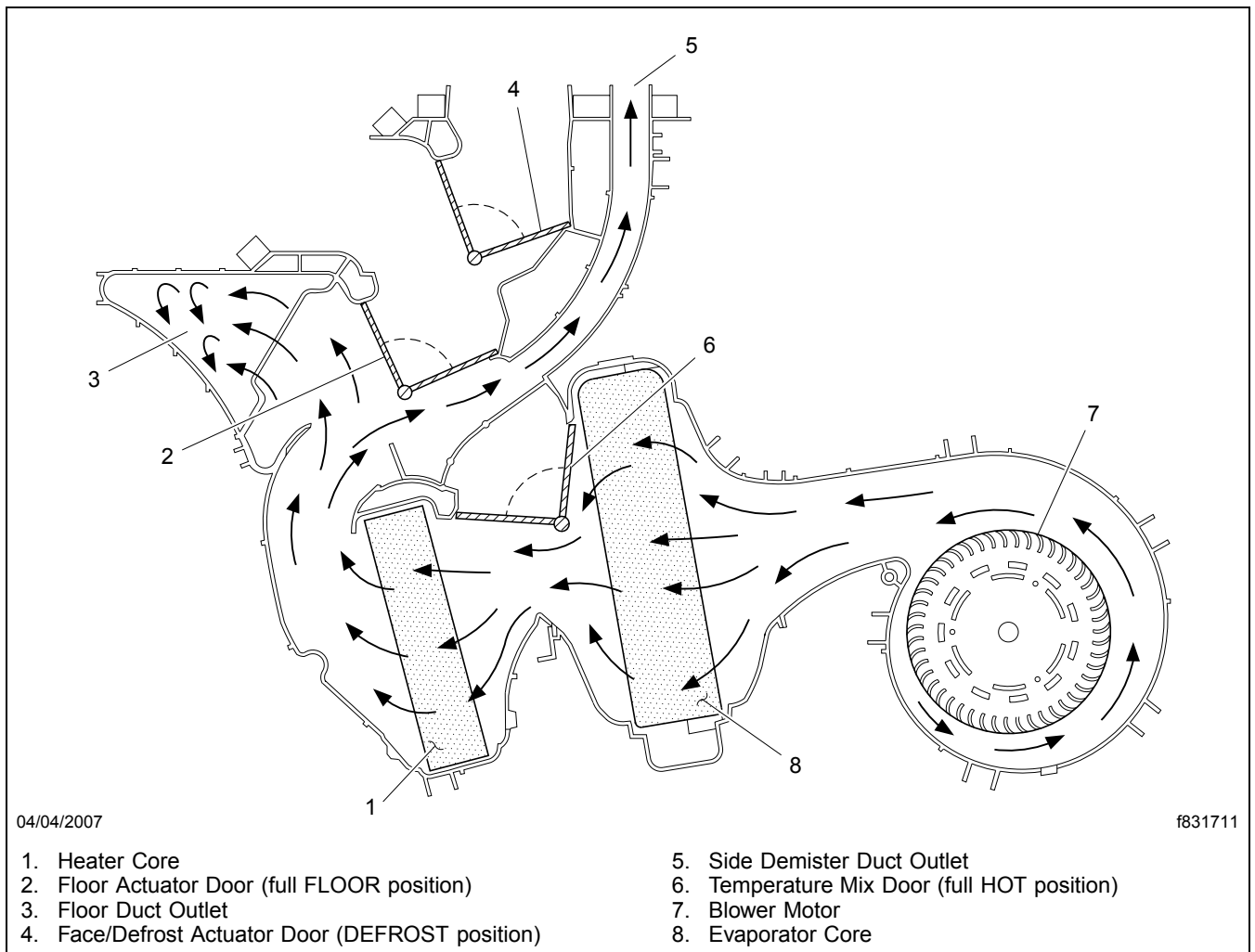


Fig. 6, Airflow Through Front HVAC Unit—Mode in Full FLOOR Position, Temperature Set to Full HOT

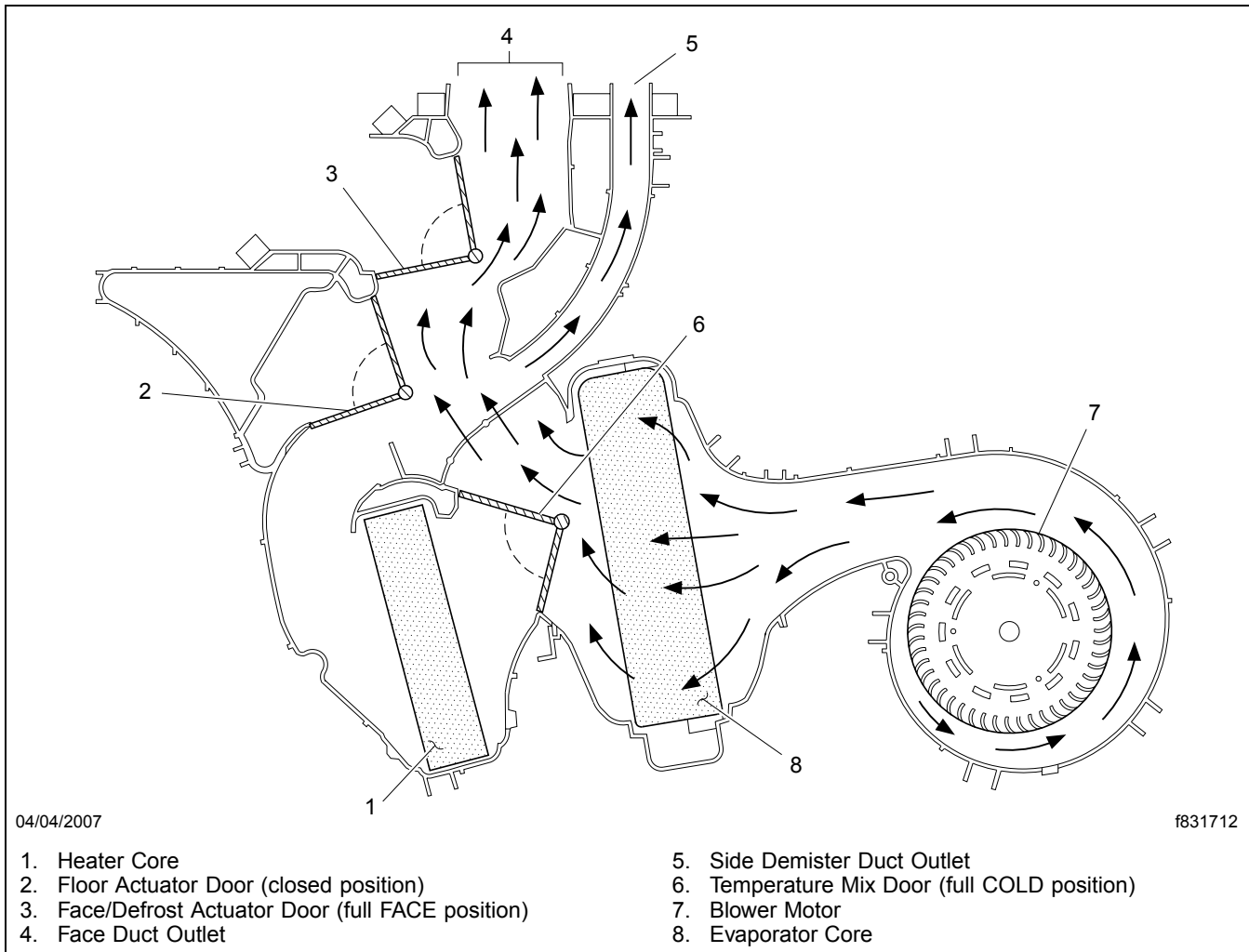


Fig. 7, Airflow Through Front HVAC Unit—Mode in Full FACE Position, Temperature Set to Full COLD (MAX A/C mode)

Manual Calibration Mode

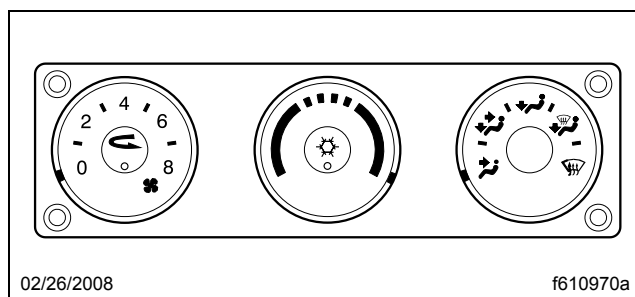


Fig. 8, Manual Calibration Mode Knob Positions

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

600 — Component Locations

HVAC Component Locations (general)

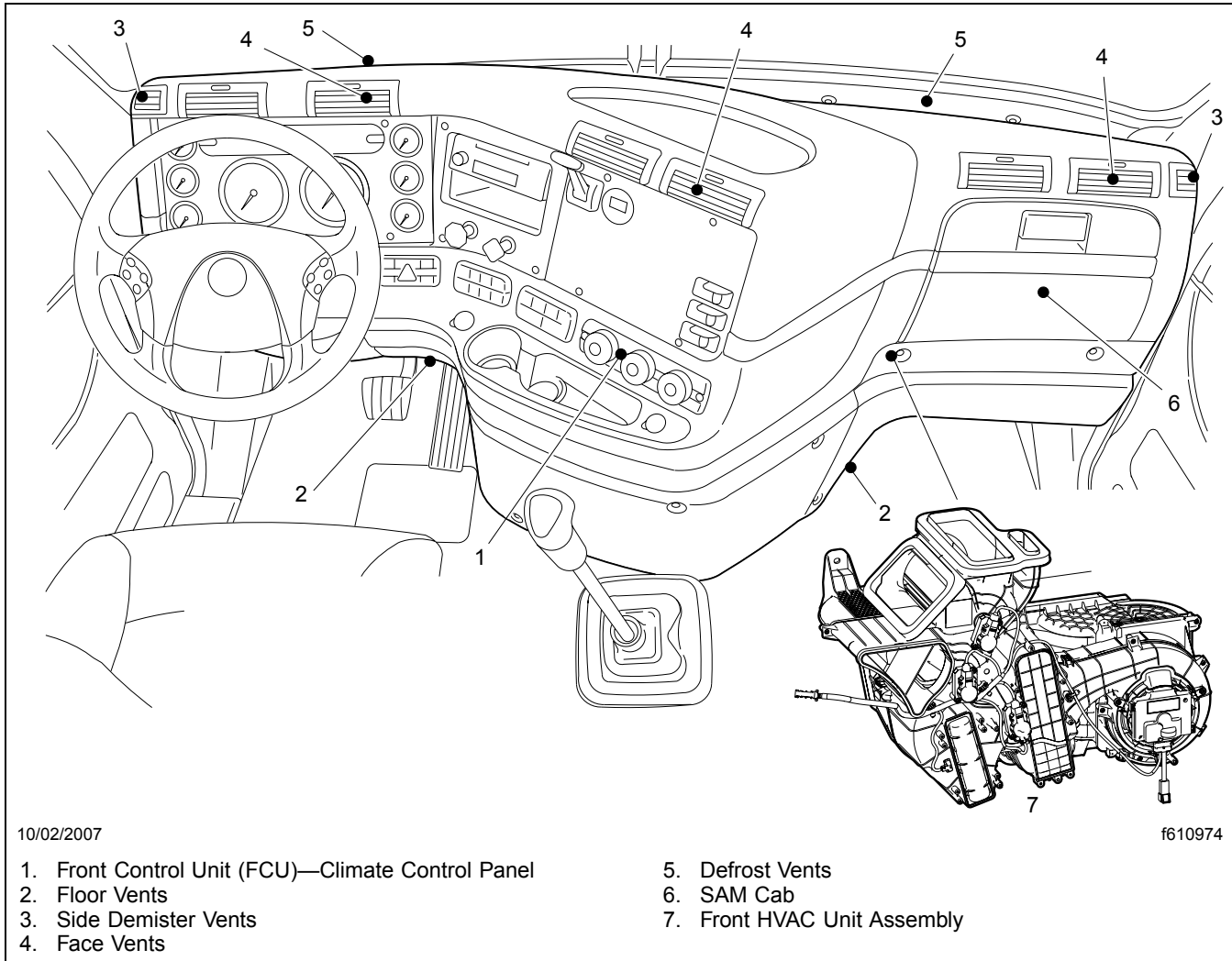


Fig. 9, HVAC Component Locations (general)

Component Locations—Front HVAC

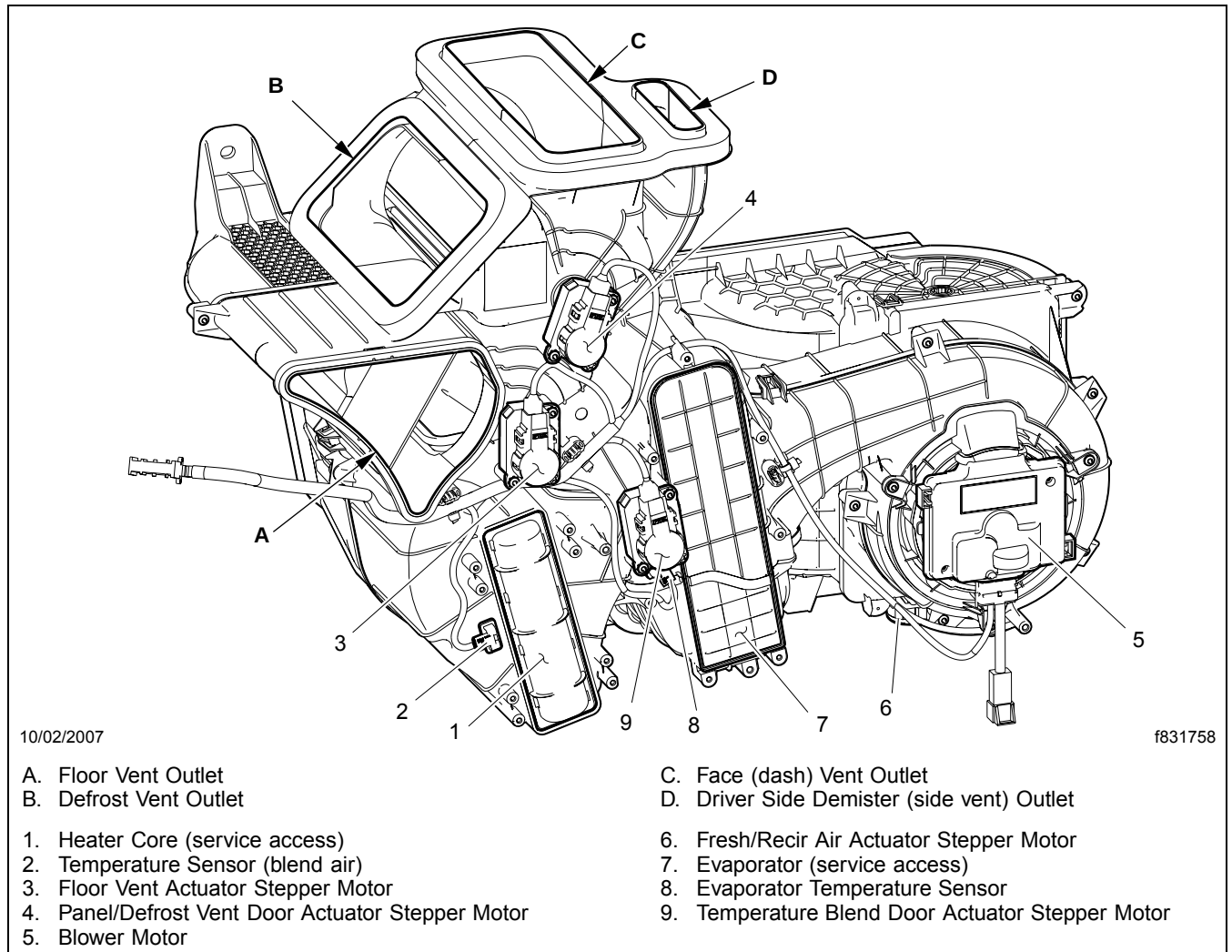


Fig. 10, Component Locations, Front HVAC

Component Locations—Sleeper HVAC

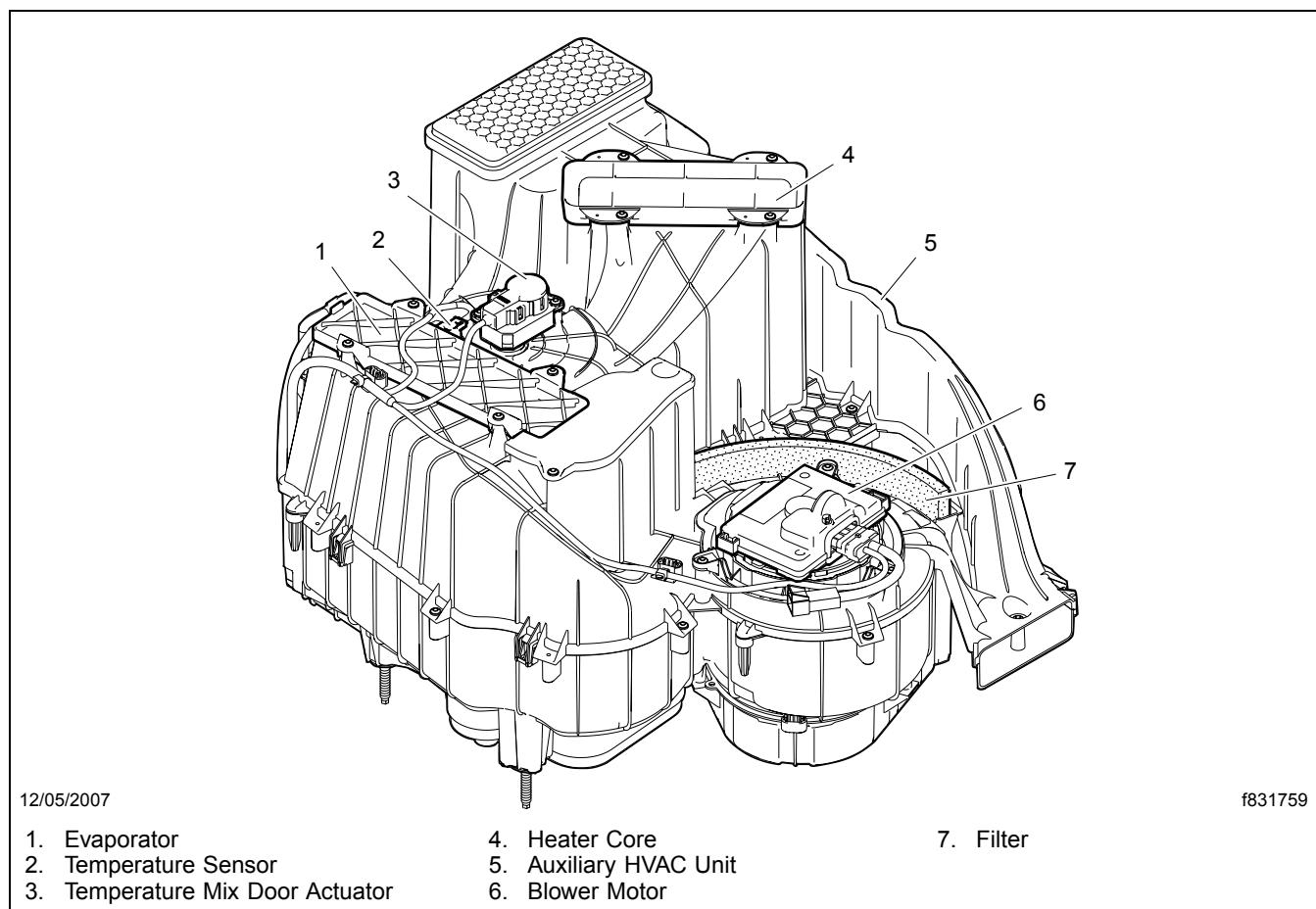


Fig. 11, Component Locations, Sleeper HVAC

601 — Component Details

Front Control Unit (FCU)

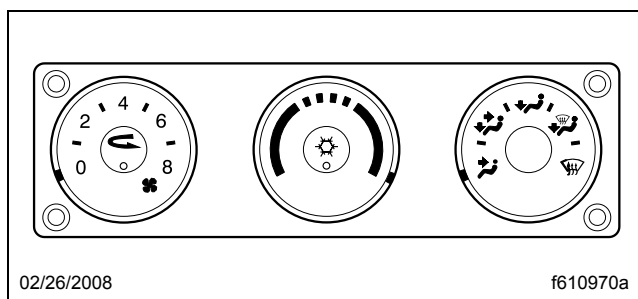


Fig. 12, Day Cab FCU

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)

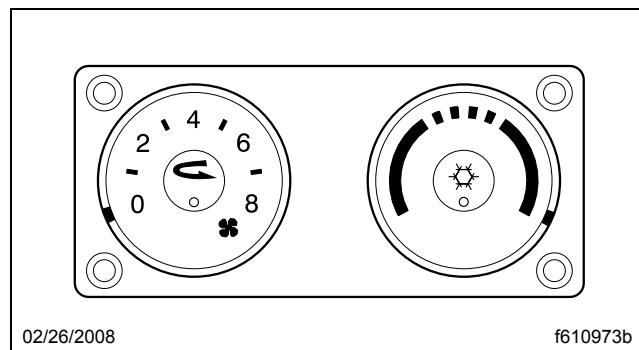


Fig. 14, Auxiliary Control Unit

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".

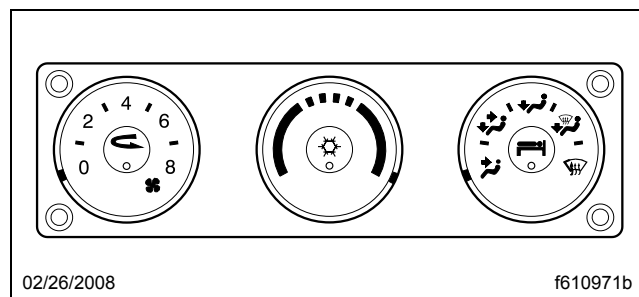


Fig. 13, Sleeper Cab FCU

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

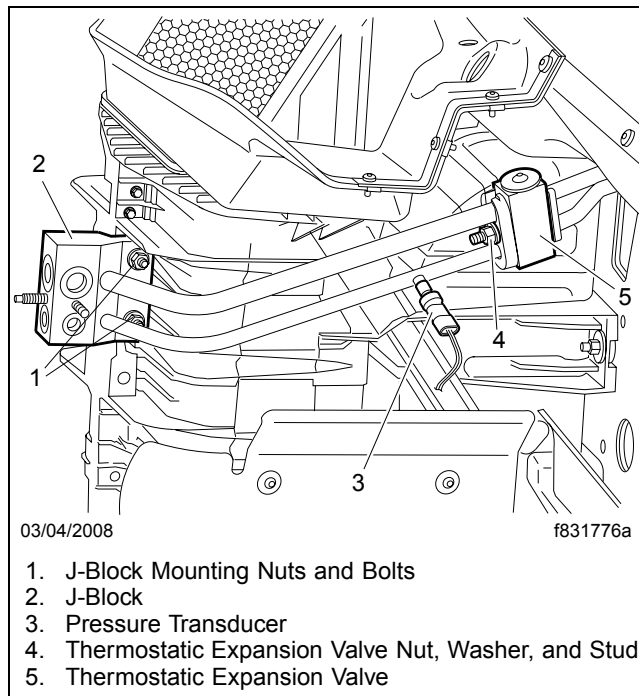


Fig. 15, Pressure Transducer

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

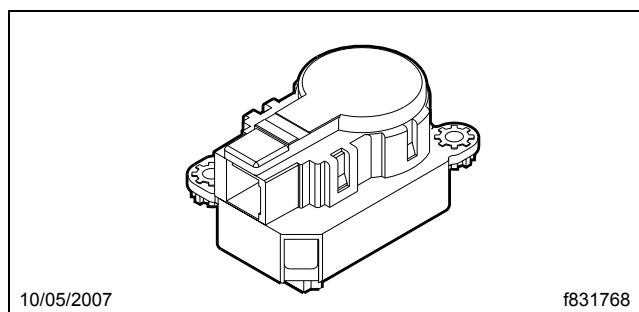


Fig. 16, Actuator

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

The diagram illustrates the connection between a 6-pin actuator and a motor (M). The actuator has two sets of contacts, A and B. Contact A is connected to pins 1, 2, and 3. Contact B is connected to pins 4, 5, and 6. The motor (M) is connected to the actuator via a cable with a connector that has a semi-circular shape on one side and a rectangular shape on the other.

10/03/2007

f545144

	0	I	II	III
1			—	—
3	—	—		
4		—	—	
6	—			—
2+5	+	+	+	+
1		—	—	
3	—			—
4			—	—
6	—	—		
2+5	+	+	+	+

Table 4, Actuator Connection and Drive Sequence

COTC Sensor

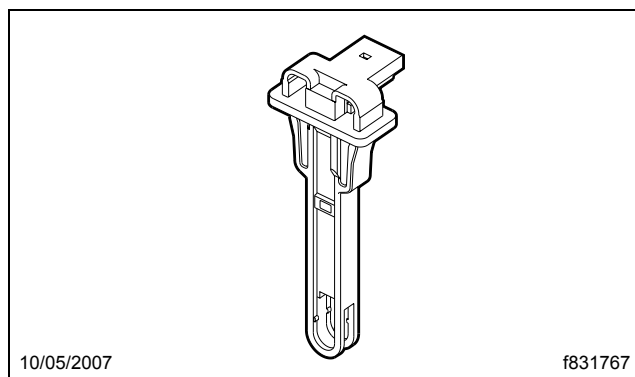


Fig. 17, COTC Temperature Sensor

The constant duct outlet temperature sensor (COTC) is used by the FCU to control the blend door position, to maintain temperature within the FCU set-points. It is a negative temperature coefficient (NTC), meaning that its resistance decreases as temperature increases.

Evaporator Sensor

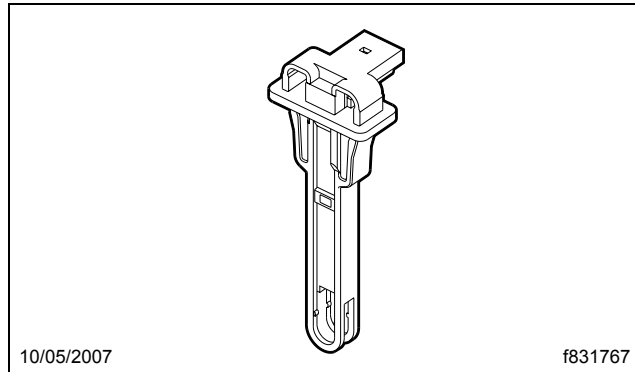


Fig. 18, Evaporator Temperature Sensor

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

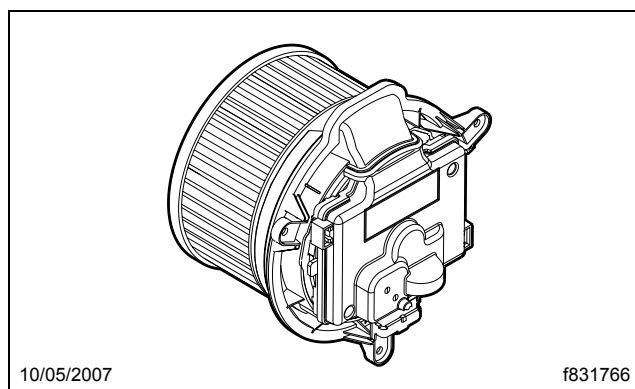


Fig. 19, Blower Motor

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 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

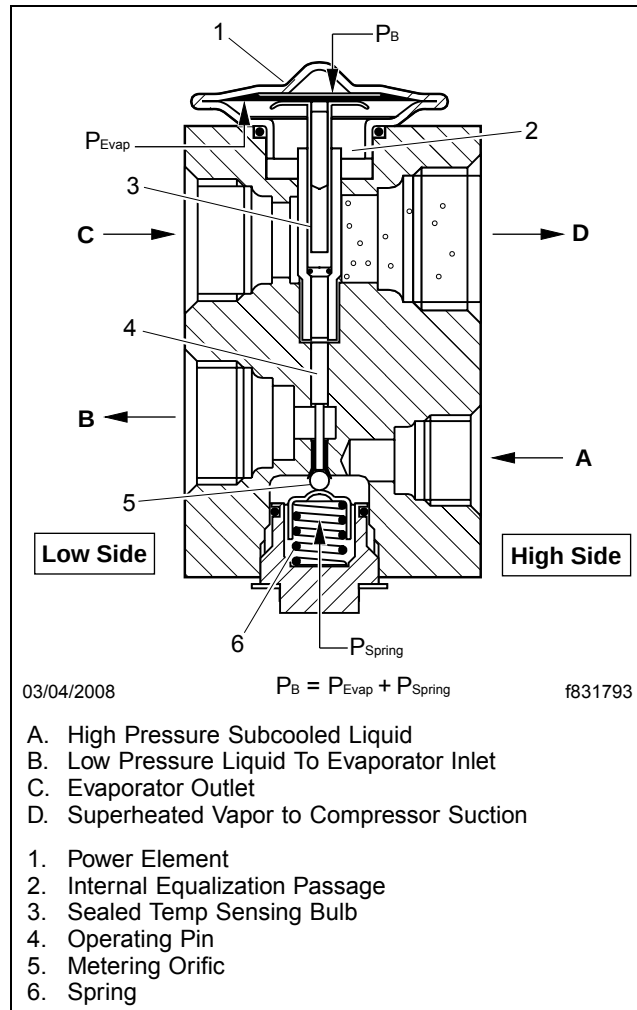


Fig. 20, Thermostatic Expansion Valve (cutaway)

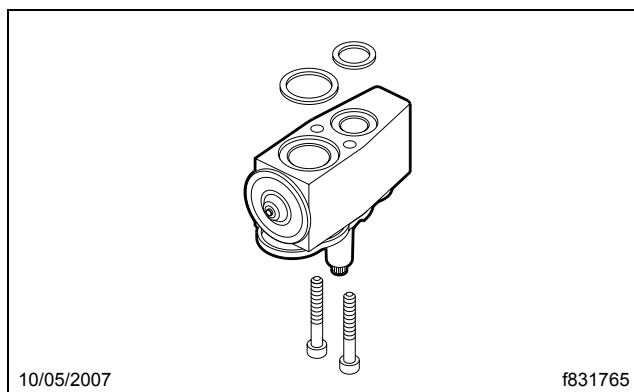


Fig. 21, Thermostatic Expansion Valve

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

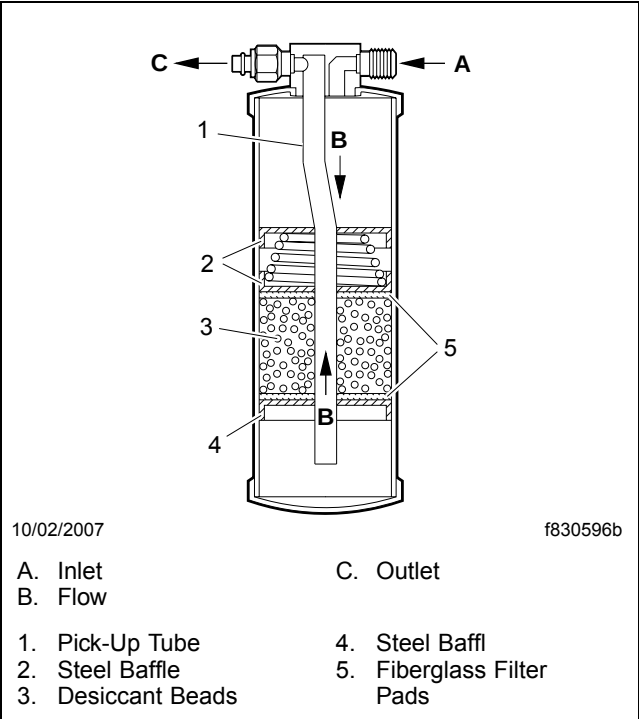
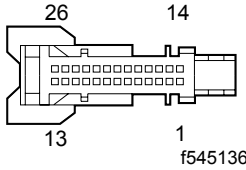


Fig. 22, Receiver-Drier

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			
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

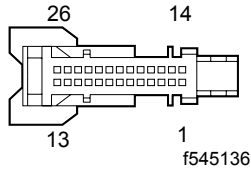
FCU 26-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
5	338A3-3	Light Blue	Floor actuator–ground (–) #3
6	338A3-1	Light Blue	Floor actuator–ground (–) #1
7	338A1-2	Light Blue	Recirc actuator–ground (–) #3
8	338A4-1	Light Blue	Recirc actuator–ground (–) #1
9	338K	Light Blue	Evaporator sensor 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

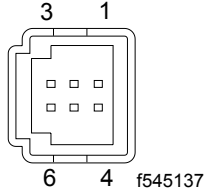
FCU 6-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(-) datalink
3	29A	Brown	Backlighting input (PWM)
4	98	Light Blue	+12V battery
5	GND	Black	Ground
6	81C	Pink	+12V ignition/acc

Table 6, FCU 6-Pin Connector

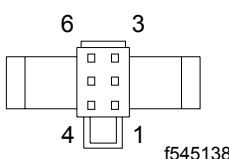
Actuator Stepper Motor 6-Pin Connector (Front Unit Actuators)						
Pin	Circuit No.				Wire Color	Circuit Description
	Fresh/Recirc	Temperature Blend	Floor	Defrost/Face		
1	338A4-1	338A1-1	338A3-1	38A2-1	Light Blue	Ground #1
2	338A4+	338A1+	338A3+	338A2+	Light Blue	Supply (+)
3	338A4-3	338A1-3	338A3-3	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)

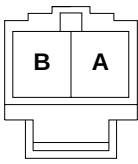
Blower Motor 2-Pin Connector (Front Unit)			 f545139
Pin	Circuit #	Wire Color	Circuit Description
A	98F	Light Blue	+12V battery
B	GND	Black	Ground

Table 8, Blower Motor 2-Pin Connector (Front Unit)

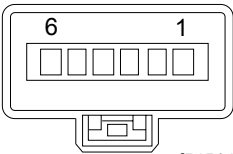
Blower Motor 6-Pin Connector (Front Unit)			 f545140
Pin	Circuit #	Wire Color	Circuit Description
1	338M	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDH	Black	Ground
4	98F	Light Blue	+12V battery
5	338H	Light Blue	Blower motor speed control signal
6	—	—	Not used

Table 9, Blower Motor 6-Pin Connector (Front Unit)

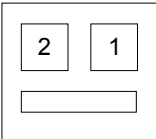
Heater Core Temperature Sensor, COTC (Front Unit)			 f545141
Pin	Circuit #	Wire Color	Circuit Description
1	338L	Light Blue	—
2	338G1	Light Blue	—

Table 10, Heater Core Temperature Sensor, COTC (Front Unit)

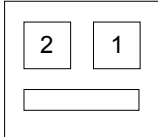
Evaporator Temperature Sensor (Front Unit)			
 f545141			
Pin	Circuit #	Wire Color	Circuit Description
1	338K	Light Blue	Evaporator Sensor Signal
2	338G	Light Blue	Ground

Table 11, Evaporator Temperature Sensor (Front Unit)

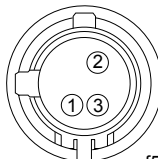
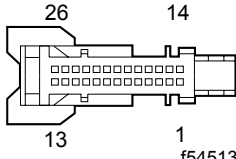
High-Side Pressure Transducer Connector			
 f545142			
Pin	Circuit #	Wire Color	Circuit Description
1	440	Gray	Sensor +5V supply
2	440Y	Gray	Sensor feedback
3	440G	Black	Sensor ground

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 (+)

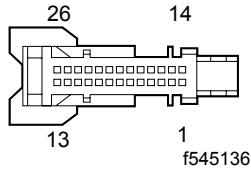
Auxiliary HVAC to Control Panel 26-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
13	—	Light Blue	Not used
14	338SA1-3	Light Blue	Blend actuator-ground (–) #3
15	338SA1-1	Light Blue	Blend actuator-ground (–) #1
16–22	—	Light Blue	Not used
23	338SM	Light Blue	Blower motor diagnostic (PWM)
24	338SH	Light Blue	Blower motor control (PWM)
25–26	—	Light Blue	Not used

Table 13, Auxiliary HVAC to Control Panel 26-Pin Connector

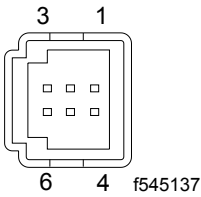
Auxiliary HVAC to Control Panel 6-Pin Connector			
Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(–) datalink
3	29A	Brown	Backlighting input (PWM)
4	98G	Light Blue	+12V battery
5	GND	Black	Ground
6	220	Pink	+12V ignition/acc

Table 14, Auxiliary HVAC to Control Panel 6-Pin Connector

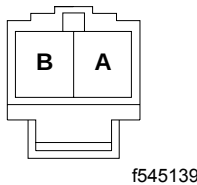
Blower Motor 2-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
A	98G	Light Blue	+12V battery
B	GNDF	Black	Ground

Table 15, Blower Motor 2-Pin Connector (Sleeper Unit)

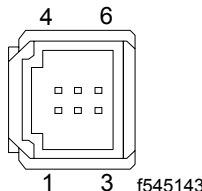
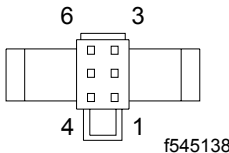
Blower Motor 6-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
1	338SM	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDF	Black	Ground
4	98G	Light Blue	+12V battery
5	338SH	Light Blue	Blower motor speed control signal
6	—	—	Not used

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

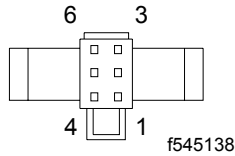
Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
5	—	—	Not used
6	338SA1-2	Light Blue	Blend actuator-ground (-) #2

Table 17, Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)

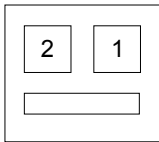
Heater Core Temperature Sensor, COTC (Sleeper Unit)			
Pin	Circuit #	Wire Color	Circuit Description
1	338SK	Light Blue	—
2	338SG	Light Blue	—

Table 18, Heater Core Temperature Sensor, COTC (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 fin . Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fin .
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.
 - Ambient temperature is between 40°F and 200°F (°4.5C to 93°C). **NOTE:** Ambient temperature is not used as a condition for A/C clutch engagement on vehicles built after 6/15/2009, or prior vehicles that have previously had the front HVAC control unit replaced with an updated part. Updated parts would be the following or newer: A22-60645-101, A22-60645-501, or A22-60669-002.
 - 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 specification 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 specification, 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.

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	—

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	—

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	—

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 specification. To balance this, the "Acceptable Leak Rates by Component", **Table 34**, in Specification 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 specification. 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.

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 specification 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 specification 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 specification for a day cab with a HD-1 condenser.

See **Table 23** for temperature and pressure specification 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

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

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

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

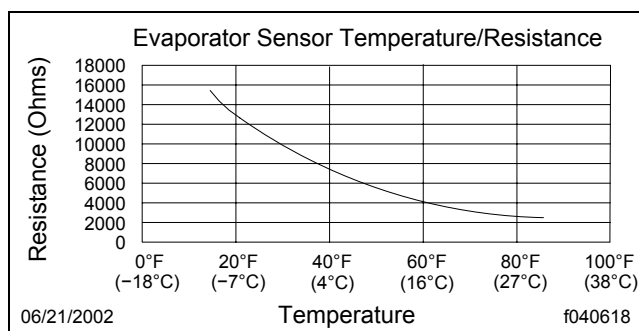


Fig. 23, Evaporator Sensor Resistance Specifications

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

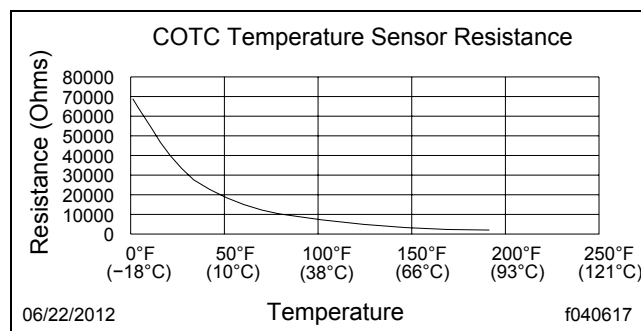


Fig. 24, COTC Sensor Resistance Specifications

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

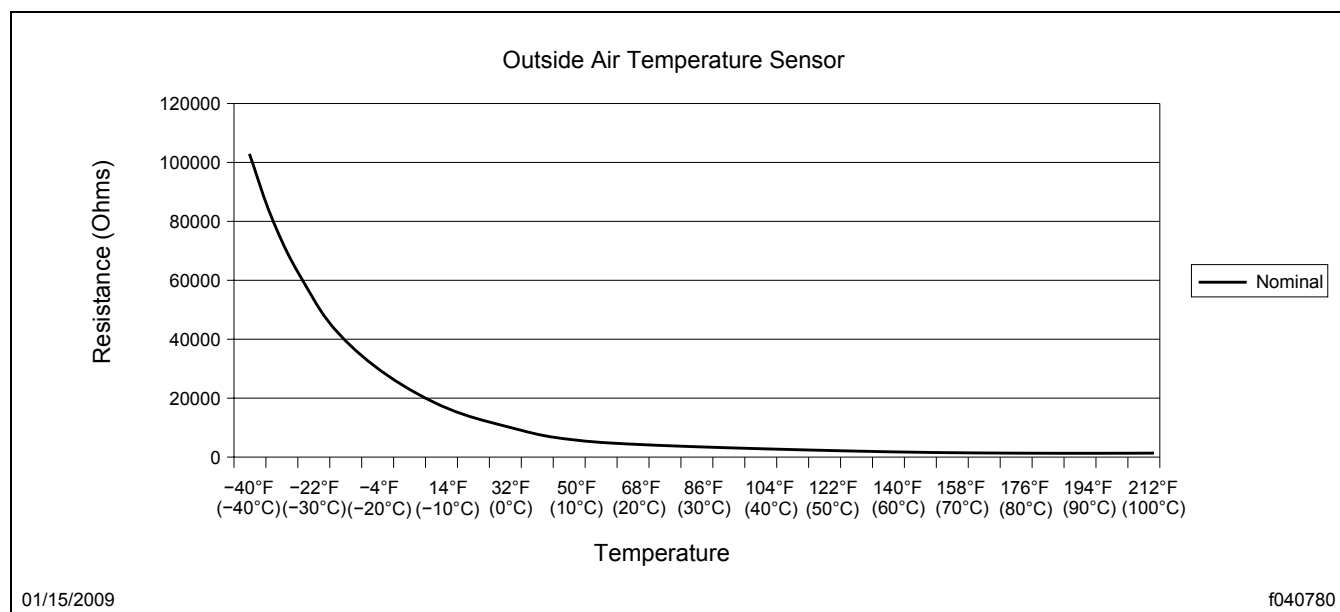


Fig. 25, Outside Air Temperature Sensor Resistance Specifications

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)	
Mini-Statoseals (2 - when the leak cannot be tied to a single seal)	0.50 oz/yr and greater condemns these components
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

System Overview

Terms and Abbreviations 500

General Information 501

ParkSmart Auxiliary HVAC Operation 502

Components

Component Locations 600

Component Details 601

Troubleshooting

Troubleshooting 700

Approved Leak Detection Methods 701

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

O/I—Detroit Diesel Optimized Idle

Parameter—A parameter is a predetermined variable in a set, each of which restricts or defines the capabilities of the system as a whole. Parameters are used to customize the configuration of the system.

PDM—Power Distribution Module

PHVAC—Parked Heating, Ventilation, and Air Conditioning

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
- Internal unit controller (PCB on Bergstrom print)
- Condenser fan
- Dedicated bank of AGM batteries on vehicles with standard configuration. On vehicles with DDC optimized idle (O/I) all batteries are used at all times.

The following components are unique and separate from the main refrigerant system:

- Refrigerant compressor
- Condenser
- High-side pressure switch
- Receiver-drier
- Evaporator

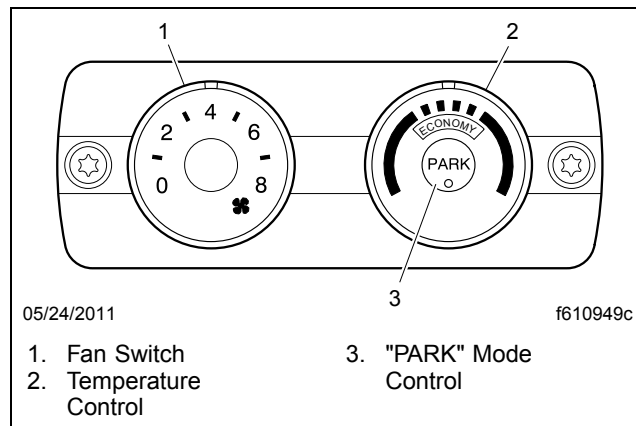
The ParkSmart system is designed to deliver heating and cooling to maintain driver comfort while the vehicle is parked, as well as when the vehicle is driving down the road. This system was designed to maintain an established temperature while the engine is off. The system does not have enough capacity 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**.

**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

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 four operating modes for the ParkSmart HVAC unit:

- Engine ON
- Engine OFF (ignition ON)
- Parked (engine OFF, ignition OFF)
- Parked, O/I activated

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
- 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.

Parked, O/I Activated—If a Cascadia vehicle is equipped O/I, it will affect the way the ParkSmart operates. When the driver initiates the O/I, the ParkSmart will operate in O/I mode as follows.

- The ParkSmart runs unless the ParkSmart fan speed control knob is turned to the "OFF" (0) position. The fan speed control knob must be set at "1" or higher.
- The engine will periodically start and run for two hours to maintain battery voltage then shut off. The ParkSmart will continue to operate during this time.
- If the O/I shuts down due to a fault in the O/I system, the ParkSmart will continue to operate until it is shut off by the driver or one of the automated failsafes.
- The ParkSmart ON/OFF button and LED indicator on the parked HVAC control module do not function when the vehicle is in O/I mode. When the vehicle is not in O/I mode, the ParkSmart ON/OFF button and LED indicator operate normally.
- The front HVAC control panel is disabled when the vehicle is in O/I mode.

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. On vehicles with DDC O/I, there is no battery isolator, and a different internal controller with different software is used.

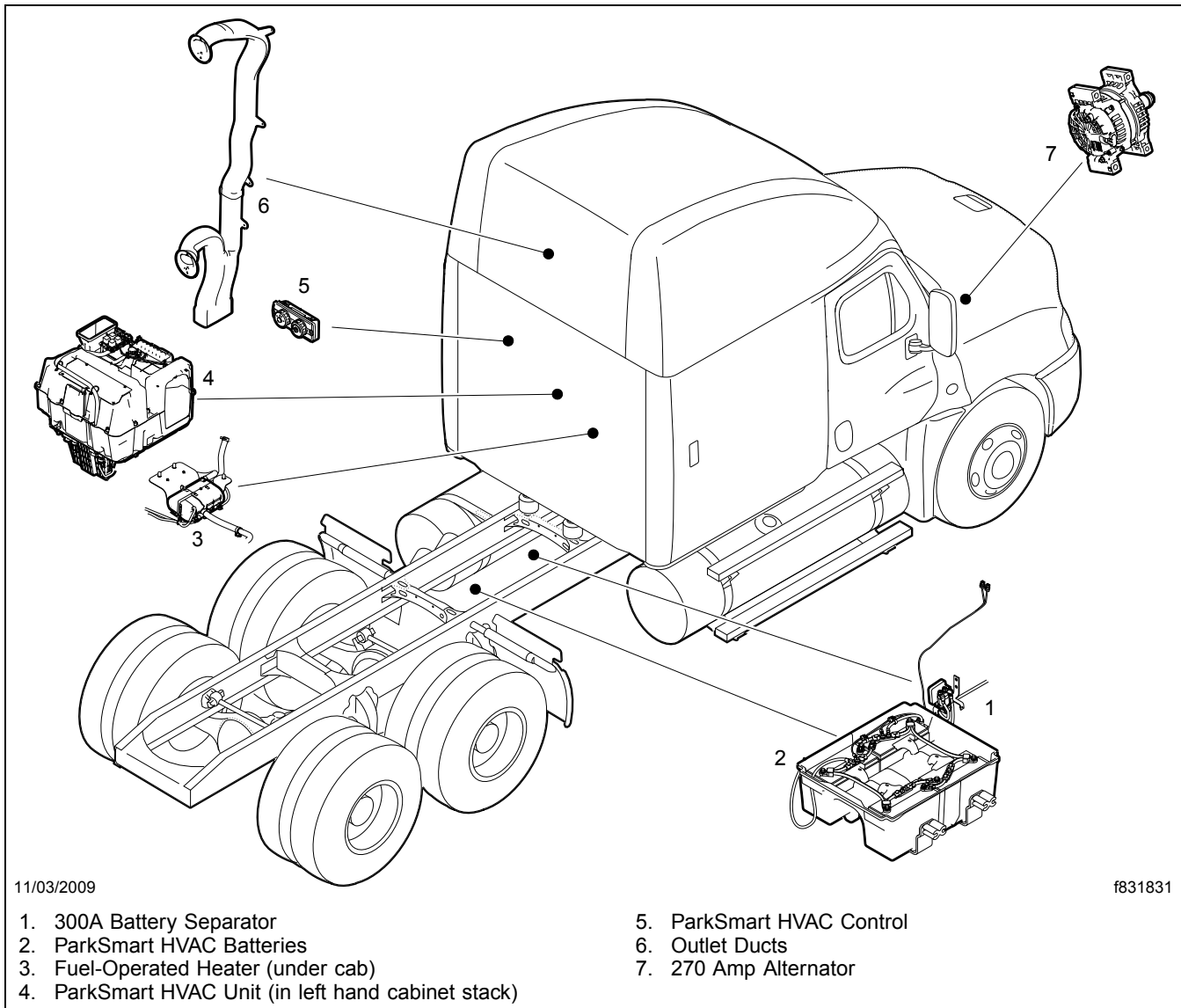


Fig. 2, Component Locations (units built before July 2011)

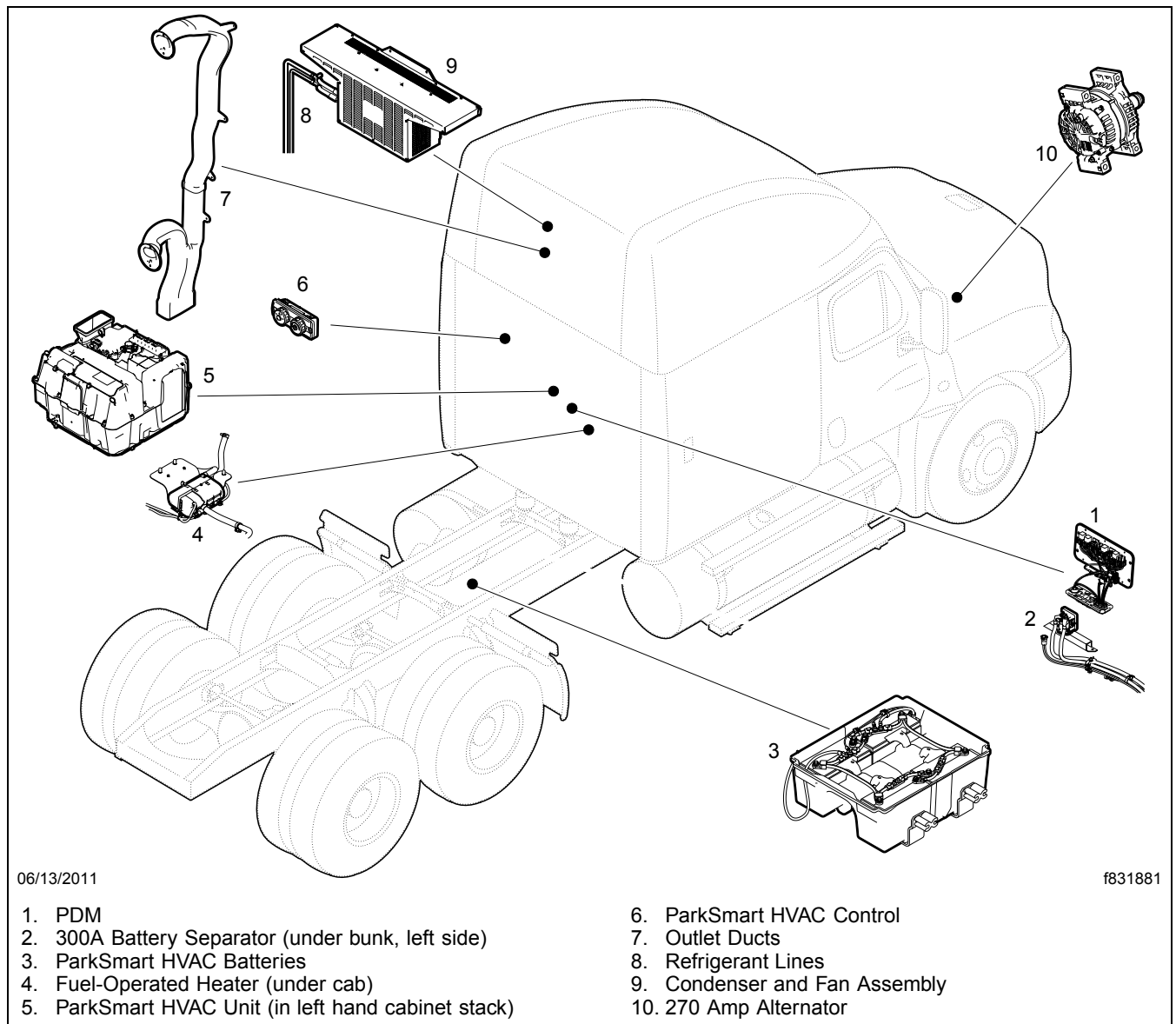


Fig. 3, Component Locations (units built from July 2011)

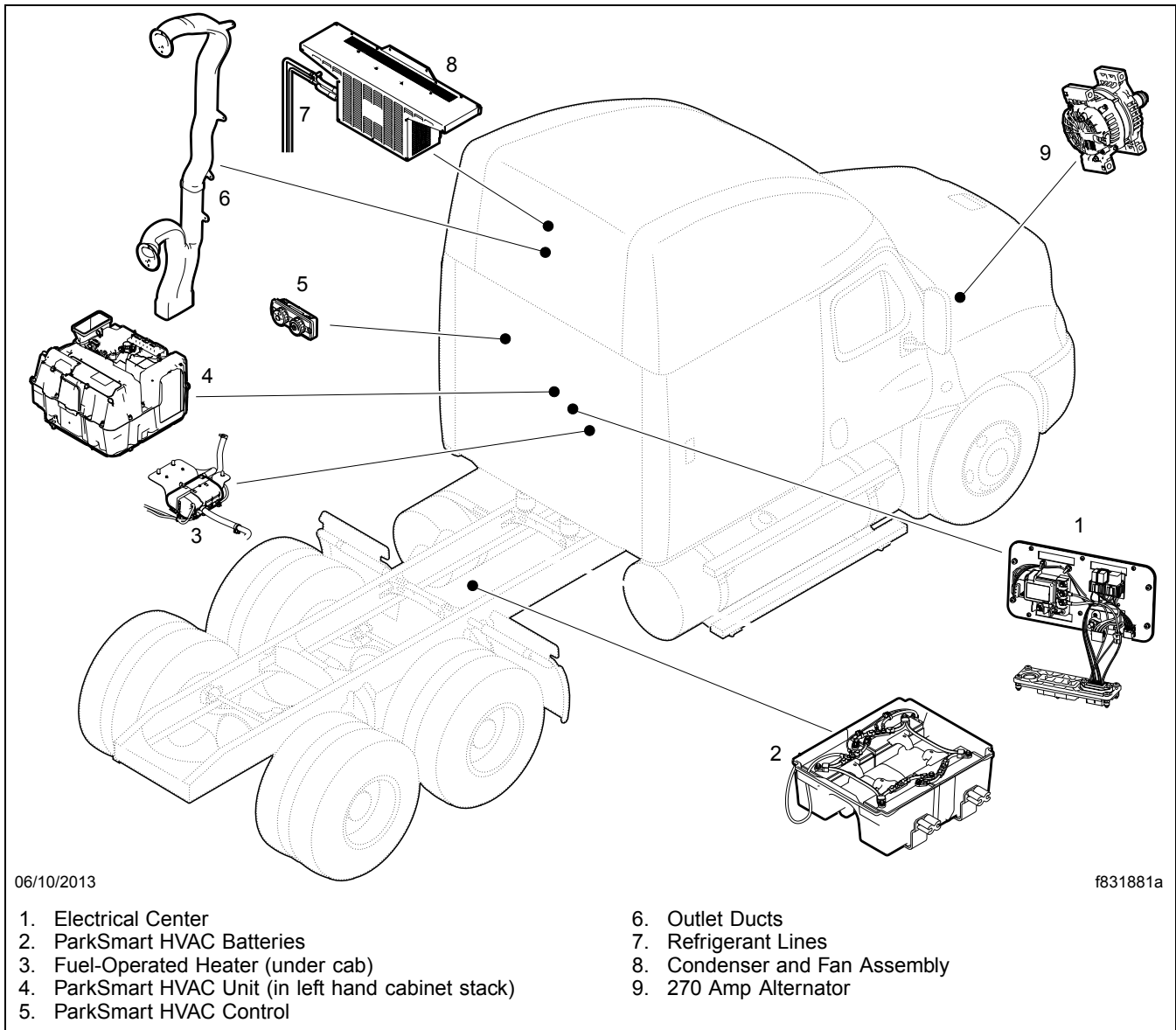


Fig. 4, Component Locations (units with O/I)

601 — Component Details

Auxiliary Control Unit (ACU)

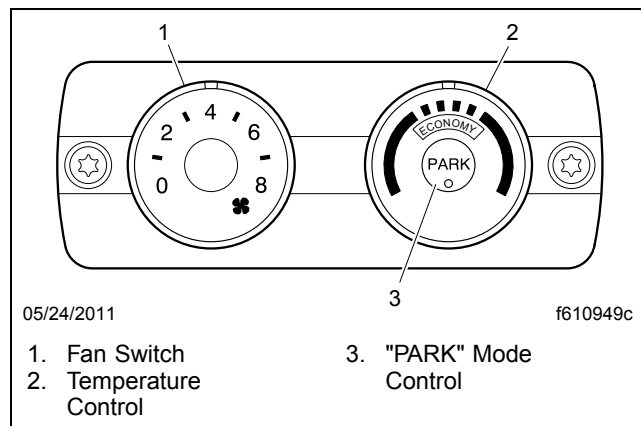


Fig. 5, ParkSmart Auxiliary Control Unit

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.

When a vehicle equipped with DDC O/I is in O/I mode, the ParkSmart ON/OFF button and LED indicator on the parked HVAC control module do not function. When the vehicle is not in O/I mode, the ParkSmart ON/OFF button and LED indicator operate normally. If the O/I shuts down due to a fault in the O/I system, the ACU will operate normally, and the ParkSmart will continue to operate until it is shut off by the driver or one of the automated failsafes.

