Electrical

General

The 12-volt negative ground system is standard on the Thomas Saf-T-Liner ER and HD buses. Two Group 31 batteries are standard; however, several options are available to obtain additional battery power when required.

All standard wiring is color-coded with the circuit number embossed on the insulation of each circuit, every 3 to 4" apart. Twelve colors are used. Certain shielded cables do not follow Thomas' coding; the same may apply to harnesses furnished by some component suppliers.

Three electrical compartments are located on the bus to house the Printed Circuit Boards (PCB), various relays, junction blocks, buzzers, fuses, power and ground studs.

The electrical compartment located beneath the driver's sash controls body systems.

Chassis systems are controlled by a compartment located inside the body, above the entrance doorstep, and another compartment in the engine compartment.

The PCB is used to reduce the number of wires in the system, as well as aid in troubleshooting the electrical system.

Three circuit boards are used in the body systems. A similar board is used in the chassis systems.

Every effort has been made in this section of the manual to assist the technician in troubleshooting and understanding the system, since there is considerable difference between this model and older units.

Before getting into the various subjects that will be covered herein, listed below are some abbreviations that may appear through this section of the manual, as well as the location of some of the components.

ECU - Electronic Control Unit - On side of engine
ECM - Electronic Control Module, Transmission - In or rear chassis front electrical compartment
VIM - Vehicle Interface Module - On bracket, right side of PCB in chassis front electrical compartment
PCB - Printed Circuit Board - Three in body electrical compartment; one in chassis electrical compartment (front)
ECU-ABS - Electronic Control Unit, Antilock Brakes - Located on front side of VIM, front electrical compartment of chassis
VEC - Vehicle Electrical Center - Located on splash panel beneath air cleaner on ER model. Located inside engine compartment electrical box on HD model.
DRL - Daytime Running Lights
LED - Light Emitting Diode - Located on PCB
ICU - Instrument Cluster Unit - The group of dash instruments
BLHD - Bulkhead
GND - Ground Circuit
IGN - Ignition Circuit, when Ignition switch is ON
BATT. - Denotes 12 volts at all times
TPS - Throttle Position Sensor - Located beneath accelerator pedal

Body Electrical System - Printed Circuit Boards

Three PCB located in the body electrical compartment beneath the driver's sash control body lights accessories.

Figures 1, 2, and **3** show the layout of the three circuit boards and the location and function of each component on each board.

On each board illustration "A" is the face side of the board.

On each board illustration "B" is the backside of the board and shows the location of the various connectors that plug into the board. Each connector has its number printed on the connector body and plugs into its corresponding receptacle in the board.

On each board illustration "C" shows the fuse number, its rating, and the circuit it protects.

On each board illustration "D" identifies the circuit monitored by each LED. The LED is useful in troubleshooting the circuit if a problem arises in the circuit. The GREEN LED indicates that the circuit has power and the PCB is sending it out. The problem is not in the PCB.

The AMBER LED indicates current is flowing through the switch to the relay,

or from the chassis inputs (turn signals, brake lights).

When both LED are glowing, it tells you the problem is downstream of the PCB, itself. Check for an open circuit, loose connection, etc. It does not tell you if a bulb has burned out, or if a motor is inoperative. It only tells you the problem is not in the switch or its power supply.

The connector side (backside) of the PCB is available by removing two 3/8" bolts from the top corners of the panel assembly and tilting it outward.

Circuit Board #1 is located in the center position on the panel; all connectors to that PCB are numbered with BLUE ink. Each numbered connector is plugged into its corresponding receptacle on the board. Circuit Board #2 is the front board and has RED numbered connectors. Circuit Board #3 is the rear board and has GREEN numbered connectors.

Circuit Boards #2 and 3 have receptacles for fuses and relays that are not used; however, the wiring is in place, making it easy to add additional circuits, accessories, lights, etc.

All ground circuits are WHITE in color.

To service the AMP connectors used throughout the body electrical system, extractor tool #755430-2 is required to remove the terminal from the connector. Crimping tool #358521-1 is required to properly install a new terminal onto a wire.

Circuit Identification to and from Each Circuit Board

Charts X-1 through X-6 lists the name of the circuit, the circuit #, the connector #, the pin # in the connector for the circuit involved, and the color of the wire for that circuit on PCB-1. At the top of each chart (**X-1 - X-6**) the color "BLUE" refers to the color of the connects on this board.

Charts Y-1 through Y-4 cover the same items for PCB-2. At the top of each chart (**Y-1 - Y-4**) the color "RED" refers to the color of the connects on this board.

Charts Z-1 through Z-4 cover the same items for PCB-3. At the top of each chart (**Z-1 - Z-6**) the color "GREEN" refers to the color of the connects on this board.

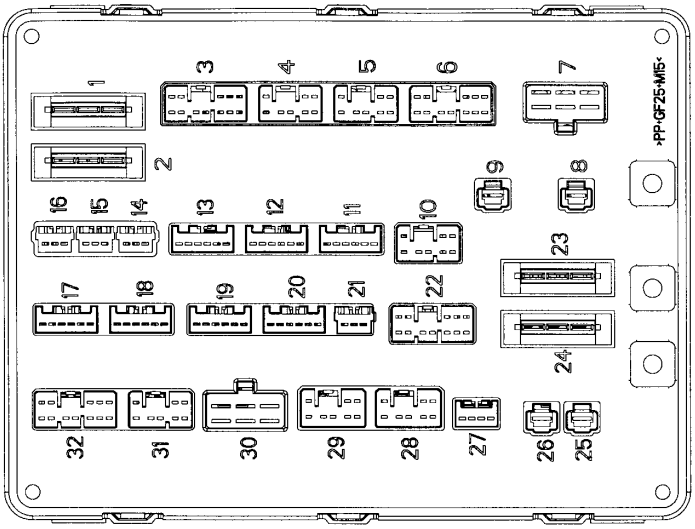
Where a relay is involved the relay number is shown. If a fuse is involved in the circuit, its rating is listed as well.

Note on these pages the number of the relay involved in certain circuits, is listed. The same applies to Figures 1, 2, and 3. The relay number is not actually shown on the relay itself. Instead, the relay number is molded into the board base where the relay plugs into its receptacle.

⚠ ***Caution***: **Do not replace a failed fuse with one of a higher rating than the failed fuse. To do so can damage the circuit or component the fuse was protecting.**

Never use a solid object to "jump" a fuse socket. This can damage the printed circuit in the board. The board is not repairable.

Strong emphasis is given to procuring the proper tools to service the connectors and terminals.



FUSE NO.	RATING	CIRCUIT DESCRIPTION
1	15A	DEFROST HEATER
2	15A	LEFT HEATER
3	15A	DRIVER HEATER
4	10A	STEPLIGHT (IGN)
5	10A	DOOR
6	5A	INTERIOR LIGHTS
7	10A	WIPER/MARKER SW
8	15A	REAR PASS. HTR
9	15A	FRONT INT. LIGHTS RELAY
10	15A	TAIL LIGHT RELAY
11	15A	STROBE LIGHT RELAY
12	15A	REAR INT. LIGHTS RELAY
13	15A	FRONT PASS. HEATER
14	10A	PUMP SWITCH
15	15A	HEATED MIRROR RELAY
16	10A	DEFROST FAN
17	10A	DEFROST FAN
18	20A	DEFROST HEATER
19	20A	REAR PASS. HEATER RLY
20	10A	STROBE LIGHT/NOISE SUPP.
21	20A	FRONT PASS. HEATER RLY
22	20A	LEFT HEATER RELAY
23	10A	WIPER MOTORS (BATT)
24	5A	PILOT LIGHT/BUZZER
25	10A	VIDEO CAMERA
26	10A	HEATED MIRRORS
27	10A	CELLULAR PHONE

C

FUSE NO.	COLOR	CIRCUIT DESCRIPTION
20	GREEN	FAN LOW 1
21	AMBER	STARTER INTERLOCK
22	GREEN	FAN HIGH 1
23	GREEN	FAN LOW 2
24	GREEN	DRIVER'S LIGHT
25	GREEN	MARKER LIGHTS
26	GREEN	DOOR OPEN
27	GREEN	LEFT HEATER
28	GREEN	DRIVER'S HEATER LOW
29	GREEN	INTERIOR LIGHTS FRONT
30	AMBER	LEFT TURN
31	AMBER	BRAKE LIGHT
32	AMBER	RIGHT TURN
33	GREEN	VIDEO
34	GREEN	FAN HIGH 2
35	GREEN	PUMP
36	GREEN	CLUSTER LIGHT
37	GREEN	PASSENGER HEATER #2
38	GREEN	PASSENGER HEATER #1
39	GREEN	DRIVER'S HEATER HIGH
40	GREEN	INTERIOR LIGHTS REAR

D

LED NO.	COLOR	RELAY NO.
1	GREEN	1
2	AMBER	1
3	GREEN	2
4	AMBER	3
5	AMBER	4
6	AMBER	5
7	GREEN	6
8	AMBER	6
9	GREEN	7
10	AMBER	7
11	AMBER	8
12	AMBER	9
13	GREEN	10
14	AMBER	10
15	GREEN	11
16	AMBER	11
17	GREEN	12
18	AMBER	12
19	GREEN	13

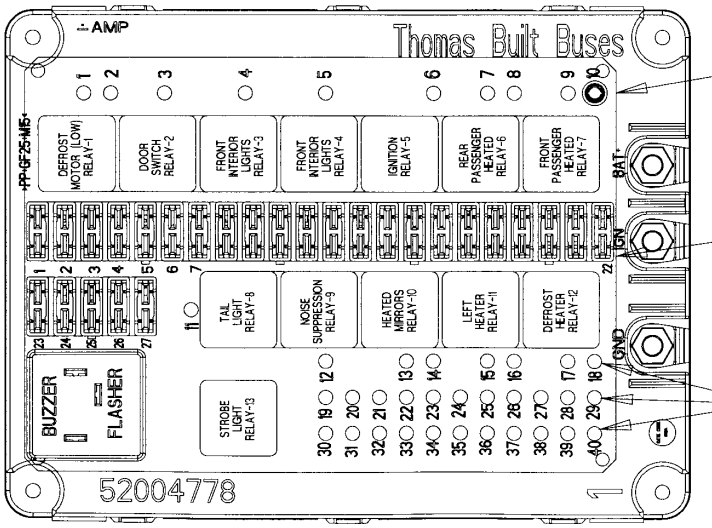
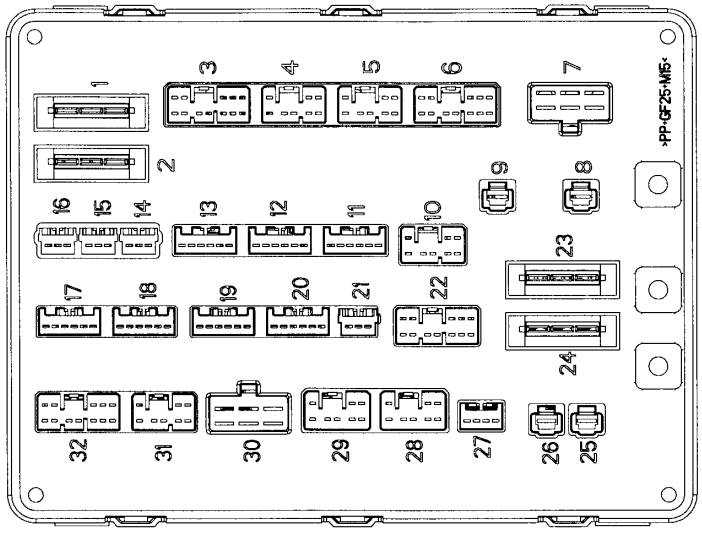


Figure 1



B

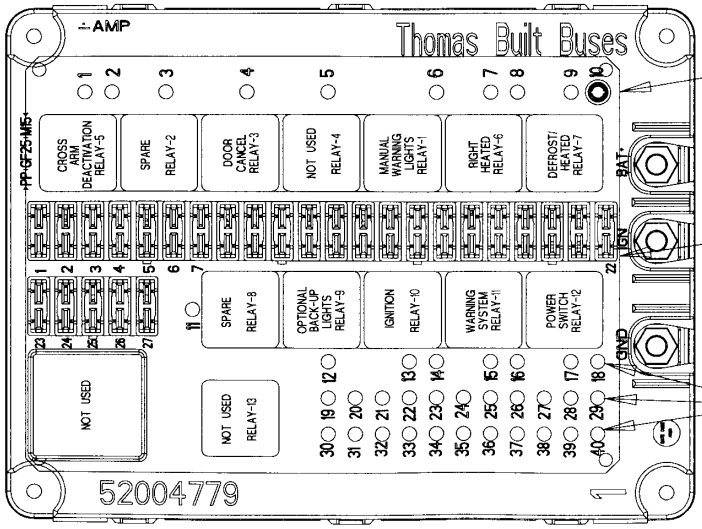
C

FUSE NO.	RATING	CIRCUIT DESCRIPTION
1	10A	32-12 SPARE (BATT)
2	3A	MANUAL OVERRIDE
3	10A	32-11 SPARE (IGN)
4		
5	10A	LIGHT MONITOR
6	7A	CROSS ARM (SWITCH)
7	10A	STOP SIGN (POWER)
8	20A	7-2 SPARE (NOISE)
9	15A	DEFROST SWITCH
10	15A	RIGHT HEATER SWITCH
11	20A	7-1 SPARE (NOISE)
12	20A	7-3 SPARE (BATT)
13	10A	OPTIONAL BACK-UP
14	10A	WARNING LIGHT SW (IGN)
15		
16	20A	WARNING LIGHT
17	20A	RIGHT HEATER (HIGH)
18	20A	7-4 SPARE (IGN)
19	20A	DEFROST (HIGH)
20	20A	7-5 SPARE (IGN)
21	20A	7-6 SPARE (IGN)
22	20A	
23		
24		
25		
26		
27		

D

FUSE NO.	COLOR	CIRCUIT DESCRIPTION
20	GREEN	LOW DEFROST/HEATERS
21	GREEN	AMBER WARNING LIGHT
22	GREEN	AMBER WARNING LIGHT
23	AMBER	AMBER WARNING LIGHT
24		
25		
26	AMBER	RED WARNING LIGHT
27	GREEN	RED WARNING LIGHT
28	GREEN	RED WARNING LIGHT
29		
30		
31	GREEN	LOW STEP HEATER
32	GREEN	AMBER WARNING LIGHT
33	GREEN	AMBER WARNING LIGHT
34	AMBER	AMBER WARNING LIGHT
35		
36		
37	GREEN	RED WARNING LIGHT
38	AMBER	RED WARNING LIGHT
39	GREEN	RED WARNING LIGHT
40		

LED NO.	COLOR	RELAY NO.
1	AMBER	1
2	GREEN	1
3		
4		
5	AMBER	DOOR OPEN
6	AMBER	5
7	AMBER	6
8	GREEN	6
9	AMBER	7
10	GREEN	7
11	GREEN	8
12		
13		
14		
15	AMBER	11
16	GREEN	11
17	AMBER	12
18		
19		



A

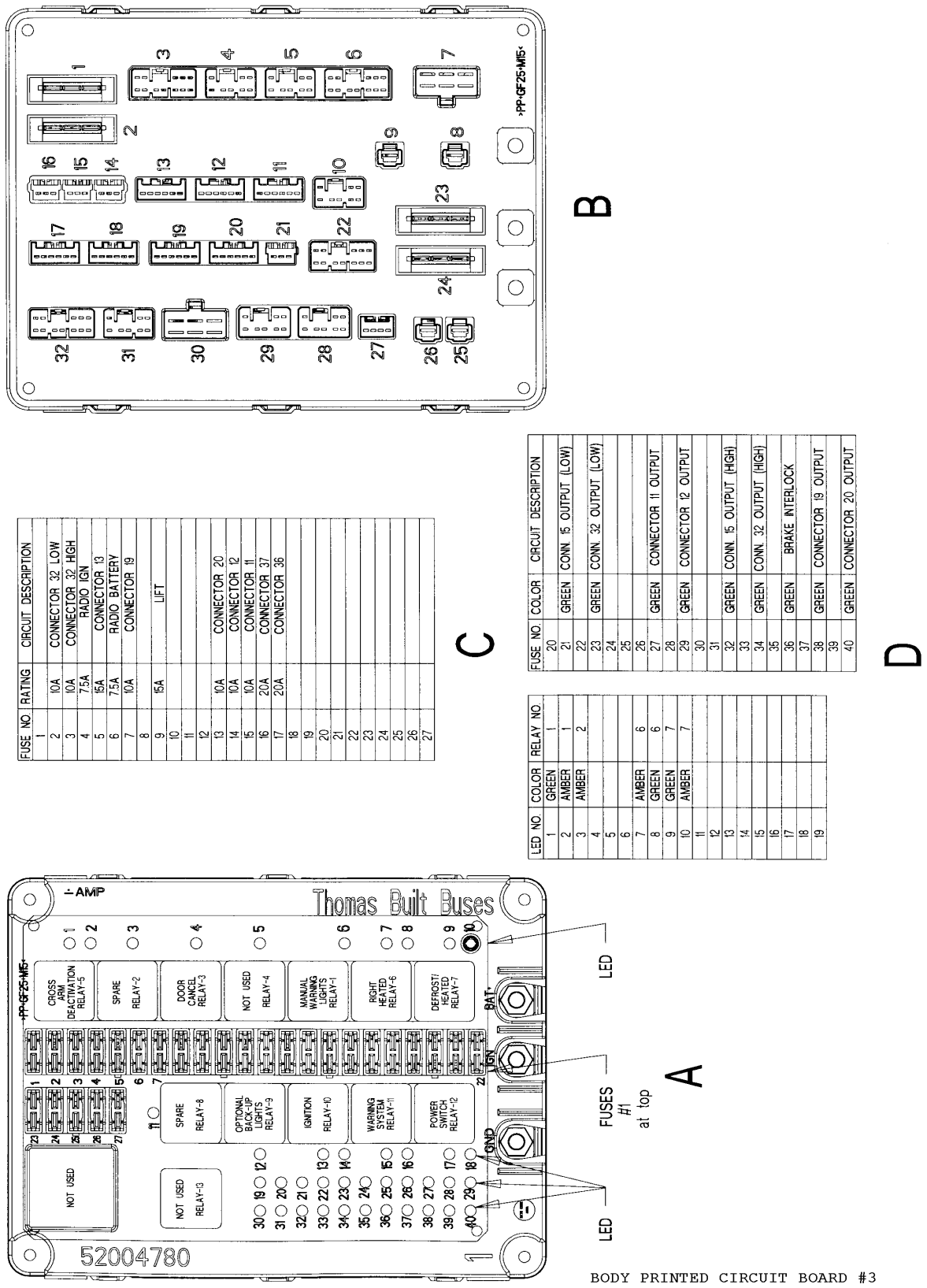
LED

FUSES #1 at top

LED

BODY PRINTED CIRCUIT BOARD #2

Figure 2



FUSE NO.	RATING	CIRCUIT DESCRIPTION
1		
2	10A	CONNECTOR 32 LOW
3	10A	CONNECTOR 32 HIGH
4	7.5A	RADIO IGN
5	15A	CONNECTOR 13
6	7.5A	RADIO BATTERY
7	10A	CONNECTOR 19
8		
9	15A	LIFT
10		
11		
12		
13	10A	CONNECTOR 20
14	10A	CONNECTOR 12
15	10A	CONNECTOR 11
16	20A	CONNECTOR 37
17	20A	CONNECTOR 36
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		

FUSE NO.	COLOR	CIRCUIT DESCRIPTION
20		
21	GREEN	CONN. 15 OUTPUT (LOW)
22		
23	GREEN	CONN. 32 OUTPUT (LOW)
24		
25		
26		
27	GREEN	CONNECTOR 11 OUTPUT
28		
29	GREEN	CONNECTOR 12 OUTPUT
30		
31		
32	GREEN	CONN. 15 OUTPUT (HIGH)
33		
34	GREEN	CONN. 32 OUTPUT (HIGH)
35		
36	GREEN	BRAKE INTERLOCK
37		
38	GREEN	CONNECTOR 19 OUTPUT
39		
40	GREEN	CONNECTOR 20 OUTPUT

LED NO.	COLOR	RELAY NO.
1	GREEN	1
2	AMBER	1
3	AMBER	2
4		
5		
6		
7	AMBER	6
8	GREEN	6
9	GREEN	7
10	AMBER	7
11		
12		
13		
14		
15		
16		
17		
18		
19		

Figure 3

BOARD #1 "BLUE" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
1		**Buzzer Power**	**SHUNT**	**52004092**
1	BATT +	N/A	Battery Power	
2	SA33	N/A	Buzzer Power Fuse # 24	5 amps
3	IGN +	N/A	Ignition Power	
2		**Step Light Power**	**SHUNT**	**52004092**
1	LM168	N/A	Tail Lights	
2		N/A	To Step Lights Relay # 2 Fuse # 4	10 amps
3	IGN +	N/A	Ignition Power	
3		**To Main Harness**	**AMP #**	**173851-1**
1	LR170A	BLUE	Back-up light feed	
2	LS38	PURPLE	To Strobe Light	
3	SA30	TAN	Pull Cord/Push Out Slash (Ground)	
4	SA29	BLUE	Rear Door Buzzer	
5	SA31	GRAY	Side Door Buzzer (Ground)	
6				
7	FD34	GRAY	Left Defroster Fan Low	
8	LD21	BLACK	Front Interior (Dome) Lights	
9	GND	WHITE	Ground	
10	SA33	PINK	Rear/Side Door Buzzer Power	
11	F317	ORANGE	Hatch Fan	
12	DS27	PINK	Identification Sign	
4		**To Main Harness (Tail Lights)**	**AMP #**	**173850-1**
1	LR13	BLUE	Right Back-up Light	
2	LR14	BLUE/WHITE	Left Back-up Light	
3	LB15	RED	Right Brake Light	
4	LT10	YELLOW	Left Turn Light	
5	LT9	GREEN	Right Turn Light	
6	LM12	BROWN/WHITE	Left Tail Light	
7	LM11	BROWN	Right Tail Light	
8	LB16	RED/WHITE	Left Brake Light	
5		**Input From Chassis To Board # 1**	**AMP #**	**173850-1**
1	LM169	TAN	Tail Lights Relay # 8, Fuse # 10	15 amps
2	LB172	RED	Brake Lights	
3	LR170	BLUE	Back-up	
4	SA32	YELLOW	Starter Interlock	
5	LP70A	BLACK	Panel Lights	
6	KEY SW	BLACK	Key Switch Relay # 5	
7	LT175	GREEN	Right Turn Lights	
8	LT174	YELLOW	Left Turn Lights	

Chart X-1

BOARD #1 "BLUE" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
6			**To Main Harness**	**AMP #**	**173851-1**
	1	LM40	BROWN	To Marker Lights	
	2	LM17	BROWN	To Cluster lights	
	3	MH468	ORANGE	To Heated Mirrors	
	4	MH469	BLUE	To Heated Mirrors	
	5	SA32	YELLOW	Starter Interlock	
	6	DF426	GREEN	To Front Door Sol.	
	7	LD20	TAN	To Driver's Dome Light	
	8	LD19	BLACK	Rear Interior (Dome) Lights	
	9	FD35	TAN	Right Defroster Fan Low	
	10	FD37	BLUE	Right Defroster Fan High	
	11	FD36	BLACK	Left Defroster Fan High	
	12	AV599	PINK	To Video L.E.D.	
7			**To Front Heater**	**AMP #**	**171898-1**
	1			Left Heater Low	
	2			Def./Heater low	
	3			Driver Heater High	
	4			Def./Heater High Relay # 11, Fuse # 18 - 20 amps	
	5			Left heater High Relay # 12, Fuse # 22 - 20 amps	
	6			Drivers Heater Low	
8			**Front Pass Low**	**AMP #**	**172128-1**
	1		RED / WHITE	Front Pass low	
9			**Rear Pass Low**	**AMP #**	**172128-1**
	1		RED / WHITE	Rear Pass Low	
10			**Defroster Fan Switch**	**AMP #**	**173850-1**
	1	FD35	TAN	Right Defroster Fan Low	
	2	FD37	BLUE	Right Defroster Fan High	
	3	FD34	GRAY	Left Defroster Fan Low	
	4	SW2 +	BLUE	Right Fan Power Fuse # 16 15 amps	
	5	SW1 +	BLUE	Left Fan Power Fuse # 17 15 amps	
	6	FD36	BLACK	Left Defroster Fan High	
	7	GND	WHITE	Ground	
	8	LP70	ORANGE	To Panel Lights	
11			**Video L.E.D.**	**AMP #**	**174923-1**
	1	IGN	RED	Ignition Power Fuse # 25 10 amps	
	2	AV599	PINK	To Video L.E.D.	
	3	LP70	ORANGE	To Panel Lights	
	4	GND	WHITE	Ground	
	5				
	6				

Chart X-2

BOARD #1 "BLUE" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
12			**To Interior Lights / Stepwell Power +**		**AMP #**	**174923-1**
	1	IGN	RED	Ignition Power	Fuse # 4	10 amps
	2		PURPLE	To Stepwell Relay #30 +	Relay # 2	
	3	LP70	ORANGE	To Panel Lights		
	4	GND	WHITE	Ground		
	5	LD21	BLACK	From Interior Lights		
	6		TAN	To Interior Lights		
13			**Heated Mirror Switch**		**AMP #**	**174923-1**
	1					
	2		YELLOW	Mirror Heat Relay # 10	Fuse # 15	15 amps
	3	LP70	ORANGE	To Panel Lights		
	4	GND	WHITE	Ground		
	5					
	6	IGN	RED	Ignition Power	Fuse # 26	10 amps
14			**Panel Lights Dimmer**		**AMP #**	**174921-1**
	1	GND	WHITE	Ground		
	2	LP70	ORANGE	To Panel Lights		
	3	LP70A	BLACK	From Chassis		
15			**Buzzer Light + More**		**AMP #**	**174921-1**
	1	SA33	PINK	Buzzer +	Fuse # 24	5 amps
	2					
	3	SA30	TAN	Buzzer -		
16			**Wiper Power**		**AMP #**	**174921-1**
	1	IGN +	RED	Ignition Power	Fuse # 7	15 amps
	2	GND	WHITE	Ground		
	3	BATT +	GREEN	Battery Power	Fuse # 23	10 amps
17			**To Board # 3**		**AMP #**	**174923-1**
	1					
	2	LP70	ORANGE	To Panel Lights		
	3	SA504	TAN	Buzzer		
	4	DS27	PINK	Identification Sign		
	5	IGN	RED	Ignition Power		
	6	F317	ORANGE	Hatch Fan		
18			**Door Switch**		**AMP #**	**174923-1**
	1	DF426	GREEN	To Front Door Sol.		
	2	DF427	YELLOW	To Manual Flasher Override		
	3	BATT +	GREEN	Battery Power	Fuse # 5	10 amps
	4	LP70	ORANGE	To Panel Lights		
	5	GND	WHITE	Ground		
	6	SD59	PINK	Door Switch Signal (Ground)		

Chart X-3

BOARD #1 "BLUE" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #	
19			**To Strobe**		**AMP #**	**174923-1**
	1	IGN	RED	Ignition Power	Fuse # 20	10 amps
	2	RLY	YELLOW	To Strobe Light Relay # 13	Fuse # 11	10 amps
	3	LP70	ORANGE	To Panel Light		
	4	GND	WHITE	Ground		
	5	LW82	GRAY			
	6	LM168	BROWN	Marker Lights		
20			**Marker/Cluster Lights**		**AMP #**	**174923-1**
	1	LM168	BROWN	Tail Lights		
	2	LM40	BROWN	Marker Lights		
	3	LM17	BROWN	Cluster Lights		
	4	GND	WHITE	Ground		
	5	LP70	ORANGE	To Panel Light		
	6	IGN	RED	Ignition Power	Fuse # 7	10 amps
21			**Power Outlet**		**AMP #**	**174921-1**
	1	BATT +	GREEN	Battery Power	Fuse # 27	20 amps
	2	GND	WHITE	Ground		
	3					
22			**Pass Heaters**		**AMP #**	**173851-1**
	1	F-L	PURPLE	Front Pass Heater Low		
	2	R-L	PINK	Rear Pass Heater Low		
	3	IGN-R-P	BLUE	Rear Pass Heater +	Fuse # 8	15 amps
	4	LP70	ORANGE	To Panel Light		
	5	IGN-P	BLUE	Pump +	Fuse # 14	10 amps
	6	R-P-N	YELLOW	Rear Pass High, Relay # 6	Fuse # 19	20 amps
	7	F-P-H	YELLOW	Front Pass High, Relay # 7	Fuse # 21	20 amps
	8					
	9					
	10	GND	WHITE	Ground		
	11	PUMP	TAN	Pump		
	12	IGN-F-P	BLUE	Front Pass +	Fuse # 13	15 amps
23			**Front Interior Lights**		**SHUNT**	**52004092**
	1		N/A	To Front Interior (Dome) Lights		
	2		N/A	From Relay #		
	3					
24			**Rear Interior Lights**		**SHUNT**	**52004092**
	1		N/A	To Rear Interior (Dome) Lights		
	2		N/A	From Relay #		
	3					
25			**Front Pass High**		**AMP #**	**174923-1**
	1		GREEN / BLACK	Front Pass High Relay # 7	Fuse # 21	20 amps

Chart X-4

BOARD #1 CONN/PIN #	"BLUE" CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
26		**Rear Pass Heater High**		**AMP #**	**172128-1**
1		GREEN / BLACK	Rear Pass High Relay # 6	Fuse # 19	20 amps
27		**Noise Suppression Switch**		**AMP #**	**174922-1**
1	RLY	YELLOW	Noise Relay # 9		
2	GND	WHITE	Ground		
3	IGN	RED	Ignition Power	Fuse # 20	10 amps
4	LP70	ORANGE	To Panel Lights		
28		**To Board #2**		**AMP #**	**173850-1**
1	GND	WHITE	Ground		
2	LW82	GRAY	Stop Arm Signal		
3	LP70	ORANGE	To Panel Lights		
4	SW +	BLUE	Noise Relay		
5	DF427	YELLOW	To Manual Flasher Override		
6	IGN	RED	Ignition Power		
7	LR170A	BLUE	Back-up Light Feed		
8	LW59	PINK	Door Switch Signal (Ground)		
29		**To Bus Front Harness**		**AMP #**	**173850-1**
1	MH470	ORANGE	Heated Mirror		
2	PUMP	TAN	Pump		
3	LM168	BROWN	To Park Lights		
4					
5	LE74	BLUE	To Stepwell Lights		
6	LT175	GREEN	Right Turn Lights		
7	LT174	YELLOW	Left Turn Lights		
8	LW59	PINK	Door Switch Signal (Ground)		
30		**Interior Light Dimmer**		**AMP #**	**171898-1**
1	LD19	BLACK	To Rear Lights		
2	LD21	BLACK	To Front Lights		
3	GND	WHITE	Ground		
4	LD19A	TAN	From Rear Light Relay # 3	Fuse # 12	15 amps
5	LD21A	TAN	From Front Light Relay # 4	Fuse # 9	15 amps
6	GND	WHITE	Ground		
31		**Interior Light Switches and Brake Light**		**AMP #**	**173850-1**
1	LD20	TAN			
2	GND	WHITE	Ground		
3	LP70	ORANGE	To Panel Lights		
4	LD19	YELLOW	Relay # 3	Fuse # 12	15 amps
5	IGN +	RED	Ignition Power	Fuse # 6	5 amps
6	LD21	YELLOW	Relay # 4	Fuse # 9	15 amps
7	BATT +	GREEN	Battery Power	Fuse # 5	10 amps
8	LB172	RED	Brake Light		

Chart X-5

BOARD #1 "BLUE"			COLOR	DESCRIPTION		CONNECTOR PART #
CONN/PIN #		CIRCUIT				
32			Left Heater Switch		AMP #	173851-1
	1	GND	WHITE	Ground		
	2	L-H-L	GRAY	Left Heater Low		
	3	LP70	ORANGE	To Panel Lights		
	4	D/H-L	BROWN	Def / Heater Low		
	5	D/H-P	BLUE	Def / Heater Switch +	Fuse # 1	15 amps
	6	D-H-L	PURPLE	Drivers Heater Low		
	7	D-H-H	TAN	Drivers Heater High		
	8	L-H-H	YELLOW	Left Heater High Relay # 12	Fuse # 22	20 amps
	9	D/H-H	YELLOW	Def / Heater High Relay # 11	Fuse # 18	20 amps
	10	D-H-P	BLUE	Drivers Heater Switch +	Fuse # 3	15 amps
	11	L-1SW	BLACK	Relay Low Def Relay # 1		
	12	L-H-P	BLUE	Left Heater Switch +	Fuse # 2	15 amps
		AMP	TBB	DESCRIPTION		
		PART #	PART #			
		173631-6	52004936	Terminal 070 series (Receptacle Contact)		
		173645-2		Terminal 070 series (Tab Contact)		
		58521-1		Hand tool Assembly (crimper 070 series)		
		755430-2		Contact Extraction Tool		
		174463-1	52003907	Multilock Connector, 070 2P (Plug Housing)		
		174460-1	52003906	Multilock Connector, 070 2P (Cap Housing)		
		174921-1	52003868	Multilock Connector, 070 3P (Plug Housing)		
		174922-1	52004060	Multilock Connector, 070 4P (Plug Housing)		
		174923-1	52003869	Multilock Connector, 070 6P (Plug Housing)		
		173850-1	52003870	Multilock Connector, 070 8P (Plug Housing)		
		173851-1	52003871	Multilock Connector, 070 12P (Plug Housing)		
		170258-2	52004076	Terminal 250 series		
		169400		Hand tool Assembly (crimper 250 series)		
		169628		Crimping dies (for 250 Hand tool)		
		172128-1	52003876	Faston Connector, 250 1P (Plug Housing)		
		172134-1	52003877	Faston Connector, 250 4P (Plug Housing)		
		171898-1	52003878	Faston Connector, 250 6P (Plug Housing)		

Chart X-6

BOARD #2 "RED" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
1		**Stop Arm Power**		**SHUNT**	**52004092**
1	IGN	N/A	Ignition Power		
2	TO FUSE	N/A	Stop Arm Power	Fuse # 7	10 amps
3	BATTERY	N/A	Battery Power		
4		**Right/Step Heater Switch**		**AMP #**	**173850-1**
1	RLY 1	YELLOW	Right Heater High, Relay # 6	Fuse # 18	20 amps
2	RLY 2	YELLOW	Def / Heater High, Relay # 7	Fuse # 20	20 amps
3	POW 1	BLUE	Switch + Relay #12	Fuse # 9	15 amps
4	GND	WHITE	Ground		
5	LP70	ORANGE	To Panel Lights		
6	LOW 1	TAN	Right Heater Low		
7	POW 2	BLUE	Switch +	Fuse # 10	15 amps
8	LOW 2	BLACK	Def / Heater Low		
6		**Warning Light Flasher**		**AMP #**	**173851-1**
1	LW56	RED	Warning Light (Red)		
2	LW149	ORANGE	Power From Relay	Relay # 11	
3	LW149	ORANGE	Power From Relay	Relay # 11	
4	LW55	YELLOW	Warning Light (Amber)		
5	LW58	YELLOW	Warning Light (Amber)		
6	LW82	GRAY	Stop Arm Signal		
7	LW59	PINK	Door Switch Signal (Ground)		
8	LW81	PURPLE	Door Open (Active Low)		
9	LAMP	BLUE	Lamp Light		
10	LW57	RED	Warning Light (Red)		
11	LW80	TAN	Flasher Start Signal		
12	GND	WHITE	Ground		
7		**Spare Fuse**		**AMP #**	**171898-1**
1	NOISE +		Noise Power	Fuse # 11	20 amps
2	NOISE +		Noise Power	Fuse # 8	20 amps
3	BATT +		Battery Power	Fuse # 12	20 amps
4	IGN +		Ignition Power	Fuse # 19	20 amps
5	IGN +		Ignition Power	Fuse # 21	20 amps
6	IGN +		Ignition Power	Fuse # 22	20 amps
9		**Warning Flasher / Switch Power**		**AMP #**	**172128-1**
1	BATT +	GREEN	Warning Flasher / Sw Power	Fuse # 17	20 amps
13		**Deactivation Crossing Arm Switch**		**AMP #**	**174923-1**
1					
2	LP70	ORANGE	To Panel Lights		
3					
4	GND	WHITE	Ground		

Chart Y-1

BOARD #2 "RED" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
15		**Power For Light Monitor**	**AMP #**	**174921-1**
1		BLUE	For Back-up Lights, Relay # 9	Fuse # 13 20 amps
2	176	RED	Monitor Feed	Fuse # 5 10 amps
3	177	WHITE	Monitor Ground	
16		**Manual Override Switch**	**AMP #**	**174921-1**
1	GND	WHITE	Ground	
2	LP70	ORANGE	To Panel Light	
3	RLY	YELLOW	Relay Signal	Relay # 5 & 3
22		**Warning Light Switches**	**AMP #**	**173851-1**
1	LW81	PURPLE	Door Open (Active Low)	
2	LW56	RED	Warning Light (Red)	
3	LAMP	BLUE	Lamp Light	
4	BK1	BLACK	Signal From Switch To Relay # 11	
5	LW58	YELLOW	Warning Light (Amber)	
6	LW59	PINK	Door Switch Signal (Ground)	
7	GND	WHITE	Ground	
8	LP70	ORANGE	To Panel Light	
9	LW57	RED	Warning Light (Red)	
10	LW55	YELLOW	Warning Light (Amber)	
11	LW80	TAN	Flasher Start Signal	
12	IGN	RED	Ignition Power	Fuse # 14 10 amps
28		**From Board #1**	**AMP #**	**173850-1**
1	GND	WHITE	Ground	
2	LW82	GRAY	Stop Arm Signal	
3	LP70	ORANGE	To Panel Light	
4	SW +	BLUE	Noise Relay	Relay # 12
5	DF427	YELLOW	Door Cancel Relay	
6	IGN	RED	Ign Relay	Relay # 10
7	LR170A	BROWN	Back -Up Light Feed	
8	LW59	PINK	Door Switch Signal (Ground)	
30		**Step Heaters And Crossing Arm**	**AMP #**	**171898-1**
1	HS120	PINK	Def / Heater Low	
2	HS122	GRAY	Right Heater Low	
3	CA443	YELLOW	Crossing Arm	
4	HS121	PURPLE	Def / Heater High, Relay # 7	Fuse # 20 20 amps
5	HS123	BLUE	Right Heater High, Relay # 6	Fuse # 18 20 amps
6				

Chart Y-2

BOARD #2 "RED" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
32		**Spare Relays # 2 & 8**		**AMP #**	**173851-1**
1	# 8 87a				
2	# 8 86				
3	# 8 30				
4	# 8 85				
5	# 8 87				
6	# 2 30				
7	# 2 85				
8	# 2 86				
9	# 2 87a				
10	# 2 87				
11	IGN +	RED	Ignition Power	Fuse # 3	10 amps
12	BATT +	GREEN	Battery Power	Fuse # 1	10 amps
33		**To Light Monitor**		**AMP #**	**171898-1**
1	LW56	RED	Input (Red)		
2	LW2	BROWN	Right Front (Red)		
3	LW1	BLACK	Left Rear (Red)		
4	LW3	ORANGE	Right Rear (Red)		
5	LW4	YELLOW	Left Front (Red)		
6	LW57	RED	Input (Red)		
34		**To Main Harness**		**AMP #**	**172134-1**
1	LW5	BLUE	Left Rear (Amber)		
2	LW1	BLACK	Left Rear (Red)		
3	LW6	WHITE	Right Front (Amber)		
4	LW2	BROWN	Right Front (Red)		
35		**To Main Harness**		**AMP #**	**172134-1**
1	LW3	ORANGE	Right Rear (Red)		
2	LW4	YELLOW	Left Front (Red)		
3	LW8	GREEN	Left Front (Amber)		
4	LW7	RED	Right Rear (Amber)		
36		**To Light Monitor**		**AMP #**	**171898-1**
1	LW8	GREEN	Left Front (Amber)		
2	LW7	RED	Right Rear (Amber)		
3	LW5	BLUE	Left Rear (Amber)		
4	LW58	YELLOW	Input (Amber)		
5	LW55	YELLOW	Input (Amber)		
6	LW6	WHITE	Right Front (Amber)		

Chart Y-3

BOARD #2 "RED"			COLOR	DESCRIPTION		CONNECTOR PART #
CONN/PIN #		CIRCUIT				
37		Stop Sign			AMP #	171898-1
	1	LW82	GRAY	Stop Arm Signal		
	2					
	3	GND	WHITE	Ground		
	4	LW56	RED	Warning Light (Red)		
	5	LW57	RED	Warning Light (Red)		
	6	POW	GREEN	Power From Fuse	Fuse # 7	10 amps

Chart Y-4

See Chart of Connector/Pin Location on following pages: **CHART Z-1 through Z-4**.

