1500
1700
2000

Series

Perkins 1500/1700/2000 Series

ElectropaK Models

ELECTRONIC APPLICATION & INSTALLATION MANUAL

1506A/C-E88TAG1-5
1706A-E93TAG1-2
1706D-E93TAG1-2
2206A/C/D-E13TAG2-6
2506A/C/D-E15TAG1-4
2806A/C E-18TAG1-3
2806A-E18TTAG4-7 2806C-E18TTAG6-7

Six cylinder diesel engines for Electric power applications

Contact Applications Engineering at Perkins Engines Company Limited for regulatory compliance information.
Note: Information in this manual is preliminary and is subject to change or withdrawal.

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Perkins Engines Company Limited
Peterborough, PE1 5FQ, United Kingdom
Tel: +44 (0)1733 583000
Fax: +44 (0)1733 582240
www.perkins.com

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Contents

1.0 Introduction and Purpose

This document is intended to provide the necessary information for correct installation of the Perkins 1500/1700/2000 series engines for use in LRC (Less Regulated Countries). The table below shows the Build List Prefix for these engines.

Sales Model	Build List Prefix
1506A/C-E88TAG1	LGAF
1506A/C-E88TAG2	LGBF
1506A/C/D-E88TAG3	LGDF
1506A/D-E88TAG4	LGEF
1506A/D-E88TAG5	LGFF
1706A-E93TAG1	YGAF
1706A-E93TAG2	YGBF
1706D-E93TAG1	YGCF
1706D-E93TAG2	YGDF
2206A/C/D-E13TAG2	TGBF
2206A/C/D-E13TAG3	TGDF
2206A-E13TAG5	TGFF
2206A-E13TAG6	TGHF
2206F-E13TAG2	TGKF
2506A/C/D-E15TAG1	MGAF
2506A/C/D-E15TAG2	MGBF
2506A/C-E15TAG3	MGDF
2506A/C-E15TAG4	MGEF
2806A/C/D-E18TAG1A	JGAF
2806A-E18TAG2	JGBF / JGYF
2806A/C-E18TAG3	JGDF / JGZF
2806F-E18TAG1	JGKF
2806A-E18TTAG4	JGEF
2806A-E18TTAG5	JGFF
2806A-E18TTAG6	JGHF
2806A-E18TTAG7	JGJF
2806C-E18TTAG6	JGLF
2806C-E18TTAG7	JGMF

The main purpose is to provide information to enable the original equipment manufacturer (OEM) to do the following:

1. To supply an appropriate application harness and components to interface with the engine harness.
2. To select and apply control protection, display and diagnostics software feature that are appropriate to the application.
3. To develop a successful data strategy for communication with the engine control unit (ECM)

Note: 1500/2000 Engines covered by this publication have an A4 ECM. 1700 Engines covered by publication have an A6E2 ECM. The Power Density 2806 E18TTAG engines have an updated version ECM. Pinouts have changed. Refer to Appendix for ECM pinouts.

Important Notice:

Note: *The information in this document is subject to change as engine feature requirements are revised and software continues to be developed.*

The OEM who integrates the engine into an application is responsible for ensuring that the end user is provided with sufficient information to ensure safety.

1.1 Important Safety Information

Most accidents that involve product operation, maintenance, and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills, and tools to perform these functions properly.

The information in this publication was based upon current information at the time of publication. Check for the most current information before you start any job. Perkins dealers will have the most current information.

Improper operation, maintenance, or repair of this product may be dangerous. Improper operation, maintenance, or repair of this product may result in injury or death.

Do not operate or perform any maintenance or repair on this product until you have read and understood the operation, maintenance, and repair information.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product, are not all inclusive. If a tool, a procedure, a work method, or an operating technique that is not specifically recommended by Perkins is used, you must be sure that it is safe for you and for other people. You must also be sure that the product will not be damaged. You must also be sure that the product will not be made unsafe by the procedures that are used.

WARNING

Before beginning any work, be sure to read and adhere to the engine and equipment operation and maintenance manuals' safety information and safe work practices.

Failure to follow applicable warnings can result in a risk of personal injury or death.

1.1.1 Welding

NOTICE

Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, the bearings, hydraulic components, electrical components, and other components.

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Welding on a Machine with an Electronic Engine:

Before welding on a vehicle equipped with an electronic engine, the following precautions should be observed.

- **Turn the engine OFF.**
- **Place the ignition key switch in the OFF position.**
- **Disconnect the negative battery cable from the battery. If the vehicle is equipped with a battery disconnect switch, open the switch.**
- **DO NOT use electrical components in order to ground the welder. Do not use the ECM or sensors or any other electronic component in order to ground the welder.**

For more information, refer to Appendix 8 of this document. Appendix 8 provides all relevant engine model Operation and Maintenance Manual and Troubleshooting Guide media numbers. Further information about welding on a machine with an electronic engine is found in these documents.

1.2 Replacement Parts

When replacement parts are required for this product, Perkins recommends using Perkins replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength, and material.

Note: All Perkins part numbers at the time of release have not been assigned with equivalent Perkins part numbers.

WARNING

When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to follow this warning may lead to premature failures, product damage, personal injury or death

1.3 Terminology

API – American Petroleum Institute

ARB – Air Resources Board

ARD – Auxiliary Regeneration Device

ATAAC – Air-to-Air Aftercooled (type of CAC)

CAC – Charge Air Cooled

CAN – Control Area Network

CCV – Closed Crankcase Ventilation

CCW – Counterclockwise

CDV – Coolant Diverter Valve

CEM – Clean Emissions Module

CW – Clockwise

DCU – Dosing Control Unit

DEF – Diesel Exhaust Fluid

DOC – Diesel Oxidation Catalyst

dP – Delta Pressure

DPF – Diesel Particulate Filter

ECM – Engine Control Module

EPA – Environmental Protection Agency

EU – European Union

FLRS – Full Load Rated Speed

GPM – Gallons Per Minute

HCMU – Hydrocarbon Metering Unit

HEST – High Exhaust System Temperature

HRC – Highly Regulated Country

HRS – High Speed Regen

ID – Inside Diameter

IPU – Industrial Power Unit

ISO – International Standards Organization

ITV – Inlet Throttle Valve

JW – Jacket Water (Engine)

kPa – Kilo Pascals (SI Unit Pressure)

LPM – Liters Per Minute

LPS – Large Power System (1706 – 2806 <750 hp)

LRC – Less Regulated Country

NRS – Nox Reduction System

OCV – Open Crankcase Ventilation

OD – Outside Diameter

OEM – Original Equipment Manufacturer

$P_1 \ldots P_2$ – Pressure Test Points

PEMS – Portable Emissions Measuring System

Perkins EST – Perkins Electronic Technician

Perkins RS – Perkins Regeneration System

PETU – Pump Electronic Tank Unit

PMS – Programmable Monitoring System

psi – Pounds per Square Inch (Non-SI Unit of Pressure)

PTO – Power Take Off

PTU – Pump Tank Unit

ROA – Rise Over Ambient

rpm – Revolutions Per Minute

SAE – Society of Automotive Engineering

SCAC – Separate Circuit Aftercooled

SCR – Selective Catalyst Reduction

SEA – Sensing Element Assembly (NOx Sensor)

STOR – Straight Thread O-Ring

$T_1 \ldots T_7$ – Temperature Test Points

TEL – Top Engine Limit

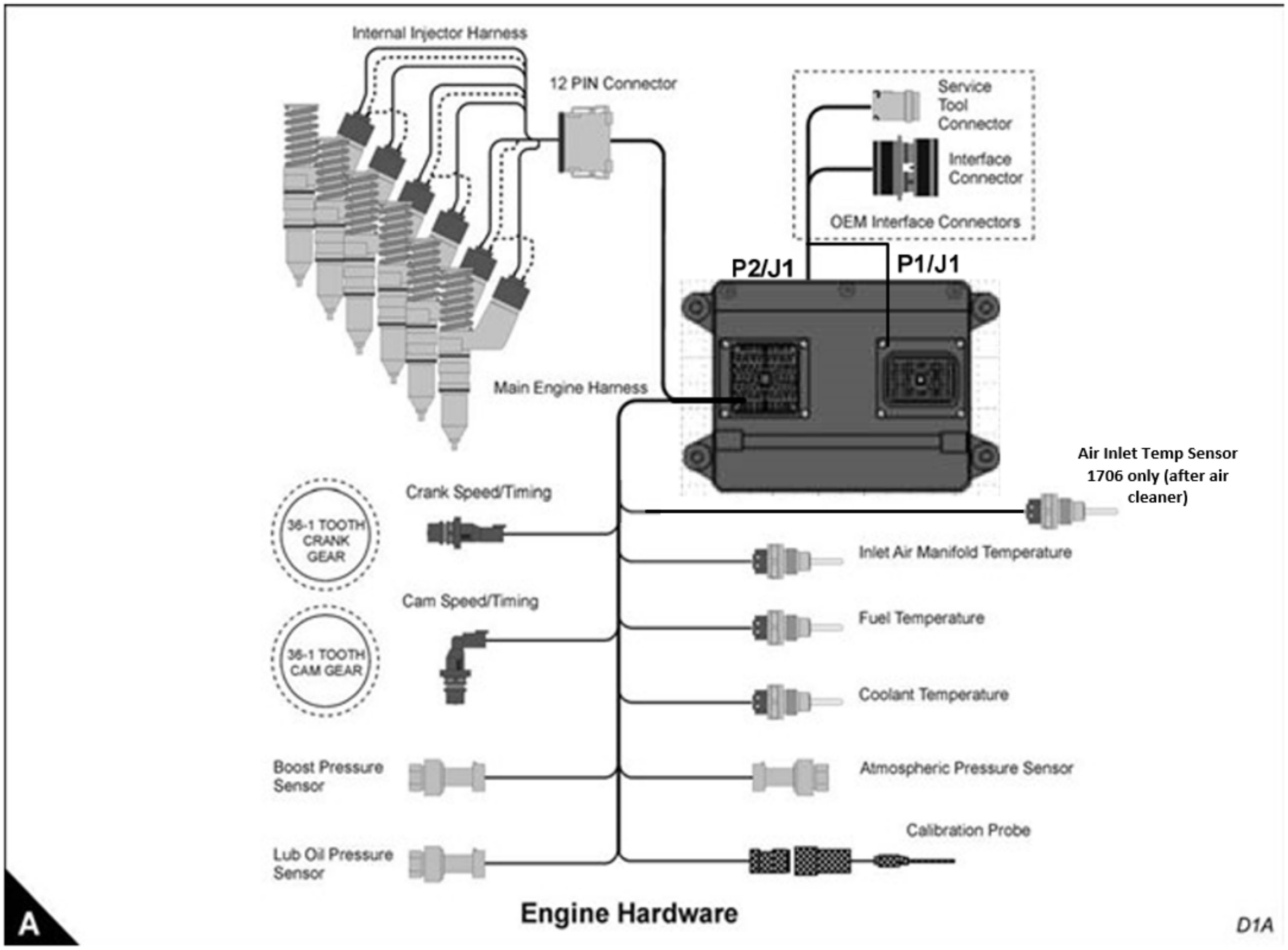
TVA – Torsional Vibration Analysis

UHT – Under Hood Thermal

USLD – Ultra Low Sulfur Diesel

2.0 Engine System Overview

All engines covered in this document are designed for electronic control. The electronic engine control system consists of the following primary components: Electronic Control Unit (ECM), electronically controlled unit injectors, engine wiring harness, and sensors. The following sections will provide information to better understand the function of the components in the engine control system and basic understanding of electronic engine control.



The electronic engine control strategy determines the timing and amount of fuel that is delivered to each cylinder based on the actual and desired conditions at any given time. The objective of the control system is to deliver best performance within emission and engine operating limits. Following are the primary functions performed by the electronic engine control strategy:

2.1.1 Engine Governing

The engine ECM determines how much fuel to deliver to each cylinder to respond to changes in operator demand or engine load conditions. The ECM uses the 'Desired Speed' input (if fitted) or the pre-programmed desired speed and compares this to the actual engine speed determined from the engine speed/timing sensors. Fueling is then controlled as necessary to keep engine speed constant.

2.1.2 Air to Fuel Ratio Control

The control system has full authority over engine fuel delivery. The mechanical fuel/air ratio control is eliminated on an electronically controlled engine. Electronic control of the fuel/air ratio provides optimum performance while limiting emissions.

2.1.3 Injection Timing Control

Injection timing is varied as a function of engine operating conditions to optimize engine performance for emissions, noise, fuel consumption, and application performance.

2.1.4 Cold Starting Strategy

Before and during cranking, the engine monitors atmospheric pressure, air inlet temperature, and/or coolant temperature. Based on these inputs, the engine executes a complex cold starting strategy that adjusts fuel volume, timing, and starting aids to start the engine. Refer to the Operation and Maintenance Manual and the Troubleshooting Guide for the engine for more information.

2.1.5 Cold Mode Operation

Cold mode operation is activated based on the coolant temperature. The engine power is limited, and the low idle speed may be elevated when in cold mode. Refer to the Operation and Maintenance Manual and the Troubleshooting Guide for the engine for more information.

2.1.6 Engine Protection and Monitoring

The engine control system uses the engine sensors to monitor engine operating conditions. Operation outside of customer or factory configured normal operating conditions will cause the engine to employ , derate, or shutdown strategies as defined in the engine protection and monitoring strategy. If any of these conditions occurs, an event is logged in the engine ECM. Refer to Engine Monitoring and Protection (section 11) for more information.

2.2 Factory Configuration Parameters

Factory configuration parameters are ECM software settings that affect the emissions, power, and identification of the engine. These parameters are programmed at the factory during engine assembly and test. Emissions control agencies require that the factory setting for these parameters is stamped on the engine information plate and any changes to these settings require that the engine plate be updated along with the change to the ECM setting. The factory configuration parameters must be reprogrammed if the ECM is replaced and/or the engine rating is changed. These parameters do not need to be reprogrammed if the ECM is re-flashed with a latest version of software flash file. Refer to the Factory Configured Parameters section of this document for more information on definition and configuration of each factory-set parameter.

Factory configuration parameters supported:

- Engine Serial Number
- Rating Number
- Full Load Setting (FLS)
- Full Torque Setting (FTS)

Notes on Programming Parameters:

1. Changing parameters protected by factory passwords may void Perkins warranty. Consult Dealer support network contacts before changing these settings.
2. For the programmed values to change, the key switch (switched power only) must be cycled off and on.
3. If there is an interlock error (personality module mismatch), then the programmed parameters will not change. It may appear that the parameters are changed, but they will not change until the “personality module mismatch” code is cleared.

2.3 Engine Component Overview

1506 – 2806 ElectropaK			
Factory Wiring	**1506**	**1706**	**2206, 2506, 2806**
Fuel injector: HEUI injector	x		
Fuel injector: MEUI injector			x
Fuel injector: Common rail		x	
High efficiency pump	x		
High pressure fuel pump		x	
Speed/timing sensor (cam)	2x	x	x
Speed/timing sensor (crank)		x	x
Fuel temperature sensor	x	x	x
Injection actuation pressure sensor	x		
Atmospheric pressure sensor	x	x	x
Boost (intake manifold air) pressure sensor	x	x	x
Intake air temperature sensor	x	x	x
Coolant temperature sensor	x	x	x
Fuel pressure sensor	x	x	X(1)
Oil pressure sensor	x	x	x
Air Inlet Temperature Sensor (after cleaner)		x	2806 PD

(1) There is no fuel pressure sensor on legacy series engine, but the fuel pressure sensor has been added to the 2806 PD.

2.3.1 Engine Control Unit (ECM)

The ECM is generally located on the left rear side of the engine. The ECM has two connectors, one for the Perkins engine harness and the other for the customer harness.

2.3.1.1 Engine Connector (120-pin/86-pin connector, J2/P2)

Engine system and control information is transmitted between the 120-pin connector (86-pin on 1700 series) on the engine ECM and the engine components through the engine harness. The engine harness provides the interface to the following engine components:

- Engine Sensors
- Fuel Injection System

2.3.1.2 Customer Connector

Customer control and display information is transmitted between the 70-pin connector J1/P1(1500/2000 series models) or 40-pin connector CH/C2 (1700 series models) on the engine ECM and the customer-installed components through the customer harness. The customer harness provides the interface to the following components:

- Battery
- Data Links
- Customer Components

2.3.2 Software Flash File

If the ECM is correlated to a computer, then the personality module (also known as “flash file”) is the software for the computer. The term flash file is derived by the method in which the software is programmed into the ECM — a technology known as flash programming. The flash file contains the operating maps that define the performance and operating characteristics of the engine as well as the ElectropaK application feature support. Once flashed, the ECM contains the following information to identify the flash file and supported ratings:

- Personality Module PN
- Software Group Release Date
- Rated Power
- Rated Peak Torque
- Top Engine Speed Range
- Test Spec

The information above can be viewed in the Configuration Parameter screen within the Perkins EST service tool.

2.3.3 Fuel Injector

2.3.3.1 Electronic Unit Injection

The engine Electronic Unit Injector fuel system controls the quantity, pressure, and timing of the fuel injected. Both positive and negative wires to each solenoid are wired directly back to the ECM. Higher voltages and sharp pulses of relatively high current are used to control the injectors. Injector cables are twisted pairs to minimize emissions of electromagnetic noise. There is no OEM connection to the injectors; however, the OEM should ensure that any systems that are sensitive to electromagnetic radiation are not in proximity to the harness that leads to the injectors.

2.3.4 High Efficiency Pump (1506, HEUI Only)

The unit injector hydraulic pump is a variable delivery piston pump. The unit injector hydraulic pump supplies a portion of the engine lubrication oil to the HEUI injectors. The high efficiency of the pump combined with the resistance to flow at the unit injectors pressurizes the oil delivered by the pump.

2.3.5 Injection Actuation Pressure Sensor (1506, HEUI Only)

The IAP sensor is installed in the high-pressure oil manifold. The high-pressure oil manifold supplies actuation oil in order to power the unit injectors. The IAP sensor monitors injection actuation pressure.

2.3.6 Fuel Pressure Sensor

Prior to exiting the fuel filter base, the fuel pressure is sampled by the fuel pressure sensor. The signals that are generated by the sensor are used by the engine control to monitor the condition of the engine’s injectors. This information is used to adjust the fuel delivery of the engine in order to optimize efficiency and to protect the injectors.

2.3.7 Dual Speed Timing Sensors

The engine speed/timing sensors are used to determine both engine speed and fuel injection timing. The 1506 sensors are both triggered by a target wheel on the camshaft. On the 1706 through 2806, the camshaft position sensor detects information from a target wheel on the camshaft and the crankshaft position sensor detects this information from a target wheel on the crankshaft. Under normal operating conditions the engine monitors one of the position sensors while cranking (camshaft) and one of the position sensors (crankshaft) while running. The design provides for optimized start capability as well as redundancy. Should a failure occur in either of the sensor circuits, the engine can be started and will run with only one sensor.

2.3.8 Fuel Temperature Sensor

Fuel temperature is measured at the fuel filter base. Fuel is sampled prior to fuel exiting the fuel filter base. Fuel temperature is monitored to adjust fuel rate calculations as part of a fuel temperature power compensation strategy to maintain constant power when fuel temperature exceeds 30°C/86°F. Refer to the Fuel Temperature (section 11.1.5) in the Engine Monitoring and Protection section for more information on fuel temperature compensation.

2.3.9 Atmospheric Pressure Sensor

The atmospheric pressure sensor is an absolute pressure sensor measuring crankcase pressure. Both the boost pressure and oil pressure communicated to service tools and over the data link are calculated by subtracting the atmospheric pressure sensor reading. The atmospheric pressure sensor can measure pressures from 0 kPa (0 psi) to 116 kPa (16.8 psi). The engine implements altitude compensation (derate) strategies based partially on input from this sensor.

2.3.10 Intake Manifold Pressure (Boost) Sensor

The boost pressure sensor is an absolute pressure sensor measuring intake manifold air pressure. Boost pressure as displayed by service tools and communicated over the data link is the value obtained by subtracting the atmospheric pressure (as measured by the atmospheric pressure sensor) from the absolute value measured by the boost pressure sensor.

2.3.11 Intake Manifold Air Temperature Sensor

Intake manifold air temperature is used to determine temperature of the air intake to the engine. This sensor output is used in controlling the inlet air heater and for engine monitoring.

2.3.12 Coolant Temperature Sensor

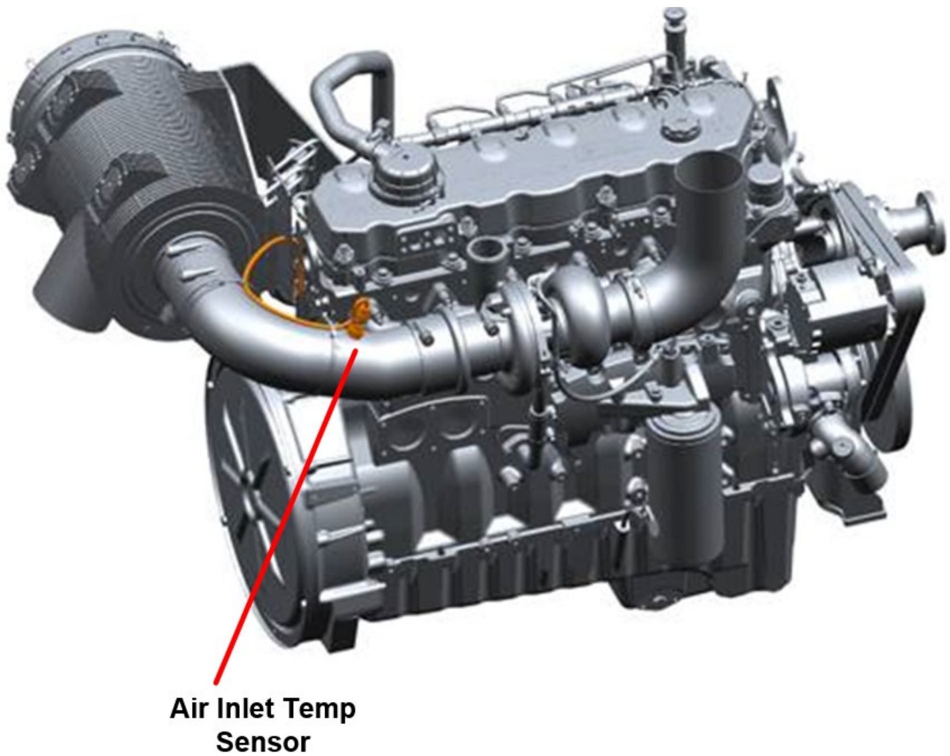
Coolant temperature sensor is used to determine temperature of the coolant leaving the engine. This sensor output is used in cold start strategies and for engine monitoring.

2.3.13 Air Inlet Temperature Sensor (1706 & 2806 PD)

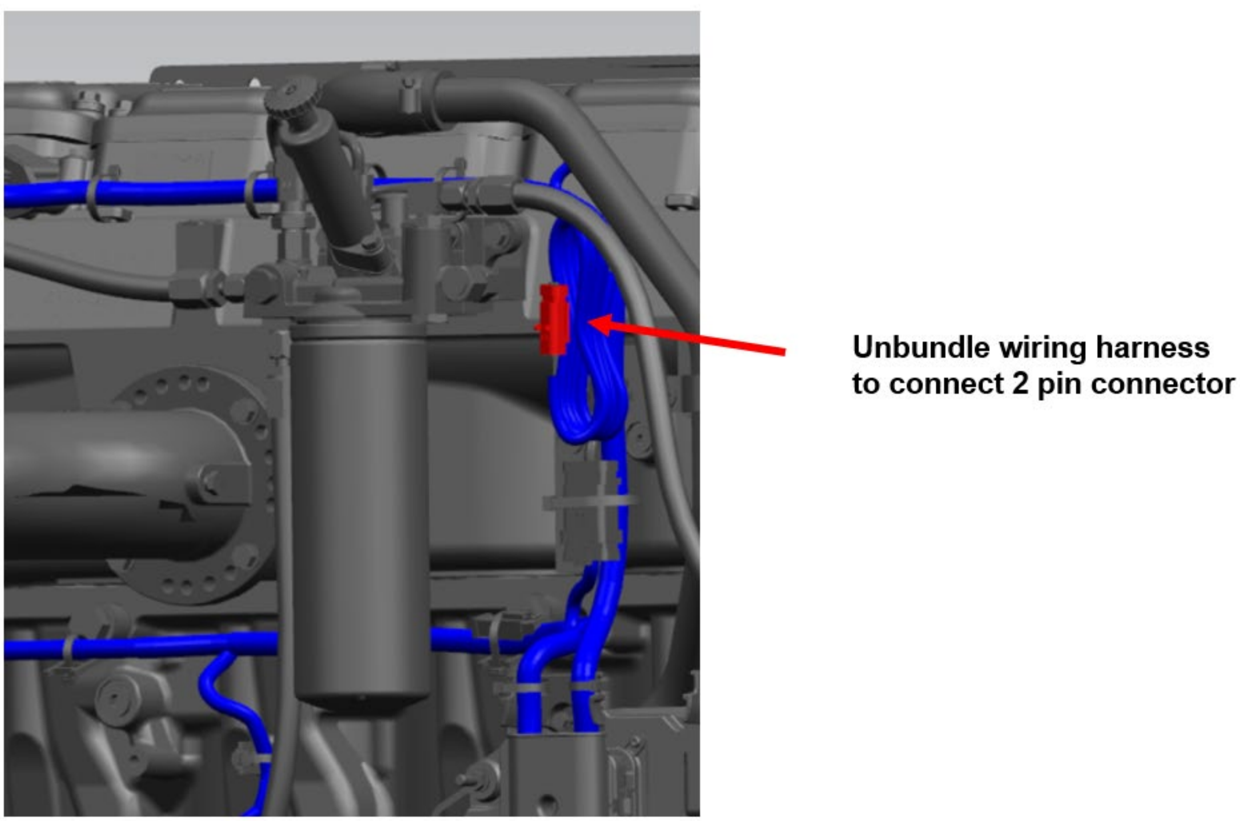
Air inlet temperature sensor is a required sensor used to determine temperature the air inlet temperature after the air cleaner. The air inlet temperature sensor is a passive sensor and will be installed from the factory. On the 1706, the wiring harness is connected to sensor. On 2806 PD engines, the harness connector will have to be mated to the sensor (see Section 2.3.13.2 for installation details).

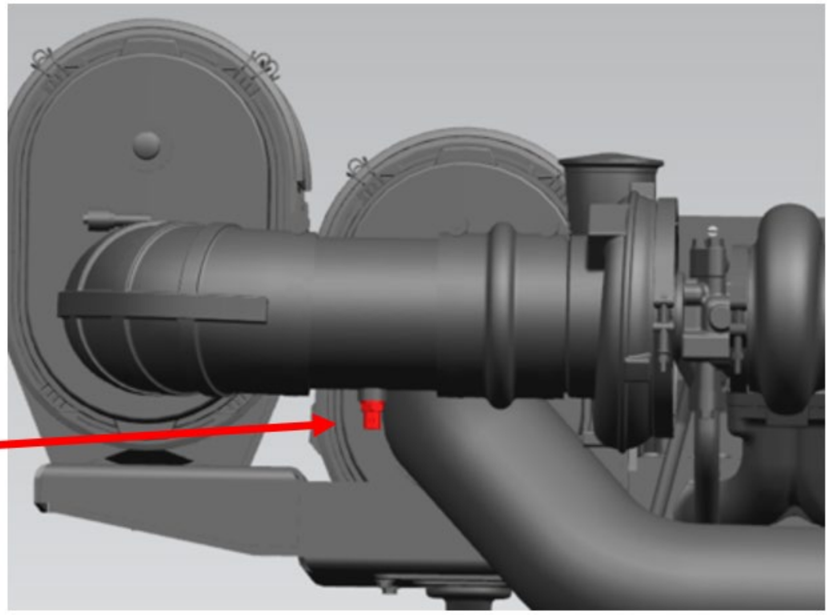
NOTE: No configuration is required for the sensor.

2.3.13.1 Location of 1706 Air Inlet Temperature Sensor



2.3.13.2 Location/Install Wiring Harness to 2806 PD Air Inlet Temperature Sensor

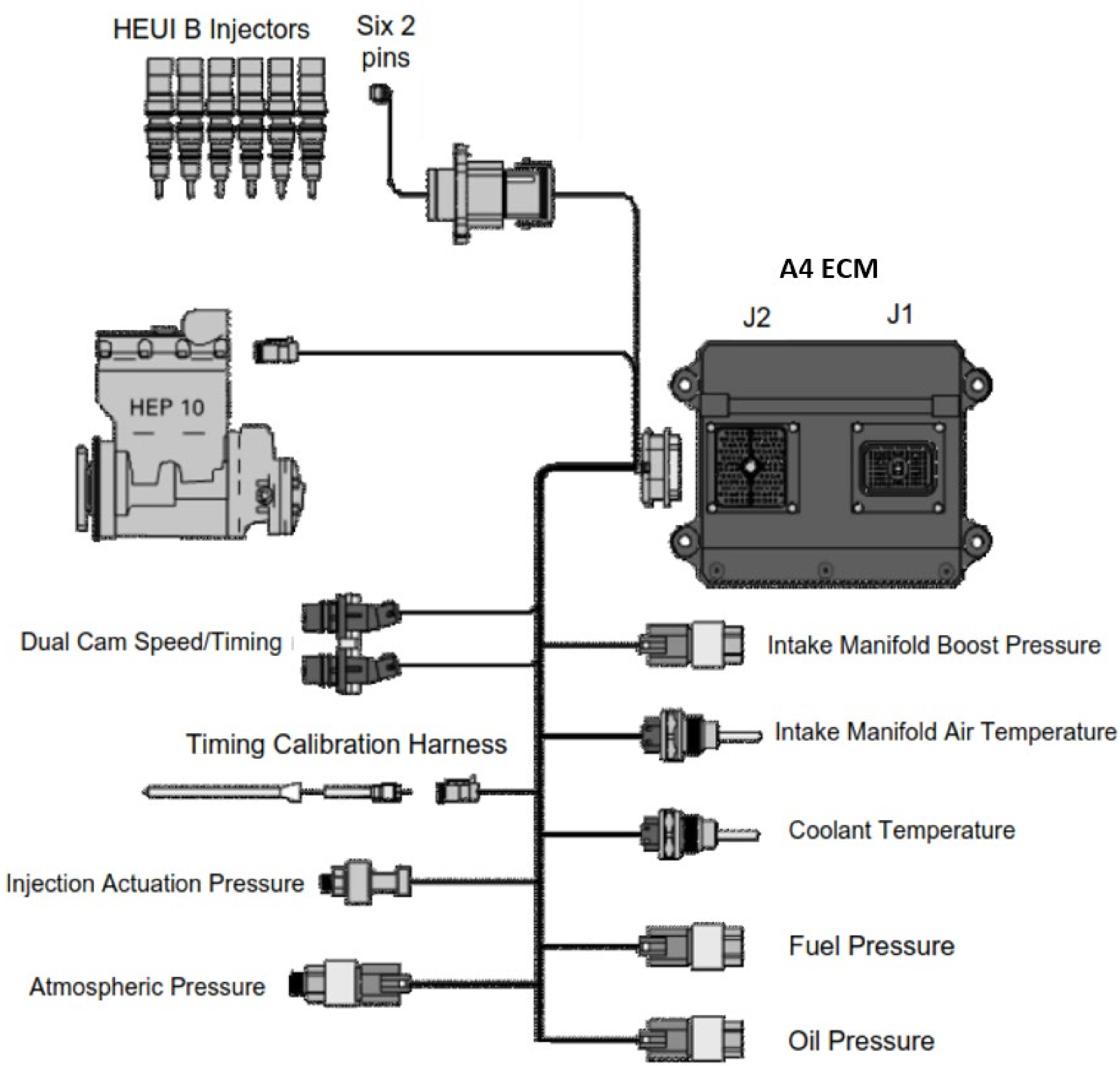




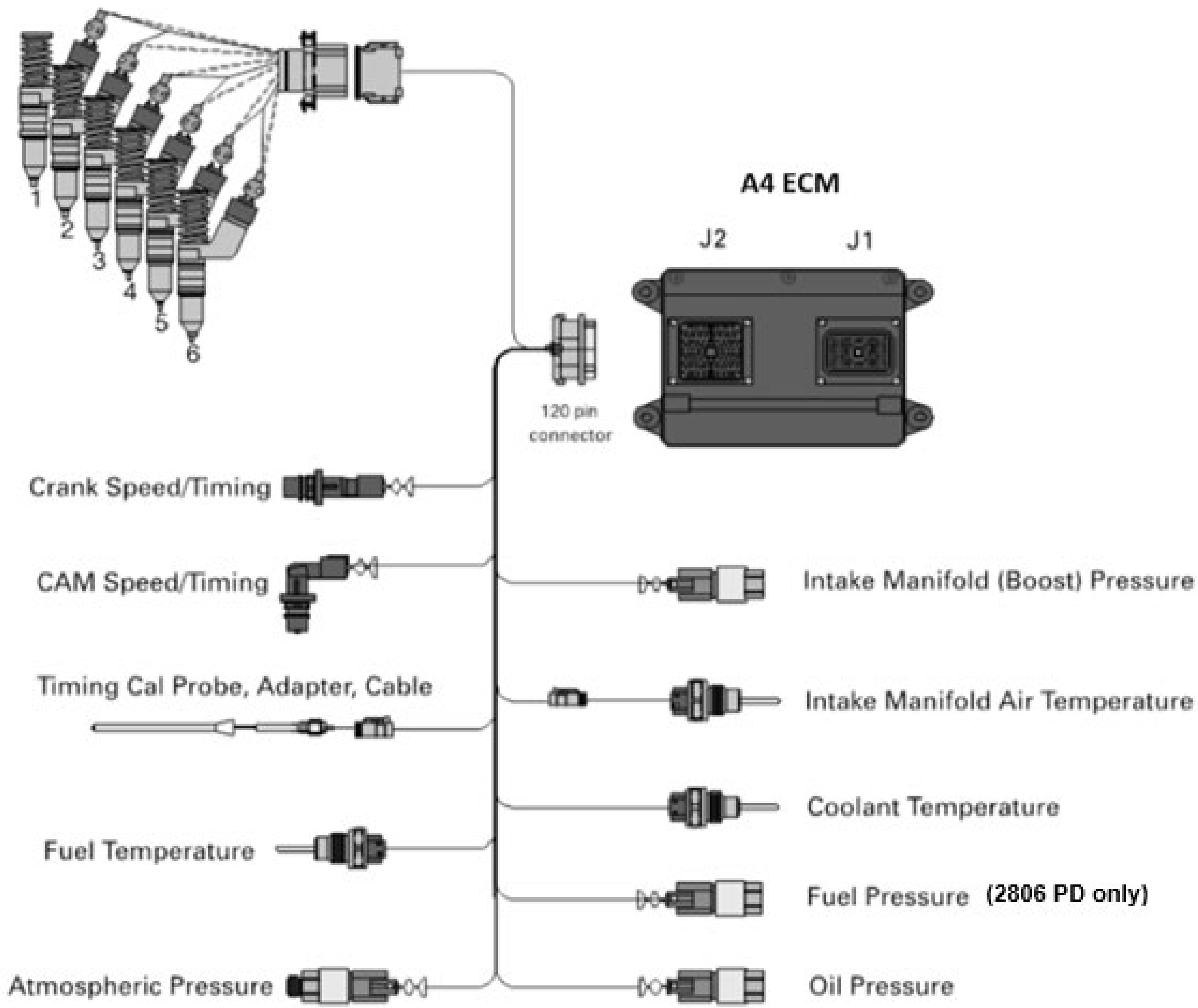
Air Inlet Temperature Sensor

2.4 Engine System Diagrams

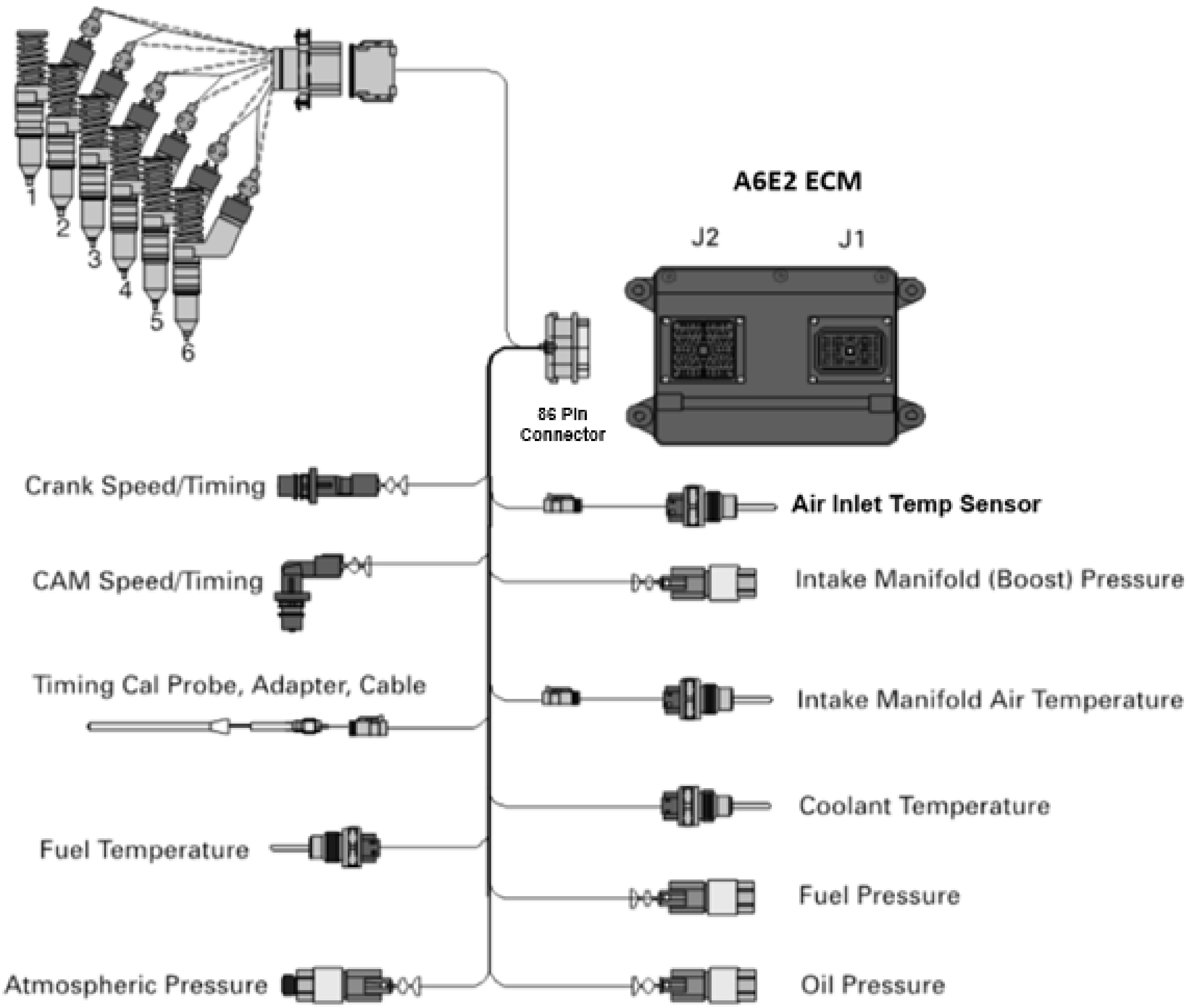
2.4.1 1506 Factory Installed Wiring and Components



2.4.2 2206 - 2806 Factory Installed Wiring and Components



2.4.3 1706 Factory Installed Wiring and Components



3.0 Customer System Overview

3.1 Customer Configuration Parameters

Customer configuration parameters are ECM software settings that the customer can change in order to suit the needs of the specific application. These parameters are changed within the configuration screen in Perkins Electronic Service Tool (EST). If a customer has more than one engine that should have the same configuration, the Fleet Configuration option is available in Perkins EST to save the configuration settings to a file and download the settings to all subsequent engines that are to have the same configuration settings.