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

ACU Pin-Out (from MOD 689 and 70C)			
PIN	Description	Typical Value	Connects To
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

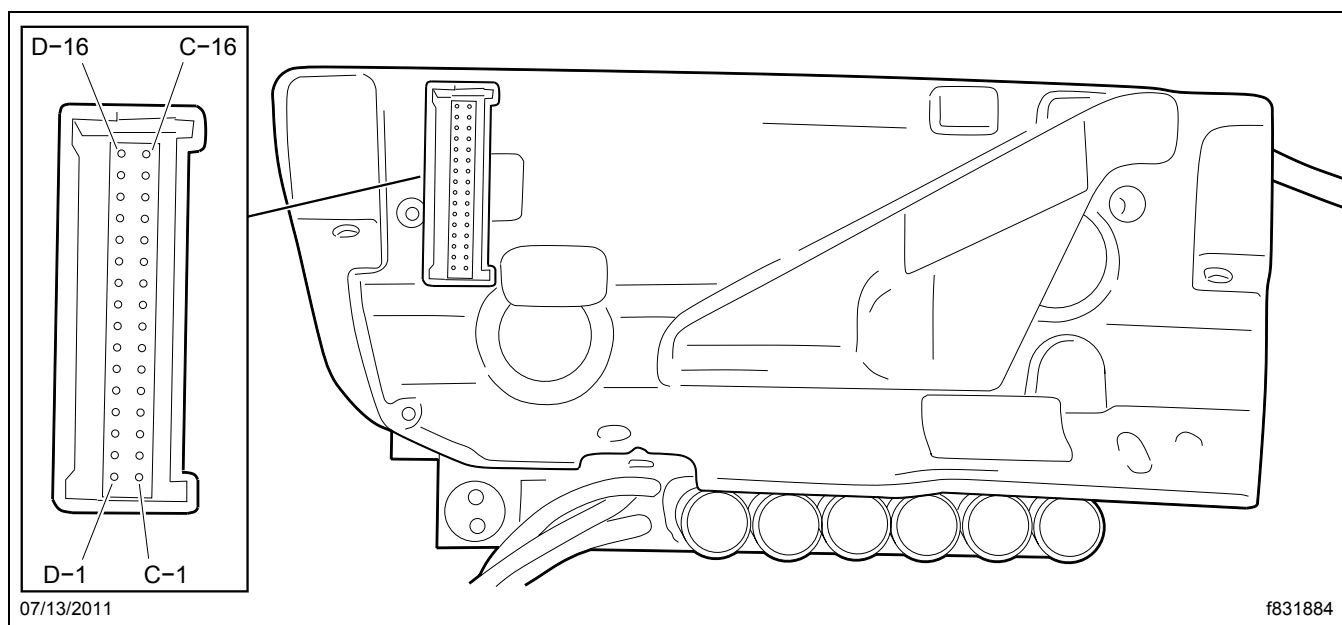


Fig. 6, Internal Controller

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 for vehicles with standard configuration

Table 5 shows the ParkSmart control module connector pinout for vehicles with Detroit Diesel Optimized Idle (O/I) configuration

ParkSmart Control Module Connector Pinout (standard)					
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	—	—

ParkSmart Control Module Connector Pinout (standard)					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
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
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

ParkSmart Control Module Connector Pinout (standard)					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
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
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 (Standard)

ParkSmart Control Module Connector Pinout (with O/I)					
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, 1.6–3.9V 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)

ParkSmart Control Module Connector Pinout (with O/I)					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
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
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

ParkSmart Control Module Connector Pinout (with O/I)					
Pin	Circuit ID	Wire Color	Function	Typical Voltage	Other End of Circuit
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 electrical center
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 electrical center
D12	RELAY3	White	Switch to Ground output to relay 3—Front HVAC Disable	Less than 0.5V in Parked, Engine Off modes, otherwise 11–14V	Relay in electrical center
D13	N/C	White	Not connected	—	—
D14	N/C	White	Not connected	—	—
D15	N/C		Not connected	—	—
D16	N/C		Not connected	—	—

Table 5, ParkSmart Control Module Connector Pinout (with O/I)

Separator (interconnect controller)

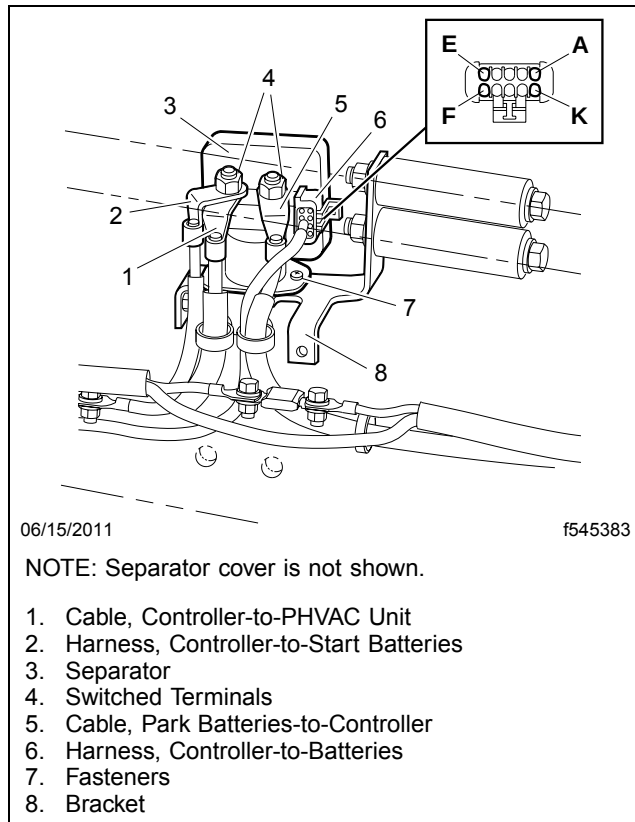


**Fig. 7, Separator (interconnect controller)
Frame-Mounted Installation (pre-July 2011)**

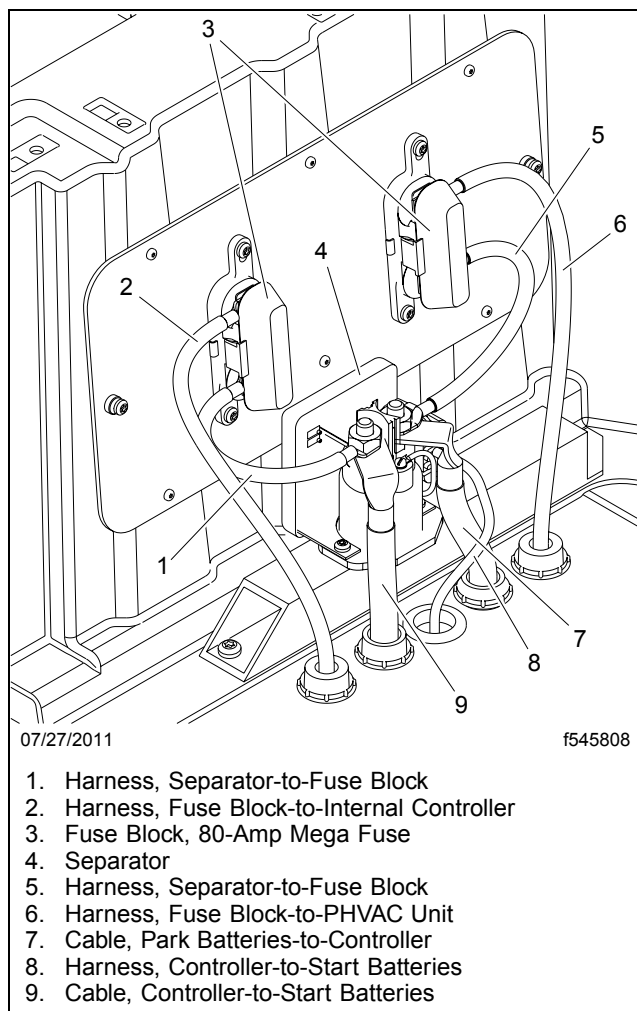


**Fig. 8, Separator (interconnect controller)
Under-Bunk Installation (pre-July 2011)**

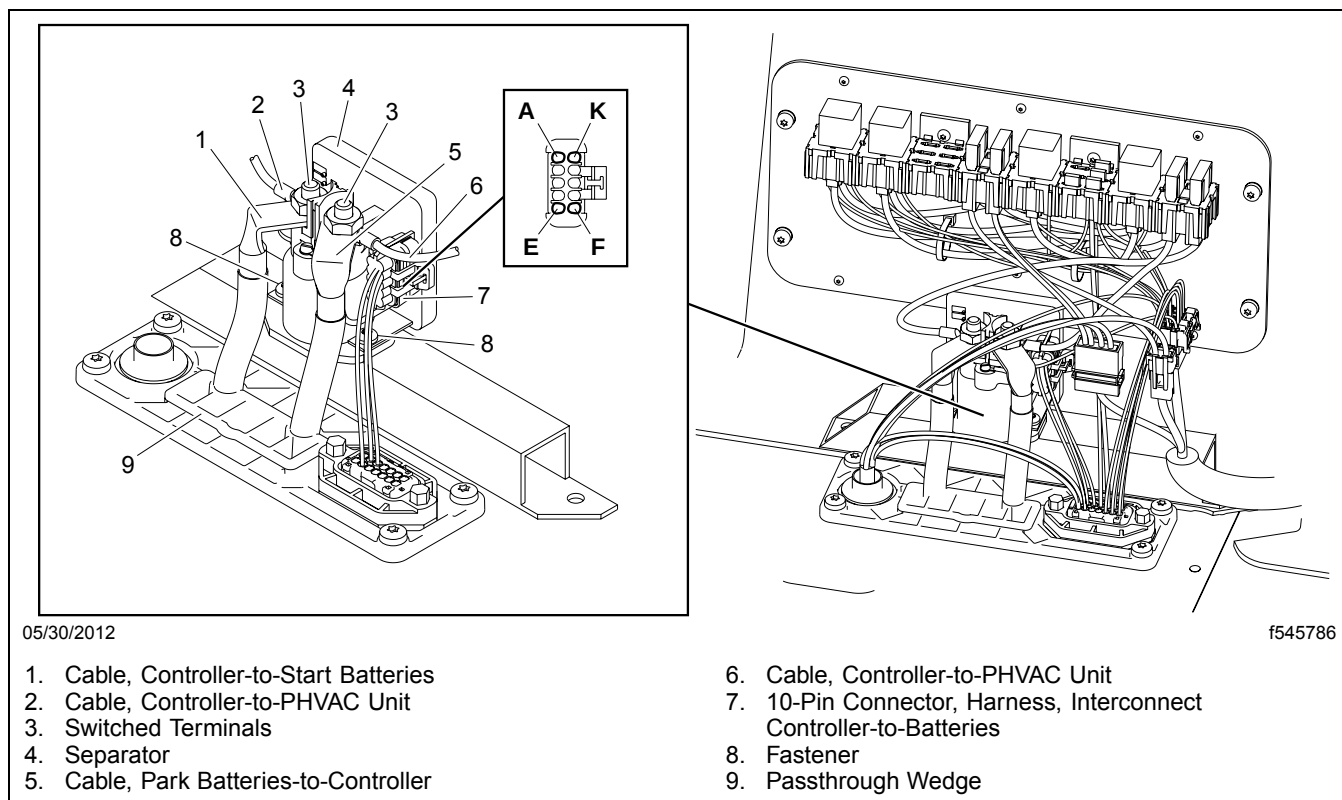


Fig. 9, Separator (interconnect controller) Installation (from July 2011)

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 from July 2011 there is a separator disconnect feature that opens the separator during cranking via a wire leading to the ignition switch. See **Table 7** for separator operating specification. On vehicles equipped with DDC Optimized Idle, there is no separator. All of the batteries are used to operate the ParkSmart system.

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	—	—

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
F	NA	—	—
G	NA	—	—
H	Ground	0 VDC	Start Batteries
J	NA	—	—
K	Remote Sense	12 VDC	Start Batteries

Table 6, 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 7, Separator Operating Specifications

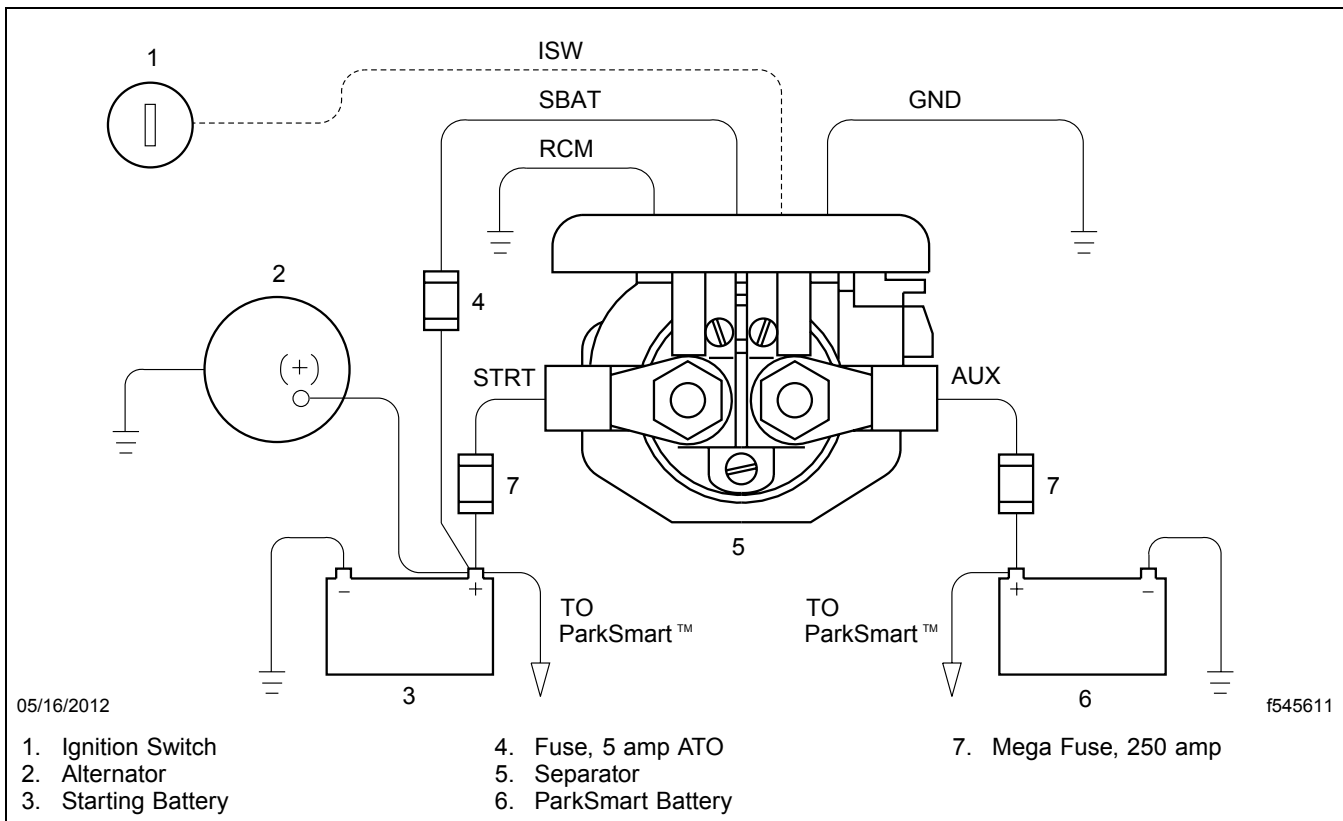


Fig. 10, Separator Wiring Diagram

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

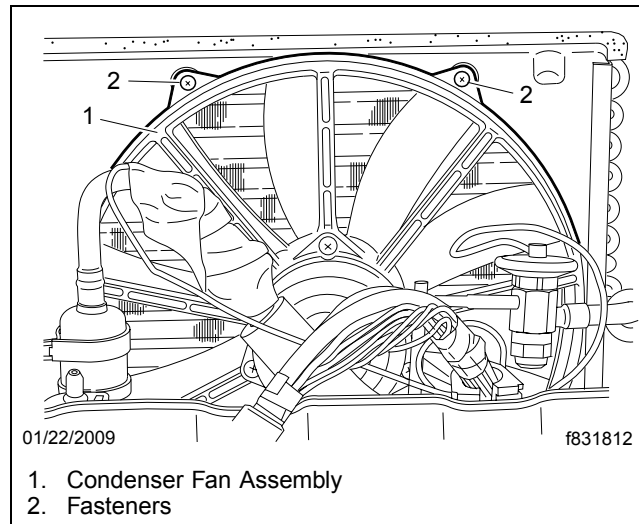


Fig. 11, Condenser Fan Installation (pre-July 2011 shown)

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 8, Condenser Fan Pin-Out (from MOD 689)

Electrical Center

On systems manufactured before July 2011, the Electrical Center is located on top of the ParkSmart unit. See **Fig. 12**. On systems manufactured from July 2011, the Electrical Center is located on the forward panel of the storage compartment under the lower bunk near the driver's side outside access door. See **Fig. 13**.

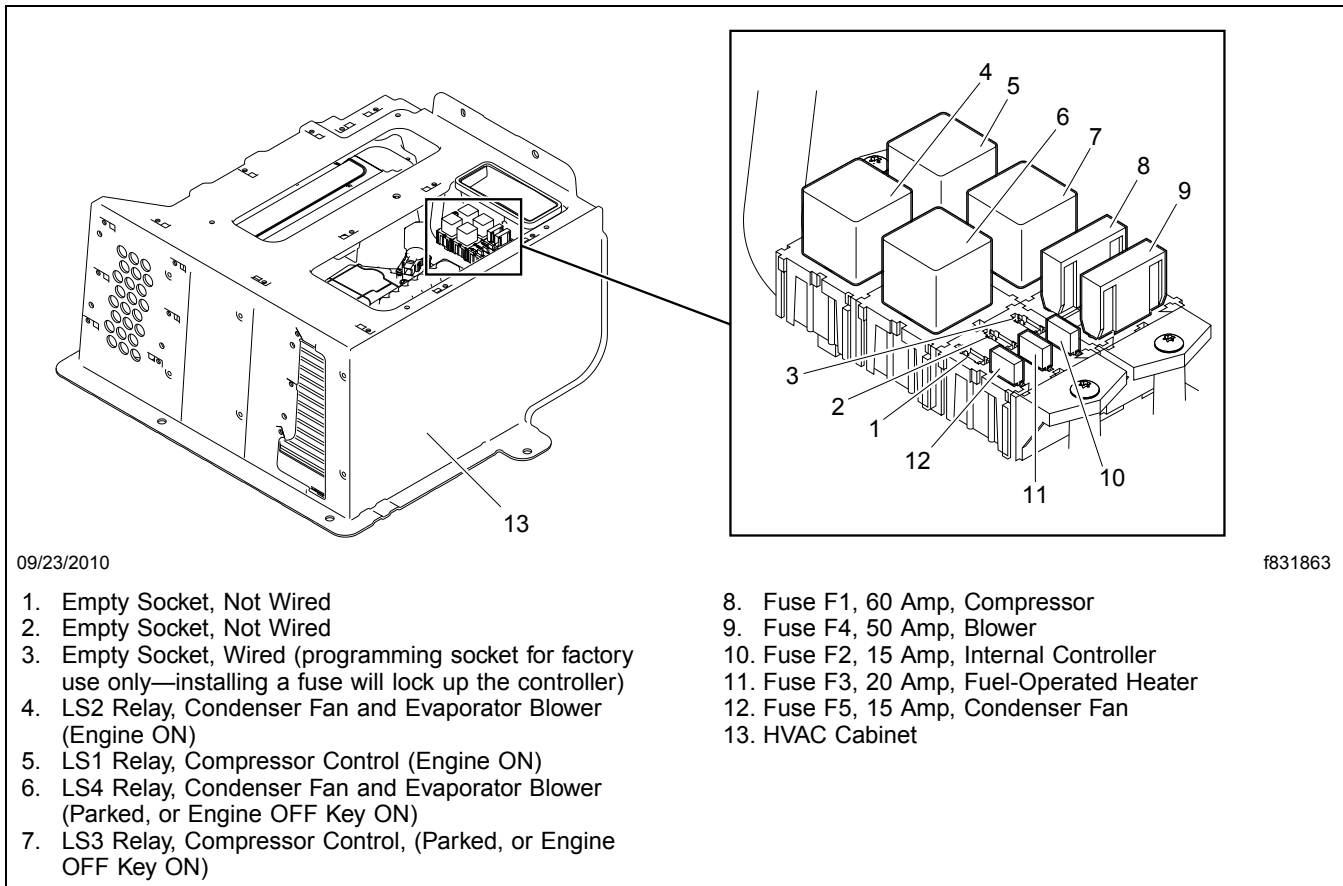


Fig. 12, ParkSmart PDM (pre-July 2011)

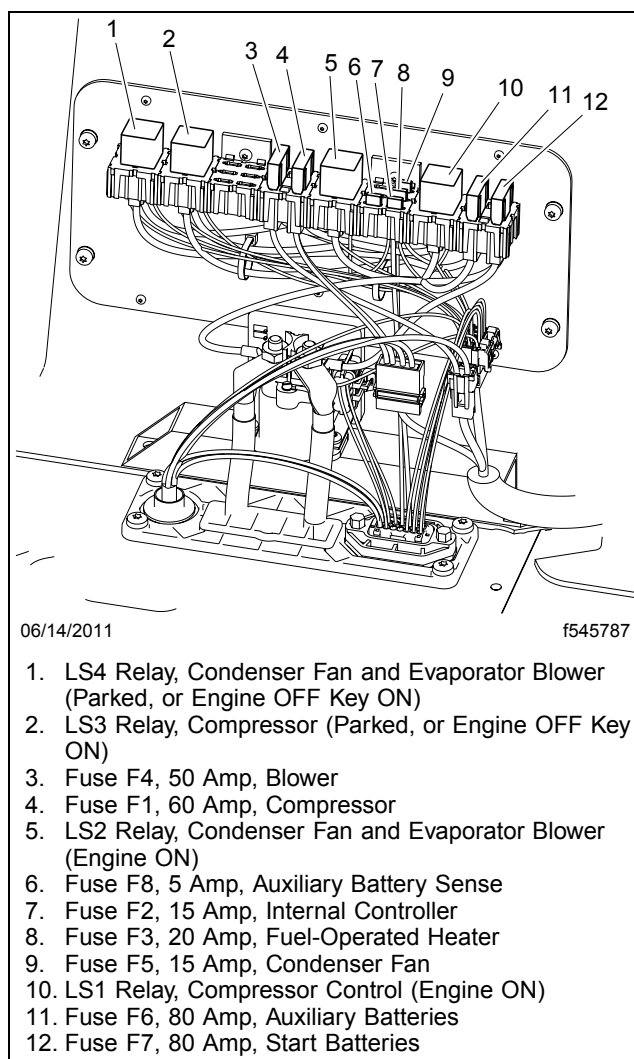


Fig. 13, ParkSmart PDM (from July 2011)

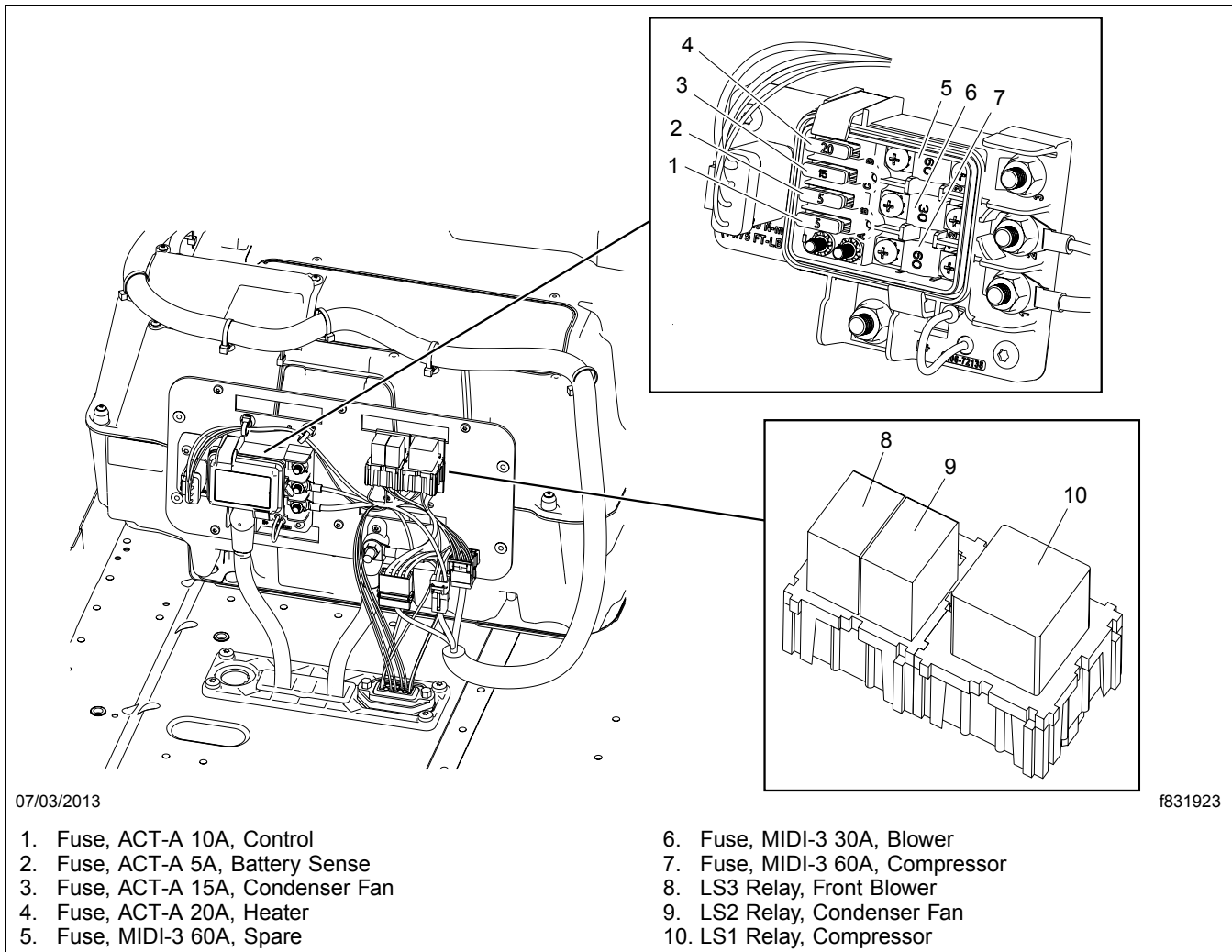


Fig. 14, ParkSmart PDM/Electrical Center (with DDC O/I)

Battery System

Standard Configuration

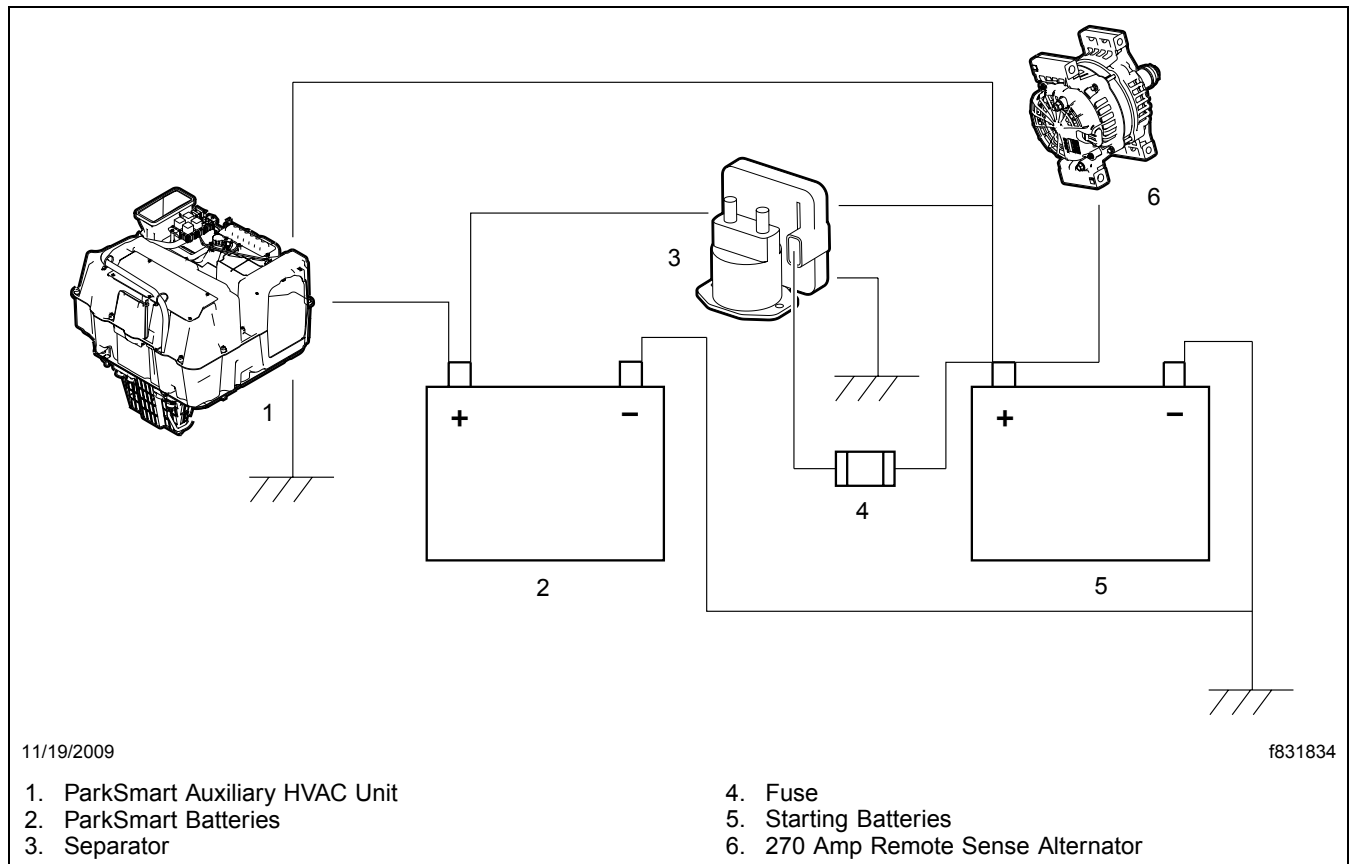


Fig. 15, Battery System

In the standard configuration 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.

Vehicles with Detroit Diesel Optimized Idle

On vehicles with DDC O/I the batteries are not isolated.

- AGM batteries are standard for all eight positions in the system.
- All eight batteries are connected in parallel.
- All eight batteries are charged at the same time.
- All eight batteries are drawn down at the same time.

Blower Motor

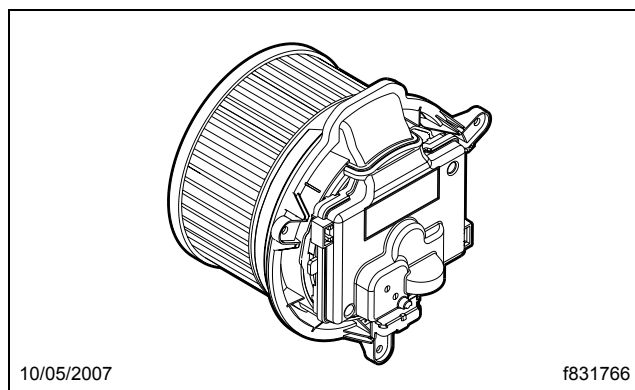


Fig. 16, Blower Motor

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 feedback 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 9**. A fault will be logged by the FCU or ACU.

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 9, 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 10, Blower Motor Pin-Out (from MOD 689)

Actuator

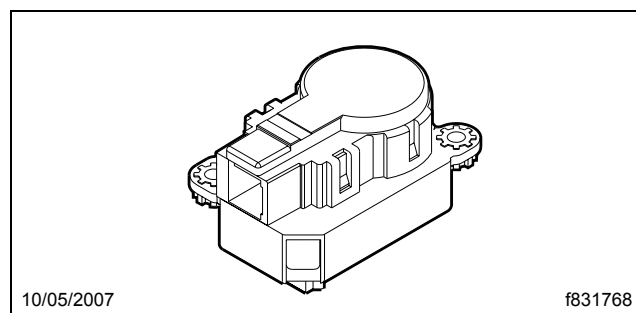


Fig. 17, Actuator

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 11**.

Actuator Connection and Drive Sequence					
Connecting Diagram		0	I	II	III
		1		—	—
		3	—	—	
		4		—	
		6	—		—
		2+5	+	+	+
		1		—	—
		3	—		—
		4		—	—
		6	—	—	
		2+5	+	+	+

Table 11, 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 12, Bunk and Ambient Air Temperature Sensor Resistance

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 13, 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 14, Ambient Air Temperature Sensor Pin-Out (from MOD 689)

Evaporator Temperature Sensor

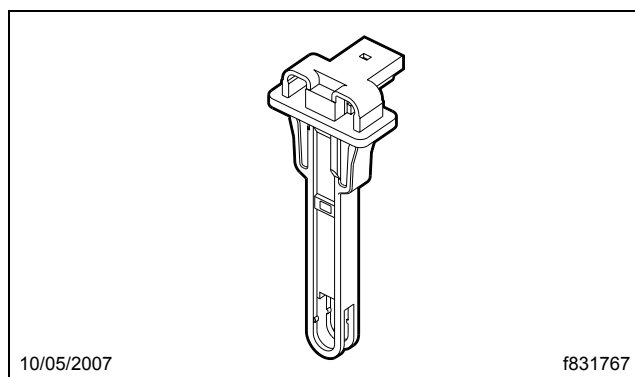


Fig. 18, Evaporator Temperature Sensor

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 15, Evaporator Temperature Sensor Resistance

Compressor

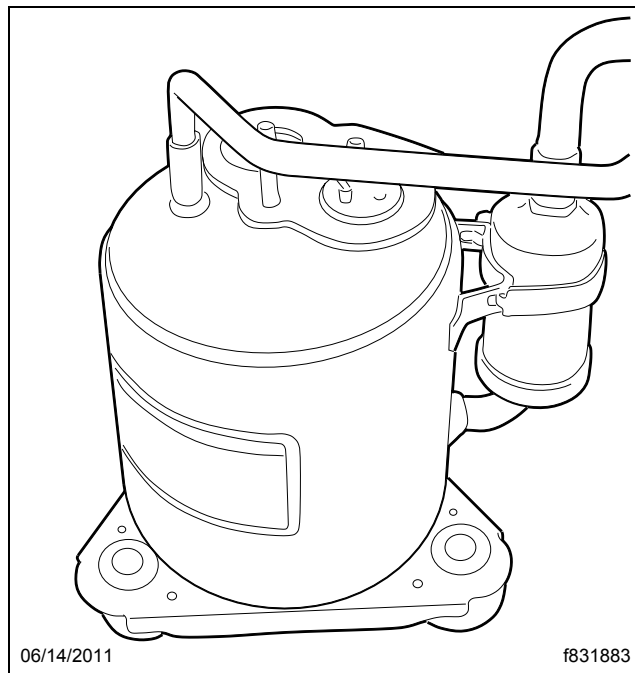


Fig. 19, Compressor

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.

**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 16, Compressor Pin-Out (from MOD 689)

High Pressure Switch

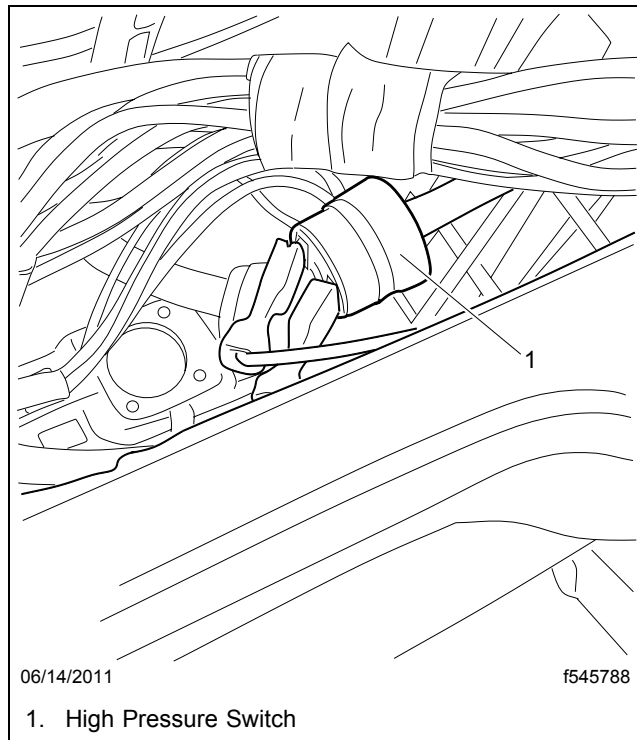
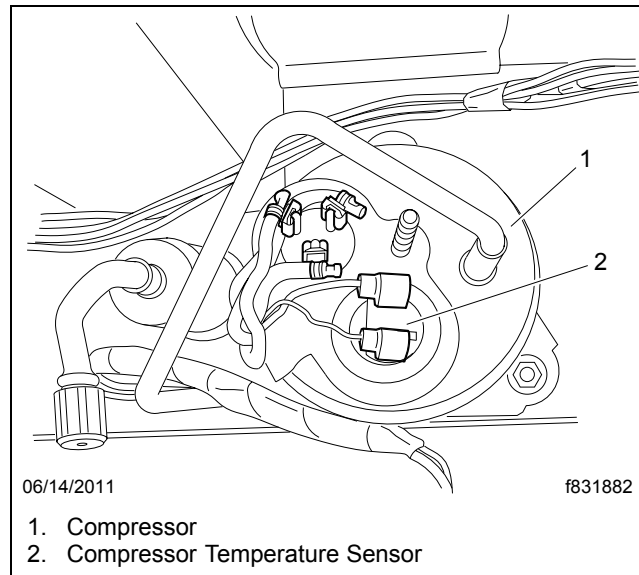


Fig. 20, High Pressure Switch

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.

Compressor Temperature Sensor

**Fig. 21, Compressor Temperature Sensor**

This is a normally-closed bi-metal switch that protects the compressor from high-temperature running conditions.

Fuel-Operated Heater

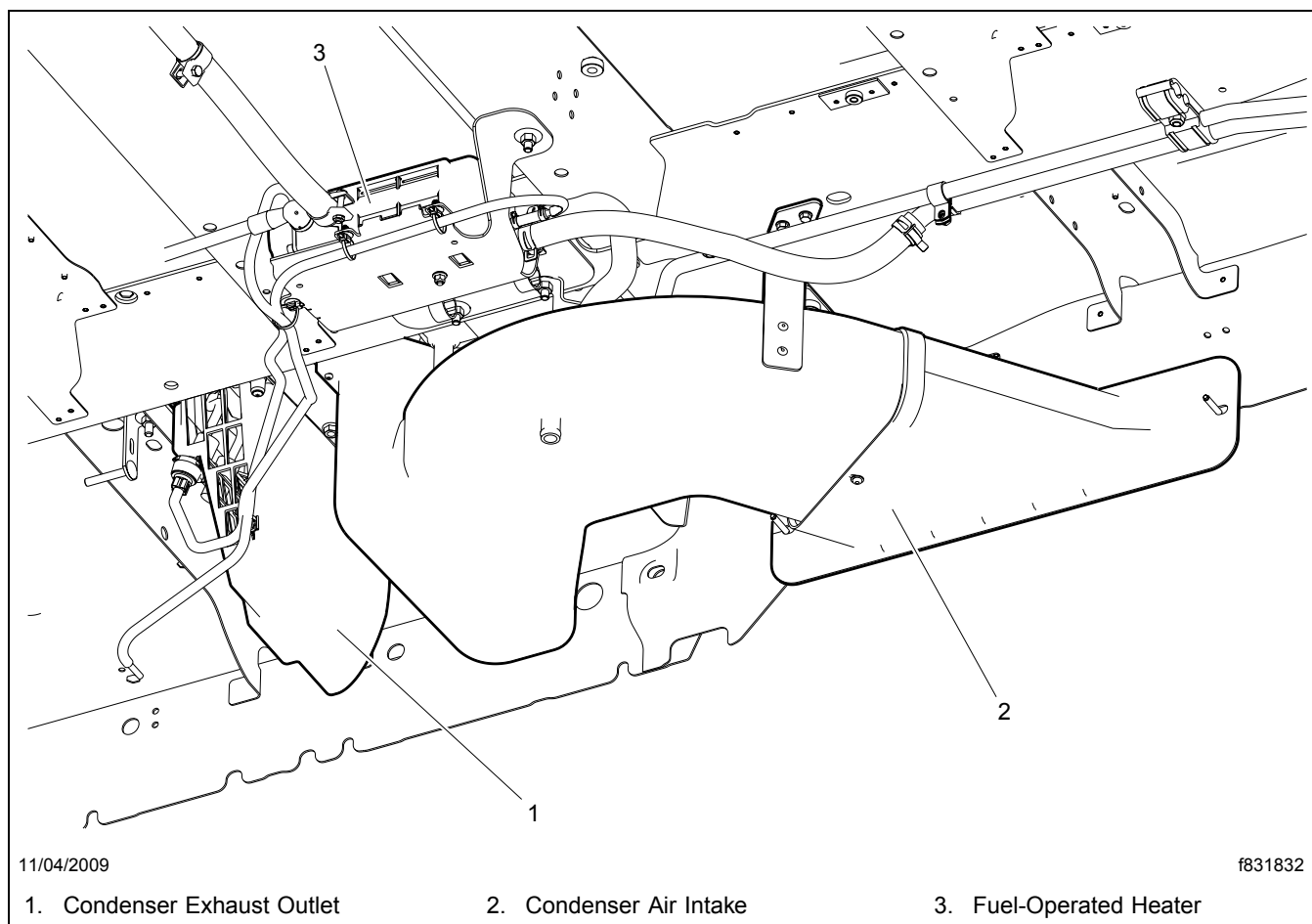


Fig. 22, Fuel-Operated Heater Location (pre-July 2011 shown)

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.

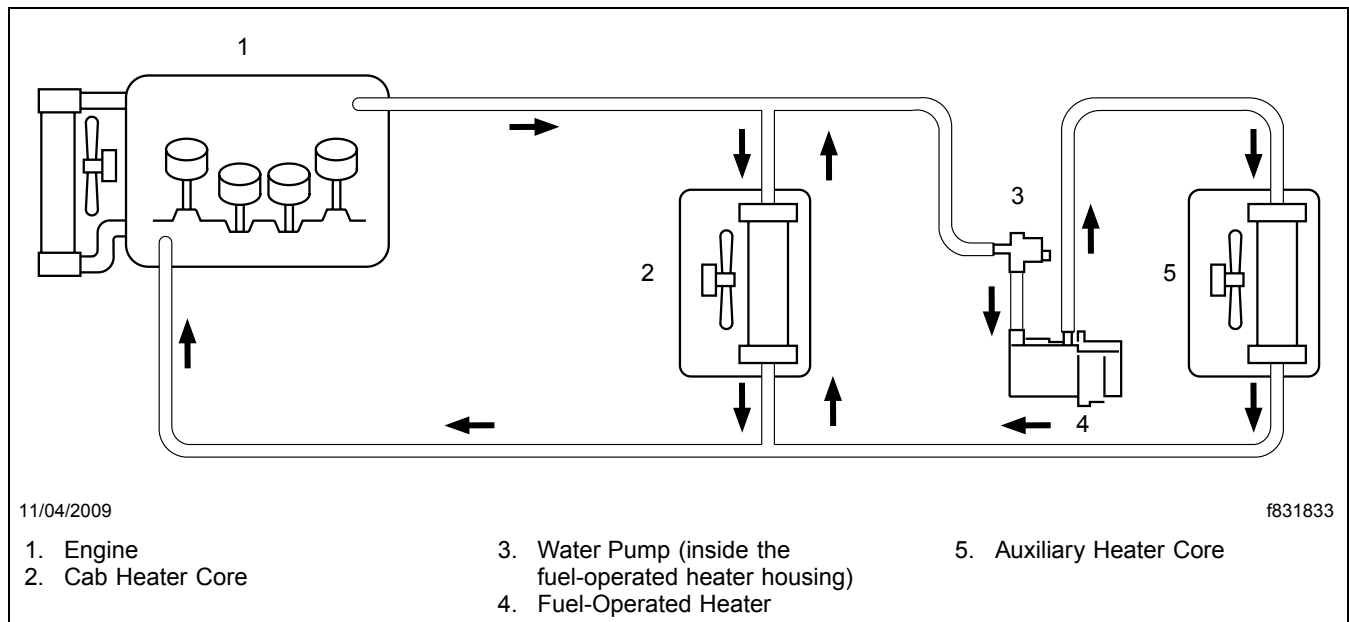


Fig. 23, Fuel-Operated Heater System

Refer to **Table 17** 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 17, Fuel-Operated Heater Operation

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 18, 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 19, 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 20, Park Brake Switch Pin-Out (from MOD 70C)

700 — Troubleshooting

Use the ParkSmart Troubleshooting Checklist (**Table 21**) 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.

Table 21 lists common ParkSmart HVAC system problems and solutions. To diagnose fuel-operated heater problems, use the recommendations in **Table 21** in conjunction with the fault code list in **Table 28**, and the heater manufacturer's service manual.

IMPORTANT: When troubleshooting a vehicle with DDC Optimized Idle, do not perform diagnostics in O/I mode.

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 All for vehicles with O/I.		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 21, ParkSmart Troubleshooting Checklist

ParkSmart Diagnostic Subjects

IMPORTANT: When troubleshooting a vehicle with DDC Optimized Idle, do not perform diagnostics in O/I mode.

Diagnostic Subject 1 – J1939 and ACU Function

If the unit does not turn on in any mode there are several components to check.

NOTE: On vehicles with O/I, if battery voltage is below 11.8V, the ParkSmart will not function. This is a system fail-safe feature. O/I will turn on at 12.2V, and the ParkSmart will then be operational. Refer to **Table 22** for low voltage disconnect schedule.

PHVAC with O/I, Low Voltage Disconnect Schedule			
PHVAC mode	Over The Road	Parked	O/I
PHVAC power profile	OTR	Parked	OTR
Off Voltage	12.05 < 50F Ambient*	12.05 < 50F Ambient 1.8 > 50F Ambient	12.0
Reset Voltage	12.7	12.7	12.7
Sense Point	At PHVAC unit	At PHVAC unit	J1939 message†

* Ambient temperature is PHVAC unit reading of condenser air inlet sensor 1.8 > 50F Ambient.

† Opt Idle LVD protection reverts to Parked LVD profile if O/I fails or message is absent.

Table 22, PHVAC with O/I, Low Voltage Disconnect Schedule

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:

- 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 with O/I, remove fuse F7, located in the rear battery box, wait 5 minutes, install the fuse, 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 (MIDI-1 for vehicles with O/I).
- Power at relays 1 (on road) and 3 (parked), and they are switching (relay LS1 for vehicles with O/I).
- 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 (fuse ATC-C for vehicles with O/I).
- Power at relays 2 (on road) and 4 (parked), and they are switching (relay LS2 for vehicles with O/I).
- 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:

- Power at fuse F4 (fuse MIDI-1 for vehicles with O/I).
- Power at relays 2 (on road) and 4 (parked), and they are switching (relay LS2 for vehicles with O/I).
- 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. (fuse ATC-D for vehicles with O/I)
- 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

NOTE: Vehicles with Detroit Diesel optimized idle do not have a battery separator.

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.

Resting Voltage		
Start:	Auxiliary:	Voltages should be different at each bank after ParkSmart operation.

Table 23, 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 24, 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 25, 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 12**. 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 12** 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.

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 26, 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. 24** or **Fig. 25**) 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. 26**. 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.

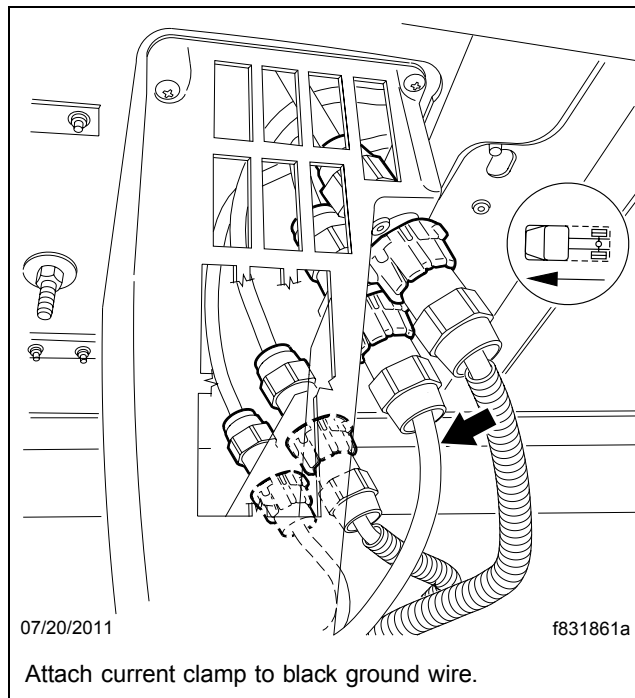


Fig. 24, Checking the Amp Draw (pre-July 2011 shown, under cab installation)

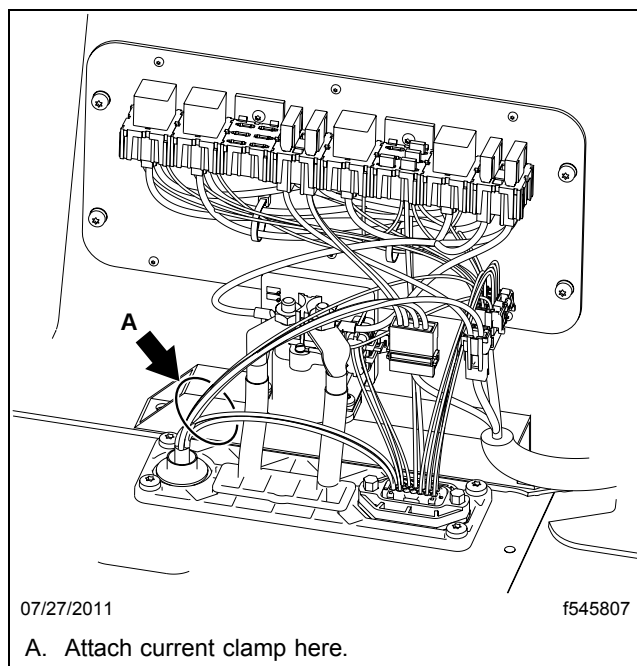


Fig. 25, Checking the Amp Draw (pre-July 2011 under bunk installation)

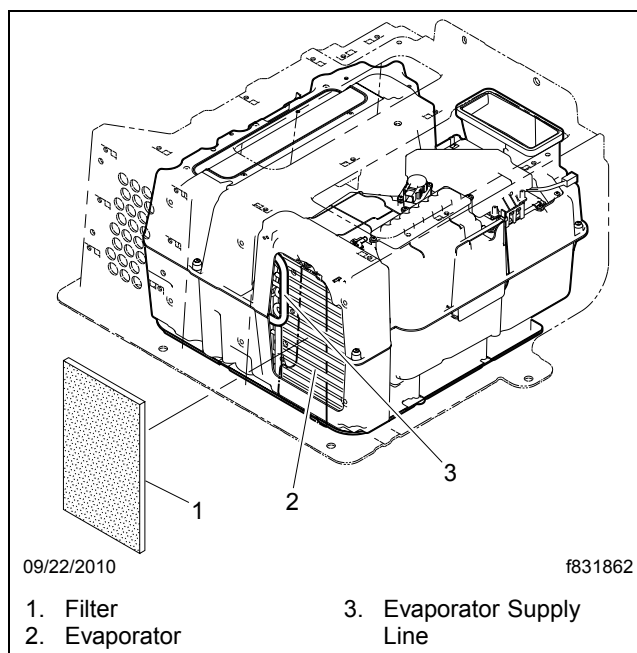


Fig. 26, Evaporator Line Check (cabinet not shown for clarity)

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

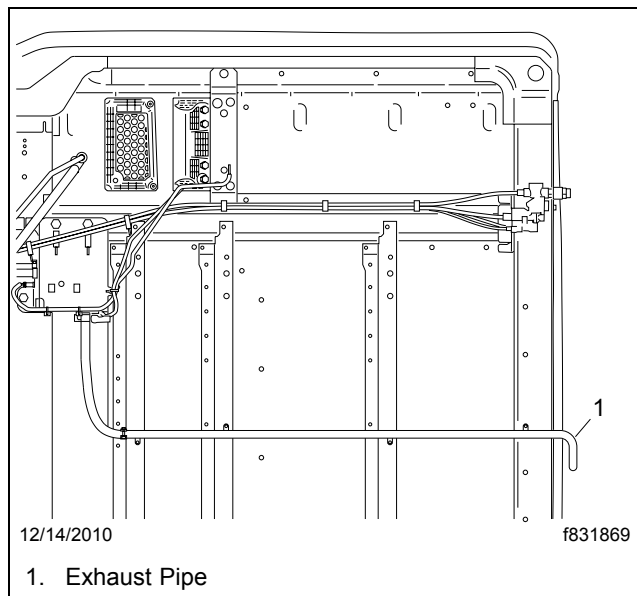


Fig. 27, Exhaust Pipe Installation

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. 28**.

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 27** for common problems with the system.

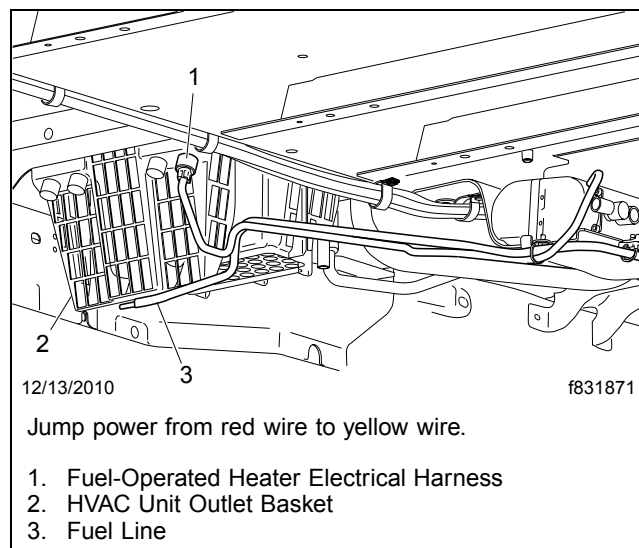


Fig. 28, Testing the Fuel-Operated Heater Function

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.

Fuel-Operated Heater Troubleshooting: "No Start" and "Heater Stops" Conditions		
Problem	Description of the Problem	Possible Reason and Method of Repair
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 than 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.
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 27, 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.

Park Brake Pressure Switch Test

When the fuel-operated heater will not start it is possible that the parking brake switch (see **Fig. 29**) 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:

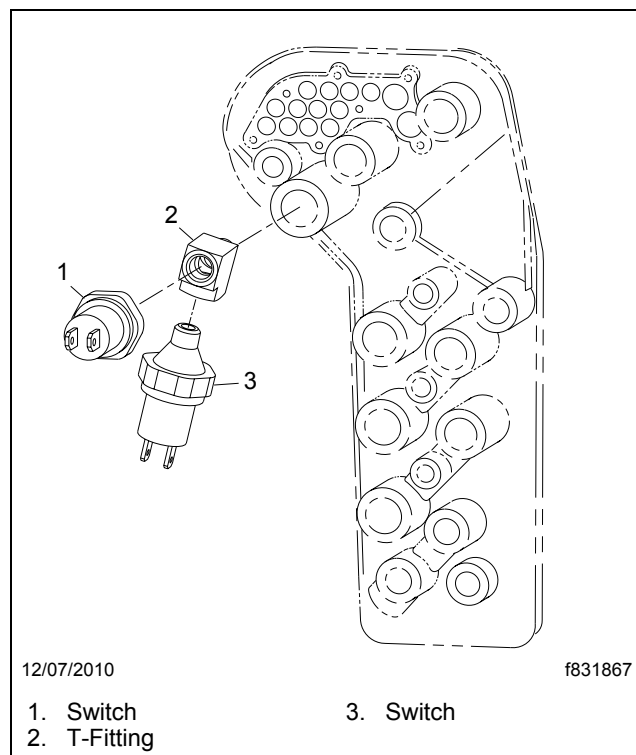


Fig. 29, Park Brake Pressure Switch Location (typical)

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.

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 28** 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	—

ParkSmart Fault Codes					
SPN	FMI	Name	Description	Transmitting Module	Limitations
605	5	Refrigerant Pressure Switch	Refrigerant pressure open circuit (over- or underpressure)	FCU/ACU/ACU	Outside temperature must be above 40°F, sleeper temperature must be above 60°F, and cooling must be requested. (Check at full cold temp setting)
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.
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 28, 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. Refrigerant oil residue on a part may be an indication of a refrigerant leak in that area, but it is not an acceptable method of determining if a part is bad.

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 manufacturer's 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.

System Overview

Terms and Abbreviations	500
General Information	501
Premium Speaker System	502
Premium Radios	503

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700
Radio Does Not Turn On	701
Radio Does Not Shut Off	702
Output Troubleshooting (front and rear speakers)	703
Subwoofer Troubleshooting	704
Poor Reception with RAMI Antenna	705

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.

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

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

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

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 audio system includes the antenna, satellite antenna, antenna multiplexer, radio head unit, speakers, and wiring. The radio head unit is located on the dash in the B-Panel. The front speakers are located in the driver and passenger doors. The SAM Cab provides BAT and GND to the radio from connector X3 on pins 11 and 19.

502 — Premium Speaker System

The premium speaker system, available in the raised roof sleeper cab, has speakers mounted in the sleeper roof halo above the upper bunk. There is a subwoofer mounted below the lower bunk. On the sleeper control panel there is a bunk sleeper shut off sub bus switch to turn off the rear speakers and the subwoofer.

503 — Premium radios

There are two premium radios available for the Cascadia, the Freightliner premium radio (746-1AG), which requires the premium speaker system to be installed, and the Delphi premium radio (746-1AN). The Delphi premium radio is connected to the J1939 datalink for additional troubleshooting capabilities. It is connected to the J1939 datalink through pins 3 (J1939+) and 4 (J1939-) on the radio connector. The Delphi premium radio also requires a digital satellite audio antenna (78C-003) for XM satellite radio service. The antenna is mounted behind the vehicle dash, and feeds up the right-hand A-Pillar and is mounted behind the center storage bin above the vehicle dash.

600 — Component Locations

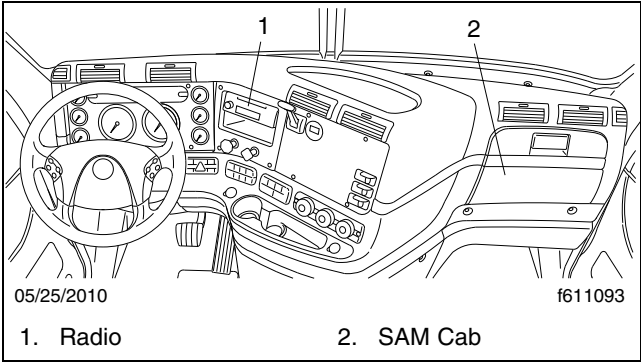


Fig. 1, Component Locations

601 — Component Details

SAM Cab Connector X3

04/15/2009

f545505

Pin	Circuit	Description
9	295SW	Amplifier Power, ACC
11	295B	Radio, BAT
17	GND3	Amplifier Power, GND
19	GND	Radio, GND

Table 1, SAM Cab Connector X3

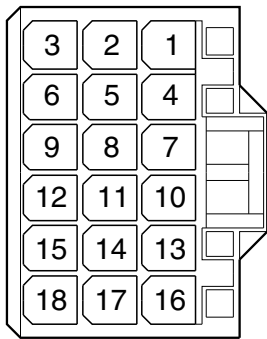
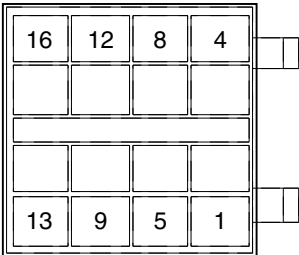
SAM Cab Connector X10		
		
04/15/2009		f545507
Pin	Circuit	Description
10	295A	Radio, ACC

Table 2, SAM Cab Connector X10

Radio Connector		
		
05/25/2010		f545658
Pin	Circuit	Description
1	95AR+	Speaker Signal, Aft, Right
2	95AR-	Speaker Return, Aft, Right
3	J1939+	J1939+ (Delphi premium radio only)
4	J1939-	J1939- (Delphi premium radio only)
5	95FR+	Speaker Signal, Forward, Right
6	95FR-	Speaker Return Forward, Right
7	—	—
8	295A	Radio Accessory Supply
9	95FL+	Speaker Signal, Forward, Left
10	95FL-	Speaker return, Forward, Left
11	295E	Subwoofer Power
12	295A	Radio Accessory Supply
13	95AL+	Speaker Signal, Aft, Left

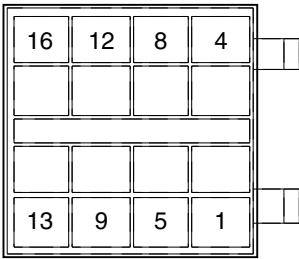
Radio Connector		
		
05/25/2010 f545658		
Pin	Circuit	Description
14	95AL–	Speaker Return, Aft, Left
15	295B	Radio Power Supply
16	GND	Ground

Table 3, Radio Connector

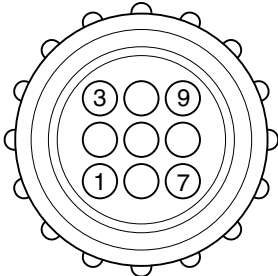
Subwoofer Connector		
		
05/25/2010 f545659		
Pin	Circuit	Description
1	GND3	General Ground 3
2	295SW	Amplifier Power, ACC
3	295E	Subwoofer Power
4	95AL+	Speaker Signal, Aft, Left
5	95AL–	Speaker Return, Aft, Left
6	95AR+	Speaker Signal, Aft Right
7	95AR–	Speaker Return, Aft, Right
8	—	—
9	—	—

Table 4, Subwoofer Connector

700 — Diagnostic Tools Required

- Digital Multimeter

701 — Radio Does Not Turn On

NOTE: If the radio display does not illuminate, or the radio does not shut off when the key is turned off, refer to **702 — Radio Does Not Shut Off**.

1. Test the voltage on the radio connector.

- 1.1 Remove the radio from the dash.
- 1.2 Measure the voltage across pins 15 and 16 on the radio connector.

Does the voltage read 12V?

YES → Install a test radio. If the test radio turns on, replace the suspect radio. Also, check the wiring at the SAM Cab and at the radio. Verify that there is not a loose wire causing an intermittent problem.

NO → Go to test 2.

2. Check output from the SAM Cab.

Measure the voltage between terminals X3.11 and X3.19 on the SAM Cab.

Does the multimeter read 12V?

YES → Go to test 3.

NO → Check fuse F8. Replace it if it is blown.

3. Perform a continuity test between the following terminal pairs:

- SAM Cab X3.11 – Radio connector terminal 15
- SAM Cab X3.19 – Radio connector terminal 16

Is there low resistance?

YES → Check all connectors and perform a functional test to determine if the problem is intermittent.

NO → Repair the affected harness.

702 — Radio Does Not Shut Off

1. Check accessory input.

- 1.1 Remove the radio from the dash.
- 1.2 Measure the voltage between terminals 16 and 8 when the key is in the ON position, and the ACC position.

Does the multimeter measure 12V at both key positions?

YES → Connect all connectors and perform a functional test to determine if the problem is intermittent.

NO → Go to test 2.

2. Measure output from SAM Cab.

2.1 Measure the voltage between SAM Cab connector X10.18 and vehicle ground when the key is in the ACC position, and the ON position.

2.2 Check that the voltage at both key positions.

Does SAM Cab connector X10.18 read 12V?

YES → Go to test 3.

NO → Go to test 4 if X10.18 does not measure 12V with the key in the ACC position, or the ON position.
Go to test 5 if X10.18 does not measure 12V with the key in the ACC position.

3. **Perform a continuity test between the following terminal pairs:**

- SAM Cab connector X10.18 and radio connector terminal 8
- SAM Cab connector X3.19 and radio connector terminal 16

Is there low resistance?

YES → Connect all connectors and perform a functional test to determine if the problem is intermittent.

NO → Repair the affected harness.

4. **Verify that interlocks are met with the starter system BAT input.**

4.1 Attach the negative probe of the multimeter to vehicle ground.

4.2 Attach the positive probe of the multimeter to SAM Cab connector X13.7.

4.3 With the key in the ACC and the ON position, measure the voltage between X13.7 and ground.

Does the multimeter measure 12V for both key positions?

YES → Check all connectors and harnesses for a loose connection or an intermittent break. Troubleshoot the ignition switch for a defect. If X10.18 is still inactive when the key is in the ACC and the ON position, install a test SAM Cab and retest. If the errors cannot be duplicated, replace the SAM Cab.

NO → Perform a continuity test between SAM Cab X13.7 and terminal A on the ignition switch. Repair the harness if low resistance is not found.

5. **Verify that interlocks are met with the starter system ACC input.**

5.1 Attach the negative probe of the multimeter to vehicle ground.

5.2 Attach the positive probe of the multimeter to SAM Cab connector X13.5.

5.3 With the key in the ACC position, measure the voltage between X13.5 and ground.

Does the multimeter measure 12V?

YES → Check all connectors and harnesses for a loose connection, or an intermittent break. Troubleshoot the ignition switch for a defect. If X10.18 is still inactive when the key is in the ACC or ON position, install a test SAM Cab and retest. Verify that SAM Cab connector X10.18 measures 12V when the key is in the ACC position. If the errors cannot be duplicated, replace the SAM Cab.

