1104D and 1106D Electrical and Electronic Installation Guide

Draft 3.2

Aug 2005

Contents

Introduction and Purpose

This document is intended to provide necessary information for correct electrical and electronic installation of 1104D or 1106D Industrial engine into an off-highway machine. Perkins Engines Company ltd expects that there will be some additions and modifications to this document as the engine program development continues, and as OEM requests for information not currently addressed are added.

Applicable Engines

This is a draft document, the information contained is the best available at the time of authoring to describe the application and installation requirements of the production software as it will be in July 2005.

Some engines shipped before this date will not have all the features described in this document. Likewise, some additional features will be added after this date. Contact the Electronic Applications Team for latest information on software feature release dates.

Electronic Applications Contacts

If the information in this document is incomplete, incorrect, or further details are required, then please contact an Electronic Applications Engineer.

Note that the Contact Details below are valid until Nov 2005

Electronic Applications Team
Oliver Lythgoe
+44 (0)1733 584171

lythgoe_oliver@perkins.com

New Features – 3056 to 1106D Comparison

The following table describes the major installation differences between the tier 3 emissions 1104D / 1106D and their predecessors the tier 2 emissions 1104C / 1106C.

1104C and 1106C Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Interface Connector		
70 pin Deutsch MIC connector	64 pin Delphi connector – direct to ECM J1 Connector	No redundant harness wires. Flexibility of customer connection
ECM power supply		
10A fuse, 16AWG wire (1.5mm2)	25A fuse	ECM has higher power requirement, as it drivers the injector solenoids
Fuel Inject Pump Power Supply		
OEM fitted fuel injection pump power supply relay	No longer required	New fuel system does not require separate power supply

1104C and 1106C Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Analogue Throttle Position		
-	New default values for analogue throttle sensors	Easier for OEM's and component manufacturers to design and validate pedals and levels for use with the engine
Cruise control / Set Speed Control / PTO mode		
SET / LOWER AND RAISE / RESUME buttons were switch to battery type DISENGAGE feature used 2 switch inputs. The PTO mode function would disengage when both inputs toggled	SET / LOWER AND RAISE / RESUME buttons will be switch to ground type The DISENGAGE feature now only requires a single switch input.	Alignment with the PTO mode feature on larger industrial engines e.g. C9
Coolant Temperature and Oil pressure Gauges		
PWM drivers available	Drivers not available	Gauges not widely used. Low cost and high quality of J1939 gauges makes PWM gauges redundant
Tachometer		
Frequency driver available	Driver not available	Low cost and high quality of J1939 gauges makes frequency driver redundant. Also, output from alternator still provides the function if required.
Lamp Outputs		
2 lamp outputs were used for cold start, warning, derate, shutdown and low oil pressure. A further 1 lamp was available for PTO mode	There will be 2 basic lamp outputs for Orange (warning) and Red (shutdown) engine lamps. Low oil pressure will be supported by an additional optional lamp. The cold start "wait to start" lamp will be on a separate lamp, and not on the Warning lamp as before The PTO mode lamp Is unchanged	Splitting the functions onto a greater number of lamps will make them more intuitive for the operator.
CANbus J1939 Shield		
Shield connection not available	Shield connection available. Connection by OEM not compulsory	Connection direct to ECM makes this connection possible

1104C and 1106C Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Variable Speed Fan Driver		
Fan driver not available	Driver available, compatible with open loop hydraulically controlled fans. **. Provision for future adding support for electronically controlled viscous fans if required (Check availability)**	New ECM has suitable inputs and outputs to control PWM type fans.
Machine Security System		
Not available	Available at engine ordering or as aftermarket enhancement **(Check availability)**	Reduced costs make solution viable
Mode Switch inputs		
3 mode switch inputs were available	2 mode switch inputs will be available	No application has been identified which requires more than 2 inputs
Additional Monitoring Capability		
Standard engine sensor monitoring only	Capability to configure ECM to monitor additional parameters with OEM fitted sensors. e.g. Coolant level, air filter restriction, Fuel water trap monitor.	New feature for added customer value
J1939 support		
	Significant changes to J1939 support: Some new parameters added to support new functions (e.g. change of rating curve) Also some parameters modified These changes will be marked in the J1939 section of this document	Additional functions added. Changes to existing functions made to make machine integration easier.
Remote Shutdown		
Not supported	A single switch input will be available for stopping the engine. This will be a normally open switch which is closed to stop the engine. Note that this is not an “Emergency Stop”	New feature

1104C and 1106C Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Electric Lift Pump Control		
Electric Fuel Lift pump on engine, controlled by the ECM via an OEM installed relay	Mechanical lift pump, so no relay required to be fitted by OEM	Change in fuel pump type

3126B and 1106D Comparison

The higher power range of the 1106D, over the 1106C, means that it may be installed in some applications that previously used a 3126B (C7). It is also accepted that some personnel may be more familiar with the Large Power Systems (LPS) industrial products, such as the C7 and C9, than with the Compact Power Systems (CPS) such as the 1104D and 1106D.

3126B Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Interface Connector		
40 pin Deutsch MIC connector	64 pin Delphi connector – direct to the ECM J1 Connector	The additional parameters allows for extra flexibility of the engine operation
ECM power supply		
15A Fuse	25A Fuse	ECM has higher power requirement, as to driver the injector solenoids, a bigger PSU is needed.
Speed Control		
The 3126B has a single throttle control option.	The 1106D electronics is a newer design with four throttle customer options.	This allows for greater flexibility in customer choice and application.
Intermediate Engine Speed Switch		
This is a hard-wired customer configured speed demand override between the ranges of Low Idle and Top Engine Limit.	Not Available	This feature is given with added functionality in the form of a Multi Position Switch.

3126B Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Maintenance Due Reset Switch and Lamp		
This switch is used to reset the counters for the maintenance indicator. The lamp shows that scheduled maintenance is due.	Not Available	This is not currently a feature of the 1106D. May be added later over J1939 datalink
Torque Limit Switch		
This allows the customer to limit the torque of the engine between the max torque and torque at rated speed.	Not Available	New mode switches offers superior capabilities to perform this function.
Mode Switches		
Not available. No rating change during operation and droop value always isochronous (0%)	Mode switches allow for the active rating and or droop value to be changed during engine operation (to any value between 0 and 10%)	New Feature
Engine Oil Temperature Sensor		
This is a sensor measuring the oil temperature in the oil gallery.	Not required	The fuel injection system on the 1104D and 1106D is fuel actuated rather than oil actuated, and thus does not require oil temperature measurement
Atmospheric Pressure Sensor		
This is an absolute pressure sensor measuring the atmospheric pressure.	Not required	Atmospheric pressure is measured only at “key on” by Boost pressure sensor.
Auxiliary Pressure Sensor		
This allows the customer to install an auxiliary pressure sensor.	Not Available	This is not a feature of the 1106D.
Auxiliary Temperature Sensor		
This allows the customer to install an auxiliary temperature sensor.	Not Available	This is not a feature of the 1106D.
Coolant Level Sensor		
This sensor allows the ECM to monitor the coolant level.	Not Available	Feature may be added in later software release in the form of configurable I/O.
Cold Start Aid		
Inlet Air Heater with on board relay and Ether.	Glow plugs are used with a customer-supplied relay are the only cold start aid.	This is due to the different engine size and head design. Glow plugs are more than sufficient on the 1106D

3126B Implementation (Tier 2)	1104D and 1106D Implementation (Tier 3)	Reason for Change
Variable Speed Fan Driver		
Not available	Compatible with visctronic fans and with open loop hydraulically controlled fans. TBA.	New Feature.
Air inlet Shutoff Control		
In the event of an over-speed, this will shut down the engine.	Not Available	No customer requirement has been identified for off highway engines of this size
Exhaust Brake		
This is a method of closing the exhaust to use the internal backpressure to slow the engine down.	Not Available	No customer requirement has been identified for off highway engines of this size

Engine Component Overview

Engine Control Module

The A4E2 ECM is located on the left rear side of the engine. The ECM has 2 connectors, one for the engine harness and the other for the machine OEM harness functionality

The ECM is fuel cooled (see mechanical installation guide for details of fuel connection requirements)

Sensor Details

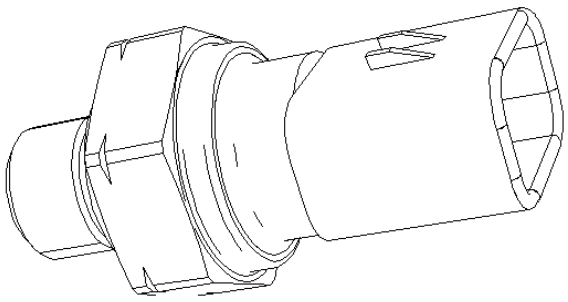
Intake manifold Pressure Sensor purpose

The intake manifold pressure signal monitors the air pressure inside the intake manifold, after the turbo, if fitted. The range is 0-339 Kpa absolute.
The sensor is used to limit fuel preventing black smoke during transient engine conditions, mainly during acceleration or upon sudden load application. i.e. If intake manifold pressure is too low for the requested fuel, then the fuel is limited to prevent the overfuel condition.

Intake manifold pressure is also used to control the smart turbo wastegate, if fitted. The smart wastegate control system regulates intake manifold pressure to the desired value, calibrated in the software. In order to do this, the software needs to know the actual value of intake manifold pressure, hence the need for the sensor.

Intake manifold pressure is also used to calculate atmospheric (barometric) pressure. Atmospheric pressure is used to limit fuel/torque at low atmospheric conditions e.g. at high altitude fuel may be limited to prevent turbo over-speed.

If the intake manifold pressure sensor/circuit fails, then a low default value is used in the software. The smart wastegate control (if fitted) will go to open loop, whereby the resultant intake manifold pressure will be low (as determined by the wastegate hardware chosen) and hence fuel will be limited under certain engine conditions, effectively providing a fuel/torque derate.



Intake Pressure Sensor

Intake Manifold Temperature Sensor

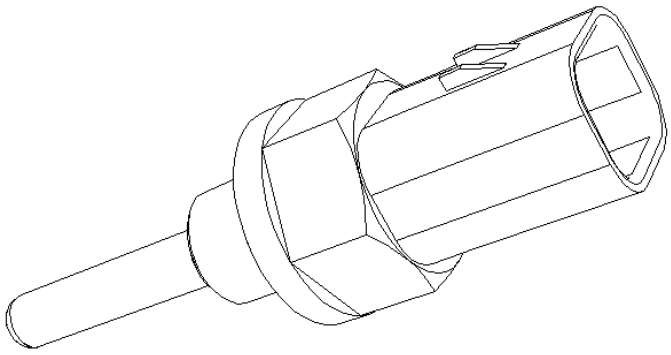
This sensor measure the temperature in the inlet air manifold in the range –40C to +120C.

