Table of Contents

ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM

INTRODUCTION

General Instructions

This section contains support information for the ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM (EGED-225) front view and the rear view of this form as well as Diagnostic Trouble Code sheet CGE-309. It includes 31 diagnostic sections, each related to an ECM circuit or function. Each of these sections include the following:

- Functional diagram of the circuit.
- Circuit function.
- Circuit diagram with wire and pin connector numbers.
- Diagnostic Trouble Codes (DTC) related to the circuit or function.
- Recommended diagnostic procedures necessary to effectively diagnose system problems.

Section 3 Table of Contents can be used to locate the appropriate diagnostic section by circuit abbreviation. The DTC Circuit Index (See Table 49, page 165) can be used to locate the appropriate diagnostic section by DTC. The diagnostic information in each section is structured as follows:

- The Functional Diagram and text is intended to show the technician the engine components related to that circuit.
- The Diagnostic page is intended to give the technician the circuit diagram and the diagnostic steps necessary to diagnose DTC's or to verify that the circuit is functioning correctly.
- The Extended Description page is intended to give the technician a description of the circuit operation, and where appropriate a description of the DTC's and their most probable causes.
- The truck cab wiring diagrams are provided when the circuit extends to the chassis or cab.

Diagnostic Forms

The front view of Electronic Control System Diagnostic Form (EGED-225) shows the engine circuit and signal values (See Figure 67, page 154). The rear view of Electronic Control System Diagnostic Form (EGED-225) shows the chassis wiring to the ECM (See Figure 68, page 155). The Diagnostic Trouble Code sheet CGE-309 shows the Diagnostic Trouble Code Number, Description, and Probable Causes (See Table 48, page 162).

A circuit diagram of the entire electronic control system is divided as follows:

- The ECM engine sensor harness with sensors (See Figure 69, page 157).
- The ECM chassis harness circuit from the ECM to the Dash Pass Through Connector (See Figure 70, page 160).
- The chassis harness circuits from the Dash Pass Through Connector back into the cab (See Figure 71, page 161).

Diagnostic Form EGED-225 (Front)

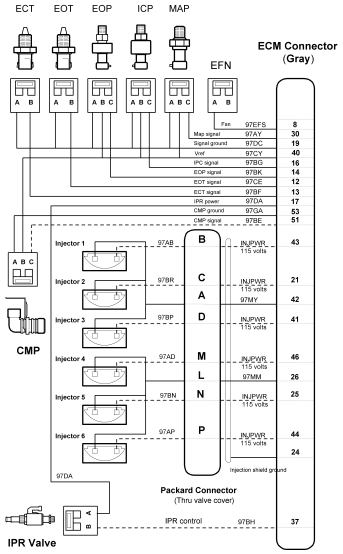
INTERNATIONAL®

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

International DT 466
International DT 530

Warning: Refer to safety instructions in Diagnostic Manual EGES-215, before starting diagnostic procedures.

Engine Mounted Components



Black = Ground circuit
Green = Signal circuit

Red = 12 volts
Purple = 115 volts

Dotted line = Frequency or switch function

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SIGNAL VALUES DT 466 and DT 530 (All values with breakout box installed on ECM and harness)

Pin	Item	Circuit	Circuit No.	Key ON	Low Idle Signal	Low Idle Data List	High Idle Signal	High Idle Data List	Operating Range	Comments
ECM CONNECTOR (GREY)										
8	EFN	Fan	97EFS	0V = Solenoid ON (fan OFF) 12V = Solenoid OFF (fan ON)						
12	EOT	Engine Oil Temperature	97CE	Temperature dependent						4.348V @ 32 °F, 0.819V @ 212 °F
13	ECT	Engine Coolant Temperature	97BF	Temperature dependent						4.33V @ -5 °F, 0.356V @ 230 °F
14	EOP	Engine Oil Pressure	97BK	0.61V	2.6V	39 psi	3.60V	60 psi	0.5V-4.64V	0.5V @ 0 psi, 4.64V @ 80 psi
16	ICP	Injection Control Pressure sensor	97BG	0.2V	0.48V	431 psi	1.97V	1370 psi	0.3V-4.5V	0.84V @ 444 psi, 3.8V @ 3000 psi
17	IPR	Injection Pressure Regulator power	97DA	B+	B+	-	B+	-	B+	Power supply for IPR valve
19	Sig_Grd D	Signal Ground D	97DC	0V	0V	-	0V	-	0V	Ground for engine sensors
21	INJ_2	Injector 2	97BR	**Do not measure voltage**						High voltage pulse width signal
24	INJ_SHD	Injector Shield Ground	970W							
25	INJ_5	Injector 5	97BN	**Do not measure voltage**						High voltage pulse width signal
26	INJ_gnd	Injector ground 4,5, and 6	97MM	**Do not measure voltage**						Bank 1 injector grounds to ECM
30	MAP	Manifold Absolute Pressure	97AY	0.92V	0.96V	0.5 psi	1.36V	3.75 psi	0.85V-4.56V	0.92V @ 0 psi, 2.72V @ 18 psi
37	IPR_CNTR	Injection Pressure Regulator Control	97BH	0V	0V	-	0V	-	0V	Duty cycle, duty controlled
40	Vref D	Voltage reference D	97CY	5 ±0.5V	5 ±0.5V		5 ±0.5V		5 ±0.5V	Vref for engine sensors
41	INJ_3	Injector 3	97BP	**Do not measure voltage**						High voltage pulse width signal
42	INJ_gnd	Injector ground 1,2, and 3	97MY	**Do not measure voltage**						Bank 2 injector grounds to ECM
43	INJ_1	Injector 1	97AB	**Do not measure voltage**						High voltage pulse width signal
44	INJ_6	Injector 6	97AP	**Do not measure voltage**						High voltage pulse width signal
46	INJ_4	Injector 4	97AD	**Do not measure voltage**						High voltage pulse width signal
51	CMP	Camshaft Position Sensor	97BE	5V/1V	2.11V	-	2.44V	-	140-600 Hz	700-3000 rpm, Hz vary with rpm
53	CMP Grd	Camshaft sensor ground	97GA	0V	0V	-	0V	-	0V	CMP sensor ground
ECM CONNECTOR (BLACK)										
1	DC/DC	Power ground for injector drivers	K97V	0V	0V	-	0V	-	0V	
2	DC/DC	Power ground for injector drivers	K97P	0V	0V	-	0V	-	0V	
3	Vref B	Voltage reference B	K97C	5 ±0.5V	5 ±0.5V		5 ±0.5V		5 ±0.5V	Vref for chassis builder sensors
4	EPG	Electronic Pressure Governor	K97HE	Input from EPG enable switch						12V enabled, 0V disabled
5	Vref C	Voltage reference C	K97DD	5 ±0.5V	5 ±0.5V		5 ±0.5V		5 ±0.5V	Vref for body builder sensors
6	RPS_Grd	Remote Pedal Sensor Ground	K97HM	0V	0V	-	0V	-	0V	Remote accelerator pedal sensor ground
7	Sig_Gnd C	Signal Ground C	K97WA	0V	0V	-	0V	-	0V	Signal ground body builder sensors
8	APS	Accelerator Pedal Sensor	K99T	0.64V	0.64V	0%	3.84V	102%	0.64V-3.84V	APS signal (min 3.65V required for 102%)
9	XCS	Input transfer case switch	K97XC							12V = Auxiliary ON, 0V = Drive line
10	CLS	Coolant Level Switch	K34A	Coolant temperature dependent					0V/5V	0V = Low cool, 5V = Full cool
11	Sig_gnd B	Signal ground B	K97D	0V	0V	-	0V	-	0V	Signal ground cab mounted sensors
12	IAT	Intake Air Temperature	K97E	Temperature dependent						3.846V @ 32 °F, 0.446V @ 212 °F
13	EPG	Electronic Pressure Gov. sensor	K97EA							0.49V @10 psi, 4.88V @ 510 psi
16	ATA (+)	Communication Link (Red)	K3A+	Digital data signal-no signal, no EST data display						Dash/Diagnostic/Programming
17	ATA (-)	Communication Link (Blue)	K3B-	Digital data signal-no signal, no EST data display						Dash/Diagnostic/Programming
18	KL31B	CAN Shield	K5AE	CAN Shield						Dash/Diagnostic/Programming
19	CAN +	CAN	K5V	Digital data Shield						
20	CAN -	CAN	K5W	Digital data Shield						
21	DC/DC	Power supply for injector drivers	K97F	B+	B+	B+	B+	B+	B+	Power from ECM power relay
22	DC/DC	Power supply for injector drivers	K97Z	B+	B+	B+	B+	B+	B+	Power from ECM power relay
23	ECM gnd	ECM ground	K97N	0V	0V	-	0V	-	0V	
24	Vref (+)	ECM ignition voltage	K97M	B+	B+	B+	B+	B+	B+	Power from ignition circuit
25	ECM_CNTR	ECM power relay control	K97J	1.15V	1.15V	-	1.15V	-	B+/1.15V	1.15V = ECM relay ON, B+ = ECM relay OFF
26	DDS	Driveline Disengagement Switch	K17E	0V = Clutch pedal down, 12V = Clutch pedal up, 0V = Transmission in gear, 12V = Transmission in neutral						
27	IVS	Idle Validation Switch	K99S	0V/12V	0V	-	12V	-	0V/12V	0V = APS ON at idle, 12V = APS OFF at idle
29	BAP	Barometric pressure sensor	K97K	4.6V	4.6V	14.7 psi	4.6V	14.7 psi	2.55V-4.8V	4.6V = Sea level, 2.6V = 10,000 ft (approx)
30	RPS	Remote Pedal Sensor	K99F			0%		102%	0.47V-3.74V	RPS signal (min 3.8V required for 102%
31	RAS	Resume/ Accelerate Switch	K46A	0V = Switch normal, 12V = Switch depressed (accelerate or resume) Note: Signal only when COO is ON.						
32	SET	Cruise set switch	K46B	0V = Switch normal, 12V = Switch depressed (cruise/PTO set) Note: Signal only when COO is ON.						
36	RVAR	Remote variable PTO	K97CC	12V = PTO ON, 0V = PTO OFF						Remote variable PTO OFF/ON switch
37	RPRE	Remote preset PTO	K97CB	12V = PTO ON, 0V = PTO OFF						Remote preset PTO OFF/ON switch
38	TCS	Torque Curve Select switch	44D							5V = Normal, 0V = Tailored
39*	VSS	Vehicle speed input	47	Digital signal from WTEC module on transmission						*Allison world class transmission only
39	VSS (+)	Vehicle Speed Sensor	K47	2.25V	2-14VAC	MPH	2.14VAC	MPH	2.14VAC	Manual and mechanical transmissions
40	VSS (-)	Vehicle Speed Sensor	K47A	2.25V	2-14VAC	MPH	2.14VAC	MPH	2.14VAC	VSS signal is an AC sin wave
41	ECM_PWR	Volts ECM power relay	K97L	B+	B+	B+	B+	B+	B+	Power is from ECM power relay
42	ECM gnd	ECM ground	K97Y	0V	0V	-	0V	-	0V	
46	ECI	Engine Crank Inhibit relay	K17M	0V	12V	-	12V	-	0V/12V	0V = Allow cranking, 12V = Inhibit cranking
47	VRE	Vehicle Retarder output	K24A	0V = Brake applied if dash switch is ON, 12V = Brake not applied if dash switch is ON.						Vehicle retarder output
49	EMI	EPG Mode Indicator	K97HG	ECM mode dependent						12V = Drive line, 0V = Auxiliary ON
54	OWL	OilCool Warn Lamp	K97WL	12V/0.06V	12V/0.6V	-	12V/0.6V	-	12V/0.6V	12V = Lamp OFF, 0.6V = Lamp ON
55	WARN	Engine warning lamp	K97EW	12V/0.06V	12V/0.6V	-	12V/0.6V	-	12V/0.6V	12V = Lamp OFF, 0.6V = Lamp ON
58	VSSCALA	Vehicle speed output	K47B	Digital frequency, 0V-12V signal for remote speedometer only						Varies with vehicle speed
59	TACA	TACH output	K97AR	Digital frequency, 0V-12V signal for remote TACH only						Varies with engine rpm, Hz = (rpm/5)

Figure 67 Electronic Control System Diagnostics form EGED-225 (front view)

The FRONT side of Electronic Control System Diagnostic Form EGED-225 includes Signal Values covering engine circuits, relevant data, and an electrical circuit diagram for engine mounted components.

Diagnostic Form EGED-225 (Rear)

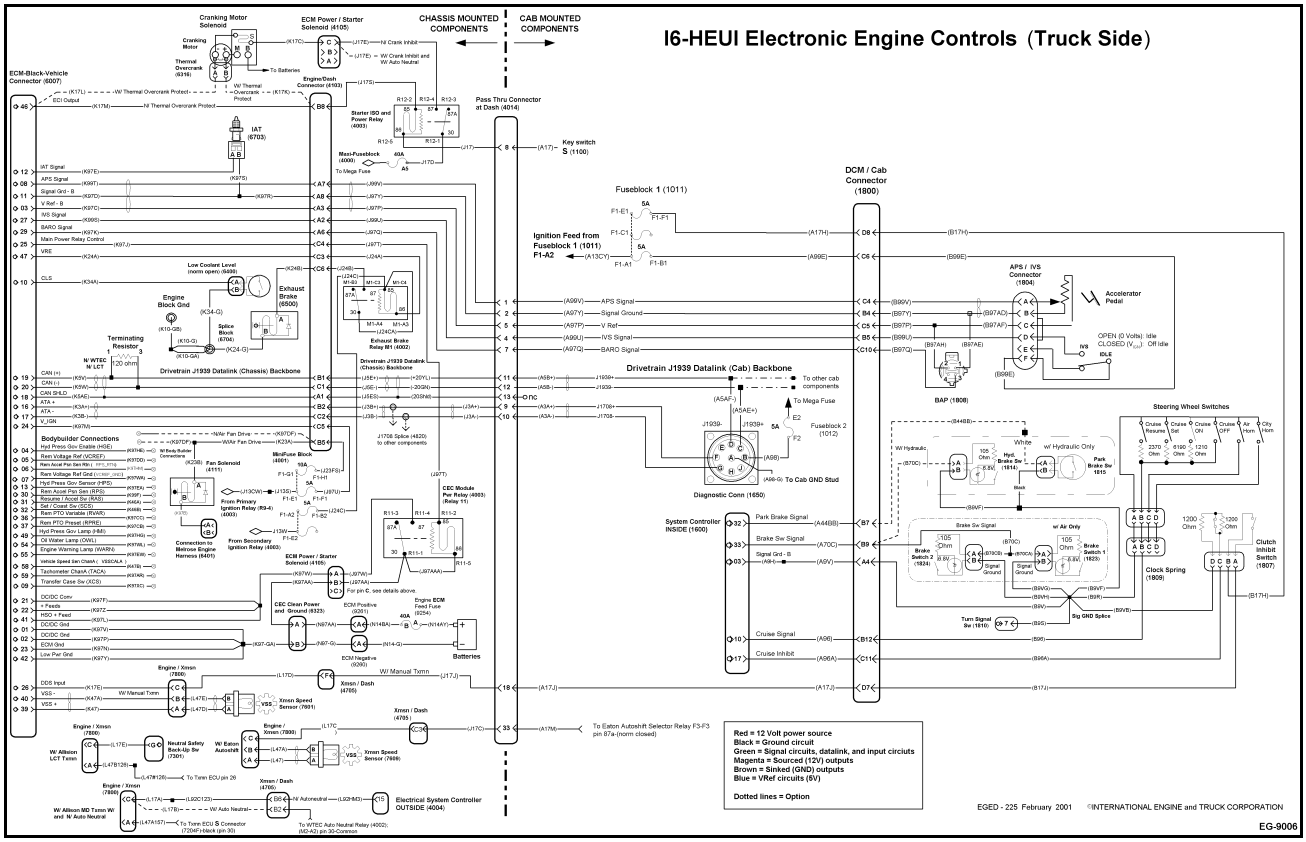

Figure 68 Electronic Control System Diagnostics form EGED-225 (rear view)

The REAR side of Electronic Control System Diagnostic Form EGED-225 consists of a circuit diagram for electrical components mounted on the vehicle, and in the cab.

Signal Values, Engine (Gray Connector) From Form EGED-225

Table 46 DT 466 and DT 530 Electronic Control System Diagnostics, ECM Connector (gray), (Form EGED-225, front side)

Signal Values, DT 466 & DT 530, (all values with breakout box installed on ECM and harness)										
ECM Connector (gray)										
Pin No.	Item	Circuit	Circuit Number	Key On	Low Idle		High Idle		Operating Range	Comments
					Signal	Data List	Signal	Data List		
8	EFN	Fan	97EFS	0V = sol ON (fan OFF). 12V = sol OFF (fan ON).						
12	EOT	Eng Oil Temp	97CE	Temperature Dependent						4.348V@32°F, 0.819V@212°F
13	ECT	Eng Coolant Temp	97BF	Temperature Dependent						4.33V@–5°F, 0.356V@230°F
14	EOP	Eng Oil Press	97BK	0.61V	2.6V	39 psi	3.60V	60 psi	0.5V-4.64V	0.5V@0 psi, 4.64V@80 psi
16	ICP	Inj Cntl Press snsr	97BG	0.2V	0.48V	431 psi	1.97V	1370 psi	0.3V-4.5V	0.84V@444 psi, 3.8V@3000 psi
17	IPR	Inj Press Reg pwr	97DA	B+	B+	—	B+	—	B+	Power supply for IPR valve
19	Sig_gnd D	Signal Gnd D	97DC	0V	0V	—	0V	—	0V	Ground for engine sensors
21	INJ_2	Inj #2	97BR	Do not measure voltage						High voltage pulsewidth signal
24	INJ_SHD	Inj Shield Gnd	97DW							
25	INJ_5	Inj #5	97BN	Do not measure voltage						High voltage pulsewidth signal
26	INJ_gnd	Inj gnd (4,5,6)	97MM	Do not measure voltage						Bank #1 inj grounds to ECM
30	MAP	Manf Abs Press	97AY	0.92V	0.96V	0.5 psi	1.36V	3.75 psi	0.85V-4.56V	0.92V@0 psi, 2.72V@18 psi
37	IPR_CNTR	Inj Press Reg cntr	97BH	0V	0V	—	0V	—	0V	Duty cycle duty controlled
40	V_{REF} D	Voltage Ref-D	97CY	5±0.5V	5±0.5V		5 ±0.5V		5 ±0.5V	V_{REF} for eng sensors
41	INJ_3	Inj #3	97BP	Do not measure voltage						High voltage pulsewidth signal
42	INJ_gnd	Inj gnd (1,2,3)	97MY	Do not measure voltage						Bank #2 inj grounds to ECM
43	INJ_1	Inj #1	97AB	Do not measure voltage						High voltage pulsewidth signal
44	INJ_6	Inj #6	97AP	Do not measure voltage						High voltage pulsewidth signal
46	INJ_4	Inj #4	97AD	Do not measure voltage						High voltage pulsewidth signal
51	CMP	Cmshft pos snsr	97BE	5V/1V	2.11V	—	2.44V	—	140-600 Hz	700-3000 rpm, Hz vary with rpm
53	CMP gnd	Cmshft snsr gnd	97GA	0V	0V	—	0V	—	0V	CMP sensor ground

Electronic Engine Controls (Engine Side)

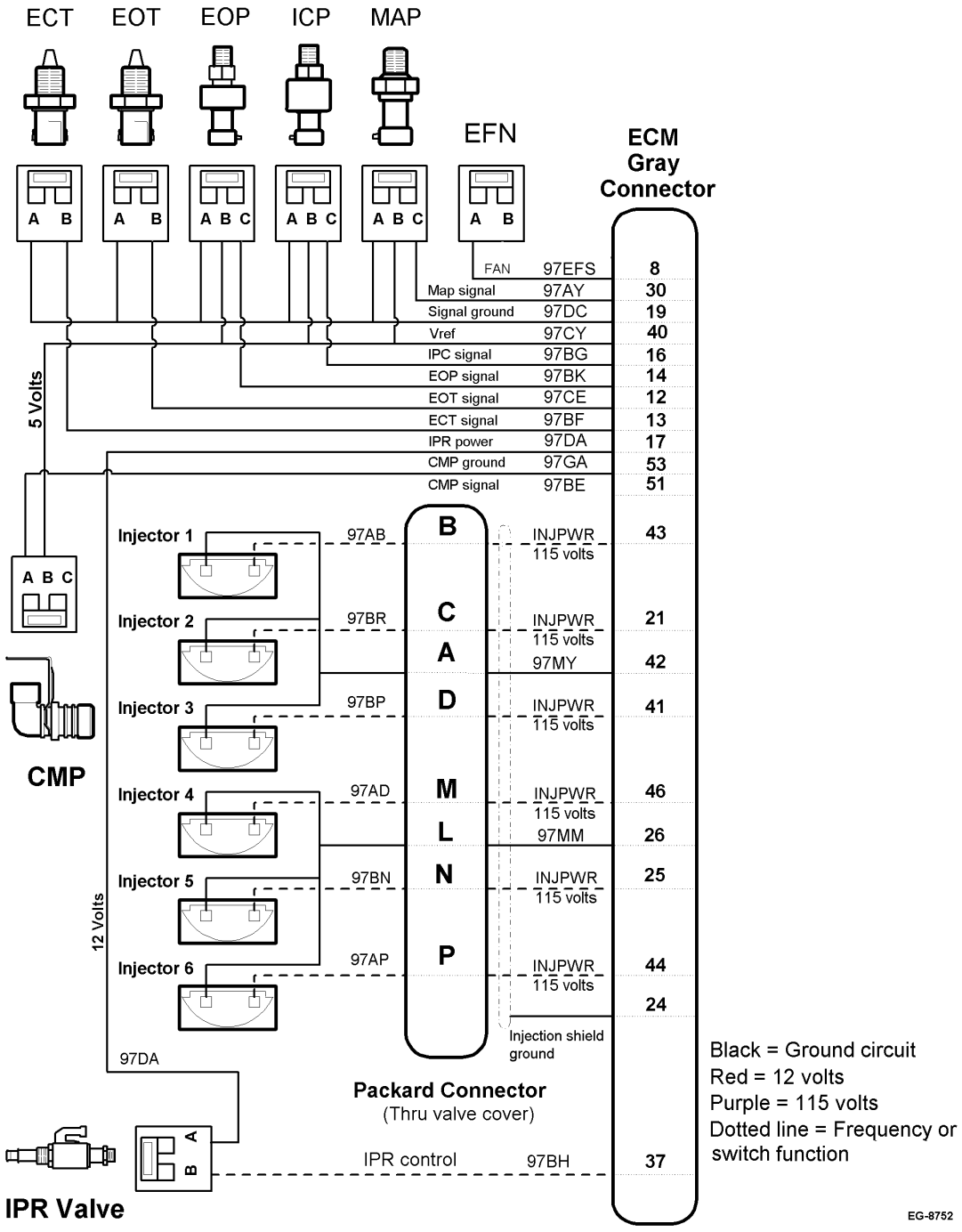

Figure 69 Engine Mounted Components

Signal Values, Chassis (Black Connector) From Form EGED-225

Table 47 DT 466 & DT 530 Electronic Control System Diagnostics, Chassis Connector (black), (Form EGED-225, front side)

Signal Values for DT 466 & DT 530, (all values with breakout box installed on ECM and harness)										
Chassis Connector (black)										
Pin No.	Item	Circuit	Circuit No.	Key On	Low Idle		High Idle		Operating Range	Comments
					Signal	Data List	Signal	Data List		
1	DC/DC	Pwr gnd for inj drvrs	K97V	0V	0V	—	0V	—	0V	
2	DC/DC	Pwr gnd for inj divrs	K97P	0V	0V	—	0V	—	0V	
3	V_{REF} B	Voltage ref B	K97C	5±0.5V	5±0.5V	—	5±0.5V	—	5±0.5V	V_{REF} for chas mounted sensors
4	EPG	Elek press gov	K97HE	Input from EPG enable switch						12V = Enabled, 0V = Disabled
5	V_{REF} C	Rem voltage ref C	K97DD	5±0.5V	5±0.5V		5±0.5V		5±0.5V	V_{REF} for body builder sensors
6	RPS_gnd	Rmt pedal snsr gnd	K97HM	0V	0V	—	0V	—	0V	Remote accel pedal sensor ground
7	Sig_gnd C	Signal gnd C	K97WA	0V	0V	—	0V	—	0V	Signal ground body builder sensors
8	APS	Accel pedal snsr	K99T	0.64V	0.64V	0%	3.84V	102%	0.64V-3.84V	APS sigl (min 3.65V reqd for 102%)
9	XCS	Transfer case sw	K97XC							12V=auxiliary ON, 0V=Driveline
10	CLS	Coolant level sw	K34A	Coolant temperature dependent					0V/ 5V	0V=Low cool, 5V=Full cool
11	Sig_gnd B	Signal gnd B	K97D	0V	0V	—	0V	—	0V	Signal ground chas mounted sensors
12	IAT	Intake air temp	K97E	Temperature dependent						3.846V@32°F, 0.446V@212°F
13	EPG	Elek press gov snsr	K97EA							0.49V@10 psi, 4.88V@510 psi
16	ATA (+)	Comm link (red)	K3A+	Digital data signal-no signal, no EST data display						Dash/Diagnostic/Programming
17	ATA (-)	Comm link (blue)	K3B-	Digital data signal-no signal, no EST data display						Dash/Diagnostic/Programming
18	KL 31B	CAN sheild	K5AE	CAN sheild						
19	CAN +	CAN	K5V	Digital data signal						
20	CAN –	CAN	K5W	Digital data signal						
21	DC/DC	Pwr sply for inj drvrs	K97F	B+	B+	B+	B+	B+	B+	Power from ECM power relay
22	DC/DC	Pwr sply for inj drvrs	K97Z	B+	B+	B+	B+	B+	B+	Power from ECM power relay
23	ECM gnd	ECM ground	K97N	0V	0V	—	0V	—	0V	
24	V_{IGN} (+)	ECM ign voltage	K97M	B+	B+	B+	B+	B+	B+	Power from ignition circuit
25	ECM_CNTRL	ECM pwr relay cntrl	K97J	1.15V	1.15V	—	1.15V	—	B+/1.15V	1.15V=ECM rly ON, B+=ECM rly OFF
26	DDS	Drvlne disenga sw	K17E	0V=Clutch pedal down, 12V= Clutch pedal up, 0V=Trans in gear, 12V=Trans in neutral						
27	IVS	Idle validation sw	K99S	0V/12V	0V	—	12V	—	0V/12V	0V=APS at idle, 12V=APS OFF at idle
29	BAP	Baro press snsr	K97K	4.6V	4.6V	14.7 psi	4.6V	14.7 psi	2.55V-4.8V	4.6V= Sea level, 2.6V=10,000 ft (approx)
30	RPS	Rmt pedal snsr	K99F			0%		102%	0.47V-3.74V	RPS sig (min 3.8V reqd for 102%)
31	RAS	Res/accel sw	K46A	0V=Switch normal, 12V=Switch depressed (accel or resume) **Note**: signal only when COO on						
32	SET	Cruise Set sw	K46B	0V=Switch normal, 12V=Switch depressed (Cruise/PTO set) **Note**: signal only when COO on						
36	RVAR	Rmt variable PTO	K97CC	12V=PTO ON, 0V=PTO OFF						Remote variable PTO ON/OFF switch
37	RPRE	Rmt preset PTO	K97CB	12V=PTO ON, 0V=PTO OFF						Remote Preset PTO ON/OFF switch
38	TCS	Torque Curve Select sw	44D							5V= Normal, 0V= Tailored
39*	VSS	Veh speed input	47	Digital signal from WTEC module on transmission						*Allison world class trans only

Table 47 DT 466 & DT 530 Electronic Control System Diagnostics, Chassis Connector (black), (Form EGED-225, front side) (cont.)

Signal Values for DT 466 & DT 530, (all values with breakout box installed on ECM and harness)										
Chassis Connector (black)										
Pin No.	Item	Circuit	Circuit No.	Key On	Low Idle		High Idle		Operating Range	Comments
					Signal	Data List	Signal	Data List		
39	VSS(+)	Veh speed snsr +	K47	2.25V	2-14VAC	MPH	2-14VAC	MPH	2-14VAC	Manual and mechanical trans
40	VSS(-)	Veh speed snsr	K47A	2.25V	2-14VAC	MPH	2-14VAC	MPH	2-14VAC	VSS signal is an AC sin wave
41	ECM_PWR	Volts ECM pwr rly	K97L	B+	B+	B+	B+	B+	B+	Power is from ECM power relay
42	ECM_gnd	ECM ground	K97Y	0V	0V	—	0V	—	0V	
46	ECI	Eng crank inhb rly	K17M	0V	12V	—	12V	—	0V/12V	0V=Allow cranking, 12V=Inhibit cranking
47	VRE	Veh retarder out	K24A	0V= Brake applied if dash switch is ON, 12V= Brake not applied if dash switch is ON.						Vehicle retarder output
49	EMI	EPG mode indicator	K97HG	ECM mode dependent						12V=Driveline, 0V=auxiliary ON
54	OWL	Oil/Cool Warn Lamp	K97WL	12V/0.6V	12V/0.6V	—	12V/0.6V	—	12V/0.6V	12V=Lamp OFF, 0.6V=Lamp ON
55	WARN	Eng warning lamp	K97EW	12V/0.6V	12V/0.6V	—	12V/0.6V	—	12V/0.6V	12V=Lamp OFF, 0.6V=Lamp ON
58	VSSCALA	Veh speed output	K47B	Digital frequency, 0V-12V signal for remote speedo only						Varies with vehicle speed
59	TACA	Tach output	K97AR	Digital frequency, 0V-12V signal for remote TACH only)						Varies with engine rpm, Hz=(rpm/5)

Electronic Engine Controls (Chassis Side)

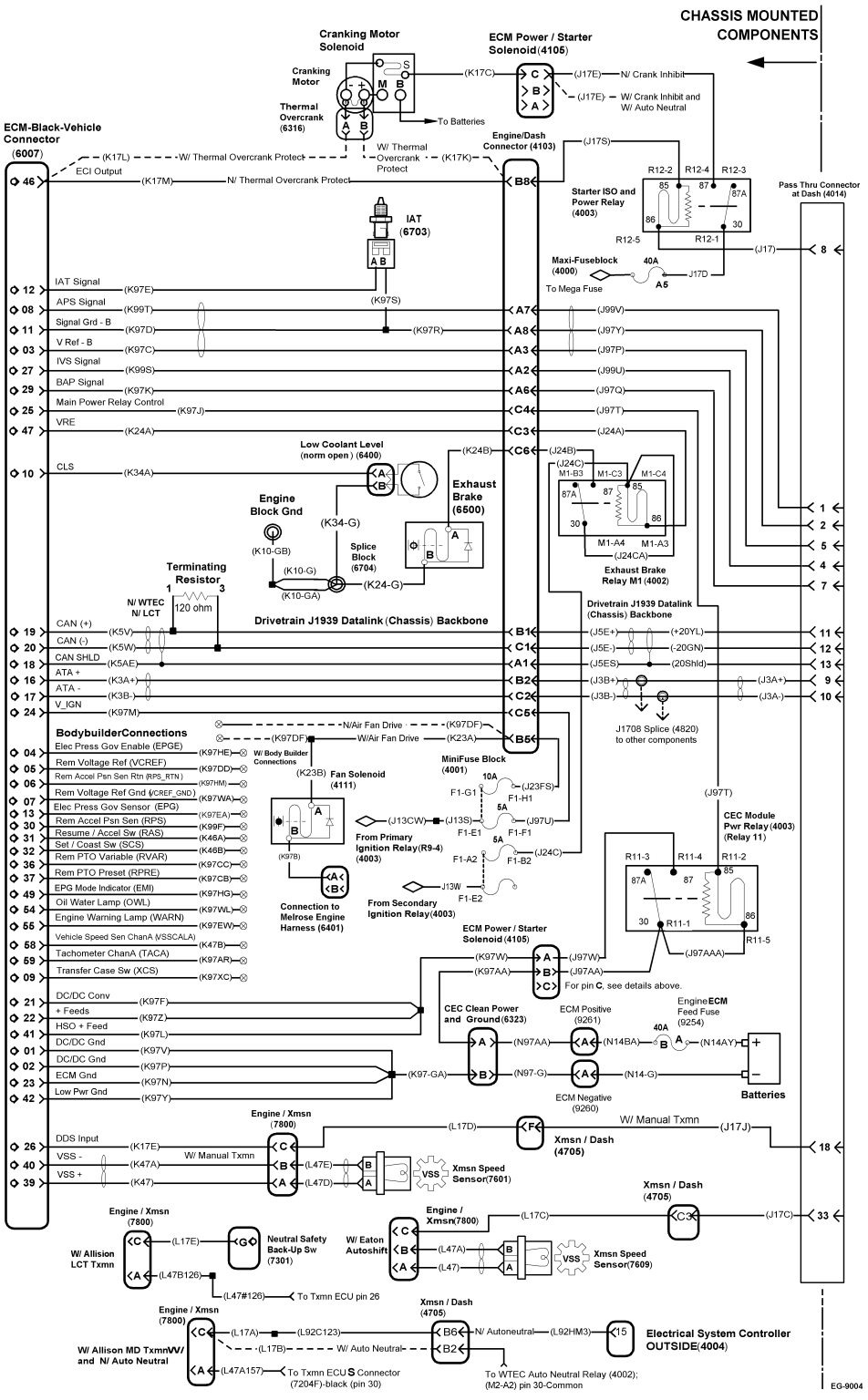

Figure 70 Electronic Engine Controls (Chassis Mounted Components)

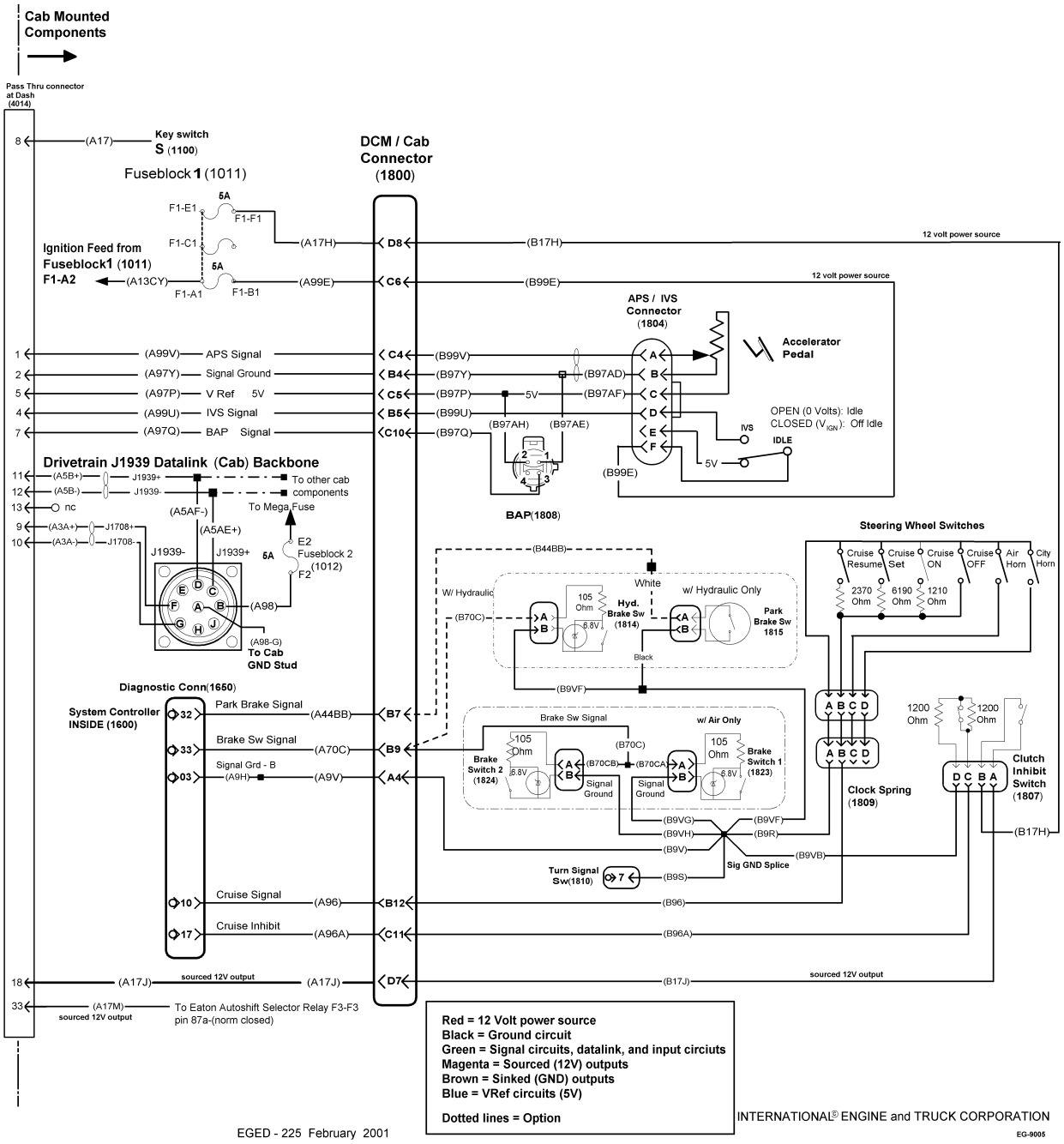

Figure 71 Electronic Engine Controls (Cab Mounted Components)

Diagnostic Trouble Code Form CGE-309

Table 48

DTC	Circuit Index	Condition / Description	Comments	Probable Causes
111	ECM	No errors detected - instrument panel flashing code only	No errors detected by the ECM	
112	ECM_PWR	Electrical system voltage B+ Out of Range HIGH	ECM voltage is continuously more than 18V	Charging system DTC
113	ECM_PWR	Electrical system voltage B+ Out of Range LOW	ECM voltage < 6.5 - cause of no start/misfire	Low batt, loose connections or resistance in circuit
114*	ECT	Engine coolant temp signal Out of Range LOW	Default 180°F (82°C), ECT sensor voltage below 0.127V	ECT signal circuit or sensor shorted to ground
115*	ECT	Engine coolant temp signal Out of Range HIGH	Default 180°F (82°C), ECT sensor voltage above 4.6V	ECT circuit or sensor open
121*	MAP	Intake manifold absolute pressure signal Out of Range HIGH	Default inferred map - low power, slow acceleration - map > 4.9V	MAP circuit shorted high, defective sensor
122*	MAP	Intake manifold absolute pressure signal Out of Range LOW	Default inferred map - low power, slow acceleration - map < 0.039V	MAP circuit short low or open
123*	MAP	Intake manifold absolute pressure in range DTC	Default inferred map - low power, slow acceleration	Hose to MAP sensor plugged
124*	ICP	ICP signal Out of Range LOW	Default open loop control - underrun at idle - ICP below 0.039V	Circuit short low, open, defective sensor
125*	ICP	ICP signal Out of Range HIGH	Default open loop control - underrun at idle - ICP above 4.897V	Circuit short high, defective sensor
131*	APS/IVS	Accelerator position signal Out of Range LOW	Signal voltage below 0.152V - engine idle only	Short to ground or open in circuit, defective sensor
132*	APS/IVS	Accelerator position signal Out of Range HIGH	Signal voltage above 4.55V - eng idle only	Short to V_{REF} or 12 volt, defective sensor
133*	APS/IVS	Accelerator position signal in range DTC	APS/IVS conflict - limited to 0% APS	Failed APS signal
134*	APS/IVS	Accelerator position and idle validation disagree	APS/IVS conflict - limited to 0% APS	Both APS and IVS signal failure
135*	APS/IVS	Idle validation switch circuit DTC	APS/IVS conflict - limited to 50% APS	Failed IVS signal
141	VSS	Vehicle speed signal Out of Range LOW	VSS signal at 0 mph <0.048V -cruise/PTO disengaged -engine speed limited	VSS circuit open or shorted to ground
142	VSS	Vehicle speed signal Out of Range HIGH	VSS signal at 0 mph >4.492V- cruise/PTO disengaged -engine speed limited	VSS circuit shorted to V_{REF} or 12 V
143	CMP	Wrong number of CMP signal transitions per camshaft revolution	CMP signal intermittent	Poor connection, defective sensor
144	CMP	CMP signal noise detected	ECM detects electrical noise in circuit	Electrical noise, injector voltage shorted to ground
145*	CMP	CMP signal inactive while ICP has increased	No CMP signal while ICP signal increased	Short high, low or open, defective CMP sensor
151	BAP	BAP signal Out of Range HIGH	BAP signal voltage above 4.9V for 1.0 sec.- defaults to 14.7 psi	BAP circuit short high or open circuit
152	BAP	BAP signal Out of Range LOW	BAP signal voltage below 1.0V for 1.0 sec - defaults to 14.7 psi	BAP circuit short low
154	IAT	Intake air temp signal Out of Range LOW	IAT signal voltage low - defaults to 77°C IAT below 0.127V	IAT signal circuit or sensor shorted to ground
155	IAT	Intake air temp signal Out of Range HIGH	IAT signal voltage low - defaults to 77°C IAT above 4.6V	IAT circuit or sensor open
211*	EOP	Engine oil pressure signal Out of Range LOW	EOP signal voltage low, below 0.039V	EOP circuit short low
212*	EOP	Engine oil pressure signal Out of Range HIGH	EOP signal voltage high, above 4.9V EOP	EOP circuit short high or open
213	RPS	Remote throttle signal Out of Range LOW	RPS sensor signal voltage below 0.249V	Open RPS circuit
214	RPS	Remote throttle signal Out of Range HIGH	RPS sensor signal voltage above 4.5V	Shorted RPS circuit

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - DTC's only available if Engine Protection is enabled**

DTC	Circuit Index	Condition / Description	Comments	Probable Causes
215	VSS	Vehicle speed signal frequency Out of Range HIGH	Speedo, cruise, PTO disabled - engine speed limited -signal >4375 hz	Misadjusted / faulty speed sensor, electrical noise on circuit
216	EPG	Electronic pressure signal Out of Range LOW	EPS signal voltage below 0.039V	Circuit open, short to ground, defective sensor
225	EOP	EOP sensor signal in-range DTC	EOP sig above 40 psi w/engine-off key-on, disables engine protection	Wire harness/connector problem, faulty sensor
226	EPG	EPG sensor signal Out of Range HIGH	EPS signal above 4.9V	Circuit short high, defective sensor
231	ATA	ATA data communication link error	ATA link open or shorted, WTEC controller interference	ATA device grounded or overloaded
236	ECL	ECL switch circuit DTC	Engine coolant level switch circuit DTC	Open or short circuits
241	IPR	Injection control press regulator OCC self test failed	IPR-output circuit check - engine OFF test only	Short high or low or open
246	EFN	Engine fan - OCC self test failed	Fan relay - output circuit check - engine off test only	Open or short circuits
256	RSE	Radiator shutter enable OCC self test failed	Shutter relay - output circuit check - engine off test only	Open or short circuits
265	VRE	Vehicle retarder relay OCC DTC	Vehicle retarder relay- OCC check - engine off test only	Open or short circuits
311*	EOT	Engine oil temp signal Out of Range LOW	Default 212°F (100°C), no fast idle, EOT above 4.8V	EOT signal circuit or sensor shorted to ground
312*	EOT	Engine oil temp signal Out of Range HIGH	Default 212°F (100°C), no fast idle, EOT below 0.2V	EOT circuit or sensor open
313	EOP**	Engine oil pressure below warning level	Engine monitor of low oil pressure, oil lamp on	No or low oil, sticking oil pressure regulator, pickup
314	EOP**	Engine oil pressure below critical level	Tube blocked or cracked, worn bearings or oil pump	Engine monitor of low oil pressure, shutdown (if equipped)
315*	CMP	Engine speed above warning level	ECM recorded excessive engine speed (above 3000 rpm)	Transmission improperly downshifted
316	ECT	Engine coolant temp unable to reach commanded set point	Enabled only when cold ambient protection enabled	Leaking thermostat, cooling system problems
321	ECT**	Engine coolant temp above warning level	Coolant temperature > 228°F (109°C)	Cooling system problem
322	ECT**	Engine coolant temp above critical level	Coolant temperature > 235°F (112.5°C)	
323	ECL	Engine coolant below warning/critical level	ECM detects low coolant level	Check coolant level if low, check for leaks
324	IST	Idle shutdown timer enabled engine shutdown	Idle shutdown timer is on and idle time exceeded limit	Idle time limit exceeded
325	ECT	Power reduced, matched to cooling system performance	Engine power reduced, normal in certain conditions	High altitude or hot ambient temp
331*	IPR	Injection control pressure above system working range	ICP above 3675 psi (25 MPa)	Grounded IPR circuit, stuck IPR valve
332*	ICP	Injection control pressure above spec with engine off	ICP signal voltage higher than expected w/engine not running	Circuit shorted to voltage, defective sensor
333*	IPR_SYS	Injection control pressure above/below desired level	ICP desired does not = ICP signal (long period of time)	Air in oil, wrong oil, wrong or stuck IPR, leaking injector O-ring, rings, ICP sensor, high pressure pump (see manual)
334	IPR_SYS	ICP unable to achieve set point in time (poor performance)	ICP desired does not = ICP signal (short period of time)	
335	IPR_SYS	ICP unable to build pressure during cranking	< 725 psi ICP pressure after 10 seconds of cranking	Air in oil, injector pressure problem (see manual)
336	EPG	Hydraulic pressure unable to achieve commanded set point		Hydraulic pressure system leakage or problem
421-426	INJ	High side to low side open (cyl. number indicated)	ECM detected a open circuit for injector circuit	Individual injector harness open
431-436	INJ	High side shorted to low side (cyl. number indicated)	ECM detected a short circuit for an injector	Injector or harness shorted low side to high side

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - DTC's only available if Engine Protection is enabled**

DTC	Circuit Index	Condition / Description	Comments	Probable Causes
451-456	INJ	High side shorted to ground or V_{BAT} (cyl. number indicated)	ECM detected injector low side shorted to ground -1 bank run	Injector harness shorted on low (control) circuit to ground
461-466	Perf. Diag.	Cylinder contribution test failed (cyl. number indicated)	ECM finds cylinder contribution insufficient	See performance diagnostics
513*	INJ	Low side to bank 1 open	High voltage supply open - cyl #1, #2, #3	Open circuit bank #1
514*	INJ	Low side to bank 2 open	High voltage supply open - cyl #4, #5, #6	Open circuit bank #2
515*	INJ	Bank 1 low side short to ground or B+	Bank #1 side high voltage circuit shorted	Shorted circuit bank #1
521*	INJ	Bank 2 low side short to ground or B+	Bank #2 left side high voltage circuit shorted	Shorted circuit bank #2
525*	ECM	Injector driver circuit DTC	ECM cannot supply sufficient voltage to injectors	Engine harness, injector harness or ECM problem
612*	CMP	Incorrect ECM installed for CMP timing wheel	Mismatch between ECM and engine target wheel (I-6, V8)	Incorrect ECM or strategy for engine
614*	ECM	EFRC/ECM configuration mismatch	Programming problem	Components changed in the field not compatible
621*	ECM	Engine using mfg default rating program engine	Engine operates at 25 hp default	ECM not programmed but installed on truck
622*	ECM	Engine using field default rating	Programming problem, engine limited to 160 hp, options not available	ECM not programmed properly, internal ECM problem
623*	ECM	Invalid engine rating code; check ECM programming	Programming problem	ECM not programmed properly
624	ECM	Field defaults active	Programming problem / ECM problem	Programming problem, internal ECM problem
626	ECM_PWR	Unexpected reset DTC	ECM momentary lost power	See ECM_PWR circuit diagnostics
631*	ECM	ROM (read only memory) self test DTC	ECM failure	Internal ECM problem
632	ECM	RAM memory-CPU self test DTC	ECM failure	Internal ECM problem
655	ECM	Programmable parameter list level incompatible	Programming problem / ECM memory problem	Programming problem
661	ECM	RAM programmable parameter list corrupt	Programming problem / ECM memory problem	Programming problem, internal ECM problem
664	ECM	Calibration level incompatible	Programming problem	Programming problem, ECM not programmed
665	ECM	Programmable parameter memory content corrupt	ECM failure	Internal ECM problem

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - DTC's only available if Engine Protection is enabled**

Diagnostic Trouble Code Circuit Index

Table 49 Diagnostic Trouble Code (DTC) Circuit Index

DTC	PID	SID	FMI	SEC. 3	CIRCUIT INDEX	DIAGNOSTIC TROUBLE CODE DESCRIPTION
111				page 235	ECM	No Errors Detected - Instrument panel flashing code Only
112	168	0	3	page 241	ECM_PWR	Electrical System B+ Voltage Out of Range, HIGH
113	168	0	4	page 241	ECM_PWR	Electrical System B+ Voltage Out of Range, LOW
114*	110	0	4	page 248	ECT	Engine Coolant Temperature Signal Out of Range, LOW
115*	110	0	3	page 248	ECT	Engine Coolant Temperature Signal Out of Range, HIGH
121*	102	0	3	page 311	MAP	Intake Manifold Absolute Pressure Signal Out of Range, HIGH
122*	102	0	4	page 312	MAP	Intake Manifold Absolute Pressure Signal Out of Range, LOW
123*	102	0	2	page 312	MAP	Intake Manifold Absolute Pressure in Range DTC
124*	164	0	4	page 286	ICP	Injection Control Pressure Signal Out of Range, LOW
125*	164	0	3	page 286	ICP	Injection Control Pressure Signal Out of Range, HIGH
131*	91	0	4	page 184	APS/IVS	Accelerator Pedal Position Signal Out of Range, LOW
132*	91	0	3	page 184	APS/IVS	Accelerator Pedal Position Signal Out of Range, HIGH
133*	91	0	2	page 184	APS/IVS	Accelerator Pedal Position Signal in Range DTC "M"
134*	91	0	7	page 185	APS/IVS	Accelerator Pedal Position and Idle Validation Switch Disagree
135*	0	230	11	page 185	APS/IVS	Idle Validation Switch Circuit DTC
141	84	0	4	page 352	VSS	Vehicle Speed Signal Out of Range, LOW
142	84	0	3	page 352	VSS	Vehicle Speed Signal Out of Range, HIGH
143	0	21	2	page 203	CMP	Incorrect Number of CMP Signal Transitions per Cam Revolution
144	0	21	8	page 204	CMP	CMP Signal Noise Detected
145*	0	21	12	page 204	CMP	CMP Signal Inactive While ICP has Increased
151	108	0	3	page 196	BAP	BAP Signal Out of Range, HIGH
152	108	0	4	page 196	BAP	BAP Pressure Signal Out of Range, LOW
154	171	0	4	page 279	IAT	Air Inlet Temperature Signal Out of Range, LOW
155	171	0	3	page 279	IAT	Air Inlet Temperature Signal Out of Range, HIGH
211*	100	0	4	page 259	EOP	Engine Oil Pressure Signal Out of Range, LOW
212*	100	0	3	page 260	EOP	Engine Oil Pressure Signal Out of Range, HIGH
213	0	29	4	page 321	RPS	Remote Throttle Signal Out of Range, LOW
214	0	29	3	page 321	RPS	Remote Throttle Signal Out of Range, HIGH
215	84	0	8	page 352	VSS	Vehicle Speed Signal Frequency Out of Range, HIGH
216	73	0	4	page 273	EPG	Electronic Pressure Signal Out of Range, LOW
225	100	0	0	page 260	EOP	Engine Oil Pressure Sensor Signal in Range DTC
226	73	0	3	page 273	EPG	Electronic Sensor Signal Out of Range, HIGH
231	0	250	2	page 191	ATA	ATA Data Communication Link Error
236	111	0	2	page 230	ECL	ECL Switch Circuit DTC
241	0	42	11	page 296	IPR	Injection Control Pressure Regulator OCC Self Test Failed
246	0	56	11	page 254	EFN	Engine Fan OCC Self Test DTC

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - Diagnostic Trouble Codes only available if Engine Protection is enabled**

Table 49 Diagnostic Trouble Code (DTC) Circuit Index (cont.)

DTC	PID	SID	FMI	SEC. 3	CIRCUIT INDEX	DIAGNOSTIC TROUBLE CODE DESCRIPTION
265	62	0	11	page 347	VRE	Vehicle Retarder Relay OCC DTC
311*	175	0	4	page 267	EOT	Engine Oil Temperature Signal Out of Range, LOW
312*	175	0	3	page 268	EOT	Engine Oil Temperature Signal Out of Range, HIGH
313	100	0	1	page 260	EOP**	Engine Oil Pressure Below Warning Level
314	100	0	7	page 261	EOP**	Engine Oil Pressure Below Critical Level
315*	190	0	0	page 205	CMP	Engine Speed Above Warning Level
316	110	0	1	page 249	ECT	Engine Coolant Temperature Unable to Reach Commanded Set Point
321	110	0	0	page 248	ECT**	Engine Coolant Temperature Above Warning Level
322	110	0	7	page 248	ECT**	Engine Coolant Temperature Above Critical Level
323	111	0	1	page 231	ECL	Engine Coolant Level Below Warning/Critical Level
324	71	0	14	page 306	IST	Idle Shutdown Timer Enabled Engine Shutdown
325	110	0	14	page 249	ECT	Power Reduced, Matched to Cooling System Performance
331*	164	0	0	page 297	IPR	Injection Control Pressure Above System Working Range
332*	164	0	13	page 286	ICP	Injection Control Pressure Above Spec. With Engine Off
333*	164	0	10	page 299	IPR_SYS	Injection Control Pressure Above/Below Desired Level
334	164	0	7	page 300	IPR_SYS	ICP Unable to Achieve Set Point in Time (Poor Performance)
335	164	0	1	page 302	IPR_SYS	ICP Unable to Build Pressure During Cranking
336	73	0	10	page 273	EPG	Electronic Pressure Unable to Achieve Commanded Set Point
421	0	1	5	page 290	INJ	Cylinder 1: High Side to Low Side Open
422	0	2	5	page 290	INJ	Cylinder 2: High Side to Low Side Open
423	0	3	5	page 290	INJ	Cylinder 3: High Side to Low Side Open
424	0	4	5	page 290	INJ	Cylinder 4: High Side to Low Side Open
425	0	5	5	page 290	INJ	Cylinder 5: High Side to Low Side Open
426	0	6	5	page 290	INJ	Cylinder 6: High Side to Low Side Open
431	0	1	4	page 291	INJ	Cylinder 1: High Side Shorted to Low Side
432	0	2	4	page 291	INJ	Cylinder 2: High Side Shorted to Low Side
433	0	3	4	page 291	INJ	Cylinder 3: High Side Shorted to Low Side
434	0	4	4	page 291	INJ	Cylinder 4: High Side Shorted to Low Side
435	0	5	4	page 291	INJ	Cylinder 5: High Side Shorted to Low Side
436	0	6	4	page 291	INJ	Cylinder 6: High Side Shorted to Low Side
451	0	1	6	page 291	INJ	Cylinder 1: High Side Shorted to Ground or V_{BAT}
452	0	2	6	page 291	INJ	Cylinder 2: High Side Shorted to Ground or V_{BAT}
453	0	3	6	page 291	INJ	Cylinder 3: High Side Shorted to Ground or V_{BAT}
454	0	4	6	page 291	INJ	Cylinder 4: High side Shorted to Ground or V_{BAT}
455	0	5	6	page 291	INJ	Cylinder 5: High Side Shorted to Ground or V_{BAT}
456	0	6	6	page 291	INJ	Cylinder 6: High Side Shorted to Ground or V_{BAT}
461	0	1	7	—	Perf. Diag.	Cylinder 1: Cylinder Contribution Test Failed
462	0	2	7	—	Perf. Diag.	Cylinder 2: Cylinder Contribution Test Failed

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - Diagnostic Trouble Codes only available if Engine Protection is enabled**

Table 49 Diagnostic Trouble Code (DTC) Circuit Index (cont.)

DTC	PID	SID	FMI	SEC. 3	CIRCUIT INDEX	DIAGNOSTIC TROUBLE CODE DESCRIPTION
463	0	3	7	—	Perf. Diag.	Cylinder 3: Cylinder Contribution Test Failed
464	0	4	7	—	Perf. Diag.	Cylinder 4: Cylinder Contribution Test Failed
465	0	5	7	—	Perf. Diag.	Cylinder 5: Cylinder Contribution Test Failed
466	0	6	7	—	Perf. Diag.	Cylinder 6: Cylinder Contribution Test Failed
513*	0	151	5	page 291	INJ	Low Side to Bank 1 Open
514*	0	152	5	page 292	INJ	Low Side to Bank 2 Open
515*	0	151	6	page 292	INJ	Bank 1 Low Side Short to Ground or B+
521*	0	152	6	page 292	INJ	Bank 2 Low Side Short to Ground or B+
525*	0	254	6	page 235	ECM	Injector Driver Circuit DTC
612*	0	21	7	page 204	CMP	Incorrect ECM Installed for CMP Timing Wheel
614*	0	252	13	page 235	ECM	EFRC / ECM Configuration Mismatch
621*	0	253	1	page 235	ECM	Engine using Mfg. Default Rating Program Engine
622*	0	253	0	page 235	ECM	Engine using Field Default Rating
623*	0	253	13	page 236	ECM	Invalid Engine Family Rating Code; Check ECM Programming
624	0	240	14	page 236	ECM	Field Default Active
626	0	254	8	page 242	ECM_PWR	Unexpected Reset DTC
631*	0	240	2	page 236	ECM	ROM (Read Only Memory) Self Test DTC
632	0	254	12	page 236	ECM	RAM / CPU Self Test DTC
655	0	240	13	page 236	ECM	Programmable Parameter List Level Incompatible
661	0	240	11	page 237	ECM	RAM Programmable Parameter List Corrupt
664	0	253	14	page 237	ECM	Calibration Level Incompatible
665	0	252	14	page 237	ECM	Programmable Parameter Memory Content Corrupt

*** - Indicates amber ENGINE lamp is ON and odometer message is displayed when Diagnostic Trouble Code is set**

**** - Diagnostic Trouble Codes only available if Engine Protection is enabled**

SENSOR AND ACTUATOR LOCATIONS

ENGINE SENSORS AND ACTUATORS

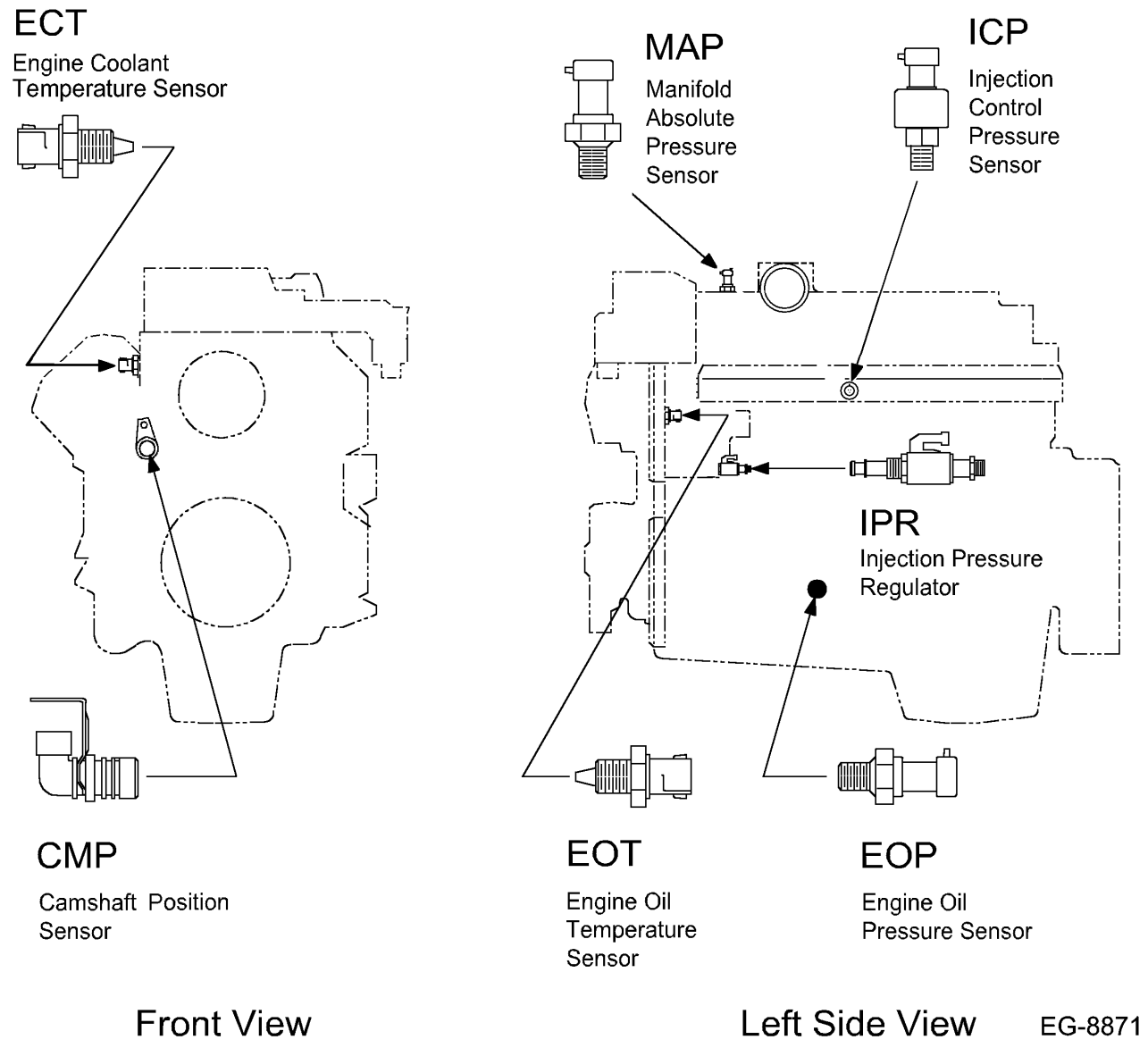

Figure 72 Engine Sensor and Actuators Locations on the Front and Left Side

ENGINE AND VEHICLE RELAYS, FUSES, AND SENSORS

The main Power Distribution Center is located just above the left front wheel in the engine compartment.