NO → Perform a continuity test between SAM Cab X13.5 and terminal E on the ignition switch. Repair the harness if low resistance is not found.

703 — Output Troubleshooting (front and rear speakers)

1. Check the voltage at the radio connectors.

If there is no sound coming from the speakers, first make sure that the fader, balance, and volume control is properly adjusted. For units with rear speakers, adjust the radio settings to output audio to the rear speakers (adjust 2-speaker mode to 4-speaker mode). Make sure that the sleeper mute button is not open.

1.1 Turn on the radio and tune it to a station with clear sound.

1.2 Adjust the fader and balance to isolate each speaker, and verify that they are working.

1.3 Check the following terminal pairs for the suspect speaker:

- Radio connector 9, 10 (front left)
- Radio connector 5, 6 (front right)
- Radio connector 13, 14 (rear left)
- Radio connector 1, 2 (rear right)

1.4 Measure the AC voltage of the terminal pair.

Does the multimeter read 0 to 1V AC voltage (depending on the volume)?

YES → Go to test 2.

NO → Install a test radio and retest. If the failure is not duplicated, replace the radio.

2. Test the speaker resistance.

2.1 Remove the radio connector from the back of the radio.

2.2 Select the terminal pair for the suspect speaker:

- Radio connector 9, 10 (front left)
- Radio connector 5, 6 (front right)
- Radio connector 13, 14 (rear left)
- Radio connector 1, 2 (rear right)

2.3 Measure the resistance of the terminal pair.

Does the resistance measure 3 to 10 ohms?

YES → Connect all connectors and test for an intermittent problem. Make sure all connectors are free of corrosion, and harnesses are secure and not pinched.

NO → Go to test 3.

3. Perform a continuity test on the terminal pairs for the suspect speaker.

- Radio terminal 9 – Left door speaker terminal A
- Radio terminal 10 – Left door speaker terminal B
- Radio terminal 5 – Right door speaker terminal A
- Radio terminal 6 – Right Door speaker terminal B
- Radio terminal 13 – Bunk sleeper shut off terminal 2

- Bunk sleeper shut off terminal 1 – Left sleeper speaker terminal A
- Left sleeper speaker terminal B – Radio terminal 14
- Radio terminal 1 – Bunk sleeper shut off terminal 4
- Bunk sleeper shut off terminal 6 – Right sleeper speaker terminal A
- Right sleeper speaker terminal B – Radio terminal 2

Is there low resistance?

YES → Go to test 4.

NO → Repair the affected harness.

4. Check speaker resistance.

- 4.1 Remove the connector at the suspect speaker.
- 4.2 Measure the resistance across the speaker terminals.

Does the resistance measure between 3 to 10 ohms?

YES → Repair or replace the speaker leads.

NO → Replace the speaker.

704 — Subwoofer Troubleshooting

1. Check for BAT power.

- 1.1 Connect the negative probe of the multimeter to the vehicle ground.
- 1.2 Turn the key to the ACC or the ON position.
- 1.3 Turn the radio on.
- 1.4 Insert a conducting probe into the following subwoofer connector pins:
 - Subwoofer connector pin 2 and ground
 - Subwoofer connector pin 3 and ground
- 1.5 Measure the voltage.

Does the voltage measure 12V across both terminal pairs?

YES → Go to test 2.

Subwoofer pin 2 is not 12V → Go to test 3.

Subwoofer pin 3 is not 12V → Go to test 4.

2. Check accessory amplifier power.

- 2.1 Insert a conducting probe into SAM Cab terminal X3.9.
- 2.2 With the key in the ACC or ON position, measure the voltage between X3.9 and ground.

Does the voltage measure 12V?

NOTE: If the battery level is too low, the LVD functionality will shut off the amplifier power. Ensure the battery is charged to avoid LVD behavior.

YES → Perform a continuity test between SAM Cab connector X3.9 and subwoofer connector pin 2. Repair the affected harness if continuity is not found.

NO → Check if fuse F9 is blown and replace as necessary. If fuse F9 is not blown, verify the starter interlocks are met for the SAM Cab to activate the amplifier power. Ssee **702 — Radio Does Not Shut Off**, step 4 and 5. If the starter interlocks have been met, replace relay 9.

3. **Check subwoofer power.**

With the radio ON (key in ACC or ON position), measure the voltage between subwoofer connector pin 3 and ground.

Does the multimeter read 12V?

YES → Go to test 5.

NO → Measure the voltage between the radio connector pin 11 and ground. If 12V is measured from the radio, perform a continuity test between radio connector pin 11 and subwoofer connector pin 3. Repair the harness if an open circuit is found.

4. **Check AC voltage at the subwoofer.**

4.1 Insert a conducting probe into the subwoofer connector to measure the AC voltage of the following terminals and ground:

- Subwoofer connector 4 – ground
- Subwoofer connector 5 – ground
- Subwoofer connector 6 – ground
- Subwoofer connector 7 – ground

4.2 Depending on the volume the AC voltage for all terminals should be about 0 to several volts.

Is there AC voltage?

YES → Go to test 6.

NO → Replace the subwoofer.

5. **Measure subwoofer resistance.**

Using conducting probes, measure the resistance on the subwoofer connector between pin 4 and 5 and pin 6 and 7.

Is the resistance within 3 to 10 ohms?

YES → Check the speaker leads and repair or replace as necessary.

NO → Replace the speaker.

705 — Poor Reception with RAMI Antenna

1. **Perform a whip antenna test.**

1.1 Remove the antenna from the bracket on the side of the vehicle.

- 1.2 Verify that each whip antenna has a good connection/solder joint at the ferrule end of the antenna.
- 1.3 Remove the antenna cap. If required, make a small cut in the heat shrink to expose the wire. Do not allow the wire to come out of the slot and uncoil.

NOTE: The wire is coated with an insulating material. Before performing a continuity test, if required, lightly sand the coiled wire end to expose a small "uncoated" portion near the tip of the antenna.

- 1.4 Using the multimeter, measure for continuity on the antenna ferrule to the tip of the coiled wire at the opposite end of the antenna. Twist and flex the bottom portion of the antenna to make sure there is not an intermittent break.

Is there low resistance?

YES → Go to test 2.

NO → Replace the whip antenna.

2. Troubleshoot the antenna brackets.

- 2.1 Check for a good grounding from the antenna brackets to the chassis ground.
- 2.2 Remove the radio from the dash.
- 2.3 Remove the AM/FM antenna from the back of the radio.
- 2.4 Remove the plastic cover from the antenna bracket.
- 2.5 Connect one probe of the multimeter to the chassis ground and touch the other probe to the antenna bracket.
- 2.6 Measure for continuity.

Is there low resistance?

YES → Go to test 3.

NO → Repair the bracket as necessary. Check all connections from the bracket to the chassis ground. Look for corrosion that may be building around the bracket.

3. Troubleshoot the cable assembly.

- 3.1 Remove the bracket from the cab wall.
- 3.2 Remove the mounting base from the bracket and unscrew the antenna cable from the base.
- 3.3 Perform the following continuity tests with the antenna cable and the AM/FM cable:
 - Connect one probe of the multimeter to the outer connector of the antenna cable. Touch the other probe to the outer connector of the AM/FM cable. *There should be continuity.*
 - Remove the probe from the outer connector of the AM/FM cable. Touch the probe to the center conductor of the AM/FM cable. *There should be no continuity.*
 - Remove the probe from the outer connector of the antenna cable. Touch the probe to the center conductor of the antenna cable. *There should be continuity.*

Do any of the tests fail?

YES → Look at the cables from the multiplexer box out to the brackets. Look for damage, such as pinched or crushed cables. Check the connections to the dash harness at the cable break, and make sure the connections are secure.

NO → Go to test 4.

4. **Troubleshoot the multiplexer box.**

4.1 Disconnect the cables from the multiplexer to the cable break connections.

4.2 Disconnect the AM/FM cable from the radio.

4.3 Perform a continuity test on the passenger- and driver-side antenna cables and the AM/FM cable.

- Connect one probe of the multimeter to the outer connector of the antenna cable. Touch the other probe to the outer connector of the AM/FM cable. *There should be continuity.*
- Remove the probe from the outer connector of the AM/FM cable; touch the probe to the center conductor of the AM/FM cable. *There should be no continuity.*
- Remove the probe from the outer connector of the antenna cable; touch the probe to the center conductor of the antenna cable. *There should be continuity.*

Do any of the tests fail?

YES → Replace the multiplexer box

NO → Continue troubleshooting. Search for corroded connectors and pinched cables. Install a test multiplexer box to verify results.

System Overview

Terms and Abbreviations 500

General Information 501

System Diagrams 502

Datalink Network Topology 503

Related Subjects 504

Components

Component Locations 600

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

– 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

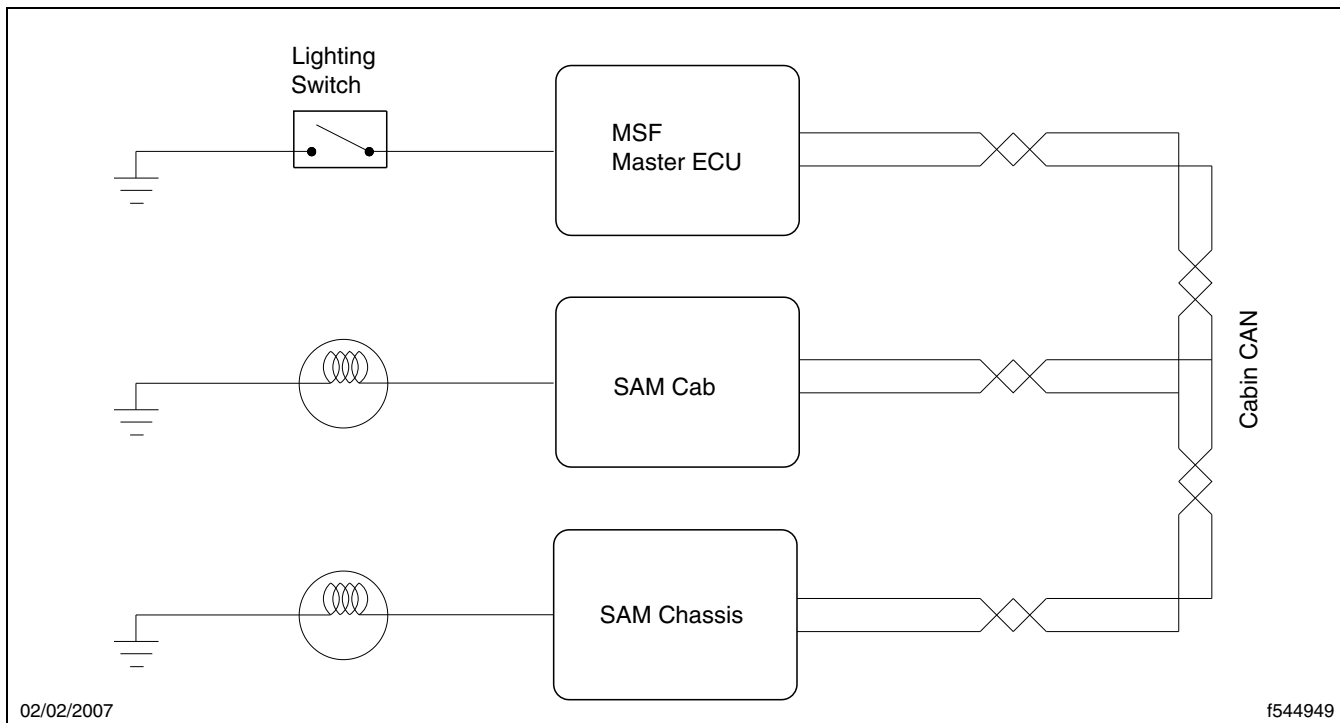


Fig. 1, Generic Diagram of the Exterior Lighting System

503 — Datalink Network Topology

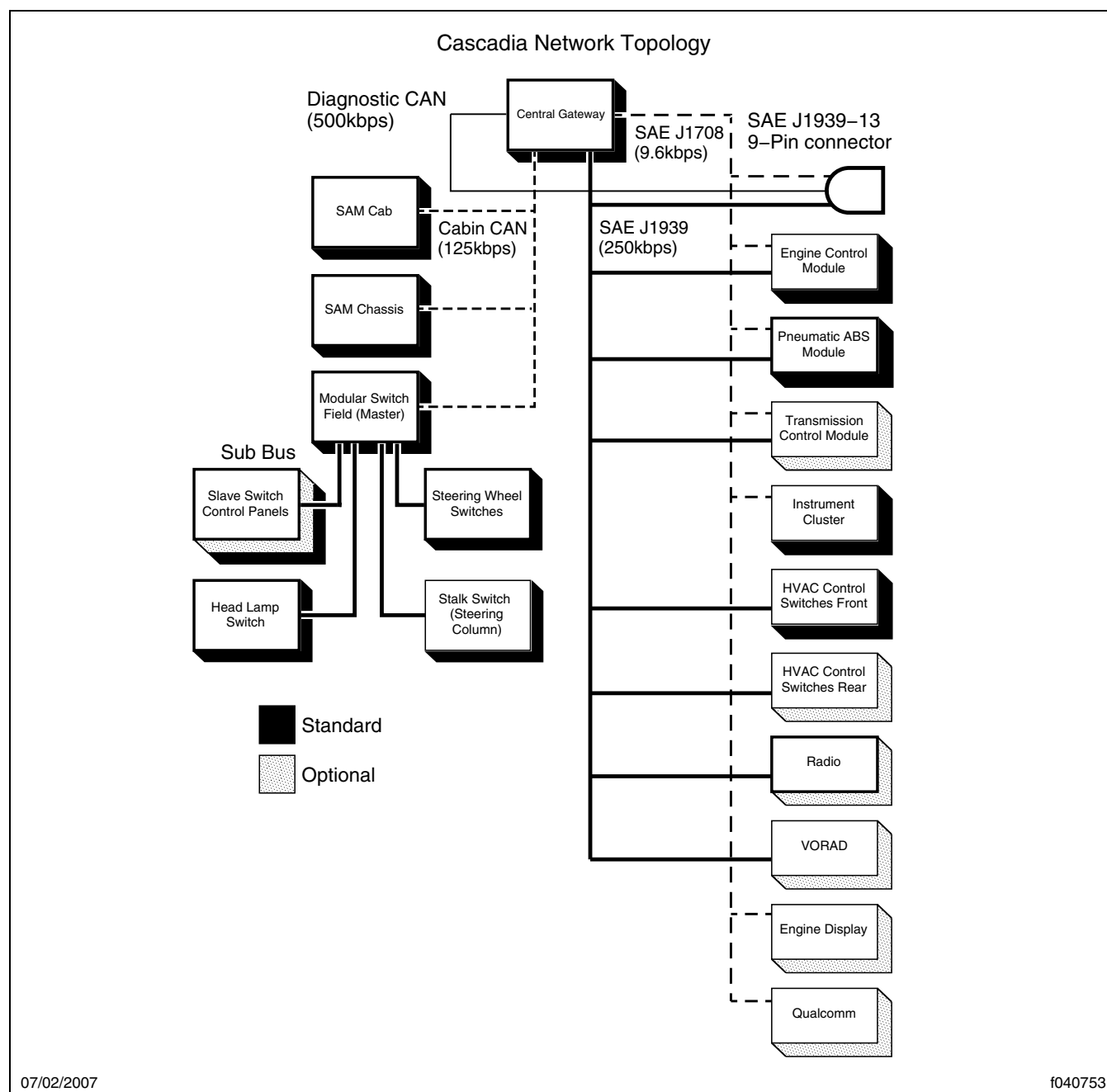


Fig. 2, Datalink Network Topology

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.

600 — Component Locations

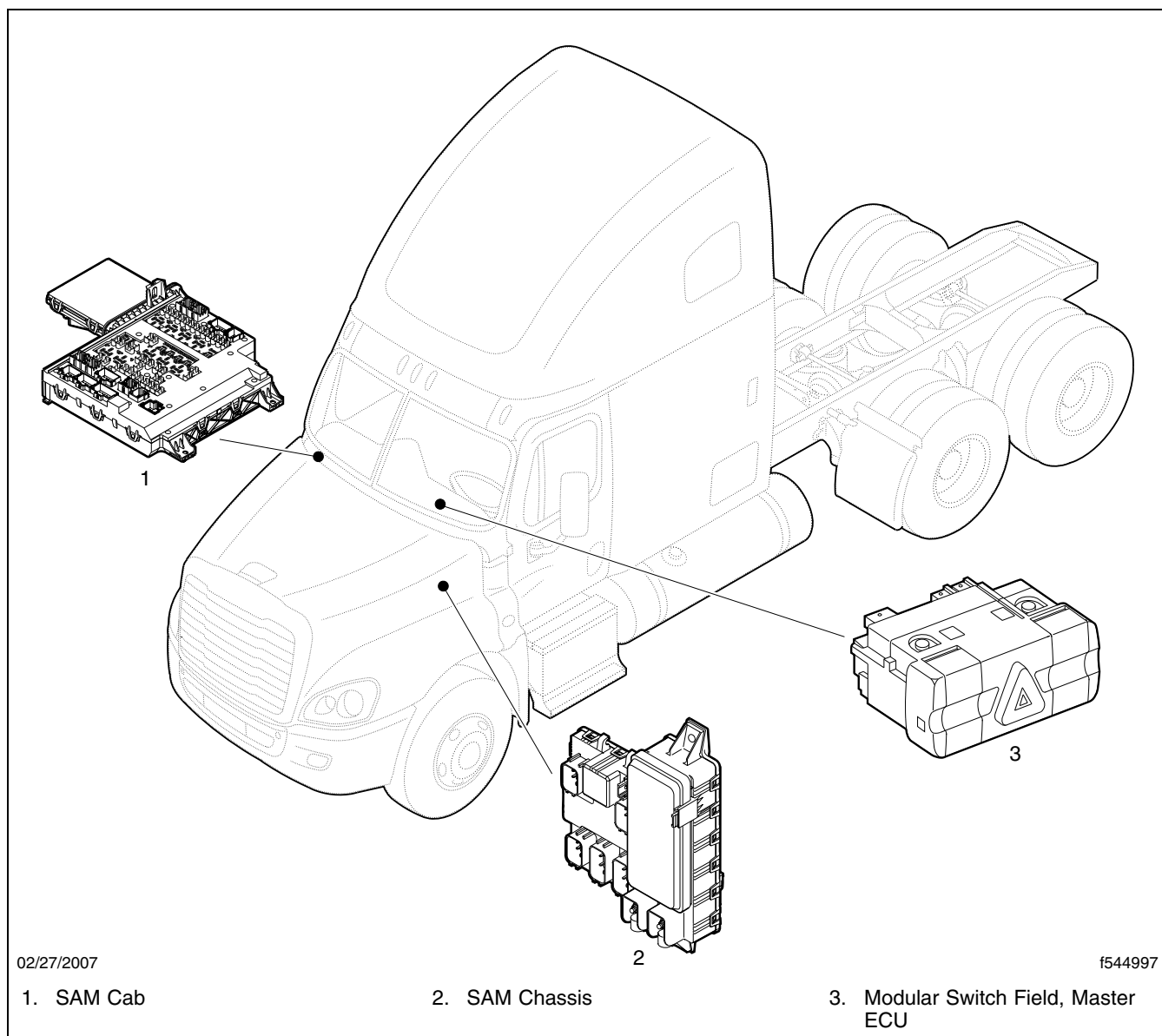


Fig. 3, Component Locations

System Overview

Terms and Abbreviations	500
General Information	501
Low Beam Headlights	502
High Beam Headlights	503
Flash-to-Pass	504
Follow Me Home	505
Datalink Network Topology	506
Related Subjects	507

Components

Component Locations	600
Component Details	601

Troubleshooting

Possible Causes	700
Pin Inputs and Datalink Messages	701
CAN Fault Codes	702

Specifications

Interlocks	800
Parameters	801

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**.

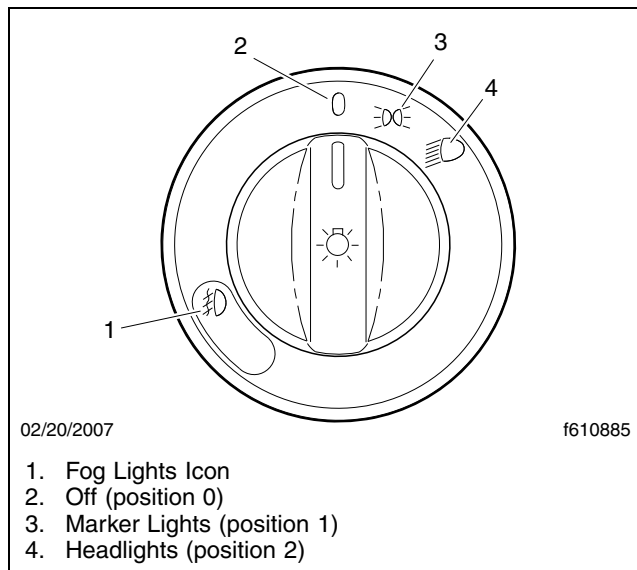


Fig. 1, Headlight Switch

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.

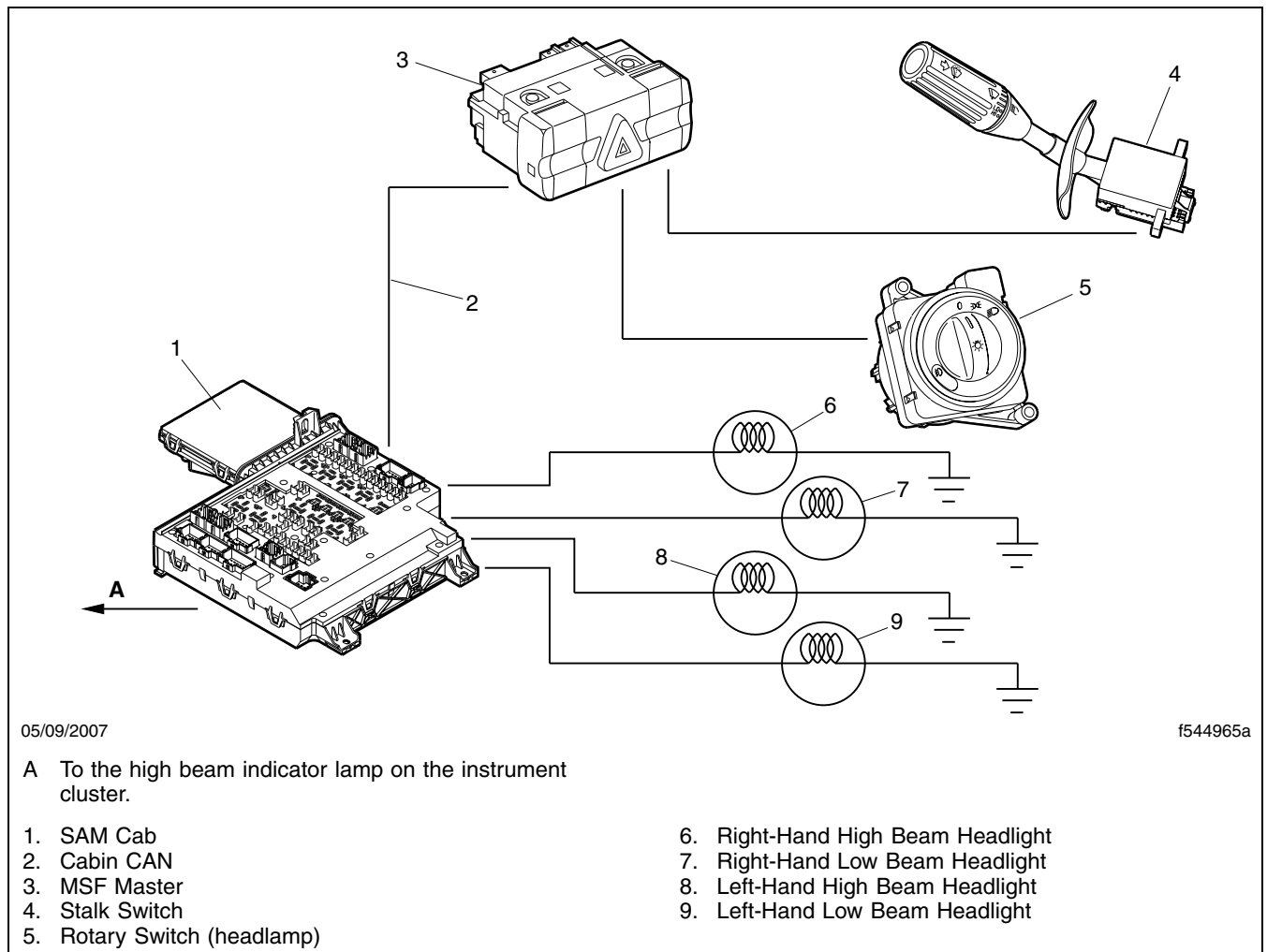


Fig. 2, Headlight System Diagram

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.

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

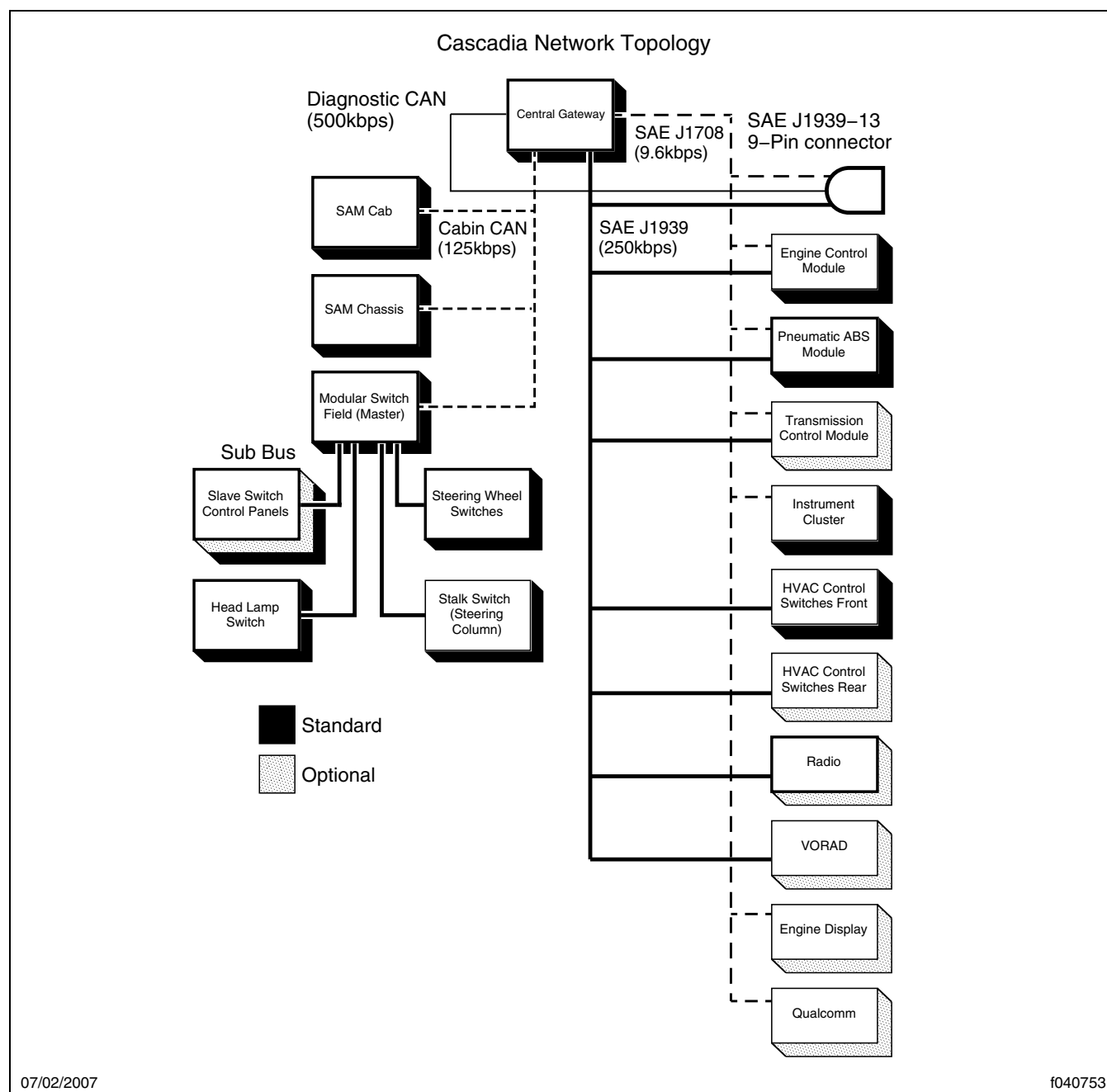


Fig. 3, Datalink Network Topology

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

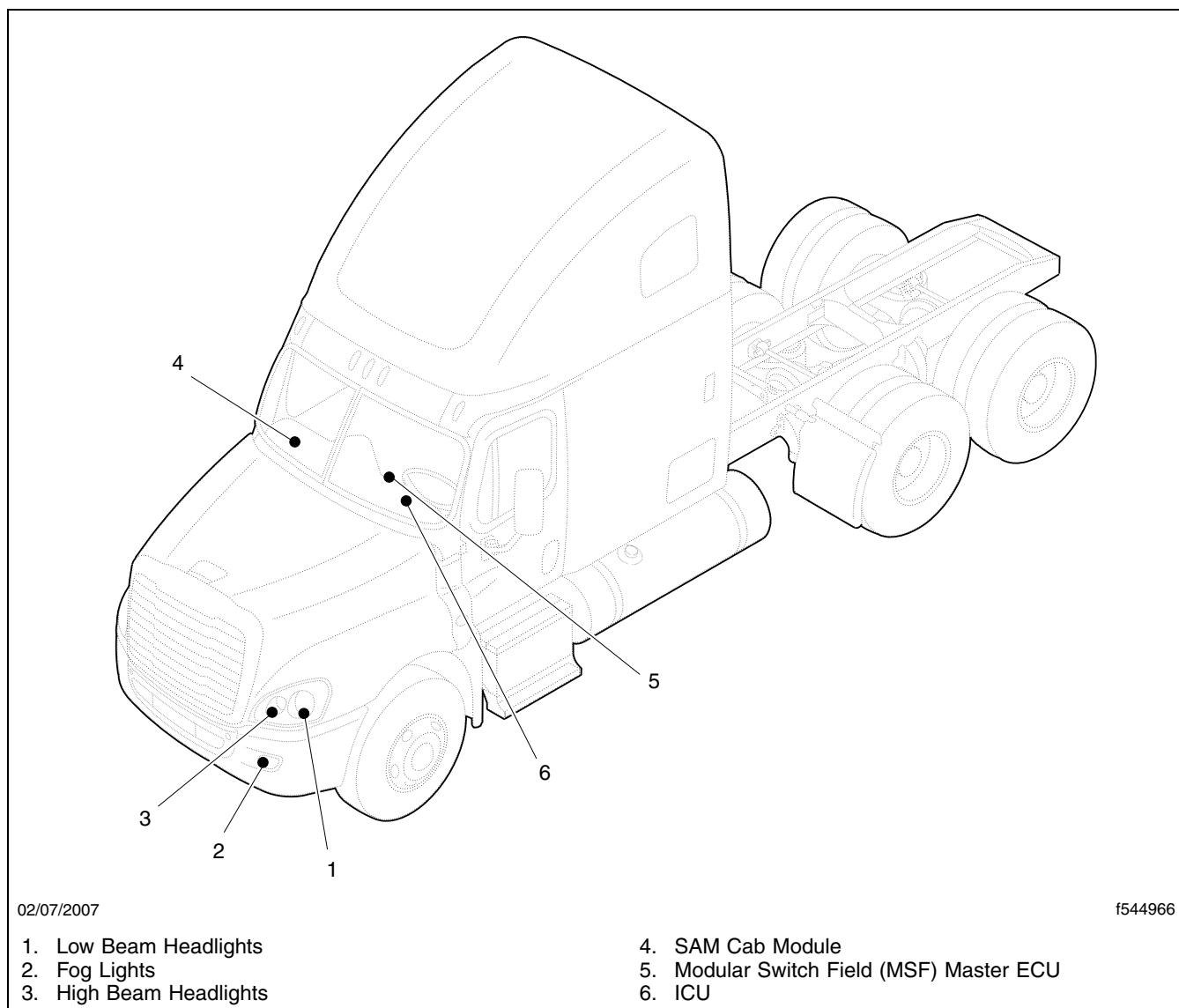


Fig. 4, Component Locations (exterior)

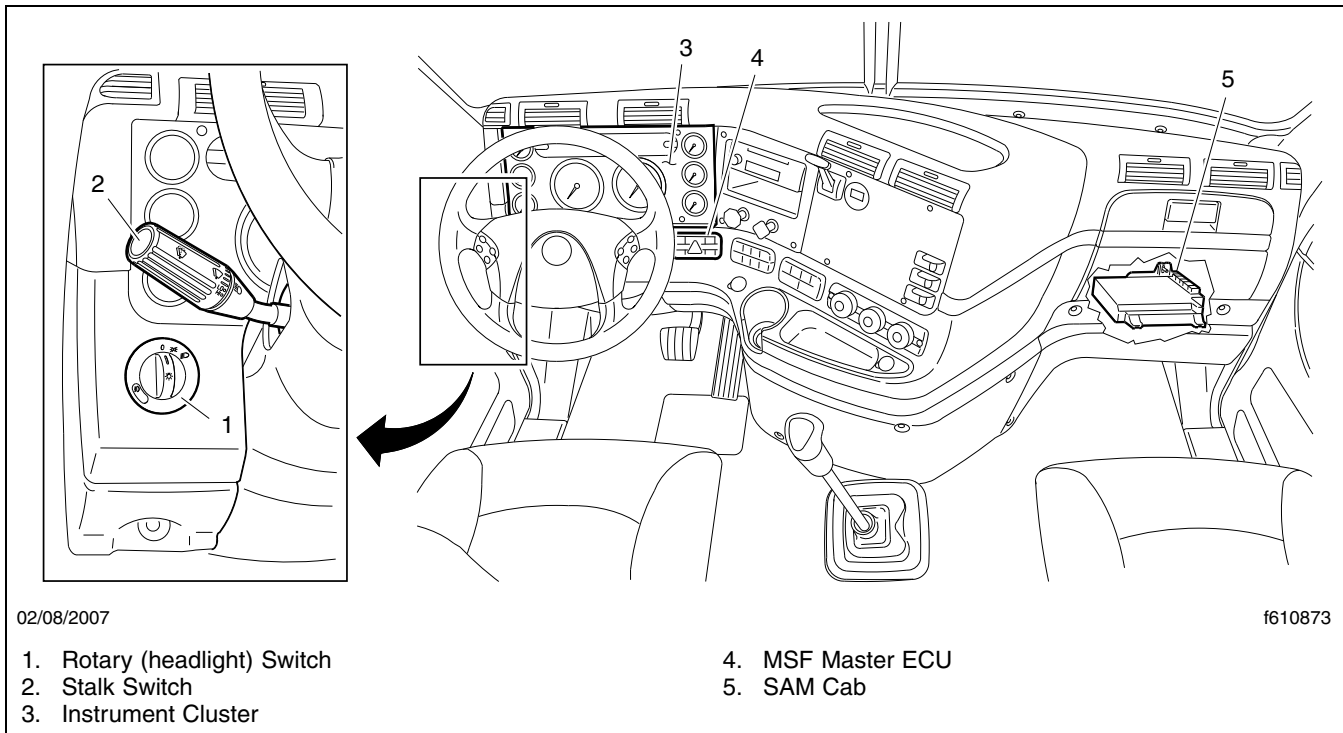


Fig. 5, Component Locations (interior)

601 — Component Details

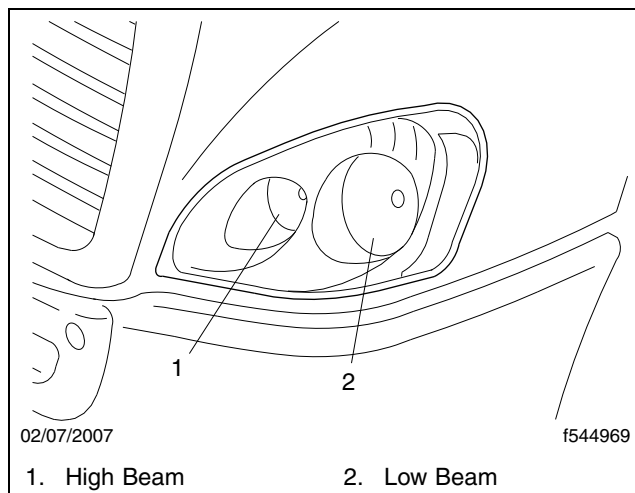


Fig. 6, Headlight (front view)

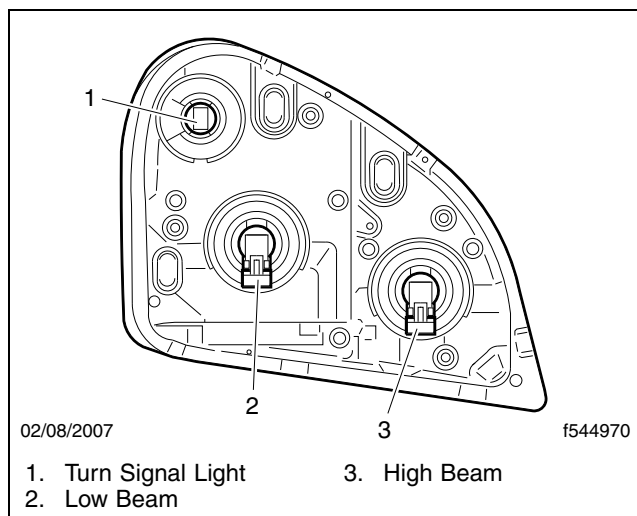


Fig. 7, Headlight (rear view)

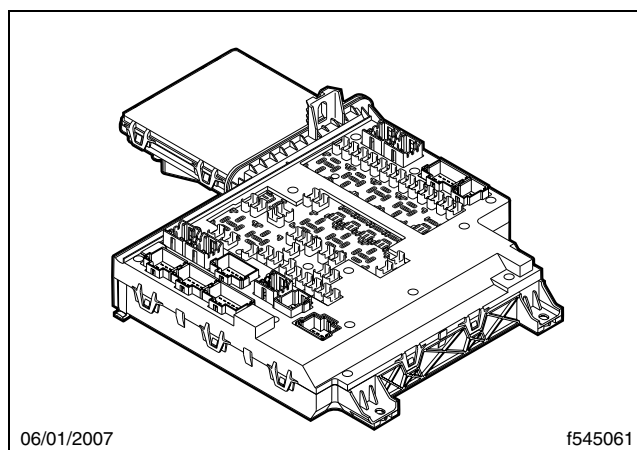


Fig. 8, SAM Cab

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

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.

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.							

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

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

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

System Overview

- Terms and Abbreviations 500
- General Information 501
- Vehicle Network Topology 502
- Related Subjects 503

Components

- Component Locations 600
- Component Details 601

Troubleshooting

- Troubleshooting Overview 700
- CAN Fault Codes 701
- Possible Causes 702

Specifications

- Inputs and Interlocks 800
- Outputs 801
- Parameters 802

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

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.

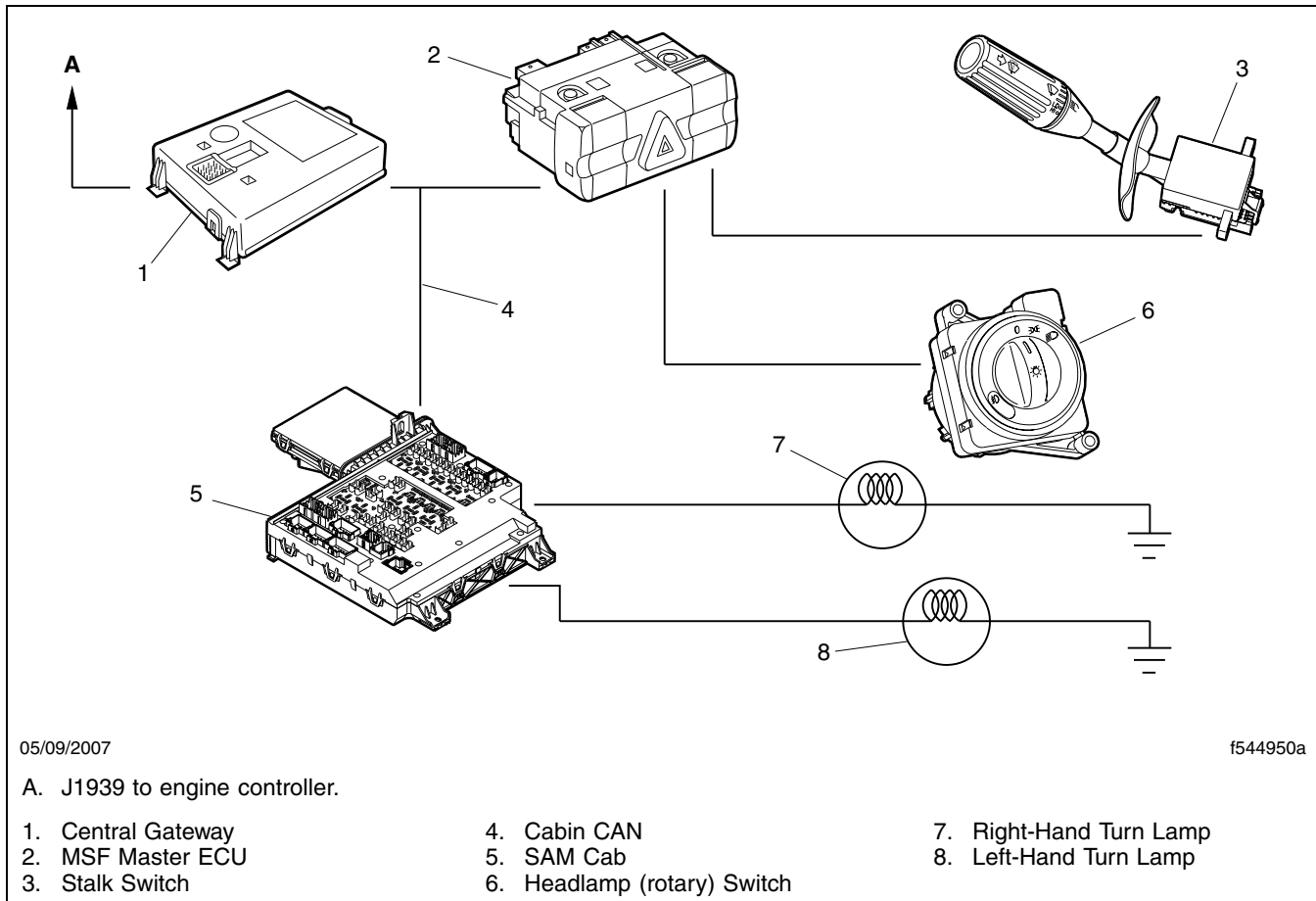


Fig. 1, System Diagram for Daytime Running Lights using Turn Lamps

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.

- 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.

502 — Vehicle Network Topology

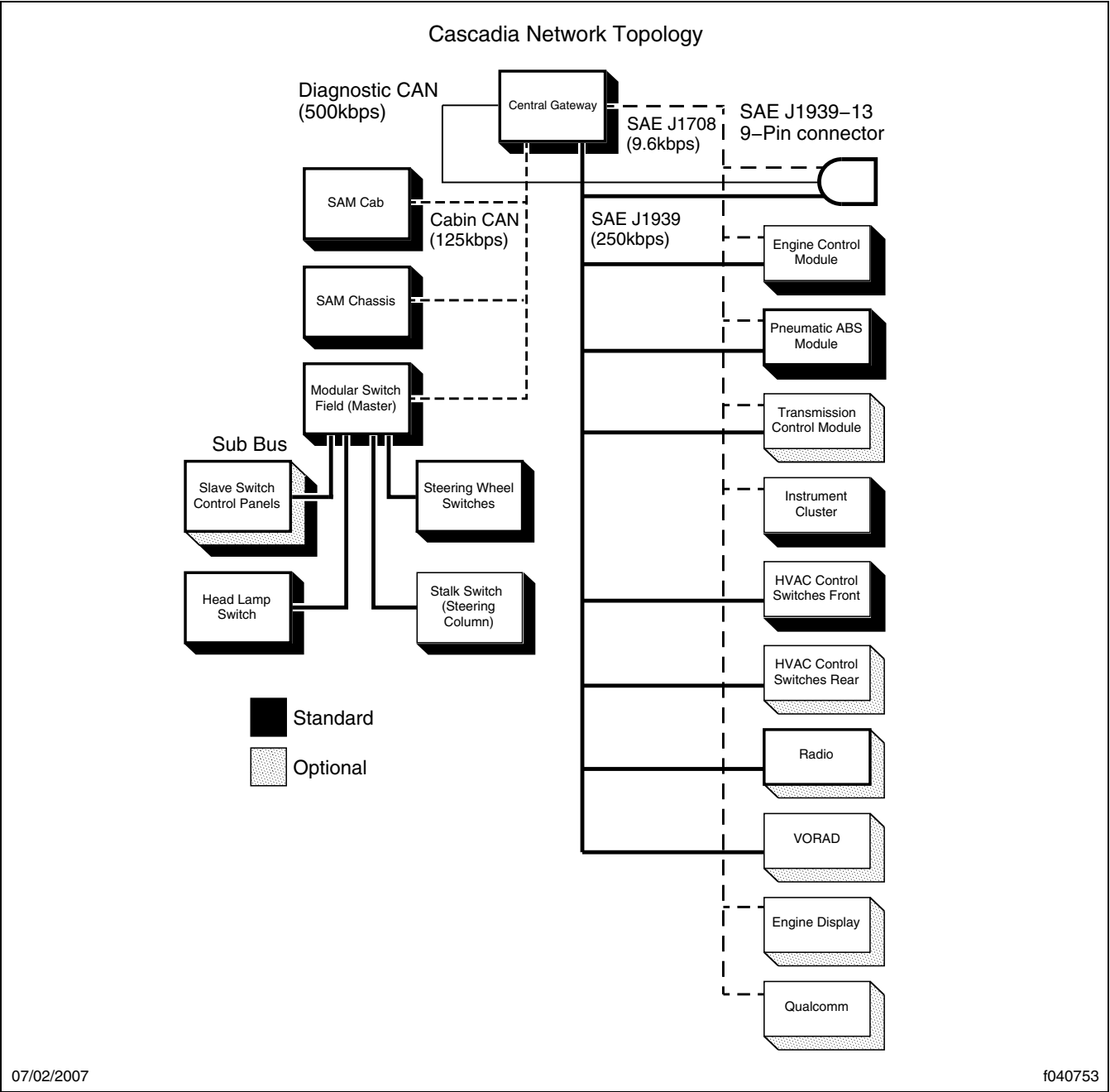


Fig. 2, Vehicle Network Topology

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

600 — Component Locations

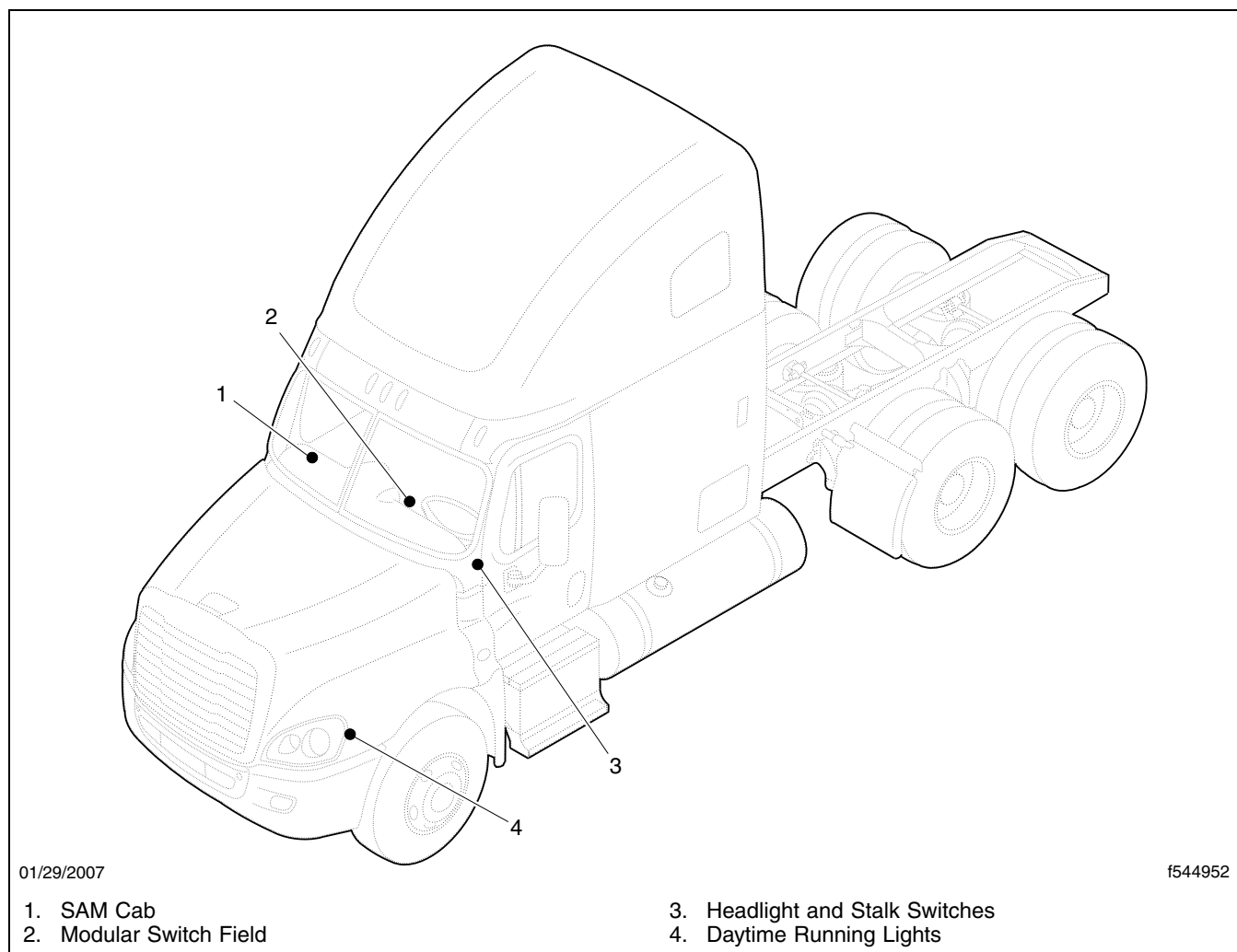


Fig. 3, Component Locations

601 — Component Details

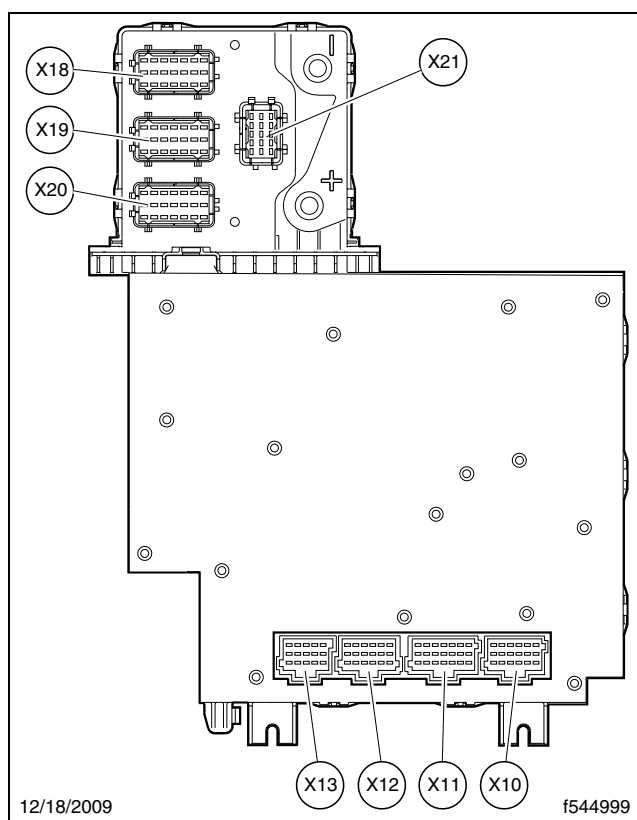


Fig. 4, SAM Cab Pin Locations (bottom)

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**.

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**.

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.

System Overview

Terms and Abbreviations	500
Stop Lamps	501
Turn Signal	502
Hazard Lights	503

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700
CAN Fault Codes	701
Input Troubleshooting	702
Output Troubleshooting	703
Turn Signals Flashing At Twice The Normal Rate	704

Specifications

Parameters	800

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 influence 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 option is present)
- hazard lights (if the combo stop/rear-turn-signal option is present)

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 influence the following features:

- hazard lights
- daytime running lights
- stop lamp (brake lights)

Activation of the turn signals is influence 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 influence 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 influence by the following features:

- Turn signals
- Stop lamps (if the combo stop/rear-turn-signal option is present)

600 — Component Locations

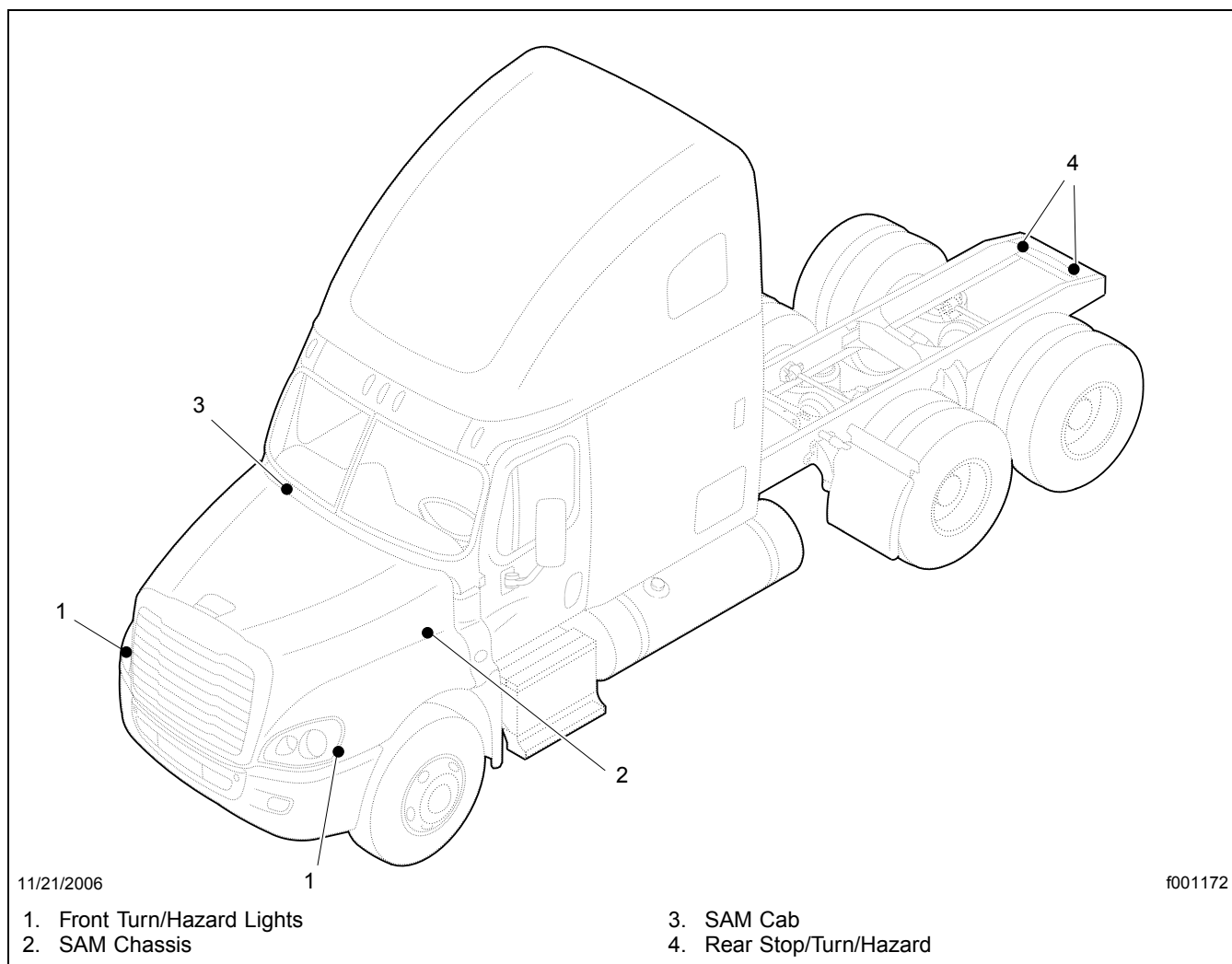


Fig. 1, Component Locations

601 — Component Details

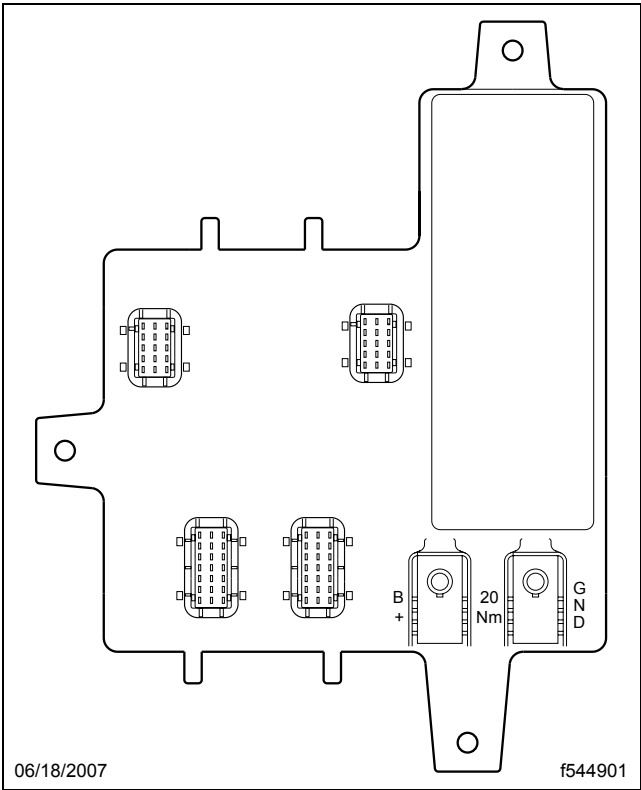


Fig. 2, SAM Chassis

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

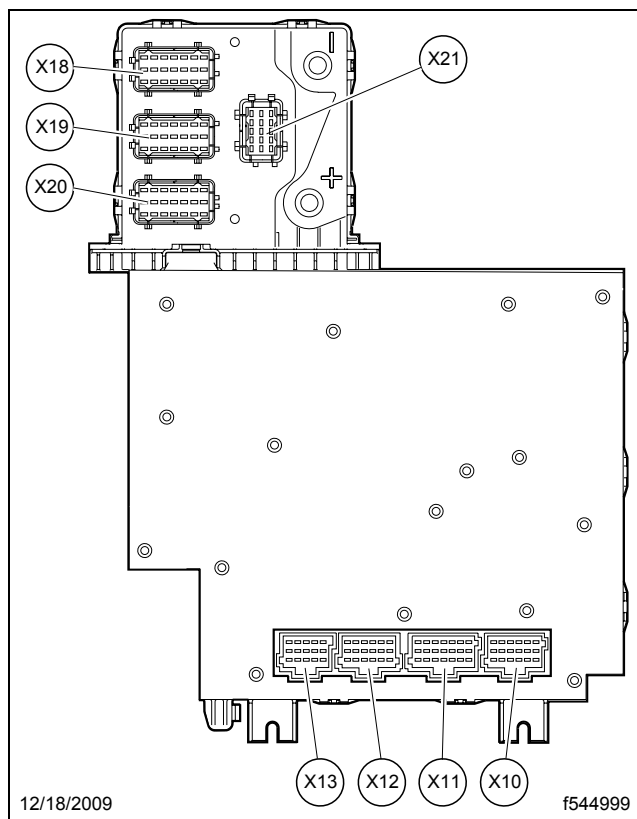


Fig. 3, SAM Cab Connectors (bottom view)

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

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

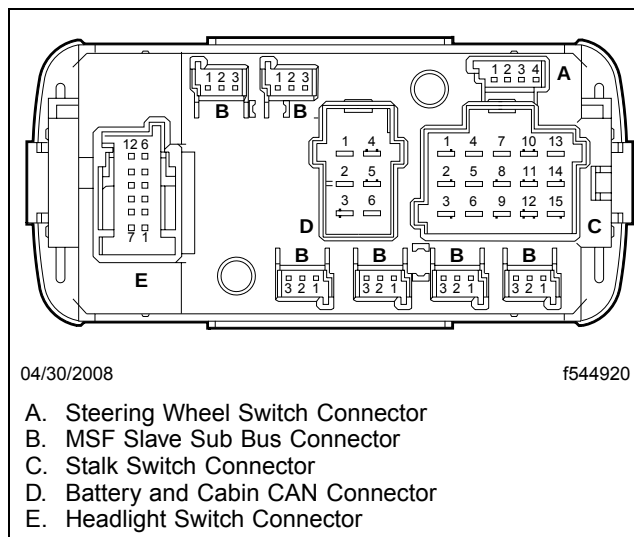


Fig. 4, MSF Master Connection Locations

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

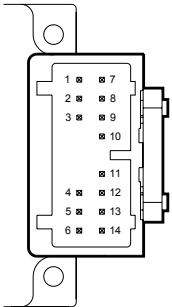
Stalk Switch Connector		
		
05/25/2012 f545038		
Function	Pin	Circuit
Left Turn	12	38C
Turn Signal Common	13	38A
Right Turn	14	38D

Table 5, Stalk Switch Connector

700 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor Template – Stop Turn Hazard Lamps
- Digital Multimeter

701 — CAN Fault Codes

NOTE: **Table 7** lists faults for the following Cabin CAN ECUs:

Cabin CAN ECUs	
Source Address	Cabin CAN ECUs
33	SAM Cab
37	Central Gateway (CGW)
49	Modular Switch Field (MSF)
71	SAM Chassis

Table 6, Cabin CAN ECUs

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	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 flashin 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 flashin 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 flashin 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 flashin at twice the normal frequency when the ignition key is in the "run" position.