Note that this is the sensor to which the engine is calibrated. Intake air temperature measurement is very sensitive to location. If the OEM adds additional inlet air temperature monitoring, for example during prototype evaluation, it should be anticipated that there may be a difference of several degrees Celsius between the engine sensor and the OEM sensor.

Intake manifold temperature is used primarily to determine the cold start strategy.

The OEM has no connection to this sensor, but if the intake air is required by some machine system, for example for fan control strategy, then the data can be accessed on the J1939 datalink.

It is possible, if extreme temperatures are measured at the intake that the engine will derate. In the event of a derate, a fault code will be generated on the J1939 datalink, or displayed on the service tool, and the warning lamp will light



Temperature Sensor

Coolant Temperature Sensor

The coolant temperature sensor is used for compensating fuel injection control, for activating the glow plugs for cold engine starting and for detecting excessively high coolant temperatures for raising an event. The range is –40C to +120C

If the sensor/circuit fails, then a (healthy) high default value is used and a diagnostic code raised. For glow plug control if this sensor/circuit is faulted, the intake manifold air temperature sensor is used. It is possible that with this sensor/circuit in a failure condition white smoke may result during a cold engine start. The Excessive Coolant Temperature event will not be raised under this fault condition.
The sensor reading of coolant temperature is also used to determine the maximum fuel allowed during engine starting. If the sensor/circuit fails, it is possible the engine will not start under cold engine conditions.

It is possible, if the coolant temperature exceeds the design limits, that the engine will derate. In the event of a derate, a fault code will be generated on the J1939 datalink, or displayed on the service tool, and the warning lamp will light

Fuel Manifold Pressure Sensor

The fuel rail pressure sensor is used to measure the fuel pressure in the high-pressure fuel rail. (The fuel in the fuel rail then feeds all injectors. Injection takes place when each injector is electrically operated.)

The fuel rail pressure measurement is used in conjunction with the high-pressure fuel pump to maintain the desired fuel pressure in the common rail. This pressure is determined by engine calibrations to enable the engine to meet emissions and performance objectives.

If the fuel rail pressure sensor/signal is faulted, a diagnostic code is set with a warning; a default value used and a 100% engine derate results. The default value for fuel rail pressure will allow the engine to run in a limp home fashion whereby a known fuel rail pressure will be controlled within reasonable engine conditions. Emissions compliance cannot be guaranteed under this fault condition.

Fuel Pump Solenoid

Fuel Rail Pump Solenoid is used to control the output from the high-pressure fuel pump.

The fuel rail pump solenoid is energized when fuel is required to be pumped into the high-pressure fuel rail. Varying the energize time of the solenoid controls the fuel delivery from the pump. The earlier the solenoid is energized (degrees before TDC), the more fuel is pumped into the fuel rail.

The solenoid forms part of the fuel rail pressure closed loop control system in conjunction with the fuel rail pressure sensor, ECM and software. The fuel rail pressure sensor measures the fuel rail pressure; the signal is processed by the ECM and software and compared to the desired fuel rail pressure for the given engine operating conditions. The control algorithm then controls the timing of energising the fuel rail pump solenoid. There is no OEM connection to this component.

If the fuel rail pump solenoid fails, it is likely that fuel will not be pumped into the fuel rail and engine shutdown or failed start is expected.

Fuel Injectors

Each fuel injector contains a solenoid to control the quantity of fuel injected. Both positive and negative wires to each solenoid are wired directly back to the ECM

There is no OEM connection to this component. Voltages of up to 70V are used to drive the injectors.

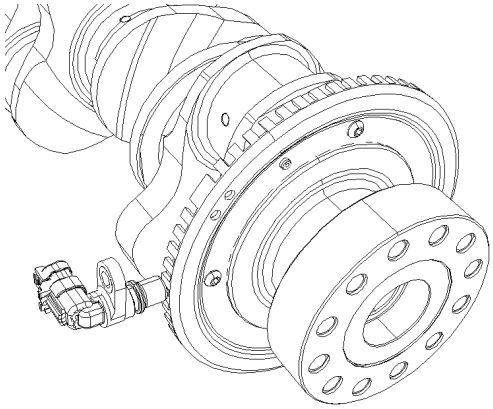
Injector cables are of the twisted pair to minimize emissions of electromagnetic noise. By their nature, however, the signals to the injectors are sharp pulses of relatively high current. The OEM should ensure that any systems that are sensitive to electromagnetic radiation are not in proximity to the harness components that lead to the injectors.

Crankshaft Speed/Timing Sensor

The crankshaft speed timing sensor is a Hall Effect Sensor. The sensor works in conjunction with the timing ring fitted to the engine crankshaft.

The sensor produces a signal as the timing ring/crank rotates past the sensor. The ECM then uses this signal to calculate engine speed and engine position. The crank speed/timing signal is used during normal engine running since is more accurate than the signal obtained from the cam speed/timing sensor.

If the crank speed/timing sensor/signal is lost or faulted, the engine is capable of starting provided the cam speed/timing signal is healthy. A diagnostic and warning will be raised if the fault occurs during engine running. A full derate will result since the engine is not then guaranteed to be emissions compliant due to the accuracy of the cam speed/timing signal. The diagnostic and derate will not be raised during engine cranking (if fault present), but the service tool will provide a means to read the condition of the cam and crank speed signals to aid fault finding.
. The OEM has no connection to this sensor. If the OEM requires accurate engine speed information then this may be obtained from the SAE J1939 datalink.



Speed Sensor

Pump / Camshaft Speed Sensor

The camshaft speed/timing sensor works in conjunction with the timing ring fitted inside the high Pressure fuel pump.

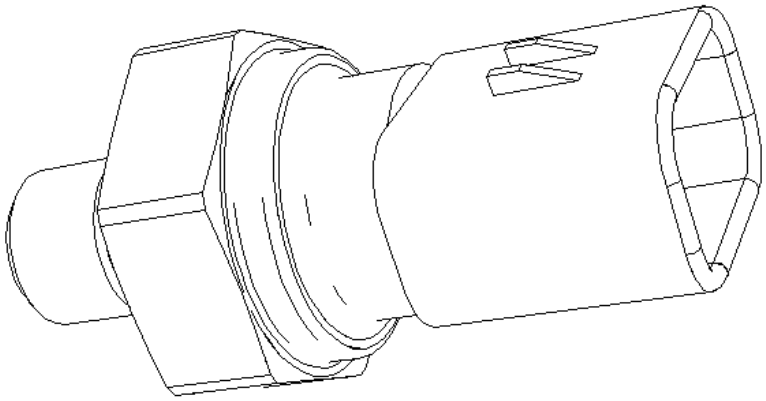
The sensor produces a signal as the timing ring/pump rotates past the sensor. The ECM then uses this signal to calculate engine speed, engine position and engine cycle. The cam speed/timing signal is required for determining the correct engine cycle and is also used for limp-home operation in the event of the crank speed sensor/circuit being faulted/lost.

If the camshaft speed/timing sensor/signal is lost or faulted, the engine will not start (since engine cycle is not known from the crank signal only), but if the engine is already running, no engine performance effect will be noticed. A diagnostic and warning will be raised if the fault occurs during engine running. The diagnostic will not be raised during engine cranking, but the service tool will provide a means to read the condition of the cam and crank speed signals to aid fault finding.

Oil Pressure Sensor

The oil pressure sensor measures the engine oil pressure in Kpa. Oil pressure is used for engine protection, whereby if insufficient oil pressure is measured for a given speed, an event for low oil pressure would be raised. The low oil pressure threshold is defined as a map against engine speed. Currently, 2 levels of event are being specified. Level 1 is the least severe and raises a warning. Level 3 is the most severe and raises a warning, which request the engine be shutdown. Automatic engine shutdown can be configured for certain applications, such as Gensets to occur when a level 3 event is raised.

If the oil pressure sensor fails, a diagnostic is raised and a default value is used by the software, which has been chosen to be a healthy (high) pressure value. It is not possible to raise an event whilst an oil pressure diagnostic is present.