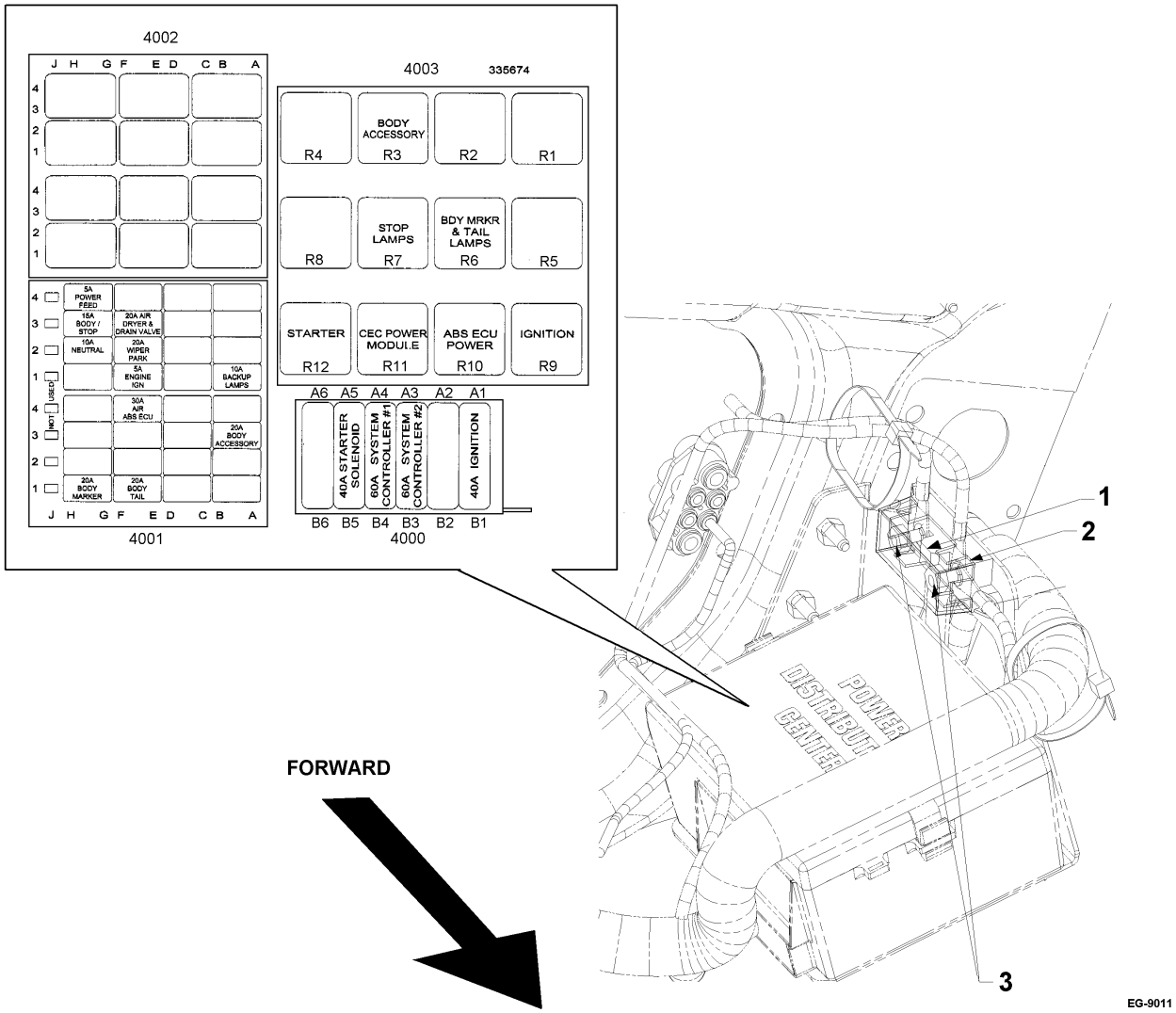

Figure 73 Power Distribution Center

1. Megafuse
2. Megafuse Holder
3. Torque Nuts to 89 in·lb (10–12 N·m)

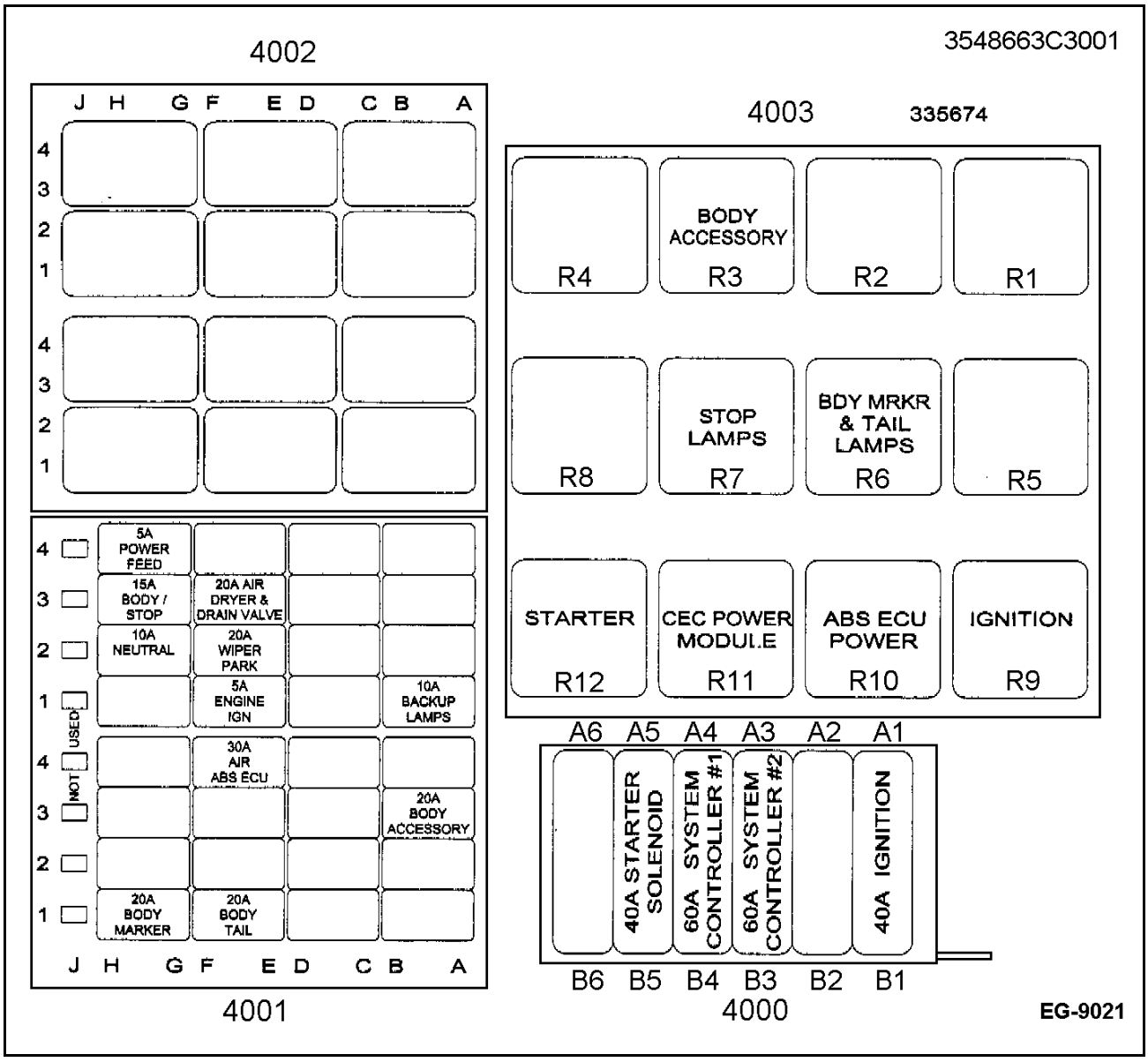

Figure 74 Power Distribution Center (Relay and Fuse Layout)

Accelerator Position Sensor / Idle Validation Switch (APS/IVS)

The APS / IVS sensor assembly is located just above the accelerator pedal.

Figure 75 APS / IVS Sensor

Barometric Absolute Pressure Sensor (BAP)

The following image shows the location of the BAP sensor. It is in the driver control module (DCM), near the steering column.

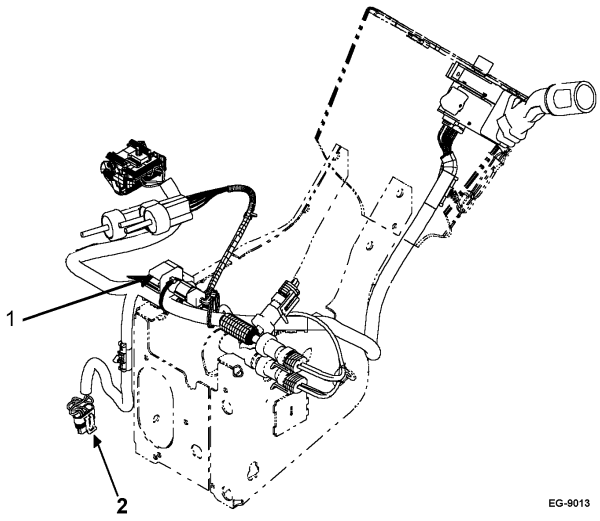

Figure 76

1. Barometric Absolute Pressure Sensor (BAP)
2. APS / IVS Sensor Harness

DIAGNOSTIC PROCEDURES FOR THE ELECTRONIC CONTROL SYSTEM

SENSOR AND ACTUATOR DIAGNOSTIC INSPECTION

NOTE – The symbols < & > & ≥ are used in each of the diagnostic sections. They are defined as follows:

(<) indicates a value less than

(>) indicates a value greater than

(≥) indicates a value equal to or greater than

Disconnect the harness connector from the sensor or actuator and inspect for corrosion, bent pins, spread terminals, or any condition that could cause an intermittent connection. Pin grip of the female terminal can be tested by inserting the appropriate tool from the terminal test adapter kit (ZTSE4435). Terminals that do not grip the sensor pins properly should be replaced, (See Figure 77, page 173).

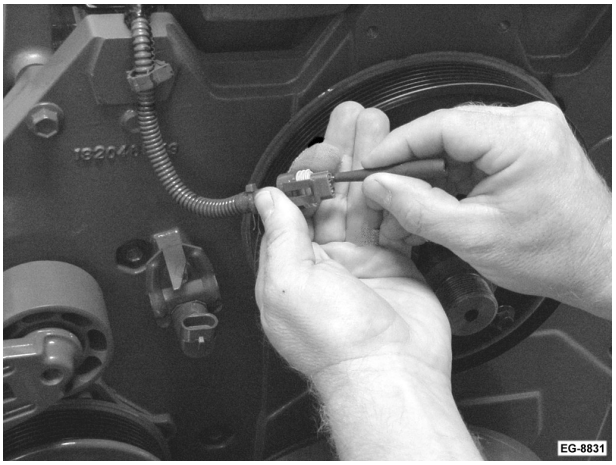

Figure 77 Testing Pin Grip

USING MASTER DIAGNOSTICS TO TEST 3 WIRE PRESSURE AND APS / IVS SENSORS

Displaying Sensor Voltages

Sensor voltages can be displayed on Master Diagnostics (Version 2.31 and above) by opening the session file **SENSOR VOLTAGE** and starting the **KEY-ON ENGINE-OFF CONTINUOUS MONITOR** test. Voltages can be displayed with the engine running by using the **KEY-ON ENGINE-RUNNING CONTINUOUS MONITOR** test. The voltage displayed by Master Diagnostics represents the voltage read by the ECM on the internal circuitry connected to the sensor signal pin of the 60-pin ECM connector. The following signal voltages will be displayed: APS, BAP ECT, EOP, EOT, EPS, IAT, ICP, MAP, RPS, IVS PWR.

Signal Circuit, Open Circuit Check (3 wire)

Use Master Diagnostics to display the sensor signal voltage. Install the breakout tee in the harness connector. Read the displayed voltage with the sensor disconnected. The displayed voltage should match the expected voltage listed in the diagnostic section for that sensor. The open circuit signal will be near zero unless the circuit is shorted or incorrectly wired to V_{REF}, B+, or other voltage sources, (See Figure 78, page 174).

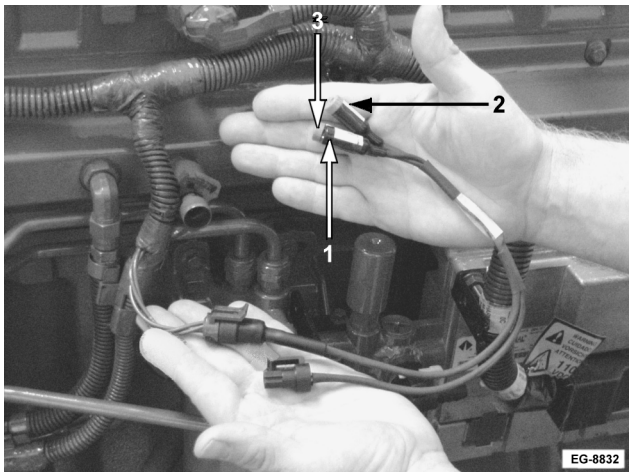

Figure 78 Testing Open Circuit Signal Voltage with ZTSE4347

1. Ground, (black)
2. Signal, (green)
3. Vref, (blue)

Reference Voltage, V_{REF} Check (3 wire)

Use a 0.5 kΩ jumper wire to connect the V_{REF} pin to the signal pin of the breakout tee. View the voltage on the EST. Reference voltage should measure greater than 4.9 volts with the sensor disconnected. If the voltage reading is lower than expected, verify reference voltage at other V_{REF} sensors that share the same circuit (V_{REF} D: EOP, MAP, CMP, ICP), (V_{REF} B: APS/IVS, BAP), (V_{REF} C: body builder accessories). If the other sensors on the shared circuit have V_{REF} that meets the expectations, the harness wire from the harness splice point to the sensor connector is at fault. If the other sensors have also lost the reference voltage, disconnect the sensors one at a time while observing the voltage. If V_{REF} returns after disconnecting a sensor, that sensor is shorting V_{REF} to ground. If V_{REF} is suspected of shorting out intermittently during engine operation, use a breakout tee on the ICP or MAP sensor. Jumping V_{REF} to the signal will allow V_{REF} to be displayed on Master Diagnostics while running the engine.

NOTE – Operation of the engine may be degraded slightly because the sensor will set an active code and fault management will take over its function. Refer to Measuring Reference Voltage with Master Diagnostics, (See Figure 79, page 175). Sensor voltage cannot be displayed while the vehicle is moving.

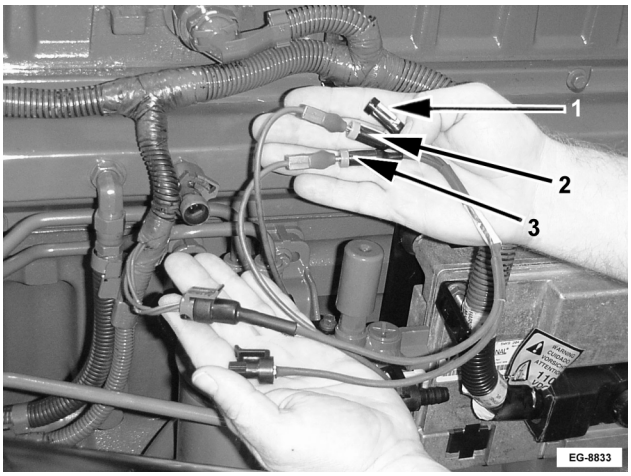

Figure 79 Measuring Reference Voltage using Master Diagnostics with ZTSE4347

1. Ground, (black pin)
2. Vref, (blue pin)
3. Signal, (green pin)

NOTE – THE ECM WILL NOT DISPLAY A SENSOR SIGNAL VOLTAGE GREATER THAN 5 VOLTS. If V_{REF} is shorted high (voltage greater than 5.5 volts) the signal voltage will also be biased higher than its true reading. The MAP sensor is the most sensitive to this higher V_{REF} and will set an in-range Diagnostic Trouble Code (DTC) before the ICP and EOP sensors.

Sensor Ground Check (3 wire)

Use a jumper wire to connect V_{REF}, the signal , and the ground together through the breakout tee. View the voltage on the EST with the sensor disconnected. The displayed voltage should match the expected voltage listed in the diagnostic section for that sensor. The displayed voltage will be near 0 volts if the ground circuit has the correct resistance. Refer to Sensor Ground Check, (See Figure 80, page 175).

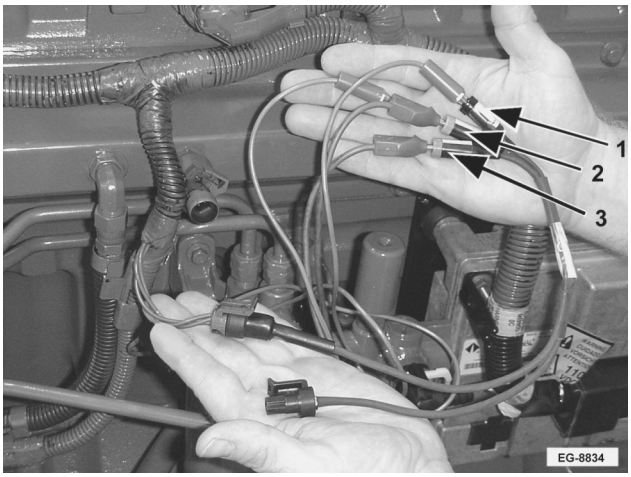

Figure 80 Sensor Ground Check with ZTSE4347

1. Ground, (black pin)
2. Vref, (blue pin)
3. Signal, (green pin)

USING MASTER DIAGNOSTICS TO TEST 2 WIRE TEMPERATURE SENSORS

Signal Open Circuit Voltage Check (2 wire)

Use Master Diagnostics to display the sensor signal voltage. Install the breakout tee in the harness connector. Do not connect the sensor. Compare the displayed voltage with the expected voltage listed in the diagnostic section for that sensor. This test will determine if the sensor circuit is shorted to ground. (See Figure 81, page 176).

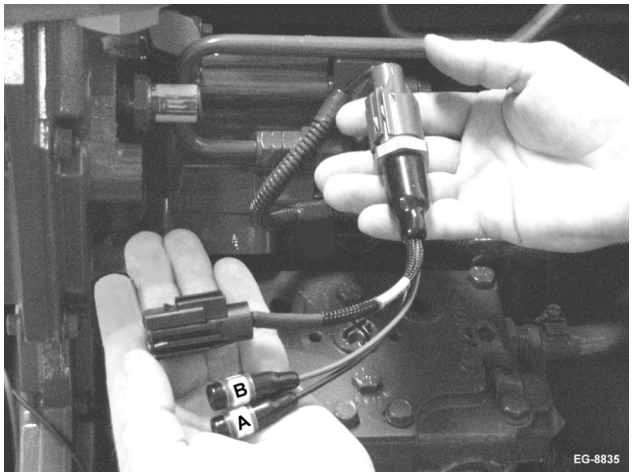

Figure 81 Testing Signal Open Circuit Voltage

1. Ground, Pin A (black)
2. Signal, Pin B (green)

Sensor Ground Check (2 wire)

Use a jumper wire to jump the signal pin to the ground pin of the breakout tee. View the voltage on the EST with the sensor disconnected. The displayed voltage should match the expected voltage listed in the diagnostic section for that sensor. When the signal wire is jumped to the ground wire the displayed voltage will be near 0 volts if the ground circuit resistance is within spec. (See Figure 82, page 177).

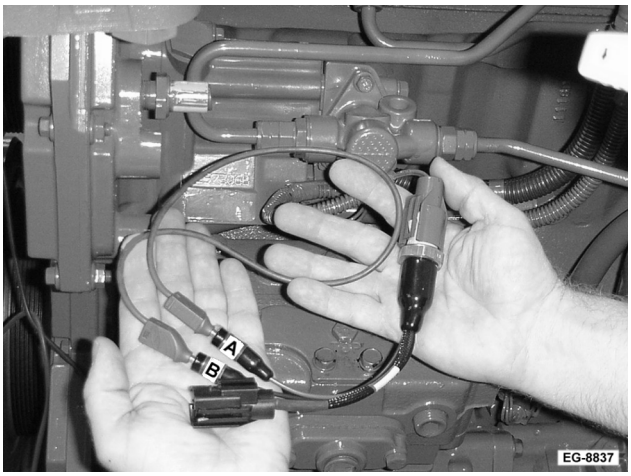

Figure 82 Sensor Ground Check with ZTSE4483 and Jumper

1. Signal, Pin A (green)
2. Ground, Pin B (black)

Sensor Voltage Supply (2 wire)

Use a 0.5 kΩ jumper wire to jump the signal pin to the ground pin of the breakout tee. View the voltage on the EST with the sensor disconnected. The displayed voltage should match the expected voltage listed in the diagnostic section for that sensor. When jumped, the displayed voltage should be less than 1.0 volt. If the EST displays greater than 1.0 volt the signal circuit is shorted to V_{REF}, B+, or other voltage sources.

Operational Voltage Checks

Use Master Diagnostics to display the operational voltages. With a breakout tee installed between the sensor and the harness, a DMM can be used to measure the voltage at the signal pin on the sensor. The displayed value and the measured value should be approximately the same. If the values do not match the circuit may have high resistance. The displayed values can also be compared to the operational voltage specifications listed in the appropriate diagnostic section. These measurements are useful for determining an in-range or intermittent fault.

ACTUATOR AND SENSOR DIAGNOSTIC PROCEDURE WITHOUT MASTER DIAGNOSTICS

Connector Voltage Checks

Turn the ignition key on. Plug the breakout tee into the harness and measure voltage at each pin with a digital multimeter (DMM). Compare meter readings with the expected voltages listed in the diagnostic section. If the tee is not available, use the appropriate tool from the terminal test adapter kit (ZTSE4435). Do not probe the connector terminals with the DMM leads directly. This test will determine if that circuit is shorted or incorrectly wired to V_{REF}, B+, or other voltage sources.

- Signal return circuits will measure 0 - 0.25V on a "Pull Down" sensor circuit or close to 5V or 12V for a "Pull Up" circuit.
- Actuator circuits may be either ON/OFF or pulse width modulated (PWM). If the actuator has an ON/OFF circuit, the ECM controls the voltage or the ground. When pulse width modulated (PWM), the ECM controls the duty cycle or on time of the power or ground.

- V_{REF} should measure 5 ± 0.5V (4.5 - 5.5 V) with the sensor disconnected. If the voltage reading is lower than expected, disconnect the sensors that operate on that V_{REF} circuit (V_{REF}-D: EOP, MAP, CMP, ICP; V_{REF} - B: APS/IVS, BAP; V_{REF} - C body builder accessories) one at a time while observing V_{REF}. If V_{REF} returns after disconnecting a sensor, that sensor is shorting V_{REF} to ground, refer to Measuring Voltage Reference, (See Figure 83, page 178).

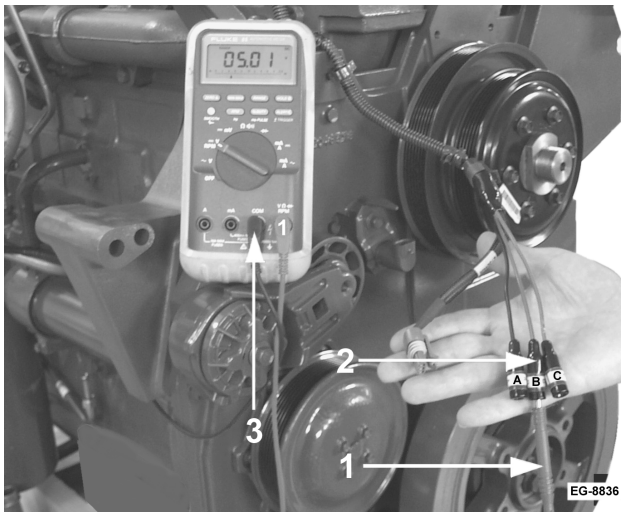

Figure 83 Measuring Vref Voltage with ZTSE4486

1. DMM Probe (red)
2. Vref, Pin B (blue)
3. DMM Probe (to engine ground)

Connector Checks To Ground

Turn the ignition switch off. Disconnect the positive battery cable. Using the breakout tee, measure the resistance from the lead of the tee to the negative battery terminal. Sensor signal ground circuits should measure less than 5 ohms. V_{REF} and signal circuits should measure greater than 1000 ohms. The control side of an actuator will measure greater than 1000 ohms, but the expected reading on the other circuit of the actuator will depend upon what the control side was switching, power or ground. If the ECM was switching the ground, “low side driver,” then the other circuit of the actuator should measure greater than 1000 ohms from the connector terminal to battery ground. If the ECM is switching the B+ side, ”high side driver,” the ground circuit will measure less than 5 ohms from terminal to battery ground, (See Figure 84, page 179).

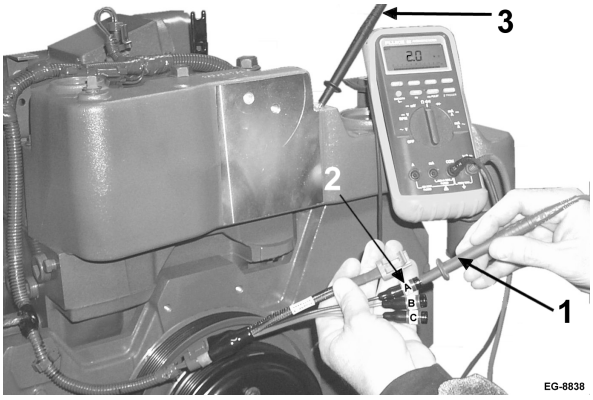

Figure 84 Measuring Resistance to Ground with ZTSE4486

1. DMM Probe (red)
2. CMP Ground, Pin A, (black)
3. DMM Probe to Engine Ground (black)

Harness Resistance Tests

Harness resistance is checked when a circuit is suspected of having high resistance or being open. Perform this test by connecting a breakout box to the ECM end of the harness and measuring resistance from the pin of the breakout tee to the pin on the breakout box. Circuit wires should have a resistance of less than 5 ohms.

OPERATIONAL VOLTAGE CHECKS

These checks are made with a DMM and a breakout tee or breakout box. The sensor is connected and the DMM is used to measure the signal voltage. These measurements are useful for determining an in-range or an intermittent fault. If a circuit has an intermittent fault you must monitor the voltage while recreating the cause.

When measuring the signal level of a circuit you must understand its function and whether it is an:

1. Analog Voltage
2. Digital Frequency
3. Sine Wave
4. Digital Communication Signal

A standard DMM has certain limitations in measuring any circuit that has a frequency.

CIRCUIT FUNCTION AND DIAGNOSTICS

ACCELERATOR PEDAL POSITION SENSOR AND IDLE VALIDATION SWITCH (APS/IVS)

Signal Functions

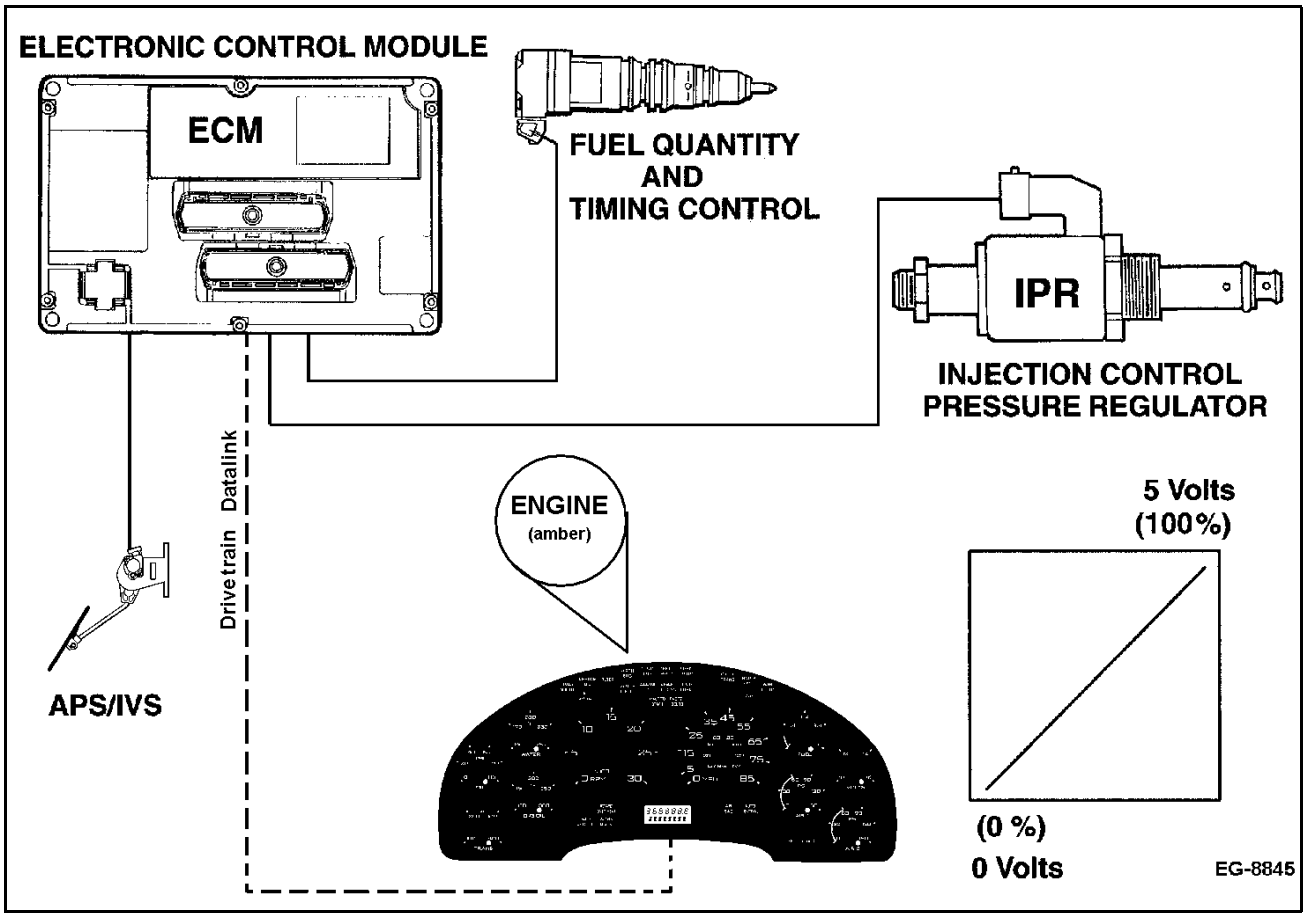

Figure 85 APS / IVS Function Diagram

The Accelerator Pedal Position Sensor (APS) is a potentiometer type sensor. When the APS receives a 5V reference signal and a ground from the Electronic Control Module (ECM), a linear analog voltage signal from the sensor will indicate the driver's demand for power. The Idle Validation Switch (IVS) provides 0V or 12V to the ECM as redundant signal to verify the pedal idle position.

Fault Detection and Management

Any detected malfunction of the APS / IVS sensor circuit will illuminate the amber ENGINE lamp and the odometer will display **WARN ENG**. If the ECM detects an APS signal Out of Range HIGH or LOW, the engine will ignore the APS signal and operate at low idle. If a disagreement in the state of IVS and APS is detected by the ECM and the ECM **determines** that it is an IVS fault, the ECM will only allow a maximum of 50% APS to be commanded. If the ECM **cannot discern** if it is an APS or IVS fault, the engine will be allowed to operate at low idle only.

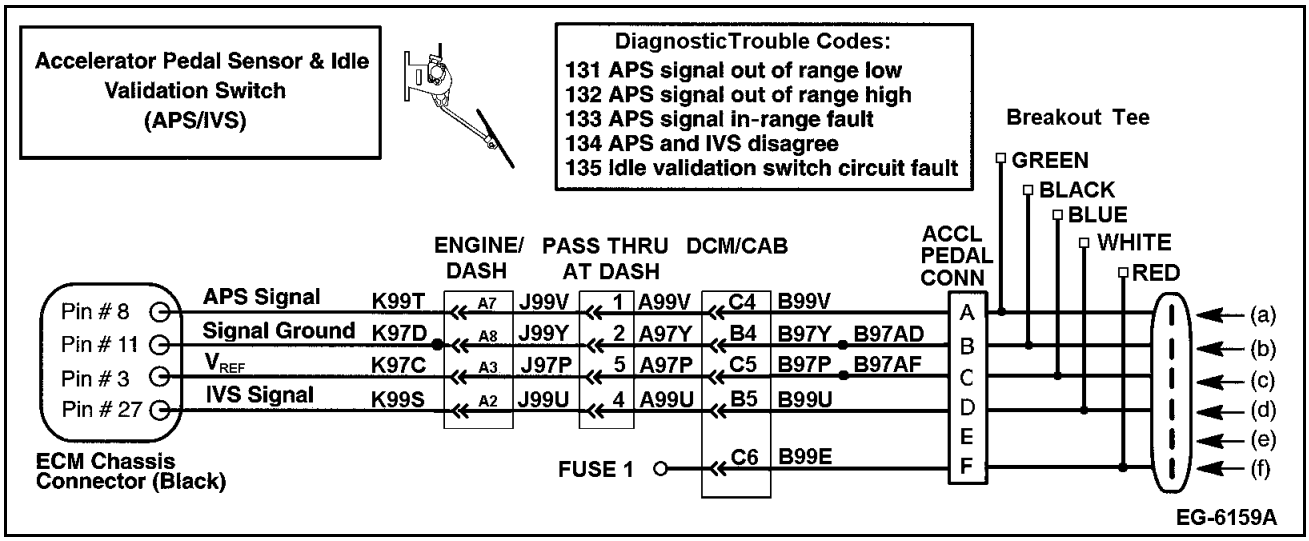

Figure 86 APS / IVS Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 50 APS Sensor Tests Using Master Diagnostics

Accelerator Pedal Position Sensor (APS) Sensor Voltage Checks. Use Sensor Circuit Specifications to verify IVS Signal, (check with key-ON engine-OFF).		
Install the 5 wire breakout tee between the APS/IVS sensor and harness connector. View APS/IVS VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 131 <0.146V, Code 132 >4.55V), complete the following steps.		
Test Condition	**Expected Voltage**	**Comments**
Sensor Disconnected	0V	Voltage >0.146V, inspect the signal circuit for short to V_{REF} or B+.
Measure voltage from PIN C to gnd using a DMM.	5V ± 0.5	If voltage is >5.5V, check V_{REF} for short to B+. If voltage <4.5V, check V_{REF} circuit for open or short to gnd. Remove the positive battery cable. Measure resistance from PIN C to PIN 3 (spec <5Ω) and from PIN C to gnd (spec >1kΩ) using a breakout box to determine if the short to gnd or open is in the harness.
0.5 kΩ jumper installed between the GREEN and BLUE pins of the breakout tee.	5V	If voltage is <4.55V, check signal circuit for open or short to ground. Remove the positive battery cable. Measure resistance from PIN C to Ground (spec >1 kΩ) and from PIN A to PIN 8 (spec <5Ω) using a breakout box to determine if short to ground or open is in the harness.
Standard Jumper installed between the BLUE, GREEN, and BLACK pins of the breakout tee.	0V	If voltage is >0.039V, check ground circuit for resistance >5Ω. Measure resistance between PIN B and PIN 11 (spec <5Ω) using a breakout box to determine if resistance is in the harness.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See APS/IVS Sensor Troubleshooting Flowchart (See Figure 88, page 186).		
Continued on Next Page		

Table 50 APS Sensor Tests Using Master Diagnostics (cont.)

OPERATIONAL VOLTAGE CHECKS (check with breakout tee installed and APS/IVS sensor connected)					
	APS test points: (+) 8 to (-) 11		**IVS test points: (+) 27 to (-) 11**		
Position	**Voltage**	**% APS**	**Voltage**	**% APS**	**Comments**
Low Idle	0.64 – 0.66V	0%	0V	0%	IVS toggles just off idle
High Idle	3.84 – 3.86V	98 -102%	12 ± 1.5V	98 -102%	
Diagnostic Trouble Code Description					
131 APS signal voltage was < 0.146 volts for more than 0.5 sec*					
132 APS signal voltage was more than 4.55 volts for more than 0.5 sec*					
133 APS signal in-range fault*					
134 APS and IVS disagree*					
135 Idle validation switch circuit fault - 50% APS only					
*** IF DIAGNOSTIC TROUBLE CODE IS SET, ENGINE OPERATION WILL DEFAULT TO RUN AT LOW IDLE SPEED ONLY**					

Table 51 APS/IVS Sensor Circuit Specifications (See Figure 86, page 181)

CONNECTOR VOLTAGE CHECKS (check with sensor disconnected from harness, key on)		
Test Points	**Spec.**	**Comments**
A to gnd	< 0.25V	Voltage >0.25V, signal is shorted to Vref or B+
B to gnd	0V	Ground circuit, no voltage expected
C to gnd	5 ± 0.5V	Voltage > spec, wire shorted to B+
D to gnd	0 - 0.25V	Voltage >0.25, IVS signal wire shorted to Vref or B+
F to gnd	12 ± 1.5V	Voltage <10.5V check circuit for open or resistance
CONNECTOR CHECKS TO CHASSIS GROUND (check with sensor connector disconnected, positive battery cable disconnected, and key off)		
Test Points	**Spec.**	**Comments**
A to gnd	>1kΩ	If <1kΩ, check for short to ground.
B to gnd	<5Ω	If >5Ω, check for open.
C to gnd	>500Ω	If <0.5kΩ, check for short to ground.
D to gnd	>1kΩ	If <1kΩ, check for short to ground.
F to gnd	>1kΩ	If <1kΩ with fuse removed, check for short to ground.
HARNESS RESISTANCE CHECKS (check with breakout box installed on chassis harness only).		
Test Points	**Spec.**	**Comments**
8 to A	<5Ω	If >5Ω check for APS signal wire open
11 to B	<5Ω	If >5Ω Signal ground open
3 to C	<5Ω	If >5Ω Vref wire open
27 to D	<5Ω	If >5Ω IVS wire open
Fuse 17 to F	<5Ω	If >5Ω IVS power wire open

Extended Description

International electronic engines use an electronic accelerator pedal assembly that includes a Accelerator Position Sensor (APS) as well as an Idle Validation Switch (IVS). These two functions are integrated into one component mounted on the pedal. The accelerator pedal assembly is serviceable to the extent that the APS/IVS switch can be replaced without replacing the complete assembly.

The Electronic Control Module (ECM) determines the accelerator pedal position by processing input signals from the Accelerator Position Sensor (APS) and the Idle Validation Switch (IVS).

The accelerator pedal position is one of the controlling variables in the calculation of desired injection control pressure.

Accelerator Position Sensor (APS)

The ECM sends a regulated 5V signal through the ECM chassis connector (black) terminal 3 to APS connector terminal C. The APS then returns a variable voltage signal (depending on pedal position) from the APS connector terminal A to the ECM at terminal 8. The APS is grounded from connector terminal B to the ECM signal ground terminal 11. System Diagram for Accelerator, BAP, and Intake Air temperature Sensors, (See Figure 87, page 185).

APS Auto-Calibration

The ECM learns the lowest and highest pedal positions by reading and storing the minimum and maximum voltage levels from the APS. In this manner the ECM "auto-calibrates" the system to allow maximum pedal sensitivity. The ECM auto-calibrates as the key is ON, but when the key is turned OFF, these values are lost. When the key is turned ON again, this process starts over. When the pedal is disconnected (or a new one is installed), the pedal does not need to be calibrated. It simply "auto-calibrates" the new pedal assembly whenever the key is turned ON again.

Idle Validation Switch (IVS)

The ECM expects to receive one of two signals through the ECM chassis connector (black) terminal 27 from APS/IVS connector terminal D:

- 0V when the pedal is at the idle position.
- 12V when the pedal is depressed.

The Idle Validation Switch receives 12V ignition voltage from the ignition fuse in the fuse box. When the pedal is NOT in the idle position (throttle applied), the IVS supplies a 12V signal to the ECM.

The ECM compares APS/IVS inputs at terminals 8 and 27 to verify when the pedal is in the idle position. If the APS signal at terminal 8 indicates throttle is being applied, the ECM expects to see 12V at IVS terminal 27. If the APS signal at terminal 8 indicates throttle is not applied, the ECM expects to see 0V at IVS terminal 27. The timing process is critical between the APS and IVS sensors. For this reason, it is very difficult to determine if the APS/IVS assembly is working properly by using a digital multimeter (DMM).

ECM Diagnostics

When the key is ON, the ECM continuously monitors the APS/IVS circuits for expected voltages. It also compares the APS and IVS signals for conflict. If the signals are not what the ECM expects to see, Diagnostic Trouble Codes will be set.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 131

ATA Code, PID 91, FMI 4

ECM: *APS Out of Range LOW (ORL)*

When code 131 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

ORL code 131 is set if the ECM detects voltage lower than 0.146V at terminal 8 then the ECM restricts engine speed to idle. Possible causes include; a short to ground or an open V_{REF}or signal circuits. If the condition causing code 131 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume.

Diagnostic Trouble Code 132

ATA Code, PID 91, FMI 3

ECM: *APS Out of Range HIGH* (**ORH**)

When code 132 is active, the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

ORH code 132 is set if the ECM detects a voltage greater than 4.55V at terminal 8 then the ECM restricts engine speed to idle. Possible cause; short to V_{REF} or 12V in the APS signal circuit. If the condition causing code 132 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume. Code 132 is displayed by either the EST or using the amber ENGINE lamp to flash the Diagnostic Trouble Codes.

Diagnostic Trouble Codes 133, 134 and 135

APS In-Range Fault

The ECM checks the voltage output of the APS by comparing the APS signal with the IVS signal. APS and IVS signals can disagree in two cases:

- The APS signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position.
- The APS signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict and set the appropriate Diagnostic Trouble Code.

Diagnostic Trouble Code 133

ATA Code, PID 91, FMI 2

ECM: APS In Range Fault

When code 133 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

If the IVS signal is changing and the APS signal is constant, the ECM assumes APS is the conflict source and sets code 133. Engine rpm is restricted to idle.

Diagnostic Trouble Code 134

ATA Code, PID 91, FMI 7

ECM: APS/IVS Disagree

When code 134 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

If neither the APS or IVS is changing, or both are changing, or the ECM cannot determine which is at fault in a specified time, code 134 is set. Engine rpm is restricted to idle.

Diagnostic Trouble Code 135

ATA Code, SID 230, FMI 11

ECM: IVS Circuit Fault

When code 135 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

If the APS is changing and IVS is constant, the ECM assumes IVS is the conflict source and sets Diagnostic Trouble Code 135. In this case the ECM limits the APS signal to a lower value, which provides less than full rpm, but does not limit engine rpm to idle.

Codes 133, 134 and 135 are caused intermittent conditions; these the codes remain ACTIVE until the vehicle has been shutdown and restarted. They do not recover without cycling the key switch.

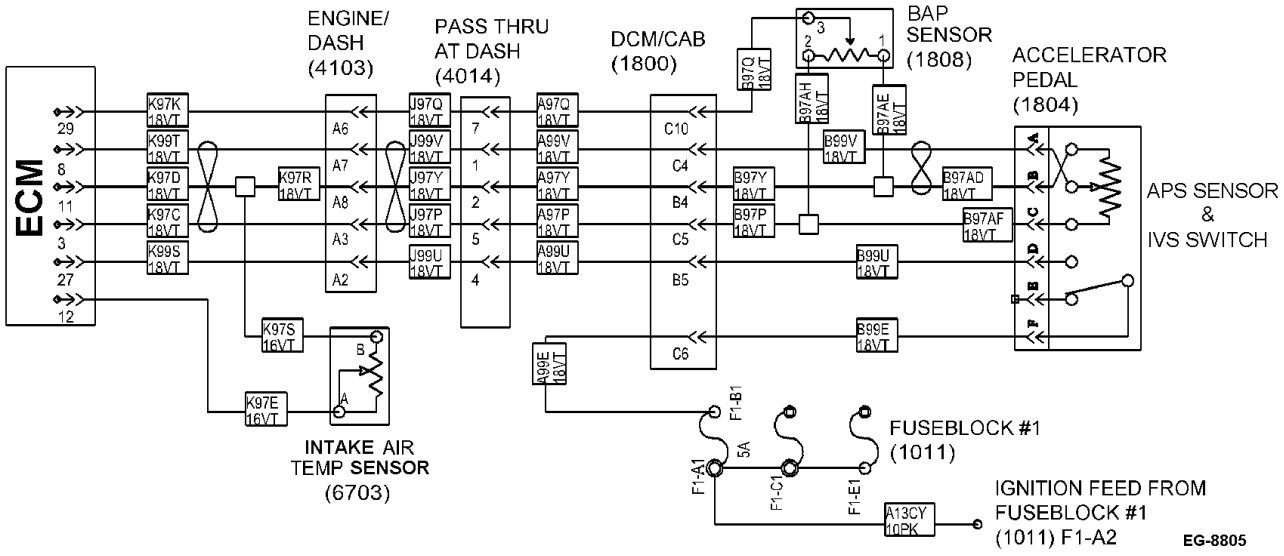

Figure 87 System Diagram for Accelerator Pedal Sensor

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

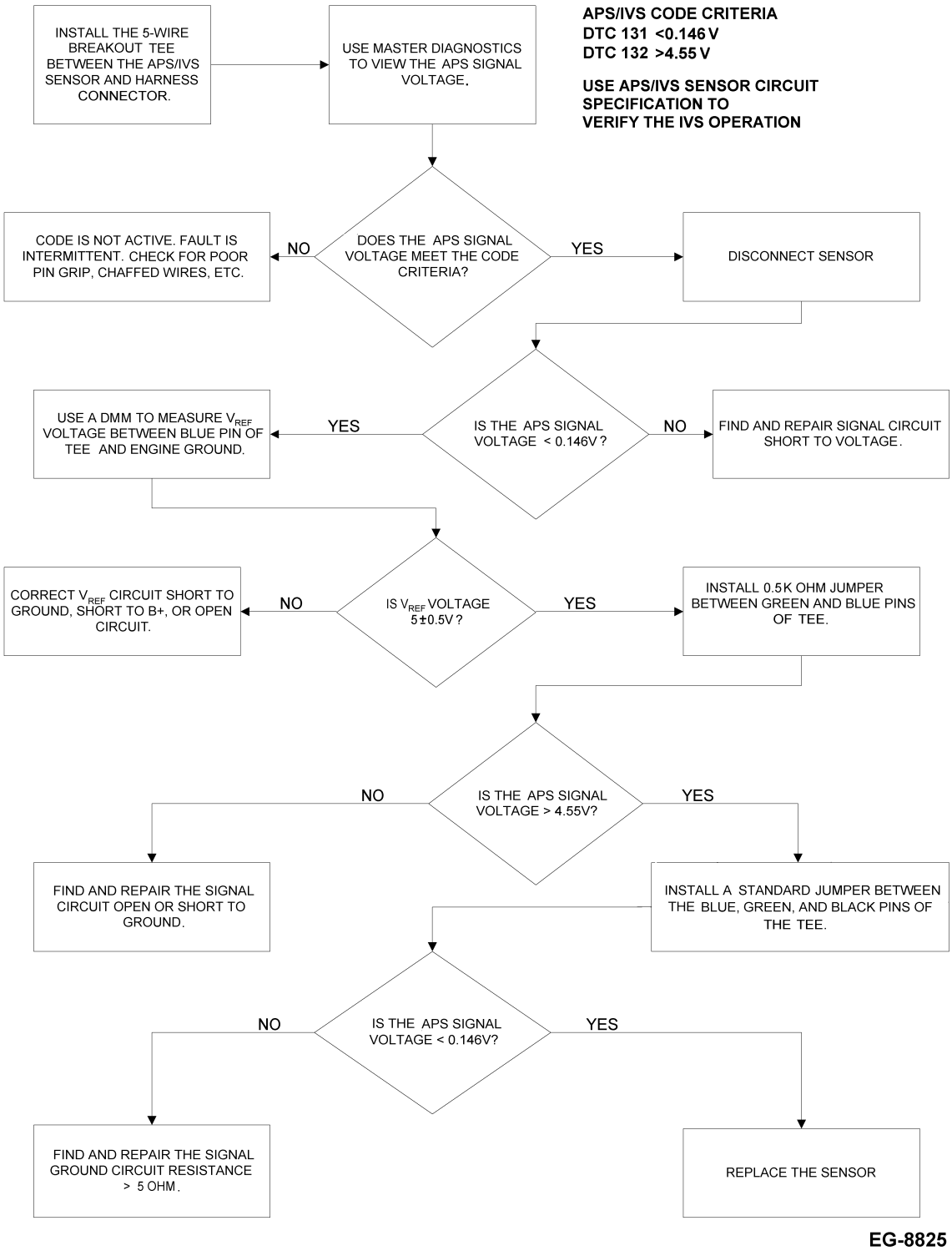

Figure 88 APS / IVS Sensor Troubleshooting Flowchart

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ATA COMMUNICATIONS, DATA COMMUNICATIONS LINK

Signal Functions

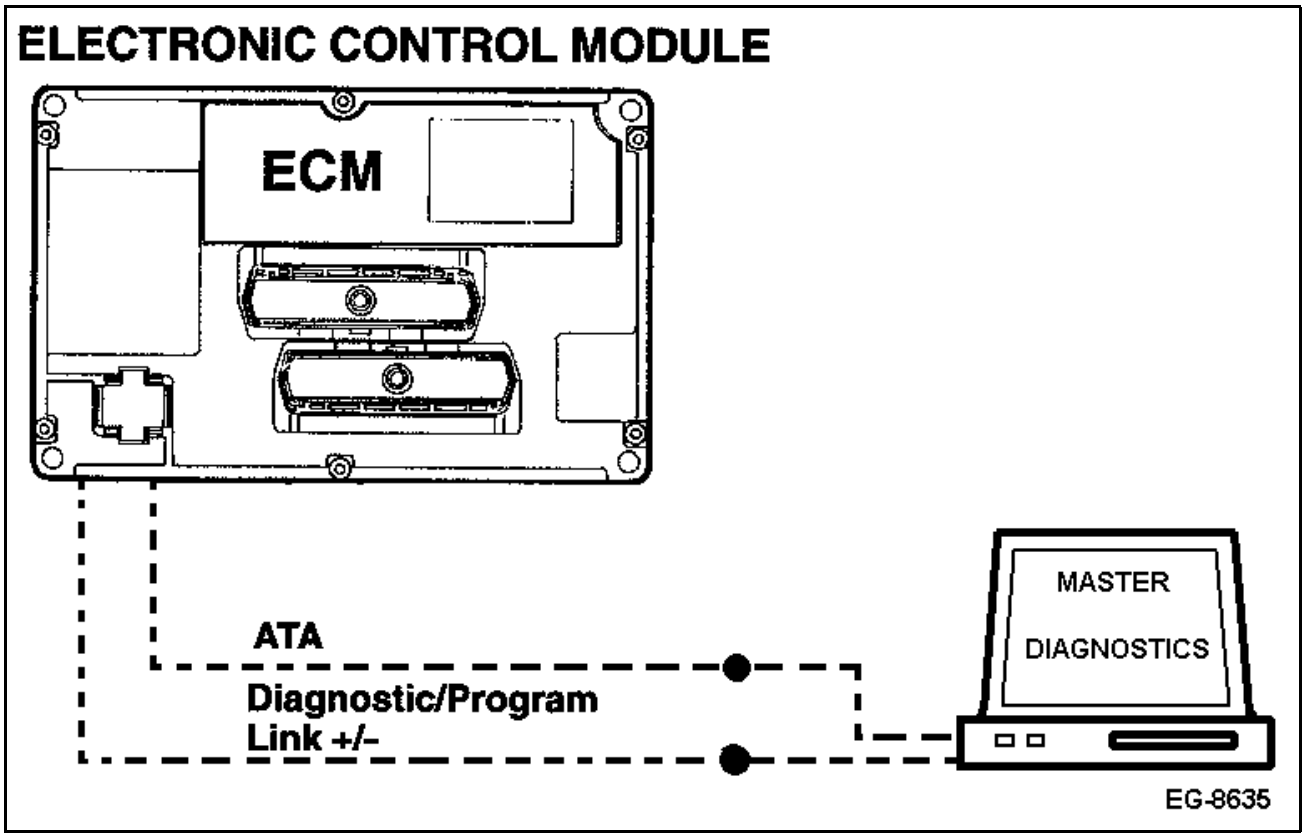

Figure 89 ATA Communications Function Diagram

Data Communication Link

The Data Communication Link signal is a 0 to 5V variable width square wave form signal that enables communication between the MD diagnostic software and the ECM. It is used for communication of diagnostic and calibration data.

Fault Detection / Management

The ECM can continuously detect an open, short, or intermittent connection on the ATA lines. If an active Diagnostic Trouble Code occurs on the ATA lines, the MD diagnostics software will not display data properly.

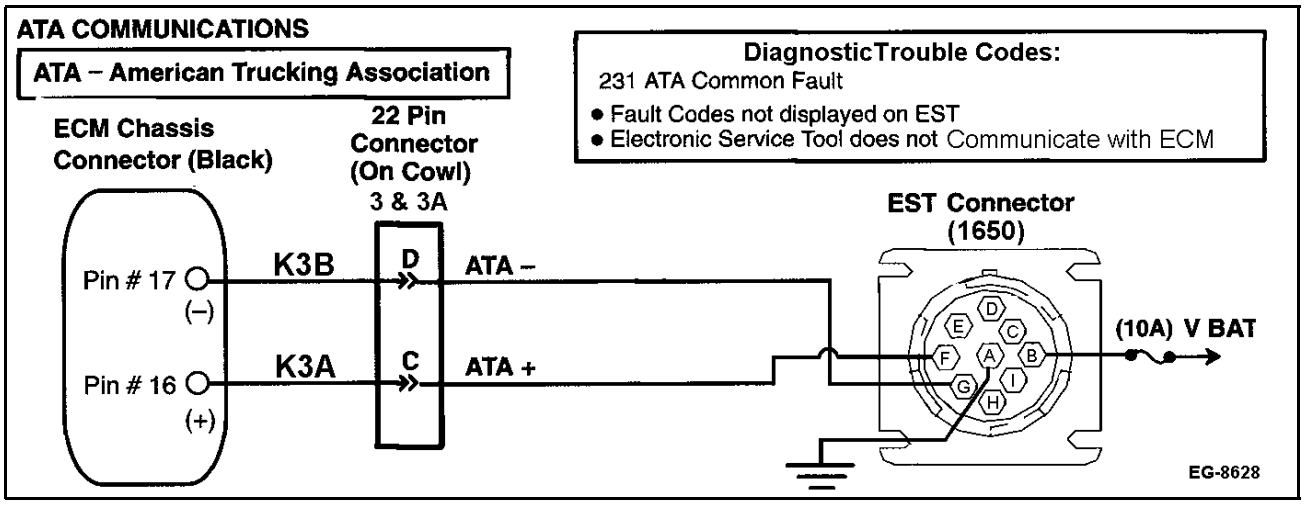

Figure 90 ATA Communications Circuit Diagram

NOTE – After removing connectors always check for damaged pins, corrosion, loose terminals.

Table 52 ATA Communications Circuit Diagnostics

Key ON Engine OFF - Voltage Checks at EST Connector (ignition key ON, engine OFF)			
+Test Point	Spec.	Signal	Comments
B to A	B+	Power	Should be power at B at all times. If no power, check ground and power circuits.
EST Checks to Ground (positive battery cable disconnected and ignition key OFF)			
Test Points	Spec.	Signal	Comments
Electronic Service Tool - EST			
F to gnd	>1kΩ	ATA +	< 1kΩ indicates a short to ground, either through the harness or internal within the ECM. Disconnect ECM & measure to ground again. If short is still present, disconnect other devices connected to data communication link and retest. If short is still present, repair harness.
G to gnd	>1kΩ	ATA –	
B to gnd	>1kΩ	PWR	With fuse removed, a reading < 1kΩ indicates a short to ground. More than 5Ω indicates an open circuit and the EST tool will not communicate.
A to gnd	<5Ω	gnd	
EST & Dash Harness Resistance Checks (check with breakout box installed, ignition key should be in the OFF position)			
Test Points	Spec.	Signal	Comments
EST Connector			
F to #16	<5Ω	ATA +	Resistance from ECM chassis connector (black) to EST connector.
G to #17	<5Ω	ATA –	Resistance from ECM chassis connector (black) to EST connector.
B to F3	<5Ω	PWR	Resistance from EST connector to power fuse.
A to gnd	<5Ω	gnd	>5Ω indicates an open circuit and will cause the EST tool not to power up.
Diagnostic Trouble Code Description			
231 ATA Common DTC - ATA wiring or connector, interference on data bus, faulty ECM. – No Data Stream or DTC's displayed on MD diagnostic software or EST will not communicate.			

Extended Description

ATA Communication

The Electronic Control Module (ECM) communicates with the MD diagnostic software (electronic service tool - EST) through connector (1650) shown in ATA Communications Circuit Diagram (See Figure 90, page 189). The EST communicates with the ECM using the American Trucking Association (ATA) datalink lines (**1**).

The ATA circuit uses a twisted wire pair. All repairs to this pair must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized (one positive and one negative) and reversing the polarity of this circuit will disrupt communications.

(1) - The ATA datalink is defined by SAE recommended practices J1708 and J1587. This link and connector (1650) were adopted by the Recommended Practices 1201 and 1202.

ATA Data Link Connector (1650)

All communication between the EST and ECM is done through the EST connector (1650). This communications link supports the following functions:

- Displaying Diagnostic Trouble Codes and operating conditions on the EST.
- Performing proprietary diagnostic tests programmed into the ECM.
- Clearing Diagnostic Trouble Codes.
- Programming performance parameter values.
- Programming calibrations and strategies.

EST connector (1650) has nine pins, labeled A through I, that provide the following:

A. Fused BATTERY power to Pin B for the Interface Cable. Pin A provides a battery ground for the Interface Cable.

B. EST connector (1650) terminal F is connected by circuit K3A (+) to the positive 4820 ATA bus and EST connector (1650) terminal G is connected by circuit K3B (–) to the negative 4820 ATA bus. These two connections allow communication with all components connected to the data link.

EST Connector (1650)

The engine control system does not detect faults in the power or ground circuits to the EST connector (1650). If the service tool does not communicate when connected, try the service tool on another vehicle if one is available to determine if the service tool is working properly. If the service tool is OK, then check power and ground circuits at the ATA connection.

EST Displays

Should the EST not communicate with the ECM, the ATA data link circuit from the EST connector to the ECM may be disrupted. Verify that the key is ON and then perform diagnostic steps in ATA Communications Circuit Diagnostics (See Table 52, page 189).

Diagnostic Trouble Code 231

ATA Code, SID 250, FMI 2

ECM: ATA Common Fault

Symptom: Code 231 **does not** turn the amber ENGINE lamp ON. This code can occur when the ECM can't access the ATA data link. If this occurs there will not be any ATA data available with the MD software. The Diagnostic Trouble Code may be retrieved using the Cruise Control buttons located within the steering wheel.

Wiring Causes: ATA positive or negative circuits between the EST and Diagnostic Connector (1650) and any other electronic devices (transmissions, brakes etc.) using the ATA bus: Shorted (high or low), open, or busy (too many devices).

NOTE – On vehicles equipped with the Allison WTEC transmission, this code may be present when attempting to program the ECM. The WTEC controller must be disconnected when programming the engine ECM.

System causes can include:

A. A defective ATA device (such as transmission controller or antilock brake controller) connected to the ATA bus is pulling the signal to ground.

B. Too many ATA devices, although this would be rare.

C. If no system causes are present, replace the ECM with a known good ECM.

The data is transmitted on the same ATA link that supplies information to the EST and the WTEC transmission controller.

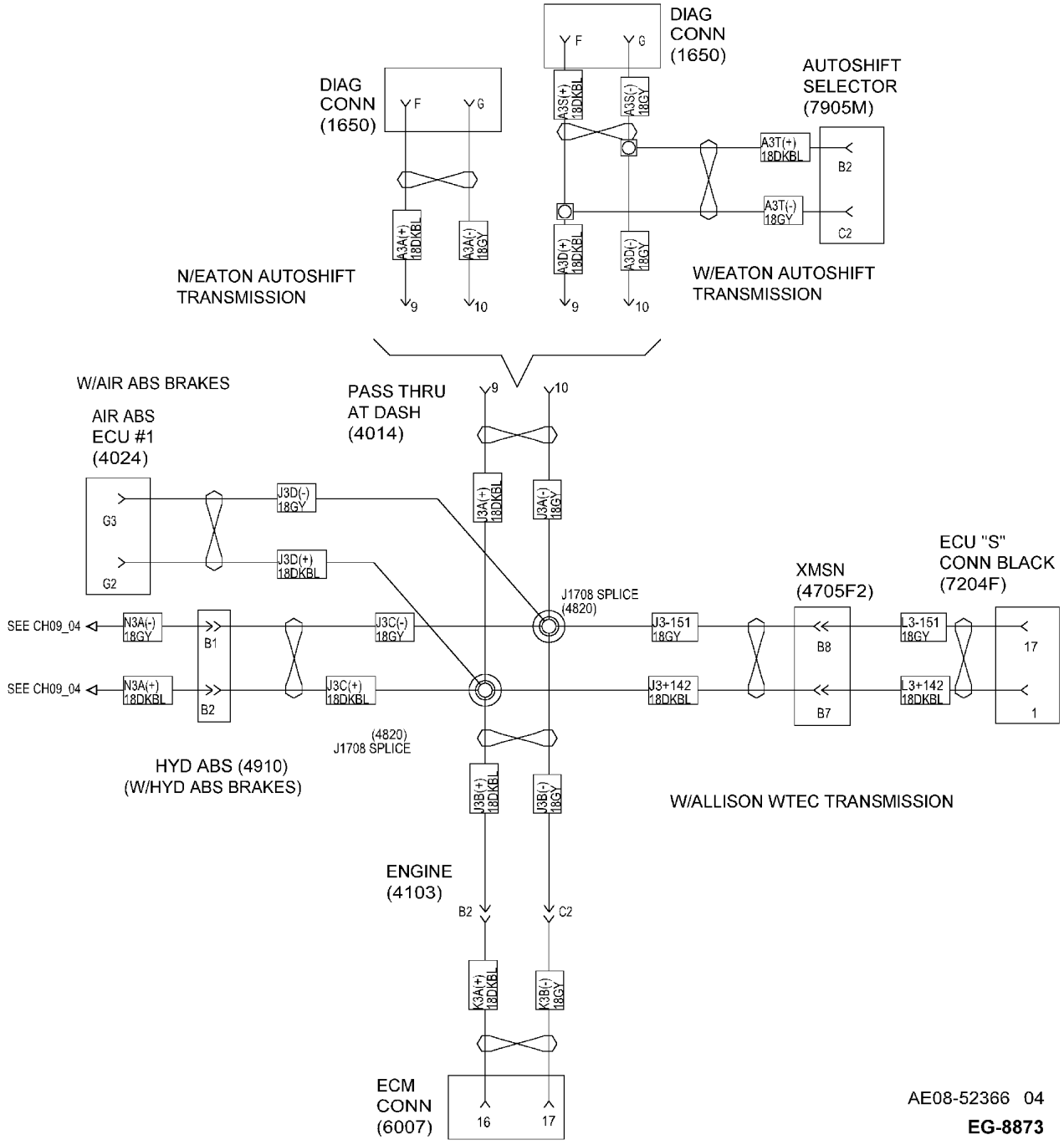

Figure 91 1708 Data Link (chassis)

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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BAROMETRIC ABSOLUTE PRESSURE SENSOR (BAP)

Signal Functions

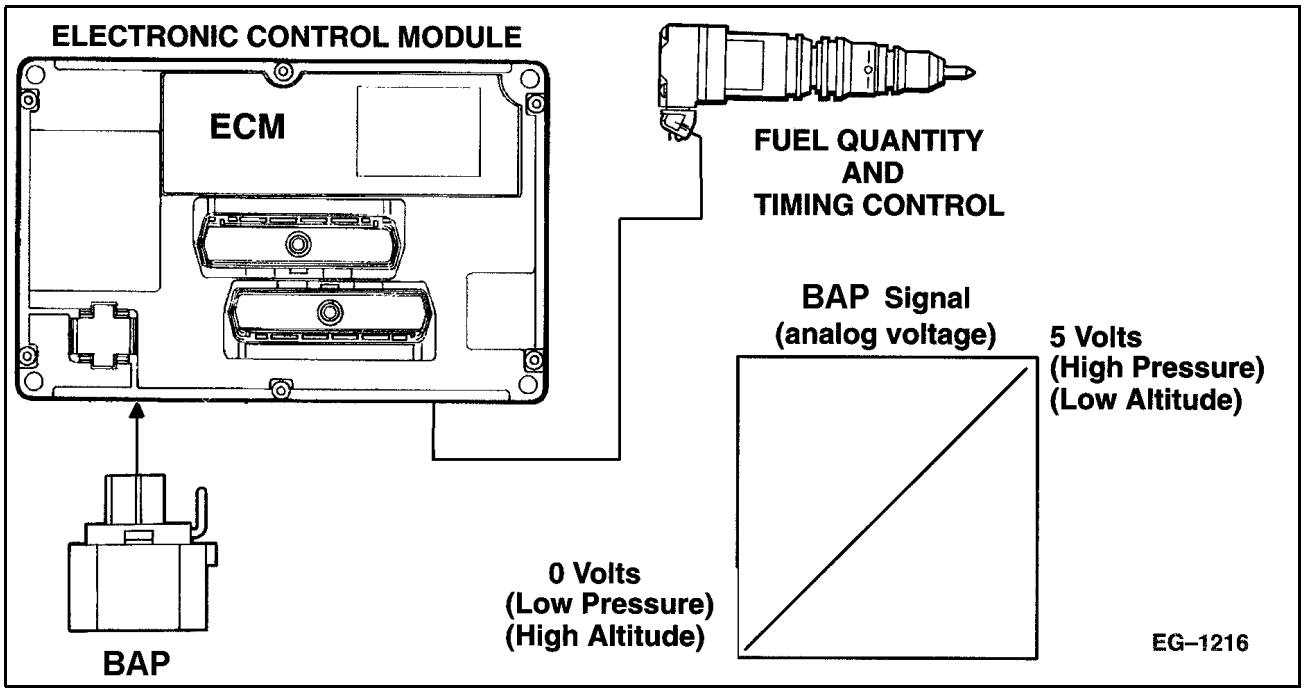

Figure 92 Barometric Absolute Pressure Sensor Function Diagram

The Barometric Absolute Pressure (BAP) sensor is a variable capacitance sensor that when supplied with a 5V reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

Timing Control - The BAP signal is used to determine altitude to adjust timing and fuel quantity to optimize engine operation and control smoke throughout all altitude conditions.

Fault Detection / Management

When BAP signal voltage is detected Out of Range HIGH or Out of Range LOW by the ECM will ignore the BAP signal and use the Manifold Absolute Pressure (MAP) signal generated at low idle as an indication of barometric pressure. If a MAP fault is also detected, the BAP signal will default to 29.6 in Hg (barometric pressure at sea level).

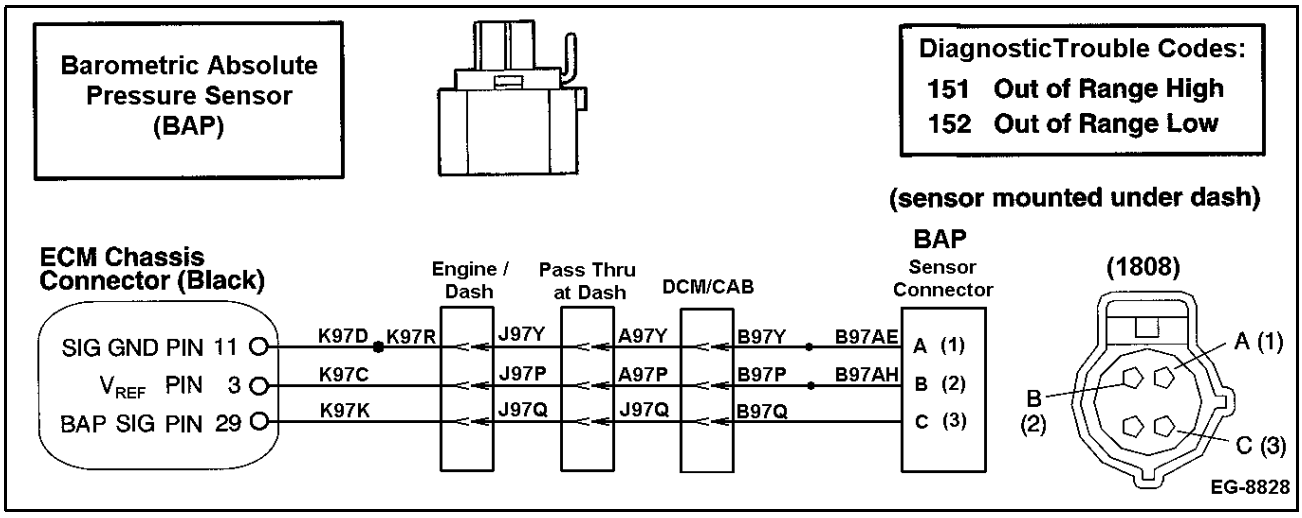

Figure 93 Barometric Absolute Pressure Sensor Circuit Diagram

NOTE – After removing connectors always check for damaged pins, corrosion, loose terminals.

