ELECTRONIC DIESEL ENGINE DIAGNOSIS SPECIALIST TEST (L2)

MEDIUM/HEAVY COMPOSITE VEHICLE TYPE 3 REFERENCE BOOKLET

This booklet is intended only for reference when preparing for and taking the ASE Electronic Diesel Engine Diagnosis Specialist (L2) Test. The medium/heavy composite vehicle control system is based on designs common to many engine and vehicle manufacturers, but is not identical to any actual production engine or vehicle.

— MEDIUM/HEAVY COMPOSITE VEHICLE INFORMATION —

GENERAL DESCRIPTION

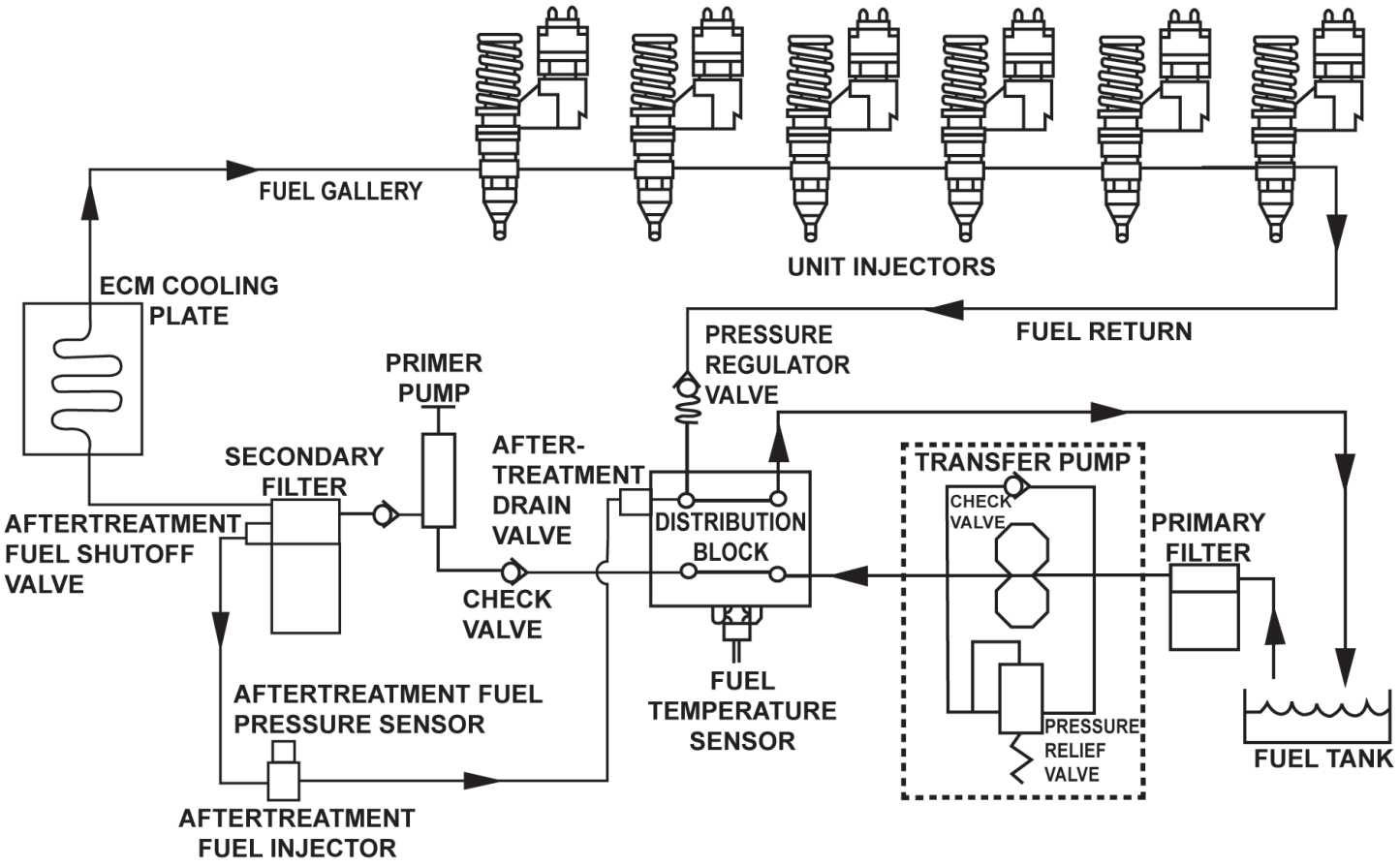
This generic in-line six cylinder diesel engine is equipped with a variable geometry turbocharger (VGT), charge air cooler (CAC), electronic unit injectors (EUI), closed crankcase ventilation, exhaust gas recirculation (EGR), and exhaust aftertreatment system. The engine rating is 400 hp at 1,800 rpm and develops a peak torque of 1450 lb. ft. at 1,200 rpm.

THE ELECTRONIC CONTROL MODULE (ECM)

The electronic control module is the microprocessor that receives electronic inputs from sensors and switches, and is calibrated to control fuel metering, injection timing, diagnostics, and engine protection. The ECM receives power from the battery and ignition switch and provides a reference voltage for some sensors. The software contained in the ECM determines how the electronic diesel engine control system operates. The ECM stores the calibration values that define rated horsepower, torque curves, and rpm specifications. The engine ECM communicates with other vehicle system control modules through the SAE J1939 data link (controller area network - CAN). The ECM is mounted on the engine.

FUEL SYSTEM

The engine requires the use of ultra-low sulfur (ULSD) diesel fuel. Fuel supply (transfer) is provided by a positive displacement, mechanically driven pump. A preset spring-operated regulating valve mounted on the cylinder head fuel outlet gallery is used to maintain fuel pressure. Fuel delivery is provided by electronically controlled unit injectors (EUI). The injector solenoids are controlled by the ECM.



ENGINE PROTECTION SYSTEM

The engine protection system monitors coolant temperature, coolant level, oil temperature, intake manifold temperature, oil pressure, fuel temperature, EGR exhaust gas temperature, and diesel particulate filter (DPF) restriction. The system has three levels of protection: warning, derate, and shutdown. In the warning mode, the yellow Check Engine Lamp (CEL) alerts the operator to a potential problem. In the derate (limp home) mode, the ECM will gradually reduce engine power after illuminating the red Stop Engine Lamp (SEL). Power derate will begin 30 seconds after the initial warning. The shutdown mode will be indicated by a flashing SEL and activate for engine coolant temperature, coolant level, engine oil pressure, or engine oil temperature failures only. Shutdown will occur when the condition reaches a preset value, after the warning and derate modes have activated. The engine protection override switch can be used to temporarily delay the shutdown mode.

High Engine Coolant Temperature
The ECM will turn the engine cooling fan on at 205 ºF.

Engine Coolant Temperature	Power Derate/ Shutdown
225 °F	20% Derate
230 °F	40% Derate
235 °F	60% Derate
240 °F	Shutdown

High Fuel Temperature
A 20% power derate begins when the fuel temperature reaches 180 ºF. The derate increases to 40% if the temperature remains high.

High Intake Manifold Temperature
ECM will turn the engine cooling fan on at 190 ºF. A 20% power derate begins when the mainfold temperature reaches 210 ºF. The derate increases to 40% if the temperature remains high.

High EGR Exhaust Gas Temperature
A 20% power derate begins when the EGR exhaust gas temperature reaches 525 ºF. The CEL is illuminated and the power derate increases to 40% when the temperature reaches 560 ºF. The SEL will not illuminate and the engine will return to full power when the temperature lowers.

Low Engine Coolant Level
After the initial warning, shutdown will occur if the coolant level remains low.