BOARD #3 "GREEN" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
3		**Radio**		**AMP #**	**173851-1**
1	SP462	GRAY	Right Front +		
2	SP110	VIOLET	Right Rear +		
3	SP465	TAN	Left Front +		
4					
5	BATT +	GREEN	Battery Power	Fuse # 6	7 amps
6	SP111	YELLOW	Left Rear +		
7	SP109	PINK	Right Rear -		
8	SP464	BLUE	Right Front -		
9	SP112	ORANGE	Left Rear -		
10	SP466	BROWN	Left Front -		
11	GND	WHITE	Ground		
12	IGN +	RED	Ignition Power	Fuse # 4	7 amps
4		**Outside Speaker Switch**		**AMP #**	**173850-1**
1	SP111-A	YELLOW	Left Rear +		
2					
3	IGN +	RED	Ignition Power	Fuse # 4	7 amps
4	SP230	BLACK	Outside Speaker		
5	LP70	ORANGE	To Panel Lights		
6	GND	WHITE	Ground		
7	RLY	BLUE	Switch To Relays # 8, 9, & 10		
8	SP111	YELLOW	Left Rear +		
6		**To Speakers**		**AMP #**	**173851-1**
1	SP110	VIOLET	Right Rear +		
2					
3	SP462	GRAY	Right Front +		
4	SP465	TAN	Left Front +		
5	SP111	YELLOW	Left Rear +		
6					
7					
8	SP466	BROWN	Left Front -		
9	SP112	ORANGE	Left Rear -		
10	SP464	BLUE	Right Front -		
11	SP109	PINK	Right Rear -		
12	SP230	BLACK	Outside Speaker		
7		**Outputs**		**AMP #**	**171898-1**
1	N/A	N/A	Output From Plug 11 Pin 2		
2	N/A	N/A	Output From Plug 12 Pin 2		
3	N/A	N/A	Output From Plug 20 Pin 2		
4	N/A	N/A	Output From Plug 19 Pin 2		
5					
6					

Chart Z-1

BOARD #3 "GREEN" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
9		**Low Speed Signal**	**AMP #**	**172128-1**
1		BLACK	Low Speed Signal	
10		**Chassis Input / Output Signals**	**AMP #**	**173850-1**
1		BLACK	Kneeling	
2		BLACK	Neutral	
3		BLACK	Brake Interlock	
4	ACC	BLACK	Accessories	
5				
6				
7		BLACK	Low Speed Signal	
8				
11		**Spare Switch Ignition Power**	**AMP #**	**174923-1**
1	IGN +	RED	Ignition Power	Fuse # 15 10 amps
2		GRAY	Output To Plug 7 Pin 1	
3	LP70	ORANGE	To Panel Lights	
4	GND	WHITE	Ground	
5				
6				
12		**Spare Switch Ignition Power**	**AMP #**	**174923-1**
1	IGN +	RED	Ignition Power	Fuse # 14 10 amps
2		GRAY	Output To Plug 7 Pin 2	
3	LP70	ORANGE	To Panel Lights	
4	GND	WHITE	Ground	
5				
6				
13		**Spare Switch With 2 Outputs**	**AMP #**	**174923-1**
1	IGN +	RED	Ignition Power	Fuse # 5 15 amps
2		PINK	Low Output	
3	LP70	ORANGE	To Panel Lights	
4	GND	WHITE	Ground	
5		PURPLE	High Output	
6				
14		**Interlock Override Switch**	**AMP #**	**174921-1**
1	BRAKE	BLACK	To Brake Interlock	
2				
3	FEED	TAN	From Brake Interlock Relay	
15		**Outputs Of Connector # 13**	**AMP #**	**174921-1**
1		PURPLE	High Output	
2		PINK	Low Output	
3		WHITE	Ground	

Chart Z-2

BOARD #3 "GREEN" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
16			**Radio Power**		**AMP #**	**174921-1**
	1	GND	WHITE	Ground		
	2	IGN +	RED	Ignition Power	Fuse # 4	7 amps
	3	BATT +	GREEN	Battery Power	Fuse # 6	7 amps
17			**To Board # 1**		**AMP #**	**174923-1**
	1					
	2	LP70	ORANGE	To Panel Lights		
	3	SA504	TAN	Buzzer		
	4	DS27	PINK	Output Plug 32 pin 10		
	5	IGN +	RED	Ignition Power	Relay # 4	
	6	F317	ORANGE	Output Plug 32 pin 4		
18			**Lift Switch**		**AMP #**	**174923-1**
	1	WC567	BLACK	From Switch		
	2	WC557	BLACK	To Switch	Fuse # 9	15 amps
	3	WC566	GREEN	Lift Light		
	4				Relays # 1, 2, & 3	
	5	GND	WHITE	Ground		
	6	LP70	ORANGE	To Panel Lights		
19			**Spare Switch Ignition Power**		**AMP #**	**174923-1**
	1	BATT +	GREEN	Battery Power	Fuse # 7	10 amps
	2		GRAY	Output To Plug 7 Pin 3		
	3	LP70	ORANGE	To Panel Lights		
	4	GND	WHITE	Ground		
	5					
	6					
20			**Spare Switch Battery Power**		**AMP #**	**174923-1**
	1	IGN +	RED	Ignition Power	Fuse # 13	10 amps
	2		GRAY	Output To Plug 7 Pin 4		
	3	LP70	ORANGE	To Panel Lights		
	4	GND	WHITE	Ground		
	5					
	6					
30			**Lift Door Power**		**AMP #**	**171898-1**
	1					
	2					
	3	SA504	GRAY	Buzzer		
	4	WC559	WHITE	Relay Ground		
	5	WC566	GREEN	Lights		
	6	WC567	BLACK	Lift Power		

Chart Z-3

BOARD #3 "GREEN" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION		CONNECTOR PART #
32		**2 Spare Switches**	**Ignition Power**	**AMP #**	**173851-1**
1	GND	WHITE	Ground		
2					
3					
4	DS27	BROWN	Output To Dest Sign		
5					
6	GND	WHITE	Ground		
7					
8	LP70	ORANGE	To Panel Lights		
9	LP70	ORANGE	To Panel Lights		
10	F317	PINK	Output To		
11	IGN	RED	Ignition Power	Fuse # 2	10 amps
12	IGN	RED	Ignition Power	Fuse # 3	10 amps
33		**Accessories**		**AMP #**	**171898-1**
1					
2					
3					
4					
5	ACC	BLACK	Accessories		
6					
36		**Spare Relay # 7**		**AMP #**	**171898-1**
1	IGN	N/A	Ignition Power	Fuse # 17	20 amps
2	87	N/A			
3	87a	N/A			
4	30	N/A			
5	85	N/A			
6	86	N/A			
37		**Spare Relay # 6**		**AMP #**	**171898-1**
1	IGN	N/A	Ignition Power	Fuse # 16	20 amps
2	87	N/A			
3	87a	N/A			
4	30	N/A			
5	85	N/A			
6	86	N/A			

Chart Z-4

General Recommendations - Maintenance and Repair

The following comments may be helpful in avoiding some of the most common problems experienced over the life of the bus.

1. Shorts in Cables and Harnesses:
   Wiring should not be allowed to chafe.

2. Corrosion in Sockets and Terminals:
   Buses operating on streets and highways using large amounts of salt and sodium chloride products are subject to corrosion.

   The use of an anti-corrosive sealant, such as Graffo 116 to coat exposed-connectors, switches, and ground terminals, is very helpful in deterring corrosion.

   The use of dielectric grease to coat the base and sockets of bulbs will deter the formation of corrosion in lamps exposed to road contaminants. It can also reduce road shock in the bulb filaments.

3. Circuit Resistance:
   Circuit resistance is usually caused by loose terminals at the point of termination, improper crimping of replacement terminals onto the wire, and unprofessional splicing of two wires together.

   Practically all replacement terminals require a special tool to insure a complete, secure bond of the terminal and the wire. If the proper crimping tool is not available, the terminal should be soldered to the wire, using rosin flux solder. Always cover the end of the terminal with a one-inch piece of heat shrink tubing to prevent the entrance of water, salt, etc.

   Twisting the wires together to splice two wires together, is acceptable only if the union is then soldered with rosin flux solder and covered with a heat shrink tubing extending one inch on each side of the union. Butt splices are also common in such a repair. Again, cover the splice with heat shrink tubing.

   Wiring left improperly sealed will corrode, and the corrosion can wick up the entire length of the wire. **Figure 4** is an example of the proper way to splice two wires together.

4. Overloaded Circuits:
   Additional electrical components should not be added to existing circuits. There is room for additional circuit breakers on the side electrical panel, if additional options are added in the field.

5. Proper Diagnosis:
   Thorough diagnosis is a must to eliminate repeat failures in the

electrical system. Determining the cause of a particular failure not only solves the problem on the unit involved, but it may be helpful in preventing failures on other similar units in the fleet.

In the event a particular fuse continues to trip, even though no short is found, it would be wise to check the circuit flow on that circuit and compare it to the rating of the fuse. The fuse may be tripping below its rating, or the current draw may be in excess of the fuse rating.

To check current draw on any given circuit, connect an ammeter in series between the circuit and a battery terminal. Energize the circuit and read the amps registered on the ammeter.

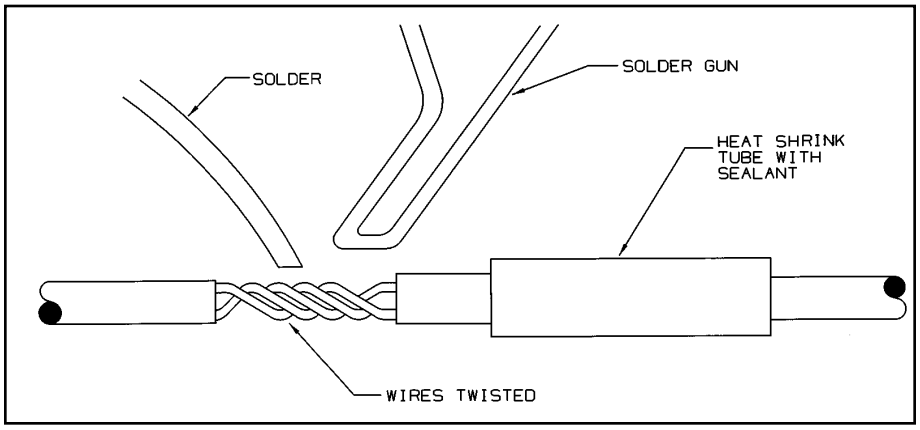


Figure 4

System Protection from Short Circuits

The electrical system has three means of protection from damage due to a short circuit in the total system:

1. A fuse protects each circuit. In some instances a fuse may accommodate more than one circuit. In no case would the combined load be in excess of the rating of the fuse if all the circuits were energized at the same time. In the event such a fuse is tripping all the time it will be necessary to check out each circuit using that fuse.
2. Two 150-amp manual-reset Master circuit breakers are located on the rear electrical panel. (One for body and one for chassis.) This will protect the electrical system from damage that may occur from a major short in any area not protected by a fuse or automatic circuit breaker. This circuit breaker must be manually reset in the event it trips. When the breaker trips, the small RED button will depress. To reset it, move the small black lever located on the left side of the breaker back against the body of the breaker. Depressing the small RED button in the center of the breaker can trip the master breaker, when the electrical system has to be taken out of service to make other repairs.

   In the event the Master breaker should trip more than once, the cause MUST be determined before placing the bus back in service.

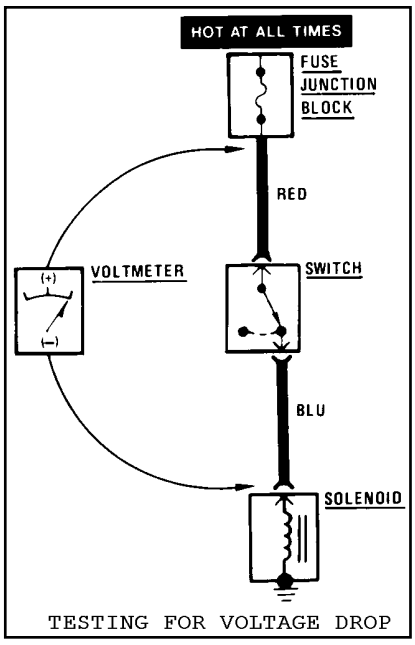


Figure 5

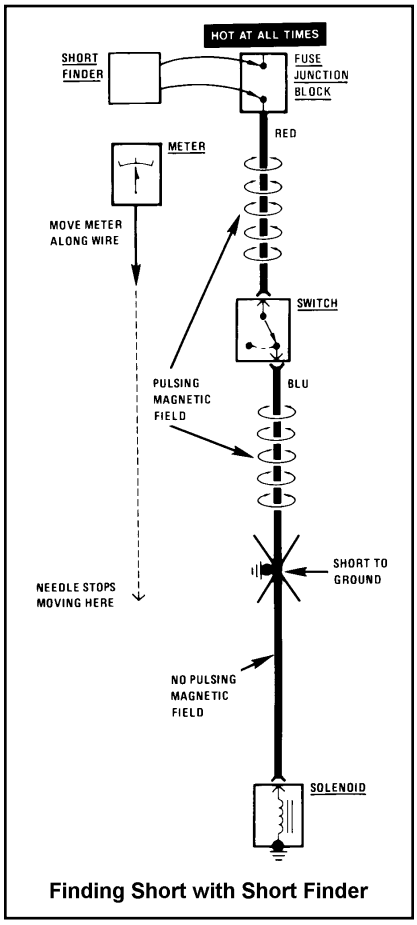


Figure 6

In addition to the above precautions to minimize damage from an electrical short, the insulation on all wiring is of a crosslink polyethylene composition which will not maintain combustion once the copper core of the wire cools. The same applies to convoluted tubing used to protect harnesses and tubing from chafing and the elements.

Testing for Voltage Drop

This test checks for voltage being lost along a wire, or through a connection or switch. See **Figure 5.**

1. Connect the positive lead of a voltmeter to the end of the wire (or to the side of the connection or switch) which is closest to the battery.
2. Connect the negative lead to the other end of the wire (or the other side of the connection or switch).
3. Operate the circuit.
4. The voltmeter will show the difference in voltage between the two points. A difference (or drop) of more than one volt indicates a problem.

Testing for Short to Ground

1. Remove the blown fuse, leaving the battery connected.
2 Connect the short finder (Thomas part #TBB 01004372) across the fuse terminals.
3. Close all switches in series with the circuit you are troubleshooting.
4. Operate the short finder. The short finder will pulse current to the short. This creates a pulsing magnetic field surrounding the circuit wiring between the fuse junction block and the short.
5. Beginning at the fuse junction block, slowly move the short finder meter along the circuit wiring. The meter will show current pulses through sheet metal and body trim. As long as the meter is between the fuse junction block and the short, the needle will move with each current pulse. When you have moved the meter past the point of the short, the needle will stop moving.

Examine the wiring in that area for the short to ground. See **Figure 6**.

Checking Current Draw

1. Connected in series IN a circuit according to polarity.
2. Measures current flow.
3. Used in a closed circuit. See **Figure 7**.

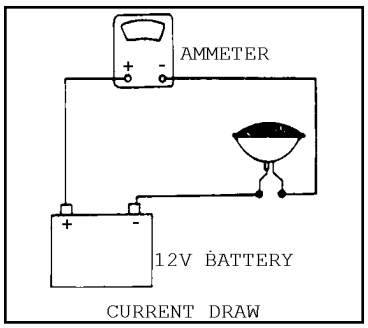


Figure 7

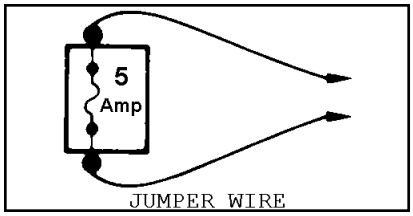


Figure 8

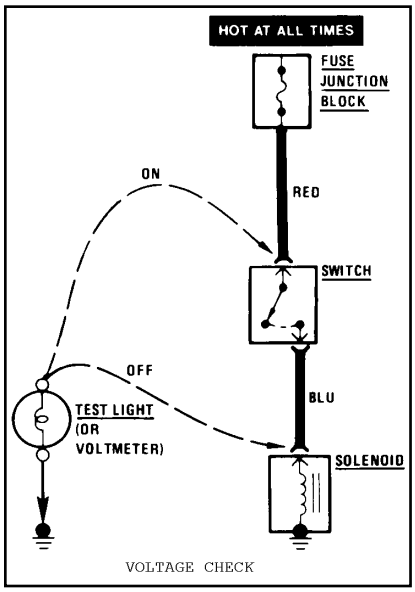


Figure 9

Troubleshooting Tools

Electrical troubleshooting requires the use of common electrical test equipment.

Test Light/Voltmeter:
Use a test light to check for voltage. A Test Light is made up of a 12-volt light bulb with a pair of leads attached. After grounding one lead, touch the other lead to various points along the circuit where voltage should be present. When the bulb goes on, there is voltage at the point being tested.

A voltmeter can be used instead of a test light. While a test light shows whether or not voltage is present, a voltmeter indicates how much voltage is present.

Never use a test light on circuits that contain solid state components, since damage to these components may result.

Jumper Wire:
A jumper wire is made up of an in-line fuse holder connected to a set of test leads. It should have a five-ampere fuse. Use it for bypassing open circuits. Never use a jumper wire across any load (motors, etc.). This direct battery short will blow the fuse. See **Figure 8**.

Short Finder:
Short Finders are available to locate hidden shorts to ground. The short finder creates a pulsing magnetic field in the shorted circuit and shows you the location of the short through body trim or sheet metal.

Troubleshooting Tests

Testing for Voltage:

1. Connect one lead of a test light to a known good ground. If you are using a voltmeter, be sure it is the voltmeter's negative lead that you have connected to ground.
2. Connect the other lead of the test light or voltmeter to a selected test point (connector or terminal).
3. If the test light glows, there is voltage present. If you are using a voltmeter, note the voltage reading. It should be within one volt of measured battery voltage. A loss of more than one-volt indicates a problem. See **Figure 9**.

Alternator and Circuits

Figure 10 outlines the alternator charging circuits. A 2-AWG cable runs from the battery (+) positive post to the starter positive (+) post.

Another 2-AWG cable runs from the starter post to the battery stud of rear electrical box. The alternator positive (+) terminal is connected to this same

post by a 2-AWG cable.

The alternator ground (-) post is connected to the starter ground post by a 2-AWG cable.

Circuit 422 from the Vehicle Electrical Center (VEC), pin C, provides 12 volts to the alternator field circuit when the ignition switch is turned ON. The circuit is protected by 15-amp circuit breaker #8 inside the VEC.

The VEC is located inside the rear electrical box on the Saf-T-Liner HD model bus. It is located on the splash panel/dust shield, beneath the air cleaner on the right side of the engine compartment on the ER model.

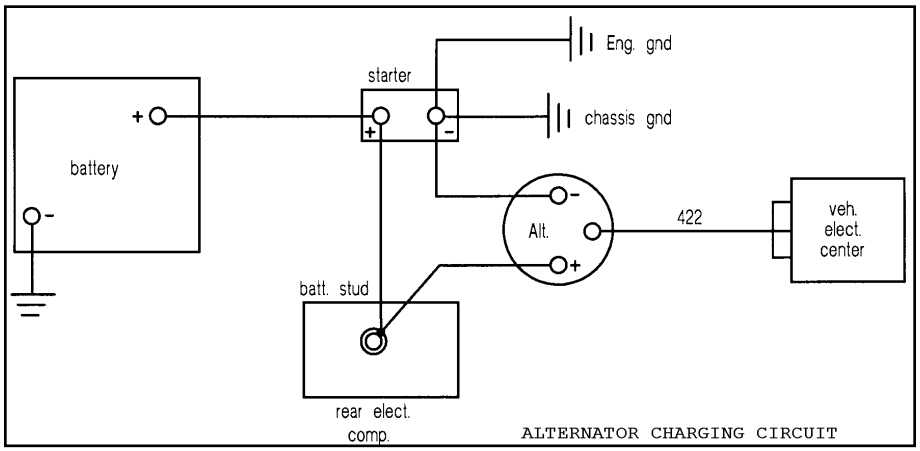


Figure 10

Leece-Neville Regulator Adjustment

The Leece-Neville JB series alternators have a replaceable, and adjustable voltage regulator. To adjust the regulator, follow as noted:

1. Before attempting adjustment, make sure all terminals and connections are tight and clean, the drive belt is properly tensioned, and the batteries are 90-100% fully charged.
2. With the engine OFF, flash the field by connecting a jumper from the NEGATIVE output post to a piece of stiff wire, or a 1/16" drill, inserted into the FULL FIELD access hole in the back of the alternator, just above the row of terminals. Hold it in place for 1 to 2 seconds. This should restore the residual magnetism in the rotor.
3. Connect a voltmeter across the battery terminals. Note the voltage.
4. Start the engine, run at fast idle of 1000 rpm. Voltage at the battery should increase to 13.9 volts to 14.1 with fully charged batteries.

   This is the proper operating voltage in the average environment. In extreme hot and dry climates it may be necessary to drop the voltage to 13.6 to prevent overcharging and loss of electrolyte.

   In extreme cold weather it may be necessary to set voltage up to 14.4 to 14.6 volts to keep the batteries fully charged.

5. To adjust the "flat top" regulator, remove the plastic screw from the plastic cover and insert a small screwdriver into the adjusting screw. Turn the screw clockwise to increase voltage output, the opposite direction to decrease output.

To adjust the DOME TOP regulator, proceed as follows:

a. Stop the engine; disconnect battery ground cable.
b. Remove 10-32 nuts and washers from the regulator terminal and disconnect the diode trio, if so equipped.
c. Remove screws from the regulator cover and lift regulator from the housing. Move it out of the way as far as possible.

   Inspect the two regulator contact pads. If dirty or corroded clean with #600 sandpaper. Note: In some cases contamination on the pads can cause LOW voltage output and voltage adjustment may not be necessary.

d. To adjust voltage, remove, and install the adjustment straps in one of the following positions: A&B = low, A&C = medium, B&C = high. Each change in position will result in a change of .4 volts, up or down.

Example:

- Voltage at battery at 1000 rpm - 13.6 volts
- Voltage recommended by Thomas - 14.0 volts
- Strap position is A&C
- Change strap to B&C would increase voltage to 14.0 volts.
- Recommend torque of strap retaining screws to be 4-5 in/lbs.

Batteries should be fully charged when checking and setting the voltage regulator; otherwise the system voltage will rise as the batteries are fully charged.

Alternator Replacement

1. Disconnect battery ground cable at battery.
2. Remove the drive belt by relieving belt tension. Use 1/2" breaker bar in the square hole in the tensioner to relieve tension.
3. Remove the upper and lower mounting bolts of alternator.
4. Pull alternator towards you far enough to disconnect cables and wiring. Tag each wire to prevent incorrect hook-up when reinstalling the same.

Alternator Installation

1. Inspect pulley fan for cracks, missing fins, being bent.
2. Install pulley spacer (if not in place), cooler fan, and pulley onto rotor shaft. The flat slinger part of the fan must be against the pulley. After pulley has been installed onto the shaft, place the pulley in a vise, using brass jaws. Torque pulley nut to 70-80 ft/lbs.
3. Tap the lower hinge bushings back into the mounting lug to provide

clearance between the mounting lugs and the bracket.

4. Reconnect cables and wires to back of alternator, and put in position on the mounting bracket. Torque the lower mounting bolts to 60-70 ft/lbs. after drive belt has been installed.

Testing/Troubleshooting Charging System

Initial charging system check, using accurate voltmeter:

1. With engine not running, connect voltmeter across the battery terminals. Make sure all electrical load is OFF. Record voltage shown on the voltmeter.

   Start engine, run at moderate RPM and observe battery voltage. If the voltage at the battery is lower (with the engine running) than the initial reading, the alternator has no output. If the voltage is higher, the alternator has output but how much is not known until the rated output test is made.

2. If the battery is overcharged, as evidenced by excessive use of water or water on top of the battery or frequent replacement of bulbs, check for battery voltage higher than 15 volts (with engine running and all systems OFF). Check all terminals and connections in the charging system for looseness and/or resistance. The same would apply if the voltmeter fluctuates.

If voltage remains above 15 volts, replace the voltage regulator.

Rated Output Test

Test equipment required:

- Voltmeter
- Ammeter
- Variable Carbon Pile Load Tester

1. Refer to **Figure 11** for test equipment hook-up. If induction pick-up type ammeter is to be used, place it around the alternator output lead.

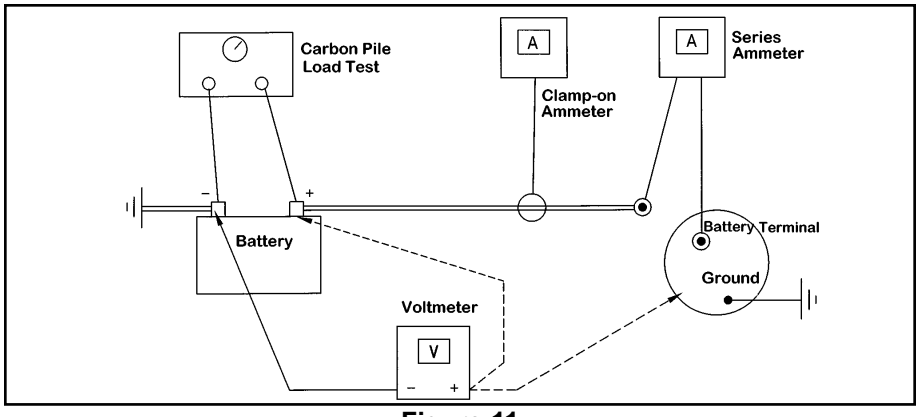


Figure 11

If a series type ammeter is to be used, place it in series with the alternator battery cable and the alternator. Be sure the negative cable is disconnected from the battery when making this installation.

2. Reconnect negative cable at battery.
3. Connect load test machine across the battery. Make sure the load test is OFF.
4. Connect voltmeter negative lead to the negative post of battery.
5. Connect voltmeter positive lead to the positive post of battery and observe voltage reading.
6. Start engine, with all electrical loads OFF, run at moderate speed. Check voltage. It should be higher than previous reading but lower than 15 volts.

   If voltage is lower than previous reading, replace voltage regulator or alternator as required. If higher than 15 volts, replace the regulator.

7. To check maximum output of the alternator: With engine still running at moderate speed, rotate the carbon pile knob until maximum amperage is shown on the machine without allowing the voltage to drop below 13 volts.

   Maximum output should be within 15 amps (+/- 15%) of the rated output stamped on the drive end flange, next to the part number.

8. With the alternator still running at maximum output, move the voltmeter positive lead from the battery positive post to a good ground on the alternator housing.

   Voltage drop for the ground circuit should not exceed 0.25 volts. If more than 0.25 volts, clean and tighten all ground connections.

9. Remove all test equipment, making sure the load test is OFF and the battery negative cable is disconnected if the series ammeter was used.
10. Reconnect battery cable.

Horn Circuit (Figure 12)

When depressed, the horn button completes the ground circuit to the horn relay located in the harness beneath the chassis printed circuit board.

Current to the relay comes from fuse #21 through board connector J20, pin #1, to post 2 on the terminal board located between the circuit board and the front bulkhead. Circuit-H16 (yellow) from post #2 goes to relay terminal 86. Circuit H49 (yellow) from post #2 carries current to relay terminal 30 and on to relay terminal 87 when the horn button is depressed. Circuit H50 (yellow) runs from relay post 87 to bulkhead connector J75, pin 23 from there it continues to the horns.

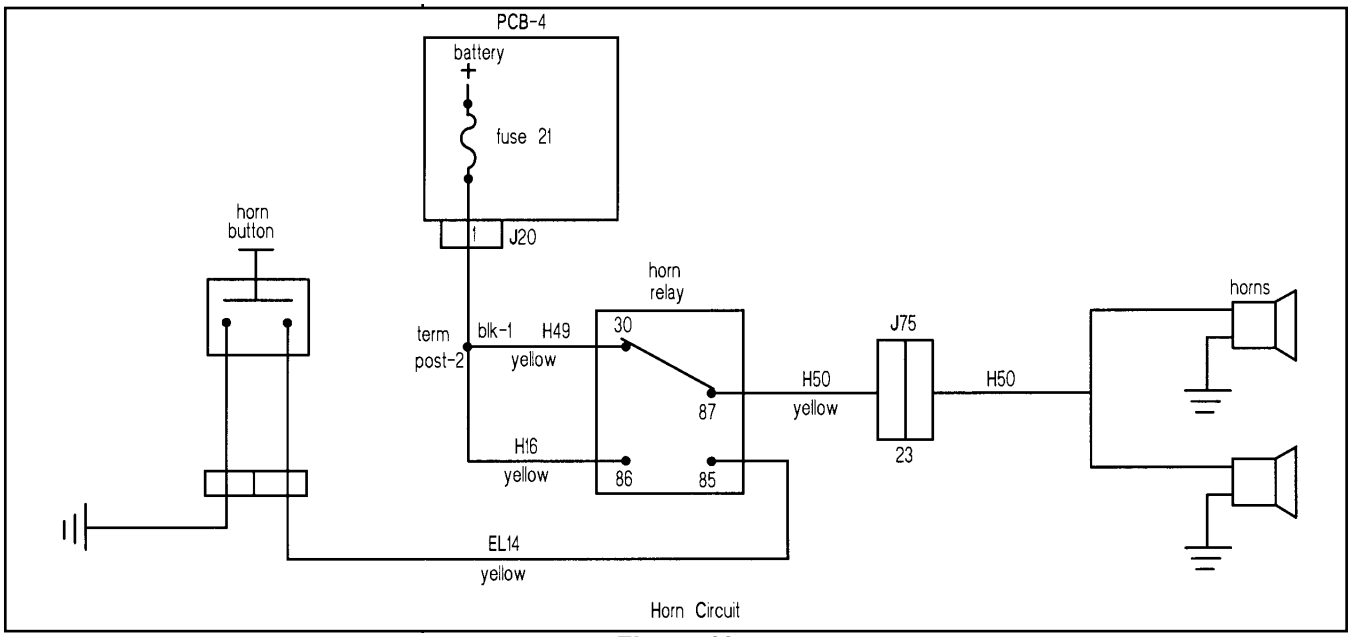


Figure 12

As mentioned before the horn relay is located beneath PCB-4 and is a part of the harness.

Low Air Pressure Warning System

Two NORMALLY OPEN-air pressure switches are located on the air manifold found at the extreme front end of the chassis, readily seen when the front access panel is lowered.

The warning buzzer is mounted inside the Instrument Cluster Unit (ICU) assembly. The warning light is located at the lower right corner of the message center part of the dash.

Figure 13 is a schematic of the simple circuit for this important safety system.

One switch monitors the primary (rear) brake system, the other monitors the secondary (front) system.

The buzzer and the warning light will operate for 3 seconds when the ignition switch is turned ON as a part of the start-up self-test procedure. If air pressure is below 66 psi, both devices will continue to function until system pressure is above 66 psi +/- 6 psi (46 +/- 4 Pa).

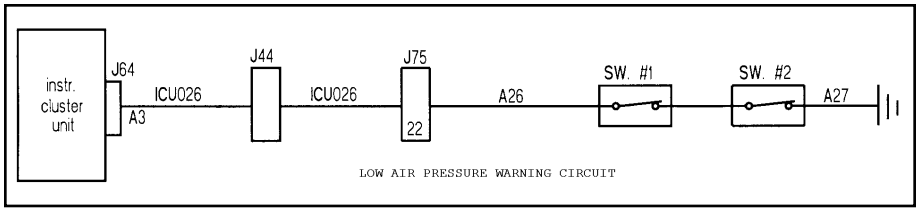


Figure 13

The system and circuit is designed so that when the switches are in the CLOSED position, i.e., with more than 66 psi system, pressure the warning devices are inoperative. The ground circuit is complete.

If one system drops below 66 psi the ground circuit is broken and the warning devices function. This is contrary to the standard wherein components will operate only when its circuit is completed.

The two switches are in series. If either switch should fail the ground circuit would be broken, the same occurs when one system is below 66 psi.

Switch #2 is connected to ground via circuit A27. A jumper wire connects switch 1 and 2. Circuit A26 runs between switch #1 and bulkhead connector J75. The circuit changes to ICU026 in between J75 and connector P44, located in the main electrical compartment. ICU026 then connects to connector J64, pin A3 at the instrument cluster assembly.

Troubleshooting

The warning devices should function for 3 seconds when the ignition switch is turned ON as part of the self-test procedure when system is above 66 psi. If pressure is below 66 psi, they will continue to function until system pressure is over 66 psi.

If the devices continue to operate above 66 psi, check for a failed switch by checking for an OPEN circuit within one of the switches. A complete ground circuit is required to turn the buzzer and warning lamp OFF.