Table 53 Barometric Absolute Pressure Sensor and Circuit Diagnostics

Connector Voltage Checks (check with sensor connector (1808) disconnected, ignition key on)			
Test	Spec.	Comments	
A to gnd	<0.25V	Ground circuit, no voltage expected.	
B to gnd	5V ± 0.5	V_{REF} check with KEY ON, if voltage not within spec., check V_{REF} circuit for short to gnd or open.	
C to gnd	<0.25V	If voltage is >0.25V, signal wire is shorted to V_{REF} or battery	
Connector Checks to Chassis Ground (check with sensor connector (1808) disconnected, positive battery cable disconnected and ignition key off)			
Test	Spec.	Comments	
A to gnd	<5Ω	Resistance to chassis ground, check with key off, > 5Ω the harness is open	
B to gnd	>1kΩ	Resistance <1kΩ indicates a short to ground	
C to gnd	>1kΩ	Resistance <1kΩ indicates a short to ground	
Harness Resistance Checks (check with breakout box installed on chassis harness only)			
Test	Spec.	Comments	
11 to A	<5Ω	Resistance >5Ω indicates wires are open	
3 to B	<5Ω	Resistance >5Ω indicates wires are open	
29 to C	<5Ω	Resistance >5Ω indicates wires are open	
Test (+) 29 to (-) 11		**Operational Voltage Checks** (check with breakout box installed in line with the ECM)	
Voltage	in Hg	kPa	Comments
4.89	31.0905	105	High atmospheric pressure.
4.60	29.61	100	Normal atmospheric pressure at sea level.
2.60	17.766	60	Normal atmospheric pressure at 10,000 feet.
Diagnostic Trouble Code Description			
151= Signal voltage was >4.95V for more than 1.0 sec.			
152 = Signal voltage was <1.0V for more than 1.0 sec.			

Extended Description

Operation

The ECM sends a regulated 5V signal from ECM (black) chassis connector terminal 3 to BAP connector terminal 2. The BAP sensor returns a variable voltage signal (representing atmospheric pressure) from BAP connector terminal 3 to the ECM at terminal 29. The BAP sensor is grounded from the BAP connector terminal 1 to the ECM signal ground terminal 11.

ECM Diagnostics

The ECM continuously monitors the signal from the BAP sensor to ECM terminal 29. If the signal voltage is out of the expected range, a Diagnostic Trouble Code is logged (warning lamp does NOT turn on) and the ECM uses the Manifold Absolute Pressure (MAP) signal generated at low idle to determine barometric pressure.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 151

ATA Code, PID 108, FMI 3

ECM: BAP Voltage Signal Out of Range HIGH (**ORH**)

BAP signal greater than 4.95V for more than 1 second.

Possible causes for Code 151 include: signal circuit shorted to V_{REF} or B+, defective sensor.

Diagnostic Trouble Code 152

ATA Code, PID 108, FMI 4

ECM: BAP Voltage Signal Out of Range LOW (**ORL**)

BAP signal less than 1.0V for more than 1 second.

Possible causes for Code 152 include: signal circuit shorted to ground or open, V_{REF} shorted to ground or open, defective sensor.

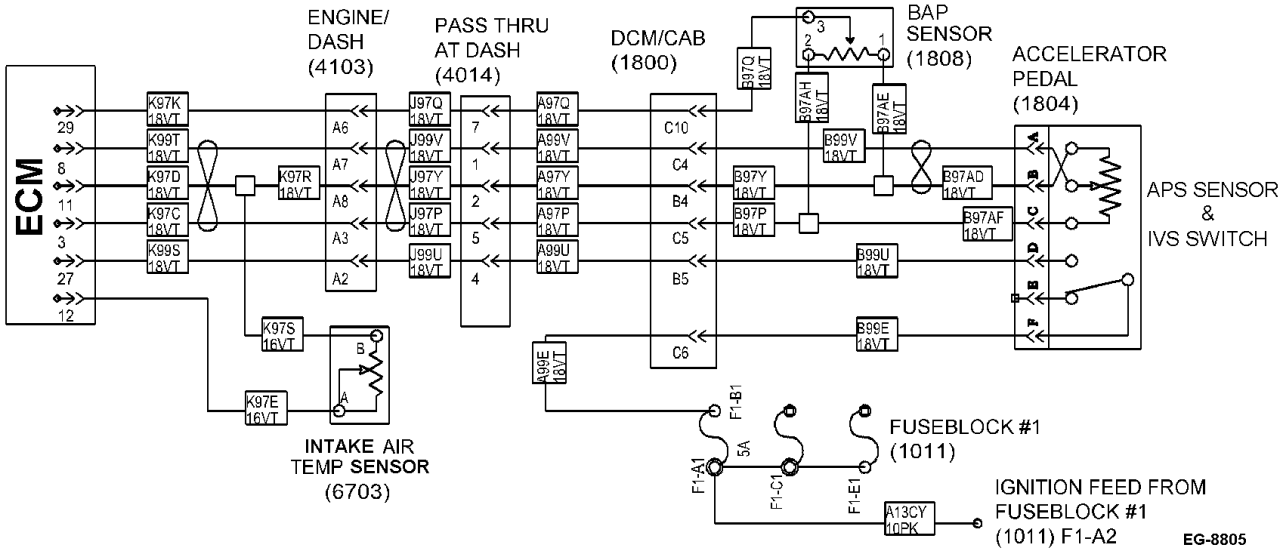

Figure 94 BAP Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

BRAKE SWITCH CIRCUITS (BRAKE)

Signal Functions

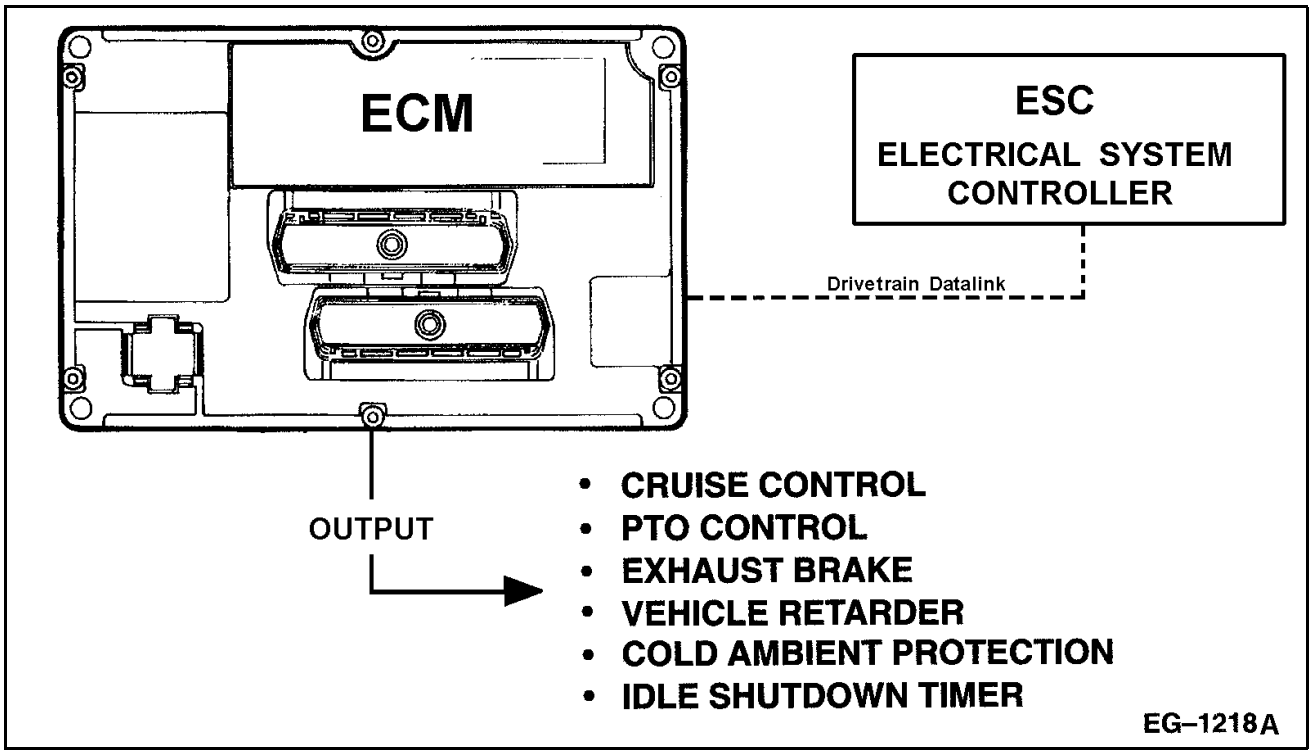

Figure 95 Service Brake Circuit Function Diagram

The service brake circuit function is to signal the ECM when the brakes are applied. This information is used to disengage the Cruise control and PTO functions. This signal is also used for ECM control of the Vehicle Retarder and exhaust brake enabling. The brake signal will also interrupt the Cold Ambient Protection feature and will reset the time interval for the Idle Shut Down feature.

Service Brake Switch Input – The service brake switch is monitored by the Electrical System Controller (ESC). When the switch changes state, the change is detected by the ESC and relayed over the Drive Train Data Link to the ECM. Stuck, open, or shorted brake switches will be detected by the ESC.

Diagnostics – If a function that requires a brake switch input does not respond correctly, use Cab Electronics Diagnostic software to monitor brake switch input to the ESC. If the switch does not change when the pedal is depressed, diagnose the brake switch circuits using the S08250 - Electrical Troubleshooting Guide - 4200/4300/4400. If the ESC is receiving the brake switch input, use the electronic engine diagnostics software (Master Diagnostics) to view the brake switch state. If the switch state does not change, verify communications exist between the ECM and the ESC (does ECM respond to other ESC inputs). If the switch state does change, verify other conditions do not exist that would stop or delay the reaction to the brake switch status.

NOTE – Refer to S08250 - Electrical Troubleshooting Guide - 4200/4300/4400.

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CAMSHAFT POSITION SENSOR (CMP)

Signal Functions

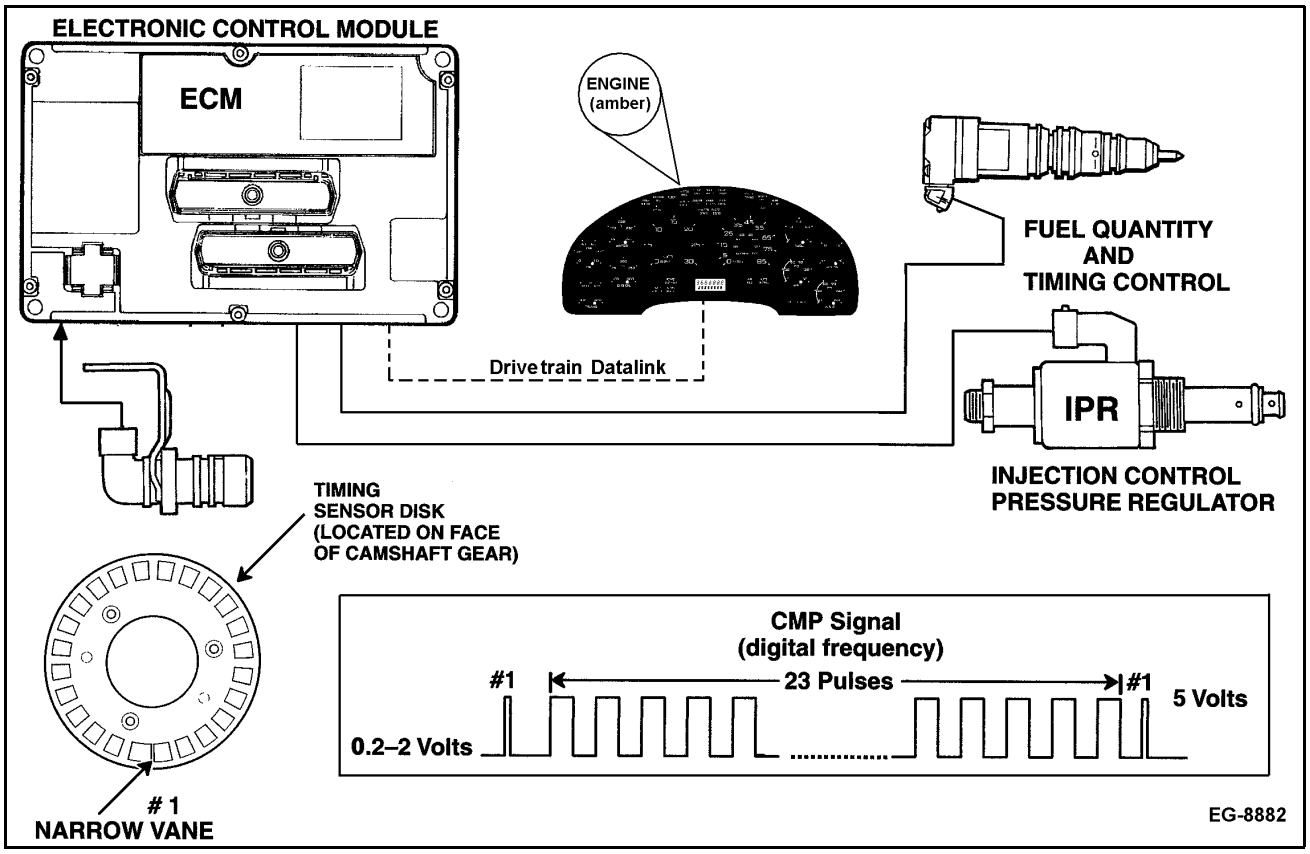

Figure 96 Camshaft Position Sensor Functions

The CMP (Camshaft Position) sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through its magnetic field. Engine speed is determined by counting 24 windows on the timing sensor disk each camshaft revolution. The position of cylinder 1 is determined by distinguishing a narrow vane on the camshaft timing sensor disk.

Engine Mode Selection - Allows the ECM to discern when the engine is in the off, crank or run mode.

Injection Control Pressure - Engine speed is one of the controlling variables in the calculation of desired injection control pressure.

Fuel Quantity Control/Torque Limiting - Engine torque and fuel is controlled and is dependent on engine speed. Fuel quantity is determined by engine speed.

Fault Detection / Management

An inactive CMP signal during cranking is detectable by the ECM. An inactive CMP signal will cause a no start condition. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding Diagnostic Trouble Code will be set.

NOTE – The engine will not operate without a functioning CMP

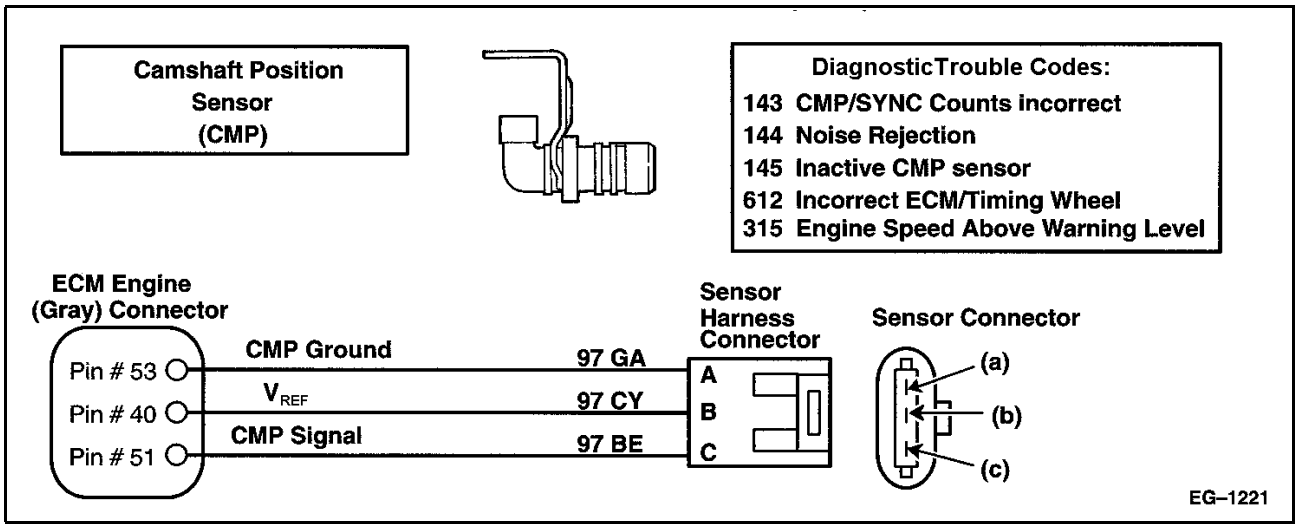

Figure 97 Camshaft Position Sensor Circuit Diagram

NOTE – After removing connectors always check for damaged pins, corrosion, loose terminals.

Table 54 Camshaft Position Sensor and Circuit Diagnostics

Connector Voltage Checks (check with sensor connector disconnected, ignition key ON, all accessories off)		
Test Points	Spec.	Comments
A to gnd	0V	Ground circuit, no voltage expected.
B to gnd	5V ± 0.5	V_{REF} not present, check open/short to ground Pin #40 to B, see V_{REF} circuit (a defective EOP, ICP or MAP sensor can short V_{REF} to ground).
C to gnd	5V ± 0.5	If < than 4.5V check for poor connection, if 0V check for open/short to ground circuit.
Connector Checks to Chassis Ground (check with sensor connector (406) disconnected, positive battery cable disconnected and ignition key OFF)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key off, > than 5Ω the harness is open.
B to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground.
C to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground.
Harness Resistance Checks (check with breakout box installed on engine harness only with ignition key Off)		
Test Points	Spec.	Comments
53 to A	<5Ω	Resistance from harness connector to 60 pin connector - Signal ground (CMP) has dedicated ground circuit, > 5Ω indicates an open circuit.
40 to B	<5Ω	Resistance from harness connector to 60 pin connector - V_{REF}.
51 to C	<5Ω	Resistance from harness connector to 60 pin connector - CMP signal.
Test Points (+) #51 to (–) #53		**Operational Voltage Checks** (check with breakout tee installed in line with the ECM and ignition key ON)
Voltage	Position	Comments
5V ± 0.5	Vane	With the breakout tee or breakout box installed, the CMP sensor & ECM connected, bar engine by hand.
0.2V to 2V	Window	The CMP signal voltage should change voltage state as timing wheel on cam is rotated.
Continued on Next Page		

Table 54 Camshaft Position Sensor and Circuit Diagnostics (cont.)

Diagnostic Trouble Code Description
612 = ECM / target disk mismatch detected (wrong ECM Programming Installed).
315 = Engine rpm exceeded 3000 rpm.
143 = Incorrect number of sync to transition counts detected, possible intermittent CMP sensor/circuit.
144 = Electrical noise detected, check wire routing and grounds.
145 = Inactive CMP signal detected during engine cranking when ICP pressure was sufficient for starting.

Extended Description

Function

The International engine control system includes a Camshaft Position Sensor (CMP). This sensor provides the Electronic Control Module (ECM) with a signal that indicates camshaft position and engine speed.

The CMP sensor signal is used by the ECM to synchronize piston position to injector firing sequence. The injector firing order sequence begins when the ECM detects the narrow vane on the timing disk indicating the position of number 1 cylinder. Engine position for each cylinder is then continuously calculated as each vane on the timing disk passes by the CMP sensor. This information is processed by the ECM and used for injection timing and fuel delivery control. The ECM can then initiate the beginning of firing.

Operation

The Camshaft Position Sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through the magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allows the ECM to detect engine speed and position. When the narrow vane passes the CMP sensor, the signal on time is less than when the other vanes pass the sensor. This produces a signal that the ECM uses to indicate engine position.

Engine speed is detected by the ECM by counting the frequency of the 24 signal pulses for each camshaft revolution.

ECM Diagnostics

Once the ECM has recognized the narrow vane (wide window) it will synchronize the engine firing order to the timing of the CMP signal. Every 2 crankshaft revolutions it will verify that synchronization. If the ECM receives too many or too few pulses for the number of engine revolutions, it will set a Diagnostic Trouble Code.

The engine will not operate without a functioning CMP signal. However, the ECM will attempt to determine the cause of an invalid signal and identify it with a Diagnostic Trouble Code. CMP codes that are set will become inactive codes if the key is turned off.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 143

ATA Code, SID 21, FMI 2

Incorrect Number of CMP Signal Transitions per Cam Revolution

Code 143 indicates the ECM has received CMP signals with the wrong number of transitions. This indicates that the ECM has counted the voltage transitions and found less than the specified number of pulses from the sensor. When this problem is continuous, the engine will stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not turn the amber ENGINE lamp on.

Possible causes for code 143: Intermittent CMP signal caused by a intermittent circuit, defective Camshaft Position Sensor or incorrect CMP sensor to timing disk clearance.

Diagnostic Trouble Code 144

ATA Code, SID 21, FMI 2

CMP Signal Noise Detected

Code 144 indicates that the ECM has detected voltage spikes or transitions other than the CMP signal. If this problem is continuous, the engine could stop running and the ECM will log an active code. If the key is shut off, the code will become inactive. This code will not turn the amber ENGINE lamp on.

Code 144 may be due to: Poor ground connections for CMP or other electronic components. Wire harness shielding missing or incorrectly installed on the engine harness. Outside components that could induce voltage signals.

Diagnostic Trouble Code 145

ATA Code, SID 21, FMI 12

CMP Signal Inactive while ICP has Increased

Diagnostic Trouble Code 145 indicates that the ECM does not detect a CMP signal. This code would be set if the engine was rotating and the ECM detected a rise in ICP pressure, but did not detect a CMP signal. To set this code the engine must be rotated long enough for the ICP pressure to increase. When this code is set, the engine will not operate.

Possible causes for Diagnostic Trouble Code 145: V_{REF} shorted to B+, defective CMP sensor, faulty sensor circuitry or improper air gap between sensor and camshaft timing disk.

Diagnostic Trouble Code 612

ATA Code, SID 21, FMI 7

Incorrect ECM Installed for CMP Timing Disk

When code 612 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 612 indicates that the ECM has monitored the CMP signal and the signal is incorrect for the programming in the ECM. This means that the ECM does not recognize the signal generated from the timing disk and CMP sensor.

Possible causes: ECM has been accidently replaced with an incorrect ECM for the particular engine application. For example, the timing disk for the I-6 and the V-8 (T 444E) are dissimilar, with each generating a distinctive signal. The ECM from the V-8 (T 444E) engine will not run an I-6 engine and vice-versa. Incorrect signal due to a defective CMP sensor or incorrect air gap between the CMP sensor and the timing disk.

Diagnostic Trouble Code 315

ATA Code, PID 190, FMI 0

Engine Speed Above Warning Level

When code 315 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 315 indicates that the ECM has detected an engine speed above 3000 rpm. The most likely cause of the excessive engine speed is an unintended down shift, steep acceleration down a hill without correct brake application or an external fuel source being ingested into the air intake system. The engine hours and miles on the last two overspeed occurrences will be recorded in the Engine Event Log.

CHANGE OIL DISPLAY

Signal Functions

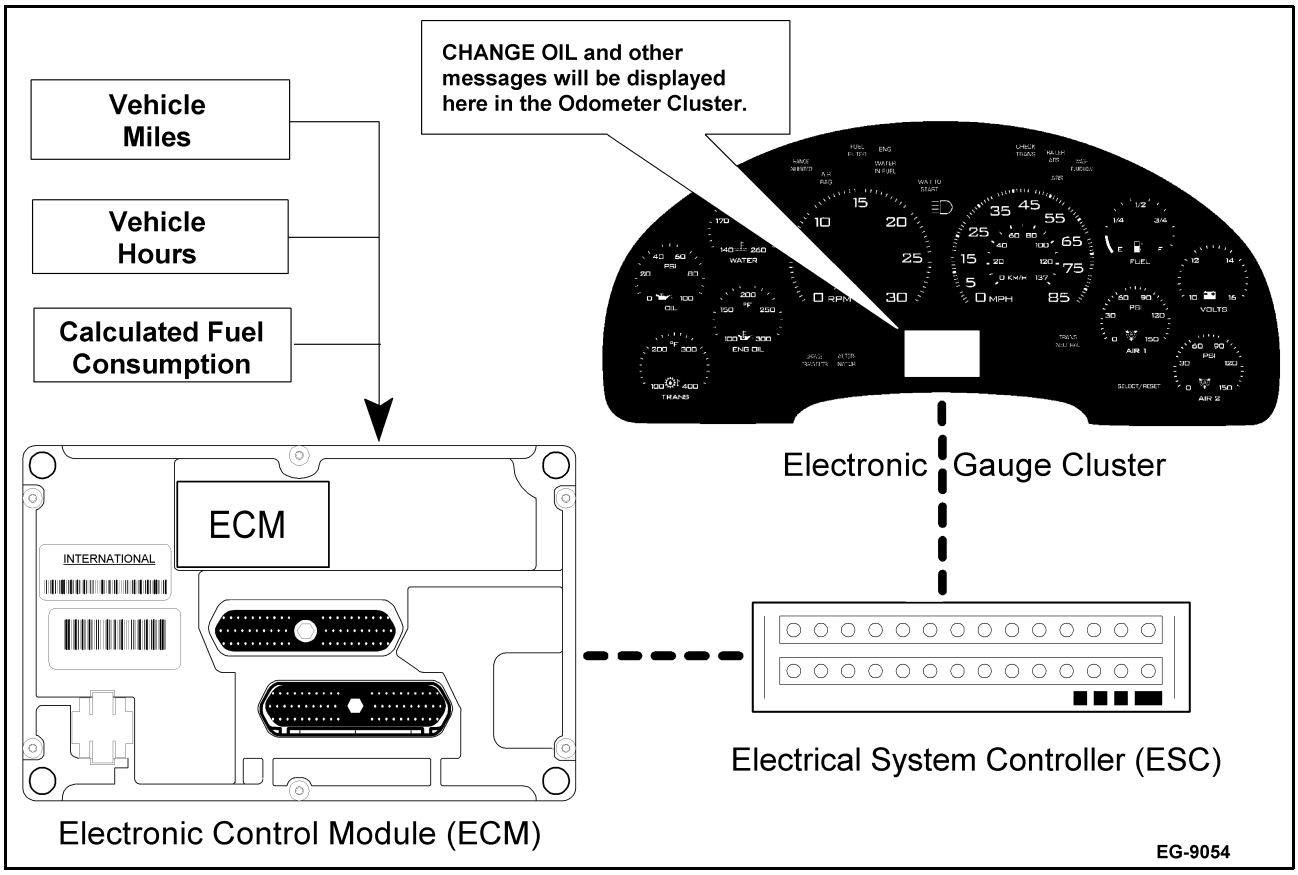

Figure 98 Function Diagram for Change Oil Message

The Change Oil message will be displayed when a customer programmable service interval has been exceeded. These limits may be set for vehicle miles, hours, or calculated fuel consumption. These service interval limits may be adjusted or the Change Oil message feature may be turned on or off using the EST tool.

Fault Detection / Management

There is no fault detection for the Change Oil message feature.

Reset Change Oil Message

NOTE – After changing the engine oil, if the vehicle utilizes the Change Oil Message feature, reset the system as follows:

1. Set parking brake (required for correct ESC signal).
2. Turn key switch to the IGN/ON position.
3. Depress and release both the Cruise On and Resume/Accel buttons simultaneously **four times (4)** times. This step 3 sequence must be performed within a **six (6)** second interval.

4. Depress and hold both the **CRUISE ON** and **RESUME/ACCEL** buttons simultaneously for **three (3)** seconds

5. Release both Cruise buttons.

NOTE – The entire sequence MUST BE completed within twelve (12) seconds. The Change Oil Message will now turn off and will reactivate when the next oil change is due.

Extended Description

Service Interval Limits

This group of parameters customizes the Service Interval feature. Service Interval allows the vehicle owner to customize when his vehicle requires servicing as in changing oil. When the programmed distance or engine hour has been reached, the Change Oil Message will be displayed to indicate its time for maintenance and service.

The limits listed below are the maximum and default values for the service internal function. Through the use of the EST tool these limits can be adjusted downward for specific customer needs, but not above the recommended factory service interval.

- **Service Interval Mode**

  This parameter indicates to the on-board electronics if this vehicle has the service interval feature.

- **Fuel Interval**

  This parameter allows the customer to program the amount of fuel used since the last service before displaying the Change Oil Message.

- **Hour Interval**

  This parameter allows the customer to program the amount of Engine Hours since the last service before displaying the Change Oil Message.

- **Distance Interval**

  This parameter allows the customer to program the amount of Distance miles/kilometers since the last service before displaying the Change Oil Message.

- **Fuel Used Starting Value**

  This parameter indicates when the last service was performed.

- **Engine Hour Starting Value**

  This parameter indicates when the last service was performed.

- **Vehicle Distance Starting Value**

  This parameter indicates when the last service was performed.

- **Service Soon Percent**

  This parameter indicates at what percentage of the service intervals should the Change Oil Message begin to flash as a warning.

- **Change Oil Message On Mode**

  This parameter indicates if the Change Oil Message is to be always ON after an engine start.

- **Change Oil Message ON Mode**

  This parameter indicates how long to activate the Change Oil Message after an engine start if it is not always ON.

- **Service Interval Reset Request**

  This parameter indicates to the on-board electronics if the vehicle has been serviced and the starting values are to be reset.

CONTROLLER AREA NETWORK COMMUNICATIONS

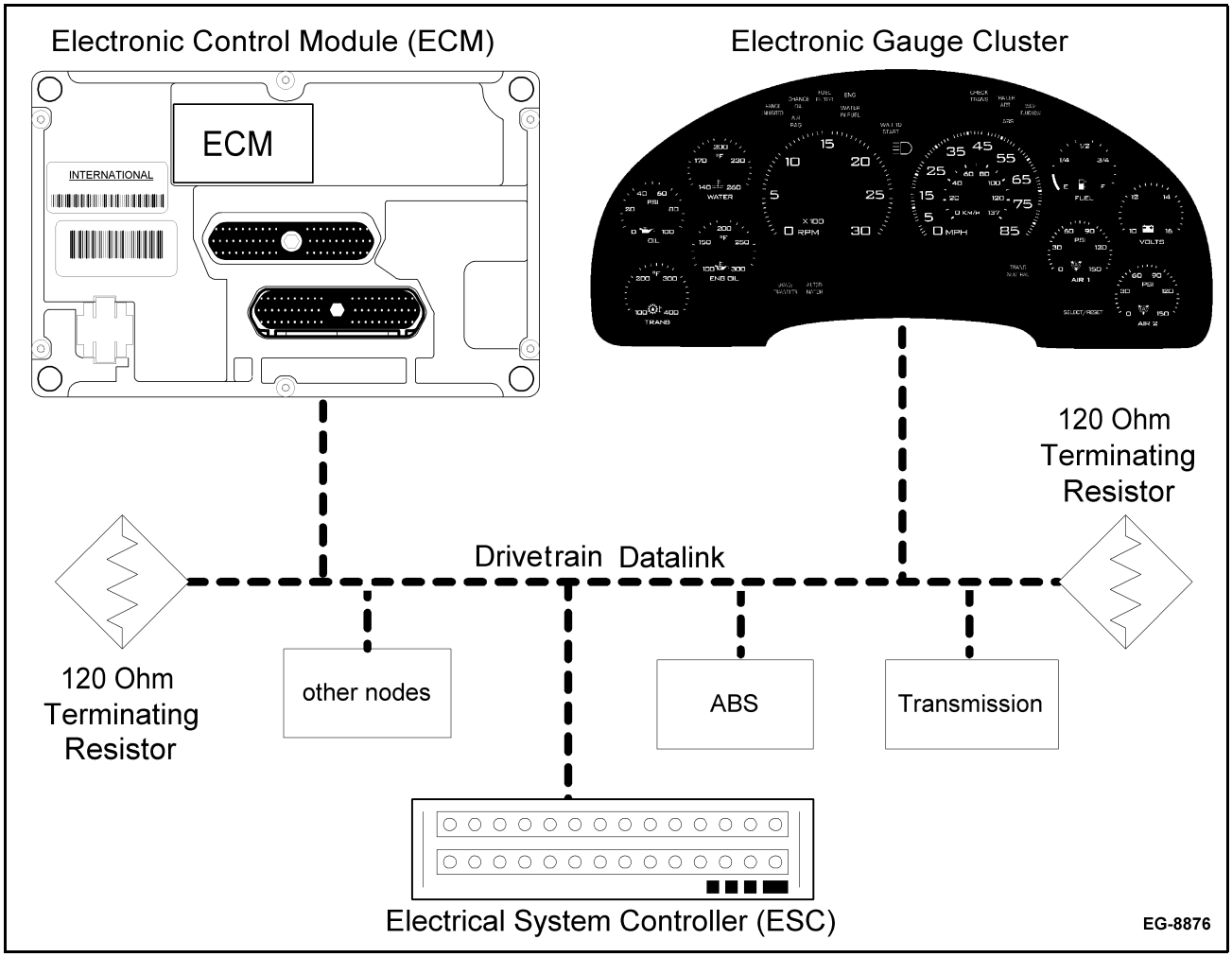

Figure 99

Drive Train Data Link - is a Society of Automotive Engineers (SAE) designation for one of the common truck data links. It is now commonly used for power train communications and control. The Drive Train Data Link (includes the ECM, ESC and the instrument cluster) will be the primary communications link between the ECM, ESC and the instrument cluster.

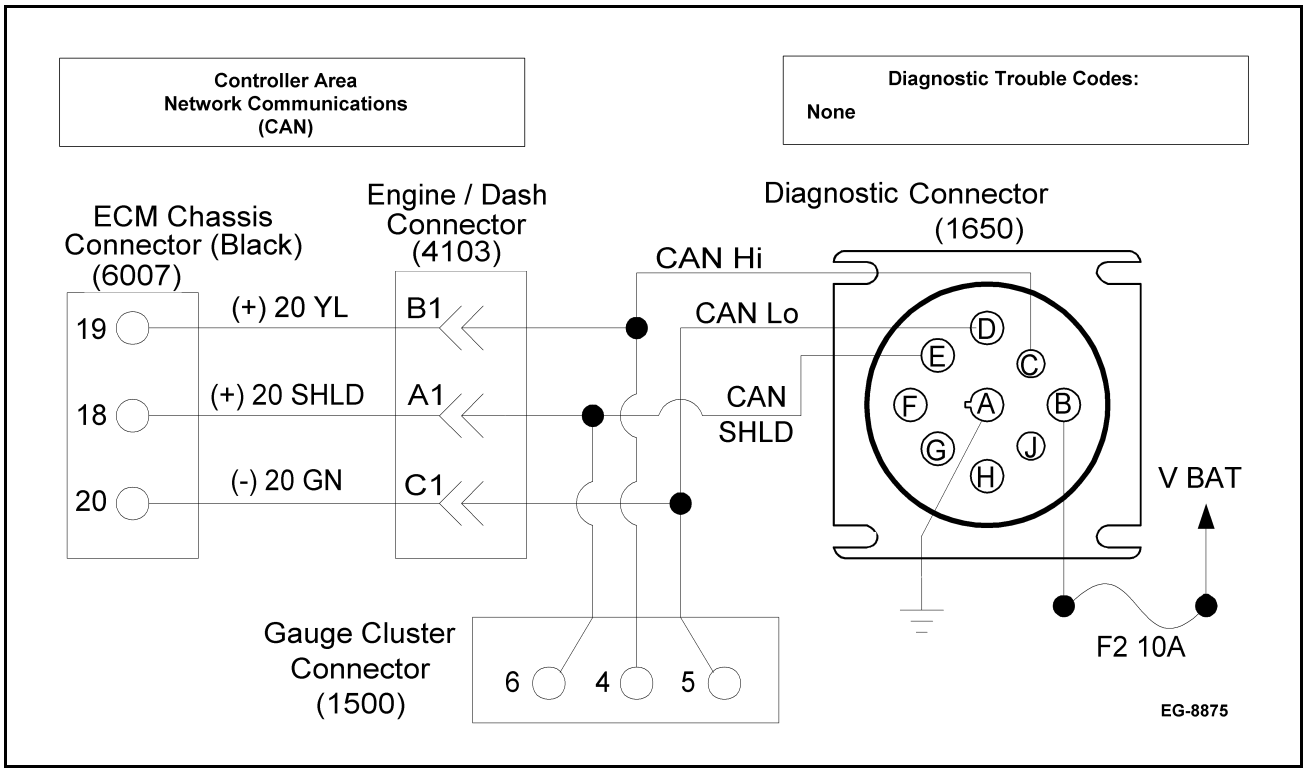

Figure 100 Communications Circuit Diagnostics

Table 55 Communications Circuit Diagnostics

Key On Engine Off - Voltage Checks at EST Connector			
Test Point	Spec.	Signal	Comments
B to A	B+	Power	Should be 12V power at B at all times. If no power, check ground and power circuits (F2).
C to A	C+	Power	Should be between 2V - 7V.
Key Off Resistance Checks at EST Connector			
Test Point	Spec.	Signal	Comments
C to D	60Ω	CAN	The datalink has two terminating resistors in parallel of 120Ω each. If >70Ω, check for missing terminating resister or open in the CAN (+) or CAN (-) wires. If <50Ω but >5Ω, check for extra terminating resistor. <5Ω indicate short between CAN (+) and CAN (-).
C to E	>1MΩ	CAN (+)	<1 MΩ indicates a short between CAN(+) and CAN(SHLD). Disconnect ECM and try again. If short no longer exists, replace ECM. If short still exists, harness or other node component is bad.
D to E	>1MΩ	CAN (-)	<1 MΩ indicates a short between CAN(+) and CAN(SHLD). Disconnect ECM and try again. If short no longer exists, replace ECM. If short still exists, harness or other node component is bad.

Engine Controller Diagnostics

All Engine Control Module diagnostics are communicated though an Electronic Service Tool (EST) such as MD software on the ATA (J1708) Data Link. (See ATA Communications, Data Communications Link, page 188).

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

Extended Description

Dashboard Information - Information transmitted from the engine controller is received by the instrument cluster via data link. Functions updated on the instrument cluster by the engine include:

- Oil Pressure Gauge
- Engine Oil Temperature Gauge
- Tachometer (Engine Speed)
- Speedometer (Vehicle Speed)
- Odometer
- Coolant Temperature Gauge
- Coolant Level Lamp
- Engine Red Lamp (Stop)
- Engine Amber Lamp (Warning)
- Change Oil Message
- Cruise Lamp

A number of features other than odometer are available from the engine controller on the cluster LCD such as:

- Engine Hours
- PTO Hours
- Fuel Economy

Multiplexing - The status of the following switches are communicated from the ESC to the ECM using the drive train data link:

- Cruise Control ON/OFF Switch (COO)
- Cruise Control Set/Cruise Switch (SCS)
- Cruise Control Resume/Accelerate Switch (RAS)
- Cruise Control Clutch Status
- Brake Pedal Status
- Exhaust Brake ON/OFF Switch
- Two Speed Axle Switch (TSA)

Two other ESC outputs are sent to the ECM using the drive train data link:

- AC Demand (Fan request)
- Self Test Input

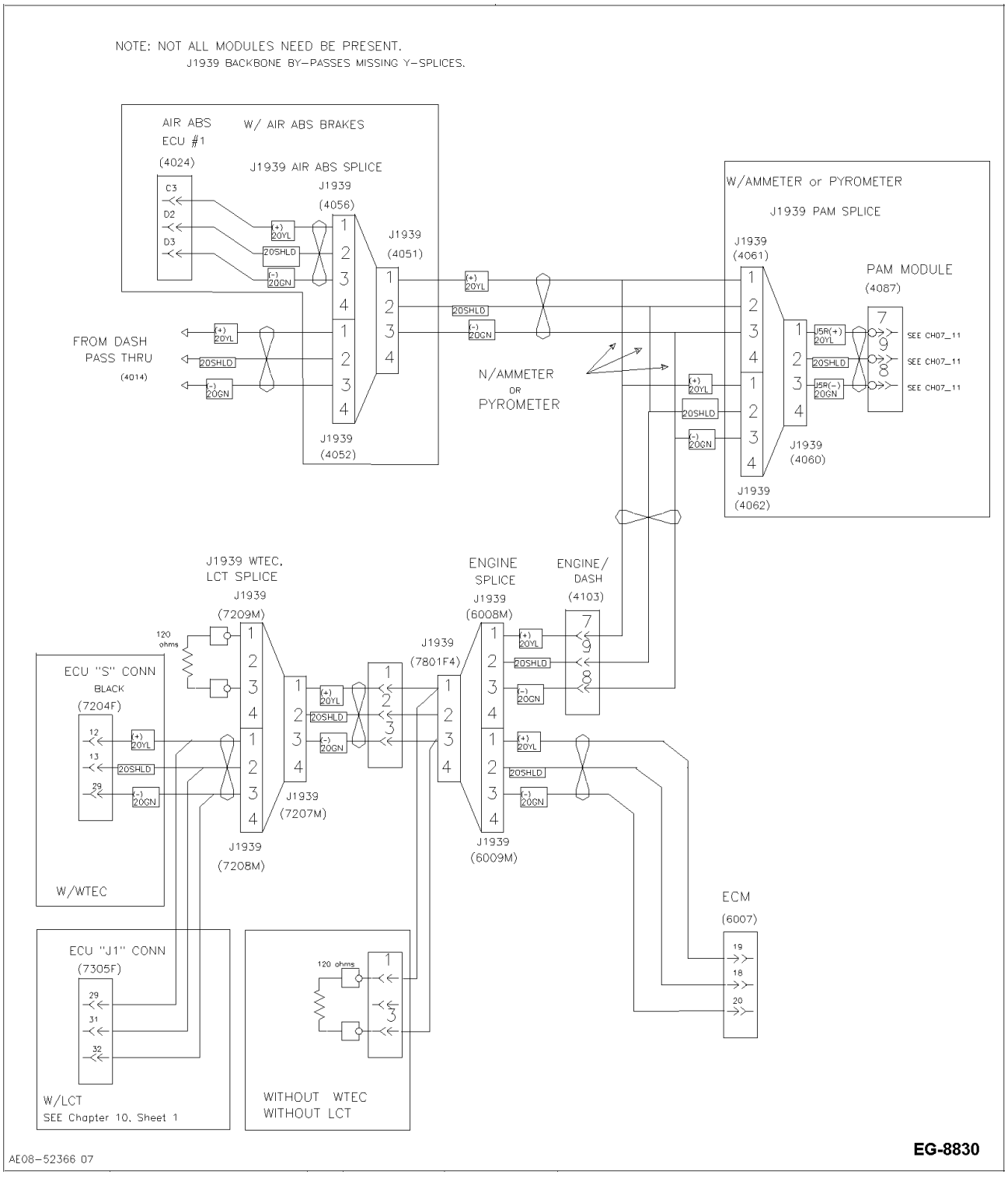

Figure 101 Drive Train Data Link (chassis)

DIAGNOSTIC TROUBLE CODE ACCESS

Signal Functions

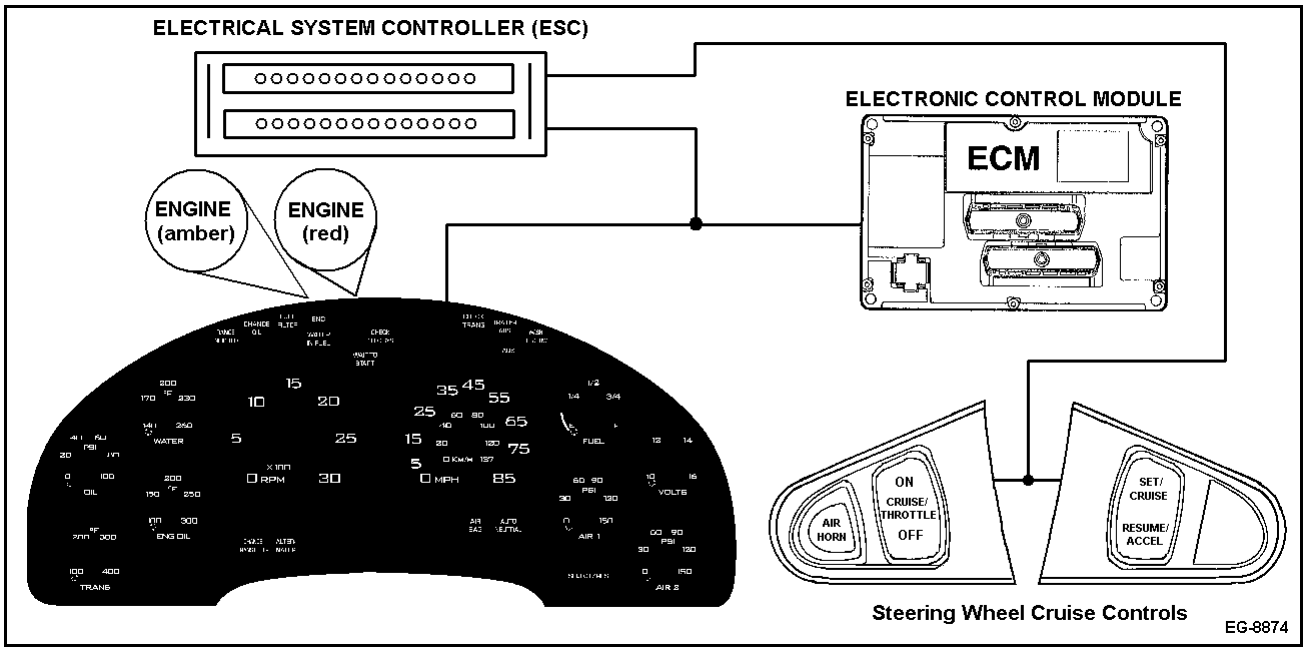

Figure 102 Diagnostics Mode Function Diagram

Diagnostic Trouble Codes

The Cruise Control switches mounted in the steering wheel can be used to cause the ECM to display the active and inactive Diagnostic Trouble Codes through the red and amber ENGINE dash lamps. If no codes are detected the code 111 will be flashed (indicates no codes are detected).

Fault Detection Management

The ECM does not monitor the red and amber ENGINE LAMP system for faults. There are no Diagnostic Trouble Codes for the lamp system.

When the key switch is turned ON, the amber ENGINE lamp turns ON and stays ON, while the ECM runs normal start-up tests, and then turns OFF. If the ECM detects a problem, the amber ENGINE lamp remains ON.

To display Diagnostic Trouble Codes without the aid of the Electronic Service Tool:

1. Set the parking brake and turn the ignition key to the ON position.

2. Press and release the **CRUISE ON** button and the **RESUME/ACCEL** button simultaneously. If no faults are present, the cluster odometer will display NO FAULT.

3. Turning the Ignition Key OFF will take the ESC and the gauge cluster out of the Diagnostic Mode.

NOTE – The Key-On Engine-Off Standard Test and the Output Circuit Check can be performed by following the steps below.

Key-ON Engine-OFF Standard Test and Output Circuit Check (OCC) Procedure

A. Set park brake (required for correct ESC signal).

B. Turn ignition key to the ON position.

C. Press and release the CRUISE ON and the RESUME/ACCEL buttons simultaneously two (2) times within three (3) seconds.

D. Standard Test will run and codes will flash.

To read the Diagnostic Trouble Codes (DTC) use the following method:

A. The red ENGINE lamp will flash once to indicate the beginning of **Active** DTC's.

B. The amber ENGINE lamp will flash repeatedly signaling active DTC's.

C. Count the flashes in sequence. After each digit of code a short pause will occur. For example **three flashes** and a pause would indicate number 3. **Two flashes**, a pause, **three flashes**, a pause, and **two flashes** and a pause would indicate Diagnostic Trouble Code **232**. If there is more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

NOTE – All DTC's are three digits. Diagnostic Trouble Code 111 indicates no DTC's have been detected.

After all active DTC's have flashed, the red ENGINE lamp will flash twice to indicate the start of **INACTIVE** DTC's. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once between each DTC. After all DTC's have been sent, the red ENGINE lamp will flash three times indicating END OF MESSAGE.

To repeat the DTC transmission, repeat the above procedure by depressing both Cruise Control buttons. The ECM will transmit the stored DTC's.

NOTE – If DTC's are set, see Electronic Control System Diagnostics (See Table 48, page 162).

Clearing Inactive Diagnostic Trouble Codes

A. Set park brake (required for correct ESC signal).

B. Turn keyswitch to the IGN/ON position.

C. Depress & hold the CRUISE ON and RESUME/ACCEL buttons simultaneously.

D. Continue holding the Cruise buttons. Depress and release the accelerator pedal three (3) times within a six (6) second interval.

E. Release both Cruise buttons.

F. Inactive codes cleared.

The Diagnostic Trouble Code procedure will also command other electronic controllers to perform their diagnostic routines. Clearing Diagnostic Trouble Codes in other electronic controllers requires different procedures.

After all repairs have been made, the ESC Diagnostic Trouble Codes can be cleared by putting the key switch in the accessory position, turning on the left turn signal, and pressing the CRUISE ON and RESUME/ACCEL buttons simultaneously.

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ENGINE CRANK INHIBIT SYSTEM (ECI)

Signal Functions

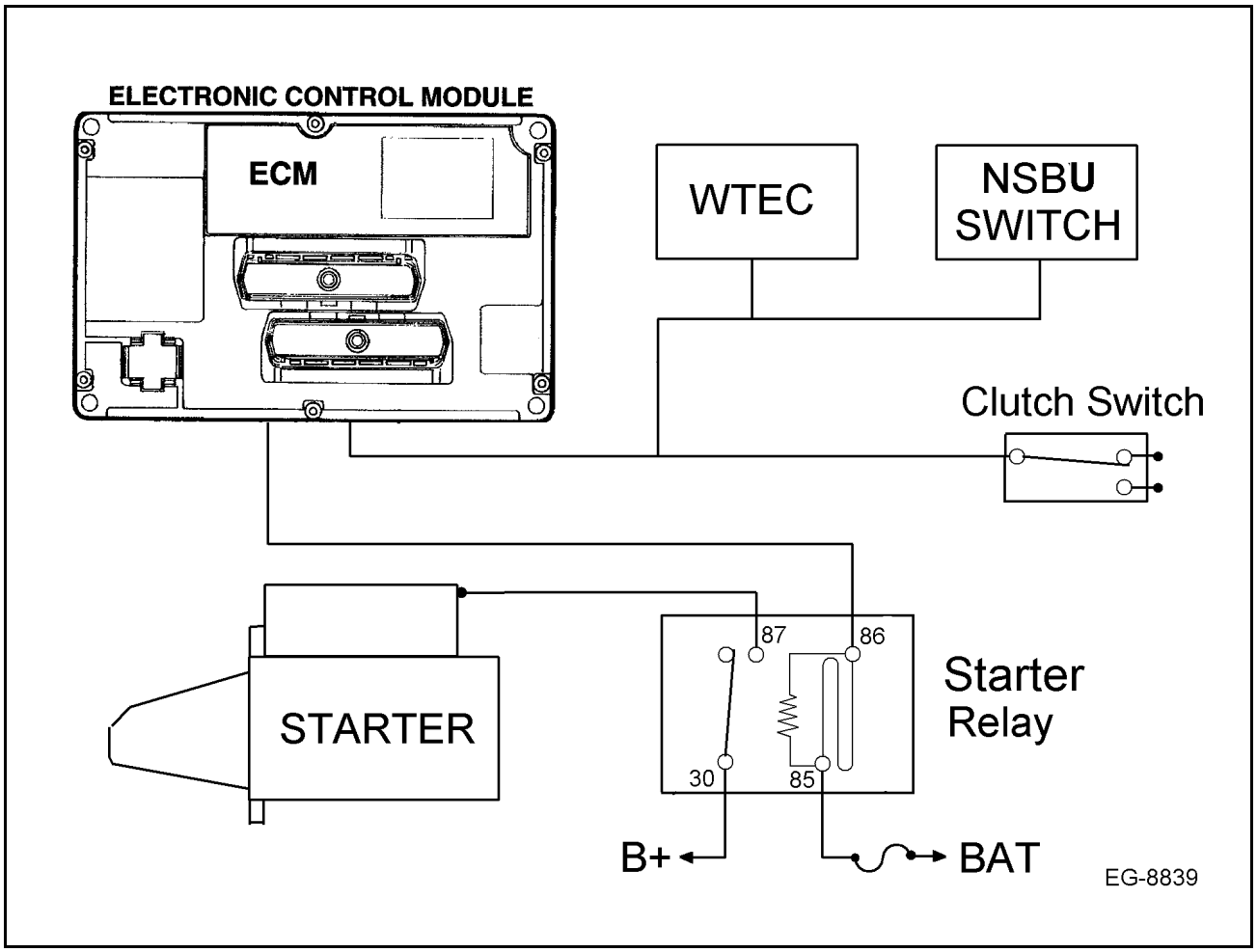

Figure 103 Engine Crank Inhibit Function Diagram

Engine Crank Inhibit Functions

The Engine Crank Inhibit feature of the ECM is used to control the operation of the cranking motor. The ECM prevents the cranking motor from being engaged when the engine is running. The transmission neutral safety switch or clutch switch will prevent the cranking motor from being engaged when the transmission is in gear or when the clutch pedal is not depressed.

Engine Crank Inhibit Relay

The engine starter relay is used to relay battery voltage to the crank motor solenoid. The relay is also controlled by an over crank thermocouple, if so equipped.

Fault Detection / Management

The ECM does not monitor the cranking system circuits. There are no Diagnostic Trouble Codes for this system.

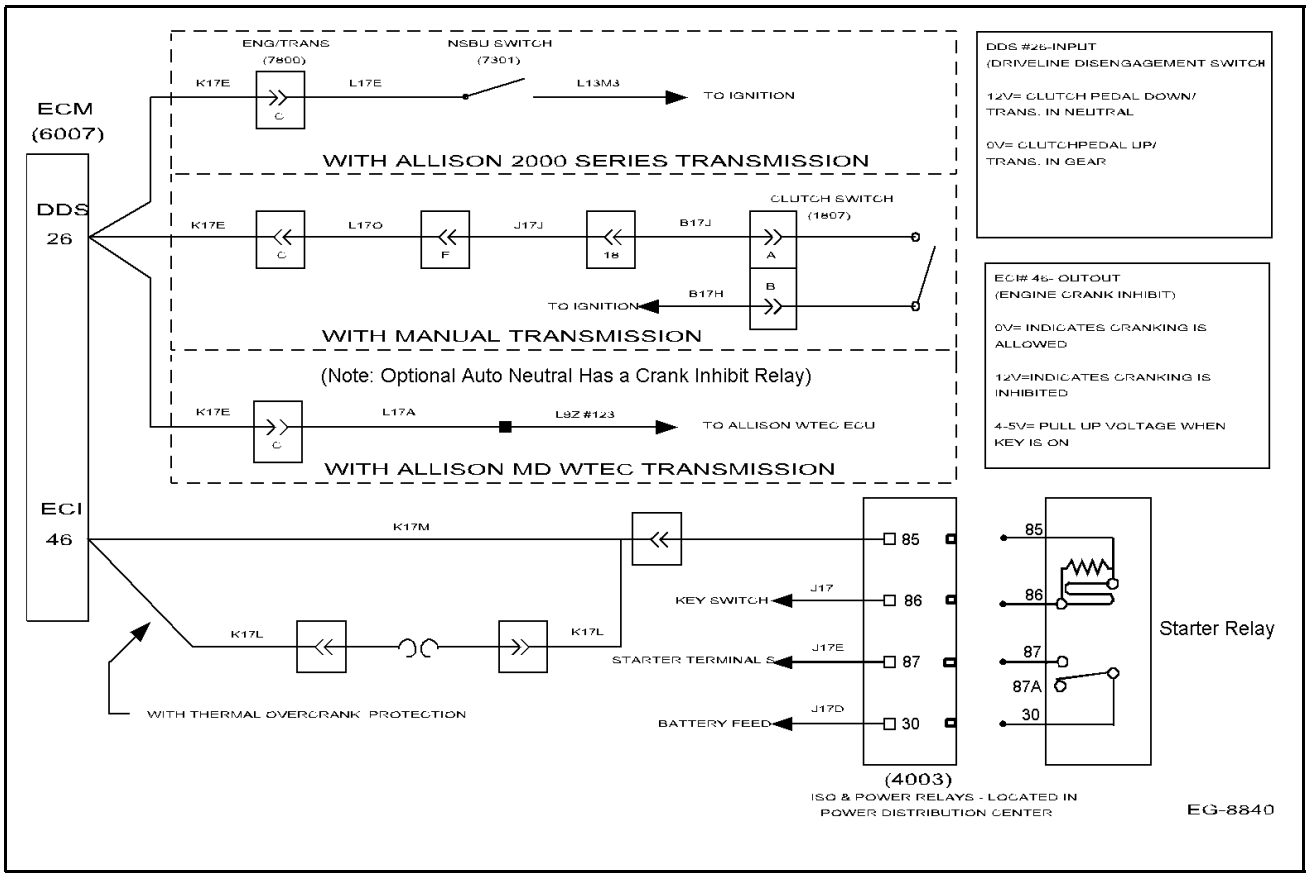

Figure 104 Engine Crank Inhibit Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

NOTE – Before testing starter relay or cranking circuits, verify that the batteries are fully charged. Check battery connections at the battery, frame and starter. See S08256 for battery and starter test procedures.

Table 56 Starter Relay Diagnostics

ECI Relay Voltage and Resistance Checks - With ECI Relay Removed.		
Test Points	Spec.	Comments
86 to gnd	12V ± 1.5	Check with relay unplugged & starter switch (key or button) engaged. If no voltage present, troubleshoot ignition crank circuit.
30 to gnd	12V ± 1.5	If no voltage is present, troubleshoot battery wiring.
85 to gnd	4V to 5V	ECM will pull circuit up to 4V to 5V with key ON and will go to 0V when the clutch is depressed or transmission is in neutral.
ECI Circuit Test- With the trans out of gear and the clutch depressed with wheels safely blocked, insert a jumper wire between socket pins #86 and #87 of the starter relay. If the engine cranks, when the start switch is engaged either the ECI relay is bad or there is a problem with the ECM or ECM wiring harness.		
Continued on Next Page		

Table 56 Starter Relay Diagnostics (cont.)

ECM Chassis (Black) Circuit Checks - Check With All Relays Installed and breakout Box Connected		
Test Points	Spec.	Comments
DDS (+26) to (-23)	0V or 12V	**Manual Trans** - 12V with clutch pedal down, 0V clutch pedal up; **Automatic Trans** - 12V with trans in neutral, 0V trans in gear.
ECI (+46) to (-23)	12V ± 1.5	**At crank w/clutch up or auto trans in gear**, if 12V is present circuit is good, cranking inhibited.
	0V to 0.6V	**At crank w/clutch down or auto trans in neutral,** if ECM pin #26 is at 12V and pin #46 is not at 0V to 0.6V, check ECM programming. Cranking allowed.
	4V to 5V	Pull up voltage from ECM w/key ON, **engine OFF or running**: trans in gear or clutch up.

Extended Description

The engine starting system is controlled by the Electronic Control Module (ECM). This is to prevent cranking motor operation while the engine is running, causing damage to the starter pinion and ring gear. Input from the clutch switch or transmission neutral switch. These switches prevent the cranking motor from being engaged unless the transmission is in neutral or the clutch is depressed.

Start Relay – The engine starter relay controls the current to the starter motor. Turning the ignition key to the start position supplies current to energize the relay at terminal 85. If the engine is not running and the driveline is not engaged the ECM terminal 46 will enable the relay by supplying a ground circuit to terminal 85 of the relay. With the relay closed current can then pass through the relay to terminals the cranking motor solenoid.

Before troubleshooting, inspect circuit connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed. **Make certain that the batteries are fully charged.** Check battery cables and grounds for clean and tight connections free of damage. Voltage readings will not be accurate if the batteries are not fully charged.

Clutch Switch – On vehicles equipped with a manual transmission, the clutch switch is used to supply a signal to the ECM that indicates the driveline is disengaged. A 12V signal on the DDS circuit indicates that the clutch is disengaged (clutch pedal down), a 0V signal indicates that the clutch is engaged (clutch pedal up).

Neutral Switch (Allison 2000 Series Transmissions) – On vehicles equipped with Allison LCT transmissions (2000 series), the neutral position switch is used to supply switched power to the starter relay and provides a signal to the ECM that indicates the driveline is disengaged. On vehicles programmed for Allison AT/MT transmissions, a 12V signal on the DDS circuit indicates that the transmission is out of gear, a 0V signal indicates that the transmission is in gear. When the transmission is in gear no power is available to the ECI relay.

WTEC MD W/Auto Neutral - On vehicles equipped with Allison MD World Transmission Electronically Controlled transmission (WTEC) w/optional Auto Neutral, the crank inhibit system has an additional relay that inhibits cranking. The additional relay is used to inhibit cranking when the transmission is in auto neutral. PIN 6 of the transmission ECU controls 12 volts to pin 86 of the crank inhibit relay. When PIN 86 receives power and the relay closes, IGN voltage is supplied to PIN 86 of the starter relay. PIN 26 of the ECM receives 12 volts from the WTEC Auto Neutral relay whenever the transmission is either shifted in neutral or auto neutral. Without the additional relay the Driveline Disengagement input (PIN 26) would allow cranking in auto neutral.

Electronic Control Module (ECM) – When the ECM recognizes that the engine is not running and the driveline is not engaged the ECM will ground terminal 46. This provides the current path for the Engine Crank Inhibit relay to close when the Start switch is engaged or the starter button is depressed. When the ECM recognizes that the engine is running or the driveline is engaged the ECM will open terminal 46. This will prevent the Engine Crank Inhibit relay from closing thus preventing the starter motor from engaging.