Default values for these parameters are set in the factory when the new ECM is flash programmed for the first time. The customer configuration parameters must be reprogrammed if the ECM is replaced and/or the engine rating is changed. These parameters do not need to be reprogrammed if the ECM is re-flashed with a latest version of software flash file.

Refer to the Appendix sections for customer configuration parameters and monitoring system parameters for a complete list of supported programmable parameters. Further definition of each parameter can be found within the section of the document that defines a software feature that uses the parameter to support installation or operation of that specific software feature.

Customer configuration parameters in legacy product that are no longer supported:

- Direct Fuel Control Mode
- Engine Power Trim

Notes on Programming Parameters

1. Changing parameters protected by factory passwords may void Perkins warranty. Consult ElectropaK Application Support Center contacts before changing.
2. For the programmed values to change, the key switch (switched power only) must be cycled off and on.
3. If there is an interlock error (personality module mismatch), then the programmed parameters will not change. It may appear that the parameters are changed, but they will not change until the “personality module mismatch” code is cleared.

3.2 Customer Component Overview

ElectropaK engines offer a set of application features that can be specified by the customer to meet the application operating requirements. Application of these features requires a different set of customer-installed components based on the features selected. Each installation requires the minimum set of customer-installed components listed in Table 1. Customer installed components for application specific features are listed in Table 2. See the section identified with each component for more information on component usage and requirements.

Table 1: Required Customer Installed Components

Required Components	Section
Battery	Power and Grounding Considerations
Battery Disconnect Switch	Power and Grounding Considerations
Key Switch	Power and Grounding Considerations
Warning Lamp	Engine Monitoring and Protection
Shutdown Lamp	Engine Monitoring and Protection
Speed Demand Input [1]	Engine Speed Demand
Engine Service Tool Connector	Connectors and Wiring Harness Requirements
Customer Interface Connector	Connectors and Wiring Harness
Injection Disable Switch	Customer System Overview 3.2.5

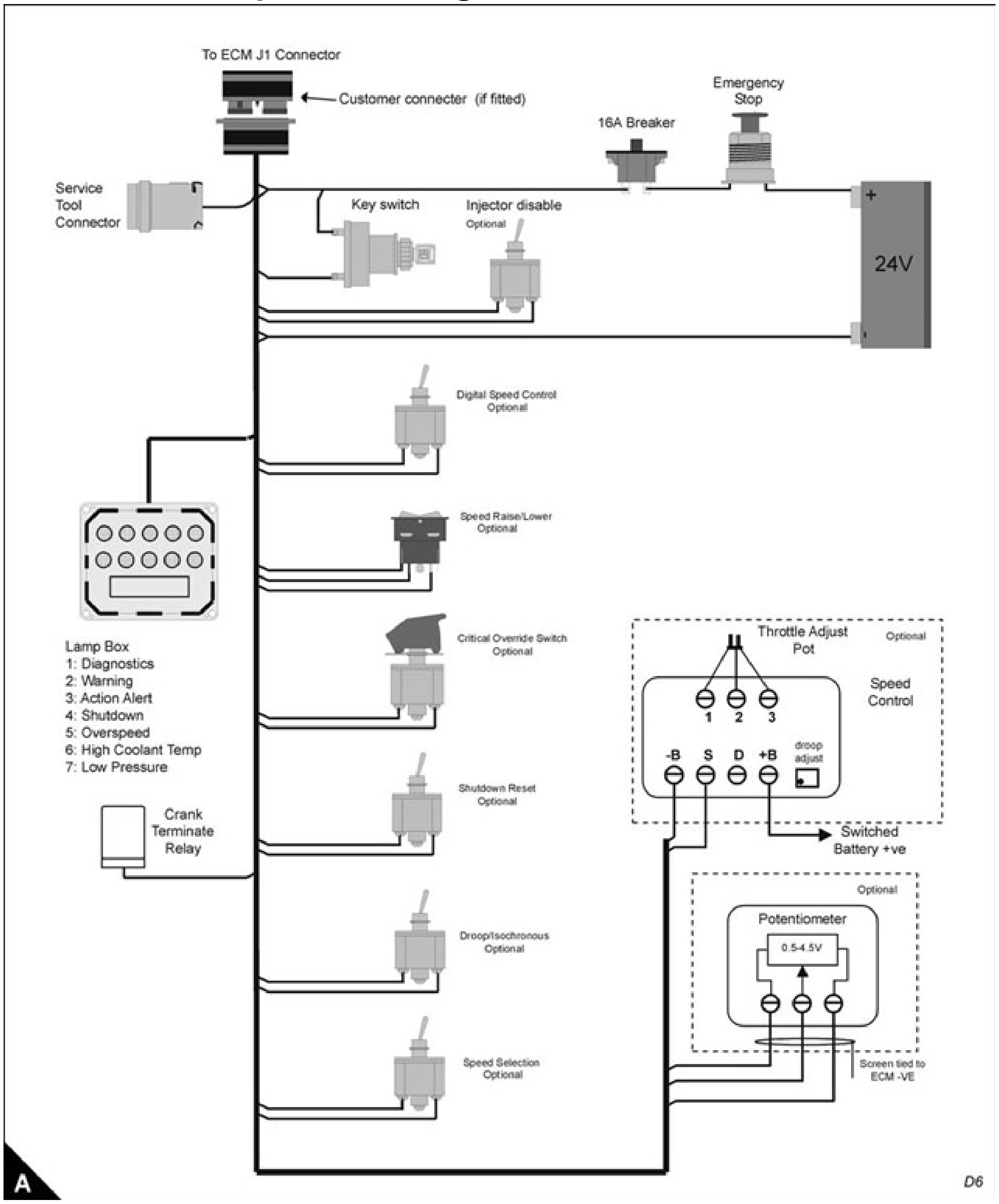
[1] Speed Demand input method selected may require components from the optional component list below.

Table 2: Optional Customer Installed Components[1]

Optional Components	Section
J1939 Data Link	Data Link Support
J1939 Terminating Resistors	Connectors and Wiring Harness Requirements
Digital Speed Control Switch Enable	Customer System Overview 3.2.5
Speed Raise/lower Switch	Customer System Overview 3.2.5
Critical Override Switch	Customer System Overview 3.2.5
Droop/Isochronous Switch	Customer System Overview 3.2.5
1500/1800 RPM Speed Selection Switch	Customer System Overview 3.2.5
PWM Speed Control Input	Customer System Overview 3.2.4
Speed Control Potentiometer (analogue)	Customer System Overview 3.2.4
Fault Resect Switch	Customer System Overview 3.2.5
Coolant Level Switch	Customer System Overview 3.2.5
Coolant Temperature Sensor	Customer System Overview 3.2.5
Oil Pressure Sensor	Customer System Overview 3.2.5
Low Idle Switch	Customer System Overview 3.2.5
Auxiliary Engine Shutdown Switch	Customer System Overview 3.2.5
Overspeed Verify Switch	Customer System Overview 3.2.5
Oil Temperature Sensor	Engine Monitoring and Protection 11.1
Starter Relay	Customer System Overview 3.2.5

[1] Review appropriate section to see what components are applicable to engine model

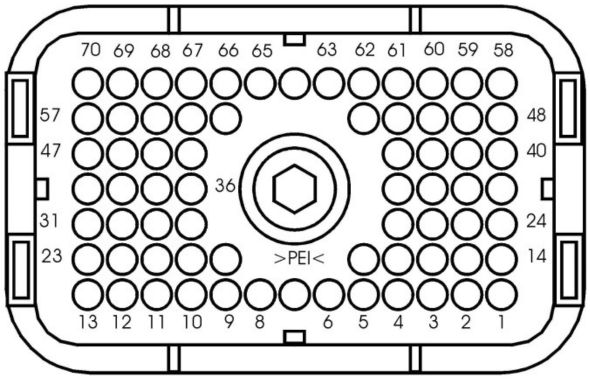
3.2.1 Customer Installed Components Diagram



3.2.1.1 Connector - engines NOT fitted with an application interface connector

The ECM J1 connector is the only connection between the application harness and the engine system.

The diagram (B), which is not to scale, shows the pin positions of the 70 pin AMP connector when viewed from the wire entry side.



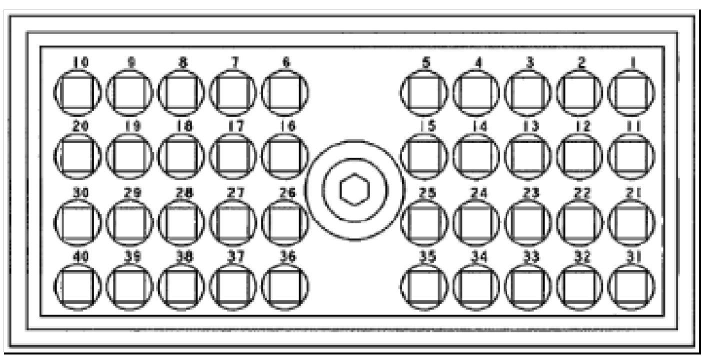
B

Wire side

D7

3.2.1.2 Connector – engines fitted with a customer interface connector

The diagram (C), which is not to scale, shows the pin positions of the 40-pin connector when viewed from the wire entry side.



C

Wire Side

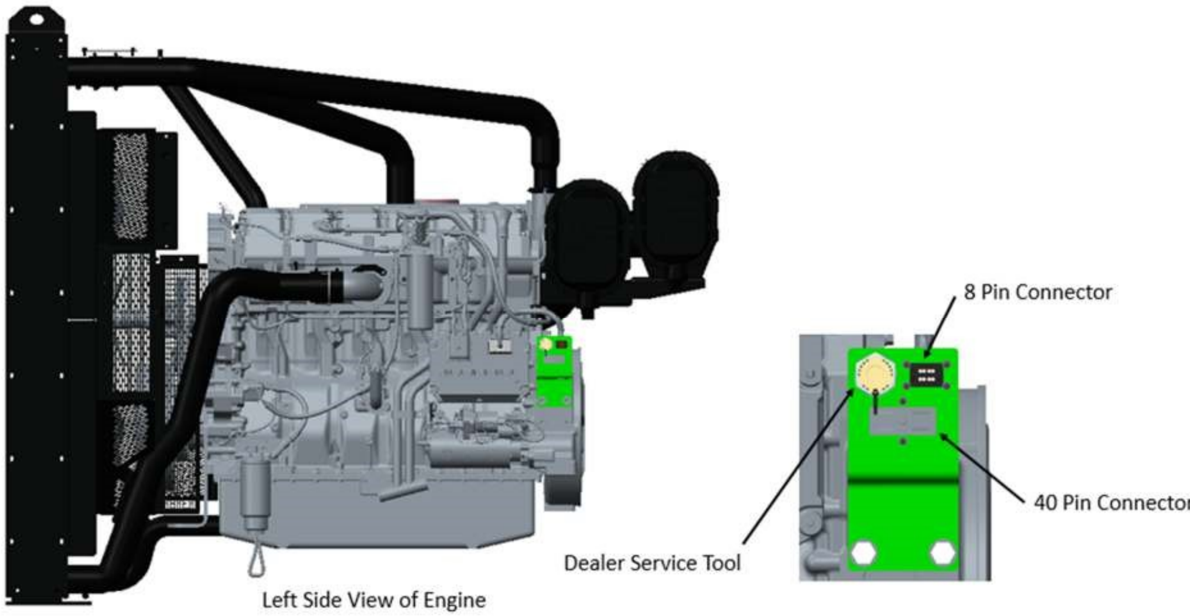
Colour coding for connection diagrams

Key letter	Colour		
N	Brown	W	White
U	Blue	Y	Yellow
R	Red Purple	B	Black
P	Green	O	Orange
G		K	Pink
		A	Grey

Refer to wiring diagram for application connections.

3.2.1.3 Connector Panel – Power Density 2806 E18TTAG4-7 Engines Only

The figure below illustrates the customer interface connectors on the Power Density 2806 engine, 40 pin and 8-pin including the service tool interface. This panel is standard configuration for PD engines consisting of an 8 pin, a 40-pin connector with 9 pin standard service tool connector. Refer to Power Density 2806 E18TTAG4-7 Engines Only connection diagram below for application connections.



8 Pin and 40 Pin Connectors

Refer to Section 3.2.3.2 – “Power Density 2806 E18TTAG4-7 Engines Only” for pinout details.

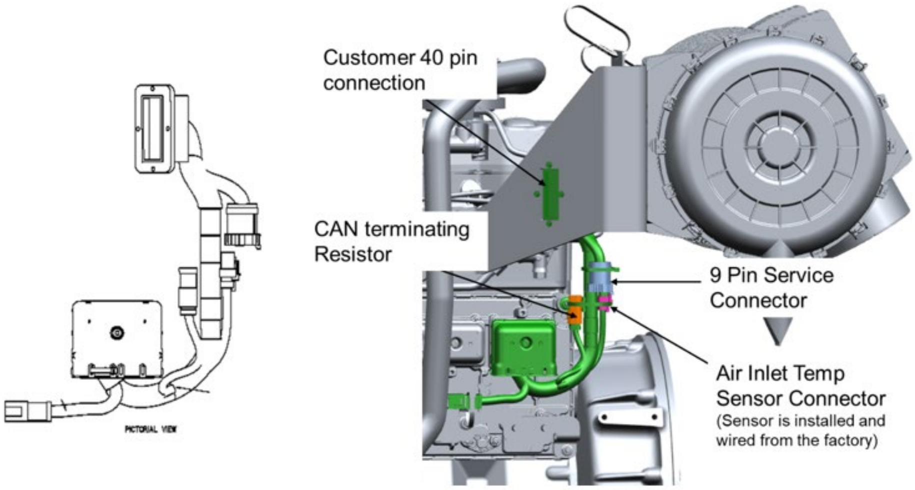
- 8 Pin Mating Connector Part Number is: T431687
- 40 Pin Mating Connector Part Number is: CH11154

Dealer Service Tool Connector

Refer to Section 5.3 – “Customer Supplied Service Tool” for pinout details. Connector part numbers are in Section 5.1.2 – “Deutsch HD-10 Connectors”.

3.2.1.4 Connector Panel – 1706A E93TAG1-2/1706D E93TAG1-2 Engines Only

The figure below illustrates the customer interface connectors on the 1706A/D engines, 40 pin and 9-pin service tool interface. This panel is standard configuration for PD engines consisting of a 40-pin customer connector with 9 pin standard service tool connector.



Refer to Section 3.2.3.3 – "1706A-E93TAG1-2/1706D-E93TAG1-2 Engines Only" for pinout details.

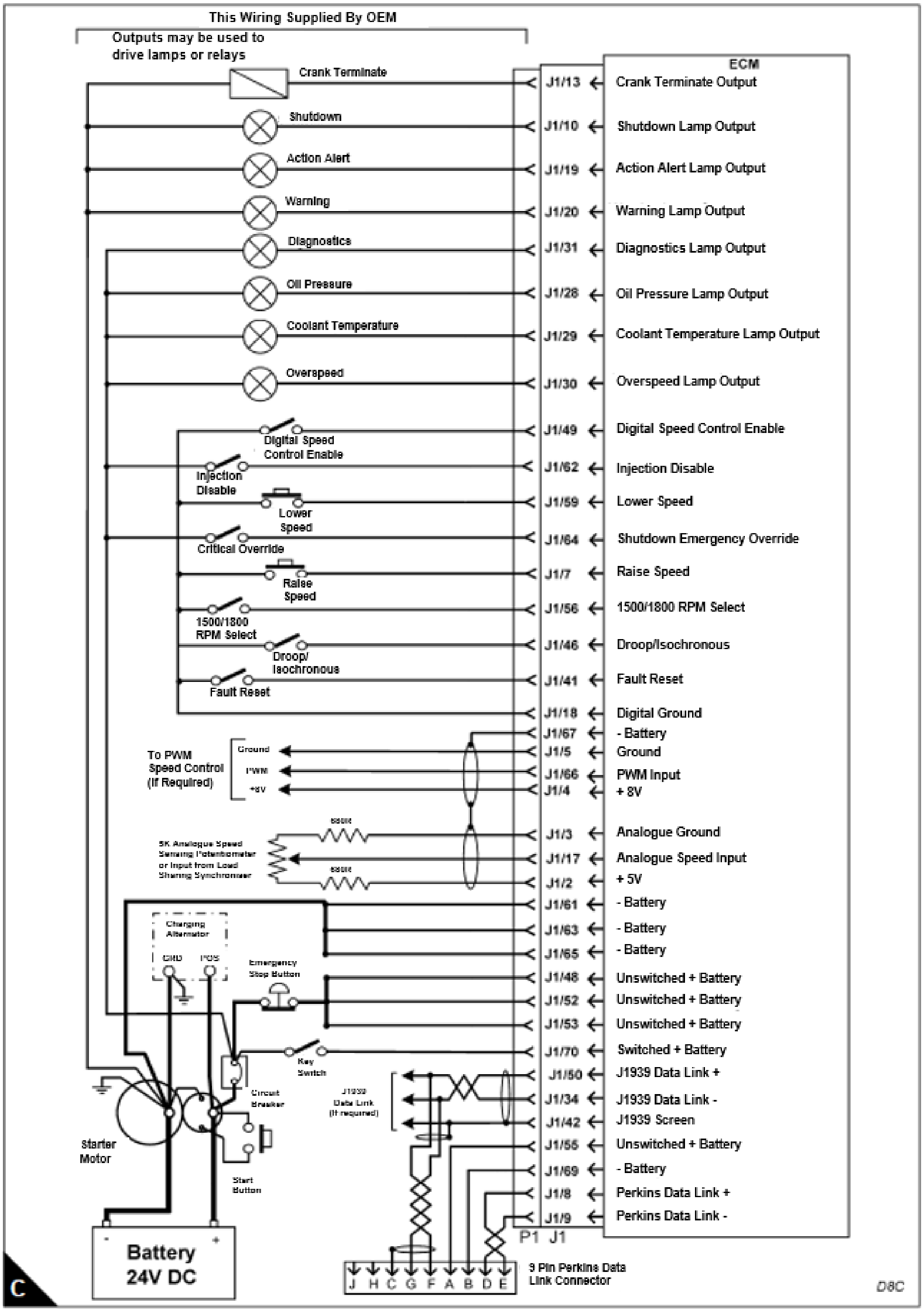
- 40 Pin Mating Connector Part Number is: CH11154

Dealer Service Tool Connector

Refer to Section 5.3 – "Customer Supplied Service Tool" for pinout details. Connector part numbers are in Section 5.1.2 – "Deutsch HD-10 Connectors".

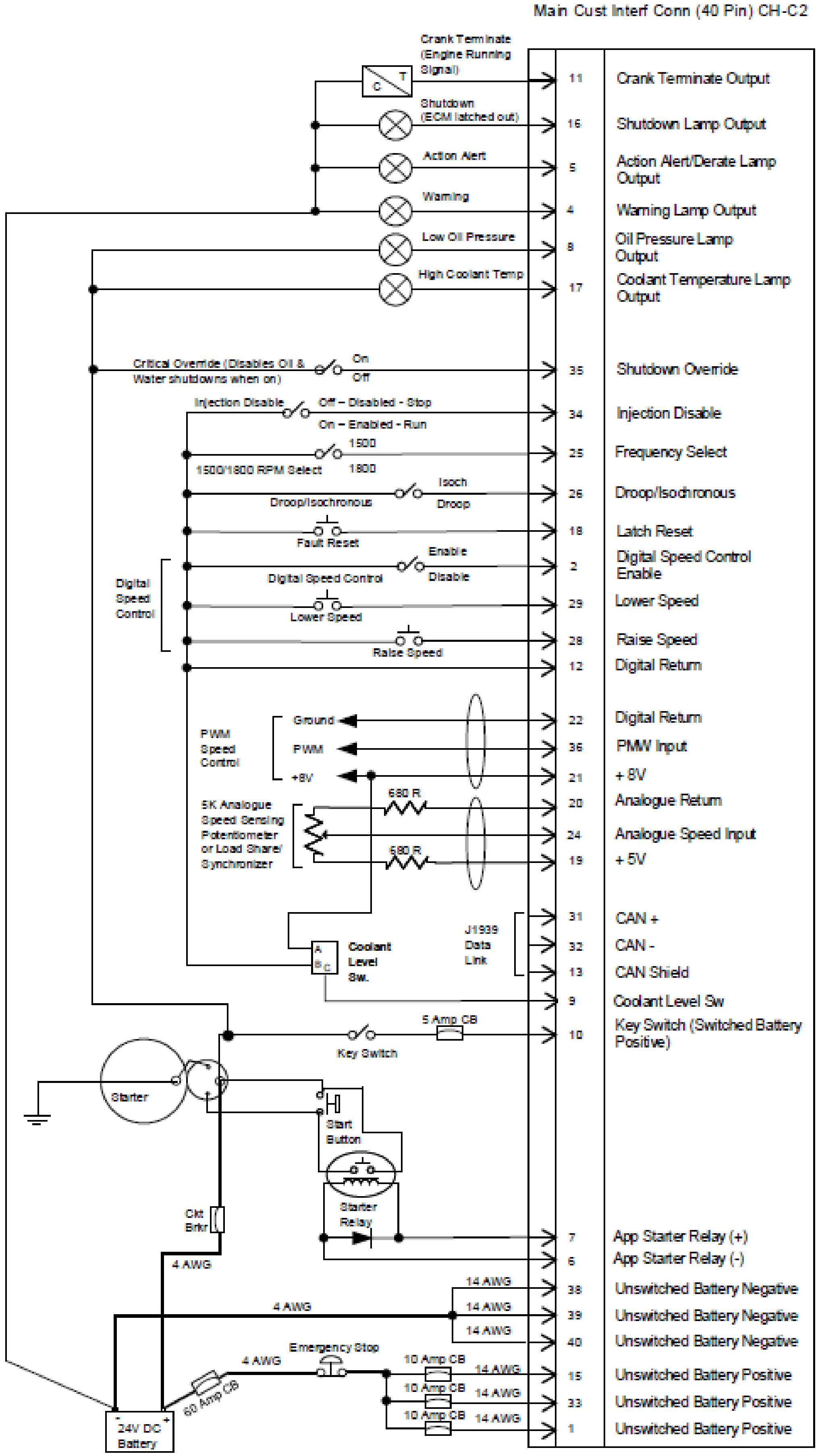
3.2.2 OEM Connection Diagram:

3.2.2.1 1506, 2206-2806 Standard TAG Engines only without Customer Interface Connector. This is not applicable to 1706. Customer must use the 40-pin connector and should not wire into the J1 directly.



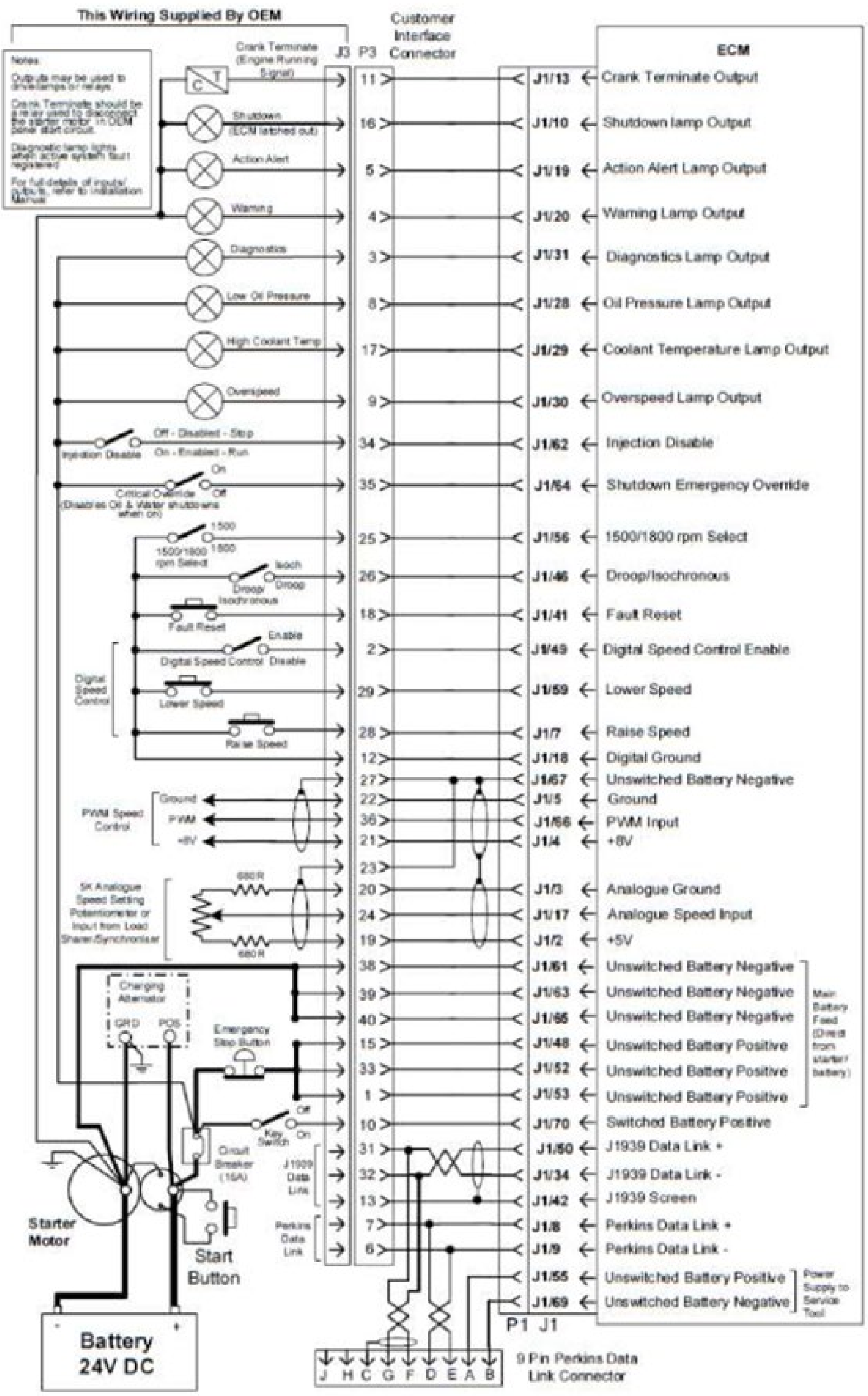
3.2.2.2 1706 EP LRC TAG Engines

Notes:
1. Outputs may by used to drive lamps or relays.
2. Crank Terminate should be a relay used to disconnect the starter motor in OEM panel start circuit.
3. Fuse or circuit breaker 60A must be as close to the battery as possible
4. ECM supply fuse/circuit breaker should be 60A or 3-10A CB as shown.
5. ECM supply must not be sourced from starter motor terminal
6. Install suppression diodes across relay coils and solenoids
7. CAN wires must be shielded twisted pair
8. Refer to the wire type and gauge size section for wire sizing details
9. For full details of inputs/outputs, refer to installation manual.

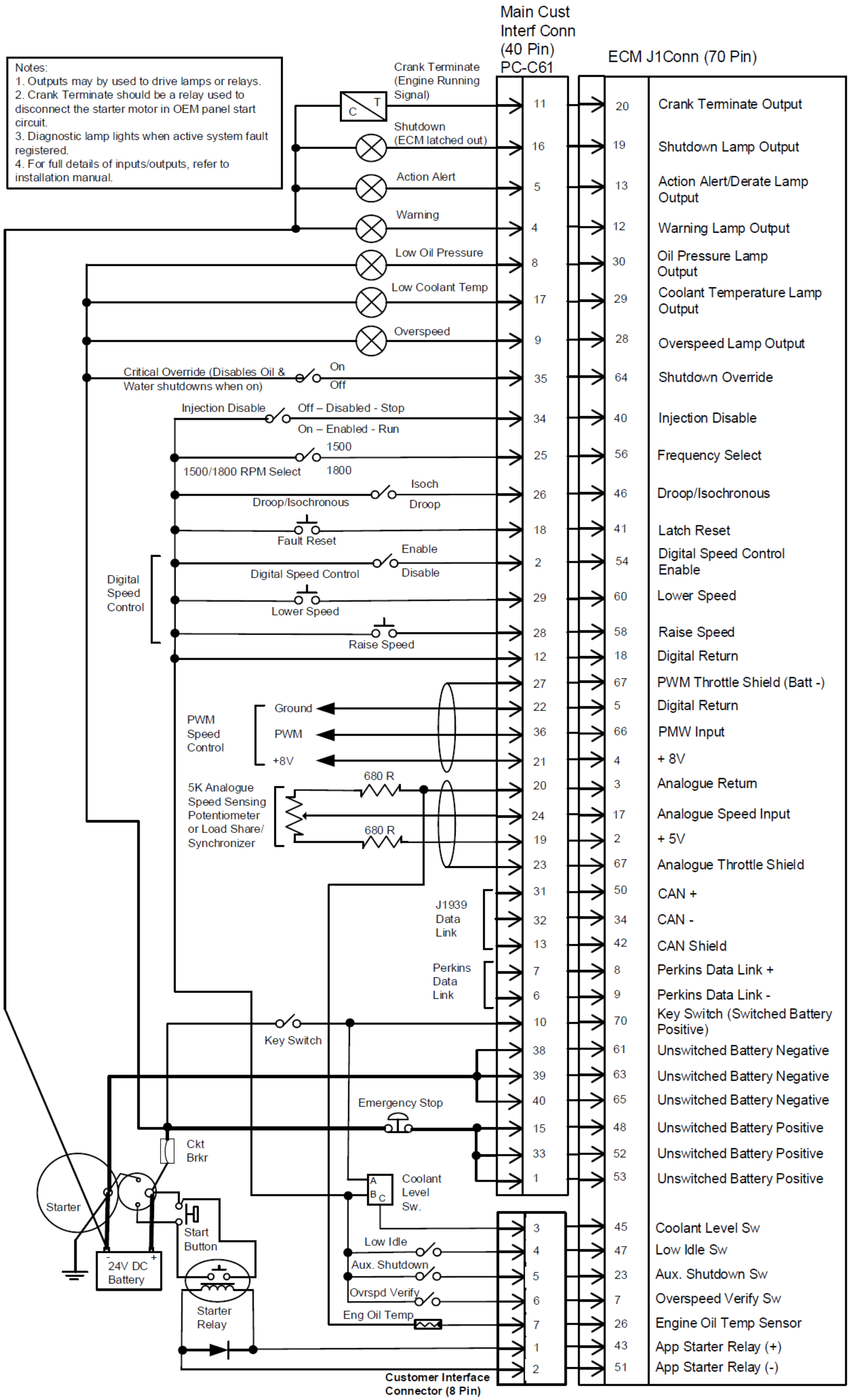


3.2.3 Application Wiring Schematic (all options):

3.2.3.1 1506, 2206-2806 Standard TAG Engines only with 40 pin Customer Interconnect Harness



3.2.3.2 Power Density 2806 E18TTAG4-7 Engines Only



3.2.4 Speed Control Hardware

A digital (push-button), an analogue or a Pulse Width Modulation (PWM) speed setting system may be used. **Only one (1) external speed control input can be used at any time.** The method of speed control is selected using the service tool. There is an option for CAN Input (J1939) speed control selected by Perkins EST as configuration parameter.

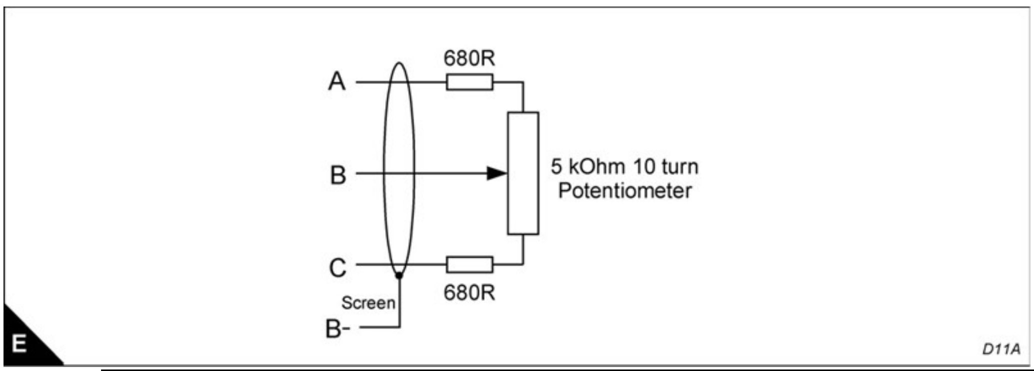
If no external speed control is required and the digital speed control option is installed, the 'Digital Speed Control Enable' Switch input pins should be open circuit and speed will then be fixed at the selected value i.e. 1500 RPM or 1800 RPM.

3.2.4.1 Analogue Speed Control Potentiometer or Speed Signal Optional

component requirements

An analogue potentiometer may be used for speed control. The configuration is as the diagram below. The cable to the potentiometer MUST be screened.

Analogue Potentiometer Connections



Key	Terminal description	Connection to ECM
A	5Vdc Supply from the ECM	VS_5_200MA
B	Accelerator position output	Analogue Input 2
C	Return 0V	VS_RETURN

Electrical Requirements

The potentiometer should be mounted OFF the engine and wired such that the output voltage increases for desired speed increase.

A potentiometer of no greater than 5 k ohm should be used. The potentiometer should have a linear resistance characteristic (position proportional to output voltage).

To avoid noise, the return path must be to the analogue ground and not via the chassis and the cable MUST be screened. **Diagnostic Zones**

There is a diagnostic zone at both min and max travel where the ECM can detect if the speed input has a short circuit or open circuit on any connection. To achieve this, the speed control output voltage at 100% should be less than 4.5V and the voltage at 0% demand should be greater than 0.5V. This requirement can be met by fitting resistors in series with the potentiometer (E).

Speed Control Range

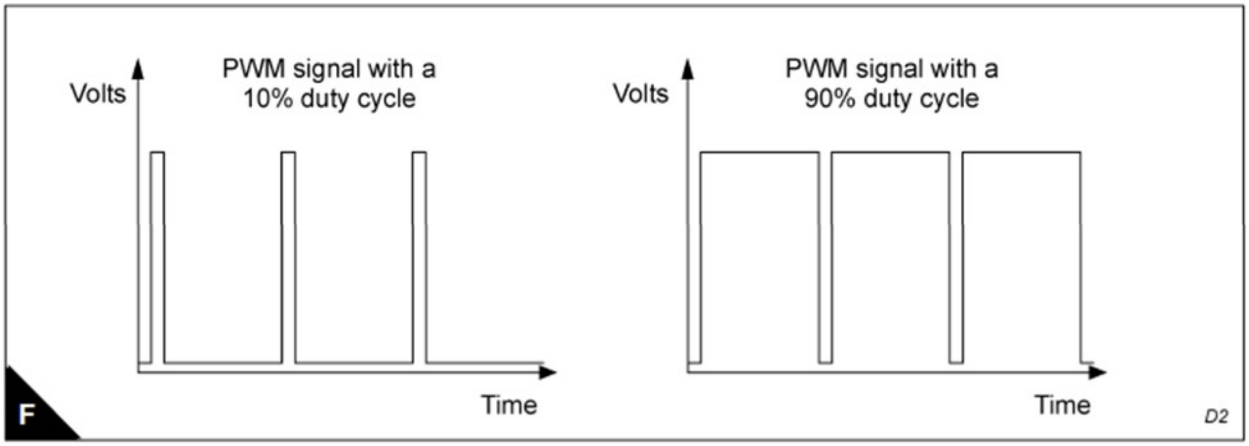
The control range of the analogue speed input can be set using the service tool, maximum range +/- 150 RPM.

3.2.4.2 PWM sensors for speed control

Optional Function
The sensor output is a constant frequency signal whose pulse width (duty cycle) varies with desired speed. The PWM signal is expressed as a percentage as shown in the diagram (F).

This type of speed control is normally part of a load sharing/automatic synchronising system. The output is required to be 8V 500Hz with a PWM output from 5% min to 95% max duty cycle. Refer to Appendix A 1.1 PWM Input.

The speed control range of the PWM input is fixed at –24% to +8% of rated speed. **PMW Signal**

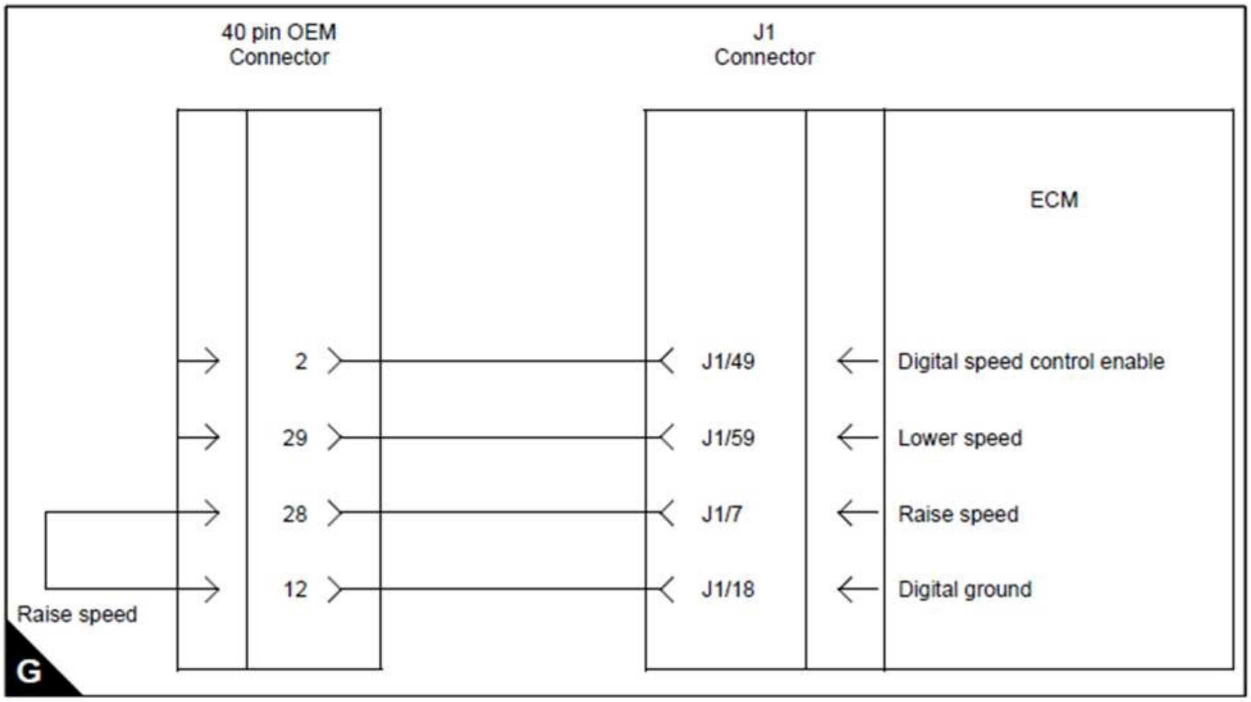


3.2.4.3 Digital Speed Control Optional function

The digital speed control allows engine speed to be controlled from raise and lower speed control push-buttons or relay contacts. To enable digital speed control, the 'Digital Speed Control Enable' switch must be open. The range of the digital speed control may be set using the service tool with a maximum speed range of +/- 150 RPM.

When the digital speed control is enabled, the ECM defaults the desired engine speed to equal the rated speed, (1500/1800 RPM). If the power is cycled to the ECM the digital speed control desired speed will revert to rated speed, i.e. on power cycle the ECM does not retain the previous set point speed.

Achieving non-synchronous engine speed on "start-up" - 1500/1800 rpm
Certain markets require engine speed to be set up to 3 rpm above the rated speed when using simplified synchronising circuits. This can be achieved as follows:



1. Connect link between Raise Speed input and Digital Ground.

   Done by the OEM on his interface connector.