Low Engine Oil Pressure
Power derate/shutdown set points are dependent on the relationship between oil pressure and engine speed. If the oil pressure falls below these specifications, power derate will begin, and shutdown will occur if oil pressure continues to decrease.

	Engine Oil Pressure	
Engine Speed	Begin Derate	Shutdown
2000 rpm	40 psi	20 psi
1800 rpm	35 psi	17 psi
1400 rpm	25 psi	12 psi
1000 rpm	15 psi	8 psi
600 rpm	5 psi	2 psi

High Engine Oil Temperature
The ECM will turn the engine cooling fan on at 245 ºF. A 40% power derate begins when the oil temperature reaches 260 °F. Shutdown occurs after 2 minutes if the temperature remains high.

High Diesel Particulate Filter Restriction
When DPF restriction reaches full soot load (level 3), the CEL is illuminated and a 40% derate begins. The SEL is illuminated and the power derate increases to 80% when the restriction reaches overfull soot load (level 4). A severely restricted DPF may cause the engine to shutdown.

SENSORS

Accelerator Pedal Position Sensor (APP) - The APP contains two potentiometers that sense the position of the accelerator pedal. A reference voltage is sent to each potentiometer and as the angle of the accelerator pedal changes, the APP varies the signal voltages to the ECM. Both APP potentiometer voltages are compared by the ECM for diagnostics. If one or both of the signals are lost, the engine will not operate above idle speed.

Engine Oil Pressure Sensor (EOP) - The variable capacitance EOP sensor monitors engine oil pressure and is installed in the main lube oil gallery. The ECM uses this signal for engine protection and the instrument panel pressure gauge.

Intake Manifold Pressure Sensor (IMP) - The variable capacitance IMP sensor monitors intake manifold pressure and is located on the intake manifold. The ECM uses this signal to control fuel metering, injection timing, and turbocharger control.

Intake Manifold Temperature Sensor (IMT) - The thermistor IMT sensor monitors air temperature in the intake manifold. The ECM uses this signal to control fuel metering, injection timing, EGR operation, engine protection, and cooling fan operation.

Barometric Pressure Sensor (BARO) - The variable capacitance BARO sensor monitors ambient air pressure. The ECM uses this signal to adjust injection timing and fuel metering based on altitude.

Engine Coolant Temperature Sensor (ECT) - The thermistor ECT sensor monitors coolant temperature and is mounted in the engine block coolant jacket. The ECM uses this signal to control fuel management, engine protection, cooling fan operation, the instrument panel temperature gauge, and DPF regeneration.

Coolant Level Sensor (CLS) - The CL sensor monitors the level of the coolant in the radiator surge tank. The ECM uses this signal for engine protection when coolant is not detected.

Fuel Temperature Sensor (FTS) - The thermistor FT sensor monitors fuel temperature and is mounted on the fuel distribution block. The ECM uses this signal to adjust calculated fuel measurements to compensate for changes in fuel temperature and for engine protection.

Engine Oil Temperature Sensor (EOT) - The thermistor EOT sensor monitors engine oil temperature and is installed in the main lube oil gallery. The ECM uses this signal for engine protection.

Inlet Air Temperature Sensor (IAT) - The thermistor IAT sensor monitors air temperature in the inlet pipe before the turbocharger. The ECM uses this signal for fuel management.

Engine Position Sensor 1 (EPS1) - The Hall-effect EPS1 generates a digital signal that varies in frequency with the speed of the engine camshaft. The ECM uses the frequency and pulse width of this signal to determine camshaft position for fuel control and injection timing. The ECM will use this signal for calculated engine speed in the event of EPS2 (crankshaft) signal failure. The engine will shutdown in the event of EPS1 (camshaft) signal failure. The EPS1 is located in the engine front cover facing the trigger/ tone wheel that is mounted on the camshaft gear.

Engine Position Sensor 2 (EPS2) - The Hall-effect EPS2 generates a digital signal that varies in frequency with the speed of the engine crankshaft. The ECM uses the frequency of this signal to determine engine speed for fuel control and injection timing. The ECM requires input from both EPS1 and EPS2 for starting. The EPS2 is located in the engine rear flywheel housing facing the trigger/tone wheel mounted on the crankshaft.

Exhaust Back Pressure Sensor (EBP) - The variable capacitance EBP sensor monitors exhaust gas pressure from a tube connected to the exhaust manifold. The ECM uses this signal for EGR valve and variable geometry turbocharger (VGT) operation.

Crankcase Pressure Sensor (CPS) - The variable capacitance CP sensor monitors pressure in the engine crankcase. The ECM uses this signal to verify the condition of the closed crankcase ventilation system and filter.

EGR Temperature Sensor (EGRT) - The thermistor EGRT sensor monitors the temperature of the exhaust gases in the outlet of the EGR cooler. The ECM uses this signal for emissions management and engine protection.

EGR Differential Pressure Sensor (EGR Delta P) - The variable capacitance EGR Delta P sensor has two ports that monitor the exhaust gas pressure across the EGR differential pressure orifice. One port is located on each side of the EGR venturi. The ECM uses this pressure drop signal and the EGR temperature signal to calculate the amount of EGR flow into the intake manifold. The ECM commands the EGR valve and the VGT actuator positions to control the amount of exhaust gases entering the engine.

EGR Position Sensor (EGRP) - The three-wire fixed potentiometer EGRP sensor monitors the position of the EGR valve. The ECM uses this signal to verify proper operation of the EGR valve and motor for emissions control and diagnostics.

Ambient Air Temperature Sensor (AT) - The thermistor AT sensor monitors the outside (ambient) air temperature and is mounted on the cab. The signal is sent from the body control module (BCM) to the ECM through the J1939 data link (CAN). The ECM uses this temperature for idle shutdown operation.

Aftertreatment Fuel Pressure Sensor (AFP) - The variable capacitance AFP sensor monitors the pressure in the aftertreatment fuel system. The ECM uses this signal in determining operation of the aftertreatment fuel injector during regeneration. Active and stationary regeneration will be disabled if a fuel pressure fault is detected.

Aftertreatment Diesel Oxidation Catalyst Inlet Temperature Sensor (EGT1) - The thermistor aftertreatment diesel oxidation catalyst (DOC) inlet temperature sensor monitors the exhaust gas temperature into the (DOC). The ECM uses this signal to control EGR and VGT actuator positions and aftertreatment fuel injection during DPF regeneration.