Components of the ECI System are:

- Ignition Switch
- Push Button Start Switch (optional)
- Starter Relay
- Crank Motor and Solenoid
- Batteries and Cables
- Neutral Safety Switch (with Allison 2000 Series Transmissions)

- Clutch Switch (with Manual Transmission)
- Crank Inhibit Relay (Allison MD WTEC w/Auto Neutral)

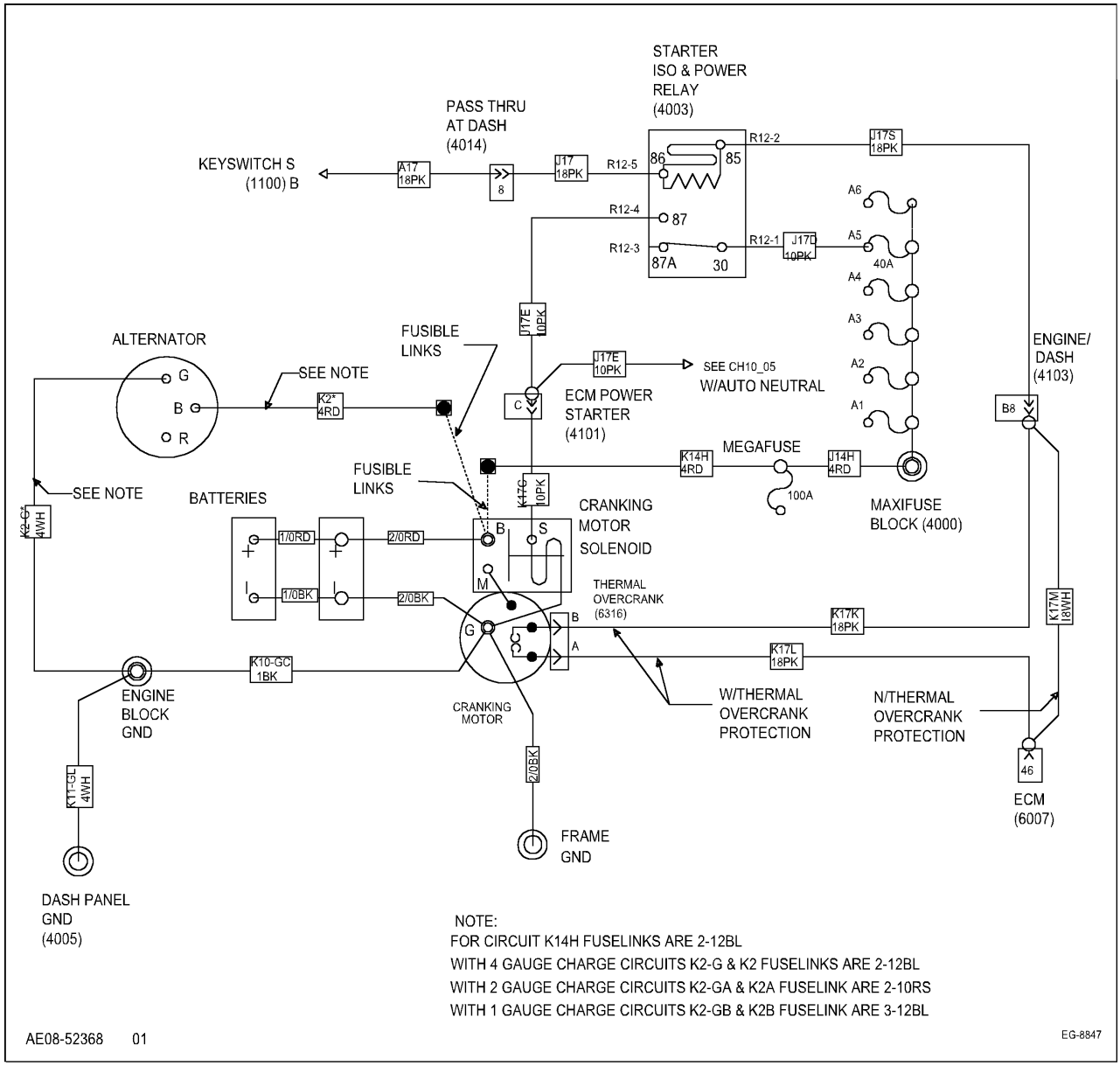

Figure 105 Cranking Circuits

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

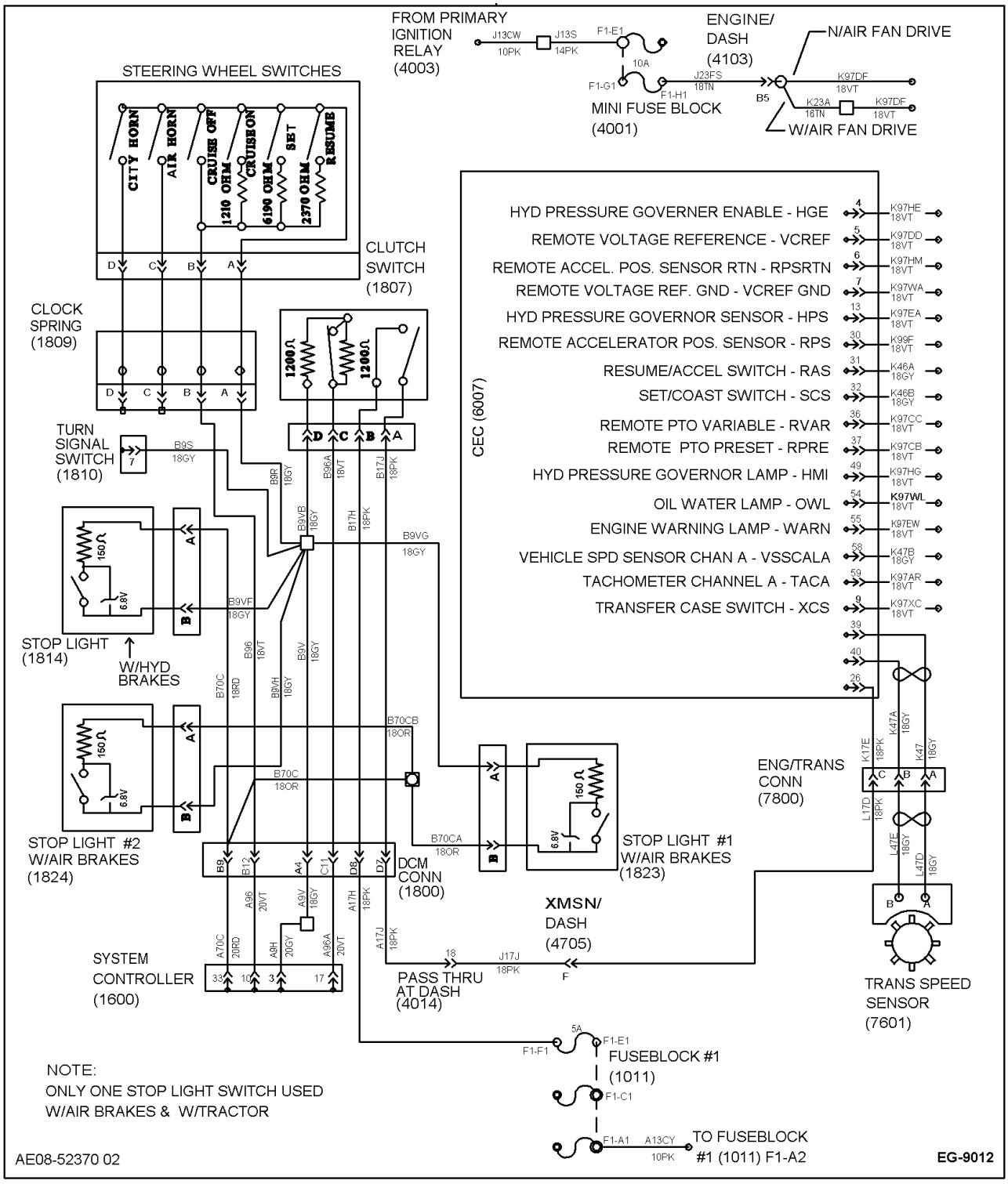

Figure 106 Cranking Circuit Connections with Manual Transmission

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

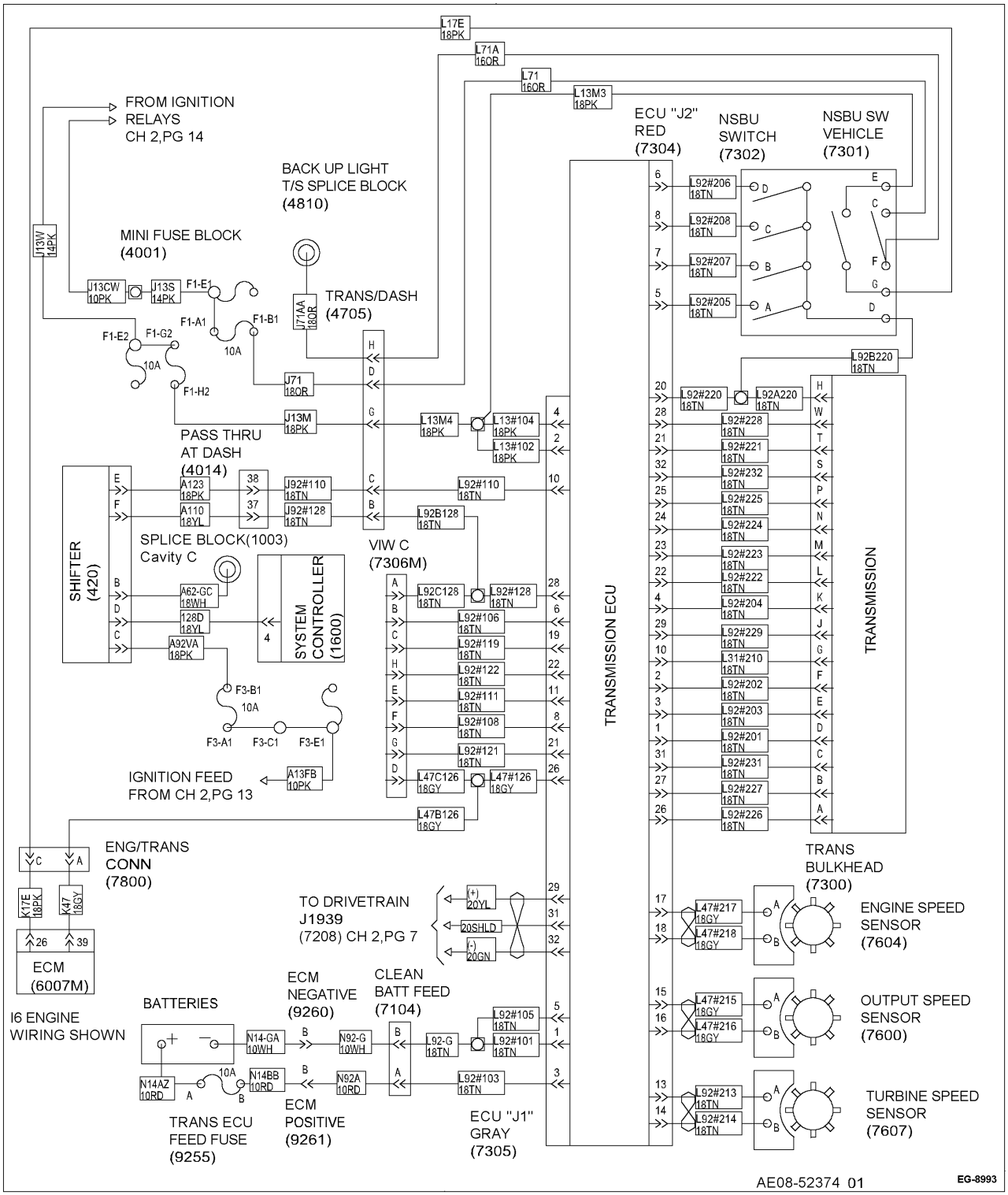

Figure 107 Allison LCT Transmission Driveline Disengagement Input

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

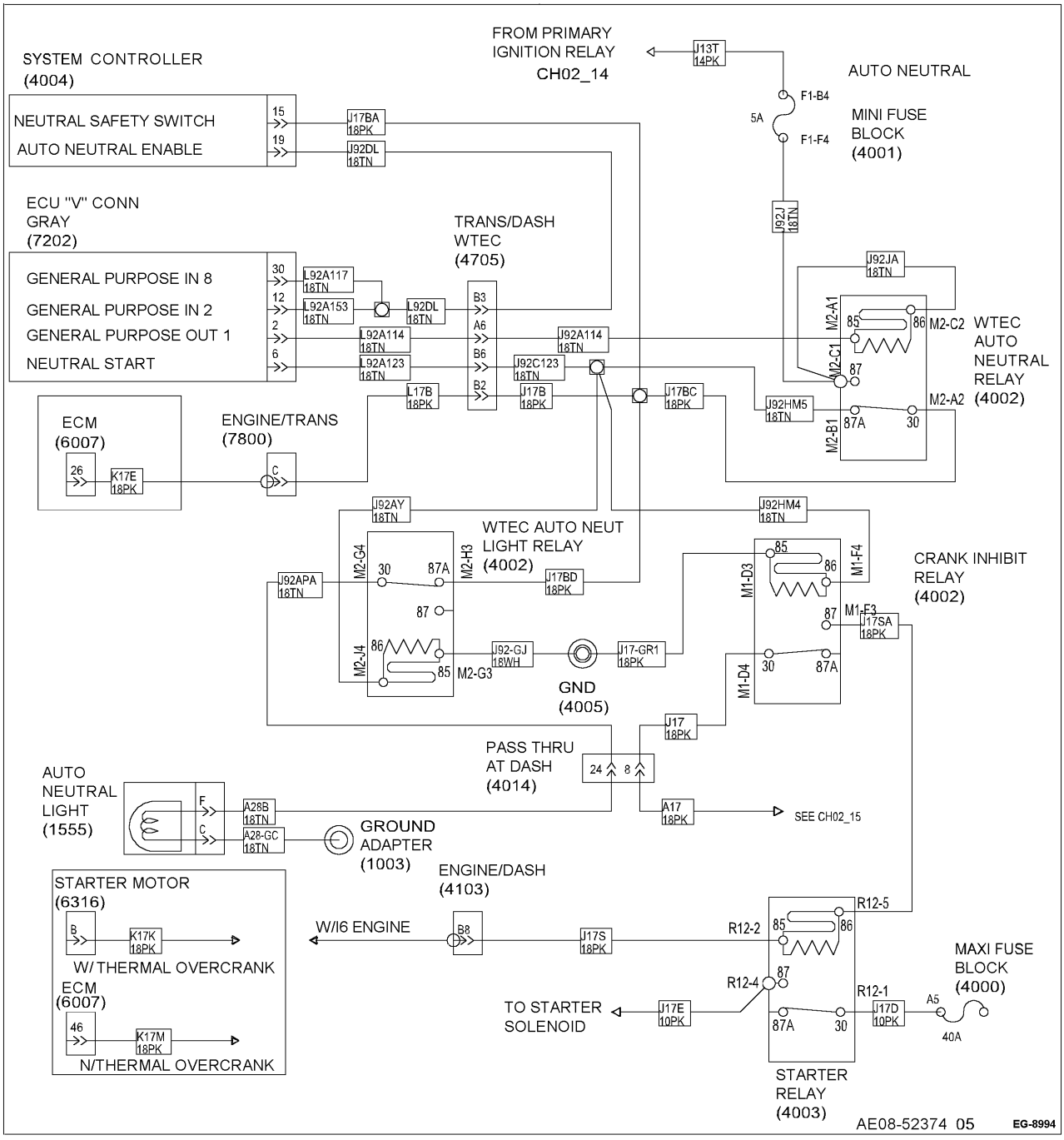

Figure 108 Driveline Disengagement Input WTEC MD or HD w/Auto Neutral

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

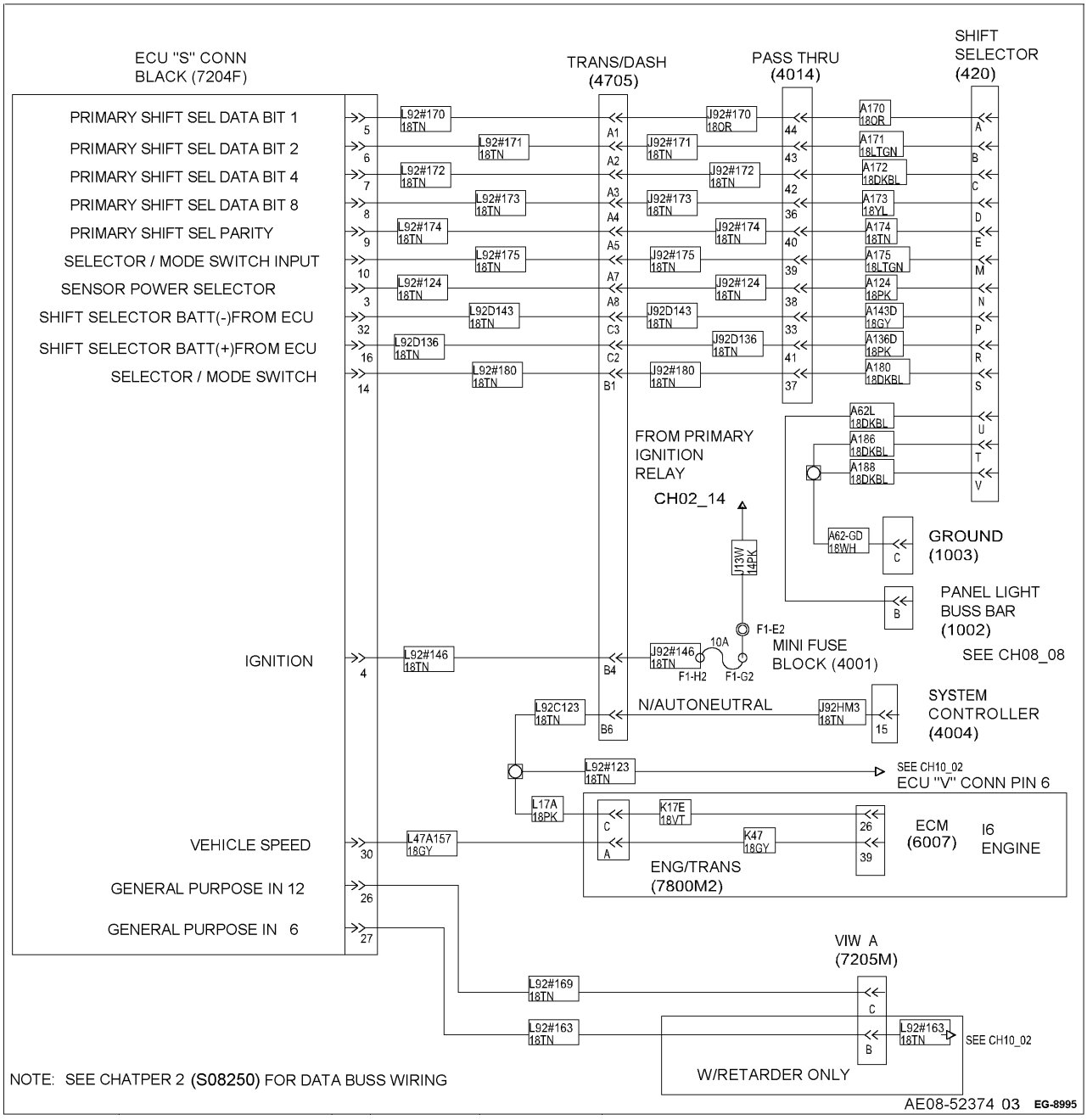

Figure 109 Allison MD Transmission Driveline Disengagement Input

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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ENGINE COOLANT LEVEL SYSTEM (ECL)

Signal Functions

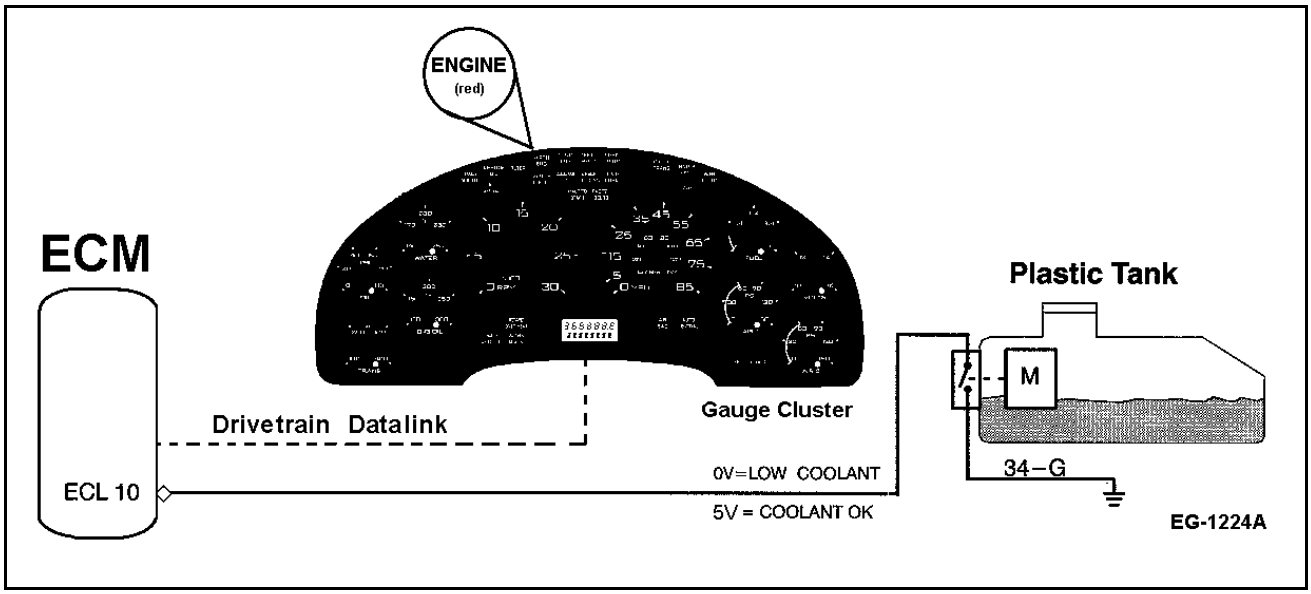

Figure 110 Engine Coolant Level System Function Diagram

The purpose of the Engine Coolant Level monitoring system is to signal the driver of a low coolant situation. Depending on the programming of the control module it is also capable of shutting off the engine to prevent damage to the engine due to low coolant level.

Coolant Level Sensor

A magnetic switch type sensor is used and located in the plastic surge tank. The magnetic switch will be open whenever the coolant level in the tank is full.

Fault Detection / Management

The ECM continuously monitors the ECL circuit for in-range faults. When an in-range fault is detected the Diagnostic Trouble Code 236 will be set. The diagnostic Trouble Code will not cause the warning lamp to be turned on. If the condition is intermittent, the code will be logged as an inactive code. The ECM can not detect opens or shorts in the ECL circuit.

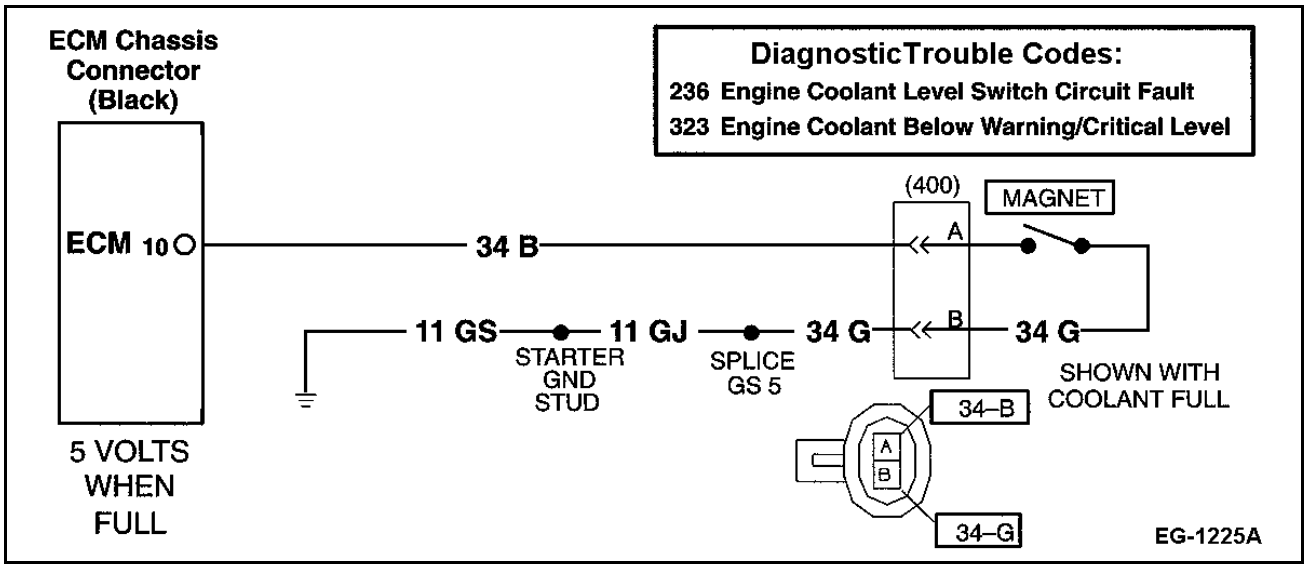

Figure 111 Engine Coolant Level Sensor Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 57 Engine Coolant Level System Diagnostics

All Tests Performed With Coolant Level Full, (plastic tank connector voltage checks)		
Coolant Level Sensor connector (400) removed and ignition switch ON		
Test Points	Spec.	Comments
A to gnd	5V ± 0.5	If <5V, open circuit 34B or defective ECM.
B to gnd	0V	If > 0V, circuit 34G shorted to another circuit.
10 to -42	5V if full	Voltage should be > 4.3V w/ tank full. Voltage should be < 3.4V w/ tank empty (use breakout box).
Connector Resistance Checks (coolant level sensor connector (400) removed, measure across sensor)		
Test Points	Spec.	Comments
(A) to (B)	>1kΩ	Low coolant, defective sensor or shorted sensor harness.
+10 to (A)	<5Ω	If >5Ω signal wire is open (with breakout box installed)
Diagnostic Trouble Code Description		
236 = ECM has detected an open or shorted circuit on the ECL circuit.		
323 = The 5V circuit at pin 10 of the ECM has been pulled to ground indicating low coolant. Check cooling system.		

Extended Description

The Engine Coolant Level sensor is used with the optional Engine Warning And Protection feature. The purpose of the Coolant Level system is to monitor the level of the coolant in the surge tank to protect the engine from damage due to engine operation when the coolant level is low. Since this is an optional feature, the system functions by programming three way warning or three way engine shutdown in the control module.

In either mode when the feature has been enabled and the engine is running, the ECM will cause the red ENGINE lamp to illuminate, an audible warning will sound, and cause the message **OIL/WATER** to be displayed on the odometer. This occurs whenever the coolant level is below the level of the sender in the surge tank. If the system is programmed for engine shut down, the ECM will cause the engine to stop running after the coolant level has been depleted below the coolant level sensor and the programmed warning time has expired. If the engine stops running in this condition, it can be restarted and run again for the warning time period, provided it is capable of restarting.

Coolant Level Sensor

The coolant level sensor uses a floating ball with a magnet and magnetic switch. With the coolant level full, the float will rise and the magnet will pull the level switch open. This will allow for 5V to be present at pin 10 of the ECM. If the level should go low, the switch will close and pin 10 of the ECM would go to 0V. The ECM must be programmed for a plastic tank for this coolant level switch to operate properly.

Programming

CAUTION – Be certain that the ECM is properly programmed for the use of a plastic surge tank.

Coolant level monitoring is a customer programmable feature that may be programmed by the EST using the customer password. Coolant level feature is operational if programmed for three way warning or three way shutdown, however, if not programmed for three way shut down at the factory it will not be possible to enable the shutdown feature. Contact Tech Service or your International dealer to program this feature.

Diagnostic Trouble Code 236

ATA Code, PID 111, FMI 33

ECM: Engine Coolant Level Switch Circuit Diagnostic Trouble Code

Diagnostic Trouble Code 236 will be active when the ECM detects an in-range voltage error in the ECL circuit. Probable causes for this condition are a high resistance connection or intermittent short to ground in the circuit. An in-range Diagnostic Trouble Code will set when the ECM detects more than 3.4V but less than 4.3V at PIN 10 of the Black ECM connector for 2.0 seconds.

Diagnostic Trouble Code 323

ATA Code, PID 111, FMI 33

ECM: Engine Coolant Below Warning/Critical Level

Diagnostic Trouble Code 323 will be active when a low coolant situation is present and the EST will indicate COOLANT LOW. After the coolant has been restored to proper levels, Diagnostic Trouble Code 323 will remain as an inactive code and the ECM will log the engine hours and odometer reading at time of the occurrence.

Troubleshooting

Use the EST to monitor the coolant level on the data list or to retrieve Diagnostic Trouble Codes. Also prior engine events can be retrieved from the Event Log using the EST. This will display the engine hours and odometer reading at which the last two events happened.

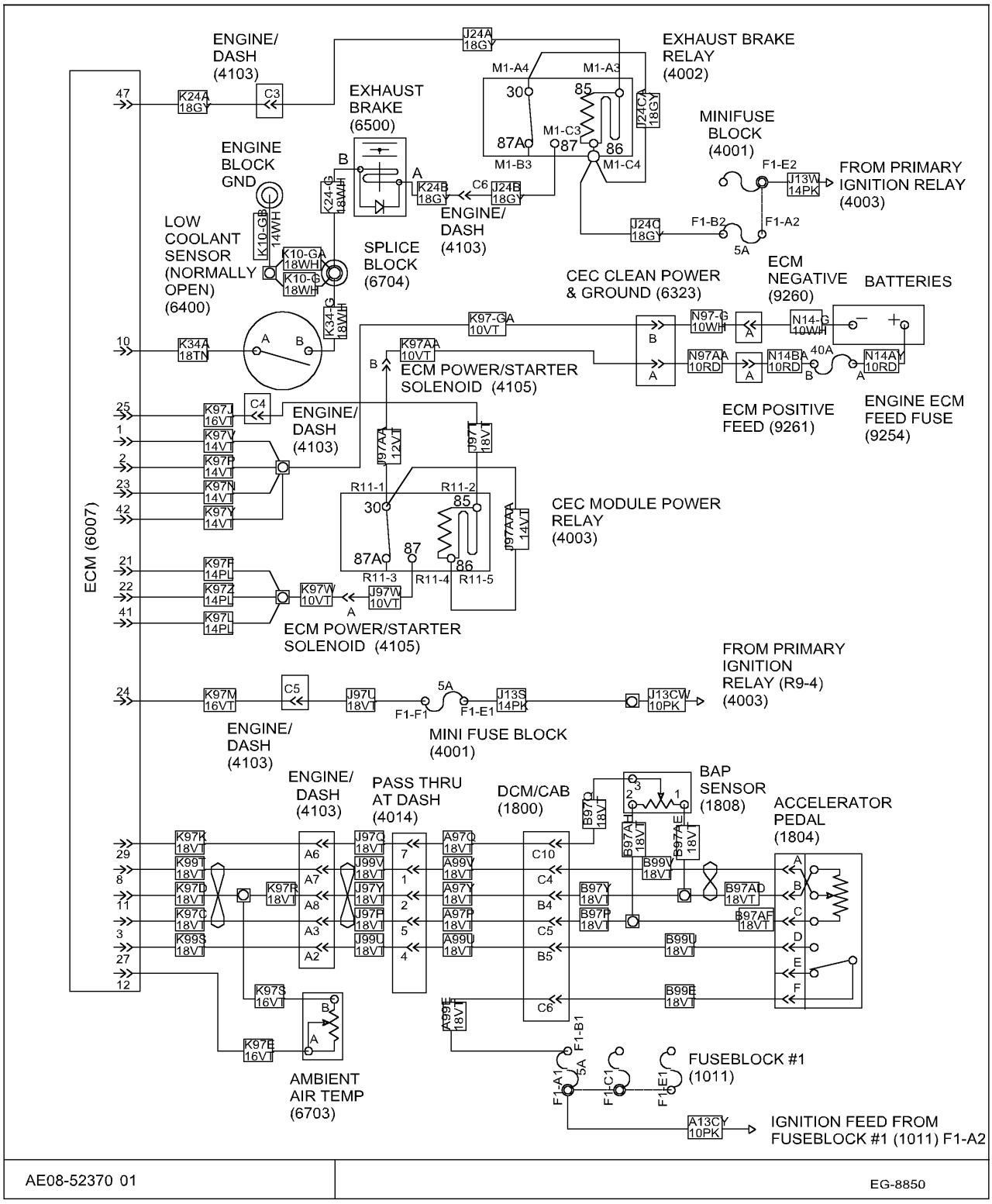

Figure 112 Surge Tank Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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ECM SELF DIAGNOSTICS

Signal Functions

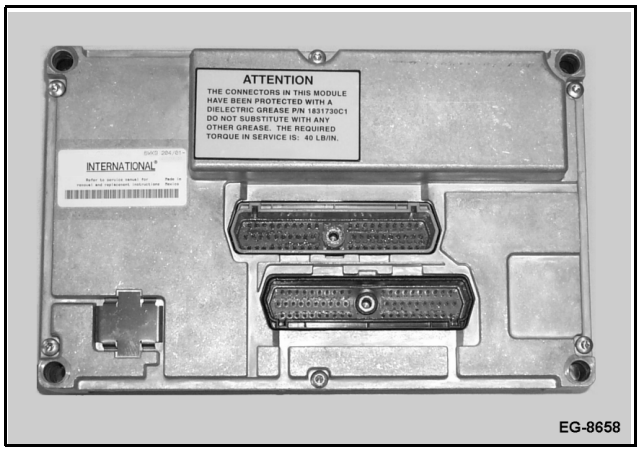

Figure 113 Electronic Control Module

The Electronic Control Module (ECM) monitors and controls engine/vehicle operation and performance, enables vehicle features such as PTO and cruise control to function, communicates engine/vehicle information to the instrument cluster, transmission (on vehicles equipped with electronically controlled transmissions) and diagnostic/programming tools.

Fault Detection / Management

During normal operation, the ECM automatically performs diagnostic checks on itself and the electronic control system. The ECM self tests include memory checks, programming checks as well as internal power supply checks for power to the injectors. The ECM is capable of internal Diagnostic Trouble Code detection and dependent on the severity of the problem, can provide Diagnostic Trouble Code management strategies to allow limited engine/vehicle operation.

ECM Self Diagnostics

Table 58 ECM Self Diagnostic Trouble Codes

DIAGNOSTIC TROUBLE CODE 111	
ATA CODE:	None
Condition Description:	No diagnostic trouble code conditions detected
Note:	Can only determine if ECM has detected continuous diagnostic trouble codes detected during an Output Circuit Check, diagnostic trouble codes generated during an On-Demand Test such as Cylinder Contribution Tests can only be accessed by an EST diagnostic tool (EST)
DIAGNOSTIC TROUBLE CODE 525	
Injector Drive Diagnostics	
ATA CODE	SID 254, FMI 6
Condition Description:	Injector Driver Circuit diagnostic trouble code
Symptoms:	Possible hard start/no start or low power condition
Possible Causes:	Shorted engine harness, injector harness or defective ECM.
Actions:	Perform injector harness checks in **INJ** circuit diagnostics, if no defects found, replace the ECM and retest.
DIAGNOSTIC TROUBLE CODE 614	
ECM Memory / Programming Diagnostics	
ATA CODE	SID 252, FMI 13
Condition Description:	EFRC/ECM, configuration mismatch.
Symptoms:	Possible hard start no/start or low power condition.
Possible Causes:	Wrong EFRC (Engine Family rating Code) selected for the ECM strategy programmed in the module.
Actions:	Check EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as necessary.
DIAGNOSTIC TROUBLE CODE 621	
ATA CODE:	SID 253, FMI 1
Condition Description:	Manufacturing Defaults Selected.
Symptoms:	Very low power (25 HP).
Possible Causes:	Programmable parameters for the ECM were never programmed in module. (Most likely to occur in new vehicle or new module).
Actions:	Program programmable parameters.
DIAGNOSTIC TROUBLE CODE 622	
ATA CODE:	SID 253, FMI 0
Condition Description:	Engine using Field Default Rating.
Symptoms:	Low power (lowest rating in engine class) and vehicle features not working.
Possible Causes:	Programmable parameters for the ECM incorrectly programmed in module.
Actions:	Program programmable parameters.

Table 58 ECM Self Diagnostic Trouble Codes (cont.)

DIAGNOSTIC TROUBLE CODE 623	
ATA CODE:	SID 253, FMI 13
Condition Description:	Invalid Engine Family Rating Code (EFRC).
Possible Causes:	Wrong EFRC (Engine Family Rating Code) selected for the ECM strategy programmed in the module.
Symptoms:	Possible hard start/no start or low power condition.
Actions:	Check the EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as necessary.
DIAGNOSTIC TROUBLE CODE 624	
ATA CODE:	SID 240, FMI 14
Condition Description:	Field Defaults Active.
Symptoms:	Low power (lowest rating in engine class) and vehicle features not functioning.
Possible Causes:	Programmable parameters for the ECM incorrectly programmed in module.
Actions:	Program programmable parameters.
DIAGNOSTIC TROUBLE CODE 631	
ATA CODE:	SID 240, FMI 2
Condition Description:	Read Only Memory (ROM) Self Test diagnostic trouble code
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DIAGNOSTIC TROUBLE CODE 632	
ATA CODES:	SID 254, FMI 12
Condition Description:	RAM Memory - CPU Self Test diagnostic trouble code.
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DIAGNOSTIC TROUBLE CODE 655	
ATA CODE:	SID 240, FMI 13
Condition Description:	Programmable Parameter List Level Incompatible.
Possible Causes:	No start or run in field defaults.
Symptoms:	Programming problem or internal ECM problem.
Actions:	Attempt to program the ECM, if no help, replace the ECM.

Table 58 ECM Self Diagnostic Trouble Codes (cont.)

DIAGNOSTIC TROUBLE CODE 661	
ATA CODE:	SID 240, FMI 11
Condition Description:	RAM Programmable Parameter List Corrupt.
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DIAGNOSTIC TROUBLE CODE 664	
ATA CODE:	SID 253, FMI 14
Condition Description:	Calibration Level Incompatible.
Symptoms:	No start or run in field defaults.
Possible Causes:	Programmable problem or internal ECM problem.
Actions:	Attempt to program the ECM, if no help replace the ECM.
DIAGNOSTIC TROUBLE CODE 665	
ATA CODE:	SID 252, FMI 14
Condition Description:	Programmable Parameter Memory Content Corrupt.
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.

ELECTRONIC CONTROL MODULE POWER SUPPLY (ECM PWR)

Circuit Functions

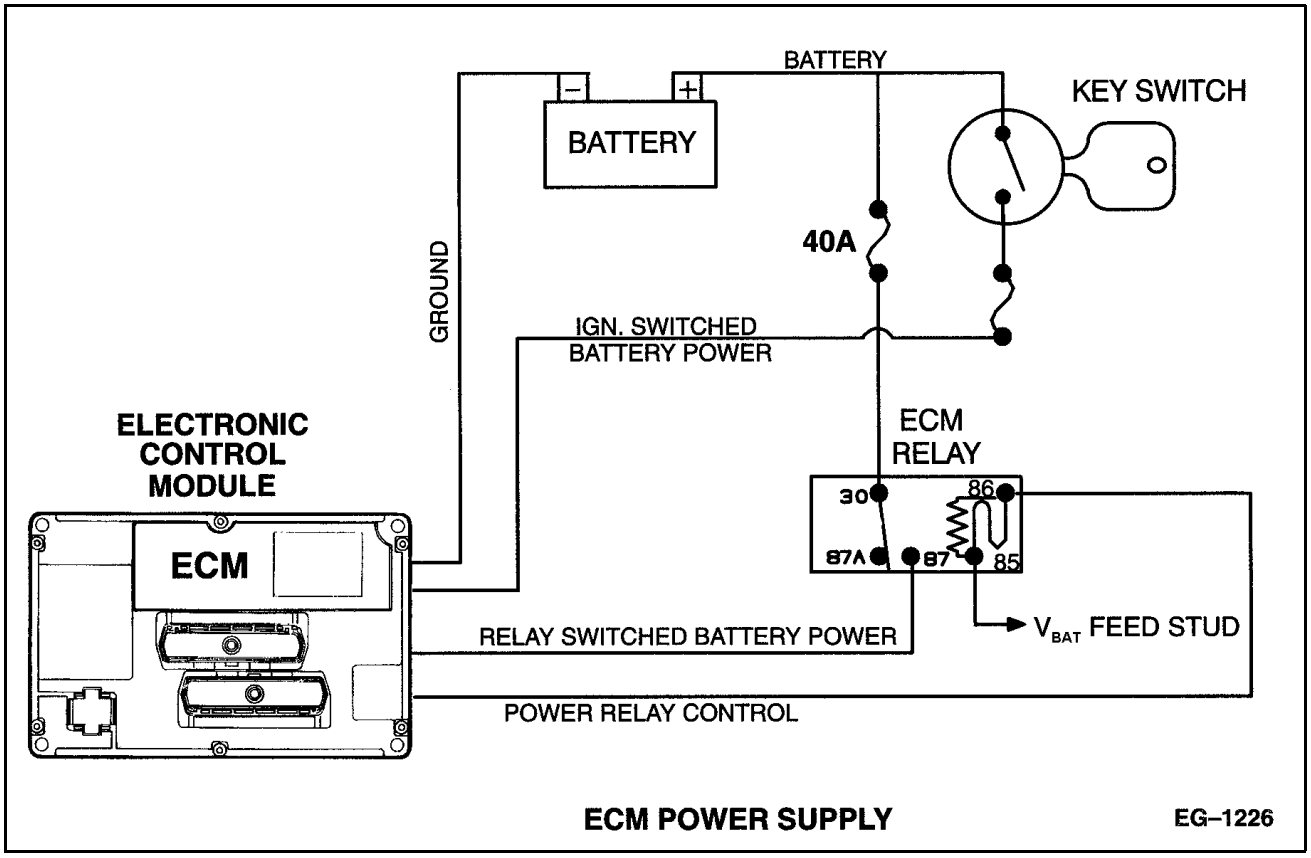

Figure 114 Electronic Control Module Power Supply Diagram

The Electronic Control Module requires a 12V source of power in order to perform its functions. It receives this operating power directly from the vehicle batteries via the ECM relay contacts each time the ignition key switch is turned to the ON position. Turning the ignition key switch ON causes the ECM to provide an internal ground to the coil side of the ECM relay. This causes the relay to close its contacts and provide the ECM with the power necessary to perform its various functions.

Fault Detection / Management

The ECM internally monitors battery voltage. If the ECM continuously receives less than 6.5V or more than 18V a Diagnostic Trouble Code will be set. The Diagnostic Trouble Code will not cause the Warning lamp to be turned ON. If the condition is intermittent, the code will be logged as an inactive code. The ECM will not operate at voltages continuously below 6.5 or above 18V.

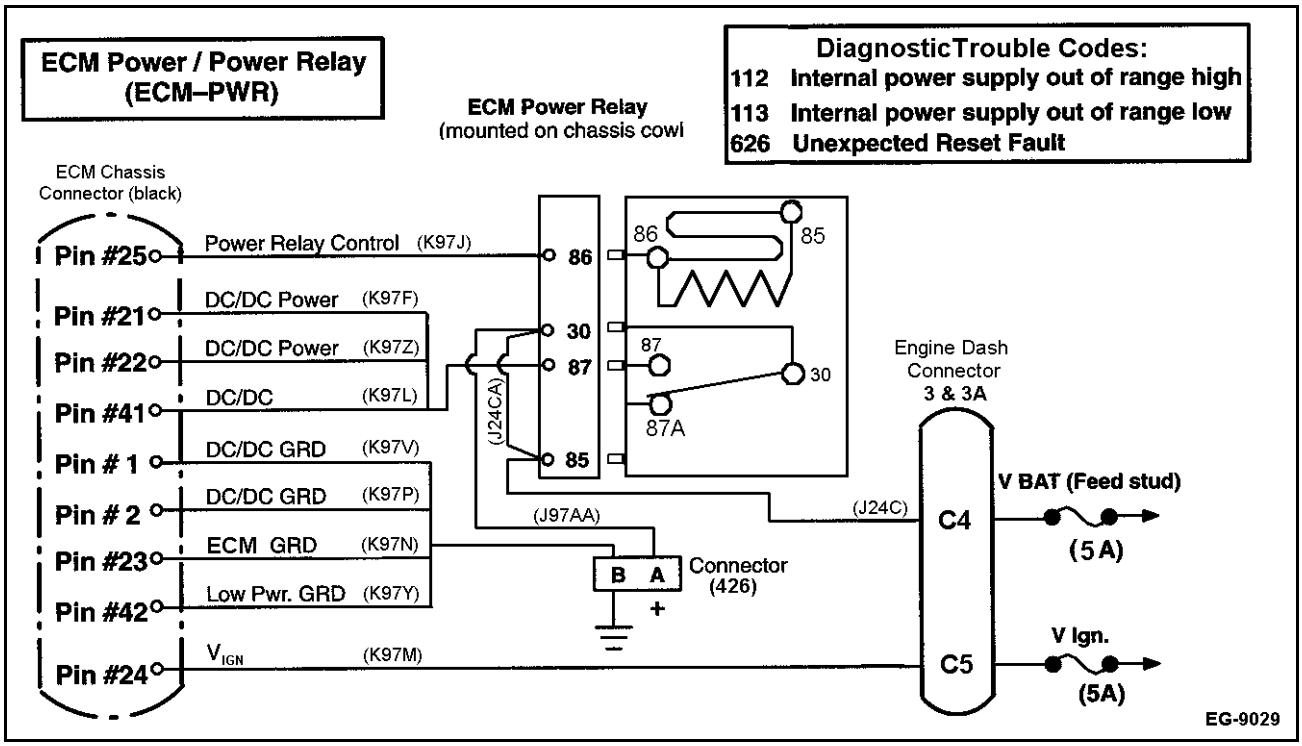

Figure 115 ECM Power Supply Circuit

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

NOTE – Make sure batteries are fully charged and terminals are clean and tight.

Table 59 ECM PWR Circuit Diagnostics

Key On Engine Off - Voltage Checks at ECM Power Relay Socket (check with ECM relay removed breakout tee installed, ignition key ON, engine OFF).		
+Test Points	Spec.	Comments
85 to gnd	12V ± 1.5	Voltage present at all times. If no voltage, check ground and power circuits from chassis connections.
30 to gnd	12V ± 1.5	Voltage present at all times. If no voltage, check ground and power circuits to battery circuits.
86 to gnd	0 to 0.25V	No voltage expected.
87 to gnd	0V	No voltage present when relay is removed.
Continued on Next Page		

Table 59 ECM PWR Circuit Diagnostics (cont.)

Key ON Engine OFF - Voltage Checks at ECM (check with breakout box installed, ECM power relay installed, and ignition key ON).		
+Test Points	Spec.	Comments
24 to gnd	12V ± 1.5	Power from ignition switch to ECM.
21 to gnd	12V ± 1.5	Power from relay to ECM
22 to gnd	12V ± 1.5	Power from relay to ECM
41 to gnd	12V ± 1.5	Power from relay to ECM
25 to gnd	0.6 to 2V	ECM grounds relay through internal transistor. Expect 1.2V with Key ON.
1 to gnd	0V	Ground - voltage reading indicates poor ground to battery.
2 to gnd	0V	Ground - voltage reading indicates poor ground to battery.
23 to gnd	0V	Ground - voltage reading indicates poor ground to battery.
42 to gnd	0V	Ground - voltage reading indicates poor ground to battery.
Circuit Resistance Checks (check with breakout box installed, ECM power relay installed and ignition key OFF).		
+Test Points	Spec.	Comments
1, 2, 23, 42 to gnd	<5Ω	Resistance from ECM grounds to battery grounds.
F11 to 25	60 - 120Ω	Measure resistance across relay coil - Remove fuse F11 to test.
30 to B+	<5Ω	Power from battery to relay (remove relay to test & test at location 30 in relay socket).
Diagnostic Trouble Code Description		
112 = Internal ECM voltage was detected above 18V.		
113 = Internal ECM voltage was detected below 6.5V.		
626 = ECM detected intermittent power loss through ECM relay.		

Extended Description

Refer to ECM Power and Ground System Circuit Diagram for the following discussion (See Figure 116, page 242).

The Electronic Control Module (ECM) receives its power directly from the vehicle batteries when the ECM power relay is energized. This allows maximum power transfer from the batteries to the ECM with a minimum amount of power loss. The wire harness that supplies the ECM power is fused at the battery to protect it from short circuits.

When the key switch is turned ON, ignition power from fuse in the Power Distribution Center (5 A) is supplied to Pin 24 of the ECM through the engine dash connector. This indicates to the ECM that the ignition switch is ON and it is time to enable the ECM power relay.

Power to the ECM Power Relay control coil (terminal 85) is provided by circuit 97CT from the battery feed stud through the engine dash connector. The ECM will enable the ECM power relay by completing the ground circuit (internally) for the relay at ECM pin 25.

When the ECM Power Relay is enabled power at terminal 30 from the vehicle batteries is switched directly to the ECM from terminal 87 of the relay to pins 21, 22 and 41 of the ECM. The vehicle battery power for this relay to switch is supplied directly from the battery through connectors 4105, 6323, 9261, and the ECM feed fuse.

ECM Diagnostics

If the ECM detects more than 18V at pins 21, 22 and 41 it will set Diagnostic Trouble Code 112. A voltage of less than 6.5V detected by the ECM will set Diagnostic Trouble Code 113. The ECM is capable of detecting an intermittent interruption of power or ground circuits. Diagnostic Trouble Code 626 will be set indicating an unexpected reset has occurred.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 112

ATA Code, PID 168, FMI 35

ECM: Internal voltage power Out of Range HIGH

Diagnostic Trouble Code 112 can be caused by:

1. Defective alternator causing an alternator output voltage in excess of 18V.

2. Additional voltage provided while attempting to jump start engine or improper external battery connections that could cause the voltage increase.

If the condition causing code 112 is intermittent, the code will change from active to inactive status. Diagnostic Trouble Code 112 will **not** cause the amber ENGINE lamp to turn ON.

Diagnostic Trouble Code 113

ATA Code, PID 168, FMI 36

ECM: Internal voltage power Out of Range LOW

Diagnostic Trouble Code 113 can be caused by consistently less than 6.5V being applied to ECM pins 21, 22 and 41. This can be caused by a defective alternator, ECM power relay, discharged batteries, and/or increased resistance in the battery feed circuits. Diagnostic Trouble Code 113 will **not** turn the amber ENGINE lamp ON. If the condition causing Diagnostic Trouble Code 113 to set is an intermittent condition when the condition is no longer present, the code status will go from active to inactive.

Diagnostic Trouble Code 626

ATA Code, PID 254, FMI 56

ECM: Unexpected Reset Diagnostic Trouble Code

Any time power is interrupted to the ECM due to intermittent power feed circuits caused by loose or dirty connections at the batteries or at ground cables, the ECM may "power down." When the power or ground circuit becomes intact again the ECM will "reboot" itself. This may cause erratic engine operation. Diagnostic Trouble Code 626 will be set anytime the flow of power is interrupted to the ECM. Turning the ignition key OFF and then ON again causes the code to change from active to inactive status. Diagnostic Trouble Code 626 will **not** cause the amber ENGINE lamp to illuminate.

Troubleshooting

If either Diagnostic Trouble Code 112 or 113 is active, see S08250 - Electrical Troubleshooting Guide - 4200/4300/4400. If Diagnostic Trouble Code 626 is active, the voltage at pins 21, 22 and 41 of the ECM should be monitored while looking for an intermittent connection in the power feed wiring. The EST may be used to indicate Diagnostic Trouble Codes to display the V_{IGN} voltage that the ECM measures to Pin 24.

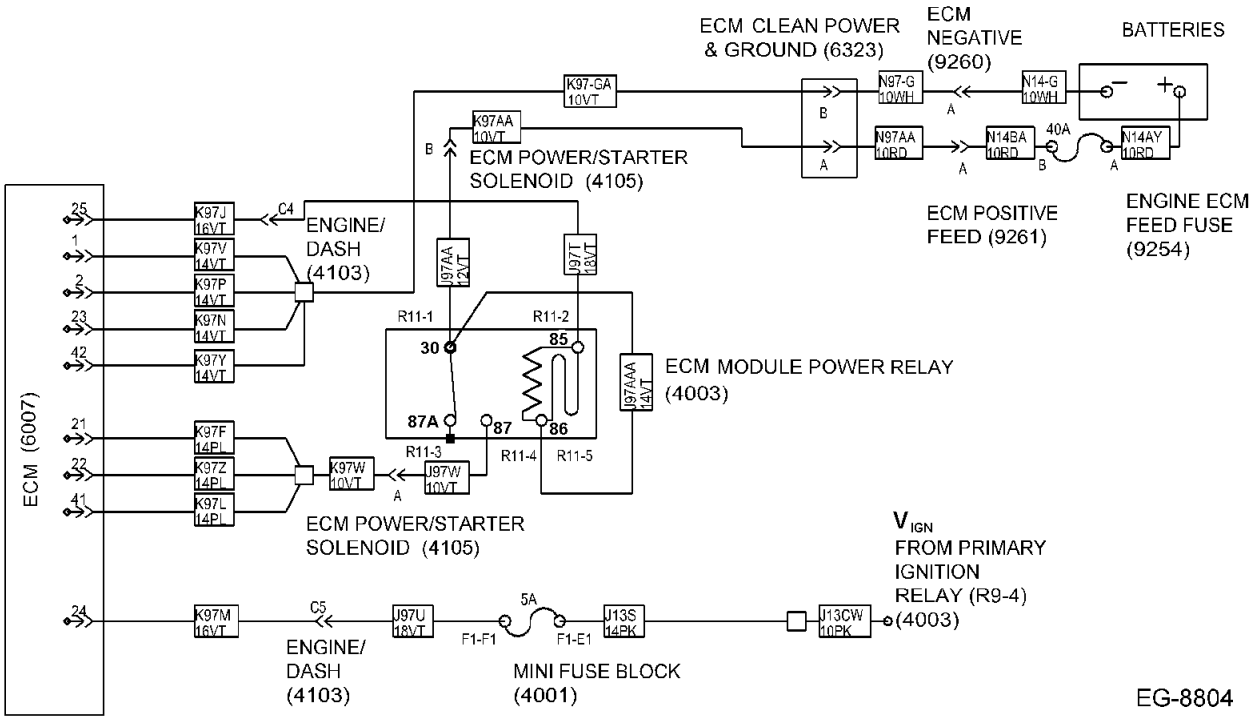

Figure 116 ECM Power and Ground System Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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ENGINE COOLANT TEMPERATURE SENSOR (ECT)

Signal Functions

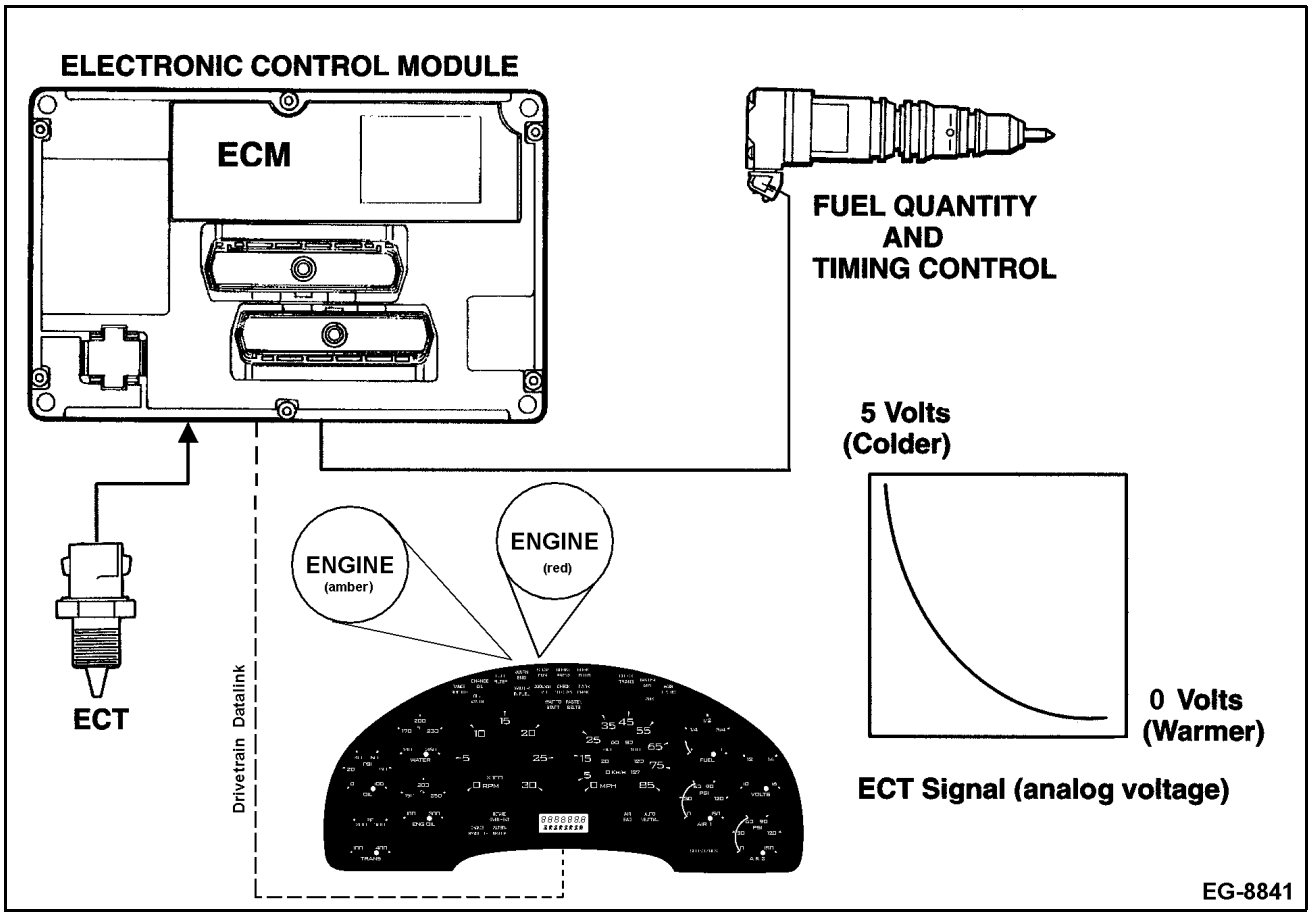

Figure 117 Engine Coolant Temperature Sensor Function Diagram

The Engine Coolant Temperature (ECT) sensor is a thermistor type sensor that changes resistance when exposed to changes in coolant temperature. When interfaced with the ECM it produces a 0 to 5V analog signal that indicates coolant temperature.

Coolant Temperature Compensation - At coolant temperatures greater than 225°F (107°C) full load fuel quantity is reduced by approximately 6% for each degree of temperature (°C), until engine temperature reaches 229°F (110°C). Above 229°F (110°C) fuel is reduced by 3% for each °C increase in temperature.

Idle Speed - At temperatures below 158°F (70°C), low idle is incrementally increased to a maximum of 875 rpm.

Engine Warning and Protection - Optional feature when enabled will the warn driver of overheat condition and can be programmed to shut the engine down.

Fault Detection / Management

When ECT signal voltage is detected Out of Range HIGH or Out of Range LOW the ECM will ignore the ECT signal and assume an engine coolant temperature of -29°F (-34°C) for starting and a temperature of 180°F (82°C) for engine running conditions. The amber ENGINE lamp will also be illuminated as long as the fault exists with the odometer displaying the message WARN ENG.

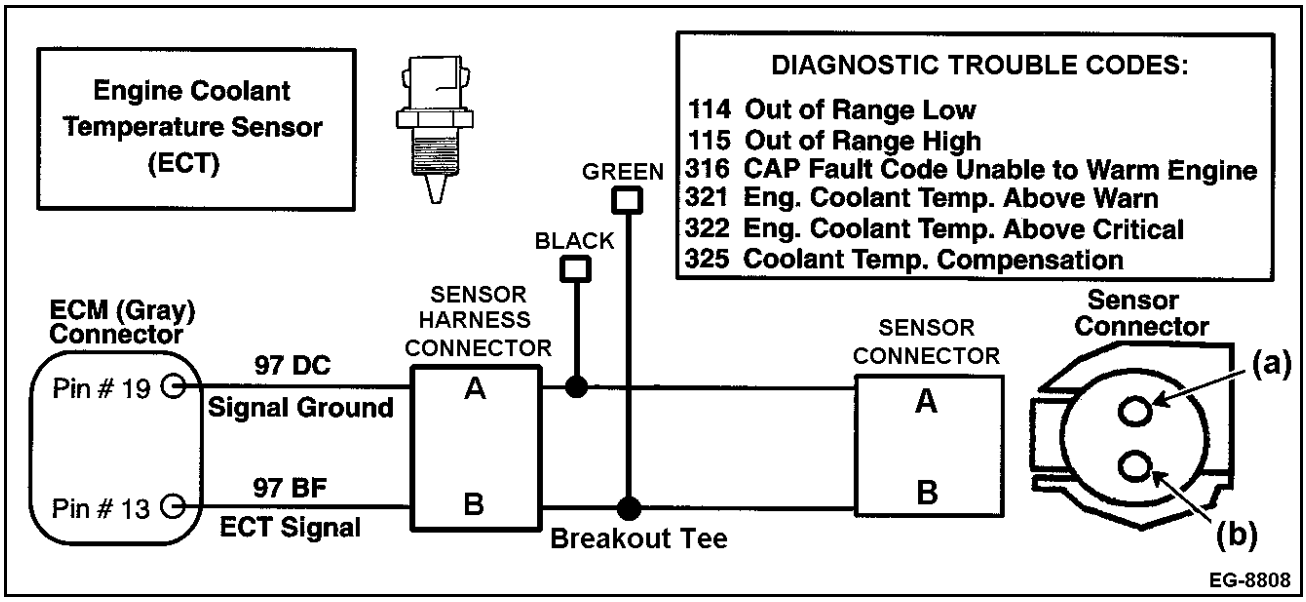

Figure 118 Engine Coolant Temperature Sensor Circuit Diagram using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 60 ECT Sensor Tests Using Master Diagnostics

Engine Coolant Temperature (ECT) Sensor Voltage Checks (check with key-ON engine-OFF)		
Install the 2 wire breakout tee between the ECT sensor and harness connector. View ECT VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 114 <0.127V, Code 115 >4.6V), complete the following steps.		
Test Condition	**Expected Voltage**	**Comments**
Sensor Disconnected	>4.6 V	Voltage <4.6, inspect the signal circuit for short to ground.
Standard jumper installed between the GREEN and BLACK pins of the breakout tee	0V	If voltage is >0.127, check ground and signal circuits for an open or high resistance. Measure resistance from PIN A to PIN 19, and from PIN B to PIN 13 (spec. <5Ω) using a breakout box to determine if the resistance is in the harness.
0.5 kΩ jumper installed between the GREEN and BLACK pins of the breakout tee	<1.0V	If voltage is >1.0V, check signal circuit for a short to V_{REF}, B+, or another sensor's signal voltage.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See ECT Sensor Troubleshooting Flowchart (See Figure 119, page 250).		
Continued on Next Page		

Table 60 ECT Sensor Tests Using Master Diagnostics (cont.)

Operational Voltage Checks			
MD Voltage: (+) # 13 to (–) #19	**Spec.**		**(check with breakout tee installed, key-ON)**
Voltage	**Temp °F**	**Temp °C**	**Sensor Resistance**
0.356V	230	110	1.19 kΩ
3.87V	32	0	69.2 kΩ
4.33V	– 5	– 20	131 kΩ
Diagnostic Trouble Code Description			
114 = Signal voltage was <0.127 volts for more than 0.1sec.			
115 = Signal voltage was >4.6 volts for more than 0.1sec.			
316 = Engine temperature has not warmed above specification after 120 min. of operation (only with engines with cold ambient protection turned on).			
321 = Engine Coolant Temperature above WARN level 228°F (109°C).			
322 = Engine Coolant Temperature above Critical level 234°F (112.5°C).			
325 = Coolant Temperature Compensation enabled reduces fuel quantity 6% per 1°C above 225°F (107°C).			

Table 61 ECT Sensor Circuit Specifications (See Figure 118, page 245)

Connector Voltage Checks (check with sensor disconnected from harness, ignition key ON)		
Test Points	**Spec.**	**Comments**
B to gnd	4.6 – 5.0V	Pull up voltage, if no voltage or low voltage, circuit is open or has high resistance or short to ground.
A to gnd	0 – 0.25V	Voltage >0.25V, wire shorted to Vref or B+
Connector Checks To Chassis Ground (check with sensor connector disconnected, positive battery cable disconnected, and key OFF)		
Test Points	**Spec.**	**Comments**
A to gnd	<5Ω	>5Ω indicates circuit is open
B to gnd	>1kΩ	<1kΩ this indicates a short to ground
Harness Resistance Checks (check with breakout box installed on chassis side only)		
Test Points	**Spec.**	**Comments**
19 to A	<5Ω	75Ω indicates ground wire open
13 to B	<5Ω	75Ω indicates signal wire open

Extended Description

Function

The International engine control system includes an Engine Coolant Temperature sensor (ECT). The ECM measures the Engine Coolant Temperature signal and uses this information for Coolant Temperature Compensation and optional high temperature warning and shut down systems.

Coolant Temperature Compensation is used to protect the engine if the coolant temperature is too high. The ECM monitors the ECT signal to determine coolant temperature. If the coolant reaches 225°F (107°C), the ECM will reduce the fuel delivery by 6% for each degree (Celsius) of temperature increase. If the coolant temperature increases to 229°F (110°C), fuel quantity will be reduced 3% for each degree (Celsius) of temperature increase. Coolant Temperature Compensation can be programmed to be inoperative in certain applications where full engine performance is required over the protection of the engine.

On engines equipped with an engine warning system, the ECM will activate the audible warning alarm and illuminate the red ENGINE lamp and cause the message **OIL/WATER** to be displayed on the odometer when the engine coolant temperature reaches 228°F (109°C).

On engines equipped with an engine shut down system, the ECM will shut the engine off when the coolant temperature reaches 235°F (113°C). The vehicle operator may restart the engine by turning the ignition key OFF and then restarting it. Upon restart, the ECM will allow the engine to run for an additional 30 seconds, before shutting off the engine again.

Operation

The Engine Coolant temperature sensor is a thermistor type sensor which changes resistance when exposed to different temperatures.

When the temperature of the coolant is decreased, the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the coolant is increased the resistance of the thermistor decreases, which causes the signal voltage to decrease.

The ECT sensor is supplied a regulated 5V reference voltage from the ECM. The sensor is grounded at terminal A through the signal return terminal at the ECM. As the coolant temperature increases or decreases, the sensor changes resistance and provides the ECM with the coolant temperature signal voltage at the ECM. This signal voltage is then read by the ECM to determine the temperature of the coolant.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the ECT circuit to determine if the voltage signal is within the expected range. If the signal voltage is higher or lower than expected the ECM will set a Diagnostic Trouble Code.

If the ECM detects a fault in the ECT circuit, the ECM will disregard the signal and default to a temperature of 180°F (82°C) for engine running operation and -29°F (-34°C) for starting the engine. If the fault is no longer present, it will be stored as an Inactive code and the ECM will return to normal operation using the ECT signal for processing.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 114

ATA Code, PID 110, FMI 4

ECT: Out of Range LOW

When code 114 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out of Range LOW code will be set if the ECM detects a voltage less than 0.127V for more than 0.1 seconds. If this Diagnostic Trouble Code is Active, the ECM will use the default value of 180°F (82°C).

Diagnostic Trouble Code 114 may be caused by a short to ground or a shorted or biased sensor.

Diagnostic Trouble Code 115

ATA Code, PID 110, FMI 3

ECT: Out of Range HIGH

When code 115 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out of Range HIGH code will be set if the ECM detects a voltage greater than 4.6V for more than 0.1 seconds. If this fault is Active, the ECM will use the default value of 180°F (82°C).

Diagnostic Trouble Code 115 may be caused by an open circuit, an open sensor, or a short to another voltage source.

Diagnostic Trouble Code 321

ATA Code, PID 110, FMI 0

Engine Coolant Temperature Above Warning Level

Diagnostic Trouble Code 321 will be set if the ECM detects engine coolant temperature above 228°F (109°C). When this occurs, the ECM illuminates the red ENGINE lamp, sounds an audible alarm and causes the message **OIL/WATER** to be displayed on the odometer (if engine protection enabled), alerting the operator that a potential for engine damage exists.

If the temperature drops below 225°F (107°C), the code will become inactive and the ECM will return to normal operation.