2. Using EST, set the following configuration.
   - Digital Speed Control Installed - Installed.
   - Speed Control Minimum Speed - 0.
   - Speed Control Maximum Speed - 3.

Configured at the factory by Perkins
The engine will now run at 3 rpm above the nominal speed when it starts.

3.2.5 Digital inputs

All Digital Inputs must be returned to Digital Return on ECM J1/P1 pin 5 or 18 (on 1700 Series, digital returns must be returned on the 40-Pin Customer Connector at pin 12 or 22). **Refer to Appendix A1.2 and Appendix A 2.0**

Ignition Key Switch
Optional but either an **ignition key switch** or a **fault reset switch** should be fitted to facilitate fault reset.

The ignition switch does not switch off power to the ECM. The ECM remains connected to the battery through a circuit breaker, even when the ignition is switched off.

The ECM does not have an output that controls the starter motor (except for 1706 engine), so provision must be made by the Installer for the starter motor to be controlled by the ignition key switch where required.

The key switch should be wired in accordance with the appropriate illustration diagram above OEM Connection Diagram or Application Wiring Schematic.

The current ratings for the ignition switch contacts are dependent on the starter motor circuit design.

Proper control of the starter is vital to not damaging the starter and engine ring gear. The starter controls should:

1. Prevent starter from throwing into a moving engine
2. Disengage the starter at an appropriate engine speed to prevent high speed over-run of pinion gear
3. Limit crank time so the starter does not overheat
4. Detect tooth abutment with engine ring gear and prevent the solenoid windings from overheating.

The following practices are recommended when operating the starter.

Starter Over Run

The starter must be disengaged at an appropriate moment during engine start up. Excessive run time with engine at normal operating speed will cause catastrophic failure of the starter. Starter should be disengaged between 400 to 500 rpm engine speed. If during cold start conditions the engine stumbles badly or stops running when the starter is disengaged, then
a 0.5 second de-bounce may be added before starter disengagement. However, the de-bounce is inappropriate for a normal engine start, so another tier of logic must be added to the software to disengage starter immediately when detecting engine speed of >600 rpm.

Rapid Re-Engagement

The starter should not be allowed a repeat start attempt before the engine and pinion gear have time to come to rest. A five second delay should be imposed between start attempts. The starter takes a longer time than the engine to coast to a stop.

Engage To Running Engine

The starter must never be engaged into a running engine, or engine speed is >0 rpm.

Crank Duration

The starter should not be used more than it can withstand before overheating. The starter rated duty cycle is3 x 30 second cranks with 2 minute rest between each crank.

Tooth Abutment Detection

It is possible that a starter may not clear a tooth abutment with the engine ring gear. In those circumstances, the solenoid should be disengaged quickly to prevent over heating of solenoid windings. If no engine speed is measured within 2 seconds of a start command, then disengage the starter. A follow up start attempt can be made to clear the tooth abutment and crank the engine.

False Speed Readings

It is sometimes the case that a speed sensor will report a momentary false high speed reading at the beginning of a start attempt. This is due to the edge of a gear tooth moving in front of the sensor as the starter engages the engine ring gear. An engine speed >0 rpm should be ignored for 200 milliseconds at beginning of crank event in order to prevent the starting software from disengaging the starter. This de-bounce time is likely built in to the engine software that reports engine speed and may not need to be included in a separate starter control algorithm.

Injection Disable (Injector Disable)

A switch connected to this input disables the injectors when the switch is open and is the preferred way of stopping the engine since it leaves the ECM fully powered up and able to communicate with the Service Tool.

- Switch to B+ to enable injection on 1506/2206 – 2806 Standard engines only.

- Switch to ground to enable injection on 1706 and 2806 Power Density engines only.

Fault Reset (Shutdown Reset)

Optional - see ignition key switch above.
This switch is used for clearing faults after an engine shutdown, switch to ground for fault reset. Faults can also be cleared by turning the ignition switch to the OFF position.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the application chassis ground.

Droop/Isochronous Optional
Switch to ground for droop governing. Enabling of this switch input and percentage droop is set using the service tool.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

1500/1800 RPM selection

Optional
Switch to ground to select 1800 RPM. Enabling of this input is controlled via the service tool.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the application chassis ground.

Digital Speed Control Enable

Optional
Input switch open to enable Digital Speed Control. This input should be linked to ground if analogue or PWM speed controls are required.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the application chassis ground.

Raise Speed

Optional
Input for Raise Speed push-button or relay contact, connect other side of switch to ground. Only available when digital speed control is enabled.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the application chassis ground.

Lower Speed

Optional
Input for Lower Speed push-button or relay contact, connect other side of switch to ground. Only available when digital speed control is enabled.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the application chassis ground.

Critical Override (Shutdown Emergency Override)

Optional - requires factory approval for implementation.
Input for Critical Override switch, open circuit for Critical Override (except Overspeed), connect to battery + to disable fault shutdowns. Only available when Critical Override is enabled via the service tool.

Low Idle

Optional
Low Idle input allows the customer to bring the engine speed to Low idle when this input is taken to digital return.

Overspeed Verify (Not supported by 1706)

Optional

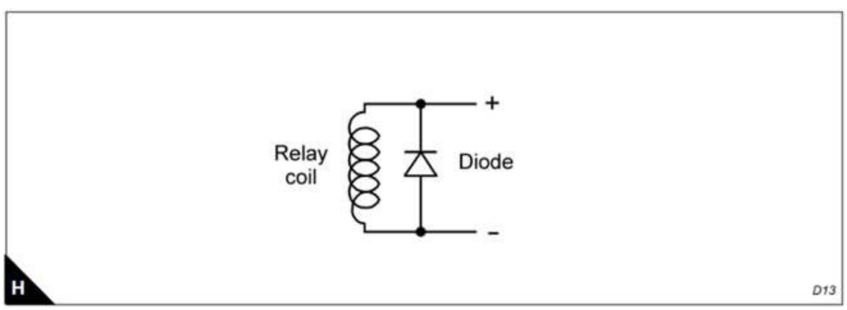
Overspeed Verify Switch allows an operator to test the Programmable Monitoring System (PMS) over speed strategy, without having to run the engine in an engine over speed condition by taking this input to digital return.

3.2.6 Digital Outputs

The OEM connection diagrams show all the digital outputs connected to lamps, but they may alternatively be connected to relays or PLC inputs. If connected to relay coils, a diode must be connected across the relay coil to suppress any voltage spikes; see diagram (H) below.

Notes:

- Use of the digital outputs is optional but if these outputs are left open circuit, this will be reflected in active diagnostics appearing on the Service Tool diagnostic screens. For the 1706/2506/2206 engines, the lamp diagnostics are disabled.
- Also, if these outputs are used to feed LED indicators or inputs, the impedance of these loads maybe too high to prevent the ECM from diagnosing an open circuit condition and LED indicators may glow dimly when the output is off.
- To avoid incorrect diagnosis, the load resistance across these outputs should not exceed 5 K ohms.



Shutdown
This output is a high side driver (switches internally to B+), current rating 1.5 amp. The output is on when the engine is in the Shutdown condition (even when Critical Override is active).

Action Alert
This output is a high side driver (switches internally to B+), current rating 1 amp. The output is on when the engine is in the Action Alert condition. It will normally be used by the OEM to initiate a controlled shutdown of the equipment.

Warning

This output is a high side driver (switches internally to B+), current rating 1 amp. The output is on when the engine is in the Warning condition. It will normally be used by the OEM to alert the operator that the engine requires attention.

Diagnostic

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a diagnostic condition exists. It will normally be used by the OEM to alert the operator that the engine requires attention. (Not available on 2806 Power Density engines.)

Oil Pressure

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a low oil pressure condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Coolant Temperature

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a high coolant temperature condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Overspeed

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when an overspeed condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Crank Terminate

This output is a high side driver (switches initially to B+), current rating 1.5 amp. The output is on when the engine is above the crank terminate speed (programmable from the Service Tool). With the engine running, this output switches off when either the key/switch or injection disable switches are opened, or when the ECM shuts down the engine.

Starter Relay

This relay is closed loop starter relay control (PWM Out + and -) to start engine when keyswitch is in start position. This control output is turned off when engine RPM reaches “run” threshold.

3.3 Customer Optional Components

3.3.1 Coolant Level Sensor

A coolant level sensor is shipped loose. The coolant level sensor is not wired to the engine ECM. This coolant sensor must be incorporated into the customer’s control system and wired to provide shutdown protection in the event of coolant loss. Wiring to ECM is optional for 1706 and 2806 Power Density engines.

Note: This sensor must be fully operational to protect the engine in the event of coolant loss.

3.3.2 Coolant Level Sensor (Ship loose)

3.3.2.1 Coolant Level Operation

The coolant level sensor switch enables the ECM to monitor the coolant level to protect the engine against operation with low or no coolant.

3.3.2.2 Coolant Level Configuration

To enable the operation of this sensor the configuration of the Coolant Level Sensor must be changed in the service tool from “Not Installed” to “Installed”.

Once the sensor is configured, the following table shows the operation of the Low Coolant Level fault system.

			Time Delay in Seconds		Set Points	
Parameter	**Action**	**Default Value**	**Range**	**Default**	**Range**	**Default**
Low Coolant Level	Warning (Least Severe)	On	1 to 120	10	Not Programmable	None
	Shutdown (Most Severe)	On	1 to 120	10	Not Programmable	None

3.3.2.3 Coolant Level Installation

This sensor is customer-installed. Refer to OEM Connection Diagram for details.

Note: This sensor must be fully operational to protect the engine in the event of coolant loss.

3.3.3 Overspeed Verify Switch (2806 PD Only)

3.3.3.1 Overspeed Verify Switch Operation

Overspeed Verify Switch allows an operator to test the Programmable Monitoring System (PMS) over speed strategy, without having to run the engine in an engine over speed condition.

The switch input allows the user to test shutoff feature at 75 percent of the engine overspeed limit.

If the Engine Monitoring System's over speed shutdown function is programmed to OFF, the overspeed verify function will not operate.

3.3.3.2 Overspeed Verify Switch Configuration

There is no configuration necessary for the overspeed verify switch.

3.3.3.3 Overspeed Verify Switch Installation

The switch is a normally open switch. When the switch is closed, and the actual engine speed is equal to or exceeds 75 percent of the Overspeed limits, Engine Overspeed feature is activated. Refer to OEM Connection Diagram for details.

3.3.4 Starter Relay

3.3.4.1 Starter Relay Operation

Starter Relay is used to turn on Starter Motor Solenoid to crank the engine when the ECM receives Engine Start command.

3.3.4.2 Starter Relay Configuration

To use the Starter Relay, ‘Starting System Type’ configuration in the Service Tool must be ‘Electrical’.
When the Starting System Type is Electrical, ECM controls and monitors Starting of the Engine.
When the Starting System Type is ‘Not Installed’, ECM does not control and Monitor Starting of the Engine.

3.3.4.3 Starter Relay Installation

Refer to OEM Connection Diagram for details.

3.3.5 Oil Temperature Sensor (2806 PD Only)

3.3.5.1 Oil Temperature Monitoring Operation

Oil temperature sensing is part of the engine monitoring system however the sensor is installed by the OEM. The Oil Temperature is monitored to automatically protect the engine from exceeding the maximum engine oil temperature limit. The oil temperature measured by the ECM is compared to a maximum oil temperature limit configured in the monitoring system for oil temperature monitoring. The maximum oil temperature is checked for each ECM action level configured in the monitoring system. If the oil temperature is above the maximum oil temperature for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

Perkins EST Description	J1939 Description	Status	SPN	FMI
High Engine Oil Temperature	Engine Oil Temperature 1	Warning	175	15
		Derate	175	16
		Shutdown	175	0

The ECM can respond to the high Oil temperature condition with any or all the following actions: Warning, Derate, and Shutdown. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Derate or Shutdown:

• Derate: Engine power is reduced according to the Oil temperature derate percent value. The power is reduced at a rate of one percent/second. The percent derate is a power reduction towards a default power curve. The 100 percent derate is typically 50 percent of the actual rated power at a given speed. The derate percent for Oil temperature is 0 percent. So effectively no derate of power.

• Shutdown: The engine will shut down immediately.

3.3.5.2 Oil Temperature Monitoring Configuration

Three parameters can be configured in Perkins EST to customize the monitoring system for high oil temperature monitoring.

1. ECM action for an event code defaults to “On” for Warning and “Off” for Derate and Shutdown. All actions can be configured to “On” or “Off.”
2. Time delay to act defaults to 15 seconds for Warning, Derate, and Shutdown. This time delay is not programable.

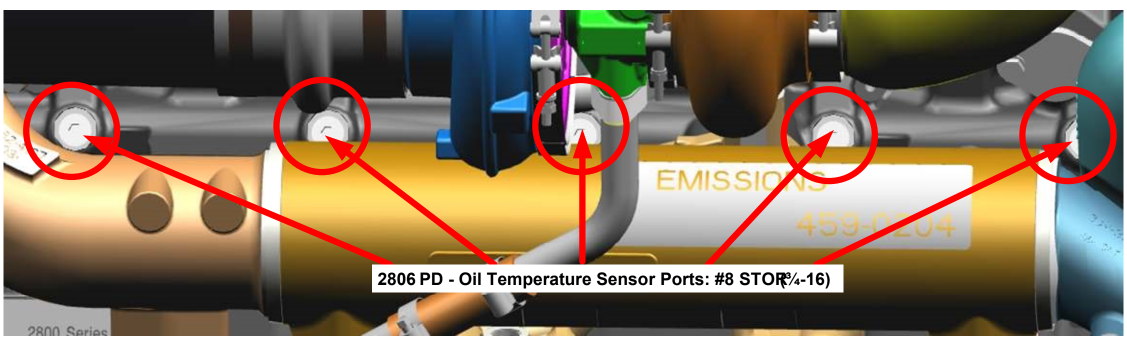
The following table summarizes the configuration default settings and configuration ranges for high Oil temperature monitoring:

High Oil Temperature Monitoring Configuration					
		Time Delay in Seconds		Set Points	
Action	**Default Value**	**Range**	**Default**	**Range**	**Default**
Warning (Least Severe)	On	Not Programmable	15	100 to 110	110 Deg c
Derate (Moderate Severity)	Off	Not Programmable	15	105 to 115	115 Deg c
Shutdown (Most Severe)	Off	Not Programmable	15	105 to 115	115 Deg c

Note: The engine must be running at engine speeds at or above low idle for 180 seconds before the above time delay is triggered.

3.3.5.3 Oil Temperature Monitoring Installation

For wiring details, refer to OEM Connection Diagrams section. OEM is responsible for installation and wiring this sensor. There is an option for factory order. The following figure shows the ports available to install the sensor. Oil Temperature Sensor part number is 886/167.



Oil Temperature Sensor Installation Ports

3.3.6 Automatic Synchronising and Load Sharing Systems

For some synchronising and load sharing units, it will be necessary to use an interface module to convert the synchronising/load sharing units output signals into the 0.5 to 4.5 volt input signal required by the EMS analogue speed input. An example of a typical automatic synchronising and load sharing system using an interface unit as shown in the line diagram (A) below.

The load sharing system should be equipped with a ramp generator to ensure that the load is applied slowly to limit any load overshoot which may occur on start-up.

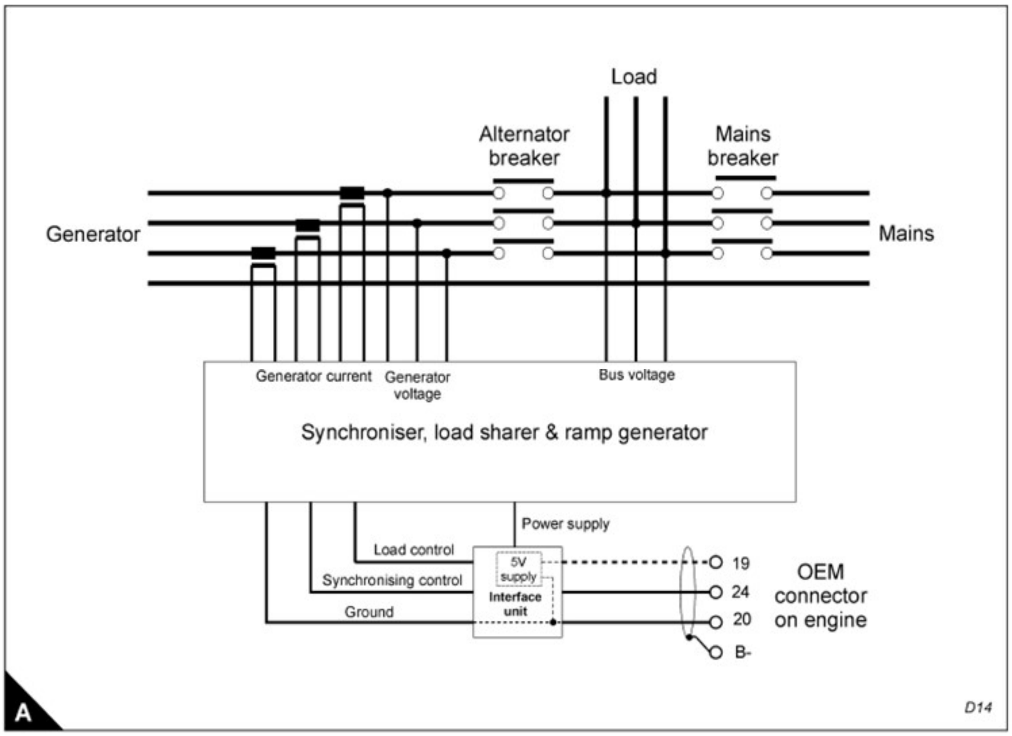
The interface unit must have the following functionality:

- Nominal output of 0.5 to 4.5 volt for full speed control.
- A preset potentiometer to enable the correct output voltage to be set to give an engine speed of 1500 RPM or 1800 RPM at no load.

- When being driven by the synchroniser or load sharing unit, a minimum change in output of +/- 500 mV from the preset speed RPM steady state output voltage to ensure adequate speed or load response from the engine.
- For optimum stability, the interface unit should contain its own 5 volt regulated supply from which the speed reference is derived. If this is provided, it is not necessary to utilise the 5 volt supply from the ECM.

Note: The cable to terminal 19 of the OEM connector is not required if the interface unit has its own 5 volt reference supply.

Typical Synchronising/Load Sharing and Interface Diagram



4.0 Power and Grounding Considerations

4.1 Power Requirements

4.1.1 System Voltage

The electronic control system can operate with either a 12 VDC or 24 VDC electrical system. The switched positive battery and the un-switched positive battery connections to the ECM are made at the P1/J1 customer harness connector.

The minimum battery voltage for the ECM to actuate the fuel injectors, regardless of system voltage (12 VDC or 24 VDC) is 9 VDC. The ECM monitors system voltage input (un-switched power) and triggers a diagnostic code if the voltage drops below 9 VDC and then returns above 9 VDC.

The batteries, charging system, starter, and associated wiring must be sized and designed correctly to allow the starter to crank the engine to an appropriate minimum engine speed to start the engine. The engine installation should meet the minimum cranking speeds at the COLDEST ANTICIPATED TEMPERATURES. For 1506 the typical minimum cranking speed required to start the engine is 150 rpm. For all other engines, the typical minimum cranking speed required to start the engine is 100 rpm. Also reference Technical Data Sheet - Electrical System Data for Minimum Cranking Speed Data.

4.1.2 Battery (+) Connection

The ECM requires four un-switched battery (+) inputs (1706 engine requires three) and an ignition key switch input. When the key switch is in the off position, the ECM is in sleep mode where it draws a very small residual current through the four un-switched battery inputs. When the key switch input is turned on, the ECM will become active, allowing the engine to start and run.

The ignition key switch input (switched power) is made through pin P1/J1-70 (1706 engine switched power is pin 10 on 40-pin connector) and carries approximately 2 mA on a 12 VDC system and 4 mA on a 24 VDC system.

> **Note:** *The ECM will begin to function when the voltage at the key switch input rises above 8 VDC and ceases to function when the voltage falls below 5 VDC. Loss of communication with EST during cranking indicates that the ECM may be shutting down due to decreasing voltage at the key switch input. It is recommended that the key switch be wired directly to battery positive through a circuit breaker. Connecting the key switch to other points in the starting system, such as the starter terminal, could cause the ECM to shut down during cranking, resulting in hard starting or failure to start.*

These four un-switched battery (+) input connections (three for 1706 engine) are made through pins P1/J1 - 48, 52, 53, and 55 (pins 1, 15, and 33 on the 40-pin connector on the 1706 engine). These four inputs (three inputs for 1706 engine) should run directly from the P1/J1 connector to the positive side of the battery. These four inputs carry nearly all power to the ECM during peak requirements. These inputs provide the ECM power when the vehicle key switch is in the off position. Refer to Table 3 for more information on ECM current requirements. All four of these un-switched battery (+) inputs must be provided to prolong the service life of the ECM.

Table 3: ECM Current Requirements

Parameter	A4*
12V	
Sleep Mode Current (key switch off)	6.5 mA
Power On with no I/O (key switch on — not running)	1500 mA
Inrush Amplitude	50 A
Inrush Duration	4 ms
Normal Operating Current — Peak	22 A
Normal Operating Current — RMS	7.7 A
24V	
Sleep Mode Current (key switch off)	12
Power On with No I/O (key switch on — not running)	850
Inrush Amplitude	96 A
Inrush Duration	3 ms
Normal Operating Current — Peak	17 A
Normal Operating Current — RMS	4.0 A

* Engines covered by this publication have an A4 ECM, except for 1706 models.

Table 4: ECM Current Requirements

Parameter	A6E2*
12V	
Sleep Mode Current (key switch off)	0.51 mA
Power On with no I/O (key switch on — not running)	500 mA
Inrush Amplitude (key switch off)	115 A
Inrush Duration (key switch off)	800 us
Normal Operating Current — PEAK** (CRIN3 fuel System)	21 A
Normal Operating Current — RMS** (CRIN3 fuel System)	5.7 A
24V	
Sleep Mode Current (key switch off)	1.3 mA
Power On with No I/O (key switch on — not running)	306 mA
Inrush Amplitude (key switch off)	224 A
Inrush Duration (key switch off)	800 us
Normal Operating Current — Peak** (CRIN3 fuel System)	12.5 A
Normal Operating Current — RMS** (CRIN3 fuel System)	3.3 A

* 1706 Engines covered by this publication have an A6E2

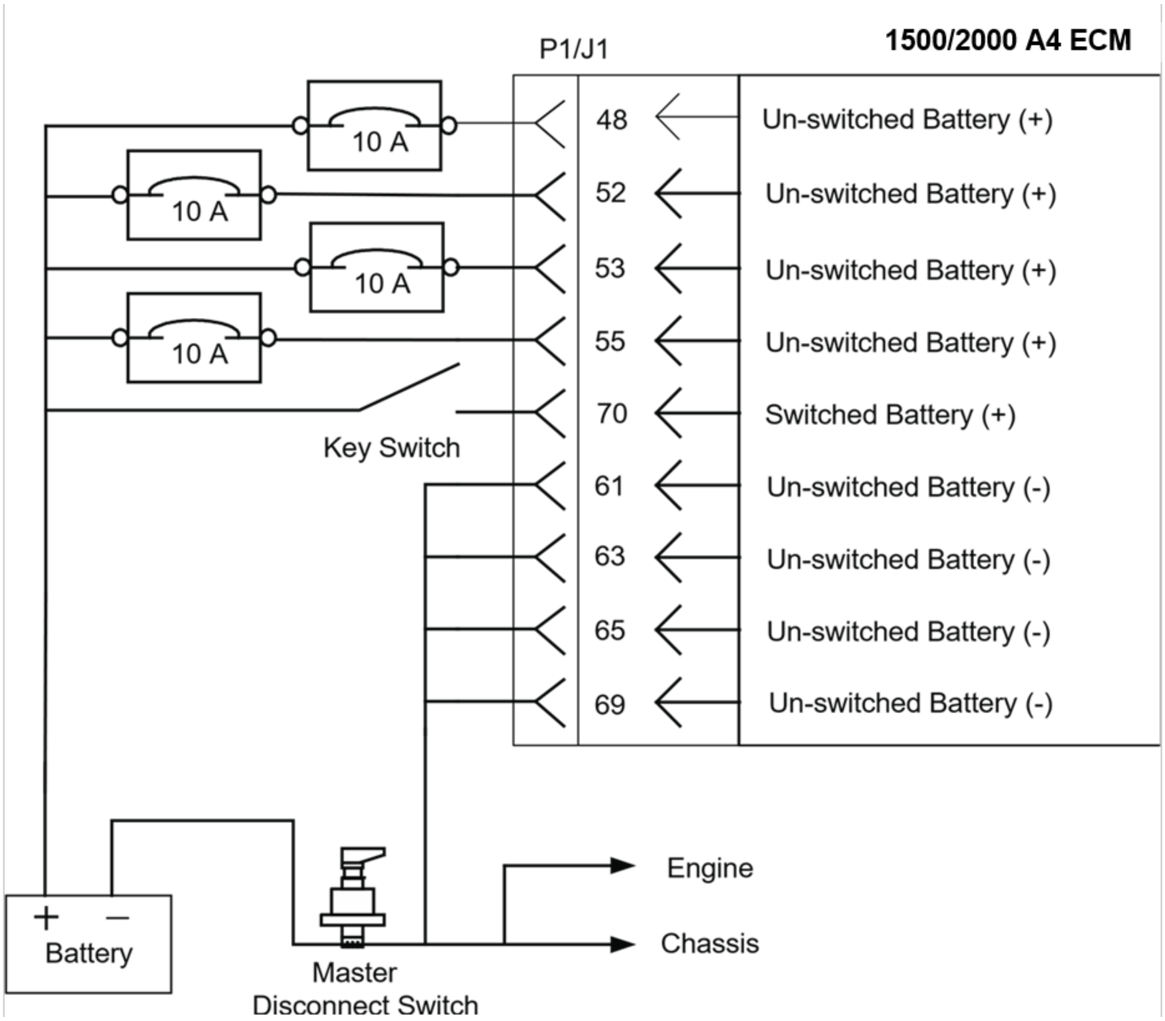
** Normal operating current is ECM digital core, internal power supplies, and 6-cylinder CRIN3 running at 3150 RPM. The average current of the ECM outputs according to PRS load table is 40A. For specific Applications, it is recommended to take the ECM RMS value and add the current output of the drivers the application is using.

4.1.3 Circuit Protection

Each of these four un-switched battery (+) inputs (three for the 1706 engine) requires a 10 Amp circuit breaker rated for a continuous duty load of 7 Amp at 12 or 24 VDC. Powering the ECM through dedicated circuits with circuit breakers reduces the possibility of degradation of electronic control system performance. This also minimizes the chance of an engine shutdown due to a short in the electrical system. Additional loads should not be connected between the ECM and the circuit protection for the ECM. Circuit protection wiring is illustrated in Figure 1. Perkins prefers the circuit protection to be in the machine cab (if applicable). If not in the cab, for ease of service, the circuit protection should be in an easily accessible and documented location.

> **Note:** *DO NOT use in-line fuses for circuit protection. Perkins recommends the use of circuit breakers for circuit protection. Circuit breakers should be located with other circuit protection in a centrally located, dedicated panel. If circuit breakers that automatically reset are used, consideration of the environment of the location of the breaker is critical and the effect on the trip point is critical. The trip point of some circuit breakers can be significantly reduced below the rated trip point if the circuit breaker is exposed to high temperatures. This can cause intermittent shutdowns that result in the needless replacement of electronic components.*

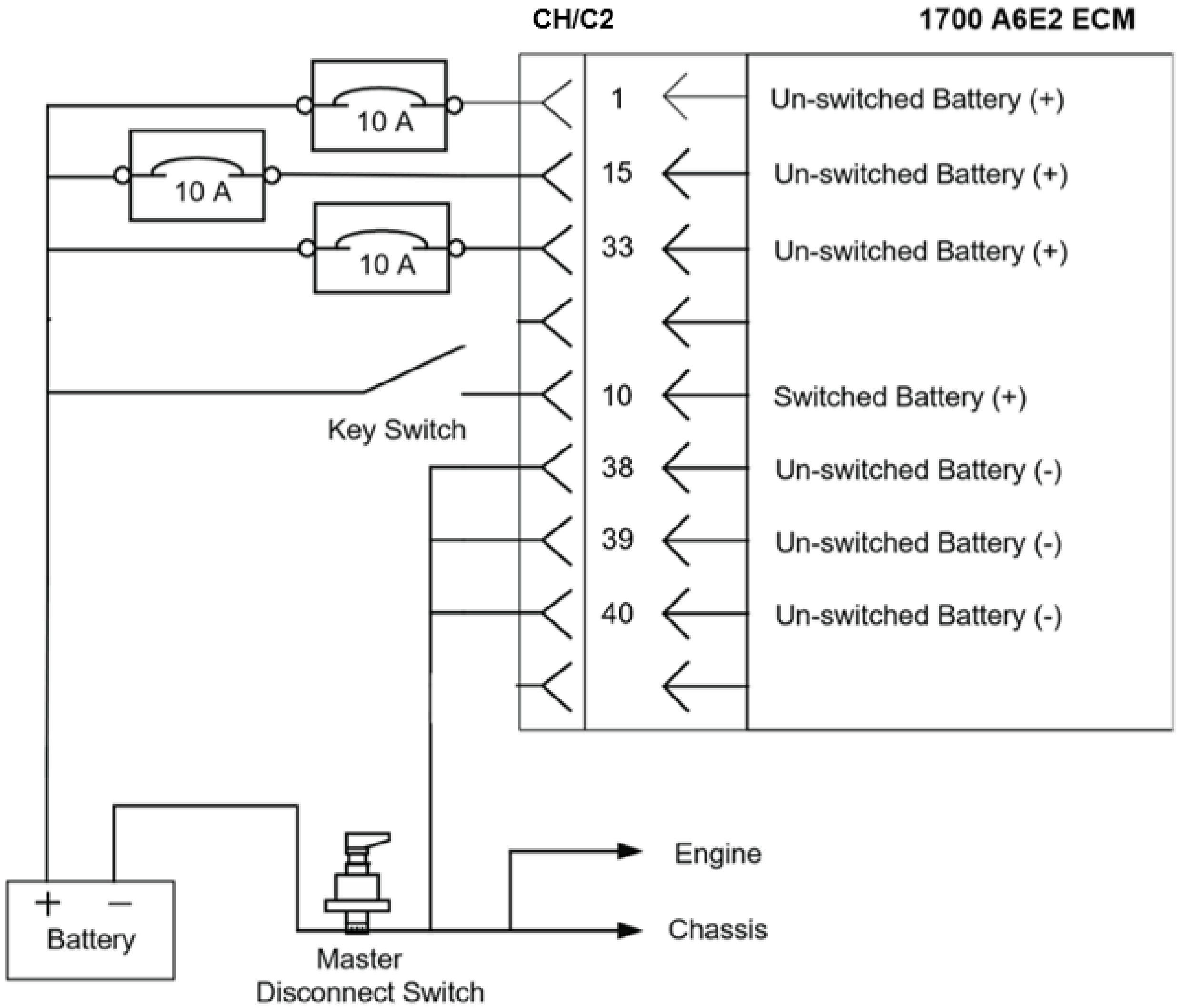
Figure 1: Battery (+) Wiring and Circuit Protection Diagram



Note: *For already installed Tier 3/Stage IIIA and earlier applications, four un-switched positive battery connections and four ground connections are recommended but not required. New installations, especially those with HEUI fuel systems, should be designed with all four un-switched positive and negative battery connections.*

Note: *For already installed Tier 3/Stage IIIA and earlier applications, a single 25 Amp circuit breaker was used. New installations, especially those with HEUI fuel systems, should be designed with four individual 10-Amp circuit breakers.*

Figure 2: Battery (+) Wiring and Circuit Protection Diagram



4.1.4 1500/2000 Series A4 ECM Internal Battery

The ECM has an internal battery that powers critical circuits and battery backed memory when all power sources are disconnected from the ECM. The internal battery is expected to meet a 15-year battery life if the ECM is stored, or switched off without any external battery connection, at a storage temperature at or below 30°C/86°F. The exact storage life is dependent on temperature. The storage life may fall to as low as 10 years if the storage temperature is elevated to 70°C/158°F.

NOTE: 1700 Series A6E2 ECM has no internal battery.

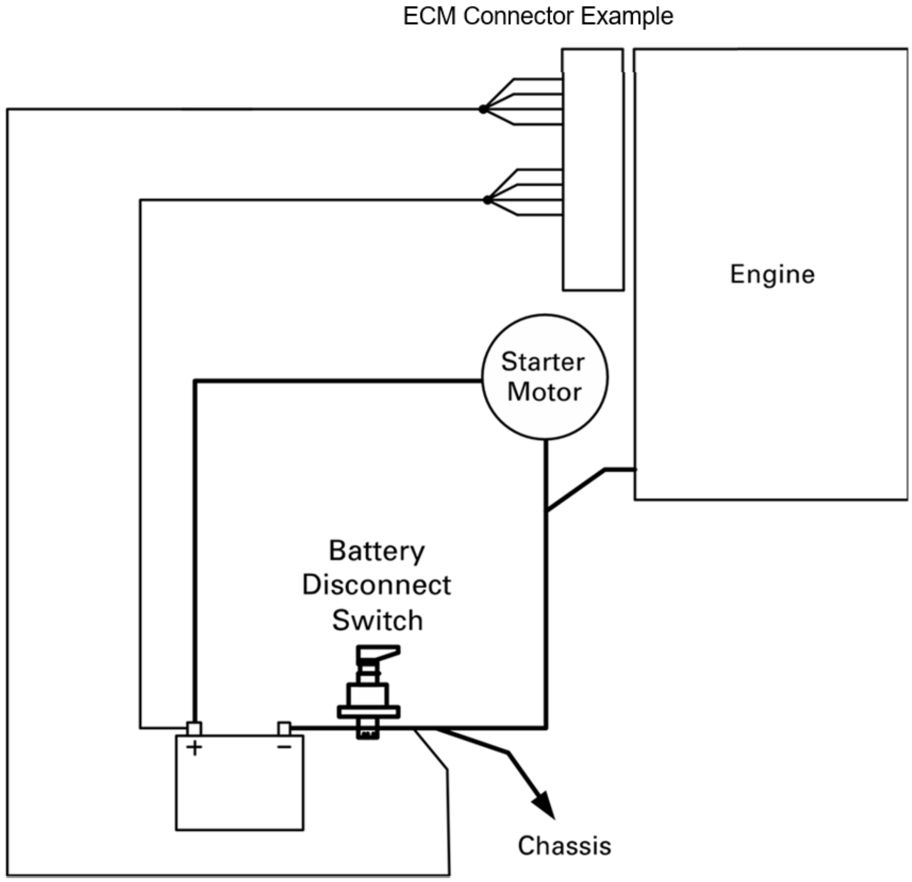
4.2 Engine Grounding

Proper grounding for vehicle and engine electrical systems is necessary for proper performance and reliability. Improper grounding results in unreliable electrical circuit paths. Stray electrical currents can damage main bearings, crankshaft journal surfaces, and aluminum components. They can also cause electrical noise, degrading control system, vehicle, speedometer, and radio performance. These problems are often very difficult to diagnose and repair.

All ground paths must be capable of carrying any conceivable fault currents.

4.2.1 Recommended Power Supply Wiring

- ECM battery (+) wires connect directly to battery, not via starter motor
- ECM battery (-) wires connect directly to battery, not via chassis or engine ground
- Power supply wires go to all four positive pins and all four negative pins on the ECM connector
- Engine is grounded and connected directly to battery



Note: *Circuit breakers are not shown in the figure above.*

4.2.2 ECM Battery (-) Connections

The A4 ECM requires four battery (-) connections (three connections for 1706 engine) to battery (-). These four ECM battery (-) input connections (three for 1706) are made through pins J1- 61, 63, 65, and 69 (pins 38, 39, and 40 on 1706 engine 40-pin connector). All of these pins should be connected directly to the negative terminal on the battery, not to the engine ground stud or any other ground location. These connections should be #14 AWG GXL wire.

Note: *For already installed Tier 3/Stage IIIA and earlier applications, four un-switched positive battery connections and four ground connections are recommended but not required. New installations, especially those with HEUI fuel systems, should be designed with all four un-switched positive battery connections.*

4.2.3 Engine Ground Stud to Vehicle Battery Ground

To ensure proper functioning of the vehicle and engine electrical systems, there must be a direct wire path from the engine ground stud to the battery negative post.

A maximum of three ring terminals are to be connected to the engine ground stud to ensure ground connection integrity. More than three terminals can cause the stud to loosen too easily. Perkins recommends splicing like-size wires together as a method of reducing ring terminal congestion at the ground stud.

A connection routed to a main frame ground can also be made if the following guidelines are followed:

1. Connections to the frame must not be made with star washers. Star washers should not be counted on to remove paint from painted surfaces. Use flat washers for this connection, with the paint completely removed in this area.
2. Any paint must be completely removed from the frame rail at the point where the connection is made. Failure to do so reduces the effectiveness of the connection.
3. The ground path is not made through frame cross members. Bolted connections of frame cross members may not always provide required continuity for this critical connection.
4. Conductive grease or other methods used to reduce/eliminate the effect of corrosion on the frame rail connection.

Perkins does not recommend a connection from the engine ground stud to the main frame rail at a connection point different than where the battery ground connection is made. A two-point frame rail connection method depends on frame rail connections. Manufacturing process control of frame rail connections is difficult to control. This multiple frame rail connection scheme is also more difficult to troubleshoot.

4.3 Air Starter Equipped Vehicles

Refer to the guidelines for connection to the main frame ground in Engine Ground Stud to Vehicle Battery Ground (section 4.2.3).

4.4 Sensor Common Connections

Certain components that interface directly with the ECM are connected to the dedicated sensor returns at the P1/J1 customer connector. On the 40-pin connector, separate sensor returns are provided for analog and digital signals.

4.4.1 Digital Sensor Return

P1/J1 Pin 5 (pin 22 on the 1706 40-pin connector) should only be connected to the ground side of the coolant level.

4.4.2 Analog Sensor Return

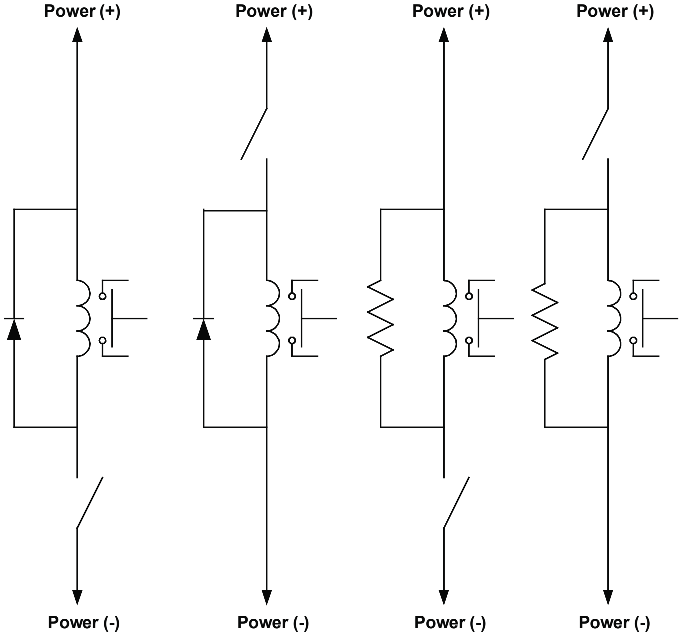
P1/J1 Pin 3 (pin 20 on the 1706 40-pin connector) should only be connected to the ground side of the sensors for the Analogue Speed Setting Potentiometer or Input from Load Sharer/Synchroniser.