To test the buzzer, warning lamp, and the circuit connect a jumper wire from #1 switch post to ground. If these devices quit working the above items are functional. In this particular system a closed ground circuit is required to cause the buzzer and warning lamp to go OFF.

See Chart of Connector/Pin Location previously shown: **Chart Y-1 through Y-4**.

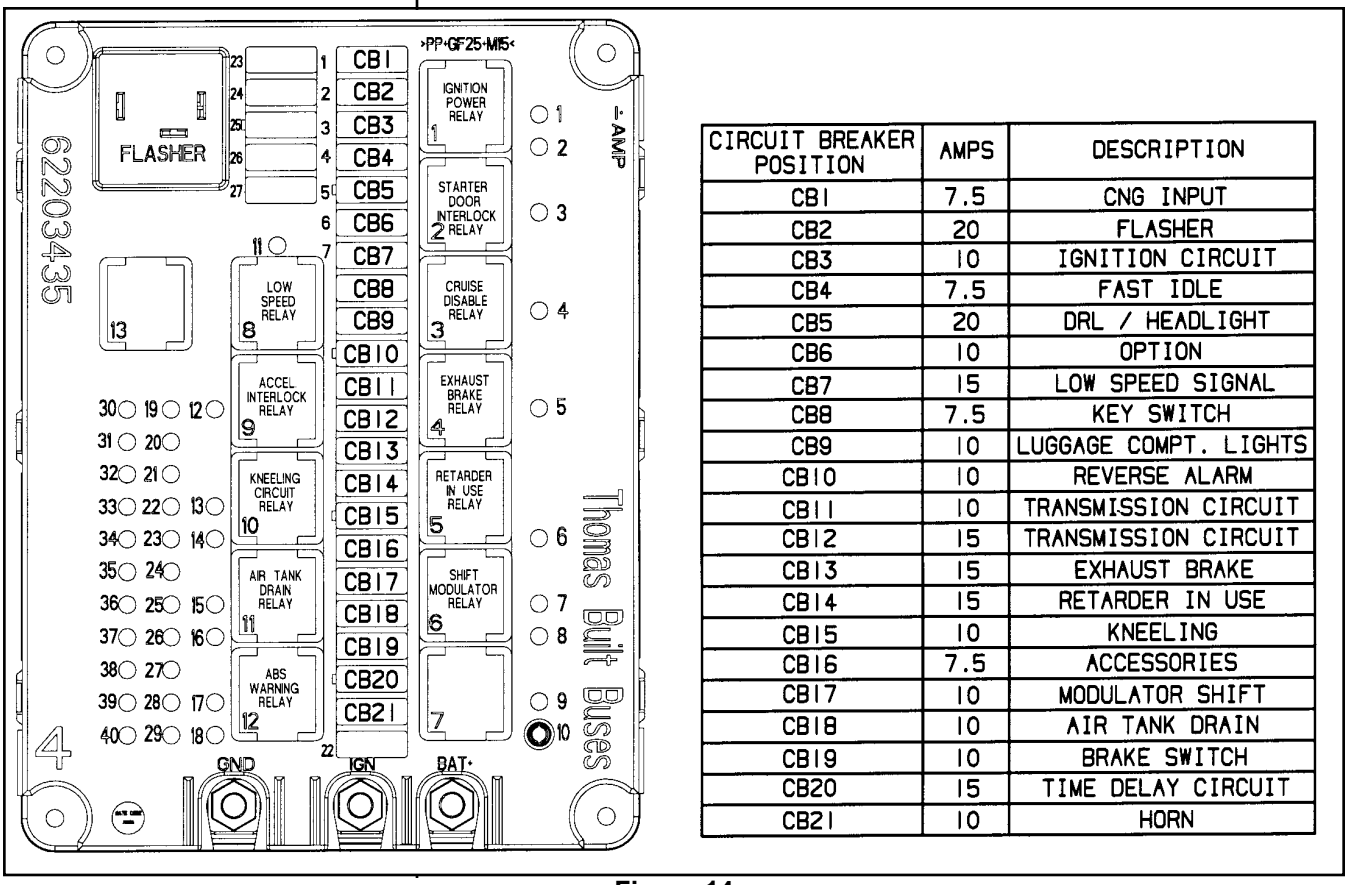
Chassis Electrical System - Compartment

The heart of the chassis electrical system is located in the compartment beneath the dash cover, above the entrance doorstep. Other components are located in the electrical module in the engine compartment. The front compartment contains a Printed Circuit Board (PCB-4), relays, fuses, the turn signal flasher, and the printed circuits, as well as select modules.

Figure 14 shows the face side of the PCB and the position of each relay. While the illustration shows a relay in all positions there may be empty receptacles on your buses because the options involved were not a part of the original order. The number of the relay is not shown on the relay itself; however, the position number is embossed in the circuit board base. Even though a relay(s) is missing, the wiring is in place to the receptacle to facilitate installation of an additional circuit or component later.

The fuse numbers begin at the top, 1 through 21. Numbers 21 through 27 are spar fuse sockets that may be used if additional circuits are needed for later installations.

Never replace a fuse with one of a rating higher than the fuse originally installed.



CIRCUIT BREAKER POSITION	AMPS	DESCRIPTION
CB1	7.5	CNG INPUT
CB2	20	FLASHER
CB3	10	IGNITION CIRCUIT
CB4	7.5	FAST IDLE
CB5	20	DRL / HEADLIGHT
CB6	10	OPTION
CB7	15	LOW SPEED SIGNAL
CB8	7.5	KEY SWITCH
CB9	10	LUGGAGE COMPT. LIGHTS
CB10	10	REVERSE ALARM
CB11	10	TRANSMISSION CIRCUIT
CB12	15	TRANSMISSION CIRCUIT
CB13	15	EXHAUST BRAKE
CB14	15	RETARDER IN USE
CB15	10	KNEELING
CB16	7.5	ACCESSORIES
CB17	10	MODULATOR SHIFT
CB18	10	AIR TANK DRAIN
CB19	10	BRAKE SWITCH
CB20	15	TIME DELAY CIRCUIT
CB21	10	HORN

Figure 14

The fuse chart on **Figure 14** shows the accessory or circuit being protected, as well as, the proper rating for the circuit being served.

The PCB-4 has a row of LEDS, but they are not used.

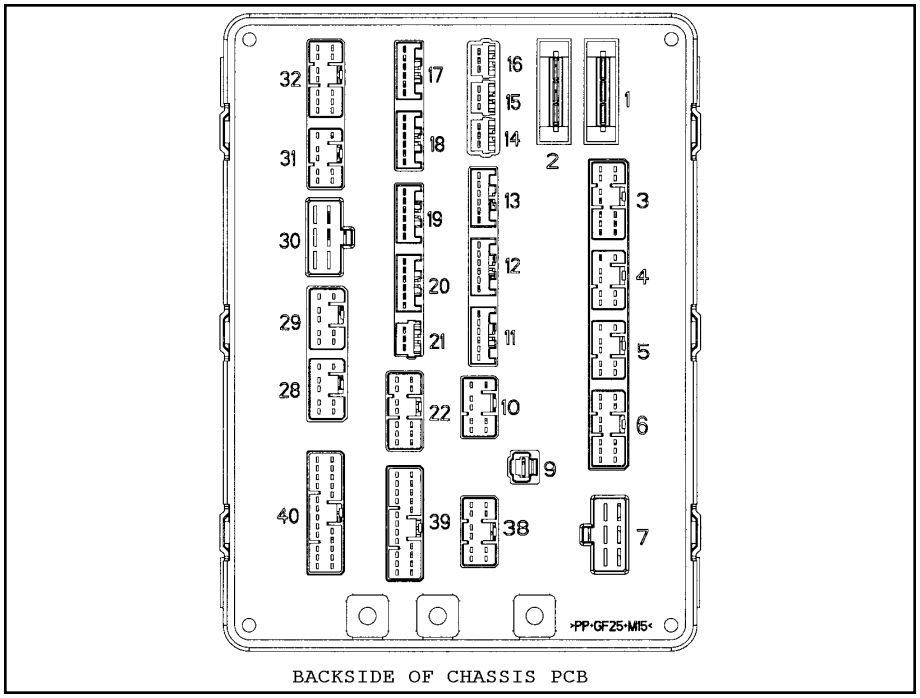


Figure 15

Figure 15 is the backside of the circuit board and lists the connector number location into the board. A WHITE tag showing the connector number is placed around the harness, near the connector.

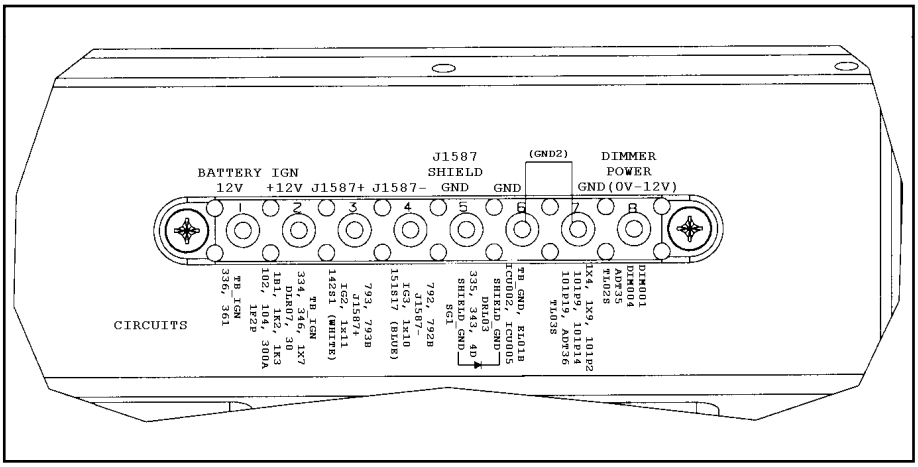


Figure 16

Figure 16 outlines the circuits that are linked at a terminal block located between the PCB and the front bulkhead.

Figure 17 outlines the front side of the bulkhead connector receptacles, where the main harnesses interface with the chassis circuits.

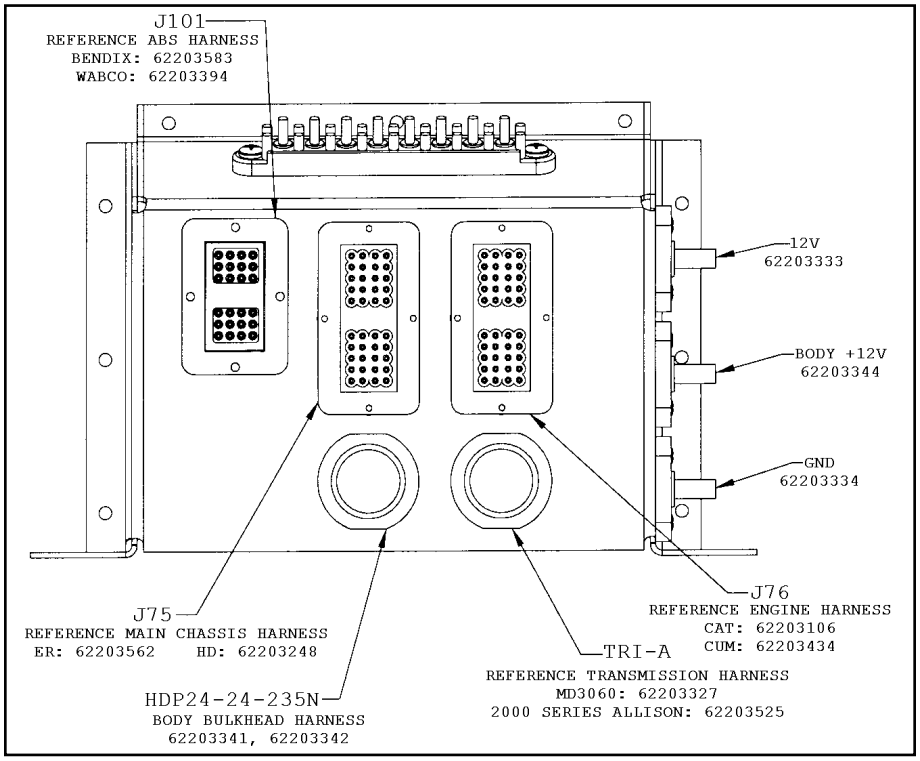


Figure 17

Knowing the function and location of each harness can be useful in the event it becomes necessary to check continuity of a given circuit.

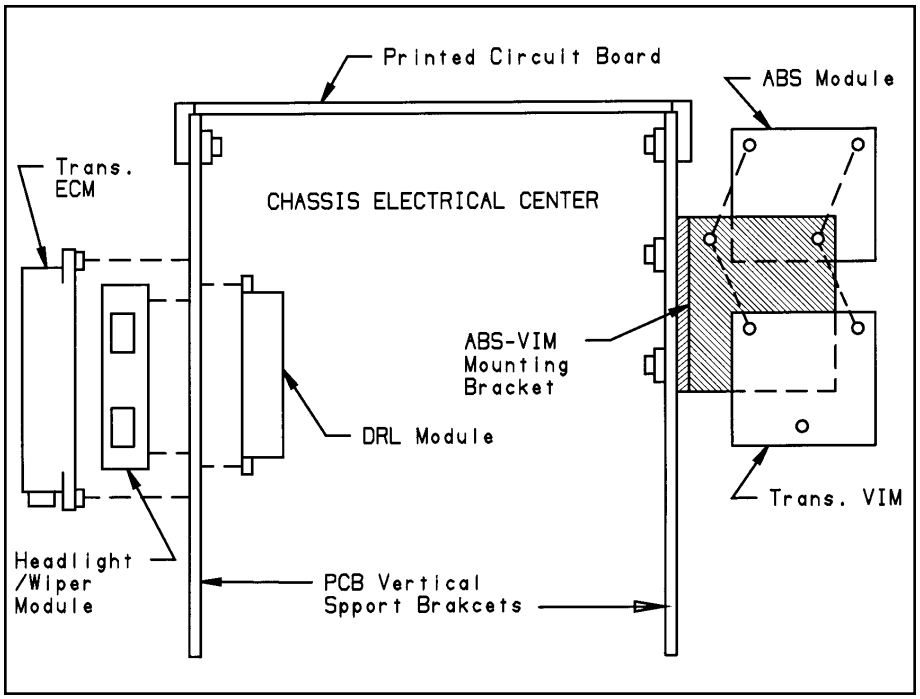


Figure 18

Figure 18 is a general description of the location of the various modules located in the front electrical compartment.

A diode block assembly that controls the Right windshield wiper motor is located on the front bulkhead in front of the PCB assembly.

Procedure to Service the ECM, DRL, VIM, ABS, and H/L Wiper Modules - (Units built prior 11/13/01, ER Chassis #88563 and HD Chassis #63085.)

The installation of so many components in the chassis electrical compartment gives a first impression of being difficult to service these components. However, by following the procedures listed hereafter, the removal/replacement of each component is relatively simple.

The modules mentioned above are mounted on the PCB vertical support brackets. See **Figure 18**.

1. **Disconnect batteries, or OPEN the master circuit breakers on top the engine compartment electrical box.**
2. Remove electrical compartment cover.
3. Remove the 2-¼" nuts from the rear corners of the circuit board assembly, where the board is attached to the vertical support brackets. Tilt the board assembly up from the rear as high as possible. It may be necessary to loosen the PCB front mounting nuts. Use a pry bar or large screwdriver to push the vertical support aside to clear the attaching shoulder bolts.

   The use of a ¼" ratchet set is recommended for use in this area. The various harnesses that fill this area can be pushed aside as required to gain access to the module mounting fasteners.

4. Transmission Electronic Control Module (ECM) - With the PCB tilted up as outlined in step 3, remove the three fasteners that attach the ECM to the vertical support. Bend the top bracket up far enough to allow the ECM to be pulled upward and out. (The top bracket mentioned above may not exist on later units.)

   Note: Push the vertical support bracket towards the center to gain adequate clearance to remove the ECM.

   To remove the gray and black connectors from the ECM, pull the RED lock from its locked position and push down on the other locking fingers while pulling the connector from its receptacle.

   When reinstalling the ECM, place it back into the area where it will be mounted and install the connectors before remounting it. The connectors are color-coded to prevent improper connection.

5. Windshield Wiper Module - Located between the ECM and the vertical support. Remove the ECM as outlined in step 4, but push it aside only as needed to gain access to the wiper module fasteners.

   With the fasteners removed, pull the wiper module outward and disconnect the harness.

When reinstalling the module be sure to reconnect the connectors before placing it back in position.

6. Daytime Running Lights Module (DRL) - Tilt the PCB up, as in step 3. Remove the rear nut, but only loosen the front retaining nut enough to permit sliding the module rearward enough to remove it. The mounting lugs are slotted.

   Remove the green sliding lock in the connector with a screwdriver, and remove the connector from the body.

   Make sure the connector is firmly in place before reinstalling the module in place.

7. Antilock Brake System Module (ABS) - The ABS module is mounted on a removable bracket that is mounted to the right vertical support. Two ½" self-locking nuts attach this bracket to the vertical support. Remove the bracket to gain access to the ABS module's 4 3/8" socket nuts.

   Disconnect the harness connectors and remove the module. Reverse the procedure to reinstall.

8. Vehicle Interface Module (VIM) - Located on the backside of the bracket mentioned above. Tilt PCB up and remove the bracket as noted in step 7.

   Remove module fasteners, lift the module up and forward, remove harness connectors and remove the module.

Note: The VIM contains fuses and relays inside the module. To remove the module cover to check or service the VIM components, the ABS/VIM mounting bracket must be removed from the vertical support to gain enough clearance to remove the cover. It is not necessary to remove the VIM from its mount, only lift it and push it forward enough to permit removal of the cover.

Procedure to Service Modules on units built on 11/13/01, ER Chassis #88563 and HD Chassis #63085.)

Certain modules were relocated in the chassis front electrical compartment to facilitate easier removal and service to the ECM, ABS, and VIM modules.

Procedure suggestions:

1. Using ¼" drive ratchet and sockets, open the two master circuit breakers on the rear electrical module.
2. Remove PCB-4 compartment cover.
3. The printed circuit board can be lifted and moved aside to gain access to the various fasteners that mount the modules to the vertical supports.

   Loosen, but do not remove, the ¼" nuts at each corner of the circuit board. Lift the rear side of the board to clear the fastener slots. Push the board forward enough to clear the front horizontal mounting slots. The board can now be moved off to the side and up enough to gain access to fasteners in between the two vertical supports.

4. Transmission ECM - With the circuit board moved out of the way,

remove the WS/HL module mounting fasteners. These fasteners also mount the ECM adapter plate.

Once the adapter plate is loose, remove the harness connectors from the ECM.

The connectors are held in place by a RED locking guard. Squeeze the ends of the RED lock together and push down on the connectors at the same time. Considerable effort may be required to disengage the connectors.

With the connectors and harnesses removed, lift and tilt the ECM assembly to remove it.

When reinstalling the ECM, be sure to connect the BLACK connector first, before attempting to remount the assembly. The connectors are color-coded to prevent improper connection.

5. WS/HL Module - This module is held in place by two sheet medal screws, 5/16" socket. Is easily accessed by lifting the circuit board and moving it aside.
6. DRL Module - Remove the bracket that supports two relays beneath the circuit board. The outer end of the bracket is slotted for easy removal of the bracket, no need to remove the fastener at that end.

   Remove the rear nut that secures the module to the vertical support. Loosen, but do not remove the front nut. The module can now be pulled out and forward for removal. 11/32" socket is required.

7. ABS Module - The ABS and VIM modules are mounted onto a bracket that is bolted to the right vertical support. The 2 ¼" bolts that mount this bracket go through key shaped holes in the vertical support. Loosen the retaining nuts, slide the assembly rearward and the modules and mounting bracket will pull away from the vertical support. Either module can then be easily removed from the bracket.

   The above mentioned bracket has been moved upward and forward to permit removal of the VIM cover without interference with the body, if it becomes necessary to check the fuses or relays within the VIM.

   Removal of the VIM module is the same as the ABS module described above.

Printed Circuit Board (PSB-4)

The printed circuit board is the centerpiece of the chassis electrical system. It serves as the distribution center for chassis battery, ground, and ignition circuits. Two-2 AWG cables from the terminals located in the front bulkhead to the posts on the right side of the circuit board provide battery power and ground circuits to the board.

The board contains relays to control certain circuits, fuses, and/or circuit breakers for circuit protection, and accommodates the turn signal flasher. In addition, it distributes the signals to the dash lights and the LEDs that may be used.

Power and ground circuits for the Instrument Cluster Unit (ICU) and the lighted dash switches, are provided by the PCB.

Other circuits controlled by the PCB include the headlight power, marker lights, brake lights, various interlock circuits that may be on the bus, transmission control signals, ABS control signals, and warning light signals.

Figure 19 is a schematic of the circuit board. The asterisks on the extreme right side of the schematic refer to the terminal points of the 2 AWG cables mentioned above.

In short, the PCB provides the power and ground circuits, through relays and fuses, to the various switches and controls of chassis related circuits.

The board is not repairable. It contains spare relays and fuse holders that permit protected, safe circuits to be added later.

Never replace a fuse with one of a higher rating than the one being replaced. DO NOT substitute a solid object for a fuse under any circumstances. To do so, will damage the PCB beyond repair.

V-1 through V-7 shows the circuits that make up each harness/connector numbered in black that plugs into its respective receptacle on the bottom side of the circuit board. See **Figure 15**.

See Circuit Board Schematic Inside

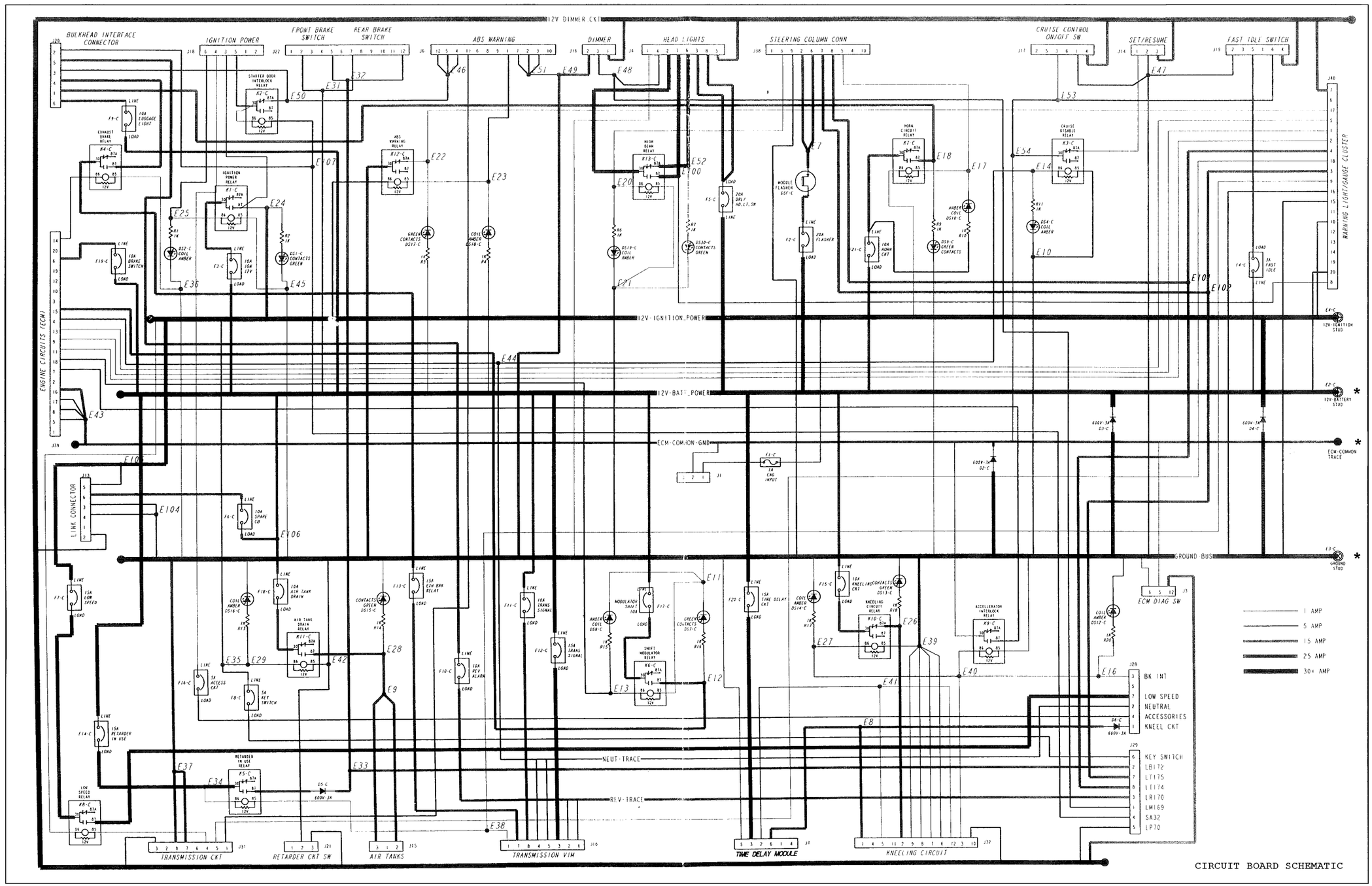

12V DIMMER CKT
BULKHEAD INTERFACE CONNECTOR
IGNITION POWER
FRONT BRAKE SWITCH
REAR BRAKE SWITCH
ABS WARNING
DIMMER
HEAD LIGHTS
STEERING COLUMN CONN
CRUISE CONTROL ON/OFF SW
SET/RESUME
FAST IDLE SWITCH
STARTER DOOR INTERLOCK RELAY
EXHAUST BRAKE RELAY
IGNITION POWER RELAY
ABS WARNING RELAY
HIGH BEAM RELAY
MODULE FLASHER
HORN CIRCUIT RELAY
CRUISE DISABLE RELAY
WARNING LIGHT/GAUGE CLUSTER
ENGINE CIRCUITS (ECM)
12V-IGNITION_POWER
12V-BATT_POWER
ECM-COMMON-GND
GROUND BUS
NEUT-TRACE
REV-TRACE
LINK CONNECTOR
12V IGNITION STUD
12V-BATTERY STUD
ECM COMMON TRACE
GROUND STUD
ECM DIAG SW
BK INT
LOW SPEED
NEUTRAL
ACCESSORIES
KNEEL CKT
KEY SWITCH
LBI72
LTI75
LTI74
LRI70
LMI69
SA32
LP70
1 AMP
5 AMP
15 AMP
25 AMP
30+ AMP
TRANSMISSION CKT
RETARDER CKT SW
AIR TANKS
TRANSMISSION VIM
TIME DELAY MODULE
KNEELING CIRCUIT
CIRCUIT BOARD SCHEMATIC

Figure 19

BOARD #4 "BLACK" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
1	NOT USED		SHUNT	
1		N/A		
2		N/A		
3		N/A		
2	NOT USED		SHUNT	
1		N/A		
2		N/A		
3		N/A		
3	ECM Diagnostic Switch		AMP #	173851-1
1				
2				
3				
4				
5	BNEG5	WHITE	ECM Common Ground	
6	IL36	WHITE	LED Switch Lamp Ground	
7				
8				
9				
10				
11				
12	IL35	RED	LED Switch Lamp Power	
4	Headlights		AMP #	173850-1
1				
2				
3	EL03	YELLOW	Headlamp Power Input	
4	EL07	BLACK	Marker Lights Input	
5	EL02	RED	LED Switch Lamp Power	
6				
7				
8	DRL04	PINK	Battery(+12V) to DRL Module	Fuse #5, 20A
5	Not Used		AMP #	173850-1
1				
2				
3				
4				
5				
6				
7				
8				

Chart V-1

BOARD #4 "BLACK" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
6		ABS		AMP #	173851-1
	1	1 E3	YELLOW	ABS Warning Lamp Relay	
	2	1A1	WHITE	Ground	
	3	1A2	WHITE	Ground	
	4				
	5				
	6				
	7	1A3	WHITE	Ground	
	8				
	9				
	10				
	11	1K1	WHITE	ABS Active Signal to Transmission	
	12				
7		Time Delay Module			171898-1
	1				
	2			Jumper to Kneeling Circuit	
	3			Battery(+12V)	Fuse #20, 15A
	4				
	5			Ground	
	6			Jumper to Kneeling Circuit	
9		Not Used		AMP #	172128-1
	1				
10		Transmission ECU			173850-1
	1			Retarder in Use	
	2	ADT302	PINK	Reverse Lamps	
	3	659	RED	Neutral Signal Power Feed	Fuse #12, 15A
	4	660	YELLOW	Neutral Signal	
	5			Neutral Signal	
	6			Reverse Lamps	
	7			Exhaust Brake Relay	Fuse #13, 15A
	8	ADT103	PINK	To Panel Lights	Fuse #11, 10 A
11		Not Used		AMP #	174923-1
	1				
	2				
	3				
	4				
	5				
	6				

Chart V-2

BOARD #4 "BLACK" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
12		Not Used	AMP #	174923-1
1				
2				
3				
4				
5				
6				
13		Adjustable Pedals/Option	AMP #	174923-1
1				
2			Dimmer Power	
3			Ground	
4			Ground	
5			Ignition Power	
6			Battery Power	Fuse #6, 10A
14		Cruise Control On/Off	AMP #	174921-1
1	BNEG3	WHITE	ECM Common Ground	
2	IL36	WHITE	LED Switch Lamp Ground	
3	IL35	RED	LED Switch Lamp Power	
15		Air Tanks	AMP #	174921-1
1				
2			Air Tank Drain Relay	
3			Air Tank Drain Relay	
16		LED Switch Lamp Dimmer Circuit	AMP #	174921-1
1	DIM001	RED	Dimmer Power Input	
2	DIM002	WHITE	Marker Lamps Output	
3	DIM003	LT. BLUE	Ground	
17		Cruise Control Set/Resume	AMP #	174923-1
1	IL36	WHITE	LED Switch Lamp Ground	
2				
3	BNEG4	WHITE	ECM Common Ground	
4	IL35	RED	LED Switch Lamp Power	
5				
6				
18		Ignition Circuit	AMP #	174923-1
1				
2				
3	IGN069	RED	Ignition Relay Output	
4	IGN115	PINK	Accessory Circuit	Fuse #16, 5A
5	STA004	PURPLE	Starter Circuit	
6	IGN002	BLACK	Ignition Relay Input	

Chart V-3

BOARD #4 "BLACK" CONN/PIN #		CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
19			**Fast Idle**	**AMP #**	**174923-1**
	1				
	2	IL36	WHITE	LED Switch Lamp Ground	
	3				
	4	IL35	RED	LED Switch Lamp Power	
	5	164	RED	Exhaust Brake/Fast Idle Switch Power	
	6	BNEG8	WHITE	ECM Common Ground	
20			**Chassis Bulkhead**	**AMP #**	**174923-1**
	1	H50	YELLOW	Horn Relay Output	
	2				
	3	ST04B	PURPLE	Start Signal	
	4	EX38	RED	Exhaust Brake	
	5	TRI07	GRAY	Reverse Alarm Wire	
	6	EL387	YELLOW	Luggage Compartment Lights	**Fuse #9, 10A**
21			**Retarder Switch**	**AMP #**	**174921-1**
	1				
	2			Ground	
	3			LED Switch Lamp Power	
22			**Brake Lights**	**AMP #**	**173851-1**
	1				
	2	BK59	RED	Brake Light +	
	3				
	4				
	5	BK60	WHITE	Brake Light -	
	6				
	7				
	8				
	9				
	10				
	11				
	12				

Chart V-4

BOARD #4 "BLACK" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
28		**Body Interface Connector #1**	**AMP #**	**173850-1**
1	Kneeling	BLACK	Kneeling	
2	Neutral	BLACK	Neutral	
3	BKINT	BLACK	Brake Interlock	
4	ACC	BLACK	Accessories	
5				
6				
7	LOWSPD	BLACK	Low Speed	
8				
29		**Body Interface Connector #2**	**AMP #**	**173850-1**
1	LM169	TAN	Marker Lights	
2	LB172	RED	Brake Lights	
3	LM168	BROWN	Park Lights	
4	SA32	YELLOW	Starter Door Interlock	
5	LE74	BLUE	Stepwell Lights	
6			Key Switch	
7	LT174	YELLOW	Left Turn Signals	
8	LT175	GREEN	Right Turn Signals	
30		**Not Used**	**AMP #**	**171898-1**
1				
2				
3				
4				
5				
6				
31		**Transmission**	**AMP #**	**173850-1**
1	ADT113	PINK	ABS Active Input Signal	
2				
3			Dimmer Power to Shifter	
4			Low Speed Relay Input	
5	ADT125	GREEN	"Check Trans" Light	
6				
7	ADT105	GRAY	Transmission ECU Ground	
8	ADT101	GRAY	Transmission ECU Ground	

Chart V-5

BOARD #4 "BLACK" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
32	Kneeling		AMP #	173851-1
1			To Time Delay Circuit	
2			To Kneeling Relay	
3			To Accelerator Interlock Relay	
4				
5			To Time Delay Circuit	
6			Ground	
7			Ground	
8			Ground	
9			Ground	
10			Dimmer Power	
11				
12			To Time Delay Circuit	
38	Steering Column		AMP #	174465-1
1				
2				
3				
4				
5	EL14	YELLOW	Horn Signal from Steering Column	
6	EL04	BLACK	Turn Signal Flasher to Steering Column	
7	EL05	ORANGE	Left Turn Signal	
8	EL06	BLUE	Right Turn Signal	
9				
10				
39	Engine		AMP #	173853-1
1				
2				
3				
4	B46	GREEN	Neutral Trace	
5	BNEG10	WHITE	ECM Common Ground	
6			Fuse #19, 10A	
7	B24	RED	Accelerator Interlock	
8	BNEG11	WHITE	ECM Common Ground	
9	B3	YELLOW	"Check Engine" Lamp	
10				
11			Intake Air Heater Lamp	
12				
13	B1	RED	"Stop Engine" Lamp	
14	A42	GRAY	Exhaust Brake Relay	
15			Shift Modulator Relay Output	
16	BNEG	WHITE	ECM Common Ground	
17	BNEG1	WHITE	ECM Common Ground	
18			Shift Modulator Relay Input	

Chart V-6

BOARD #4 "BLACK" CONN/PIN #	CIRCUIT	COLOR	DESCRIPTION	CONNECTOR PART #
40	DASH		AMP #	174952-1
1	ICU799		"Check Engine"	
2	ICU250		Intake Air Heater	
3	ICU042		Right Turn Signal	
4	ICU043		Left Turn Signal	
5	ICU659		"Stop Engine"	
6				
7	ICU035		Dimmer	
8			High Beam	
9			Retarder In Use	
10	ICU012		Ignition Power	
11				
12				
13				
14				
15	ICU036		Ground	
16	ICU003		Ground	
17	ICU1E1		ABS Warning	
18	ICU115		"Check Trans"	
19				
20	ICU121		Battery Power	

Chart V-7

Connector Locations - Chassis

During the course of this manual there may be occasions where a harness or circuit connector is indicated. The chassis electrical system in total, on both the Saf-T-Liner ER and HD models, (including all options that are available) could incorporate many of the 140 connectors listed under *Connector Locations*. The intent in listing the location of the connectors is to assist in locating any given connector if it becomes necessary to trace a circuit. As mentioned elsewhere the connector number should be listed on an identification tag wrapped around the harness, near the connector. All connectors on the chassis harnesses are identified with the letter "P" preceding the connector #. The letter "J" designates the connector receptacles on the printed circuit board. When a receptacle is a part of a vendor supplied component it would be designated as a "J" connector.

On **Figure 19** note all connectors (receptacles) are shown as "J" numbers. **Figure 15** shows the location of each "J" connector on the bottom side of the PCB.

The connectors that plug into these "J" connectors will carry a P-C number. Using **Figure 19** as an example, refer to the "fast idle switch" connector J19 shown in the extreme upper right corner of the schematic. Harness connector P19C would plug into J19 beneath the circuit board.

Circuit/Wiring Identification

Each circuit in the chassis electrical system should have the circuit # embossed on the insulation, every 4" or so, apart. Component manufacturers furnish a small number of harnesses, and their wiring may not show a Thomas circuit number. The color of the wire in their harness may not match the color of its mating wire in the Thomas harness. Therefore, if a circuit is being traced by color make sure the color does not change when it passes through a connector, when interfacing with a vendor supplied harness.

Each wire in a harness carries a one or two letter prefix to the circuit #. Example: ST65 is "starter circuit #65".

Some of the letter prefixes found on the wires are listed below and should be helpful in tracing a given circuit.

En - Engine Related Circuit
DRL - Daytime Running Light circuits
WP - Windshield Wiper circuits
H - Horn Circuits
BNEG - Ground Circuit
IGN - Ignition Circuit
EL - Circuit involving External Lights
IL - Circuit involving Internal Lights
BK - Brake Circuits

ST - Starter Circuits
T or TR - Transmissions Circuits
A - ABS Circuits
ICU - Instrument Cluster Unit Circuits

Front Bulkhead Connectors/Receptacles

Deutsch connectors/receptacles are used in the front electrical compartment harness-to-bulkhead interfaces. Sixteen and 18 gauge wiring is used in the harnesses involved; however, the same pin and socket is used on both.