Diagnostic Trouble Code 322

ATA Code, PID 110, FMI 7

Engine Coolant Temperature Above Critical Level

Diagnostic Trouble Code 322 will be set if the ECM detects engine coolant temperature above 235°F (112.5°C). When this occurs, the red ENGINE lamp illuminates, causing the message **OIL/WATER** to be displayed on the odometer, and an audible warning (if engine protection enabled), alerting the operator that the temperature is increasing (having set code 321) indicating a potential for engine damage. With code 322 active, the engine

will shut down. At the same time a Diagnostic Trouble Code, current engine hours and odometer reading will be recorded in the ECM as an Engine Event.

If the temperature drops below 235°F (112.5°C), the code will become inactive and the ECM will return to normal operation. Should the engine shut down, it can be restarted to move the vehicle to a safe place.

Diagnostic Trouble Code 325

ATA Code, PID 110, FMI 14

Power reduced or matched to cooling system performance

Diagnostic Trouble Code 325 will be set if the cooling system temperature exceeds 225°F (107°C). At this temperature the ECM will reduce the fuel delivered to the engine. For each one Celsius degree of temperature the fuel will be reduced 6%. This reduces the heat produced by the engine thereby reducing the burden on the engine cooling system. It will also slow the vehicle speed encouraging the operator to downshift, thus increasing the efficiency of the cooling system.

As the temperature is reduced the compensation level is reduced until the temperature drops below 225°F (107°C) at which normal operation is resumed.

Diagnostic Trouble Code 316

ATA Code, PID 110, FMI 1

CAP Diagnostic Trouble Code - Unable to warm engine

Diagnostic Trouble Code 316 will only be set with engines that have CAP (Cold Ambient Protection) strategy enabled. This code is set after the engine has run for greater than 120 minutes and has not exceeded the following specifications for engine coolant temperature. This code can be cleared with the EST diagnostic tool.

DT 466 / DT 530
Manual Transmission 142°F (61°C)
Automatic Transmission 106°F (41°C)

NOTE – This code only indicates that the engine has not been able to reach operating temperature. It does not indicate an electronic fault.

Table 62 Possible System Faults and Recommended Actions for ECT Sensor Problems

Recommended Actions:	
Condition	**Action**
Extended idle time	Recommend to customer to reduce idle time or increase idle speed
Cold ambient temperatures (may require use of winter front)	Recommend use of winter front
Thermostat stuck in open position	Perform thermostat tests per service manual
Incorrect coolant hose routing (thermostat bypassed)	Verify correct cooling system routing
Auxiliary heater cores cooling off engine	Reduce flow to heater cores or slow down fan speed of heater
Fan clutch locked on	Verify proper fan clutch operation

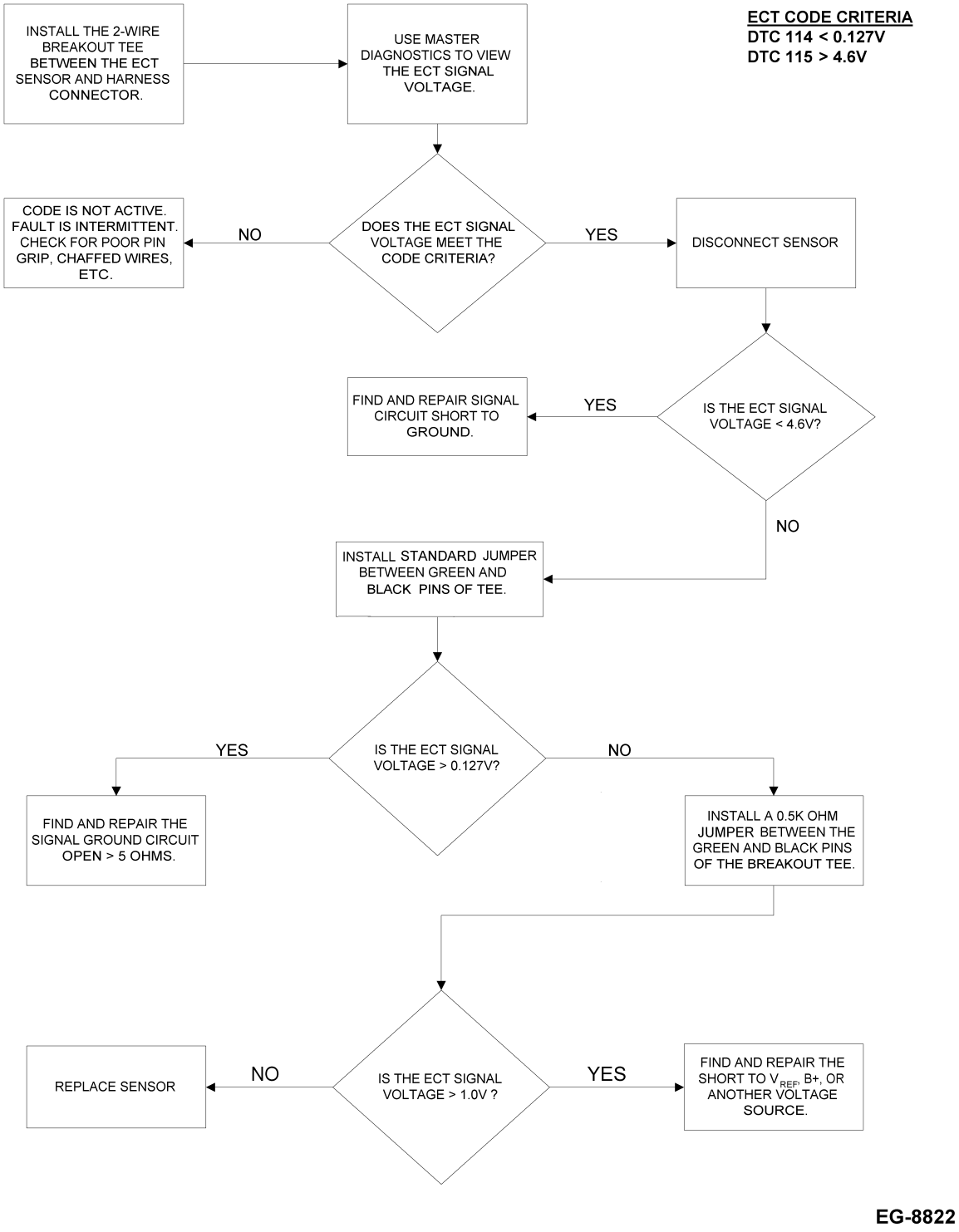

Figure 119 Engine Coolant Temperature Sensor Troubleshooting Flowchart

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ENGINE FAN CONTROL (EFN)

Signal Functions

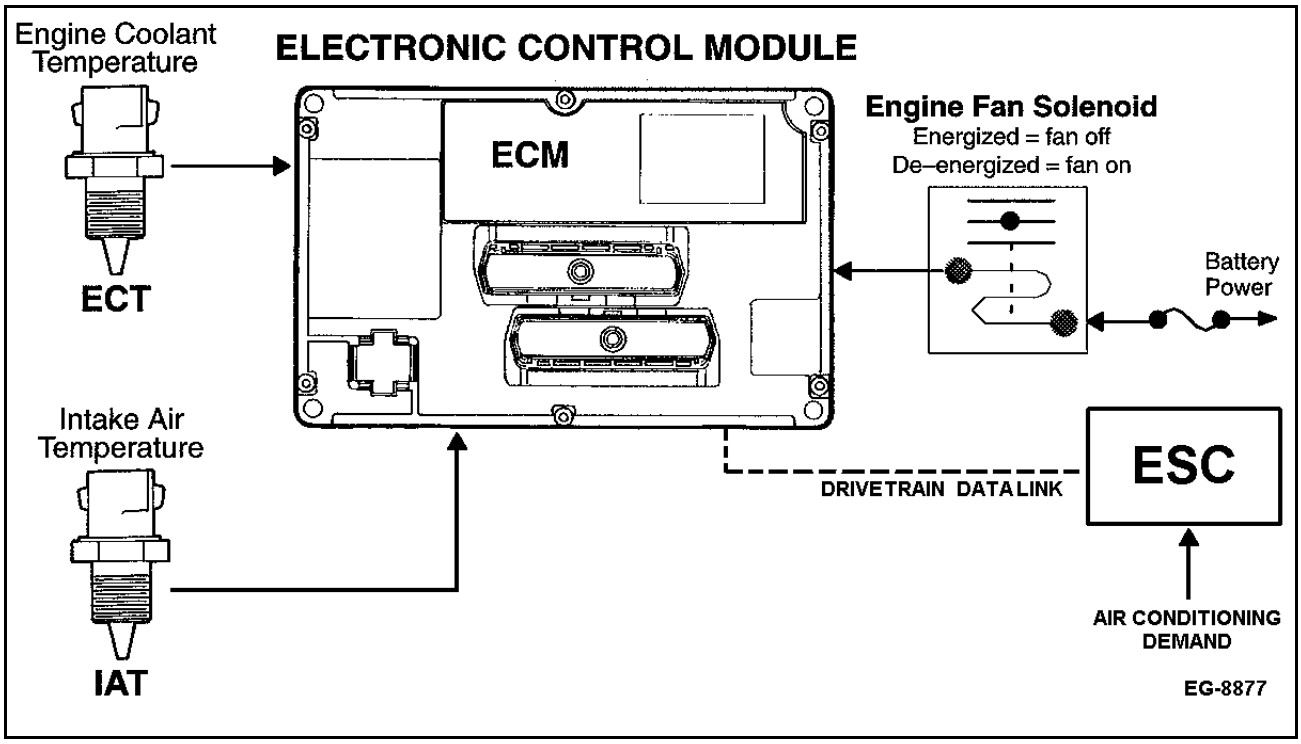

Figure 120 Engine Fan Control Function Diagram

The purpose of the Engine Fan Control is to provide ON/OFF control of the engine cooling system fan and to provide a load for vehicle retarding when required. The strategy in the ECM that controls the Fan solenoid monitors engine coolant temperature, intake air temperature, engine mode selection (engine in an operating mode or diagnostic mode) and the programmable limits and settings programmed in the ECM. Engine fan is accessible with the EST diagnostic tool and it can be programmed according to the following list:

1. Disabled (OFF)
2. Coolant temperature activation and AC demand
3. Coolant temperature activation and Retarder Operation

Fault Detection / Management

An open or short to ground in the EFN circuitry can be detected by the ECM during an “On Demand" Engine Standard Test by the technician. IAT and ECT are monitored on a continuous basis. If a Diagnostic Trouble Code is detected, in either circuit, the EFN control is disabled and the engine fan is on all the time.

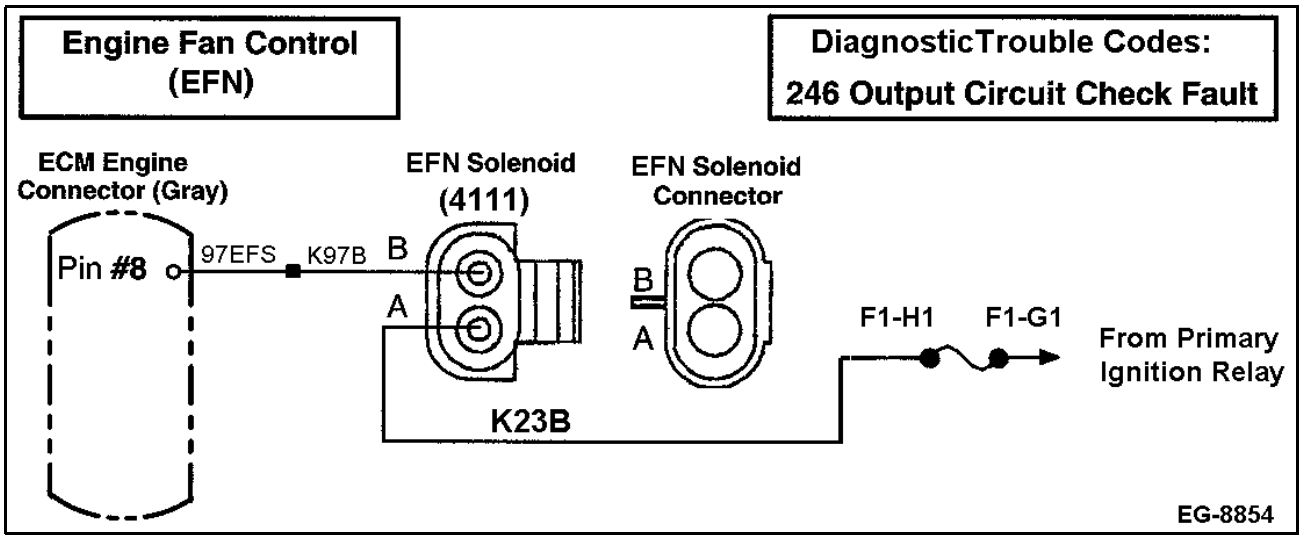

Figure 121 Engine Fan Control Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 63 Engine Fan Control Diagnostics

Key ON Engine Off - Voltage Checks at EFN Connector (solenoid disconnected, key ON)		
+Test Points-	Spec.	Comments
A to gnd	12V±1.5	Power should be available with key on, check fuse and/or circuit or open/shorts
B to gnd	0V	If voltage present, check for short to power
Circuit Resistance Checks (check with EFN solenoid and battery positive cable disconnected, breakout box installed & ignition key OFF)		
+Test Points-	Spec.	Comments
8 to B	<5Ω	If >5Ω, check for open circuit
F1-H1 to A	<5Ω	If >5Ω, check for open circuit
8 to gnd	>1kΩ	If <1kΩ, check for short to ground
A to gnd	>1kΩ	If <1kΩ, check for short to ground, check with fuse removed
Operational Checks (check with EFN solenoid connected and breakout box installed)		
NOTE – This test should be done only when there are no ECT or IAT DTC's present. Voltage will change from 12V to 0V when fan is turned on by using the Output State Test.		
+Test Points-	Spec.	Comments
8 to 19	0V	Solenoid energized (ON) - fan OFF
8 to 19	12V	Solenoid de-energized (OFF) - fan ON
NOTE – Normal fan ON temperature is 212°F (100°C). Normal fan OFF temperature is 207.5°F (97.5°C).		
Diagnostic Trouble Code Description		
246 = The Engine Fan Control relay failed the output check during a Key ON engine OFF Standard Test. **NOTE – For test purposes, EFN solenoid can be turned ON/OFF through the Output State Test.**		

Extended Description

Function

The purpose of the Engine Fan Control is to provide the proper logic to determine when the Fan should be turned on or off by energizing/de-energizing the fan drive solenoid. The purpose of the engine fan is to allow a higher air flow for heat exchange between the radiator and the ambient air when needed. In addition, the engine fan may be used as a vehicle retarding device.

Engine Fan Control: This parameter indicates to the on-board electronics whether or not the truck has the electronic engine fan control feature.

AC Fan Activation: This feature will allow fan activation though the ECM when requested through the ESC during AC operation.

Disable: Feature is turned off at all times.

Coolant Temp Activation Only: Feature will allow fan activation based on coolant temperature only.

Coolant Temp Activation and as Retarder: Feature will allow fan activation based on coolant temperature or as a vehicle retarding device.

Fan On Temperature: This parameter indicates the coolant temperature that the fan will be electronically activated.

Fan Off Temperature: This parameter indicates the coolant temperature that the fan will be electronically deactivated.

Diagnostic Trouble Code 246

ATA Code, SID 56, FMI 11

Engine Fan Control OCC Self Test Failed

Diagnostic Trouble Code 246 is set only during the Key On Engine Off Standard test. During this test the ECM performs an output circuit test that momentarily enables the EFN solenoid and measures the voltage drop across the solenoid. Refer to Fan Wiring Circuit Diagram (See Figure 122, page 255).

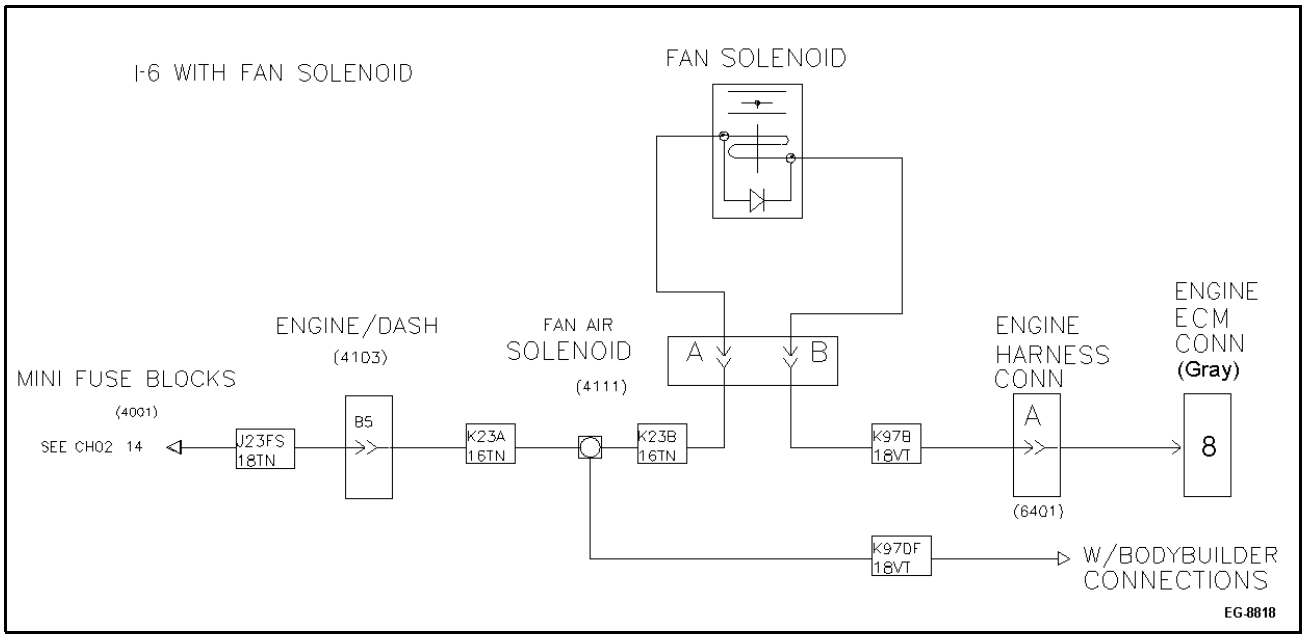

Figure 122 Engine Fan Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

ENGINE OIL PRESSURE SENSOR (EOP)

Signal Functions

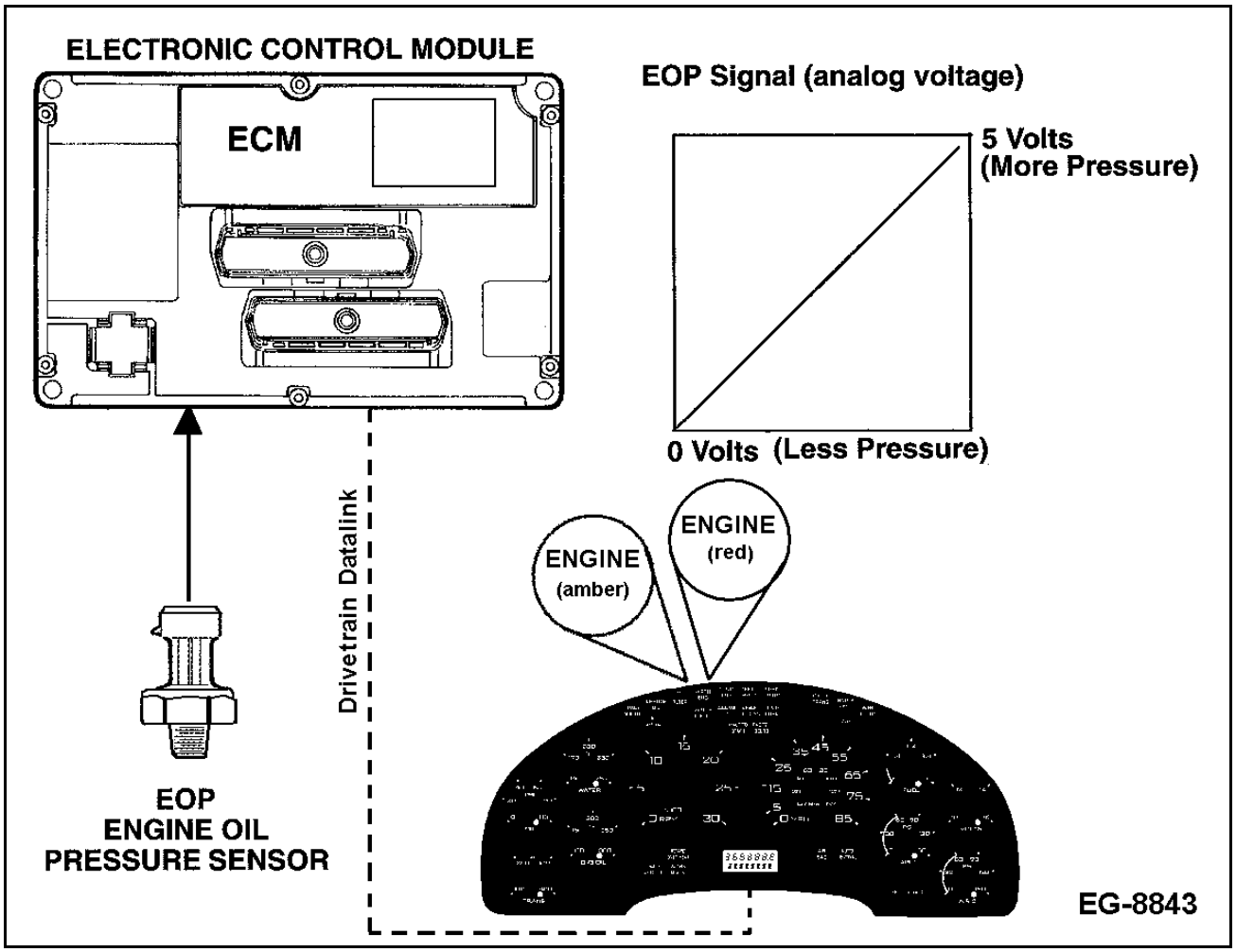

Figure 123 Engine Oil Pressure Sensor Function Diagram

The Engine Oil Pressure (EOP) sensor is a variable capacitance sensor. The ECM applies a 5V reference signal to this sensor and it produces a linear analog voltage signal that indicates engine oil pressure.

Engine Warning and Protection - An optional feature which, when enabled, will warn the driver of a low engine oil pressure condition and can be programmed to shut the engine down.

Instrument Cluster Display - The ECM transmits sensed engine oil pressure information on the drive train data link which is for display on the instrument cluster.

Fault Detection / Management

When EOP signal voltage is detected Out of Range HIGH or Out of Range LOW the ECM will cause the engine to ignore the EOP signal and disable Engine Warning and Protection.

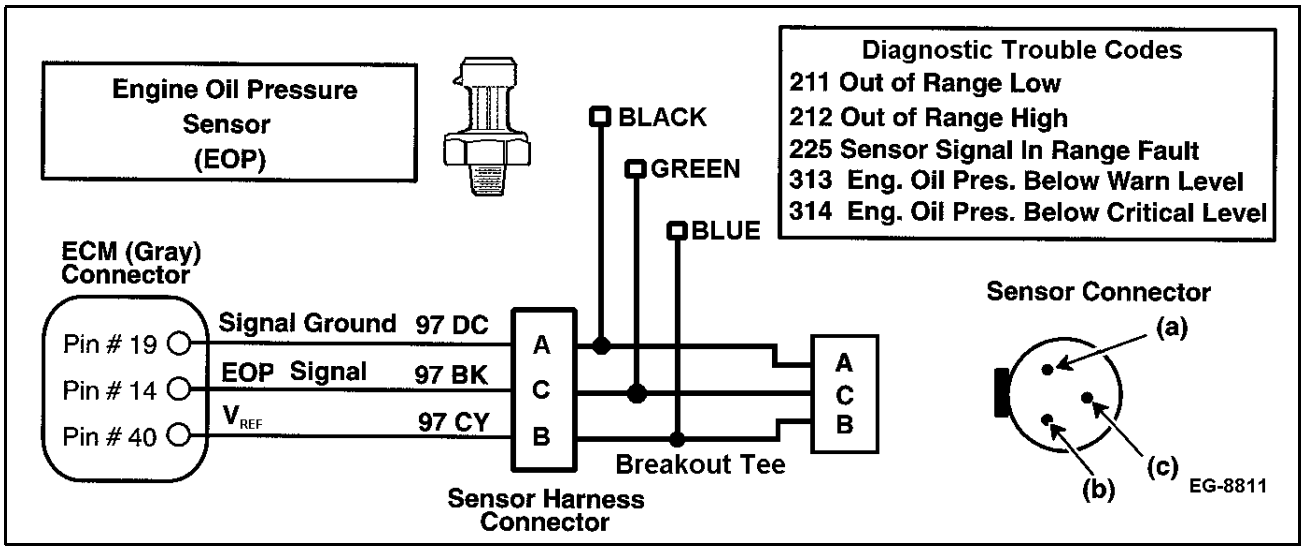

Figure 124 Engine Oil Pressure (EOP) Sensor Circuit Diagram using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 64 Engine Oil Pressure Sensor Tests Using Master Diagnostics

Engine Oil Pressure (EOP) Sensor Voltage Checks (check with key-ON engine-OFF)		
Install the 3 wire breakout tee between the EOP sensor and harness connector. View EOP VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 211 < 0.039V, Code 212 >4.9V, Code 225 >1.49V), complete the following steps.		
Test Condition	**Expected Voltage**	**Comments**
Sensor Disconnected	0V	Voltage > 0.039V, inspect the signal circuit for short to V_{REF} or B+.
Measure voltage from PIN B to gnd using a DMM.	5V ± 0.5	If voltage is > 5.5V, check V_{REF} for short to B+. If voltage is < 4.5V, check V_{REF} circuit for open or short to ground.
0.5 kΩ jumper installed between the GREEN and BLUE pins of the breakout tee.	5V	If voltage is < 4.9V, check signal circuit for open or short to ground. Remove positive battery cable. Measure resistance from PIN C to Ground (spec >1 kΩ) and from PIN C to PIN 14 (spec < 5Ω) using a breakout box to determine if short to ground or open is in the harness.
Standard jumper installed between the BLUE, GREEN, and BLACK pins of the breakout tee.	0V	If voltage is > 0.039V, check ground circuit for resistance. Measure resistance between PIN A and PIN 19 (spec < 5Ω) using a breakout box to determine if resistance is in the harness.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See EOP Sensor Troubleshooting Flowchart (See Figure 125, page 262)		
Continued on Next Page		

Table 64 Engine Oil Pressure Sensor Tests Using Master Diagnostics (cont.)

MD Voltage: (+)14 to (-)19		**Operational Signal Checks** (compare voltage reading at breakout tee with voltage and psi displayed on Master Diagnostics)	
Voltage	psig	kPa	Comments
0.89V	5	34	Pressure will vary with engine speed and temperature
1.15V	10	69	
2.40V	35	241	
3.61V	60	414	
Diagnostic Trouble Code Description			
211 = Signal voltage was <0.039 volts for more than 0.1sec.			
212 = Signal voltage was >4.9 volts for more than 0.1sec.			
225 = Eng. oil press. was sensed >15 psi with the ignition key ON, engine OFF.			
313 = Eng. oil press. <5 psi (34 kPa)@700 rpm or 10 psi (69 kPa)@1400 rpm or 20 psi (138 kPa)@2000 rpm.			
314 = Eng. oil press. <2 psi (14 kPa)@700 rpm or 5 psi (34 kPa)@1400 rpm or 12 psi (83 kPa)@2000 rpm.			

Table 65 EOP Sensor Circuit Specifications (See Figure 124, page 257)

Connector Voltage Checks (check with sensor connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	0V	Signal ground no voltage expected
B to gnd	5V ± 0.5	V_{REF} check with key ON, if voltage is not within spec., check for open or short to ground
C to gnd	<0.25V	If > 0.25V, signal ground wire is shorted to V_{REF} or battery
Connector Checks to Chassis Ground (check with sensor connector disconnected, positive battery cable disconnected & ignition key OFF)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key off, if >5Ω the circuit is open
B to gnd	>500Ω	Resistance <500Ω indicates a short to ground
C to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground
Harness Resistance Checks (check with breakout box installed on engine harness only)		
Test Points	Spec.	Comments
19 to A	<5Ω	>5Ω indicates ground wire is open
40 to B	<5Ω	>5Ω indicates V_{REF} wire is open
14 to C	<5Ω	>5Ω indicates signal wire is open

Extended Description

Function

The Engine Oil Pressure sensor (EOP) is standard in the International engine control system. Engine Shutdown and Protection is an option that can be ordered with the vehicle or activated at the dealer.

The ECM measures the EOP signal to monitor the oil pressure during engine operation. If the oil pressure drops below 5.0 psi (34 kPa) @ 700 rpm or 10.0 psi (69 kPa) @ 1400 rpm or 20.0 psi (138 kPa) @ 2000 rpm, the ECM will illuminate the red ENGINE lamp, sound an audible alarm, and cause the message **OIL/WATER** to be displayed on the odometer. If the vehicle is equipped with the Engine Shutdown system and the oil pressure drops to 2.0 psi (14 kPa) @ 700 rpm or 5.0 psi (34 kPa) @ 1400 rpm or 12.0 psi (83 kPa) @ 2000 rpm, the ECM will shut the engine off.

Operation

The Engine Oil Pressure sensor is a variable capacitance sensor located on the engine crankcase that produces a linear analog voltage signal output. The EOP sensor is supplied 5V from ECM PIN 40 to terminal B of the sensor. A return circuit (ground) is supplied from ECM pin 19 to terminal A of the sensor. Pressure applied to the EOP sensor changes the capacitance of the sensor, which varies the signal voltage sent to the ECM PIN 14. As oil pressure increases, the voltage signal increases.

ECM Diagnostics

The ECM continuously monitors the signal from the EOP sensor to ensure that the signal is within the correct operating range. If the signal voltage is higher or lower than expected, the ECM will set a Diagnostic Trouble Code. If the ignition key is shut off, the code will be stored as an inactive code.

During engine operation, the ECM also monitors the engine speed signal. It compares the expected oil pressure specification versus engine speed. If the ECM detects that the oil pressure is low for a given engine speed, the ECM will set a Diagnostic Trouble Code. If the pressure is lower than the "critical" level, the ECM will record a Diagnostic Trouble Code. The ECM will automatically record this as a low oil pressure "Event" which is stored in the ECM memory and cannot be erased using the EST. This becomes a record of operation of the engine.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 211

ATA Code, PID 100, FMI 4

Engine Oil Pressure signal Out of Range LOW

When code 211 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out Of Range LOW code will be set if the ECM detects a voltage less than 0.039V for more than 0.1 second. If this Diagnostic Trouble Code is set, the ECM will ignore the EOP signal and continue to operate normally. Diagnostic Trouble Code 211 may be caused by an open or shorted V_{REF} feed, open to ground signal circuit, or a defective sensor.

Diagnostic Trouble Code 212

ATA Code, PID 100, FMI 3

Engine Oil Pressure signal Out of Range HIGH

When code 212 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out Of Range HIGH code will be set if the ECM detects a voltage more than 4.9V for more than 0.1 seconds. If this Diagnostic Trouble Code is set, the ECM will ignore the EOP signal and continue to operate normally. Diagnostic Trouble Code 212 may be caused by an open signal return circuit, a short to a voltage source or a defective sensor.

Diagnostic Trouble Code 225

ATA Code, PID 100, FMI 0

Engine Oil Pressure signal In Range

When code 225 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 225 will be set if the ECM detects an EOP signal voltage higher than expected with the key on and the engine off (a signal that indicates 15 psi). If the ECM detects this fault, it will ignore the EOP signal. This code most likely will be set, because of a defective EOP sensor or a biased circuit.

Diagnostic Trouble Code 313

ATA Code, PID 100, FMI 1

Engine Oil Pressure Below Warning Level

Diagnostic Trouble Code 313 indicates that the oil pressure has dropped **below the warning level**. The specification for the warning level is 5.0 psi (34 kPa) @ 700 rpm or 10.0 psi (69 kPa) @ 1400 rpm or 20.0 psi (138 kPa) @ 2000 rpm.

Diagnostic Trouble Code 313 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure (with a mechanical gauge) to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.

NOTE – It may be possible to set this code at start-up, especially if the oil was just changed, or after a rebuild until the oil system is primed.

Diagnostic Trouble Code 314

ATA Code, PID 100, FMI 7

Engine Oil Pressure Below Critical Level

If Diagnostic Trouble Code 314 is set, this indicates that the oil pressure has dropped **below the critical level**. The specification for the critical level is 2.0 psi (14 kPa) @ 700 rpm or 5.0 psi (34 kPa) @ 1400 rpm or 12.0 psi (83 kPa) @ 2000 rpm.

Diagnostic Trouble Code 314 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure (with a mechanical gauge) to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.

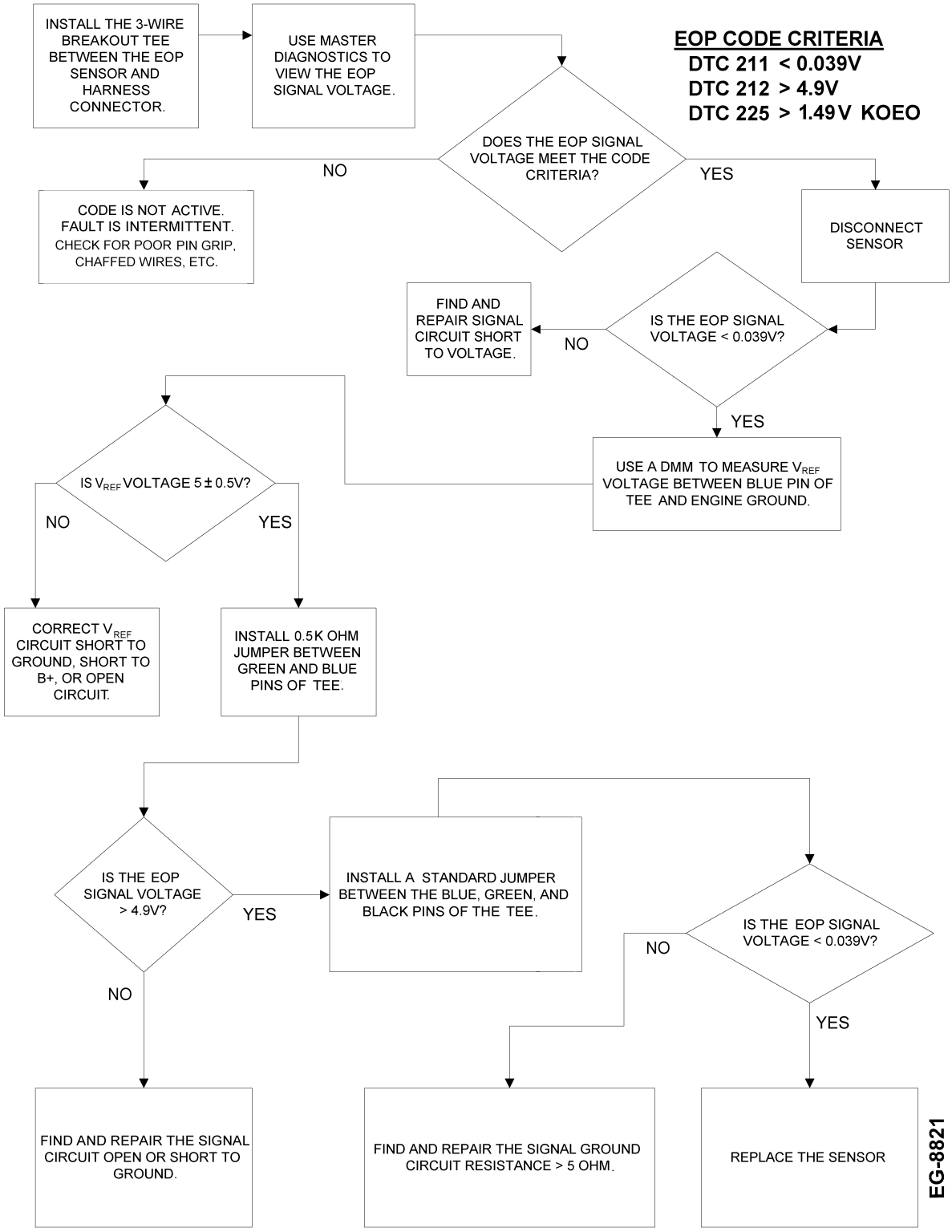

Figure 125 Engine Oil Pressure Sensor Troubleshooting Flowchart

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ENGINE OIL TEMPERATURE SENSOR (EOT)

Signal Functions

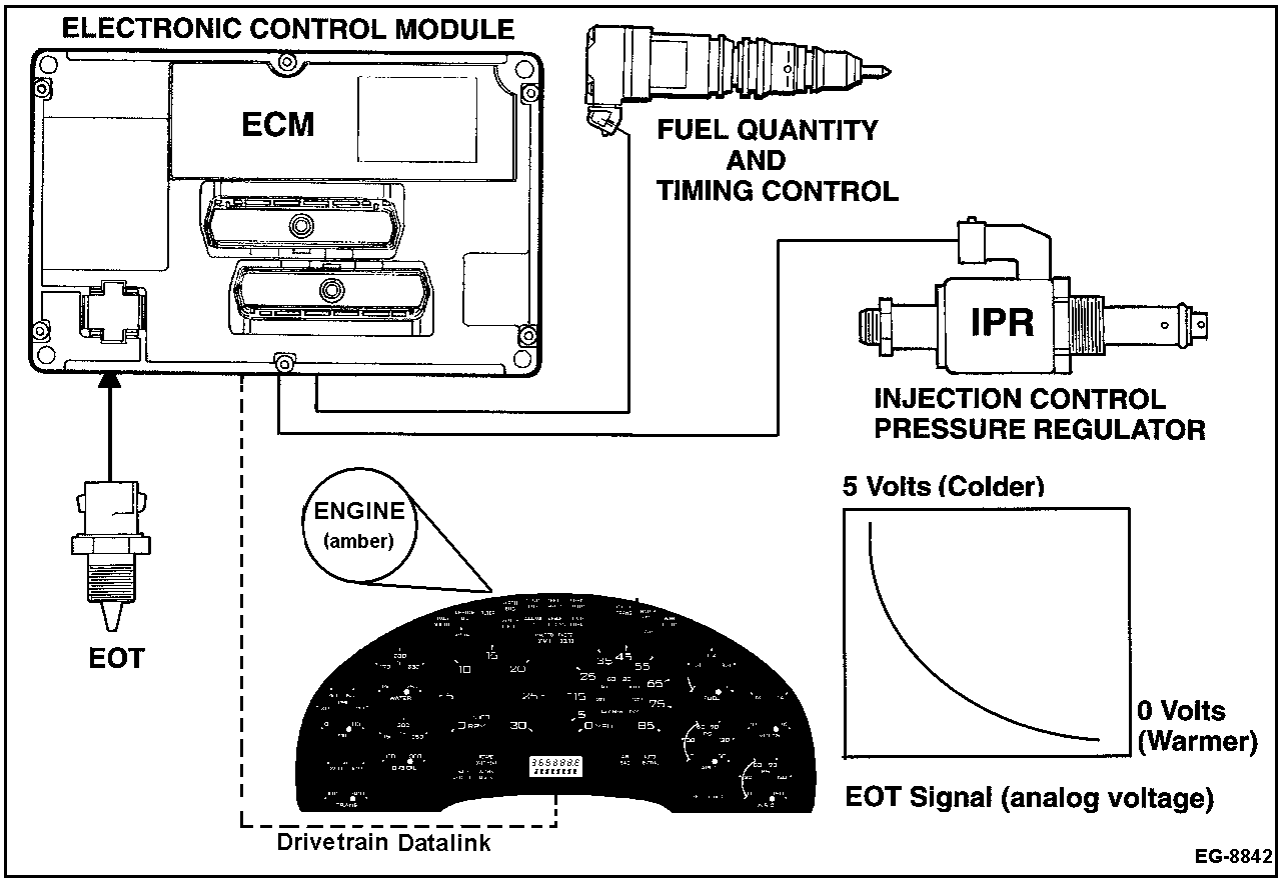

Figure 126 Engine Oil Temperature Sensor Function Diagram

The Engine Oil Temperature (EOT) sensor is a thermistor type sensor that has a variable resistance which changes when exposed to different temperatures. When interfaced with the ECM, it produces a 0 to 5V analog signal that indicates temperature.

Cranking Fuel Quantity/Timing Control - The EOT signal is used to determine the timing and quantity of fuel required to optimize starting over all temperature conditions.

Temperature Compensation - Fuel quantity and timing is controlled throughout the total operating range to compensate for oil viscosity changes due to temperature variations and insure that adequate torque and power is available.

Fault Detection / Management

When EOT signal voltage is detected Out of Range HIGH or Out of Range LOW the ECM will ignore the EOT signal and default to the engine coolant temperature (ECT) sensor. The amber ENGINE lamp will be illuminated as long as the fault condition exists with the odometer displaying WARN ENG. If both the EOT and ECT sensors are not functioning, the ECM will assume a 212°F (100°C) value for engine oil temperature.

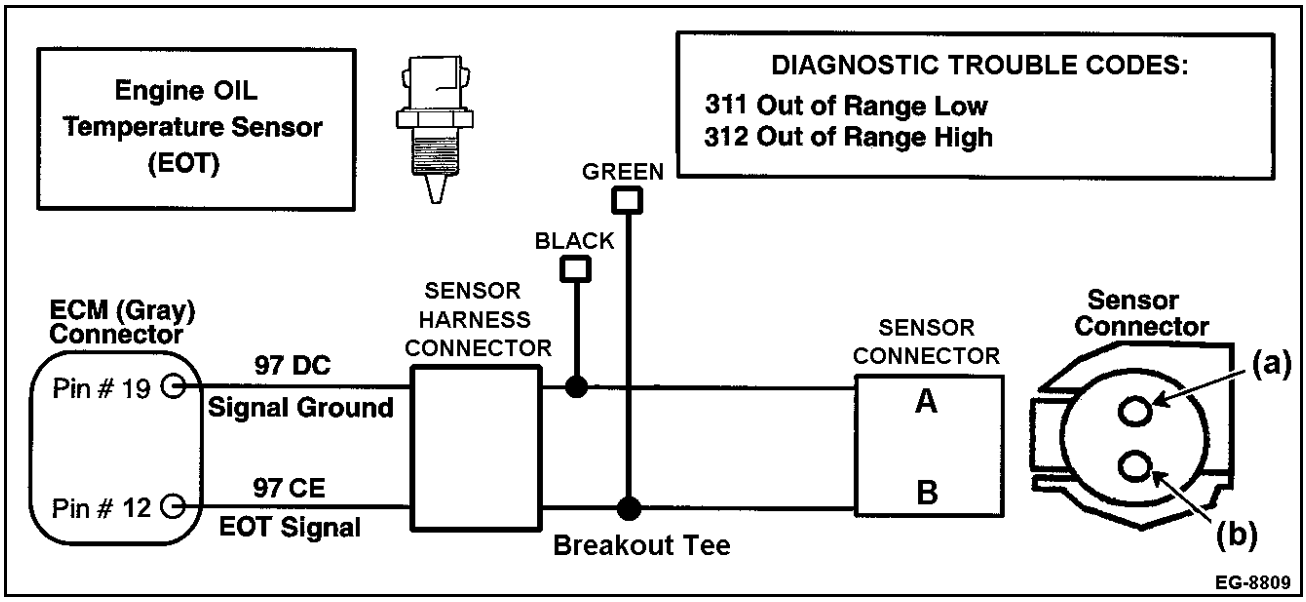

Figure 127 Engine Oil Temperature Sensor Circuit Diagram using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 66 EOT Sensor Voltage Checks Using Master Diagnostics

Engine Oil Temperature (EOT) Sensor Voltage Checks (check with key-ON engine-OFF)		
Install the 2 wire breakout tee between the EOT sensor and harness connector. View EOT VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 311= < 0.2V, Code 312 =>4.78V), complete the following steps.		
Test Condition	**Expected Voltage**	**Comments**
Sensor Disconnected	≥ 4.78V	Voltage <4.78V, inspect the signal circuit for short to ground.
Standard jumper installed between the GREEN and BLACK pins of the breakout tee	0V	If voltage is >0.2, check ground and signal circuits for an open or high resistance. Measure resistance from PIN A to PIN 19, and from PIN B to PIN 12 (spec. =<5Ω) using a breakout box to determine if the resistance is in the harness.
0.5 kΩ jumper installed between the GREEN and BLACK pins of the breakout tee	< 1.0 V	If voltage is > 1.0V, check signal circuit for a short to V_{REF}, B+, or another sensor's signal voltage.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See EOT Sensor Troubleshooting Flowchart (See Figure 128, page 269) .		
Continued on Next Page		

Table 66 EOT Sensor Voltage Checks Using Master Diagnostics (cont.)

MD Voltage: (+) #12 to (-) #19		**Operational Signal Checks** (check with breakout tee installed in-line with the sensor)	
Oil Temp °F	Temp °C	Resistance	Volts @ Resistance
32	0	91.1kΩ	4.348V
68	20	35.5 kΩ	3.782V
212	100	2.0 kΩ	0.819V
Diagnostic Trouble Code Description			
311 = Signal voltage was <0.2 volts for more than 0.1 sec.			
312 = Signal voltage was >4.78 volts for more than 0.1 sec.			

Table 67 EOT Circuit Specifications (See Figure 127, page 265)

Connector Voltage Checks (check with sensor connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
B to gnd	4.8V to 5.0V	Pull up voltage, if low or no voltage, circuit has open or high resistance or short to ground
A to gnd	0V to 0.25V	If > 0.25V, signal ground wire is shorted to V_{REF} or battery
Connector Checks to Chassis Ground (check with sensor connector disconnected, ignition key OFF & positive battery cable disconnected)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key OFF, if > 5Ω check for open
B to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground
Harness Resistance Checks (check with breakout box installed on engine harness only)		
Test Points	Spec.	Comments
19 to A	<5Ω	>5Ω indicates ground wire is open
12 to B	<5Ω	>5Ω indicates signal wire is open

Extended Description

Function

The International engine control system includes an Engine Oil Temperature (EOT) sensor. The ECM monitors engine oil temperature via the EOT sensor signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment. This insures that adequate power and torque are available under all operating conditions.

Operation

The Engine Oil Temperature Sensor is a thermistor type sensor that changes resistance when exposed to the oil operating temperatures.

When the temperature of the oil is decreased the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the oil is increased, the resistance of the thermistor decreases, causing the signal voltage to decrease.

The EOT sensor is supplied a regulated 5V reference signal at terminal B from the ECM. A return circuit (ground) is supplied at terminal A from the ECM. As the oil temperature increases or decreases, the sensor changes resistance and provides the ECM with the oil temperature signal voltage. This signal voltage is then read by the ECM to determine the temperature of the oil.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the EOT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a Diagnostic Trouble Code.

If the ECM detects a fault, it will use the value of the Engine Coolant Temperature signal, in place of the EOT signal. If the ECT sensor has a fault, the ECM will default to 29°F (-1.7°C) for starting, or 212°F (100°C) for engine running operation. If the ignition key is shut off, the code will become inactive. EOT codes will cause the ECM to illuminate the amber ENGINE lamp and cause the odometer to display the message WARN ENG.

EOT Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 311

ATA Code, PID 175, FMI 4

Engine Oil Temperature signal Out of Range LOW

When code 311 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 311 Out of Range LOW, will be set if the signal voltage was less than 0.2V for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of -4°F (-20°C) for starting or 212°F (100°C) for engine running operation.

Diagnostic Trouble Code 311 may be set due to a short to ground in the signal circuit or a defective sensor.

Diagnostic Trouble Code 312

ATA Code, PID 175, FMI 3

Engine Oil Temperature signal Out of Range HIGH

When code 312 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 312 Out of Range HIGH, will be set if the signal voltage is more than 4.8V for more than 0.1 seconds. If this code is set, the ECM will default to an EOT value of -4°F (-20°C) for starting or 212°F (100°C) for engine running operation.

Diagnostic Trouble Code 312 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause code 312 to be set.

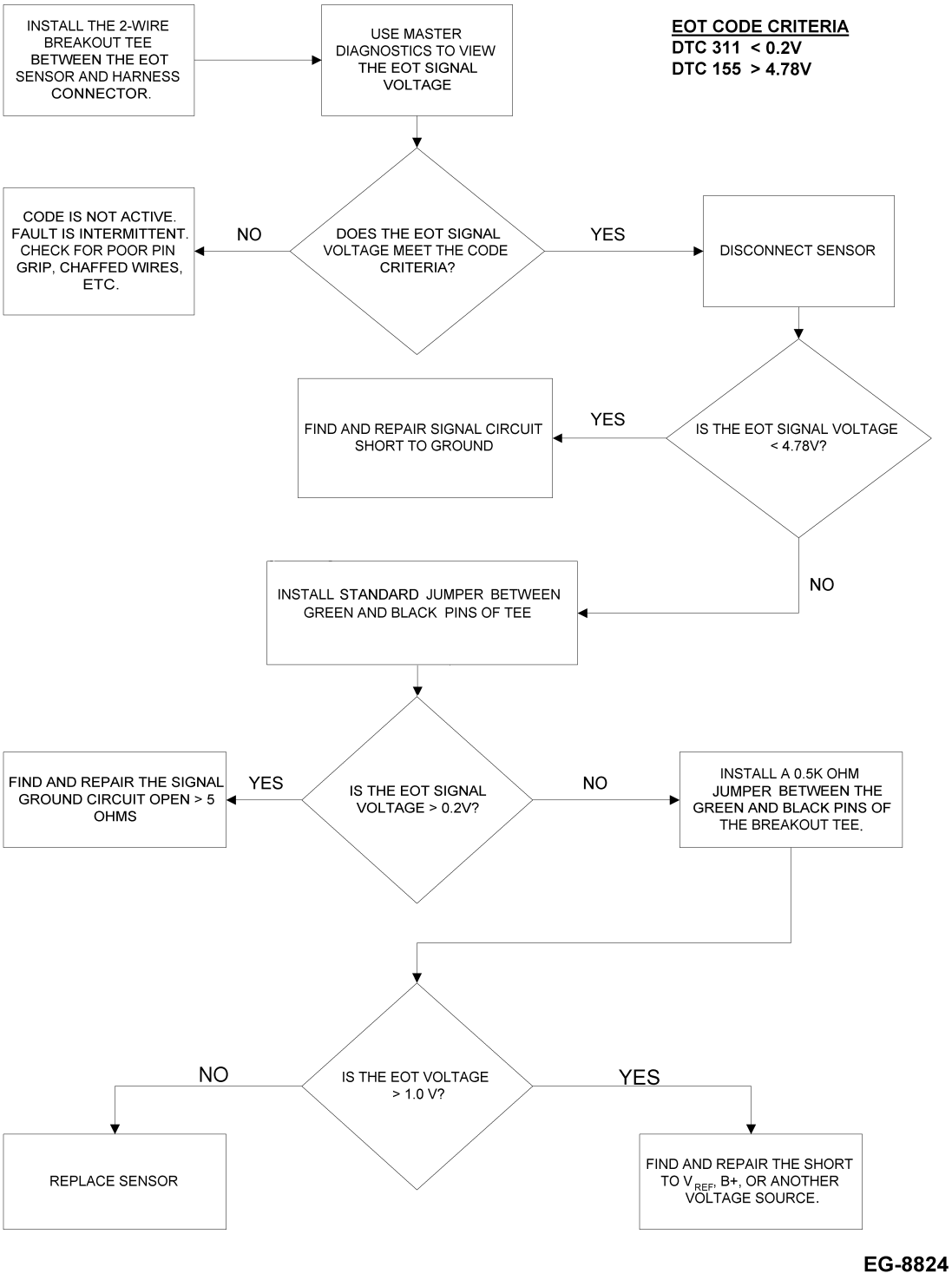

Figure 128 Engine Oil Temperature Sensor Troubleshooting Flowchart

ELECTRONIC PRESSURE GOVERNOR (EPG)

Signal Functions

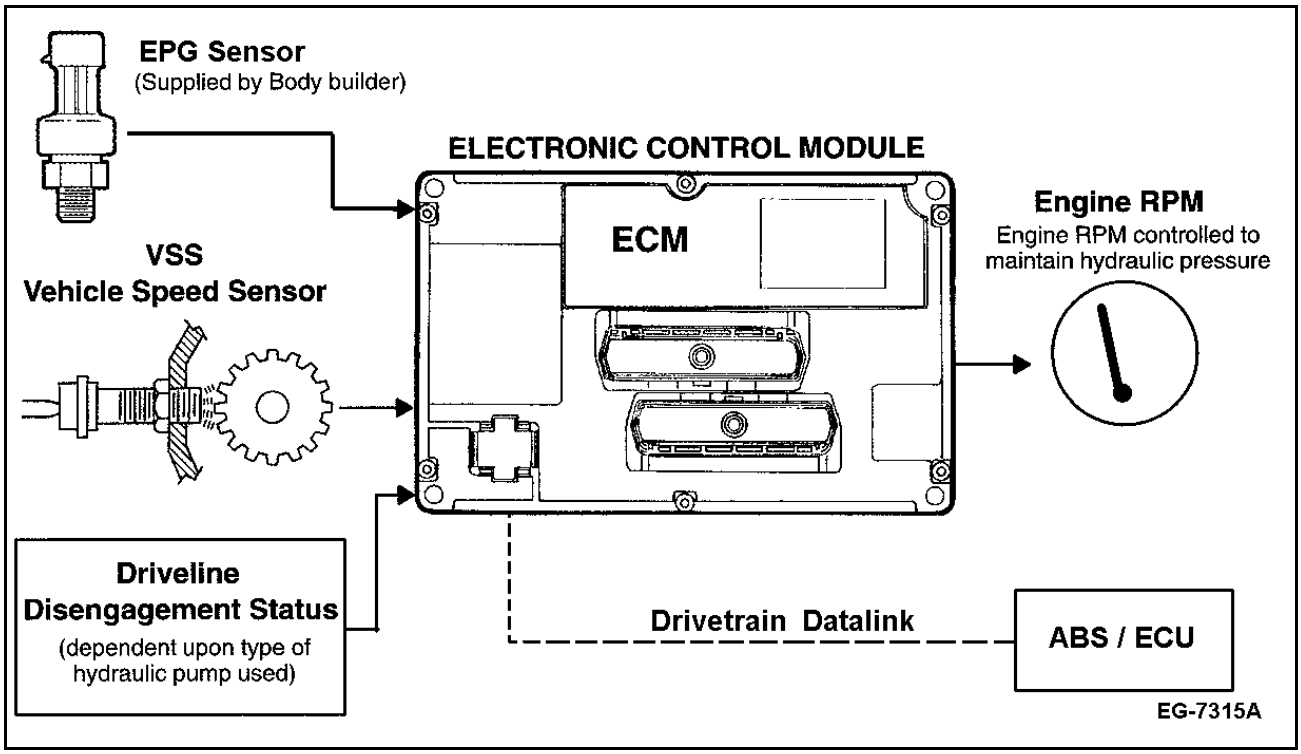

Figure 129 Electronic Pressure Governor Function Diagram

The Electronic Pressure Governor (EPG) is an optional feature used for closed loop control of hydraulic pressure based on an external hydraulic pressure input and a programmable desired hydraulic pressure. This feature is targeted for fluid delivery pumps, especially fire truck applications.

The EPG feature is active when no EPG (pressure sensor) Diagnostic Trouble Code exists, the driveline is in its proper state (which is dependent on the type of pump used), the vehicle is stationary and its corresponding programmable parameter is turned on.

Diagnostic Trouble Code Detection / Management

If the ECM detects an Out of Range HIGH or LOW condition in the EPG circuit, it will set a Diagnostic Trouble Code and disable EPG operation. The system will drop to idle speed with all control presets reset to standby conditions.

The ECM also monitors hydraulic pressure, engine speed and the status of the EPG select switch. If pressure loss is detected (also referred to as steady state error) the EPG feature is turned off and a corresponding Diagnostic Trouble Code is set. The system will drop to idle speed with all control presets reset to standby conditions.

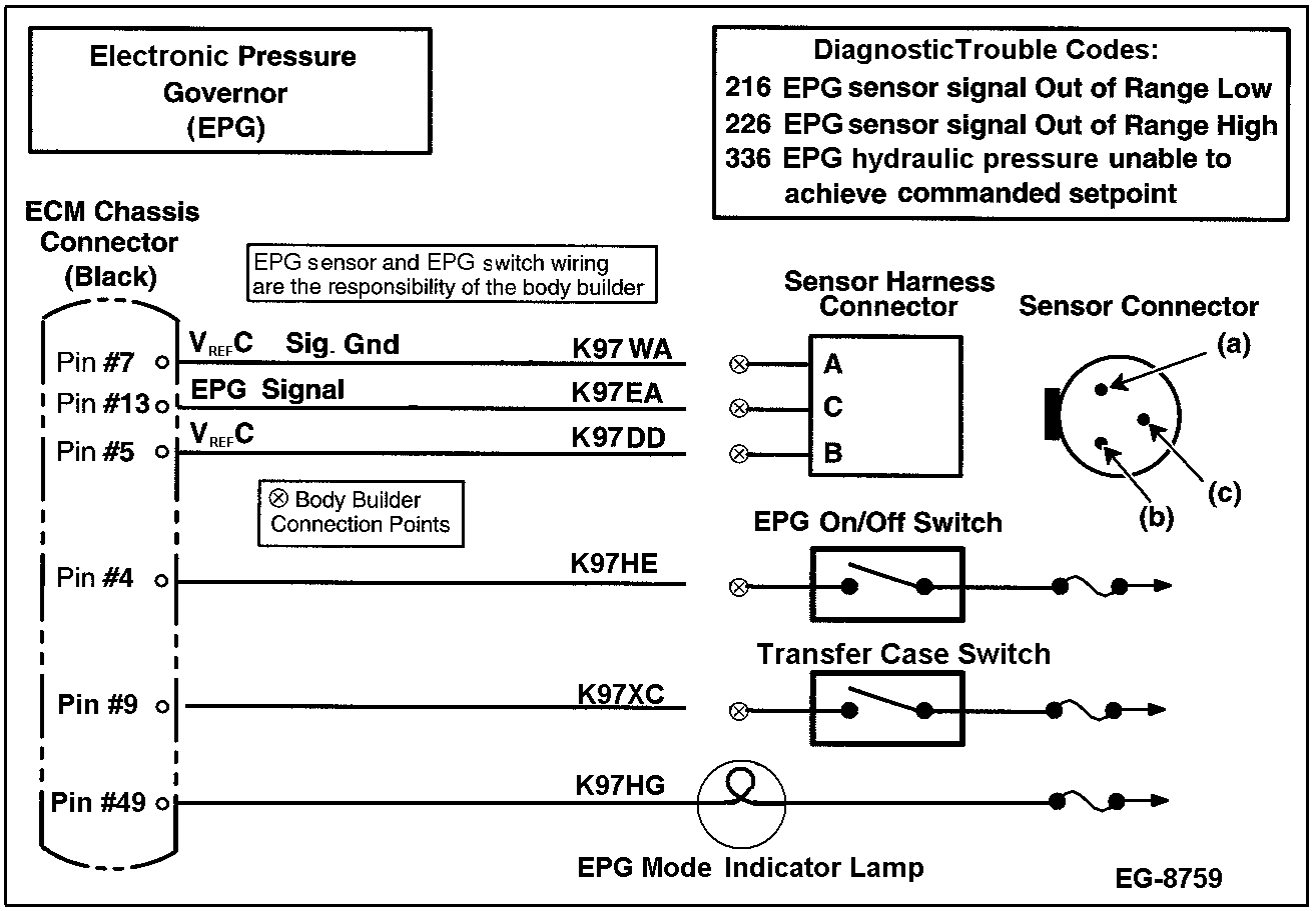

Figure 130 Electronic Pressure Governor Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 68 Electronic Pressure Governor Diagnostics

Sensor Connector Voltage Checks (check with sensor connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	0V	Signal ground no voltage expected
B to gnd	5V ± 0.5	V_{REF} check with key ON, if voltage not in specs, see V_{REF} circuit
C to gnd	<0.25V	If > 0.25V, signal wire is shorted to V_{REF} or battery
Sensor Connector Checks to Chassis Ground (check with sensor connector disconnected, positive battery cable disconnected & ignition key OFF)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key off, if > than 5Ω the circuit is open
B to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground
C to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground
Harness Resistance Checks (check with breakout box installed on chassis harness only)		
Test Points	Spec.	Comments
7 to A	<5Ω	>5Ω indicates ground wire is open
5 to B	<5Ω	>5Ω indicates V_{REF} wire is open
13 to C	<5Ω	>5Ω indicates signal wire is open

Table 68 Electronic Pressure Governor Diagnostics (cont.)

Test Points	Switch / Lamp State
4 to gnd	12V = EPG enabled, 0V = EPG disabled
9 to gnd	12V = auxiliary on, 0V = driveline
49 to gnd	0V = auxiliary on, 12V = driveline
Diagnostic Trouble Code Description	
216 = Signal voltage was <0.039V for more than 0.1 sec.	
226 = Signal voltage was >4.9V for more than 0.1 sec.	
336 = Hydraulic pressure unable to achieve commanded set point (cavitation protection).	

Extended Description

When the EPG feature is first initiated, the desired hydraulic pressure is ramped up at a programmable ramp rate. The limited desired pressure (set point) is then used along with the actual hydraulic pressure signal (feedback) to control desired engine speed required to achieve the desired hydraulic pressure.

- **Electronic Pressure Governor Parameters -** This group of parameters customizes the electronic pressure governor feature.
- **Electronic Pressure Governor -** This parameter indicates to the on-board electronics if the vehicle has the electronic pressure governor feature.

  OFF: Feature is turned off at all times.

  ON: Feature is enabled and may be turned on and activated by the operator.
- **Electronic Pressure Governor DDS -** This parameter indicates how the driveline disengagement signal should be interpreted by the on-board electronics.

  NEUTRAL OPERATION: Driveline must be disengaged at all times for electronic pressure governor operation.

  SPLIT SHAFT: If the DDS status changes the Electronic Pressure Governor will be deactivated. DDS engaged, must receive XCS “Auxiliary ON” signal to enable.
- **EPG Mode Indicator -** This parameter indicates if the Electronic Pressure Governor operation mode indicator is available.

  OFF: Indicator is not available.

  ON: Indicator is available.
- **Pressure Ramp Rate -** This parameter indicates the rate that the water pressure is to be increased when the operator depresses and holds the Resume/Accel button.
- **EPG Integral Gain Adjust -** This parameter allows the customer to fine tune how the Electronic Pressure Governor will control the water pressure.
- **EPG Proportional Gain Adjust -** This parameter allows the customer to fine tune how the Electronic Pressure Governor will control the water pressure.

ECM Diagnostics

EPG Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 216

ATA Code, PID 73, FMI 4

Electronic Pressure Governor signal Out of Range LOW

An Out of Range LOW code 216 will be set by the ECM if the signal voltage is less than 0.039V for more than 1 second. When this code is set, the EPG function is disabled.

Diagnostic Trouble Code 216 may be set due to an open or short to ground on the signal circuit, a defective sensor or connector or an open V_{REF} circuit.

Diagnostic Trouble Code 226

ATA Code, PID 73, FMI 3

Electronic Pressure Governor signal Out of Range HIGH

An Out of Range HIGH code 226 will be set by the ECM if the signal voltage is greater than 4.9V for more than 1 second. When this code is set, the EPG function is disabled.

Diagnostic Trouble Code 226 may be caused by a short on the signal circuit to a voltage source or a defective sensor.

Diagnostic Trouble Code 336

ATA Code, PID 73, FMI 10

Hydraulic Pressure Unable to Achieve Commanded Set Point

The ECM has detected that the hydraulic system has not been capable of achieving the hydraulic pressure requested by the system. When this Diagnostic Trouble Code is active, the EPG function is disabled.