4.5 Suppression of Voltage Transients

Note: *The installation of transient suppression at the source of the transient is required. Perkins follows a stringent electrical environment standard that is similar to SAE recommended practices.*

The use of inductive devices such as relays and solenoids can result in the generation of voltage transients in electrical circuits. Voltage transients that are not suppressed can exceed SAE specifications and lead to the degradation of the performance of the electronic control system.

Figure 2: Voltage Suppression Diagram



The customer should specify relays and solenoids with built-in voltage transient suppression. Refer to Figure 2 for ways to minimize voltage transients from relays and solenoids without built-in voltage transient suppression. Techniques include the installation of a diode or resistor of the proper size in parallel with the solenoid or the relay coil.

Diodes and resistors accomplish suppression in different ways. Diodes clamp the voltage across the coil to approximately -0.7 V when the switch opens. The current circulates in the loop until it eventually diminishes. Suppression resistors will allow the transient voltage to increase to a value determined by the forward current flow through the coil and the value of resistance of the suppression resistor. However, resistor suppression causes the current in the loop to diminish much faster than would a diode.

Diode selection should be based on the normal voltage and current seen by the coil. For example, if the normal voltage applied to the coil is 24 V and the coil has a resistance of 50 ohms, then the current passing through the coil is 480 mA (I=V/R). The diode then would need to be able to withstand a reverse voltage of 24 V and a forward current of 480 mA when the current to the coil is interrupted by the opening of the switch since the collapse of the coil's magnetic field will attempt to maintain that current. The T403200 suppressor would function well in this application since it can withstand a reverse voltage of 600 V and a forward current of 2 A.

Suppression resistors are low-cost alternatives and can be less stressful on relay coils. Resistor selection should be determined by the voltage applied across the coil, the resistance of the coil, maximum power dissipation allowed, and the level of transient voltage to be tolerated. For example, if the coil is 50 ohms and the voltage applied is 24 V, an 82 ohm suppression resistor would allow the transient voltage to reach -39.6 V (V=IR= -.48 A X 82 ohms, the voltage is shown as negative since the polarity reverses when the switch opens). Using a 330 ohm resistor would allow a -158 V transient but the current would diminish in the loop faster. For power dissipation concerns, the resistor's power rating should be considered. For example, if 24 V is applied across a 330 ohm resistor, the power dissipated by the resistor would be 1.75 W (P=V2/R).

Therefore, the 330 ohm resistor should be selected that could dissipate at least 2 W. The heat generated by the resistor should be considered when selecting a resistor.

Note: *If the resistance of the suppression resistor is too low, the driver circuitry in the ECM may be loaded to a point where the relay or solenoid does not function properly. If the resistance is too high, the transient voltage may reach undesirable levels.*

There are other techniques that can be used for transient suppression. Snubbers, Zener diodes, and varistors are all methods that have characteristics that make them better suited for some applications. But, for the simple applications of relays or solenoids, diodes or resistors should suffice.

Inductive devices such as relays or solenoids should be located as far as possible from the components of the electronic control system. Wiring harnesses that are installed by the customer should be routed as far as possible from the wiring harness of the electronic control system to avoid problems that are associated with electrical noise.

4.6 Battery Disconnect Switch

The Application OEM should incorporate a battery disconnect switch on the negative battery side of the battery circuit. The purpose of this switch is to disconnect the battery during long-term storage and to prevent electrical shock during Application service. This switch should not be used as an emergency shutdown switch or as an E-stop. Refer to Power Requirements (section 4.1) for information on ECM battery life.

Note: *The battery disconnect switch is not an emergency shutdown switch and should not be used to stop the engine.*

5.0 Connectors and Wiring Harness Requirements

ElectropaK engines have several attachments that provide different options for the customer to interface to the engine ECM. The options are summarized as follows:

- ECM Only (standard option)
- Customer Harness

This section covers component and wiring harness design requirements for the customer to design the required harnessing to interface to the engine. The requirements spelled out in this section are the same used by Perkins in the construction of engine wiring harnesses. Adherence to these requirements by the customer will provide the same level of reliability, durability, and performance that are characteristics of Perkins engine harnesses. For example, when properly constructed, the customer harness should protect against moisture entry into the connectors when the connectors are temporarily immersed in water. The pinout information for the ECM and customer harness connectors are not included in this section. The pinout information can be found within the section that defines a components installation and in pinout summary tables in the Appendix.

5.1 Wiring Harness Components

5.1.1 Deutsch DT Connector

The DT connector is the low-cost preferred choice for inline applications. The connector is available in 2, 3, 4, 6, 8, and 12 terminal configurations. It is also intended for SAE J1939 application use. The wire size range that the connector will accept is 0.8 mm^2 (18 AWG), 1.0 mm^2 (16 AWG), and 2.0 mm^2 (14 AWG). The plug

assembly with interface seal accepts socket terminals and the receptacle assembly accepts pin terminals. Sealing plugs are to be used in unused wire cavities.

The DT connector has a wedge that locks the pins and the sockets in place. The wedge can be removed and replaced without cutting the wires. The wedge removal tool (p/n 28170079) can be used to aid in the removal of the wedges. When the receptacle is inserted into the plug, a click should be heard as the two halves lock together. The connector should not be able to be pulled apart.

The following tables contain the Perkins part numbers for DT inline connector plug and receptacle kits for all available number of pin positions. The kit is comprised of the plug or receptacle and the respective locking wedge.

STANDARD DT CONNECTORS		
Terminal Numbers	**Perkins Part Number**	
	Plug Kit	**Receptacle Kit**
2	28170051	28170055
3	28170056	28170052
4	28170057	T402643
6	28170059	28170061
8	28170062	28170063
12	28170041	28170064

J1939 DT Connectors (All 3 Terminal)	
Component	**Perkins Part Number**
Plug Kit	T401867
Receptacle Kit	T400034
Plug Resistor	T400033
Receptacle Resistor	T406061
Receptacle Tee	T402642

The connector has also been configured for bulkhead mountings and integral component applications (e.g. lamp housing, engine sensor, etc.). Terminal configurations and mounting configurations vary for these applications. Contact the local Deutsch sales contact for more information on these connectors.

5.1.2 Deutsch HD-10 Connectors

This circular connector is used for inline and bulkhead applications. It is more expensive than other connector choices but easier to adapt to wire harness conduit applications (i.e. CSA, Marine, etc.). The connector is available in 3, 6, and 9 terminal configurations. The wire size range that the connector will accept is 0.8 mm^2 (18 AWG), 1.0 mm^2 (16 AWG), and 2.0 mm^2 (14 AWG), and 3.0 mm^2 (12 AWG). The plug assembly with interface seal accepts socket terminals and the receptacle assembly accepts pin terminals. Sealing plugs are to be used in unused wire cavities.

Ensure that the wires in the plug align with the corresponding wires in the receptacle. Ensure that the index markings on the plug and the receptacle are aligned. Rotate the plug until the plug slips into the receptacle. Rotate the coupling by approximately 90 degrees until a click is heard. Ensure that the plug and the receptacle cannot be pulled apart.

The following table contains the Perkins part numbers for HD-10 inline connector plug and receptacle for all available number of pin positions. Most common usage for the HD-10 connector is the 9-position connectors used for Perkins service tool interface.

HD-10 CONNECTORS		
Terminal Numbers	**Plug Kit**	**Receptacle Kit**
3	T402644	T402647
6	T402645	T402648
9	T402646	28170049

Interface sealing caps and wire strain reliefs are available for the connectors. Contact the local Deutsch sales contact for more information on these components.

5.1.3 Deutsch DRC/AEC Connector

The connector is available in 24, 40, and 70 terminal configurations. It can be used for inline or bulkhead mountings. The connector is frequently used in electronic box applications. The wire size range that the connector will accept is 0.8 mm^2 (18 AWG), 1.0 mm^2 (16 AWG), and 2.0 mm^2 (14 AWG). The plug assembly with interface seal accepts socket terminals and the receptacle (header) assembly accepts pin terminals. Sealing plugs are to be used in unused wire cavities.

The optional Perkins harness uses the DRC 40 terminal configuration. Customer interface with this harness is the 40-position plug connector. This connector is labeled as P61 on engine wiring schematics. The DRC connectors are keyed to align correctly when the two parts are mated together. An allen head screw holds the two connectors in place. Ensure that the Allen head screw is tightened to a torque of 2.25 + 0.25 N•m (20 + 2 lb-in.).

5.1.4 1500/2000 Series A4 ECM 70-Pin Connector

5.1.4.1 ECM 70-Pin Mating Connector (J1)

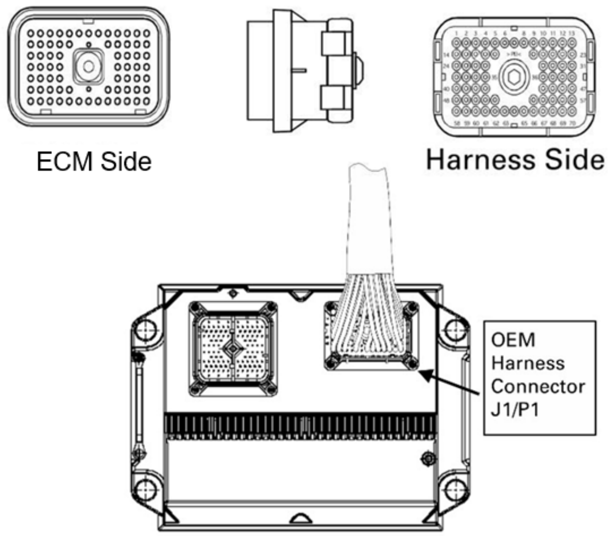
The ECM uses an integral rectangular 70-terminal AMP connector to interface to the OEM vehicle wiring harness (AMP part number 776241-1, Perkins part number 28170123). ECM connector screw torque should be 6 Nm ±1 Nm (4.4 lb-ft ± 0.7 lb-ft, 53 lb-in. ± 8.9 lb-in.). Refer to Figure 1 for connector picture and placement on the ECM.

5.1.4.2 ECM Connector Endbell

An AMP 776498-1 (Perkins part number T402649) connector endbell is available to provide additional protection and controlled wire routing for the harness at the ECM. This is a new part number for the A4 control.

> **Note:** *Unless special arrangements are made with Perkins, the AMP 70-Pin connector and connector endbell are available only through the Perkins parts system.*

Figure 1: 1500/2000 Series A4 ECM Customer Connector (J1)

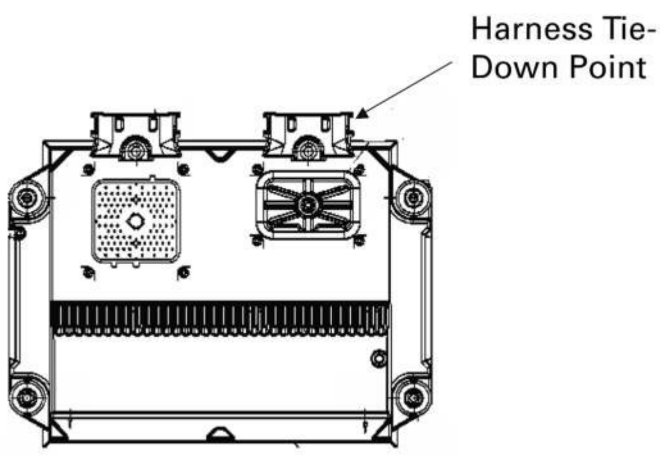


NOTE: See Section 3.2.1.4 1706A/D Connector Panel for the 40-pin Customer Interface

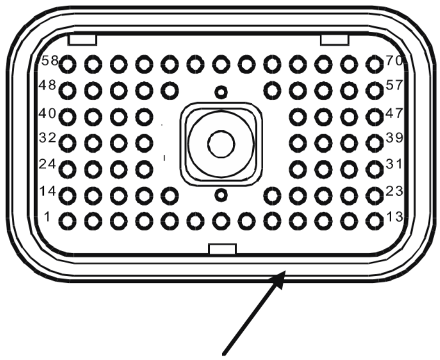
5.1.4.3 ECM Harness Tie-Down Point

The A4 ECM has a harness mounting bracket (Perkins part number CH11932) mounted to the ECM. The wiring harness exiting the ECM connector (J1) must be secured to the ECM housing mounting bracket using a tie wrap clamp (Perkins part number CH11932). The wiring harness design is to adhere to design guidelines such that the ECM harness at the J1 connector meets the requirements defined in Wiring Harness Design (section 5.2).

The wire harness for ECM connector J1 must be secured to the engine within 600 mm from the ECM harness bracket, preferably 300 ± 50 mm. The referenced length is measured along the centerline of the harness bundle. The wire harness is not to be pulled tight between the ECM harness bracket and first engine tie-down point such that the mounting interferes with the ECM shock mounting.



5.1.4.4 ECM 70-Pin Connector Sealing (Weatherproofing)
ECM connector interface seal is serviceable using Perkins part number T402650.



5.1.5 Connector Terminal Contacts
There are two types of terminal contacts available for production use: machined, stamped, and formed. Machined terminal contact, also referred to as a solid contact, is used for low volume harness production and for field repair. Stamped and formed contact is used for high volume harness production and is the lowest cost terminal contact option.

Terminal contacts are available with nickel or gold plating. Gold plating should be used for applications of 5 volts or less and/or less than 100 milliamps. Typically, these low-level circuits require low resistance at the pin/socket connection and gold plating is the best low-cost choice. Nickel-plated contacts can be used in power-type circuits or circuits where low resistance at the pin/socket connection is not a concern.

Gold-plated contacts can be used in all circuit applications regardless of the voltage and current requirements. Gold plating provides some marginal improvement in vibration versus nickel plating. Perkins requires that only gold-plated sockets be used in the ECM connector (J1).

Note: *Deutsch nickel-plated stamped and formed terminals are not recommended for use because of excessive voltage drop experience in laboratory tests.*

Wire Usage (AWG-type)	Contact	Type	Plating	Perkins P/N
ECM Connector (J1)				
#14 - All	Socket	Machined	Gold	28170024
#16/#18	Socket	Machined	Gold	2900A016
HD-10/DT Connector (Standard)				
#14	Socket	Machined	Nickel	T400044
#14	Pin	Machined	Nickel	T400048
#16/#18	Socket	Machined	Nickel	T402651

#16#18	Pin	Machined	Nickel	T400927
#14	Socket	Machined	Gold	28170024
#14	Pin	Machined	Gold	28170023
#16/#18	Socket	Machined	Gold	2900A016
#16/#18	Pin	Machined	Gold	T400046
DT Connector (J1939 only)				
#16/#18 (J1939)	Socket (extended)	Machined	Gold	T402652
#16/#18 (J1939)	Pin (extended)	Machined	Gold	T402653

5.1.6 Wire Type and Gauge Size

5.1.6.1 Wire Selection

Wire must be of a type suitable for the application. Wire must be selected so that the rated maximum conductor temperature is not exceeded for any combination of electrical loading, ambient temperature, and heating effects of bundles, protective braid, conduit, and other enclosures. Typical factors to be considered in the selection are voltage, current, ambient temperature, mechanical strength, connector sealing range, abrasion, flexure, and extreme environments such as areas or locations susceptible to significant fluid concentrations.

5.1.6.2 Wire Size

The minimum conductor size used on Perkins products is 0.8 mm^2 (18 AWG). Smaller conductors are susceptible to breakage and fatigue failures. SAE J1614, wiring distribution systems for construction, agricultural, and off-road work machines require wire sizes no smaller than 0.8 mm^2 (18 AWG).

ECM wire size requirements per connection are:

Circuit	Size (AWG)
Battery Negative	14
Positive Battery: Switched	14-18
Positive Battery: Un-switched	14
Digital Sensor Power	16-18
Digital Sensor Return	16-18
Analog Sensor Power	16-18
Perkins Data Link (1) (Not supported on 1706)	18
J1939 (CAN) Data Link (2)	18
Switch to Ground Input	18
Low Side (300 mA) Driver	18
High Side (2 A) Driver	14-16
Active Analog Input	18
Passive Analog Input	16-18
PWM Input	18

(1) T403539 Cable (Twisted Pair)

(2) T402656 Cable (Shielded Twisted Pair)

5.1.6.3 Wire Insulation

Note: *Thermoplastic Polyvinyl Chloride (PVC) insulation shall not be used in wire harness designs because of its low operating temperature range (-40*°C/-40°F *to 85°C/185*°F*), and melt/flammability characteristics.*

Cross Linked Polyethylene (XLPE) is the primary wire insulation type used in chassis, cab, and engine compartment locations. It has a temperature rating of -50°C/-58°F to 120°C/248°F. The voltage rating for Cat1E0815 wire and SAE J1128, Type SXL is 50 volts. The circuit voltage shall be considered when making wire selections. This wire insulation is also available with 50, 150, 300, or 600-volt ratings.

Outside diameter insulation range is 2.26 to 3.33 mm (0.089 to 0.131 in.). The table below provides insulation diameter range for each gauge and wire type.

ECM CONNECTOR WIRE INSULATION AND GAUGE SIZE		
Wire Type	**Wire Gauge**	**Insulation Diameter**
GXL	14	0.114 - 0.125
	16	0.098 - 0.112
	18	0.089 - 0.098
SXL	16	0.116 - 0.131
	18	0.103 - 0.118

METRIC EQUIVALENTS FOR AWG WIRE NUMBERSE							
AWG	20	19	18	16	14	12	4
Diameter	0.5	0.65	0.8	1	2	3	19

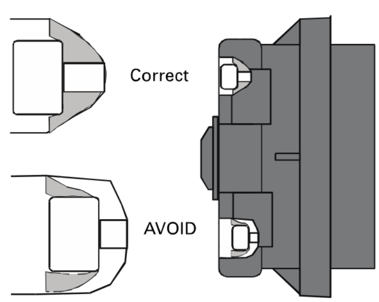
5.1.6.4 Battery Cable Insulation

The preferred minimum cable size for the starting system is 2/0 AWG wire size with a wire specification that meets SAE J1127 for Low Voltage Battery Cable, type SGX. The start motor to frame ground cable shall be no smaller than the battery cables but may need to be larger for dual starting motor systems. This is to ensure that starting currents will be adequately handled in jump-start conditions.

5.1.7 Connector Seal Plug

All unused cavities for sockets and pins must be filled with seal plugs in order to ensure that the connector is sealed. Two options are available for plugging unused connector cavities. Either the Deutsch 114017 (Perkins part number 2900A011) or PEI Genesis 225-0093-000 (Perkins part number T402654) sealing plugs can be used.

Figure 2: Plug Insertion in Unused Connector Cavity



The seal plugs are installed from the wire insertion side of the plug or receptacle. Correct installation of either of these cavity plugs is critical to maintain connector sealing integrity. Figure 2 illustrates the correct insertion of the plug. The seal plug cap is designed to rest against the seal, not inserted in the hole in the seal.

5.2 Wiring Harness Design

5.2.1 Harness Routing

Wiring shall be routed to ensure reliability and to offer protection from the following:

1. Chafing/rubbing/vibrating against other parts.
2. Use as handholds or as support for personal equipment.
3. Damage by personnel moving within the vehicle.
4. Damage by impact or thrown or falling debris.
5. Damage by battery acid fumes, engine and hydraulic oil, fuel, and coolant.
6. Abrasion or damage when exposed to rocks, ice, mud, etc.
7. Vandalism damage (to the maximum extent practicable).
8. Damage by moving parts.
9. Harsh environment such as nitrite mines, high temperatures, or areas susceptible to significant fluid or fume concentration.

Wire harnesses shall not be in close proximity to oil and fuel fluid fill areas or below fuel and oil filter locations. If these locations cannot be avoided, additional protective covers and shields must be provided to protect the harness.

Harnesses shall be located a minimum of 50 mm from high heat sources (e.g. exhaust manifolds, turbochargers, hydraulic components, etc.) to avoid insulation and/or connector deterioration.

5.2.2 Maintenance Considerations

The maintainability of the wiring system shall be an important consideration in the selection, design, and installation of harnesses, cable assemblies, and other wiring system components. All wiring components shall be accessible, repairable, and replaceable (i.e. connector terminals).

High-pressure wash systems are now in frequent use by maintenance people. When locating electrical connectors, place them in accessible locations while using other physical elements for protection and prevention of direct exposure to wash systems (e.g. brackets, housings, sheet metal structure, etc.). Where direct exposure to high pressure wash systems cannot be avoided, protective shields will need to be designed and installed.

5.2.3 Appearance

The primary purpose for the wiring system is to provide electrical and electronic component function. There is, however, another important and intangible value to consider when designing the wiring system. The appearance of the wire harness and its routing path should reflect an orderly, well-thought-out design plan. A poorly executed plan can have a negative impact on customer perceptions of the entire product. Use the product’s horizontal and vertical lines for routing paths. Design preformed bends into large harnesses to facilitate product assembly and improve appearance. Use other product elements to shield or hide the harness from view. Benchmark new automotive product applications for ideas.

5.2.4 Harness Bends

Routing of the harness should insure connector seals are not stressed because the harness curvature is too close to the connector. This applies to routing of customer lines on or near the engine harness as well as the ECM customer connector (J1/P1) and 1700 Series 40-Pin Customer Connector.

The minimum bend radius for a braided wire harness as measured from the inside of the bend shall be four times the outer diameter of the harness. Tighter bends are possible if the bend is pre-formed during harness manufacture. The bend radius size and location must be specified on the wire harness drawing.

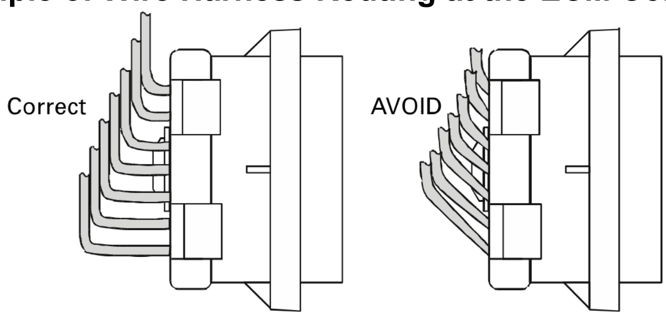
Bends in jacketed cables shall be based on manufacturer recommendations. A bend must not adversely affect the operating characteristics of the cable. For flexible coaxial cables, the bend radius must not be less than six times the outside diameter. For semi-rigid coaxial cable, the bend radius must not be less than ten times the outside diameter of the cable.

The minimum bend radius for flexible conduit must be six times the outer diameter of the conduit. Conduit bends shall not cause internal chafing of the wiring.

5.2.5 Harness Bends near Connectors

Avoid wire harness bends within 25 mm (1 in.) of the connector. When a harness bend is too close to the connector, the connector seal is stretched away from the wire, providing an opening for moisture entry. The wire should exit perpendicular to the connector before curving as necessary for routing. Refer to illustration in Figure 3.

Figure 3: Example of Wire Harness Routing at the ECM Connector



Wire harness bends near a connector must be no less than twice the wire harness diameter. Special consideration shall be given to connectors with large wire counts. Stresses placed upon the retention system of the connector can cause contact retention failures and wire pull-out. To avoid this problem, consider the following options:

1. Pre-form the harness to the required bend. The harness assembly drawing shall detail the harness bend requirements (e.g. location and radius). The harness braid protection should be applied up to the tangent point of the bend furthest from the connector. Connector orientation to the bend may be necessary and should be specified on the harness print.
2. If harness braiding is used, increase the unbraided harness length to 150 mm. This will allow the wires to fan out when the harness is bent, greatly reducing the forces placed on the connector contact retention system. The connector should also be oriented properly with respect to the harness so that upon installation to the product the harness will not need to be twisted to align the connector.
3.

5.2.6 Drip Loop

When a harness is routed downward to a connector, terminal block, panel, or junction box, a trap or drip loop shall be provided in the harness. This feature will prevent fluids or condensate from running into the above devices.

5.2.7 Sealing Splices and Ring Terminals

Perkins requires all ring terminals and splices connected to the engine ECM be sealed using Raychem ES2000 adhesive lined heat shrink tubing or equivalent. Refer to Table 1 for heat shrink tubing sizing information.

Table 1: Heat Shrink Tubing Reference Table

Perkins Part Number	I.D. Before Shrink		I.D. After Shrink	
	(mm)	(inch)	(mm)	(inch)
T403529	5.72	0.225	1.27	0.050
T403530	7.44	0.293	1.65	0.065
T403531	10.85	0.427	2.41	0.095
T402657	17.78	0.700	4.45	0.175

5.2.8 Wire Connection Guidelines

The following requirements ensure the correct installation of solid contacts into connector terminals:

- Do not solder the contact (socket or pin) to the wire.
- Never crimp more than one wire into a contact. Connector contacts are designed to accept only one wire of a specified gauge or gauge range, do NOT insert multiple wires of a smaller gauge.
- All contacts should be crimped on the wires. Use the Crimp Tool (Perkins part number CH11155) for 12 to 18 AWG wire.
- Perform the pull test on each wire. The pull test is used to verify that the wire is properly crimped in the contact and the contact is properly inserted in the connector terminal. Each contact and connector terminal should easily withstand 45 N (10 lb.) of pull such that the wire remains in the connector body.

5.2.9 ECM Guards

Petroleum ATEX engines require additional guards to meet ATEX directives. The guards are added to protect against physical damage that may result from falling tools or debris. The guards are utilized to reduce the chance of an arc or spark.

Guards supplied with all ATEX engines include an ECM guard and a valve cover base wire entry guard. The fuel temperature sensor on 2806 engine has a guard as well.

> **Note:** *All guards must be kept in place during engine operation. Any guard that has been removed, modified, or replaced with a non-certified guard will void the ATEX certification.*

5.3 Customer Supplied Service Tool Connector (J66) Wiring

NOTE: This harness is standard on the 1506/1706 engines. On the 1506, it is shipped loose. On the 1706, it is installed from the factory.

A standard Perkins customer harness is available and is called a “Harness — ECM Interconnect” in the ElectropaK Price List’s Optional Attachments. This standard customer harness provides a service tool connector designated as J63. If this customer harness is not utilized, a customer supplied service tool connector is required. The schematics listed in sections 2.5.1 through 2.5.3 designate this customer supplied service tool connector as J66. The Perkins service tool cable (part number T402655) has a Deutsch HD 9position plug connector, thus the customer must supply the mating receptacle on the engine harness.

For an engine compartment-mounted diagnostic connector, Perkins recommends grounding the engine data link connector directly to the engine ground stud. It must not be grounded to ECM sensor common connections.

The Perkins Service Tool (EST) communicates with ElectropaK engines via the Perkins Data Link only. Service tool support is not available on the J1939 data link.

It is recommended that one service tool connector is near the engine, and a second service tool connector is located in the machine cab or at the operator station. Proper wiring of the customer-supplied service tool connector is essential for reliable communications. The maximum length of the Perkins Data Link cable is 30 meters (100 ft).

Figure 4 illustrates the pinout location on the Deutsch HD 9-position connector for ease of reference. All customer-supplied wiring shown in Figure 4 is required. This includes power and ground as well as all Perkins Data Link and J1939 data link wiring. Wiring from the ECM to the service tool connector is illustrated in Figure 5. The Perkins Data Link wiring should be twisted two-conductor cable (18 AWG wire) with one twist per 25 mm (approx. 1 inch). See section 5.4 for J1939 Data Bus wiring requirements.

> **Note:** *ElectropaK engine communication to Perkins EST is via Perkins Data Link only. SAE J1939 data link is not used for Perkins EST communication at this time.*

Figure 4: Service Tool Connector Pin Locations

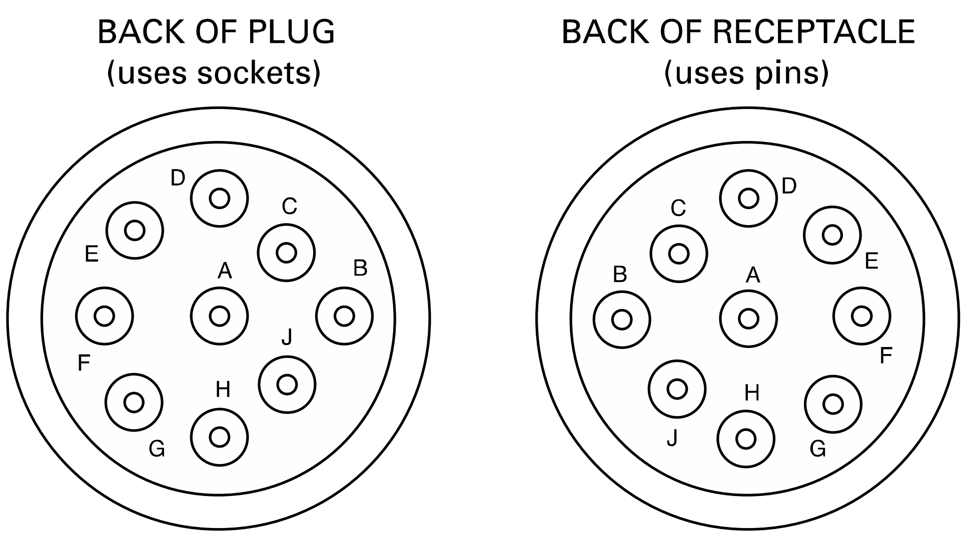
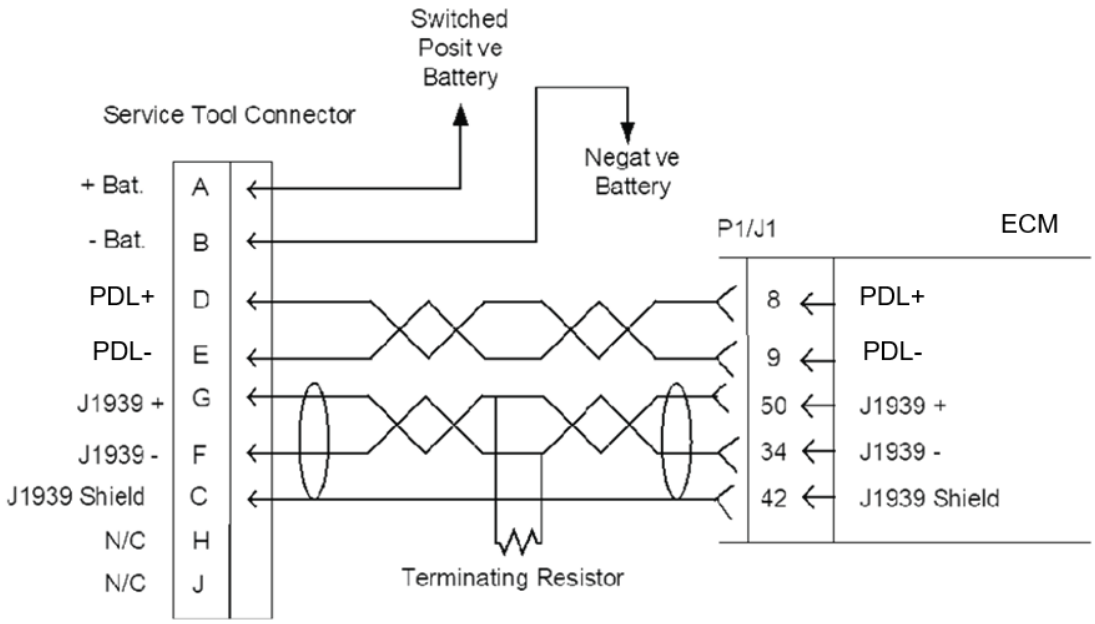


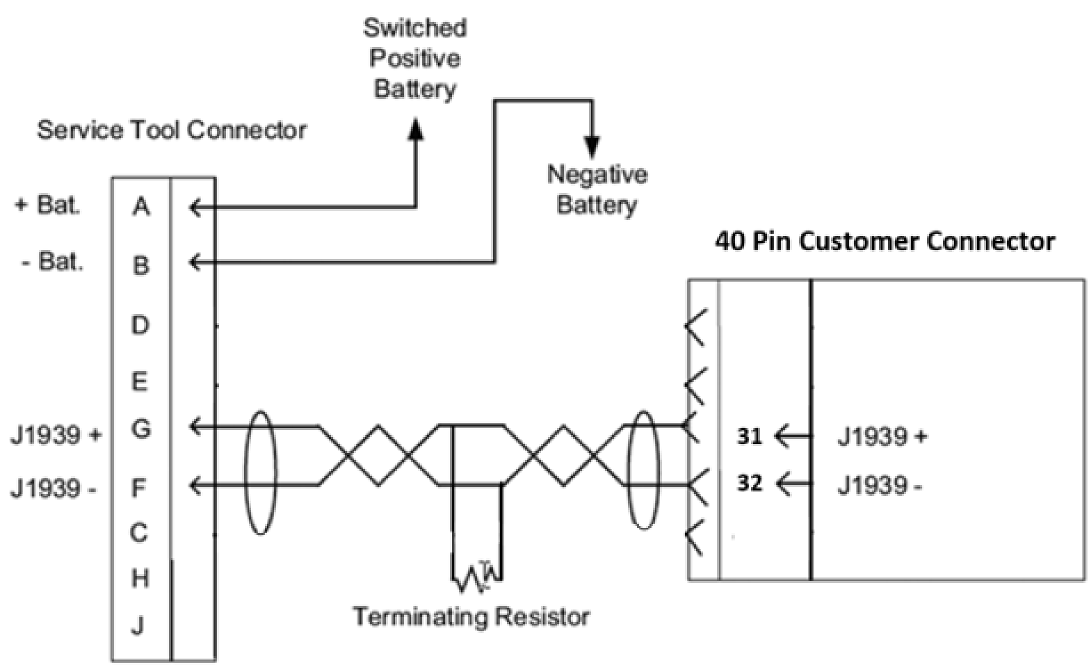
Figure 5: 1500/2000 Series Service Tool Connector Wiring Diagram



Note: *All 7 wires, J1939, Perkins Data Link, power and ground as shown in this diagram are required.*

Note: *The ECM provides the only ground necessary for the J1939 Shield. Do not apply any other grounding to this line.*

Figure 5A: 1700 Series Service Tool Connector Wiring Diagram (Provided by factory)



5.4 SAE J1939/11 — Data Bus Wiring

5.4.1 J1939 Data Bus Harness Design

The data bus connector that Perkins uses is a modified DT connector, special wedge, cable, and extended socket. The harness assembly requirements are unique to typical Perkins wire harnesses. Perkins recommends 2 conductor shielded cable from Raychem Corp (Raychem part number 2019D0309-0/Perkins part number T402656) for all J1939 data link wiring. This is twisted pair wiring. If the Perkins recommended cable is not used, the cable must meet J1939 specifications for conductors (refer to Table 2). For additional information regarding the electrical system design see the SAE publication J1939/11 "Physical Layer." The minimum bend radius for the data bus cable is 40 mm.

Table 2: J1939 Conductor Specifications

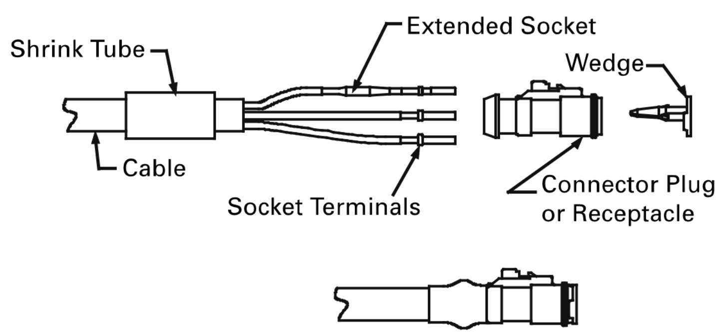
J1939 SPECIFICATIONS FOR CONDUCTORS			
	Minimum	**Nominal**	**Maximum**
Impedance (ohm)108	120	132	1.27
Capacitance between conductors (pF/m)0	40	75	1.65
Capacitance between the	10.85	0.427	2.41
conductors and the shield (pF/m)0	70	110	4.45

In order that the data bus will function as intended the following requirements must be identified on the customer wire harness print.

1. Remove 75 mm of the outer jacket of data link shielded cable. (Reference Perkins part number T402656)
2. Remove the foil shield from the exposed wires to within 3 mm of the cable jacket end.
3. Crimp gold-plated socket terminals to the wires and the extended socket terminal to the drain wire.
4. Slide heat shrink tube over the cable end. (Reference Perkins part number T402657)
5. Install the terminals into the appropriate connector cavity positions.
6. Install the wedge into the connector.
7. Apply the heat shrink tube over the back of the connector body and the jacket of the cable.

The above components and assembly procedures must be used to ensure the cable to connector joint will be sealed. Failure to conform to these requirements will result in cable contamination and result in loss of shield performance. See Figure 6.

Figure 6: SAE J1939 Connector Assembly



Note: *Refer to SAE J1939-11 "Physical Layer" document for more information.*

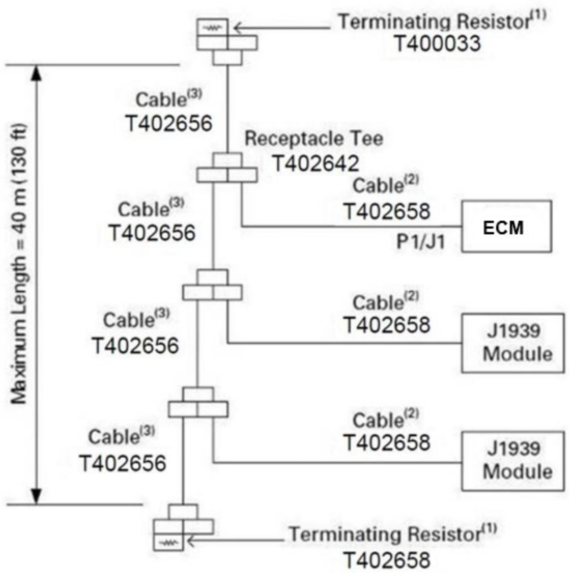
5.4.2 Connecting Modules to the CAN Data Link

The SAE J1939 data link is used to communicate engine information to an SAE J1939 compatible display or other desired SAE J1939 compatible modules. Refer to SENR9764 “Installation Guide for Industrial Electronic Engine Displays” for more information on connecting J1939 displays to Perkins ElectropaK engines.

The illustration in Figure 7 shows two J1939 modules properly connected to the J1939 data bus. The key components to note are as follows:

- The total length of the data link between terminal resistors must not exceed 40 m (130 ft).
- Length of each branch, or stub length, must not exceed 1 m (3.3 ft). Reference cable assembly (Perkins part number T402658) that is .15 m long with Deutsch DT 3 pin plug on one end and J1939 signal and shield wires with appropriate crimped socket on the other end for insertion into J1939 module connector.
- All splices and end nodes can be implemented using a connector tee. (Reference Deutsch DT receptacle assembly — Perkins part number T402642).
- Two terminal resistors must be installed. One resistor is required at each end of the data link to ensure proper operation. These two terminal resistors are critical for the proper operation of the network. (Reference Deutsch DT plug with integrated termination resistor — Perkins part number T400033).

Figure 7: J1939 Multiple Module Installation Example



Note: *If the requirements for J1939 data link connections are met, any number of display modules or service tool connectors may be connected to the J1939 data link.*

Note: *One terminal resistor for the J1939 data link is included in the optional customer harness. If the optional customer harness is not present, two terminal resistors must be installed. Any J1939 data link must have a terminal resistor at each end of the data link.*

Note: *A terminal resistor is required at the terminal ends of the data link cable. A terminal resistor is not required at each node on the data link.*

Note: *The shield for the J1939 data link must be grounded at one central point of data link cable. Do not ground at both ends. Grounding at only one point helps to prevent ground loop interference.*

6.0 Customer Equipment I.D. and Passwords

6.1 Equipment Identification

6.1.1 Equipment Identification Operation

Equipment Identification is a configuration parameter that the customer can program in the ECM to uniquely identify an engine installation. Typical uses for the equipment identification parameter include manufacturer model number, machine number, installation location, etc. Configuration of this parameter is optional as the parameter is for customer reference only.