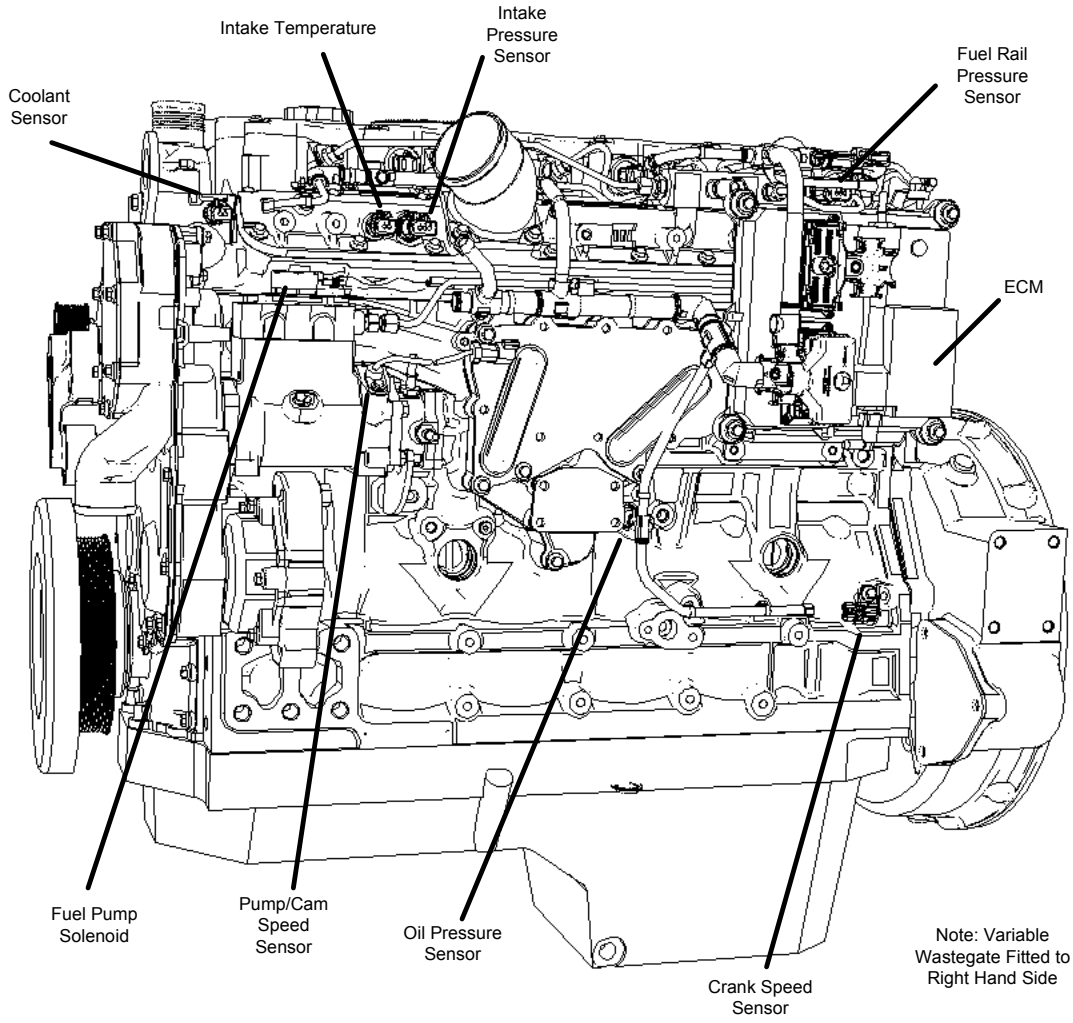


Oil Pressure Sensor

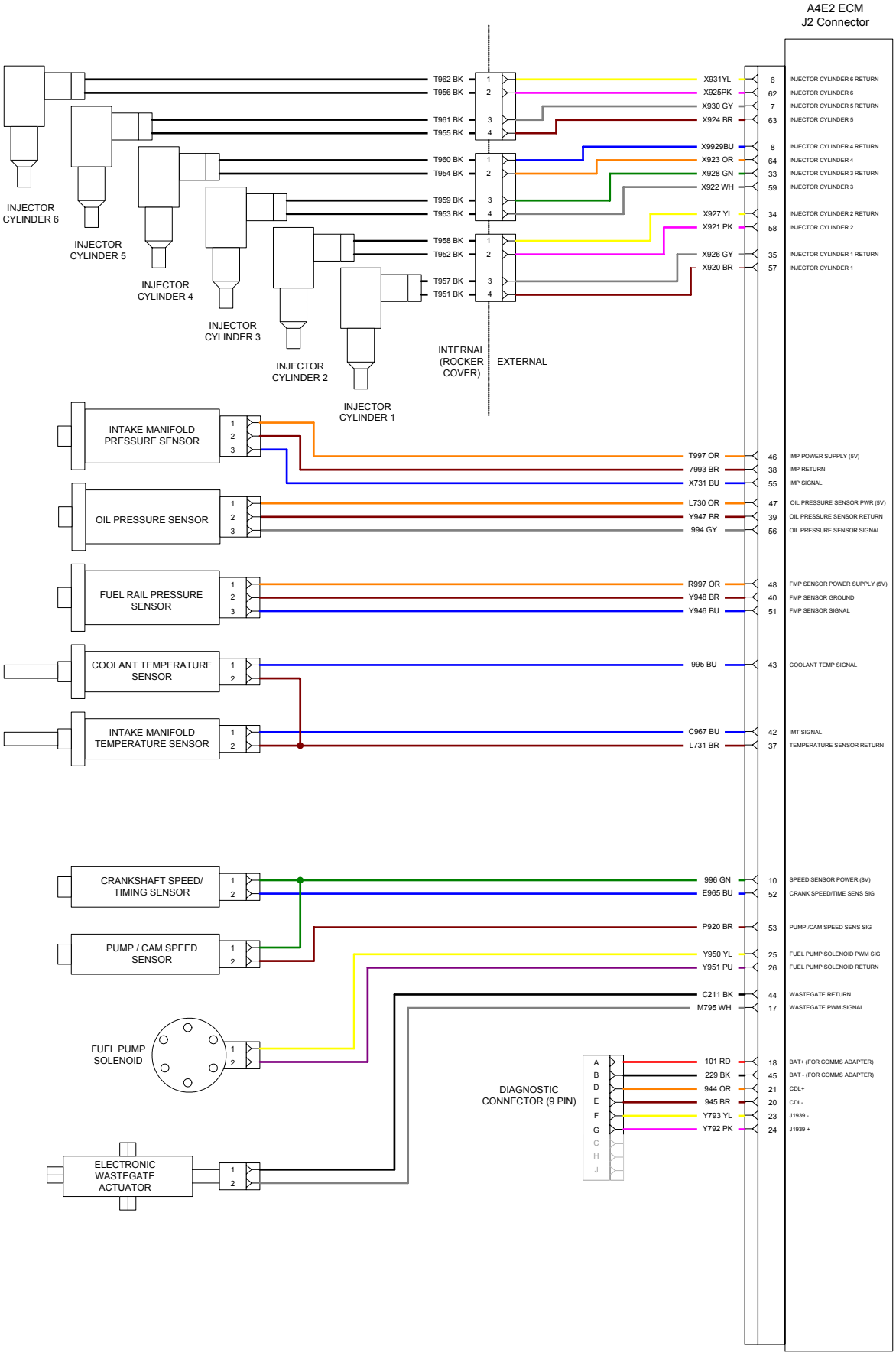
Smart Turbo Wastegate

Some engine models will be fitted with a turbocharger with a “smart” wastegate

Principal engine electronic components



Schematic Diagram of Engine Harness



Example OEM Schematic Diagram

The engine can be configured and wired many different ways dependant on the requirements of the OEM. The following four example schematics provide a guide for the OEM

Example 1 Basic Engine Application

This solution is suitable for applications where very little integration or additional engineering is a requirement when compared to the solution used for a mechanical engine. This solution can be used in most replacement engine situations. The OEM needs to consider only basic functions these being Power Supply, Operator Indication, Cold Start Aid and a simple method of controlling the engine speed.

Example 2 Construction Application

An application where the engine, in response to an arrangement of switched inputs will operate at one of a range of defined speeds. This is suitable for applications where the device has multiple operating speeds that are either defined for the specific output reasons, for simplicity of operator use or for operation dependent upon the environment - e.g. quiet modes. This could include: auxiliary engine on road sweeper, multiple speed water pumps, etc. There are sixteen possible set speeds based on four discrete ECM inputs. In addition to the Key-Switch a separate engine shutdown switch is used to stop the engine.

Example 3 Industrial Open Power Unit Application

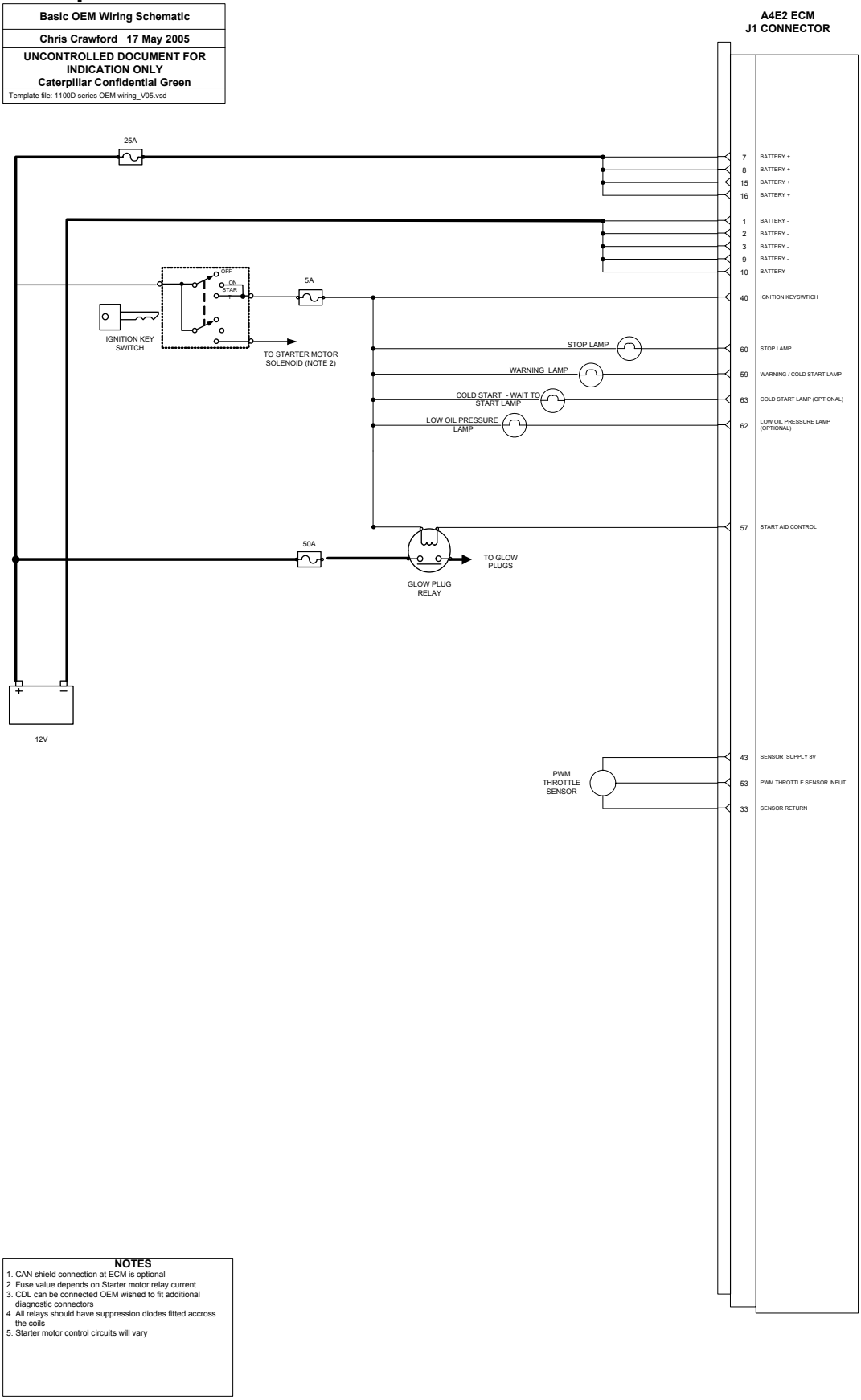
An application where the engine, in response to a control input, e.g. a button press, accelerates from idle speed up to the pre-defined operating engine speed. Once at the pre-defined operating speed, the engine speed may be raised or lowered by increment / decrement button presses. This is suitable for enhancing some of the applications of the single speed (set speed) control, or to provide a variable speed control without having a throttle pedal / lever. This functionality may benefit when the user wants to use ‘set speed operation’, but with the capability to adjust it themselves - users may have a favorite operating speed. This could include concrete pumps, hydraulic driven machines.