To prevent damage to the pin or socket or connector body when removing a terminal it is critical that Deutsch Removal Tool, #0411-204-1605, be used. To remove a terminal from the connector, snap the removal tool over the wire to be removed. Slide the tool along the wire into the cavity until it engages contact and resistance is felt. Do not twist or insert the tool at an angle. Pull the terminal and wire from the connector.

The following (Deutsch) items should be in the operator's inventory and can be procured from your area Thomas dealer.

Terminal Removal Tool - #0411-204-1605
Terminal Crimping Tool - #DTT-16-00
Pin - #1060-16-0122
Socket - #1062-16-0122

To install a pin or socket properly, remove ¼" (6.3mm) insulation from the wire. Use crimping tool DTT-16-00. After crimping, test the crimping quality by pulling on the terminal and the wire.

Grasp the wire approximately 1" behind the terminal and push it into the connector body until it engages solidly. It should not pull out at this point.

Pin Location

Reference will be made on occasion to pin position in its connector. The pin # is embossed on the surface of the connector body in small print.

Figure 20 shows the pin positions in the Deutsch connectors in the front bulkhead, as shown from the front of the bus.

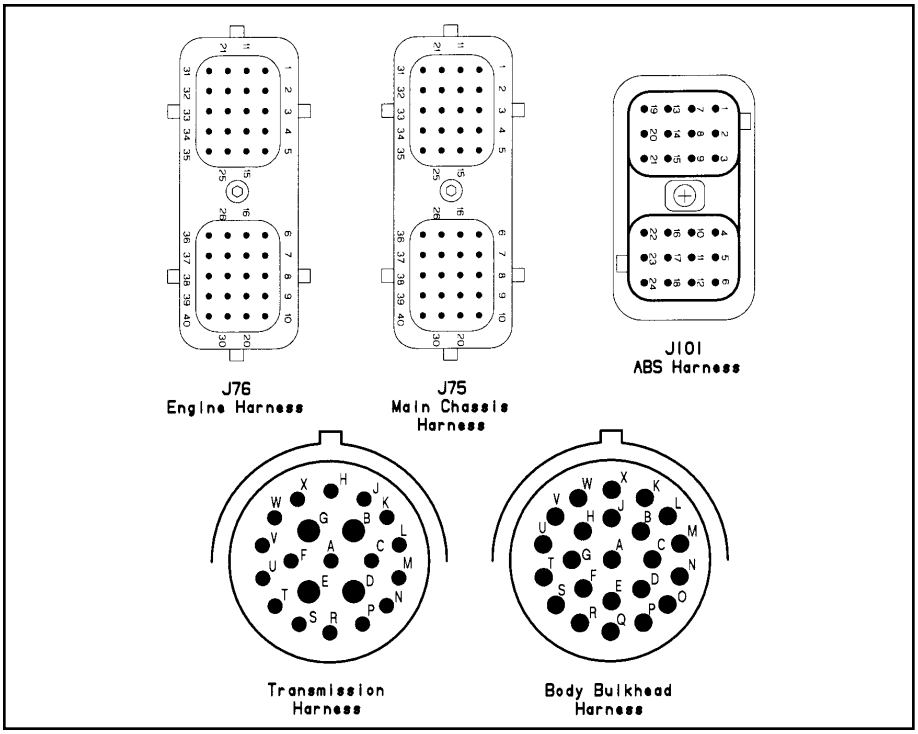


Figure 20

CONN. DES.	COMPONENT	LOCATION
P3	Horn #1	Behind Grill
P4	Park Brake Switch	Dash
P5	Wheelchair Lift Alarm	Behind Grill
P6	Low Air Pressure Switch	Behind Grill
P7	Low Air Pressure Switch	Behind Grill
P8	Headlight/DRL Connector RS	Headlight Assembly
P9	Headlight/DRL Connector LS	Headlight Assembly
P10	Throttle Position Sens (Rear)	Rear Mod Box
P11	Throttle Position Sens (Front)	Drivers Area
P12	Turn Signal RS	At F. TS.
P13	Turn Signal LS	At F. TS.
P14	Kneel Solenoid	Front Axle Area
P15	Brake Interlock	Front Axle Area
P16	Vehicle Speed Input	Engine Area
P17	Engine ECM (CAT 3126)	At Engine
P18	Engine Air Inlet Htr Relay	At Engine
P19	Fuel Gauge Sender	Fuel Tank (Midway)
P20	Air Dryer	Near Rear Axle
P21	Hydraulic Oil Level Sensor	Engine Area
P22	Hydraulic Oil Temperature Sensor	Engine Area
P23	Trans Temp Sensor	On Trans
P24	Oil Pressure Sensor	Rear of Engine
P25	Oil Temperature Sensor	Rear of Engine
P26	Water Temperature Sensor	On Engine
P27	Coolant Level Sensor Module Conn.	On Engine
P28	Low Speed Switch	NA

P29	Neutral Switch	Fwd of Trans
P30	Reverse Switch	Dash Area
P31	Horn Sw. Conn.	Steering Col.
P32	Rear Box Bulkhead	Rear Box
P33	Audible Turn Signals	Behind Dash
P34	Transmission TR1	Fr. Bulkhead
P35	Transmission TR2	Rear Axle
P36	Transmission TR3	On Trans
P37	Trans Eng. Speed Sensor	On Trans
P38	Trans Output Speed Sensor	On Trans
P39	Transmission HSOL	On Trans
P40	Transmission ASOL	On Trans
P41	Transmission RTemp	On Trans
P42	Transmission Modulator (AT/MT)	Near Trans
P43	DRL Module Connector	Elect Compt FR
P44	Interior Bulkhead Interface #1	Elect Compt FR
P45	Elect Turn Sig Module Output #1	Elect Compt FR
P46	Elect Turn Sig Module Output #2 - Wiper	Elect Compt FR
P47	Elect Turn Sig Module Input #2 - Wiper	Elect Compt FR
P48	Interior Bulkhead Interface #2	Elect Compt FR
P49	Reserved BH Bulkhead	
P50	Ignition Switch	Dash
P51	Fast Idle Switch	Dash
P52	Engine Diagnostic Switch	Dash
P53	Cruise On/Off	Dash
P54	Cruise Set/Res	Dash
P55	Exhaust Brake Switch	Dash
P56	Air Tank Drain #1	Dash
P57	Air Tank Drain #2	Dash
P58	Retarder On/Off	Dash
P59	Headlight Switch	Dash
P60	Dimmer Switch	Steer Column
P61	Turn Signal Switch "View A"	Steer Column
P62	Wiper Switch "View B"	Steer Column
P63	Headlight Dimmer Switch "View C"	Steer Column
P64	Instrument Cluster (24 Pin)	Dash
P65	Instrument Cluster (32 Pin)	Dash
P66	Transmission ECU/S	Elect Compt FR
P67	Transmission ECU/V	Elect Compt FR
P68	Transmission ECU/T	Elect Compt FR
P69	Trans VIM (Green)	Elect Compt FR
P70	Trans VIM (Blue)	Elect Compt FR
P71	Trans VIM (Black	Elect Compt FR
P72	Trans VIM (Grey)	Elect Compt FR
P73	(reserved trans)	
P74	Horn SW. Conn #1	Steer Column
P75	Main Chassis Bulkhead Connector	Fr. Bulkhead
P76	Engine Bulkhead Connector	Fr. Bulkhead
P77	ABS Bulkhead Connector	Fr. Bulkhead

P78	Vehicle Elect Center Conn A	Top of R. Box
P79	Vehicle Elect Center Conn B	Top of R. Box
P80	Vehicle Elect Center Conn C	Top of R. Box
P81	Vehicle Elect Center Conn D	Top of R. Box
P82	Fuel Water Separator	Engine Area
P83	Rear Mod Box Data Link Connector	R. Mod Box Area
P84	Allison Trans Speed Signal Output	Engine Area
P85	Vehicle Elect Center Pwr Conn	R. Mod Box Area
P86	Air Inlet Heater Conn #1	Engine Compt
P87	Air Inlet Heater Conn #2	Engine Compt
P88	Air Inlet Heater Contactor	Engine Compt
P89	Air Inlet Heater ECU Output	Engine Compt
P90	Exhaust Brake	LS Eng Compt
P91	Air Tank Drain	Air Tanks
P92	Air Tank Drain	Air Tanks
P93	SAE J1939 Wye to Mod Box	Engine Compt
P94	SAE J1939 Wye to WTEC III Tans ECU	Elect Compt Fr
P95	SAE J1939 Wye to ABS/Dash Connections	Elect Compt Fr
P96	Water in Fuel	Engine Compt
P97	Manual Trans Clutch Switch	Toeboard
P98	Data Link Diagnostic Plug	Mod Box
P99	ABS ECU Connector (30 Way)	Elect Compt Fr
P100	ABS ECU Connector (18 Way)	Elect Compt Fr
P101	ABS Feed Through (24 Way)	Fr. Firewall
P102	ABS RF Modulator	R.F. Axle
P103	ABS RF Speed Sensor	R.F. Axle
P104	ABS LF Modulator	L.F. Axle
P105	ABS LF Speed Sensor	L.F. Axle
P106	ABS RR Modulator	R.R. Axle
P107	ABS RR Speed Sensor	R.R. Axle
P108	ABS LR Modulator	L.R. Axle
P109	ABS LR Speed Sensor	L.R. Axle
P110	ABS Traction Solenoid	Rear Axle
P111	Throttle Pos. Sensor	Throttle
P112	Air Dryer	
P113	Exhaust Brake Switch (CAT 3126)	Dash
P114	Exhaust Brake Switch (Cum. ISB)	Dash
P115	Allison MD WTEC III Shifter Conn.	Dash
P116	Transmission ECU/V to PCB Interface	Elect Compt FR
P117	Trans BH Interface P117 (Neutral/Speed	Elect Compt FR
P118	Reverse Alarm	Engine Compt
P119	Adjustable Pedal Switch Connector	Dash
P120	Adjustable Pedal Switch Conn. (Pedal)	Dash
P121	Snow Chains Switch	Dash
P122	Data Link Diagnostic Plug	Elect Compt FR
P123	J1939 "T" Connector	
P124	J1939 "T" Connector	
P125	J1939 "T" Connector	
P126	J1929 Cummins	

P127	Idle Diagnostic Switch	
P128	Fast Idle Relay Connector (ADT 200)	Elect Compt FR
P129	Retarder Modulator RMR #1	Elect Compt FR
P130	Retarder Modulator RMR #2	Elect Compt FR
P131	Retarder Modulator RMR #3	Elect Compt FR
P132	Retarder Brake Press SW #1	Main Chassis
P133	Retarder Brake Press SW #2	Main Chassis
P134	Retarder Brake Press SW #3	Main Chassis
P135	Retarder Modulator Main	Elect Compt FR
P136	Allison AD2000 Trans J1939 Conn.	Chassis Xmbr
P137	Rear Box Conn. 31 Pin Silver	Rear Box HD
P138	Rear Box Conn. 31 Pin Black	Rear Box HD
P139	Rear Box J1939 Connector HD	
P140	Pressure Switch DRL	R Box Mtg Bkt
P141	Horn Connector Relay	
P142	Dash, Cummins Interface	
P143	Engine Power Conn.	
P144	Engine Power Conn. (Cummins)	Engine Comp

Rear Electrical Compartment

The rear electrical compartment is located in the engine compartment.

The starter solenoid is mounted on the outboard side of the left side of the compartment, sometimes called "the rear box" on the ER model. It is located on the front side of the compartment on the HD model.

If the ammeter option was specified on the bus, a shunt will be found inside the compartment for each ammeter on the bus, for a maximum of two.

Two 10-amp fuses are built into their respective harnesses inside the compartment. Circuits ign01A and ign01B has a 10-amp in-line fuse joining these two circuits, and is the power supply for the ignition circuit, through the toggle switch located on the rear compartment access door. This switch must be ON to complete the power circuit to the front ignition switch.

Circuit 334A and 334B has a 10-amp in-line fuse joining them to provide power to the Data Link.

The Vehicle Electrical Center (VEC) is located inside the rear box on the Saf-T-Liner HD models, and is located on the dust panel beneath the air cleaner on the ER models.

A power stud or terminal provides battery voltage to the entire bus electrical systems, and is located on the left side of the rear box on the ER models. On the HD models, it is located inside the rear box. Power to this terminal comes through a heavy cable from the positive post on the starter.

Two 150-amp master circuit breakers mounted atop the rear compartment

receive power from the above power stud.

In the event a major short should occur in the electrical system, the 150-amp master circuit breaker would trip, or OPEN. To reset it, push the reset lever located on the side of the breaker back in place.

A major short is required to cause the master circuit breaker to trip. If it should trip again after being reset, the bus should be taken out of service until the problem has been identified and repaired.

150-amp circuit breaker #1 located on the top left side of the compartment, provides power to the chassis electrical system.

Circuit breaker #2 provides power to the three PCBs controlling body electrical circuits.

Figure 21 shows the 12V battery circuit from the starter positive (+) post to

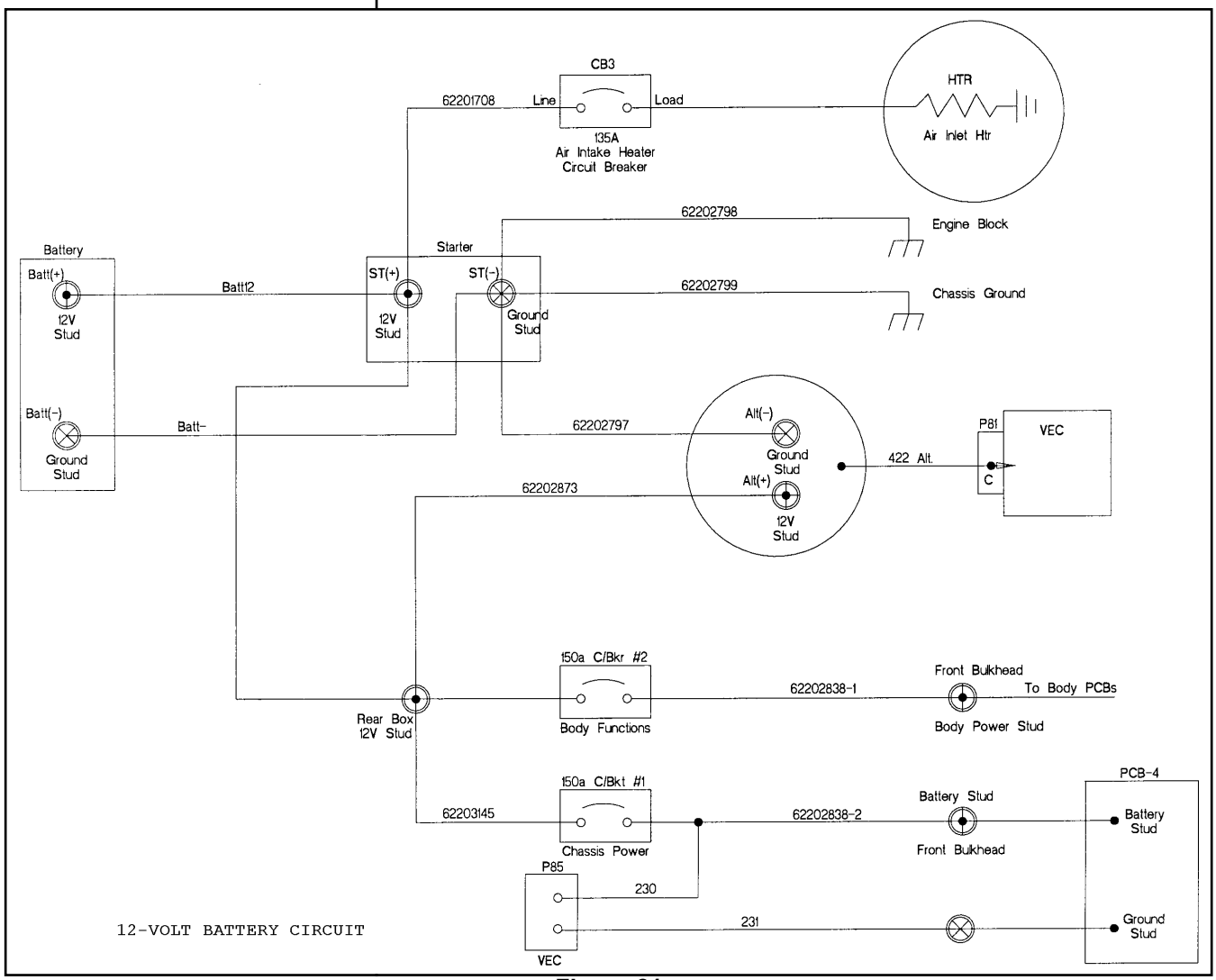


Figure 21

the battery post of PCB-4, which controls most chassis circuits.

CB #1 picks up its power from the battery power stud on the side of the rear box. With the circuit breaker CLOSED, current flows through circuit #62202838-2 in the chassis harness to the power stud (terminal) in the front electrical compartment bulkhead. Circuit 62203333 completes the power circuit to PCB-4.

Figure 21 also outlines the alternator circuits. Circuit 422 from the Vehicle Electrical Center (VEC) provides 12V to energize the alternator when the ignition switch is ON.

Ignition Circuits – Saf-T-Liner ER

The circuits and relays involved in the ignition circuits are outlined in **Figure 22**. The Vehicle Electrical Center, Printed Circuit Board 1, and Printed Circuit Board 4 each contain a relay that is involved in the various circuits.

Relay #1 in chassis PCB-4, when energized, sends a 12-volt signal to the VEC relay to power the engine ECU. It also sends the same signal to the body PCB-1 to power all body functions.

The rear ignition switch, as well as the dash ignition switch, must be ON to energize the bus electrical systems. Current for the chassis ignition controlled circuits comes from the main battery terminal in the rear electrical compartment.

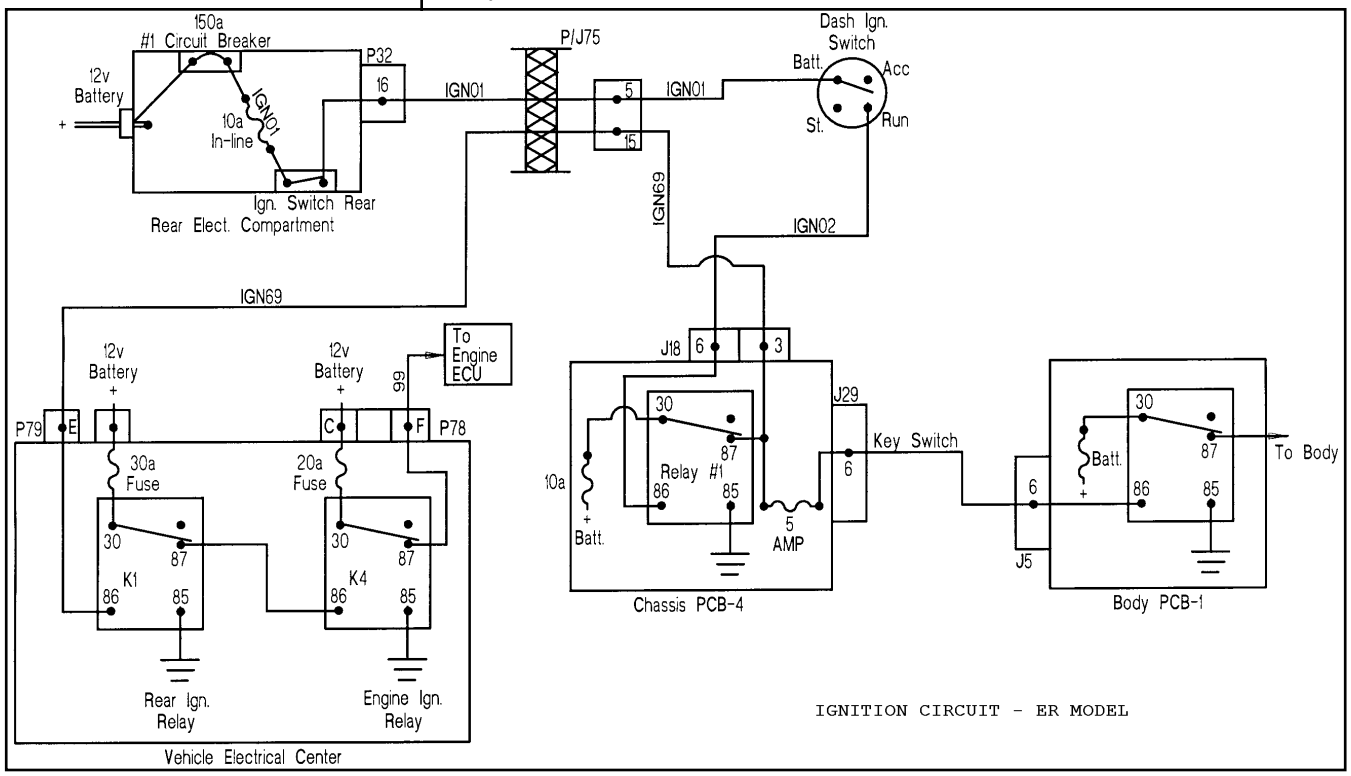


Figure 22

Circuit IGN01 connects the circuit breaker to the rear ignition switch, with a 10-amp in-line fuse in the circuit. IGN01 exits the rear box through connector P32, pin 16 that is located on the engine side of the box, and continues to connector J75, pin 5 at the front of the body. From there it continues to the battery post of the dash ignition switch.

With the rear and dash switches closed, circuit IGN02 from the RUN port of the dash switch energizes PCB-4 relay #1 through connector J18, pin 6, thereby energizing the VEC and PCB-1 relays.

Pertinent Component Locations:

- 150-amp circuit breaker – top of rear electrical compartment
- IGN01 10-amp fuse - in-line – inside rear compartment
- VEC – top of splash panel, beneath air cleaner (ER model)
- PCB-4 - in chassis electrical compartment
- PCB-1 – center circuit board, beneath driver's sash

Connectors:

- J75 – front of body, between ABS and J76 connectors
- P32 – main connector, left side of rear compartment
- P79 – gray connector on VEC
- P78 - black connector on VEC

Ignition Circuits – Saf-T-Liner HD

Figure 23 shows the difference in the rear ignition circuits of the ER and HD models. From the IXI break on **Figure 56** the circuits are the same after P/J75 connector. On the HD model circuits IGN01 and IGN69 enter the rear electrical compartment through connector P137, one of the major connectors

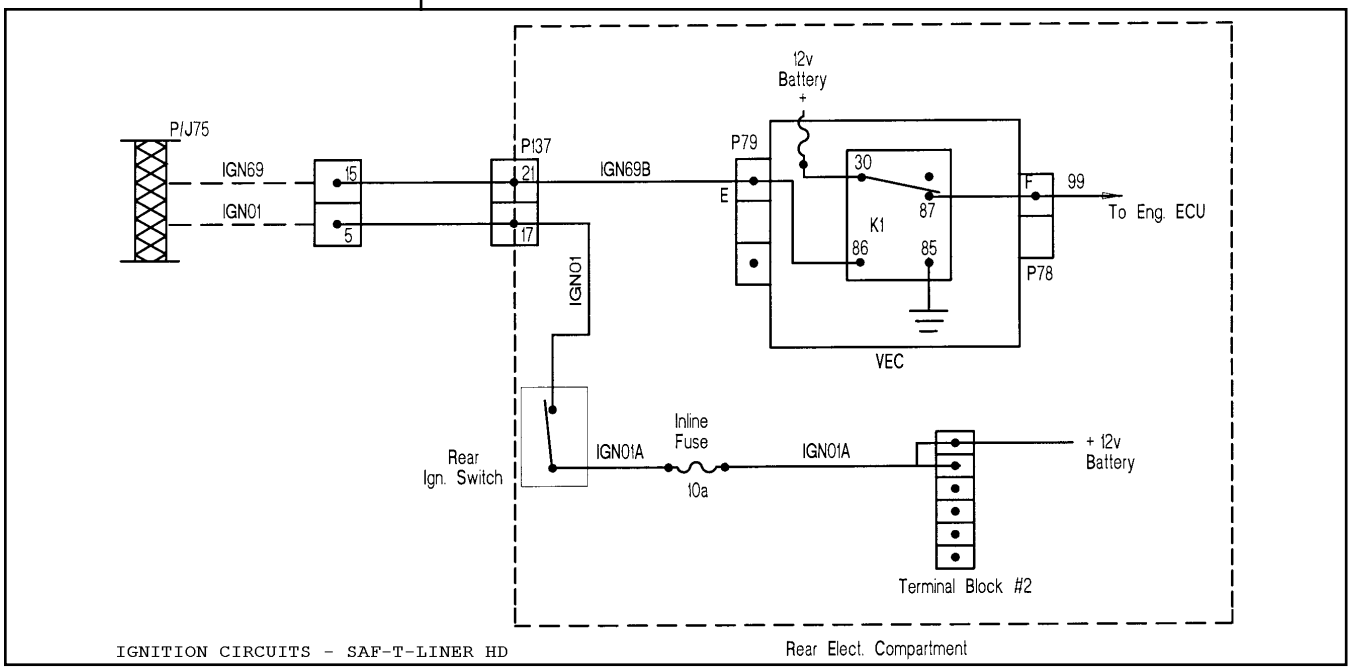


Figure 23

into the compartment.

The VEC is located inside the compartment, as is terminal block #2.

Note that the circuit IGN01A from the rear switch to the terminal block contains an in-line 10-amp fuse. Relay K1 is inside the VEC.

Starter Circuits

Figure 24 outlines the circuits and components involved in the starter circuit. An understanding of the flow of the start signal from the ignition/start switch to the starter solenoid is vital.

Components involved:

- Ignition/Start Switch
- Starter Interlock Relay #2 on PCB #4
- Vehicle Electrical Center (VEC)
- Transmission Vehicle Interface Module (VIM)
- Starter Interlock Switch, engine compartment door
- Starter Relay, side of rear electrical box
- Starter Solenoid, mounted on starter
- PCB #1, when equipped with vandalock, or lift

The arrows on **Figure 24** indicate current flow to energize the starter when all components are in proper position for the start mode.

The transmission shifter must be in the Neutral mode to cause the ECU to signal the neutral relay in the VIM to unite Circuits 323NO and 323CM within the VIM.

Starter Interlock Relay #2 on PCB #4 carries the signal through normally closed contacts.

The VEC, located in the engine compartment contains a relay that controls starting the bus from the rear.

The engine compartment rear door incorporates a starter interlock switch that must be closed to complete the start circuit, whether by hand or by closing the door.

With the above in mind, listed below is a verbal walk-through of the starter circuits.

When the start switch is energized, current flows from the switch through circuit ST04 to starter interlock relay #2 located on PCB #4 in the chassis electrical compartment. ST04 enters the circuit board through connector J18, pin 5 and exits the board on J20, pin 3. ST04 then goes through the front bulkhead connector J75, and continues through the main chassis harness to the VEC located in the engine compartment. On the ER model it is located on

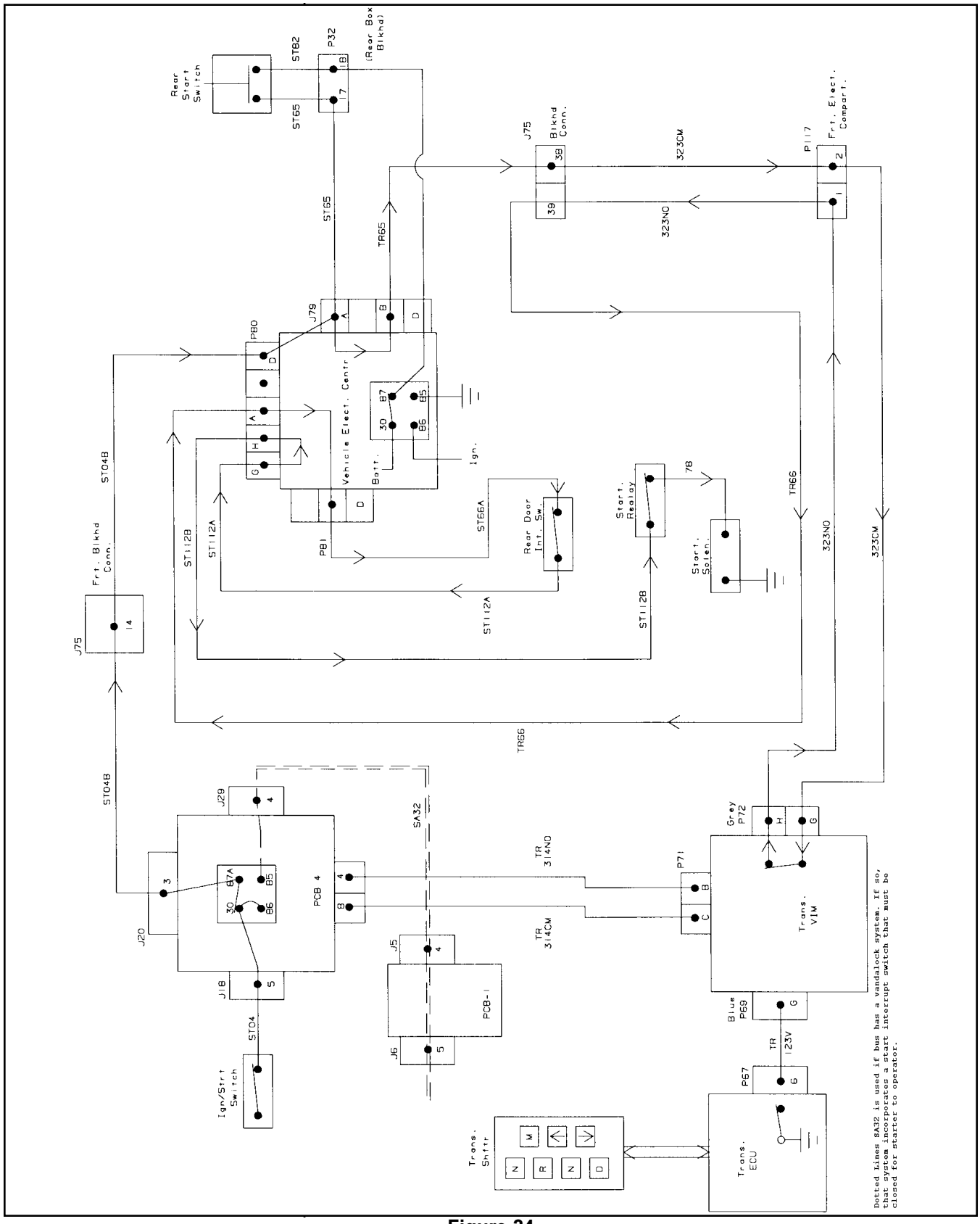

Rear Start Switch
ST62
ST65
P32
(Rear Box Blkhd)
J75
Blkhd Conn.
323CM
323NO
P117
Frt. Elect. Compart.
ST65
TR65
J79
P80
Vehicle Elect. Centr
Batt.
Ign.
P81
ST66A
Rear Door Int. Sw.
Start. Relay
78
Start. Solen.
TR66
ST04B
Frt. Blkhd Conn.
ST112B
ST112A
J29
SA32
PCB 4
J20
J18
ST04
Ign/Strt Switch
TR 314NO
TR 314CM
J5
PCB-1
J6
P71
Grey P72
Trans. VIM
Blue P69
TR 123V
P67
Trans. ECU
Trans. Shftr
N
R
N
D
Dotted lines SA32 is used if bus has a vandalock system. If so, that system incorporates a start interrupt switch that must be closed for starter to operator.

Figure 24

the splash panel beneath the air cleaner, on the HD model it is inside the rear electrical box.

ST04B enters the VEC on P80, pin "D". A jumper inside the VEC connects pin "D" with pin "B" of J79. ST04B now becomes TR65 as it exits pin "B" and goes back to J75 connector (front bulkhead connector). It becomes 323CM on the other side of J75, pin #38 and continues to the gray connector, pin "G" of the Transmission Interface Module located on the right side of PCB #4. A relay in the VIM receives a signal from the transmission ECU (when the shift control is in Neutral), closing the contacts to bridge pin "G" and pin "A" of the gray connector. 323CM becomes 323NO as it leaves pin "A" and returns to J75, pin 39.

323NO becomes TR66 as it leaves J75 and returns to the VEC on pin "A" of connector P80. A jumper inside the VEC connects P80-“A” with P81-"D", ST66A exits from P81-"D" and goes to the starter interlock switch on the engine compartment rear door.

ST66A now becomes ST112A at the switch and returns to the VEC, P80, pin "G". A jumper inside the VEC transfers ST112A to ST112B, which exits the VEC on P80, pin "H" and continues to the starter relay located on the side of the rear electrical box.

Circuit 78 completes the start circuit from the relay to the starter solenoid.

Be aware if the bus is equipped with a vandalock system, or if it has a handicap lift, and additional starter interlock switch may be included in the starter circuit as a safety factor.

Rear Starting

The ignition switch must be in the RUN position. With rear door open, the starter interlock switch must be closed at the same time the rear start switch is energized.

Relay post 30 in the VEC provides 12V current from connector J79, pin "D" to the rear start switch through circuit ST82. ST82 passes through connector P32, pin 18 located at the rear electrical compartment bulkhead. With the starter button engaged ST65 enters the VEC through pin "A" of J79 and follows the same path as the front start.

Troubleshooting the System

Problem: Starter solenoid clicks, starter does not operate.
Suggestions:

1. Check for 12V at the starter solenoid with all switches closed. If no voltage, go upstream of circuits after checking first to see if 12V is going to post 30 of #2 relay on circuit board #4.
2. Check for 12V entering and leaving starter relay located on the side of

the rear electrical box.

3. Check for 12V entering the VEC on pin "D" of connector J80, and leaving the VEC on pin "B" of J79.
4. Check for 12V entering the VIM on gray connector, P72, pin "G", and leaving the VIM on pin "H". The VIM, located on the right side of the PCB, contains a relay with the contacts normally closed when the ignition switch is ON and the transmission shift control is in the "N" mode. If 12V enter the VIM, but does not exit, check the relay or its controlling circuits. The ECU controls the relay ground circuit, when in Neutral.
5. Check the rear door interlock switch for being closed, or has continuity. If equipped with a Vandalock system or a lift, check for an OPEN or failed starter interlock switch in that circuit.

   If all above checks are positive, check for an open circuit in the various circuits involved.

All the components listed in the opening paragraph are involved in the starter system.

Rear Mounted Instruments – Saf-T-Liner ER

Figure 25 outlines the current flow to the rear mounted oil pressure gauge.

The VEC is mounted on the splash panel beneath the air cleaner on this model.

Relay #8, protected by fuse #6, both located inside the VEC, provides 12V through pin "C", P79 to circuit GA109. GA109 enters the main harness and runs to pin 9 of connector P32. Located on the right side of the rear electrical compartment. Inside the rear compartment GA109 connects to the gauge.

Circuit GA110 runs from the sender to P32, and on to the gauge.

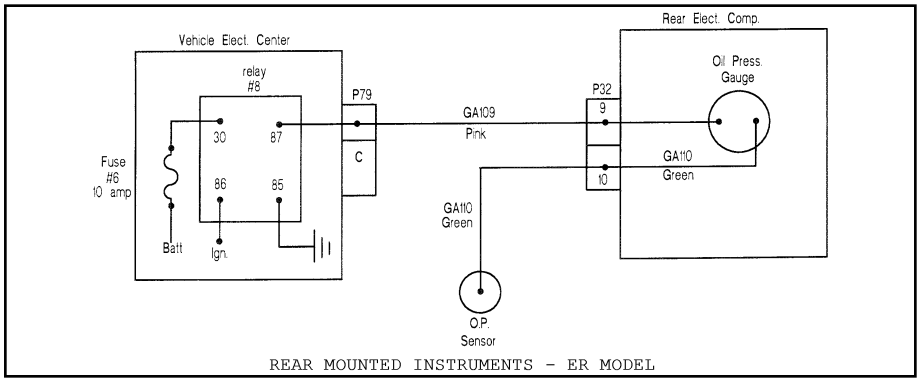


Figure 25

Engine Compartment Instruments – Saf-T-Liner HD

Figure 26 outlines the current flow for instruments mounted on the rear electrical panel (in the engine compartment) when ordered as an option.

The Vehicle Electrical Center (VEC) is located inside the rear electrical compartment on the HD model. Relay #8, protected by fuse #6, is located in the VEC (pin #9, P79) provides power to each of the gauges that may be installed on the panel. A splice in GA109 provides 12V to each of the gauges.