6.1.2 Equipment Identification Configuration

One parameter must be updated with Perkins EST to set the equipment ID. The equipment ID defaults to "not programmed" and can be set to a customer-defined identification for the engine. A maximum of 17 characters may be entered in the field. Characters can be any alphanumeric character.

6.2 Customer Passwords

6.2.1 Customer Passwords Operation

Customer passwords are sometimes referred to as "OEM passwords." Customer passwords may be programmed to limit access to certain parameters. There are two customer passwords available. Both customer passwords do not need to be programmed to provide protection. If both customer passwords are programmed, then both are required to access and change the password-protected parameters. If a customer password is forgotten or lost, these can be reset, but factory passwords are required to change them.

The following parameters are protected with customer passwords:

- Throttle Position Sensor
- Coolant Level Sensor

6.2.2 Customer Passwords Configuration

One or two parameters must be configured in Perkins EST prior to using customer passwords:

1. Customer Password #1
2. Customer Password #2

Both passwords default to an empty field. Whether the password is set or not, the display shows "********". A maximum of eight alphanumeric characters may be entered for each of the two available customer passwords. These passwords are case sensitive.

Note: ***Customer Password changes do not take effect until EST is disconnected.***

7.0 Factory Configured Parameters

7.1 Engine Serial Number

7.1.1 Engine Serial Number Operation

The engine serial number is programmed in the factory during engine assembly. It is used to identify the engine to electronic monitoring systems and the Perkins EST service tool. The programmed engine serial number should match the engine serial number stamped on the engine information plate.

7.1.2 Engine Serial Number Configuration

One parameter must be configured in Perkins EST to change the engine serial number. The engine serial number defaults to the engine serial number set in the factory. Engine serial number should be programmed to match the engine serial number that is stamped on the engine information plate. If the ECM is replaced, the engine serial number from the engine information plate should be programmed into the new ECM.

7.2 Rating Number

7.2.1 Rating Number Operation

ElectropaK engine software can support multiple engine ratings in a software flash file. The multiple ratings allow the customer to change the performance and operating characteristics of the engine without changing the engine performance iron. The engine rating and number of ratings supported in the software flash file is specific to a set of engine performance iron. A rating number is assigned to each engine power curve within a software flash file. The rating number is set in the factory to the corresponding number for the rating specified by the customer in the engine order.

> **Note:** *The customer should carefully consider the rating required prior to purchase. A rating change after purchase may require an iron update and will incur an up-rate charge for the specified rating or a minimum maintenance fee to update engine documentation*

7.2.2 Rating Number Configuration

One parameter must be configured in Perkins EST to change the engine rating. Changing the rating number requires factory passwords. The rating number defaults to the engine rating set in factory and can be set to any other rating supported within the software flash file. The available engine ratings peak torque and rated power are correlated to a rating number that is displayed in the Perkins EST configuration screen. All rating changes will result in an up-rate charge for the specified rating or a minimum maintenance fee to update engine documentation.

7.3 FLS (Full Load Setting)

Changing FLS or FTS may void your engine warranty or make your engine non-compliant with applicable emissions regulations. FLS is a number that represents the adjustment to the fuel system that was made at the factory to set the engine to a factory-defined nominal power. The correct value for this parameter is stamped on the engine information plate. Factory passwords are required to change FLS. Contact Dealer Support network prior to changing FLS.

7.4 FTS (Full Torque Setting)

Changing FLS or FTS may void your engine warranty or make your engine non-compliant with applicable emissions regulations. FTS is similar to “FLS” in that it is a calibration parameter set at the factory. Factory passwords are required to change FTS. Contact Dealer Support Network prior to changing FTS.

8.0 Stopping the Engine

8.1 Auxiliary Engine Shutdown Switch (Only available on 2806 PD Engines)

8.1.1 Auxiliary Engine Shutdown Switch

An auxiliary shutdown feature is provided to allow a convenient method of stopping the engine from a remote position, other than the key switch/control panel. The feature provides a rapid shutdown function without removing power from the ECM. It is not designed to be a fail-safe device and should not be used to assure the protection of either personnel or equipment. A large, red, mushroom-type E-stop button must not be used for the auxiliary stop switch.

Once activated, the ECM latches into an injection disabled state. An active event will appear while the auxiliary shutdown is engaged or latched. The event code is 970-31 (Engine Auxiliary Engine Shutdown Switch). To restart the engine, the switch must be reset and the ECM must be reset. This can be accomplished in 3 ways. The first is using the latch reset input. The second is removal of unswitched battery power via the battery disconnect switch for 3 seconds. The third option is to send a DM11 message (PGN 65235) over J1939.

8.1.2 Auxiliary Shutdown Switch Configuration (2806PD)

There is no Perkins EST configuration necessary for the axillary shutdown switch to function.

8.2 J1939 Engine Shutdown

8.2.1 J1939 Engine Shutdown Operation

ElectropaK engine software released November 2007 and later (see the software availability chart that follows) provides the J1939 Engine Shutdown feature with the purpose of allowing another controller to command the engine control, via the J1939 data link, to disable fuel injection and shut down the engine. **The device requesting the shutdown must broadcast the request over the data link at a one-second interval until the engine has stopped completely.** Fuel injection will be enabled if the requesting device changes the broadcast message from “Shutdown” to “Run” or if the engine control does not receive and shutdown request within three seconds of the last broadcasted request. An ECM reset also enables fuel injection since the engine control software will initialize to the “Run” status. Refer to Section 12.1.2 for more detail on the J1939 Parameter Group Number (PGN) used for the broadcast of the engine shutdown request.

Engine Model	Rated Power (h)p	J1939 Engine Shutdown Availability	Engine Model	Rated Power (hp)	J1939 Engine Shutdown Availability
1506	275	No	2506	475	No
1506	300	No	2506	540	Yes
1506	325	Yes	2506	580	Yes
1506	350	No	2506	595	Yes
1506	375	No	2806	575	Yes
1706	ALL	Yes	2806	600	Yes
2206	475	No	2806	630	Yes
2206	520	No			
2506	440	No			

Note: *This chart shows availability at the time of publication, for more current information, contact the Perkins DSN.*

8.2.2 J1939 Engine Shutdown Configuration

There is no EST configuration necessary for the J1939 Engine Shutdown to function.

8.2.3 J1939 Engine Shutdown Installation

No installation is required to implement the J1939 Engine Shutdown feature.

8.3 Emergency Shutdown

It is the customer's responsibility to complete a risk assessment on their product when considering the use and function of an emergency stop device.

The most appropriate method of emergency stop will depend on the application and appropriate industry regulations. Using a combination of the methods below may provide a more robust emergency stop solution. Using the emergency stop in situations other than an emergency could result in engine damage. In the event of an injector failure, cutting electrical power on electronic engines may not stop the engine.

Perkins 1500/1700/2000 ElectropaK Software does not provide an emergency shutdown feature. The 2806 PD Auxiliary Shutdown feature discussed in Section 8.1 cannot be used as a standalone emergency shutdown method to assure the protection of either personnel or equipment.

For 1500/1700/2000 non PD engines the options described below may be used in conjunction with other emergency shutdown methods.

Cut electrical power to engine – Unswitched positive - Power should be isolated between the battery positive terminal and the battery positive pins on the engine ECM.
Cut electrical power to engine – Un-switched positive and negative - Power should be isolated between the battery positive terminal and the battery positive pins on the engine ECM. Cutting negative return - A double pole/double throw switch should be placed in a position on Genset that will ensure main negative power and main positive power are disconnected upon switch activation.
Cut air supply to engine - Slicer valve placed after the turbocharger compressor.

9.0 Engine Speed Demand

The ECM is provided with 3 speed adjustment inputs for load sharing/synchronising i.e. a PWM input, an analogue input and a digital (push-button or relay) input. For flash files dated November 05 or later, a speed control via J1939/CAN bias is also available.

There are 3 speed adjustment input options available for load sharing/synchronising used by the ECM to control engine speed. The application requirements determine which option, or combination of options, should be selected. Following are the different methods of controlling the speed of the engine:

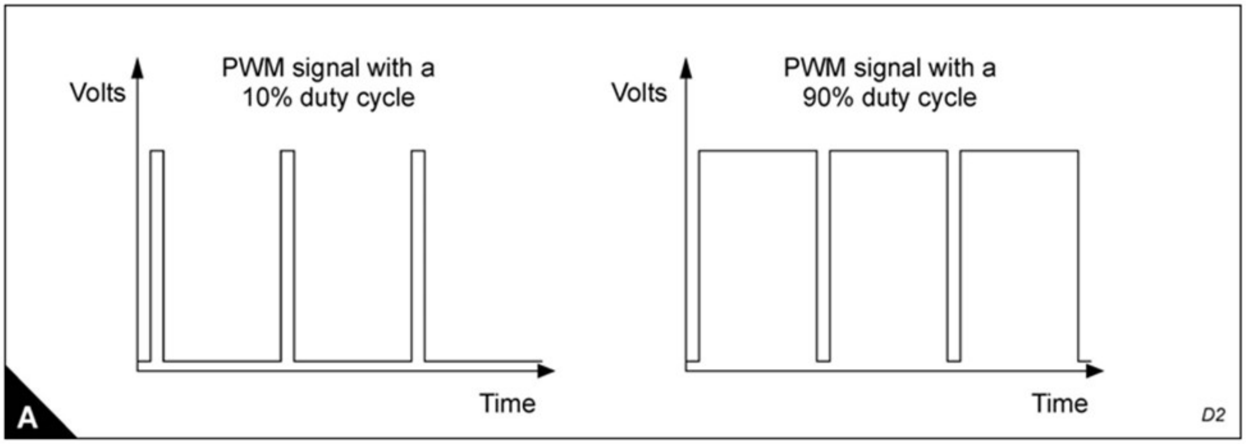
- PWM Speed Control Input
- Analogue Speed Control Input
- Digital Speed Control Input
- J1939 Speed Control (TSC1) Data Link Command

The service tool is used to enable either the analogue or PWM input via a customer password. Changing between analogue and PWM input selection is only possible when the engine is stationary.

9.1 PWM Speed Control

9.1.1 PWM Speed Control Operation

The PWM input is a single ended nominal 500 Hz with a duty cycle of 10-90%. The duty cycle range equates to a desired speed adjustment of between -24% and +8% of rated speed. The 0% shall equate to the nominal desired speed setting.



Note: The PWM speed adjustment range is pre-set and cannot be changed.

9.1.2 PWM Speed Control Configuration

The ECM views the desired speed when a valid PWM signal is detected on the PWM Input of the ECM. The speed range is preset and cannot be changed. Using Perkins EST, the “PWM” must be programmed in the Desired Speed Input Configuration parameter for this feature to be enabled. Default is the Analogue “0-5 VDC”. This parameter is used to select the input for Primary speed input. The Secondary Desired Speed Input Configuration is defaulted to J1939. If this input is the only desired speed input, then the Secondary speed input must be programmed “Not Installed”.

9.1.3 PWM Speed Control Installation

Refer to Application Wiring Schematic or OEM Connection Diagram in section 3 for wiring details.

9.2 Analogue Speed Control Input

9.2.1 Analogue Speed Control Operation

The analogue speed adjustment is nominally a 0 to 5V analogue voltage input. The voltage is referenced to the ECM analogue ground reference voltage. The input range for the analogue speed input is 0.5 to 4.5V. The speed range of the analogue control is determined by the settings from the service tool. The maximum is +/150 RPM.

9.2.2 Analogue Speed Control Configuration

Using Perkins EST, the “0-5 VDC” must be programmed in the Desired Speed Input Configuration parameter for this feature to be enabled. Default is the Analogue “0-5 VDC”. This parameter is used to select the input for Primary speed input. The Secondary Desired Speed Input Configuration is defaulted to J1939. If this input is the only desired speed input, then the Secondary speed input must be programmed “Not Installed”.

9.2.3 Analogue Speed Control Installation

Refer to Application Wiring Schematic or OEM Connection Diagram in section 3 for wiring details.

9.3 Digital Speed Control

9.3.1 Digital Speed Control Operation

Digital speed control enables the engine speed to be controlled by digital loadsharing and synchronising equipment and the engine can interface directly with manual synchronising selector switches or push-buttons. To provide this facility the ECM incorporates speed raise/lower inputs and a digital speed control enabled switch.

- Digital speed control enable. ○ A switch input when closed enables the speed to be adjusted using the digital speed raise/lower inputs. The input is a low side input, connected to ground to enable.
- Digital speed control ramp rate. ○ This parameter is adjustable via the service tool and determines the rate of change of engine speed using the raise/lower digital inputs, it is scaled in steps of rev/min/sec.
- Digital speed control - raise speed. ○ This switch raises the engine speed at a rate defined by the digital speed control ramp rate. The adjustment range is +/- 150 rev/min of nominal speed, this range can be set using the service tool. This input is a low side input, connected to ground to enable.
- Digital speed control - lower speed. ○ This switch lowers the engine speed at the rate defined by the digital speed control ramp rate. The adjustment range is +/- 150 rev/min of nominal speed, this range can be set using the service tool. This input is a low-side input, connected to ground to enable.

The digital speed control is capable of being enabled at any time i.e. not password protected but the selection only comes into effect when the engine is stationary. This feature is enabled when Digital Speed Control Enable switch is closed to ECM digital return pins 5 or 18 of J1/P1 (pins 12 or 22 on the 1706 40-Pin connector).

9.3.2 Digital Speed Control Configuration

The Digital Speed Control Installed parameter must be programmed to “Installed” using Perkins EST.

9.3.3 Digital Speed Control Installation

Refer to Application Wiring Schematic or OEM Connection Diagram in section 3 for wiring details.

9.4 J1939 Speed Control (TSC1) (Data Link Command)

9.4.1 J1939 Speed Control (TSC1) Operation

J1939 CAN speed control is available via the J1939 data link (TSC1 modes 1 and 3). J1939 CAN data link engine speed control signals will override any engine speed control signal with the exception of intermediate engine speed.

9.4.2 J1939 Speed Control Configuration

There is no configuration required to use J1939 speed control. Previous model engines used a parameter called desired speed input configuration. This parameter is no longer required. Refer to J1939 Section for more detail on the J1939 CAN TSC1 message.

9.4.3 J1939 Speed Control Installation

If a customer requires engine control through the SAE J1939 data link, the data link wiring must be properly installed. See the Connectors and Wiring Harness Requirements section for proper data link installation information.

9.5 EST Override (Dyno Test Mode)

The EST override (dyno test mode) is only for engine test purposes. This feature may not be supported by all versions of EST.

9.6 Low Idle Speed

9.6.1 Low Idle Speed Operation

Low Idle Speed is a programmable parameter that allows the customer to program the engine's low idle speed. Low idle speed is the minimum allowable operating speed for the engine.

9.6.2 Low Idle Speed Configuration

One parameter must be configured in Perkins EST to program low idle speed. Low idle speed must be set to the customer's desired minimum operating speed. Typically, Low Idle defaults to 1100 rpm and can be programmed from 900 to 1100 rpm on 1706 and 2806 PD. On 1506 and 2000 series engines, the range is 600 to 1200 rpm.

9.6.3 Low Idle Speed Installation

No installation is necessary.

9.7 Engine Acceleration Rate

9.7.1 Engine Accel. Rate Operation

Engine Accel. Rate is a programmable parameter. It allows the customer to program the acceleration and deceleration rate during intermediate speed operations. See Intermediate Engine Speed for further information.

9.7.2 Engine Accel. Rate Configuration

Refer to Intermediate Engine Speed configuration.

9.7.3 Engine Acceleration Rate Installation

No installation is necessary.

10.0 Load Calculations

10.1 Load Factor

Load Factor is the percentage of maximum possible load that the engine can produce under the current operating conditions. For example, if the load factor is 50 percent, the engine is currently loaded to 50 percent of the load that it can accept under the current operating conditions. Load factor can be viewed with Perkins EST as a current measured value in the Status screen, as an average over the life of the engine in the Current Totals screen, and in 2-D and 3-D histograms over the life of the engine in the Histograms screen.

Average load factor provides a good indication of how hard an engine has worked over the engine operating life. This parameter is calculated using maximum fuel, idle fuel, and fuel used. Following is the equation used to calculate average load factor:

$$\text{Average Load Factor (\%)} = \frac{\text{(Total Actual Fuel Consumed - Total Idle Fuel Consumed)}}{\text{(Maximum Possible Fuel Consumed - Maximum Possible Idle Fuel Consumed)}} * 100$$

Where:

Total Actual Fuel Consumed: time integral of the fuel consumption rate (liters/hr.) / 13,623

Total Idle Fuel Consumed: time integral of idle fuel rates (liters/hr.) / 13,623 (idle = 550 to 1150 rpm)

Maximum Possible Fuel Consumed: time integral of rated fuel rate (liters/hr.) / 13623

Maximum Possible Idle Fuel Consumed: time integral of maximum idle fuel rate (liters/hour) / 13623

Note: *Rated Fuel Rate considers: fuel temp compensation, torque limit maps, white smoke map, FARC map, turbo outlet pressure, engine speed, atmospheric pressure, and other engine operating conditions.*

10.2 Percent Load

Percent Load provides information on how hard the engine is operating compared to the maximum possible output. It is calculated using maximum fuel, idle fuel, and fuel used. The details of this calculation are shown below:

$$\textbf{Percent Load (\%)} = \frac{\textbf{(Actual Fuel – No Load Fuel)}}{\textbf{Speed Fuel – No Load Fuel)}} \textbf{X 100} \quad \textbf{(Rated}$$

11.0 Engine Monitoring and Protection

The engine control system provides an Engine Monitoring System to monitor critical system parameters for conditions that can damage the engine. The ECM monitors the following sensor signals:

- Fuel Pressure Sensor
- Fuel Temperature Sensor
- Engine Coolant Temperature Sensor
- Engine Oil Pressure Sensor
- Engine Speed/Timing Sensors
- Inlet Air Temperature Sensor
- Exhaust Temperature (calculated value)
- Engine Oil Temperature (Optional for 2806 PD engines)
- Coolant Level (1706/2206/2806 EP including PD)

The monitoring system has programmable settings that give the customer the ability to customize how the engine control system reacts to possible engine, or system, damaging conditions. The settings the customer can program determine when the control system should act and what level of action the ECM should take in response to the harmful condition. The levels of action the ECM can be configured to take are defined as follows:

- Warning (Least Severe) — warn operator of the critical condition
- Derate (Moderate Severity) — reduce engine power to a safe operating level
- Shutdown (Most Severe) — shutdown the engine

The level of action the ECM can be configured to take is dependent on the operating condition that is being monitored. Not all action levels are available for each condition. The customer can configure the engine monitoring system to take one, two, or all the ECM action level options for a specific monitored condition. The timing for when the ECM acts is based on set point and time delay settings. A set point and time delay are defined for each monitored parameter action level available for a monitored parameter. The set point is the lower (or upper) limit of a monitored parameter's normal operating range. The delay time is how long the monitored parameter must exceed the set point before the ECM will take the programmed action (warning, derate, or shutdown). Not all set points and delay times can be configured for each monitored parameter.

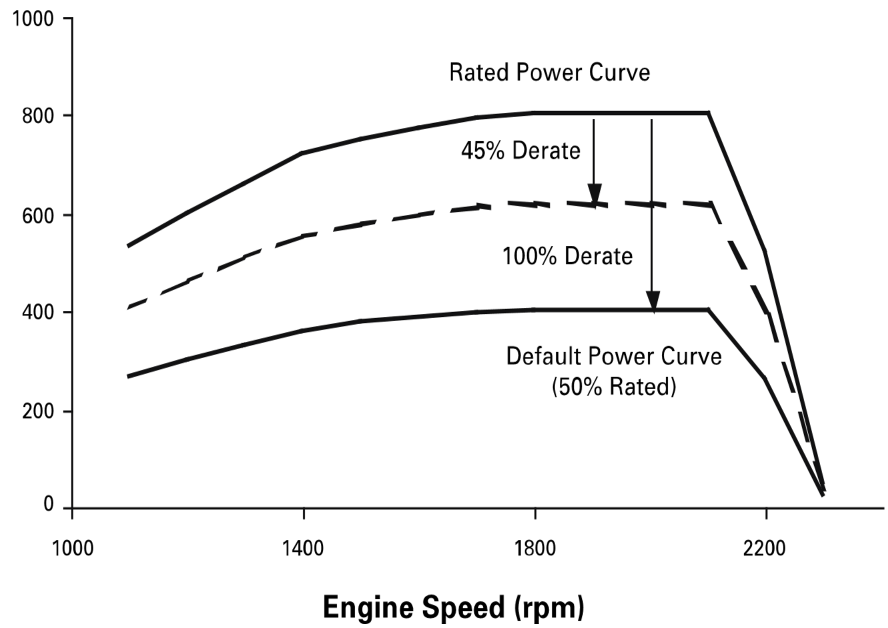
The action level, set point, and time delay settings are configured in the Monitoring System Configuration screen in Perkins EST. The customer does not have the option to change some of the monitoring system settings for certain monitored parameters. The parameter settings that cannot be configured will default to the setting programmed in the factory. See the subsections within Engine Monitoring and Protection section for each of the monitored parameters for more information on configuring the monitoring system.

The following actions are taken by the ECM when a warning, derate, or shutdown condition is detected:

- ECM logs an event code
- Event code information is broadcast on the J1939 CAN data link
- Event code is available for display on Perkins EST
- Warning lamp is turned "ON"
- Diagnostic lamp is turned "ON" (only event codes with flash codes) • ECM performs specified derate or shutdown action

The monitoring system will reduce rated power when derate or shutdown action is specified. The rated power is reduced as a percentage from the rated power at a given engine speed. The percent derate can be a percentage drop from the rated power curve or a percent reduction towards a default power curve. When using a default curve, the default curve is typically set to 50 percent of the rated power curve. Figure 1 illustrates the power derate using a default power curve.

Figure 1: Torque Curve Derate Curve



The power rating is limited in a derate condition, so this does not affect performance unless the power demand is for rated power. In other words, if you have a 10 percent derate but you are only using 10 percent of the rated power, you will have no change in operation.

11.1 Engine Monitoring Parameters

> **Note:** For the monitoring system configuration parameters, the software for ElectropaK engines equates the option “Least Severe (1)” to Warning, “Moderate Severity (2)” to Derate, and “Most Severe (3)” to Shutdown. See Appendix A 5.

11.1.1 Oil Pressure

11.1.1.1 Oil Pressure Monitoring Operation

Engine oil pressure is monitored to automatically protect the engine from operating without sufficient oil pressure. The minimum oil pressure used for low oil pressure monitoring is defined in a graph of minimum oil pressure vs. engine speed. The graph is engine platform specific and has two different curves based on ECM response to low oil pressure condition: Warning curve and Derate/Shutdown curve (refer to graphs below).

1506 TAG Engine Oil Pressure Monitoring

Engine Speed	Warning	Shutdown
rpm	kpa	kpa
0	0	0
500	0	0
1600	154	104
2400	154	104

1706 TAG Engine Oil Pressure Monitoring

Engine Speed	Warning	Shutdown
rpm	kpa	kpa
0	0	0
700	38	28
800	48	38
1400	128	93
1700	148	113
2100	163	128
2400	163	128

2206 TAG Engine Oil Pressure Monitoring

Engine Speed	Derate	Shutdown
rpm	kpa	kpa
0	2	1
500	2	1
580	10	1
800	100	70
1400	150	110
1700	150	110
2100	150	110

2506 – 2806 Standard TAG Engine Oil Pressure Monitoring

Engine Speed	Derate	Shutdown
rpm	kpa	kpa
0	2	1
500	2	1
580	10	1
800	100	70
1400	250	200
1700	250	200
2100	250	200

2806 PD TTAG Engine Oil Pressure Monitoring

Engine Speed	Warning	Shutdown
rpm	kpa	kpa
0	0	0
600	81	45
700	81	45
1200	210	175
1400	235	195
1600	264	232
2200	305	270

The oil pressure measured by the ECM is compared to the minimum oil pressure specified in the oil pressure graph at the current operating speed. The minimum oil pressure is checked for each ECM action level configured in the monitoring system for oil pressure monitoring. If the oil pressure is below the minimum oil pressure for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

Perkins EST Description	J1939 Description	Status	SPN	FMI
Low Engine Oil Pressure	Engine Oil Pressure	Warning	100	17
		Shutdown	100	01

The ECM can respond to the low oil pressure condition with any or all of the following actions: Warning, Derate, and Shutdown. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Derate or Shutdown:

- Derate: Engine power is reduced to 35 percent below rated power over two seconds (at a rate of 17.5 percent/second).
- Shutdown: The engine will shut down immediately.

11.1.1.2 Oil Pressure Monitoring Configuration

One parameter can be configured in Perkins EST to customize the monitoring system for low oil pressure monitoring. The ECM action level is the only programmable setting for oil pressure monitoring. The ECM action level defaults to “On” for Warning and Derate and “Off” for Shutdown. All actions can be configured to “On” or “Off.”

The time delay and set point are defined by the factory and cannot be modified. The following table summarizes the configuration default settings and configuration ranges for all low engine oil pressure monitoring configuration parameters:

1506 Engines					
Low Engine Oil Pressure Monitoring Configuration					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	Always On	None	8	Map	Maps are not programmable. (1)
Shutdown	Always On		4		

(1) Maps are engine model specific.

1706 LRC Engines					
Low Engine Oil Pressure Monitoring Configuration					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	Always On	Not Programmable	8	None	None
Shutdown	Always On		4		

2206 Engines					
Low Engine Oil Pressure Monitoring Configuration					
Action	Default Value	Time Delay (sec)		Set Points (kpa)	
		Range	Default	Range	Default
Warning	On	0-60	60	150-250	200 kpa
Derate	Always On	None	2	Map	Maps are not programmable. (1)
Shutdown	Always On	None	2		

(1) Maps are engine model specific.

2205 - 2806 Standard Tag Engines					
Low Engine Oil Pressure Monitoring Configuration					
Action	Default Value	Time Delay (sec)		Set Points (kpa)	
		Range	Default	Range	Default
Warning	On	0-60	60	250-300	300 kpa
Derate	Always On	None	2	Map	Maps are not programmable. (1)
Shutdown	Always On	None	2		

(1) Maps are engine model specific.

Note: The engine must be running at engine speeds at or above low idle for 10 seconds before the above time delays are triggered.

2806 Power Density Engines					
Low Engine Oil Pressure Monitoring Configuration					
Action	Default Value	Time Delay in Seconds		Set Points	
		Range	Default	Range	Default
Warning (Least Severe)	Always On	Not Programmable	8	Not Programmable	Map
Shutdown (Most Severe)	Always On	Not Programmable	4	Not Programmable	Map

11.1.1.3 Oil Pressure Monitoring Installation

No installation is required for oil pressure monitoring to function.

11.1.2 Coolant Temperature

11.1.2.1 Coolant Temperature Monitoring Operation

Coolant temperature is monitored to automatically protect the engine from exceeding the maximum engine top tank temperature limit. The coolant temperature measured by the ECM is compared to a maximum coolant temperature limit configured in the monitoring system for coolant temperature monitoring. The maximum coolant temperature is checked for each ECM action level configured in the monitoring system. If the coolant temperature is above the maximum coolant temperature for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

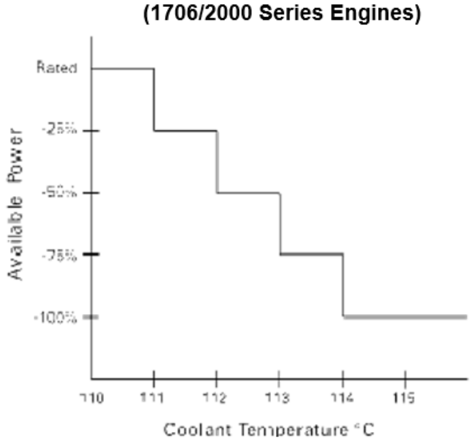
Perkins EST MS Description	J1939 Description	Status	SPN	FMI
High Engine Coolant Temperature	Engine Coolant Temperature	Warning	110	15
		Derate	110	16
		Shutdown	110	00

The ECM can respond to the high coolant temperature condition with any or all the following actions: Warning, Derate, and Shutdown. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Derate or Shutdown:

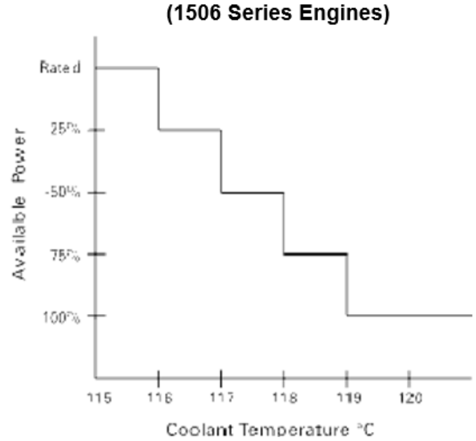
Derate: Engine power is reduced according to the coolant temperature derate graph below. The power is reduced at a rate of one percent/second. The percent derate is a power reduction towards a default power curve. The 100 percent derate is typically 50 percent of the actual rated power at a given speed.

- Shutdown: The engine will shut down immediately.

Coolant Temperature Derate Graph (1706/2000 Series Engines)



Coolant Temperature Derate Graph (1506 Series Engines)



11.1.2.2 Coolant Temperature Monitoring Configuration

Three parameters can be configured in Perkins EST to customize the monitoring system for high coolant temperature monitoring.

1. ECM action for event code defaults to “On” for Warning and Derate and “Off” for Shutdown. All actions can be configured to “On” or “Off.”
2. Time delay to act defaults to 10 seconds for Warning, Derate, and Shutdown. Time delay to derate or shutdown can be set between one and 120 seconds.
3. Coolant temperature maximum limits default is specific to the engine model and is defined in the configuration table on the next page. The maximum temperature limit for warning, derate, and shutdown can be lowered within the range specified in the configuration table that follows.

The following table summarizes the configuration default settings and configuration ranges for high coolant temperature monitoring:

High Coolant Temperature Monitoring Configuration (1506)					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	None	10	None	113°C/235°F
Derate	Off	None	10	None	116°C/241°F
Shutdown	On	None	10	87°C/189°F to 116°C/241°F	116°C/241°F

High Coolant Temperature Monitoring Configuration (1706)					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	None	10	85°C/185°F to 109°C/228°F	109°C/228°F
Derate	Off	1-120	10	86°C/187°F to 111°C/232°F	111°C/232°F
Shutdown	On	1-120	10	87°C/189°F to 112°C/234°F	112°C/234°F

High Coolant Temperature Monitoring Configuration (2206-2806 Standard)					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	On	0-60s	60	95°C/203°F to 105°C/221°F	104°C/219°F
Derate	Always On	None	10	None	105°C/221°F
Shutdown	Always On	None	10	None	108°C/226°F

High Coolant Temperature Monitoring Configuration (2806 PD)					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	Not Programmable	10	85°C/185°F to 109°C/228°F	100°C/212°F
Derate	Off	1 to 120	10	86°C/187°F to 111°C/232°F	102°C/216°F
Shutdown	On	1 to 120	10	87°C/189°F to 114°C/237°F	105°C/221°F

Note: *Perkins EST may allow the Derate Set Point Range to be programmed even though the chart above indicates that it is Not Programmable. If the set point in Perkins EST is altered, this will only change the temperature at which an Event Code is logged. The programmed value will NOT change the temperatures at which the engine takes action in Derate.*

Note: *The engine must be running at engine speeds at or above low idle for 180 seconds before the above time delay is triggered.*

11.1.2.3 Coolant Temperature Monitoring Installation

No installation is required for coolant temperature monitoring to function.

11.1.3 Engine Speed

11.1.3.1 Engine Speed Monitoring Operation

Engine speed is monitored to automatically protect the engine from exceeding the maximum engine or drivetrain speed limit. The engine speed measured by the ECM is compared to a maximum engine speed limit configured in the monitoring system for engine speed monitoring. The maximum engine speed is checked for each ECM action level configured in the monitoring system. If the engine speed is above the maximum engine speed for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

Perkins EST Description	J1939 Description	Status	SPN	FMI
Engine Overspeed	Engine Speed	Warning	190	15
		Shutdown	190	00

The ECM can respond to the engine overspeed condition with any or all the following actions: Warning and Shutdown. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Shutdown:

- Shutdown: The engine will shut down immediately.

11.1.3.2 Engine Speed Monitoring Configuration

Two parameters can be configured in Perkins EST to customize the monitoring system for engine overspeed monitoring.

1. ECM action for event code defaults to “On” for Warning and Shutdown. All actions can be configured to “On” or “Off.”
2. Engine speed maximum limit default is specific to the engine model and is defined in the configuration table below. The maximum speed limit for warning and shutdown can be lowered within the range specified in the configuration table below.

The time delay is defined by the factory and cannot be modified. The following table summarizes the configuration default settings and configuration ranges for engine overspeed monitoring:

1506 Engines					
Engine Overspeed Monitoring Configuration					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	None	1.0	None	2200 RPM
Shutdown	Always On	1-5	1.0	1200 to 2400 RPM	2300 RPM

1706 Engines					
Engine Overspeed Monitoring Configuration					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	None	0.6	1200 to 2400 RPM	2070 RPM
Shutdown	Always On	None	0.6	1200 to 2400 RPM	2124 RPM

2206 – 2806 Standard Engines					
Engine Overspeed Monitoring Configuration					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	On	None	1.0	1650-2050 RPM	2000 RPM
Derate	Always On	None	0.0	None	2050 RPM
Shutdown	Always On	None	0.0	None	2140 RPM

Engine Overspeed Monitoring Configuration (2806 PD)					
		Time Delay in Seconds		Set Points	
Action	Default Value	Range	Default	Range	Default
Warning (Least Severe)	Always On	Not Programmable	0	1200 to 2400	2070 rpm
Shutdown (Most Severe)	Always On	Not Programmable	0	1200 to 2400	2124 rpm

11.1.3.3 Engine Speed Monitoring Installation

No installation is required for engine speed monitoring to function.

11.1.4 Inlet Air Temperature

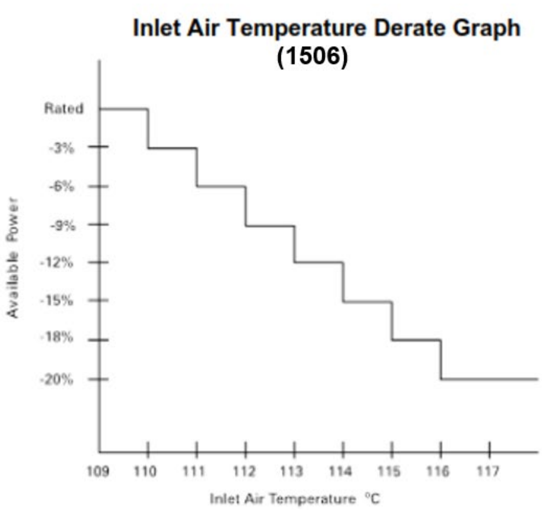
11.1.4.1 Inlet Air Temperature Monitoring Operation

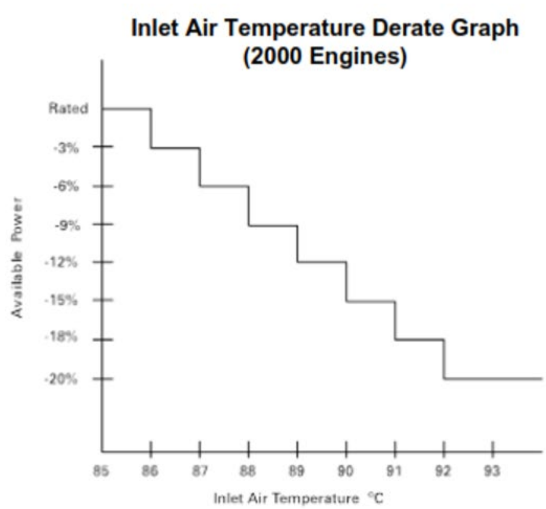
Inlet air temperature is monitored to automatically protect the engine from exceeding a maximum inlet air temperature limit. The inlet air temperature measured by the ECM is compared to a maximum inlet air temperature limit configured in the monitoring system for inlet air temperature monitoring. The maximum inlet air temperature is checked for each ECM action level configured in the monitoring system. If the inlet air temperature is above the maximum inlet air temperature for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

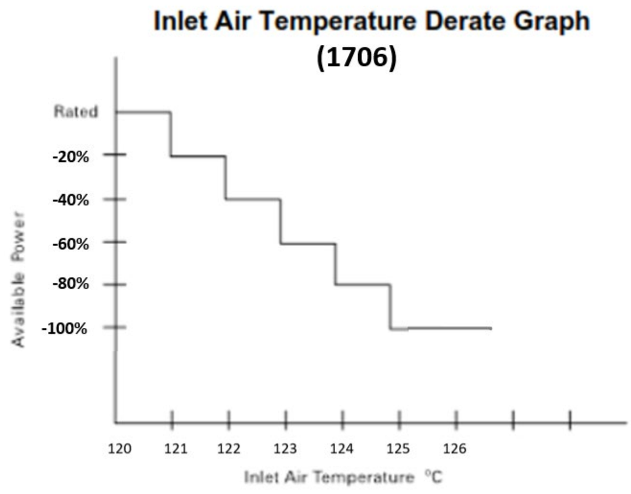
Perkins EST Description	J1939 Description	Status	SPN	FMI
High Inlet Air Temperature	Air Inlet Temperature	Warning	172	15
High Inlet Air Temperature	Air Inlet Temperature	Derate	172	16

The ECM can respond to the high inlet air temperature condition with any or all of the following actions: Warning and Derate. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Derate:

- Derate: Engine power is reduced according to the inlet air temperature derate graph below. The power is reduced at a rate of one percent/second. The percent derate is a power reduction below the rated power curve.







11.1.4.2 Inlet Air Temperature Monitoring Configuration

Two parameters can be configured in Perkins EST to customize the monitoring system for inlet air temperature monitoring.

1. ECM action for event code defaults to "On" for Warning and Derate. All actions can be configured to "On" or "Off."
2. Inlet air temperature maximum limit default is specific to the engine model and is defined in the configuration table below. The maximum temperature limit for warning and derate can be lowered within the range specified in the configuration table below.

The time delay is defined by the factory and cannot be modified. The following table summarizes the configuration default settings and configuration ranges for high inlet air temperature monitoring:

High Inlet Air Temperature Monitoring Configuration (1506)					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	Always On	None	8	None	90°C/194°F
Derate	Off	None	8	None	110°C/230°F

High Inlet Air Temperature Monitoring Configuration (1706)					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	Always On	None	8	100°C/212°F - 125°C/257°F	115°C/239°F
Derate	Off	None	4	100°C/212°F - 125°C/257°F	120°C/240°F

High Inlet Air Temperature Monitoring Configuration (2206-2806 Standard)					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	On	0-60	60	65°C/149°F -78°C/172°F	75°C/167°F
Derate	Always On	None	10	None	78°C/172°F

High Inlet Air Temperature Monitoring Configuration (2806 PD)					
		Time Delay in Seconds		Set Points	
Action	**Default Value**	**Range**	**Default**	**Range**	**Default**
Warning	Always On	Not Programmable	4	Not Programmable	82 Deg c
Derate	Off	Not Programmable	4	Not Programmable	86 Deg c

Note: Perkins EST may allow the Derate Set Point Range to be programmed even though the chart above indicates that it is Not Programmable. If the set point in Perkins EST is altered, this will only change the temperature at which an Event Code is logged. The programmed value will NOT change the temperatures when the engine takes action in Derate.

Note: The engine must be running at engine speeds at or above low idle for 180 seconds before the above time delay is triggered.

11.1.4.3 Inlet Air Temperature Monitoring Installation

No installation is required for inlet air temperature monitoring to function.