Example 4 Agricultural Application

The application will allow single or twin throttles, engine twin set speed control, Multi mode operation, integrated display drive, etc. The ECM dependant on engine temperatures varies the engine-cooling fan.

This set-up is suitable for applications where the customer requires a high degree of operator control over the machine’s behavior. It is one of the most complex applications. Typically this is used in mobile applications that may be driven to the place of work and then require operator selectable speed operation whilst performing their chosen task. This could include: Tractors, Combines, Backhoe loaders.

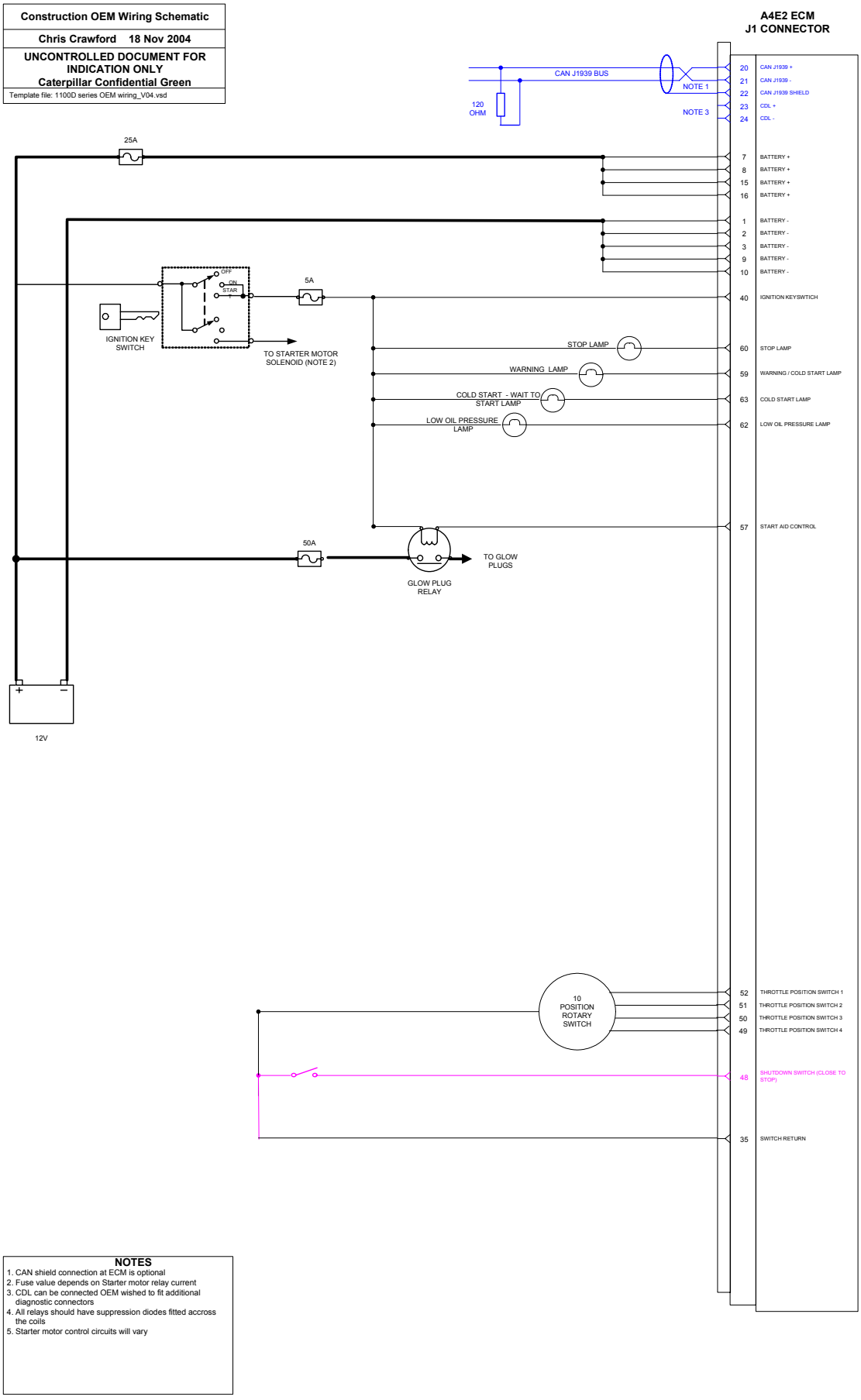
Example 1 - Basic Schematic OEM Harness



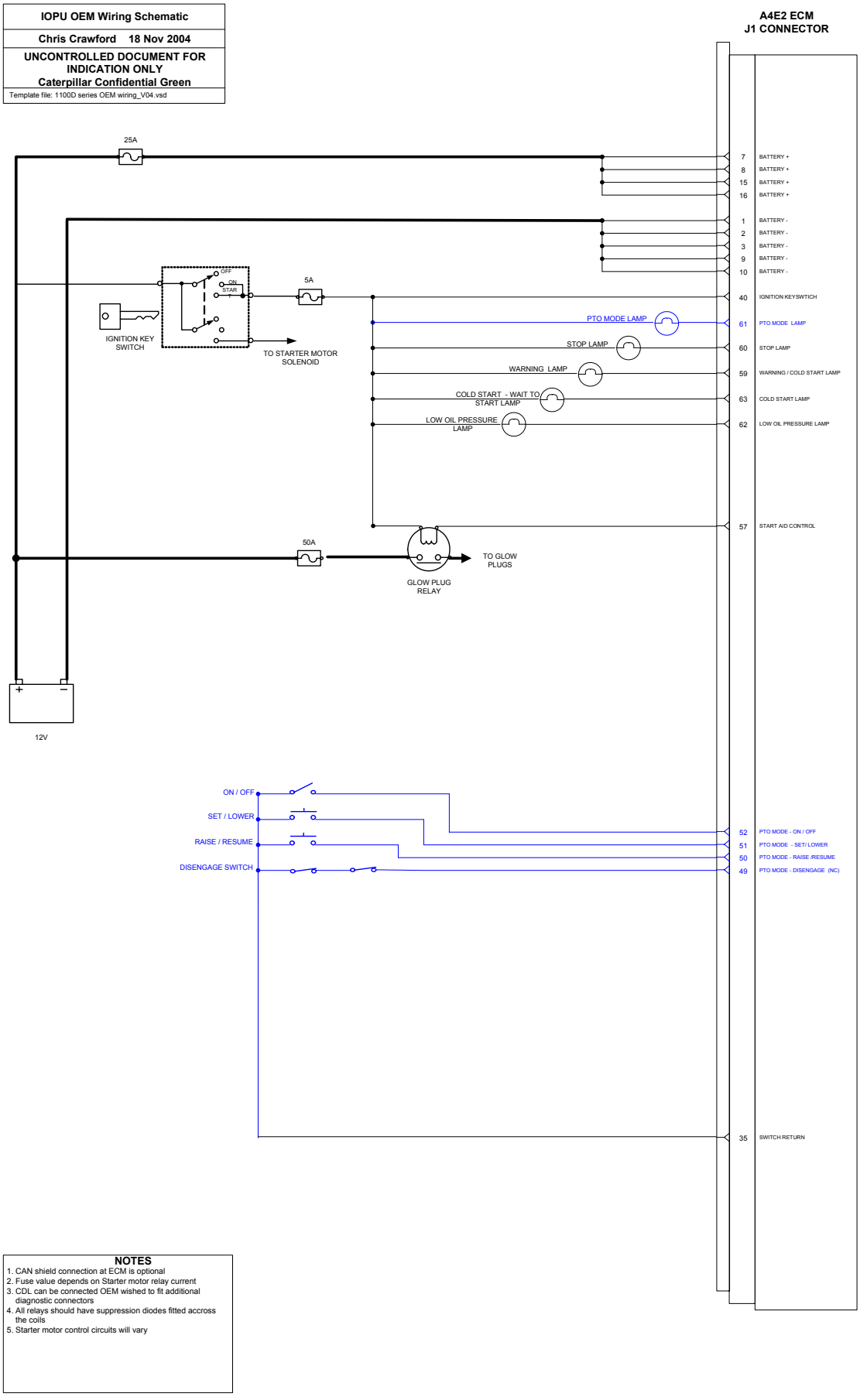
NOTES

1. CAN shield connection at ECM is optional
2. Fuse value depends on Starter motor relay current
3. CDL can be connected OEM wished to fit additional diagnostic connectors
4. All relays should have suppression diodes fitted accross the coils
5. Starter motor control circuits will vary

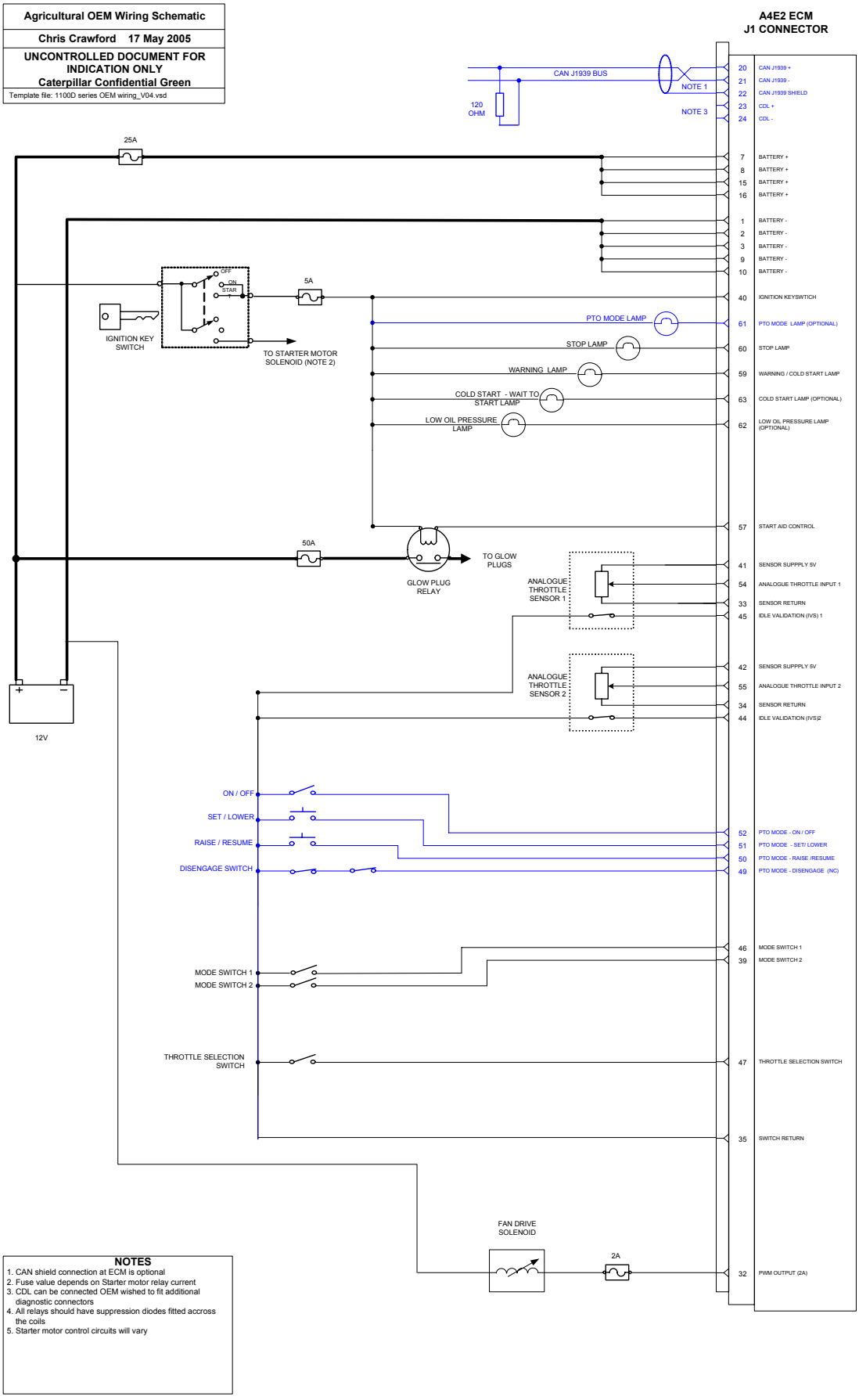
Example 2 - Construction Schematic OEM Harness