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 flashin 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 flashin at twice the normal frequency when the ignition key is in the "run" position.

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.	Active when the right front turn signal lamp is open, or if there is 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 flashin 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 flashin 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 flashin 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 flashin at twice the normal frequency when the ignition key is in the "run" position.

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
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.							
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.							

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
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.
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 flashin 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 flashin 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.							

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
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 flashin at twice the normal frequency when the ignition key is in the "run" position.
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 flashin 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 flashin 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.							

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
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 flashin 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 7, CAN Fault Codes

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.

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
 - 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.

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.

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.

704 — Turn Signals Flashing At Twice The Normal Rate

Turn signals will flash at twice their normal rate when there is an active fault on any of the turn signal lamps. This behavior was introduced with Cascadia electrical system release 5.4.

To troubleshoot, read any active CAN fault codes from the SAM Cab and SAM Chassis in ServiceLink. For any turn or stop lamp faults, use the appropriate troubleshooting information in **701 — CAN Fault Codes**.

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 flashe .	PARM-CAB, TUS, TUT, X5	SAM Cab
301	002 447 85 58	Turn tip present, with 3 flashe .	PARM-CAB, TUS, TUT, X3	SAM Cab
311	001 447 84 58	Headlamps.	PARM-CAB, HDLP, NO CNT	SAM Cab

Parameters				
Module Number	Part Number	Description	Parameter	ECU
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

Parameters				
Module Number	Part Number	Description	Parameter	ECU
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
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

Parameters				
Module Number	Part Number	Description	Parameter	ECU
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 8, Parameters

System Overview

Terms and Abbreviations	500
General Information	501
Marker Interrupt Switch	502
Controls	503

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700

Specifications

Marker, Tail, Clearance, and License Plate Light Output	800
Parameters	801

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**.

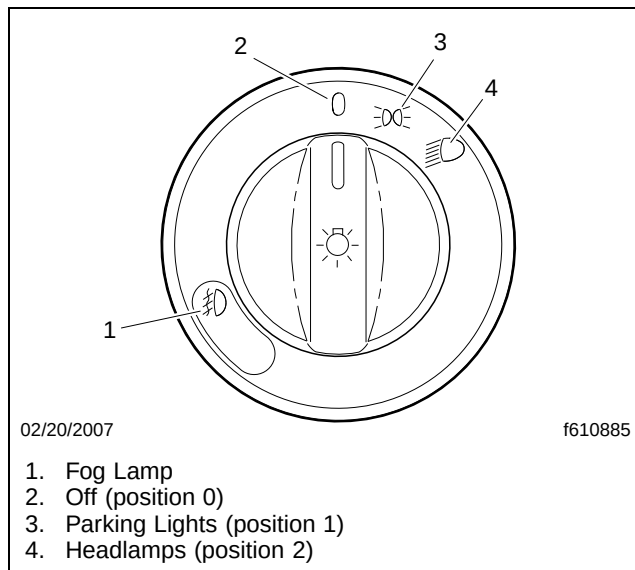


Fig. 1, Headlight Switch

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

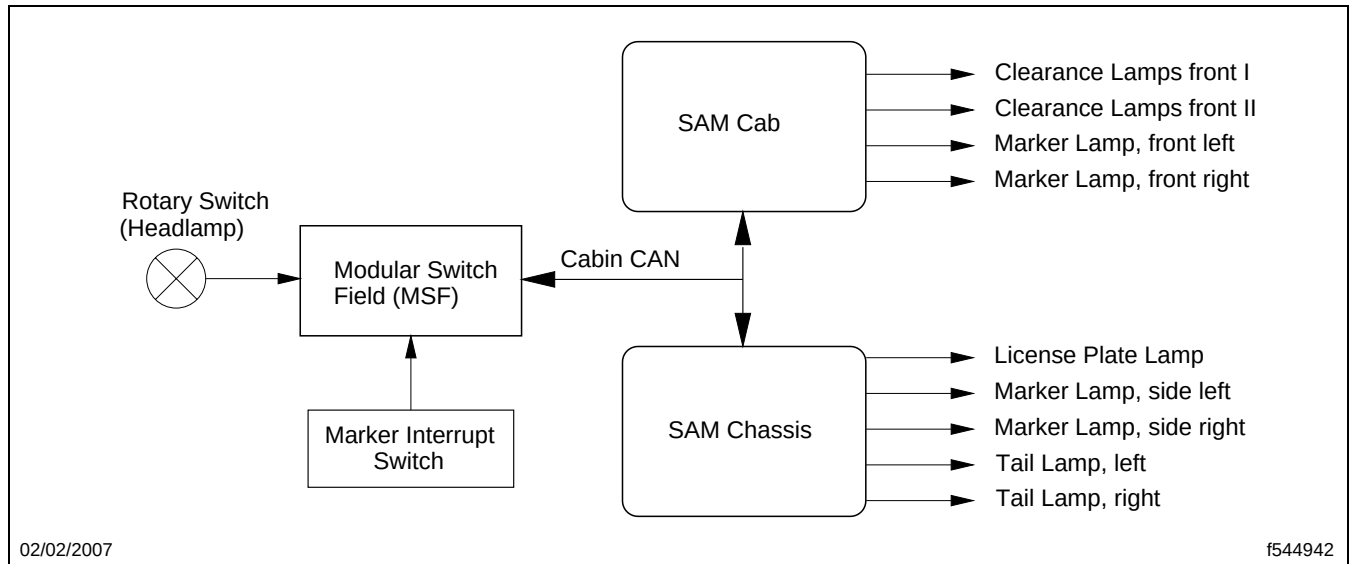


Fig. 2, Tail and Marker Light System Diagram

600 — Component Locations

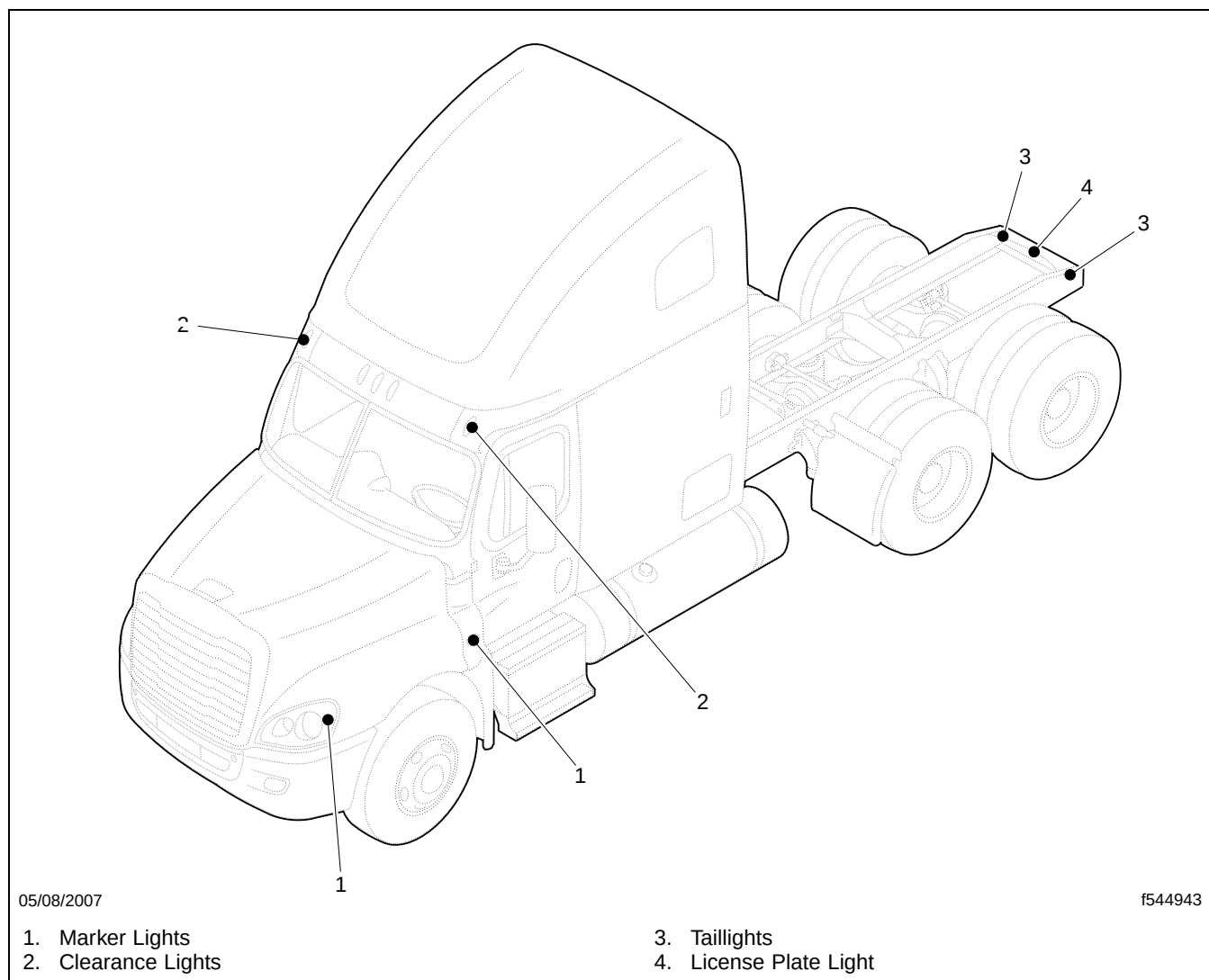


Fig. 3, Component Locations

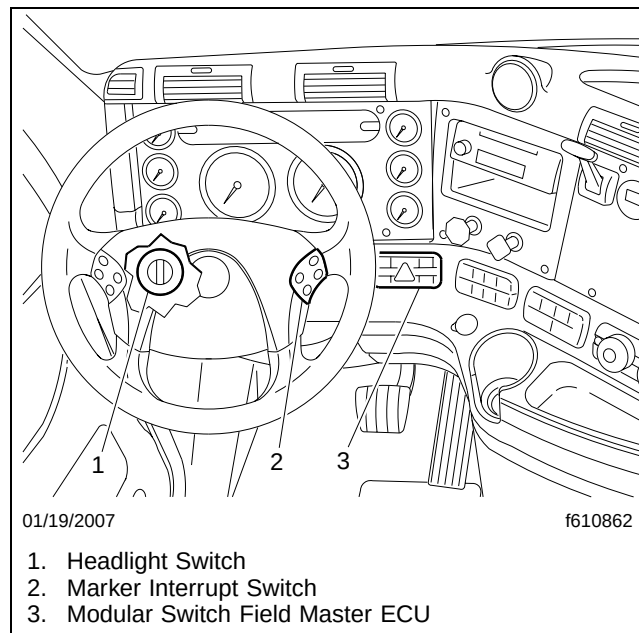


Fig. 4, Light Switches

601 — Component Details

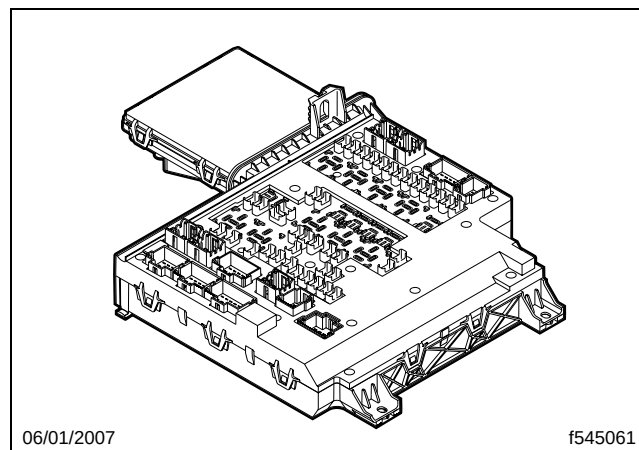


Fig. 5, SAM Cab

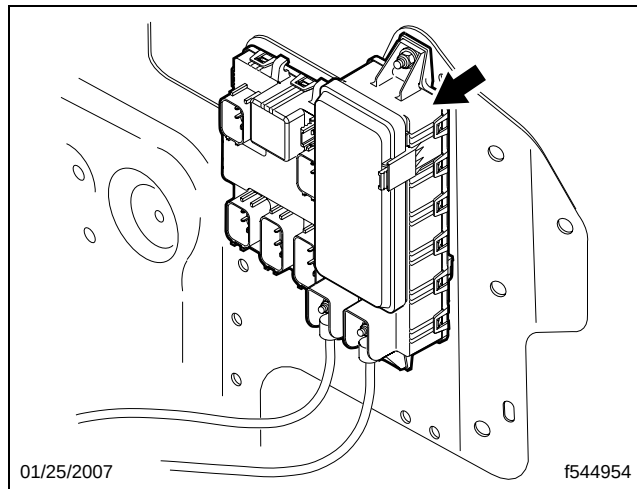


Fig. 6, SAM Chassis

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	—

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

System Overview

 Terms and Abbreviations 500

 General Information 501

 Controls 502

Components

 Component Locations 600

 Component Details 601

Troubleshooting

 Troubleshooting Overview 700

 Diagnostic Tools Required 701

 CAN Fault Codes 702

 Inputs and Interlocks 703

 Input Troubleshooting 704

 Output Troubleshooting 705

Specifications

 Parameters 800

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.

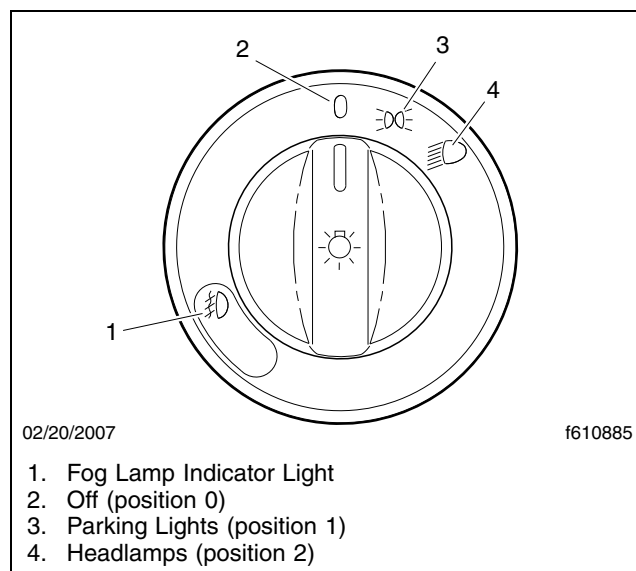


Fig. 1, Headlight Switch

Activation of the fog lights is influenced by the following features:

- Headlight Switch, Position 1

- Headlight Switch, Position 2
- High Beams/Flash-to-Pass

502 — Controls

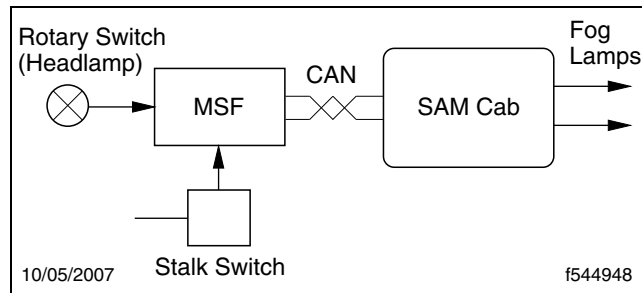


Fig. 2, Controls

600 — Component Locations

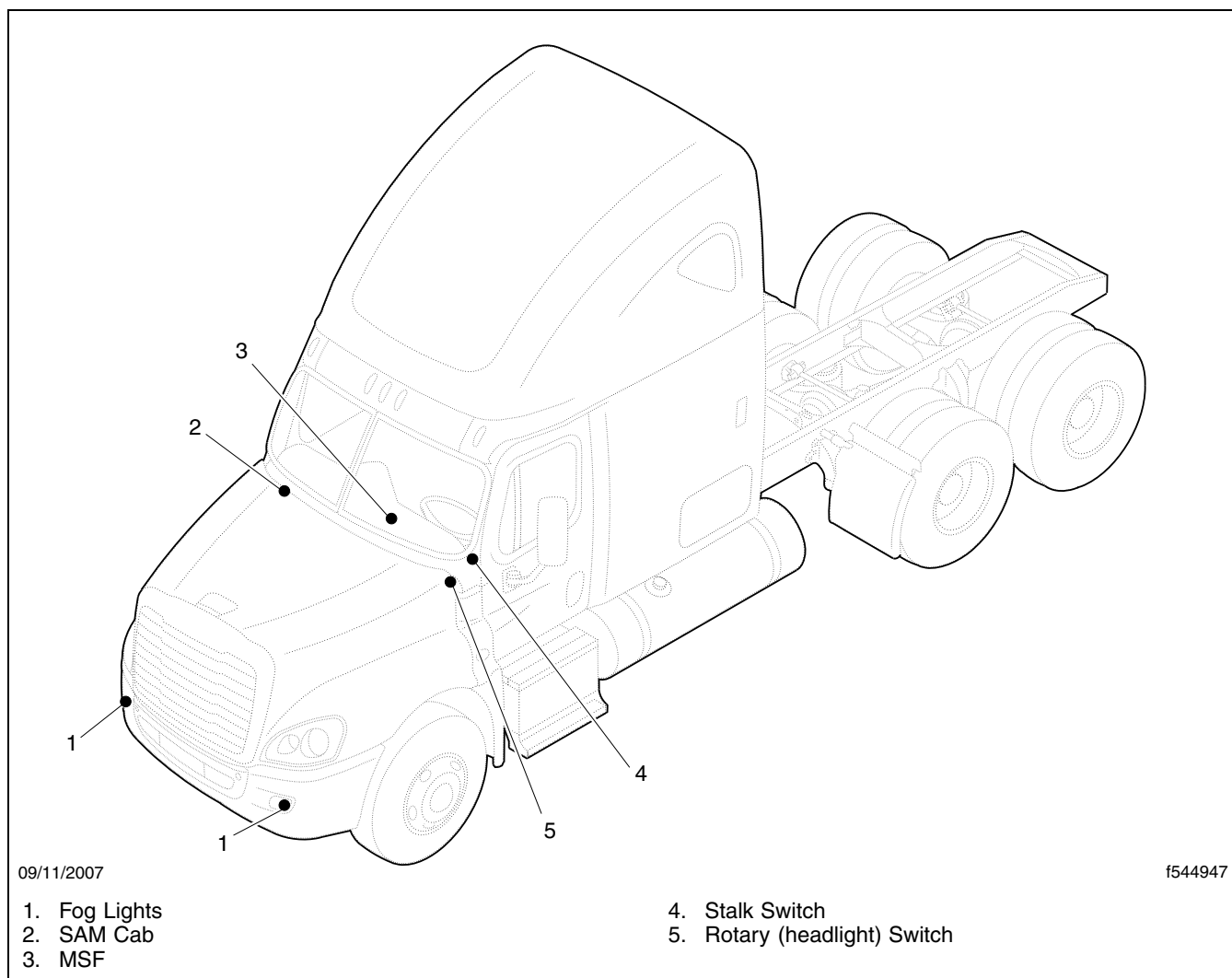


Fig. 3, Component Locations

601 — Component Details

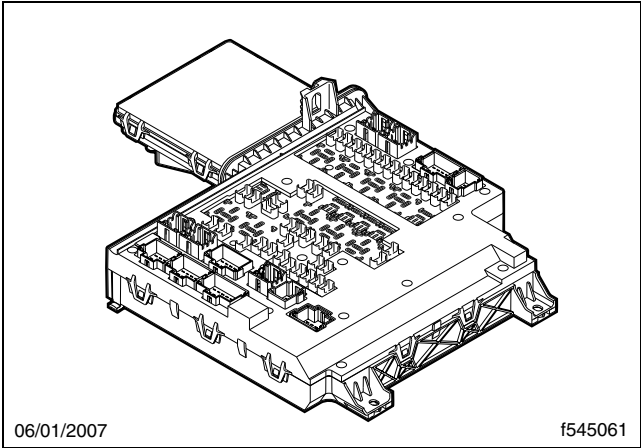


Fig. 4, SAM Cab

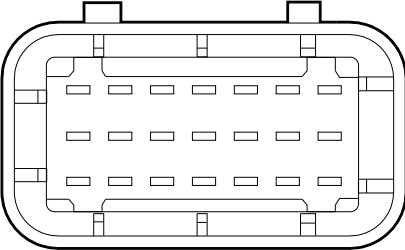
SAM Cab Connector X20			
			
09/12/2007 f545131			
Function	Connector	Pin	Circuit
Fog Light, Left	X20	8	28L
Fog Light, Left, Ground	X20	3	GND1
Fog Light, Right	X20	17	28R
Fog Light, Right, Ground	X20	1	GND2

Table 1, SAM Cab Connector X20

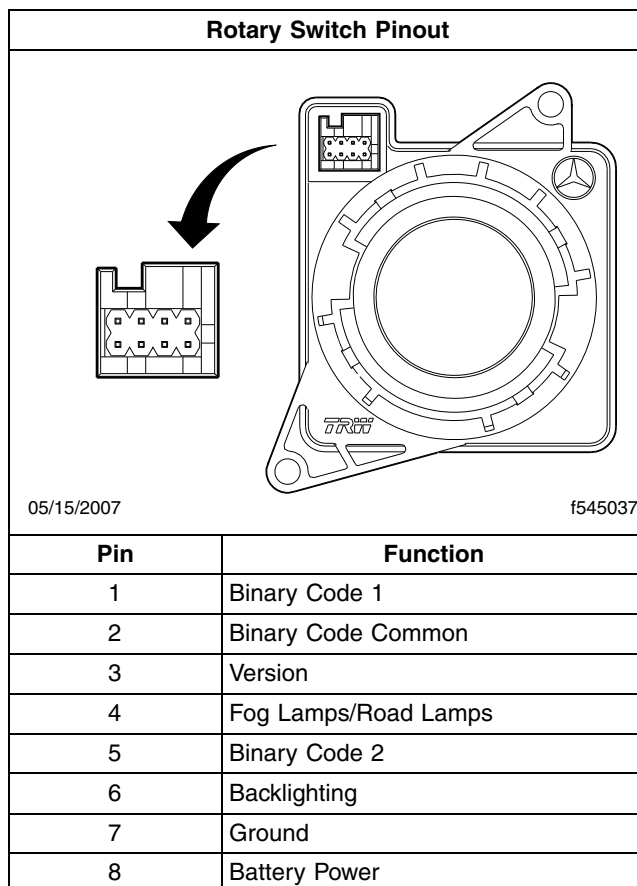


Table 2, Rotary Switch Pinout

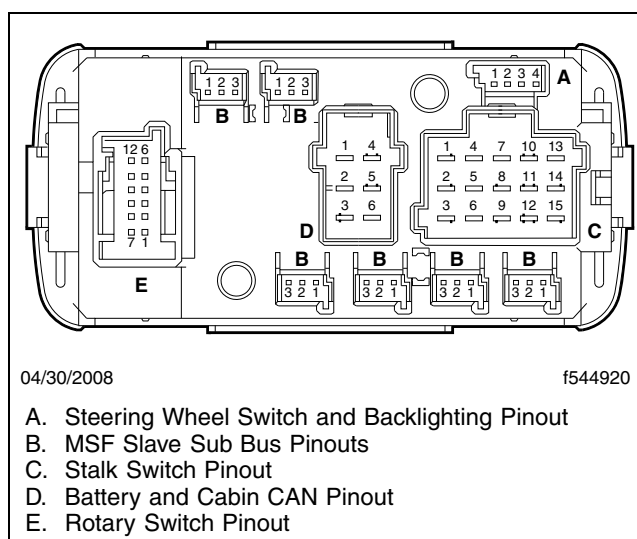


Fig. 5, MSF (connector side)

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.

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.

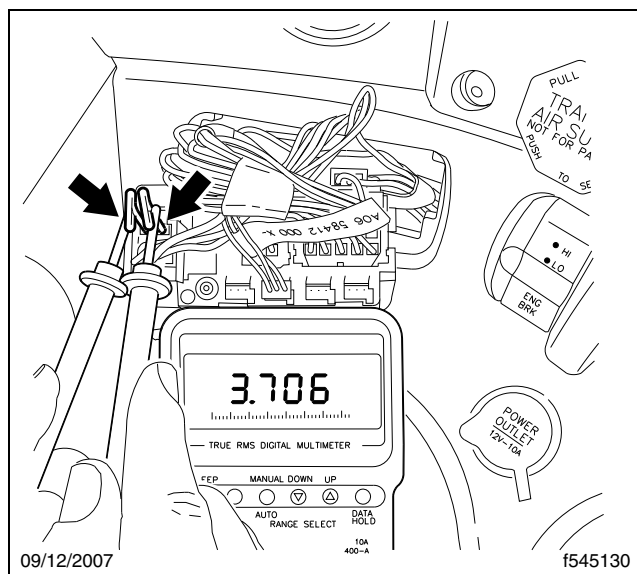


Fig. 6, Measuring Voltage Between Terminals 6 and 12

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).

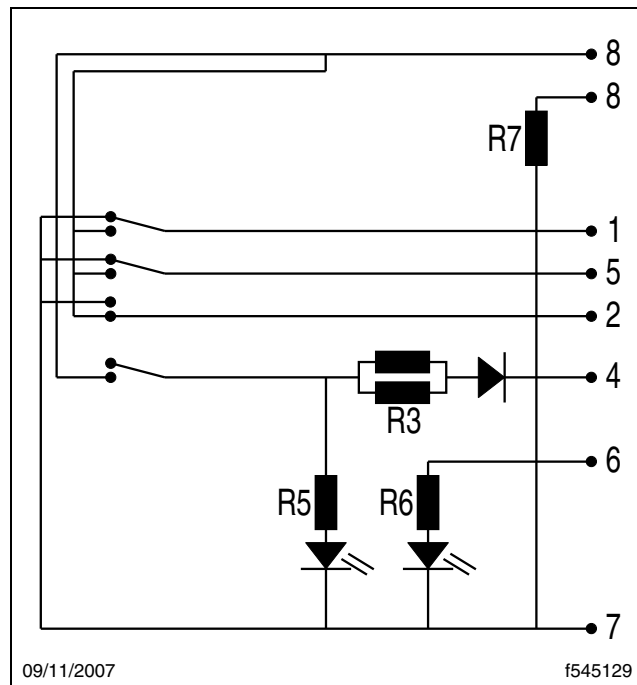


Fig. 7, Headlight Switch Pins

- 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?

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

System Overview

Terms and Abbreviations	500
General Information	501
End of Frame Primary Receptacle	502
Primary Receptacle	503

Components

Component Locations	600
Component Details	601

Specifications

Parameters	800

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.

600 — Component Locations

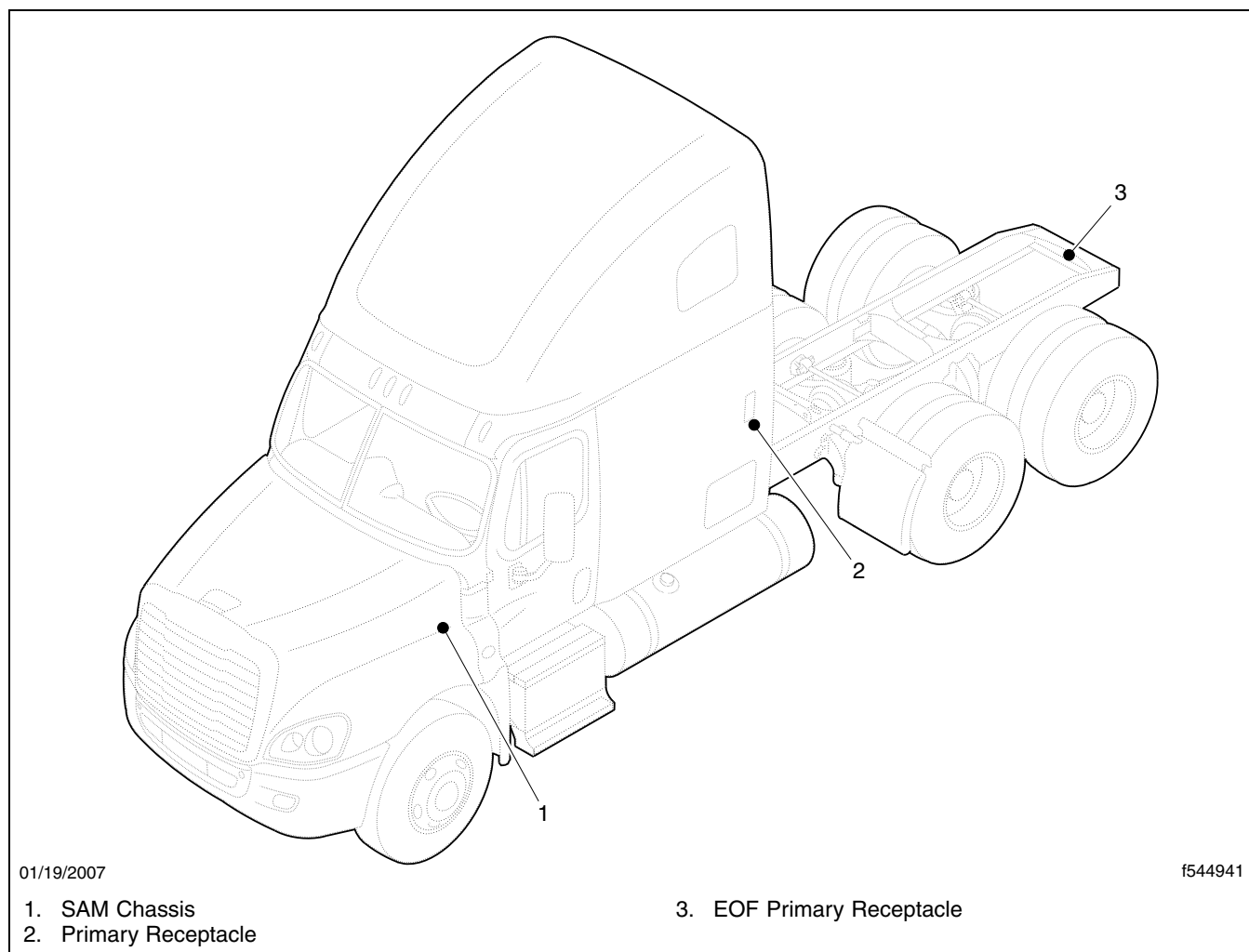


Fig. 1, Component Locations

601 — Component Details

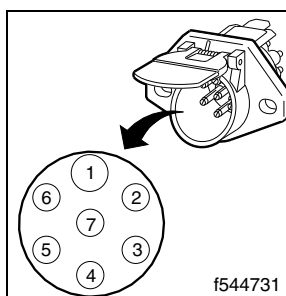


Fig. 2, Primary Receptacle 7-Pin Connector

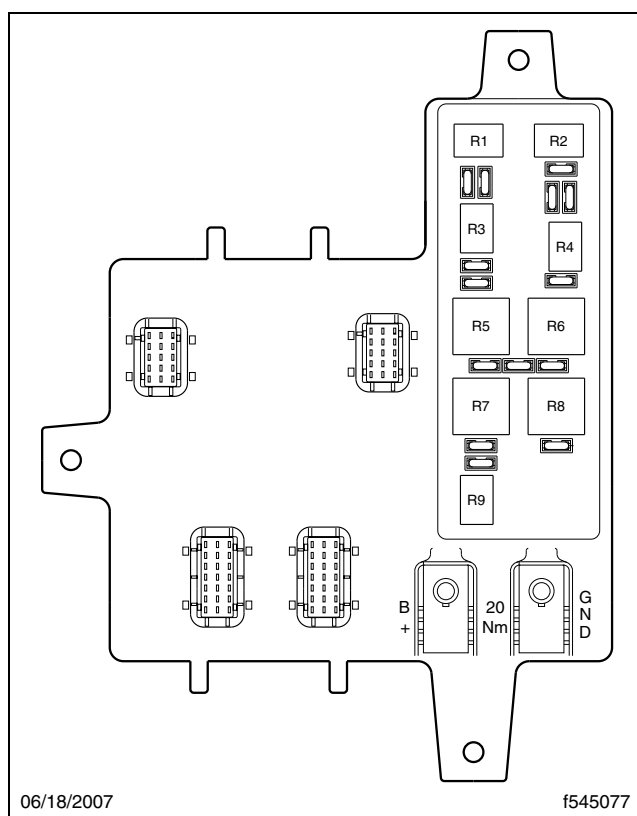


Fig. 3, SAM Chassis

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

System Overview

Terms and Abbreviations 500

General Information 501

Dimming Conditions and Timer Logic. 502

Lamp Control Modes 503

Dimmable Lighting 504

Components

Component Locations 600

Component Details 601

Troubleshooting

Troubleshooting Overview 700

CAN Fault Codes 701

Diagnostic Tools Required 702

Input Troubleshooting 703

MSF Input Troubleshooting 704

Output Troubleshooting 705

Specifications

Parameters 800

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

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.

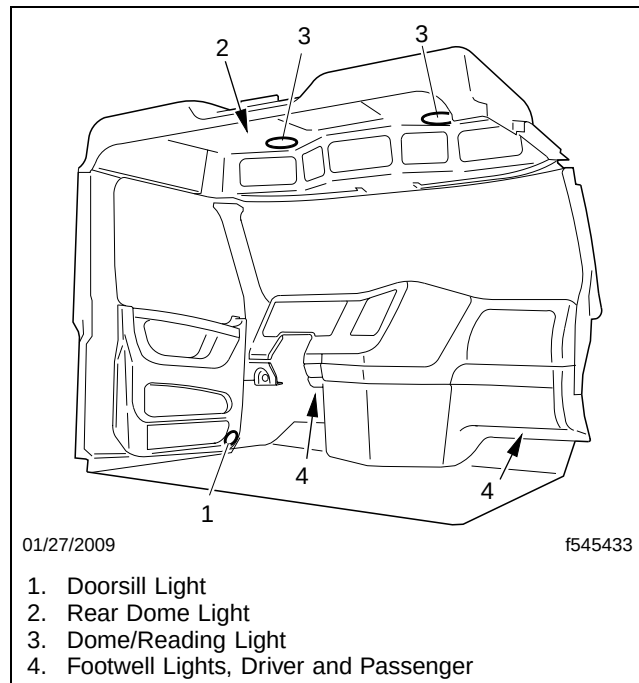


Fig. 1, Component Locations

601 — Component Details

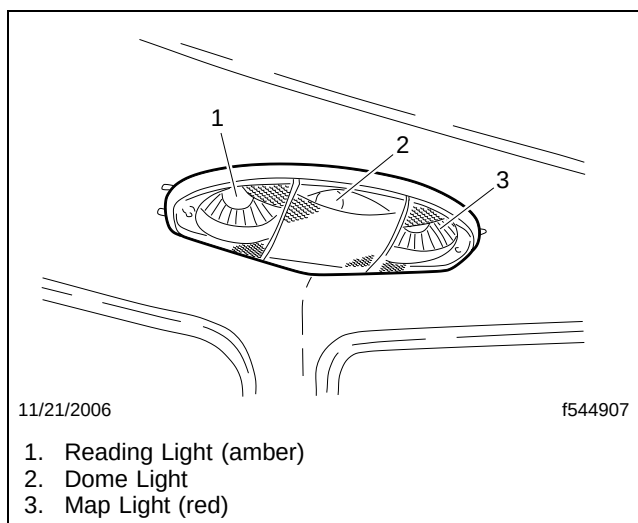


Fig. 2, Dome Light (driver-side)

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

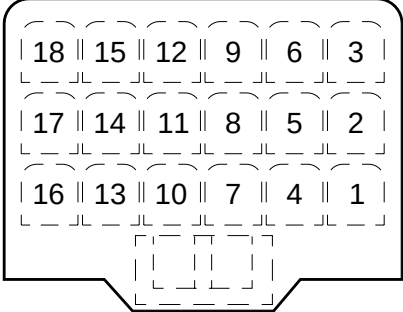
SAM Cab Connector X12		
		
06/21/2007 f545093		
Pin	Circuit	Description
3	108A	Footwell Lamp
10	GND	Footwell Lamp, GND

Table 2, SAM Cab Connector X12

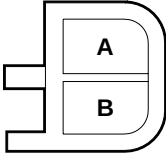
Footwell Lamp Connector		
		
06/21/2007 f545095		
Pin	Circuit	Description
A	108A	Footwell Lamp
B	GND	Footwell Lamp, GND

Table 3, Footwell Lamp Connector

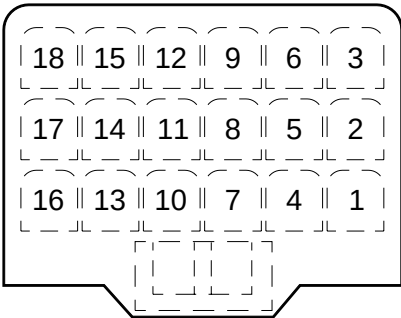
SAM Cab Connector X16		
		
06/21/2007 f545093		
Pin	Circuit	Description
7	41	Dome Lamp, Cab, Battery
11	108D	Dome Lamp, Driver, Forward, Overhead
14	108D	Dome Lamp, Passenger (rear dome lamp)
15	GND	GND, General Cab (forward dome lamp)

Table 4, SAM Cab Connector X16

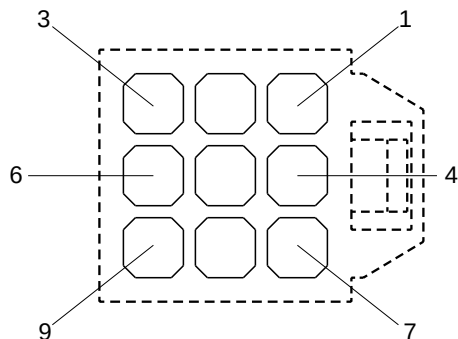
SAM Cab Connector 17		
		
01/09/2008 f545187		
Pin	Circuit	Description
5	108U	Door Open, Passenger Side

Table 5, SAM Cab Connector 17

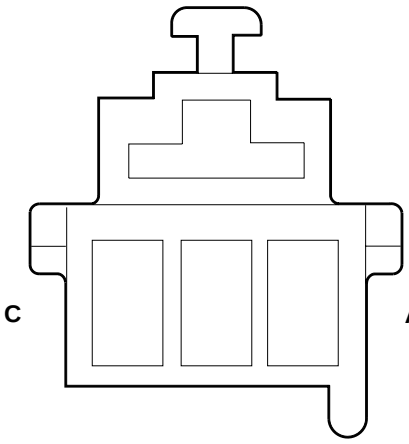
Front Dome Lamp Connector		
		
05/10/2007 f545031		
Front Dome Lamp Connector, Driver Side		
Pin	Circuit	Description
A	41	Reading/Dome/Map Light, Battery Power
B	GND	Dome Lamp, GND
C	108D	Dome Lamp, Door Activated
Front Dome Lamp Connector, Passenger Side		
Pin	Circuit	Description
A	108D	Dome Lamp, Door Activated
B	GND	Dome Lamp, GND
C	41	Reading/Dome/Map light, Battery Power

Table 6, Front Dome Lamp Connector

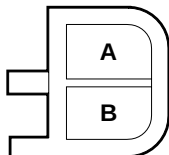
Vanity Mirror Light Connector			
			
06/21/2007		f545095	
Vanity Mirror Light Connector, Driver Side			
Pin	Circuit	Color	Description
A	GND	Black	GND, General Cab/Chassis
B	41	Purple/White	Dome Lamp constant 12V supply
Vanity Mirror Light Connector, Passenger Side			
A	GND	Black	GND, General Cab/Chassis
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.							

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

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:

- 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.

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

System Overview

Terms and Abbreviations	500
General Information	501
Sub Bus Switches	502
Lamp Control Modes	503
ECU Switched Lamps	504
Locally Switched Lamps	505
Theater Lighting	506
Dimmable Lighting	507

Components

Component Locations	600

Troubleshooting

Troubleshooting Overview	700
Diagnostic Tools Required	701
CAN Fault Codes	702
Input Troubleshooting	703
Output Troubleshooting	704

Specifications

Parameters	800

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.

- **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.

600 — Component Locations

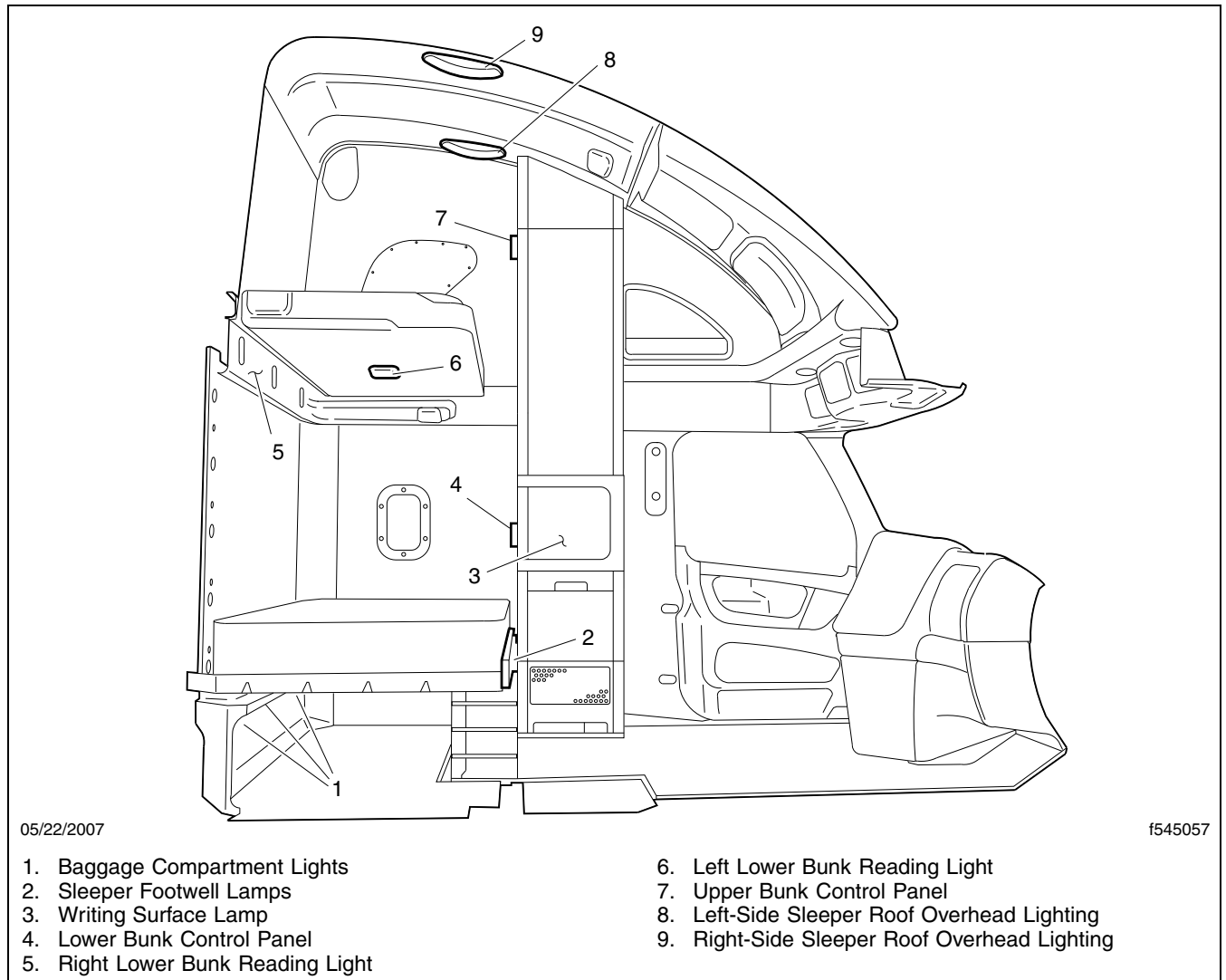


Fig. 1, Component Locations

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.

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.							

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 — <i>Logic Controlled Unfused Outputs</i> 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 — <i>Logic Controlled Unfused Outputs</i> 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.

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.

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.

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

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

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

System Overview

Terms and Abbreviations	500
General Information	501
Lamp Control Modes	502
ECU Switched Lamps	503
Theater Lighting	504

Components

Component Locations	600
Component Details	601

Troubleshooting

Troubleshooting Overview	700
Diagnostic Tools Required	701
CAN Fault Codes	702
Input Troubleshooting	703
Output Troubleshooting	704
Dash Light Troubleshooting (not MSF related)	705
MSF Panel Lamp Incremental/Decremental Sub Bus Switch Troubleshooting	706
MSF Backlighting Troubleshooting	707
MSF Sub Bus Switch Illumination Troubleshooting	708
Headlight Switch Illumination Troubleshooting	709
CAN Wiring Troubleshooting	710

Specifications

Parameters	800

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
- Door Switches

The backlighting circuit is a pulse width modulated (PWM) signal. See **Fig. 1** for an illustrated example of pulse width modulation.

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 inform the ServiceLink user of the brightness level. For more information on lighting modes, refer to **Table 1**.

Backlighting Modes		
Lighting Mode	Active Conditions	Illumination Value
Daytime	Active when the headlamp switch position is OFF, and the ignition is ON.	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, regardless of ignition switch position.	The illumination value is at a brightness set by parameter "PARM-CAB, ICU, DDO, DDC, STD, 30DM". Refer to 800 — Parameters for more information.
Marker Interrupt	This mode is active when pressing the marker interrupt switch and the ignition is ON.	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

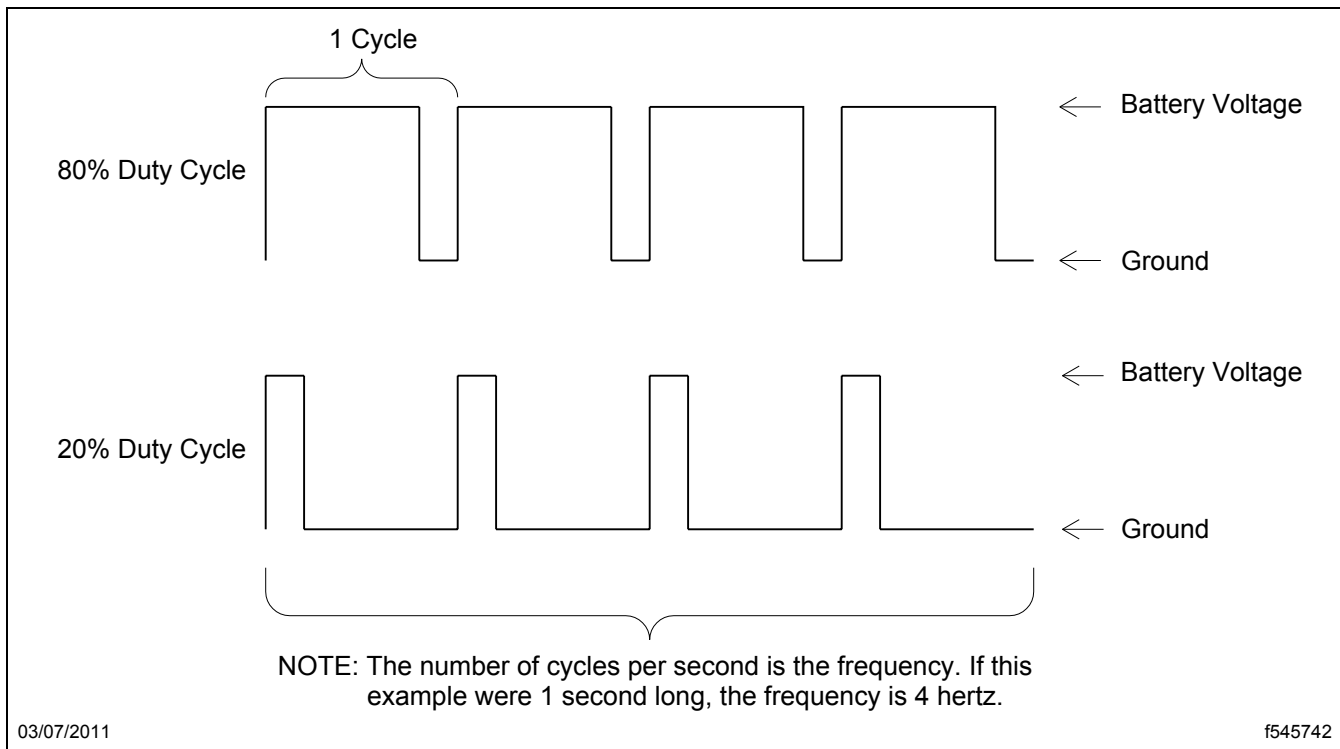


Fig. 1, Pulse Width Modulation

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

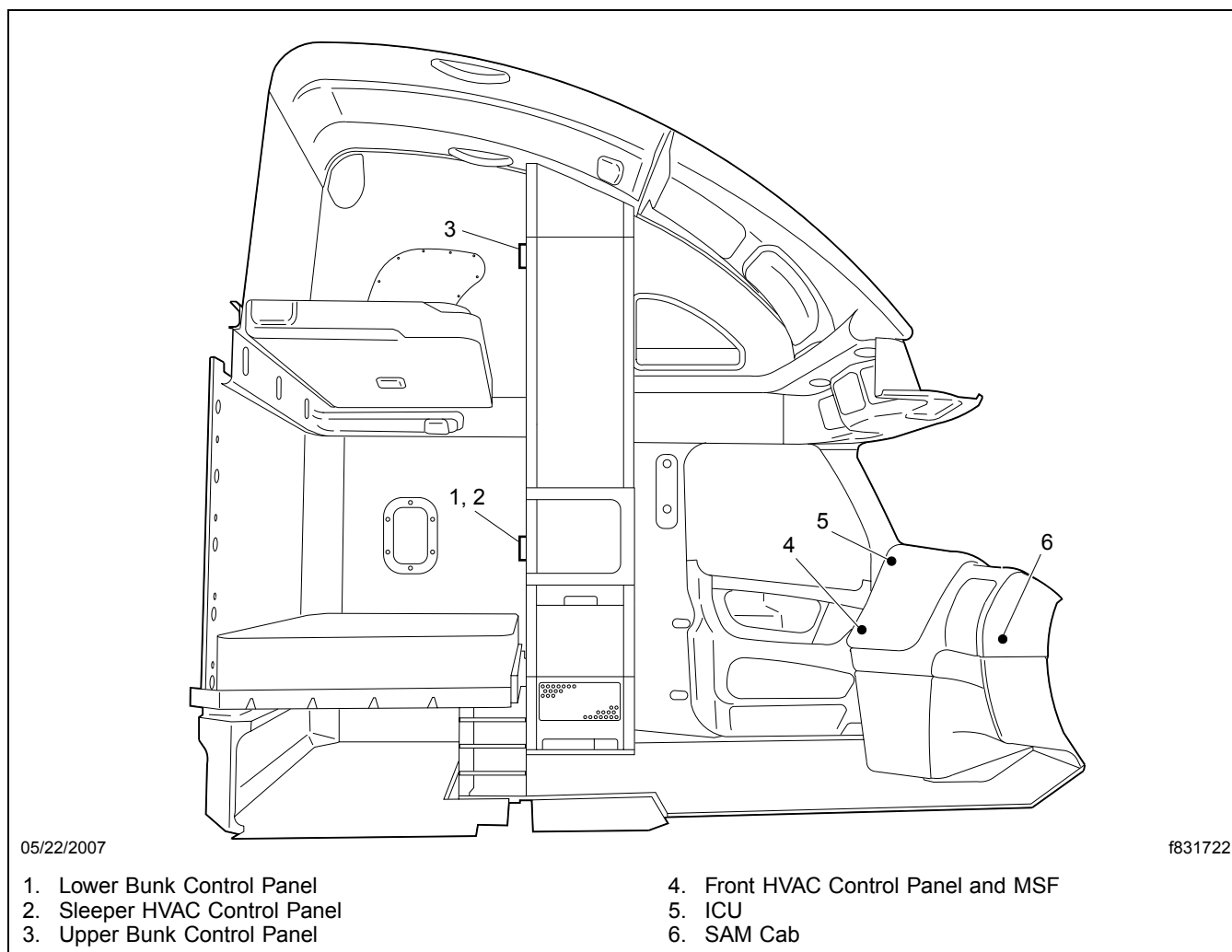


Fig. 2, Component Locations

601 — Component Details

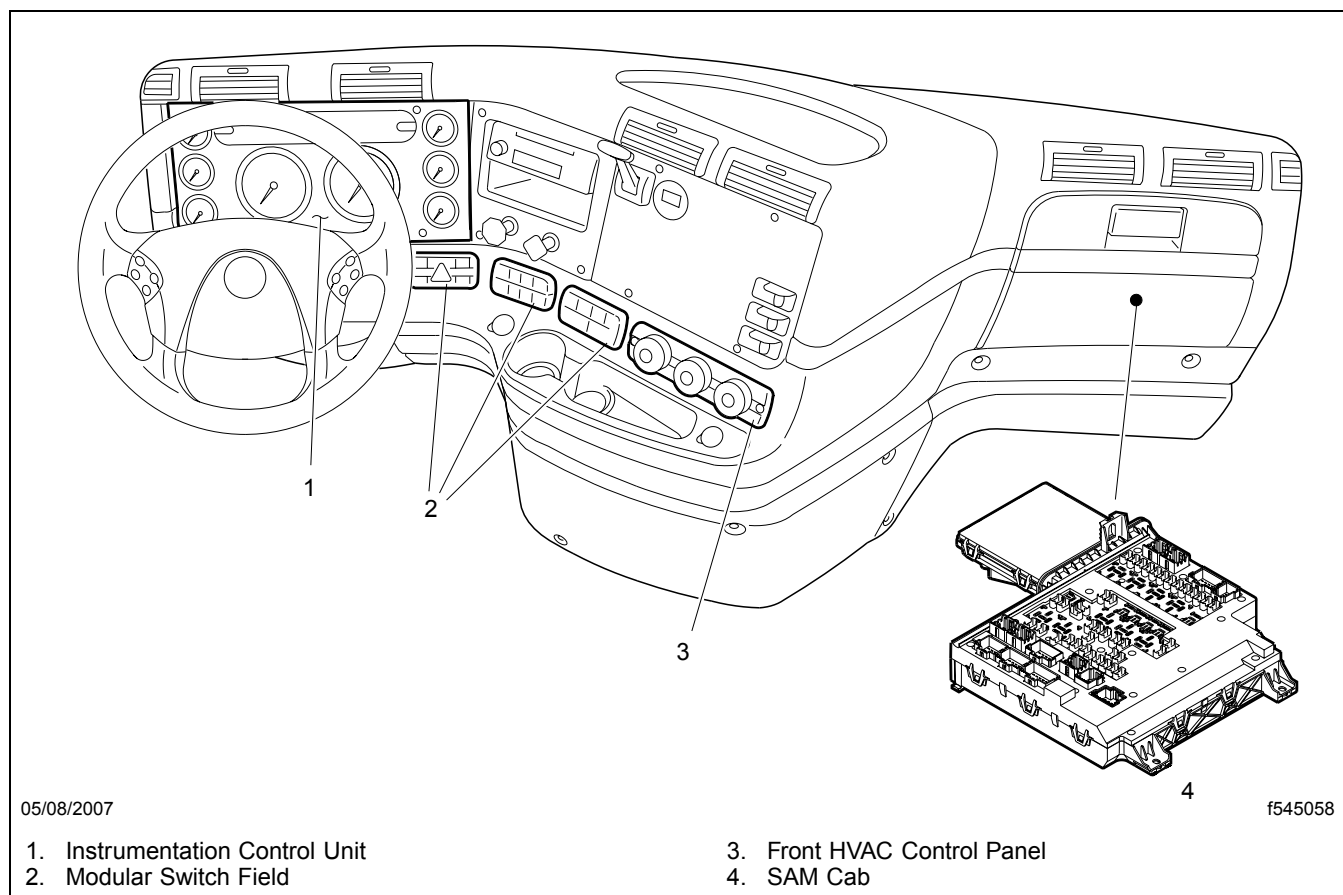


Fig. 3, Component Details

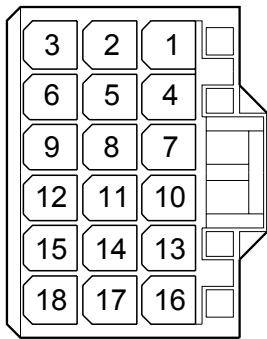
SAM Cab Connector X10		
 04/15/2009 f545507		
Pin	Circuit	Description
4	GND	Panel Lamps, GND
13	29A	Panel Lamps, PWM

Table 2, SAM Cab Connector X10

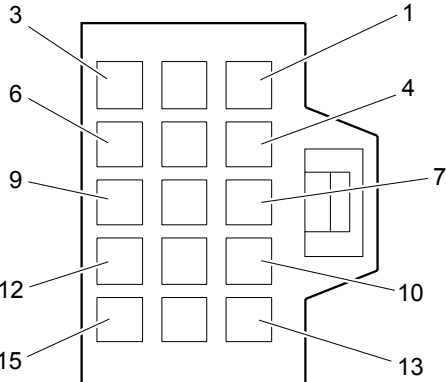
SAM Cab Connector X13		
 05/10/2007 f545030		
Pin	Circuit	Description
5	52B	Ignition Switch, Accessory
6	52D	Ignition Switch, ON (ignition)
7	52	Ignition Switch, BAT

Table 3, SAM Cab Connector X13

HVAC and Auxiliary HVAC Connectors		
01/23/2009 1 4 2 5 3 6 f545435		
Pin	Circuit	Description
3	29A	Panel Lamps, PWM

Table 4, HVAC and Auxiliary HVAC Connectors

ICU 24-Pin Connector		
01/23/2009 B1 B12 A1 A12 f545436		
Pin	Circuit	Description
A1	29A	Panel Lamps, PWM

Table 5, ICU 24-Pin Connector

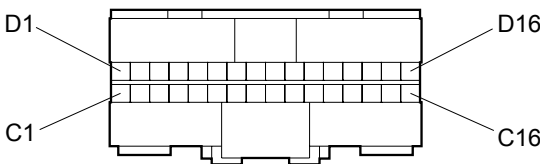
ICU 32-Pin Connector		
 Diagram of the ICU 32-Pin Connector. The connector is shown from a top-down perspective. Pins are labeled D1, D16, C1, and C16. D1 and D16 are on the top row, while C1 and C16 are on the bottom row. The connector has a central block and two side blocks.		
01/23/2009 f545437		
Pin	Circuit	Description
D3	GND	Panel Lamps, GND

Table 6, ICU 32-Pin Connector

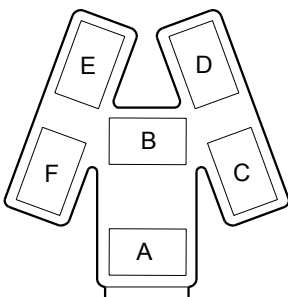
Ignition Switch		
 Diagram of the Ignition Switch. The switch is shown from a top-down perspective. It has six positions labeled A, B, C, D, E, and F. Position A is at the bottom, B is in the middle, and C, D, E, and F are arranged in a circle around B. The switch has a central block and two side blocks.		
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

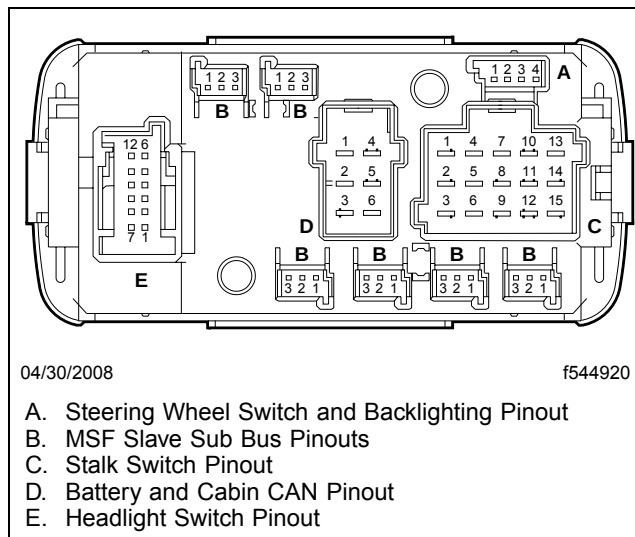


Fig. 4, MSF Master Connection Locations

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

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

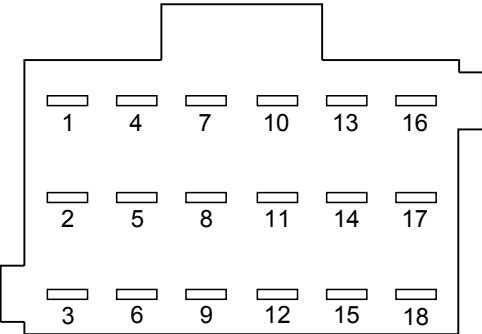
Starpoint Connector	
	
12/04/2006 f544912	
Pin	Function
10	Cabin CAN High
12	Cabin CAN Low
17	Ground

Table 12, Starpoint Connector

Headlight 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, Headlight Switch Pinout

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 PWM Circuit – Voltage below normal, or shorted to low source.	The fault is active when the amperage measured by the SAM 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 on full brightness setting, measure the voltage at conn X10 pin 13. The voltage should be close to battery voltage. If it is not, troubleshoot circuit 29A for a short to GND. Check circuit 29A between conn X10 pin 13 and ICU pin A1 for continuity. Refer to additional troubleshooting procedures in this section for more information.							
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.							
49	520607	4	conn A, pin 2 conn E, pin 7	—	—	Backlighting — Voltage below normal or shorted to ground	The backlighting PWM circuit is at ground.
Action: Troubleshoot circuit 29A between MSF connector E pin 7 and headlight switch pin 6 and also circuit 474BA2 between MSF connector A pin 2 and the steering wheel switches for a short to GND. Repair as required.							

Table 15, CAN Fault Codes

703 — Input Troubleshooting

Panel Backlighting is influence 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.

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, Headlight, Steering Wheel" to troubleshoot the headlight and steering wheel switches. Continue troubleshooting inputs as necessary.

3. Locate open circuit in the ignition switch.

- 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?

YES → Install the connectors and perform a functional test to determine whether the problem is intermittent. Load DataLink Monitor Template "MSF Switches: Hazard, Headlight, 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 Back probe 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.**

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 Back probe 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.

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

System Overview

Terms and Abbreviations	500
General Information	501
Wiper Motor	502
Washer Fluid Pump and Reservoir	503
Washer Fluid Reservoir Float Switch (optional)	504
Wiper Controls (momentary wiping)	505

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700
CAN Fault Codes	701
Wipers Inoperative in All Modes	702
High Speed Inoperative	703
Low Speed and Intermittent Settings Inoperative, High Speed OK	704
Wipers Do Not Park	705
Wipers Stay On or Wipe Intermittently Until Ignition is Turned Off	706
Washers Inoperative	707
Stalk Switch Troubleshooting	708

Specifications

Wiper Motor Specification	800

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.