11.1.5 Fuel Temperature Monitoring

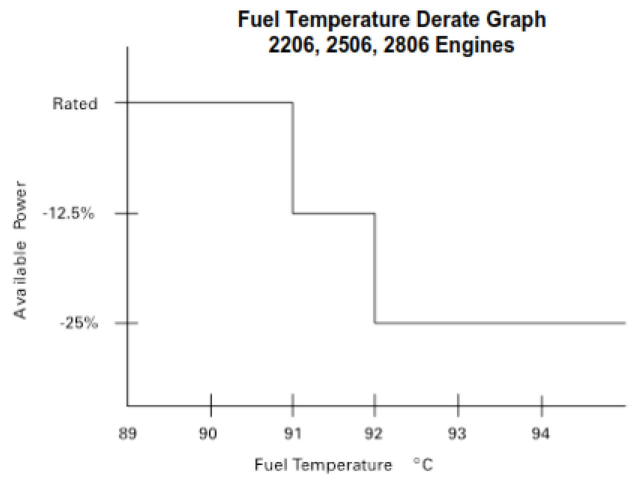
11.1.5.1 Fuel Temperature Monitoring Operation

All engines have a fuel temperature sensor included in the standard sensor package. Fuel temperature is monitored to adjust fuel rate calculations and to make fuel temperature power corrections when fuel temperatures exceed 30°C/86°F to provide constant power. The fuel temperature measured by the ECM is compared to a maximum fuel temperature limit configured in the monitoring system for fuel temperature monitoring. The maximum fuel temperature is checked for each ECM action level configured in the monitoring system. If the fuel temperature is above maximum fuel temperature for the specified action level delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

Perkins EST MS Description	J1939 Description	Status	SPN	FMI
High Fuel Temperature	Engine Fuel Temperature	Warning	174	15
		Derate	174	16
		Shutdown	174	00

The ECM can respond to the high fuel temperature condition with any or all of the following actions: Warning, Derate, and Shutdown. The ECM logs an event code and illuminates the lamps for all action levels. The ECM will respond with the following additional actions when the monitoring system is configured to Derate and Shutdown:

- Derate: Engine power is reduced according to the fuel temperature derate graph below. The power is reduced at a rate of one percent/second. The percent derate is a power reduction below the rated power curve.
- Shutdown: The engine will shut down immediately.
-



11.1.5.2 Fuel Temperature Monitoring Configuration

Three parameters can be configured in Perkins EST to customize the monitoring system for fuel temperature monitoring.

1. ECM action for event code defaults to “On” for Warning and Derate and “Off” for Shutdown. All actions can be configured to “On” or “Off.”
2. Time delay to act defaults to 30 seconds for Warning and 10 seconds for Derate and Shutdown. The time delay to act on high fuel temperature event can be set within the range specified in the configuration table below.
3. Fuel temperature maximum limit default for Warning is 90°C/194°F and for Derate and Shutdown is 91°C/196°F. The maximum temperature limit can be lowered within the range specified in the configuration table below.

The following table summarizes the configuration default settings and configuration ranges for high fuel temperature monitoring:

Fuel Temperature Monitoring Configuration (1506)					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	Always On	0 to 120s	30	65°C/149°F to 90°C/194°F	90°C/194°F
Derate	Off	0 to 120s	10	65°C/149°F to 91°C/196°F	91°C/196°F
Shutdown	Off	0 to 120s	10	65°C/149°F to 92°C/198°F	92°C/198°F

Fuel Temperature Monitoring Configuration (2206-2806 Standard)					
Action	Default Value	Time Delay (sec)		Set Points	
		Range	Default	Range	Default
Warning	On	0 to 60s	60	50°C/122°F to 70°C/158°F	60°C/140°F
Derate	Always On	None	60	None	68°C/154°F

High Fuel Temperature Monitoring Configuration (1706/2806 PD)					
Action	**Default Value**	**Time Delay in Seconds**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	Always On	1 to 120	30	75°C/167°F to 90°C/194°F	79°C/174°F
Derate	Off	30 to 120	30	Not Programmable	79°C/174°F
Shutdown	Off	1 to 120	10	75°C/167°F to 90°C/194°F	90°C/194°F

Note: 2806PD High Fuel Temp Derate is fixed 20%

Note: 1706 EP LRC High Fuel Temp Derate is fixed 25%

Note: *Perkins EST may allow the Derate Set Point Range to be programmed even though the chart above indicates that it is Not Programmable. If the set point in Perkins EST is altered, this will only change the temperature at which an Event Code is logged. The programmed value will NOT change the temperatures at which the engine takes action to Derate.*

Note: *Engine must be running at engine speeds at or above low idle for 180 seconds before the above time delay is triggered.*

11.1.5.3 Fuel Temperature Monitoring Installation

No installation is required for fuel temperature monitoring to function.

11.1.6 Fuel Pressure (1506, 1706, 2806 PD Only)

11.1.6.1 Fuel Pressure Monitoring Operation

The 1506, 1706, and 2806 PD engines have a fuel pressure sensor included in the standard sensor package. Fuel pressure is monitored to automatically protect the engine from exceeding a maximum fuel pressure limit. The fuel pressure measured by the ECM is compared to a maximum fuel pressure limit configured in the monitoring system for fuel pressure monitoring. If the fuel pressure is above the maximum fuel pressure for the specified warning delay time, then the ECM takes the appropriate action to respond to the fault condition. Once the fault is detected, the ECM illuminates the warning and diagnostic lamps and logs the appropriate event code from the following table for the action taken:

1506				
Perkins EST Description	**J1939 Description**	**Status**	**SPN**	**FMI**
Low Fuel Pressure	Fuel Delivery Pressure	Warning	94	17
		Derate	94	18
		Shutdown	94	1
High Fuel Pressure	Fuel Delivery Pressure	Warning	94	15
		Derate	94	16
		Shutdown	94	0

1706				
Perkins EST Description	**J1939 Description**	**Status**	**SPN**	**FMI**
Low Fuel Pressure	Fuel Delivery Pressure	Warning	5580	17
		Derate	5580	18
High Fuel Pressure	Fuel Delivery Pressure	Derate	94	16

2806 PD				
Perkins EST Description	**J1939 Description**	**Status**	**SPN**	**FMI**
Low Fuel Pressure	Fuel Delivery Pressure	Warning	5580	17
		Derate	5580	18
High Fuel Pressure	Fuel Delivery Pressure	Derate	5580	16

11.1.6.2 Fuel Pressure Monitoring Configuration

One parameter can be configured in Perkins EST to customize the monitoring system for high fuel pressure monitoring. The ECM action level is the only programmable setting for fuel pressure monitoring. ECM warning level action defaults to “On” and can be configured to “On” or “Off.”

The time delay and set point are defined by the factory and cannot be modified. The following table summarizes the configuration default settings and configuration ranges for all high fuel pressure monitoring configuration parameters:

HIGH FUEL PRESSURE MONITORING CONFIGURATION					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	On	8-14	8	None	758 kPa (gauge)

LOW FUEL PRESSURE MONITORING CONFIGURATION					
Action	**Default Value**	**Time Delay (sec)**		**Set Points**	
		Range	**Default**	**Range**	**Default**
Warning	On	5-10	10	400-450	400 kPa (gauge)

Note: *The engine must be running at engine speeds at or above low idle for 60 seconds before the above time delay is triggered.*

11.1.6.3 Fuel Pressure Monitoring Installation

No installation is required for fuel pressure monitoring to function.

11.1.7 Altitude (Exhaust Temperature)

11.1.7.1 Altitude (Exhaust Temperature) Monitoring Operation

Engine operation at higher altitudes can reduce engine performance because of limited air intake by the engine. When air intake is limited, the fuel delivered to the engine needs to be reduced to minimize engine exhaust temperatures and thermal wear on the exhaust system and turbochargers. Engines with the A4 ECM have a new altitude derate strategy that reduces fuel quantity delivered to the engine based on a calculated percent exhaust temperature derate. The old altitude derate strategy was based on a calculated percent altitude derate.

The old altitude derate strategy only used the measured atmospheric (barometric) pressure to calculate a percent altitude derate. The new altitude derate strategy uses a calculated exhaust temperature to calculate a percent exhaust temperature derate. The exhaust temperature is calculated using measured atmospheric pressure, inlet air temperature, and engine speed.

The exhaust temperature derate calculation is specific to the engine family, arrangement, and rating. Refer to the published engine performance data for the specific engine rating to determine altitude capability and percent derate at altitude. If the exhaust temperature is above the maximum exhaust temperature, then the ECM takes the appropriate action to respond to the derate condition. When the derate occurs, the ECM broadcasts the event code in the following table:

Perkins EST Description	J1939 Description	Status	SPN	FMI
High Exhaust Temperature	Exhaust Gas Temperature	Derate	173	16

The ECM does not illuminate the warning or diagnostic lamp when a high exhaust temperature derate condition is detected. Perkins EST will display “Exhaust Temperature Derate Active” in the status flag area on the status screen.

Note: *There is NOT an exhaust temperature sensor on the engine.*

Note: *Underground applications and high-altitude applications present special application design challenges. Before designing an ElectropaK engine into an application, consult your dealer and the ElectropaK engine application and installation engineer.*

11.1.7.2 Altitude (Exhaust Temperature) Monitoring Configuration

No configuration is required for the altitude derate protection to function.

11.1.7.3 Altitude (Exhaust Temperature) Monitoring Installation

11.1.8 Boost Pressure (1706/2206-2806 Standard Engines Only)

11.1.8.1 High Boost Pressure Monitoring Operation

The Boost pressure is monitored by the engine management system to automatically protect the engine from exceeding piping and hose pressure limits and to ensure airflow is within the normal operating range.

11.1.8.2 High Boost Pressure Monitoring Configuration

Using the Perkins EST service tool, the following parameters can be configured.

Engine Monitoring System Parameter Table						
Parameter	Action	Default Value	Time Delay in Seconds		Set Points	
			Range	Default	Range	Default
High Boost Pressure	Warning	On	0-60	60 sec	200-310	300 kpa
	*Derate	Always On	None	5 sec	None	None

*Derate trip points are map based with engine speed.

11.1.8.3 High Boost Pressure Monitoring Installation

No installation is required for the High Boost Pressure Monitoring.

11.2 Engine Monitoring Lamps

11.2.1 Warning Lamp

11.2.1.1 Warning Lamp Operation

The warning lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. Parameters with Warning set to ON will activate this lamp. Installation of a warning lamp is required. An alternative display product can be used instead of a lamp if the display alerts the operator of the engine operation condition.

The lamp will illuminate when the ECM detects engine operating parameters exceeding a specified limit. The ECM identifies the operating condition with an event code. The lamp will remain ON as long as the engine operating condition exceeds the specified limit. The illuminated lamp will be solid or flash, depending on the event type and severity. The diagnostic lamp turns OFF when the engine returns to normal operation.

Upon ECM power-up, a self-test of lamp circuits occurs. The lamps will come ON for five seconds when the ECM is first turned on to indicate that the lamp circuit is functional.

11.2.1.2 Warning Lamp Configuration

No configuration is required for operation of this warning lamp.

11.2.1.3 Warning Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

REQUIRED PARTS		
Part Number	Description	Qty
2900A016	Connector Socket	1
N/A	Lamp	1
N/A	18 AWG Wire (ECM)	(1)

(1) Cut to length

11.2.2 Action Alert/Derate Lamp

11.2.2.1 Action Alert/Derate Lamp Operation

The Action Alert/Derate lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. This Action Alert lamp relates to Section 12 — Engine Monitoring and Protection. Parameters from Section 12 with Derate set to ON will activate this lamp. Installation of an Action Alert lamp is required. An alternative display product can be used instead of a lamp as long as the display alerts the operator of the engine operation condition.

The lamp will illuminate when the ECM detects engine operating parameters exceeding a specified limit. The ECM identifies the operating condition with an event code. The lamp will remain ON as long as the engine operating condition exceeds the specified limit. The illuminated lamp will be solid or flash, depending on the event type and severity. The Action Alert lamp turns OFF when the engine returns to normal operation.

Upon ECM power-up, a self-test of lamp circuits occurs. The lamps will come ON for five seconds when the ECM is first

11.2.2.2 Action Alert/Derate Lamp Configuration

No configuration is required for operation of this warning lamp.

11.2.2.3 Action Alert/Derate Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

Refer to Warning Lamp Parts Table for component details.

11.2.3 Shutdown Lamp

11.2.3.1 Shutdown Lamp Operation

The Shutdown lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. This Shutdown lamp relates to Section 12 — Engine Monitoring and Protection. Parameters from Section 12 with Shutdown set to ON will activate this lamp. Installation of Shutdown lamp is required. An alternative display product can be used instead of a lamp as long as the display alerts the operator of the engine operation condition.

The lamp will illuminate when the ECM detects engine operating parameters exceeding a specified limit. The ECM identifies the operating condition with an event code. The lamp will remain ON as long as the engine operating condition exceeds the specified limit. The illuminated lamp will be solid or flash, depending on the event type and severity. The Shutdown lamp turns OFF when the engine returns to normal operation.

Upon ECM power-up, a self-test of lamp circuits occurs. The lamps will come ON for five seconds when the ECM is first turned on to indicate that the lamp circuit is functional.

11.2.3.2 Shutdown Lamp Configuration

No configuration is required for operation of this warning lamp.

11.2.3.3 Shutdown Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

Refer to Warning Lamp Parts Table for component details.

11.2.4 Overspeed Lamp

11.2.4.1 Overspeed Lamp Operation

NOTE: Not applicable on 1706 engine

The Overspeed lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. This Overspeed lamp relates to Section 12 — Engine Monitoring and Protection. Parameters from Section 12 with Engine Overspeed Warning, Shutdown set to ON will activate this lamp. Installation of Overspeed lamp is required. An alternative display product can be used instead of a lamp as the display alerts the operator of the engine operation condition.

11.2.4.2 Overspeed Lamp Configuration

No configuration is required for operation of the warning lamp.

11.2.4.3 Overspeed Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

Refer to Warning Lamp Parts Table for component details.

11.2.5 High Coolant Temperature Lamp

11.2.5.1 High Coolant Temperature Lamp Operation

The High Coolant Temperature lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. This High Coolant Temperature lamp relates to Section 12 — Engine Monitoring and Protection. Parameters from Section 12 with Engine High Coolant Temperature Warning, Derate, Shutdown set to ON will activate this lamp. Installation of High Coolant Temperature lamp is required. An alternative display product can be used instead of a lamp as long as the display alerts the operator of the engine operation condition.

11.2.5.2 High Coolant Temperature Lamp Configuration

No configuration is required for operation of the warning lamp.

11.2.5.3 High Coolant Temperature Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

Refer to Warning Lamp Parts Table for details.

11.2.6 Low Oil Pressure Lamp

11.2.6.1 Low Oil Pressure Lamp Operation

The Low Oil Pressure lamp is used to alert the operator of an engine operating condition that has the potential to cause engine damage. This Low Oil Pressure lamp relates to Section 12 — Engine Monitoring and Protection. Parameters from Section 12 with Engine Low Oil Pressure Warning, Shutdown set to ON will activate this lamp. Installation of Low Oil Pressure lamp is required. An alternative display product can be used instead of a lamp as long as the display alerts the operator of the engine operation condition.

11.2.6.2 Low Oil Pressure Lamp Configuration

No configuration is required for operation of the warning lamp.

11.2.6.3 Low Oil Pressure Lamp Installation

Refer to Customer OEM Connections Diagram and Application Schematic Diagram sections for wiring details.

Refer to Warning Lamp Parts Table for details.

11.3 Diagnostic Lamp (Not Supported on 1706/2806 Power Density Engines)

11.3.1 Diagnostic Lamp Operation

The diagnostic lamp is used to alert the operator of an engine electronic system malfunction. Installation of a diagnostic lamp is required. An alternative display product can be used instead of a lamp as long as the display alerts the operator of the fault status.

The lamp will illuminate when the ECM detects a component operating outside of specified normal operating range. The ECM identifies the failed component with a diagnostic code. The lamp will remain ON as long as the diagnostic code remains active. The diagnostic lamp turns OFF when the suspect component returns to normal operation and the ECM determines the diagnostic code is no longer active.

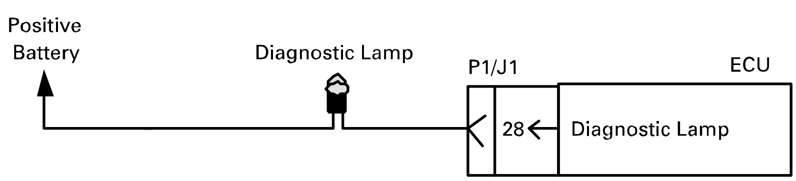
The diagnostic lamp will flash (cycle ON, then OFF) in a defined sequence to a Perkins proprietary two-digit flash code. The sequence of flashes represents the system diagnostic message (flash code). The first sequence of flashes represents the first digit of the flash code. After a two-second pause, a second sequence of flashes, which represents the second digit of the flash code, will occur. Any additional flash codes will follow after a pause. These flash codes will be displayed in the same manner. Flash codes should only be used to indicate the nature of a diagnostic condition. Do not use flash codes to perform detailed troubleshooting. Refer to the Troubleshooting Guide for the engine for more detailed information on diagnostic codes and flash codes.

Upon ECM power-up, a self-test of lamp circuits occurs. The lamps will come ON for five seconds when the ECM is first turned on to indicate that the lamp circuit is functional.

11.3.2 Diagnostic Lamp Configuration

No configuration is required for operation of the diagnostic lamp.

11.3.3 Diagnostic Lamp Installation



REQUIRED PARTS		
Part Number	**Description**	**Qty**
2900A016	Connector Socket	1
N/A	Lamp	1
N/A	18 AWG Wire (ECM)	(1)

(1) Cut to length

12.0 Data Link Support

Perkins engines provide two data link connections on the engine ECM. OEM communication with the engine is via the CAN bus using SAE J1939 protocol. Perkins service tool communication with the engine is via the proprietary Perkins Data Link. Perkins recognizes that other CAN bus standards (higher level protocols) do exist and are used in off-highway applications, so the following sections provide some information for users of those standards.

1500/1700/2000 Series Engines - J1939 Data Link Capability

The list below summarises the functionality to be supported by the ECM. Technical details of the J1939 implementation are given in the Appendices.

Measurement Parameters

The engine parameters listed in the Appendix can be read over the data link in accordance with J1939-71.

DM1 -Active diagnostics

As previously, the ECM supports reading of Active diagnostic and event codes in accordance with J1939-73. The list of codes supported is detailed in the Appendix.

DM2 -Logged diagnostics - Flashfile release date of November 05 or later

The ECM now supports reading of Logged diagnostic and event codes in accordance with J1939-73. Clearing of these codes is only supported using the TIPSS/EST service tool.

DM11 - Fault reset request - Flashfile release date of November 05 or later

When a valid request is sent via J1939 DM11, the engine ECM will reset latched faults and shutdowns. If the request is sent while engine speed is present, the signal will be ignored.

This feature supports desired speed requests via J1939 PGN 0. The signal over the J1939 datalink is a speed command. The signal sent is in units of RPM. The accepted range of speed control is approximately - 24% to + 8% of nominal speed. A loss of the J1939 signal will result in an engine speed of 1100 rpm and a 247-9 'J1939 Datalink abnormal update' diagnostic will be generated.

Fuel enable/disable request - Flashfile release date of November 05 or later

This feature supports fuel enable requests via J1939 PGN 61441-SPN 970, the signal over the datalink is a request to enable or disable fuel. If the J1939 datalink is lost, the engine will stop and a 247-9 'J1939 Datalink abnormal update' diagnostic will be generated.

12.1 SAE J1939

The SAE J1939 standard was initially developed for the U.S. truck and bus industry. It has been expanded and is now the most widely used data link standard for ElectropaK powertrains.

12.1.1 Summary of Key J1939 Application Issues

This is a summary of key points and answers to frequently asked questions relating to design of a J1939 compatible network. It is intended to give a design overview and does not in any way replace or contradict the recommendations contained in the SAE J1939 standard documents.

12.1.1.1 Physical Layer

- The data rate is 250 KBits/sec.
- Twisted-pair cable, of a 120-Ohm impedance characteristic, should be used throughout. Note that most commercially available twisted-pair cable is not suitable.
- It is recommended that this cable is shielded (as per J1939-11) and that the screen is grounded at a central point in the network. Some machine manufacturers use unshielded twisted-pair cable (as per J1939-15), offering lower cost but lower immunity to electromagnetic noise.

- The bus is linear and should be terminated with 120-Ohm resistors at either end. It is a common mistake to use one 60-Ohm resistor instead of two 120-Ohm resistors. This does not work correctly, however.
- Maximum bus length is 40 m.
- The terminating resistors should not be contained in network nodes.
- Network nodes are connected to the bus via stubs of the maximum recommended length of one meter.

12.1.1.2 Network Layer

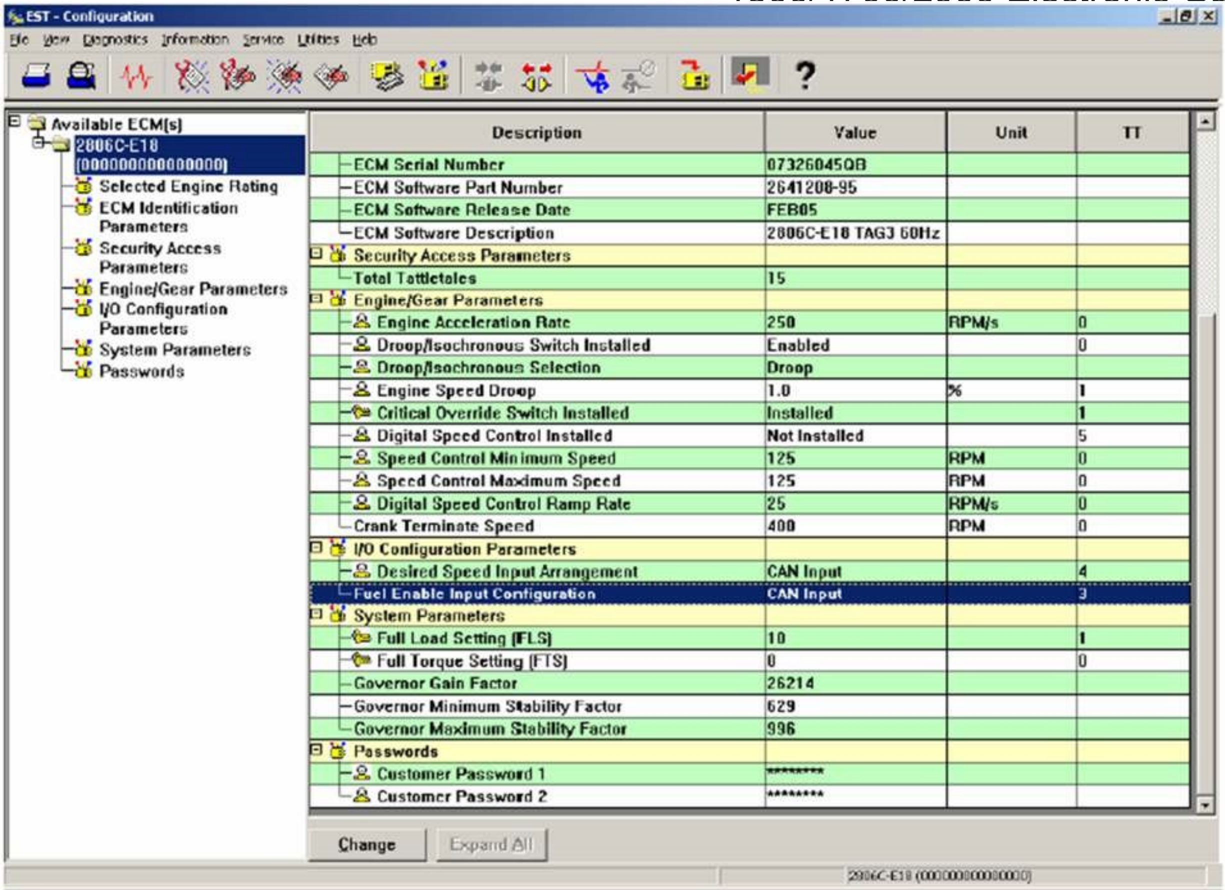
- J1939 recommends a bit sample point of 87 percent. This relatively late sample point gives best compromise for immunity to noise and propagation delay. This does restrict the size of the software jump width (SJW).
- All nodes should have the same bit timing.
- Accurate bit timing is essential (4ºs +/- 0.2 percent).
- It is recommended that the average bus load not be greater than 40 percent.
- Hardware filtering (masking) of CAN messages should be used under high bus loads to limit demands on processors.
- The engine ECM always assumes a fixed address of 0. It will not change its address in the arbitration process described in J1939-81.
- The transport protocol (described in J1939-21) is used for sending messages with more than eight bytes of data. In the ElectropaK engine application this will be used principally for the diagnostic messages DM1 and DM2.
- Information may be broadcast, at regular intervals, or requested. For example, the engine will broadcast its “current speed” every 20 ms,, but it will only send “hours run“ information if another node requests it.

12.1.1.3 Application Layer

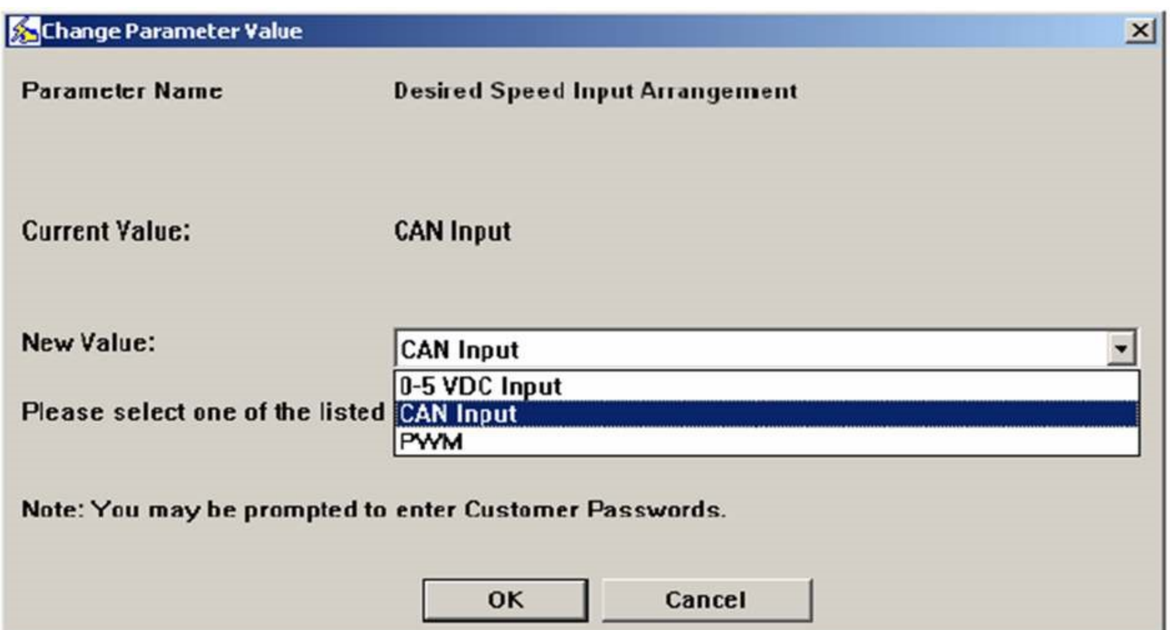
- Data link messages are used by devices on the CAN bus for monitoring and display of engine information or as control interface between integrated control modules.
- Messages on the J1939 data link are sent in packets of logically grouped system information. These packets, or data link strings, are referenced by the Parameter Group Number (PGN) that is assigned to each message by the SAE standard.
- The PGNs supported by the Perkins ElectropaK ECM are only a subset of the messages described in J1939-71 and J1939-73.
- Some PGNs may be partially supported, i.e. only those bytes for which the ECM has valid data will be supported.
- Unsupported data bytes are generally sent as FF (hex), and incorrect/invalid information is sent as FE.

12.1.1.4 Enabling J1939 Control in TIPSS/EST

The selection of J1939 speed control is done using the existing Desired Speed Input Arrangement selection box on the Configuration screen. To allow selection of Injection Disable via switch or J1939, an additional line has been added to the Configuration screen as shown below.

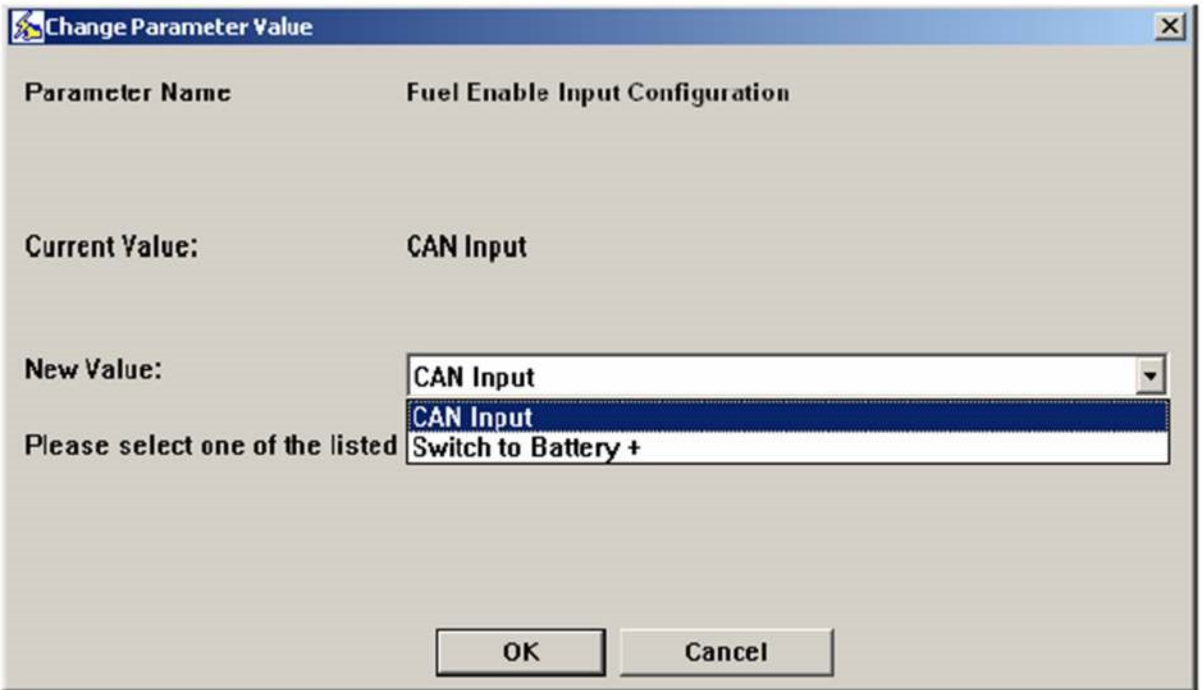


12.1.1.5 Selection of Desired Speed Input Arrangement The screen shot below shows the additional CAN input selection.



12.1.1.6 Selection of Fuel Enable Input Configuration

The screen shot below shows the additional CAN input selection.



12.1.2 Supported Parameters — Section 71: Engine System Parameters

This section defines the engine control system support and implementation of parameter groups defined in the vehicle application layer of the SAE J1939 standard (J1939-71).

These parameter groups are used by devices on the CAN bus for engine control and monitoring and display of engine performance and status information.

The message identifier, update rate, and parameter group definition is specified for each supported parameter group. SPN support is indicated by an “X” in the Send or Receive column. Any deviation from the SAE recommended practice is noted below each parameter group table.

The engine control system supports the parameter group numbers (PGN) listed in the following table:

Parameter Group	PGN		SPN	Parameters Supported
	Dec	Hex		
Torque/Speed Control 1 (TSC1)	0	0000	695	Engine Override Control Mode
			898	Engine Requested Speed/Speed Limit
			518	Requested Torque/Torque Limit
			897	Override Control Mode Priority
Electronic Brake Controller 1 (EBC1)	61441	F001	970	Auxiliary Engine Shutdown Switch
Electronic Transmission Controller 1 (ETC1)	61442	F002	191	Transmission Output Shaft Speed
Electronic Engine Control 2 (EEC2)	61443	F003	91	Accelerator Pedal Position 1
			92	Engine Percent Load at Current Speed
Electronic Engine Control 2 (EEC1)	61444	F004	513	Actual Engine — Percent Torque
			190	Engine Speed

Auxiliary Analog Information	65164	FE8C	441	Oil Temperature #1
			1387	Auxiliary Pressure #1
Electronic Engine Control 3 (EEC3)	65247	FEDF	515	Engine's Desired Operating Speed
			514	Nominal Friction — Percent Torque
Shutdown	65252	FEE4	1081	Wait-to-Start Lamp
Engine Hours/Revolutions	65253	FEE5	247	Engine Total Hours of Operation
Fuel Consumption	65257	FEE9	250	Engine Total Fuel Used
Engine Temperature	65262	FEEE	110	Engine Coolant Temperature
			174	Engine Fuel Temperature
Engine Fluid Level/Pressure	65263	FEEF	94	Engine Fuel Delivery Pressure
			100	Engine Oil Pressure
			111	Engine Coolant Level
Fuel Economy (Liquid)	65266	FEF2	183	Engine Fuel Rate
Inlet/Exhaust Conditions	65270	FEF6	102	Engine Turbocharger Boost Pressure
			105	Engine Intake Manifold 1 Temperature
Vehicle Electrical Power	65271	FEF7	168	Electrical Potential (Voltage)
			158	Battery Potential (Voltage), Switched
Engine Configurator Message	65251	FEE3	188	Engine Speed at Idle, Point 1
			539	Percent Torque at Idle, Point 1
			528	Engine Speed at Point 2
			540	Percent Torque at Point 2
			529	Engine Speed at Idle, Point 3
			541	Percent Torque at Idle, Point 3
			530	Engine Speed at Point 4
			542	Percent Torque at Point 4
			531	Percent Torque at Point 5
			543	Percent Torque at Point 5
			532	Engine Speed at High Idle, Point 6
			544	Reference Engine Torque
Component Identifier	65259	FEEB	586	Make
			587	Model
			588	Serial Number

12.1.2.1 Torque Speed Control 1 (TSC1): PGN 0

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
0C 00 00 xx	10(1)	0000	3	0	xx	00

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	(unit/bit)	Min	Max
		Engine Override Control Mode	695	1	1	2			binary	00b	11b
	X	Override Disabled					00				
	X	Speed Control					01				
	X	Torque Control					10				

	X	Speed/Torque Limit Control					11				
		Engine Requested Speed Control Conditions	696	1	3	2			binary	00b	11b
	X	Override Control Mode Priority	897	1	5	2			binary	00b	11b
		Not Defined	—	1	7	2					
	X	Engine Requested Speed/ Speed Limit	898	2-3		16		rpm	0.125	0	8032
	X	Engine Requested Torque/ Torque Limit	518	4		8		%	1	-125	125
		Not Defined	—	5-8							

(1) Excessive loading of the J1939 data link by communication traffic of other devices may interfere with the reception of the TSC1 command by the ECM. The TSC1 message must be received by the engine ECM at a minimum of once every 30 milliseconds. If after 30 milliseconds the ECM does not receive a TSC1 message, speed control will be determined by arbitration (see 9.14 Throttle Arbitration Strategy). Resumption of TSC1 command control will take place as soon as the ECM begins receiving the TSC1 commands again.

The original SAE design for the TSC1 message was for truck applications as a temporary means for the transmission to override engine speed during gear shifts. More advanced system integration has evolved the use of the TSC1 message for use as a permanent means of controlling engine speed by off engine control systems. This is particularly common in machines that have complex hydraulic systems.

This is a powerful feature, but special care must be taken by the OEM with the implementation of TSC1 to ensure that the speed demanded of the engine is one that is safe and appropriate for the current operating conditions of the engine. It is the responsibility of the OEM to ensure that this is so and to perform the necessary risk assessment validation of the software for the electronic modules on the applications that are transmitting TSC1 speed demand messages to the engine.

Speed Control Mode — The engine control system will allow other modules to request engine speed for any length of time when operating in speed control mode. The TSC1 message will override any other engine speed demand, such as PWM throttle pedal input, to the engine speed governor. The transition from the hard- wired speed demand input to CAN override speed demand is controlled by the engine speed governor and the rate of engine speed change is not limited by the engine acceleration rate limit configured via service tool. The one exception to TSC1 message overriding any other speed control is that the Speed Limit Control is nonfunctional when the engine is configured to Torque Governing (refer to Section 12.2). The OEM can control the rate of engine speed change when initiating override by ramping the requested speed from the speed demand prior to initiating override (broadcast in EEC3 message) to the desired speed demand at a controlled rate of change. A similar process can be followed prior to relinquishing override control, but this is only possible if the speed demand input that will regain control is known (i.e. determine from accelerator pedal position broadcast in EEC2).

Speed Limit Mode — The engine control system will allow other modules to limit engine speed for any period when operating in speed limit mode. The TSC1 message sets the maximum limit for the speed demand input to the engine speed governor. The transition to or from the requested speed limit is controlled by the engine speed governor and the rate of engine speed change is not limited by the engine acceleration rate limit configured via the service tool. The OEM can control the rate of engine speed change when initiating override by setting the requested speed limit to an engine speed greater than the speed demand prior to initiating override (broadcast in EEC3 message) and ramp the speed limit up or down at a controlled rate of change. Reverse process can be followed when removing the engine speed limit. Ramp the requested engine speed limit until the engine speed demand is no longer limited or speed demand limit is equal to high idle speed.

Destination Address — The engine control system responds to the TSC1 message with destination address 00 but does not monitor the source address of the TSC1 message. No restriction on the TSC1 message source has the following impact to the OEM:

- Messages from modules with any source address are accepted (i.e. TSC1 messages do not necessarily have to be sent by the transmission).
- The control system does not handle TSC1 messages differently based on message source.
- The engine control system has no means to arbitrate between speed requests or limits from more than one source, thus the OEM must ensure that TSC1 messages are not sent from more than one source at a time as failure to do so may result in erratic engine operation.

The engine control system needs to differentiate between the end of a transmission by another controller and an intermittent failure. The engine control expects, therefore, that when a controller no longer wishes to demand engine speed it will terminate with at least one message with the control override bits set to 00.

12.1.2.2 Electronic Brake Controller 1 (EBC1): PGN 61441

This feature is not supported.

12.1.2.3 Electronic Transmission Controller 1 (ETC1): PGN 61442

This feature is not supported.

12.1.2.4 Electronic Engine Controller 2 (EEC2): PGN 61443

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
0C F0 03 00	50	F003	3	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Accelerator Pedal 1 Low Idle Switch	558	1	1	2			binary	00b	10b
		Accelerator Pedal Kickdown Switch	559	1	3	2			binary	00b	11b
		Road Speed Limit Status	1437	1	5	2			binary	00b	01b
		Accelerator Pedal 2 Low Idle Switch	2970	1	7	2			binary	00b	11b
X		Accelerator Pedal Position 1	91	2		8		%	0.4	0	100

X		Engine Percent Load at Current Speed	92	3		8		%	1	0	125
		Remote Accelerator Pedal Position	974	4		8		%	0.4	0	100
		Accelerator Pedal Position 2	29	5		8		%	0.4	0	100
		Vehicle Acceleration Rate Limit Status	2979	6	1	2			binary	00b	11b
		Not Defined	—	6	3	6					
		Not Defined	—	7-8							

Accelerator Pedal Position 1 — Accelerator pedal position broadcast is post arbitration. Only includes linear throttle sensors configured for throttle 1 and 2 inputs.

Engine Percent Load at Current Speed — The percent load calculation is not accurate at low loads or under transient conditions.

12.1.2.5 Electronic Engine Controller 1 (EEC1): PGN 61444

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
0C F0 04 00	15	F004	3	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Engine Torque Mode	899	1	1	4			binary	0000b	1110b
		Not Defined	—	1	5	4			binary	00b	11b
		Drivers Demand Engine — Percent Torque	512	2		8		%	1	-125	125
X		Actual Engine Percent Torque	513	3		8		%	1	-125	125
X		Engine Speed	190	4-5		16		rpm	0.125	0	8031
		Source Address of Controlling Device for Engine Control	1483	6		8		none	1	0	253
		Engine Starter Mode	1675	7	1	4			binary	0000b	1111b
		Not Defined	—	7	5	4					
		Engine Demand — Percent Torque	2432	8		8		%	1	-125	125

Broadcast Rate — The J1939 standard describes the frequency of transmission of this PGN as engine speed dependent. The ECM transmits the message every 15 ms irrespective of engine speed.