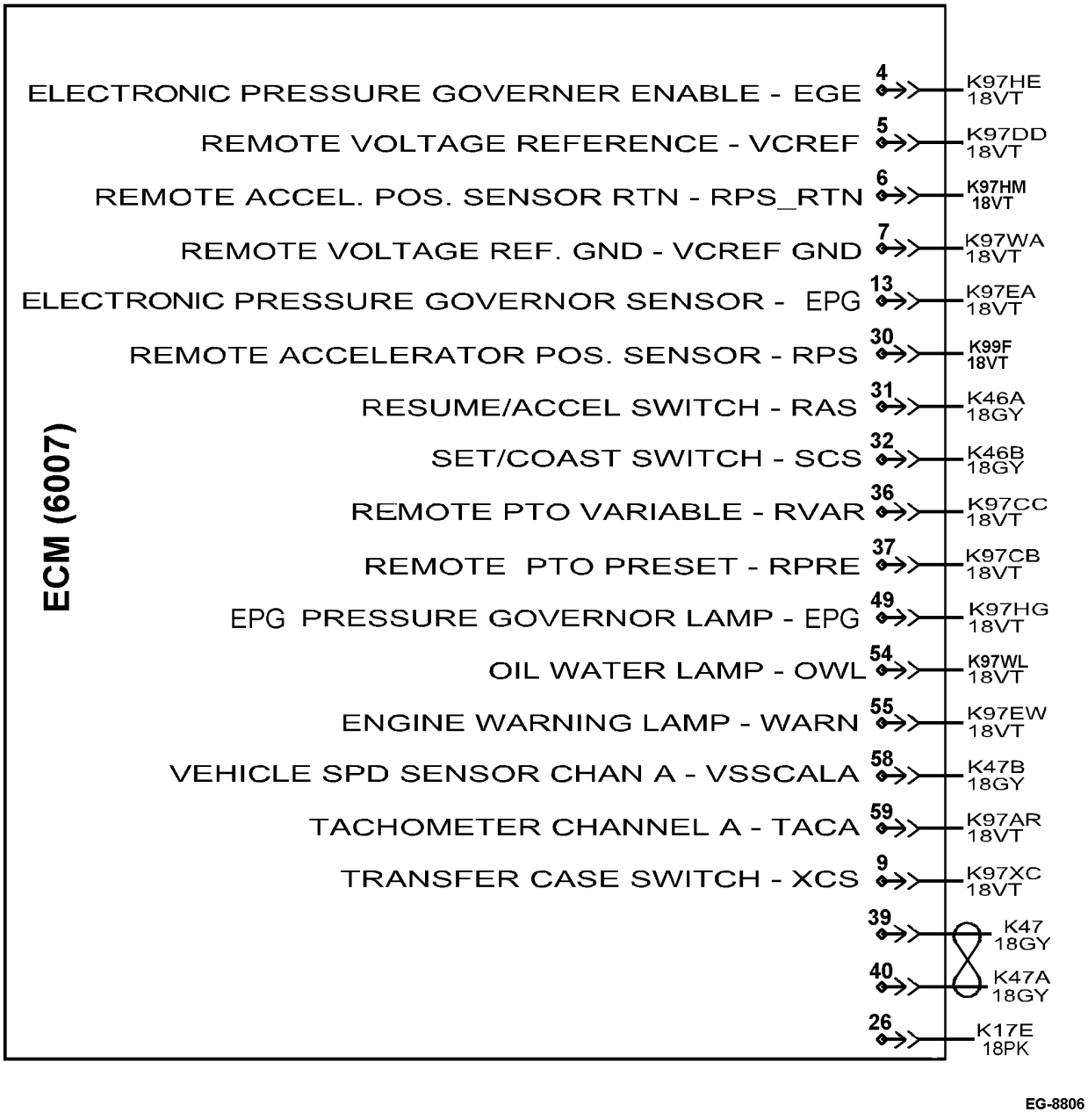

Figure 131 ECM Body Builder Connections

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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INTAKE AIR TEMPERATURE SENSOR (IAT)

Signal Functions

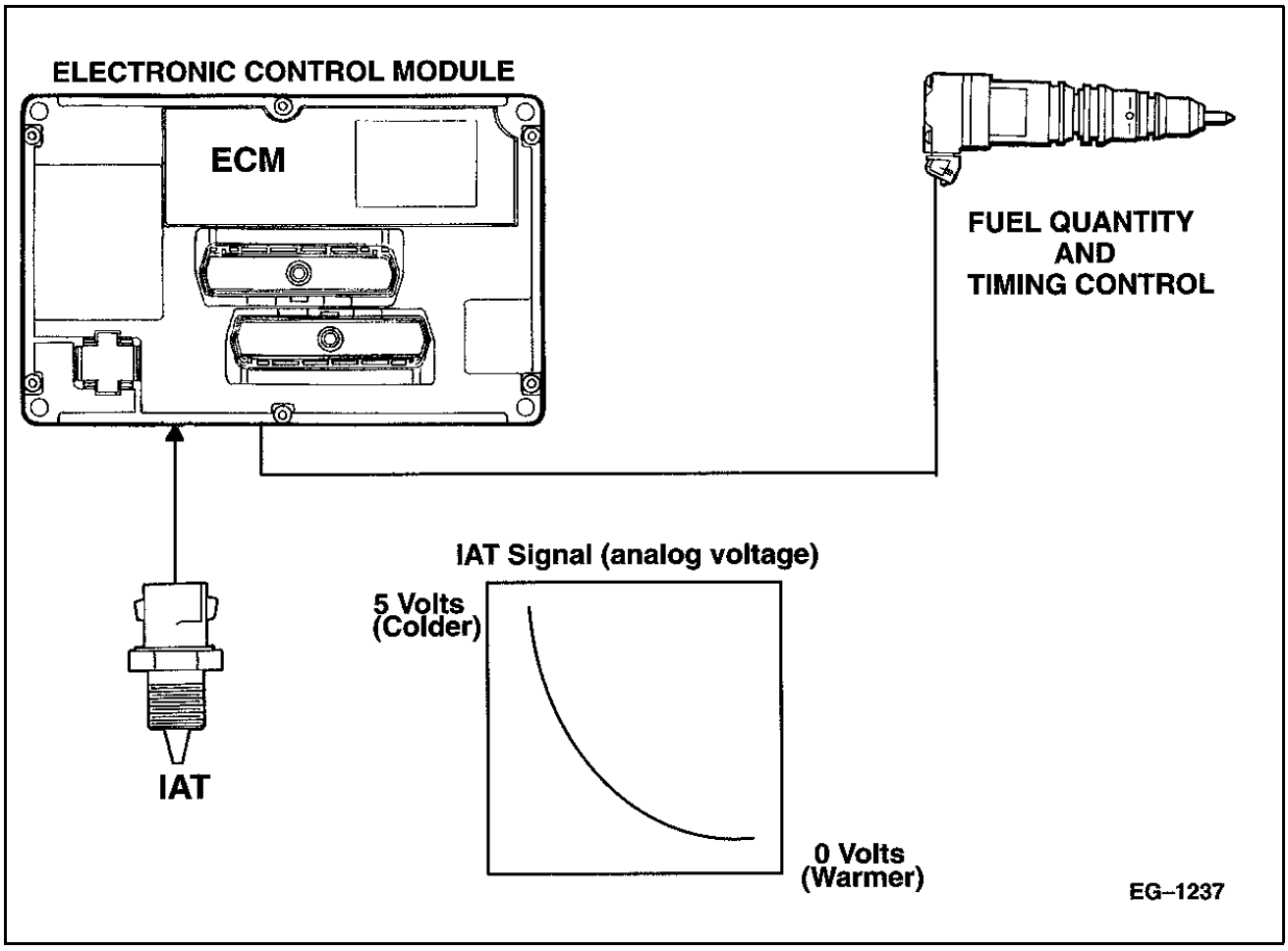

Figure 132 Intake Air Temperature Sensor Function Diagram

The Intake Air Temperature (IAT) sensor is a thermistor type sensor that changes resistance when exposed to different temperatures. When interfaced with the ECM it produces a 0-5V analog signal that will indicate intake air temperature.

Timing and Fuel Rate - The IAT sensor's primary function is to measure intake air temperature in order to control timing and fuel rate while starting the engine in cold weather to limit smoke emissions.

Diagnostic Trouble Code Detection / Management

An IAT signal that is detected Out of Range HIGH or LOW by the ECM will cause the engine to ignore the IAT signal, and assume an ambient temperature of 77°F (25°C).

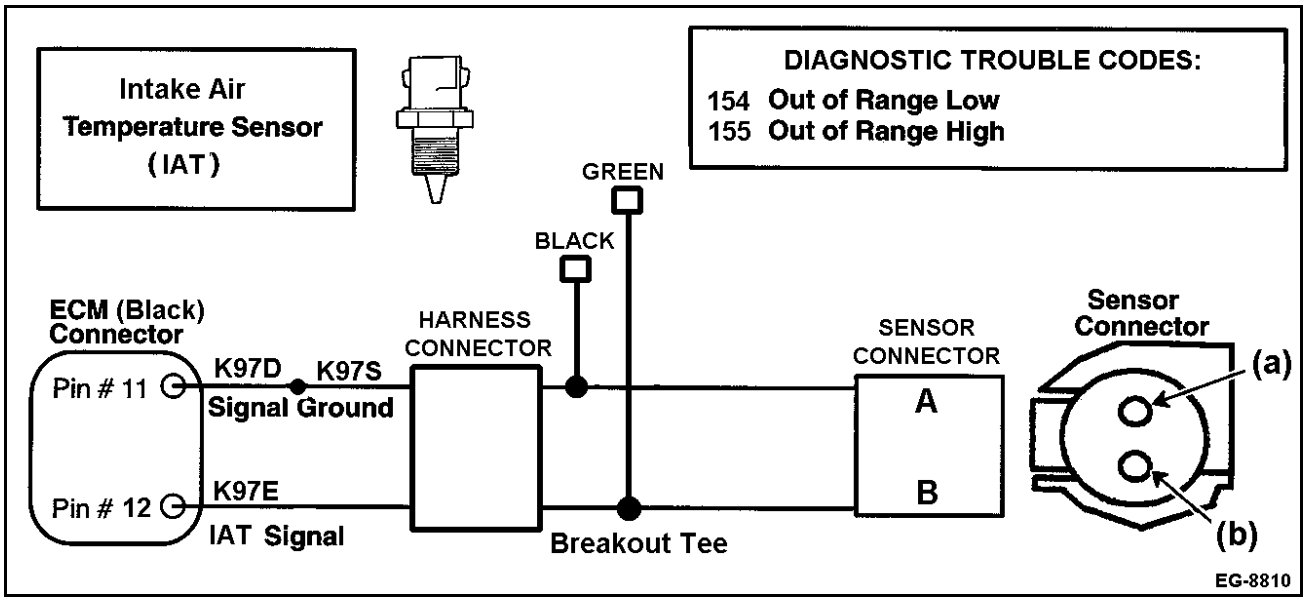

Figure 133 Intake Air Temperature Sensor Circuit Diagram using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 69 IAT Sensor Tests Using Master Diagnostics

Intake Air Temperature Sensor (IAT) Voltage Checks (check with key-ON engine-OFF)			
Install the 2 wire breakout tee between the IAT sensor and harness connector. View IAT VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 154 <0.127V, Code 155 >4.6V), complete the following steps.			
Test Condition		**Expected Voltage**	**Comments**
Sensor disconnected		≥ 4.6 V	Voltage < 4.6V, inspect the signal circuit for short to ground.
Standard jumper installed between the GREEN and BLACK pins of the breakout tee		0 V	If voltage is > 0.127V, check ground and signal circuits for an open or high resistance. Measure resistance from PIN A to PIN 11, and from PIN B to 12 (spec. =<5Ω) using a breakout box to determine if the resistance is in the harness.
0.5 kΩ jumper installed between the GREEN and BLACK pins of the breakout tee		< 1.0 V	If voltage is > 1.0V, check signal circuit for a short to V_{REF}, B+, or another sensor's signal voltage.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See IAT Sensor Troubleshooting Flowchart (See Figure 135, page 280).			
Test Points: (+)12 to (-)11		**Operational Signal Checks** (check with breakout tee installed in-line with the sensor)	
Temp °F	Temp °C	Min. Resistance	Volts@ min. resistance
32	0	91.1 kΩ	3.846V
68	20	35.5 kΩ	3.041V
212	100	2.0 kΩ	0.446V
Continued on Next Page			

Table 69 IAT Sensor Tests Using Master Diagnostics (cont.)

Diagnostic Trouble Code Description
154 = Signal voltage was <0.127 volts for more than 0.2 sec.
155 = Signal voltage was >4.6 volts for more than 0.2 sec.

Table 70 IAT Sensor Circuit Specifications (See Figure 133, page 277)

Connector Voltage Checks (check with sensor connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	0 to 0.25V	Green wire, no voltage expected. If >0.25V, signal wire is shorted to V_{REF} or battery
B to gnd	4.6 to 5.0V	Pull up voltage, if no voltage, circuit has open or high resistance or short to ground
Connector Checks to Chassis Ground (check with sensor connector disconnected, positive battery cable disconnected & ignition key OFF)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key off, if >5Ω the circuit is open
B to gnd	>1kΩ	Resistance < 1kΩ indicates a short to ground
Harness Resistance Checks (check with breakout box installed on chassis harness only)		
Test Points	Spec.	Comments
11 to A	<5Ω	>5Ω indicates ground wire is open
12 to B	<5Ω	>5Ω indicates signal wire is open

Extended Description

Function

The International engine control system includes an Intake Air Temperature Sensor (IAT). The ECM measures the signal from the IAT sensor to determine the temperature of the air entering the engine. The ECM uses this data to adjust timing and fuel rate for starting in cold weather to limit smoke emissions.

Operation

The Intake Air Temperature Sensor is a thermistor type sensor that changes resistance when exposed to different air temperatures. When the temperature of the intake air decreases, the resistance of thermistor increases which causes the signal voltage to increase. When the air temperature increases, the resistance of the thermistor decreases causing the signal voltage to decrease.

The IAT sensor is supplied a regulated 5V reference signal at terminal B from the ECM. A return circuit (ground) is supplied at terminal A from the ECM. As the air temperature increases or decreases, the sensor changes resistance and provides the ECM with the air temperature signal voltage reading.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the IAT signal to determine if it's within expected values. If the signal voltage is above or below the expected levels, the ECM will set a Diagnostic Trouble Code. If the IAT sensor is not sending a correct signal, the ECM will default to 77°F (25°C).

IAT Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 154

ATA Code, PID 171, FMI 4

Intake Air Temp signal Out of Range LOW

An Out of Range LOW code will be set if the ECM detects the signal voltage to be less than 0.127V for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25°C) for starting.

Diagnostic Trouble Code 154 may be set due to a short to ground in the signal circuit or a defective sensor.

Diagnostic Trouble Code 155

ATA Code, PID 171, FMI 3

Intake Air Temp signal Out of Range HIGH

An Out of Range HIGH code will be set if the ECM detects the signal voltage to be more than 4.6V for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25°C) for starting.

Diagnostic Trouble Code 155 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause code 155 to be set.

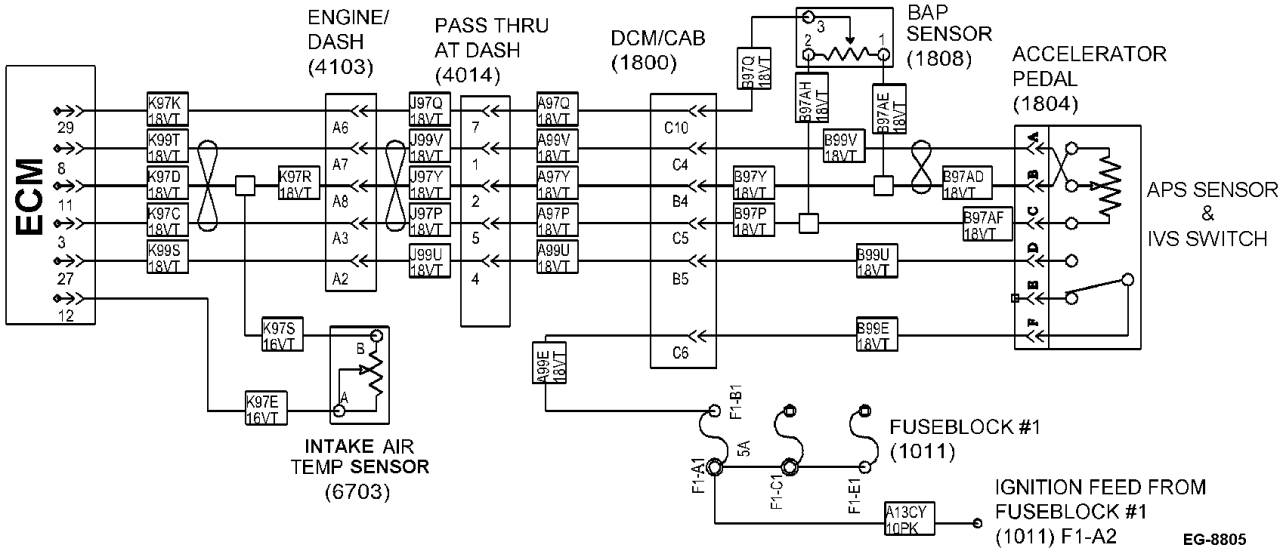

Figure 134 Accelerator, BAP, IAT Sensor Systems Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

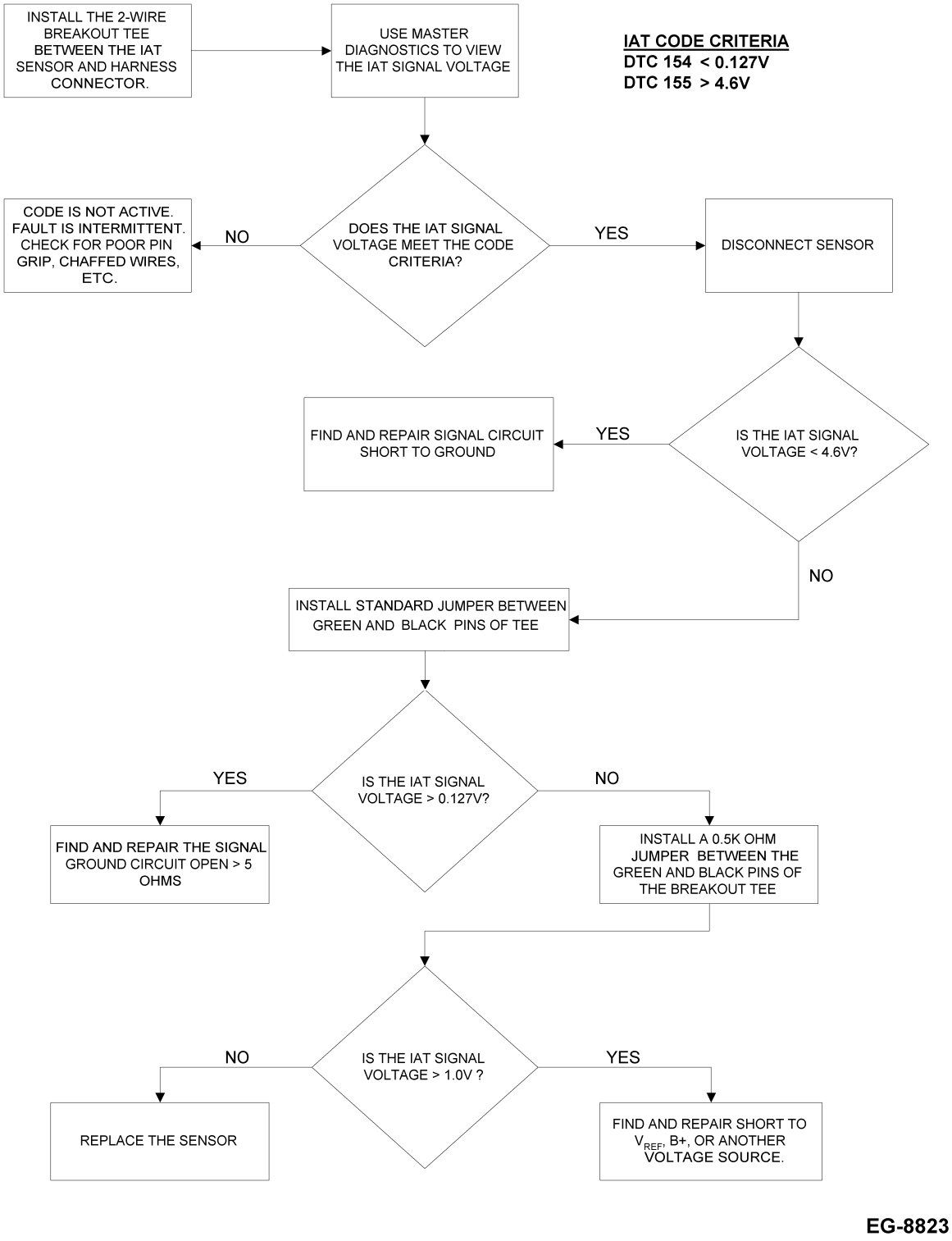

Figure 135 Intake Air Temperature Sensor Troubleshooting Flowchart

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INJECTION CONTROL PRESSURE SENSOR (ICP)

Signal Functions

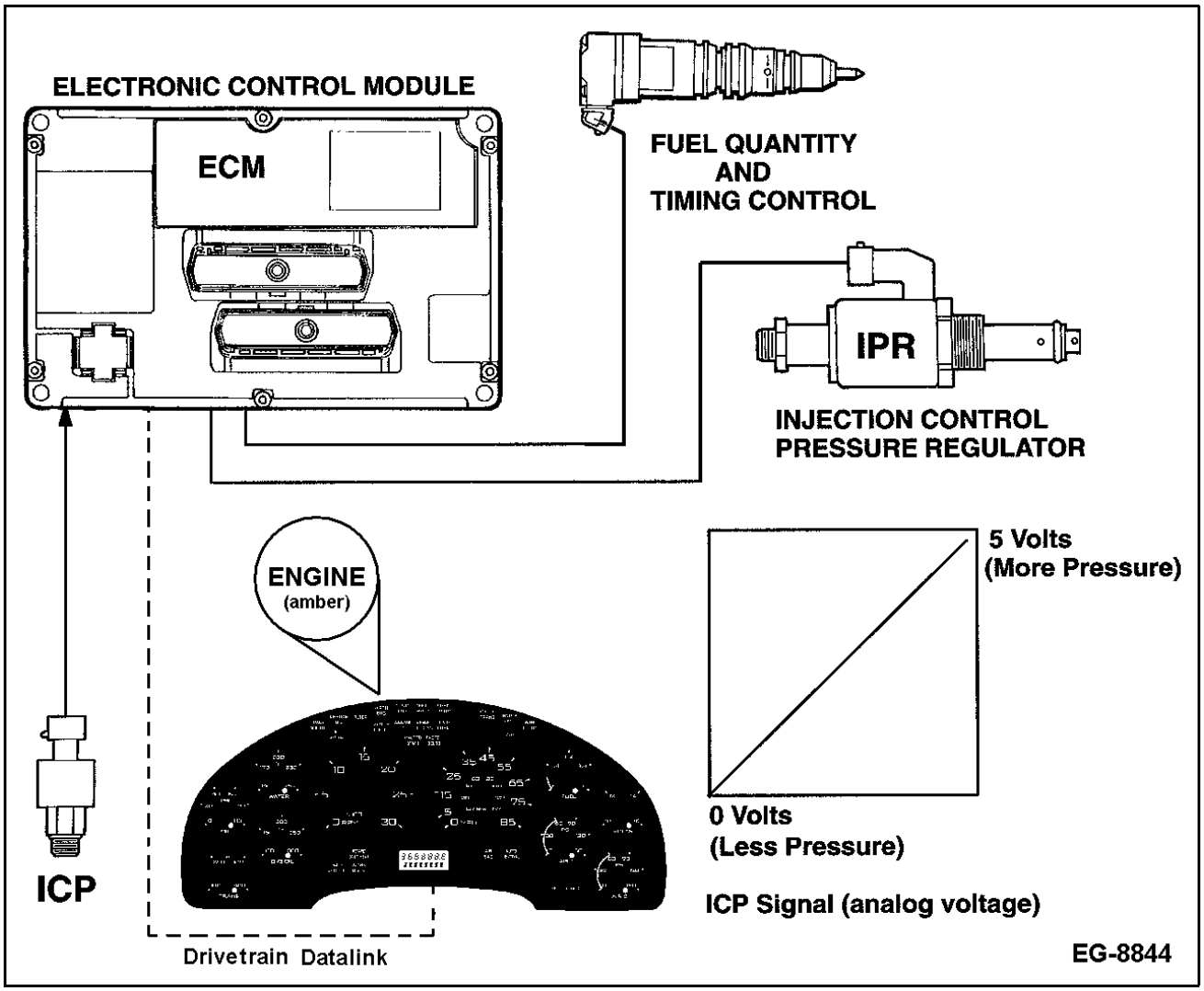

Figure 136 Injection Control Pressure Sensor Function Diagram

The Injection Control Pressure (ICP) sensor is a variable capacitance sensor that when supplied with a 5V reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

The ICP sensor's primary function is to provide a feedback signal to indicate injection control pressure to enable the ECM to command the correct injector timing and pulse width and the correct injection control pressure for proper fuel delivery at all speed and load conditions.

Fault Detection / Management

If the ECM detects a malfunctioning ICP sensor or a problem in the ICP sensor circuit, the ECM will illuminate the amber ENGINE lamp and the odometer will display the message **WARN ENG**. The ECM will go to open loop control of injection control pressure (operate from an estimated ICP pressure).

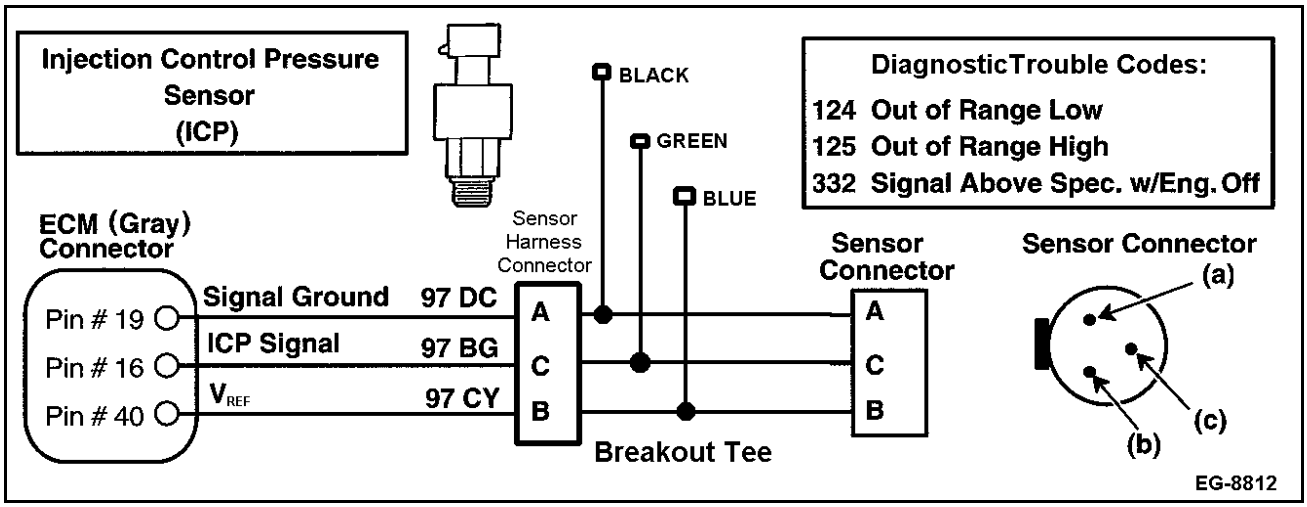

Figure 137 Injection Control Pressure Sensor Circuit Diagram Using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, loose terminals etc.

Table 71 ICP Sensor Tests Using Master Diagnostics

Injection Control Pressure (ICP) Sensor Voltage Checks (check with key-ON engine-OFF)		
Install the 3 wire breakout tee between the ICP sensor and harness connector. View ICP VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code124 <0.039V, Code 125 >4.9V, Code 332 >1.625V), complete the following steps. Tests must be performed in order.		
Test Condition	**Expected Voltage**	**Comments**
Sensor Disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Measure voltage from PIN B to gnd using a DMM.	5V ± 0.5	If voltage is >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} for open or short to Ground.
0.5 kΩ jumper installed between the GREEN and BLUE pins of the breakout tee.	5V	If voltage is <4.9V, check signal circuit for open circuit or short to ground. Remove positive battery cable. Measure resistance from PIN C to Ground (spec >500Ω) and from PIN C to PIN 16 (spec <5Ω) using a breakout box to determine if short to ground or open is in the harness.
Standard jumper installed between the BLUE, GREEN, and BLACK pins of the breakout tee.	0V	If voltage is >0.039V, check ground circuit for resistance. Measure resistance between PIN A and PIN 19 (spec <5Ω) using a breakout box to determine if resistance is in the harness.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor <u>is not at fault</u> if one or more of the sensor tests does not produce the expected results. See ICP Sensor Troubleshooting Flowchart (See Figure 138, page 287).		
Continued on Next Page		

Table 71 ICP Sensor Tests Using Master Diagnostics (cont.)

OPERATIONAL VOLTAGE CHECKS		
MD Voltage: Signal (GREEN tee) to gnd	**Spec.**	**Check with breakout tee installed, key ON**
Voltage	**psi**	**Comments**
0.15 to 0.3V	0	Atmospheric pressure with key-ON engine-OFF
1.0V	580	Minimum at engine cranking speed
0.74 - 0.81V	425 - 475	Normal warm low idle
3.33V	2550	Snap accel
Diagnostic Trouble Code Description		
124 = Signal voltage was <0.039 volts for more than 1.0 sec.		
125 = Signal voltage was >4.9 volts for more than 1.0 sec.		
332 = Signal voltage was >1.625 volts, ignition key ON, engine OFF (1160 psi).		

Table 72 ICP Sensor Circuit Specifications (See Figure 137, page 283)

CONNECTOR VOLTAGE CHECKS (check with sensor disconnected from harness, key ON)		
Test Points	**Spec.**	**Comments**
A to gnd	0V	Signal ground, no voltage expected
B to gnd	5±0.5V	If voltage not in spec., Vref circuit shorted to gnd or B+
C to gnd	<0.25V	If voltage > spec., wire shorted to Vref or B+
CONNECTOR CHECKS TO CHASSIS GROUND (check with sensor connector disconnected, positive battery cable disconnected, and key OFF)		
Test Points	**Spec.**	**Comments**
A to gnd	< 5Ω	> 5Ω, indicates circuit is open
B to gnd	> 500Ω	< 500Ω, indicates short to ground
C to gnd	> 1kΩ	< 1kΩ, indicates short to ground
HARNESS RESISTANCE CHECKS (check with breakout box installed on chassis side only)		
Test Points	**Spec.**	**Comments**
19 to A	<5Ω	If >5Ω indicates ground wire open
40 to B	<5Ω	If >5Ω indicates V_{REF} wire open
16 to C	<5Ω	If >5Ω indicates signal wire open

Extended Description

Function

The International engine control system includes an Injection Control Pressure Sensor. The ECM measures the signal from the ICP sensor to determine the Injection Control Pressure as the engine is running to modulate the Injection Control Pressure Regulator. This is a closed loop function which means the ECM continuously monitors and adjusts for ideal Injection Control Pressure which is determined by operating conditions such as load, speed, and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the pressure reading is lower or higher than the value that was commanded, the ECM will set a Diagnostic Trouble Code. This strategy is also used during the On Demand tests, commanded by the EST and referred to as the Engine Running tests.

Operation

The Injection Control Pressure Sensor is a variable capacitance sensor that is supplied with a 5V reference voltage at terminal B from ECM terminal 40. The ICP sensor is also supplied with a return circuit (ground) at terminal A from ECM terminal 19. The ICP sensor sends a signal from terminal C of the sensor to ECM terminal 16.

The ICP signal voltage changes in direct proportion to the injection control pressure.

ECM Diagnostics

The ECM continuously monitors the voltage signal of the ICP sensor to determine if the signal is within an expected range. If the signal voltage is higher or lower than expected, the ECM will set a Diagnostic Trouble Code. The ECM will then ignore the ICP sensor signal and will use a preset value determined by engine operating conditions. If the ignition key is shut off, the code will become inactive.

ICP Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

If the ignition key is shut off, the code will become inactive. ICP codes will cause the ECM to illuminate the amber ENGINE lamp and the odometer to display the message WARN ENG.

Diagnostic Trouble Code 124

ATA Code, PID 164, FMI 4

ICP signal Out of Range LOW

When code 124 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out of Range LOW code 124 will be set by the ECM if the signal voltage is less than 0.039V for more than 1.0 seconds.

Diagnostic Trouble Code 124 may be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit.

Diagnostic Trouble Code 125

ATA Code, PID 164, FMI 3

ICP Signal Out Of Range HIGH

When code 125 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

An Out of Range HIGH code 125 will be set by the ECM if the signal voltage is greater than 4.9V for more than 1.0 seconds.

Diagnostic Trouble Code 125 may be set by an open return circuit (ground), short to a voltage source on the ICP signal circuit or a defective sensor.

Diagnostic Trouble Code 332

ATA Code, PID 164, FMI 13

Injection Control Pressure above Specification with Engine Off

When code 332 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 332 will be set by the ECM if the signal from the ICP sensor is higher than expected with the engine not running. If the ECM detects this fault, the ECM will ignore the ICP signal and will operate the IPR with fixed values determined from engine operating conditions.

Code 332 may be caused by a defective sensor or a biased circuit.

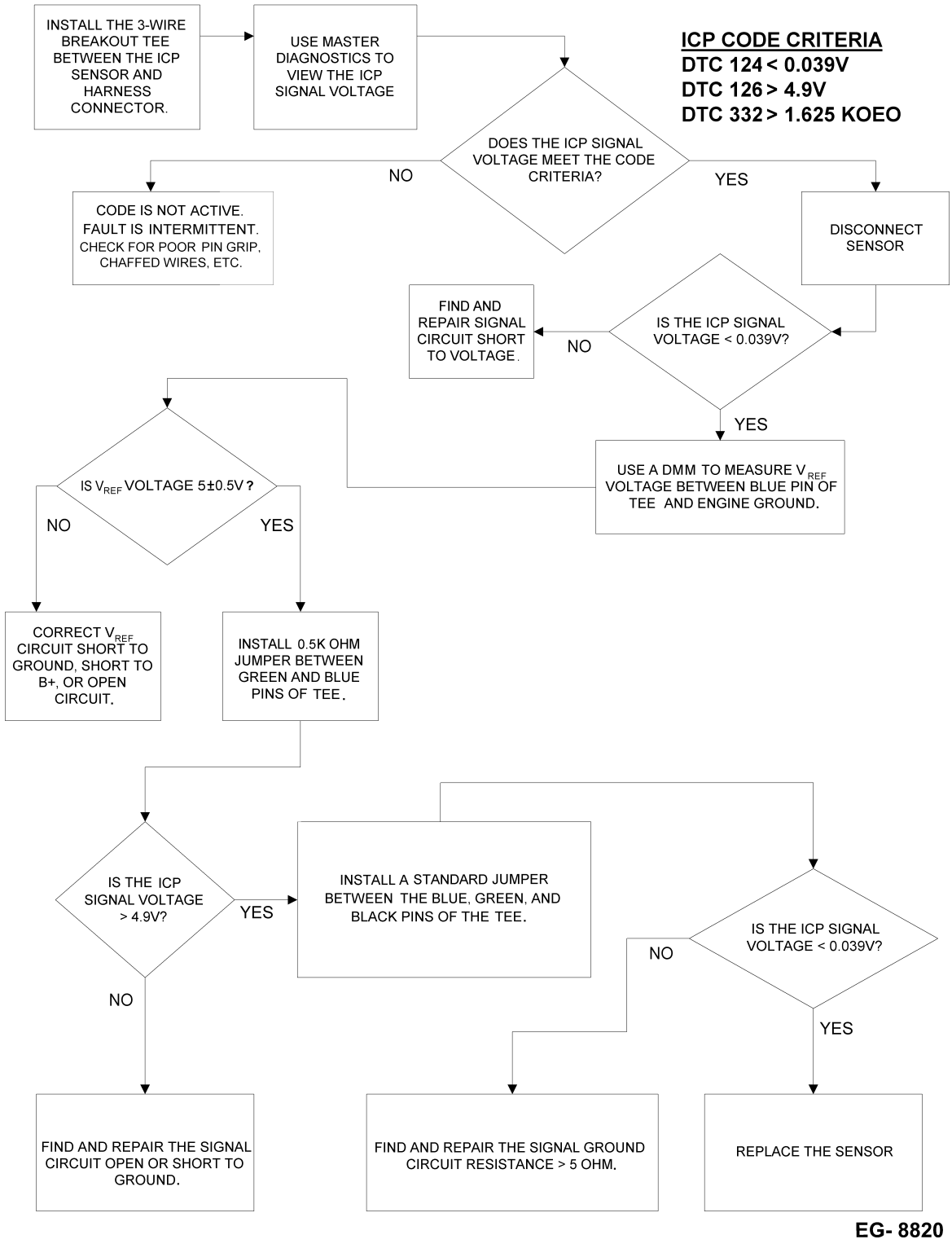

Figure 138 Injection Control Pressure Sensor Troubleshooting Flowchart

INJECTOR DRIVE CIRCUITS (INJ)

Circuit Functions

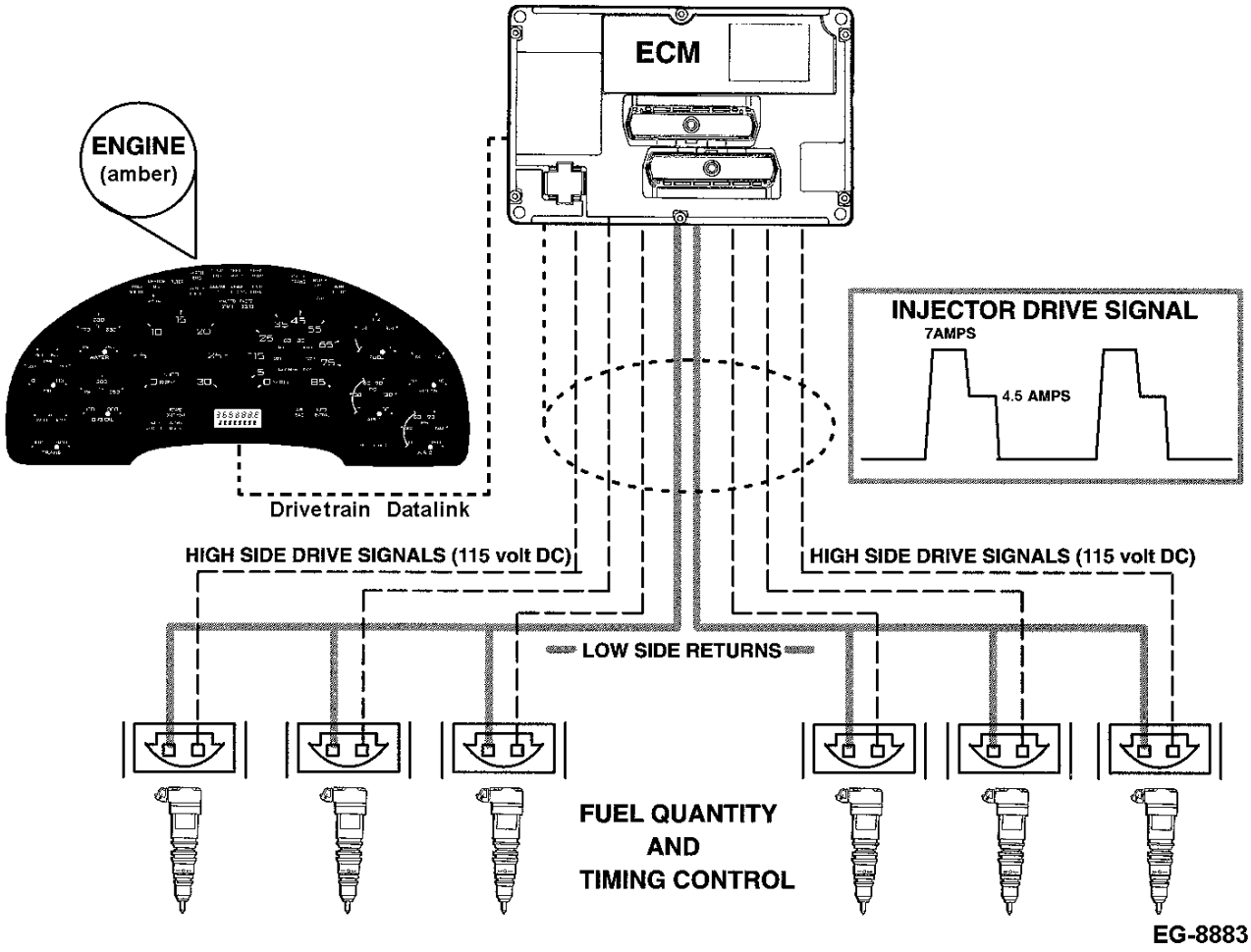

Figure 139 Injector Drive Circuit Function Diagram

The high side drive outputs control the individual injector “On Time” (fuel quantity), injection timing (in relation to TDC) and sequencing (firing order). The ECM controls each individual injector by supplying current to each injector solenoid. Sufficient injection control pressure and a valid CMP signal must be received by the ECM before an injector will be allowed to fire. The injector solenoids are grounded through the low side return circuits. The ECM monitors the low side return signal for diagnostic purposes.

Fault Detection / Management

The ECM is capable of detecting, while the engine is running, individual injector open or short circuits either to ground or power. If individual injector faults are detected while the engine is operating, the ECM can command a single injector or a bank of injectors to turn off to enhance engine running and life as well as provide a limp home capacity.

A number of special On-Demand service bay tests can be commanded by the operator to verify injector circuit continuity as well as injector operation while the engine is operating in a test mode.

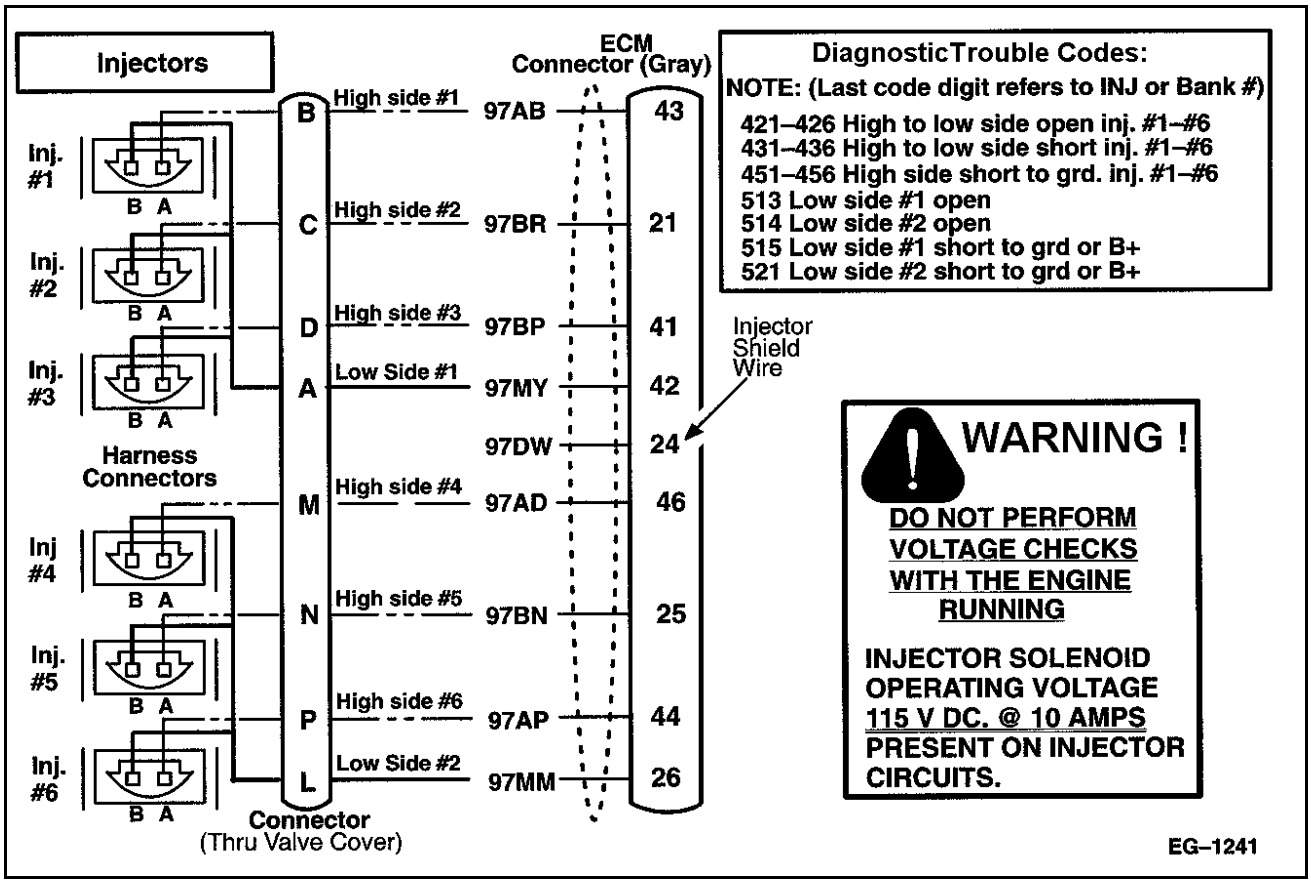

Figure 140 Injector Drive Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 73 Injector Drive Circuit Diagnostics

Engine Harness Connector Checks to Chassis Ground (check through connector with test pin, ignition key OFF)		
+Test Points –	Spec.	Comments
43 to gnd	>1kΩ	Injector #1 high side power supply.
21 to gnd	>1kΩ	Injector #2 high side power supply.
41 to gnd	>1kΩ	Injector #3 high side power supply.
42 to gnd	>1kΩ	Low side voltage return injectors #1, #2, #3.
46 to gnd	>1kΩ	Injector #4 high side power supply.
25 to gnd	>1kΩ	Injector #5 high side power supply.
44 to gnd	>1kΩ	Injector #6 high side power supply.
26 to gnd	>1kΩ	Low side voltage return injectors #4, #5, #6.
If < 1kΩ, check engine harness, undervalve cover harness and injector circuits for short to ground		
Continued on Next Page		

Table 73 Injector Drive Circuit Diagnostics (cont.)

Injector/Under Valve Cover Harness/Engine Harness-Circuit Continuity Check (check through connector with test pin, ignition key OFF)		
+Test Points–	Spec.	Comments
43 to 42	3.4 ± 2 Ω	Injector circuit #1
21 to 42	3.4 ± 2 Ω	Injector circuit #2
41 to 42	3.4 ± 2 Ω	Injector circuit #3
46 to 26	3.4 ± 2 Ω	Injector circuit #4
25 to 26	3.4 ± 2 Ω	Injector circuit #5
44 to 26	3.4 ± 2 Ω	Injector circuit #6
Resistance measured through complete injector circuit, including injector solenoid. If resistance is high or circuit is open, isolate problem to harness, connector or injector solenoid.		

System Description

The International engine control system consists of a single ECM (Electronic Control Module) that provides voltage and current required by the injectors to fuel the engine.

Fuel quantity, fuel rate and timing are all controlled by the single engine mounted ECM. The desired fuel quantity and timing are calculated and controlled by the ECM from the input signals of various engine and vehicle sensors as well as the limits programmed into its internal memory.

ECM Injector Diagnostics

The ECM monitors the voltage on each of the individual driver circuits and is capable of detecting an open or shorted circuit. If the ECM detects a short to ground or multiple fault in an injector circuit, it is capable of disabling an individual injector or a bank of three injectors allowing the engine to limp home on the remaining three cylinders. The ECM will illuminate the amber ENGINE lamp and the odometer to display the message **WARN ENG** when an injector circuit fault is present.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

NOTE – For the following Diagnostic Trouble Codes 421- 426, 431- 436, 451- 456, the last digit of each of these Diagnostic Trouble Codes refers to the affected cylinder number. For example, DTC 421 indicates that cylinder number 1 has an open circuit between the ECM high side driver and the low side (signal return) to the ECM. The SID numbers 1- 6, indicate cylinder numbers in a similar manner.

Diagnostic Trouble Codes 421– 426

ATA Code, SID 1 through 6, FMI 5

High Side to Low Side Open

When codes 421- 426 are active the amber ENGINE lamp **will not** illuminate and the odometer **will not** display any message.

Diagnostic Trouble Codes for High Side to Low Side Open indicate an open circuit between the ECM high side driver and the low side (Signal return) to the ECM. The ECM will compensate for engine misfire to keep the engine operating.

Possible causes: Open wire in injector harness, open injector return circuit or injector solenoid. See the appropriate Diagnostic Trouble Code:

Diagnostic Trouble Code 431– 436

ATA Code, SID 1 through 6, FMI 4

High Side to Low Side Short

When codes 431- 436 are active the amber ENGINE lamp **will not** illuminate and the odometer **will not** display any message.

Diagnostic Trouble Codes for High Side Shorted to Low side indicate the return voltage is too high due to a short circuit between the high side driver and return circuit. The ECM will compensate for engine misfire to keep the engine operating.

Possible causes: Shorted injector solenoid or wiring harness.

Diagnostic Trouble Code 451– 456

ATA Code, SID 1 through 6, FMI 6

High Side Shorted to Ground or V

When codes 451- 456 are active the amber ENGINE lamp **will not** illuminate and the odometer **will not** display any message.

Diagnostic Trouble Codes for High Side Shorted to Ground or V_{BAT} indicate the return circuit shorted to ground. If the ECM detects this Diagnostic Trouble Code, it will disable the entire bank of cylinders associated with the cylinder indicated.

Diagnostic Trouble Code 513

ATA Code, SID 151, FMI 5

Low Side to Bank 1 Open

When code 513 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

With the Low Side to Bank 1 Open, the ECM has detected an open circuit to the injectors on cylinders 1 through 3. With Diagnostic Trouble Code 513 active, the drivers for cylinders 1 through 3 are inoperative. The ECM will compensate for misfire to keep the engine operating.

Possible causes: Shorted injector solenoid or wiring harness to ground.

Diagnostic Trouble Code 514

ATA Code, SID 152, FMI 5

Low Side to Bank 2 Open

When code 514 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

With the Low Side to Bank 2 Open, the ECM has detected an open circuit to the injectors on cylinders 4 through 6. With Diagnostic Trouble Code 514 active, the drivers for cylinders 4 through 6 are inoperative. The ECM will compensate for misfire to keep the engine operating.

Diagnostic Trouble Code 515

ATA Code, SID 151, FMI 6

Bank 1 Low Side Short to Ground or B+

When code 515 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 515 indicates that the ECM has detected excessive current draw on the low side driver for cylinders 1 through 3. With Diagnostic Trouble Code 515 active, the driver for cylinders 1 through 3 will be disabled. The ECM will compensate for engine misfire to keep the engine running.

Diagnostic Trouble Code 521

ATA Code, SID 152, FMI 6

Bank 2 Low Side Short to Ground or B+

When code 521 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 521 indicates that the ECM has detected excessive current draw on the low side driver for cylinders 4 through 6. With Diagnostic Trouble Code 521 active, the driver for cylinders 4 through 6 will be disabled. The ECM will compensate for engine misfire to keep the engine operating.

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INJECTION PRESSURE REGULATOR (IPR)

Output Functions

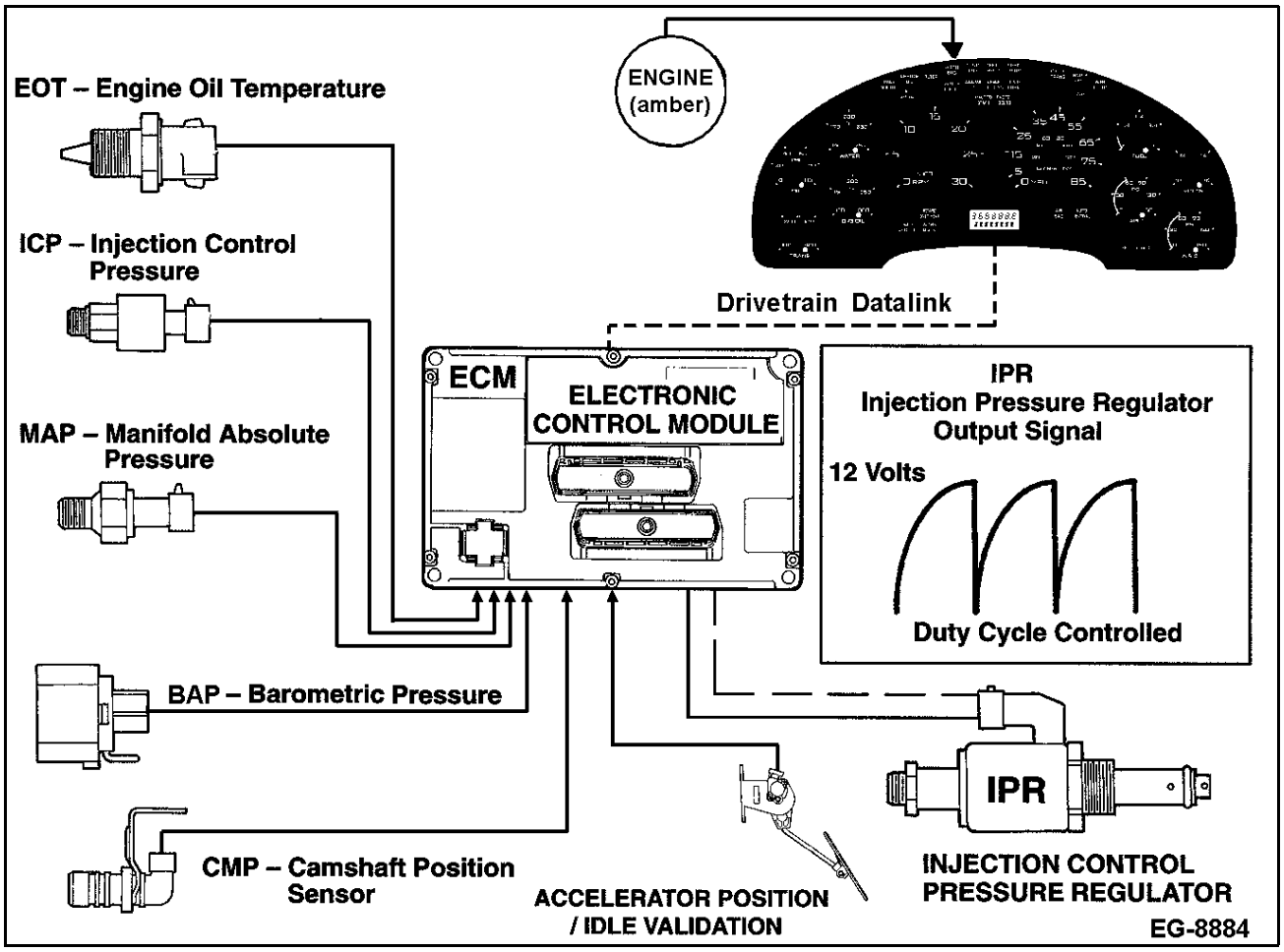

Figure 141 Injection Pressure Regulator Function Diagram

Injection Pressure Regulator (**IPR**)

The Injection Pressure Regulator is a variable position valve that controls injection control pressure. Battery voltage is supplied to the IPR when the ignition key is in the ON position. Valve position is controlled by switching the control circuit to ground inside the Electronic Control Module (ECM). ON / OFF time is modulated from 0-60% depending on the desired injection control pressure.

Diagnostic Trouble Code Detection / Management

An open or a short to the ground control circuit can be detected by an on demand output circuit check performed during the engine off test. The ECM is capable of detecting, while the engine is running, if desired injection control pressure is equal to measured injection control pressure. If the measured injection control pressure does not reasonably compare to the desired injection control pressure, the ECM ignores the measured ICP signal and attempts to control the engine with the desired value.

NOTE – The engine will not operate with an IPR circuit that is not functioning.

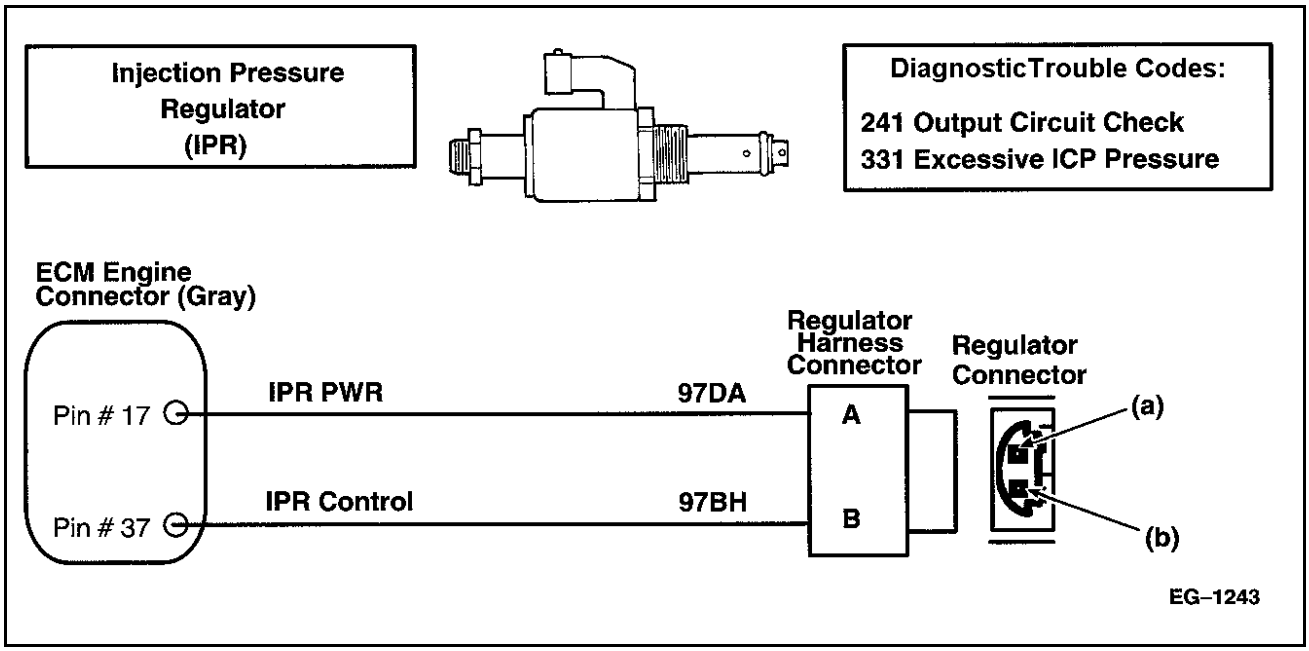

Figure 142 Injection Pressure Regulator Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 74 Injection Pressure Regulator and Circuit Diagnostics

IPR Voltage Check (check with regulator connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	B+	IPR power voltage from ECM
B to gnd	0 to 0.25V	If > 0.25V, control wire is shorted to V_{REF} or battery
Connector Checks to Ground (B-) (check with IPR connector disconnected and ignition key OFF, positive battery cable disconnected)		
Test Points	Spec.	Comments
A to gnd	>1kΩ	Resistance to chassis ground. If < 1kΩ, check for short to ground in circuit
B to gnd	>1kΩ	< 1kΩ circuit shorted to ground
Harness Resistance Checks (check with breakout box installed on engine harness only)		
Test Points	Spec.	Comments
17 to 37	5 to 20Ω	Resistance through entire IPR circuit including regulator, check with regulator connector connected to IPR
17 to A	<5Ω	If > 5Ω IPR power wire is open
37 to B	<5Ω	If > 5Ω IPR control wire is open
Diagnostic Trouble Code Description		
241 = Output Circuit Check detected during Standard Test, indicates high or low resistance in circuit.		
331 = ICP pressure was >3675 psi (25 MPa) for 1.5 sec. Possible grounded IPR control circuit. See ICP diagnostics if not an electronic diagnostic trouble code.		

Extended Description

Function

The International engine control system includes an Injection Pressure Regulator (IPR) valve that controls oil pressure in the high pressure injection control system used to actuate the injectors. The IPR valve consists of a solenoid, poppet and spool valve assembly. It is mounted in the high pressure oil pump. The ECM regulates injection control pressure by controlling the duty cycle or ON/OFF time of the injection control pressure solenoid. This increase or decrease of ON/OFF time positions poppet and spool valve inside the IPR, which either maintains pressure in the injection control pressure system or vents pressure to the oil sump via the front cover. See Section, Engine Control system Overview, in this manual for a more complete description of the IPR operation and function.

Operation

The IPR valve is supplied with voltage from the ECM at terminal A of the IPR connector when the ignition key is turned on. Control of the injection control system is accomplished by the ECM grounding terminal B of the IPR valve through pin #37 of the ECM. Precise control is accomplished by varying the pulse width or percentage of ON/OFF time of the IPR solenoid. Normal ON/OFF times varies from 8% to 60%. A high duty cycle indicates a high amount of injection control pressure is being commanded, a low duty cycle is an indication of less pressure being commanded.

ECM Diagnostics

The ECM monitors the Injection Control Pressure while the engine is in operation. If the actual pressure is greater or less than the desired pressure, the ECM will set a Diagnostic Trouble Code. When this occurs, the ECM will ignore the ICP sensor and control the engine using programmed values for the IPR.

The EST is used to perform the Engine Running Standard Test which enables the ECM to vary the command signal to the IPR and monitor the performance of the Injection Control Pressure system. If the system does not respond within the specified parameters, the ECM will set a Diagnostic Trouble Code.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 241

ATA Code, SID 42, FMI 11

Injection Control Pressure Regulator OCC Self Test Failed

Diagnostic Trouble Code 241 is set only during the Engine Off Standard Output Circuit Check. This test indicates the ECM has performed an output circuit test, measured voltage drop across the IPR circuit and determined it is below or above specification.

If this Diagnostic Trouble Code is present, the engine will not run. The ECM will **not** illuminate the amber ENGINE lamp if this fault is active, however, this code will be transmitted at the completion of the Output Circuit Check, using the EST or Diagnostic Trouble Code retrieval method.

Possible causes: Poor connection of the IPR solenoid.

Diagnostic Trouble Code 331

ATA Code, PID 164, FMI 0

Injection Control Pressure above System Working Range

When code 331 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 331 indicates the ECM has detected injection control pressure greater than 3,675 psi (25 MPa), which is greater than the maximum allowable working pressure.

Possible causes:

- Incorrect ICP signal due to faulty circuit or sensor
- Incorrect ICP sensor
- A malfunction in the injection control pressure system due to a sticking or blocked IPR valve

INJECTION PRESSURE REGULATION SYSTEM (IPR_SYS)

System Functions

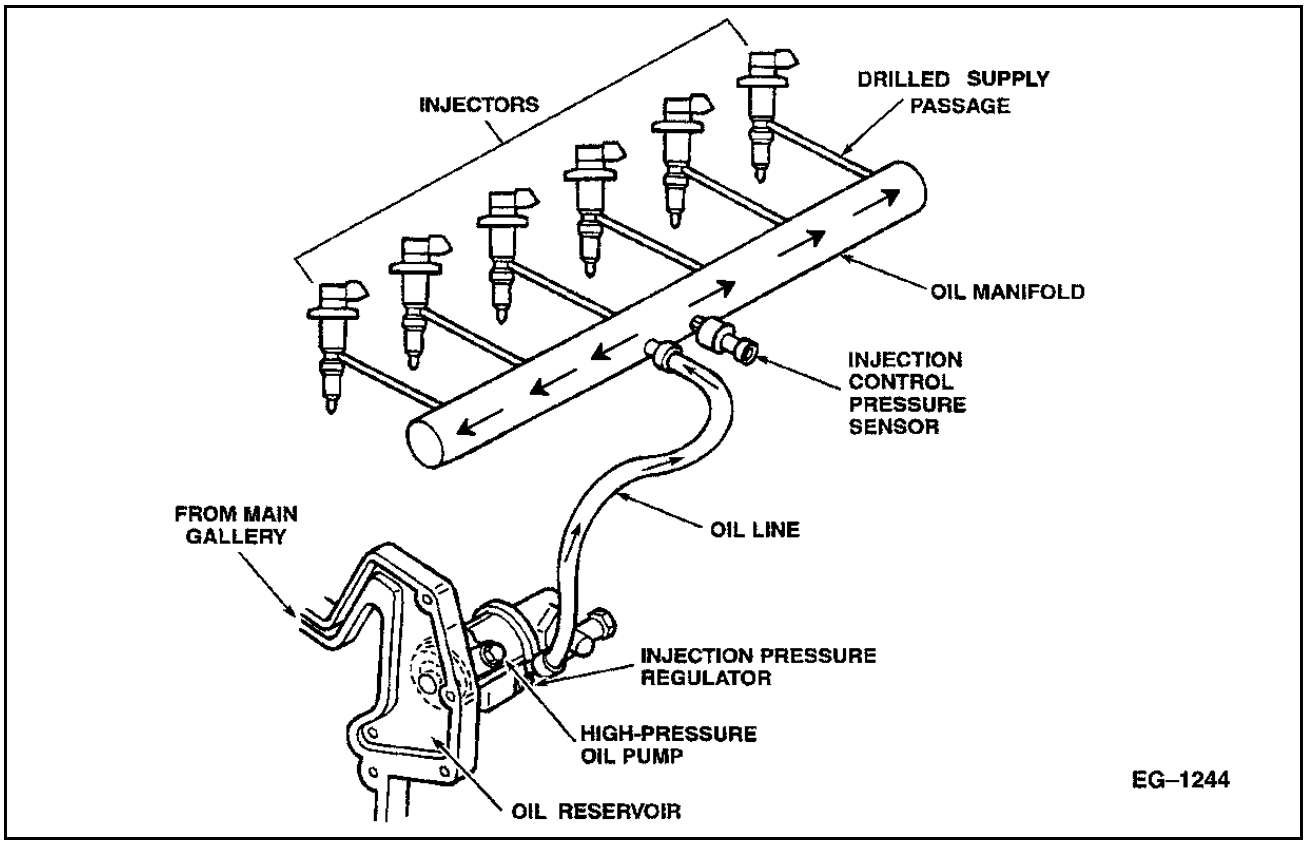

Figure 143 Injection Control Pressure Regulation System

The Injection Control Pressure System consists of the low pressure oil lubrication system, passages in the front cover and reservoir, high pressure oil pump, high pressure oil line as well as the high pressure oil rail mounted on the side of the cylinder head. The injection control pressure system also includes the injectors (and their respective sealing O-rings), the IPR valve (injection pressure regulator) and the ICP (injection control pressure) sensor and associated wiring.

The function of this system is to develop, maintain and control the high pressure injection control pressure to provide the force to actuate the injectors and provide fuel to the engine.