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

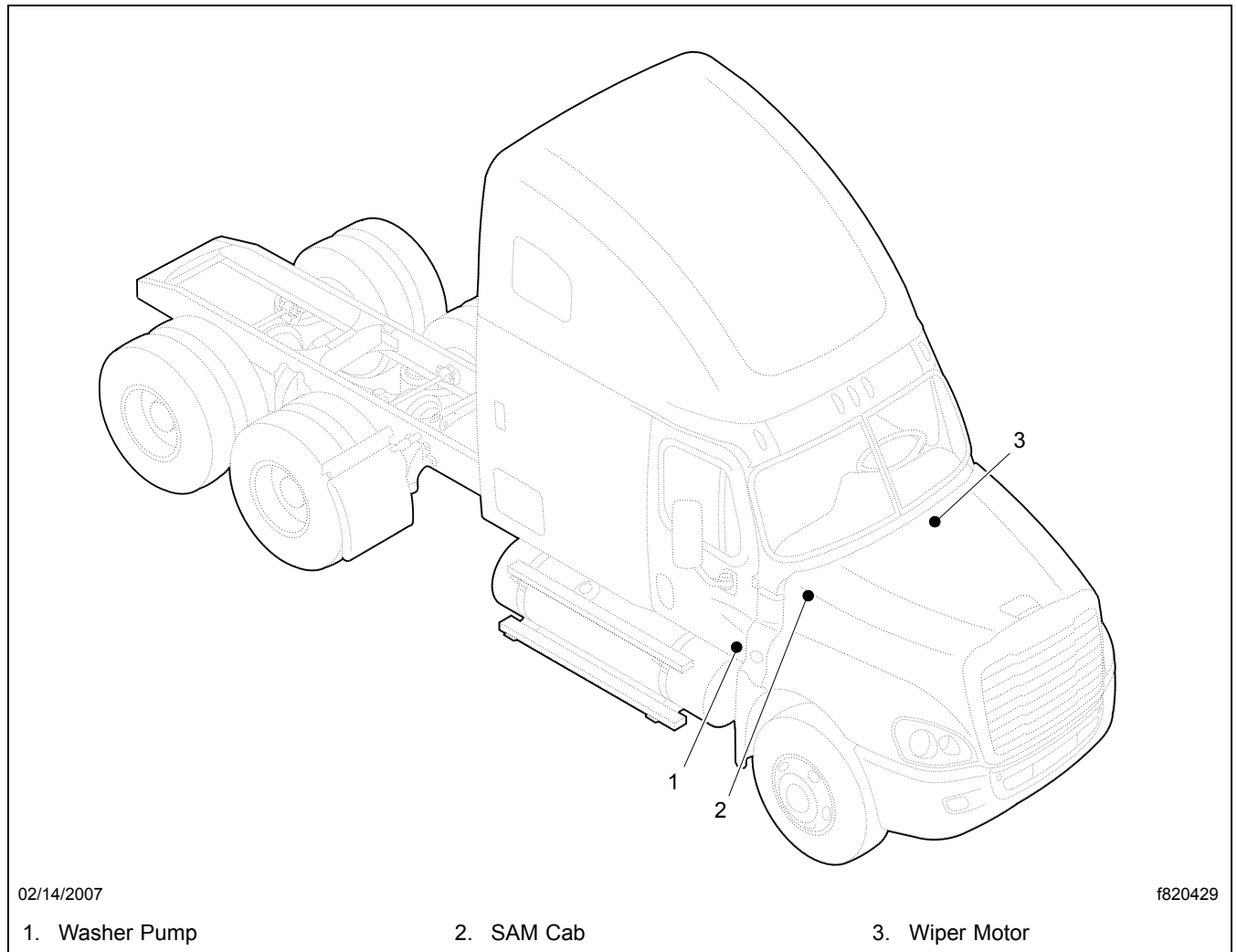


Fig. 1, Component Locations

601 — Component Details

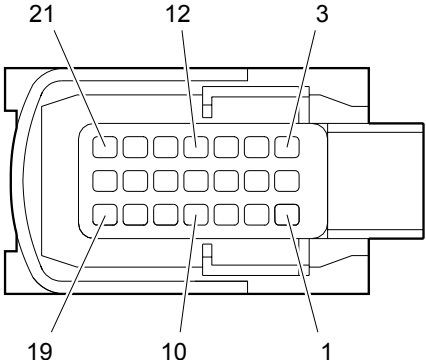
SAM Cab connector X20 Pins			
 04/14/2009 f545498			
Pin	Circuit Number	Wire Color	Circuit Description
7	GND	Black	Washer Pump Ground
20	320	Dark Blue	Washer Pump Control
21	320A	Dark Blue	Wiper Fluid Level

Table 1, SAM Cab connector X20 Pins

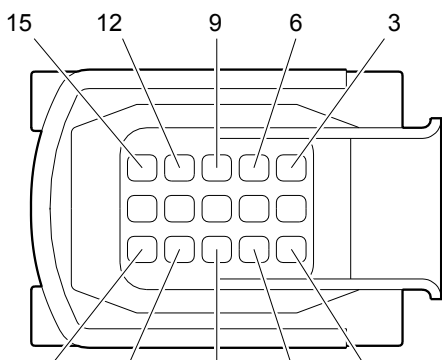
SAM Cab connector X21 pins			
 04/14/2009 f545499			
Pin	Circuit Number	Wire Color	Circuit Description
3	GND	Black	Wiper Motor Ground
9	315P	Dark Blue	Wiper Motor Park Mode Supply
12	315L	Dark Blue	Wiper Motor Low Supply
15	315H	Dark Blue	Wiper Motor High Supply

Table 2, SAM Cab connector X21 pins

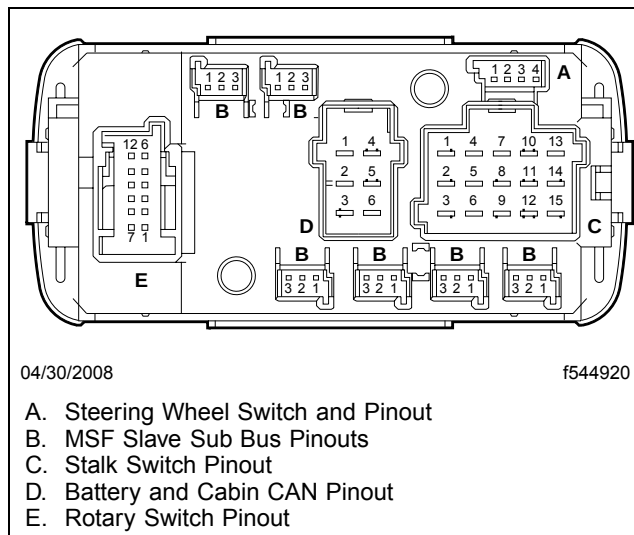


Fig. 2, MSF Master Connection Locations

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

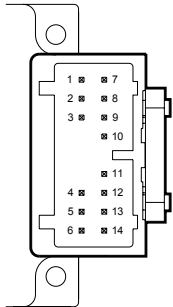
Stalk Switch Connector	
	
05/25/2012	f545038
Pin	Circuit Number
1	Turn Signal Switch Supply Voltage
2	Binary Code A
3	Binary Code B
4	Binary Code C
5	Washer Signal
6	Not Connected
7	Not Connected
8	Not Connected
9	Headlamp High Beam Flash Signal
10	Headlamp High Beam Signal
11	Headlamp Low Beam Signal
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

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 2 when the washer fluid level indicator is active.
Action: Measure the voltage on conn X11, pin 2. 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.							

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	520415	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**.

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.**

- 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.

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

System Overview

Terms and Abbreviations 500

General Information 501

Components

Component Locations 600

Component Details 601

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.

600 — Component Locations

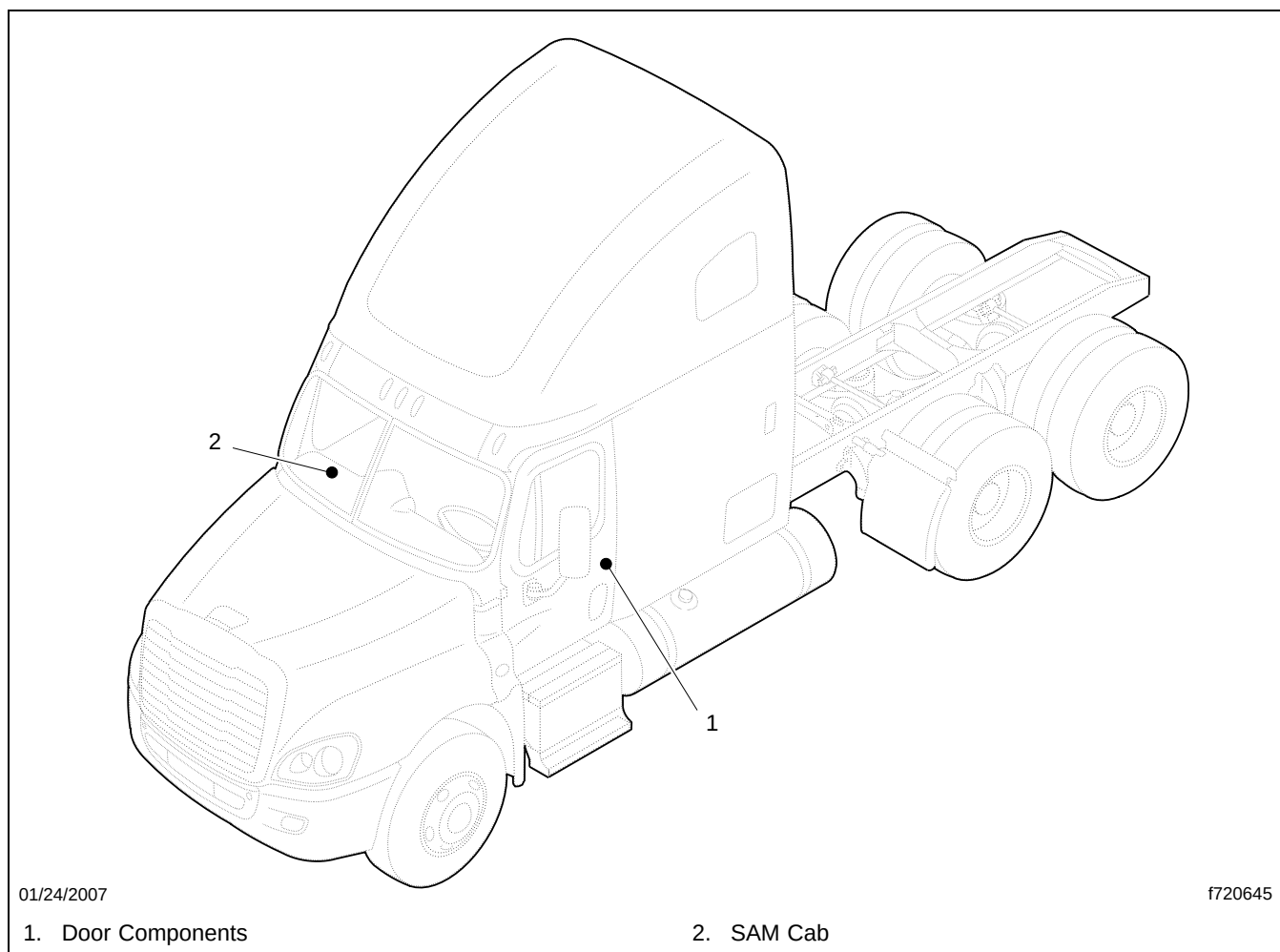


Fig. 1, Component Locations

601 — Component Details

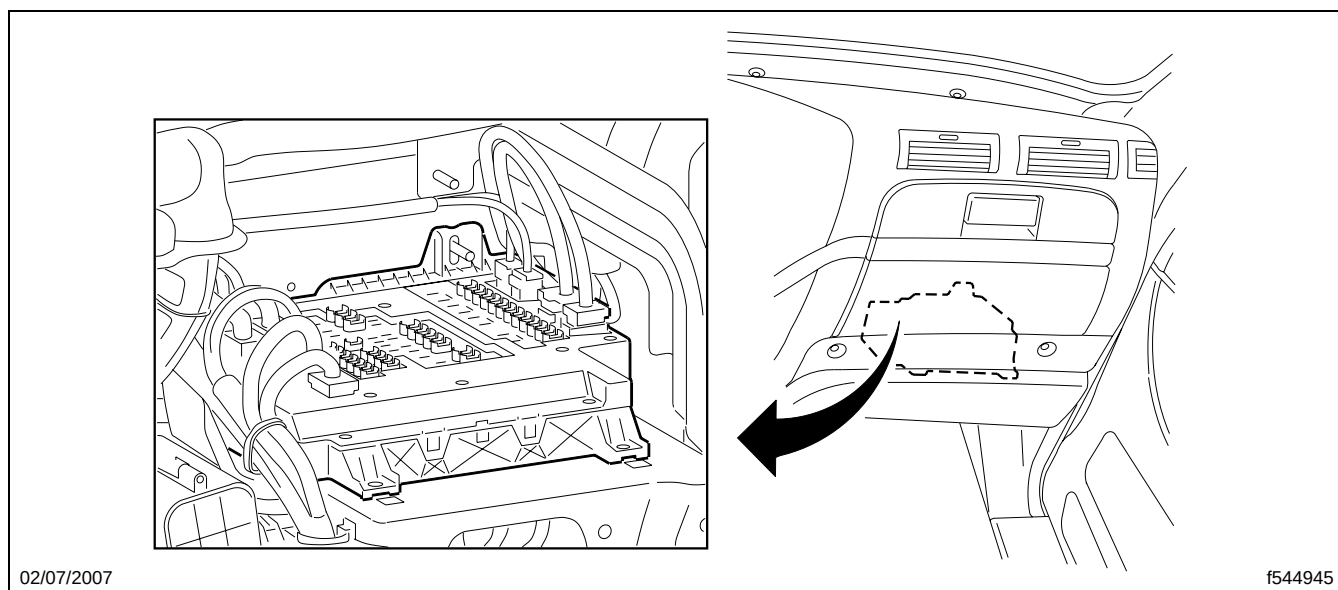


Fig. 2, SAM Cab

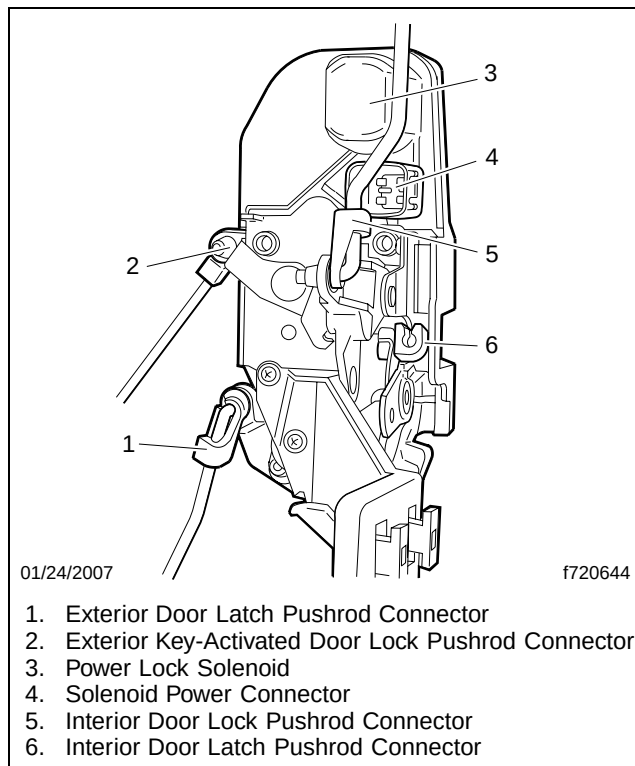


**Fig. 3, Door Lock/Latch and Solenoid Mechanism
Detail**

System Overview

Terms and Abbreviations 500

Air Horn 501

Electric Horn 502

Components

Component Locations 600

Component Details 601

Troubleshooting

Troubleshooting Overview 700

Possible Causes 701

CAN Fault Codes 702

Components

Parameters 800

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**.

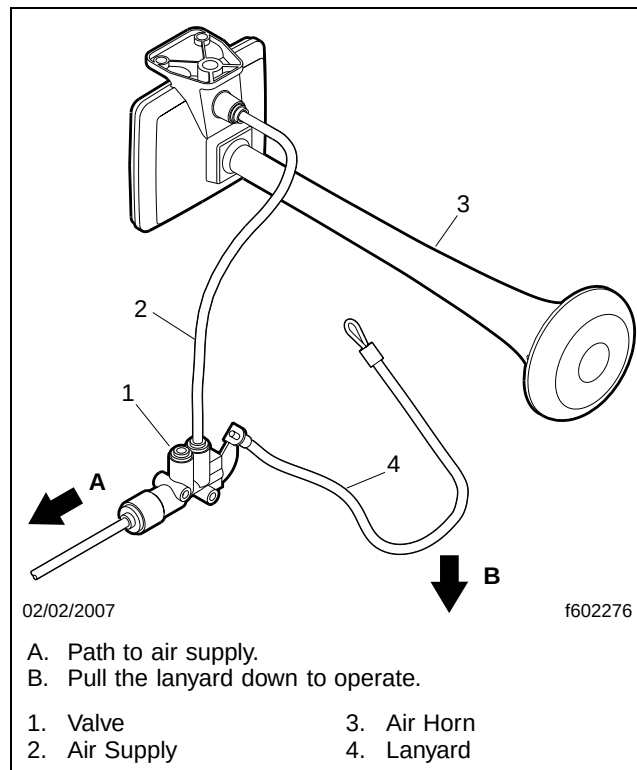


Fig. 1, Air Horn

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**.

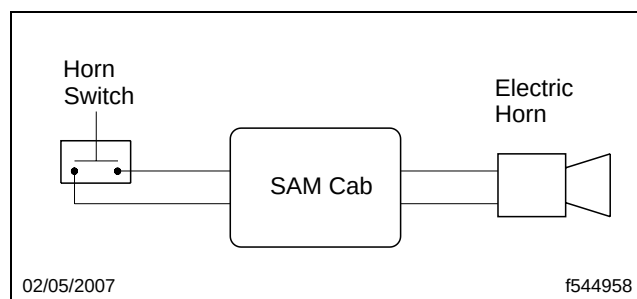


Fig. 2, Electric Horn Wiring

600 — Component Locations

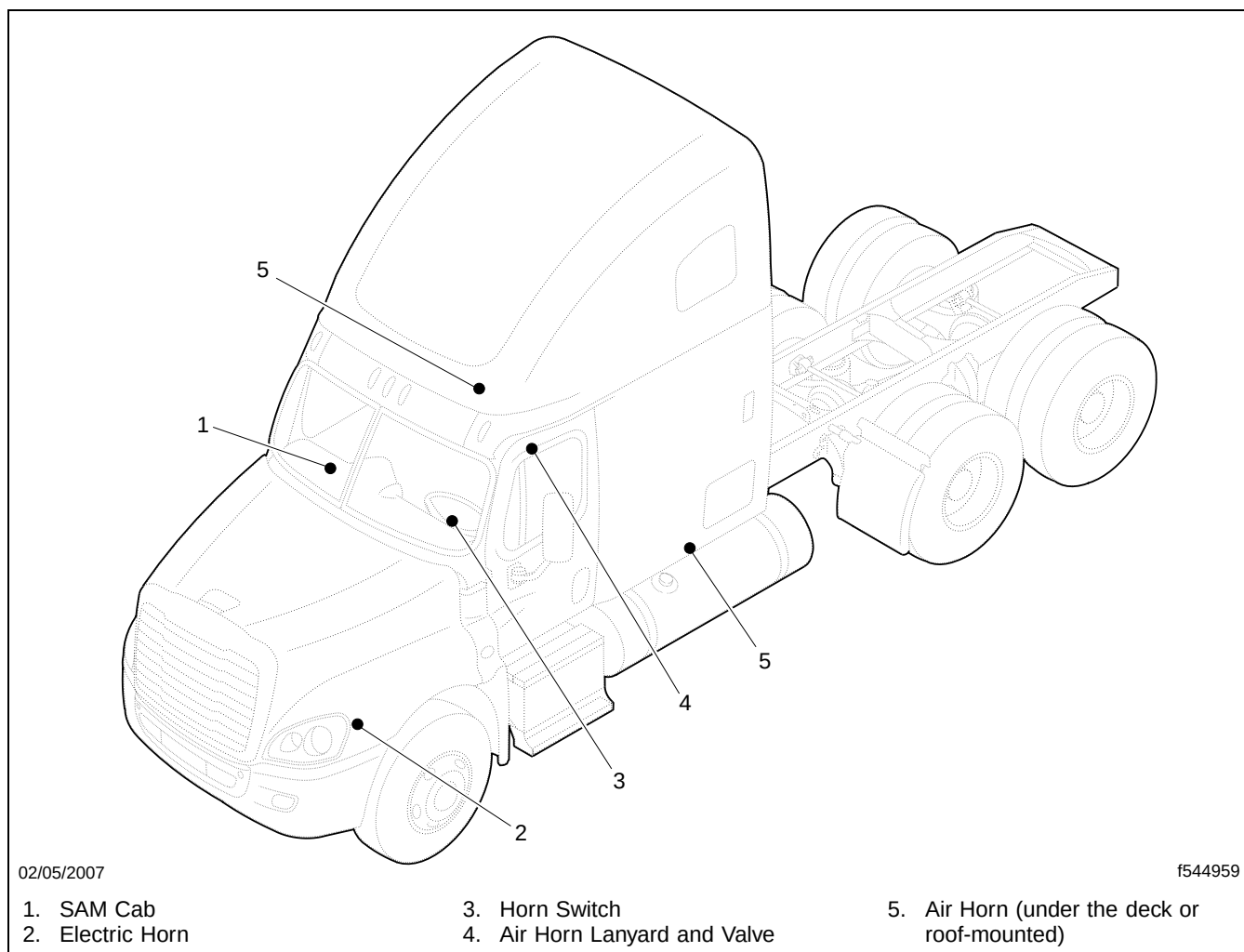


Fig. 3, Component Locations

601 — Component Details

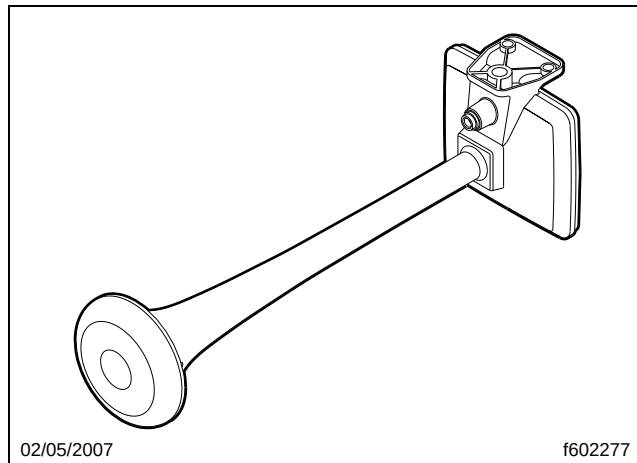


Fig. 4, Air Horn

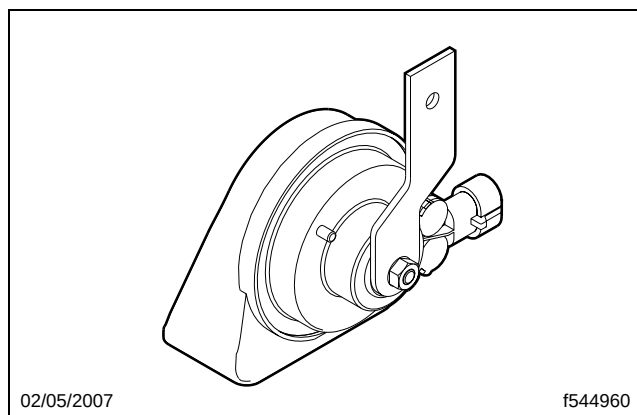
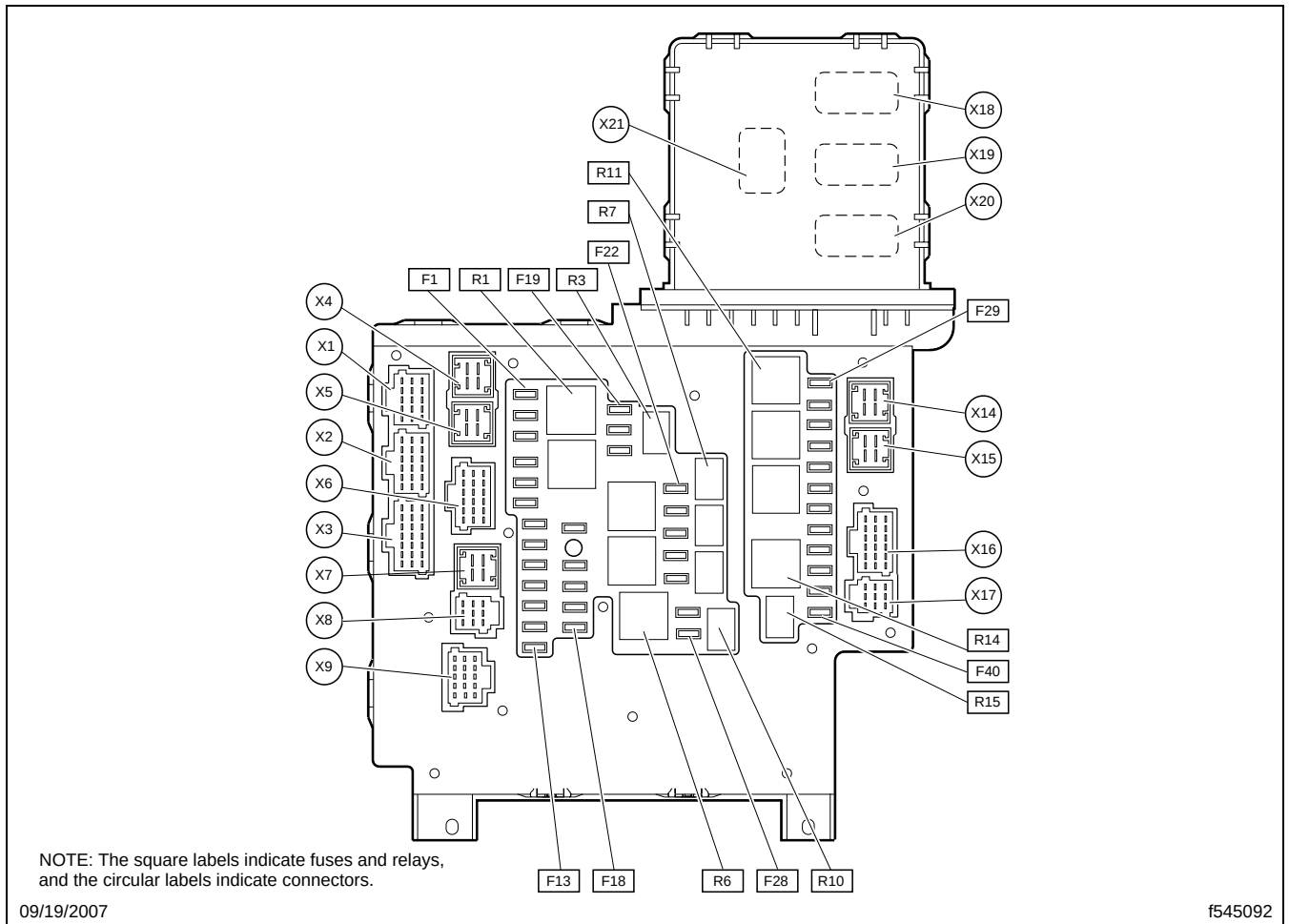


Fig. 5, Electric Horn

**Fig. 6, SAM Cab Pin Locations (top)**

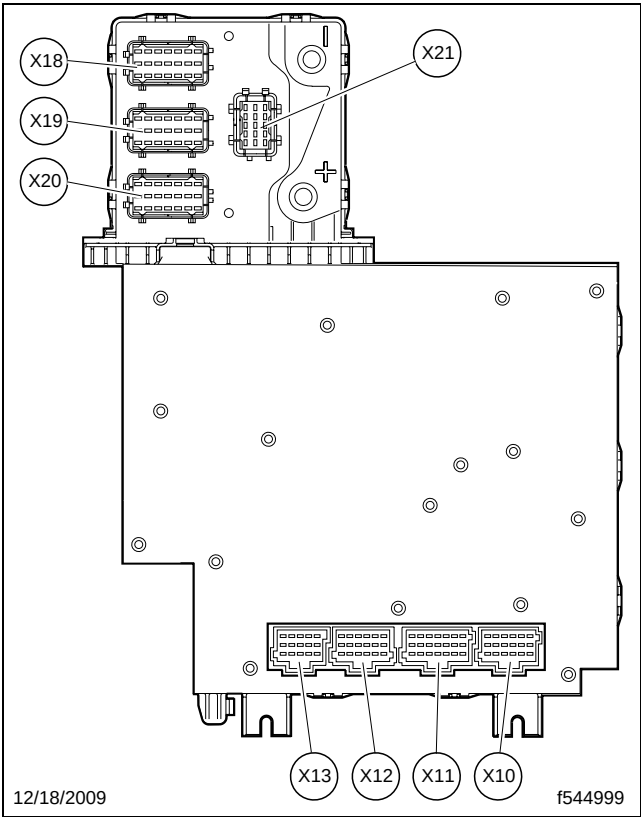


Fig. 7, SAM Cab Pin Locations (bottom)

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**.

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

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

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

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

System Overview

 Terms and Abbreviations 500

 General Information 501

Components

 Component Locations 600

 Component Details 601

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**.

600 — Component Locations

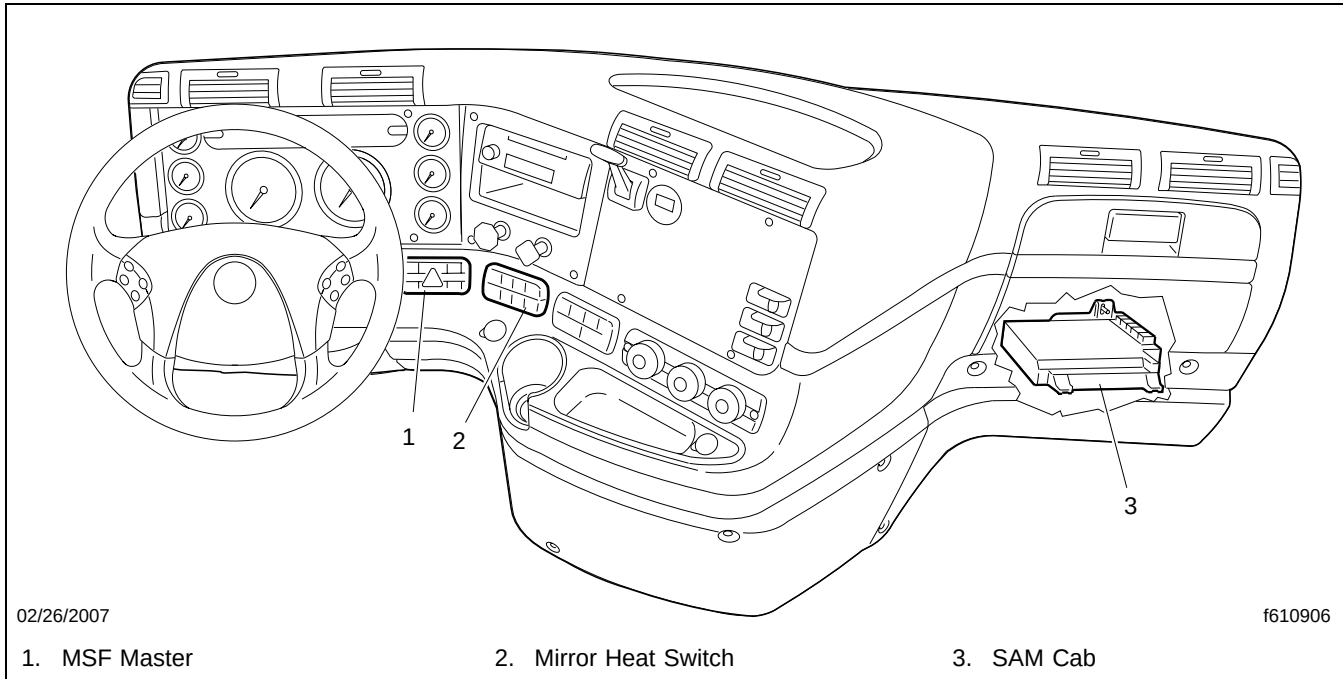


Fig. 1, Component Locations

601 — Component Details

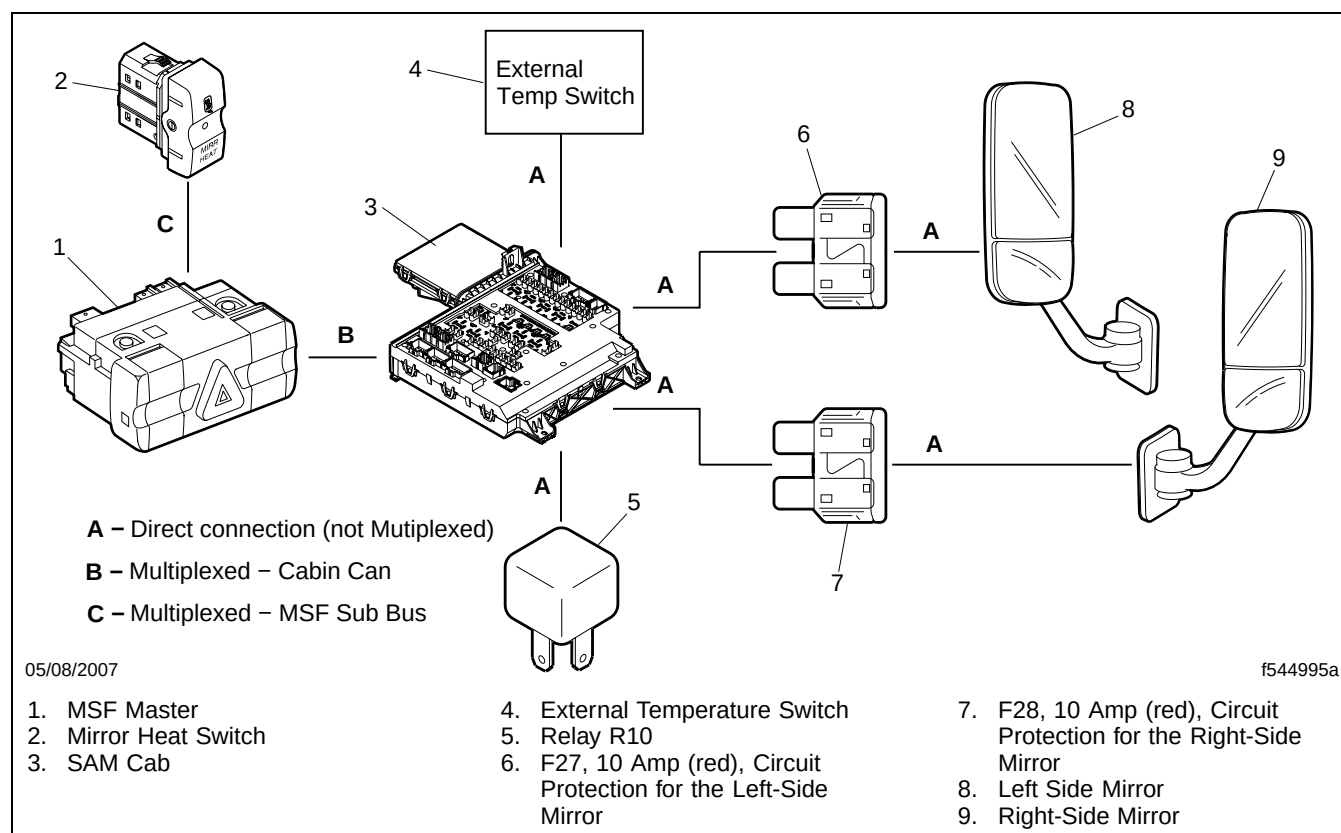


Fig. 2, Heated Mirror Wiring

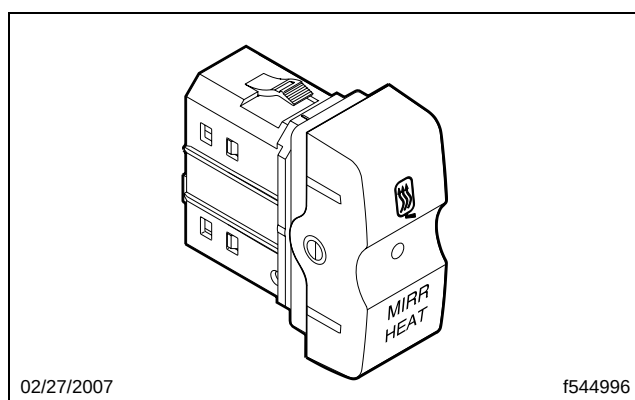


Fig. 3, Mirror Heat Switch Detail

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600
Component Details	601

Specifications

SAM Cab Power Mirrors Pinout	800

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 on circuit 157, which comes from a splice with circuit 363R coming from cavity X17/1 on the SAM Cab (refer to wiring in modules 74E and 66A). The switch is grounded in common with the heated mirrors system on pin X8/2. 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.

600 — Component Locations

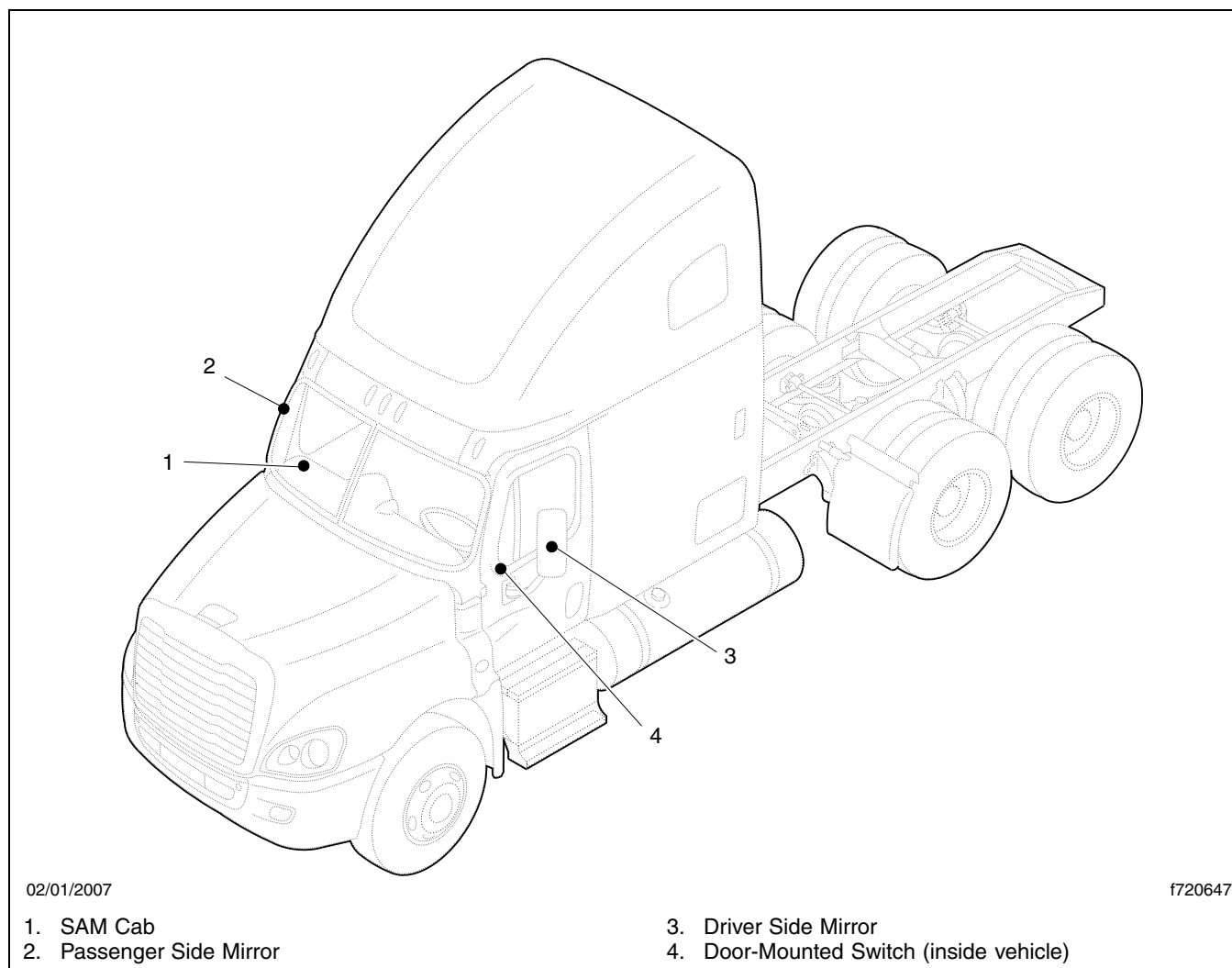


Fig. 1, Component Locations

601 — Component Details

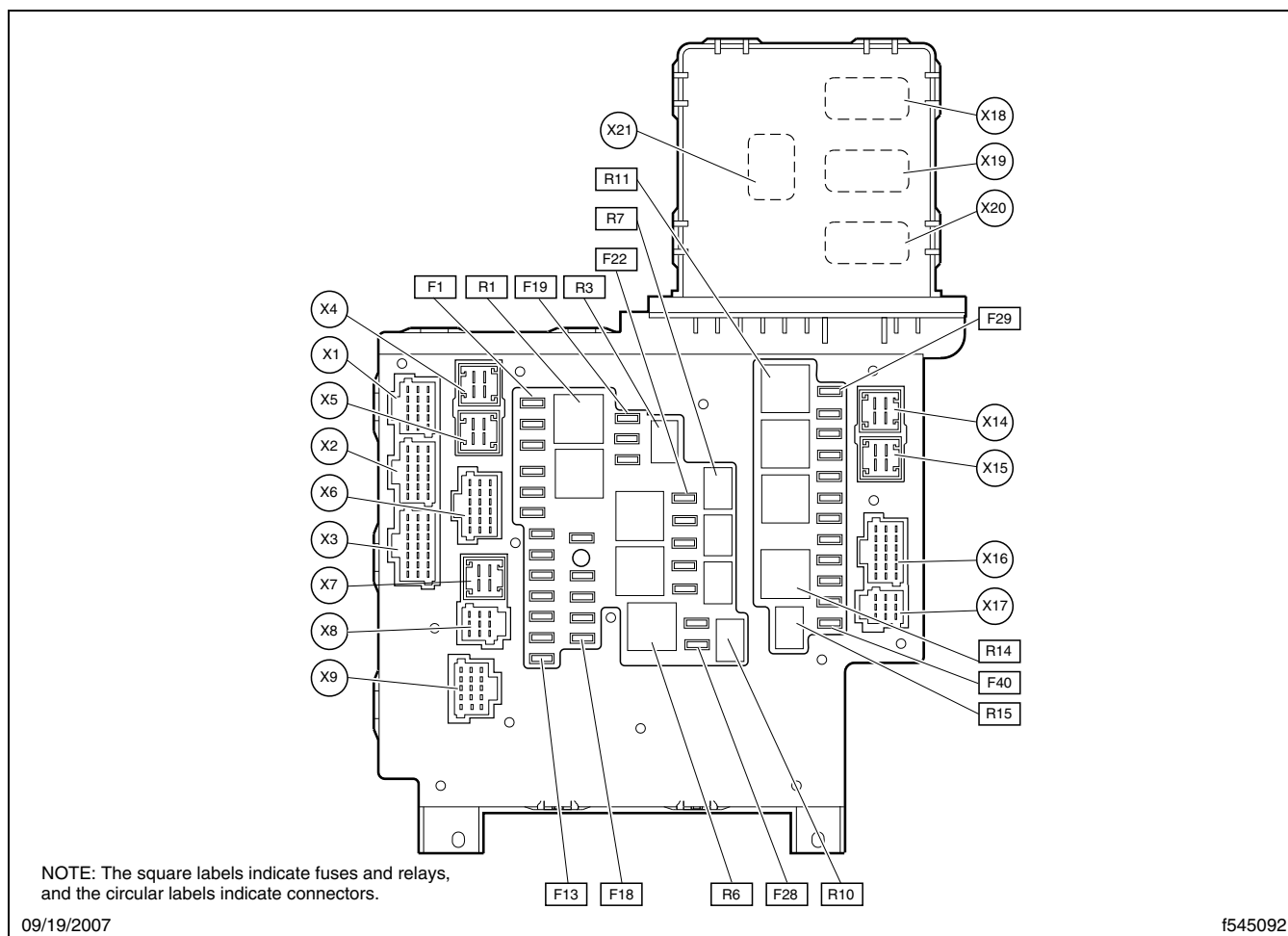


Fig. 2, SAM Cab Fuses and Relays

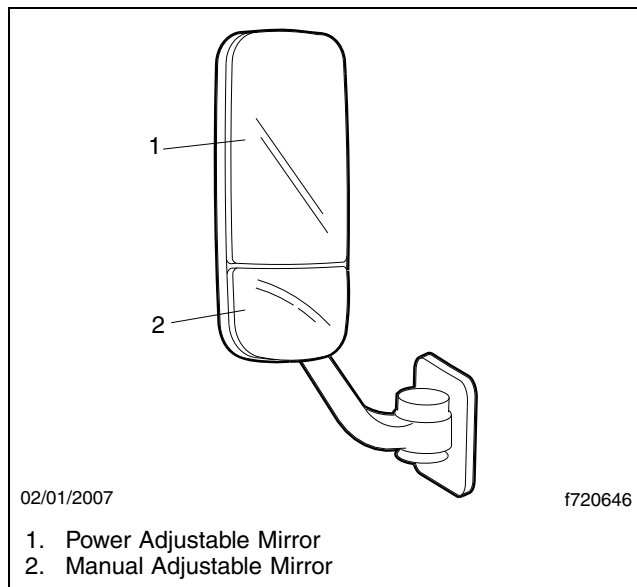


Fig. 3, Mirror Detail

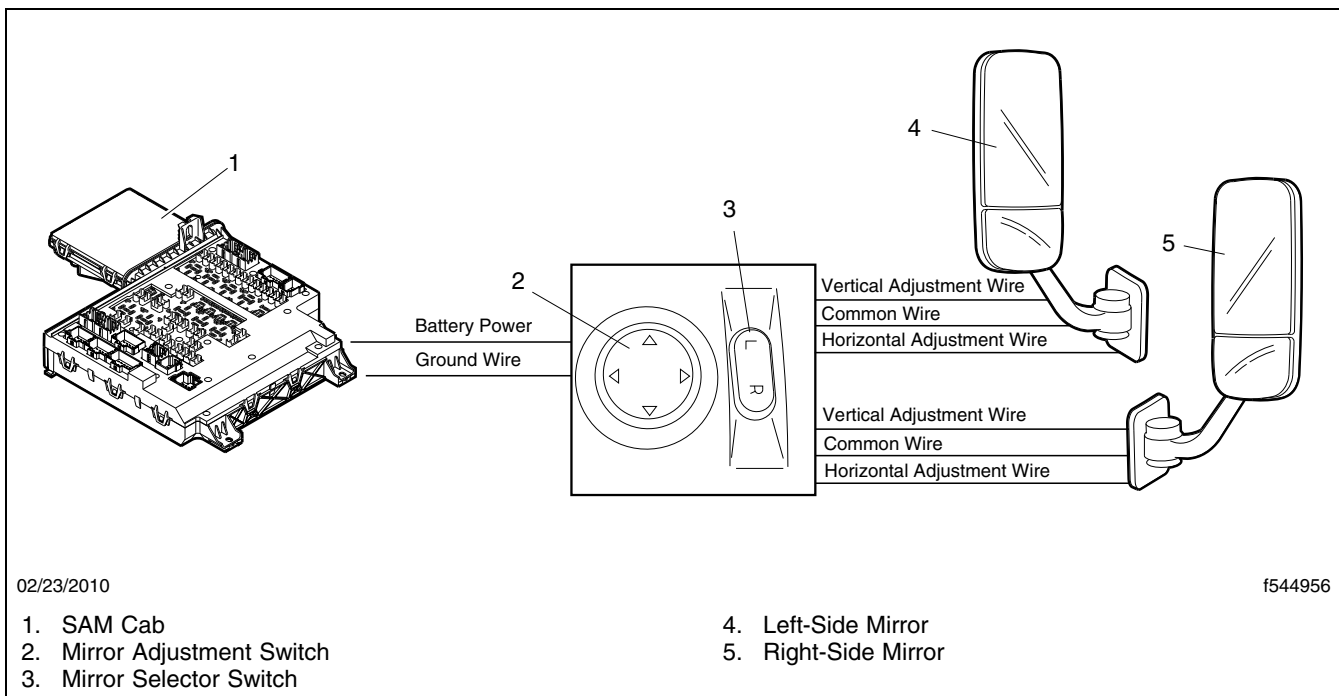


Fig. 4, Power Mirror Adjustment Wiring

800 — SAM Cab Power Mirrors Pinout

SAM Cab Power Mirrors Pinout					
Connector/Pin	Description	Circuits	Relay (normally open or closed)	Fuse (rating in amps)	Details
conn X17 pin 1	Power Window, Passenger- Side, Accessory	363R, 157*	R15 (NO)	F39 (15)	Wiring in modules 74E and 66A. Refer to G02.04 — SAM Cab, 708 — <i>Logic Controlled Relayed Fused Outputs</i> for a generic troubleshooting procedure for this pin type. No Datalink Monitor templates are available for Power Mirrors.
conn X8 pin 2	Mirror Heating Driver, Ground	GND1	—	—	Wiring in module 74E.

* Circuit 363R at SAM Cab, circuit 157 at mirror adjust switch.

Table 1, SAM Cab Power Mirrors Pinout

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600
Component Details	601

Troubleshooting

Troubleshooting Overview	700
Wiring Schematic	701
Diagnostic Tools Required	702
Power Window Diagnostics—Driver Side	703
Power Window Diagnostics—Passenger Side	704

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.

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

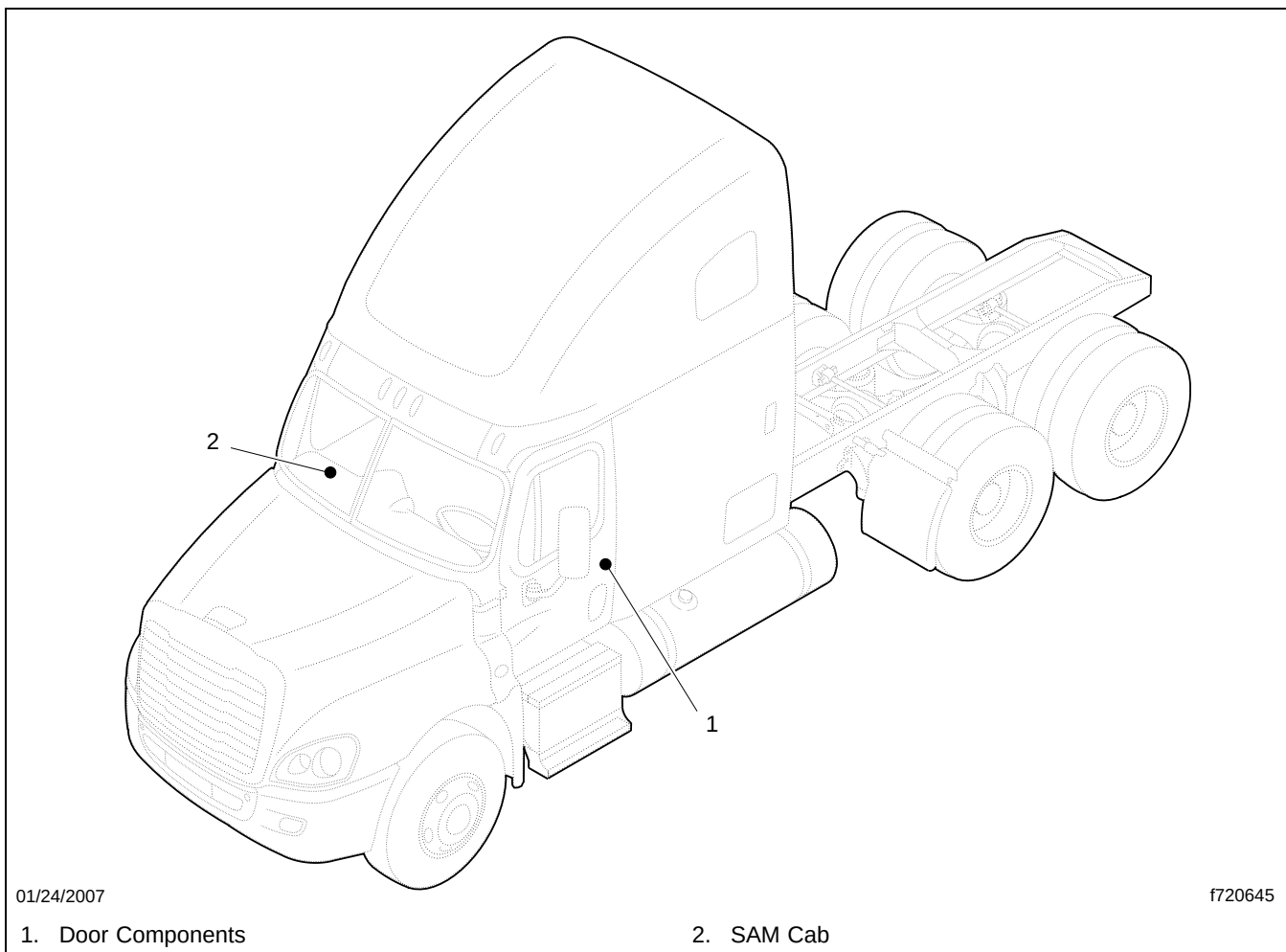


Fig. 1, Component Locations

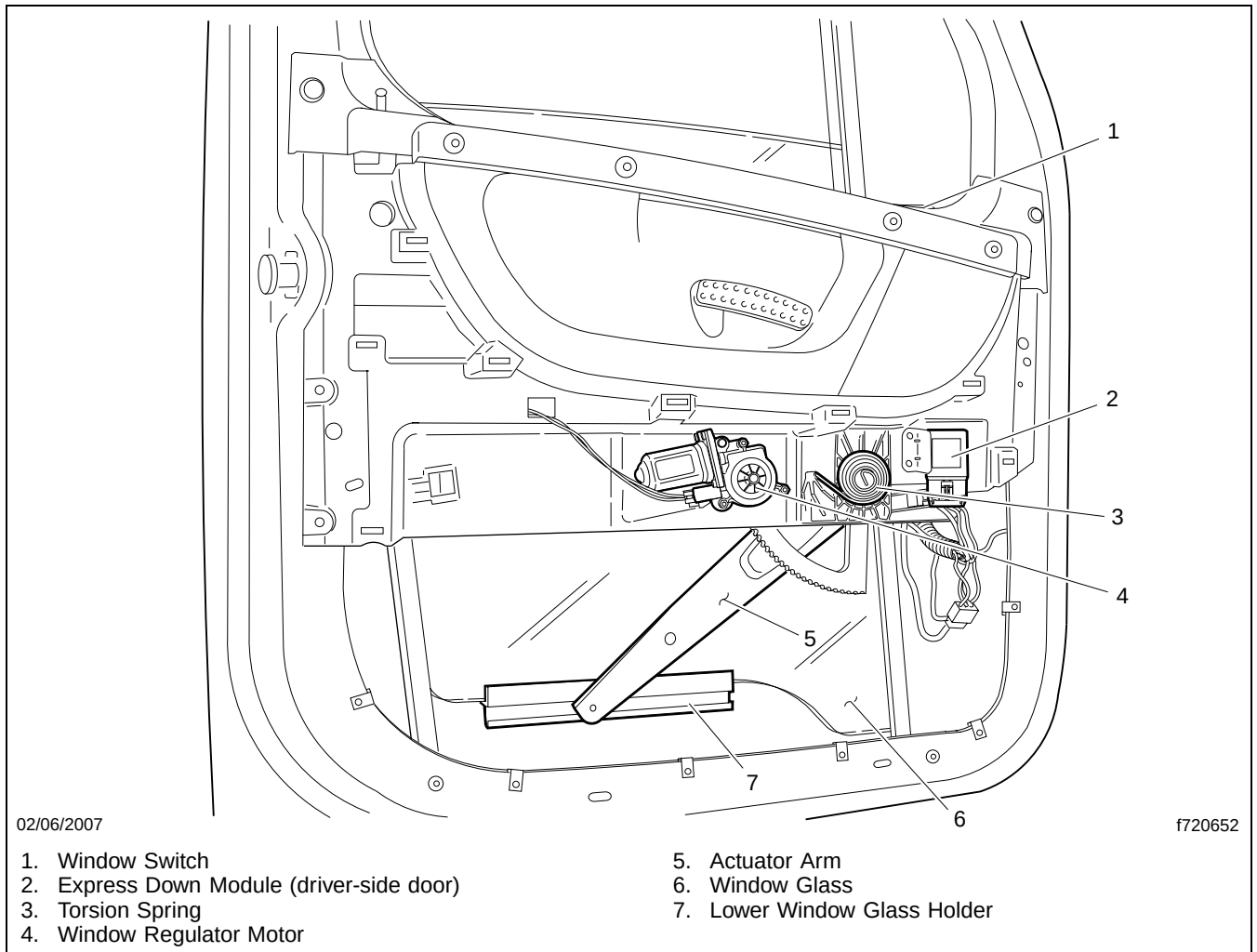


Fig. 2, Door Component Locations (driver-side shown)

601 — Component Details

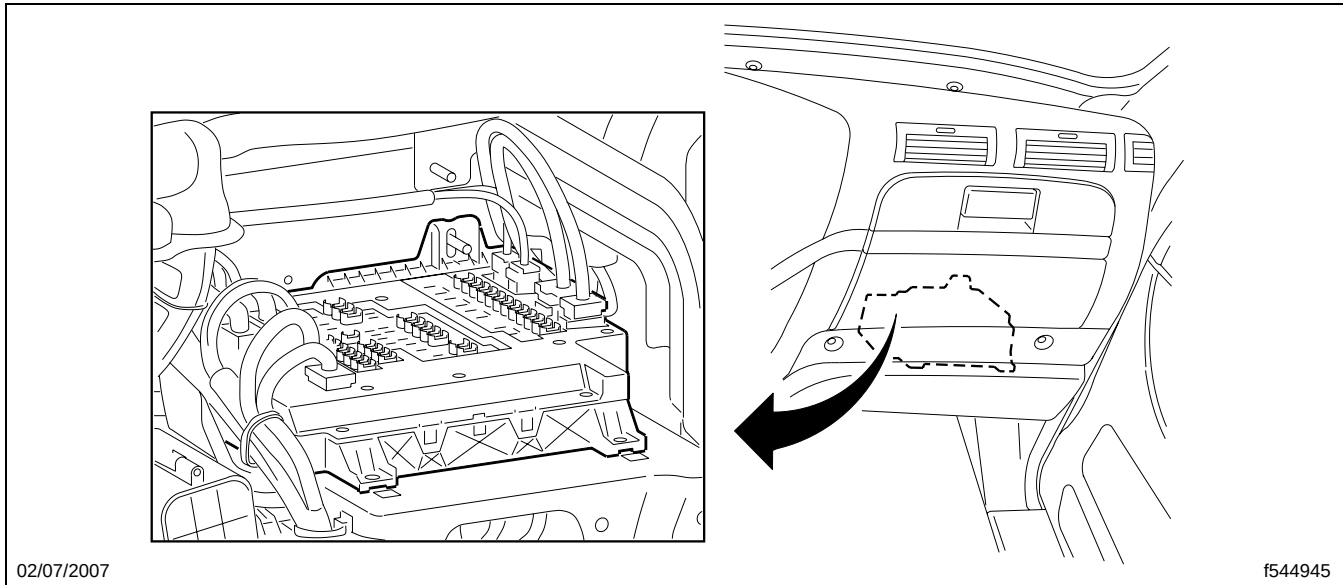


Fig. 3, SAM Cab

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.

701 — Wiring Schematic

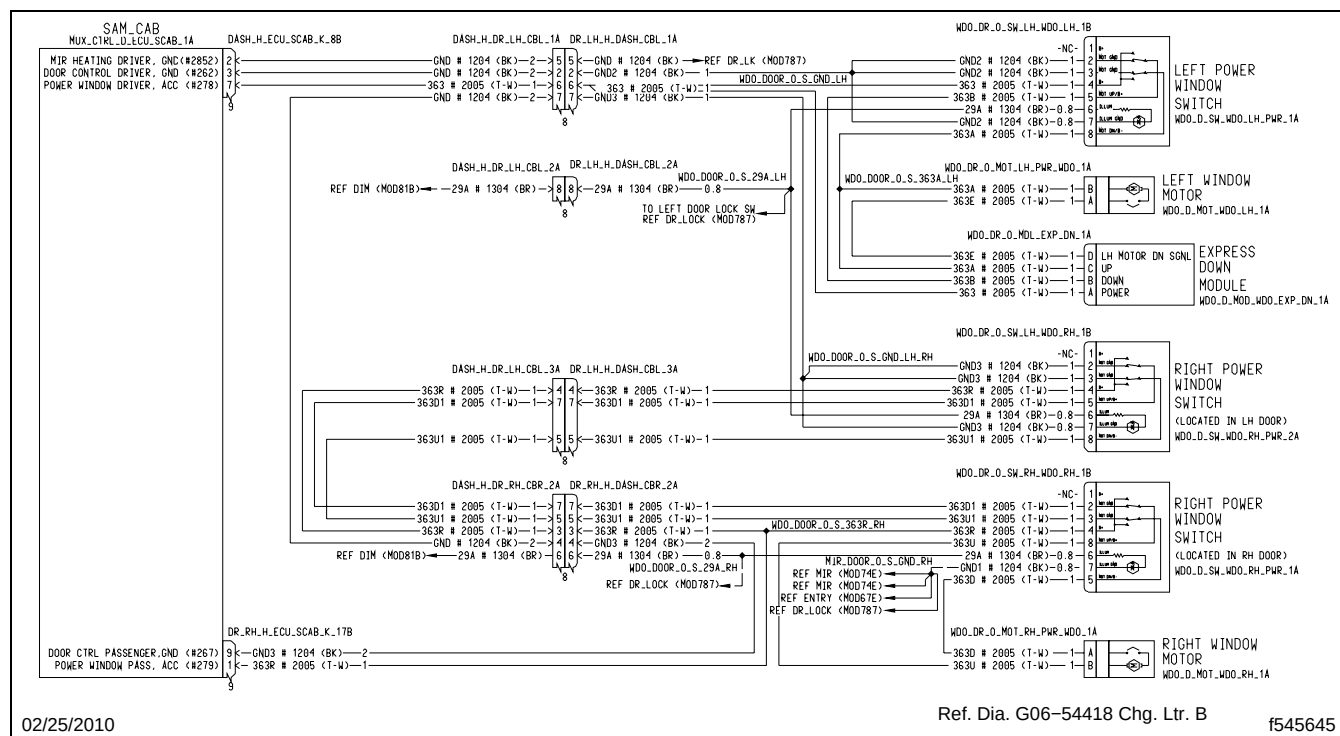


Fig. 4, Wiring Schematic, Power Windows

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.