Engine Speed — Actual engine speed is set to 0 rpm when there is a fault detected with speed sensor measurement instead of EF00 as defined in standard. This avoids issues on engine crank with controls that do not correctly interpret the error code.

12.1.2.6 Auxiliary Analog Information: PGN 65164

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
1C FE 8C 00	On req	FE8C	7	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Auxiliary Temperature #1	441	1		8		°C	1	-40	210
		Auxiliary Temperature #2	442	2		8		°C	1	-40	210
X		Auxiliary Pressure #1	1387	3		8		kPa	16	0	4000
		Auxiliary Pressure #2	1388	4		8		kPa	16	0	4000
		Auxiliary Level	3087	5-6		16		mm	0.1	0	6425
		Not Defined	—	7-8		1		%	1	-125	125

12.1.2.7 Electronic Engine Controller 3 (EEC3): PGN 65247

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE DF 00	250	FEDF	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Nominal Friction — Percent Torque	514	1	1	8		%	1	-125	125
X		Engine Desired Operating Speed	515	2-3		16		rpm	0.125	0	8031
		Engine Desired Operating Speed Asymmetry Adjustment	519	4		8		ratio	1	0	250
		Estimated Engine Parasitic Losses — Percent Torque	2978	5		8		%	1	-125	125
		Not Defined	—	6-8		24		mm	0.1	0	6425

Engine Desired Operating Speed — Engine desired operating speed is the speed at which the engine would run if all load were removed and current speed demand conditions maintained. This is also the resulting arbitrated speed demand from all speed demand inputs and CAN override speed.

12.1.2.8 Shutdown: PGN 65252 (Not available – Intake Air Heater feature not used. 1506 Engines Only)

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE E4 00	1000	FEE4	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Engine Idle Shutdown Has Shut Down Engine	593	1	1	2			binary	00b	01b
		Engine Idle Shutdown Driver Alert Mode	594	1	3	2			binary	00b	01b
		Engine Idle Shutdown Timer Override	592	1	5	2			binary	00b	01b
		Engine Idle Shutdown Timer State	590	1	7	2			binary	00b	01b
		Not Defined	—	2	1	6					
		Engine Idle Shutdown Timer Function	591	2	7	2			binary	00b	01b
		A/C High Pressure Fan Switch	985	3	1	2			binary	00b	01b
		Refrigerant Low Pressure Switch	875	3	3	2			binary	00b	01b
		Refrigerant High Pressure Switch	605	3	5	2			binary	00b	01b
		Not Defined	—	3	7	2					
		Engine Wait-to-Start Lamp	1081	4	1	2			binary	00b	01b
X		Off					00				
X		On					01				
		Not Defined	—	4	3	6					
		Engine Protection System Has Shut Down Engine	1110	5	1	2			binary	00b	01b
		Engine Protection System Approaching Shutdown	1109	5	3	2			binary	00b	01b
		Engine Protection System Timer Override	1108	5	5	2			binary	00b	01b
		Engine Protection System Timer State	1107	5	7	2			binary	00b	01b
		Not Defined	—	6	1	6					
		Engine Protection System Configuration	1111	6	7	2			binary	00b	01b
		Engine Alarm Acknowledge	2815	7	1	2			binary	00b	11b
		Engine Alarm Output Command Status	2814	7	3	2			binary	00b	11b

		Engine Air Shutoff Command Status	2813	7	5	2			binary	00b	11b
		Engine Overspeed Test	2812	7	7	2			binary	00b	11b

Shutdown PGN only broadcasts on 1506 engines, and intake air heater control feature is enabled.

Wait-to-Start Lamp — Intake air heater control strategy determines the status of the wait-to-start lamp parameter. The status is set to “ON” when the intake air heater strategy is in preheat mode during which the engine speed should remain at 0 rpm.

12.1.2.9 Engine Hours/Revolutions: PGN 65253

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE E5 00	1000	FEE5	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Engine Total Hours of Operation	247	1-4		32		hr	0.05	0	210,554,060
		Engine Total Revolutions	249	5-8		32		rev	1000	0	4,211,081,215,00

The SAE standard defines this PGN as send “on request.” There are some gauges and displays on the market which require this to be broadcast to display correctly, thus the engine control system will broadcast at a low update rate (1 sec) to ensure compatibility with these devices.

12.1.2.10 Fuel Consumption: PGN 65257

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE E9 00	On Req	FEE9	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Engine Trip Fuel	182	1-4	1	32		L	0.5	0	2,105,540,607
X		Engine Total Fuel Used	250	5-8	1	32		L	0.5	0	2,105,540,607

Total Fuel Used — This parameter is not a direct measurement. It is an estimation based on standard test fuel at standard test temperatures. It is recommended, therefore, that this value be taken as an indication only of the fuel used by an engine.

12.1.2.11 Engine Temperature (ET1): PGN 65262

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE EE 00	1000	FEEE	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Engine Coolant Temperature	110	1		8		°C	1	-40	210
X		Engine Fuel Temperature	174	2		8		°C	1	-40	210
		Engine Oil Temperature 1	175	3-4		16		°C	.03125	-273	1735
		Engine Turbocharger Oil Temperature	176	5-6		16		°C	.03125	-273	1735
		Engine Intercooler Temperature	52	7		8		°C	1	-40	210
		Engine Intercooler Thermostat Opening	1134	8		8		%	0.4	0	100

Fuel Temperature — This parameter is only available 2206, 2506 and 2806 engines.

12.1.2.12 Engine Fluid Level/Pressure (EFL/P1): PGN 65263

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE EF 00	500	FEEF	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Engine Fuel Delivery Pressure	94	1		8		kPa	4	0	1000
		Engine Extended Crankcase Blow-by Pressure	22	2		8		kPa	.05	0	12.5
		Engine Oil Level	98	3		8		%	0.4	0	100
X		Engine Oil Pressure	100	4		8		kPa	4	0	1000
		Engine Crankcase Pressure	101	5		16		kPa	1/128	-250	251
		Engine Coolant Pressure	109	7		8		kPa	2	0	500
X		Engine Coolant Level	111	8		8		%	0.4	0	100

Engine Fuel Delivery Pressure — Fuel delivery pressure is defined in the SAE standard as the fuel in the system as delivered from the supply pump to the injection pump. Perkins ElectropaK engines with HEUI and MEUI fuel systems have fuel pressure sensors located in the position specified by the SAE standard, assuming the injector is a form of injection pump.

Engine Coolant Level — This SPN is intended for linear coolant level measurement between minimum and maximum level. The coolant level input to the engine control system is a switch type sensor, thus this sensor can only detect when coolant goes below a fixed level. Legacy product supported this PGN to display coolant level at 0 percent (level low) and 100 percent (level good), thus current product will continue to support this PGN in the same way for any legacy display and monitoring systems. The preferred method to monitor coolant level via a switch input is to monitor DM1 messages for an active diagnostic code when the coolant level low condition is detected.

NOTE: Coolant level is supported on all T4 EP applications (1706, 2206, 2806 including power density). This feature has to be installed through EST. Once enabled, the monitoring system events can be enabled through the PMS/CMPS screen on ET. Once the level goes low, the switch is tripped and the events will come up. The engine will derate or shutdown accordingly.

12.1.2.13 Fuel Economy — Liquid (LFE): PGN 65266

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE F2 00	100	FEF2	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Engine Fuel Rate	183	1-2	1	16		L/hr	0.05	0	3212
X		Engine Instantaneous Fuel Economy	184	3-4	1	16		km/kg	1/512	0	125.5
		Engine Average Fuel Economy	185	5-6	1	16		km/kg	1/512	0	125.5
		Engine Throttle Position	51	7	1	8		%	0.4	0	100
		Not Defined	—	8	1	8					

Engine Fuel Rate — The engine control system does not directly measure total fuel flow. The fuel rate is a calculated parameter based on related engine information. It is recommended, therefore, that this value be taken as an indication only of the fuel quantity injected.

12.1.2.14 Inlet/Exhaust Conditions (IC): PGN 65270

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE F6 00	500	FEF6	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Engine Particulate Trap Inlet Pressure	81	1		8		kPa	0.5	0	125
X		Engine Turbocharger Boost Pressure	102	2		8		kPa	2	0	500

X		Engine Intake 1 Manifold Temperature	105	3		8		°C	1	-40	210
		Engine Air Inlet Pressure	106	4		8		kPa	2	0	500
		Engine Air Filter Differential Pressure	107	5		8		kPa	0.05	0	12.5
		Engine Exhaust Gas Temperature	173	6-7		16		°C	.03125	-273	1735
		Engine Coolant Filter Differential Pressure	112	8		8		kPa	.5	0	125

Engine Turbocharger Boost Pressure — The engine control system will limit boost pressure to 0 kPa even though it is possible that a slight depression at the inlet will result in negative boost pressure on some engines when running at low idle speed.

12.1.2.15 Vehicle Electrical Power (VEP): PGN 65271

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE F7 00	1000	FEF7	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
		Net Battery Current	114	1		8		amp	1	-125	125
		Alternator Current	115	1		8		amp	1	0	250
		Alternator Potential (Voltage)	167	3-4		16		V	0.05	0	3212
X		Electrical Potential (Voltage)	168	5-6		16		V	0.05	0	3212
X		Battery Potential (Voltage), Switched	158	7-8		16		V	0.05	0	3212

Battery/Electrical Potential — The engine control system measures voltage between the battery positive and battery negative terminals of the engine control. This value is used for both electrical potential and battery potential parameters.

12.1.2.16 Engine Configuration: PGN 65251

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE E3 00	5	FEE3	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Engine Speed at Idle, Point 1	188	1-2		2		rpm	.125 rpm/bit	0	8031
X		Percent Torque at Idle, Point 1	539	3		1		%	1%/bit	-125	125
X		Engine Speed at Point 2	528	4-5		2		rpm	.125 rpm/bit	0	8031

X		Percent Torque at Point 2	540	6		1		%	1%/bit	-125	125
X		Engine Speed at Point 3	529	7-8		2		rpm	.125 rpm/bit	0	8031
X		Percent Torque at Point 3	541	9		1		%	1%/bit	-125	125
X		Engine Speed at Point 4	530	10-11		2		rpm	.125 rpm/bit	0	8031
X		Percent Torque at Point 4	542	12		1		%	1%/bit	-125	125
X		Engine Speed at Point 5	531	13-14		2		rpm	.125 rpm/bit	0	8031
X		Percent Torque at Point 5	543	15		1		%	1%/bit	-125	125
X		Engine Speed at High Idle, Point 6	532	16-17		2		rpm	.125 rpm/bit	0	8031
		Gain (Kp) of the Endspeed Governor	545	18-19							
X		Reference Engine Torque	544	20-21		2		N•m	1 N•m/bit	0	64255
X		Maximum Momentary Engine Override Speed, Point 7	533	22-23							
		Max. Momentary Override Time Limit	534	24							
X		Req. Speed Control Range Lower Limit	535	25		1		rpm	10 rpm/bit	0	2500
X		Req. Speed Control Range Upper Limit	536	26		1		rpm	10 rpm/bit	0	2500
		Req. Torque Control Range Lower Limit	537	27							
		Req. Torque Control Range Upper Limit	538	28							
		Extended Range Req. Speed Control									
		Range Upper Limit	1712								
		Engine Moment of Inertia	1794								
		Default Engine Torque Limit	1846								

The ElectropaK engine control system supports the parameter group numbers (PGN) listed in the following table:

Parameter Group	PGN		SPN	Parameters Supported
	Dec	Hex		
Active Diagnostics Trouble Codes (DM1)	65226	FECA	623	Red stop lamp
			624	Amber warning lamp
			987	Protect lamp
			1214	SPN
			1215	FMI
			1706	SPN conversion method
			1216	Occurrence count
Previously Active Diagnostic Trouble Codes (DM2)	65227	FECB	623	Red stop lamp status
			624	Amber warning lamp status
			987	Protect lamp status
			1214	SPN
			1215	FMI
			1706	SPN conversion method
			1216	Occurrence count
Diagnostic Data Clear/Reset of Previously Active DTCs (DM3)	65228	FECC	—	

12.1.3 Supported Parameters — Section 73: Diagnostics

This section defines the engine control system support and implementation of parameter groups defined in the diagnostic application layer of the SAE J1939 standard (J1939-73). These parameter groups are used by devices on the CAN bus for monitoring and displaying engine diagnostic information.

The message identifier, update rate, and parameter group definition are specified for each supported parameter group. Any deviation from the SAE recommended practice is noted below each parameter group table.

12.1.3.1 Active Diagnostics Trouble Codes (DM1): PGN 65226

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE CA 00	1000	FECA	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Protect Lamp	987	1	1	2			binary	00b	01b
X		Amber Warning Lamp	624	1	3	2			binary	00b	01b
X		Red Stop Lamp	623	1	5	2			binary	00b	01b
		Malfunction Indicator Lamp	1213	1	7	2			binary	00b	01b
		Reserved	—	2	1	8					
X		SPN — 8 Least Significant Bits	1214	3	1	8		none	hex	00h	FFh
X		SPN — Second Byte		4	1	8		none	hex	00h	FFh
X		SPN — 3 Most Significant Bits		5	6	3		none	hex	0h	7h
X		FMI	1215	5	1	5		none	hex	00h	1Fh
		SPN Conversion Method	1706	6	8	1			binary	0b	1b
X		Conversion Method 4					0				
		Conversion Method 1-3					1				
X		Occurrence Count	1216	6	1	7		counts	1	0	126

DM1 Broadcast Rate — The engine control system will only broadcast the DM1 message when there is an active fault detected. The message will then be broadcast at a one-second update rate. DM1 only identifies active faults, so a broadcast termination message is sent in the event all faults become inactive. The DM1 termination message is a single fault message with SPN/FMIs set to zero.

DM1 Message Identifier — If a single fault code is present, then DM1 will be sent as a single message with the identifier 18FECA00. If there is more than one fault code present, the DM1 message will be longer than eight bytes and the transport protocol will be used to send the message.

SPN Conversion Method — The SPN conversion method is transmitted as zero. The SPN is transmitted in the preferred format (version 4) described in the J1939-73 specification.

Lamp Status — The engine control system supports the DM1 lamp status parameter byte, but the Perkins definition of each lamp parameter differs from the parameter definition in the SAE J1939-73 standard. Perkins implementation uses these lamps to indicate levels of warning severity. The Perkins strategy defines these as Warning Category Indicators (WCI). There are three levels of warning indicators that have specific actions identified for each level. The engine control system definitions and support for the lamp status parameters are defined in the table on the following page:

Parameter Group	SAE J1939-73 Definition	Perkins Implementation
Malfunction Indicator Lamp	Lamp used to relay only emissions related trouble code information.	Not supported
Red Stop Lamp	Lamp used to relay trouble code information that is of a severe enough condition that it warrants stopping the vehicle.	Lamp status "ON" whenever there is at least one diagnostic trouble code with a warning category indicator = 3 Generally used to indicate engine shutdown due to fault
Amber Warning Lamp	Lamp used to relay trouble code information that is reporting a problem with the vehicle system, but the vehicle need not be immediately stopped.	Lamp status "ON" whenever there is at least one diagnostic trouble code with a warning category indicator = 2 Generally used to indicate engine shutdown due to fault
Protect Lamp	Lamp used to relay trouble code information that is reporting a problem with a vehicle system that is most probably not electronic subsystem related. For instance, engine coolant temperature is exceeding its prescribed temperature range.	Lamp status "ON" whenever there is at least one diagnostic trouble code with a warning category indicator = 1 Generally used for warning only

12.1.3.2 Previously Active Diagnostic Trouble Codes (DM2): PGN 65227

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE CB 00	1000	FECB	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Protect Lamp	987	1	1	2			binary	00b	01b
X		Amber Warning Lamp	624	1	3	2			binary	00b	01b
X		Red Stop Lamp	623	1	5	2			binary	00b	01b
		Malfunction Indicator Lamp	1213	1	7	2			binary	00b	01b
		Reserved	—	2	1	8					
X		SPN — 8 Least Significant Bits	1214	3	1	8		none	hex	00h	FFh
X		SPN — Second Byte		4	1	8		none	hex	00h	FFh
X		SPN — 3 Most Significant Bits		5	6	3		none	hex	0h	7h
X		FMI	1215	5	1	5		none	hex	00h	1Fh
		SPN Conversion Method	1706	6	8	1			binary	0b	1b
X		Conversion Method 4					0				
		Conversion Method 1-3					1				
X		Occurrence Count	1216	6	1	7		counts	1	0	126

DM2 Broadcast Rate — The engine control system will only broadcast the DM2 message when there is a previously active fault logged in the engine control system's non-volatile memory. The message will then be broadcast at a one-second update rate. DM2 only identifies logged faults, so a broadcast termination message is sent in the event all faults are cleared from memory. The DM2 termination message is a single fault message with SPN/FMIs set to zero.

All other application notes for message identifier, SPN conversion method, and lamp status for DM1 also apply to the DM2 message.

12.1.3.3 Diagnostic Data Clear/Reset of Previously Active DTCs (DM3): PGN 65228

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 FE CC 00	On Req	FECC	6	0	00	—

Send	Receive	Subgroup Name	SPN	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range	
										Min	Max
X		Request to Clear Fault Codes									

This message is sent as a request PGN. When the ECM receives a DM3 message, it will clear all diagnostic codes but not event codes. The ECM will send an acknowledge (ACK) message to say that this action is complete.

Diagnostic codes are those that relate to faults of the electronic system (e.g. sensor failure). Event codes are those where there is a problem with the engine operation (e.g. coolant temperature high warning). Event codes can only be cleared with the service tool and require a factory password.

12.1.4 Supported Parameters — Section 21: Data Link Layer

12.1.4.1 Transport Protocol — Connection Management (TP, CM)

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
1C EC FF 00	—	EC00	7	0	—	—

Support as per J1939-21. Note that the transport protocol is used principally for sending messages larger than eight bytes of data (e.g. diagnostic messages DM1 and DM2). This is achieved by sending a broadcast announce message (TP.CM_BAM) which describes the PGN to be sent, the number of bytes of data, and the number of packets into which it is to be divided. The actual data will follow in data transfer packets (TP.DT) as described in the following sections.

12.1.4.2 Transport Protocol — Data Transfer (TP, DT)

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
1C EB FF 00	—	EB00	7	0	—	—

If a module is required to decode any information that is sent via the transport protocol, then it must be capable of receiving and processing messages with the same identifier within 50 ms.

12.1.4.3 Acknowledge

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 E8 xx xx	—	E800	6	0	—	—

Both acknowledge (ACK) and negative acknowledge (NACK) are supported as per the J1939 specification.

12.1.4.4 Parameter Group (PG) Request

Identifier	Rate (msec)	PGN	Default Priority	DP	Source	Destination
18 EA xx xx	—	EA00	6	0	—	—

Support as per the J1939 specification. This PGN is sent to the ECM to request parameters that are only sent “on request.” For example, if an electronic module on the machine requires engine hours information, it must send a request PGN for the engine hours/revolutions PGN.

The engine system is to support PGN 59904 (00EA00), providing the capability to respond to requests for parameter group information globally or from a specific destination. This feature will allow any module on the J1939 data link to access information in the engine system supported parameter list. Response to the parameter group request will comply with request response requirements defined in SAE recommended practice for J1939 data link layer (J1939-21).

12.1.5 Supported Parameters — Section 81: Network Management

The engine does support the network initialization requirements as outlined in Specification J1939-81.

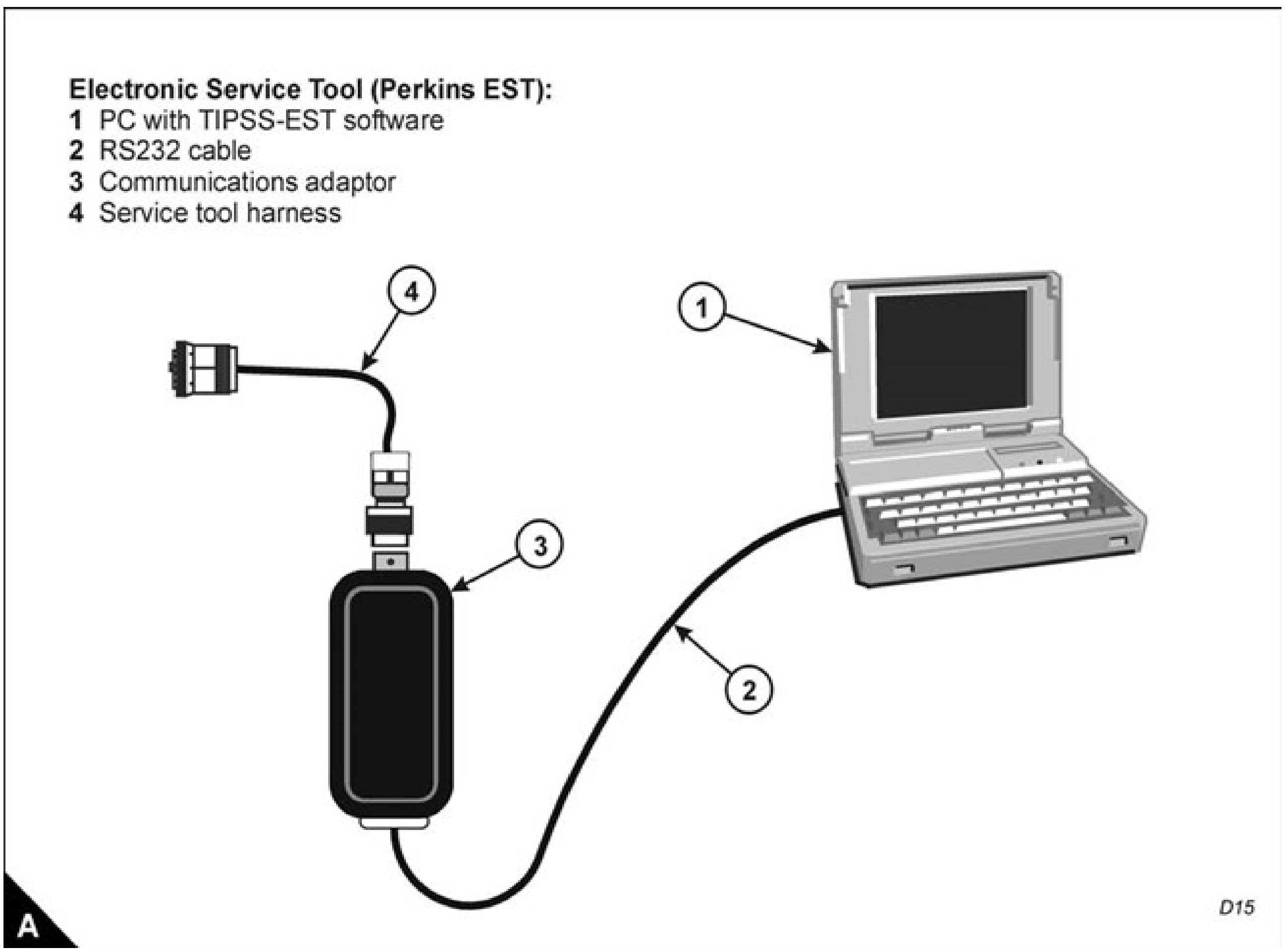
This includes the claiming of addresses. The engine will always claim address zero and will not accept any other address.

12.2 Perkins Data Link

NOTE: 1706 engine does not support Perkins Data Link

For ElectropaK engines, the Perkins Data Link is principally used for service tool support. If an application does have a requirement to communicate with another system on Perkins Data Link, for example with a Perkins display, please contact your local applications team for further information.

12.2.1 Diagnostic and Configuration Tools



This tool is designed for use on a laptop computer to communicate with the ECM via a communications interface. The following functions are available on the electronic service tool:

Active diagnostic codes

Provides information to warn the operator of a potential problem and indicates to the service technician the nature of the problem.

Logged diagnostic codes

Provides a list of diagnostic codes logged by the ECM. These codes are similar to the active diagnostic codes except they are logged over time.

Logged event codes

Provides a list of event codes logged by the ECM.

These codes indicate to the manager or technician how the machine/equipment is being operated. These codes are similar to the logged diagnostic codes, except that the event represents the symptom of the operational problem.

File manager

Displays file names and descriptions and allows access to data saved.

Status tool

The status tool monitors ECM data as it occurs. When running the Status tool for the first time, you must select a group of parameters to monitor.

Summary screen

The ECM Summary screen allows you to view all of the useful ECM and Perkins EST software information.

This screen is automatically displayed each time that you start Perkins EST or establish a new connection through the Connect function under the Data Link menu.

Totals

The Totals screen allows you to view the current total values for the different parameters listed.

Data log recorder

Data log recorder allows you to capture or log performance data, which aids in diagnosing potential problems. Includes a pre-trigger capture of data and an auto-trigger capture when specific conditions occur.

Data log viewer

Data log viewer allows you to either view the logged data from data log recorder graphically or export the file to view as a *.txt file.

Real time graphing

Real time graphing monitors ECM data and displays it in graphical form as it occurs. When running real time graphing for the first time, you must select a set of parameters to graph.

Configuration tool

The configuration tool allows you to view and change the ECM's configurable information

The ECM replacement function

The ECM replacement function allows you to copy configuration parameters from an existing ECM to another ECM, for physically changing the ECM on a machine.

Once an ECM has been programmed by the ECM replacement function, the data on the screen is cleared. This keeps you from programming more than one ECM with the data from another ECM **WinFlash.**

The WinFlash program enables the service technician to program the flash memory of onboard ECMs. Selecting this menu option initiates the Perkins EST WinFlash program.

This program also runs from the Perkins EST group box in Windows.

Further information

Refer the Perkins EST service tool manual. Hand held diagnostic code devices are also available, contact Perkins for details.

12.2.2 J1939 Diagnostic Codes Quick Reference

The data transmitted on the J1939 bus is in the format described in the SAE documents J1939-73. For more detail please refer to the SAE specifications.

J1939 Diagnostic Codes			
J1939 SPN-FMI	**Diagnostic Code Description**	**J1939 SPN-FMI**	**Diagnostic Code Description**
J0651-11	Injector Cylinder #1 Fault	J0620-3	5 Volt Sensor Power Supply, voltage above normal or shorted high
J0652-11	Injector Cylinder #2 Fault	J0620-4	5 Volt Sensor Power Supply, voltage below normal or shorted low
J0653-11	Injector Cylinder #3 Fault	J0102-3	Pressure Sensor shorted high
J0652-11	Injector Cylinder #2 Fault	J0102-4	Turbocharger Outlet Pressure Sensor shorted low
J0653-11	Injector Cylinder #3 Fault	J0108-3	Atmospheric Pressure Sensor shorted high
J0654-11	Injector Cylinder #4 Fault	J0108-4	Atmospheric Pressure Sensor shorted low
J0655-11	Injector Cylinder #5 Fault	J1111-2	Check Configurable Parameters
J0656-11	Injector Cylinder #6 Fault	J0100-17	Low Oil Pressure (Warning)
J0678-3	ECM 8 Volt DC Supply voltage above normal or shorted high	J0100-18	Low Oil Pressure (Action Alert)
J0678-4	ECM 8 Volt DC Supply voltage below normal or shorted low	J0100-01	Low Oil Pressure (Shutdown)
J0091-8	PWM Throttle Position Sensor abnormal signal	J0102-15	High Boost Pressure (Warning)
J0100-3	Engine Oil Pressure Sensor shorted high	J0102-16	High Boost Pressure (Action Alert)
J0100-4	Engine Oil Pressure Sensor shorted low	J0110-15	High Coolant Temperature (Warning)
J0110-3	Engine Coolant Temperature Sensor shorted high	J0110-16	High Coolant Temperature (Action Alert)
J0110-4	Engine Coolant Temperature Sensor shorted low	J0110-00	High Coolant Temperature (Shutdown)
J0168-2	Battery Voltage intermittent	J0172-15	High Inlet Air Temperature (Warning)
J0172-3	Intake Manifold Air Temperature Sensor shorted high	J0172-16	High Inlet Air Temperature (Action Alert)
J0172-4	Intake Manifold Air Temperature Sensor shorted low	J0174-15	High Fuel Temperature (Warning)
J0174-3	Fuel Temperature Sensor shorted high	J0174-16	High Fuel Temperature (Action Alert)
J0174-4	Fuel Temperature Sensor shorted low	J0190-15	Overspeed (Warning)
J0190-2	Engine Speed Sensor Loss of Signal	J0190-16	Overspeed (Action Alert)
J0190-11	Engine Speed Sensor Mechanical Fault	J0190-00	Overspeed (Shutdown)
J0234-2	Incorrect ECM Software	J1108-31	Critical Override Enabled
J0228-13	Engine Timing Calibration Required		

12.3 Other Data Link Standards

12.3.1 CANopen

CANopen may become a popular choice for CAN higher level protocol in off-highway machines that use significant numbers of electro-hydraulic controllers.

If CANopen is used as the main communications standard in a vehicle, then a J1939 gateway is required. A specification for a CANopen to J1939 gateway may be obtained from the website of "CAN in Automation (CIA)."

12.3.2 OEM Proprietary CAN Standards

It is accepted that the J1939 standard cannot meet all the diverse needs of the many specialized applications in the off-highway market. The OEM may have to use a small number of proprietary messages on the same bus as the J1939 messages. If a large number of proprietary messages are required for an application, the machine designer should consider the use of a CAN gateway to isolate the proprietary messages from the J1939 bus. There is also a risk that OEM-defined messages will clash with some of the J1939 standard messages.

Appendix:

A 1.0 ECM Interface Requirements

A 1.1 PWM Input

The PWM input measures the frequency and duty cycle of a 500 Hz PWM signal. The input is a single-ended digital input. The signal input is to switch between 0 VDC (max 1.0 VDC) low state and 5 VDC (min 3.75 VDC max 24 VDC) high state. The normal operating range for the 500 Hz PWM signal duty cycle is 5% to 95% and frequency is 150 Hz to 1000 Hz. Signal operation outside of this range will result in an abnormal signal diagnostic code on the ECM.

Connection of the PWM signal to the ECM should be through wire size of #16 to #18 AWG with a wire specification that meets SAE J1128 for low-tension primary cable, type SXL. Reference Connectors and Wiring Harness Requirements section for more information on wire selection.

A 1.2 Switch to Ground Input

The information in this section is general knowledge for connecting switches to the ECM switch to ground input. Specific information for a particular switch is located with the engine feature to which the switch belongs. Switch to ground inputs on the ECM are all pulled up to an internal power supply.

A 1.2.1 Measuring Voltage in Switch Circuits

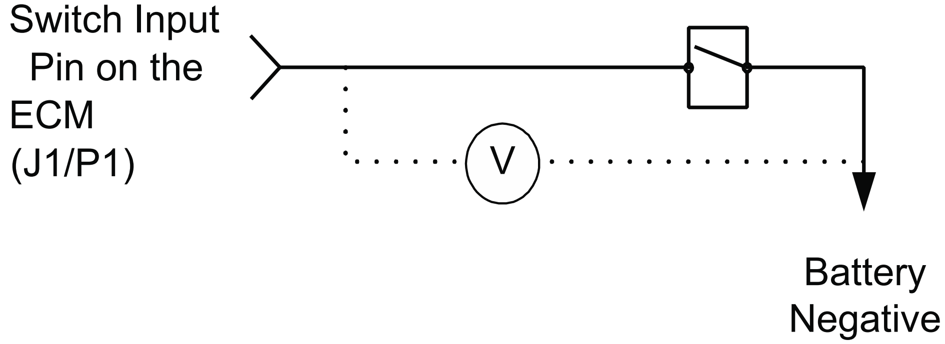
Voltage that is supplied from the ECM to the switches will not normally exceed 13 VDC, regardless of the system voltage.

When any of the switch contacts are closed, the voltage drop through the switch circuit must be less than 1.4 VDC. This measurement should be taken at the ECM pin that supplies the switch and at the negative battery input to the ECM. This measurement includes the following values:

- Ground Potential Differences
- Voltage Drop Across the Switch
- Voltage Drop Across the Wiring Harness

When a switch contact is opened, or the wiring harness has an open circuit, the internal pull-up voltages of the ECM force the respective input to 13 VDC. Closing an OEM-installed switch must short circuit the switch input to the negative battery ground stud that is located near the ECM customer connector (J1/P1). Refer to the Power and Grounding Considerations section of this publication.

Switch Status	Measured Voltage (VDC)
Closed	< 1.4 VDC
Open	> 2 .4 VDC



V = voltage measurement with digital multimeter

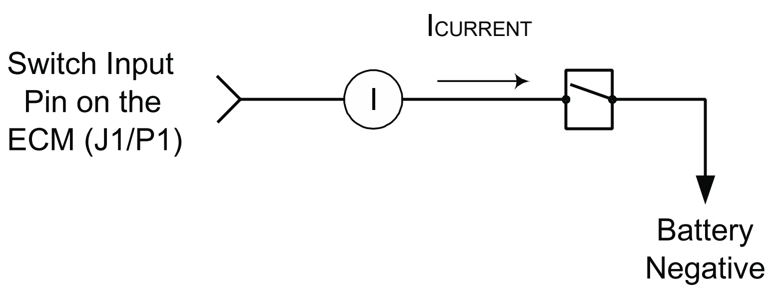
For Models 1706A/D, use CH-C2 for pin-out, Appendix 2.0.3

A 1.2.2 Measuring Current in Switch Circuits

Normal current output from the ECM through the switches ranges from a minimum of 6 mA to maximum of 10 mA. Current may flow through unintended paths. Possible paths for current leakage may exist within the following components:

- Connectors
- Harnesses
- Switches

Switch Status	Measured Current (I)
Closed	6-10 mA
Open	0 mA



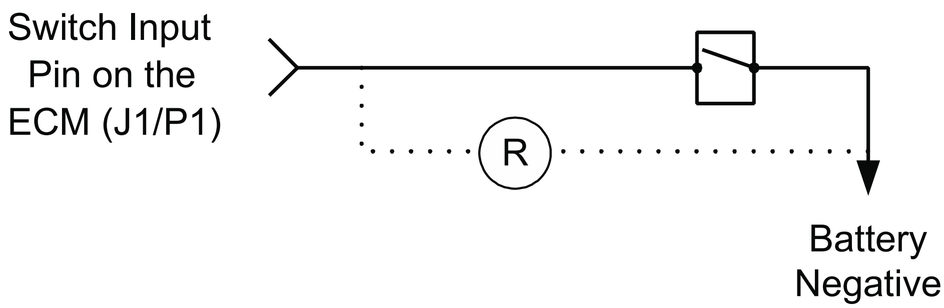
I = current measurement with digital multimeter

- **For Models 1706A/D, see CH-C2 for pin-out, Appendix 2.0.3**

A 1.2.3 Measuring Resistance in Switch Circuits

When any of the switch contacts are open, the resistance between the pin that supplies the switch and at the negative battery input to the ECM should be greater than 4,000 ohms.

Switch Status	Measured Resistance (R)
Closed	< 50 ohms
Open	< 50 ohms



R = resistance measurement with digital multimeter

For Models 1706A/D, use CH-C2 for pin-out, Appendix 2.0.3

A 1.3 High-Side Current Driver (2 A) Output

The high-side current driver (2 A) output is a digital output that is switched to battery for driving a source that has a continuous current draw that is less than or equal to 2 A. This output is typically used to control devices such as LEDs, relays, and solenoids that require large amounts of current. These drivers are capable of functioning during engine cranking, jumpstart, and load dump, although the driver output voltage will depend directly upon the instantaneous voltage applied to the ECM battery positive and negative inputs.

The driver sources (delivers) current through the device to a return pin located on the ECM. The amount of current sourced depends on the resistance of the device and on the system battery voltage. The ECM limits the sourced current to approximately 3.5 A to handle “in-rush” conditions. The driver will turn off automatically when a “load dump” is present and will turn back on when the “load dump” has dissipated. Any load connected to the driver should be able to withstand “load dumps.”

The ECM will source 2.0 A at normal operating conditions. The maximum leakage current with the driver off is 1 mA. At cold operating conditions, the ECM may source as low as 1.0 A to the solenoid or relay. Select components that normally operate between 1.0 A and 2.0 A. The driver application must not be designed to source more than 2.0 A. Perkins recommends that transient suppression is used on inductive load in addition to the ECM internal protection.

Connection of the high-side current driver output to the ECM should be through wire size of #14 to #16 AWG with a wire specification that meets SAE J1128 for low-tension primary cable, type SXL. Reference Connectors and Wiring Harness Requirements section for more information on wire selection.

A 1.4 Low-Side Current Driver (300 mA) Output

The low-side ECM driver provides a path to the negative battery terminal to activate the device (lamp, etc.) that is connected to the circuit. While circuit protection is recommended for the lamp driver circuit, Perkins does not require dedicated circuit protection.

When the ECM turns the driver on, the output pin will be within about 1 volt of the ECM negative battery terminal. The driver is designed to sink 300 mA over the ECM operating temperature range. The maximum leakage current with the driver off is 1 mA.

The driver will sink more than 300 mA briefly to handle “in-rush” situations such as turning on incandescent lights. Resistances for incandescent lamps or other dynamic devices are typically 10 percent of the steady state value for up to 150 ms when current is limited to 300 mA. Under these conditions, the driver shall not pulse on and off or current limit until the load reaches steady state resistance.

The ECM is capable of detecting if the continuous current exceeds 300 mA. The driver must never be expected to sink more than 300 mA continuous current. The driver will turn off automatically when a “load dump” is present and will turn back on when the “load dump” has dissipated. Any load connected to the driver should be able to withstand “load dumps.”

The lamps are to be connected to battery (+) to provide power to drive the lamps on. If the driver is connected to a discrete load (lamp, buzzer, etc.) the battery (+) connection for the load should be switched. Avoid having battery (+) connected to the load while the ECM is off.

Connection of the low-side driver to the ECM should be through wire size of #16 to #18 AWG with a wire specification to meet SAE J1128 for low-tension primary cable, type SXL. Reference Connectors and Wiring Harness Requirements section for more information on wire selection.