Fault Detection / Management

The Diagnostic Trouble Codes associated with this system may indicate an electrical or electronic control system failure, but **most likely will indicate a mechanical or hydraulic problem with the injection control pressure system.**

The ECM constantly monitors the injection control pressure in the system to assure the control system is providing the proper control pressure at all times. If the oil pressure feedback provided by the ICP sensor does not meet the ECM's desired values, the ECM will set a Diagnostic Trouble Code, illuminate the amber ENGINE lamp and control the operation of the injection control system by calculating the correct oil pressure for all engine operating conditions until the system is diagnosed and repaired.

The ECM also monitors the injection control pressure developed while cranking the engine. If pressure does not develop within the ECM's expected time limit, it will set an appropriate Diagnostic Trouble Code which will aid the technician in diagnosing the no start or hard start condition.

The EST may be used by the technician to command the ECM to perform an engine running test on the Injection Control Pressure system. The ECM controls the pressure regulator in a programmed sequence to evaluate system performance. At the end of the test, the ECM will transmit the appropriate Diagnostic Trouble Code(s) if system performance is unsatisfactory.

ECM Diagnostics

Diagnostic Trouble Code 333

ATA Code, PID 164, FMI 10

Injection Control Pressure above/below Desired Level

When code 333 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 333 may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test. It indicates that the measured pressure does not match the pressure that the ECM expects. Code 333 will be set if the measured value is less than or greater than 362 psi (2.5 MPa) of desired injection control pressure for a period greater than 7 seconds. When this code is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve from programmed default values.

Diagnostic Trouble Code 333 is usually associated with poor engine performance. Symptoms include slow acceleration time, low power at full load and possible engine under run.

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Possible Causes:

- Low oil level, contaminated or aerated engine oil.
- Trapped air in the ICP system (particularly after an injector or high pressure pump replacement).
- Defective or stuck injection pressure regulator.
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals or pulled back pins.
- Leaking injector O rings.
- Problem with ICP sensor and/or sensor circuit, incorrect sensor, system biased high or low.
- High pressure pump.

See Diagnostic Trouble Code 333 Recommended Actions (See Table 75, page 300).

Table 75 Diagnostic Trouble Code 333 Recommended Actions

Recommended Actions:	
Test	**Comments**
Check repair history - (Determine if air entrapment could be caused by ICP system disassembly)	If system was disassembled assure vehicle is operated 15 to 20 miles after injection control system has been serviced
Check oil level and quality	Check oil level and for contamination and correct API classification
Check active and inactive Diagnostic Trouble Codes	Repair any ICP sensor codes first
Perform a Key-ON Engine-OFF Standard Test	Test will verify IPR circuit continuity
Perform a Key-ON Engine-Running test	ICP step test will verify a gross ICP system failure
Perform Key On Engine Running Continuous Monitor Test (intermittent Diagnostic Trouble Code detection)	When running the Key On Engine Running Continuous Monitor Test, pull / wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If Diagnostic Trouble Code is set or engine dies, inspect wires at point of connection, check codes.
Perform ICP Pressure test - Performance Diagnostic Form (Oil aeration)	Will verify if oil is aerated at high idle Step #9 on the Performance Form
Test high pressure (injection control pressure system) for leaks	See ICP Leakage tests in Section 2

DIAGNOSTIC TROUBLE CODE 334

ATA Code, PID 164, FMI 7

Injection Control Pressure (ICP) Unable to Reach Set Point - Poor Performance

The purpose of Diagnostic Trouble Code 334 is to determine if a rapid increase in injection control pressure can be developed when commanded by the operator while the engine is running. Diagnostic Trouble Code 334 is an ICP system response time Diagnostic Trouble Code that compares measured injection control pressure to desired injection control pressure and looks for a large pressure difference, 1300 psi (9 MPa) for a short period of time (3 seconds). Its primary function is to detect injection control pressure system Diagnostic Trouble Codes. When this code is active the ECM will ignore the ICP sensor and control IPR valve operation from programmed default values.

An active 334 code is usually associated with poor engine performance conditions including slow acceleration times and lower power concerns.

Possible Causes:

- Low oil level, contaminated or aerated engine oil.
- Trapped air in the ICP system particularly after an injector or high pressure pump replacement.
- Defective or stuck injection pressure regulator.
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals or pulled back pins.
- Leaking injector O rings.
- Problem with ICP sensor and/or sensor circuit, incorrect sensor, system biased high or low.

See Diagnostic Trouble Code 334 Recommended Actions (See Table 76, page 301).

Table 76 Diagnostic Trouble Code 334 Recommended Actions

Recommended Actions:	
Test	**Comments**
Check repair history - (Determine if air entrapment could be caused by ICP system disassembly)	If the ICP system was disassembled, assure vehicle is operated 15 to 20 miles after injection control system has been serviced
Check oil level and quality	Check oil level and for contamination and correct API classification
Check active and inactive diagnostic trouble codes	Repair any ICP sensor codes first
Perform a Key ON Engine OFF Standard Test	Test will verify IPR valve circuit continuity
Perform a Key ON Engine Running test	ICP step test will verify a gross ICP system failure
Perform Key ON Engine Running Continuous Monitor test	When engine is running enable test, pull/wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If diagnostic trouble code is set or engine dies, inspect wires at point of connection, check codes.
Perform ICP Pressure test - Performance Diagnostic form (Oil aeration)	Will verify if oil is aerated at high idle Step #9 on the Performance form
Test high pressure (injection control pressure system) for leaks	See ICP Leakage Tests in Section 2

Diagnostic Trouble Code 331

ATA Code, PID 164, FMI 0

Injection Control Pressure (ICP) above Working System Range

When code 331 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

The purpose of Diagnostic Trouble Code 331 is to detect when the injection control pressure is above its normal working range, 3675 psi (25 MPa). This code may indicate a mechanical injection control pressure system problem, wiring, or ICP sensor problem. When code 331 is active the ECM ignores the ICP sensor signal and uses estimated ICP values to operate the engine.

NOTE – If the engine still performs well when this code is set, the problem is more likely in the ICP sensor circuit.

Possible Causes:

- Contaminated or improper grade of engine oil
- Defective or stuck injection pressure regulator (IPR) valve
- Improperly matched parts (IPR valve, ICP sensor, high pressure pump, front cover)
- Grounded IPR control wire
- Problems with ICP sensor or circuit causing signal to be biased high

Diagnostic Trouble Code 335

ATA Code, PID 164, FMI 1

Injection Control Pressure (ICP) Unable to Build Pressure During Cranking

The purpose of Diagnostic Trouble Code 335 is to determine if injection control pressure is being developed during engine cranking. It is an ICP system check and will be set after 8 to 10 seconds of engine cranking with less than 725 psi (5 MPa) of detected injection control pressure. The period of engine cranking time before Diagnostic Trouble Code 335 is set varies with engine temperature. Engine cranking speed must be greater than 130 rpm before Diagnostic Trouble Code detection can begin.

An active code 335 is normally associated with a no start condition or lengthy starting period.

Possible Causes:

- Lack of or insufficient quantity of engine oil in the crankcase
- Air in the injection control pressure system, particularly after an injector or high pressure pump replacement
- Defective or stuck injection pressure regulator.
- Leaking injector O-rings
- Loose high pressure pump gear
- Defective high pressure pump

See Diagnostic Trouble Code 335 Recommended Actions (See Table 77, page 302).

Table 77 Diagnostic Trouble Code 335 Recommended Actions

Recommended Actions:	
Test	**Comments**
Visual Inspection	Check to see if IPR regulator and ICP sensor wiring is connected. Check for oil leaks, and see if injection control system has recently been disassembled (air entrapment). Ensure that the vehicle is operated at least a minimum of 15 to 20 miles if the symptom is hard starting with evidence of recent ICP system disassembly.
Check oil level and pressure.	Check oil level and for contamination, check for oil in the oil reservoir (remove EOT sensor, oil should flow out) , verify lube oil pressure during engine cranking.
Check active and inactive diagnostic trouble codes.	Repair any ICP and CMP sensor codes first.
Perform a Key ON Engine OFF Standard Test.	Test will verify IPR valve circuit continuity.
Perform Key ON Engine Running Continuous Monitor Test.	When engine is running enable test, pull / wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If diagnostic trouble code is set or engine dies inspect wires at point of connection, check for codes.
Perform ICP Pressure test - No Hard/No Start Diagnostic form.	Will verify if oil is aerated at high idle Step #9 on the Performance form.
Test high pressure (injection control pressure system) for leaks.	See ICP Leakage tests in Section 2

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IDLE SHUTDOWN TIMER (IST)

System Functions

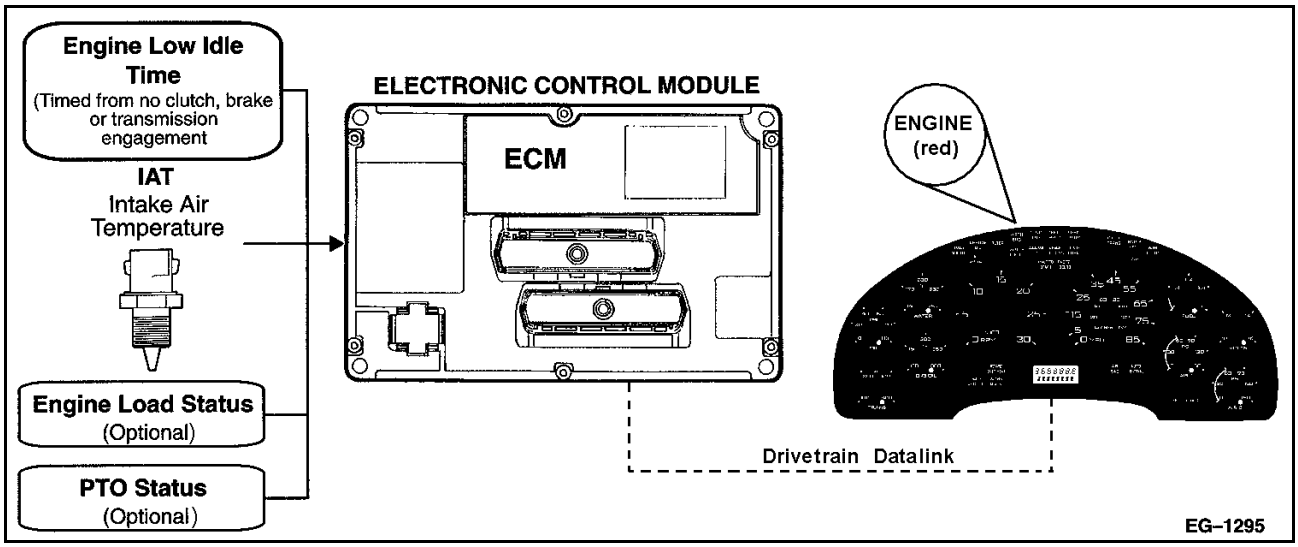

Figure 144 Idle Shutdown Timer Function Diagram

The Idle Shutdown feature is an optional feature that allows the ECM to shut off the engine if an idle condition has been detected for more than the customer specified programmed period (2 to 120 minutes). Prior to engine shutdown the red Engine lamp illuminates and causes the message **OIL/WATER** to be displayed on the odometer. The lamp will flash for 30 seconds to warn the driver of the pending shutdown. The idle time is measured from the last clutch or break pedal transition. The engine must be out of gear for the idle shutdown timer to be initiated. This feature can be programmed to operate only at specific ambient air temperatures to allow prolonged engine operation in cold or hot weather operation. For PTO applications this feature can also be programmed not to be turned on under specific load levels or when the PTO switches are on.

Fault Detection / Management

Diagnostic Trouble Code 324

The Idle Shutdown feature is internal to the ECM. All subsystems that input the idle shutdown strategy have their own Diagnostic Trouble Code detection and management strategy (e.g. IAT temperature sensor circuit). A Diagnostic Trouble Code will be set if the idle shutdown timer has been activated. **This is not a system Diagnostic Trouble Code. Its only purpose is to indicate to the owner, driver or technician that the idle shutdown timer has been activated and that the engine has been shut down.**

Diagnostic Trouble Code 324

NOTE – This Diagnostic Trouble Code does not indicate any system or circuit faults, no diagnostics are necessary. If the (IST) programming parameters need to be changed, see the following Extended Description.

Extended Description

The following list of parameters are essential to setting the IST function to meet the customer's needs and expectations. They are accessible by using the EST.

Engine Idle Shutdown Control Parameters

This group of parameters customizes the prolonged engine idle automatic shutdown feature. The purpose of this feature is to shut down the engine after a programmable period of idle time has been exceeded. This allows fuel conservation, a reduction of engine wear and emissions. Thirty (30.0) seconds prior to an automatic engine shutdown, the operator will be warned via the red ENGINE lamp and causes the message **OIL/WATER** message being displayed on the odometer. This lamp will begin flashing until the engine is shut down. The operator may override the electronics at any time. After an engine shutdown occurs, the red ENGINE lamp will stop flashing and a Diagnostic Trouble Code (324) will be recorded. The Diagnostic Trouble Code is recorded to assist in diagnosing possible service complaints of the engine shutting down.

Currently, there are four states of electronic operation:

1. **Idle Shutdown Timer** –This parameter indicates to the on-board electronics if this vehicle has the Idle Shutdown timer feature.

    A. **OFF** - Feature is turned off at all times.

    B. **PTO Available** - Feature will allow prolonged engine idle shutdown only when the engine is in the low idle no load condition and PTO operation is off.

    C. **No Engine Load** - Feature allows prolonged engine idle shutdown when the engine is in the low idle no load condition.

    D. **Tamper Proof** - Feature is tamper proof from operator over ride.

2. **Idle Shutdown Time** –This parameter indicates the length of engine idle time before the engine may be shut down.

3. **Maximum Intake Ambient Air Temperature (IAT) for Idle Shutdown** – This parameter indicates the maximum ambient intake air temperature that the on-board electronics may shut down during prolonged idling engine. This temperature is used to circumvent the shutting down of an engine when it is running because the air conditioning may be turned on.

4. **Minimum Intake Ambient Air Temperature (IAT) for Idle Shutdown** – This parameter indicates the minimum ambient intake air temperature that the on-board electronics may shut down during prolonged idle time. This temperature is used to circumvent engine shut down when it is running because of cold ambient temperature.

Diagnostic Trouble Code 324

ATA Code, PID 71, FMI 14

Idle Shutdown Timer Enabled Engine Shutdown

This Diagnostic Trouble Code is set when the engine has been shut off by the ECM because the programmed idle time criteria has been exceeded. The idle shutdown feature must be turned on for this Diagnostic Trouble Code to be displayed. This Diagnostic Trouble Code can be cleared using the EST.

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MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

Signal Functions

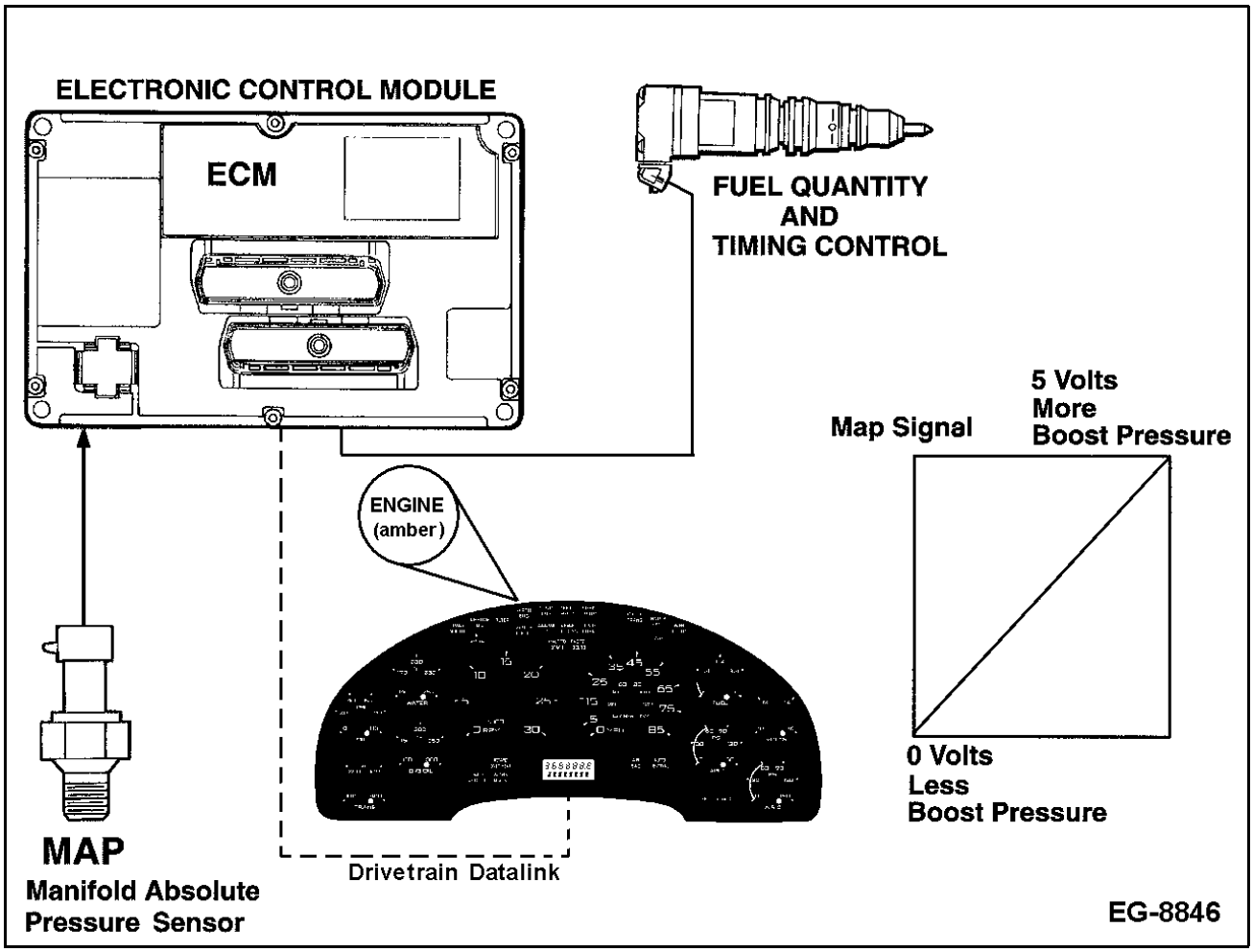

Figure 145 Manifold Absolute Pressure Sensor Function Diagram

The Manifold Absolute Pressure (MAP) sensor is a variable capacitance sensor that operates on a 5V reference signal from the ECM to produce a linear analog voltage signal that indicates pressure.

Smoke Control

The MAP signal is used to control smoke by limiting fuel quantity during acceleration until a specified boost pressure is obtained.

Dynamic Injection Timing

Optimizes injection timing for boost pressure measured.

Fault Detection / Management

A MAP signal that is detected by the ECM to be Out of Range or an incorrect value for specific conditions will cause the ECM to ignore the MAP signal and continue to operate the engine with the values from estimated MAP (Operate from a calculated boost pressure signal).

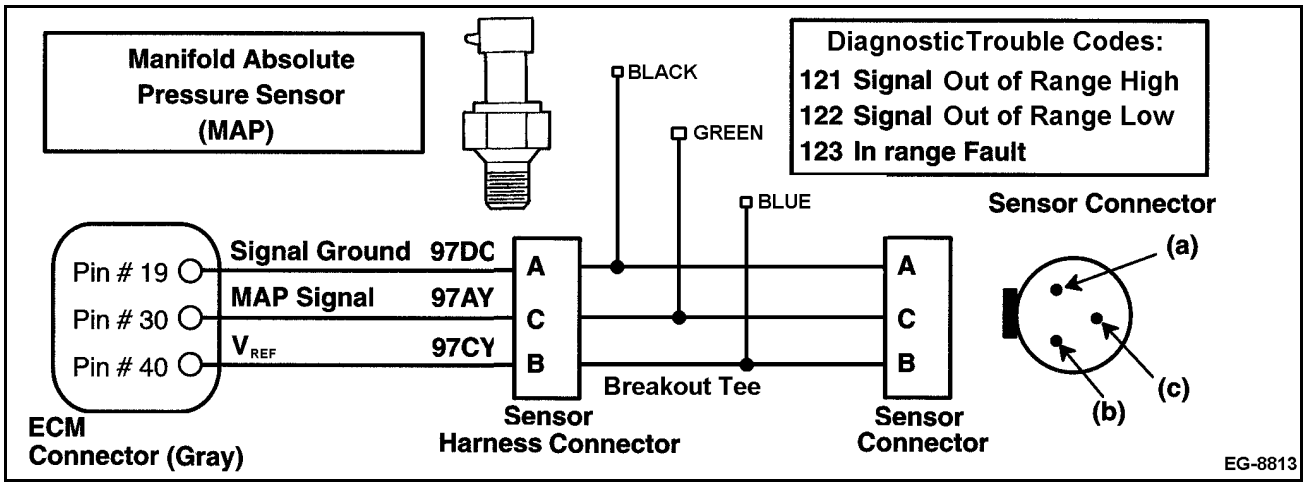

Figure 146 Manifold Absolute Pressure Sensor and Circuit Diagnostics Using a Breakout Tee

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

SENSOR TESTS

Table 78 MAP Sensor Voltage Tests Using Master Diagnostics

Manifold Absolute Pressure (MAP) Sensor Voltage Checks (check with key-ON engine-OFF)		
Install the 3 wire breakout tee between the MAP sensor and harness connector. View MAP VOLTAGE using the **Continuous Monitor** test found under the diagnostics menu in MASTER DIAGNOSTICS. If the circuit has an active fault according to the voltage level (Code 121 <4.9V, Code 122 <0.039V, Code 123 ≥1.0 V), complete the following steps. Tests must be performed in order.		
Test Condition	**Voltage**	**Comments**
Sensor Disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Measure voltage from PIN B to gnd using a DMM.	5V ± 0.5	If voltage is >5.5V, check V_{REF} for short to B+. If voltage is <4.5V check V_{REF} circuit for open or short to ground.
0.5 kΩ jumper installed between the GREEN and BLUE pins of the breakout tee.	5V	If voltage is <4.9V, check signal circuit for open circuit or short to ground. Remove positive battery cable. Measure resistance from PIN C to Ground (spec >500Ω) and from PIN C to PIN 30 (spec <5Ω) using a breakout box to determine if short to ground or open is in the harness.
Standard jumper installed between the BLUE, GREEN, and BLACK pins of the breakout tee.	0V	If voltage is >0.039V, check ground circuit for resistance >5Ω. Measure resistance between PIN A and PIN 19 (spec < 5Ω) using a breakout box to determine if resistance is in the harness.
Replace the sensor if the code is active and the expected results are obtained with all the sensor tests. The sensor is not at fault if one or more of the sensor tests does not produce the expected results. See MAP Sensor Troubleshooting Flowchart (See Figure 147, page 313).		
Continued on Next Page		

Table 78 MAP Sensor Voltage Tests Using Master Diagnostics (cont.)

MD Voltage: (+)30 to (-)19		**Operational Voltage Checks** (check with breakout tee installed in-line with the sensor)	
Voltage	psi	kPa	Comments
0.039V	N/A	N/A	Out of range LOW limit.
0.92V	0	0	Voltage with key ON engine OFF. Atmospheric pressure dependent on altitude and BAP pressure.
1.73V	8.0	55	
2.72V	18.0	124	
Diagnostic Trouble Code Description			
121 = Signal voltage was >4.9 volts for more than 1.0 sec.			
122 = Signal voltage was <0.039 volts for more than 1.0 sec.			
123 = Detected boost signal >2.0 psi (13.8 kPa) at low idle.			

Table 79 MAP Sensor Circuit Specifications (See Figure 146, page 309)

Connector Voltage Checks (check with sensor connector disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	0 to 0.25V	If > 0.25V, check ground circuit for open or high resistance, check signal ground is shorted to V_{REF} or battery.
B to gnd	5V ± 0.5	V_{REF} check with key ON, if voltage not in spec. See V_{REF} circuit.
C to gnd	0 to 0.25V	If > 0.25V, signal ground is shorted to V_{REF} or battery.
Connector Checks To Chassis Ground (check with sensor connector disconnected, positive battery cable disconnected & ignition key OFF)		
Test Points	Spec.	Comments
A to gnd	<5Ω	Resistance to chassis ground, check with key OFF, if >5Ω the harness is open.
B to gnd	>500Ω	Resistance <500Ω indicates a short to ground.
C to gnd	>1kΩ	Resistance <1kΩ indicates a short to ground.
Harness Resistance Checks (check with breakout box installed on engine harness only)		
Test Points	Spec.	Comments
19 to A	<5Ω	If >5Ω ground signal wire is open.
40 to B	<5Ω	If >5Ω V_{REF} is open.
30 to C	<5Ω	If >5Ω MAP signal is open.

Extended Description

Function

The International engine control system includes a manifold absolute pressure (MAP) sensor. The ECM measures the signal from the MAP sensor to determine intake manifold (boost) pressure. With this information, the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

Operation

The MAP sensor is a variable capacitance sensor located on the intake manifold that produces a linear analog voltage signal output. The MAP sensor is supplied 5V from ECM pin 40 to terminal B of the sensor. A return circuit (ground) is supplied from ECM pin 19 to terminal A of the sensor. Pressure applied to the MAP sensor changes the capacitance of the sensor which varies the signal voltage sent to the ECM on Pin #30. As boost pressure increases, the voltage signal increases.

ECM Diagnostics

The ECM monitors the MAP sensor output signal for expected values. If the ECM detects the MAP voltage signal that is greater than or less than the desired value, the ECM will set a Diagnostic Trouble Code.

If an active MAP sensor Diagnostic Trouble Code is set, the ECM will ignore the MAP signal. It will operate the engine using programmed default values. If the ignition key is turned off, the Diagnostic Trouble Code will be stored as an Inactive code.

MAP Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 121

ATA Code, PID 102, FMI 8

Map Signal Out of Range HIGH

When code 121 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 121 will be set if the ECM detects a MAP signal voltage greater than 4.9V for more than 0.1 second. When code 121 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values.

Possible Causes: Defective MAP sensor or sensor signal wire shorted to V_{REF} or B+.

Diagnostic Trouble Code 122

ATA Code, PID 102, FMI 11

Map Signal is Out of Range LOW

When code 122 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 122 will be set, if the ECM detects a MAP signal voltage less than 0.039V for more than 0.1 second. When code 122 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values.

Possible causes: A defective MAP sensor or MAP sensor signal circuits may be open or shorted to ground.

Diagnostic Trouble Code 123

ATA Code, PID 102, FMI 2

Map Signal above Specified Level at Low Idle

When code 123 is active the amber ENGINE lamp is illuminated and the odometer displays the message WARN ENG.

Diagnostic Trouble Code 123 is set when the MAP signal is greater than 17 psi (115 kPa) absolute at low idle. When code 123 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values.

Possible Causes: Restricted or plugged sensor inlet, a defective MAP sensor, or V_{REF} shorted to a voltage source higher than 5.5V.

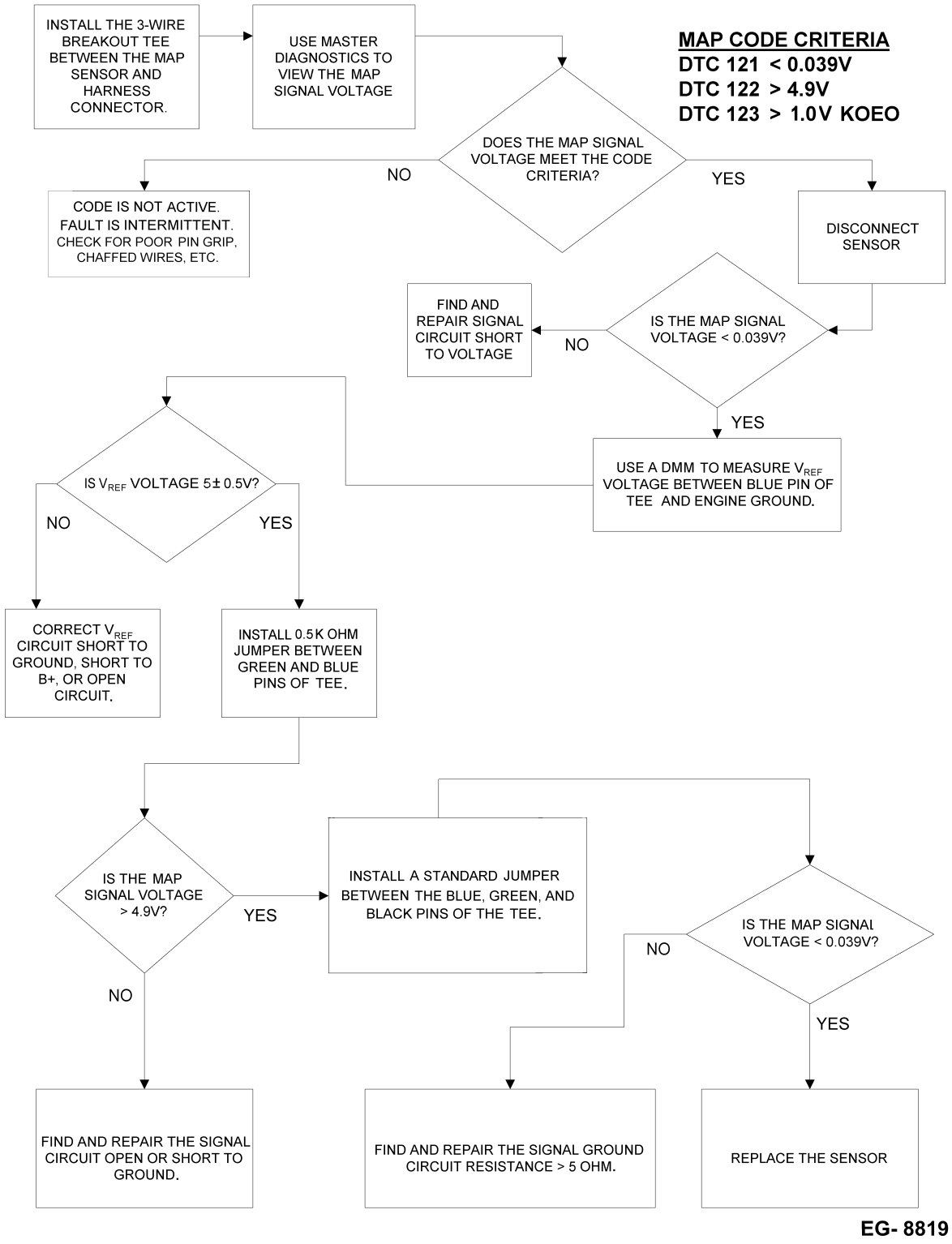

Figure 147 Manifold Absolute Pressure Sensor Troubleshooting Flowchart

ENGINE WARNING AND PROTECTION SYSTEM (EWPS)

Signal Functions

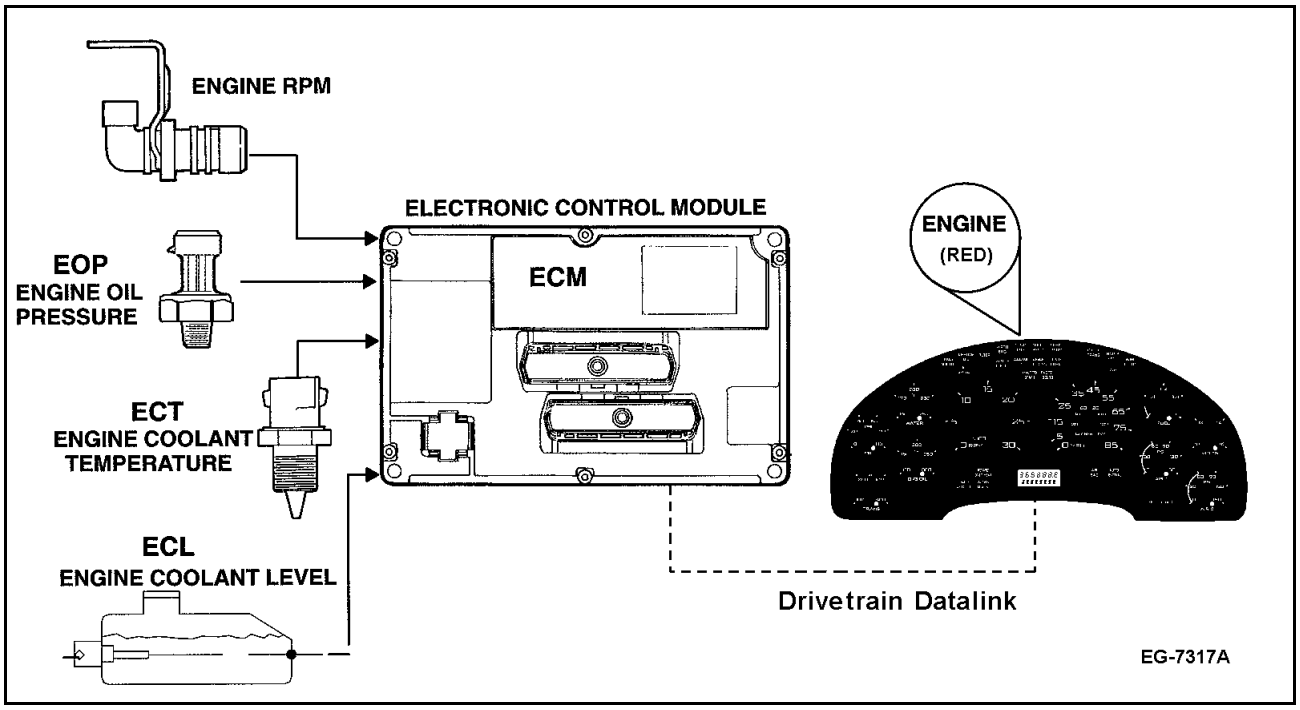

Figure 148 Engine Warning and Protection System Functions

The red ENGINE lamp is turned on when conditions are present that will cause impending damage to the engine. The level of protection is dependent on which Engine Warning And Protection Systems (EWPS) are turned on in the ECM. See Extended Description.

The ECM does not monitor the EWPS system for faults. Requests by the ECM to turn on the red ENGINE lamp on the dash are sent over the Power Train Data Link. There are no Diagnostic Trouble Codes for this system.

Extended Description

Engine Warning and Protection System

This group of parameters customizes the engine warning and protection feature. The engine warning and protection system safeguards the engine from undesirable operating conditions in order to prevent engine damage and to prolong engine life. When a warning condition is detected, the on-board electronics will illuminate the red ENGINE lamp.

When a critical condition is detected, the on-board electronics will shut down the engine if the engine warning and protection system has its protection features enabled. After an engine shutdown, the operator may restart the engine for a thirty second run time if desired.

The event logging feature will also record when an excessive (i.e., critical) engine event has occurred in both engine hours and odometer readings. There are four states of Engine Warning and Protection.

Four States of Engine Operation

- Standard
- 2-Way Warning
- 3-Way Warning
- 3-Way Protection

EWPS Mode

This parameter indicates to the on-board electronics the desired mode of operation for the engine warning and protection feature.

Standard Warning (rpm, ECT)

Engine overspeed and engine overheat are provided as the default operating mode. No engine shutdown is available.

2-Way Warning (rpm, ECT, EOP)

Engine overspeed, engine overheat and low engine oil pressure are monitored in the engine warning operating mode. No engine shutdown is available.

3-way Warning (rpm, ECT, EOP, ECL)

Engine overspeed, engine overheat, low engine oil pressure, and engine coolant are monitored in the engine warning operating mode. No engine shutdown is available.

3-Way Protection (rpm, ECT, EOP, ECL)

Engine overspeed, engine overheat, low engine oil pressure, and engine coolant are monitored in the engine protection operating mode. Engine shutdown is available if an critical engine condition is detected. Critical engine conditions include overheat, low oil pressure and low coolant level.

ECT Warning Temperature

This parameter indicates when an engine overheat condition warrants the OIL/WATER lamp to be illuminated and the warning buzzer to be activated.

ECT Critical Temperature

This parameter indicates when an engine overheat condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP RPM Boundry 1

This parameter indicates the rpm range that engine oil pressure level 1 is used for the loss of engine oil pressure detection.

EOP RPM Boundry 2

This parameter indicates the rpm range that engine oil pressure level 2 is used for the loss of engine oil pressure detection.

EOP RPM Boundry 3

This parameter indicates the rpm range that engine oil pressure level 3 is used for the loss of engine oil pressure detection.

EOP Warning Level 1

This parameter indicates when a loss of engine oil pressure warrants the OIL/WATER lamp to be illuminated and the warning buzzer to be activated.

EOP Warning Level 2

This parameter indicates when a loss of engine oil pressure condition warrants the OIL/WATER lamp to be illuminated and the warning buzzer to be activated.

EOP Warning Level 3

This parameter indicates when a loss of engine oil pressure condition warrants the OIL/WATER lamp to be illuminated and the warning buzzer to be activated.

EOP Critical Level 1

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP Critical Level 2

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP Critical Level 3

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

ECM Diagnostics

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

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REMOTE ACCELERATOR PEDAL SENSOR (RPS)

Signal Functions

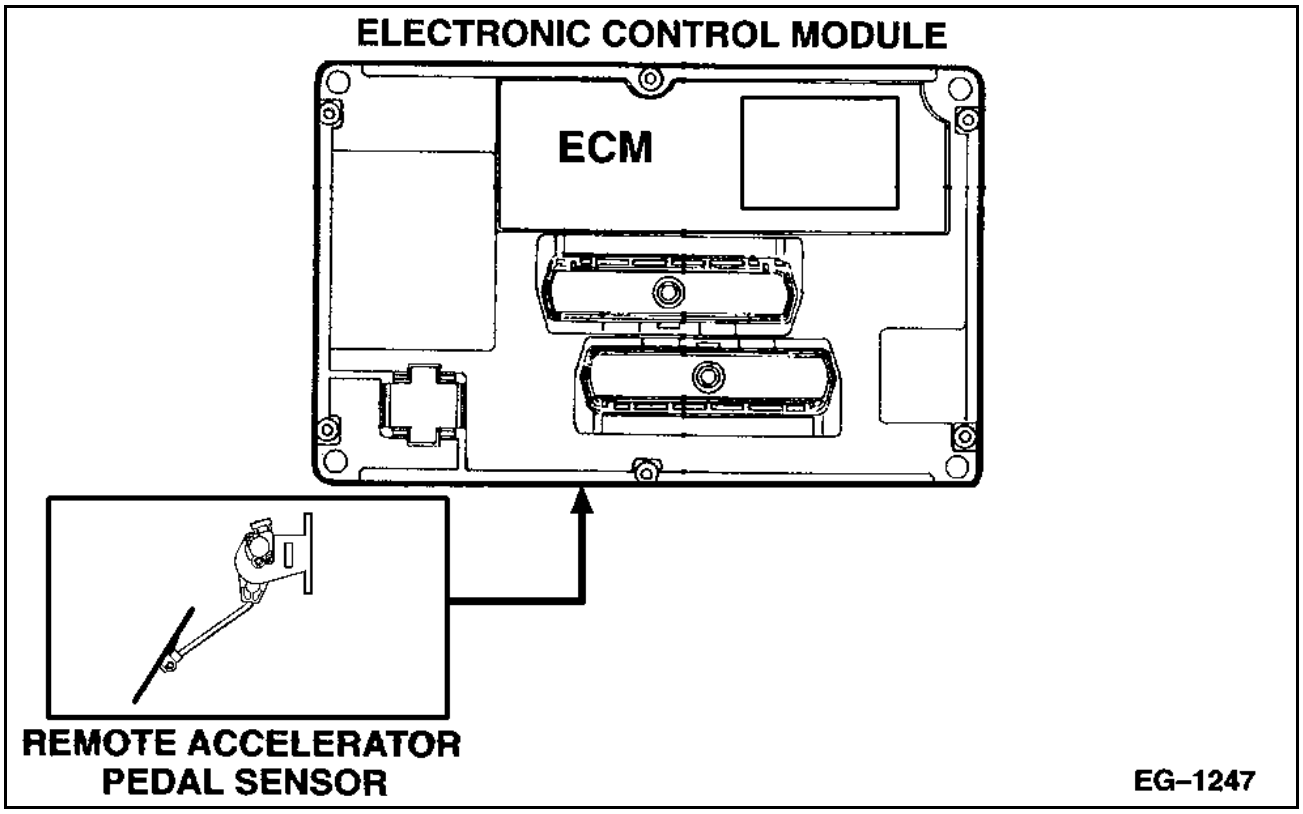

Figure 149 RPS Function Diagram

NOTE – The RPS, the ON/OFF switch, and the circuit are supplied by the body builder.

The purpose of the remote accelerator pedal sensor (RPS) is to allow an operator to adjust engine speed from a remote location. The RPS functions similar to the accelerator position sensor. The RPS sensor is a potentiometer that sends a variable analog voltage signal to the ECM that indicates a desired speed. In order for the RPS to function, the control module must be programmed for remote RPS enable. To activate the RPS the remote variable terminal of the ECM must receive a 12V signal.

Pedal Operation

The pedal receives a 5V reference signal and a signal return from the ECM through the body builder connections. By depressing the pedal the RPS signal voltage increases indicating a request to increase engine speed.

Fault Detection / Management

The ECM monitors the voltage at the RPS terminal for voltage to determine if the signal is in range. A minimum voltage level is established to verify that the circuit is not open and a maximum voltage level is established to verify that the signal is not shorted to a voltage source. When the ECM detects a voltage Out of Range, the pedal will be disabled and Diagnostic Trouble Code 213 for Out of Range LOW or code 214 for Out of Range HIGH will be set.

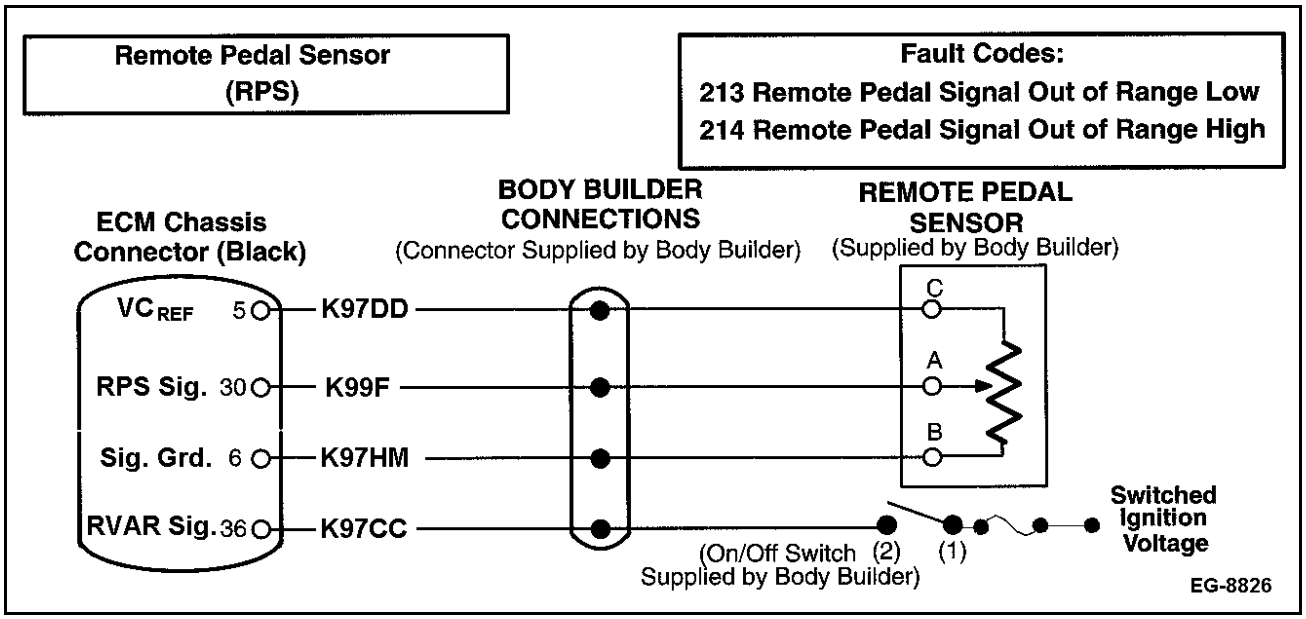

Figure 150 Remote Accelerator Pedal Sensor Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 80 Remote Accelerator Pedal Sensor Circuit Diagnostics

Remote Pedal Sensor Connector Voltage Checks (check with remote pedal sensor disconnected and ignition key ON)		
Test Points	Spec.	Comments
A to gnd	0V	A positive voltage reading indicates a short to another circuit.
B to gnd	0V	A positive voltage reading indicates a short to another circuit.
C to gnd	5V ± 0.5	Voltage out of specification indicates; an open circuit, short to ground, or short to B+.
(2) to gnd	12V	ON/OFF switch voltage when switch is in the ON position.
Remote Pedal Sensor Connector Resistance Checks (check with remote pedal sensor disconnected, ignition key OFF and all accessories off)		
Test Points	Spec.	Comments
A to gnd	>1kΩ	< 1kΩ indicates a short to ground.
B to gnd	<5Ω	> 5Ω indicates circuit is open.
C to gnd	>1kΩ	< 1kΩ indicates a short to ground.
(1) to gnd	>1kΩ	< 1kΩ indicates a short to ground with switch closed and fuse removed.
Harness Resistance Checks (check with breakout box installed on chassis harness only & sensor connector disconnected)		
Test Point	Spec.	Comments
5 to C	<5Ω	> 5Ω indicates a high resistance or an open circuit.
6 to B	<5Ω	> 5Ω indicates a high resistance or an open circuit.
30 to A	<5Ω	> 5Ω indicates a high resistance or an open circuit.
36 to (1)	<5Ω	> 5Ω indicates a high resistance or an open circuit with switch closed and fuse removed.
Continued on Next Page		

Table 80 Remote Accelerator Pedal Sensor Circuit Diagnostics (cont.)

Operational Voltage Checks (check with breakout box installed & RPS sensor connected to connector)		
Test Points	Spec.	Comments
30 to 6	0.5 to 4V	Voltage should be low at idle position and should increase by depressing the pedal. Voltage reading should change smoothly and there should be no position that causes a sudden increase or decrease in voltage.
36 to gnd	12V or 0V	ON/OFF switch voltage: 12V when ON, 0V when OFF.
Diagnostic Trouble Code Description		
213 = RPS Signal was <0.49V. Circuit open or shorted to ground.		
214 = RPS Signal was >3.91V. Sensor shorted internally or short to V_{BAT} or V_{REF}.		

Extended Description

The RPS is used for engine speed control outside of the vehicle cab. As part of the PTO engine speed control, connections for the RPS are supplied through the body builder's connections.

To operate the RPS, a 5V reference voltage is supplied by the ECM from pin 5 through the body builder's connections circuit K97DD. Signal return for the RPS is supplied by a dedicated terminal number 6 through the body builder's connections circuit K97HM. The remote pedal sensor is a potentiometer that uses the 5V reference voltage and signal return to supply an analog voltage to terminal 30 through the body builder's connections circuit K99F. In the idle position, the voltage signal from the RPS is low. As the pedal is depressed, the voltage increases, indicating an increase in demand for speed from the operator.

Before the RPS is operational the ECM must first have a 12V signal at pin 36. This is supplied through the body builder's connections circuit K97CC to enable the operation of the RPS.

PTO speed control operation interruption will occur:

- If the remote variable circuit is opened. The engine will return to idle.
- If the brake or clutch pedal is depressed or with an automatic transmission, the transmission is placed in gear. The engine will return to idle.
- If the ECM receives a signal from the vehicle speed sensor (VSS) the engine will return to idle. Remote PTO speed control will not function if the brake or VSS circuits are in fault and the RPS will not operate if the RPS system has an active Diagnostic Trouble Code present.
- If the option has been programmed in the ECM for PTO Operation. The brake, clutch or transmission will not interrupt the PTO speed control.

Programming

The ECM must be programmed to enable the RPS. From the programmable parameters menu under the option PTO controls, select RPS and program for "enable." If it is desired that the cab controls (APS brake and clutch) do not impede the operation of the PTO speed control, select the option PTO Operation. Disable, and select "enable." PTO mode must be programmed to remote. If the RPS is enabled and there is no pedal signal present, the ECM will log a Diagnostic Trouble Code. The PTO maximum engine speed will allow programming for the maximum engine speed allowed when in PTO mode.

ECM Diagnostics

The ECM monitors the voltage at the RPS terminal to determine if the signal is within range. A minimum voltage level is established to verify that the circuit is not open and a maximum voltage level is established to verify that the signal is not shorted to a voltage source. When the ECM sees the voltage Out of Range the pedal will be disabled and a Diagnostic Trouble Code 213 for Out of Range LOW or 214 for Out of Range HIGH will be set. If the ignition is shut off a Diagnostic Trouble Code will be recorded as an inactive code.

Diagnostic Trouble Code 213

ATA Code, SID 29, FMI 4

Remote Throttle Signal Out of Range LOW

Diagnostic Trouble Code 213 indicates that ECM pin 30 voltage was less than 0.25V. This indicates an open or shorted circuit for the V_{REF} supply from ECM pin 5 or an open or shorted RPS signal circuit to pin 30 from the RPS. It may also result from a defective (open or shorted) remote pedal sensor.

Diagnostic Trouble Code 214

ATA Code, SID 29, FMI 3

Remote Throttle Signal Out of Range HIGH

Diagnostic Trouble Code 214 indicates that ECM pin 30 voltage was greater than 4.5V. This indicates a possible open circuit in RPS return to pin 6 or a short circuit to another voltage supply on the RPS signal circuit. It may also result from a defective (shorted) remote pedal sensor.

Troubleshooting

The EST can be used to monitor the status of the PTO controls. Comparing the switch reading to actual operation will indicate if the controls are operating properly. Using the menu option of programmable parameters, the programming can verify that the ECM is programmed properly for that specific application. Also the data list can be used to monitor the parameters that cause the interruption of PTO speed control. Use the diagnostic code menu to read the Diagnostic Trouble Codes.

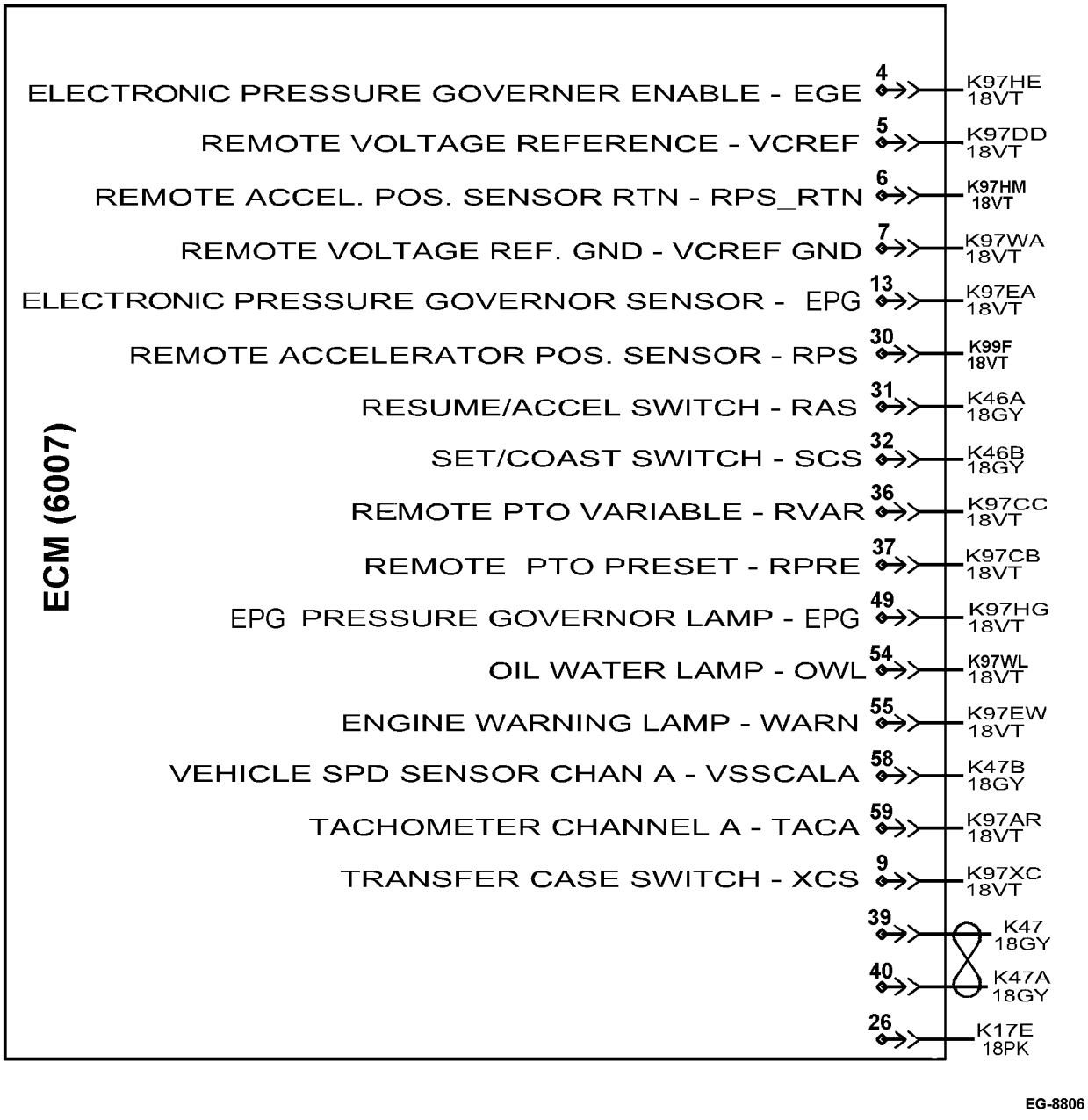

Figure 151 Electronic Engine Controls, Cruise Control Connections with Manual Transmission

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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REMOTE PTO SPEED CONTROL (RPTO)

System Functions

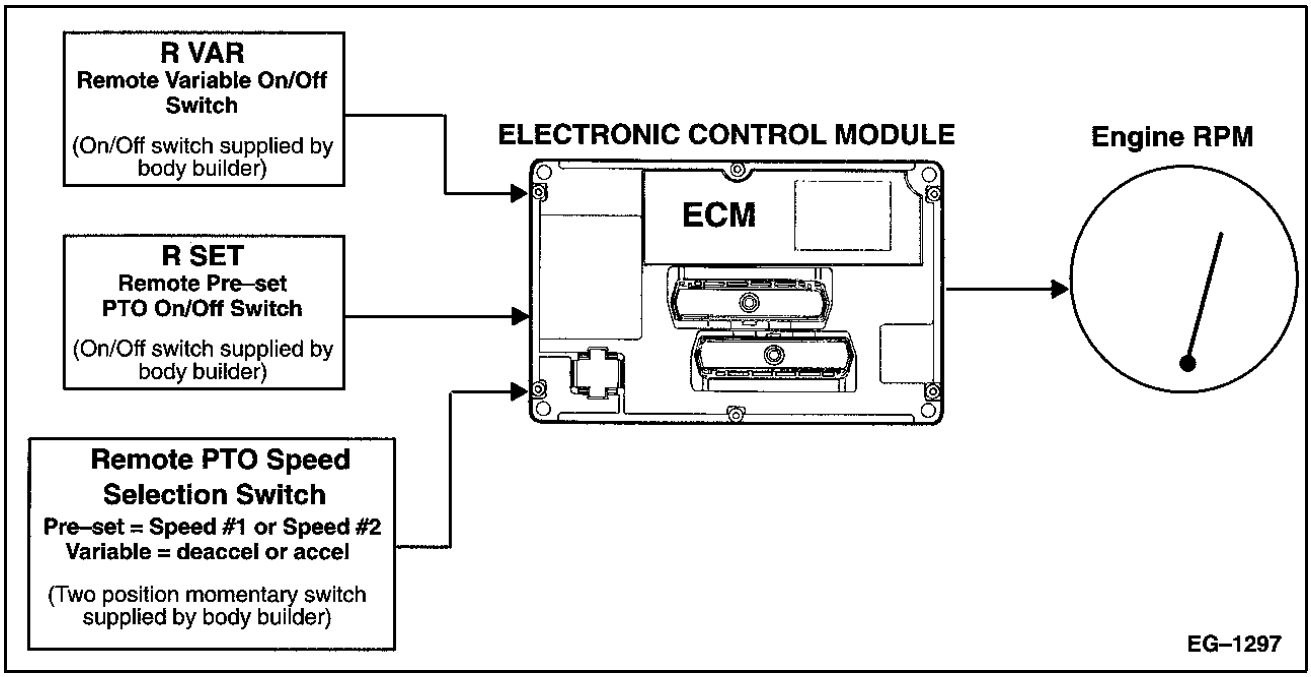

Figure 152 Remote PTO Speed Control Function Diagram

The purpose of the remote power takeoff feature is to allow the control of engine speed via remote switches for the use of ancillary engine devices such as hydraulic pumps, lift gates, etc.

Mode Selection

Variable speed or preset PTO control (up to two speeds selected) can be selected and programmed into the module via EST.

Speed Selection

Variable PTO speed is either increased or decreased by depressing the momentary speed control switch to the Set or Resume position. The speed at which the engine accelerates is noted as the "ramp rate" or rpm per seconds of acceleration that the engine is allowed to accelerate. “Ramp rate" and maximum PTO speed are programmable by using the EST.

In the preset PTO mode, the momentary speed control switch allows for two preset speeds to be selected. By momentarily depressing the switch in the preset #1 mode the first speed is selected, by momentarily depressing the switch in the preset #2 position a second speed can be selected. These speeds are programmable in the ECM by using the EST.

Fault Detection / Management

Disagreements in speed selection states will be detected by the ECM and a Diagnostic Trouble Code will be set. The most common source of RPTO problems are blown fuses to the ON/OFF circuit, an incorrectly programmed ECM, or improper wiring of the body builder connectors and speed control switches.

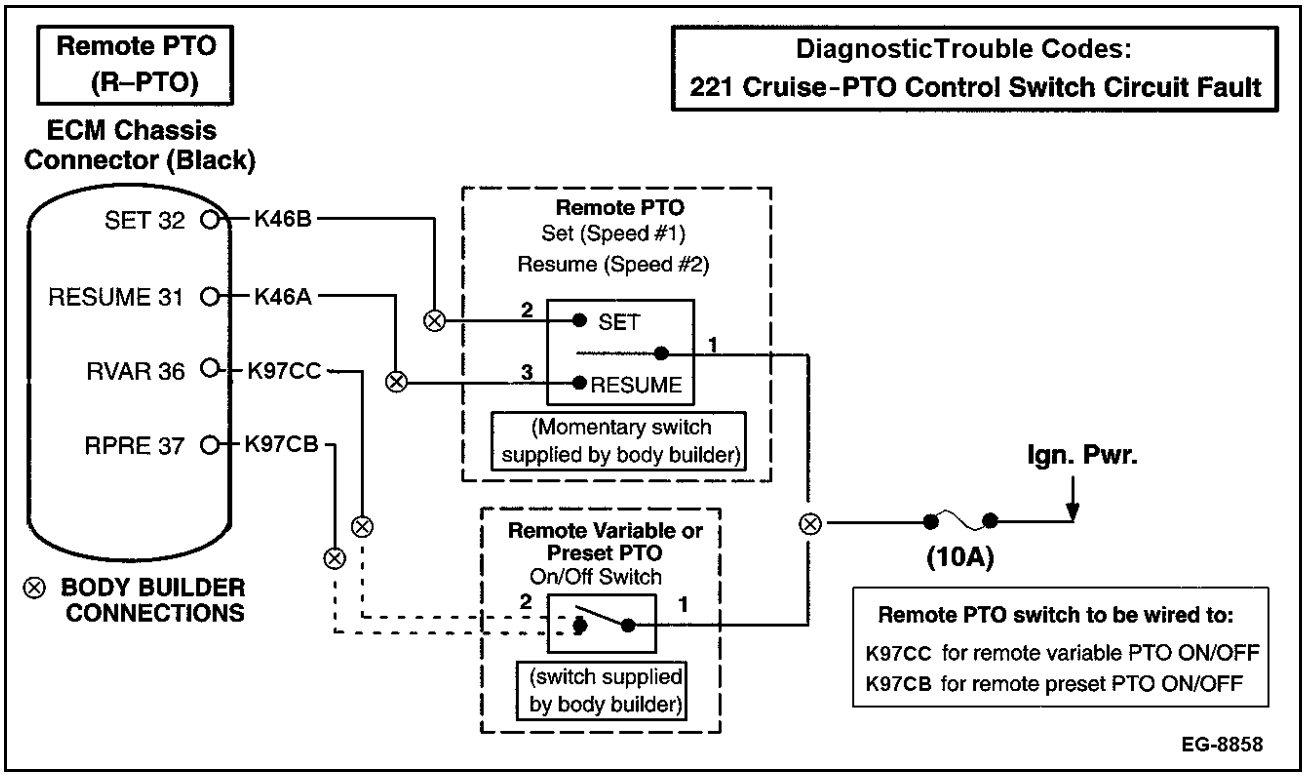

Figure 153 Remote PTO Speed Control Circuit Diagram

NOTE – See Body Builder Connections (See Figure 154, page 328).

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals. Check for blown fuses.

Table 81 Remote PTO Speed Control Circuit Diagnostics

Voltage Circuit Checks at ECM Connector (check with breakout box installed and ignition key ON)		
REMOTE PTO SPEED SELECTION SWITCH (TWO POSITION INTERMITTENT ROCKER SWITCH)		
Set Switch Circuit (Speed #1 - preset PTO) (Deaccel - variable PTO)		
Test Points	Spec.	Comments
32 to gnd	12V ± 1.5	Switch held in Set position - If no voltage, check switch and circuit for open or ground.
32 to gnd	0V	Switch in Middle position - If voltage is present, switch or circuit is shorted to power.
Resume Switch Circuit (Speed #2 - preset PTO) (Accel - variable PTO)		
31 to gnd	12V ± 1.5	Switch held in Resume position - If no voltage, circuit is open or shorted to ground.
31 to gnd	0V	Switch in Middle position - If voltage is present, switch or circuit is shorted to power.
Remote Variable PTO ON/OFF Switch - Switch must be ON for remote PTO to function.		
36 to gnd	12V ± 1.5	Switch in ON position - If no voltage, open circuit, switch or fuse from switch.
36 to gnd	0V	Switch in OFF position - If voltage is present, switch or circuit is shorted to power.
Remote Preset PTO ON/OFF Switch - Switch must be ON for remote PTO to function.		
37 to gnd	12V ± 1.5	Switch in ON position - If no voltage, open circuit, switch or fuse from switch.
37 to gnd	0V	Switch in OFF position - If voltage is present, switch or circuit is shorted to power.

Extended Description

Power Take Off Speed Control

The purpose of the remote power takeoff feature is to allow the control of engine speed via remote switches for the use of ancillary engine devices such as hydraulic pumps, lift gates, etc.

Mode Selection

Variable speed or preset PTO control (up to two speeds selected) can be selected and programmed into the module via EST.

The mode, variable and/or preset PTO must be selected and "turned on" by the EST tool for this feature to function. On/off switches must also be installed to provide a 12V signal to the appropriate pin in the ECM. The Remote PTO feature will be disabled when vehicle speed is detected, the clutch pedal is depressed or if the engine is put into gear (automatic transmission only).

Power Take Off (PTO) speed control provides a method for the operator to set and maintain a regulated engine speed, without using the accelerator pedal, for the purpose of operating auxiliary equipment. The power take off feature has a in-cab and a remote operator interface. Depending on configuration, the operator may turn on and activate PTO speed control while in the comfort of the cab or at the convenience of the remote interface. If both in-cab and remote operations are enabled, the on-board electronics senses which interface is active depending on operator actions. No active mobile PTO operation is possible when the PTO speed control is turned on using the remote interface.

This feature also has the bump up and bump down functions. Where, the operator may bump up the rpm in 25 rpm increments when the Resume/Accel button is momentarily pressed. The operator may bump down the rpm in 25 rpm increments when the Set/Cruise button is momentarily pressed.

Power Take Off

This parameter indicates to the on-board electronics if the vehicle has the Power Take Off speed control feature.

PTO Programmable Features

- **Disable**: Feature is turned off at all times.
- **Remote Operation Only**: Feature is enabled and may only be turned on and activated using the remote PTO ON/OFF switches.
- **In-Cab Operation Only**: Feature is enabled and with use in-cab to PTO speed control while in the in-cab operation.
- **Remote and In-Cab Operation**: Feature is enabled and will allow both remote and in-cab operations. However, the remote operation takes precedence over the in-cab operations.

PTO Max VS (vehicle speed)

This parameter indicates the maximum road speed that the PTO speed control may be engaged while in Mobile PTO operation.

PTO In-Cab Mode

This parameter indicates how the steering wheel mounted Cruise Control buttons are to be interpreted.

- **None**: The steering wheel mounted Cruise Control ON/OFF switch is ignored.
- **Stationary Preset**: The steering wheel mounted Cruise Control buttons operate only in the **Preset** state of operation.
- **Stationary Variable**: The steering wheel mounted Cruise Control buttons operate in a variable state of operation.
- **Mobile Variable**: The steering wheel mounted Cruise Control buttons operate in a variable state of operation while allowing the vehicle to be mobile.

PTO In-Cab Interface

This parameter indicates to the on-board electronics if PTO speed control is on and active the operator in-cab interfaces are ignored. These interfaces include accelerator pedal, driveline engagement signal, brake pedal and the steering wheel mounted Cruise Control buttons.