Example 3 – Industrial Open Power Unit Schematic OEM Harness



Example 4 - Agricultural Schematic OEM Harness



Power and Grounding Recommendations

Engine Block Grounding

Although the engine electronics are all directly grounded via the ECM connector, it is also necessary that the engine block be properly grounded to provide a good return path for components such as Starter Motor, Alternator and cold Start Aids.

Improper grounding results in unreliable electrical circuit paths. Stray electrical currents can damage mechanical components, and make electronic systems prone to interference. These problems are often very difficult to diagnose and repair.

There are 2 acceptable methods of grounding the engine.

Ground stud on Starter Motor

If the Starter motor has a grounding stud then this should be used. The ground connection should be preferably be made directly back to the battery negative terminal.

The starter motor ground path must not include any flanges or joints. Painted surfaces and flexible mounts in particular must be avoided. Star washers must not be relied upon to make contact though paint.

The ground cable should be of cross section 67.4 mm² (00 AWG) or greater.

Ground Connection to Tapping on engine Block

If there is no grounding stud on the Starter motor then a ground cable, direct from the Battery Negative terminal, should be connected to a ring terminal Which connects to one of the three tappings shown in diagram 1 and 2. The tapped holes will be reserved for customer use and can be used for grounding purposes.

If a tapping is used then it should be checked to be free of lacquer, paint and dirt before the connection is made. A M10 metric screw should be used plated with Zinc. A washer should retain the ring terminal and the screw tightened to 44 Nm (32lbft)

It is preferable to use a conductive grease to ensure the reliability of this connection.

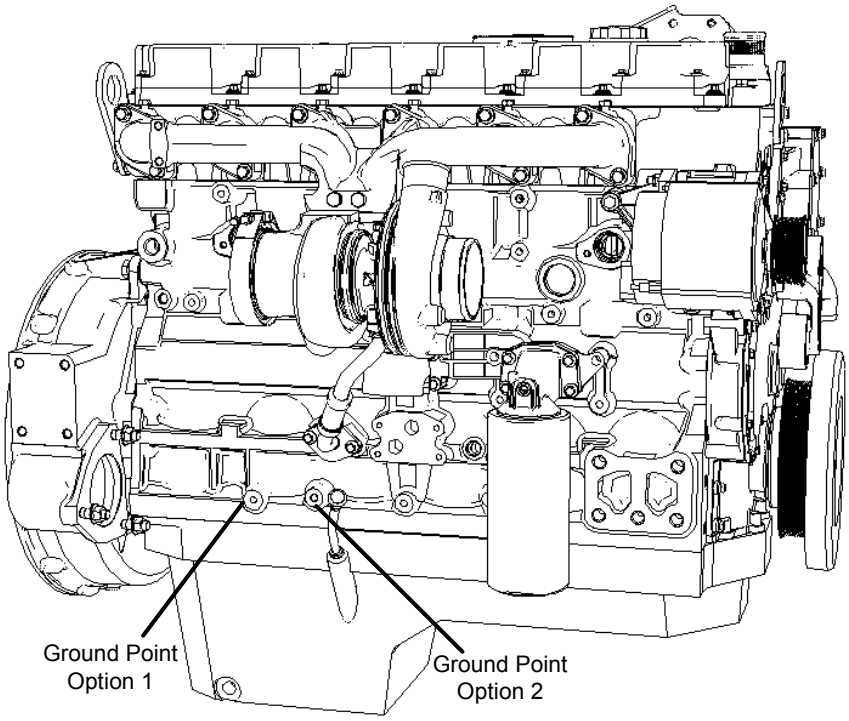


Diagram 1 Ground Point 1 & 2

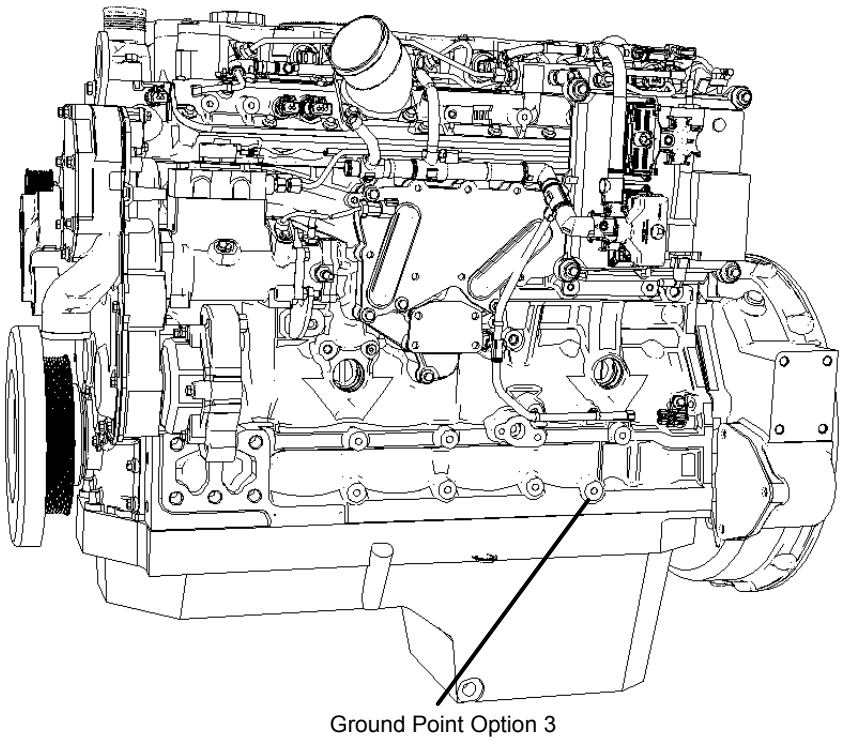


Diagram 2 Ground Point 3

ECM battery and Ground Connections

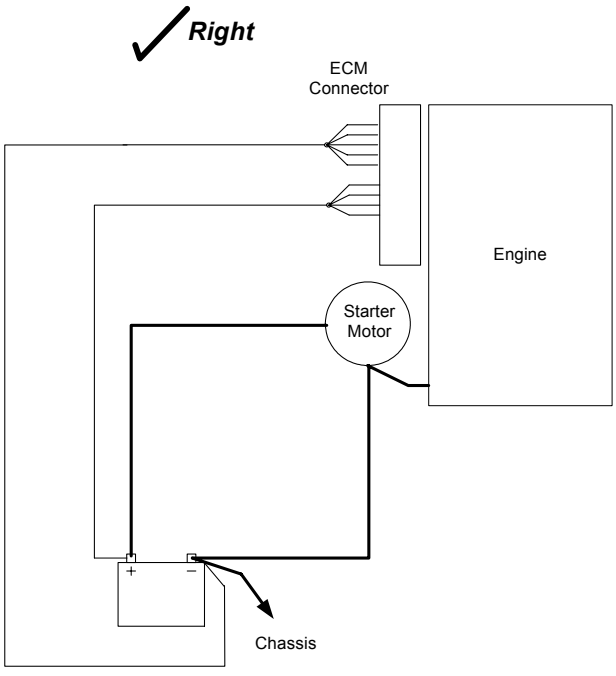
The ECM power supply (battery + and battery -) is normally permanently connected to the machine battery. The exception to this is if the machine is fitted with a battery isolation switch, which disconnects the battery during storage, transport or maintenance.

When the ignition key switch is off the ECM is in a sleep mode where it draws a very small residual current. When the ignition key switch is turned on the ECM will become active. It is recommended, therefore that the ignition keyswitch is turned to the off position when connecting or disconnecting the ECM J1connector, to prevent large sparks which may cause damage to the pins.

The power supply to the ECM should be taken from the battery, and not from the starter motor terminals to avoid unnecessary system noise and voltage drops.

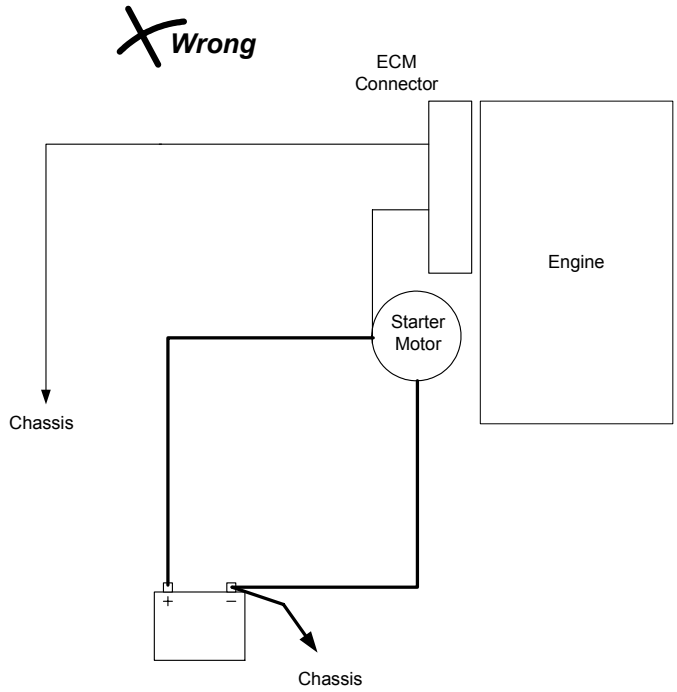
Note that there are 4 ECM pins allocated for battery positive and 5 for battery negative. All 9 pins must be used. It is also necessary to route the battery return via dedicated cable rather than a return through the machine chassis.