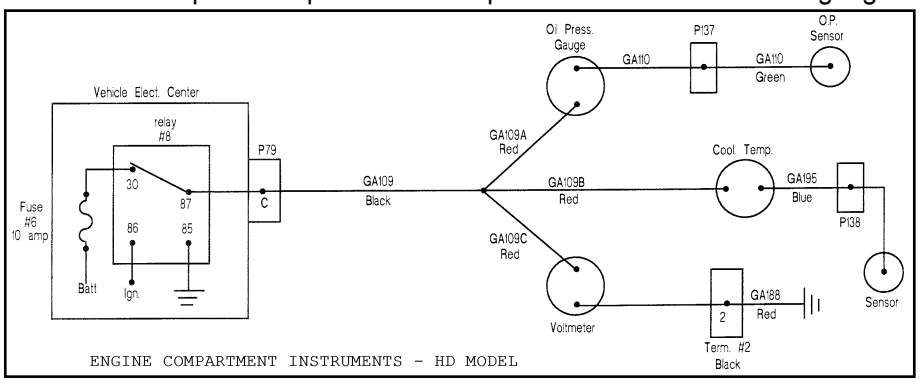


Figure 26

Oil Pressure Gauge

Circuit GA110 from the oil pressure sensor which is located in a manifold beneath the air cleaner assembly, runs to and through connector P137 on the front side of the electrical compartment. P137 should have an identifying label on the harness. From P137, GA110 connects to the gauge.

Coolant Temperature Gauge

Circuit GA195 from the temperature sender on the engine runs to and through Connector P138, adjacent to P137 on the front side of the electrical box, and continues on to the gauge itself.

Voltmeter

Circuit Ga188 goes from a ground terminal inside the compartment to #2 post on junction block #2, and on to the voltmeter.

If all of the gauges are inoperative, check for blown fuse #6. If the fuse is OK, check for a failed relay or an open circuit at pin "C" of connector P79.

Headlight and Daytime Running Lights

Figure 27 outlines the circuits involved in both the DRL system and the headlight system.

Circuit EL03 from chassis PCB-4, connector J4, pin #3 to the switch supplies 12-Volt power to the headlight switch.

Twenty-amp fuse #5 located adjacent to relay #2 on top of the circuit board, protects the headlight circuits.

Circuit EL13 from the headlight switch sends current to the windshield

wiper/headlight module, pin "d" and the Daytime Running Lights (DRL) module, pins "j" and "h".

See **Figure 27** for the location of these modules.

Headlight System:
The windshield wiper/headlight module and the combination dimmer, turn signal and wiper switch, which is mounted on the steering column, control the headlights. The column switch determines high and low beams.

High Beam Circuit:
High beam circuit EL11 from pin "b" of the module connector P45 goes through bulkhead connector J75, pin #8 to connector P8 and P9, and to the headlamps. P8 and P9 are seen when the front access panel is lowered.

EL11 has a branch circuit to P64 connector, located at the instrument cluster, to illuminate the high beam indicator on the dash.

Low Beam Circuit:
Low beam circuit EL12 from pin "c" of the windshield/headlight module follows the same route as EL11.

Daytime Running Lights:
The DRL lights are ON when the ignition switch is in the RUN position. (Some states may call for the option to have the DRL lights ON only when the engine is running.)

Ignition power to the DRL module comes from post #2 of the terminal block located between the bulkhead and PCB-4.

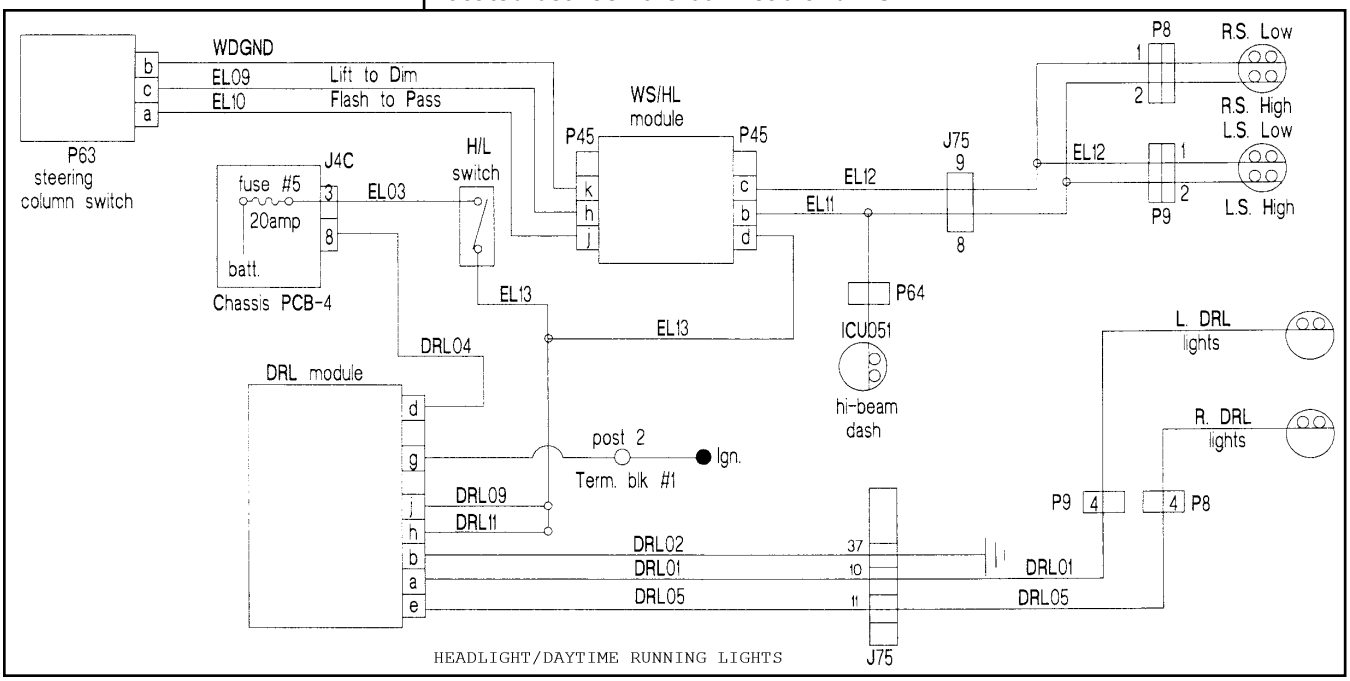


Figure 27

The DRL lamps contain dual elements. With ignition ON and headlights OFF, the bright element will glow. When the headlights are ON, the DRL bright element goes OFF, and the other element becomes active and serves as a park light along with the 8" amber above the headlamp assembly. This element, dimmer in brightness, glows when the headlights are ON.

The DRL module is involved in the turn signal comments.

Tail, Marker, Park, Identification Lights

Power to the above circuits originates in chassis Printed Circuit Board #4 from 20-amp fuse #5. From that point power flows through board #4 connector J4, pin 3 to the head light switch on EL03.

Circuit EL07 comes out of the switch and splits into two branches. One branch goes to connector P75, pin #13 to power the front amber park lights, and through connectors P8 and P9. These are seen when the front panel is lowered. The other branch returns to board #4 through circuit EL07 and connector J4, pin #4. This circuit provides the signal to body board #1 to power tail, marker, and identification lights.

The above circuits are protected by 20-amp fuse #5 located on chassis board #4.

Circuit EL07 from the headlight switch passes through pin #13 of the J75 bulkhead connector and into PCB-4 through connector J4, pin #4. Circuit EL07 changes to LM169 internally in the circuit board and exits board #4 on J29, pin #1.

LM169 enters body PCB-1 on J5, pin #1, and connects to post 86 of #8 relay. When post 86 is energized by the switch, the relay closes and the above circuits are activated by post 87 (relay 8).

Relay 8 is protected by 15-amp fuse #5 in PCB #1.

The four circuits named above are split into their individual circuits within board #1. Listed below are the circuit, connector, and pin numbers for each circuit leaving board #1.

Circuit	Circuit #	Color	Connector #	Pin #
Tail Lights, LS	LM11	Brown	J4	7
Tail Lights, RS	LM12	Brown	J4	6
Marker Lights	LM40	Brown	J6	1
Front & Rear I.D.	LM17	Brown	J6	2
Park Lights	LM168	Black	J29	3

Figure 28 schematic is an outline of the circuits involved.

Tail Lights:
Tail light circuits LM11 and LM12, after leaving board #1, become parts of the main body harness. Connector P7 is located above the front window, beneath the curtain rail. At the rear of the body the two circuits go through connectors P8 and P9 located at the top of the engine compartment door, pin "b".

Park Circuits:
Circuit LM168 from connector P29, pin #3 board #1, goes through external connectors easily seen when the front access panel is lowered.

Marker Light Circuits:
Circuit LM40 from board #1, connector J6, and pin #1, serves the marker light circuits. Connector J20 has a jumper wire at pin #1 that picks up the signal from relay #8, post 87 and separates LM17 and LM40. The jumper takes the signal from pin #1 of J20 and sends it back into board #1 to serve both LM17 and LM40 from J6, pins #2 and #1, respectively.

Front and Rear Identification Lights:
Circuit LM17 serves these circuits from pin #2 of J6, board #1. See above paragraph.

Stop Light Circuits

The stop light switches are located on the brake treadle valve, in view when the front access panel beneath the windshield is lowered.

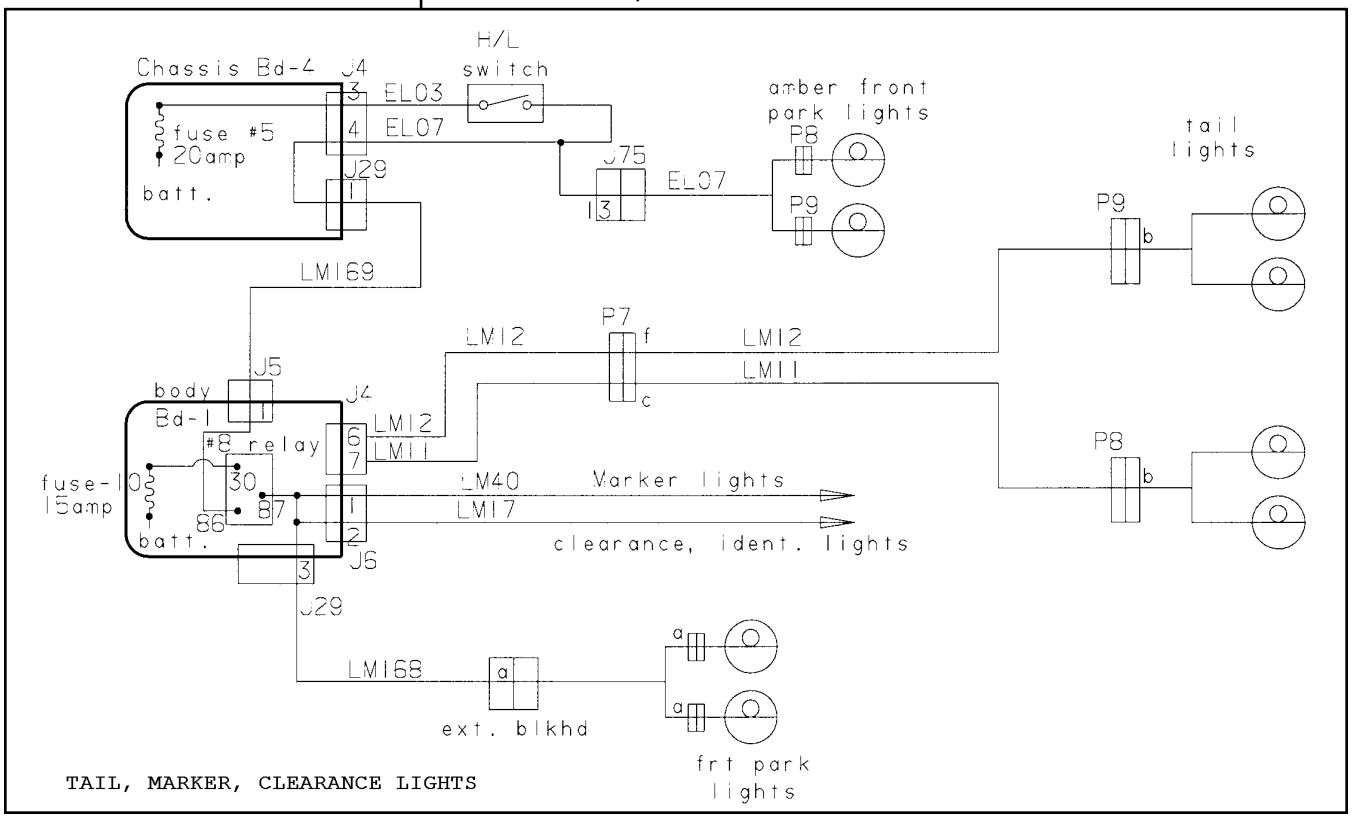


Figure 28

Power to the switches comes from the Battery circuit within chassis Printed Circuit Board #4 through connector J22, pin #2. Refer to **Figure 15** for the location of the "J" connectors on the backside of the PCB. The stop light circuit makes use of J22 and J29 located on the PCB.

Figure 29 is a schematic of the stop light circuits. Listed below is a verbal walk-through of current flow from the PCB to the stop lamps.

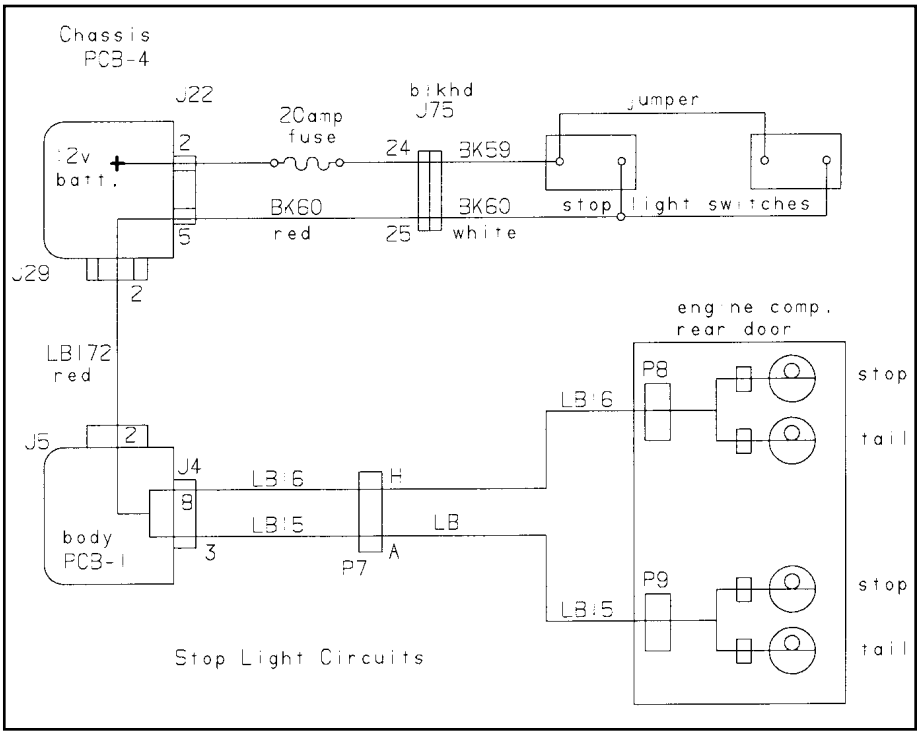


Figure 29

1. Battery 12V in chassis PCB-4 to PCB connector J22.
2. Circuit Bk 59 (red) from J22, pin #2 to bulkhead connector J75, pin #24. A 20-amp fuse is built-in in the circuit between the two connectors. It is visible in the harness beneath the circuit board.
3. Circuit Bk 59 continues from bulkhead connector J75 to the first stop light switch. A jumper wire completes the circuit to the second switch.
4. Circuit BK 60 carries the current (back) to J75, pin #25, when the brakes are applied.
5. Circuit Bk 60 (red) continues from J75, pin #25 to J22, pin #5.
6. The stop light circuit is transferred within the PCB-4 to J29.
7. New circuit LB172 from J29, pin #2 continues to body PCB #1, J5 connector, pin #2.
8. PCB #1 splits the circuit internally to circuits LB15 and LB16. They exit board #1 through connector J4, pin #3 and #8 respectively. Both circuits continue to body connector P7, which is located beneath the left curtain rail, above the front window.
9. LB15 serves the right rear stop lamps; LB16 serves the left rear lamps. From P7 the two circuits continue to connect P8 and P9 in the engine compartment.

Turn Signal Circuits

See **Figure 30** for a schematic of the circuits, connectors, and printed circuit boards involved in the turn signal circuits.

The turn signal flasher is mounted on top of the board; the only external circuit to it is EL04 from the turn signal switch. It passes through connector P61 en route to chassis PCB #4, connector J38, pin #6.

Connector P61 is located where the turn signal/windshield wiper harness exits the upper section of the steering column.

Left turn EL05 and Right turn circuits EL06 go through the same connector, P61, en route to chassis PCB #4, connector J38, pins #7 and #8. Internally in the board EL05 changes to LT174, and leaves the board through connector J29, pin #7. It continues to body PCB #1, connector J5, pin #8.

Right turn circuit EL06 enters board #4 through connector J38, pin #8 and changes to circuit LT175 internally in the board. It continues on to body board #1 through connector J5, pin #7.

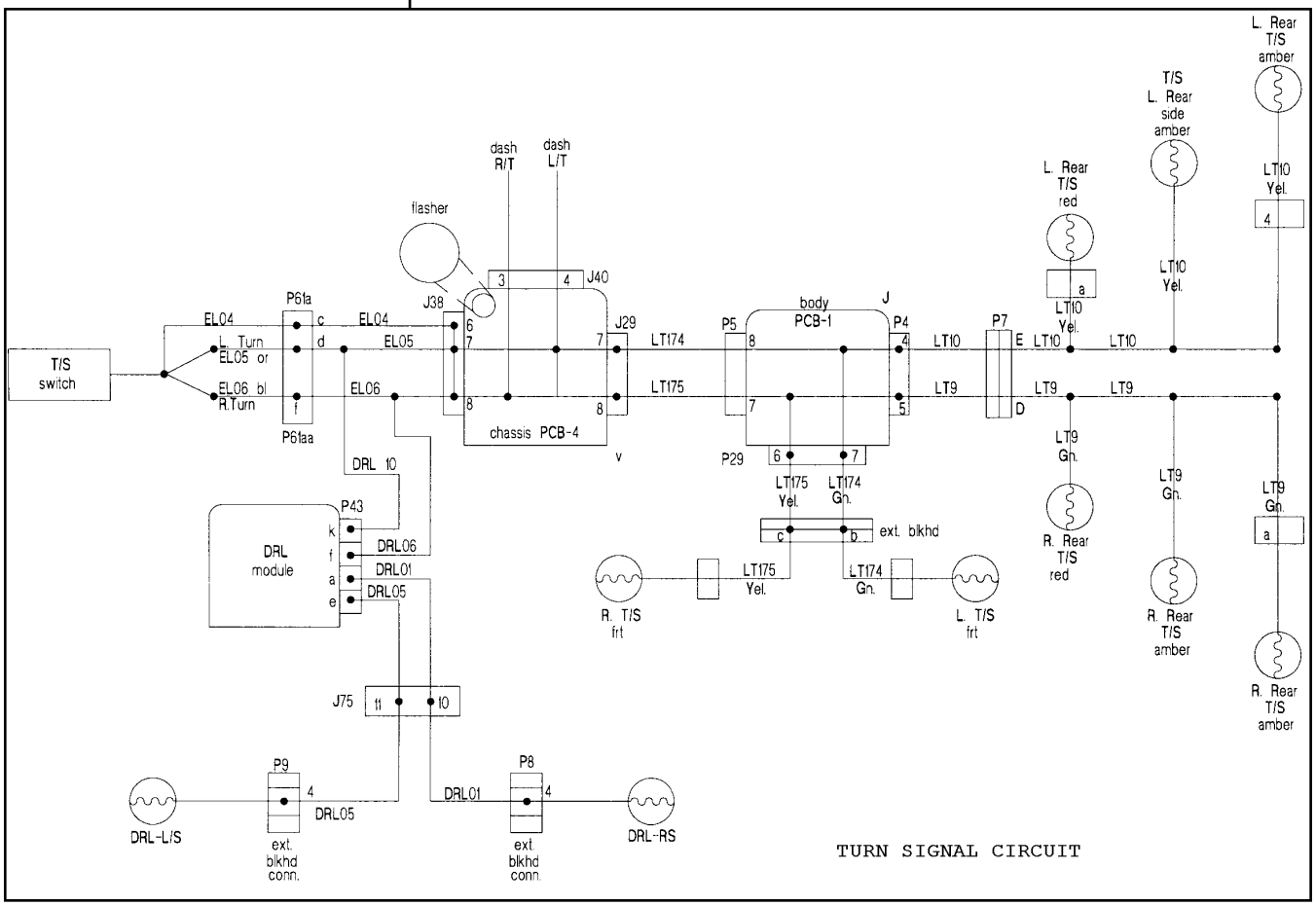


Figure 30

The dash indicator lights, circuits ICU042 (left turn) and ICU043 (right turn), come from the two above circuits internally in board #4, and leave the board from connector J40, pins #4 and #3, respectively. They join connectors P12 and P13 behind the dash.

Internally in PCB #1 circuit LT174 branches into two circuits, LT10 and LT174. (Color green) LT174 serves the left front turn signal through board #1, connector P29, pin #7, goes through the external bulkhead connector, pin "b" and on to the small connector near the amber turn signal lamp.

LT175 follows the same path, exiting PCB #1 through connector P29, pin #6. LT175 serves the Right front turn signal lamp.

Back to circuit LT10, serving all turn signal lamps on the left rear side of the body. LT10 comes out of board #1 on connector J4, pin #4 and continues in the body harness up to connector P7, pin "E". P7 is located beneath the left curtain rail, above the front window. After the connector the circuit continues to the rear of the body where it branches off at the rear of the body to serve the Left rear side lamp, the rear amber lamp, and the red lamp. LT10 is yellow in color.

LT09 exits PCB #1 through connector P4, pin #5 and follows the same route as LT10. LT09 is green in color. It branches off at the rear of the body to serve the turn signal lamps on the Right rear side of the body.

The DRL also becomes turn signal lamps when the turn signal switch is actuated and the DRL are ON. At that time the DRL on the side actuated will flash along with the amber lamp mounted above it.

Circuit DRL10 branches off EL05 in between the P61 connector and the chassis board #4, connector J38. Circuit DRL06 branches off EL06. Both circuits connect to the DRL module on pins "k" and "f", respectively.

The DRL module controls the flashing of the DRL lamps, depending on the signal sent from the turn signal switch.

Circuits DR101 and DRL05 leave the module on pins "k" and "b", continue through bulkhead connector J75, pin #10 and #11 and on to the external connectors P8 and P9. These connectors are found in front of the bulkhead when the front access panel is lowered.

Back-up Alarm and Lights

See **Figure 31** for schematic of circuits involved. The relay that controls the back-up lights and alarm is located inside the Vehicle Interface Module (VIM). The VIM is located on the right side of the printed circuit board in the chassis electrical center.

The transmission ECU completes the relay ground circuit (TR113) to relay

post 86 when the shift module on the dash is moved to the "R" mode. Power to relay post 30 comes from fuse #12 in PCB-4 through circuit TR313CM. When the relay is energized, current flows from post 30 through post 87 and back to PCB-4 via circuit TR313NO.

The circuit board splits the signal (internally) sent by the VIM, with circuit LR170 being sent to body PCB-1 and circuit TR107 routed through the main chassis harness to the back-up alarm at the rear of the bus.

Fuse #10 in PCB-4 protects the reverse alarm circuit.

Fuse #2 in the VIM protects the reverse relay.

The circuits involved in the back-up alarm and lights are shown in **Figure 31**, as are the various connectors involved in these circuits.

Troubleshooting the Two Circuits:
PROBLEM: Back-up alarm is inoperative, but back-up lights are okay.

- Check for blown fuse #10 in PCB-4.
- Check for 12V on circuit TR107 at the alarm, when the back-up lights are lit.

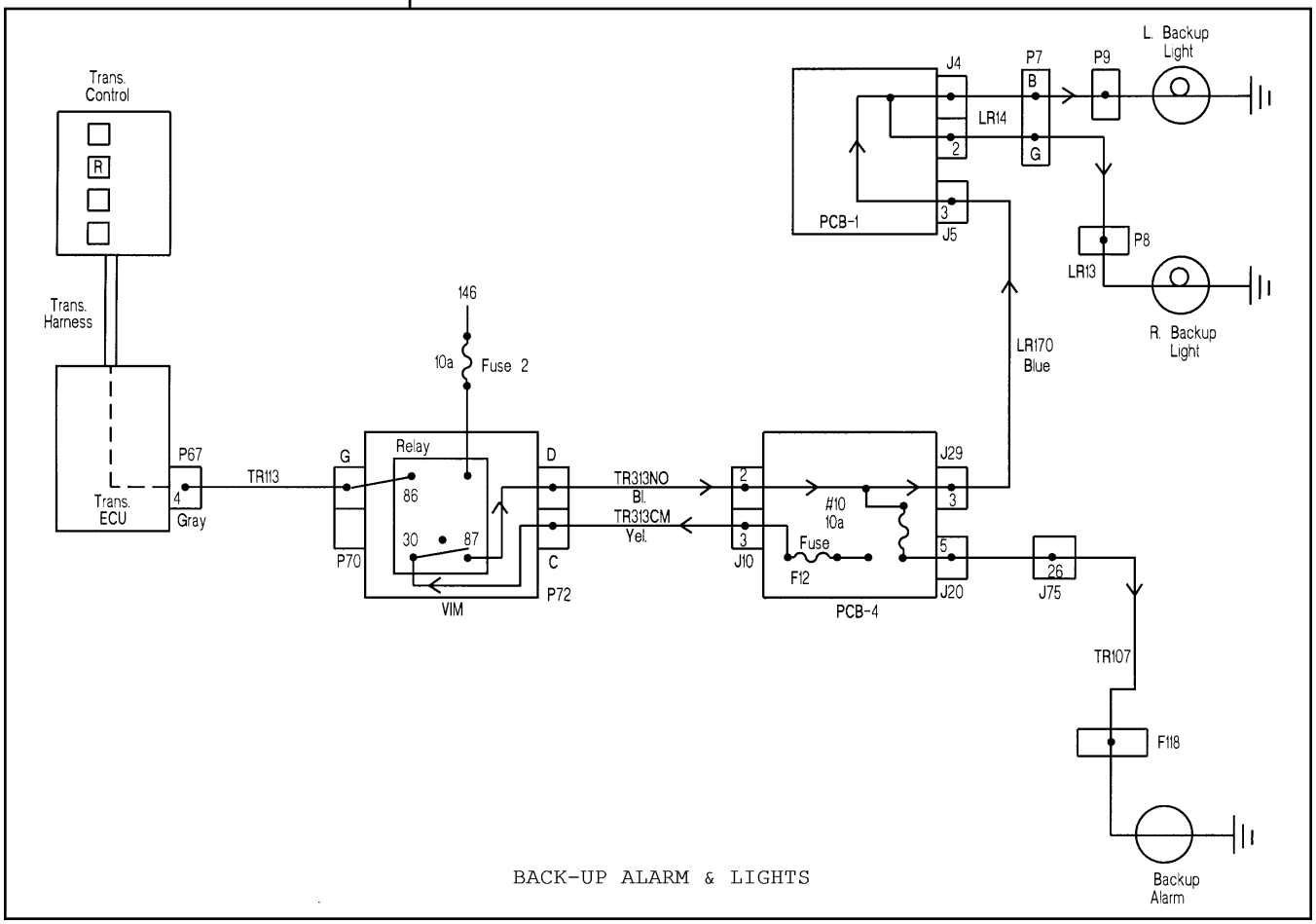


Figure 31

- If 12V present, check for poor ground. Check for failed alarm.
- If fuse #10 is okay, but no voltage at alarm, check for open circuit TR107. It leaves PCB-4 on pin 5 of connector J20, goes to pin 26 of bulkhead connector J75, through the chassis main harness to the rear of the bus, and through connector P118 in the engine compartment.

PROBLEM: No back-up lights, alarm sounds.

- Check bulb condition, check for 12V at each lamp.
- If no voltage at lamps, check for 12V at pin 2 of PCB-1 connector J4 in body electrical compartment.

Circuits LR13 and LR14 from the circuit board enter the body main harness (beneath the curtain rail above the left windows) through connector P7, and continue to the rear of the body.

Connectors P8 and P9 are in the engine compartment.

- If no voltage out of PCB-1, check for 12V from PCB-4 on circuit LR170. This circuit runs from PCB-4 on circuit LR170. This circuit runs across the front of the body, from PCB-4 to PCB-1.
- Check for blown fuse #F12 in PCB-4.
- Check for blown fuse #2 in the VIM.
- Check for inoperative relay.
- Check circuit TR113 completing ground circuit when transmission is in "R" and ignition ON.

Refer to **Figure 31** for circuit numbers and connectors involved.

Vehicle Electrical Center

The Vehicle Electrical Center (VEC) is referred to in many instances in the process of troubleshooting or tracing a given circuit. **Figure 32** is an exploded view of the circuits within the VEC. It is located on the splash panel beneath and in front of the air cleaner assembly on the Saf-T-Liner ER model. It is inside the rear electrical compartment on the HD model.

VEC Connector Identification:

Vendor Connector #	Thomas #	Connector Color
#1	P78	Black
#2	P79	Gray
#3	P80	Blue
#4	P81	Green
#5	P21	Gray
#6	P85	Black

Figure 32 shows the location of the various fuses and relays in the VEC. Fuses are standard; however, circuit breakers are requested by certain users. Fuses 1 through 10 are identified on **Figure 32**. The relay numbers are shown on **Figure 32**, also.

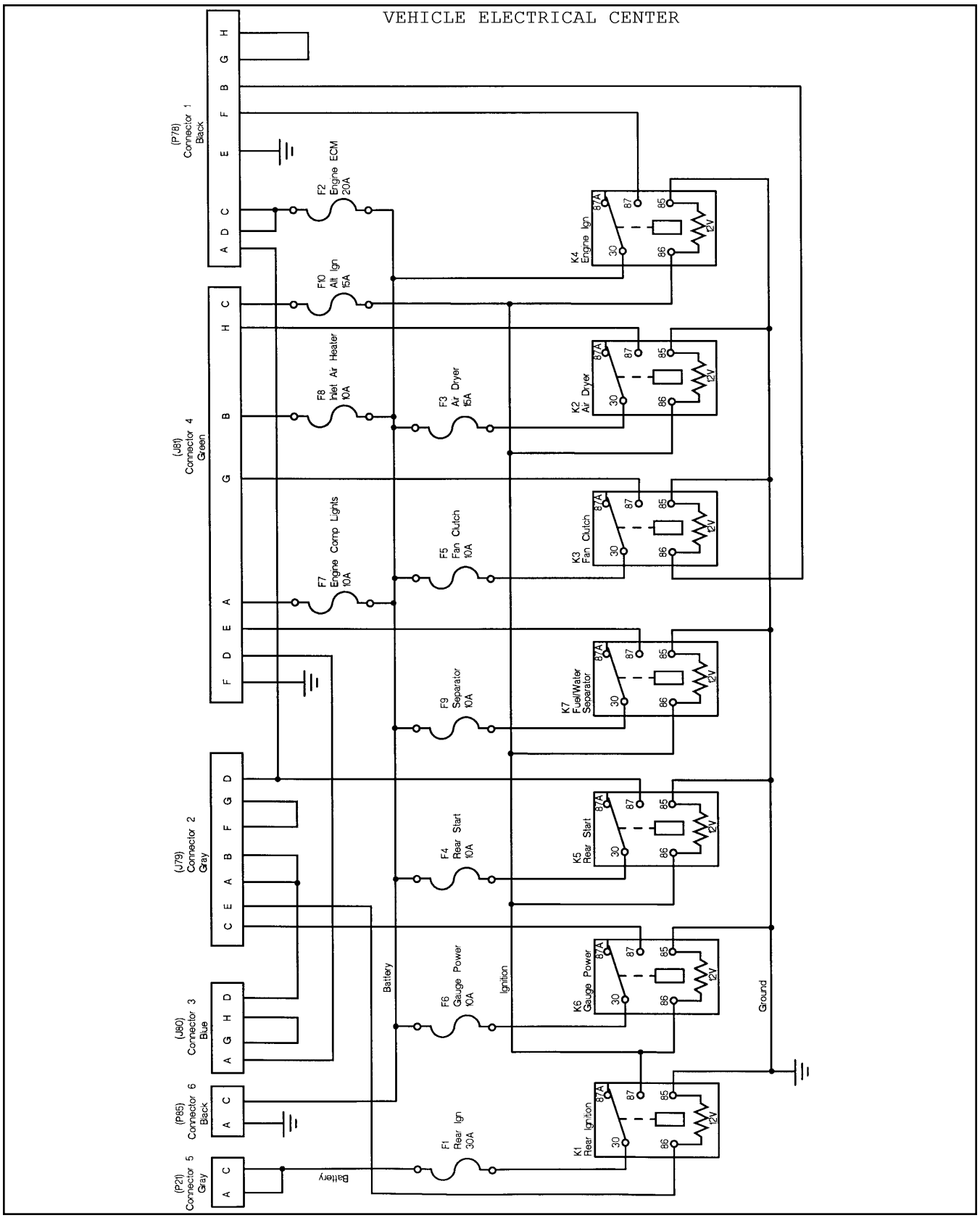

VEHICLE ELECTRICAL CENTER
(P78) Connector 1 Black
(J81) Connector 4 Green
(J79) Connector 2 Gray
(J80) Connector 3 Blue
(P85) Connector 6 Black
(P21) Connector 5 Gray
F2 Engine ECM 20A
F10 Alt Ign 15A
F8 Inlet Air Heater 10A
F3 Air Dryer 15A
F7 Engine Comp Lights 10A
F5 Fan Clutch 10A
F9 Separator 10A
F4 Rear Start 10A
F6 Gauge Power 10A
F1 Rear Ign 30A
K4 Engine Ign
K2 Air Dryer
K3 Fan Clutch
K7 Fuel/Water Separator
K5 Rear Start
K6 Gauge Power
K1 Rear Ignition
Battery
Ignition
Ground
87A
87
85
86
30
12V

Figure 32

Accelerator/Brake Interlock Circuits

When specified by the owner/operator the rear brakes are applied and engine RPM is reduced to idle when a side door is opened, or the handicap lift is in use.

Figure 33 outlines the circuits in these two features.

A Normally Open switch located in the door handle assembly door completes the ground circuit to Interlock relay #3 on PCB-3 when the door is open or the lift is in use.

Before getting involved in how the interlock systems operate, it may help to know the location of certain components that are a part of the circuits involved.

Component	Location
PCB-4	Chassis Electrical Compartment
PCB-3	Body Electrical Compartment – Rear Board
Neutral/Brake Relay #1	On PCB-3
Brake Interlock Relay #3	On PCB-3
Fuse #9	On PCB-3
Accelerator Interlock Relay #9	On PCB-4
Door Switch	Door Handle Assembly
Brake Override Switch	Left Switch Panel
Brake Solenoid Valve	Body Electrical Compartment
30 PSI Pressure Regulator	Body Electrical Compartment
Connector J76	Major Connector – Front Bulkhead

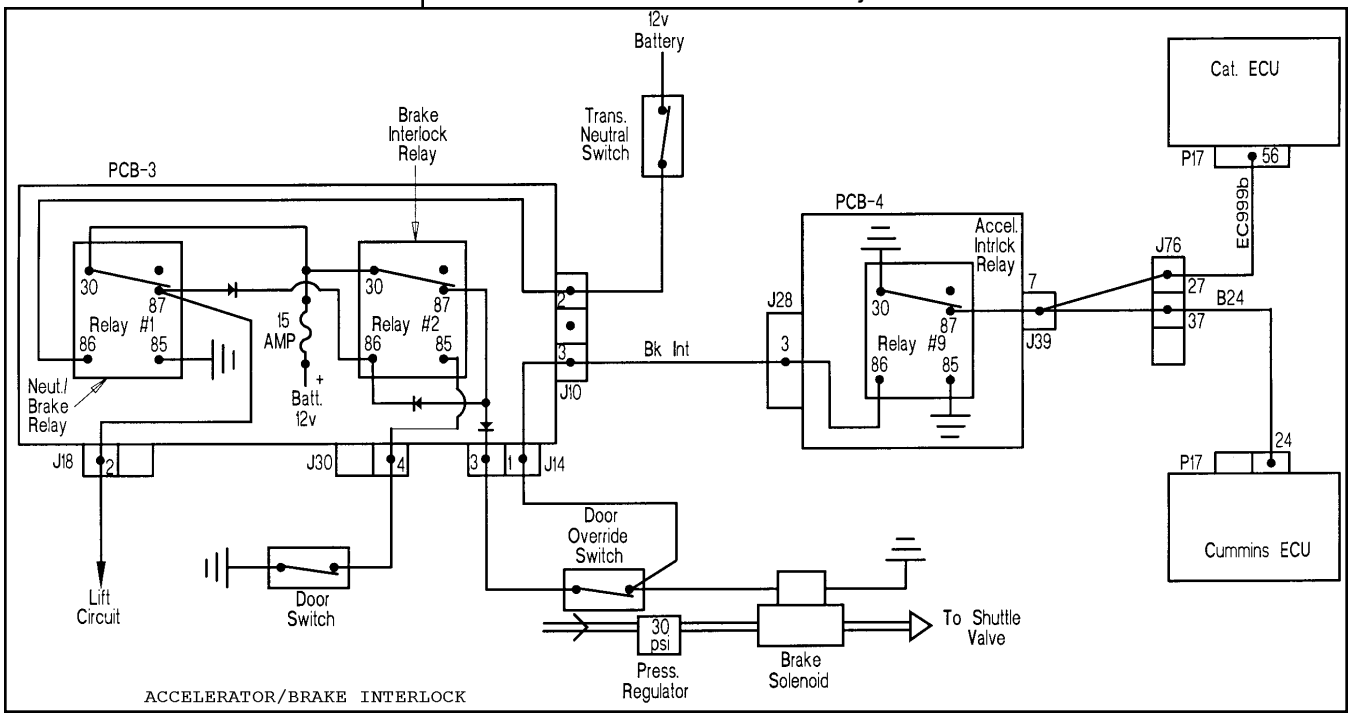


Figure 33

Interlock Operation

With the transmission in Neutral, 12V power enters PCB-3 through connector J10, pin 2 to post 86 of Neutral Brake Relay #1, energizing the relay. Relay post 30 receives 12V current though fuse #9. When energized the relay transmits current to relay post 87, through a diode to post 86 of brake interlock relay #3 (also located on board #3). The ground circuit for post 85 is completed when the Normally Open door switches close (when the door is opened).