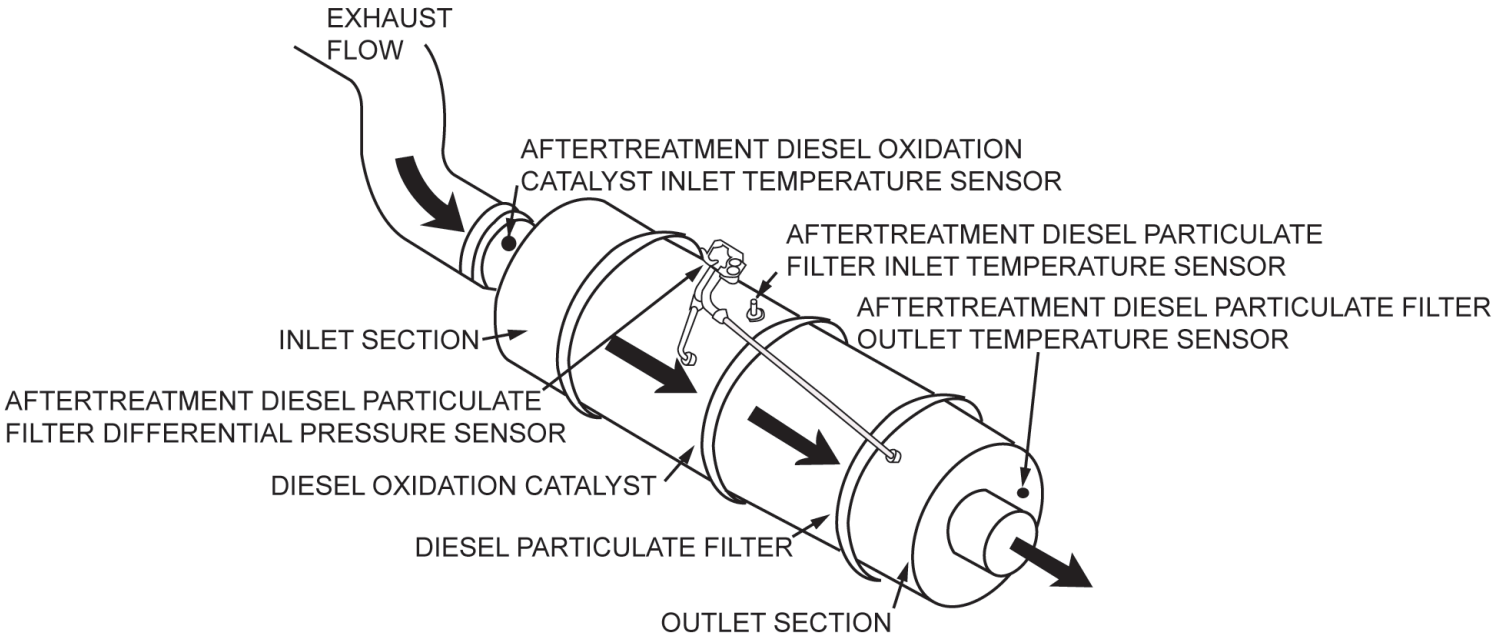
Aftertreatment Diesel Particulate Filter Inlet Temperature Sensor (EGT2) - The thermistor aftertreatment diesel particulate filter (DPF) inlet temperature sensor monitors the exhaust gas temperature entering the DPF. The ECM uses this signal in determining EGR and VGT actuator positions and aftertreatment fuel injection during DPF regeneration.

Aftertreatment Diesel Particulate Filter Outlet Temperature Sensor (EGT3) - The thermistor aftertreatment diesel particulate filter (DPF) outlet temperature sensor monitors the exhaust gas temperature at the outlet of the DPF. The ECM uses this signal in determining EGR and VGT actuator positions and aftertreatment fuel injection during DPF regeneration.

Aftertreatment Diesel Particulate Filter Differential Pressure Sensor (DPF Delta P) - The variable capacitance DPF exhaust pressure sensor has two ports that monitor the exhaust gas pressure across the diesel particulate differential pressure orifice. One port is located on each side of the DPF. The ECM uses this pressure drop signal to calculate the amount of DPF restriction.

Based on the amount of DPF restriction, the ECM will illuminate the series of warning lamps below:

- Level 1- Low soot load. The DPF status lamp is illuminated.
- Level 2- Moderate soot load. The DPF status lamp is flashing.
- Level 3- Full soot load. The DPF status lamp is flashing and the yellow CEL is illuminated.
- Level 4- Over-full soot load. The DPF status lamp is flashing and the red SEL is illuminated.



SWITCHES

Engine Cooling Fan Control Switch - This is a normally open switch that, when closed by the operator, requests that the ECM de-energize the engine cooling fan solenoid. This will cause the engine cooling fan to operate continuously.

Diagnostic Switch - This is a normally open momentary switch that, when pressed (closed) and released, requests the ECM to enter diagnostic mode. The yellow check engine lamp (CEL) will come ON and flash inactive fault codes. The red stop engine lamp (SEL) will come ON and flash active fault codes. If both lights momentarily turn ON and then OFF, no fault codes are present.

Air Conditioning High Pressure Switch - This normally closed pressure switch opens when the air conditioner high-side pressure reaches a preset value. This signals the ECM to operate the engine cooling fan.

Cruise Control On/Off Switch - This normally open switch enables cruise control operation when it is closed by the operator.

Cruise Set/Resume Switch - This switch has two momentary positions: SET/COAST and RESUME/ACCELERATE. Vehicle cruising speed can be set by pressing SET/COAST. Once a speed has been set, and then disengaged using the brake or clutch, the ECM will return to the previously set speed when RESUME/ACCELERATE is pressed. Vehicle cruise control set speed is adjusted lower by pressing SET/COAST and higher by pressing RESUME/ACCELERATE. The two set/resume switch positions are also used for engine speed settings during PTO operation.

Clutch Pedal Switch - This normally closed switch opens when the clutch pedal is depressed. This signals the ECM to cancel cruise control, power take-off mode, or engine braking and to override the idle shutdown timer.

Service Brake Pedal Switch - This normally closed pressure switch opens when the service brake pedal is depressed. This signals the ECM to enable engine braking, cancel cruise control and power take-off mode, and to override the idle shutdown timer.

Engine Brake On/Off Switch - This normally open switch signals the ECM that the operator is requesting engine brake system activation when closed. The ECM will energize the engine brake solenoids based on inputs from the accelerator pedal and the cruise control on/off, clutch and service brake switches.

Engine Brake Selector Switch - This three-position switch sets the level of engine braking (LOW, MEDIUM, or HIGH). The engine brake solenoid for engine cylinders 3 & 4 is energized for the LOW level. The engine brake solenoids for cylinders 1 & 2 and cylinders 5 & 6 are energized for the MEDIUM level. All three solenoids are energized for the HIGH engine braking level.

Power Take-Off (PTO) On/Off Switch - This normally open switch enables PTO mode operation when closed. In this mode, the cruise control set/resume switch is used for two preset PTO engine speeds. SET/COAST is pressed for the first engine speed setting and RESUME/ACCELERATE is pressed for the second setting.

Power Take-Off (PTO) Remote Switch - This normally open switch is mounted outside the cab and enables remote PTO mode operation at a preset engine speed when closed.

Engine Protection Override Switch - This is a normally open momentary switch that, when pressed (closed) and released during the shutdown warning period, requests the ECM to override (delay) an engine protection shutdown for 30 seconds.

Diesel Particulate Filter Regeneration Switch - This normally open momentary switch that, when pressed (closed) and released, requests the ECM to enable a stationary or parked DPF regeneration.

Parking Brake Switch - This normally closed switch opens when the parking brake is released. The switch position signal is sent from the body control module (BCM) to the ECM through the J1939 data link (CAN). The ECM uses this input to control stationary or parked DPF regeneration, idle shutdown, and PTO operation.

ACTUATORS

Electronic Unit Injectors (EUI) - These electromechanical diesel fuel injectors contain a solenoid controlled by the ECM to manage fuel timing and metering. The ECM injector driver circuitry supplies high voltage to the injector solenoids which are energized by controlling the ground circuits within the ECM. Injector calibration codes need to be programmed into the ECM to compensate for manufacturing tolerances.

Engine Cooling Fan Solenoid - When energized by the ECM, this normally closed solenoid supplies air pressure to disengage the engine cooling fan clutch and turn the fan OFF. The solenoid can be de-energized by the ECM, shutting off air pressure to engage the fan clutch and turn the fan ON. The ECM engages the fan to assist with engine braking when the selector switch is in the HIGH position. The ECM will operate the fan for engine protection when coolant temperature reaches 205ºF, engine oil temperature at 245ºF, intake manifold temperature at 190ºF, and when the A/C high-pressure switch opens.

Stop Engine Lamp - The red stop engine lamp (SEL) illuminates when the engine protection system is in the derate and shutdown modes. The red SEL can also be used to read active fault “flash” codes when in the diagnostic mode.

Check Engine Lamp - The amber/yellow check engine lamp (CEL) illuminates when the engine protection system is in the warning mode, or when electronic control system failures are occurring and an active fault is present. The yellow CEL can also be used to read inactive fault “flash” codes when in the diagnostic mode. The CEL and SEL are used in combination with the aftertreatment regeneration status lamp (DPFR) for DPF restriction status and regeneration requirements.