It will normally be necessary to splice the power supply wires from one larger conductor into the 4 or 5 smaller ones. This splice may be achieved either by a crimped and soldered metal band (appropriate for low volume manufacture) or by ultrasonic slicing (for medium and high volume manufacture). All splices should be insulated with adhesive lined heat shrink sleeve. The Cross Sectional Area of wire on both sides of the splice must be balanced so both sides fall within the Cross Sectional Area range of the heat shrink sleeve insulator. The distance between the edge of the splice joint and the wire insulation should be 5.0mm ± 1.5mm.



Correct Power Supply Wiring

- ECM Positive wires connected direct to battery, not via starter motor
- Power supply wires go to all 4 positive pins and all 5 negative pins on the ECM Connector
- Negative is wired to the battery rather than return through chassis
- The engine is grounded



Incorrect wiring

- Positive wired via starter motor. High volt drop to ECM on starting
- Single pin on ECM used for each of positive and negative supply. Possibly exceeding pin ratings and possibly causing risk of arcing or over heating.
- ECM return through chassis – risk of conducted noise and also additional voltage drop.
- Engine not grounded – risk of engine component damage.

Voltage and Current requirements and considerations

The ECM has an internal switched mode power supply and is thus capable of withstanding normal low voltage situations, such as occur during starting / cranking. ECM power supply cables sizes should be selected with care, however to ensure that the average voltage during cranking is at least 6V at the ECM.

To achieve this, the total resistance of the power supply wiring, including both positive and negative paths, should not exceed 100mOhms and the voltage at the battery terminals should not be less than 7.5Volts 2 seconds after the start of cranking.

Information regarding ECM Power Supply requirements is provided in Table 1. Information is supplied for both 12V and 24V systems. All measurements are based on nominal voltages expected when the engine is running, 13.8V for 12V systems and 27.8V for 24V systems.

Table 1 - ECM Supply Voltage and Current Requirements.

VOLTAGE SUPPLY SYSTEM	12V	24V
Max Peak Current	40A	30A
Max RMS Current*	13A	7.5A
Suggested Fuse Rating**	25A	20A
Sleep Current	<8mA	<10mA
Min Voltage	9V	18V
Max Voltage***	16V	32V

*Max RMS current measurements conducted on engine running at rated speed and load. RMS current will vary with engine speed (assuming constant voltage) no Lamp Drivers or application side components fitted during measurement.

** Suggested fuse rating are based on automotive blade type fuses and are for guidance only.

***The ECM can survive higher voltages. ECM will survive for at least 2 minutes on a supply voltage of 30V for 12V systems and 48V for 24V systems.

Warning – Welding

Welding can cause damage to the on engine electronics. The following precautions should be taken before and during welding:

- Turn the engine OFF. Place the ignition keyswitch in the OFF position
- Disconnect the negative battery cable from the battery. If the machine is fitted with a battery disconnect switch then open the switch
- Clamp the ground cable of the welder to the component that will be welded. Place the clamp as close as possible to the weld.
- Protect any wiring harnesses from welding debris and splatter.

DO NOT use electrical components in order to ground the welder. Do not use the ECM or sensors or any other electronic components in order to ground the welder.

Warning - Electrostatic Paint Spraying

The high voltages used in electrostatic paint spraying can cause damage to on engine electronics. The damage can manifest itself through immediate failure of components, or by weakening electronic components causing them to fail at a later date.

The following precautions should be taken when using electrostatic paint spraying techniques on engines:

- Connect all 64 pins of the ECM Connector directly to the spraying booth ground.
- Connect the engine block to ground at 2 points. Ensure that good screwed connections onto bright metal are used.

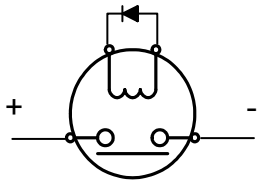
Warning – Jump Starting

Jump-starting an engine can cause higher than normal voltages to appear across the battery terminals. Care must be taken that this does not exceed the recommended maximum voltage for the ECM.

Inductive Energy – Fly-back Suppression Diode

When an inductive load is suddenly switched off fly-back energy is introduced to the circuit. This is can be observed as a voltage spike. When using an ECM output to drive an inductive load such as a relay or solenoid, circuit protection needs to be considered. To prevent

unnecessary ECM circuit loading a fly- back suppression diode/component should be used to suppress induced fly-back energy.



Relay with Suppression Diode

Connectors and Wiring Harness Requirements

ECM connector

The A4E2 uses an integral rectangular 64-pin Delphi connector to interface to the OEM machine wiring harness.

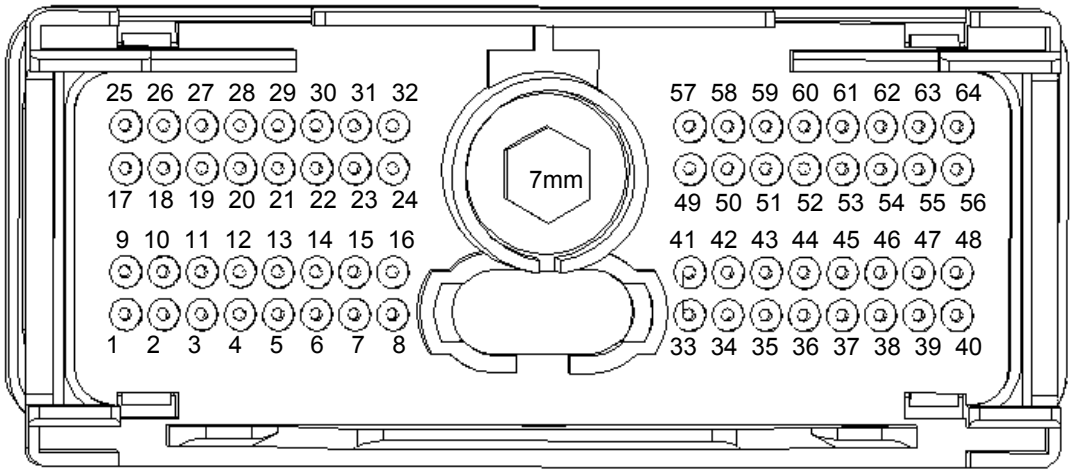
The connector comprises the following components

Qty	Description	Delphi Part Number	Perkins Part Number
1	Plug Assembly	15488667	TBA
1	Wire Dress Cover	15488664	TBA
2	Terminal Lock (TPA_)	15404650	TBA
N/A	Contact Socket (Terminal)	15359002	TBA
N/A	Sealing Plug	12129557	TBA

The above component will be available in kit form. The kit will provide all the necessary components to make one basic engine connection.

The wire dress cover must be fitted to prevent direct jet washing onto the rear connector seals

The diagram below illustrates the pin layout, looking from the rear of the connector



Tightening the OEM Connector

A central 7mm AF hex screw retains the connector. This screw should be tightened to a torque of 5Nm+/- 1 (3.7+/-0.7lbft).

Perkins Engines Company ltd does not recommend the use of “non conductive grease” with the ECM connector.

ECM connector Wire Gauge Size

All connections must be made with 0.82mm² (18AWG) wire with GXL type insulation.

Min outside diameter (Inc Insulation) = 1.85mm
Max outside diameter (Inc Insulation) = 2.5mm

ECM Connector Terminals

The OEM connector terminals should be Delphi p/n 15359002

The terminals should be crimped according to the following instructions

Hand Crimping For Prototype machines and Low Volume Production:

A hand crimp tool and appropriate Die are required for crimping Contact sockets - (Delphi p/n 15359002). The hand crimp tool and removal tool for removing the Sockets from the connector body are available from Power and Signal Group (PSG)7

Existing Delphi Solution

Component	Perkins part number	Supplier Part number
Contact sockets	TBA	15359002
HT micro 100W Crimp Tool with Die – European Use Only	N/A	HT42000480-1
Delphi Crimp Tool	XX	12129557
Removal tool	N/A	15314902

New solution

New contacts are being developed which are compatible with the crimp tools used at tier 2. This is expected to be released in September 2005 and will be the preferred solution.

Component	Perkins part number	Supplier Part number
Contact socket	TBA	N/A
Crimp Tool number	1U5804	Deutsch HDT-48-00
Removal tool	N/A	15314902

Note: The insulation should be stripped to 5 mm from the end of the wire. Only a single wire must be crimped into each terminal.

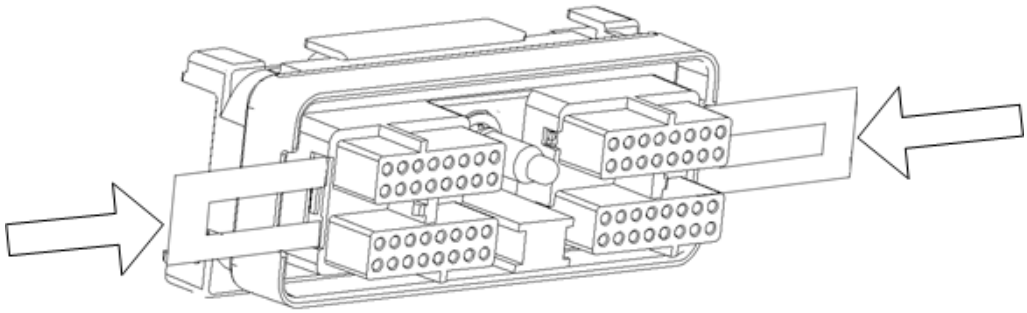
Machine Crimping For High Volume Production

The hand tool may not be the appropriate solution for crimping terminals in a high volume production environment. The OEM's harness manufacturer should contact PSG directly for details of high volume crimp solutions:

Terminal Retention

Once all terminals have been crimped and inserted into their correct holes in the connector body, then they should be held in place with the two terminal position assurance parts. Terminal Position Assurance - (Delphi p/n 15404650)

Note: It is critical that two terminal position assurance components are used.