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.

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.

System Overview

 Terms and Abbreviations 500

 General Information 501

 Powernet Management 502

Components

 Component Locations 600

 Component Details 601

Troubleshooting

 Diagnostic Tools Required 700

 CAN Fault Codes 701

 Output Troubleshooting 702

Specifications

 Parameters 800

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.

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 SAM Cab.

Four more power receptacles (3 through 6) are offered as optional 12V power output in the sleeper section of the cab. Receptacle power is available regardless of the ignition switch position.

The location of power receptacles 3-6 depend on the configuration of the vehicle.

The following power receptacles are designed as house loads in the power management feature:

- Power receptacle 1 – Dash
- Power receptacle 2 – Dash
- Power receptacle 3 – driver side cabinet

The following power receptacles are designated as comfort loads in the power management feature:

- Power receptacle 4 - Passenger side cabinet
- Power receptacle 5A – Passenger side cabinet
- Power receptacle 5B – Driver side cabinet
- Power receptacle 5C – Driver side cabinet
- Power receptacle 6A – Forward bunk partition
- Power receptacle 6B – Forward bunk partition

Refer to **600 — Component Locations** for more information.

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.

Refer to **C06.09 — Powernet Management** for more information.

600 — Component Locations

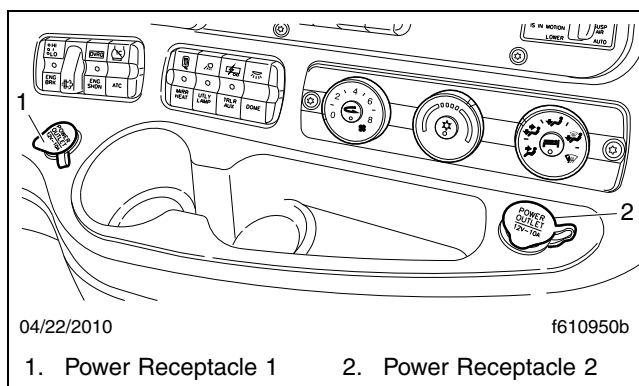


Fig. 1, Dash Power Receptacles

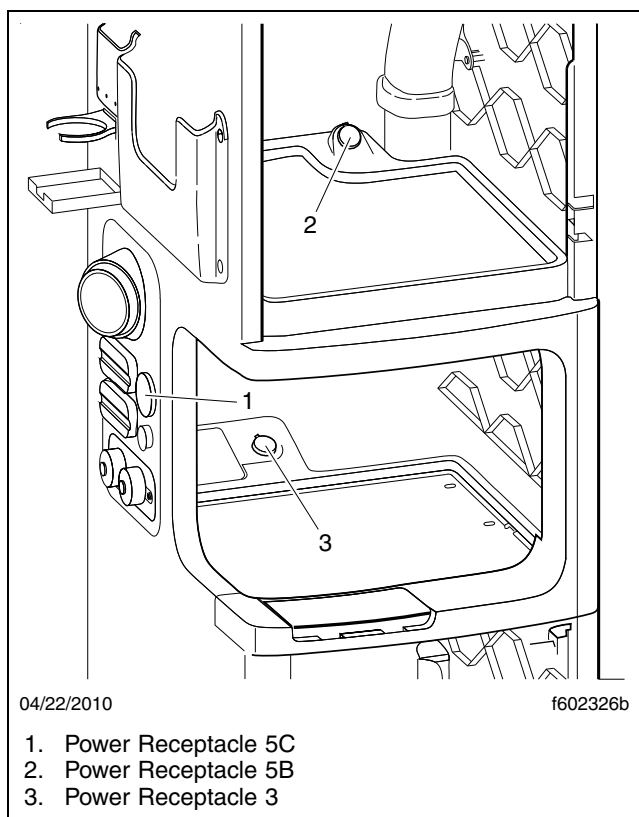


Fig. 2, Left-Side Cabinet Power Receptacles

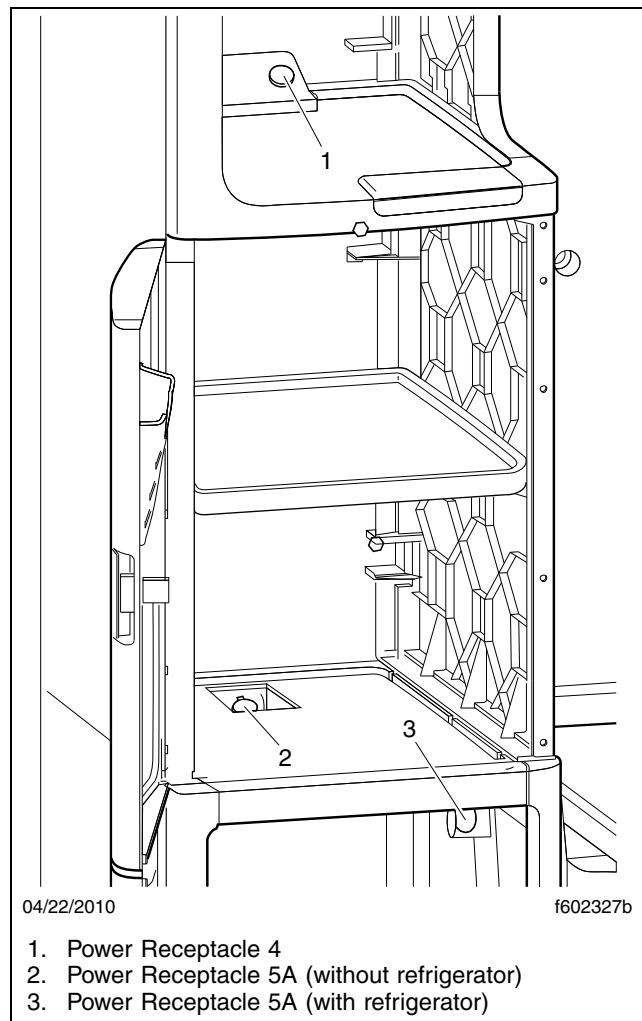


Fig. 3, Right-Side Cabinet Power Receptacles

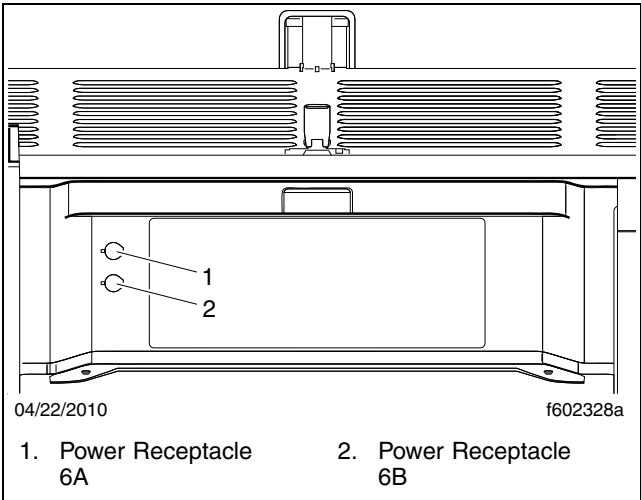


Fig. 4, Forward Bunk Partition Power Receptacles

601 — Component Details

SAM Cab Connector, X3		
04/15/2009		f545505
Terminal	Circuit	Description
3	57B	12V Power Receptacle 4, BAT
15	57C	12V Power Receptacle 3, BAT

Table 1, SAM Cab Connector, X3

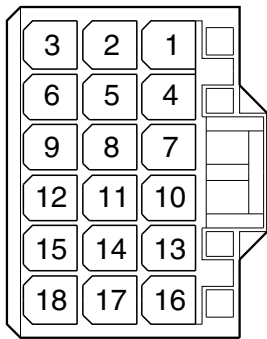
SAM Cab Connector, X6		
		
04/15/2009		f545507
Terminal	Circuit	Description
9	57D	2V Power Receptacle 2, BAT
15	57	12V Power Receptacle 1, BAT

Table 2, SAM Cab Connector, X6

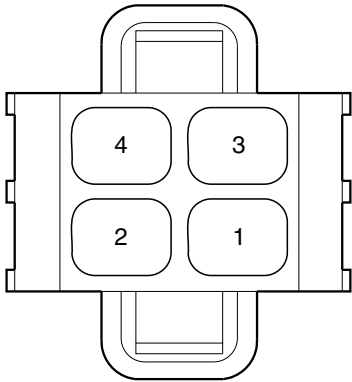
SAM Cab Connector, X14		
		
04/15/2009		f545508
Terminal	Circuit	Description
1	57B	12V Power Receptacle 5, BAT
2	57A	12V Power Receptacle 6
3	GND	12V Power Receptacle 3 and 4, GND
4	GND	12V Power Receptacle 5 and 6, GND

Table 3, SAM Cab Connector, X14

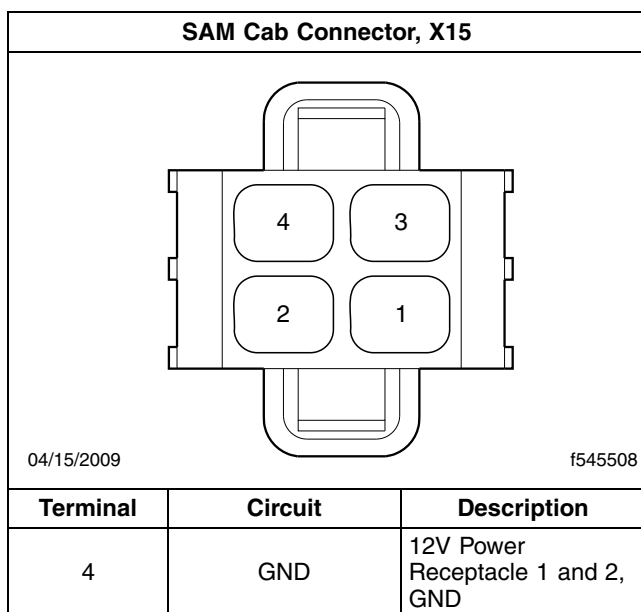


Table 4, SAM Cab Connector, X15

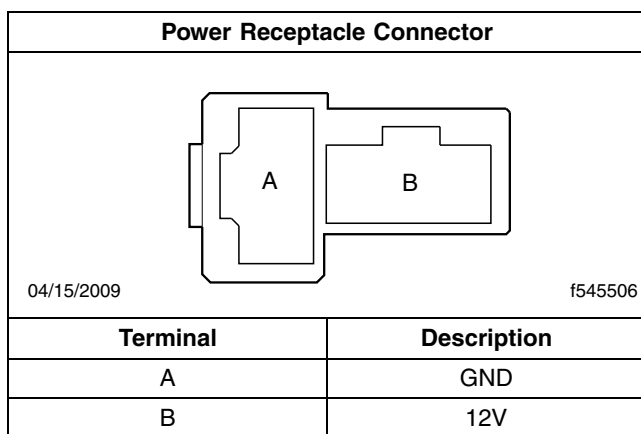


Table 5, Power Receptacle Connector

NOTE: Refer to A06- or G06- drawings in module 284 for more information on the circuits listed above.

700 — Diagnostic Tools Required

- ServiceLink
- DataLink Monitor Template "Cab Power Receptacles"
- Multimeter

701 — CAN Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
33	521502	4	conn X14 pin 2	F30	R11	12 V power receptacle 6 – Voltage below normal, or shorted to low source.	The SAM Cab is detecting excessive current draw through fuse F30 or the excessive current draw resulted in a blown fuse at F30.
Action: Check F30 for voltage on both side of the fuse. If the voltage is low at connector X14, pin 2, disconnect the wire at connector X14, pin 2 and test for operating voltage at the SAM Cab pin. After disconnecting this wire, if the ignition voltage returns to operating level trace the short to GND or the reason for the excessive current draw. Refer to G02.04 — SAM Cab, 708 — Logic Controlled Relayed Fused Outputs for a generic troubleshooting procedure for that pin type.							

Table 6, CAN Fault Codes

702 — Output Troubleshooting

NOTE: There are no inputs on the cab power receptacles to troubleshoot.

Before performing the following tests, make sure the outputs are not being controlled by the powernet management progressive low voltage disconnect (PLVD) feature. Ensure that the batteries are fully charged. Use the template "Cab Power Receptacles" in ServiceLink to monitor PLVD and receptacle status.

1. Measure the output voltage for the suspect power receptacle.

Insert a multimeter into the contacts of the power receptacle, remove the receptacle and measure directly off of the connector terminals.

Does the multimeter read system BAT voltage?

YES → Check the connector on the power receptacle and the ECU connector on the SAM Cab to determine if the problem is intermittent.

NO → Go to test 2.

2. Verify ECU output.

Verify the output of the SAM Cab by measuring the SAM Cab terminal for the affected power receptacle. Use **Table 7** and the associated G06 drawing to locate the appropriate receptacle. Use a multimeter to measure the voltage across the positive and negative terminal.

Cab Power Receptacle Locations			
Power Receptacle	Location	Positive Terminal	Negative Terminal
1	Dash Power Receptacle (driver side)	X6.15	X15.4
2	Dash Power Receptacle (passenger side)	X6.9	X15.4
3	Sleeper Control Panel	X3.15	X14.3
4	TV Shelf, Passenger-Side Cabinet	X3.15	X14.3
5A	Lower Shelf/Refrigerator, Passenger-Side Cabinet	X14.2	X14.4
5B	Lower Shelf, Driver-Side Cabinet	X14.1	X14.3

Cab Power Receptacle Locations			
Power Receptacle	Location	Positive Terminal	Negative Terminal
5C	Upper Shelf, Driver-Side Cabinet	X14.1	X14.3
6A	Sleeper Bunk #1	X14.2	X14.4
6B	Sleeper Bunk #2	X3.3	X14.4
6C	Underbunk Cooler	X3.3	X14.4

Table 7, Cab Power Receptacle Locations

NOTE: Depending on the configuration of the vehicle, not all power receptacles will be present.

Is the voltage the same as system BAT?

YES → Go to test 3.

NO → Go to test 4.

3. Perform a continuity test.

3.1 Select the SAM Cab connector from the terminal pairs shown in **Table 8**.

3.2 Remove the connector from the power receptacle.

3.3 Measure the resistance between the terminals.

Power Receptacle Terminals	
Power Receptacle	Terminals
1	A – X15.4
1	B – X6.15
2	A – X15.4
2	B – X6.9
3	A – X14.3
3	B – X3.15
4	A – X14.3
4	B – X3.15
5A	A – X14.4
5A	B – X14.2
5B	A – X14.3
5B	B – X14.1
5C	A – X14.3
5C	B – X14.1
6A	A – X14.4
6A	B – X14.2
6B	A – X14.4
6B	B – X3.3

Power Receptacle Terminals	
Power Receptacle	Terminals
6C	A – X14.4
6C	B – X3.3

Table 8, Power Receptacle Terminals

Is there a low resistance?

YES → Reconnect the power receptacle connectors and the SAM Cab connector. Evaluate functionality to determine if the problem is intermittent. Using Datalink Monitor Template "Cab Power Receptacles", verify the SAM Cab is broadcasting the datalink message to activate the power receptacles.

NO → Repair the affected harness.

4. **Check the fuse for the corresponding pin that is not reading 12V.**

Refer to **Table 9**, and locate the pin that is measuring 0V.

Is there a blown fuse?

YES → Replace the bad fuse.

NO → Perform a functional test to determine if the problem is intermittent. Verify the relay associated with the circuit is functioning properly. Replace the relay as necessary.

Power Receptacle Fuses			
Fuse	Pin	Power Receptacle	Relay
F6	X6.15	1	R4
F7	X6.9	2	R4
F15	X3.15	3, 4	R6
F17	X3.3	6B, 6C	R14
F30	X14.2	5A, 6A	R11
F31	X14.1	5B, 5C	R12

Table 9, Power Receptacle Fuses

800 — Parameters

Parameters				
Module	Part Number	Description	Parameter	ECU
284	002 447 52 58	SAM Cab parameter, battery power, receptacle 6 power.	PARM-CAB, REC, BAT	SAM Cab

Table 10, Parameters

System Overview

Terms and Abbreviations	500
Progressive Low Voltage Disconnect	501
Emergency Power System Overview	502
Output Responses to a SAM Failure	503

Components

Component Locations	600
Component Details	601

Troubleshooting

Troubleshooting Overview	700
Diagnostic Tools Required	701
Progressive Low Voltage Disconnect Diagnostics	702
Emergency Power Diagnostics	703
All Gauges in the ICU Drop to Zero, Engine Cannot Be Restarted	704
Turn Signal Indicators Flash Alternately, Engine Can Be Restarted	705
Turn Signal Indicators Flash Alternately, Engine Cannot Be Restarted	706

Specifications

Parameters	800

500 — Terms and Abbreviations

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 a part of or item on a device failed.

LVD—Low Voltage Disconnect

MFJB— MEGA® Fuse Junction Block

MGJB—Main Ground Junction Block

MSF—Modular Switch Field

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

PLVD—Progressive Low Voltage Disconnect

PNM—Powernet Management

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

SAM—Signal Detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab (a.k.a. "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 — Progressive Low Voltage Disconnect

Progressive low voltage disconnect (PLVD) shuts off electrical power to selected circuits based on the battery voltage, ignition switch position, and engine running status. There are three groups of circuits with increasing levels of priority for disconnect. Some of the circuits that have disconnect capability are powered through relays. Other circuits are powered directly through FET controlled outputs of the SAM Cab.

See **Table 1** for PLVD prioritization.

See **Table 2** for PLVD circuit identification.

Progressive Low Voltage Disconnect Operation				
Type of Load	Battery Voltage			
	Greater than 12.5	12.5 to 12.3	12.3 to 12.1	Less than 12.1
Priority 1 Comfort Loads	ON	ON if engine running OFF if engine off	OFF	OFF
Priority 2 House Loads	ON	ON	ON if key ON/ACC OFF if key OFF	OFF
Priority 3 Basic Loads	ON	ON	ON	ON if key ON/ACC OFF if key OFF

Table 1, Progressive Low Voltage Disconnect Operation

One minute before the basic and house circuits are shut off, the alarm in the instrument cluster beeps for 10 seconds. The alarm does not sound before comfort loads are shut off. When the interior lights are shut off by PLVD, pressing the light switch will override PLVD and the lights will come back on.

PLVD stays at each level for a minimum amount of time to prevent rapid cycling between levels. When PLVD changes its level, the battery voltage may raise slightly due to the reduced load.

Bi-stable relays are used in SAM version 6.0 and higher. These relays are actively controlled to switch to the open and closed position. The SAM disconnects power from the coil circuit of the relay after it powers it to the open or closed position. SAM versions 5.4 and lower use conventional relays that keep the coil power applied when the circuits are controlled to the open position.

PLVD Circuits with Connector, Fuse, and Relay							
Priority	Circuit Function	SAM 5.0 through 5.4			SAM 6.0 and 6.2		
		Conn, Pin	Fuse	Relay	Conn, Pin	Fuse	Relay
Priority 1 Comfort Loads	Amplifie power, accessory	X3, 9	F9	R9	X3, 9	F9	R9
	Footwell light	X12, 3	Controlled directly by SAM. No fuse or relay.*		X12, 3	Controlled directly by SAM. No fuse or relay.*	
	Reading light 1 (dimnable/theater)	X12, 6			X12, 6		
	Reading light 2 (dimnable/theater)	X12, 16			X12, 12		
	Rear baggage compartment light	X12, 16			X12, 12		
	12V power receptacle 5 (sleeper, cigar), battery	X14 ,1	F31	R12	X14 ,1	F31	BR25
	Auxiliary circulation fan-sleeper, battery	X1, 13	F36	R14	X1, 13	F36	BR25
	Reading light 4 (switched locally), battery	X16, 13	F36	F14	X16, 13	F36	BR25
	12V power receptacle 4 (sleeper, cigar), battery	X3, 3	F17	R14	X3, 3	F17	BR25
	Heated seats, ignition	X1, 12	F19	R3	X1, 12	F19	R3

PLVD Circuits with Connector, Fuse, and Relay							
Priority	Circuit Function	SAM 5.0 through 5.4			SAM 6.0 and 6.2		
		Conn, Pin	Fuse	Relay	Conn, Pin	Fuse	Relay
Priority 2 House Loads	12V power receptacle 2 (dash, phone), battery	X6, 9	F7	R4	X6, 9	F7	BR23
	12V power receptacle 1 (dash, cigar), battery	X6, 15	F6	R4	X6, 15	F6	BR21
	Sleeper HVAC controller, accessory	X1, 15	Controlled directly by SAM. No fuse or relay.*		X1, 15	Controlled directly by SAM. No fuse or relay.*	
	Cabin HVAC controller, accessory	X1, 10			X1, 10		
	Radio, accessory (clamp 15R)	X10, 18			X10, 18		
	Power feed spare output I, battery	X4, 1	R1	F1	X4, 1	R1	BR21
	Power feed spare output III, battery	X4, 2	F1	R1	X4, 2	F1	BR21
	12V power receptacle 6 (sleeper, refrigerator)	X14, 2	F30	R11	X14, 2	F30	BR24
	Mirror heating, passenger	X17, 2	F28	R10	X17, 2	F28	R10
	Mirror heating, driver	X8, 8	F27	R10	X8, 8	F27	R10
	Power feed spare output IV, battery	X5, 2	F3	R2	X5, 2	F3	BR22
	Power feed spare output II, battery	X5, 1	F3	R2	X5, 1	F3	BR22
	Fuel water separator heater element, ignition	X57, 15†	F2†	R1†	X57, 15†	F2†	R1†
	Air dryer (pneumatic, electrically heated), accessory	X57, 4†	Controlled directly by SAM. No fuse or relay.*		X57, 4†	Controlled directly by SAM. No fuse or relay.*	
	Auxiliary circulation fan-windshield, accessory	X16, 5			X16, 5		
	Auxiliary heater (ESPAR) power	X2, 1			X2, 1	F16	BR23
	Utility light 1	X3, 7			X3, 7	No fuse or relay.*	
	Utility light 2	X21, 14				—	
	Dome light rear	X12, 17			X12, 17	No fuse or relay.*	
	Area lighting (lower bunk and sleeper work surface), battery	X2, 15	F21	R13	X2, 15	F21	BR24
	Dome light cab, battery	X16, 7	F34	R13	X16, 7	F35	BR24
	Overhead compartment lights, battery	X16, 17	F35	R13	X16, 17	F34	BR24
	12V power receptacle 3 (sleeper, cigar), battery	X3, 15	F15	R6	X3, 15	No fuse or relay	
	Stand-alone HVAC, battery	X3, 5	F16	R6	—		

PLVD Circuits with Connector, Fuse, and Relay							
Priority	Circuit Function	SAM 5.0 through 5.4			SAM 6.0 and 6.2		
		Conn, Pin	Fuse	Relay	Conn, Pin	Fuse	Relay
Priority 2 House Loads	Advertising light, accessory	X3, 4	Controlled directly by SAM. No fuse or relay.*		X3, 4	Controlled directly by SAM. No fuse or relay.*	
	Dome light passenger	X16, 14			X16, 14		
	Dome light driver/forward overhead	X16, 11			X16, 11		
Priority 3 Basic Loads	CB radio, battery	X6, 3	F14	R5	X6, 3	F14	BR23
	Fleet management system, battery	X6, 2	F14	R5	X6, 2	F14	BR23
	Trailer power, battery or ignition	X55, 1†	F14	R8†	X55, 1†	F14†	R8†

* Circuits controlled directly by the SAM often have diagnostic latching. The SAM turns off these circuits when a fault is detected. The SAM will not restore power to most of these circuits until the ignition cycle, AFTER the fault condition is repaired.

† SAM chassis circuits.

Table 2, PLVD Circuits with Connector, Fuse, and Relay

502 — Emergency Power System Overview

The emergency power feature allows 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 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, or memory damage.
- **CAN Communication Failure:** Cabin CAN communication failure between the SAM Cab and SAM Chassis due to a Cabin CAN network fault.

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 and the engine can be restarted.

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).

Ignition ON Activity with SAM Cab Failure		
Failed ECU	Function	Response
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, Ignition ON Activity with a SAM Cab Failure

Ignition ON Activity with a SAM Chassis Failure		
Failed ECU	Function	Response
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

Ignition ON Activity with a SAM Chassis Failure		
Failed ECU	Function	Response
SAM Chassis	Rear turn signal lights	Flashing
	Trailer tail lights	Flashing
	Rear stop lights	Off

Table 4, Ignition ON Activity with a SAM Chassis Failure

Ignition ON Activity When the Load Disconnect Switch is Open		
Failed ECU	Function	Response
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, Ignition ON Activity When the Load Disconnect Switch is Open

600 — Component Locations

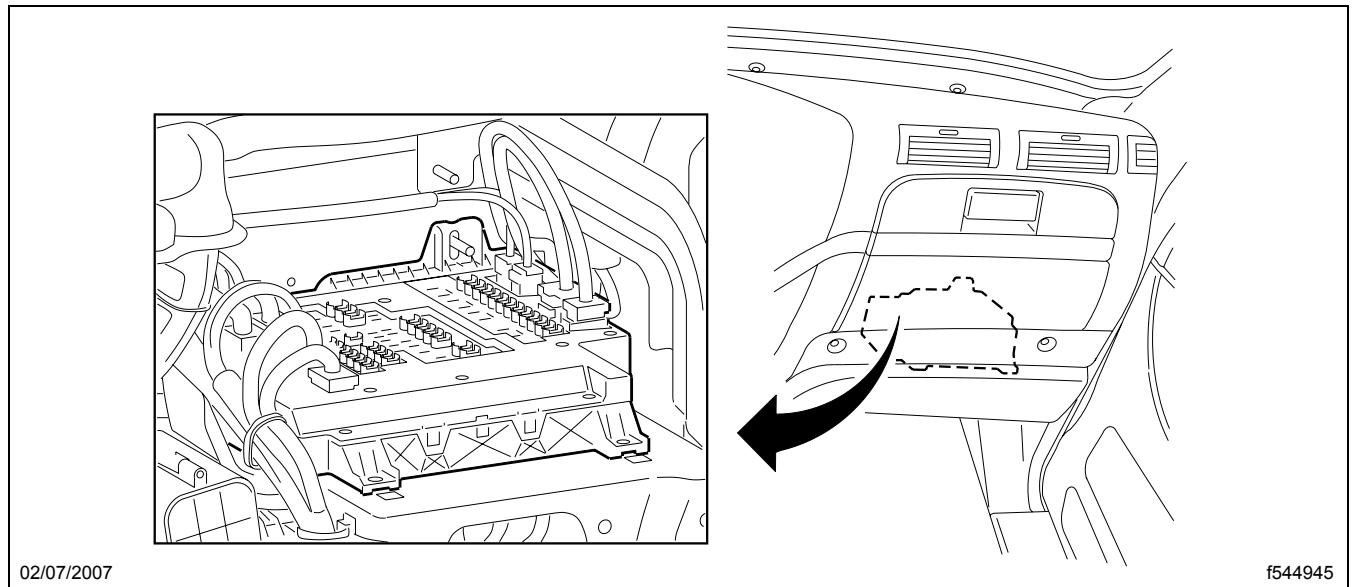


Fig. 1, SAM Cab

601 — Component Details

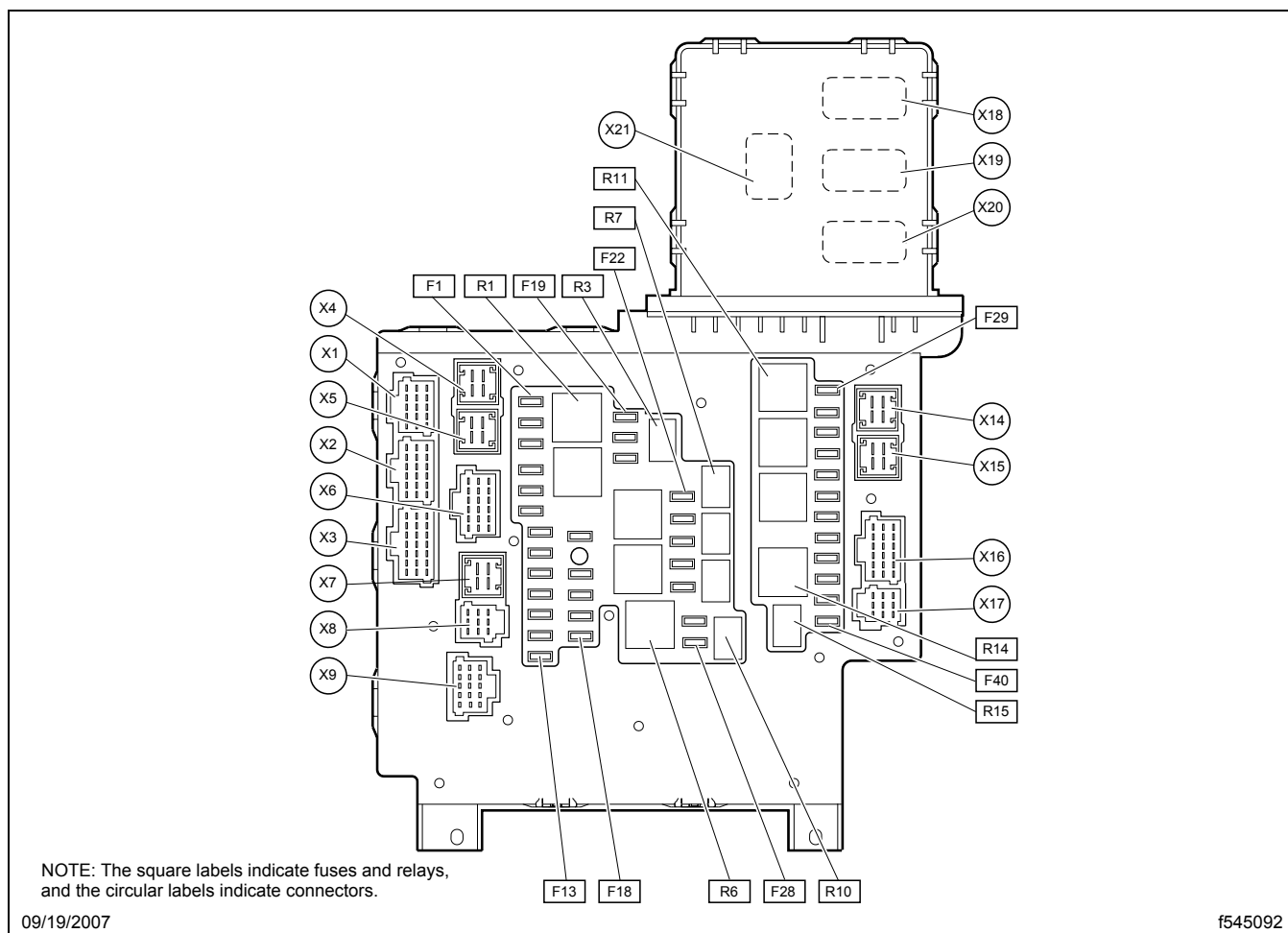


Fig. 2, SAM Cab Fuses and Relays

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 SAM Cab senses battery voltage for PLVD on connector X21, pin 13. This circuit is sourced through fuse F7 in the powertrain PDM on EPA07 vehicles, and fuse B in the PNDB on EPA10 vehicles.

Use **Table 2** to identify the connector and pin that sources power to each of the circuits that are affected by PLVD. Test the fuse and relay where applicable. Relays with the designation "BR" are bistable relays. The SAM only applies power to the coil of these relays for a few microseconds when it is being switched. These relays latch into the intended position.

ServiceLink Templates

ServiceLink makes a template available for PLVD diagnosis. The template shows which level the PLVD is currently operating at. Basic, Comfort, and House circuits will be powered or unpowered according to the PLVD level as displayed on the ServiceLink template.

703 — Emergency Power Diagnostics

NOTE: Refer to the symptoms in **Table 6** when the ignition switch is in the ON position. If the key is in the OFF or ACC position, these symptoms do not apply.

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 flas alternately, engine can be restarted	Refer to 705 — Turn Signal Indicators Flash Alternately, Engine Can Be Restarted .
Turn signal indicators flas alternately, engine cannot be restarted	Refer to 706 — Turn Signal Indicators Flash Alternately, Engine Cannot Be Restarted .

Table 6, 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?

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 7, Parameters

System Overview

Terms and Abbreviations	500
General Information	501
Controls	502

Components

Component Locations	600
Component Details	601

Troubleshooting

Troubleshooting Overview	700
Diagnostic Tools Required	701
CAN Fault Codes	702
Input Troubleshooting, Manual and Automated Transmissions	703
Output Troubleshooting	704

Specification

Parameters	800

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.

502 — Controls

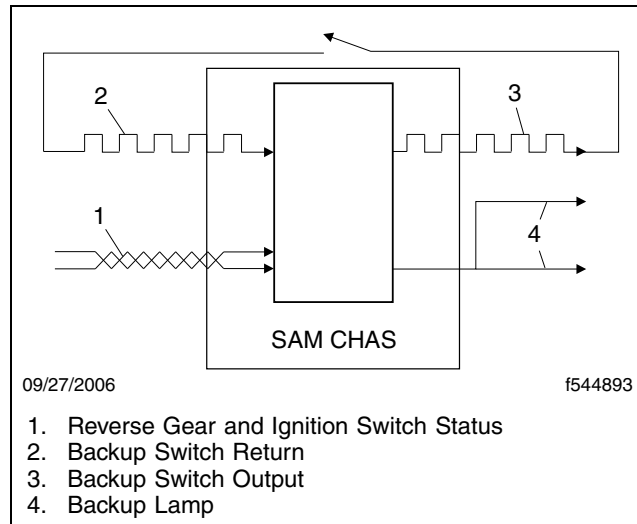


Fig. 1, Controls

600 — Component Locations

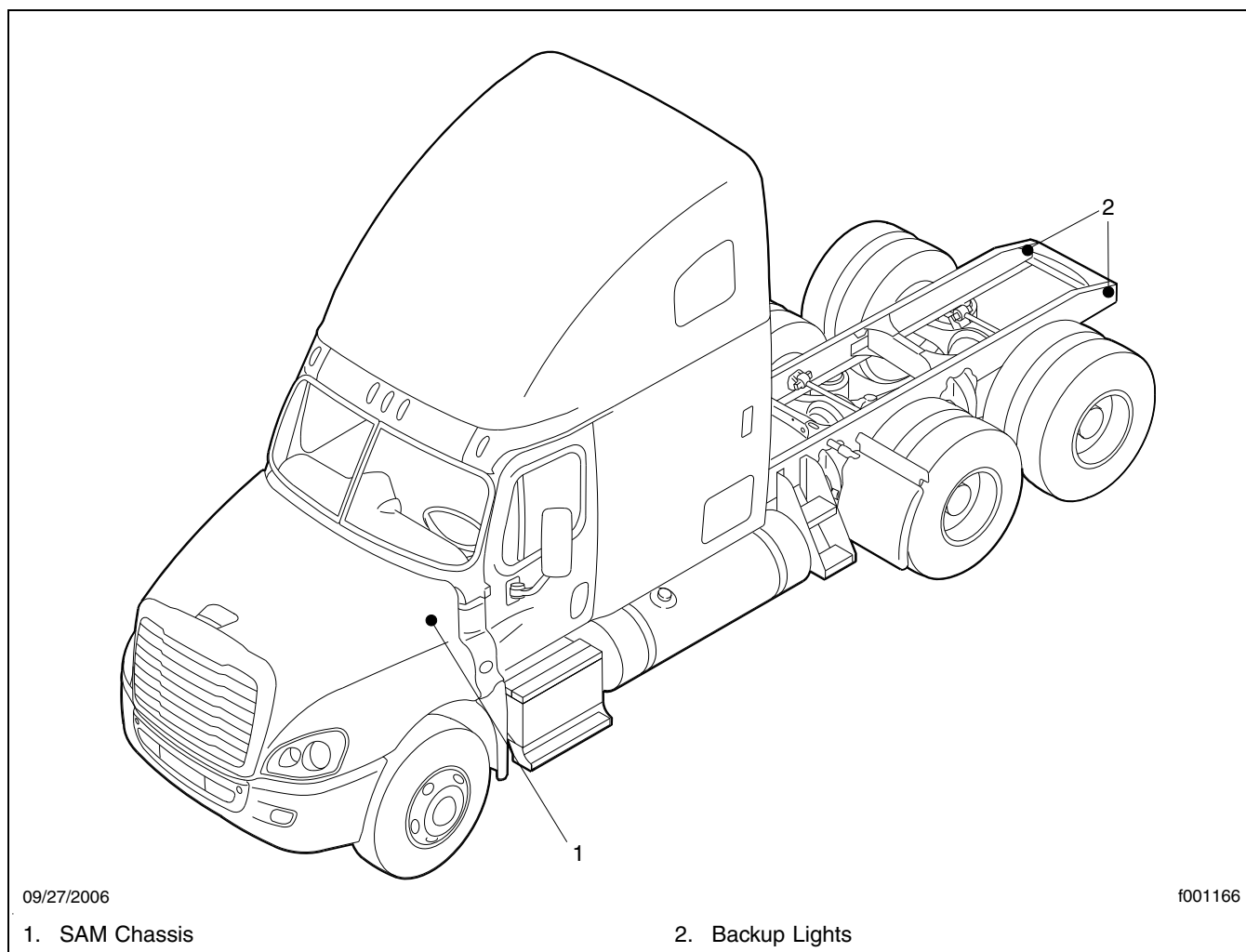


Fig. 2, Component Locations

601 — Component Details

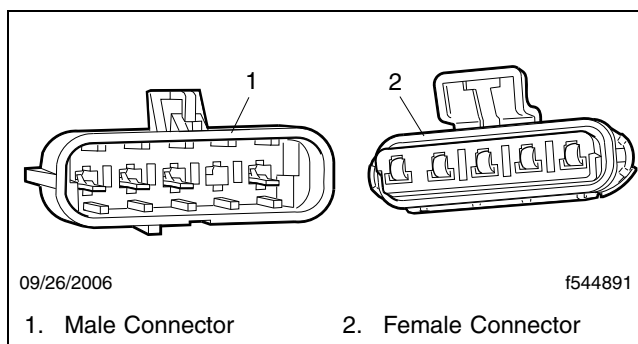


Fig. 3, Backup Light Connector

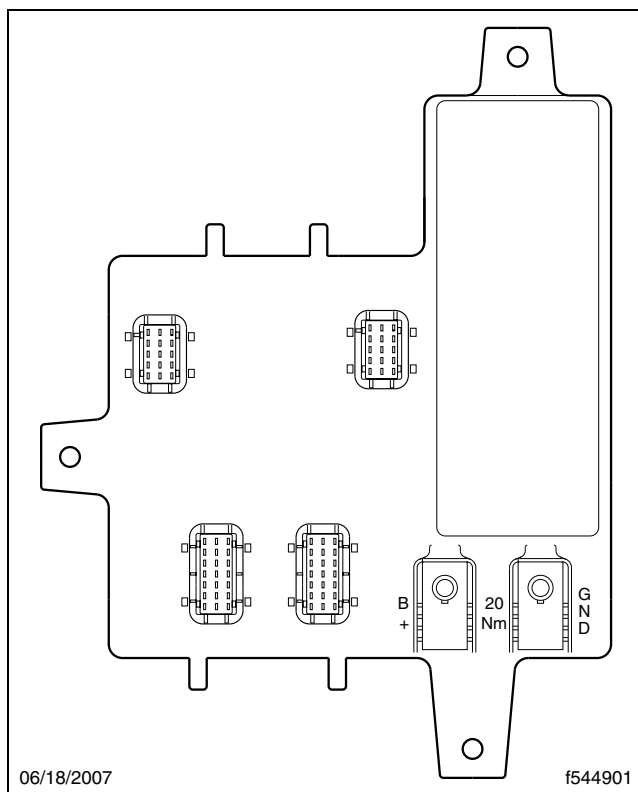


Fig. 4, SAM Chassis

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**.

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.

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

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.

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

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600

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.

600 — Component Locations

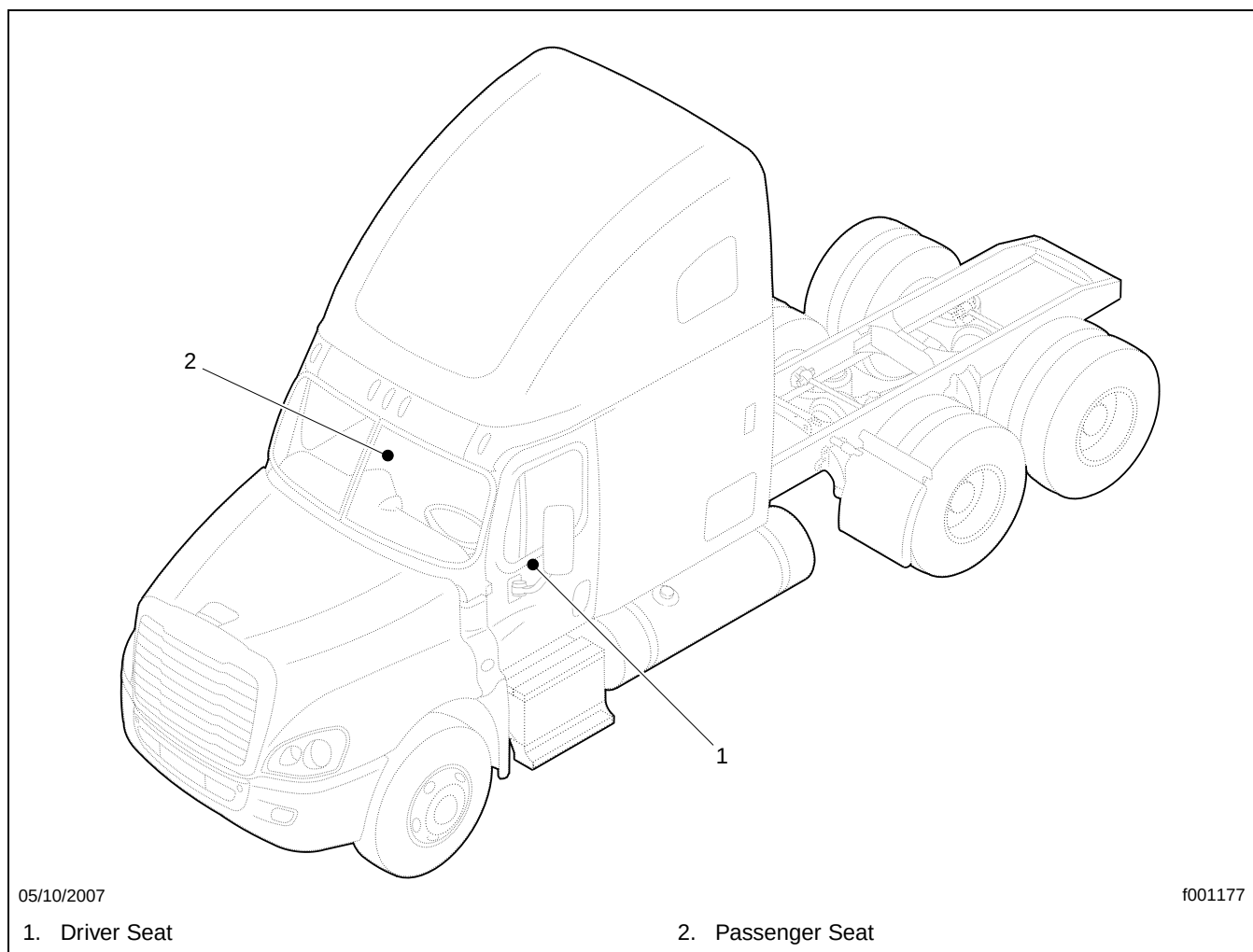


Fig. 1, Component Locations

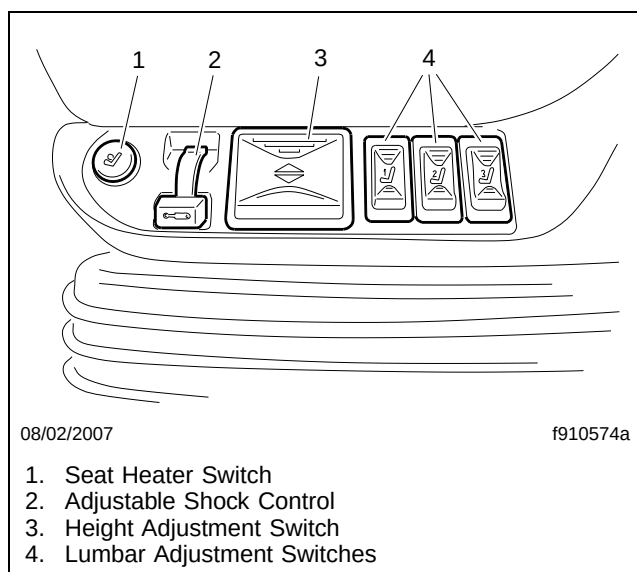
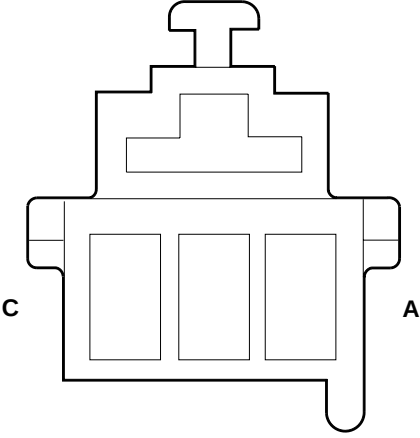


Fig. 2, Seat Module

SAM Cab Connector, X1			
05/10/2007 f545030			
Pin	Circuit	Color	Description
5	GND	Black	Heated Seats, GND
12	242A	White	Heated Seats, IGN

Table 1, SAM Cab Connector, X1

Driver- and Passenger-Side Seat Module



05/10/2007f545031

Pin	Circuit	Color	Description
A	242A	White	Heated Seats, IGN
B	GND	Black	Heated Seats, GND

Table 2, Driver- and Passenger-Side Seat Module

System Overview

 Terms and Abbreviations 500

 General Information 501

Components

 Component Locations 600

 Component Details 601

Troubleshooting

 Troubleshooting Overview 700

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

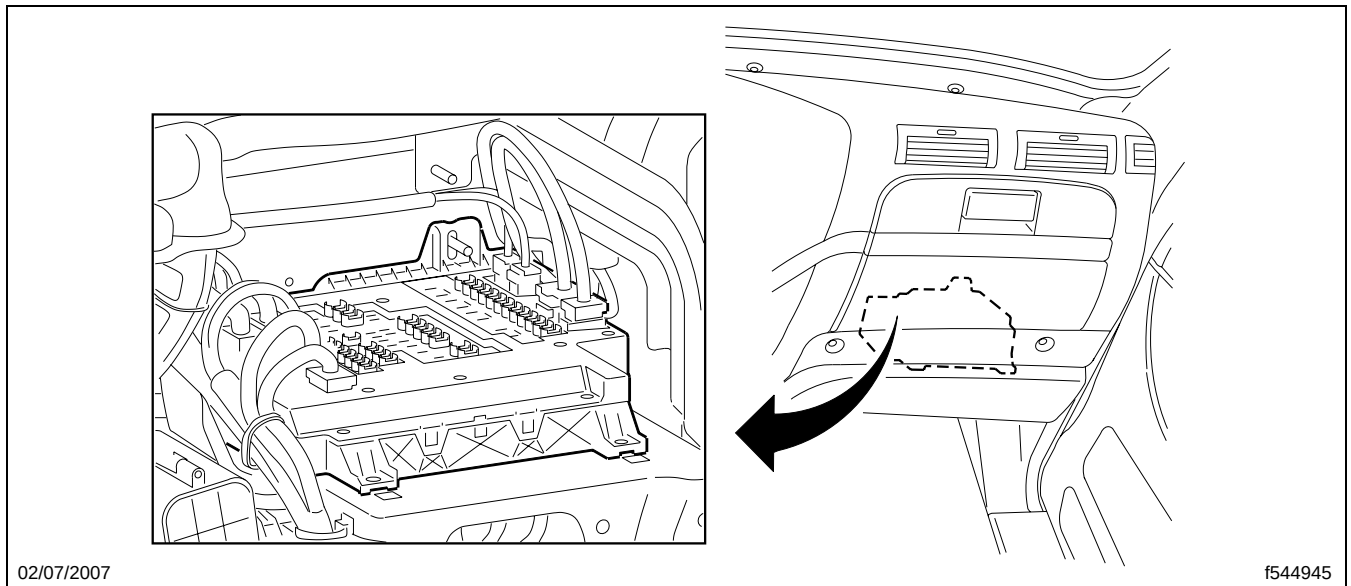


Fig. 1, SAM Cab

601 — Component Details

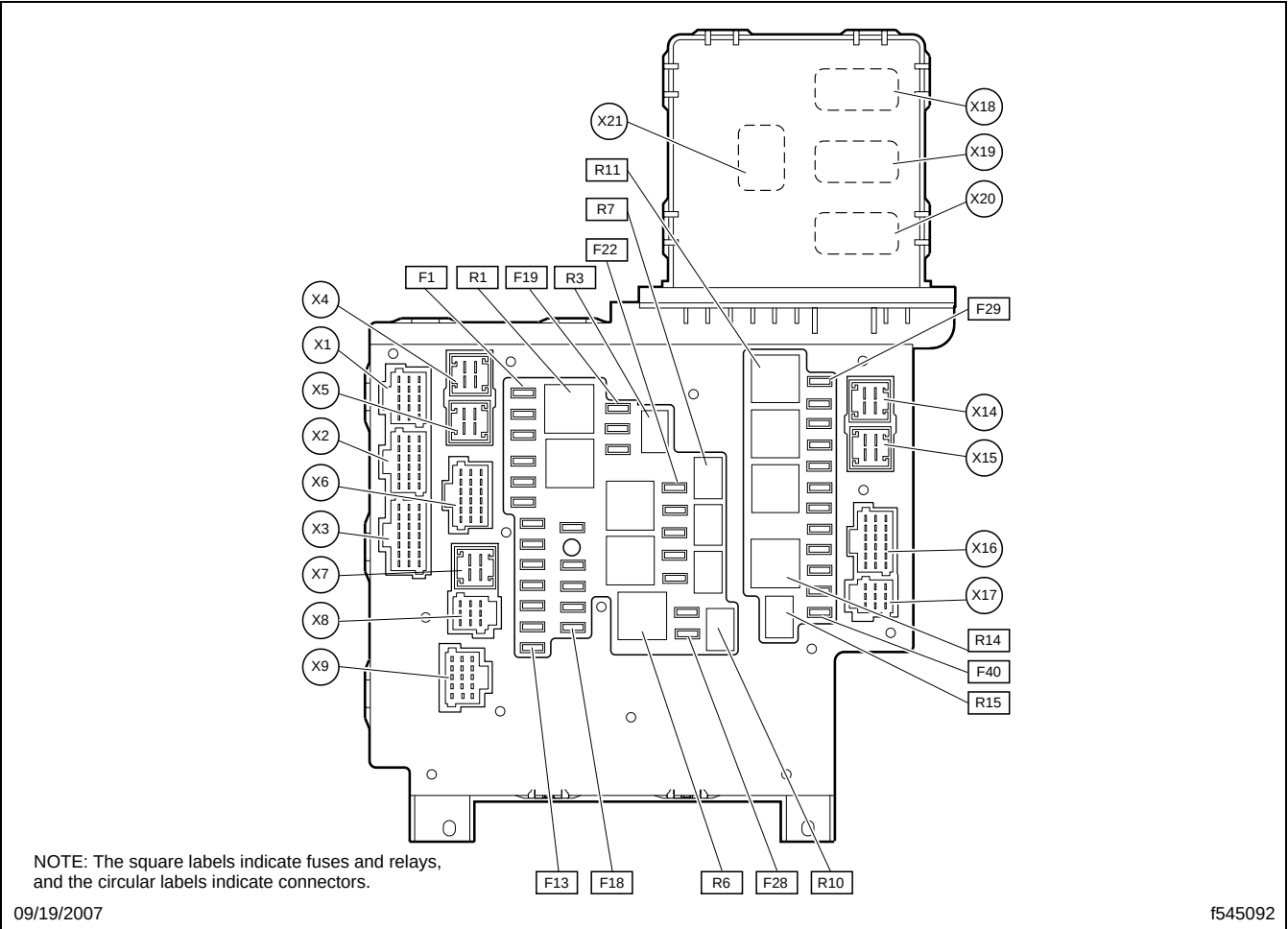


Fig. 2, SAM Cab Fuses and Relays

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	—	—

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.

System Overview

Terms and Abbreviations	500
General Information	501
Safety Precautions	502

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostics	700
RollTek Diagnostic Procedure	701
Fault Codes	702

Specifications

SRS Wiring Schematics	800

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.

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 inflator . 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

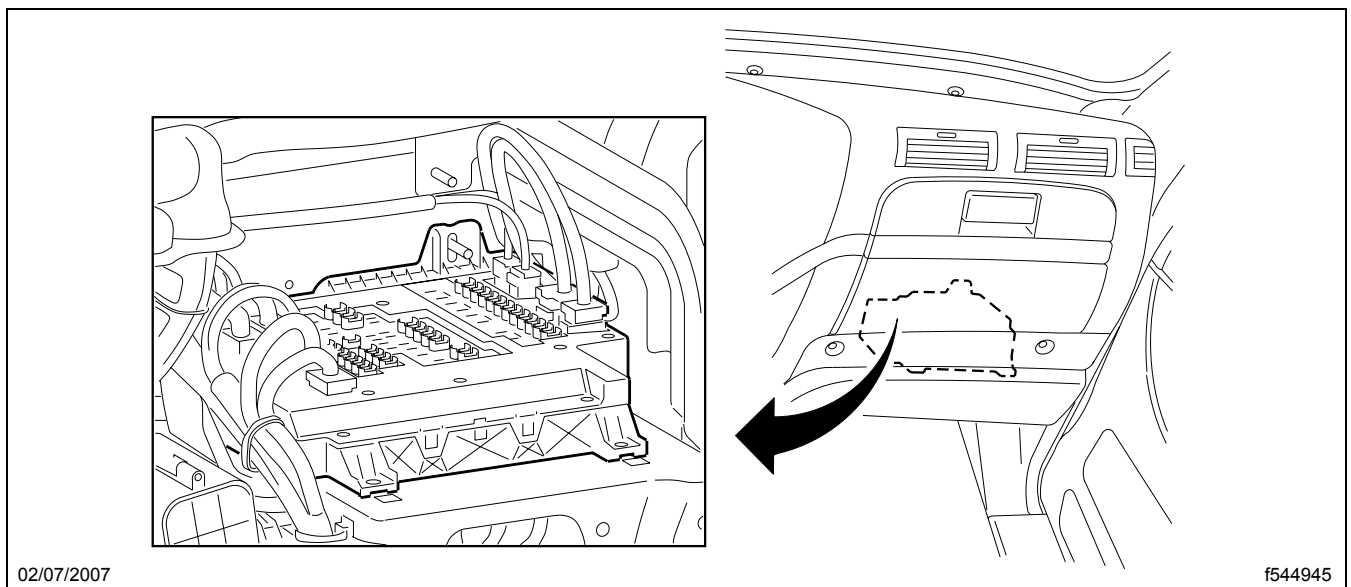


Fig. 1, SAM Cab

601 — Component Details

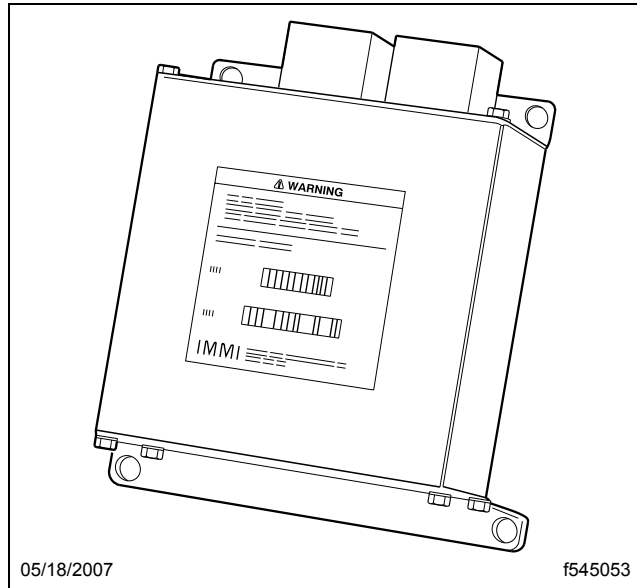


Fig. 2, SRS Module

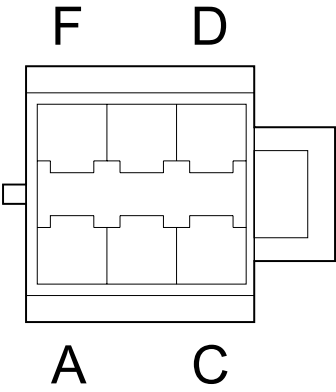
6-Pin Driver-Side SRS Module (systems with a front airbag)			
			
05/17/2007		f545042	
Pin	Circuit Number	Wire Color	Description
A	81C	PK	+12V Ignition Power
B	GND	BK	Ground
C	1587+	DKG	(+) J1587 Datalink
D	1587–	O	(–) J1587 Datalink
E	454L	Y-W	SRS Warning Lamp
F	—	—	Not Used

Table 2, 6-Pin Driver-Side SRS Module (systems with a front airbag)

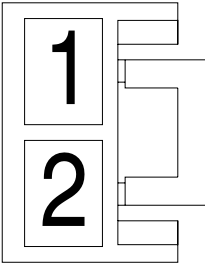
2-Pin Driver-Side SRS Module (systems with a front airbag)			
			
05/17/2007		f545043	
Pin	Circuit Number	Wire Color	Description
1	454A+	Y-W	(+) Front Airbag Signal
2	454A–	Y-W	(–) Front Airbag Signal

Table 3, 2-Pin Driver-Side SRS Module (systems with a front airbag)

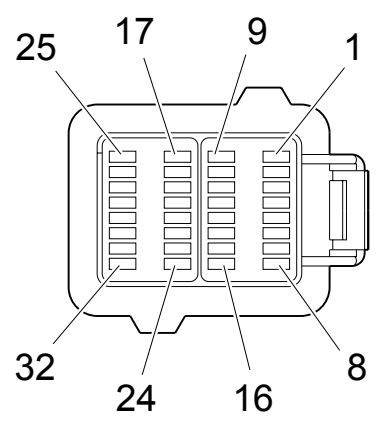
32-Pin Driver-Side SRS Module (systems without a front airbag, RollTek Only)			
 05/17/2007 f545045			
Pin	Circuit Number	Wire Color	Description
1-2	—	—	Not Used
3	454L	Y-W	SRS Warning Lamp
4	GND	BK	Ground
5	—	—	Not Used
6	81C	PK	+12V Ignition Power
7	GND	BK	Ground
8	—	—	Not Used
9	1587+	DKG	(+) J1587 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)

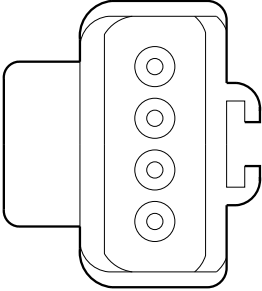
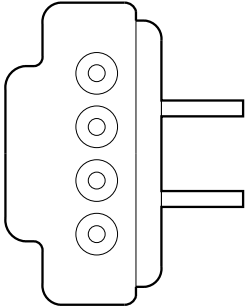
4-Pin Driver-Side SRS Module (systems with passenger RollTek)			
 05/17/2007 f545046			
Pin	Circuit Number	Wire Color	Description
1	454C+	Y-W	(+) Passenger-Side Suspension Seat Safety System Signal
2	454C–	Y-W	(–) Passenger-Side Suspension Seat Safety System Signal
3	454B+	Y-W	(+) Passenger-Side Airbag 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

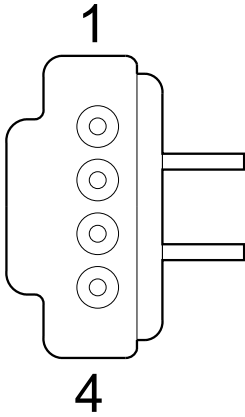
4-Pin Passenger-Side SRS Module (systems with passenger RollTek)			
 05/17/2007 f545047			
Pin	Circuit Number	Wire Color	Description
3	454B+	Y-W	(+) Passenger-Side Airbag Signal
4	454B-	Y-W	(-) Passenger-Side Airbag Signal

Table 6, 4-Pin Passenger-Side SRS Module (systems with passenger RollTek)

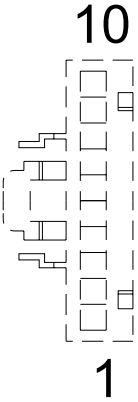
10-Pin Clockspring Connector (systems with front airbag)			
 05/17/2007 f545044			
Pin	Circuit Number	Wire Color	Description
1	454A+	Y-W	(+) Front Airbag Signal
2	454A-	Y-W	(-) Front Airbag Signal
3-10	—	—	Not Part of the Airbag System

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."

- 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.