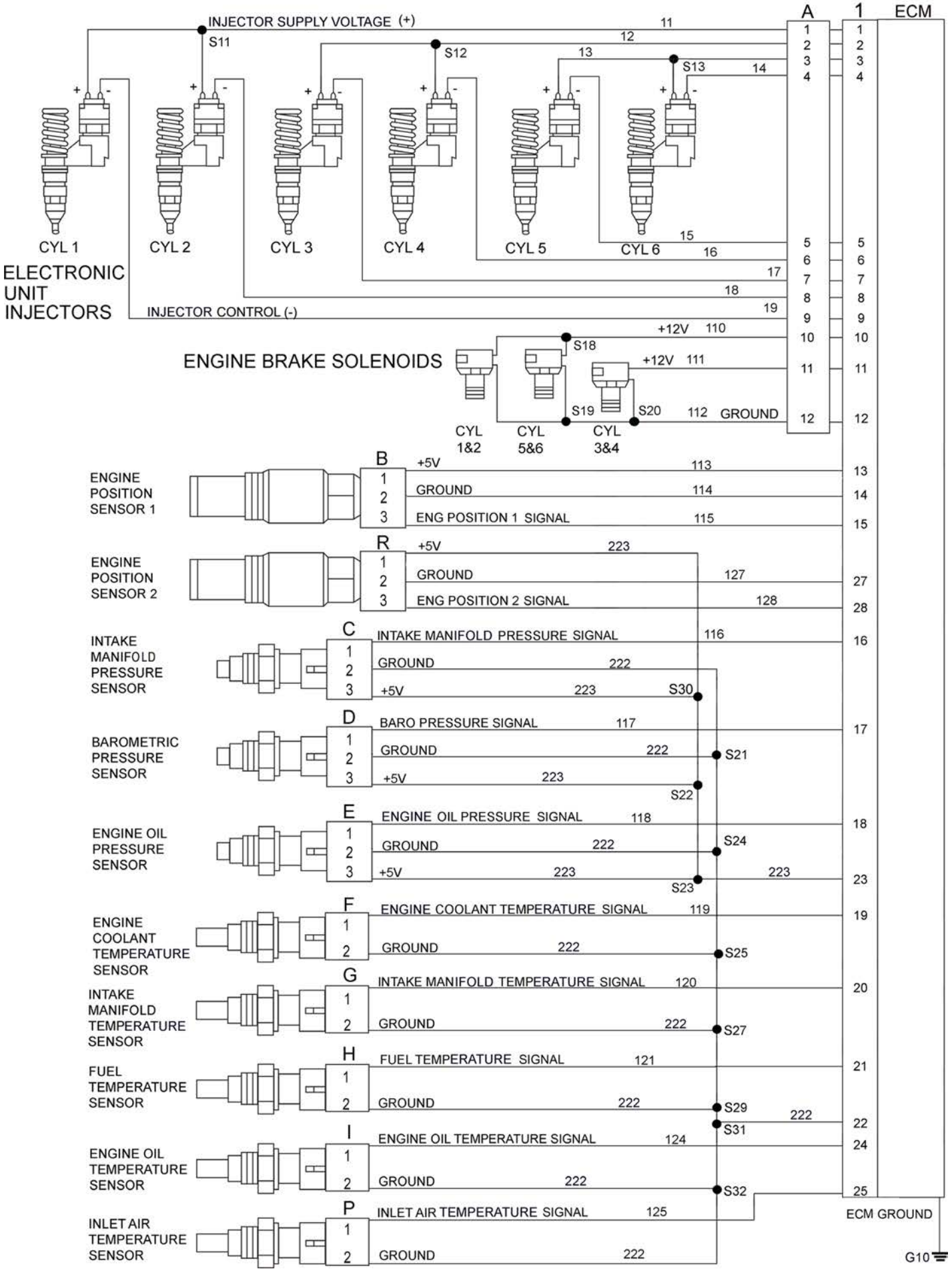
Engine Brake Solenoids - These three solenoids can be energized by the ECM to provide engine braking on two, four or all six cylinders. The engine brake can be activated during cruise control operation. The solenoids will be energized after the set speed has been exceeded or when the service brake pedal is depressed and the accelerator pedal is released. The ECM will not energize the solenoids when the clutch pedal is depressed.

EGR Valve Motor - The EGR valve stepper motor is mounted on the EGR valve and controlled by the ECM through the J1939 data link (CAN). Exhaust gases flow through the EGR cooler to the EGR valve and into a venturi (mixing chamber combining intake air and exhaust gas) at the intake manifold. The ECM will disable the EGR valve (default closed position) in the event of motor data link communication failure.

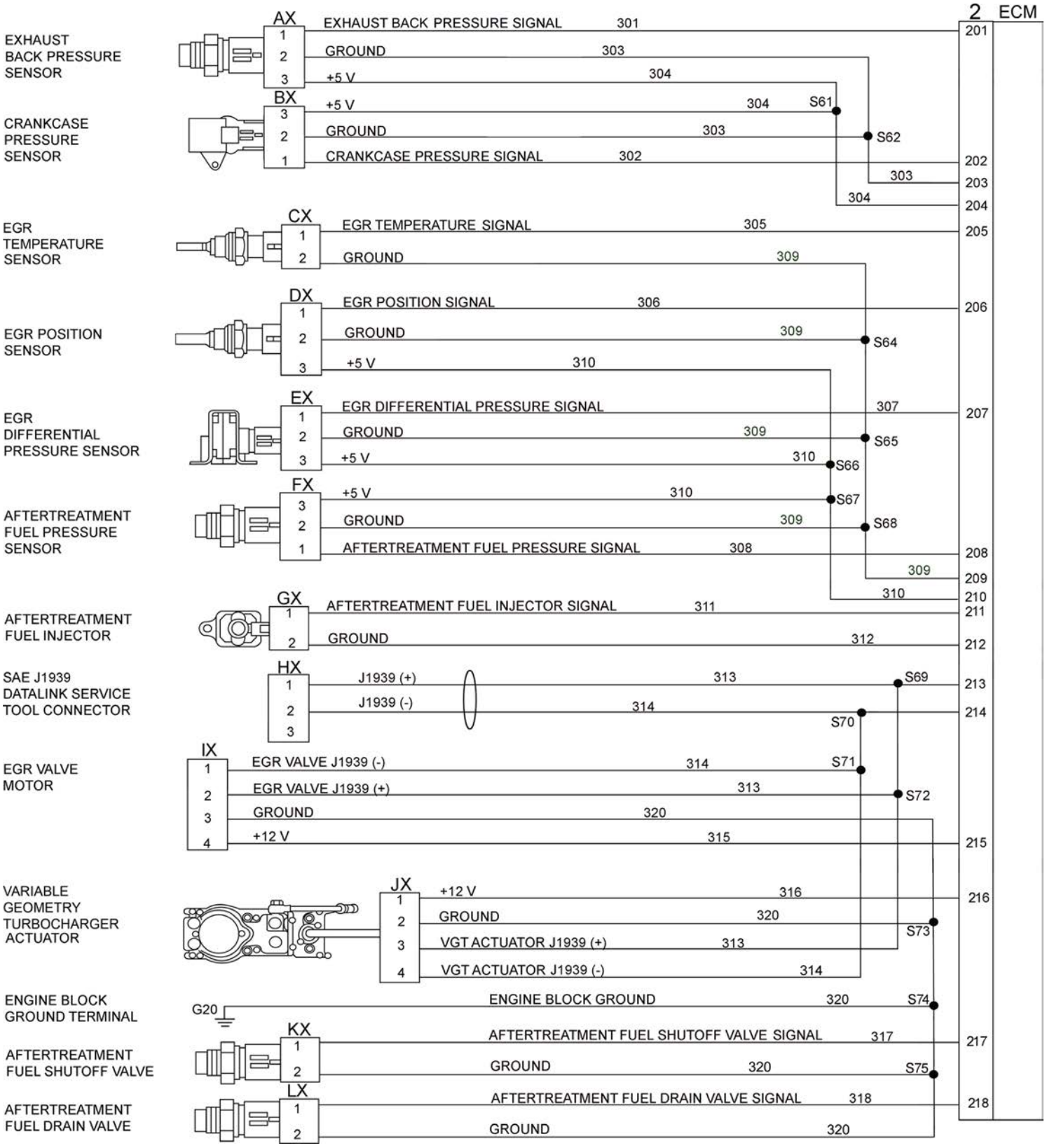
Variable Geometry Turbocharger Actuator - The VGT actuator is mounted on the turbocharger and controlled by the ECM through the J1939 data link (CAN). The actuator operates an internal sliding nozzle ring in the turbine housing. The sliding nozzle ring allows for control of turbine shaft speed and by regulating exhaust gas flow through the turbocharger. As the ring is moved from the open to the closed position, exhaust gas flow velocity increases. The actuator has self-diagnostic capabilities and has a preset default position in the event of actuator failure. The ECM calculates turbocharger shaft speed for displayed data and diagnostics.