When relay #3 is energized, current from relay post 30 to post 87 is transmitted to connector J14 pin 3, and to the Normally Closed momentary brake override switch panel. With this switch the brake solenoid valve is actuated, allowing 30 psi air pressure to be applied to the rear brake chambers.

The purpose of the Brake Override switch is to allow the driver to move the bus in the event of an emergency. As soon as the override switch is released the brakes are immediately reapplied until the door/lift is closed and completely latched.

Accelerator Interlock

At the same time the brakes are applied, the engine RPM is reduced to IDLE by the Accelerator Interlock relay #9 on PCB-4.

The engine controls the idle rpm when the ground circuit from relay #9 to the engine ECU is completed.

12V current from PCB-3 is transmitted via circuit BK INT to connector J28 pin 3 of PCB-4 at the same time the brakes are applied, energizing relay #9.

Post 30 of #9 is grounded. When the relay is activated the ground circuit is completed through post 87.

The completed ground circuit exits PCB-4 on connector J39 pin 7 to front bulkhead connector J76 as circuit EC999B on the Caterpillar engines, as B24 on Cummins engines.

The 30 psi pressure regulator and the brake solenoid valve controlling rear brake application are located in the body electrical compartment beneath the driver's sash.

The shuttle valve mentioned is mounted on or near the ABS relay valve mounted on the crossmember just ahead of the rear axle.

Adjustable Pedals

Figure 34 outlines the circuits involved in the adjustable pedals, if so

equipped.

Power for the circuit (PDL002) comes from the 12V ignition grid on the chassis printed circuit board (PCB-4), through connector P13 pin 5. The ground circuit (PDL005) comes from the PCB connector P13 pin 4. From the PCB the two circuits go to the adjustable pedal switch mounted on the dash.

Connector P109 plugs into the dash switch.
Connector P110 plugs into the motor connector.
Connector P113 plugs into the PCB.

The pedal travels back with 12V power to pin 1 and ground to pin 2.

The pedal travels forward with 12V power to pin 2 and ground to pin 1.

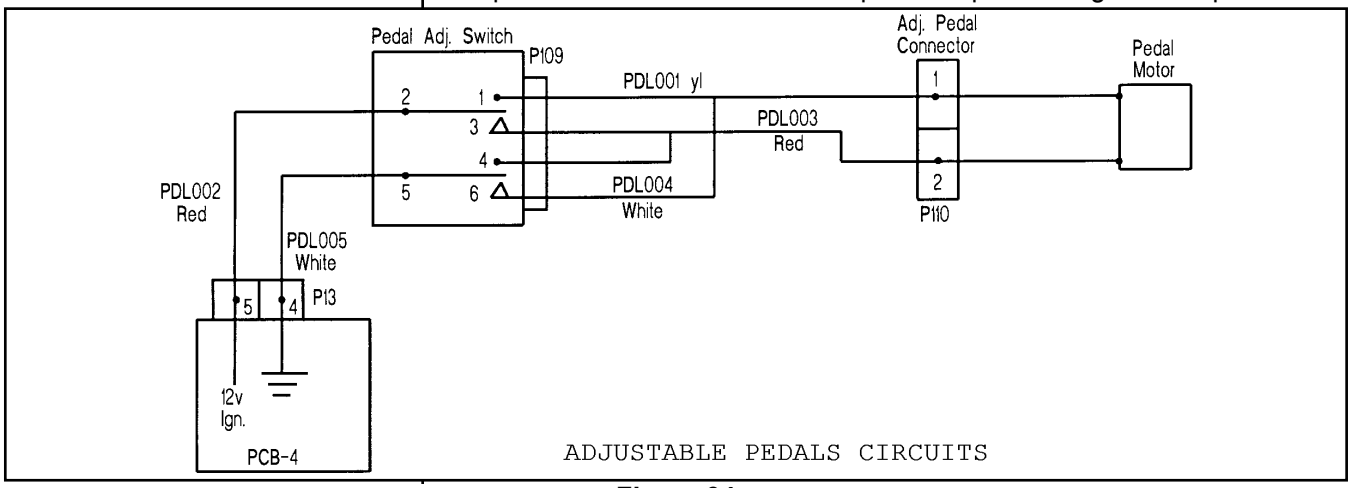


Figure 34

Intake Air Temperature and Fan Control

Figure 35 outlines the electrical circuits involved in the fan controlling coolant and intake air temperature. A relay, #K3 in the VEC provides 12V to connector P81 pin G of the VEC. 10-amp fuse 5 in the VEC protects the battery circuit to the relay as well as the controller. Circuit FA216 continues through connector P138 out of the rear box, through a fan drive harness to the fan drive controller, pin B.

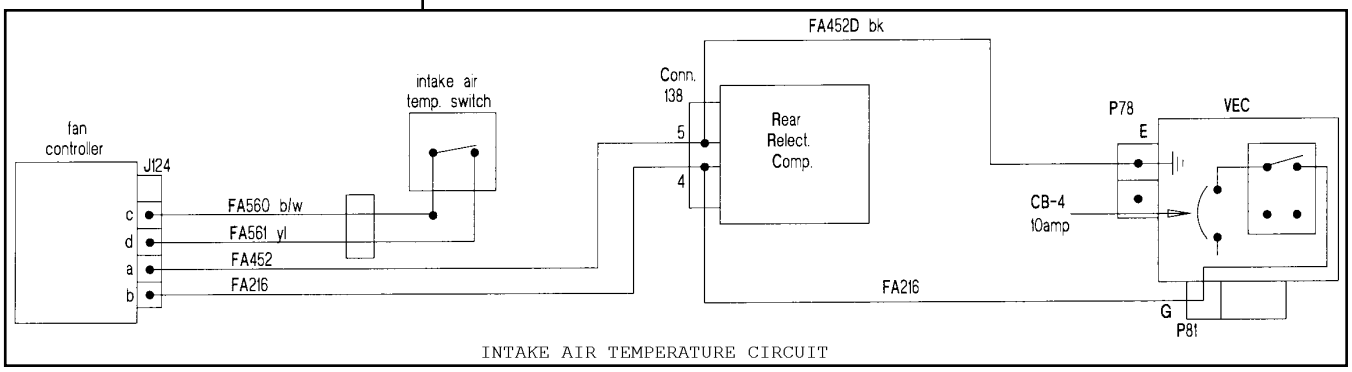


Figure 35

Controller ground circuit FA452 runs from the controller (pin A) to pin 5 of P138, and from there to the VEC, connector P78, pin E. The ground circuit is completed within the VEC.

Circuits FA560 and FA561 tie the intake air sensor to the fan controller, part of controlled harnesses.

Sensor functions and location is outlined in the first two paragraphs above.

The VEC is located inside the rear electrical box.

The controller reduces the voltage to the sensor to 5 volts. Sensor voltage back to the controller will vary, depending on the intake air temperature. This permits the incremental increase in fan speed up to 160°F (71°C).

The system is designed to operate at full fan rpm in the event of any malfunction of any type in the fan drive circuitry, whether it is a sensor failure, controller failure, open circuit, or poor ground.

Operation and troubleshooting of the fan drive system is explained in detail in the *Cooling System* Section of this manual.

Fan Control and Service for ER Model see *Cooling* section.

Air Dryer Circuit

Figure 36 outlines the air dryer heater circuit.

Power to the heater element comes from relay #8 inside the Vehicle Electrical Center (VEC). Fuse #1, or a circuit breaker, (in the VEC) in the relay battery circuit protects the air dryer circuit. Circuit AD100 runs from pin "H" of VEC connector "D" (P81) to the air dryer.

The air dryer, when so equipped, contains a thermostat and heating element in the exhaust cover that senses the temperature of the end cover. When the end cover temperature drops to 40°F (4°C) the thermostat closes,

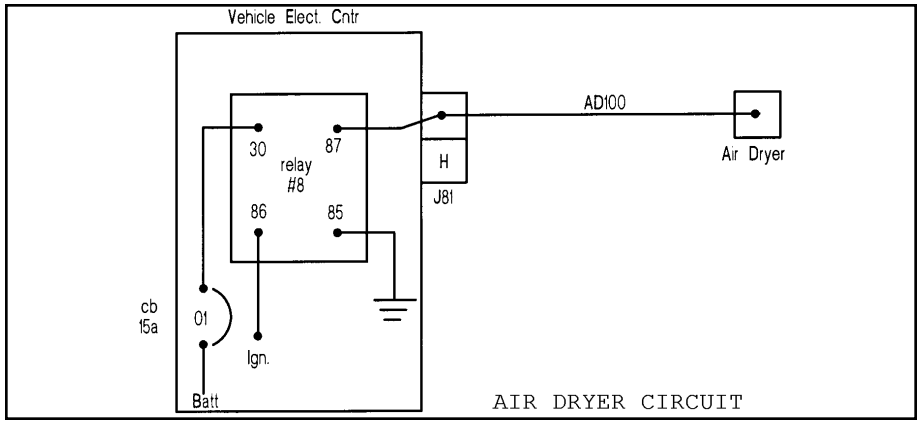


Figure 36

completing the ground circuit for the heating element.

Excessive moisture in the tanks, or ice in the system indicates the dryer is not functioning properly. Until the dryer has been serviced the tanks should be drained manually by the drain cocks in each tank, daily.

In the event the heating element is not working, use the following procedure to check the element:

1. Remove the electrical lead from the dryer purge valve located in the end cover.
2. With ignition ON, connect a voltmeter to the lead; check for 12V.
3. If no, or low, voltage, check for a blown fuse, (tripped circuit breaker) in the VEC.
4. Check relay #8 for proper operation; should have 12V at pin "H" of VEC connector "D" (P81).
5. If circuit AD100 has 12V at the dryer, it will be necessary to check the heating element and the thermostat in the exhaust cover. **Make sure the air system is drained before removing the cover**.
6. Remove the 3-1/4" capscrews securing the cover, remove the cover and place it in a refrigerator, or outdoors if the ambient temperature is near freezing. Remember the cover temperature must be below 40^{o}F (4^{o}C) to complete the ground circuit.
7. With the cover properly chilled, place an ohmmeter lead to the pin in the center of the cover female connector, and the other lead to the cover body. The resistance reading should be 2.0 to 4.0 ohms. Warm the cover to 90^{o}F (32^{o}C), the resistance should be approximately 1000 ohms.
8. If resistance values are within these limits the thermostat and heating elements are OK, otherwise replace the cover assembly.

Note: The VEC could contain either fuses or circuit breakers, depending on customer specifications.

Note: It would not be necessary to remove the cover for checking resistance values if the bus has exposed to below freezing temperatures for several hours.

Antilock Braking System - WABCO

The WABCO Antilock Brake System (ABS) is standard on the Saf-T-Liner ER and HD models. The system electronically monitors wheel speeds and at the same time controls wheel lock-up in conjunction with the air brake system. During normal braking the ABS passively monitors the speed of all wheels at all times. When the ECU receives a signal , one of the wheels is approaching lock-up, the ECU in turn, sends a signal to the modulator valve controlling that wheel, regulating air pressure to the brake chamber as necessary to prevent lock-up.

The system is composed of a signal generating tone wheel on each hub and a corresponding sensor. East tone wheel contains 100 notches. As the wheel turns the notch teeth interrupt the magnetic field created by the sensor. These interruptions create electrical pulses that are transmitted to the ABS ECU. Each sensor has its own captive harness direct to the ECU.

The ECU contains micro-computers that monitor the speed of each wheel.

The ECU is mounted in front of the transmission VIM. Both are mounted on a bracket attached to the right support of the PCB in the chassis electrical compartment.

Each axle is controlled by a valve package. The front axle package contains two modular control valves and a quick release valve. The rear axle package contains two valves and the service brake relay valve. Each valve has its own captive harness direct to the ECU.

The two modulator valve harnesses and the two rear sensor harnesses merge into a separate ABS harness that runs alongside of the main chassis harness to the front of the chassis. The two front sensor and modulator harnesses enter into this harness, which ends at the ABS bulkhead connector P101. Harness, part #TBB 62203655 continues the circuits from P101 to the ABS ECU.

Figure 37 is a schematic of the circuits involved between the controlling ECU and the modulators and the wheel sensors. This can be useful in the event it is necessary to check continuity of any given circuit.

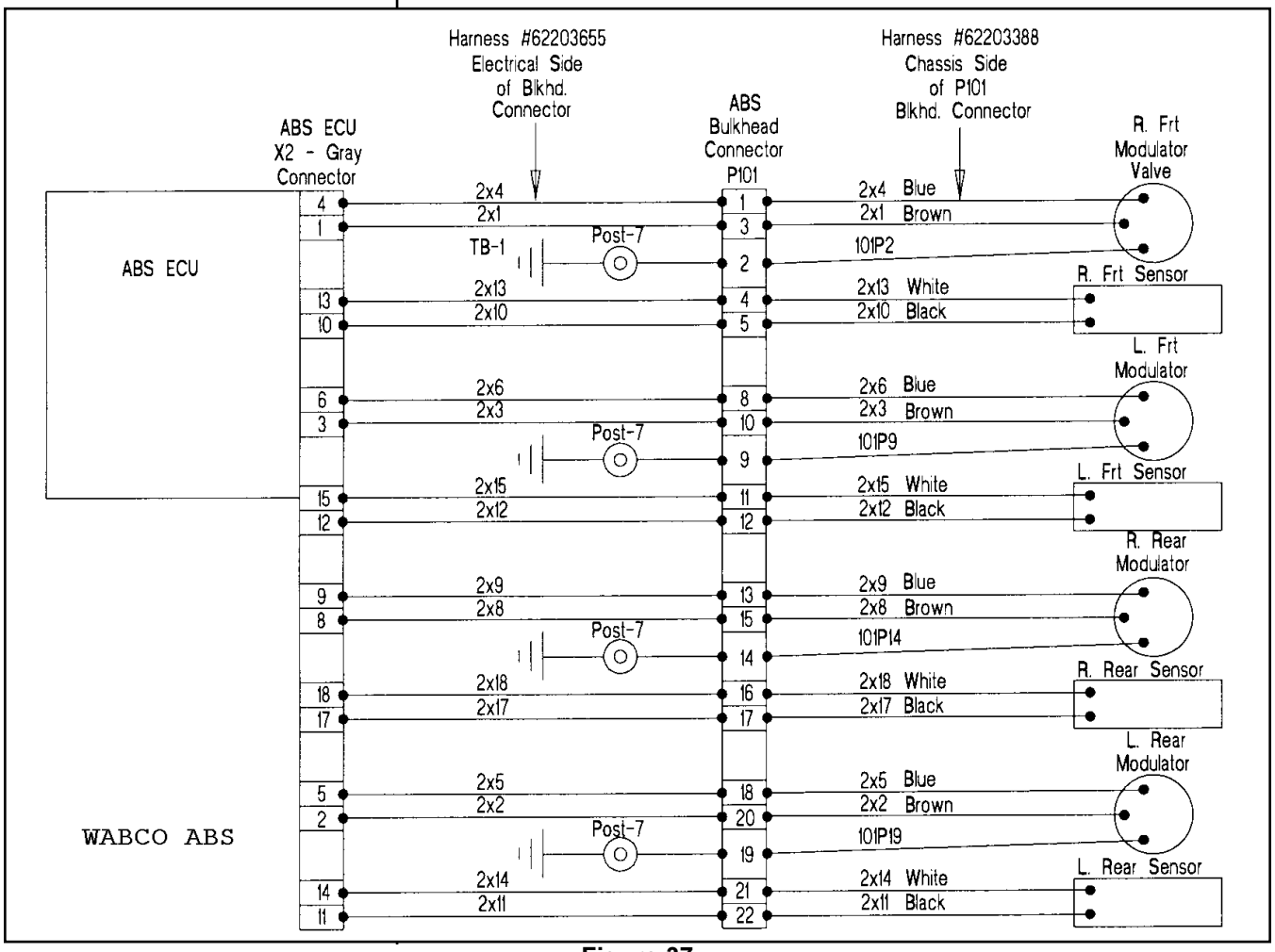


Figure 37

See the *Brake Section* of this manual for more information concerning this subject.

Cruise Control

The cruise control feature, when specified, operates in much the same manner as the average automobile; i.e. a single pole-single throw ON/OFF switch turns the cruise control ON. A separate SET/RESUME switch controls setting the cruise speed when reached as well as resuming cruise speed when it has been interrupted.

The principle of operation is basically the same on Cummins and Caterpillar powered units; however, the circuits are different. On each, the ECM controls all facets of the cruise control operation. The ECM regulates the amount of fuel being delivered to the engine to provide the desired road speed. There are no external rods, cables, cylinders, etc. as was used on older vehicles.

Cummins Cruise Control

A normally closed switch, installed in the brake application pressure hose, completes the cruise control ground circuit to the ECM when the cruise control is ON. This circuit is broken when the brakes are applied, rendering the cruise control inoperative. To resume operation, use the RESUME switch

The above switch is installed on the small air manifold located beneath the driver's floor panel.

Figure 38 outlines the circuits involved in the cruise control. The schematic shows that the three (3) switches involved complete the ground circuits for the

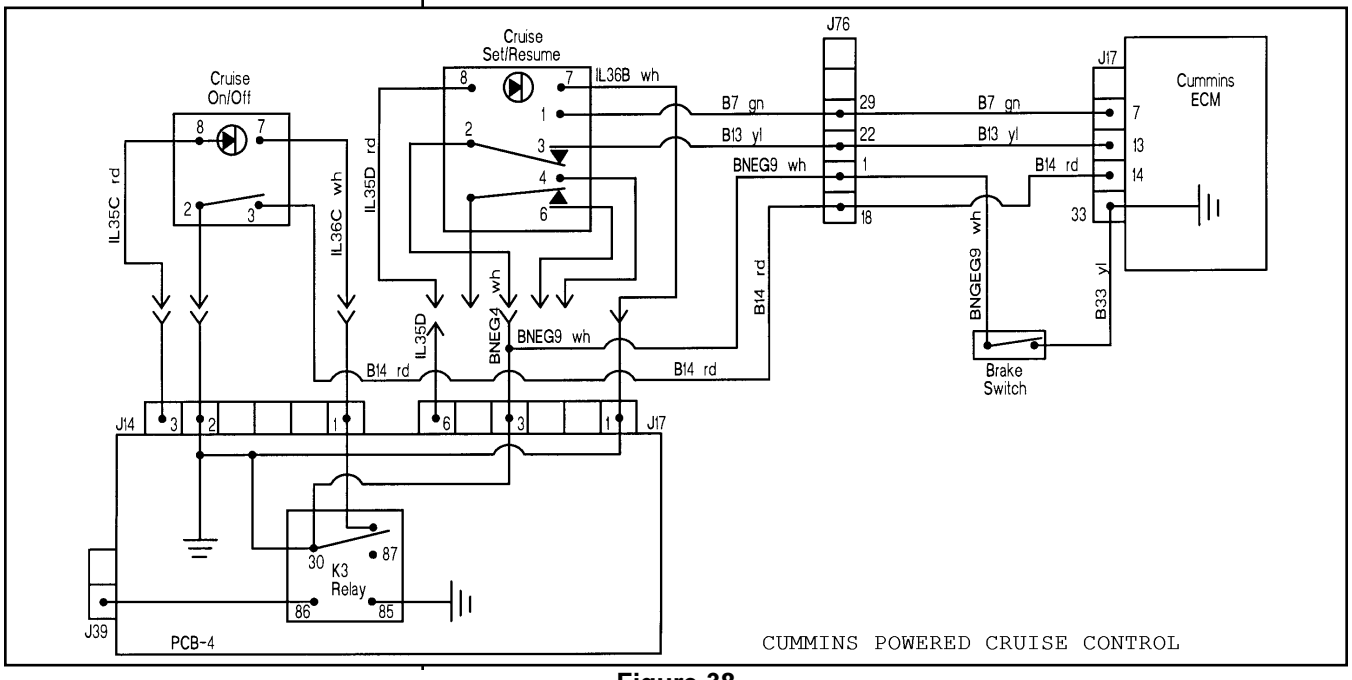


Figure 38

ECM to control the cruise control.

Troubleshooting the Cruise Control System

To properly diagnose any problems associated with the ECM, the use of Cummins' INSITE program is highly recommended, along with Cummins ISC Troubleshooting and Repair Manual, part #3666245, and the proper test equipment. Without the proper service information and equipment, damage can be done to the ECM, sensors, connectors, and terminals. A number of circuits served by the ECM, throttle control, fan drive, do not operate at 12 volts.

Troubleshooting tips for Cummins:

1. With cruise control switch ON, check for closed brake switch when brakes NOT applied. Switch should be closed with normal air system pressure and brakes not applied.
2. Check for inoperative ON/OFF switch.
3. Check operation of relay #3.
4. Check operation of SET/RESUME switch, ignition switch OFF.
   Move switch to SET position - Circuit B7 should have no resistance from pin P17 B7 to a good ground.

   Move to RESUME position – Circuit B13 should show no resistance between pin B13 and good ground.

5. If system checks out OK, use the INSITE program or refer the problem to your area Cummins service facility.

Location of components that may be helpful:

- Relay #3 - on PCB 4
- Connector J76 – on front bulkhead
- Brake Switch – on air manifold mounted on backside of front crossmember.

Caterpillar Cruise Control

The principle of cruise control operation is basically the same as Cummins powered units in that the ECM controls the cruise control system. The major differences: 1) Caterpillar completes the POSITIVE circuits in its system, whereas Cummins completes the GROUND circuits. 2) The circuit numbers are different between the two systems.

See **Figure 39** for an overview of the current flow in the Caterpillar cruise control system.

The brake pressure switch in circuit 458-900 is mounted on the backside of the front crossmember. This switch is normally open when the brake pedal is released, it closes when the brakes are applied and completes the positive circuit to the cruise control switch through the ECM on pin #64.

The cruise control cannot be set to cruise at a speed lower than 30 mph or higher than 75 mph.

Holding the SET or RESUME switch longer than 15 seconds will cause the cruise control to "kick out". To place it back in service, turn the ON/OFF switch OFF and then back ON.

At this point the technician is advised to refer to section PB-15 in the Caterpillar Electronic Troubleshooting Manual #7ASI-UP in the event a serious problem arises in the cruise control system. This manual is a MUST in your shop library, and is available from your area Caterpillar dealer. This manual takes you through the troubleshooting process step-by-step. Section P-1.0 in this manual outlines the Electronic Service Tools required to effectively troubleshoot problems associated with the engine electronic systems. Your area service representative can assist in procuring the necessary equipment.

Listed are several suggestions that might be helpful if the cruise control does not operate, and you do not have the necessary test equipment on hand:

1. Cruise ON/OFF switch turned OFF or an OPEN circuit to the ON/Off switch.

   Check for a failed pressure switch in the brake.

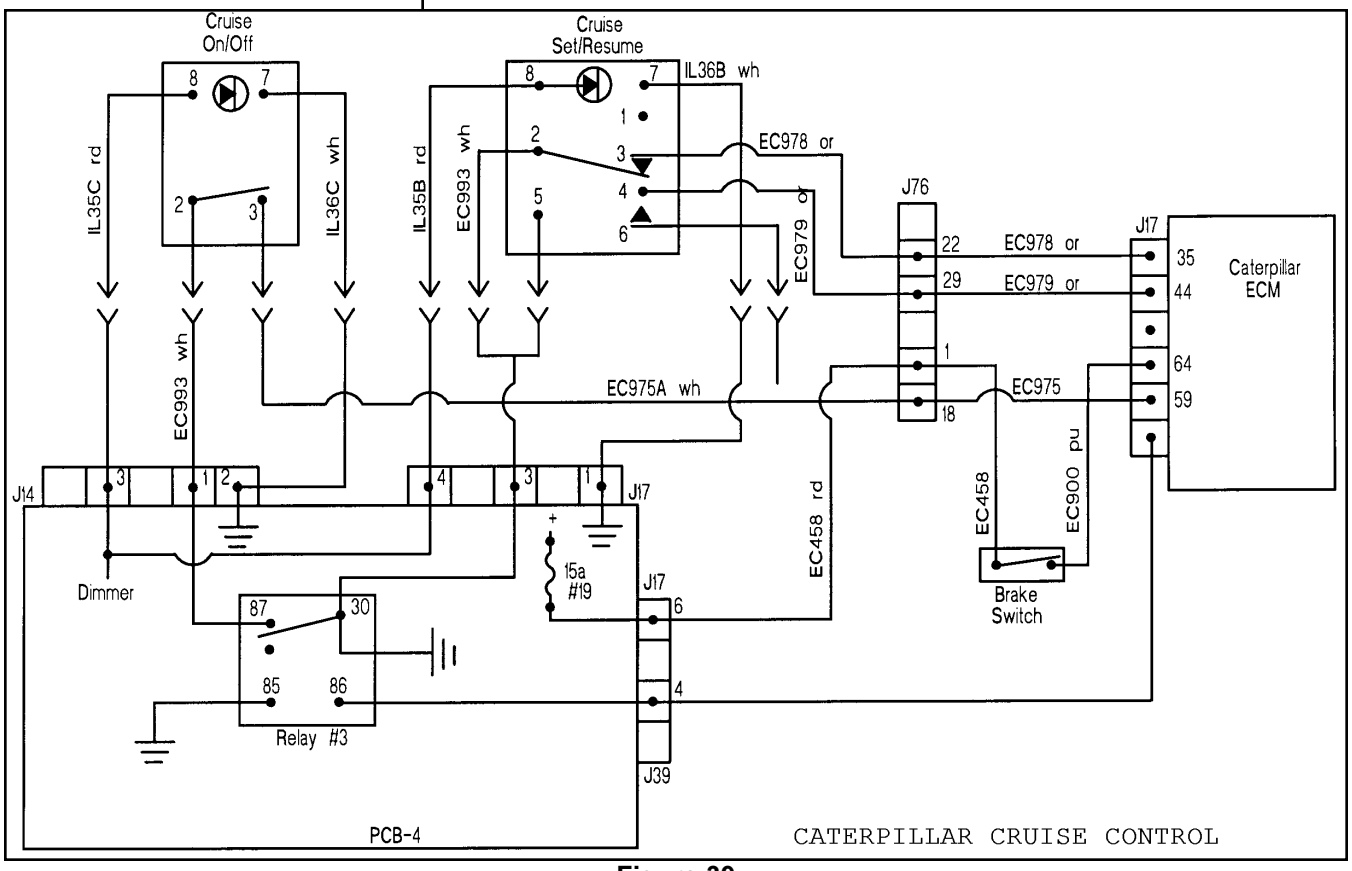


Figure 39

2. Vehicle speed signal is erratic. Road test to see if speedometer registers smoothly.
3. Check with driver to see if he/she depressed the SET/RESUME switch longer than 15 seconds. To do so will cause the cruise control to "kick out".

The 12-volt positive circuit mentioned in the first paragraph comes from the 12-volt battery grid in the printed circuit board (PCB-4) through fuse #19 (15 amp) to pin 6, connector P39 of PCB-4. From pin 6 circuit EC458 (rd) runs to pin 1 of bulkhead connector J76, and from there to the brake switch.

The circuit number changes to EC900 (pu) and runs through the main chassis harness direct to pin 64 connector P19 of the Caterpillar ECU.

Relay #3 on the PCB completes ground circuit EC993 to the ON/OFF switch. With the switch in the ON position, circuit EC975 runs to bulkhead connector J76, pin 18. From pin 18 circuit EC975 runs through the main chassis harness direct to pin 59 of ECU connector P19.

Refer to **Figure 39** for other circuits involved in the cruise control system.

Location of system components that may be helpful:

- Relay #3 – on PCB-4
- Fuse #19 – on PCB-4
- J76 Connector – on front bulkhead
- Brake Switch – on backside of front crossmember

Ether Start (Caterpillar only) Saf-T-Liner ER

This option is used only when specified by the customer and only with Caterpillar engines.

Spraying a starting fluid directly into the intake air inlet is a dangerous practice. This can cause an explosion with resultant damage to the engine and possible injury. The ether start system used by Thomas is an automatic injection system that injects the ether after inlet air has passed the intake air grid heaters.

A fixed amount of ether is injected when the coolant temperature is below 130^{O}F (54^{O}C), at which time the N/O thermostat (temperature sensor) closes to complete the ground circuit to the solenoid valve.

Circuit ST104A (black) from the starter relay carries 12 volts to the VEC, gray connector P79-pin F, and on to the ether solenoid valve via ST104B.

When the solenoid valve is energized with the ground circuit completed, a predetermined, one-time only amount of ether is injected into the intake manifold. Once the initial injection is made, no further ether flow occurs, unless the ignition switch is turned OFF, and the starter re-engaged. It will

then inject only the predetermined amount. See **Figure 40** for a schematic of the circuits.

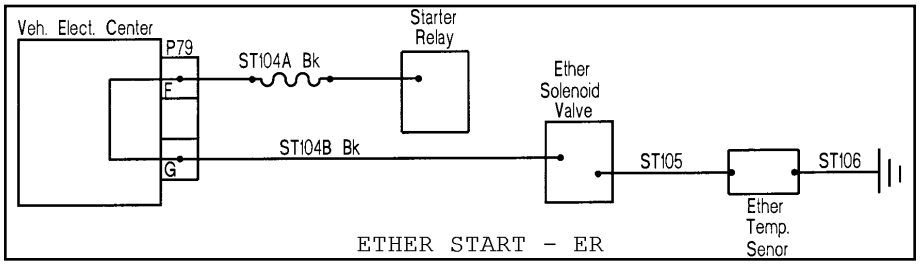


Figure 40

Ether Start (Caterpillar only) Saf-T-Liner HD

The comments above are the same for the HD model with the following exception: On the HD model circuits ST104A and ST104B are routed through rear electrical box connector J138. See **Figure 41**.

A 10-amp in-line fuse in circuit ST104A, between J138 and the VEC, protects the ether start circuit.

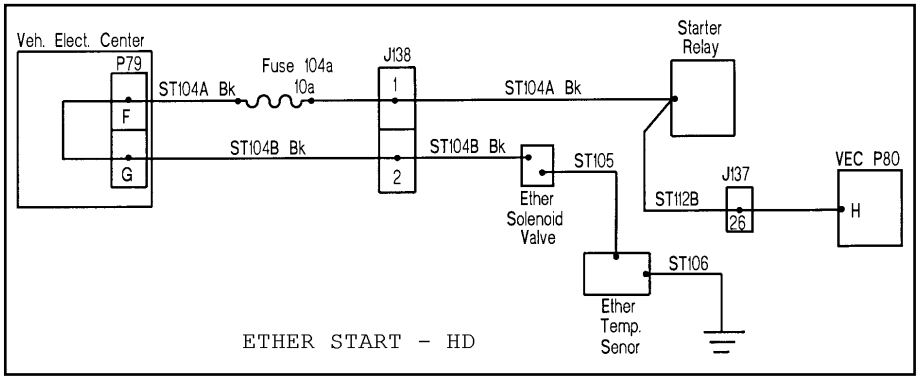


Figure 41

Fuel Gauge Circuit

Access to the fuel gauge-sending unit is gained by removing the access plate in the center aisle, above the fuel tank.

In the event the fuel gauge is registering improperly, remove the sending unit from the tank and check the resistance values with an ohmmeter, based on the chart below.

Indication	Resistance Range – Ohms
EMPTY	244.0 – 249.0
1/8	194
¼	149.6 – 154.5
½	102.5 – 103.5
¾	66.2 – 67.8
FULL	29.4 – 30.0

The circuits involved in this gauge circuit are as follows:
Ground circuit FG6G (white) runs from the gauge retaining screw to bulkhead connector J75, pin 20. The circuit number changes to ICU06G on the opposite side of J75, runs to connector P44 located in the chassis electrical compartment. From P44, pin 4, ICU06G goes to pin D2 of connector P65 of the ICU. (P65 plugs into backside of the ICU.)

Be aware that a poor ground connection at the sensor can cause an inaccurate reading of the fuel gauge.

Circuit FG 6 (purple) transmits the resistance signal to J75, pin 2. The circuit number changes to ICU06 on the opposite side of J75, goes to post 3 of P44, and to pin D1 of P65 at the ICU.

Figure 42 outlines the fuel gauge circuits.

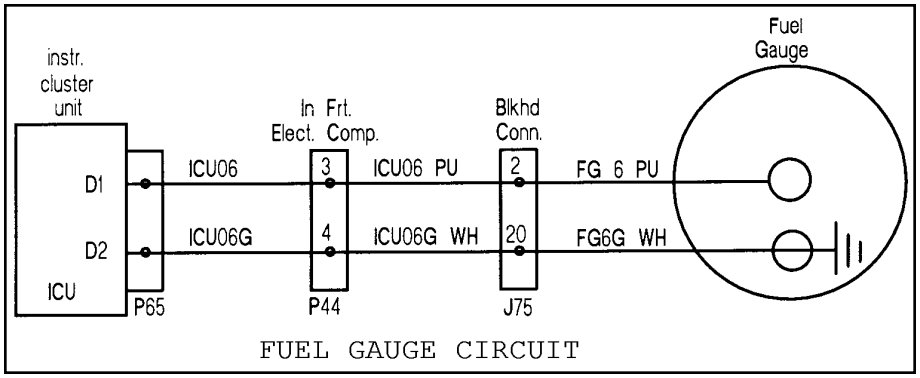


Figure 42

Fuel/Water Separator

Units operating in areas of extreme winter temperatures are usually equipped with fuel/water separators that include a heating element. An automatic thermostat within the filter assembly completes the heater ground circuit as the fuel temperature drops to 35°F (2°C). At this point the heater element heats the fuel to remove and prevent the formation of wax crystals that impede the flow of fuel through the filter element. In addition to preventing the formation of crystals while en route, the heater element is vital at start-up after the bus has been parked for any length of time in severe weather.

On start-up, turn the ignition switch ON and wait at least five minutes before attempting to start the engine. This allows any fuel crystals that may have formed in the fuel filter assembly to be dissolved.

Figure 43 outlines the relatively simple electrical circuits involved in the fuel heater system.

Fuel/Water Separator – Saf-T-Liner ER

The fuel heater element is a part of the filter assembly.

Relay K7 for this circuit is located inside the Vehicle Electrical Center, which is mounted on the splash panel beneath the air cleaner assembly.

Figure 43 outlines the simple circuits involved in the fuel/water separator filter heater. Note on the schematic that circuits FS141 and FS142 do not go through a connector on the ER model, the two circuits run direct between the VEC and the heater.

10-amp fuse #F9 protects the 12V power circuit to post 30 of the relay. The relay is grounded internally in the VEC. Post 86 of the relay is energized from the VEC ignition buss bar when the ignition switch is in the RUN position.

Circuit FS141 from VEC connector J81 (green) pin "E" is the 12V positive circuit to the heater element.

Circuit FS142 (white) from the "F" pin is the ground circuit to the heater.