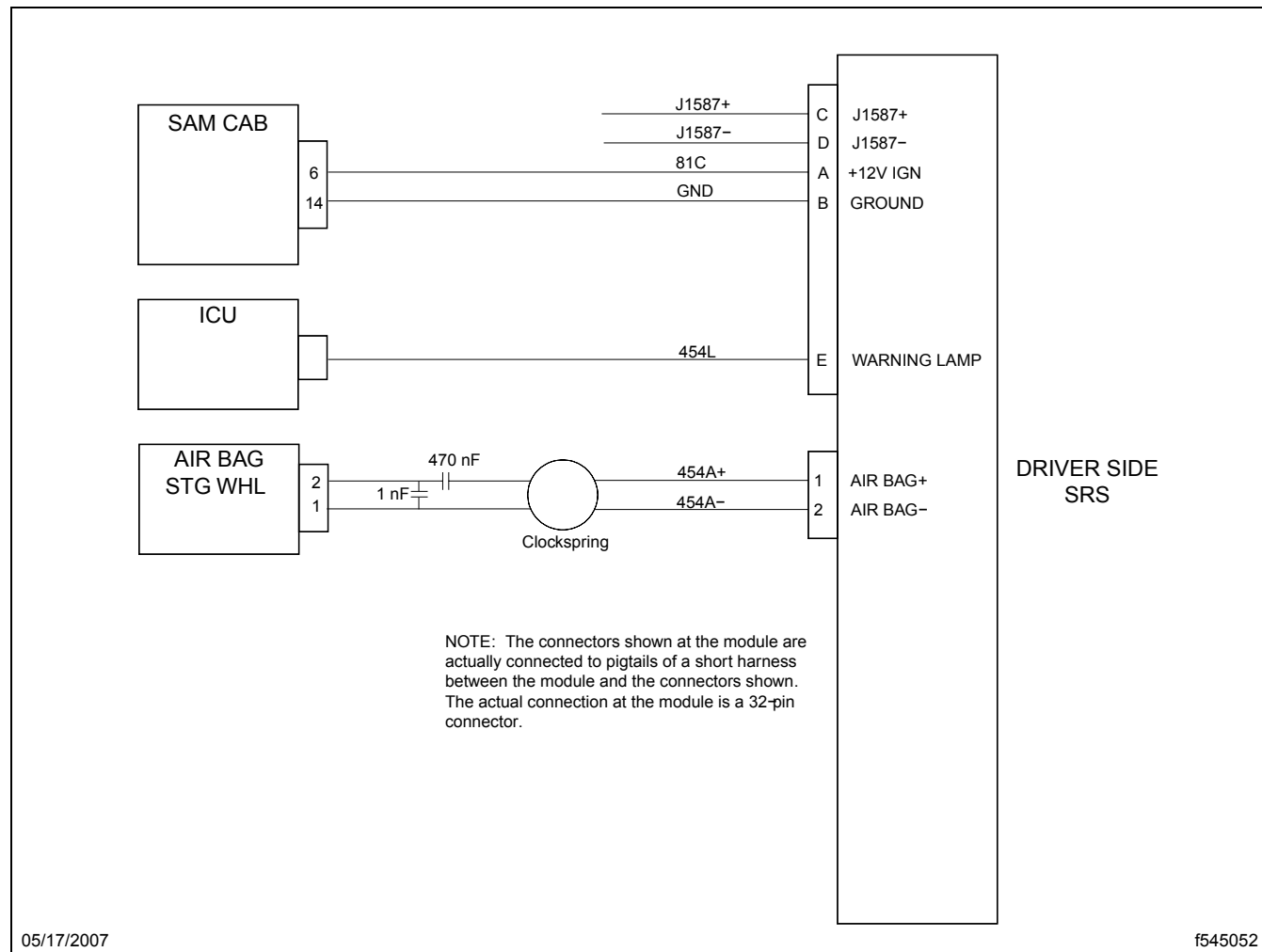
702 — Fault Codes

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
5	3	232	Warning Lamp Circuit Shorted High
5	4	232	Warning Lamp Circuit Shorted Low
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)**

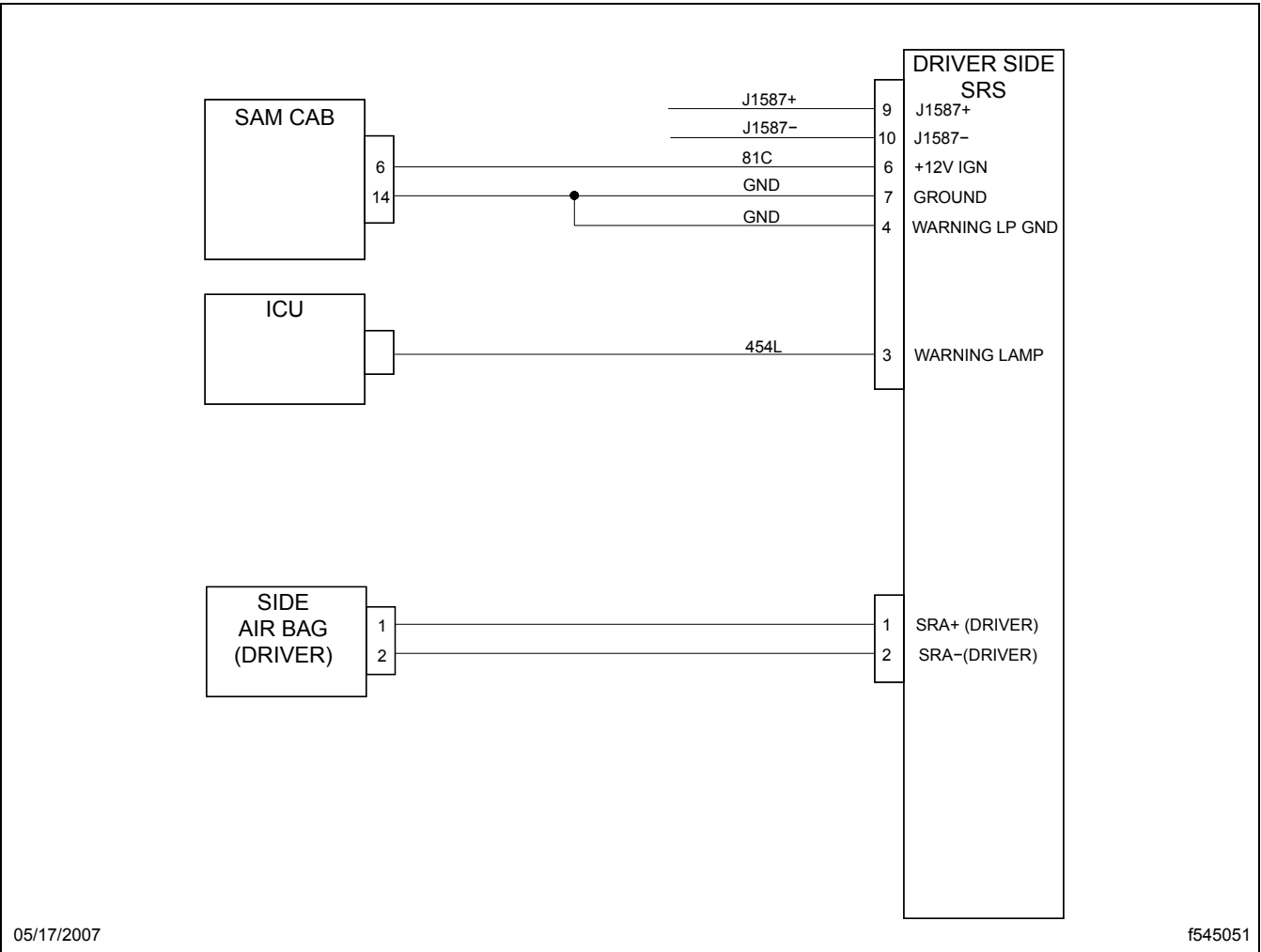
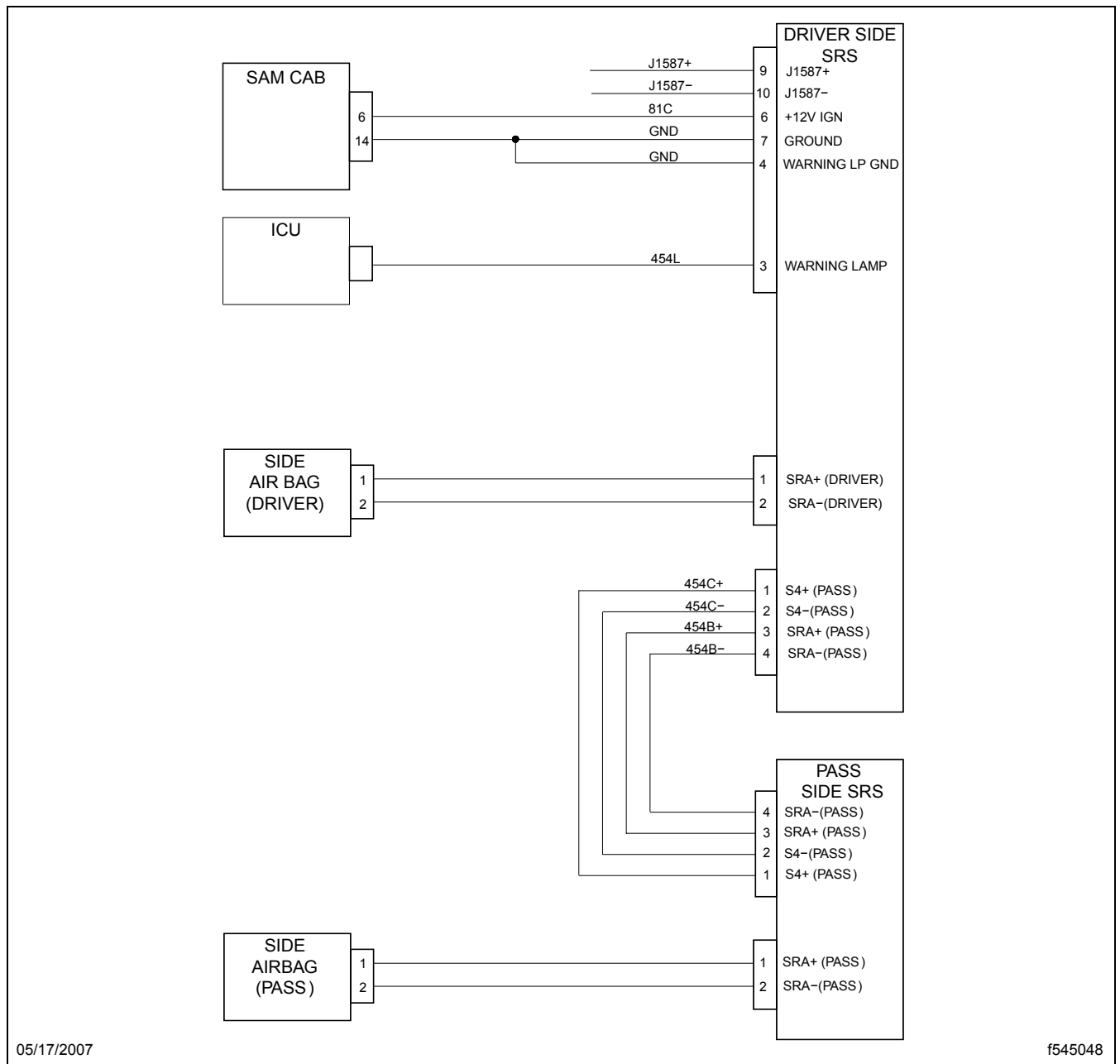


Fig. 4, Wiring Schematic, Driver-Side (rollover protection only)

**Fig. 5, SRS Wiring Schematic, Driver- and Passenger-Side (rollover protection only)**

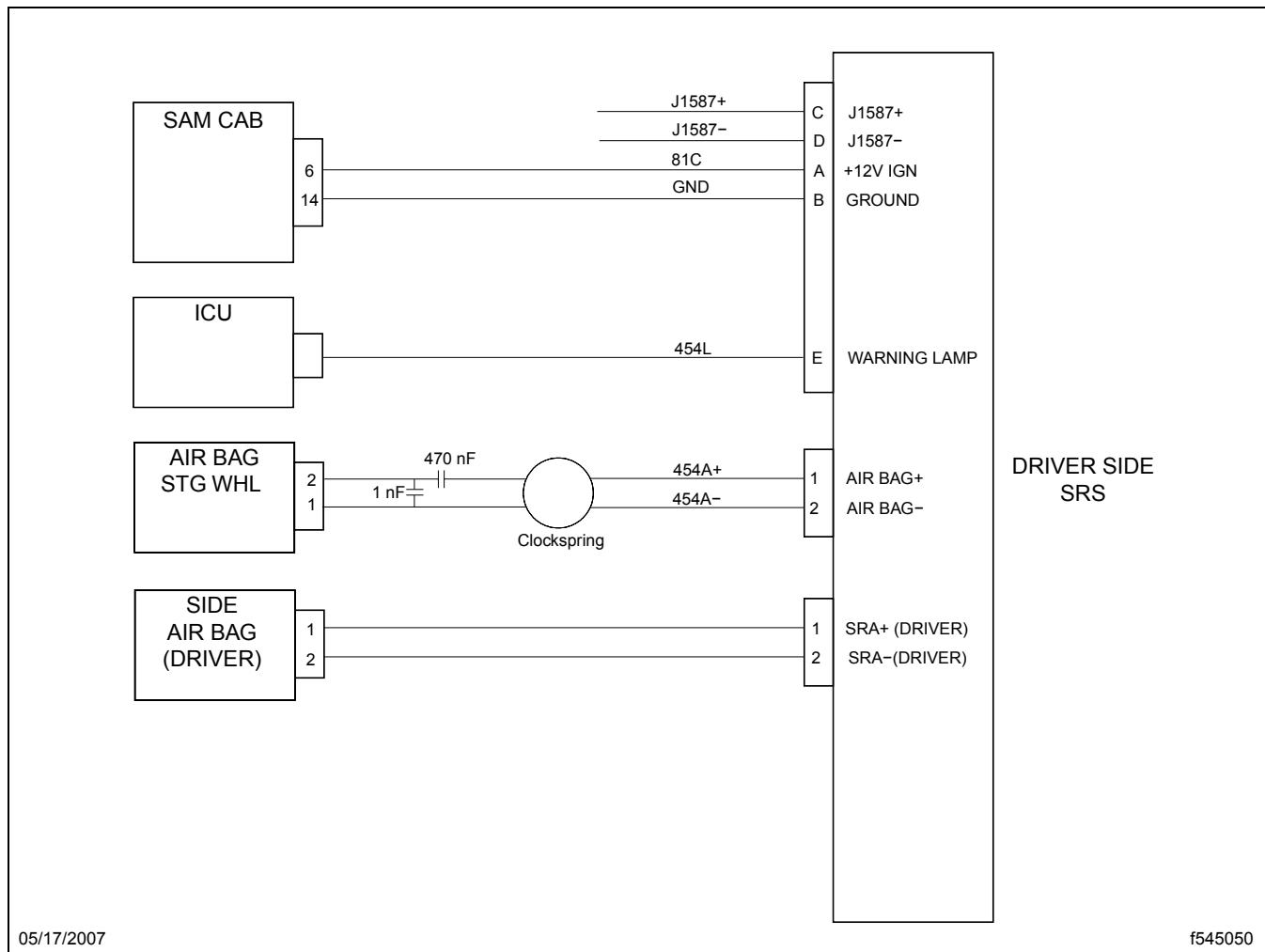


Fig. 6, SRS Wiring Schematic, Driver-Side (rollover protection and front airbag)

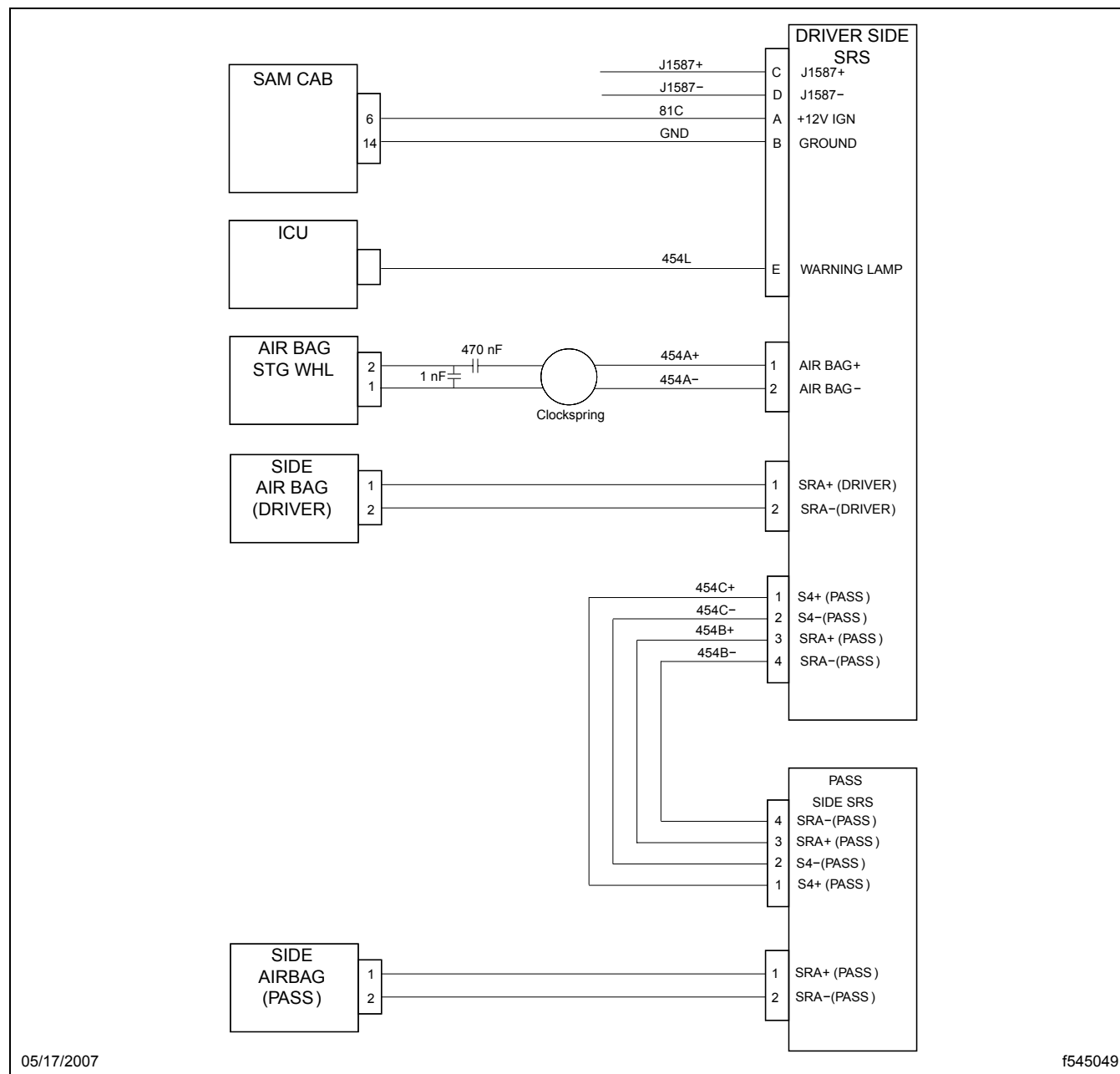


Fig. 7, SRS Wiring Schematic, Driver- and Passenger-Side (rollover protection and front airbag)

System Overview

Terms and Abbreviations	500
General Information	501
Safety Precautions	502

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostics	700
Fault Codes	701

Specifications

SRS Wiring Schematics	800

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



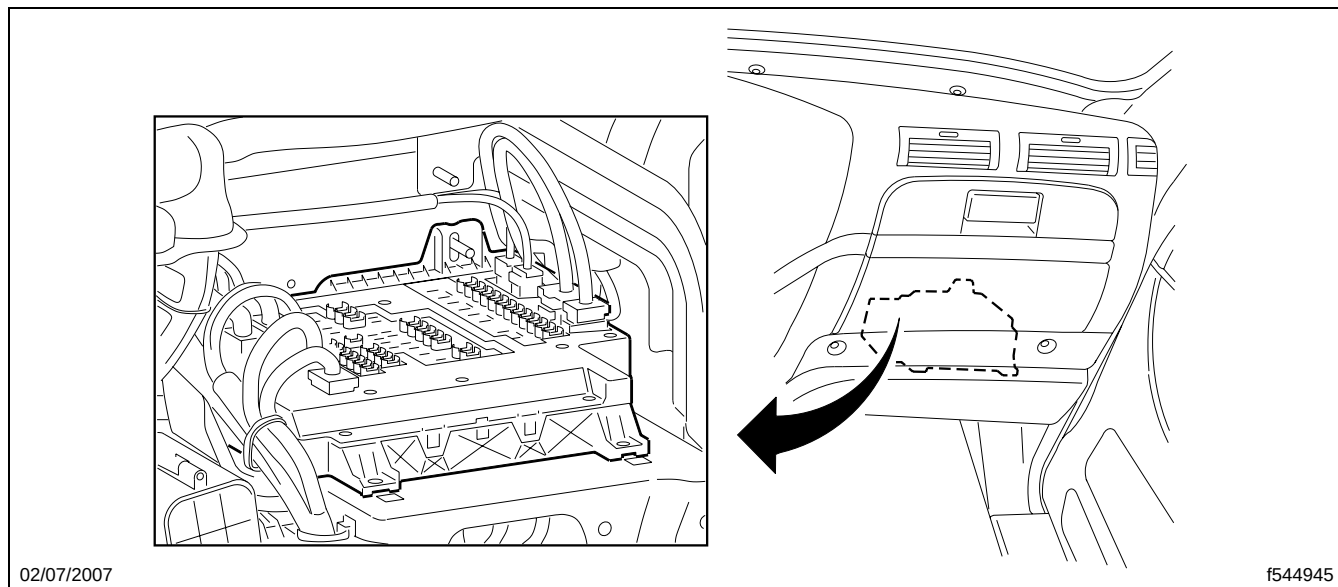
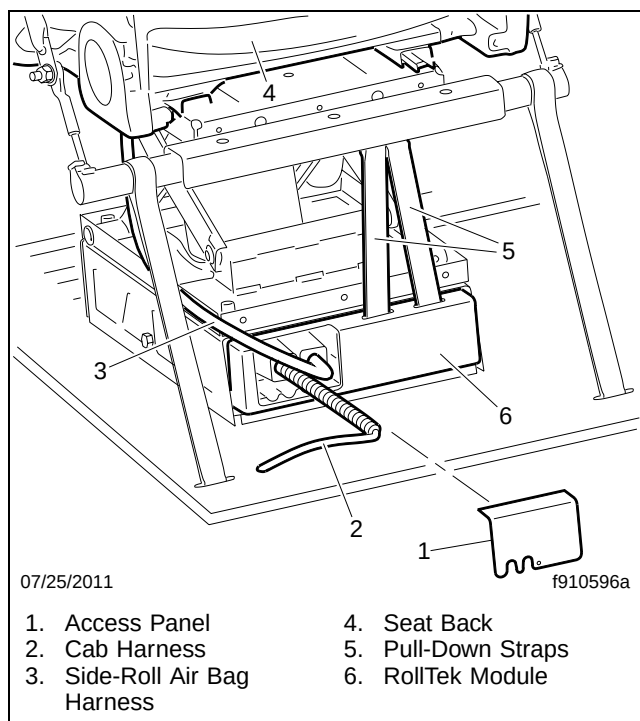
Before performing any work on the RollTek system, review all service literature and comply with the following warnings and precautions. Unintentional or improper deployment of the RollTek system can result in injury or death.

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****Fig. 2, RollTek Module**

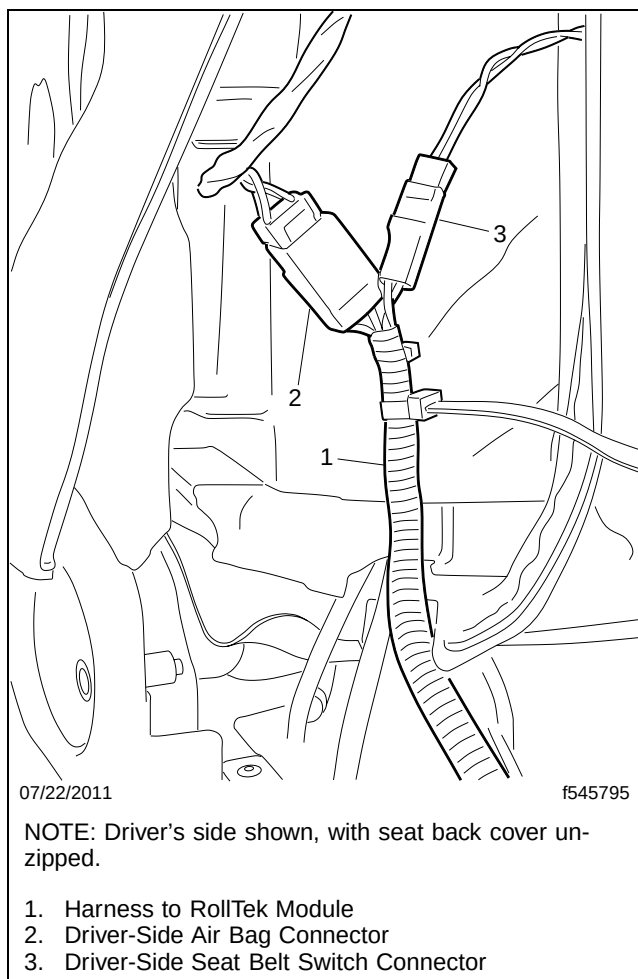


Fig. 3, Seat Back Connectors

601 — Component Details

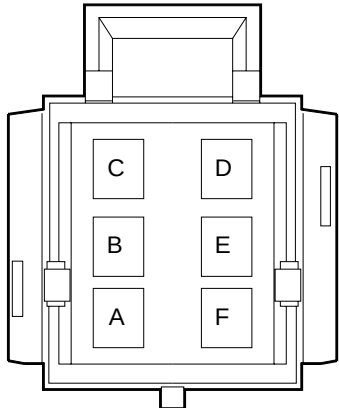
6-Pin Communication and Power Connector Pin Destination				
Connector Manufacturer: Packard Housing Part Number: 12064754 Secondary Lock Part Number: 12064755 Terminal Part Number: 12034047 Color: Black  f545796 Connector Front View				
Connector Name	Location	Pin	Wire Color	Description
A	B-Pillar (frontal 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

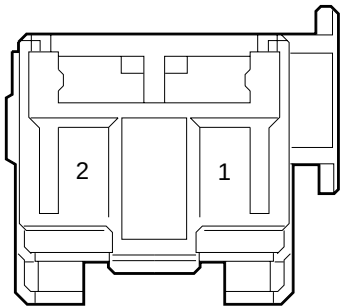
2-Pin Front Air Bag Connector Pin				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
 f545797				
Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
B	On RollTek Module	1	Yellow/White	Driver Front Air Bag (+)
		2	Yellow/White	Driver Front Air Bag (-)

Table 2, 2-Pin Front Air Bag Connector Pin

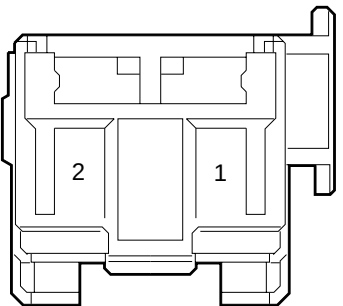
2-Pin Driver-Side Air Bag Connection				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
 f545797				
Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
C	Back of Driver Seat	1	Blue	Driver SRA (+)
		2	White	Driver SRA (-)

Table 3, 2-Pin Driver-Side Air Bag Connection

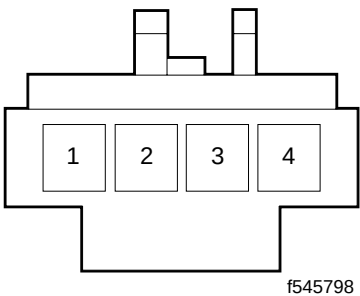
4-Pin Signal to Deploy Passenger-Side Pyrotechnics				
Connector Manufacturer: FCI Housing Part Number: 54550400 Terminal Part Number: 54001803 Color: Yellow				
				
Connector Name	Location	Pin	Wire Color	Description
D	Inside Driver-Side Component Box	1	Yellow/White	Passenger S4 (+)
		2	Yellow/White	Passenger S4 (–)
		3	Yellow/White	Passenger SRA (+)
		4	Yellow/White	Passenger SRA (–)

Table 4, 4-Pin Signal to Deploy Passenger-Side Pyrotechnics

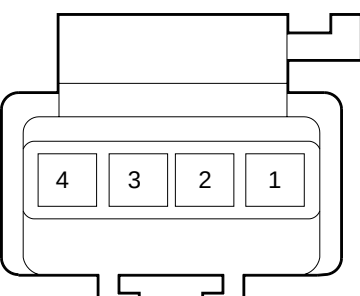
4-Pin Passenger-Side Pyrotechnics				
Connector Manufacturer: FCI Housing Part Number: 54550402 Terminal Part Number: 54001819 Color: Yellow				
				
Connector Name	Location	Pin	Wire Color	Description
E	Inside Passenger-Side Component Box	1	Yellow/White	Passenger S4 (+)
		2	Yellow/White	Passenger S4 (–)
		3	Yellow/White	Passenger SRA (+)
		4	Yellow/White	Passenger SRA (–)

Table 5, 4-Pin Passenger-Side Pyrotechnics

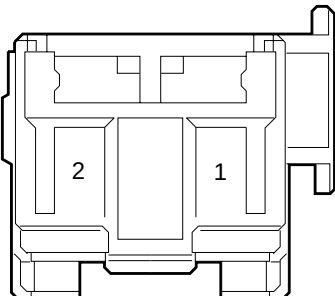
2-Pin Passenger-Side Air Bag				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
 f545797 Wire Insertion Side				
Connector Name	Location	Pin	Wire Color	Description
F	Back of Driver Seat	1	Blue	Passenger SRA (+)
		2	White	Passenger SRA (-)

Table 6, 2-Pin Passenger-Side Air Bag

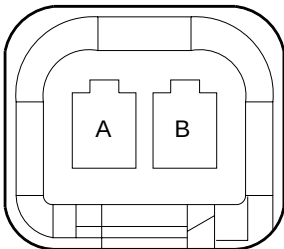
Driver's Buckle Connector				
Connector Manufacturer: Packard Housing Part Number: 12047663 Lock Part Number: 12047665 Terminal Part Number: 12047581 Color: Black				
 f545800 Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
G	Back of Driver Seat from AB10-ECU	A	Gray	Driver's Buckle (+)
		B	White	Driver's Buckle (-)

Table 7, Driver's Buckle Connector

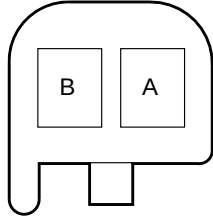
Passenger Buckle Switch From AB10-ECU				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				
 f545801 Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
H	Inside Driver's Component Box	A	Tan/White	Driver's Buckle (+)
		B	Tan/White	Driver's Buckle (-)

Table 8, Passenger Buckle Switch From AB10-ECU

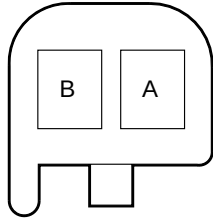
Buckle Connector Passenger and Driver				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				
 f545801 Connector Front Side				
Connector Name	Location	Pin	Wire Color	Description
I	End of Buckle Harness (driver and passenger)	A	Tan/White	Driver's Buckle (+)
		B	Tan/White	Driver's Buckle (-)

Table 9, Buckle Connector Passenger and Driver

700 — Diagnostics

Connect to the J1939 databus using ServiceLink or DiagnosticLink 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.

 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. FMI 14, Warning Lamp Circuit Configuration, may also occur if the incorrect SRS sensor is installed under the driver's seat. Check PartsPro module 725 for the correct SRS sensor part number and compare it to the part number of the sensor actually installed on the vehicle. If the SRS sensor on the vehicle is incorrect, replace it with the correct sensor.
	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		

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		

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 +/- 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		

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 .

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 .

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

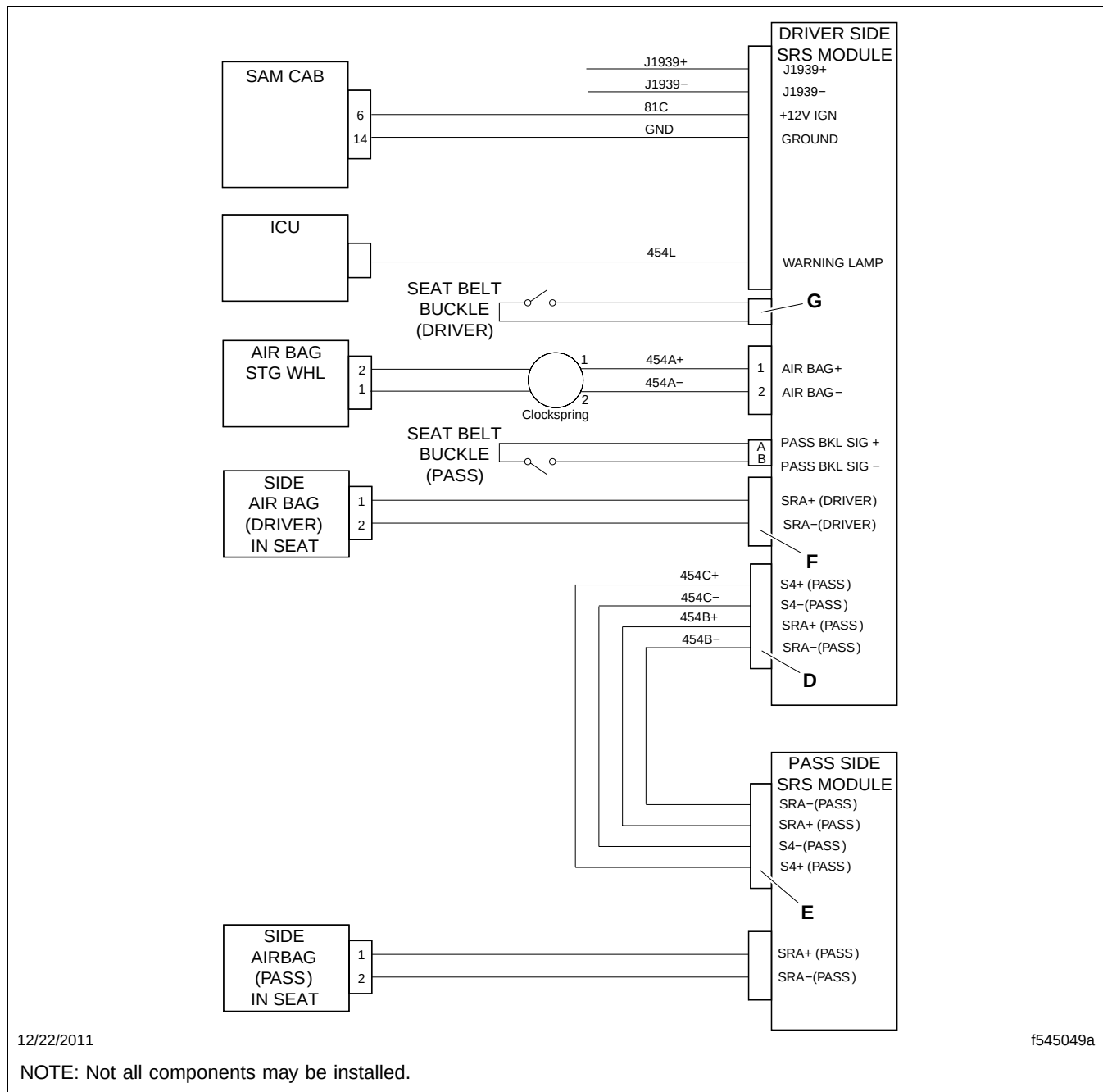


Fig. 4, SRS Wiring Schematic

System Overview

Terms and Abbreviations	500
General Information	501
Related Subjects	502

Components

Component Locations	600
Component Details	601

Troubleshooting

Required Tools	700
Possible Causes	701
Top of Clutch Switch	702
Fault Codes	703
Diagnostic Tests	704

Specifications

Parameters	800

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. 3**. Pressing the "On/Off" button changes a resistance value 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.

The engine controller monitors the position of the accelerator pedal, and uses an algorithm to adjust engine speed to keep the speed of the vehicle constant.

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 engine controller. These switches include:

- Service brake
- Top-of-clutch switch
- Parking brake switch

The engine controller 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, park brake, or the clutch, there are optional parameters that may disengage cruise control with any one of the following conditions:

NOTE: These parameters are only available for Detroit™ engines.

- The hazard lights are enabled.
- Windshield wipers are at any setting other than off.
- The headlight switch is at any setting other than off.

When adding the optional parameters, the engine programming may need to be modified

See **Table 1** for the correct combination of cruise control parameter settings for Detroit engines.

NOTE: When the cruise control disengages by using the CNCL button, the engine PTO mode is not cancelled; only the cruise control mode is disengaged. The vehicle speed is retained in memory.

Cruise Control Parameter Settings				
ECU	Service Tool	Parameter Name	Value/Part Number	Application/Type
SAM Cab	ServiceLink	PARM-CAB, CRC, NO CNT	A0024471858	Disengaging with CNCL Button, On/Off Button, Service, Park Brake, or Clutch.
CPC2	DDDL	CC Pause Switch Confi	3 - CCVS3	
SAM Cab	ServiceLink	PARM-CAB, CRC, DIS, HDL, WW	A0024471958	Disengaging also with Hazard Lights On, Headlights On, or Wipers On.
CPC2	DDDL	CC Pause Switch Confi	5 - CCVS2 or CCVS3	

Table 1, Cruise Control Parameter Settings

The steering wheel switches, hazard lights, headlight 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

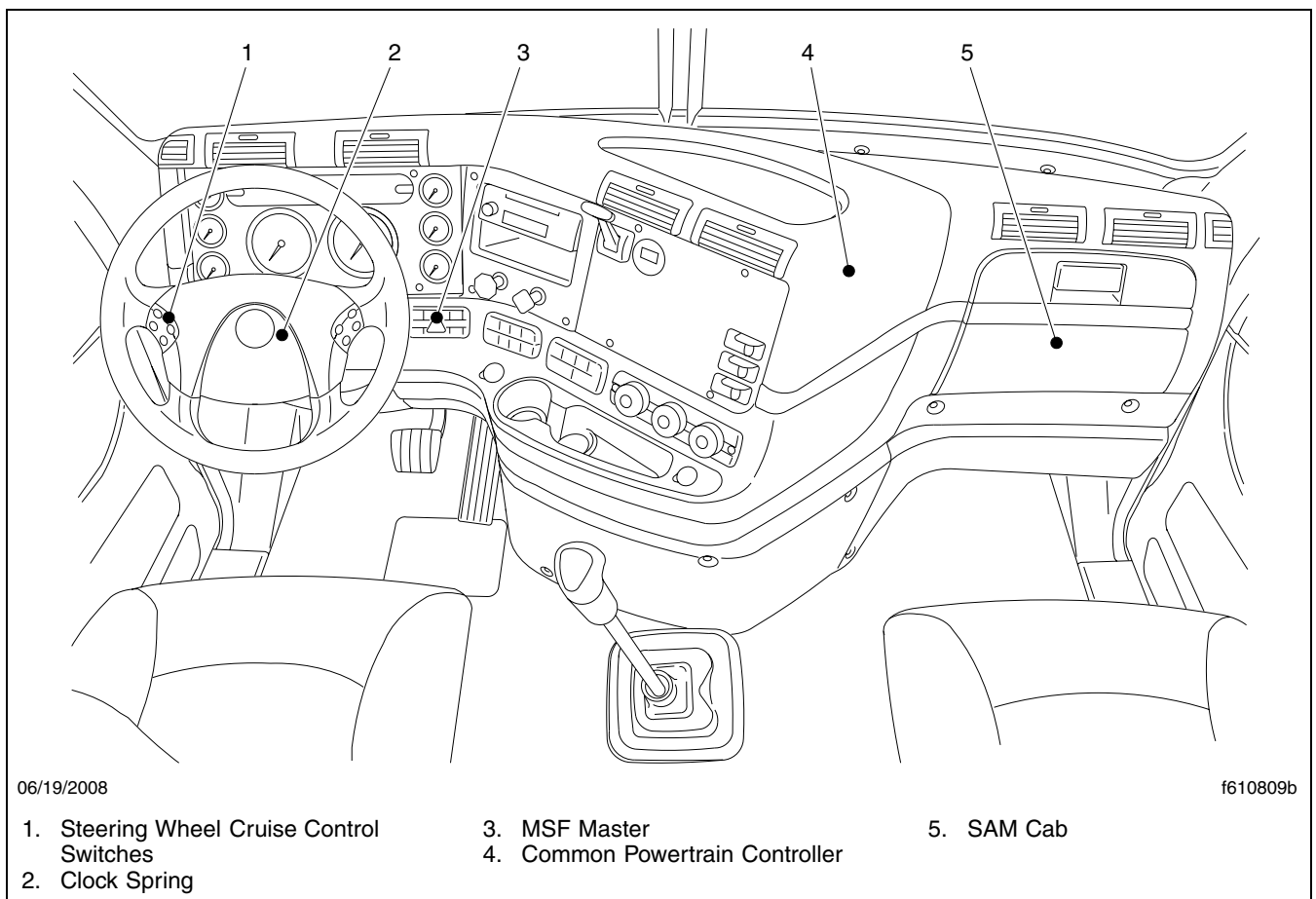


Fig. 1, Component Locations

601 — Component Details

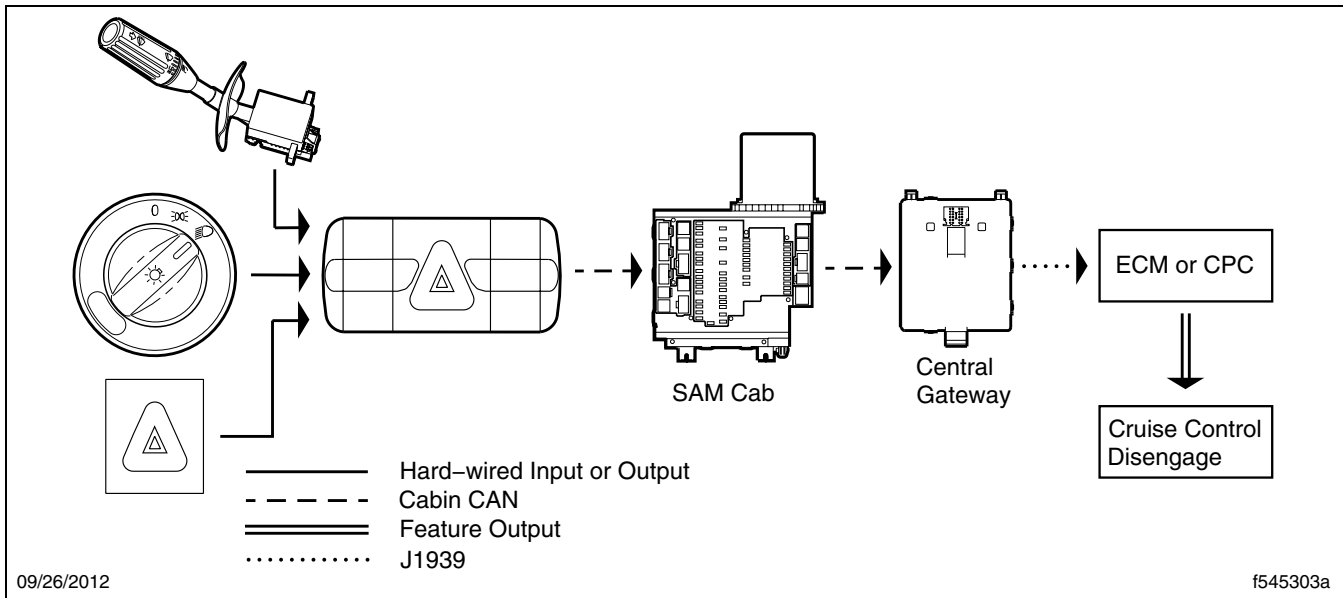


Fig. 2, Function Path of the Cruise Control Disengage

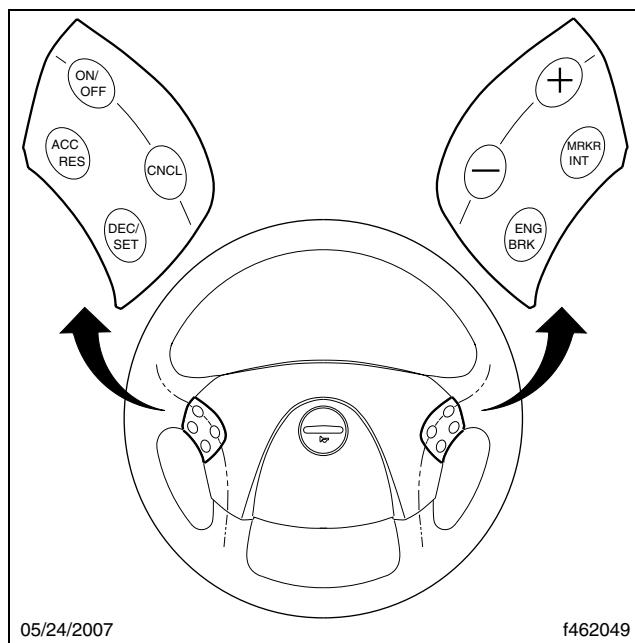


Fig. 3, Steering Wheel Switches

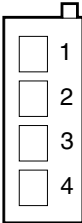
Steering Wheel Switches	
	
05/15/2007	f545039
Pin	Function
1	Steering Wheel, Left Switch Signal (S2)
2	Backlighting PWM
3	Steering Wheel, Right Switch Signal (S1)
4	Ground

Table 2, Steering Wheel Switches

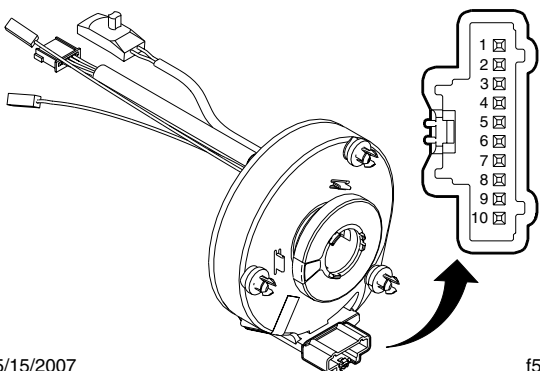
Clock Spring Connector	
	
05/15/2007	f545040
Pin	Function
1	Air Bag (+), if used
2	Air Bag (-), if used
3	Not Used
4	Backlighting Ground
5	Steering Wheel, Right Switch Signal (S1)
6	Backlighting PWM
7	Steering Wheel, Left Switch Signal (S2)
8	Not Used
9	Horn Signal
10	Horn

Table 3, Clock Spring Connector

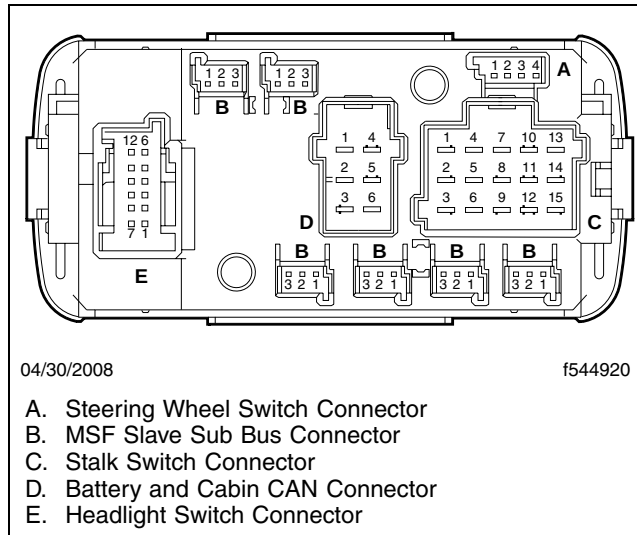


Fig. 4, MSF Master

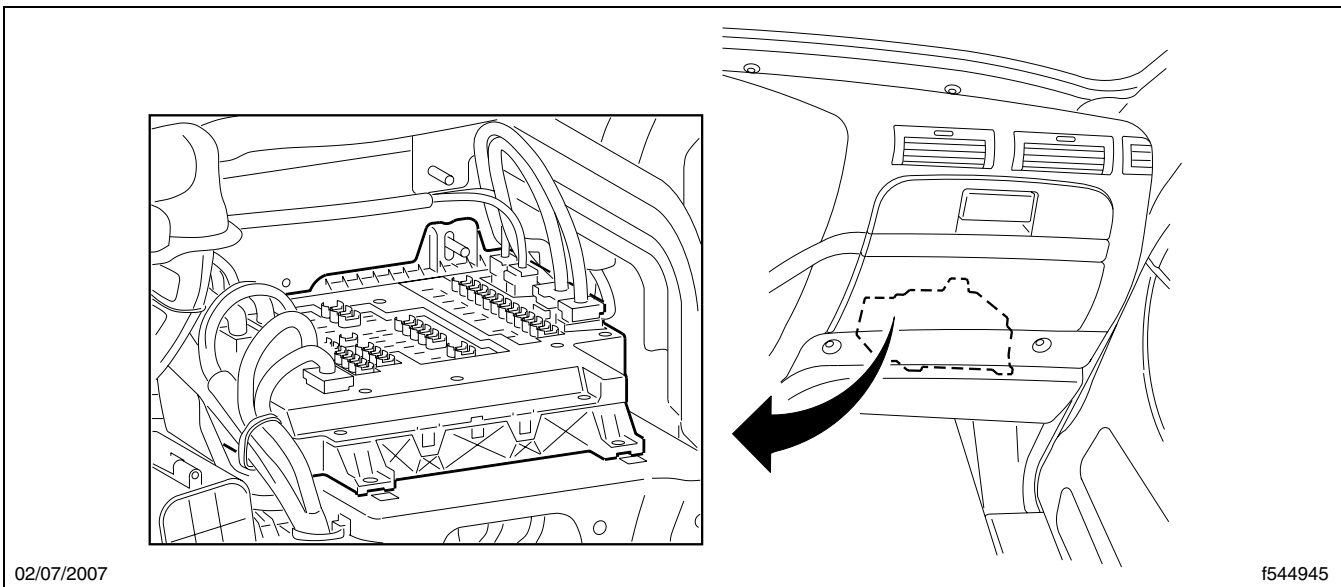


Fig. 5, SAM Cab

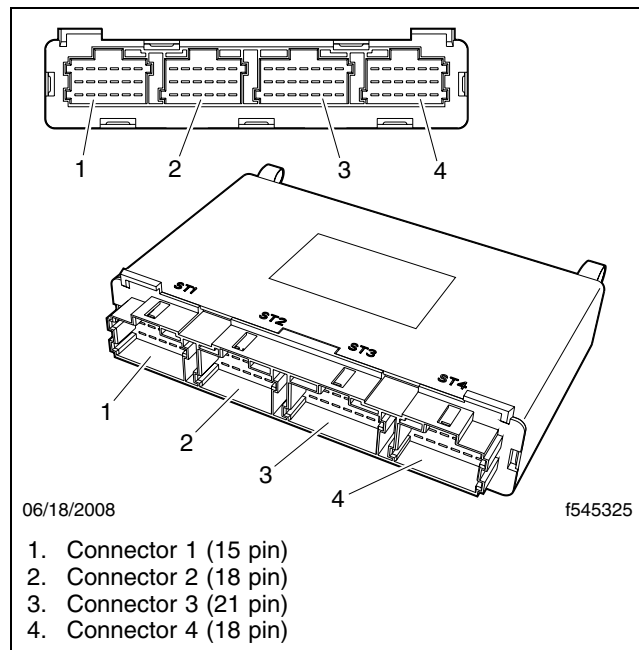


Fig. 6, Common Powertrain Controller

700 — Required Tools

- ServiceLink
- DDDL (Detroit Diesel and Mercedes engines)

701 — Possible Causes

- Incorrect parameter for the SAM Cab
- Incorrect parameter for the CPC
- Wiring, connections
- Switches

702 — Top of Clutch Switch

The top of clutch switch must be closed for the cruise control to engage. SAM Cab connector X11, pin 17 is the source of a 5 HZ square wave signal for the top of clutch switch. When the clutch is at the top of travel, this switch closes and the circuit is grounded through pin 16 of the same connector. Open the ServiceLink template titled "Cascadia Cruise Control" to view the status of the top of clutch switch.

703 — Fault Codes

CAN Fault Codes							
SA	SPN	FMI	Conn/Pin	Fuse	Relay	Description	Details
49	520203	3	conn A, pin 1 conn A, pin 3	—	—	Steering wheel switch circuit S2 or S1, voltage above normal or open circuit	The voltage present at the MSF is higher voltage than expected. This circuit could be open or shorted to a high source.
Action: Use the ServiceLink "Steering Wheel Switches" template to monitor for any activity on the steering wheel switches. Connect an oscilloscope, scope meter, or use the Midtronics 1000 HD in scope mode to observe this signal. The MSF produces a square wave signal on this circuit. When any of the steering wheel switches are pressed, the peak voltage of this signal is reduced. Each of the four switches reduce it by a different level. Continue to check the signal through the clockspring in the steering wheel up to the switches to locate the open circuit. This circuit continues as the blue wire in the steering wheel switches.							
49	520203	4	conn A, pin 1	—	—	Steering wheel switch circuit S2, voltage below normal or shorted to ground	The signal received at the MSF is lower voltage than expected. This circuit could be shorted to ground.
Action: Connect an oscilloscope, scope meter, or use the Midtronics 1000 HD in scope mode to observe this signal. The MSF produces a square wave signal on this circuit. The signal detected at the MSF is too low of peak voltage to be valid. Disconnect connector A and test for a short to ground or a short between pins 1 and 3. Continue to check the signal through the clockspring in the steering wheel up to the switches to locate the short circuit. This circuit continues as the blue wire in the steering wheel switches.							

Table 4, CAN Fault Codes

704 — 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?

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

NOTE: These parameters are only available for Detroit™ engines.

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 5, Parameters

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700
Diagnostic Tests	701
PCC Message Not Received (SA 0, SPN 524287, FMI 9)	702
PCC Device Reporting Error (SA 0, SPN 524287, FMI 19)	703
CPC Timeout (SA 17, SPN 639, FMI 2)	704
No GPS Data (SA 17, SPN 841, FMI 2)	705

Specifications

System Schematic	800
Fault Codes	801
Parameters	802

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 1.25 miles (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 interaction required from the driver. 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 antenna. The controller interacts with the CPC using proprietary J1939 messages to control vehicle speed and monitor parameter information.

Predictive Cruise Control status is displayed on an LCD display contained in a 2-inch (50-mm) diameter gauge located on the auxiliary dash panel.

600 — Component Locations

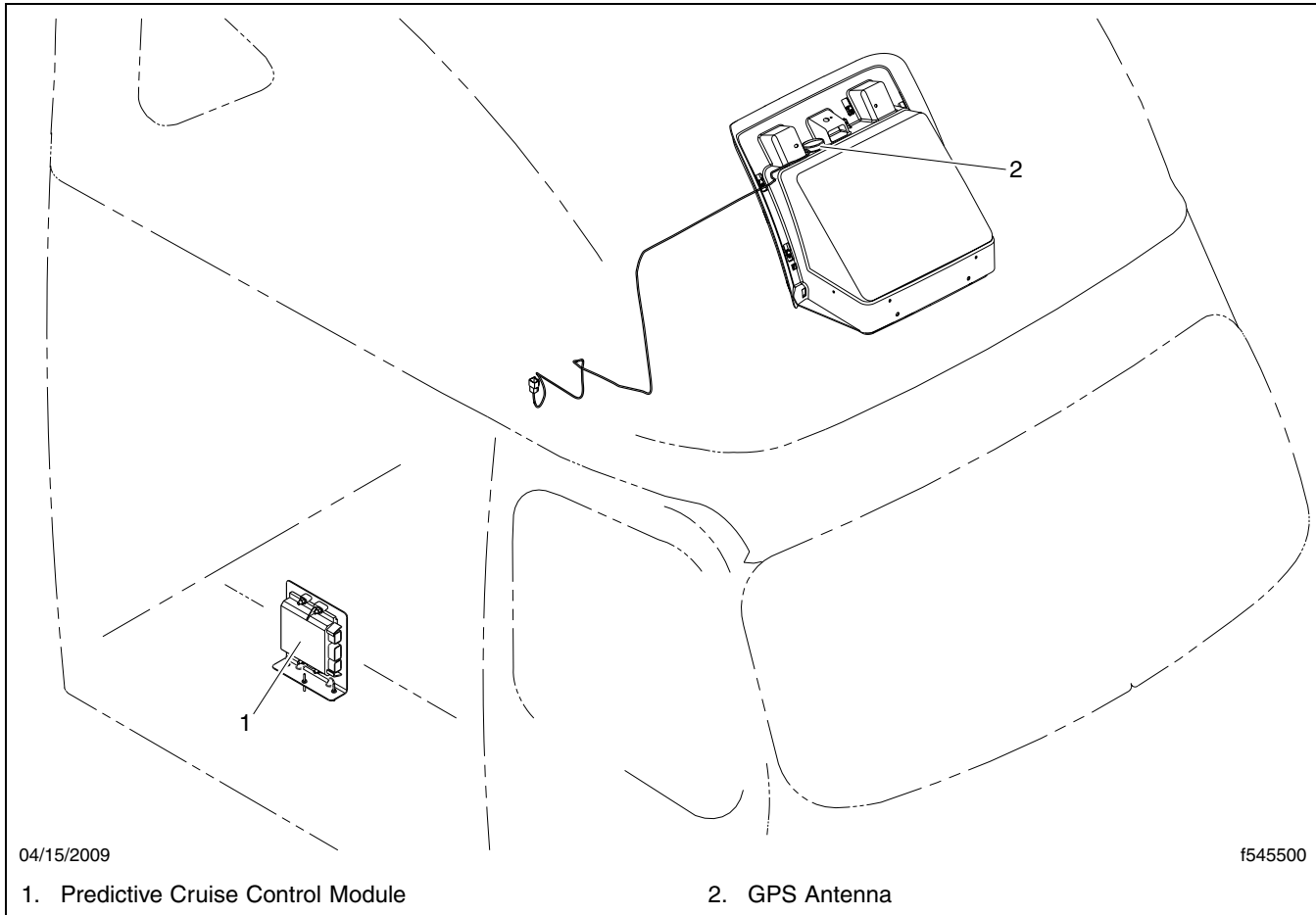


Fig. 1, Component Locations

601 — Component Details

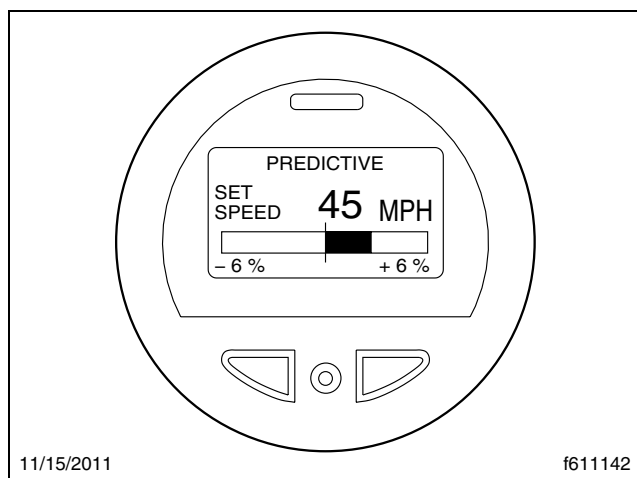


Fig. 2, Predictive Cruise Control Gauge

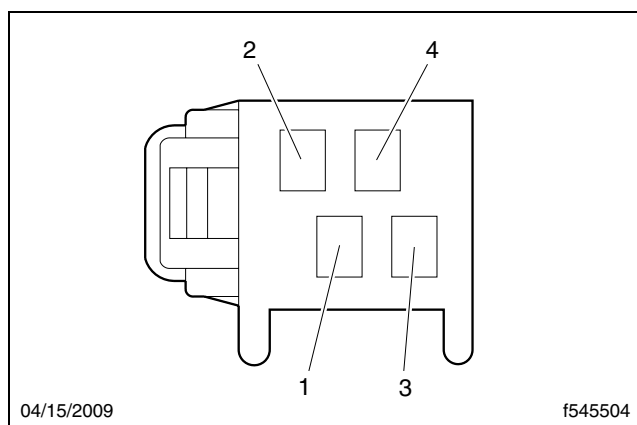


Fig. 3, Wire-Insertion View of the GPS Antenna

GPS Antenna Connector		
Pin	Circuit	Description
1	250XV	5V Supply to Antenna
2	250XG	Antenna Ground
3	250XT	Antenna TX
4	250XR	Antenna RX

Table 1, GPS Antenna Connector

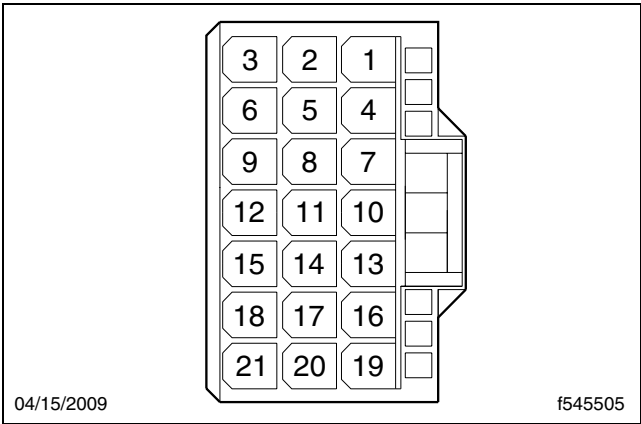


Fig. 4, SAM Cab, X11

SAM Cab, X11		
Pin	Circuit	Description
18	GND	Ground, general, cab/chassis
19	250XS	PCC, Power through Fuse F18

Table 2, SAM Cab, X11

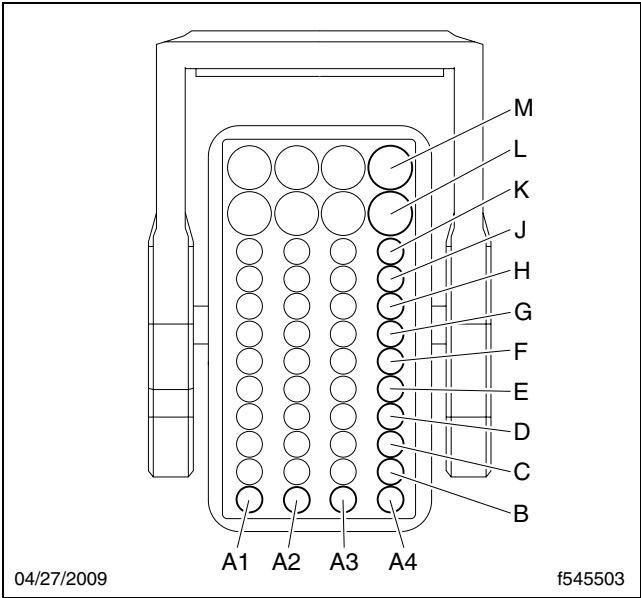


Fig. 5, Predictive Cruise Control Module, Connector J2

Predictive Cruise Control, Connector J2		
Pin	Circuit	Description
A3	250XR	PCC, Antenna RX
B3	250XT	PCC, Antenna TX
H1	1939+	J1939 datalink (+)
H2	1939–	J1939 datalink (–)
L1	81C	Ignition
L3	250XG	PCC, Antenna GND
M1	GND	Ground, general, cab/chassis
M2	250XS	Battery, power
M4	250XV	PCC Antenna, 5V power

Table 3, Predictive Cruise Control, Connector J2

Predictive Cruise Control Devices	
Device	J1939 Source Address
CPC – Common Powertrain Controller	0
PCC Module	17
Dash Display Gauge	40

Table 4, Predictive Cruise Control Devices

The Run Smart Predictive Cruise label is displayed on the dash of Cascadia vehicles equipped with PCC. See Fig. 7.