Connector body and terminal assurance components

When a terminal has been properly crimped and retained correctly, it will be able to withstand a “pull test” of 45N (10lb)

ECM connector sealing plug installation guidelines

All unused connector socket slots must be filled with sealing plugs - Delphi p/n 12129557.

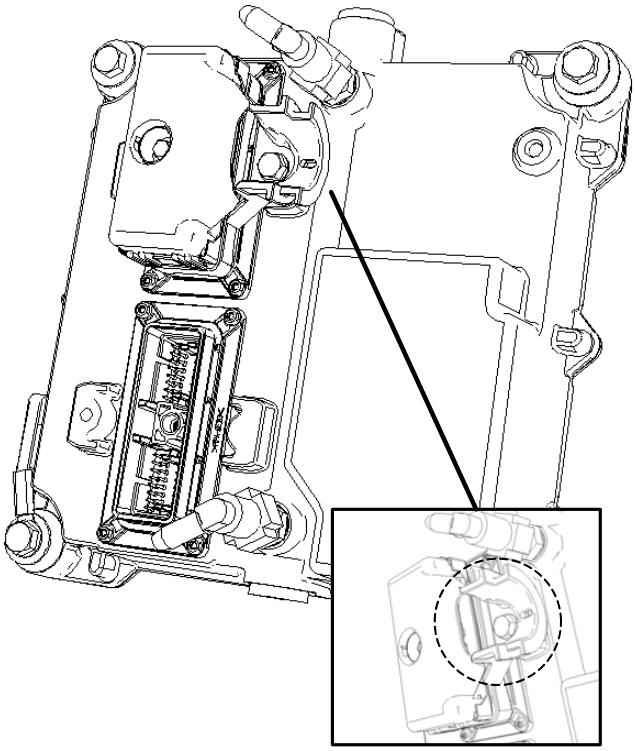
Due to the small size of the sealing plugs, it may be quicker to install sealing plugs in all cavities, and then remove those which are not required, rather than to try to fit the sealing plugs when wires have already been inserted into the back of the connector.

Note: do not use “non conductive” grease to seal unused terminal cavities.

OEM harness Retention at the ECM

A wire strain relief component should be used to prevent ECM connector damage. The wire strain relief component is assembled to the ECM using a tap tight screw. See diagram below:

Strain relief Perkins part number 1757P0679



Harness Wiring Standards

General Recommendations for Machine Wiring harnesses

The following are general “good practice” for wire harnesses. It is the responsibility of the machine designer to follow standards appropriate to the application type and to the geographical territory where the machine will be operated. These recommendations do not replace in any way any industrial standards or legislative requirements:

Connectors

It is strongly recommended that high quality, sealed connectors are used throughout. Automotive standard components are not necessarily suitable as they are often only designed for a very low number of disconnect/reconnect cycles.

Connectors should be horizontally mounted rather than vertically mounted to prevent ingress of water/chemicals. Whenever possible, connectors should be mounted such that they are protected from direct exposure to extreme cold. Connectors can be damaged by frost if water does penetrate the seals.

Cables should not bend close to the connector seals, as the seal quality can be compromised.

The correct wire seal must be selected for the diameter of wire used.

Cables should be selected of an appropriate cross section for the current and voltage drop requirements

Where large numbers of wires go to the same connector, it is essential that no single wire is significantly shorter than the others, such that it placed under exceptional strain.

Cable routing.

Cables should be routed such that bend radii are not too tight. A cable should not be either in compression or tension, nor should it be excessively long or loose, such that sections may

become caught or trapped. Clips should be used at regular intervals to support cables. These clips should be of the correct diameter to grip the cable firmly without crushing it.

Ideally, harnesses should not rub against any mechanical components. The only points of contact should be clamps and connectors. If this is not possible then as a minimum they should not touch components that are hot, that move or vibrate, or that have sharp edges

Conductors carrying high currents or voltages, particularly when these are alternating or switched, should be physically separated from conductors carrying small signal currents. In particular, high current and signal wires should not run parallel in the same harness bundle for any significant distance. Ideally, if high current wires must be in proximity to signal wires then they should cross at right angles.

The engine harness should not be used by the installer for as a support for any components that are not supplied as part of the engine. For example, external hoses and wires should not be tied to the engine harness.

Mounting location for electronic modules

The least harsh possible location should be selected for an electronic component or module, even one that is robustly designed. Select the mounting location carefully, therefore, considering exposure to frost, vibration, heat, mechanical damage, or ingress of water, dust or chemicals.

Care should be taken during design to ensure that components are accessible for repair and possible replacement in the field. Poor maintenance access may lead to poor quality repairs in the field.

Electromagnetic Compliance (EMC)

Special measures should be taken to shield cables if the application is to be used in extreme electromagnetic environments – e.g. aluminum smelting plants.
If screened cable is used, the screens should be connected to ground at one point only. That point should be central if possible

Connector Supplier Contact Details

All the components required for OEM connection to the ECM are available from Power and Signal who are the main distributor for Delphi connectors. The UK and US Power and Signal offices will assist with Delphi connector procurement

Delphi Connector Supply:
Europe and Asia

Andy Huggett –Key Accounts Manager
Power and Signal Group
Tel: (+44) 1933 226747

Email: ahugget@powersignal.com

North America

Mark Domasky – Strategic Accounts Manager – Midwest
Power and Signal Group
Tel: (+001) 920-589-2112
Fax: (+001) 920-589-2114
Email: mdomasky@powersignal.com
Technical Information regarding the connector is available form the Electronic Application team

Diagnostic Connector

A 9 pin diagnostic connector is fitted to the engine wire harness on all industrial engines. Various diagnostic and development tools may use the connector to access the engine data links.

If the connector is inaccessible when the engine is in the application or no connector is fitted to the engine wire harness, provisions should be made to allocate an alternative location for diagnostic connection. In this case it is recommended that a diagnostic connector be wired in a location that can be easily accessed, free from possible water/dirt ingress and impact damage. The engine wire harness must not be changed or modified. To wire a diagnostic connection use the data link pins available on the OEM J1 ECM connector.

It is recommended that all machines with an off engine diagnostic connector wire the J1939 CAN bus and the proprietary CDL/PDL data link.

Mandatory Requirement for Prototype Machines

It is mandatory for all prototype machines to have access to the engines CDL/PDL and J1939 CAN data links.

Termination Resistor

If the engine is the only CAN J1939 devise used on the machine termination resistors will be required in the circuit to enable error free J1939 communication. It is recommended that the termination resistors be wired to the OEM machine harness.

9 Pin Diagnostic Connector Part Numbers

Description	Deutsch Part Number	Perkins Part Number
Receptacle (With Flange)	HD10-9-96P	TBA
Receptacle	HD14-9-96P	TBA
Receptacle End Cap	HDC-16-9	TBA

Pin Information

Pin Description	Diagnostic Connector	J1 OEM 64 way Connector
Battery +	Pin A	
Battery -	Pin B	
PDL/CDL +	Pin D	23
PDL/CDL -	Pin E	24
J1939 -	Pin F	21
J1939 +	Pin G	20

Stopping the Engine (and Preventing Restart)

There is often some confusion about the different methods and devices used to either stop the engine or to prevent it from starting. These devices may be divided into the following categories:

- Ignition Keyswitch
- Emergency Stop Button
- Battery Isolation Switch
- Remote Stop Button
- Datalink stop

Each of these devices is described below to assist the OEM in selecting the method that is most suitable for his machine and his market. It remains, however, the responsibility of the OEM to ensure compliance of the machine with legislation in the territories into which it is sold.

It is recommended that the OEM performs a risk assessment such as a Failure Mode Effects Analysis (FMEA) on the application to determine the most appropriate method of stopping the engine and/or preventing it from being restarted.

Ignition Keyswitch

It is a Perkins requirement that all machines have an simple intuitive and accessible method of stopping the engine. This will normally be a directly wired Ignition Keyswitch. When the keyswitch is turned to the off position or when the key is removed, power **must** be removed from the ignition keyswitch pin (pin 40) of the ECM J1 connector.

Emergency Stop Button

An emergency Stop button is a failsafe method for an operator to stop a machine to protect people or equipment.

Emergency Stop buttons are defined by national or international standards in terms colour, functionality, shape, size, latching /locking. In the EU for example, they are described in the Machinery Directive.

For mobile machines, however, true emergency stop buttons are not always appropriate and are rarely fitted, due to the following issues:

- The legislation is designed principally for static industrial machinery (e.g. lathe) where the main power source is mains electricity.
- Stopping a diesel engine in a mobile machine may not always be safe. In particular the vehicle may need the power to move to a safe position (for example off the public highway, or off a railway track)
- In practice it is difficult to find components such as safety relays which are suitable for mounting on mobile machines due to the high vibration and water ingress protection, and the low voltages that occur during starting
- Fail-safe wiring can be a cause of machine unreliability and can create faults which are difficult to detect in the field.

If a true emergency stop button is required for an application it is recommended that it is implemented such that both the +battery and the ignition keyswitch lines are cut directly by the emergency stop button.

Perkins do not provide a standard recommendation, or approval, for a circuit for multiple emergency stop buttons, as the differences between application mean that significant time and resources are necessary to design a system which will be fail safe without adversely affecting reliability.

Battery Isolation Switches

Battery Isolation switches are usually fitted in the battery or the engine compartment of a machine. On some machines there may be a small number of low current devices which are not switched off by this device e.g. clocks or anti-theft tracking devices.

The function of a battery isolation switch is as follows:

- Prevent battery discharge during vehicle shipping or storage
- Protect service technicians from danger caused by inadvertent engine crank or start .To offer good protection of service personnel is it possible to provide a switch which can be locked in the open position (e.g. with a padlock) and the key removed and given to the service engineer who is working on the dangerous components

The battery isolation switch is not a suitable method for stopping an engine as it is not guaranteed to stop the engine as the ECM may continue to operate with power generated by the alternator.

It is also possible that opening the battery isolation switch when the engine is running will cause an “alternator load dump”. This is a kind of electrical transient which can cause damage to electronic components

Battery isolation switches are normally fitted in the negative path, close to the battery.

Remote Stop Button

Remote stop is intended to provide a convenient method of stopping the engine. It is not designed to be fail safe and so should not be used assure the protection of either personnel or equipment

Remote stop buttons may be used on large machines, which can be operated from ground level and where the operator wants to stop the machine without climbing into the cab.

There are a number of variations on remote stop button circuits. The 1106D uses single normally open contacts, which must be closed to stop the engine.