(Actuator section continues after the following wiring diagrams.)

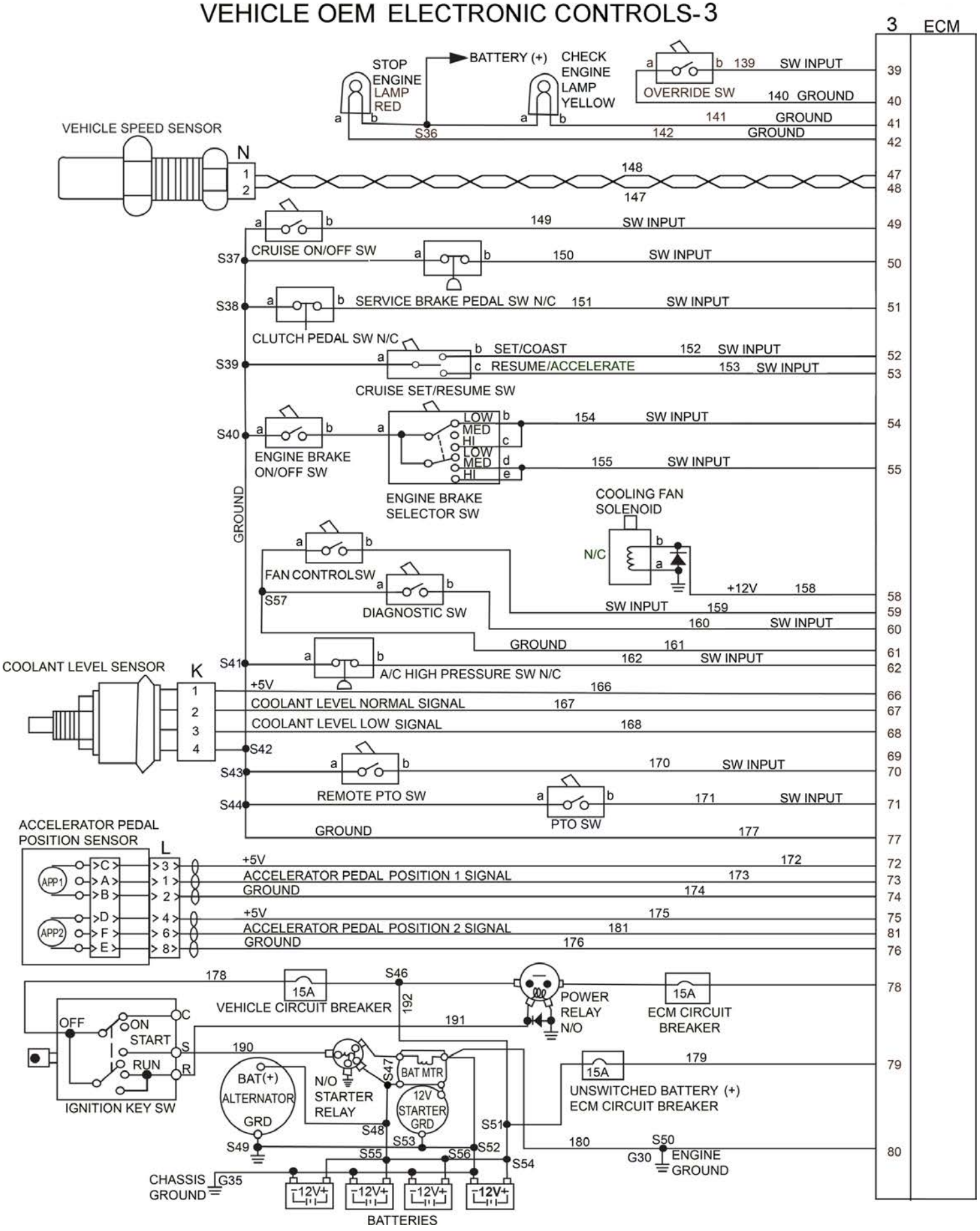
DIESEL ENGINE ELECTRONIC CONTROLS-1



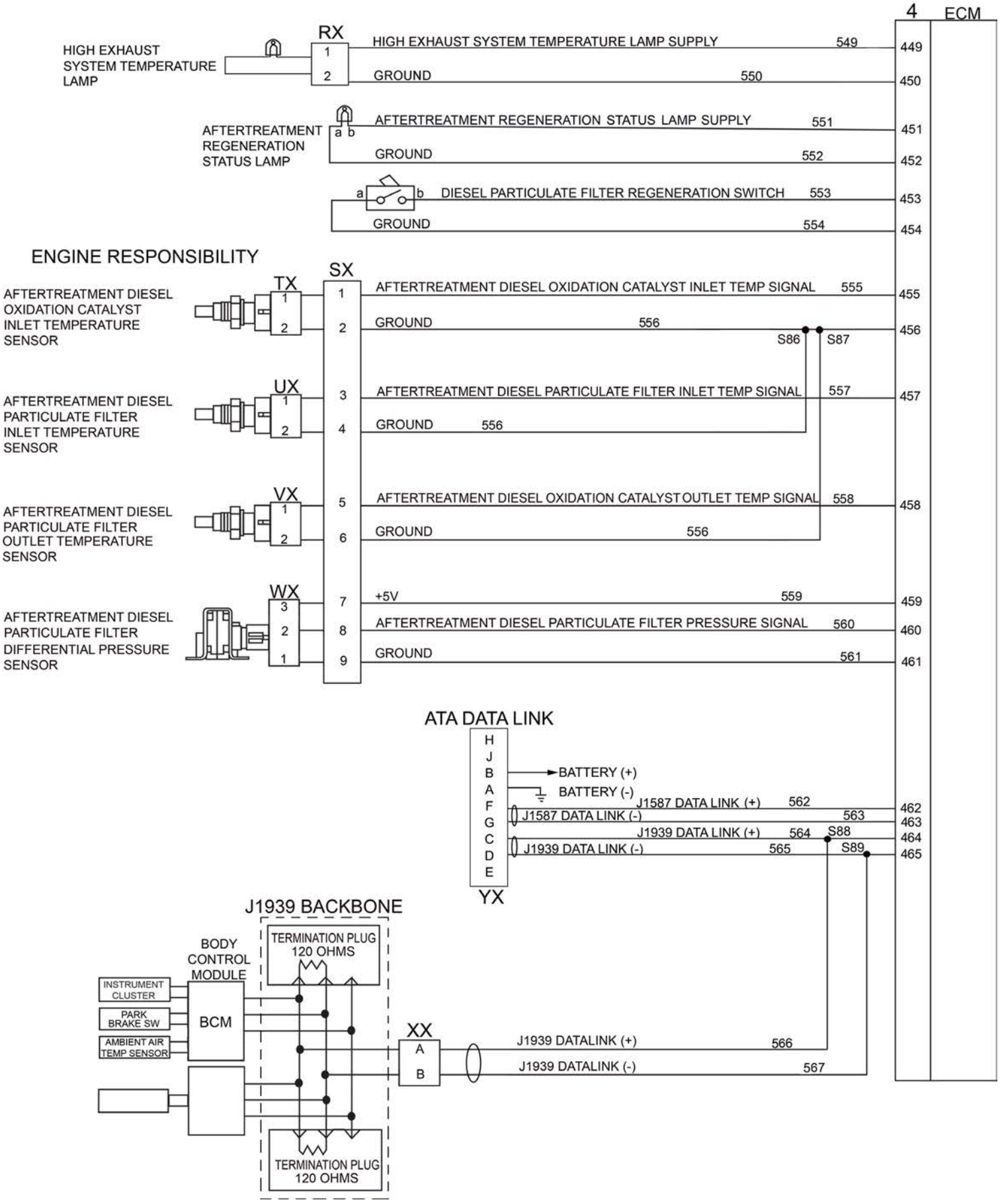
DIESEL ENGINE ELECTRONIC CONTROLS-2



VEHICLE OEM ELECTRONIC CONTROLS-3



VEHICLE OEM ELECTRONIC CONTROLS - 4



Idle Shutdown Timer (IST)

The idle shutdown feature reduces the amount of fuel burned and increases engine life by shutting down the engine after a period of engine idling with no driver activity. Thirty seconds before the shutdown occurs, the stop engine lamp flashes to alert the driver of an impending shutdown. The driver can override the shutdown by depressing the service brake, clutch, or accelerator pedals during the warning period. If the override is successful, the SEL will continue flashing for two minutes. The idle shutdown time period will restart when the idle condition is detected by the ECM.

Idle shutdown can interact with the PTO feature. It can cause the engine to shutdown when in PTO mode. If the idle shutdown percent load threshold is not exceeded, the engine will be shutdown.

The following conditions must be set for the idle shutdown timer to activate. Any change to one or more of these conditions will reset or disable the IST.

Enable Conditions for IST:

- Engine is idling below 750 rpm.
- Vehicle speed is 0 mph.
- No active vehicle speed sensor diagnostic faults.
- PTO/Remote PTO is operating below the percent load threshold. (Customer Programmable Parameters)
- Ambient air temperature is between 40 °F and 80 °F (CAN message from body control module). (Customer Programmable Parameters)
- No active inlet air temperature sensor diagnostic faults.
- Engine coolant temperature is above 140 °F.
- No active engine coolant temperature sensor diagnostic faults.
- Stationary diesel particulate filter (DPF) regeneration is inactive.
- Accelerator pedal position is released (at idle).
- Service brake pedal switch is closed.
- Clutch pedal switch is closed.
- Parking brake applied (CAN message from body control module).

EXHAUST AFTERTREATMENT

High Exhaust System Temperature Lamp (HEST) - The (HEST) lamp is illuminated by the ECM when the exhaust gas temperatures monitored by EGT3 exceed 850 °F and vehicle speed is below 5 mph.

Aftertreatment Regeneration Status Lamp (DPFR) - The ECM illuminates the aftertreatment regeneration status lamp when DPF restriction reaches set points based on the input from the DPF differential pressure sensor (DPF Delta P). This indicates the need for DPF regeneration based on the following levels:

- Level 1- Low soot load. The DPFR status lamp is illuminated.
- Level 2- Moderate soot load. The DPFR status lamp is flashing.
- Level 3- Full soot load. The DPFR status lamp is flashing and CEL is illuminated.
- Level 4- Over-full soot load. The DPFR status lamp is flashing and the SEL is illuminated.

Aftertreatment Fuel Injector (AFI) - Fuel transfer pressure is supplied to the pulse width modulated (PWM) aftertreatment fuel injector from a shutoff valve located on the secondary fuel filter outlet. The ECM injects diesel fuel into the exhaust gas, upstream of the diesel oxidation catalyst (DOC), to raise the temperature. When DOC inlet temperature is 600 °F, the ECM begins operating the AFI and the duty cycle is varied until the exhaust temperature increases to the desired level for regeneration.