A 2.0 ECM Connector (J1/P1) Pinout Table

2.0.1 Models 1506/2206/2506/Standard 2806 (TAG) Engines Only

Engine Connector (J1/P1)

*J1 pin#	Application Function	ECM Hardware	*J1 pin#	Application Function	ECM Hardware
1		PWM In 3	36	--	Speedo +
2	Analog sensor power	5V Analog Power	37	--	Speedo -
3	Analog sensor return	Analog Return	38	--	Tacho +
4	TC-L Throttle power +8V	8V Digital Power	39	--	Tacho -
5	TC-L Throttle return	Digital Return	40		GND Switch 3
6		GND Switch 16	41	Reset	GND Switch 4
7	Digital Speed Control - Raise	GND Switch 17	42	J1939 Shield	CAN A Shield
8	Perkins data link +	ATA +	43		PWM Out 3 +
9	Perkins data link -	ATA -	44		GND Switch 7
10	Shutdown Lamp	Dout 7: 2A Source	45		GND Switch 8
11		Dout 8: 2A Source/PWM	46	Droop/Isoch Control	GND Switch 9
12	Reserved for J2	Dout 9: 2A Source	47	Low Idle Switch	GND Switch 10
13	Crank Terminate Relay	Dout 10: 2A Source	48	+B direct (14 AWG)	"+" Battery
14		PWM In 4	49	Digital Speed Control - Enable	GND Switch 11
15		Prog. Analog 1	50	J1939 +	CAN A +
16	Reserved for J2	Prog. Analog 2	51		PWM Out 3 -
17	Analog Throttle	Prog. Analog 3	52	+B direct (14 AWG)	"+" Battery
18	Return	Digital Return	53	+B direct (14 AWG)	"+" Battery
19	Action Alert Lamp	Dout 11: 2A Source	54		GND Switch 12
20	Warning Lamp	Dout 12: 2A Source	55	Power Out to Service Tool	"+" Battery
21	Relay	Dout 15: 2A Source/PWM	56	Frequency select	GND Switch 13
22		GND Switch 1	57	--	"+" Battery
23		GND Switch 2	58		GND Switch 14
24	Reserved	Dout 6: 0.3A Sink/PWM	59	Digital Speed Control -Lower	GND Switch 5
25	Reserved for J2	Dout 17: 3A Source	60		GND Switch 15
26	Optional Oil Temp.	Prog. Analog 4	61	-B (14 AWG)	"-" Battery
27	Reserved for J2	Prog. Analog 5	62	Run/Stop (Inj. Disable)	"+" Bat Switch 1
28	Low Oil Press Lamp	Dout 2: 0.3A Sink	63	-B (14 AWG)	"-" Battery
29	High Coolant Temp Lamp	Dout 3: 0.3A Sink	64	Shutdown Override	"+" Bat Switch 2
30	Engine Overspeed Lamp	Dout 4: 0.3A Sink	65	-B (14 AWG)	"-" Battery

31		Dout 5: 0.3A Sink/PWM	66	Throttle	PWM In 1
32		Diff. Speed 4+	67	--	"-" Battery
33		Diff. Speed 4 -	68	Droop	PWM In 2
34	J1939 -	CAN A -	69	Power Return from Service Tool	"-" Battery
35		GND Switch 6	70	Key Switch	Key Switch

* All Wire size is 18 AWG unless otherwise noted i.e. pin 65 –B (14 AWG).

2.0.2 Power Density 2806 Model (TTAG) Engines Only

J1 pin #	Application Function	ECM Hardware	J1 pin #	Application Function	ECM Hardware
1		PWM In 3	36		Speedo +
2	5V Analog Sensor Supply	5V Analog Power	37		Speedo -
3	Analog Sensor Return	Analog Return	38		Tacho +
4		8V Digital Power	39		Tacho -
5		Digital Return	40	Run/Stop	GND Switch 3
6		GND Switch 16	41	Latch Reset	GND Switch 4
7	Overspeed Verify Switch	GND Switch 17	42	J1939 Shield	CAN A Shield
8	CDL +	ATA +	43	App Starter Relay +	PWM Out 3 +
9	CDL -	ATA -	44		GND Switch 7
10		Dout 7: 2A Source	45	Coolant level switch	GND Switch 8
11		Dout 8: 2A Source/PWM	46	Droop/Isoch Control	GND Switch 9
12	Warning lamp	Dout 9: 2A Source	47	Low Idle Switch	GND Switch 10
13	Action alert/Derate lamp	Dout 10: 2A Source	48	+Battery	+ Battery
14		PWM In 4	49		GND Switch 11
15		Prog. Analog 1	50	J1939 Data Link (+)	CAN A +
16	Reserved for J2	Prog. Analog 2	51	App Starter Relay -	PWM Out 3 -
17	Analog Speed Input	Prog. Analog 3	52	+Battery	+ Battery
18		Digital Return	53	+Battery	+ Battery

19	Shutdown lamp	Dout 11: 2A Source	54	Digital speed control enable	GND Switch 12
20	Crank terminate lamp	Dout 12: 2A Source	55	+Battery	+ Battery
21		Dout 15: 2A Source/PWM	56	Frequency select switch	GND Switch 13
22		GND Switch 1	57		+ Battery
23	Auxiliary Engine Shutdown	GND Switch 2	58	Digital speed control High switch	GND Switch 14
24	Reserved	Diff. Speed 3 +	59		GND Switch 5
25	Reserved for J2	Diff. Speed 3 -	60	Digital speed control Low switch	GND Switch 15
26	Engine Oil Temp.	Prog. Analog 4	61	-Battery	- Battery
27	Reserved for J2	Prog. Analog 5	62		+ Bat Switch 1
28	Overspeed lamp	Dout 2: 0.3A Sink	63	-Battery	- Battery
29	Coolant temp lamp	Dout 3: 0.3A Sink	64	Monitoring system shutdown override	+ Bat Switch 2
30	Oil pressure lamp	Dout 4: 0.3A Sink	65	-Battery	- Battery
31		Dout 5: 0.3A Sink/PWM	66	Throttle	PWM In 1
32		Diff. Speed 4+	67	-Battery	- Battery
33		Diff. Speed 4 -	68		PWM In 2
34	J1939 Data Link (-)	CAN A -	69	-Battery	- Battery
35		GND Switch 6	70	Key Switch	Key Switch

2.0.3 1706A/D Model

Customer Harness Connection 40 Pin - CH-C2								
Pin	Interface Description	Circuit ID	AWG		Pin	Interface Description	Circuit ID	AWG
1	Battery +	150-RD	14		21	Supply +8V	167-OR	18
2	Digital Speed Control Enable	180-GN	18		22	Digital Ground	P696-BR	18
3					23	Low Idle Control Switch	386-PK	18
4	Warning (Amber) Lamp	F420-GN	18		24	Analog Throttle	R914-OR	18
5	Action Alert Lamp	H401-GN	18		25	Frequency Select Switch	N997-WH	18
6	Starter Relay -	P883-BR	18		26	Droop/ISOH Control	E722-PK	18
7	Starter Relay +	A753-PU	18		27			
8	Low Oil Pressure Lamp	F404-RD	18		28	Digital Speed Control High Sw	A366-BR	18
9	Coolant Level Switch	C984-YL	18		29	Digital Speed Control Low Sw	A741-BU	16
10	Key Switch	120-YL	18		30			
11	Crank Terminate	Y737-YL	18		31	J1939 Data Link +	F711YL	18
12	Digital Ground	P967-PU	18		32	J1939 Data Link -	F712GN	18
13	J1939 Data Link Shield	A234-BK	18		33	Battery (+)	150-RD	14
14					34	Run/Stop	R775-OR	18
15	Battery +	150-RD	14		35	Shutdown Override	N755-OR	18
16	Shutdown (Red) Lamp	604-OR	18		36	PWM Throttle	F702-GN	18
17	High Coolant Temp Lamp	F420-BK	18		37			
18	Latch Reset	E826-GY	18		38	Battery (-)	229-BK	14
19	Supply +5V	125-OR	18		39	Battery (-)	229-BK	14
20	Analog Ground	J767-GY	18		40	Battery (-)	229-BK	14

A 3.0 Customer Configuration Parameter Table

A 3.1 1506 System Configuration Parameter Table

Customer Configuration Parameter Table 1506			
Parameter	Available range or Options	Default	Required Password
ECM Identification Parameters			
Equipment ID	17 or less Alphanumeric Characters	Not Programmed	CPS
Engine Serial Number	15 Digit	Not Programmed	FPS
ECM Serial Number	Read Only	Read Only	Read Only
Software Group Part Number	Read Only	Read Only	Read Only
Software Group Release Date	Read Only	Read Only	Read Only
Software Group Description	Read Only	Read Only	Read Only
Selected Engine Rating			
Rating Number	Software Dependent	Software Dependent	FPS
Rated Frequency	Read Only	Read Only	Read Only
Rated Genset Speed	Read Only	Read Only	Read Only
Rated Real Genset Power	Read Only	Read Only	Read Only
Rated Apparent Genset Power	Read Only	Read Only	Read Only
Engine Rating Application Type	Read Only	Read Only	Read Only
External Speed Selection Switch Installed	Enabled/disabled	Enabled	CPS
Engine Gear Parameters			
Engine Acceleration Rate	5 rpm/s to 2000 rpm/s	500 rpm/s	CPS
Droop/Isochronous Switch Installed	Disabled/Enable	Disabled	CPS
Droop/Isochronous Selection	Droop / Isochronous	Droop	CPS
Engine Speed Droop	0 to 8%	3%	CPS

Digital Speed Control Installed	Installed/Not Installed	Installed	CPS
Speed Control Minimum Speed	0 to 150 rpm	150 rpm	CPS
Speed Control Maximum Speed	0 to 150 rpm	150 rpm	CPS
Digital Speed Control Ramp Rate	5 rpm/s to 2000 rpm/s	10 rpm/s	CPS
Crank Terminate RPM	200 rpm to 700 rpm	400 rpm	None
I/O configuration Parameters			
Desired Speed Input Arrangement	0-5 VDC Input/CAN Input/PWM	0-5 VDC Input	CPS
Fuel Enable Input Configuration	Switch to Battery+ /CAN Input	Switch to Battery+	None
Critical Override Switch Installed	Installed/Not Installed	Installed	FPS
Emergency Shutdown Override Input Configuration	Switch to Battery+ /CAN Input	Switch to Battery+	None
Engine Fan Type Configuration	Read Only	Unavailable	None
System Settings			
Governor Gain Factor #1	1 to 65534	Software Dependent	None
Governor Minimum Stability Factor #1	1 to 65534	Software Dependent	None
Governor Maximum Stability Factor #1	1 to 65534	Software Dependent	None
Full Load Setting (FLS)	Factory Programmed	Not Programmed	FPS
Full Torque Setting (FTS)	Factory Programmed	Not Programmed	FPS
Passwords			
Customer Password 1	8 Alphanumeric characters	********(blank)	CPS
Customer Password 2	8 Alphanumeric characters	********(blank)	CPS
Security Access Parameters			
Total Tattletales	Read Only	Read Only	Read Only

A 3.2 1706 EP LRC System Configuration Parameter Table

Customer Configuration Parameter Table			
Parameter	**Available Range/Options**	**Default**	**Required password**
ECM Identification Parameters			
Equipment ID	17 or less Alphanumeric characters	Not Programmed	None
Engine Serial Number	15 digit	Not Programmed	One time free and subsequent change needs FPS
ECM Serial Number	Read Only	Read Only	None
Software Group Part Number	Read Only	Read Only	None
Software Group Release Date	Read Only	Read Only	None
Software Group Description	Read Only	Read Only	None
Selected Engine Rating			
Rating Number	Software dependent	Software dependent	FPS
Rated Frequency	Read Only	Read Only	Read Only
Rated Engine Speed	Read Only	Read Only	Read Only
Rated Real Genset Power	Read Only	Read Only	Read Only
Rated Apparent Genset Power	Read Only	Read Only	Read Only
Rating Configuration	Read Only	Read Only	Read Only
Engine/Gear Parameters			
Engine Acceleration Rate	10 rpm/s - 2000 rpm/s	500 rpm/s	None
Engine State Control Input Configuration	Hardwired Input	Hardwired Input	None
Cool down Duration	0 min - 30 min	3 min	None
Low Idle Speed	900 rpm - 1100 rpm	1100 rpm	None
Engine Speed Droop	0 % - 8 %	3%	None
Crank Terminate RPM	200 rpm - 500 rpm	400 rpm	None
Crank Duration	10 sec - 30 sec	10 sec	None
Maximum Number of Crank Cycles	1 to 3	3	None
Droop/Isochronous Selection	Droop, Isochronous	Isochronous	None
Digital Speed Control Installed	Installed, Not Installed	Not Installed	CPS
Speed Control Minimum Speed	0 rpm - 150 rpm	125 rpm	CPS
Speed Control Maximum Speed	0 rpm - 150 rpm	125 rpm	CPS
Digital Speed Control Ramp Rate	5 rpm/s - 2000 rpm/s	10 rpm/s	CPS
Starting System Type	Not installed, Electrical	Not Installed	None
I/O Configuration Parameters			
Engine Oil Temperature Sensor Installation Status	Installed, Not installed	Not Installed	None
Desired Speed Input Arrangement	CAN input, PWM,0-5VDC	CAN Input	None
Secondary Desired Speed Input Configuration	Not installed, CAN Input, PWM,0-5VDC	Not Installed	None
Droop/Isochronous Switch Installed	Disabled, Enabled	Disabled	CPS
Critical Override Switch Installed	Not Installed, Installed	Not Installed	CPS

Emergency Shutdown Override Input Configuration	Switch to Battery +, CAN Input	Switch to Battery +	None
External Speed Selection Switch Installed (1706A only)	Disabled, Enabled	Disabled	CPS
Coolant Level Sensor	Installed, Not Installed	Not installed	None
Engine Fan Type Configuration	Unavailable	Unavailable	None
System Settings			
Governor (Proportional) Gain Percentage	1.0% - 1000%	100%	None
Governor (Integral) Stability Percentage	1.0% - 1000%	100%	None
Governor Transient Response Loop Gain Percentage	1.0% - 1000%	100%	None
Full Load Setting (FLS)	Factory Programmed	Not Programmed	One time free and subsequent change needs FPS
Full Torque Setting (FTS)	Factory Programmed	Not Programmed	One time free and subsequent change needs FPS
Passwords			
Customer Password 1	8 Alphanumeric characters	********(blank)	CPS
Customer Password 2	8 Alphanumeric characters	********(blank)	CPS
Security Access Parameters			
CAN Communication Protocol Write Security	Seed and Key access	Seed and Key access	None
CAN Communication Protocol Read Security	Seed and Key access, No Security	Seed and Key access	FPS
Total tattletales	Read Only	Read Only	Read Only

A 3.3 2000 Series (non-PD) LRC System Configuration Table

Customer Configuration Parameter Table			
Parameter	Available range or Options	Default	Required Password
ECM Identification Parameters			
Equipment ID	17 or less Alphanumeric Characters	Not Programmed	CPS
Engine Serial Number	15 digit	Not Programmed	FPS
ECM Serial Number	Read Only	Read Only	Read Only
Software Group Part Number	Read Only	Read Only	Read Only
Software Group Release Date	Read Only	Read Only	Read Only
Software Group Description	Read Only	Read Only	Read Only
Selected Engine Rating			
Rating Number	Software Dependent	Software Dependent	FPS
Rated Frequency	Read Only	Read Only	Read Only
Rated Genset Speed	Read Only	Read Only	Read Only
Rated Real Genset Power	Read Only	Read Only	Read Only
Rated Apparent Genset Power	Read Only	Read Only	Read Only
Engine Rating Application Type	Read Only	Read Only	Read Only
External Speed Selection Switch Installed	Enabled/Disabled	Enabled	CPS
Engine Gear Parameters			
Engine Acceleration Rate	5 rpm/s to 2000 rpm/s	500 rpm/s	CPS
Droop/Isochronous Switch Installed	Disabled/Enable	Disabled	CPS
Droop/Isochronous Selection	Droop / Isochronous	Droop	CPS
Engine Speed Droop	0 to 8%	3%	CPS
Digital Speed Control Installed	Installed/Not Installed	Installed	CPS
Speed Control Minimum Speed	0 to 150 rpm	125 rpm	CPS

Speed Control Maximum Speed	0 to 150 rpm	125 rpm	CPS
Digital Speed Control Ramp Rate	5 rpm/s to 2000 rpm/s	10 rpm/s	CPS
Crank Terminate RPM	200 rpm to 700 rpm	400 rpm	None
I/O configuration Parameters			
Desired Speed Input Arrangement	0-5 VDC Input/CAN Input/PWM	0-5 VDC Input	CPS
Fuel Enable Input Configuration	Switch to Battery+ /CAN Input	Switch to Battery+	None
Critical Override Switch Installed	Installed/Not Installed	Installed	FPS
Emergency Shutdown Override Input Configuration	Switch to Battery+ /CAN Input	Switch to Battery+	None
System Settings			
Governor Gain Factor #1	1 to 65534	Software Dependent	None
Governor Minimum Stability Factor #1	1 to 65534	Software Dependent	None
Governor Maximum Stability Factor #1	1 to 65534	Software Dependent	None
Full Load Setting (FLS)	Factory Programmed	Not Programmed	FPS
Full Torque Setting (FTS)	Factory Programmed	Not Programmed	FPS
Passwords			
Customer Password 1	8 Alphanumeric characters	********(blank)	CPS
Customer Password 2	8 Alphanumeric characters	********(blank)	CPS
Security Access Parameters			
Total Tattletales	Read Only	Read Only	Read Only

A 3.4 2806 PD TTAG Engines

Parameter	Available Range or Options	Default
ECM Identification Parameters		
Equipment ID	Not Programmed	17 Alphanumeric Characters
Engine Serial Number	Not Programmed	15 Digits
ECM Serial Number	Read Only	Read Only
Software Group Part Number	Read Only	Read Only
Software Group Release Date	Read Only	Read Only
Software Group Description	Read Only	Read Only
Selected Engine Rating		
Rating Number	Software Dependent	Software Dependent
Rated Frequency	Read Only	Read Only
Rated Engine Speed	Read Only	Read Only
Rated Real Genset Power	Read Only	Read Only
Rated Apparent Genset Power	Read Only	Read Only
Rating Configuration	Read Only	Read Only
Engine/Gear Parameters		
Engine Acceleration Rate	10-2000 rpm/s	500 rpm/s
Engine State Control Input Configuration	Hardwired Input	Hardwired Input
Cooldown Duration	0-30 min	3 min
Low Idle Speed	900-1100 rpm	1100 rpm
Engine speed Droop	3-8%	3.00%
Crank Terminate RPM	200-700 rpm	400 rpm
Crank Duration	0-60 sec	10 sec
Maximum Number of Crank Cycles	3--10	3
Droop/Isochronous Selection	Droop,Isochronous	Isochronous
Digital Speed Control Installed	Installed, Not Installed	Not Installed

Speed Control Minimum Speed	0-150 rpm	125
Speed Control Maximum Speed	0-150 rpm	125
Digital Speed Control Ramp Rate	5-2000 rpm/sec	10 rpm/s
Starting System Type	Not Installed,Electrical	Not Installed
I/O Configuration Parameters		
Engine Oil Temperature Sensor Installation Status	Installed, Not Installed	Not Installed
Desired Speed Input Arrangement	0-5VDC Input,CAN Input,PWM	CAN Input
Secondary Desired Speed Input Configuration	Not Installed,0-5VDC Input,CAN Input,PWM	Not Installed
Droop/Isochronous Switch Installed	Enabled, Disabled	Disabled
Critical Override Switch Installed	Installed, Not Installed	Not Installed
Emergency Shutdown Override Input Configuration	CAN Input, Switch to Battery +	Switch to Battery +
External Speed Selection Switch Installed	Enabled (For TTAG4/5, unavailable for TTAG6/7)	Enabled
Coolant Level Sensor	Installed, Not Installed	Not Installed
System Settings		
Governor (Proportional) Gain Percentage	1%-1000%	100%
Governor (Integral) Stability Percentage	1%-1000%	100%
Governor Transient Response Loop Gain Percentage	1%-1000%	100%
FLS	(-128) to 127	Not Programmed
FTS	(-128) to 127	Not Programmed
Security Access Parameters		
CAN Communication Protocol Write Security	------	Seed and Key Access
CAN Communication Protocol Read Security	Seed and Key Access, No Security	Seed and Key Access

A 4.0 Customer Parameter Worksheet

Providing the customer with a printed copy of the “Configuration” and the “Monitoring System” screens from Perkins EST is good practice. The following table may be copied for the customer.

Parameter	Value
Equipment ID	
Engine Serial Number	
ECM Serial Number	
Personality Module Part Number	
Software Group Release Date	
Rating Number	
Rated Power	
Rated Peak Torque	
Top Engine Speed Range	
Test Specifications	
Top Engine Limit	
Engine Acceleration Rate	
Low Idle Speed	
High Idle Speed	
Intermediate Engine Speed	
Customer Password #1	
Customer Password #2	
Air Shutoff	
Maintenance Indicator Mode	
PM1 Interval	
Coolant Level Sensor	
Last Tool to Change Customer Parameters	
Last Tool to Change System Parameters	
Engine Governor Primary Mode Configuration	
Total Tattletale	
Run Out Control	
Information from Engine Information Plate	
FLS	
FTS	

A 5.0 Engine Monitoring System Parameter Table

A 5.1 1506 TAG Engine System Monitoring Parameter Table

1506 Engine Monitoring System Parameter Table						
Parameter	Action (3)		Time Delay in Seconds		Set Points	
		Default Value	Range	Default	Range	Default
Engine Overspeed	Least Severe (1) Most Severe (3)	Always On Always On	None 1-5	1 sec 1 sec	None 1200-2400	2200 rpm 2300rpm
High Engine Coolant Temperature	Least Severe (1) Moderate Severity (2) Most Severe (3)	Always On Off On	None None None	10 sec 10sec 10sec	None None 87-116	113 Deg C 116 Deg C 116 Deg C
High Engine Inlet Air Temperature	Least Severe (1) Moderate Severity (2)	Always On Off	None None	8 sec 8 sec	None None	90 Deg C 110 Deg C
High Engine Oil Temperature	Least Severe (1) Moderate Severity (2) Most Severe (3)	On On On	4-30 4-30 None	15 sec 15 sec 15 sec	100-110 105-115 None	110 Deg C 110 Deg C 110 Deg C
High Fuel Filter Pressure Restriction	Least Severe (1) Moderate Severity (2) Most Severe (3)	Off Off Off	None None None	3600 sec 28800 sec 28800 sec	None None None	None None None
High Fuel Pressure	Least Severe (1) Moderate Severity (2) Most Severe (3)	On Off Off	8-14 None None	8 sec 10 sec 12 sec	None None None	758 kpa 760 kpa 762 kpa
High Fuel Temperature	Least Severe (1) Moderate Severity (2) Most Severe (3)	Always On Off Off	0-120 0-120 0-120	30 sec 10 sec 10 sec	65-90 65-91 65-92	90 Deg C 91 Deg C 92 Deg C
Low Engine Oil Pressure	Least Severe (1) Most Severe (3)	Always On Always On	None None	8 sec 4 sec	None None	None None
Low Fuel Pressure	Least Severe (1) Moderate Severity (2) Most Severe (3)	On Off Off	5-10 5-10 5-10	10 sec 10sec 10sec	400-450 390-440 380-430	400 kpa 390 kpa 380 kpa

A 5.2 1706 EP LRC Engines

1706 Engine Monitoring System Parameter Table						
Parameter	Action (3)	Default Value	Time Delay in Seconds		Set Points	
			Range	Default	Range	Default
Engine Overspeed	Least Severe (1) Most Severe (3)	Always On Always On	None None	0.6 sec 0.6 sec	1200-2400 1200-2400	2070 rpm 2124 rpm
High Boost Pressure	Least Severe (1) Action Alert (2)	On Always On	0-60 None	60 sec 5sec	200-310 None	300 kpa None
High Engine Coolant Temperature	Least Severe (1) Action Alert (2) Most Severe (3)	Always On Off On	None 1-120 1-120	10 sec 10 sec 10 sec	85-109 86-111 87-112	109 Deg C 111 Deg C 112 Deg C
High Engine Inlet Air Temperature	Least Severe (1) Action Alert (2)	Always On Off	None None	8 sec 4 sec	100-125 100-125	115 Deg C 120 Deg C
High Fuel Temperature	Least Severe (1) Action Alert (2) Most Severe (3)	On Always Off Off	1-200 30-120 1-120	30 sec 30 sec 10 sec	75-90 None 75-90	79 Deg C 79 Deg C 90 Deg C
Low Coolant Level	Least Severe (1) Most Severe (3)	On On	1-120 1-120	10 sec 10 sec	Not programmable Not programmable	None None
Low Engine Oil Pressure	Least Severe (1) Most Severe (3)	Always On Always On	Not programmable Not programmable	8 sec 4 sec	None None	None None
High Engine Oil Temperature	Least Severe (1) Action Alert (2) Most Severe (3)	On Off Off	All Not programmable	15 15 15	100-110 105-115 105-115	110 115 115
High Fuel Filter Degradation	Least Severe (1) Action Alert (2)	On On	1-120 1-120	1 1	60%-80% 70%-130%	70% 100%

A 5.3 Standard TAG Engines (2206 – 2806)

2206-2806 Engine Monitoring System Parameter Table						
Parameter	Action (3)	Default Value	Time Delay in Seconds		Set Points	
			Range	Default	Range	Default
Engine Overspeed	Least Severe (1) Action Alert (2) Most Severe (3)	On Always On Always On	None None None	1 sec 0 sec 0 sec	1650-2050 None None	2000 rpm 2050 rpm 2140 rpm
High Boost Pressure	Least Severe (1) Action Alert (2)	On Always On	0-60 None	60 sec 5sec	200-310 None	300 kpa None
High Engine Coolant Temperature	Least Severe (1) Action Alert (2) Most Severe (3)	On Always On Always On	0-60 None None	60 sec 10sec 10sec	95-105 None None	104 Deg C 105 Deg C 108 Deg C
High Engine Inlet Air Temperature	Least Severe (1) Action Alert (2)	On Always On	0-60 None	60 sec 10 sec	65-78 None	75 Deg C 78 Deg C
High Fuel Temperature	Least Severe (1) Action Alert (2)	On Always On	0-60 None	60 sec 60 sec	50-70 None	60 Deg C 68 Deg C
Low Coolant Level	Least Severe (1) Action Alert (2) Most Severe (3)	On Off Always On	4-65 4-65 4-65	10 sec 10 sec 10 sec	None None None	None None None
Low Engine Oil Pressure	Least Severe (1) Action Alert (2) Most Severe (3)	On Always On Always On	0-60 None None	60 sec 2 sec 2 sec	250-300 None None	300kpa None None

A 5.4 Power Density 2806 E18TTAG4-7 Engines Only

Power Density TTAG Engines (2806 PD)						
			Time Delay in Seconds		Set Points	
Parameter	**Action**	**Default Value**	**Range**	**Default**	**Range**	**Default**
Engine Overspeed	Warning (Least Severe)	Always On	Not Programmable	0	1200 to 2400	2070 rpm
	Shutdown (Most Severe)	Always On	Not Programmable	0	1200 to 2400	2124 rpm
High Engine Coolant Temperature	Warning (Least Severe)	Always On	Not Programmable	10	85 to 109	100 Deg c
	Derate (Moderate Severity)	Off	1 to 120	10	86 to 111	102 Deg c
	Shutdown (Most Severe)	On	1 to 120	10	87 to 114	105 Deg c
High Engine Oil Temperature	Warning (Least Severe)	On	Not Programmable	15	100 to 110	110 Deg c
	Derate (Moderate Severity)	Off	Not Programmable	15	105 to 115	115 Deg c
	Shutdown (Most Severe)	Off	Not Programmable	15	105 to 115	115 Deg c
High Fuel Temperature	Warning (Least Severe)	Always On	1 to 120	30	75 to 90	79 Deg c
	Derate (Moderate Severity)	Off	30 to 120	30	Not Programmable	79 Deg c
	Shutdown (Most Severe)	Off	1 to 120	10	75 to 90	90 Deg c
High Intake Manifold Air Temperature	Warning (Least Severe)	Always On	Not Programmable	4	Not Programmable	82 Deg c
	Derate (Moderate Severity)	Off	Not Programmable	4	Not Programmable	86 Deg c
Low Coolant Level	Warning (Least Severe)	On	1 to 120	10	Not Programmable	None

	Shutdown (Most Severe)	On	1 to 120	10	Not Programmable	None
Low Engine Oil Pressure	Warning (Least Severe)	Always On	Not Programmable	8	Not Programmable	Map
	Shutdown (Most Severe)	Always On	Not Programmable	4	Not Programmable	Map

A 6.0 Switch Specifications

The OEM supplies all switches. All switches that are provided by the OEM and connected to the Electronic Control Unit (ECM) must be of a two-wire design. These switches must be externally connected to the negative battery ground stud. Do not use switches that are grounded internally to the case.

Momentary opening or closing of the switches and contact chatter should not exceed 100 milliseconds in duration. Vibration or shock that is normally found in the application should not cause opening or closing of the switches.

The plating on the contacts should not be susceptible to corrosion or oxidation. Gold-plated switch contacts are recommended.

If a problem occurs with an undetermined cause, connect Perkins EST and observe the status of the switch. Refer to the appropriate troubleshooting service manual for your engine.

A 7.0 Installation Checklist

Following is a checklist of installation design parameters that result in the majority of start-up issues if not implemented correctly. Use this as a guide when reviewing installation design with the customer or OEM:

- **Battery Connections**
  - Are all battery + and - leads connected to the ECM?
  - Is circuit protection adequate (i.e., correct number of circuit breakers that are sized appropriately)?
  - Is circuit protection in an easily accessible location?

- **Is the engine grounded appropriately?**
  - Are all ground wires appropriately sized?
  - Has any paint or debris been removed at ground stud locations to facilitate grounding?

- **Do all relays and solenoids have adequate noise suppression (i.e., flyback diodes)?**

- **Is the starting system sized appropriately to crank the engine to the minimum required starting speed under anticipated parasitic load conditions and anticipated temperature extremes?**

- **Are all configuration parameters configured correctly?**
  - Are throttles appropriately configured and calibrated?

  Note: *Failure to properly set throttle input duty cycle will cause:*

• Failure to reach low idle

• Failure to reach high idle

• Failure to reach full power

• Failure to activate compression brake

- Have configuration parameters been downloaded to a PC and saved? Printed and filed? Written down for future reference?

• **Is the Monitoring System configured appropriately for the application?**

• **Will this application require operation at high altitude or low altitude? If so, contact your application support engineer.**

• **Wiring**

- Are all wires sized appropriately?
- Are wire bend radii generous enough so that the connector remains sealed and there is no strain on the wires?
- Do unused pin locations have seal plugs installed?
- Are wiring harnesses routed away from high heat areas on the machine?
- Are wiring harnesses adequately supported? Are harness clips (p-clips or ladder clips) used to support and secure harnesses? Are runs between clip points short enough to allow adequate support?
- Are there any wire harness rub points? Do harnesses route over any sharp edges, corners, or brackets?

• **Is a service tool connector installed in close proximity to the engine? Is it accessible?**

- If the machine is particularly large, or if the cab or operator station is a significant distance from the engine, the OEM customer may want to install additional service tool connectors on the machine.

• **SAE J1939 Data Link Wiring** -

Has shielded wiring been used?

- Is the shield connected?
- Are terminating resistors of the appropriate size installed on either end of the backbone?

A 8.0 Reference Media Numbers

For additional information, use the following publications:

- Pocket Guide, SEBD0402, “Guidelines for Routing and Installing Wire Harness Assemblies”
- Installation Guide, SENR9764, “Installation Guide for Electronic Engine Displays”
- Special Instruction, REHS0970, “Cross-Reference for Electrical Connectors”
- Special Instruction, SEHS9615, “Servicing DT Connectors”
- Installation Supplement, LEBH20804, IPU Control Panel.

1506 ElectropaK Engines:

- Operation and Maintenance Manual, SEBU9070
- Troubleshooting, UENR4512
- Electrical Schematic, UENR5440

1706 ElectropaK Engines:

- Operation and Maintenance Manual, M0098787
- Troubleshooting, M0098123
- Electrical Schematic, UENR7540

2206 ElectropaK Engines:

- Operation and Maintenance Manual, SEBU8337
- Troubleshooting, KENR6908
- Electrical Schematic, KENR6909

2506 ElectropaK Engines:

- Operation and Maintenance Manual, SEBU8313
- Troubleshooting, KENR6224
- Electrical Schematic, RENR6233

2806 ElectropaK Engines:

- Operation and Maintenance Manual, SEBU8085
- Users Handbook, TPD1516
- Workshop Manual, TPD1517

A 9.0 Issue Change Summary

TPD1970 Issue 10 Changes:

1. Updated Issue 10 to Issue 11 page 1.
2. Updated 1706 Wiring Schematic (starter connection), Section 3, page 30.
3. Changed Aux.Temperature to Oil Temperature. SPN 441. Section 12, page 99.
4. Added LEBH20804 IPU Control Panel Installation Supplement reference, page 141.
5. Added change summary in Appendix 9, page 142

TPD1970 Issue 9 Changes:

1. Updated Issue 9 to Issue 10 page 1.
2. Updated Figure 5A Service Too Connector wiring for 1700 Series, Section 5, page 64.
3. Added change summary in Appendix 9, page 142.

TPD1970 Issue 8 Changes:

1. Changed title of Section 1.1 page 9.
2. Added Warning and Notice to Section 1.1.1, page 10.
3. Added Warning in Section 1.2 Replacement Parts, page 11.

TPD1970 Issue 7 Changes:

1. Removed Remote Shutdown Switch in Table 2 and changed E-Stop to Auxiliary Engine Stop in Section 3.2, page 23.
2. Updated schematic for 2806 PD, changed E-Stop pin 23 to Auxiliary Stop, Section 3.2.3.2, page 31.
3. Removed Optional E-Stop section, Section 3.2.5, page 37.
4. Updated wording and removed note about battery disconnect switch, Section 6.4, page 53.
5. Section 8.1 renamed, page 71.
6. Section 8.1.1 rewritten and note removed, page 71.
7. Section 8.1.2 renamed to Auxiliary Shutdown, page 71.
8. Section 8.1.3 removed (along with wiring diagram) since remote shutdown not supported on engines, page 71.
9. Section 8.3 rewritten to align with other engines, page 72.
10. Appendix A Section 2.0.2 2806 Table pin 23 renamed to Auxiliary Engine Shutdown, page 132.
11. Appendix A Section 3.2 1706A System Configuration, removed E-Stop switch input type configuration, p. 137.
12. Appendix A Section 3.3 2806 I/O Configuration Parameters, removed E-Stop switch input type configuration, page 141.

TPD1970 Issue 6 Changes:

1. Added 2806 PD Air Inlet Temperature Sensor information, Section 2.3.13.2, page 18.
2. Update Section 4.1.1 ESM reference to Technical Data Sheet, page 43.

TPD1970 Issue 5 Changes:

1. Changed Model ‘2206A/C/D-E13TAG2-5’ to ‘2206A/C/D-E13TAG2-6’, page 1
2. Changed 1706 EP LRC Schematic, added pin out 23, Low Idle Switch, Section 3.2.2.2, page 28
3. Section 3.2.3.2 Power Density 2806 Wiring Schematic, page 30
4. Removed “(Not supported by 1706)” from Low Idle paragraph, page 36
5. Added pin out 23 description (Low Idle Control Switch) for 1706 EP LRC 40 pin chart, page 133

TPD1970 Issue 4 Changes:

1. Changed 1706 EP LRC Schematic, Section 3.2.2.2, page 28.
2. Added starting details in Section 3.2.5, page 34.

TPD1970 Issue 3 Changes:

1. General:
    a. Issue changes to reflect added 1706 model engines.
    b. Cover changed to include 1706A-E93TAG1-2 and 1706D-E93TAG1.
    c. Several grammar edits were made throughout the document.
    d. Production Issue level changed to Issue 4.
    e. Updated Table of Contents (TOC).
    f. Reformatted various tables/margins.
2. Section 1:
    a. Inserted table for Build List Prefix for Engine Sales Models.
    b. Noted different ECM for 1706 engines.
3. Section 2.3. - Updated Engine Component Overview for new models.
4. Section 2.3.13 - Added Air Inlet Temperature (1706)
5. Section 2.4.3 – Added schematic for 1706 - Factory Installed Wiring and Components.
6. Section 3.2.1.4 – Added details on 1706 Connector Panel.
7. Section 3.2.3.3 – Added OEM Connection Diagram for 1706.
8. Section 4.1.2 – Updated Battery (+) connections to show difference with 1706 model.
    a. Added Figure 2 to show 1706 Battery (+) Wiring and Circuit Protection Diagram
9. Section 4.1.4 – Added NOTE: A6E2 ECM has no internal battery (1706).
10. Section 4.2.2 – Updated Battery (-) connections to show difference with 1706 model.
11. Section 5.3 – Included Service Tool Connector Wiring information for 1706 model.
12. Section 8.3 – Updated Emergency Shutdown information.
13. Section 9.3.1 – Added details on pin-outs for 1706 model.
14. Section 11.1 – Added charts for 1706 models: Engine Monitoring Parameters.
15. Section 11.1.8 – Updated details on Boost Pressure Configuration.
16. Section 11.2.4 – Updated details on Overspeed Lamp for 1706 model.
17. Section 12.2 – Added NOTE: Perkins Data Link not supported on 1706 model.
18. Appendix 2.0.3 – Added ECM Connector Pinout Table for 1706A/D models.
19. Appendix 3.2 – Added Customer Configuration Parameters for 1706 models.
20. Appendix 8 – Updated Issue changes.

TPD1970 Issue 2 Changes:

1. General:
    a. Issue changes to reflect added 2806 Power Density (PD) model engines.
    b. Cover changed to include 2806A,C E18TTAG 4-7.
    c. Several grammar edits were made throughout the document.
    d. Production Issue level changed to Issue 3.
    e. Updated Table of Contents (TOC).
    f. Removed references to Cat and replaced Perkins as appropriate (including part numbers).
    g. Removed Intentionally Blank pages.
2. Section 1:
    a. Inserted table for Build List Prefix for Engine Sales Models.
    b. Noted different ECM for PD engines.
3. Section 2.3 – Clarified fuel pressure sensor application.
4. Section 3.2:
    a. Remove diagnostic lamp and moved Injection Disable Switch from optional table 2 to required table 1.
    b. Added the following components to optional table: Coolant Level Switch, Low Idle Switch, E- Stop Switch, Overspeed Verify Switch, Oil Temperature Sensor and Starter Relay.
    c. Section 3.2.1.3 – Added Customer Interface Connector panel.

   d. Section 3.2.3.2 – Added Power Density engine wiring diagram.
5. Section 5.1.5 – Corrected Connected Terminal Contacts table.
6. Section 6.2.1 – Removed several parameters from password protected list.
7. Section 6.3 – Removed Parameter Lockout subsection.
8. Section 8.0:
   a. Noted that Remote Shutdown Switch feature is not available on 2806 PD engines.
   b. Section 8.3 – Noted customer's responsibility for complete risk assessment on their product when considering this feature.
9. Section 9.7 – Removed Top Engine Limit section.
10. Section 11.0 – Removed the Auxiliary Pressure and Temperature Sensors and added the Engine Oil Temperature and Coolant Level sensors to Section 3.
11. Section 12.1.2.2 and 12.1.2.3 – Removed Electronic Brake Controller 1 and Electronic Transmission Controller 1 features because they are not supported.
12. Appendix 3 – Removed due to redundancy with Section 3 Wiring Diagrams.
13. Appendix 8 – Updated 1506 media numbers.

TPD1970 Issue 1 Changes:

1. General:
   a. Removed "TPS or Throttle Position Sensor and PTO" reference from the document.
2. Cover page:
   a. Added 1506D Application rating update for E88TAG3 and E88TAG5.
   b. Update Issue 1 to Issue 2.
3. Page 20:
   a. Removed "Diagnostic Lamp" feature from required component list.
   b. Deleted reference to "Throttle Position Sensor and PTO" in sentence following required component list.
4. Page 23-24:
   a. Removed Diagnostic Lamp from the OEM Connection Diagram. Section 3.2.2
5. Removed Diagnostic Lamp from the Application Wiring Schematic Section 3.2.3
6. Page 88:
   a. Corrected high fuel temperature monitoring configuration table to read "Fuel Temperature Monitoring Configuration" instead. Section 11.1.5.2.
7. Page 127:
   a. Removed E-Stop feature from J1/P1 pinout table pin 23. Appendix A 2.0.
8. Page 128:
   a. Removed Diagnostic Lamp feature from J1/P1 pin 31 on the pinout table. Appendix A 2.0
9. Page 129:
   a. Added "Key" to Switched Battery (+) J3/P3 pin 10 on the pinout table. Appendix A3.0 9. Page 130/131:
10. Corrected Customer Configuration Parameter Table: Appendix 4.0
   a. Droop/Isochronous Selection default "Droop to Isochronous"
   b. Emergency Shutdown Override Input Configuration range and default to read "Switch to (+) Battery".
11. Page 133:
   a. Corrected High Engine Oil Temperature Warning Set Points Range to 100-110. Appendix A6.0