700 — Diagnostic Tools required

- Digital Multimeter
- ServiceLink
- Detroit Diesel Diagnostic Link

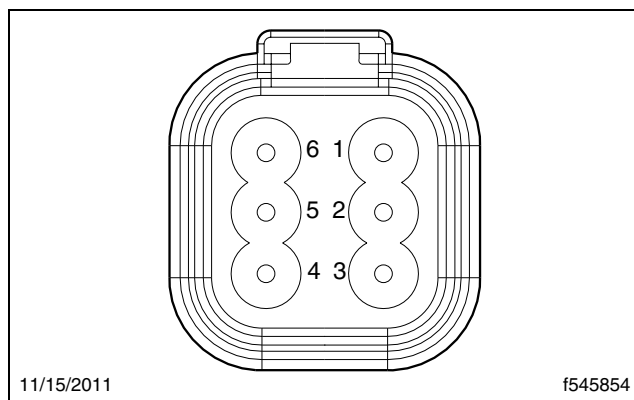


Fig. 6, PCC Gauge Connector



Fig. 7, PCC Label

Refer to module 149 for applicable wiring drawings.

701 — Diagnostic Tests

Verify that the batteries are fully charged, all ECU connectors are securely fastened, and SAM Cab fuse F18 has continuity.

1. Connect the communication adaptor to the vehicle diagnostic adaptor.
2. Connect to the vehicle with ServiceLink using J1939.
3. Review the General Info screen for missing ECUs.
4. Load the Fault screen, and review the list for active faults.

702 — PCC Message Not Received (SA 0, SPN 524287, FMI 9)

When the CPC CC_Mode_Selection parameter is set with Predictive Cruise Control enabled, the CPC expects to receive messages from the PCC module when the ignition switch is in the ON position. If messages are not received for approximately 1 minute, the CPC will activate this fault.

If the vehicle is equipped with the On-Guard headway system, it is likely that there will also be multiple faults from the headway system SA 42. Troubleshoot and repair the Predictive Cruise Control SPN 524287 fault first then clear all fault codes and cycle ignition power.

1. Disconnect connector J2 at the PCC module and with the ignition switch in the ON position, check for power as follows:
 - Ignition power on pin L1. This circuit is sourced through dash splice pack circuit 81C.
 - Battery power on pin M2. This circuit is sourced through the SAM Cab fuse F18.
 - Ground on pin M1

Repair any wiring faults found then clear fault codes. Otherwise continue troubleshooting.

2. Turn the ignition switch OFF and disconnect the batteries. Measure the resistance of the J1939 datalink at the PCC module connector J2 on pins H1 and H2. Compare the resistance to the following and repair the databus as appropriate. If there is no databus fault, replace the PCC module.
 - $60 \pm 6 \Omega$: The J1939 wiring is intact and both terminating resistors are installed.
 - $120 \pm 12 \Omega$: There is a terminating resistor missing. 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 Ω : There is a short between J1939+ and J1939– somewhere on the datalink.
- 1000 Ω or greater: There is an open circuit between the J1939 connector on the PCC module and the J1939 backbone or both terminating resistors are missing or open.

703 — PCC Device Reporting Error (SA 0, SPN 524287, FMI 19)

When the CPC CC_Mode_Selection parameter is set with Predictive Cruise Control enabled, the CPC uses information from the PCC module when the ignition switch is in the ON position. If the PCC module determines that it has an internal error, it will broadcast that it is in an error state and/or that the information that it normally would broadcast is not available. The CPC will activate this fault to draw attention to the error with the PCC module.

The CPC will also set this fault when the last 3 messages from the PCC module within a 300ms period are not contiguous or if the PCC status 1 message is not received within 300ms.

This fault could be set due to high J1939 data bus traffic load or an intermittent condition somewhere on the databus interrupting messaging. It can also be caused by the PCC module itself detecting an internal error condition that requires replacement of the PCC module.

704 — 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 and battery power switched off or disconnected, measure the resistance at PCC connector J2-H1 and J2-H2. Compare results.
 - 60 $\pm$ 6 Ω : The J1939 wiring is intact and both terminating resistors are installed.
 - 120 $\pm$ 12 Ω : There is a terminating resistor missing or a short present. Check the resistance across the terminating resistors.
 - 40 $\pm$ 4 Ω : 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 $\pm$: There is a short between J1939+ and J1939– somewhere on the datalink.
 - Resistance is greater than 1000 Ω : 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.
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.

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.

11/15/2011

Ref. Dia. G06-69575 Sheet 1 of 1 Chg. Ltr. A

f545853

Fig. 8, System Schematic

801 — Fault Codes

J1587 Fault Codes				
MID	SID	FMI	Fault Description	Fault Trigger
0	524289	9	Predictive Cruise Control Message Not Received	When the CPC parameter CC_Mode_Selection is set for Predictive Cruise Control, this fault will set when no messaging is received from the PCC module after 1 minute, when the ignition is in the ON position.
0	524287	19	Predictive Cruise Control Device Reporting Error	This fault will be set when: 1. The PCC reports that its "PCC state" is ERROR or Not Available. 2. The CPC has not received a "PCC status 1" message for 300ms. 3. The last 3 PCC messages received by the CPC are not contiguous.
17	639	2	CPC Timeout - No data received from the CPC	This fault will set when no messaging is received from the CPC for 20 seconds and the ignition is in the ON position.
17	841	2	No GPS Data	This fault will set when no data is received from the GPS antenna for 100 seconds and the ignition is in the ON position.

Table 5, J1587 Fault Codes

J1939 Fault Codes					
SA	SPN	FMI	Fault Description	Fault Trigger	Action
0	524287	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.	There is an error internal to the PCC module. Replace the PCC module.
0	524287	9	Predictive Cruise Control Message Not Received.	When the parameter in the CPC is set for predictive cruise control, the CPC will set this fault if no messaging is received for 1 minute when the ignition switch is in the ON position.	Troubleshoot for an open J1939 databus between the PCC module and the J1939 backbone. Also troubleshoot for battery, ignition power, and ground to the PCC module.
17	639	2	CPC Timeout (no connection to CPC or J1939 fault).	If CPC communication is not detected after 20 seconds, an active fault is set.	See 704 — 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 100 seconds, an active fault is set.	See 705 — No GPS Data (SA 17, SPN 841 FMI 2)

Table 6, J1939 Fault Codes

802 — Parameters

Parameters		
ECU	Parameter	Value
CPC2	PCC_Feature_Enable	0-Normal Cruise Control 1-Soft Cruise Enabled 2-Predictive Cruise/Normal Cruise as Backup 3-Predictive Cruise/Soft Cruise as Backup
CPC2	PCC_Eng_Brake_Mode	0-Overspeed with standard thresh 1-Overspeed 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 7, Parameters

System Overview

Terms and Abbreviations	500
General Information	501
Forward Looking Radar	502
Driver Interface Unit	503
Forward Looking Collision Warning System	504
Side Object Detection	505
SmartCruise	506

Components

Component Locations	600
Component Details	601

Troubleshooting

J1939 Fault Codes	700
CAN Fault Codes	701

Specifications

Parameters	800

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.

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.

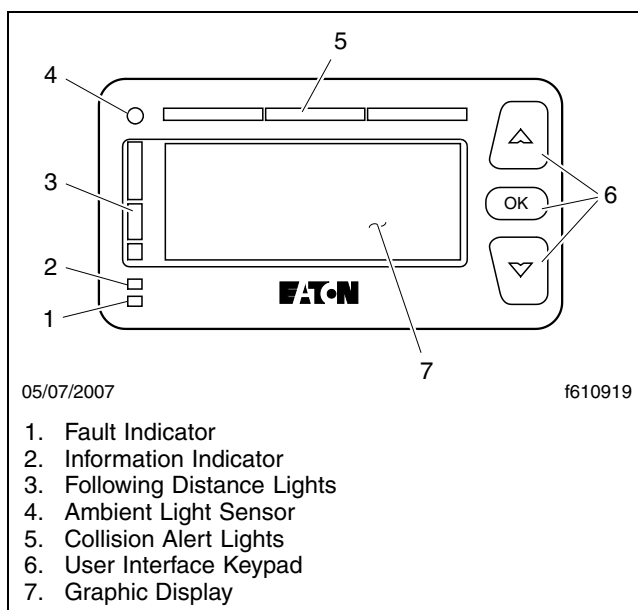


Fig. 1, Driver Interface Unit

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.

Object Detected

When an object is in the host vehicle's lane of travel, the VS-400 system displays the following message and tone:

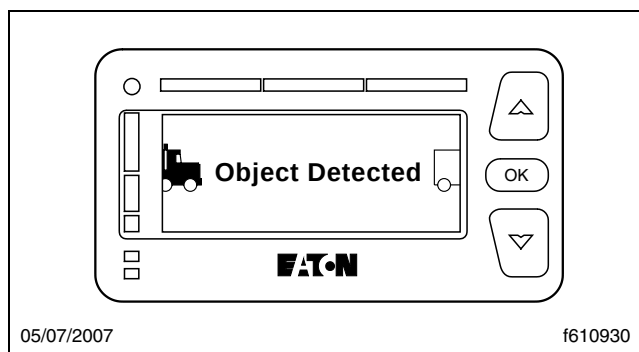


Fig. 2, Object Detected Message

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:

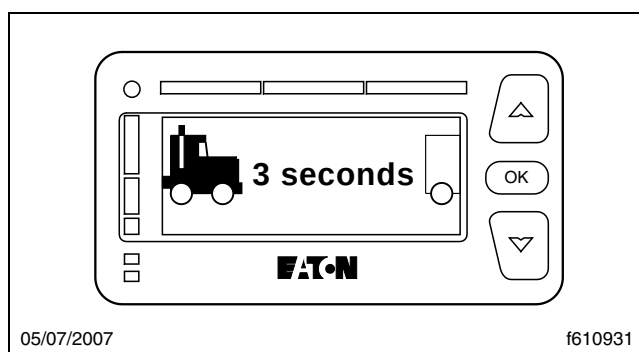


Fig. 3, Three Seconds Message

Tone Sequence: no tone is sounded.

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:

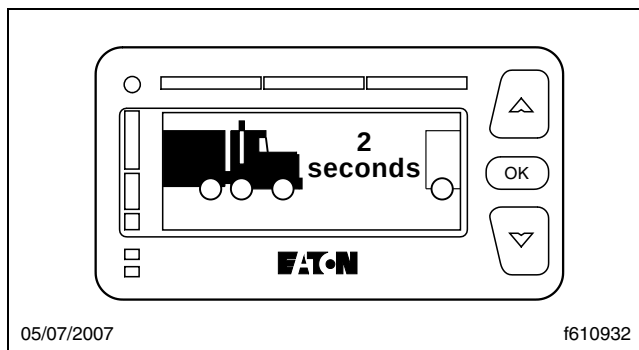


Fig. 4, Two Seconds Message

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.

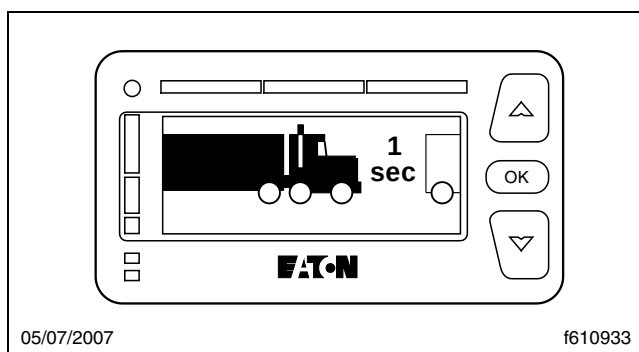


Fig. 5, One Second Message

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 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.

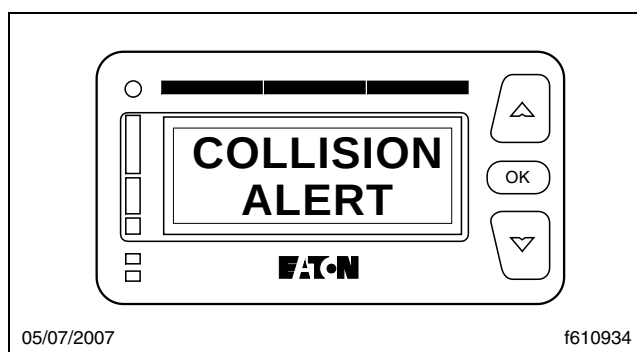


Fig. 6, 1/2 Second Message

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:

C08.03 VORAD Adaptive Cruise Control and Collision Warning System

- 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.

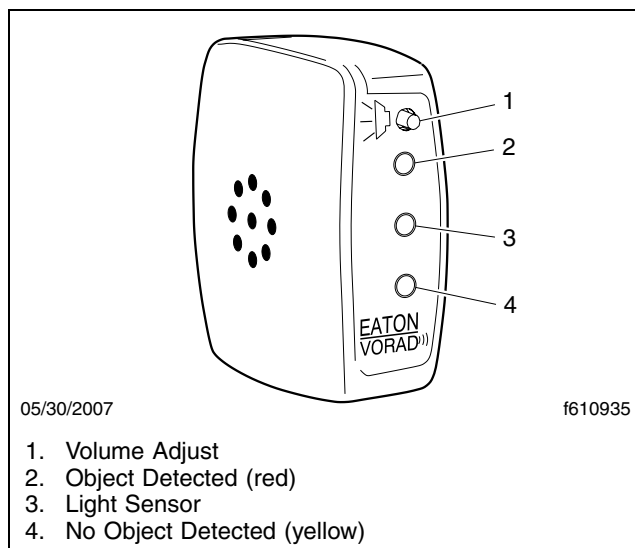
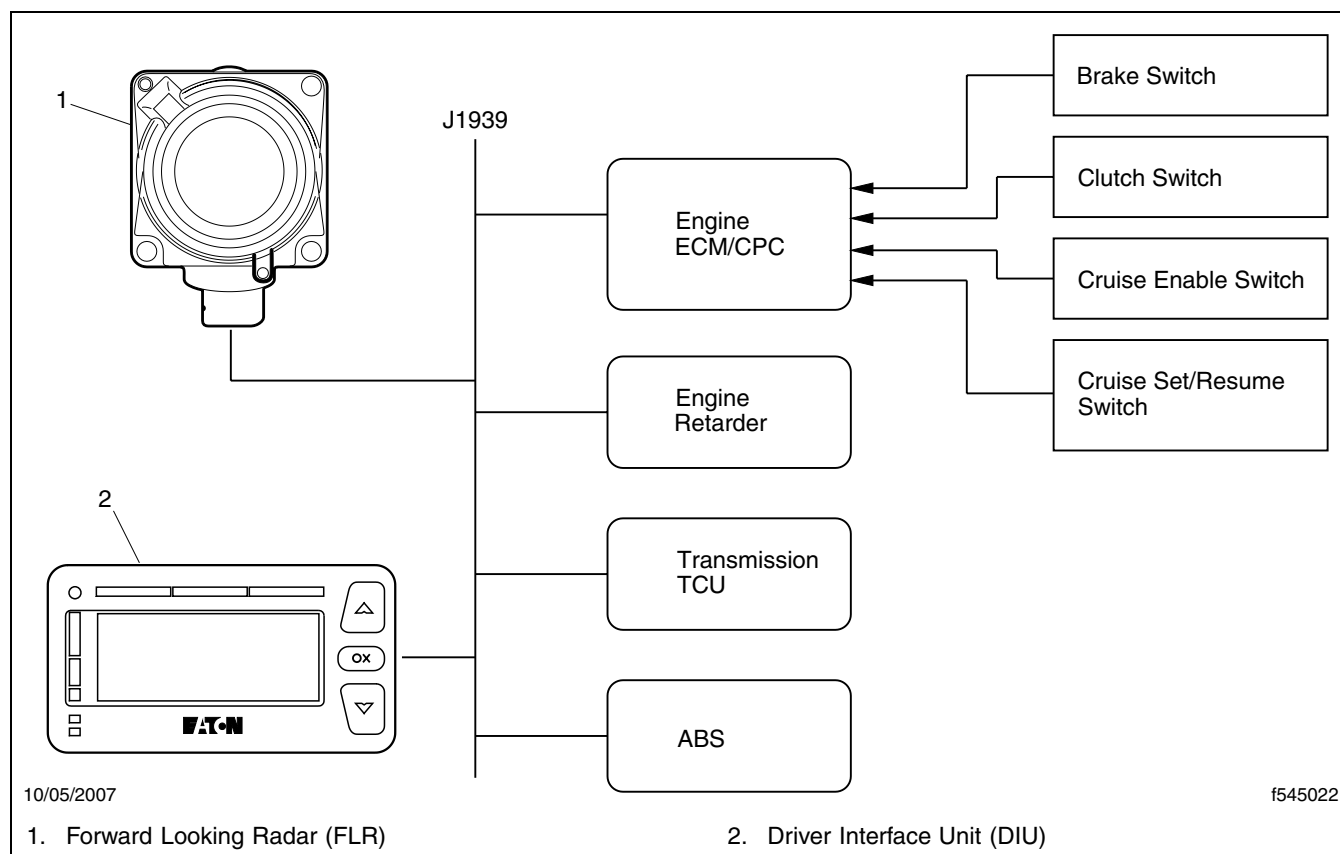


Fig. 7, Side Object Detection Module

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.

**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.

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:

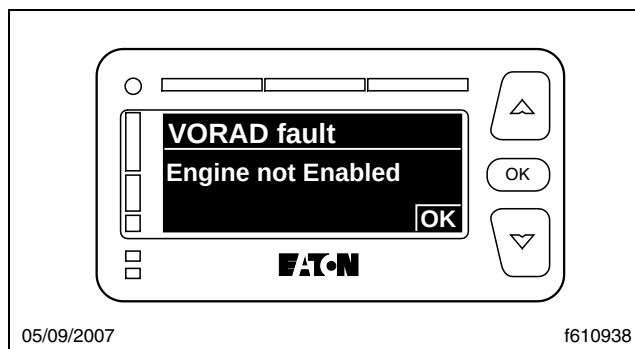


Fig. 9, Engine Not Detected

600 — Component Locations

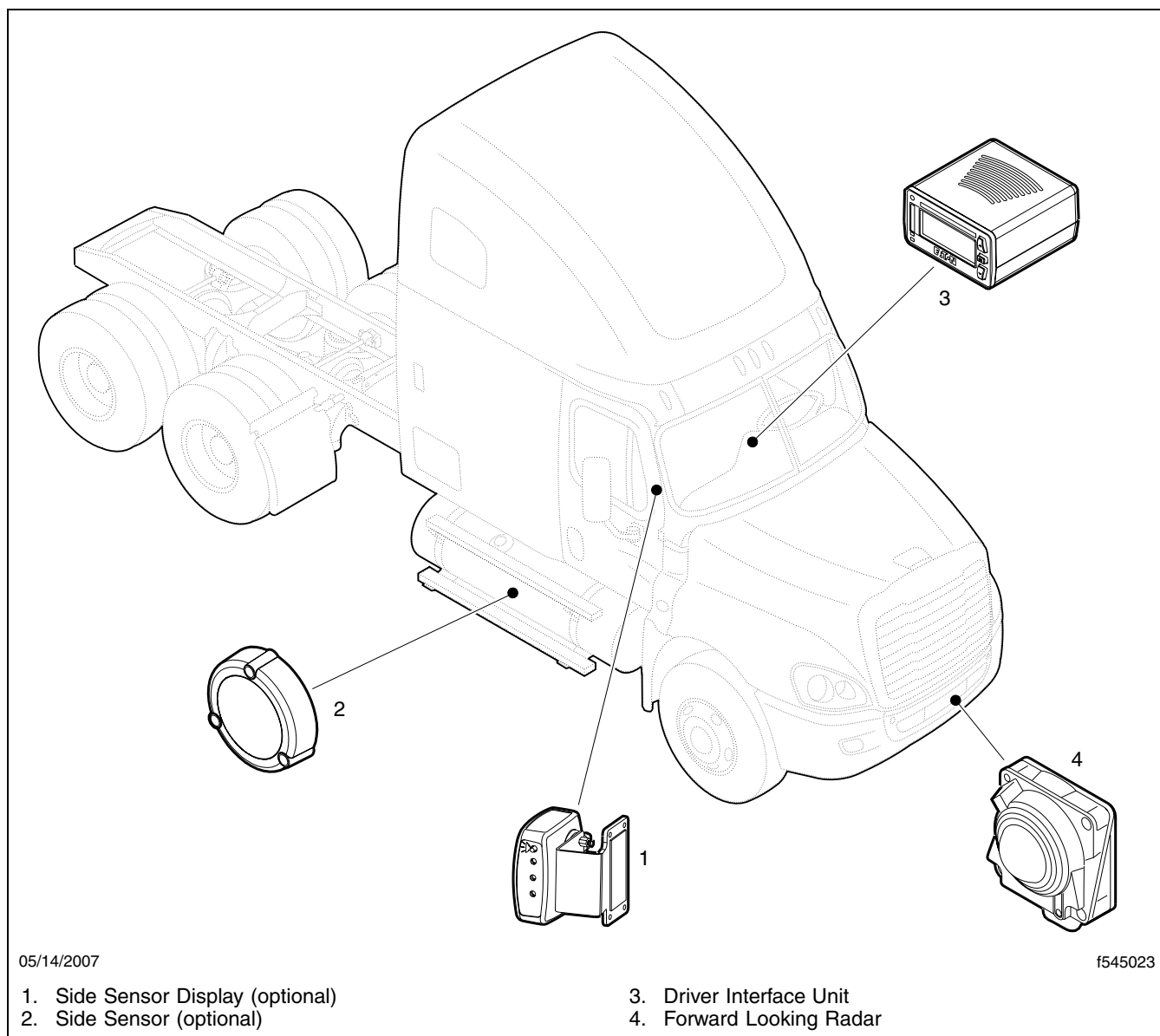


Fig. 10, Component Locations (exterior)

C08.03 VORAD Adaptive Cruise Control and Collision Warning System

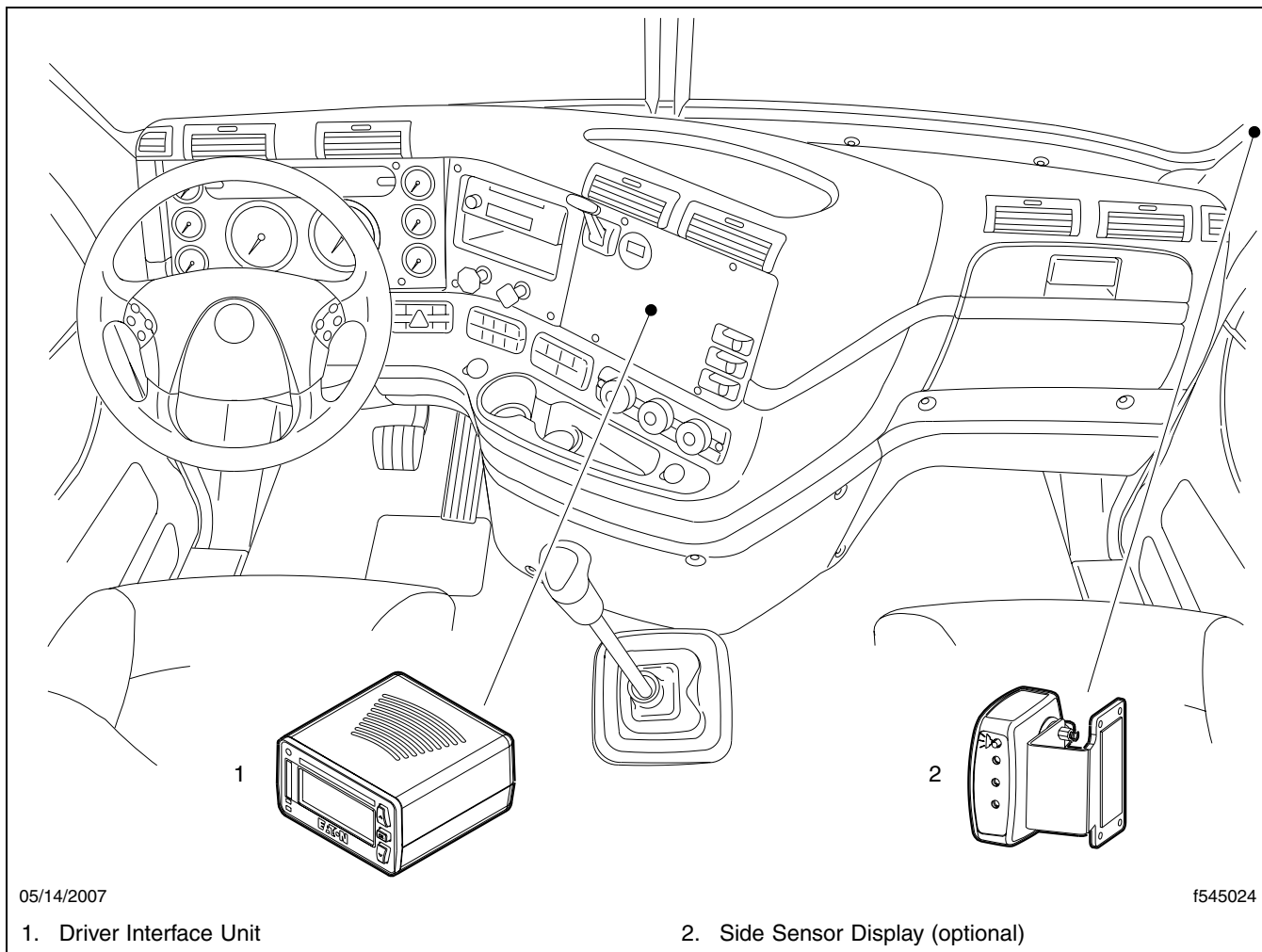


Fig. 11, Component Locations (interior)

601 — Component Details

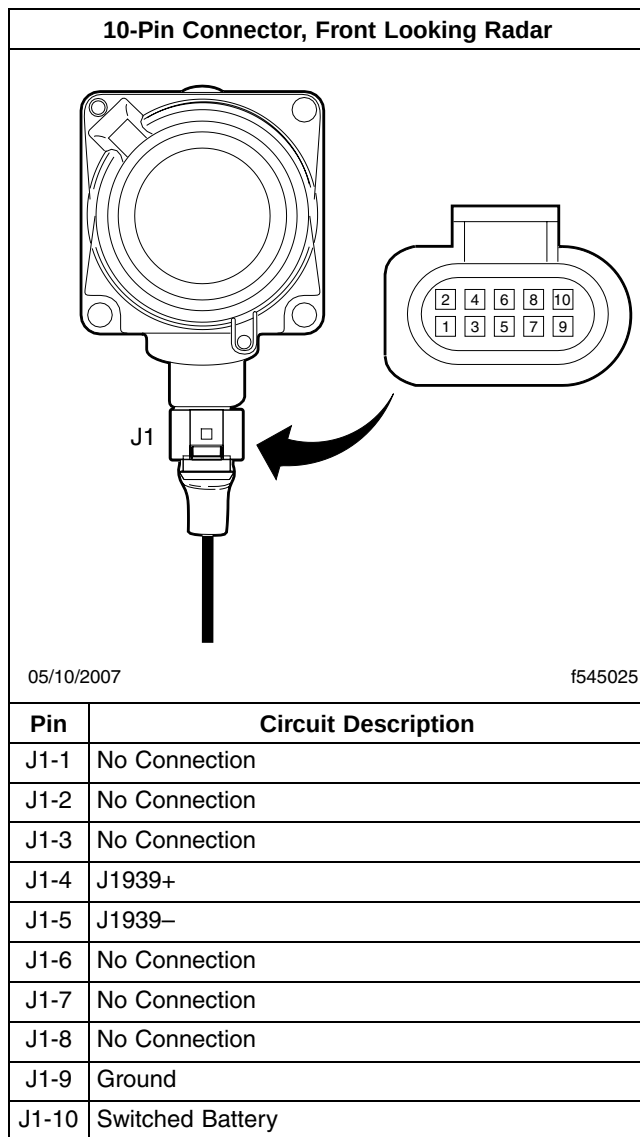


Table 1, 10-Pin Connector, Front Looking Radar

C08.03 VORAD Adaptive Cruise Control and Collision Warning System

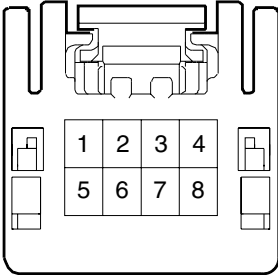
DIU 8-Pin Connector	
	
05/10/2007 f545027	
Pin	Circuit Description
J1-1	Right Speaker (optional)
J1-2	Left Speaker (optional)
J1-3	Not Used
J1-4	Switched Battery
J1-5	Ground
J1-6	J1939+
J1-7	J1939–
J1-8	Not Used

Table 2, DIU 8-Pin Connector

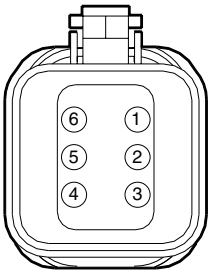
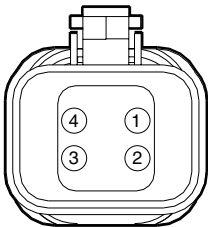
6-Pin Connector, Side Sensor	
	
05/10/2007 f545028	
Pin	Circuit Description
J2-1	Ignition (12V switched)
J2-2	Ground
J2-3	Communication (to side sensor display)
J2-4	Power (to side sensor display unit)
J2-5	Side Object Detector Display Unit Signal Ground
J2-6	No Connection

Table 3, 6-Pin Connector, Side Sensor

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 configure properly.	
886	42	14	FLR blocked.	
893	140	12	DIU internally defective.	

C08.03 VORAD Adaptive Cruise Control and Collision Warning System

J1939 Fault Codes				
SPN	SA	FMI	Fault Description	Fault Trigger
898	42	13	Engine not configure for SmartCruise operation.	Tested only if SC configure
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 configure
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.

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

System Overview

Terms and Abbreviations	500
General Information	501

Components

Component Locations	600
Component Details	601

Troubleshooting

Diagnostic Tools Required	700
Possible Causes	701
Diagnostic Tests	702

500 — Terms and Abbreviations

CNG—Compressed Natural Gas

Cryogenic—Very cold temperatures

LNG—Liquified Natural Gas. Natural gas cooled to below approximately -259°F (-162°C).

NG—Natural Gas. A hydrocarbon gas mixture consisting primarily of methane.

501 — General Information

WARNING

As with all pressure vessels, CNG/LNG storage and fuel delivery systems are inherently dangerous and should be treated as such. Beyond basic visual inspections, all maintenance and repairs to compressed natural gas (CNG) or liquified natural gas (LNG) systems should be performed by trained personnel. Individuals who are not trained in all aspects concerning CNG/LNG fuel delivery systems are not permitted to service, maintain, test, or inspect a system in any way. Failure to comply with safety regulations may lead to fire or explosion, resulting in property damage, personal injury, or death.

CNG

IMPORTANT: The compressed natural gas (CNG) fuel system should be routinely inspected for gas leakage per the fuel management system (FMS) manufacture's and the engine manufacture's instructions. Use a natural gas detector to check fuel cylinders, fuel filtering and regulating mechanisms, and fuel lines. Replace or repair any component that is leaking per the manufactures procedures.

CNG is made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. When vaporized at ambient temperatures, natural gas is less dense than air, and it will rise and disperse. Cold atmospheric conditions may prevent natural gas from disbursing quickly when released in large amounts.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

Commercial CNG normally contains an odor-producing chemical. However, a natural gas detector, or an approved natural gas leak checking solution, is recommended for leak checking.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

The CNG fuel system consists of:

- Fuel cylinders that store CNG at high pressure
- Pressure relief and manual fuel shutoff valves
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line
- A high-pressure fuel filter
- A pressure control regulator that reduces the high fuel cylinder pressure to the lower pressure needed for the engine
- A gas-air mixer to produce a flammable mixture for the engine
- A dash-mounted fuel contents gauge that indicates the available fuel supply in the cylinders

LNG

LNG is created by condensing natural gas into a liquid by cooling it to approximately -259°F (-162°C). When vaporized at ambient temperatures, natural gas is less dense than air, and it will rise and disperse. Cold atmospheric conditions may prevent natural gas from disbursing quickly when released in large amounts.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

The LNG fuel system consists of:

- A fuel tank that stores LNG at an extremely low temperature
- Pressure relief and manual fuel shutoff valves
- A vaporizer or heat exchanging device that changes LNG to gaseous form
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line
- A pressure control regulator that reduces the high fuel tank pressure to the lower pressure needed for the engine
- A gas-air mixer to produce a flammable mixture for the engine
- An economizer, or pressure control regulator, that opens at pressures above 120 psi (827 kPa) to reduce pressure in the fuel tank
- A dash-mounted fuel contents gauge that indicates the fuel supply in the tank

If a natural-gas-fueled vehicle is involved in an accident and the fuel tank is damaged, remove the tank from service and have it inspected and repaired by the tank manufacturer. Repair or replace any damaged or leaking fuel lines, fittings, or other components. Install parts and components in accordance with the manufacturer's instructions.

600 — Component Locations



Fig. 1, Natural Gas Detection System Components

601 — Component Details

Leak Detection Control Panel

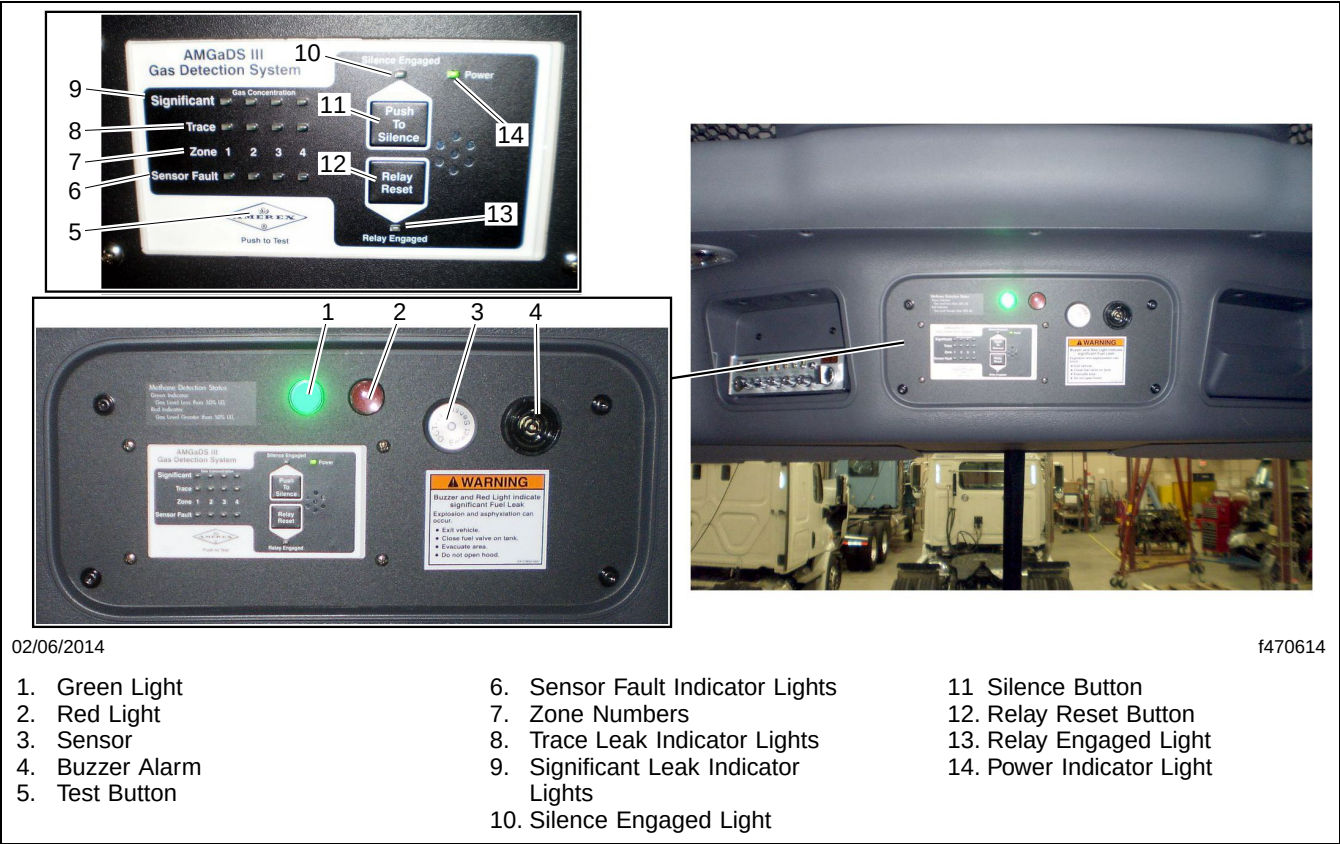


Fig. 2, Leak Detection Control Panel

The lights and buzzers on the panel indicate the condition of the system. The panel also holds the zone 1 sensor.

Sensor

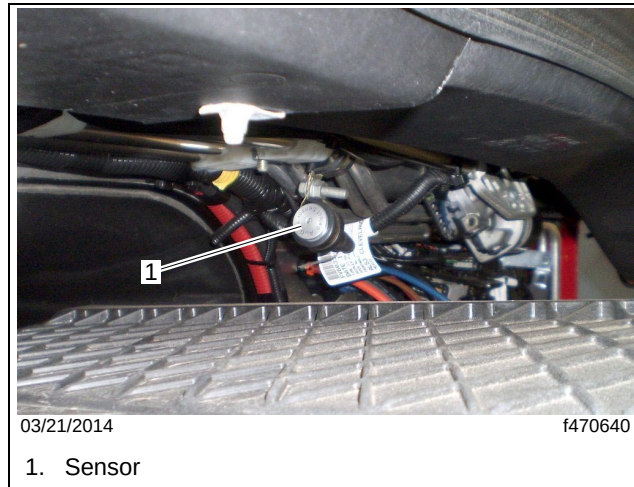


Fig. 3, Sensor, Engine Compartment

The sensors detect the presence of natural gas near their location. Sensors are located in the cab, sleeper if equipped, and in the engine compartment on the frontwall.

Harness

Wiring connecting the control panel to the sensors.

700 — Diagnostic Tools Required

Qualified personnel will need the following tools to safely perform troubleshooting on the natural gas system.

- Digital multimeter
- Electronic methane leak detector
- Approved natural gas bubble solution
- Protective clothing and equipment for cryogenic (LNG) and high pressure (CNG) systems

701 — Possible Causes

- Damaged or contaminated sensor
- Damaged wiring
- Inoperative main panel
- Low or no voltage to the system
- Leaks in the system

702 — Diagnostic Tests

Methane Detection System

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 83.04, 100 of the *Cascadia Workshop Manual* before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

The Cascadia is equipped with a four-zone natural gas detection system. Only three zones are normally used. Gas detection sensors are located on the cab overhead console (zone 1), in the engine compartment on the frontwall (zone 2), and in the sleeper, if equipped (zone 3). The sensors are located in high areas, where rising gas vapors will pass by or accumulate. On some vehicles, there is a sensor located under the cab floor (zone 4). Zone 4 is not used on DTNA vehicles. The system is powered directly from the vehicle batteries and is active at all times, unless the batteries are disconnected. When the system has power, and is operating normally with all sensors confirmed operational, and no leaks detected, the green "Power" LED, and the large green light are on. When the presence of gas is detected in any zone, an indicator LED will illuminate depending on the level of gas detected. If a problem with a sensor or wiring occurs, a "Fault" LED will illuminate for the zone that is affected. When a fault is present, no detection is operational in that zone. The following diagnostic tests show all the different possible light combinations, what they indicate, the troubleshooting procedures, and the suggested remedy. For vehicle-specific wiring diagrams, refer to G06-89262 (page 2) in EZWiring.

IMPORTANT: Before performing any troubleshooting, allow the system 60 seconds to complete the initialization process.

Green "Power" and Large Green LED On

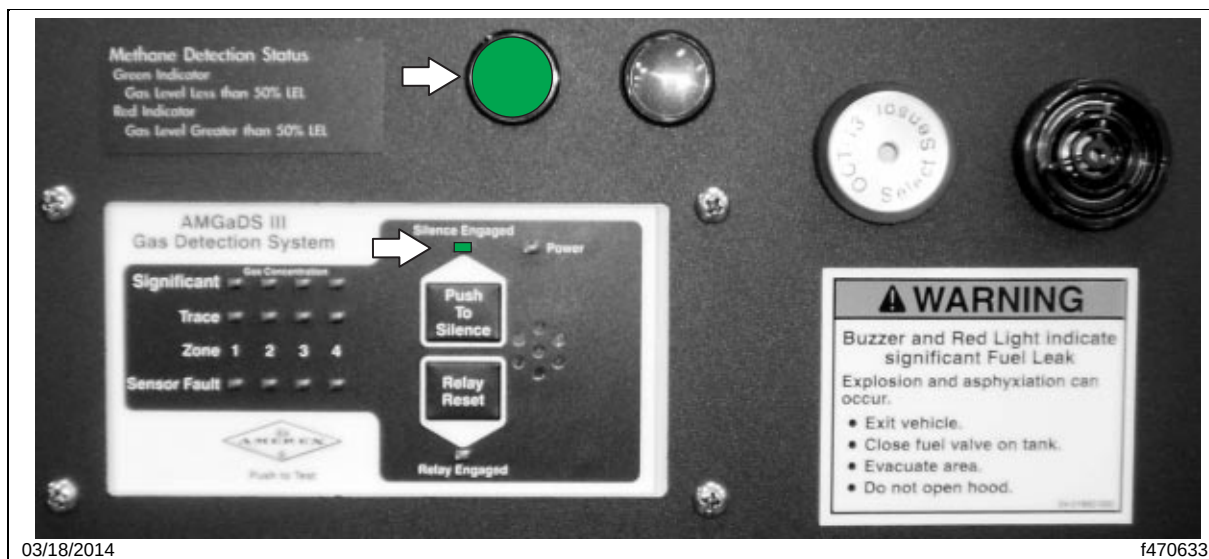


Fig. 4, Green "Power" and Large Green LED On

When only the green "Power" LED on the main panel and the large green LED are on, the system has power and is operating normally. In this state the panel and all sensors are confirmed operational.

No Lights on Front Panel

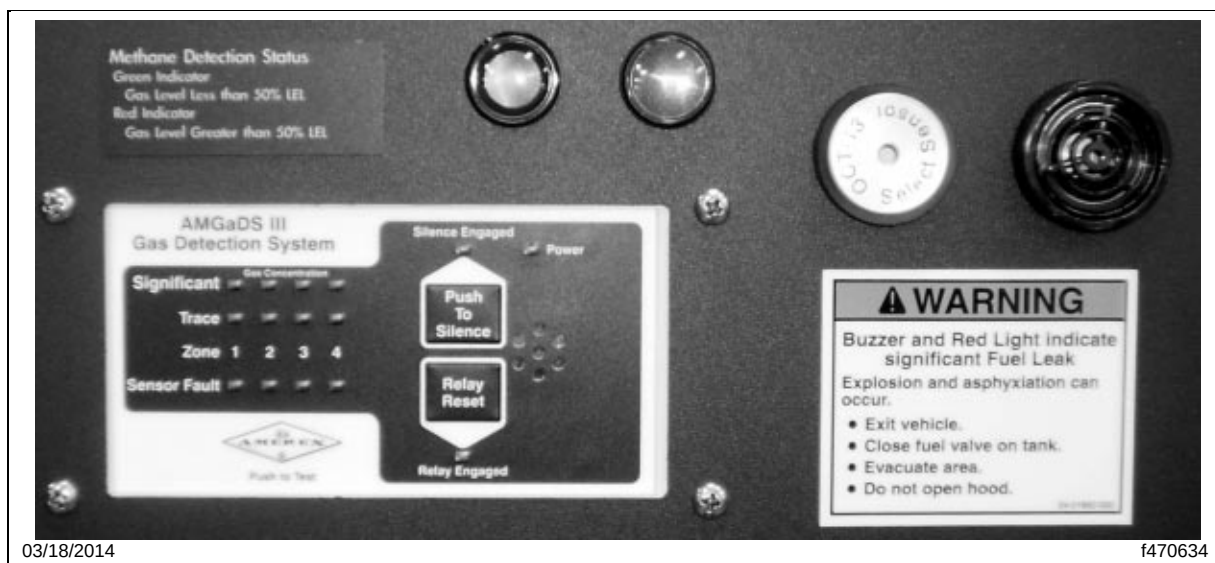


Fig. 5, No Lights on Front Panel

The panel has no power. No gas detection or warning is possible.

Are all of the connectors plugged in at the back of the panel?

YES → Go to the next step.

NO → Plug in the connector. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

Is there power (9-14 vdc) and ground at the panel?

YES → Replace the panel.

NO → Go to the next step.

Check the terminal on the back of the panel for loose or improperly installed pins. Were there any bad pins?

YES → Repair and go to the next step. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Is the fuse blown or missing at the power-net distribution box (PNDB)?

YES → Replace the fuse. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Does the circuit have continuity or high resistance?

YES → If it has continuity, and still has no power, go to PNDB troubleshooting.

NO → If there is no continuity, or high resistance go to the next step.

Check the connectors at the fire wall and PNDB. Have any of the cables been pinched, cut, or damaged?

YES → Replace the damaged cable(s).

NO → Contact the vendor.

Amber "Sensor Fault" Light On

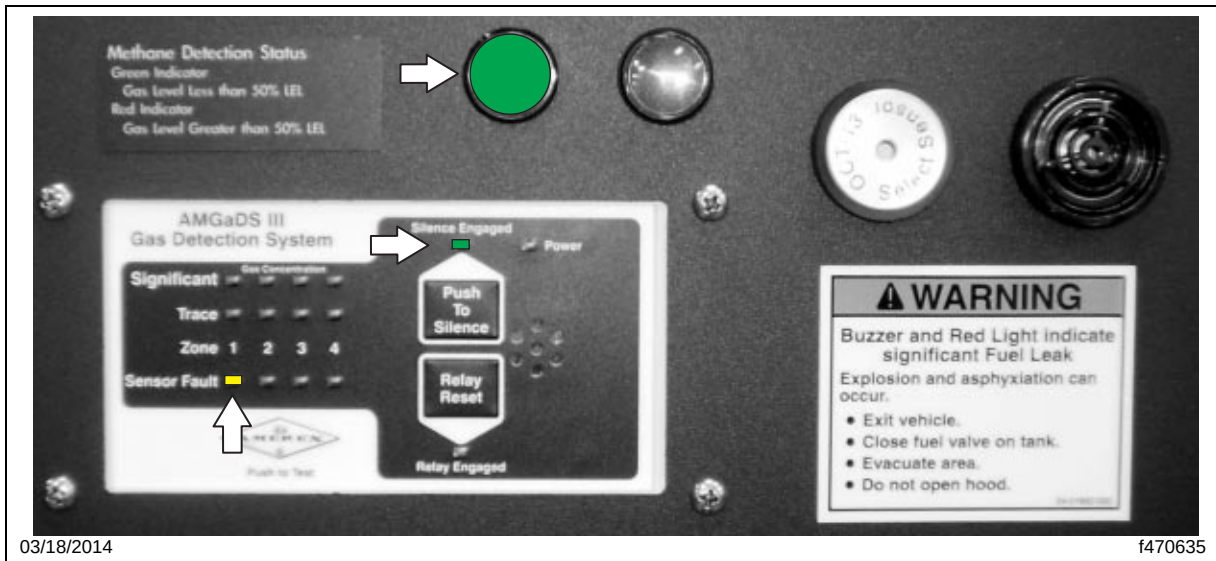


Fig. 6, Amber "Sensor Fault" Light On

The amber "Sensor Fault" light indicates that there is a problem in the zone specified. When a fault light is on, detection is not possible in any zones where a fault is present.

Check the sensor connections at the back of the panel and at the sensors. Are the connectors loose or damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Check the pins in the connectors on the panel and in the sensors. Are the pins loose or damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

If both "Sensor Fault" lights are on, skip this step and proceed to the next step. Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?

YES → If the fault moves with the cable, proceed to the next step.

NO → If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

Check for continuity in the harness. Is there high resistance in the sensor harness?

YES → Replace the harness.

NO → Replace the sensor, unless it is both, then replace the panel.

Amber "Trace" Light Flashing

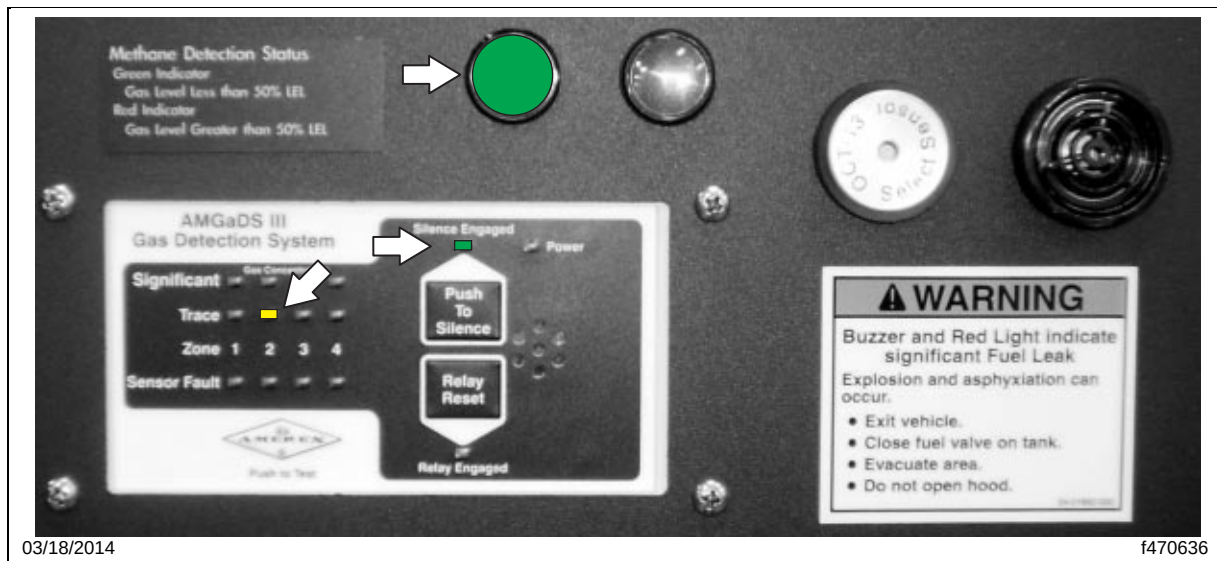


Fig. 7, Amber "Trace" Light Flashing

The flashing amber "Trace" light indicates that a trace amount of gas (greater than 20% and less than 50%) has been detected in the specified zone.

Using an approved NG testing method, check all fuel fittings and fuel lines for leaks. Verify that pressure relief devices are not venting or leaking. Is there a gas leak?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.

YES → Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Check the connectors and pins on the panel and sensors. Are they damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?

YES → If the fault moves with the cable, proceed to the next step.

NO → If it stays, replace the panel. If the problem is resolved, no further work is needed.

Check continuity and resistance in the sensor harness. Is the harness good?

YES → Replace the sensor.

NO → Replace the harness.

WARNING

The following tests should only be performed after determining that it is safe to do so.

Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.).

Have the problem repaired by qualified personnel before further operation of the vehicle.

Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the non-presence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.

Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzer 1

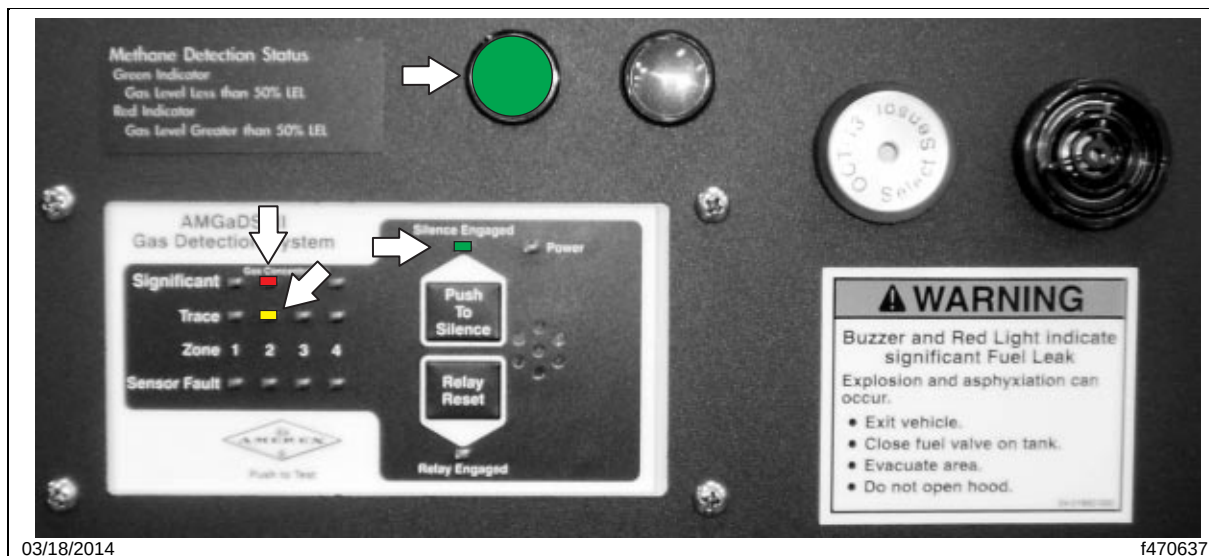


Fig. 8, Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzer 1

The red "SIGNIFICANT" light and amber "Trace" lights and buzzer 1 indicate that a significant level of combustible gas (greater than 50% lower explosive limit [LEL]) has been detected in the applicable zone.

Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.).

Have the problem repaired by qualified personnel before further operation of the vehicle.

Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the nonpresence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.

Is the "Amerex Push to Test" button being held?

YES → Let go.

NO → Go to the next step.

Using an approved NG testing method, check all fuel fittings and fuel lines for leaks. Verify that pressure relief devices are not venting or leaking. Is there a gas leak?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.

YES → Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Check the connectors and pins on the panel and sensors. Are they damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed.

NO → Go to the next step.

Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?

YES → If the fault moves with the cable, proceed to the next step.

NO → If it remains illuminated, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

Check continuity and resistance in the sensor harness. Is the harness good?

YES → Replace the sensor.

NO → Replace the harness.

Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzers 1 and 2

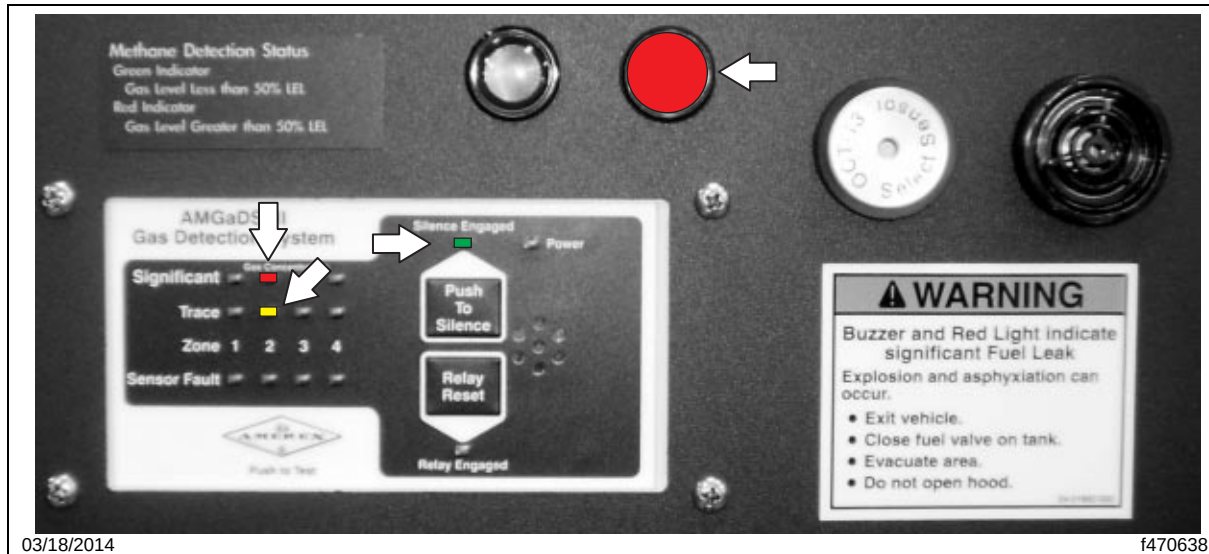


Fig. 9, Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzers 1 and 2

The red "Significant" light and amber "Trace" lights along with buzzers 1 and 2 indicate that a significant level of combustible gas (greater than 50% LEL) has been detected in the applicable zone. Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.). Have the problem repaired by qualified personnel before further operation of the vehicle. The large red LED and buzzer 2 indicates the significant gas detection has been present for over 15 seconds and the relay has engaged. Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the nonpresence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.

Is the "Amerex Push to Test" button being held and has it been held continuously for 15 seconds causing the relay to trip?

YES → Release the button, and press the "Shutdown/Reset" button to reset the relay. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Using an approved NG testing method, check all fuel fittings and fuel lines for leaks. Verify that pressure relief devices are not venting or leaking. Is there a gas leak?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.

YES → Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Check the connectors and pins on the panel and sensors. Are they damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed.

NO → Go to the next step.

Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?

YES → Repair as needed. If the problem is resolved, no further work is needed.

NO → If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

Check continuity and resistance in the sensor harness. Is the harness good?

YES → Replace the sensor.

NO → Replace the harness.

Red "Relay Engaged" LED, Large Red LED, and Buzzer 2

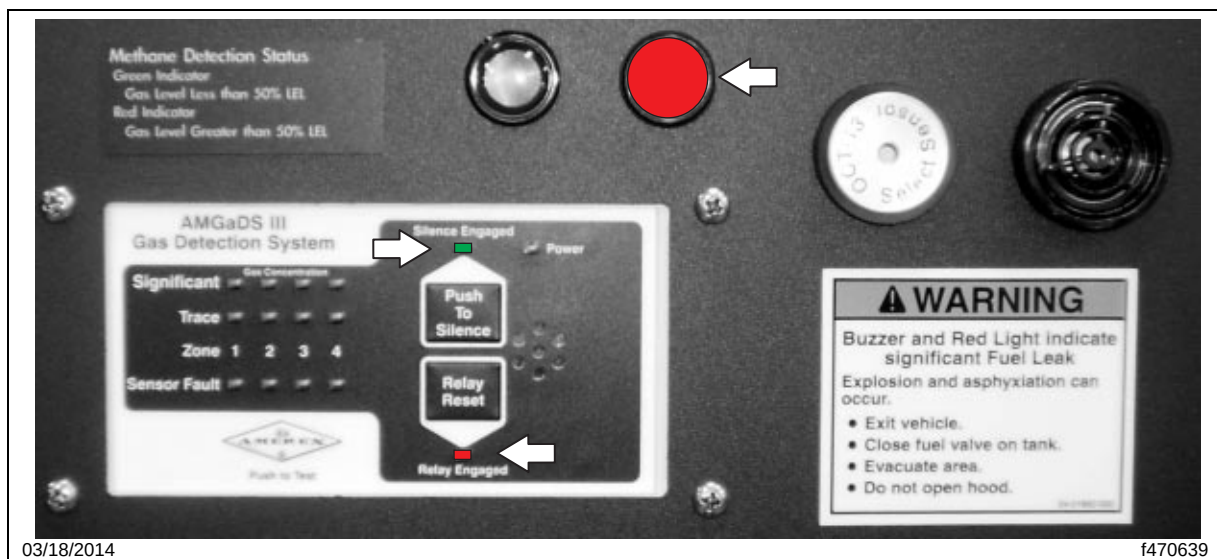


Fig. 10, Red "Relay Engaged" LED, Large Red LED, and Buzzer 2

The red "Relay Engaged" LED and the large red LED along with buzzer 2 indicates that a significant level of gas (greater than 50%) was detected at some point. The significant gas level is no longer present, as the "SIGNIFICANT" LED and "Trace" LED are no longer illuminated. The panel relay has engaged and must be reset by pressing the "Shutdown/ Reset" button. Do not troubleshoot the system until the reason for the significant alarm is understood.

Has the "Amerex Push to Test" button been pressed and held for 15 seconds causing the relay to trip?

YES → Press the "Shutdown/Reset" button. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Using an approved NG testing method, check all fuel fittings and fuel lines for leaks. Verify that pressure relief devices are not venting or leaking. Is there a gas leak?

YES → Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.

YES → Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

NO → Go to the next step.

Check the connectors and pins on the panel and sensors. Are they damaged?

YES → Repair as needed. If the problem is resolved, no further work is needed.

NO → Go to the next step.

Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?

YES → If the fault moves with the cable, proceed to the next step.

NO → If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.

Check continuity and resistance in the sensor harness. Is the harness good?

YES → Replace the sensor.

NO → Replace the harness.