Aftertreatment Fuel Shutoff Valve (AFS) - The AFS controls the fuel flow to the supply valve on the secondary fuel filter housing when commanded by the ECM. After startup and during the first minute of engine operation, the ECM performs a self-test on the system by opening the AFS to pressurize the aftertreatment fuel system. The AFD is then opened to relieve the fuel pressure while the ECM monitors the AFP sensor readings. The ECM will disable active and stationary regeneration until the next key cycle if a problem is detected.

Aftertreatment Fuel Drain Valve (AFD) - The AFD valve is used to maintain and relieve the fuel pressure in the aftertreatment fuel system. The ECM commands the AFD to open and allow fuel to flow into the fuel return line.

Aftertreatment Regeneration System Operation - The aftertreatment diesel particulate filter accumulates soot and ash during engine operation. Soot is oxidized and removed during regeneration. Ash accumulates in the DPF over the service life of the unit. The DPF needs to be disassembled and the ash is removed by a special cleaning process.

Regeneration is passive or active based on engine operating conditions, DPF restriction level, and driver's response requirement. The ECM will not enable active or stationary regeneration if the DPF restriction is at Level 4.

Passive regeneration occurs when the exhaust temperatures are high enough through normal engine operation. This typically happens when the vehicle is driven at highway speeds and/or under heavy loads.

Active regeneration occurs when the exhaust temperatures are not high enough to oxidize the soot collected in the DPF. This will occur more frequently in vehicles with low speed and low load duty cycles. The ECM will inject diesel fuel into the exhaust gas before the inlet of the diesel oxidation catalyst (DOC) to raise the temperature for regeneration. The ECM will enable and disable active regeneration as needed. The speed threshold for active regeneration to take place is 25 mph and it will stop when the vehicle speed drops below it. The exhaust temperature during active regeneration can reach up to 1,500 °F.

Stationary (Parked) regeneration is needed when conditions are not reached during vehicle operation. This is a form of active regeneration initiated by the operator using the DPF Regeneration Switch when the vehicle is not moving. The vehicle must be parked with the transmission in NEUTRAL and the parking brake set. There can be no input from the accelerator, brake, and clutch pedals. The ECM controls the regeneration process that can last up to 1 ½ hours depending on the amount of DPF restriction.

DATA LINK COMMUNICATIONS

The SAE J1939 data link bus (controller area network - CAN) allows the ECM to communicate with other vehicle control systems such as transmission, automatic traction control, antilock brake, and body controllers. The J1939 data link is an unshielded twisted pair (UTP). The ECM will broadcast public data link messages when the key switch is in the ON position and stops when the key switch is OFF. The ECM will also broadcast private data link messages to drive actuators using J1939 protocol during engine operation and diagnostic programming. The Society of Automotive Engineers (SAE) recommends a maximum backbone harness of 131 feet (40 meters) in length. The harness is terminated at each end with a 120 ohm resistor. Up to 30 different devices can be attached to the J1939 backbone harness at one time. Each device is connected to the backbone harness with a 3 pin stub connector and can be a maximum of 3.3 feet (1 meter) in length.