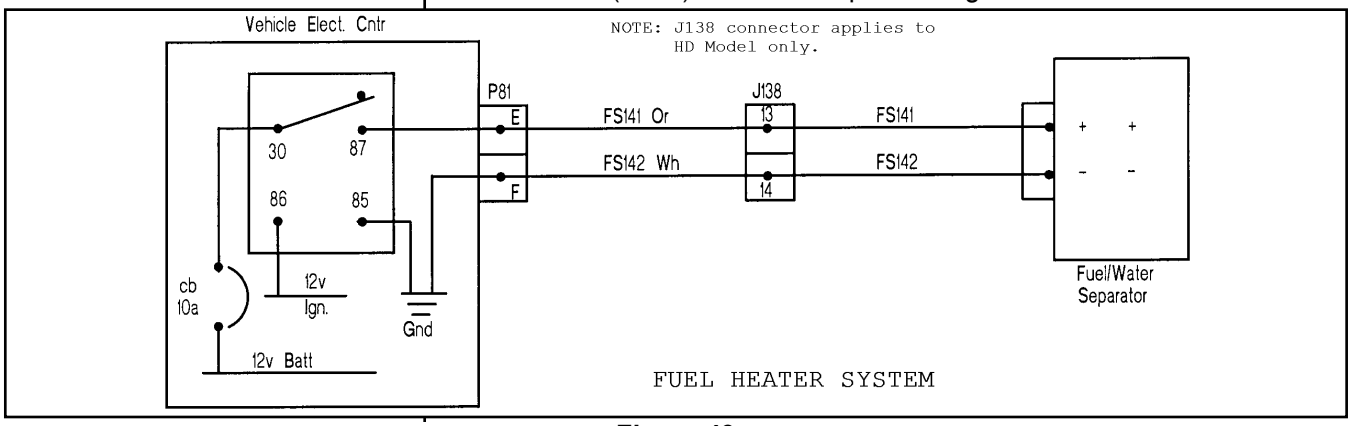


Figure 43

Fuel/Water Separator Heater – Saf-T-Liner HD

The fuel heater element is a part of the filter assembly. The relay for this circuit is located inside the Vehicle Electrical Center, which is mounted inside the rear electrical compartment. 12-volt power circuit, FS141 (orange) from the relay exits the VEC through connector P81 (green) pin E, and connects to J138 pin 13 inside the compartment. FS141 runs to the fuel heater from J138.

Heater ground circuit, FS142 (white) exits the VEC on P81, pin F to pin 14 of J138, and on to the heater.

A 10-amp circuit breaker inside the VEC, between the battery circuit and relay post 30, protects the circuit.

When the ignition is ON, current will flow to relay post 86. The relay will close when the fuel heater thermostat drops 35^{O}F (2^{O}C), completing the ground circuit. The heater will not function above 35^{O}F.

In the event the fuel heater is inoperative, disconnect FS141 and FS142 from the fuel heater. If 12V is present, replace the filter bowl containing the heater

element, both, ground and power circuits, are OK.

If no voltage, check both circuits back upstream.

Heated Automatic Drain Valves

When heated automatic drain valves are ordered it will be installed in the WET tank first, but can be installed in other tanks if desired.

These valves dump a small amount of moisture or sludge when system pressure reaches air governor cut-off pressure around 125 psi. The valve will remain open until the governor cuts back in around 95 psi.

To ensure these valves are functioning properly, at each PM inspection insert a thin tool in the exhaust port to unseat the exhaust valve. If an excessive amount of contaminant comes out, it is an indication that the valve is not functioning properly. It should be removed and cleaned, or replaced, if necessary.

See **Figure 44** for a schematic of the heater element circuits.

The heater, when specified, is energized when the valve body temperature drops to 35°F (1°C), and is de-energized when the body temperature reaches 85°F (29°C).

Power to the drain valve(s) comes from relay #11 on PCB-4. Fuse #18 on the board protects the heater circuits, A81 and A85. The ground circuit is completed when valve body temperature drops to 35°F.

Circuits A81 and A85 exit the PCB-4 via pins 1 and 2 of PCB connector P15, and runs to bulkhead connector J75, pins 17 and 16. The circuits continue from J75 to the valves.

Troubleshooting Tips:
In the event the heater element malfunctions, check as follows.

1. Disconnect the lead from the valve. With ignition ON, check for 12v in

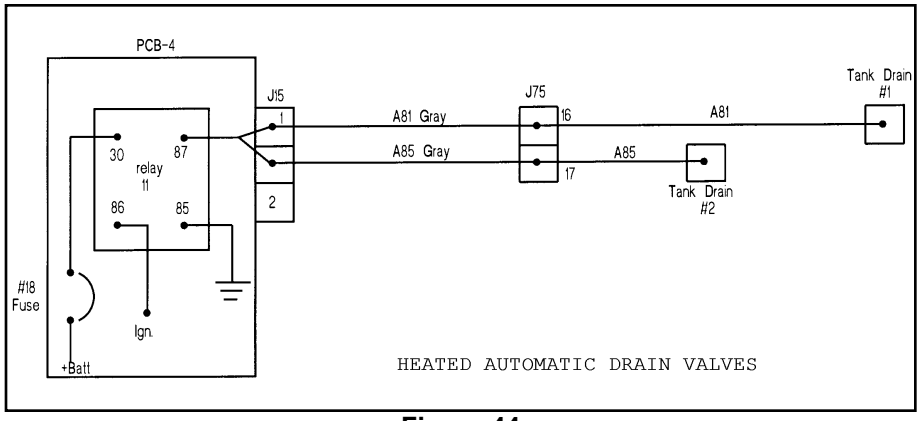


Figure 44

the lead. If 12v is present, the element has failed.

2. If no voltage, check for blown fuse #18 in the circuit board.
3. If fuse is OK, check for 12v at pins 1 or 2 in connector P15 at the board.
4. If no voltage, check for failed relay #11.
5. If voltage is present at all above checkpoints, check for an open circuit in the circuit involved, possibly at J75 connector.

Retarder System (See *Transmission* section for more information pertaining to this system.)

Figure 45 outlines in general the circuits involved in the retarder system. Missing in this schematic are the circuits involved in the operation of the transmission itself.

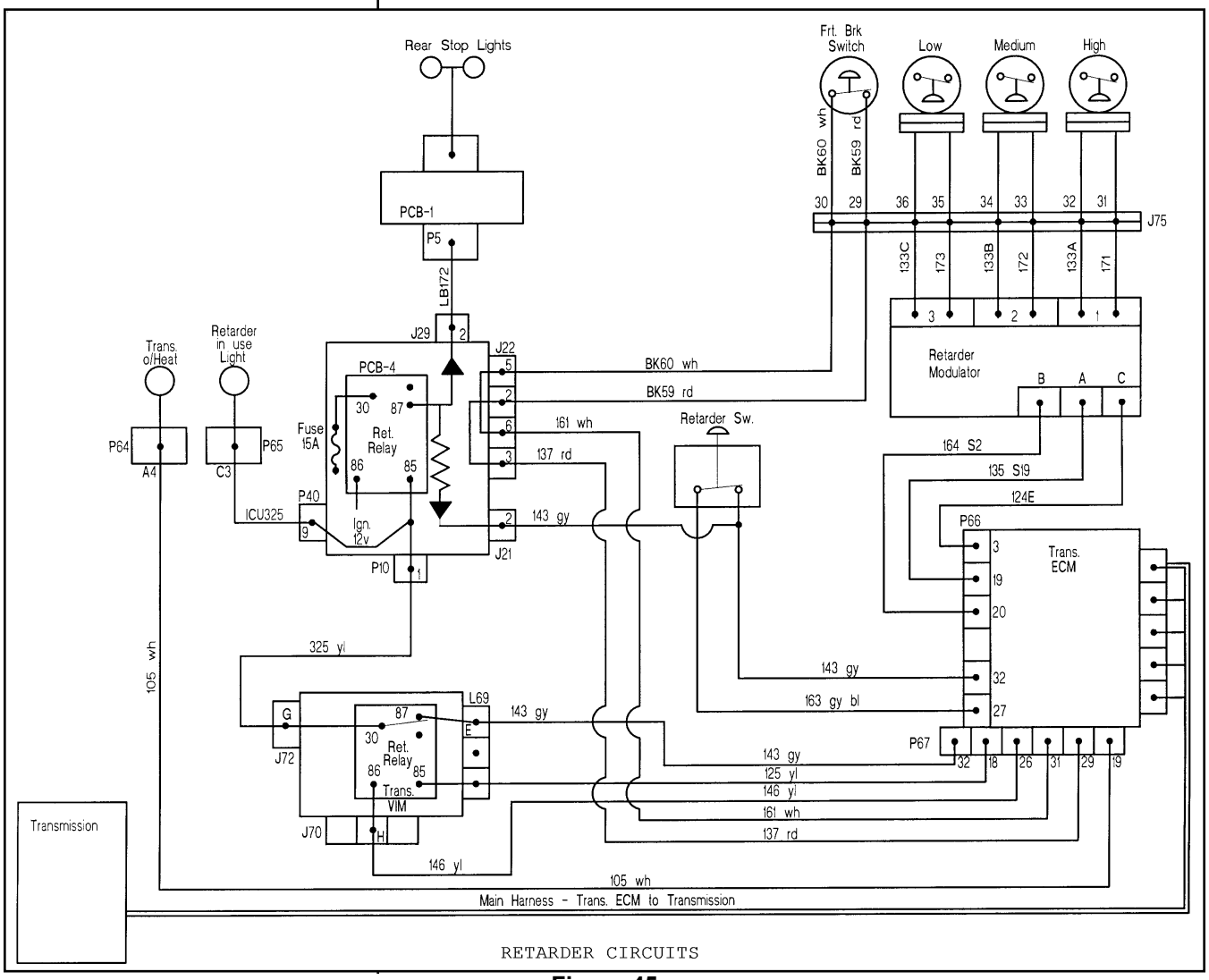


Figure 45

Windshield Wipers

Two modules located in the front of the body controls the Windshield Wipers.

The Windshield/Headlight Module is located between the Transmission Control Unit (TCU) and the left support of Printed Circuit Board #4 (PCB-4). The other wiper module, sometimes call "diode block", is beneath the windshield on the inside of the body front panel, above and to the left of PCB-4.

The Windshield/Headlight Module receives its signals from the wiper switch, which is part of the Turn Signal-Headlight Control. The control is mounted on the steering column. This module receives its ground, battery, and ignition circuits from PCB-1 located beneath the driver's sash.

Fuse #23, 15-amp, protects the battery circuit (green) to the module. This circuit runs from pin 3, of PCB-1 connector J16 to the "F" pin of #1 connector on the module.

Fuse #7, 15-amp, in the PCB-1 protects the ignition circuit (black) to the module, from pin 1 – J16 to pin "A" of module connector #1.

The module is grounded from pin "H" to #2 pin of J16.

When the Windshield/Headlight Module #1 receives a signal (high, low, or park) from the switch, the signal is transferred to the wiper module #2 (diode block) located on the front panel. This module is required because the Windshield/Headlight module cannot handle the current demanded by both wiper motors. Module #2 receives the signal from #1 and transfers it direct to the driver's wiper. At the same time that signal is received, #2 acts on that signal and provides separate circuits to the passenger (right side) wiper motor. Therefore, if the Right wiper should not operate, either module #2 or the wiper motor itself would be suspect.

See **Figure 46** for a schematic of the circuits involved.

Circuits WPA, WPB, WPC, and WPD are in a transfer harness from the Left side of the body to the chassis electrical compartment, beneath the windshield. A connector joins this harness with the harness coming out of the steering column (connector P62).

The WL and WR circuits shown on **Figure 46**, from module #2, go to and through the body bulkhead connector located beside the transmission connector in the chassis electrical compartment. After leaving the bulkhead connector each wiper has a separate harness to its motor with a connector approximately 18" from the motor. They are visible when the front access panel is lowered.

Windshield Washer Pump Circuit

When the wiper switch energizes the wiper wash circuit (WPD), a signal is sent from the switch to the Windshield-Headlight (#1) module, pin "B" of module connector #2 (P47). The module transmits that signal through pin "G"

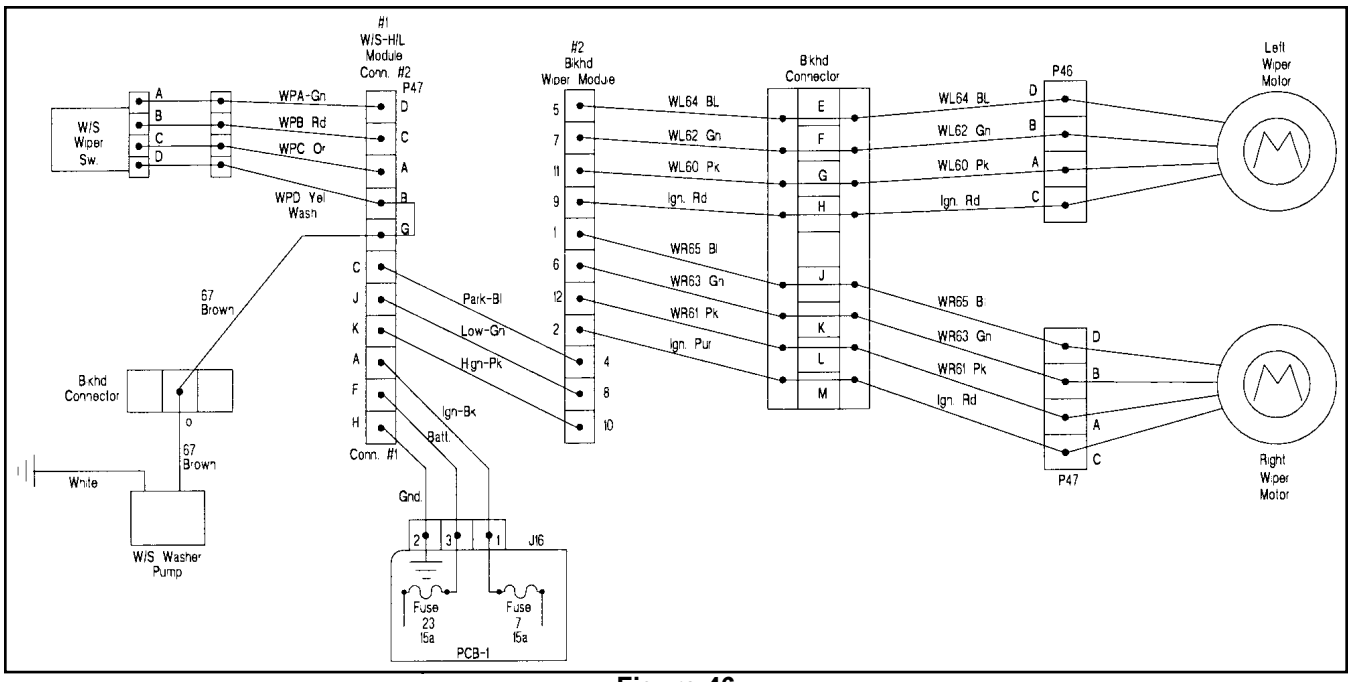


Figure 46

of P47 via circuit 67 to pin "O" of the bulkhead connector. From there, circuit 67 continues to the washer pump located in the washer fluid container.

Body Key Ignition Circuits (Figure 47)

Circuits in the body electrical system are controlled by a Key Ignition Circuit Relay on each of the three body Printed Circuit Boards. Each PCB has its own “Battery” and" Ignition” Buss Bars.

Relay #5 in PCB-1 energizes PCB-1 Ignition Buss Bar from relay post 87,

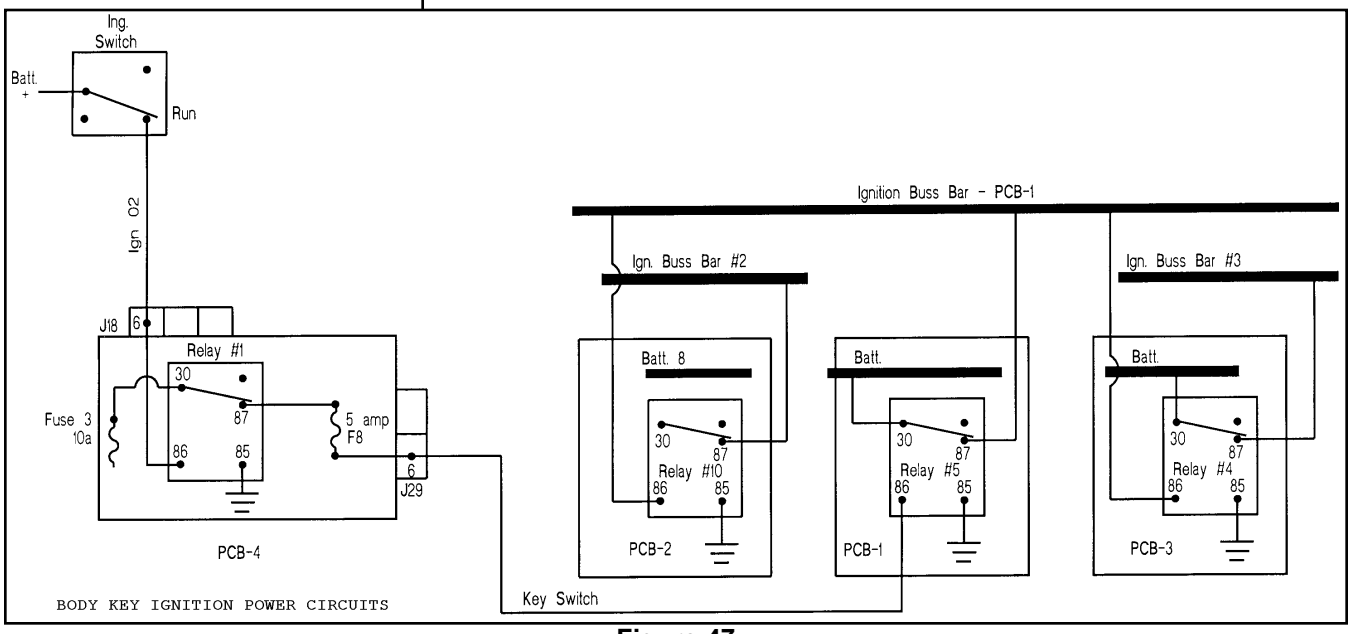


Figure 47

when the ignition switch is on RUN position. Circuits taking power from PCB-1 will connect with PCB-1's Ignition Buss Bar.

PCB-2 Ignition Buss Bar would be energized by current from its relay #10, post 87.

PCB-3 Ignition Buss Bar would be energized by current from its relay #4, post 87.

Referring to **Figure 47**, note these two relays receive their "trigger" circuits from PCB-1's Ignition Buss Bar to relay post 86.

As noted above PCB-1's relay #5 controls all circuits related to the body.

Relay #5 (PCB-1) receives its "trigger" circuits to post 86 from chassis PCB-4, connector J29, pin 6, via circuit Key Switch. This circuit is a part of the harness that runs across the front of the body that ties body and chassis functions together.

In studying **Figure 47**, note the Key Ignition circuit is protected by a 5-amp fuse F8 between relay post 87 and connector J29, pin 6. It is also protected by 10-amp fuse #3 between "Battery" and post 30 of relay #1. Therefore, if the body PCBs are not functioning, check fuses 3 and 8 in PCB-4 before getting involved in extensive checking procedures.

Relay #1 on PCB-4 is energized when the Ignition Switch is in the RUN mode.

Troubleshooting:
Complaint: Body PCBs inoperative.

1. Check fuses #3 and 8 in PCB-4.
2. Check for inoperative relay #5 in PCB-4.
3. Check for 12V at pin 86 on PCB-1 relay #5 with Ignition Switch on RUN. If 12 volts are present, but no voltage to PCB-1, Ignition Buss Bar, relay #5 is defective.

If circuits involving PCB-1 and PCB-3 are inoperative:

1. Check for 12 volts at PCB-1 Ignition Buss Bar.
2. If OK, check for 12 volts at post 87 of the PCB relay involved. If no voltage, replace relay involved.

Exhaust Brake System

Caution: The exhaust brake switch should be in the OFF position during wet or slippery road conditions. Failure to do so can result in reduced control of the bus, and possibly result in personal injury and damage to the bus.

The purpose of the exhaust brake is to slow the bus on grades and curves, and to reduce wear on brake linings and brake drums. It is most useful on long down grades, where speed reduction is required but an extended application of the service brakes is not desired.

Maximum retarding effort is generated at maximum rated engine rpm; however, exhaust brake performance decreases in proportion to decreased in

⚠ ***Caution***: The exhaust brake should NOT be used in conjunction with the service brakes under such conditions.

engine rpm. The brake will become inoperative when engine RPM drops below 900 – 1000 rpm.

The following conditions must exist to cause the exhaust brake to function:

1. The exhaust brake switch must be ON.
2. The operator's foot must be OFF the accelerator pedal. (The pedal must be in the IDLE position.)
3. Engine speed must be above 1000 rpm.

The engine ECM actually controls the activation and deactivation of the exhaust brake based on signals sent to it by various sensors on the engine and transmission system, and the above three conditions are met. It will operate only when no additional fuel is being sent to the engine.

The anti-lock brake system may interrupt the operation of the exhaust when the ABS is actuating.

The exhaust brake switch should be in the OFF position during wet or slippery road conditions. Failure to do so can result in reduced control of the bus, and possibly result in personal injury and damage to the bus.

The exhaust brake should NOT be used in conjunction with the service brakes under such conditions.

Caterpillar Engines:
Figure 48 outlines the circuits involved in the exhaust brake system when used on the Caterpillar engine. As mentioned earlier the engine ECM controls the engagement of the exhaust brake, by completing the 12V ignition circuit to the brake solenoid through K4 relay on the chassis PCB-4.

The 12V ignition circuit is initiated when the dash mounted exhaust brake switch is ON, from the switch to the transmission VIM relay, post 30.

The transmission ECM signals the relay to close and transmit the current to PCB-4 relay K4 via circuit 332NC. Fuse #13 in the PCB protects the power circuit to the relay. With the three conditions mentioned above met, the exhaust brake solenoid is activated by the engine ECM.

Listed below are the locations of certain components involved in the exhaust brake system that may be useful in the event troubleshooting the entire system is necessary.

Components and Locations:

- Printed Circuit Board (PCB) – See **Figure 5** (At the front of this section.)
- Transmission Vehicle Interface Module (VIM) – See **Figure 5**.
- Transmission Electronic Control Module (ECM) – See **Figure 5**.
- Exhaust Brake Switch – Right side of dash console.
- PCB-4 Relay K4 – In #4 position on PCB board.
- VIM relay – Inside the VIM.

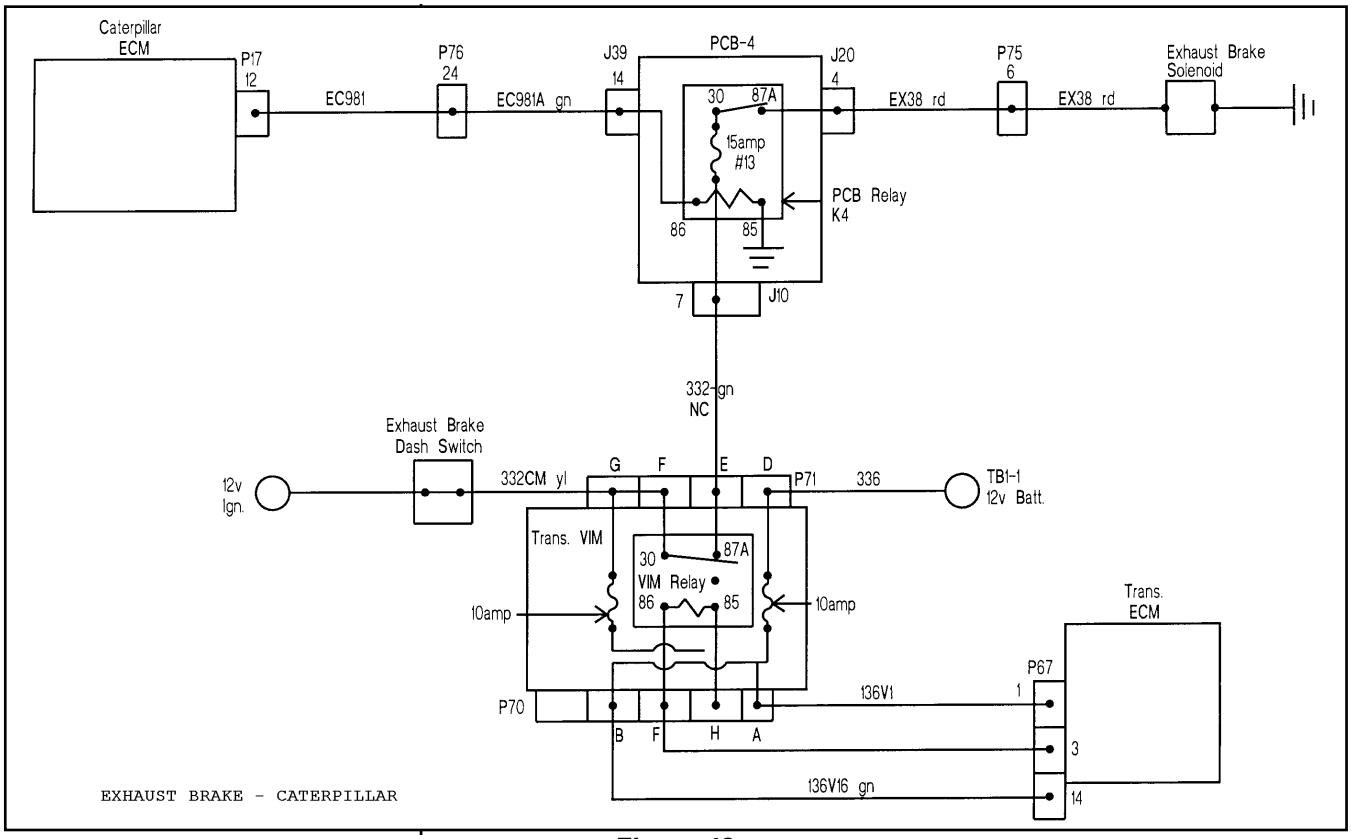


Figure 48

- Engine ECM – Mounted to engine.

Location of pertinent connectors:

- P10 – Connects to PCB-4, see **Figure 8**.
- P17 - Connects to engine ECM
- P20 – Connects to PCB-4, see **Figure 8**.
- P67 – Connects to transmission ECM
- P70 – Connects to transmission VIM
- P71 – Connects to transmission VIM
- P75 – Front Bulkhead Connector, see **Figure 4**.
- P76 – Front Bulkhead Connector, see **Figure 4**.

Cummins Engines:
The operation of the exhaust brake on the Cummins engine is basically the same as on the Caterpillar engines; however, different circuits are used in some instances.

Figure 49 outlines the Exhaust Brake circuits on the Cummins engines.

The transmission ECM controls the VIM relay, which completes the 12V-power circuit to the exhaust brake relay on the PCB-4.

The engine ECM controls the ground circuit for the PCB relay. When this relay is closed, 12V current flows through the PCB relay to the brake solenoid.

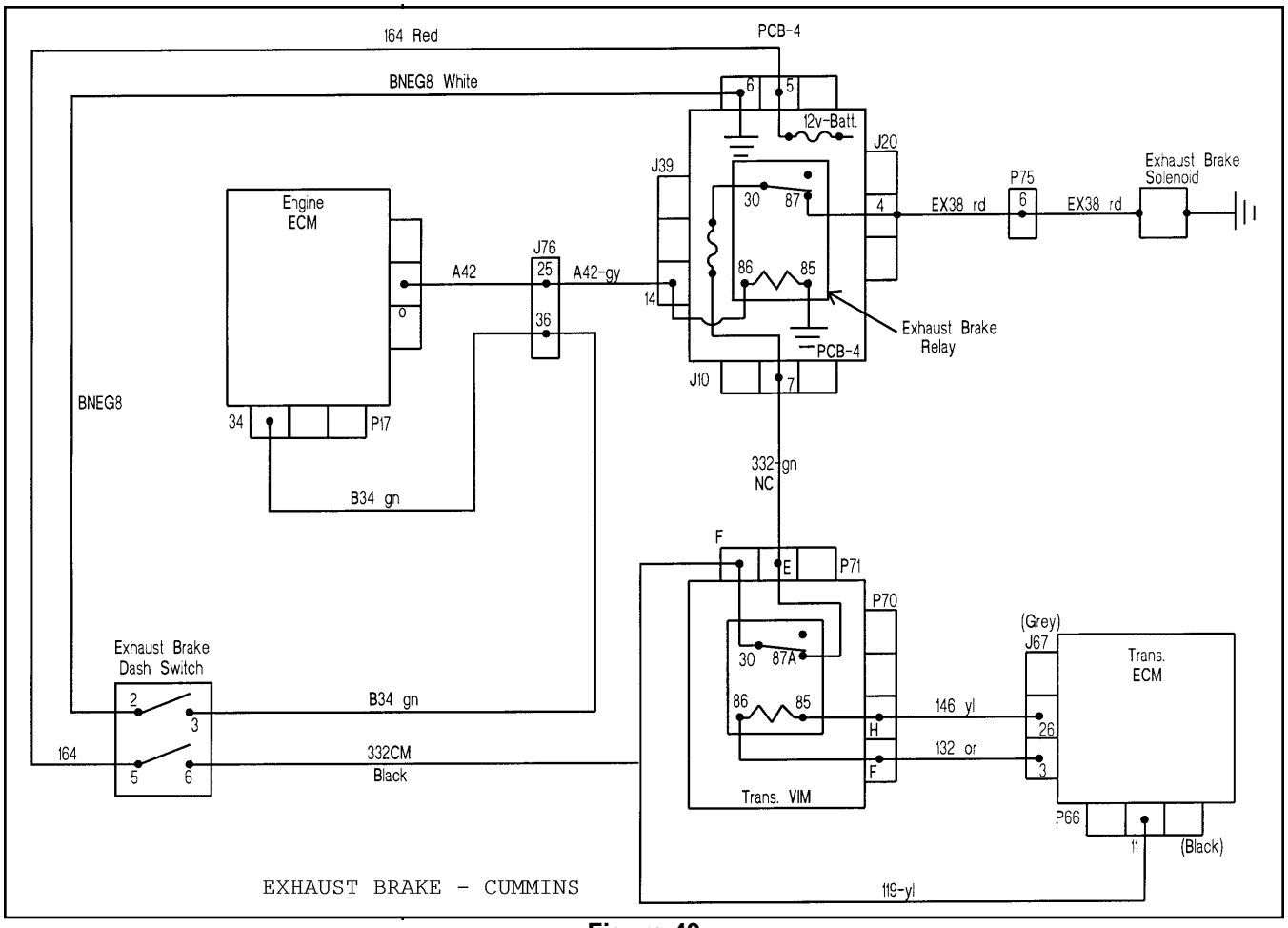


Figure 49

Fast Idle

Fast Idle is controlled by the engine ECM, and is preset at 700 rpm at time of assembly.

Fast Idle of 1000 rpm (+/– 50 rpm) is activated by energizing the Fast Idle switch on the dash, and with the transmission in Neutral. Fast Idle will drop out when the shift is moved into any gear.

Fast Idle speed can be increased incrementally from 700 to 1000 rpm by “toggling” the Fast Idle switch momentarily.

Idle and Fast Idle are controlled by the ECM by regulating the fuel to the injectors.

Cummins Fast Idle

Figure 50 relates to the Cummins Fast Idle circuits. With the transmission in Neutral (Neutral Switch Closed), 12-volt Current flows from the VIM through PCB-4 connector J10, pin 4 to J39, pin 4, then through circuit B46 to post 85

of the Fast Idle relay. This activates the relay, completing the ground circuit to the engine ECU when the Fast Idle switch is ON.

Ground circuit BNEG8 comes from PCB-4 connector J19, pin 6 and runs to relay post 86. Circuit 88a tees off this circuit to post 30 of the relay. When the relay is energized the relay contact loses to post 87. B46A completes the ground circuit to post 2 of the Fast Idle switch. With the switch closed (ON) circuit B46 (gn) continues to bulkhead connector J76, pin 34 and on to the engine ECU, pin 46.

Component locations:

- VIM – located in chassis electrical compartment
- Fast Idle Relay – mounted behind the dash
- J76 Connector – located on front bulkhead.

Troubleshooting Tips:

1. Check for 12 volts at relay post 85, with ignition ON and transmission in Neutral.
2. Check for completed ground circuit at post 2 of the Fast Idle switch ON transmission in Neutral.
3. Check continuity of Fast Idle switch with switch ON.
4. Check continuity of circuit B46 (yl) at ECU pin 46, with the connector removed.
5. If all check OK, use INSITE program or refer the problem to your area Cummins service facility.

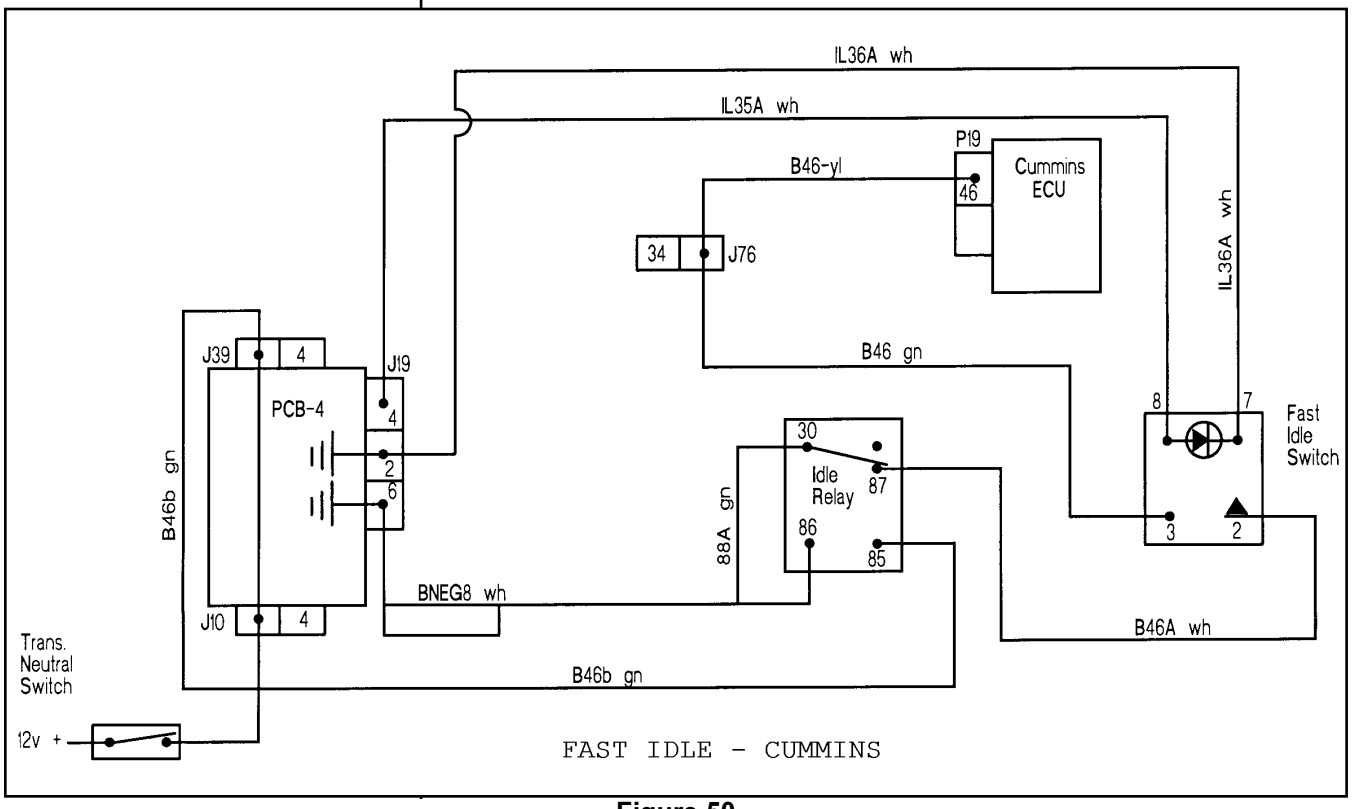


Figure 50

Caterpillar Fast Idle

Low Idle is set at 700 rpm, Fast Idle can be set up to 1000 rpm by toggling the Fast Idle switch. Fast Idle is disengaged when the brakes are applied.

Figure 51 outlines the circuits involved in the Fast Idle system.

12-volt current for the Fast Idle system comes from the printed circuit board, connector P19, pin 5 to the Fast Idle switch through circuit EC88A. This circuit is protected by a 3-amp fuse (#4) on the PCB. Circuit EC905A carries the current from the switch to bulkhead connector J76, pin 20; from pin 20 EC905 continues through the main chassis harness to the engine ECM, connector P19, pin31.

The ECM controls the idle rpm through the ground circuits involved in the system. In addition to the Fast Idle switch that completes circuits 993 and 902, a Normally Closed brake switch is incorporated to complete the ground circuit between the ECM, connector P19, pin 45 and PCB-4, connector J39, pin 5. The brake switch is mounted on an air manifold located behind the front crossmember. When the brakes are applied the switch OPENS, breaking the ground circuit 993 and 992. This cancels the Fast Idle.