- **Enable**: Continue to monitor in-cab operator interfaces.
- **Disable**: Ignore in-cab operator interfaces.

PTO Remote Pedal

This parameter indicates to the on-board electronics that a remote throttle control is available for use to control the PTO rpm setting.

- **Disable**: Remote throttle is not available.
- **Enable**: Remote throttle is available.

PTO Preset rpm 1

This parameter indicates the rpm setting when the operator depresses the Set/Cruise button with the STATIONARY PRESET in-cab mode of operation.

PTO Preset rpm 2

This parameter indicates the rpm setting when the operator depresses the Resume/Accel button with the **Stationary Preset** in-cab mode of operation.

PTO Preset rpm Ramp Rate

This parameter indicates the rate that rpm is increased when the operator depresses and holds the Resume/Accel button.

PTO Max rpm

This parameter indicates the maximum rpm that the PTO speed control may be engaged.

Troubleshooting

The EST can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating properly. Using the menu of programmable parameters, the ECM programming can also be verified to insure that the ECM is properly programmed for PTO applications.

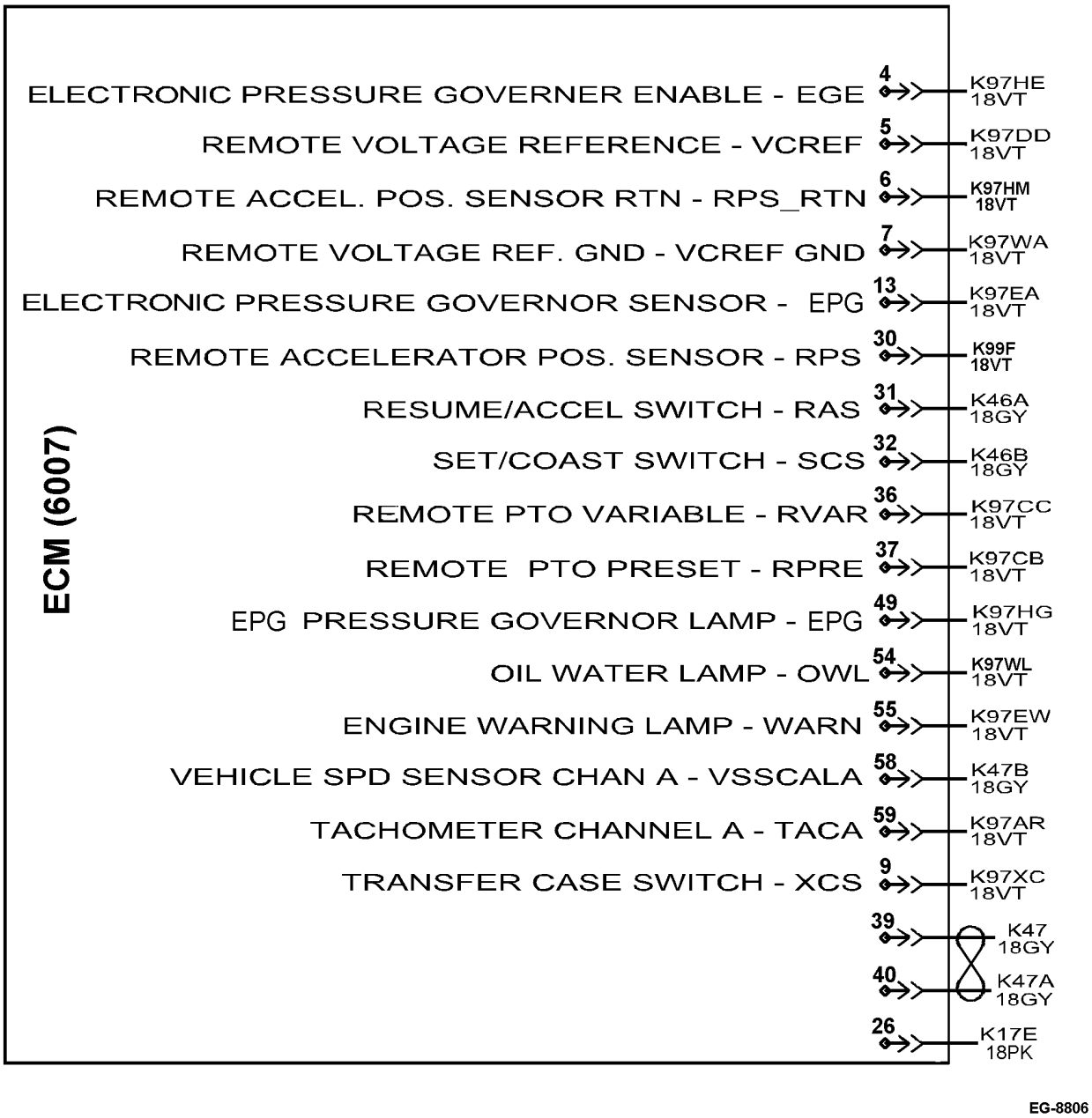

Figure 154 ECM Body Builder Connections Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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SPEED CONTROL COMMAND SWITCHES (SCCS)

Signal Functions

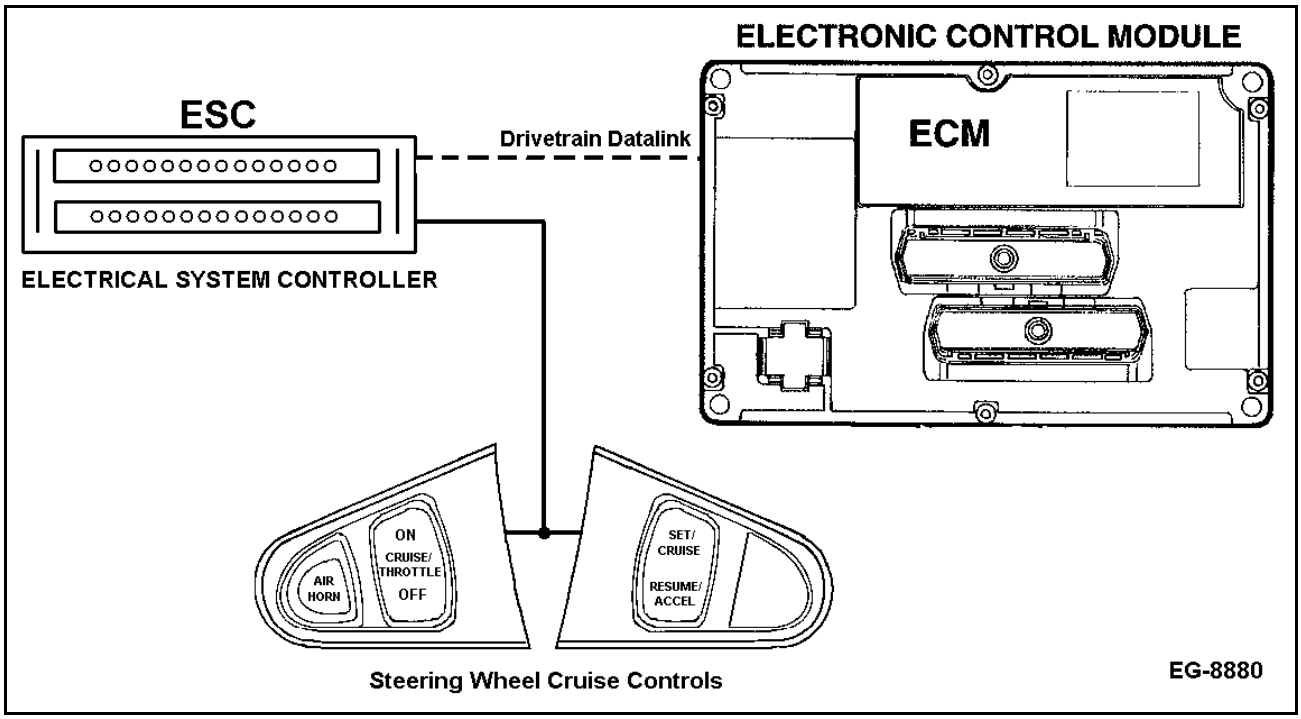

Figure 155 Cruise Control, PTO, Hand Throttle System Function Diagram

Cruise Control

The ECM will control engine speed to maintain a constant road speed with cruise control. Depressing the set switch when the vehicle is at the desired speed with the Cruise button in the ON position activates the cruise control. Speed is increased or decreased by depressing Accel or Cruise buttons. The cruise control is deactivated by depressing the OFF switch, applying the brake pedal, clutch pedal, or on vehicles equipped with automatic transmissions, by placing the transmission in neutral.

PTO Control

Engine speed can be controlled by the SCCS switches if the PTO option has been programmed into the ECM and the vehicle is stationary. Variable as well as preset speeds are available depending on ECM programming. The PTO function is turned ON by switching the cruise button ON. Depressing the Set/Cruise or Resume/Accel button will increase or decrease engine speed depending on PTO programming.

Fault Detection / Management

The ECM does not monitor the SCCS system for faults. There are no Diagnostic Trouble Codes for this system.

Diagnostics

If the engine does not respond to the cruise control switches, use the cab electronics diagnostic software to monitor cruise switch input to the ESC. If the switch state does not change when the steering wheel cruise controls are depressed, diagnose the cruise switch circuits using the S08250 - Electrical Troubleshooting Guide - 4200/4300/4400. If the ESC is receiving the cruise switch input, use the electronic engine diagnostic software (Master Diagnostics) to view the cruise switch state. If the switch state does not change as the switch is depressed, verify communication exists between the ECM and the ESC (does the ECM respond to other ESC inputs). If the switch state does change, verify that other conditions do not exist that would stop or delay the reaction to the input. Examples include:

- RPM below minimum
- RPM above maximum
- Road speed below minimum / Road speed above maximum
- Brake pedal depressed
- Clutch / driveline disengaged

Extended Description

Cruise Control

Cruise control allows the ECM to control the engines power delivery to maintain a constant vehicle speed. The speed set point is determined by the driver, however high and low set points are programmed in the ECM. These are the cruise high set limit and cruise low set limit. Also the minimum engine speed at which the cruise control can be engaged is programmed in the ECM. See Cruise Control, Body Builder Connections Circuit Diagram (See Figure 154, page 328).

Operate cruise using the following switch functions:

Table 82

Cruise ON/OFF button:	ON enables and OFF disables the Cruise Control functions.
SET/CRUISE:	If the cruise is active but a speed is not set, depressing the SET switch will select the current vehicle speed as the set speed.
	If the cruise is active an a speed is set, depressing the SET switch will cause the vehicle speed to decrease.
RESUME/ACCEL:	If the cruise is ON, but has been deactivated by application of the brake or clutch pedal, depressing the RESUME switch will cause the vehicle speed to resume to the last set speed.
	If the cruise is ON and active, depressing the RESUME switch will cause the vehicle speed to increase.

Depressing the OFF switch, brake, clutch or placing the automatic transmission in neutral will deactivate the cruise control. Cruise control will not be functional if the VSS signal is in fault.

PTO (engine Speed) Control

PTO speed control allows an operator to set a fixed engine speed, either in the cab or remotely. In-cab PTO uses the same switches on the steering wheel as are used for cruise control. Remote PTO uses switches that are installed by a body builder and are wired to the vehicle’s wiring harness at the "body builder’s connections." There are two features that utilize the PTO speed controls. Remote Accelerator Pedal and Electronic Pressure Governing. See RPS and EPG in this section of manual.

In-Cab PTO

In-Cab PTO has three different modes of operation. These modes are selected by programming the ECM In-Cab PTO Mode. These modes are:

1. In-Cab Preset
2. In-Cab Variable
3. In-Cab Mobile

In-Cab Preset

In-Cab Preset is selected by programming the ECM programmable parameters for In-Cab Mode to In-Cab Preset. This allows the operator to select one of two programmed values for engine speed. To operate, turn the ON/OFF switch to the ON position. Then depress either the Set or Resume switch. This will cause the engine speed to run at the value programmed into PTO Set Speed.

Depressing the OFF switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS or Brake signal is in fault.

In-Cab Variable

In-Cab Variable is selected by programming the ECM Programmable Parameters for In-Cab Mode to In-Cab Variable. This option allows the driver to set the engine speed to a desired value. The control module will then maintain this speed over varying load conditions up to the engines rated power in the selected speed range.

To enable, turn the ON/OFF switch to the ON position. Speed may be adjusted two ways. First the operator may adjust the engine speed with the accelerator and then depress the Set switch. Second, the operator may depress the Resume/Accel to increase engine speed incrementally or depress the Set/Cruise switch to decrease the engine speed.

Engine set speed will be limited to the value programmed in the ECM for Maximum PTO speed.

Depressing the OFF switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS, (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS or Brake signal is in fault.

In-Cab Mobile

In-Cab Mobile is selected by programming the ECM programmable parameters for the In-Cab mode to In-Cab Mobile. This allows the operator to use the engine speed control the same as In-Cab Variable, however, in this mode the vehicle can be moving while the mode is active. See In-Cab Variable for more details. The maximum speed of the vehicle is programmable up to 20 m.p.h. This mode is the same as In-Cab Variable, however, a speed signal will not disable the speed control until the programmed maximum speed is exceeded.

Remote PTO

Remote PTO can be enabled by two means, Remote Preset and Remote Variable. Operation of the speed control depends on which signal is enabled.

Remote Preset

When in the preset mode, the set switch will cause the engine to run at the programmed set speed. The resume switch will allow the engine to run at the programmed resume speed.

With the remote preset enabled, the speed is adjusted as with In-Cab preset. See In-Cab preset for more details.

Turning the ON/OFF switch OFF, depressing the brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However, the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS or Brake signal is in fault.

Remote Variable

Enabling the remote variable signal allows for the engine speed to be adjusted to the desired level. Depressing the Resume /Accel switch will cause the engine speed to increase, depressing the Set/Cruise switch will cause the engine speed to decrease.

With remote variable enabled the speed is adjusted as with In-Cab Variable.

Opening the switch to pin 36, depressing the ON/OFF switch to OFF, depressing the brake or clutch pedal or placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS or Brake signal is in fault.

PTO Speed Ramp Rate

The rate at which the speed of the engine will change will depend on load conditions and on a programmed value called PTO speed ramp rate. A higher value will cause the engine to change speed more quickly.

Troubleshooting

The EST can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating properly. Using the menu option of programmable parameters the programming can be verified to be sure the ECM is programmed properly for the application. Also the data list can be used to monitor the parameters that cause interruption of PTO speed control.

TACHOMETER INPUT CIRCUITS

Circuit Functions

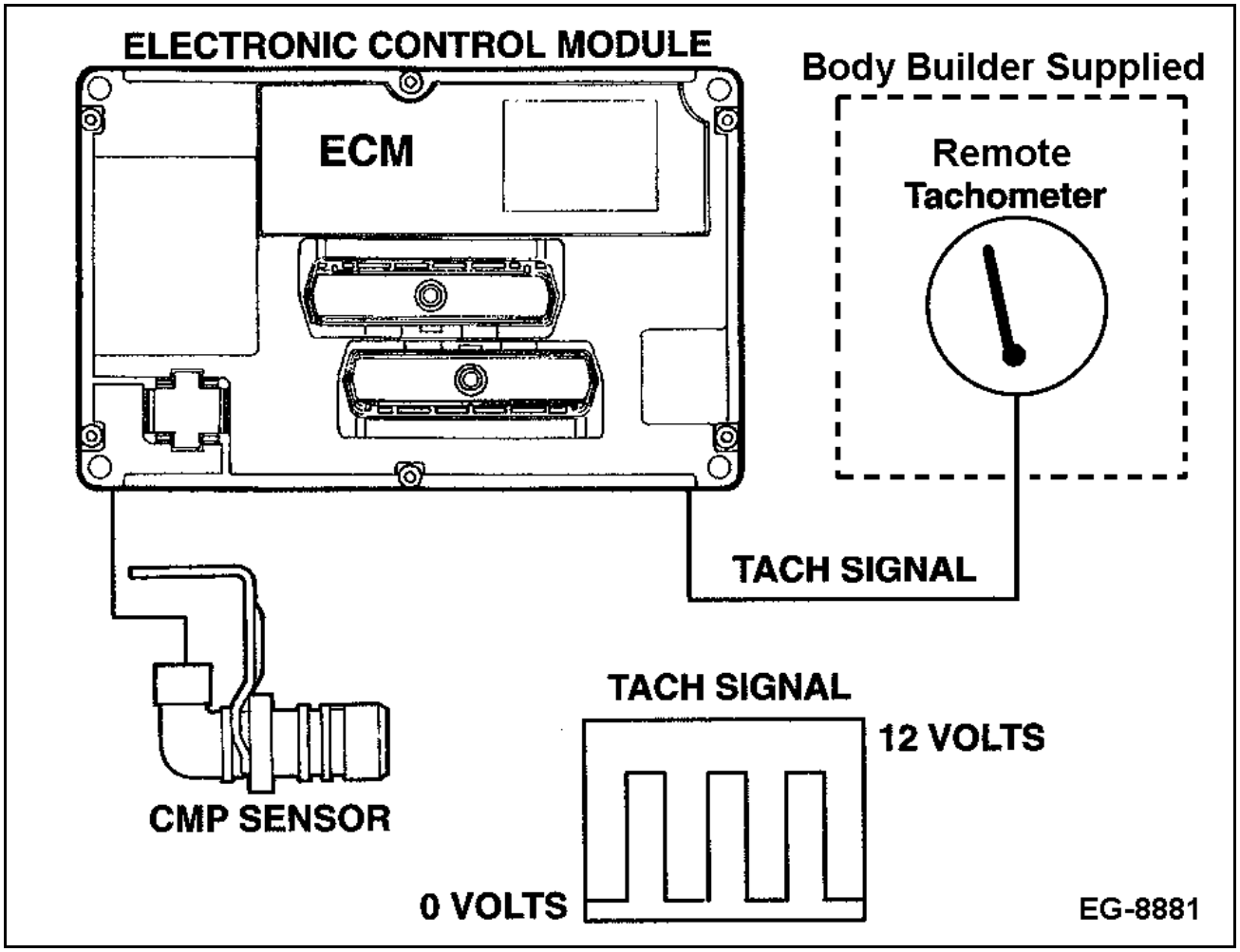

Figure 156 Tachometer Input Circuit Function Diagram

The Electronic Control Module (ECM) provides an output for a remote tachometer with a 0-12V digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine rpm.

Diagnostic Trouble Code Detection

No Diagnostic Trouble Code detection is available for communication between the ECM and the remote tachometer.

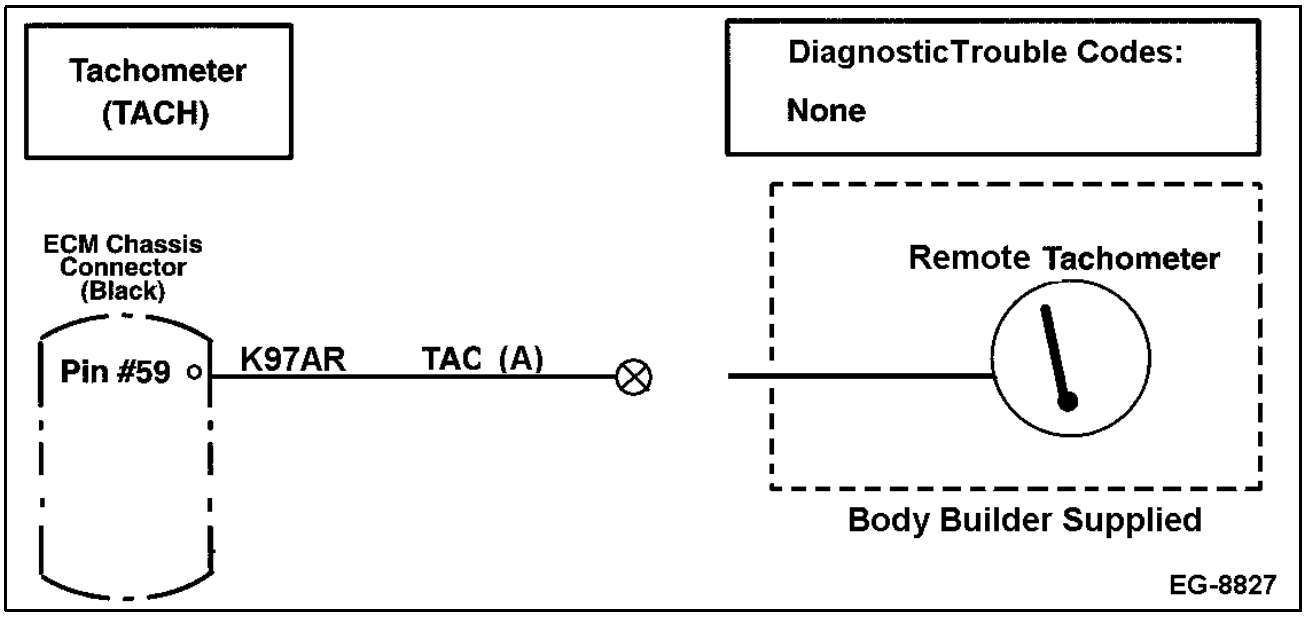

Figure 157 Tachometer Input Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 83 Tachometer Input Circuit Diagnostics

Key-On Engine-Off Voltage Checks at ECM (check with breakout box installed and the ignition key ON, Engine OFF)			
Test Points	Spec.	Signal	Comments
59 to 23	12V ± 1.5	TACH A	The signal is pulled up by the ECM with the key ON engine OFF.
Connector Checks to Ground at ECM (check with breakout box installed and the ignition key should be in the OFF position)			
Test Points	Spec.	Signal	Comments
59 to 23	>1kΩ	TACH A	< 1kΩ indicates a short to ground either through the harness or internal in the ECM. Disconnect the ECM from the breakout box and measure to ground again. If short is still present, repair harness.
Harness Resistance Checks (check with breakout box installed, and the ignition key should be in the OFF position)			
Test Points	Spec.	Signal	Comments
59 to Tach	<5Ω	TACH	Resistance from ECM connector to TACH input - Optional Owner/Operator Tach.
Key-On Engine-Running Signal Checks - TACH (check with breakout box installed)			
Test Points	Spec.	Comments	
59 to 23	5V to 7V/140 to 540 Hz	TACH signal from the ECM is a frequency that is engine rpm ÷ 5.	

NOTE – The instrument cluster tachometer does not use these outputs. See Drive Train Data Link for instrument cluster tachometer diagnostics.

Extended Description

Tachometer Input Signal This section does not apply to the instrument cluster tachometer.

The ECM receives a signal from the CMP sensor and calculates engine speed (rpm). The ECM sends the calculated engine speed as a digital buffered TACH signal from the ECM connector to the owner installed tachometer.

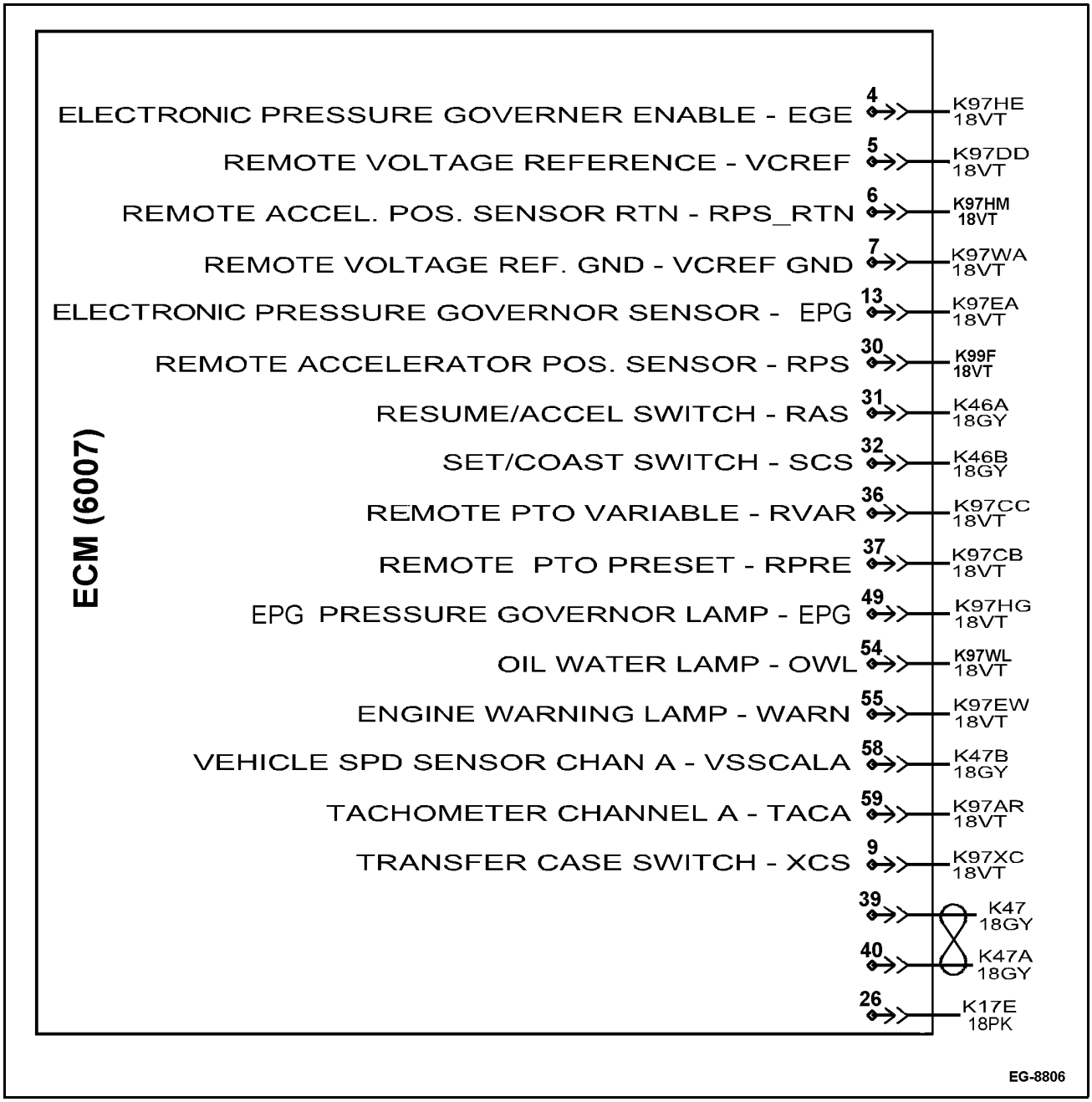

Figure 158 ECM Body Builder Connections

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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TWO SPEED AXLE SPEEDOMETER CIRCUIT

Signal Functions

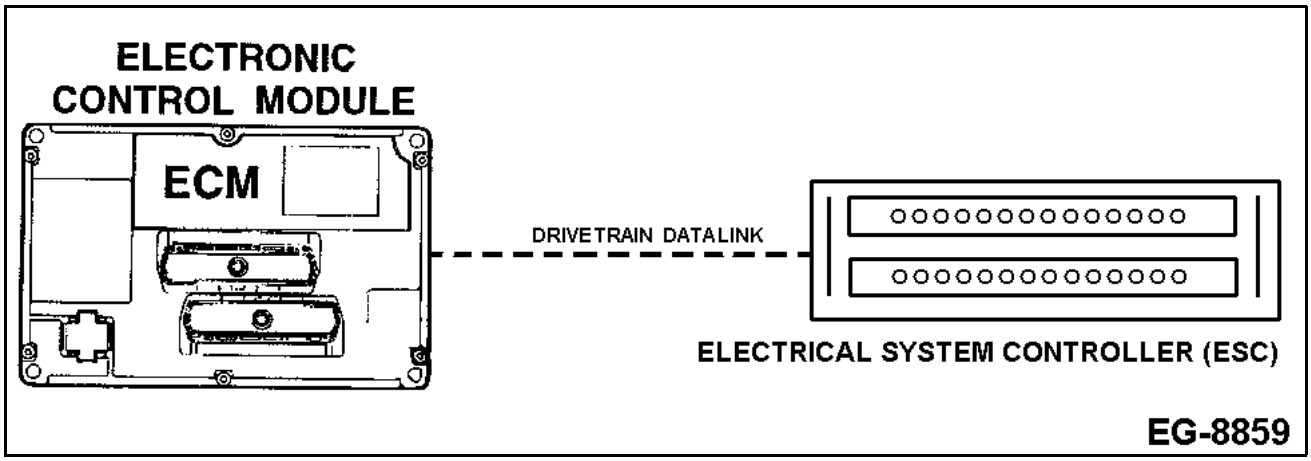

Figure 159 Two Speed Axle Circuit Function Diagram

Two Speed Axle

The ECM is programmed with the high and low rear axle ratios. The ratios are used to calculate the speedometer signal, depending on which mode the switch is in. The ECM uses the high ratio unless the ESC signals the ECM that the two speed selector switch is in the low range.

Diagnostic Trouble Code Detection / Management

There are no ECM diagnostics for the two speed axle circuits.

Troubleshooting

1. Use the EST diagnostic tool to verify the correct ECM programming including correct rear axle ratios (high and low):
   a. If programmed correctly, go to step 2.
   b. If the programming is not correct, make necessary programming corrections.
2. If the engine does not respond to the two speed axle (TSA) switch, use Cab Electronics Diagnostic software to monitor TSA input to the ESC. If the switch state does not change when the axle switch is depressed, diagnose the switch circuits using the S08250 - Electrical Troubleshooting Guide - 4200/4300/4400. If the ESC is receiving the TSA switch input, use the electronic engine diagnostics software (Master Diagnostics) to view the TSA switch state. If the switch state does not change as the switch is depressed, verify communication exists between the ECM and the ESC.

ECM Diagnostics

There are no ECM diagnostics for this circuit.

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REFERENCE VOLTAGE (V_{REF})

Circuit Functions

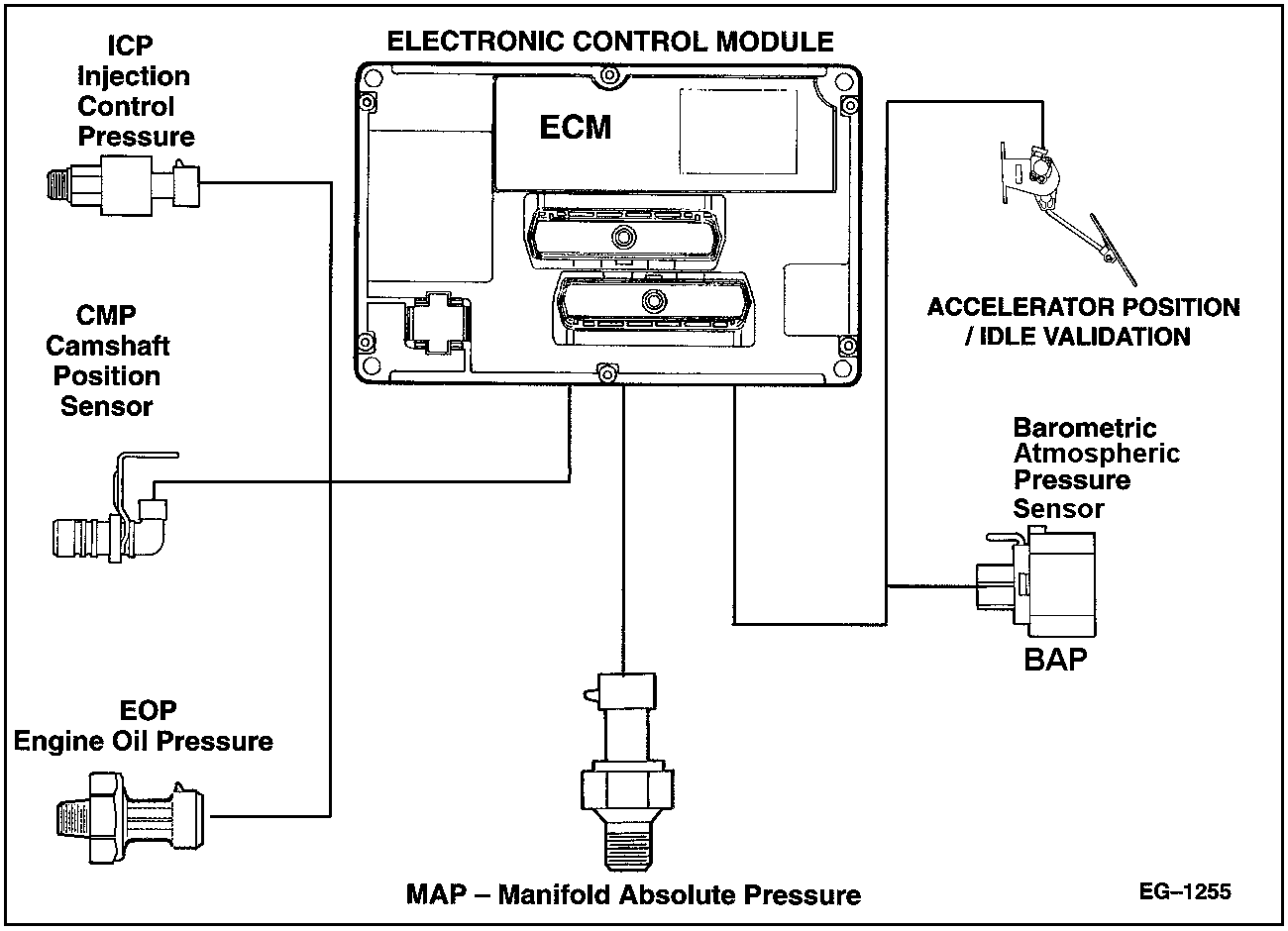

Figure 160 Reference Voltage Function Diagram

The Reference Voltage circuit is a 5V ± 0.5 power supply from the ECM that provides power to the three wire engine and vehicle sensors it also provides a benchmark or Reference Voltage for the ECM.

There are three separate Reference Voltage circuits in this system.

1. V_{REF} B –For Chassis Sensors
2. V_{REF} C –For Body Builder Sensors
3. V_{REF} D –For Engine Sensors

Fault Detection / Management

There is no fault detection specifically for the V_{REF} signal directly, but if there is a V_{REF} circuit fault the sensor(s) in the section of the circuit affected may set an Out of Range HIGH or LOW code. Multiple HIGH or LOW codes are usually an indication of a V_{REF} or in some instances a Signal Ground fault condition.

A V_{REF} signal shorted to ground will cause the ECM to reset causing either a stumble or no start condition.

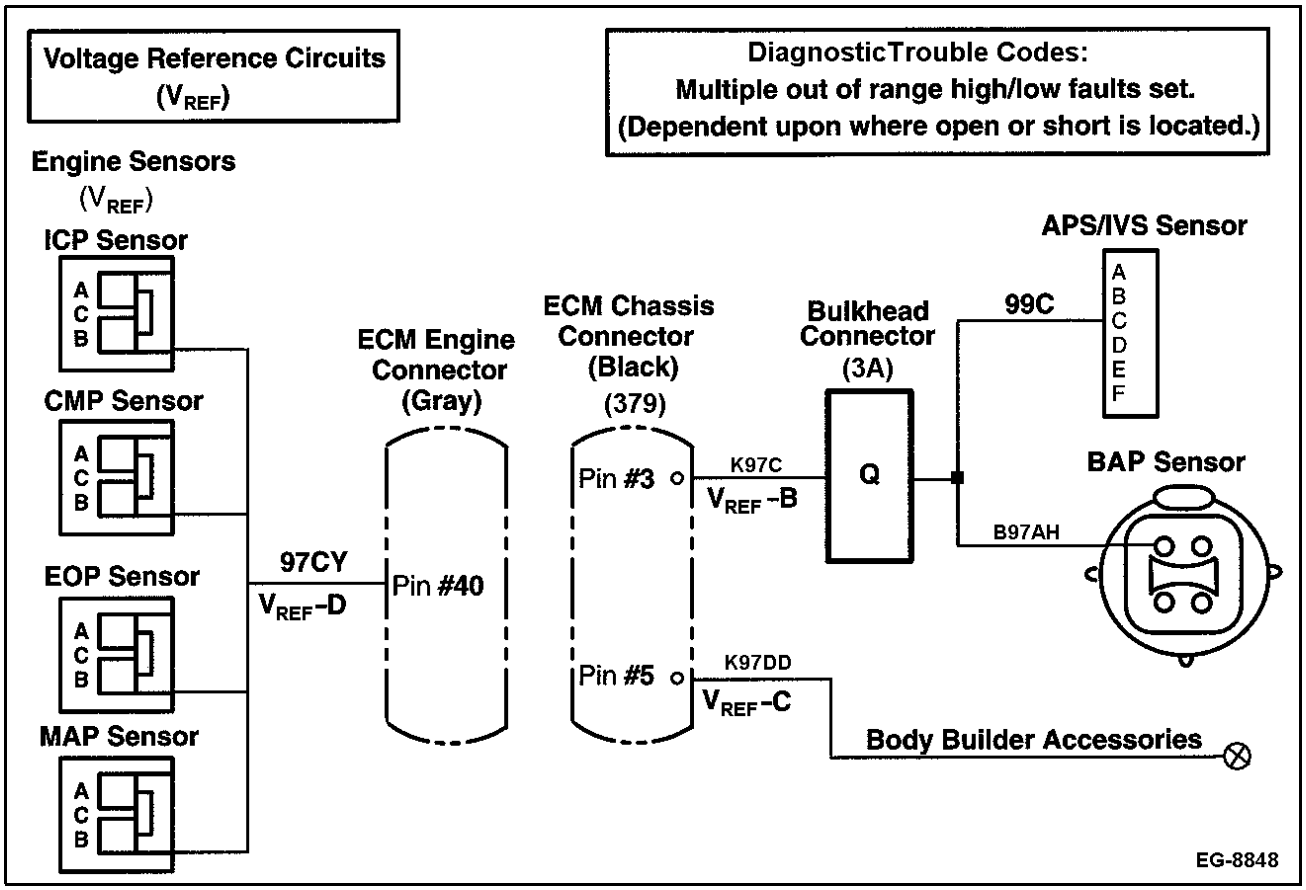

Figure 161 Voltage Reference Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 84 Voltage Reference Circuit Diagnostics

Voltage Reference Connector Checks (if multiple diagnostic trouble codes are set, remove and measure V_{REF} at suspected sensor circuits)			
Sensor	Test Points	Spec.	Comments
ICP	B to gnd	5V ± 0.5	Check V_{REF} at suspected sensors one at a time. Identifying which sensors do not have a V_{REF} and which ones share a common V_{REF} feed will aid in helping to isolate the area of a short or open circuit. If disconnecting a sensor causes V_{REF} to be present in the circuit that had no previous V_{REF}, it is likely that the disconnected sensor had shorted V_{REF} to ground.
CMP	B to gnd	5V ± 0.5	
MAP	B to gnd	5V ± 0.5	
APS/IVS	C to gnd	5V ± 0.5	
BAP	B to gnd	5V ± 0.5	
Connector Checks to Chassis Ground (sensors disconnected, + BAT cable disconnected, key OFF)			
Sensor	Test Points	Spec.	Comments
ICP	B to gnd	>500Ω	Resistance < 500Ω indicates a short to ground. If a short to ground condition is identified, remove all sensor connectors that are connected to V_{REF} and ECM to determine if short is in a sensor, ECM, or in a wiring harness. Spec is >1kΩ with all common sensors disconnected from harness.
CMP	B to gnd	>500Ω	
MAP	B to gnd	>500Ω	
APS/IVS	C to gnd	>1kΩ	
BAP	B to gnd	>1kΩ	
Continued on Next Page			

Table 84 Voltage Reference Circuit Diagnostics (cont.)

Harness Resistance Checks (check with sensor connector(s) disconnected and ignition key OFF, all accessories OFF with breakout box installed)			
Sensor	Test Points	Spec.	Comments
ICP	B to 40	<5Ω	The measurement is taken from the sensor connector to the ECM 60 pin connector. Resistance > 5Ω indicates high resistance or an open in the V_{REF} supply circuit.
CMP	B to 40	<5Ω	
MAP	B to 40	<5Ω	
APS/IVS	C to 3	<5Ω	
BAP	B to 3	<5Ω	

Extended Description

Function

The Electronic Control Module contains a regulated 5V DC voltage reference source to power engine and vehicle sensors. The sensor signals are compared to the Voltage Reference to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

Operation

The ECM supplies V_{REF} when the ignition key is ON at terminals 40 for the engine (gray connector) and terminals #3 & #5 for the chassis and body builder connections (black connector).

ECM Voltage Reference Diagnostics

If multiple sensor codes are set, it is possible that the V_{REF} circuit is open or shorted to ground, or the return signal circuit is open. Follow troubleshooting procedures to determine if V_{REF} circuits are at fault causing a Diagnostic Trouble Code. The engine will not run without a valid V_{REF} signal to the CMP sensor.

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VEHICLE RETARDER (VRE)

Circuit Functions

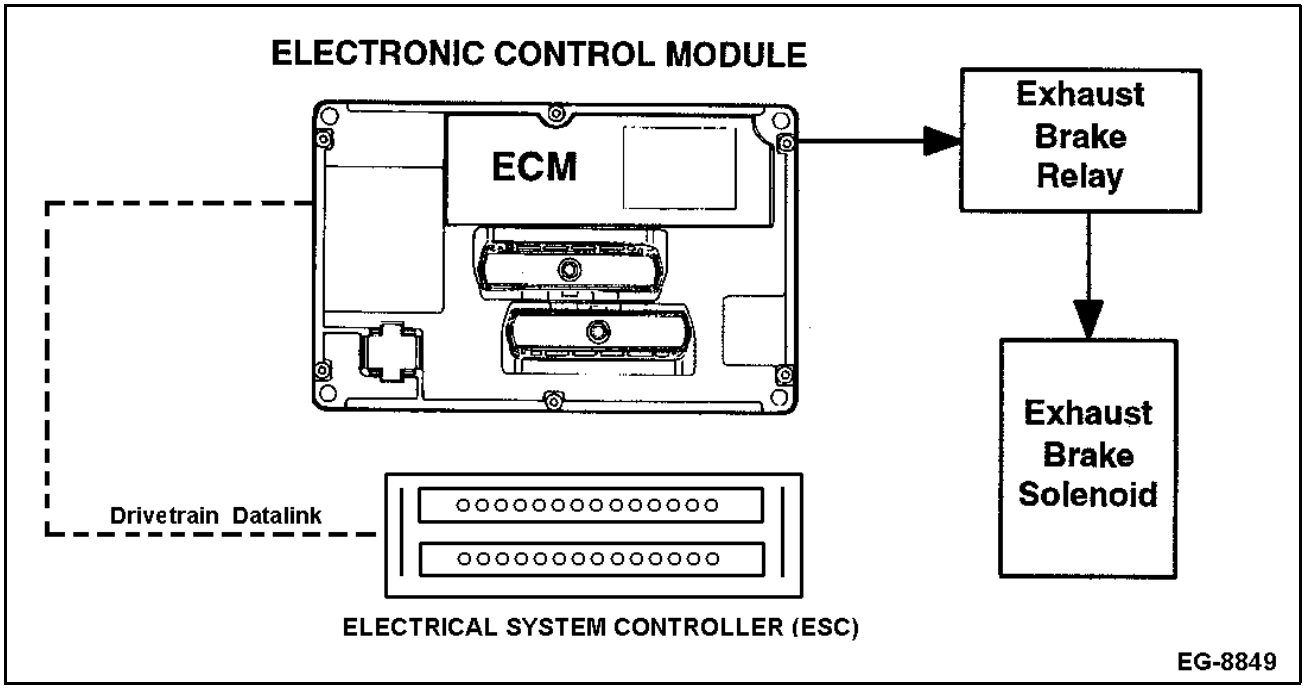

Figure 162 Vehicle Retarder Function Diagram

On engines/vehicles equipped with an exhaust brake the VRE (Vehicle Retarder Circuit) circuits function is to control the relay that turn the brake on and off. This circuit has many applications and can be wired in many configurations. **The applicable wiring diagram for the correct application must be used for troubleshooting the correct circuit.**

Whenever a vehicle retarder is installed, regardless of type or mode of operation, the operator is supplied with an in-cab switch that will allow the system to be turned ON or OFF. The switch signals the operator's request to the Electrical System Controller (ESC) and the ESC relays that request to the Power Train Data Link to the ECM.

Fault Detection / Management

An open or short to ground can be detected on the coil side of the engine brake relay during an "On Demand" Engine Standard Test by the technician.

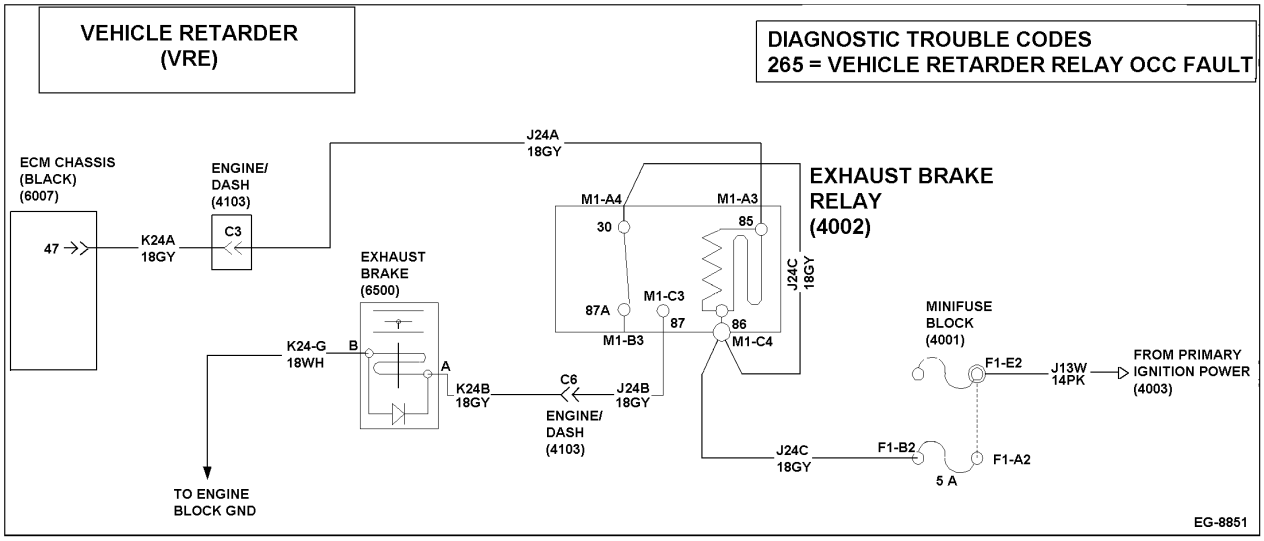

Figure 163 Vehicle Retarder Circuit Diagram

NOTE – After removing connector always check for damaged pins, corrosion, and loose terminals.

Table 85 Vehicle Retarder Circuit Diagnostic Checks

Exhaust Brake Solenoid Voltage/Resistance Checks - With Exhaust Brake Solenoid Unplugged (check with ignition key ON and exhaust brake activated)		
Exhaust Brake Solenoid		
Test Points	Spec.	Comments
Pin A of Ex-Brake Solenoid	12V ± 1.5	If no voltage is present, either relay is not ON or open in circuit to solenoid (test with in-line connector unplugged, check voltage from exhaust brake relay).
Pin B of Ex-Brake Solenoid to gnd	<5Ω	Solenoid will not operate unless grounded.
Pin A to Pin B of Ex-Brake Solenoid	5 to 30Ω	Check resistance of exhaust brake solenoid. Resistance will vary with manufacturer, but solenoid coil should not indicate infinite resistance (open coil).
Exhaust Brake Relay Voltage Checks - With Exhaust Brake Relay Unplugged (check with EFC solenoid and battery positive cable disconnected, with breakout box installed)		
Exhaust Brake Relay		
Test Points	Spec.	Comments
30 to gnd	12V ± 1.5	Voltage should be present with ignition key ON. If 0V, check fuse and power circuit
86 to gnd	12V ± 1.5	Voltage should be present with ignition key ON. If 0V check fuse and power circuit.
85 to gnd	0V	No voltage expected
87 to gnd	0V	No voltage expected
Continued on Next Page		

Table 85 Vehicle Retarder Circuit Diagnostic Checks (cont.)

Operational Voltage Checks (check with breakout box installed and exhaust brake relay & solenoid plugged in)		
Test Points	Spec.	Comments
47 to 23	0V	Voltage value when exhaust brake is activated by ECM. ECM grounds relay to turn it on.
47 to 23	12V ± 1.5	Voltage value when exhaust brake is turned OFF - ECM grounds relay to turn it on.
Diagnostic Trouble Code Description		
265 = Exhaust brake relay failed the output circuit test during a Key-ON Engine-OFF Standard Test.		

Extended Description

Vehicle Retarder

This group of parameters customizes the retarder feature. The purpose for the Vehicle Retarder is to provide the proper logic to enable or disable a mechanical engine/transmission brake. Several types of engine brakes exist.

- Engine Exhaust Brakes
- Transmission Retarders
- Anti-lock Braking Devices

The purpose of these devices is to aid in the deceleration rate of the vehicle by providing additional vehicle or engine load. This can reduce brake wear for vehicles in situations that require frequent braking. Also provided is over-speed protection which will decrease the odds of engine damage due to excessive engine speed.

The on-board electronics provides the proper control logic necessary to determine when the vehicle retarder should be enabled. Currently, there are five states of electronic operation; OFF, LATCHED, COAST, TRANSMISSION LATCHED and overspeed

Vehicle Retarder

This parameter indicates to the on-board electronics the desired mode of operation for the vehicle retarder feature.

- **OFF**- Feature is disabled at all times.
- **Latched** - The vehicle retarder will be enabled when the proper engine/vehicle conditions are satisfied. When either cruise control or PTO speed control is on, the brake pedal must be applied before vehicle retarder will be enabled. The vehicle retarder will remain enabled until the accelerator pedal is depressed or low idle speed has been reached.
- **Coast** - The vehicle retarder will be enabled when the proper engine/vehicle conditions are satisfied. When either the cruise control or PTO speed control is on, the brake pedal must be applied before vehicle retarder will be enabled. The vehicle retarder will remain enabled only if the brake pedal is continually depressed.
- **Transmission Latched** - The vehicle retarder will be operated similarly to the LATCHED state, however the engine is allowed to operate at a higher rpm range in this state because the transmission is the retarding device.
- **Overspeed** - This protection is provided in all active vehicle retarder states. This is included so the vehicle retarder will become enabled when rpm is too high.

ECM Diagnostics

There are three components required for vehicle retarder operation:

- The operator request for vehicle retarder operation. This is accomplished with an in-cab switch that will allow the system to be turned ON or OFF. The switch signals the operator's request to the Electrical System Controller (ESC) and the ESC relays that request over the Power Train Data Link to the ECM. The operator's request for vehicle retarder operation can be verified by viewing the condition of the vehicle retarder dash switch with an EST. If the ECM receives the request from the ESC, the EST will show the Switch State as ON.
- The programmable parameter "retarder mode" must be set for the desired operational mode. The parameter enables the engine strategy which checks engine operational conditions to determine if the vehicle retarder should be engaged. The parameter can be checked using the EST.
- The ECM PIN 47 controls the vehicle retarder relay. This is accomplished by grounding PIN 85 of the vehicle retarder relay. This can be checked with a breakout box installed on the chassis side of the ECM.

Diagnostic Trouble Code 265

ATA Code, PID 62, FMI 11

Vehicle Retarder Relay OCC Diagnostic Trouble Code

The Output Circuit Test, performed during an ON Demand Engine Standard Test, will test the coil side of the vehicle retarder relay and circuit for an open or short condition. If an Out of Range condition exists, Diagnostic Trouble Code 265 will be set.

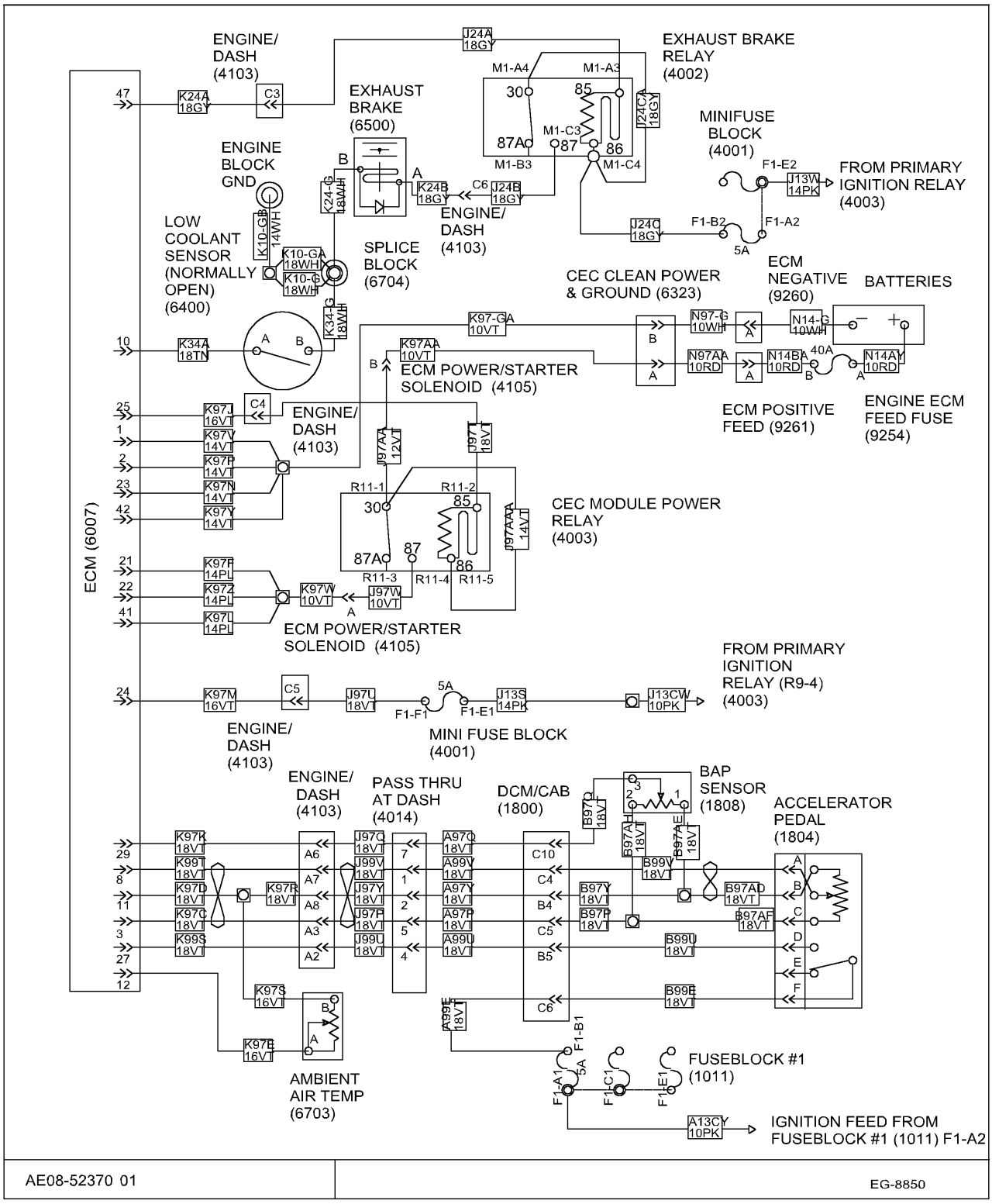

Figure 164 Electronic Engine Controls Circuit Diagram

NOTE – Refer to S08285 - Electrical Circuit Diagrams - 4200/4300/4400

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VEHICLE SPEED SENSOR (VSS)

Signal Functions

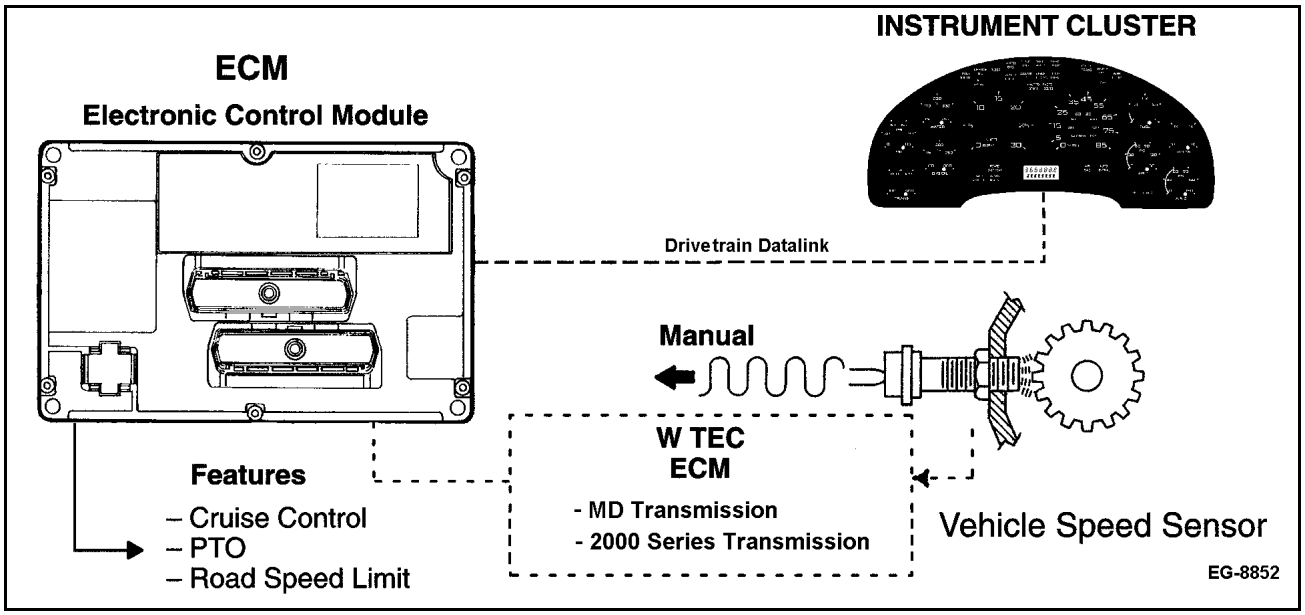

Figure 165 Vehicle Speed Sensor Function Diagram

Transmission tailshaft speed is detected by a magnetic pickup mounted on the transmission that senses the rotation of a 16 toothed gear installed on the rear of the transmission. The resultant AC (alternating current) sine wave signal is received by the ECM and is utilized along with tire size and axle ratio, to calculate vehicle speed. Calculated vehicle speed is transmitted to the instrument cluster through the Drive Train Data Link to operate the speedometer within the instrument cluster. Calculated vehicle speed is also utilized in the control strategies that control features such as Cruise Control, PTO operation and Road Speed Limiting.

Allison WTEC MD and 2000 Series Transmissions utilize an internal VSS sensor that sends a signal to the transmission ECM. The transmission ECM buffers the signal and sends a square wave signal to the Engine ECM.

Fault Detection / Management

When the ECM determines that the vehicle is operating at 0 M.P.H., the ECM performs diagnostic checking on the VSS circuitry. A voltage signal is transmitted on the VSS circuitry by the ECM and will detect if the return voltage is Out of Range HIGH or LOW . When a VSS Diagnostic Trouble Code condition is detected, the ECM disables Cruise Control, PTO operation and if Road Speed Limiting is enabled, will limit engine rpm in all gears. On vehicles equipped with Allison MD (WTEC) and 2000 Series Transmissions, no Diagnostic Trouble Codes will be sent in the event of a VSS sensor circuit failure. Any VSS Diagnostic Trouble Codes set with vehicles equipped with MD transmissions only diagnose the communication circuit between the Engine ECM and the Transmission ECM.

NOTE – See Allison WTEC maintenance/diagnostic manual to diagnose any MD VSS sensor problems.

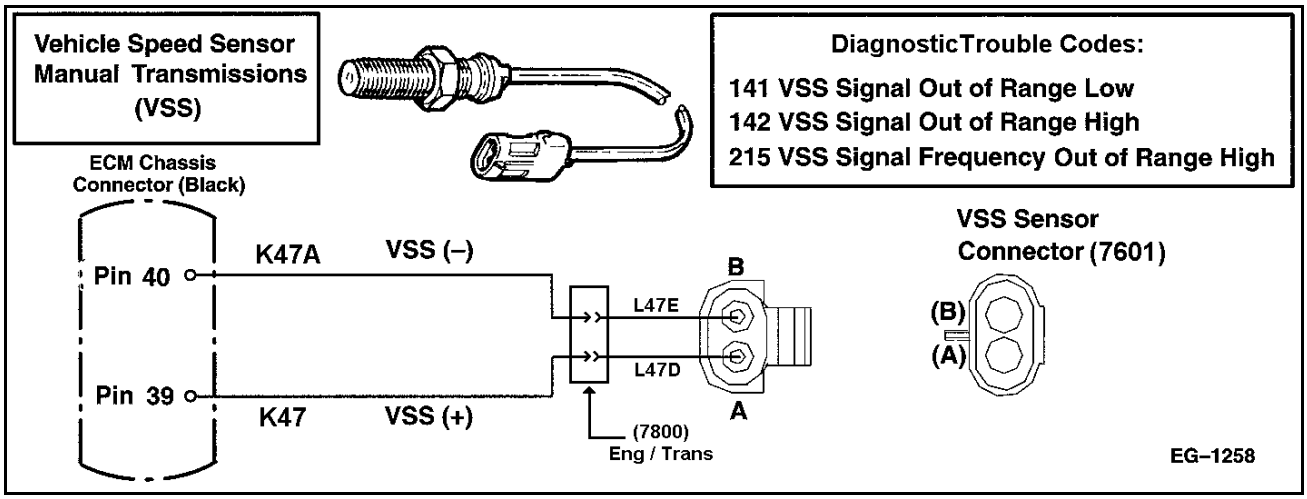

Figure 166 Vehicle Speed Sensor Circuit Diagram

Table 86 Vehicle Speed Sensor Connector Checks

Key ON Engine OFF - Voltage Checks at VSS Connector (check with VSS sensor connector disconnected, ignition key ON, engine OFF)		
(+) Test Points (-)	Spec.	Comments
B to gnd	2 to 3V	ECM pull up voltage when sensor disconnected, if no voltage is present check for an open or short to ground.
A to gnd	2 to 3V	
VSS Sensor Continuity Checks (check with VSS sensor disconnected, measure resistance through the sensor)		
(+) Test Points (-)	Spec.	Comments
B to gnd	>100Ω	If <100Ω, check for short to ground.
A to gnd	>100Ω	If <100Ω, check for short to ground.
B to A	600 - 800Ω	Manual transmission.
B to A	See Allison manual	MD Automatic Transmission (electronically controlled), 2000 Series (LCT) Automatic Transmission (electronically controlled).
Harness Resistance Checks (check with VSS sensor disconnected, battery disconnected and breakout box installed)		
(+) Test Points (-)	Spec.	Comments
40 to B	<5Ω	If >5Ω, check for open circuit.
39 to A	<5Ω	If >5Ω, check for open circuit.
40 to gnd	>100Ω	If <100Ω, check for short to ground.
39 to gnd	>100Ω	If <100Ω, check for short to ground.
Continued on Next Page		

Table 86 Vehicle Speed Sensor Connector Checks (cont.)

Operational Check (check with VSS sensor connected and breakout box installed)		
WARNING – PLACE REAR AXLES ON JACK STANDS WITH FRONT WHEELS BLOCKED.		
NOTE – MEASURE WITH TRANSMISSION IN HIGH GEAR, ENGINE AT LOW IDLE.		
(+) Test Points (-)	Spec.	Comments
40 to 39	>2V AC	If <2V AC, check sensor adjustment or replace defective sensor.
Diagnostic Trouble Code Description		
141 = ECM detected low "test" voltage across VSS circuit for >0.5 seconds. Possible open or short to ground.		
142 = ECM detected high "test" voltage across VSS circuit for >0.5 seconds. Possible internal sensor short or short to power.		
215 = ECM detected a VSS frequency signal >4.365 kHz.		

NOTE – Refer to S08250 – Electrical Troubleshooting Guide – 4200/4300/4400.

Extended Description

The Vehicle Speed Sensor (VSS) is located on the transmission and sends an AC signal to the ECM. The VSS sensor contains a permanent magnet which creates a magnetic field. The AC signal is created when the transmission speedometer gear rotates breaking the magnetic field created by the sensor. The ECM processes the AC signal and transmits vehicle speed data on the Drive Train Data Link and utilizes it for various engine and vehicle control strategies. On a manual transmission, the VSS sensor is mounted at the rear of the transmission.

ECM Diagnostics

Diagnostic Trouble Codes can be retrieved using the Electronic Service Tool (EST) or by reading the Diagnostic Trouble Code flashes from the amber and red ENGINE lamps, see page 70.

Diagnostic Trouble Code 141

ATA Code, PID 84, FMI 4

VSS Out of Range LOW

This code is set when the ECM detects an Out of Range LOW condition in the VSS circuit. This is a continuous monitor code and can be set any time the vehicle is operating. It may be displayed as an active or inactive diagnostic trouble code. When this code is set the amber ENGINE lamp will not be illuminated.

Possible Causes: Open sensor wiring, open sensor, short to ground in wiring or sensor.

Diagnostic Trouble Code 142

ATA Code, PID 84, FMI 3

This code is set when the ECM detects an Out of Range HIGH condition in the VSS circuit. This is a continuous monitor code and can be set any time the vehicle is operating. It may be displayed as an active or inactive diagnostic trouble code. When this code is set the amber ENGINE lamp will not be illuminated.

Possible Causes: Wiring short to power (V_{REF} or battery), internal short in VSS sensor.