Any of the following conditions will cause the data communications bus to fail and result in the storage of network DTCs: either data line shorted to power, to ground, or to the other data line.
The data bus will remain operational when one of the two modules containing a terminating resistor is not connected to the network. The data bus will fail when both terminating resistors are not connected to the network. Data communication failures do not prevent the ECM from providing fuel management.

The Diagnostic Tool communicates with the ECM through the 9 pin ATA connector using J1708 protocols over the J1939 and/or J1587 data links. This allows for diagnostic information retrieval and parameter calibration setting. The 9 pin ATA type data link connector is located in the cab.

DIAGNOSTIC TROUBLE CODES (DTC)

Trouble codes can be active or inactive. Active codes indicate that the problem currently exists and inactive codes indicate that a problem once existed. Flash codes represent digits assigned to diagnostic trouble codes, so that DTCs can be retrieved through the warning lamps when the diagnostic switch is activated. Active codes are indicated by the red stop engine lamp (SEL). Inactive codes are indicated by the yellow check engine lamp (CEL). When using the diagnostic tool, DTCs are formatted under SAE J1939 standards and descriptions.

DIAGNOSTIC EQUIPMENT

A breakout tool can be connected into a circuit to measure voltage signals and resistance values with a digital multimeter (DMM). A diagnostic tool can be connected to the data link connector to read engine data, diagnostic codes, and set programmable parameters. ECM software updates (re-flash) can be performed using a PC based diagnostic tool.

The Displayed Data chart shows how diagnostic tool data will be presented in some Composite Vehicle test questions. The chart includes how the status of components (switches and lamps) or operational modes will be indicated. The minimum – maximum measurement range and values for engine data (voltages, temperatures, pressures, and speeds) is also shown.

(Please refer to the chart that follows.)

Displayed Data

Displayed Data	Value Range	Displayed Data	Value Range
Aftertreatment Diesel Oxidation Catalyst Inlet Temperature	0 - 2000ºF	Engine Coolant Level	Low/Normal
Aftertreatment Diesel Oxidation Catalyst Inlet Temperature Sensor Signal Voltage	0.0 – 5.0V	Engine Coolant Temperature	-40º - 260ºF
Aftertreatment Diesel Particulate Filter Differential Pressure	0 – 30 inHg	Engine Coolant Temperature Sensor Signal Voltage	0.0 – 5.0V
Aftertreatment Diesel Particulate Filter Differential Pressure Sensor Signal Voltage	0.0 – 5.0V	Engine Oil Pressure	0 – 125 psi
Aftertreatment Diesel Particulate Filter Inlet Temperature	0 – 2000ºF	Engine Oil Pressure Sensor Signal Voltage	0.0 – 5.0V
Aftertreatment Diesel Particulate Filter Inlet Temperature Sensor Signal Voltage	0.0 – 5.0V	Engine Oil Temperature	-40º - 260ºF
Aftertreatment Diesel Particulate Filter Lamp Status	On/Off	Engine Oil Temperature Sensor Signal Voltage	0.0 – 5.0V
Aftertreatment Diesel Particulate Filter Outlet Temperature	0 – 2000ºF	Engine Protection Shutdown	On/Off
Aftertreatment Diesel Particulate Filter Outlet Temperature Sensor Signal Voltage	0.0 – 5.0V	Engine Speed	0 – 3000 rpm
Aftertreatment Diesel Particulate Filter Regeneration Start Switch Status	On/Off	Exhaust Back Pressure	0 – 125 InHg
Aftertreatment Fuel Pressure	0 – 200 psi	Exhaust Back Pressure Sensor Signal Voltage	0.0 – 5.0V
Aftertreatment Fuel Pressure Sensor Signal Voltage	0.0 – 5.0V	Fuel Temperature	-40º - 260ºF
Aftertreatment High Exhaust System Temperature Lamp Status	On/Off	Fuel Temperature Sensor Signal Voltage	0.0 – 5.0V
Accelerator Pedal Position	0 – 100%	Inlet Air Temperature	-40º - 260ºF
Amber/Yellow Check Engine Lamp Status (CEL)	On/Off	Inlet Air Temperature Sensor Signal Voltage	0.0 – 5.0V
Air Conditioning High Pressure Switch	On/Off	Intake Manifold Air Temperature	-40º - 260ºF
Battery Voltage	0 – 18 V	Intake Manifold Air Temperature Sensor Signal Voltage	0.0 – 5.0V
Barometric Air Pressure	0 – 30 inHg	Intake Manifold Pressure (Gauge)	0 – 60 psi
Barometric Air Pressure Sensor Signal Voltage	0.0 – 5.0V	Intake Manifold Pressure Sensor Signal Voltage	0.0 – 5.0V
Clutch Pedal Switch	Released/ Depressed	Fan Control Switch	On/Off
CMP/Engine Position 1 Signal	Yes/No	Key (Ignition) Switch	On/Off
CKP/Engine Position 2 Signal	Yes/No	Outside (Ambient) Air Temperature	-40º - 260ºF
Crankcase Pressure	0 – 40 inH20	PTO On/Off Switch	On/Off
Crankcase Pressure Sensor Signal Voltage	0.0 – 5.0V	PTO Status	Active/Inactive
Cruise Control On/Off Switch	On/Off	Red Stop Engine Lamp Status (SEL)	On/Off
Cruise Control Set/Resume Switch	Set/Neutral/Resume	Remote PTO Switch	On/Off
Diagnostic Switch	On/Off	Sensor Supply 1	0.0 – 5.5V
ECM Time (Key On Time)	HH:MM:SS	Sensor Supply 2	0.0 – 5.5V
EGR Differential Pressure	0 – 30 inHg	Sensor Supply 3	0.0 – 5.5V
EGR Differential Pressure Sensor Signal Voltage	0.0 – 5.0V	Service Brake Pedal Switch	Released/ Depressed
EGR Temperature	0º - 1000ºF	Synchronization State	Yes/No
EGR Temperature Sensor Signal Voltage	0.0 – 5.0V	Turbocharger Actuator Position Commanded (Percent Closed)	0 - 100%
EGR Valve Position Measured (Percent Open)	0 – 100%	Turbocharger Actuator Position Measured (Percent Closed)	0 - 100%
EGR Valve Position Sensor Signal Voltage	0.0 – 5.0V	Turbocharger Actuator Position Commanded (Percent Closed)	0 - 100%
Engine Brake On/Off Switch	On/Off	Turbocharger Speed	0 – 200,000 rpm
Engine Brake Selector Switch	Low/Med/High	Vehicle Speed	0-127 mph

PROGRAMMABLE PARAMETERS

Programmable parameters are the specifications that can be set within the ECM to control operating functions. The parameters are stored in non-volatile memory. A customer password is available for programming protection. A list of parameter ranges and their settings are shown below.