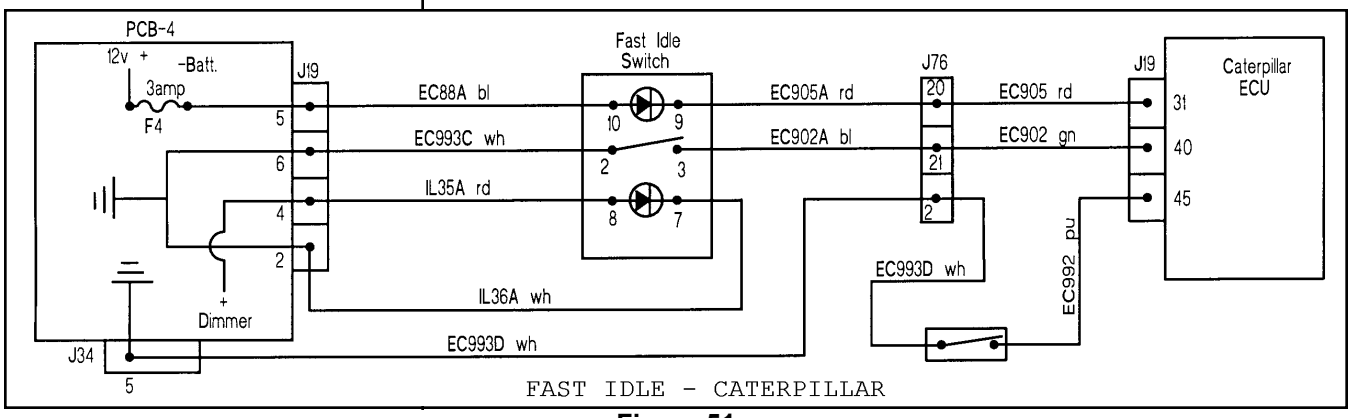


Figure 51

Troubleshooting the Circuits

1. Turn Fast Idle switch ON. Disconnect circuits 902 and 993 from the switch. Check for continuity in the switch.
2. Check for 12 volts on EC905 at ECM connector P19, pin 31 with the connector removed from the ECM, and with the ignition switch and the Fast Idle switch both, ON.

   If no voltage, check for defective #4 fuse on PCB-4.

3. Check continuity of the brake switch with full system pressure and brakes NOT applied.
4. If all checks are OK, use the electronic tools and Caterpillar Service Manuals to investigate further.

Check Transmission Light

This circuit is controlled by the transmission ECU, based on signals sent to it by circuits from the transmission. See **Figure 52**.

Circuit TR115 leaves the ECU via pin 31, connector P66 and runs to printed circuit board connector P31, pin 5. The circuit board transfers the circuit internally to board connector P40, pin 18. From this point the circuit becomes ICU115 and runs to pin A7 of the instrument cluster connector. See **Figure 52**.

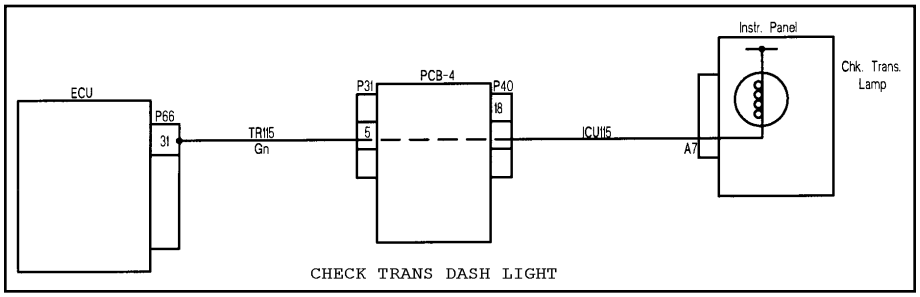


Figure 52

Throttle Control Circuits – Cummins Engines

Refer to the *Cummins Engine* section of this manual for extended comments on the operation and troubleshooting of the throttle control circuits on the Cummins engine.

Figure 53 outlines the circuits involved in the throttle control circuits for this engine. The engine ECU controls throttle operation through signals from the accelerator pedal sensors.

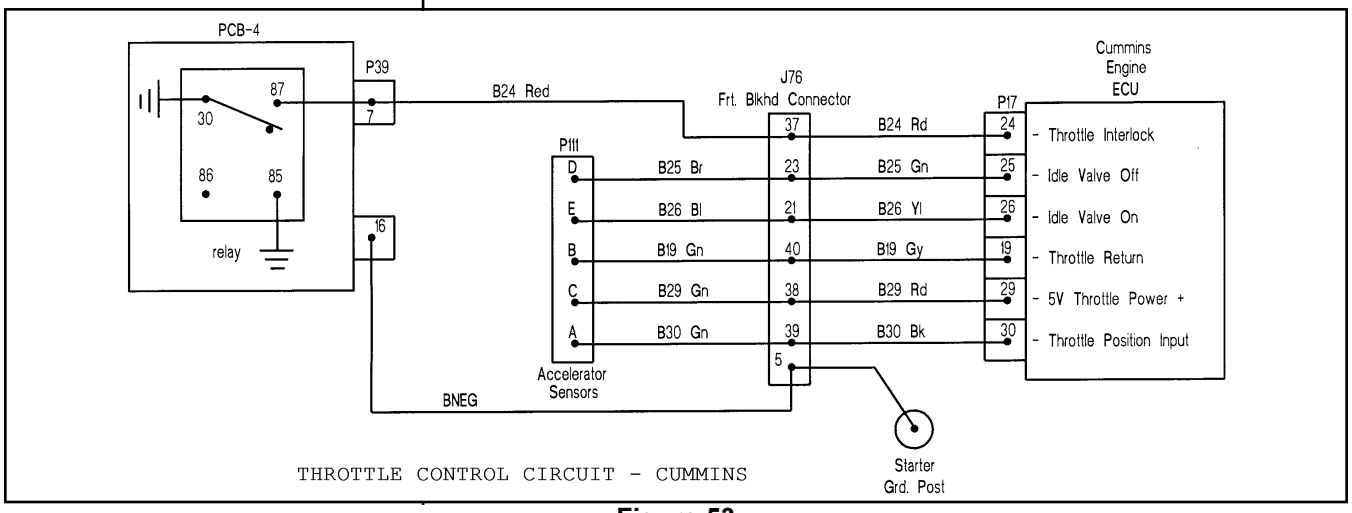


Figure 53

Throttle Control Circuits – Caterpillar Engines

Figure 54 outlines the circuits involved in the throttle control on Caterpillar Engines. Refer to the *Caterpillar Engine* section of this manual for extended

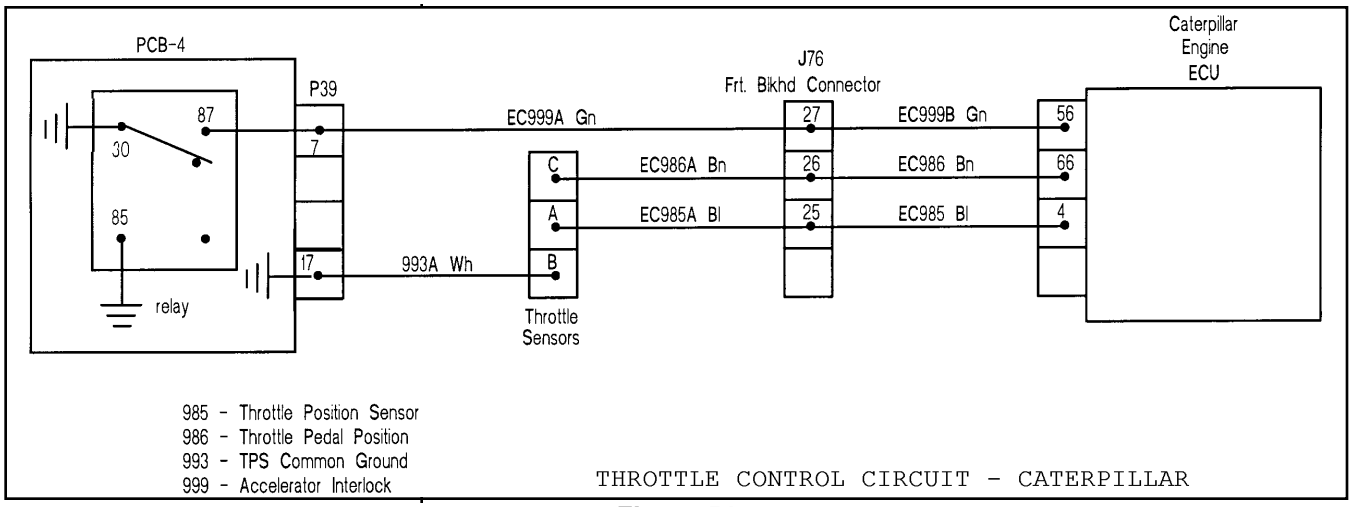


Figure 54

information on the throttle system.

Transmission Overheat Warning Lamp

Retarder-equipped units will have a warning lamp on the dash cluster to indicate an overheat condition of the transmission fluid during retarder operation. The warning lamp will come ON when fluid temperature reaches 330°F (166°C).

See **Figure 55** for an outline of the warning lamp circuits.

The overheat warning sensor, located at the transmission, sends a signal via circuit 138 through Allison harnesses to pin 28 of the ECU blue connector P68. Circuit 135A is the sensor ground circuit, through the ECU.

The warning lamp should self-test when the ignition switch is turned on, for 3 seconds, and then go OFF.

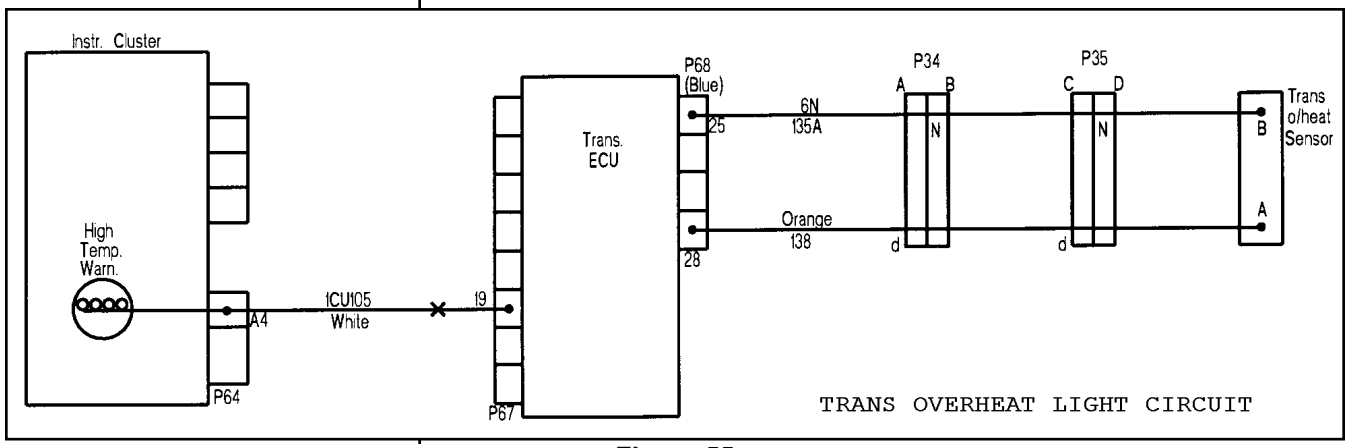


Figure 55

Transmission Temperature Gauge Circuit

The transmission temperature gauge circuits TR55 (+ yellow) and TR55G

(- white) begin at connector 23 on the transmission temperature sender. These two circuits enter the main chassis harness and run to the front bulkhead connector J75, pins 7 and 21, respectively. TR55 changes to ICU055 (green) on the opposite side of J75 and runs top in #2 of connector 44 located in the front electrical compartment. TR55G changes to ICU055G (white) and runs to pin #5 of P44. From P44 the two circuits continue to the "C" connector of the front side of the instrument cluster assembly. ICU055 goes to pin C13, ICU055G goes to pin C12.

See **Figure 56** for schematic of the temperature gauge circuits.

The resistance range for the temperature sensor is 83 ohms (low temperature) to 6738 ohms (high temperature). If the resistance drops below 83 ohms, or fails shorted for 5 seconds or so, the gauge will be driven to FULL scale.

If the resistance goes over 6738 ohms or fails OPEN, the gauge will go to zero.

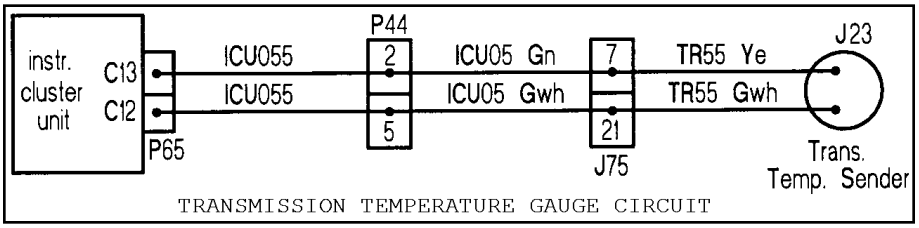


Figure 56

Dash – Instrument Cluster ICU3

The instrument cluster assembly, ICU3, is a long-life, non-repairable component of the dash assembly. A 59-pin connector on the backside of the ICU3 directs all circuits into and out of the cluster assembly. Connectors P64 (blue) and P65 (gray) plug into the 59-pin connector, with signals to and from the chassis.

Connector P64 accommodates pins A and B, P65 accommodates pins C and D.

With exception of the high beam indicator lamp, the right and left turn signal indicators, the fuel gauge, and transmission temperature gauge, all other indicator lamps and instruments are ground activated and controlled by ICU3.

Battery power, ignition power, and ground circuits to ICU3 come from chassis PCB-4, connector 40.

Self-Test

When the ignition switch is turned ON, ICU3 initiates a power-up self-test within 0.1 second, activating the indicator lamps, instrument needle movement, the buzzer, and checks the memory of the diagnostic system for

any recorded failure codes.

During this test all needles will sweep in unison from the OFF position to full scale and return to OFF within 12 seconds. At the same time the indicator lamps will illuminate for 3 seconds as a bulb check, the buzzer will sound for 3 seconds, and the seatbelt lamp will glow for 15 seconds.

High beam indicator and the turn signal lamps will not test during this time. They are tested, only, by operating the appropriate switch.

The Liquid Crystal Display will display all segments of each character involved in the LCD. This will be discussed later.

The buzzer, a part of ICU3, will sound during normal operations only in the event of an alarm due to low oil pressure, or if the park brake is applied and road speed is greater than 2 mph.

Battery voltage will be displayed during the self-test procedure as registered by the engine ECU. Normal operating range for ICU3 is 9.0V to 16.0V.

Out of Range Voltage

The cluster will shut down (emergency) if battery voltage at pin D14 on P65 (gray) connector goes outside this range, either above or below. During an emergency shutdown, if one should occur, the instrument needles will freeze in position, the LCD display will blank, and the micro driven lamps will turn off. When power is restored to within the operating range (9.0V to 16.0V) following an emergency shutdown, the needles will resynchronize to zero and the self-test will be performed before returning to normal operation. This is done automatically within the ICU3.

The cluster will also shutdown if the ignition circuit D15 is interrupted. Transient dropouts will not affect normal operation as long as the dropout if less than two occurrences per second. During such a shutdown the needles will return to zero, the display will go blank, and all micro lamps powered by ignition will turn OFF, assuming battery voltage is within normal operating range.

When normal voltage is returned to the ignition circuit, the self-test will automatically be performed before resuming normal operation.

Communication

The cluster (ICU3) receives and transmits information broadcast throughout the bus via J1708/J1587 data bus.

Instrument Input Loss

The loss of input data to the instrument will cause the gauge(s) needle to

move to zero.

A gauge using J1587 parameter input will be driven to zero if the input loss lasts 5 seconds or more. If all J1587 data is lost, all micro J1587 gauges will go to zero.

If the ICU3 loses the J1587 voltage parameter input from the engine ECU for 5 seconds, the voltage display will show all zeros.

If the received voltage is valid and greater than 19.9V, the display will show 19.9V.

The valid resistance range for the fuel level sensor is 27-261 ohms. An open or short circuit would be an out-of-range resistance value. If this occurs for 5 seconds or longer, the gauge would go to zero.

The same applies to the transmission temperature sensor input. The valid resistance range for this sensor is 83-6738 ohms. If sensor input resistance goes out of range on the high side or fails OPEN for 5 seconds, the gauge will be driven to zero.

If the resistance goes below 83 ohms for 5 seconds the gauge will be driven to FULL scale.

Both the fuel level gauge and the transmission temperature circuits are discussed elsewhere in the electrical section.

Indicator Lamps

The operator is responsible to check for proper operation of each indicator lamp during the self-test (when the ignition is first turned ON). The ICU3 microprocessor performs no diagnostics of the indicator lamps or circuits. Listed below is the circuit # and ICU3 pin # for activating each lamp in the event a complete circuit check is needed.

Lamp	Circuit #	Color	Pin #	Activated by
Left T Signal	ICU042	or	C8	T/S Switch
Right T Signal	ICU043	or	D8	T/S Switch
High Beam	ICU051	gy	A12	H/L Switch
Eng. Protect	B4	viol	C16	Engine ECU
Check Engine	799	gn	C15	Engine ECU
ABS Warning	1X15	or	B1	Grnd Activated
Low Air Pressure	ICU026	gn	A3	Microprocessor
Park Brake	ICU001	gy	C5	Microprocessor
HVAC - Recir. Air			C10	Grnd Activated
Air Filter	ICU005	wh	A5	Grnd Activated
Trans Temp Warn	ICU105	wh	A4	Grnd Activated
High Coolant Temp.	J1708			Microprocessor
Low Oil Pressure	J1708			Microprocessor

Low Battery	J1708			Microprocessor
Fasten Seat Belt	J1708			Microprocessor
No Charge			A9	Grnd Activated
Stop Engine	ICU059B	gn	C14	Grnd Activated
Wait to Start	ICU830	bl	A6	Grnd Activated
Check Trans.	ICU115	n	A7	Grnd Activated
Air Intake Htr.	ICU250	gn	A8	Grnd Activated
Water in Fuel	ICU825	gn	B8	Grnd Activated
Rear Wheel Spin (option)			C11	Grnd Activated
Buzzer, Stop Engine	ICU658A	rd	B12	Grnd Activated
Panel Light Power	ICU035	rd	A1	Dash Switch
Retarder in Use	ICU325		C3	Grnd Activated
ICU3 Battery Circuit	ICU121	rd	D14	12V Batt. PCB-4
ICU3 Ignition Circuit	ICU015	rd	D15	12V Batt. PCB-4
ICU3 Ground Circuit	ICU003	wh	D13	Grnd. PCB-4
Headlight Power -	ICU013	yl	D16	12V Batt.
To Check Odometer				
J1939 – Positive			D5	
J1939 – Negative			D9	
J1939 – Shield			D11	
J1708/1587 – Positive			B3	
J1708/1587 – Negative			B10	
Trans Temp Sensor	ICU006	wh	C12	Negative
Trans Temp Sensor	ICU055	lt/gn	C13	Positive
Fuel Gauge Sensor	ICU006	pu	D1	Positive
Fuel Gauge Sensor	ICU066	wh	D2	Negative

Figures 57 and 58 outline the circuits involved in the dash indicator lamps that give warnings related to the Caterpillar and Cummins engines.

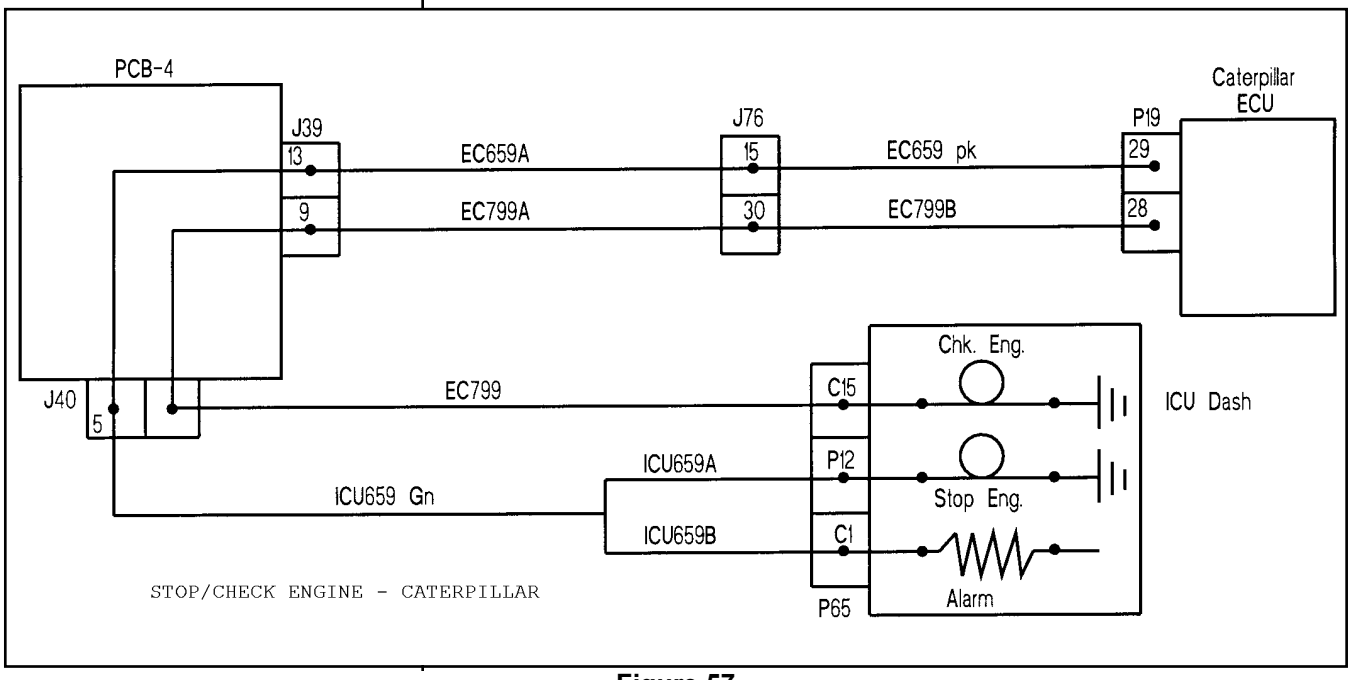


Figure 57

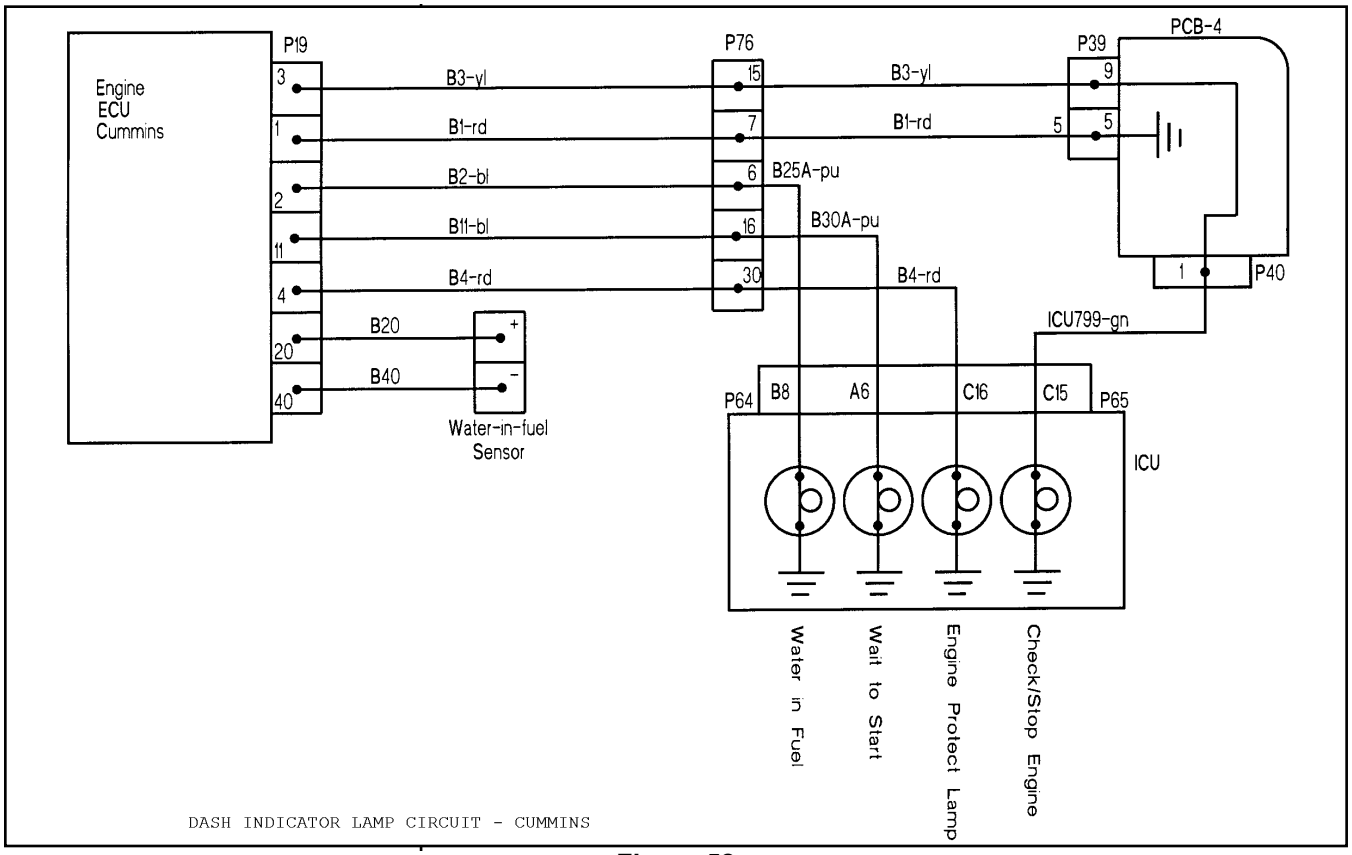


Figure 58

J1708/J1587 Roll Call

During the self-test the ICU3 will request faults from the engine and ABS to determine if the ECU is responding on the J1708 datalink. The ICU3 will also “listen” for any messages transmitted by the engine and ABS.

If the engine does not respond and is not transmitting, the ICU3 will record the fault “no engine”. If the engine responds with active faults(s), the ECU3 will record the fault “ECU 128 - - -” and the related fault code information.

The same procedure will occur with the ABS system. If it does not respond and is not transmitting, the ICU3 will record the fault “NO ABS”.

The displayed “no engine” fault code is MID 128 SID 254 FMI 07.
The displayed “no ABS” fault code is MID136 SID254 FMI 07.

Liquid Crystal Display (LCD) Driver Message Center

The driver’s message center uses a positive mode LCD to display the various messages, or information that will appear during the self-test sequence, or when the RESET/MODE button is depressed (which is covered later).

During the self-test all segments of the LCD will be displayed to assure the

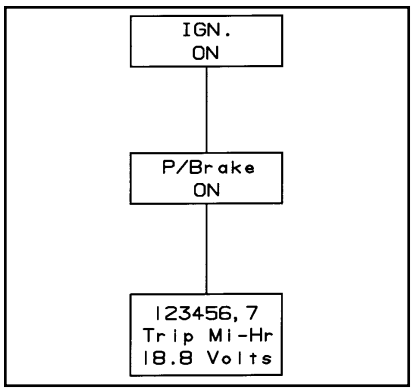


Figure 59

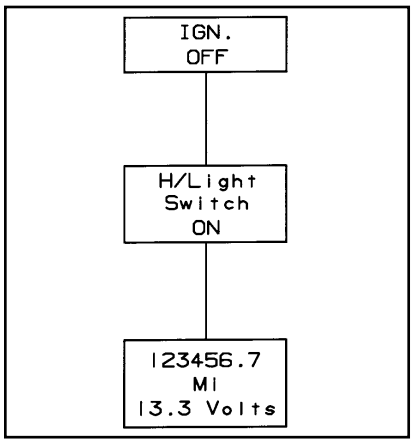


Figure 60

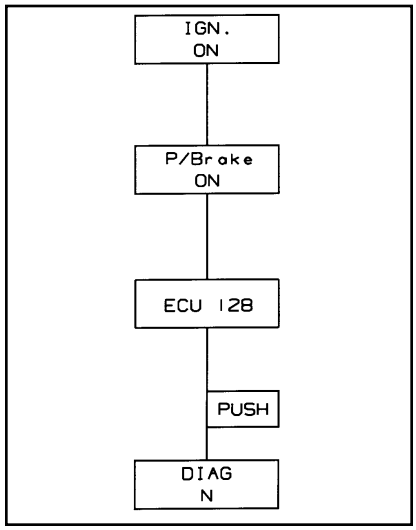


Figure 61

driver that all segments of each character are functioning. See **Figure 59**. These segments are current mileage, trip miles, engine hours, and voltage.

Odometer

The odometer reading will display as soon as the ignition switch is turned ON, if no faults are registered, after self-test is completed.

To display the odometer with the ignition OFF or if the key is not available, the headlight switch must be activated. See **Figure 60**. Circuit ICU013 into the CU3 on pin D16 provides current for this function.

Voltmeter

Battery voltage, as reported by the engine ECU will be shown during the self-test sequence.

If no J1708/J1587 data is present for one second, the display will show “no data” until the data is received or the ignition switch is turned OFF.

Diagnostic Messages

The ICU3 will broadcast only ACTIVE fault codes.

During the power-on self-test, with the park brake ON, if an active fault is received by the ICU3 the Diagnostic Message screen will display the failure code of the unit or system involved (e.g. ECU-128).See **Figure 61**. If multiple faults are on record, the screen will display the first fault for three seconds and the next fault for three seconds. The message screen will continue to repeat the faults until the ignition is turned OFF.

If no faults are on record, the message screen will display the current mileage on the odometer and the system voltage. All of this occurs during the power on self-test procedure. The Diagnostic screen will appear only if faults are on record. See **Figure 60**.

Once the Diagnostic screen is present PUSH the RESET/MODE button once to display the DIAGn message, which denotes the number of active faults on record. (The letter “n” denotes the number of faults.) HOLD the RESET/MODE button down to sequence the faults on record. The first fault shown is designated FAULT 1. PUSH the button down will bring up the Unit and MID #. PUSH it again and the failure code will appear. PUSH again if more than one failure has occurred in that unit. See **Figure 62**.

After reading the faults listed, HOLD the button down to return to the DIAG. screen.

To clear the screen at this point, PUSH the button once to sequence the CLEAR screen. HOLD the button down, and the odometer mileage will

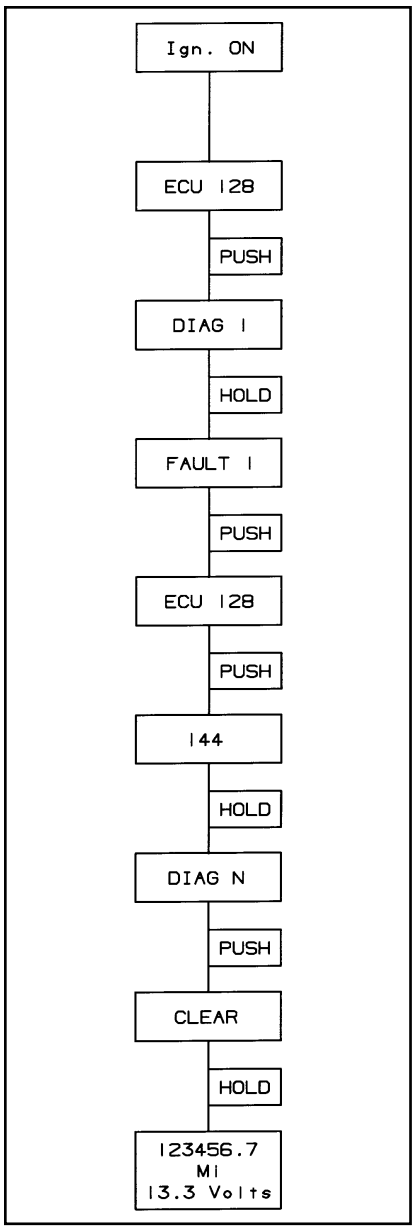


Figure 62

appear.

As mentioned above, if no faults exist the LCD display will return to the odometer display.

If a fault is recorded the message screen will display the unit or system involved and its MID #. Examples: ICU relates to the Instrumentation Control Unit. ECU relates to the Engine Control Unit.

The next three numbers represent the J1587 Message Identifier (MID). Example: the ICU's MID # is 140. The ECU's MID # is 128. The display would read ICU 140, as an example.

Other MID numbers that may appear are:

ABS 136- -Antilock Brake Unit
tCU 130- -Transmission Control Unit
tSU 223- -Transmission Shift Unit
SbU 232- -Seat Belt Unit

At this point the RESET/MODE button on ICU3 comes into use.

Reset/Mode Button Operation

The RESET/MODE (R/M) button (switch) enables the operator to access the portion of the display set aside for "Trip Distance", "Trip Hours", and Diagnostic screens. The R/M switch has two functions: 1) MODE (push or press), 2) RESET (hold). When the switch is "pushed" for less than (1.2) seconds (variable) the button acts as MODE switch. When the button is "HELD" for (1.2) seconds or more (variable) the button acts as a RESET switch.

Trip Miles and Trip Hours - Check and Reset

Once the odometer display is present, push the R/M button once to display the trip distance since the last time the distance was reset. See **Figure 63**.

Trip Hours:
PUSH the R/M button again to access the engine hours elapsed since the last "time hours" was reset PUSH the button a third time to access the SELECT screen and the current units (MI or KM) will blink at one second intervals. PUSH the button a 4th time and the odometer will be displayed steadily.

To reset the Trip Mileage back to zero, HOLD the button down while in the TRIP MI mode on the display screen. HOLD the button down until the display reads ZERO to cause the ICU to reset internally.

To reset the Engine Hours, move to the "Trip Hours" display on the display screen, HOLD the button down until ZERO appears in the screen.

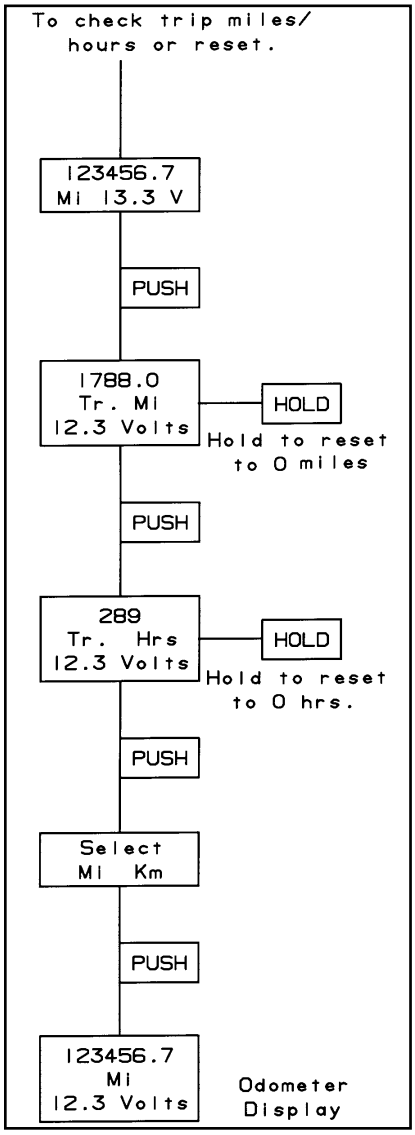


Figure 63

ICU3 Replacement - Service

The only components in the ICU3 that can be replaced in the field are the air pressure gauges and the indicator lamp bulbs.

ICU3 Removal

1. Bleed system air pressure completely.
2. Remove the 4 Torx head screws from the driver side of the bezel. Use T25 Torx head screwdriver.

   ⚠ ***Caution***: Do not forcibly pull the ICU3 from the dash. This may dislodge wires from the harness connectors on the back of the ICU3 housing, and damage the wires, the dash, or the ICU3.
3. Pull the ICU3 away from the dash. Pull the top towards you until the back of the housing is free, then pull up and remove the entire unit.
   a. Disconnect the two connectors from the center of the ICU3.
   b. Disconnect the two hoses to the air gauges.

Installation

Reverse the above procedure, taking extreme care in joining the connectors to the main body.

After installation, turn Ignition ON. All electronic gauges should make one complete sweep and return to their normal position. The indicator lights should turn on and go off.

⚠ ***Caution***: Electronic components in the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a cab or work bench ground. If not available, touch a grounded component before touching the ICU3 with a tool or body part.

Air Pressure Gauge Replacement

1. With the ICU3 removed from the dash, place it on a clean protected surface.
3. Carefully pry the nine large white clips away from the sides of the ICU housing. Use a small thin piece of metal, or a spade terminal to hold each clip away from the housing.