Feature	Range	Setting	Feature	Range	Setting
Road Speed Governor			PTO/Remote PTO		
Accelerator Max. Road Speed	30-120 mph	65 mph	Max PTO Speed	600-2500 rpm	1000 rpm
Accelerator Upper Droop	0-3 mph	0 mph	Min PTO Speed	600-2500 rpm	700 rpm
Accelerator Lower Droop	0-3 mph	1 mph	Set PTO Speed	600-2500 rpm	900 rpm
Global Max. Road Speed	0-120 mph	120 mph	Resume PTO Speed	600-2500 rpm	1000 rpm
Gear Down Protection (GDP)			Remote PTO Speed	600-2500 rpm	1000 rpm
GDP Light Load Vehicle Speed	30-1000 mph	54 mph	Max. Engine Load	0-1850 ft.lb.	800 ft.lb.
GDP Heavy Load Vehicle Speed	30-1000 mph	60 mph	Max. Vehicle Speed	0-30 mph	0 mph
Idle Speed Control			Ramp Rate	100-2500 rpm/sec	250 rpm/sec
Idle Engine Speed	600-850 rpm	700 rpm	Aftertreatment		
Idle Shutdown			Stationary Regeneration in PTO	Enabled/Disabled	Enabled
Idle Shutdown Timer	1-100 min.	5.0 min.	Automatic Stationary Regeneration	Enabled/Disabled	Enabled
Idle Shutdown Lower Ambient Air Temp.	0-100ºF	40ºF	Mobile/Active Regeneration	Enabled/Disabled	Enabled
Idle Shutdown Upper Ambient Air Temperature Override	0-100ºF	5.0 min.	Automatic Stationary Regeneration	Enabled/Disabled	Enabled
Idle Shutdown Percent PTO Load Override	0-100%	100%	Diesel Particulate Filter Lamp	Enabled/Disabled	Enabled
Idle Shutdown	Enabled/Disabled	Enabled	Diesel Particulate Filter Regeneration Permit Switch	Enabled/Disabled	Enabled
Idle Shutdown Manual Override	Enabled/Disabled	Enabled	Diesel Particulate Filter Regeneration Start Switch	Enabled/Disabled	Enabled
Fan Control			High Exhaust System Temperature Lamp	Enabled/Disabled	Enabled
Minimum Fan On Time	0-1000 sec.	240 sec.	Vehicle Setup Parameters		
Fan Control Solenoid Logic		0 Volts ON	Rear Axle Ratio	2-15.98	4.1
Fan On During Engine Braking	Enabled/Disabled	Enabled	Tire Size	301-700 rev/mile	501
Fan Vehicle Speed Interaction	Enabled/Disabled	Enabled	No. of Tailshaft Gear Teeth	1-64	16
Fan Control A/C Press Switch	Enabled/Disabled	Enabled	Vehicle Speed Sensor Type		Magnetic
Fan Control Switch	Enabled/Disabled	Enabled	Max. Engine Speed w/out VSS	1400-3000 rpm	1800 rpm
Cruise Control/Engine Brakes			Max. Engine Speed with VSS	1400-3000 rpm	2100 rpm
Max. Cruise Control Speed	30-102 mph	65 mph	Trans. Top Gear Ratio	0.1-2	1.00
Cruise Control Upper Droop	0-3 mph	0 mph	Trans. One Gear Down Ratio	0.1-16	1.34
Cruise Control Lower Droop	0-3 mph	2 mph	Transmission Type		Manual
Cruise Control Speed Delta for Max. Engine Brake	0-6 mph	5 mph	Multiplexing Ambient Air Temperature Sensor		J1939
Cruise Control Speed Delta for Min. Engine Brake	0-102 mph	3 mph	Ambient Air Temperature Source Address	0-255	51
Cruise Control Feature	Enabled/Disabled	Enabled	Multiplexing Parking Brake Switch		J1939
Engine Brake Cruise Control Activation	Enabled/Disabled	Enabled	Parking Brake Source Address	0-255	49
Engine Brake Min. Vehicle Speed	0-35 mph	0 mph	Engine Protection		
Engine Brake Delay	0-10 sec.	0 sec.	Engine Protection Shutdown Feature	Warning/Derate/ Shutdown	Shutdown
Engine Brake Service Brake Activation	Enabled/Disabled	Enabled	Engine Protect Restart Inhibit	Enabled/Disabled	Enabled
Engine Brake Control	Enabled/Disabled	Enabled	Manual Override	Enabled/Disabled	Enabled

ENGINE OPERATING SPECIFICATIONS

Fuel Supply Pressure
Cranking: 20 psi. min.
Rated rpm: 90-100 psi.

Intake Manifold Pressure
Rated rpm: 30-45 psi.

Engine Oil Pressure
Idle: 15-35 psi. min.
Rated rpm: 50-70 psi.

ELECTRICAL SPECIFICATIONS

J1587 Data Link
Positive Wire to chassis ground:
2.5 to 5.0 VDC
Negative Wire to chassis ground:
0.0 to 2.5 VDC

J1939 Data Link
Positive wire to negative wire
50 to 70 ohms
Terminal Resistance
110 to 130 ohms

ECM
9.0 to 16.0 VDC supply voltage
Maximum voltage drop on all
circuits (except injectors): 0.5 VDC

ECM 5V-Reference Sensor Supply Groups

Circuit Group	ECM Pin Numbers
Sensor Supply 1	13, 23, 66, 204
Sensor Supply 2	459, 210
Sensor Supply 3	72, 75

5 V Reference Power Supply
At ECM: 4.75 to 5.25 VDC
At Harness: 4.75 to 5.25 VDC

All Shorts to External Voltage
OK: if less than 1.5 VDC

All Shorts to Ground
OK: If greater than 100K ohms
(No short circuit)

All Continuity Checks
OK: if less than 10 ohms
(No open circuit)

Fuel Injectors
0.5 to 5.0 ohms resistance
100 to 120 VDC supply voltage

SENSOR SPECIFICATIONS

Vehicle Speed Sensor
Coil Resistance: 1100 to 1500 ohms

All Temperature Sensors
Resistance: 600 to 1600 ohms

Intake Manifold Pressure Sensor

Pressure psig	inHg.	Voltage VDC
atmospheric	atmospheric	0.50
12.5	25.45	1.50
25.0	50.90	2.50
37.5	76.35	3.50
50.0	101.80	4.50

Barometric Pressure Sensor

Pressure inHg.	Altitude feet	Voltage VDC
29.9	0 (sea level)	4.00 - 4.50
26.8	3000	3.50 - 4.30
24.0	6000	3.10 - 3.90
21.4	9000	2.90 - 3.70
19.1	12000	2.50 - 3.30

Engine Oil Pressure Sensor

Pressure kPa	Pressure psi	Voltage VDC
0	0	0.50
172	25	1.50
345	50	2.50
517	75	3.50
689	100	4.50

All Temperature Sensors (except exhaust aftertreatment and EGR)

Temperature °C	Temperature °F	Voltage VDC
120	248	0.50
82	180	0.75
54	130	1.50
32	90	2.50
0	32	3.60
-40	-40	4.50

Aftertreatment Fuel Pressure Sensor

Pressure kPa	Pressure psi	Voltage VDC
0	0	0.50
345	50	1.50
689	100	2.50
1034	150	3.50
1379	200	4.40

Coolant Level Sensor

Coolant present: CL Normal signal = 5 VDC, CL Low signal near 0 VDC
Coolant NOT present: CL Low signal = 5 VDC, CL Normal signal near 0 VDC

Accelerator Pedal Position Sensor

Potentiometer Resistance:
Between supply and return wires:
2000 to 3000 ohms.
Between supply and signal wires:
Released pedal -
1500 to 3000 ohms
Depressed pedal -
250 to 1500 ohms.

Accelerator Pedal Position Sensor

Accelerator Pedal Position % depressed	APP 2 Sensor Voltage	APP 1 Sensor Voltage
0	0.50	1.50
5	0.65	1.65
10	0.80	1.80
15	0.95	1.95
20	1.10	2.10
25	1.25	2.25
40	1.70	2.70
50	2.00	3.00
60	2.30	3.30
75	2.75	3.75
80	2.90	3.90
100	3.50	4.50

EGR Position Sensor

EGR Valve (% Open)	Sensor Voltage
0	0.50
25	1.50
50	2.50
75	3.50
100	4.50

All Sensor Signal Voltages

Out of Range Low = Less than 0.20 VDC
Normal Range = 0.5 – 4.5 VDC
Out of Range High = Greater than 4.80 VDC

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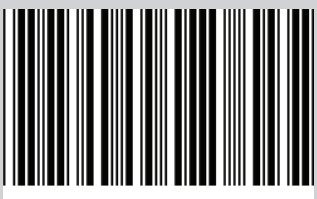
Prometric Inventory Code:



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