The remote stop button will function as follows:
A single switch to ground input on pin 48 of the ECM J1 Connector (Several stop buttons can therefore be connected in parallel)
When the switched is closed (or if a button is stopped for longer than 150mS), then the engine will stop.
The ECM will remain ON, so it will continue to communicate over J1939 and with the service tool. Note however that it will continue to draw power from the battery so if it is left in this state it will eventually result in a flat battery.

The engine may be restarted by opening the switch and activating the starter motor.

The red “mushroom” emergency stop buttons must not be used for remote stop functions as they may be mistaken for emergency stop buttons as described above.

Datalink stops

It will be possible to stop the engine via a datalink (J1939 or CDL). As per the remote stop button, described above, the datalink stop is not fail safe and does not meet the requirements of emergency stop legislation so should not be relied on to assure the safety of machine operators or other personnel.

Datalink stops may be used in the following circumstances

- Immobilisers
- Machine protection strategies
- Automatic machine features (e.g. idle shutdown timer)

- Stopping machines by radio control or other telemetry. Geo-fencing is a particular application, where a machine will not operate outside defined map coordinates

It is recommended that if such features are implemented, then they are clearly documented and communicated to the final users and owners of the machine. If this is not done then there may be complaints that the engine is stopping unexpectedly.

Common problems with the application of stop devices

- It is possible, although extremely rare, that diesel engines continue to run even if all electrical power is removed. This can happen when high quantities of oil vapour or other inflammable gases are present in the air into the engine. The only way to prevent this is to provide an air inlet shut-off valve (slicer valve). It is not common practice to fit such devices to all engines, but they should be considered where there is a risk of flammable gases (e.g. in petroleum applications), or where the application demands high engine gradebility (slopes)
- Some hazards are present when the engine is being cranked by the starter motor, as well as when it is running. For example, components will still rotate, hydraulic pressure will still be present, fuel may still be pump to high pressures.
- If an emergency stop button is pressed, to cut power to ECM and ignition, but is released while the engine is still turning, it is possible for the engine to continue to run.

Engine Speed Demand

There are 5 different methods of controlling the speed of the engine.

- Analog Sensor
- Pulse Width Modulation (PWM) Sensor
- PTO mode - also known as “engine speed cruise control” or “set speed control”.
- Multi Position Throttle Switches
- Torque Speed Control - TSC1 (Speed control over CAN J1939)

The speed demand options must be selected at the time of engine order so that the ECM will be configured correctly. For the type or pedal, lever or control device selected.

Analog Sensor

Device Description

Two inputs are available for Analog throttle devices, which may be either a pedal, lever or cable operated. The Analog sensor gives a DC Analog output in the range 0.5 to 4.5 volts, when connected to the engine ECM. A regulated 5V 200mA power supply is provided by the ECM.

The Analog sensor should use non-contact Hall effect technology. Robust potentiometer contact sensors designed for use in vehicles may be considered **under no circumstances should ordinary carbon track or wire wound potentiometers be used, as they will not be reliable.**

For all mobile applications, and those where a rapid change in engine speed could cause a hazard, an idle validation switch is required. The idle validation switch closes to ground when the sensor is in the minimum position.

Off idle switches and kickdown switches are not monitored by the engine ECM.

This Analog input must only be used to control engine speed from a direct operator input, and is not suitable as the mechanism for speed control by another electronic controller.

There is no special requirement for a relationship between angular movement of the pedal and output voltage.

This document does not measure component acceptability in terms of:

- Temperature
- Vibration
- Electromagnetic Compatibility
- Design life
- Supply voltage requirements (min, max, stability)
- Legal Compliance

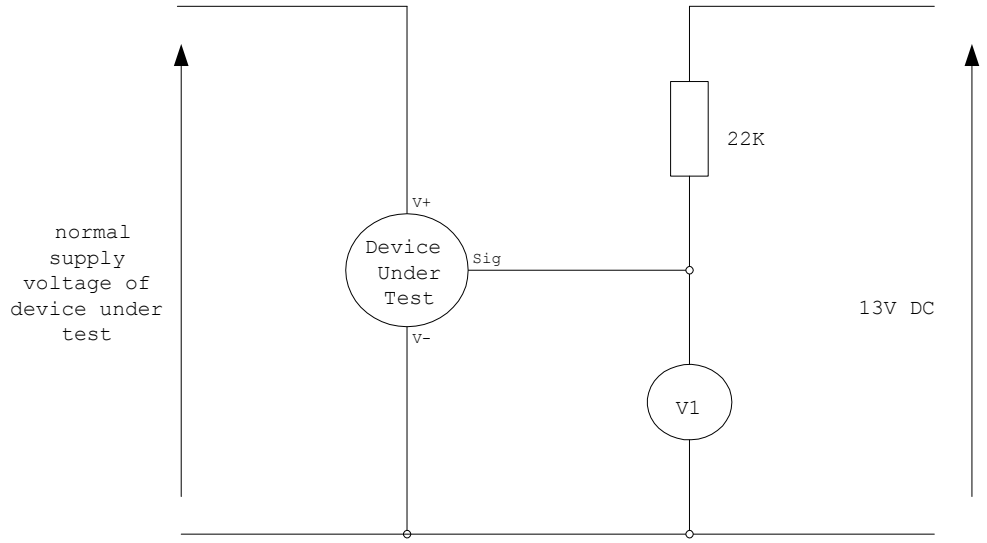
It the responsibility of the OEM and the throttle device manufacturer to ensure that the component is suitable for the application in which it is to be used.

Evaluating Component Compatibility

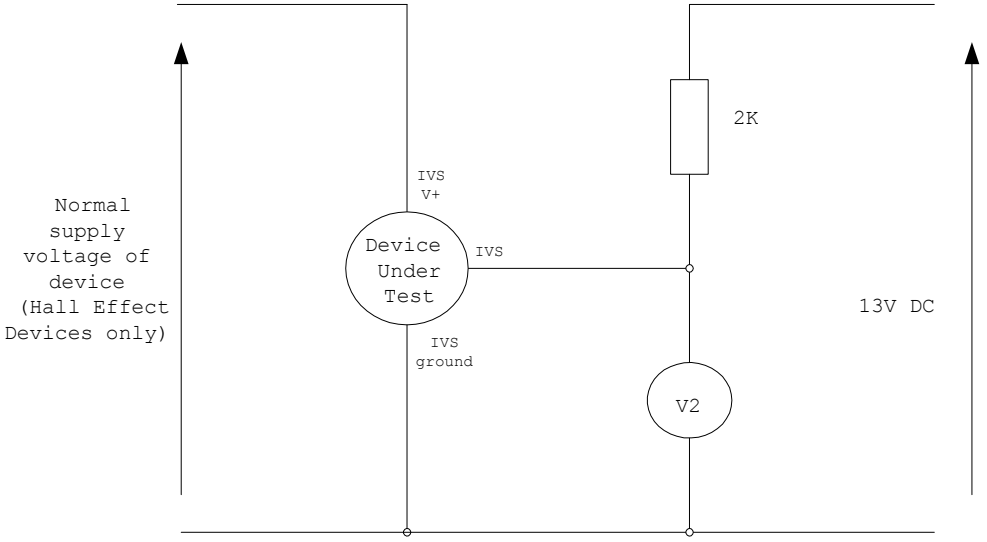
The following procedure should be used to evaluate whether an Analog throttle is compatible with the engine ECM. This may be used either by the OEM in selecting components or by the manufacturer of devices which are to be connected to the engine.

The following test circuits must be used when evaluating Analog throttle devices.

Analog Input Test circuit



Idle Validation Switch Test Circuit



Test Procedure

Test 1: Output at Min position

Place the Device Under Test (DUT) in it's minimum or "released" condition.
Measure the voltage V1

Test 2: Output at Min position: forced

Without causing damage, pull the pedal/ handle hard against the minimum travel end stop.
Measure the voltage V1

Test 3: Output at Max position

Place the DUT in it's maximum or "fully depressed" condition.

Measure the voltage V1

Test 4: Output at Max position: forced

Without causing damage push the pedal/ handle hard against the maximum travel end stop.
Measure the voltage V1

Test 5: IVS switch Closed Voltage

Place the DUT in it's minimum or "released" condition.
Measure the voltage V2

Test 6: IVS switch Opening Threshold

Place the DUT in it's minimum or "released" condition.

Test 7: IVS switch Open Voltage

Place the DUT in it's maximum or "fully depressed" condition.
Measure the voltage V2

Test 8: IVS switch Closing Threshold

Place the DUT in it's minimum or "released" condition.

Test 9: track resistance (potentiometer type sensors only)

If the DUT is a potentiometer type device, disconnect it from the test circuit and measure the resistance across the track (from V+ to V-)

Required Values

If the results obtained from the tests above are in the ranges specified below, then the device will be compatible with the default values in the ECM.

Test	*Parameter*	*Units*	*Min*	*Nominal*	*Max*
1	Output at Min position	Volts	0.45	0.6	0.7
2	Output at Min position: forced	Volts	0.4	0.6	-
3	Output at Max position	Volts	3.8	4	-
4	Output at Max position: forced	Volts	-	4	4.5
5	IVS switch Closed Voltage	Volts	0	0.5	1.2
6	IVS switch Opening Threshold	Volts	1.08	1.15	1.22
7	IVS switch Open Voltage	Volts	4	10	24
8	IVS switch Closing Threshold	Volts	1.08	1.15	1.22
9	Potentiometer Track resistance	K Ohms	1	2.5	3

If the results of the tests are not in the range specified in the table above, then the device will not be compatible with the default settings in the ECM. Contact the electronic applications team to determine whether it will be possible to configure the input to meet the device.

Analog Sensors –Connection details

Analog input 1

Sensor terminal	**ECM J1 Connector Pin Assignment**
Sensor +	41
Sensor signal	54
Sensor –	33
Idle validation Switch	45
Switch return	35

Analog input 2

Sensor terminal	ECM J1 Connector Pin Assignment
Sensor +	42
Sensor signal	55
Sensor –	34
Idle validation Switch (closed at idle)	44
Switch return	35

PWM Sensor - Compatibility

Device Description

One input is available for a PWM throttle devices which may be either a pedal, lever or cable operated. A regulated 8V, 100mA power supply is provided by the ECM.

Component Compatibility

The sensor should have a sinking output driver with a frequency of 500hz (+/- 50hz). The sensor should give a valid output within 150ms of power being applied.

When mounted on the pedal and lever the duty cycle should be as follows

Position	Acceptable signal duty cycle range
Released (low idle)	10 to 22%
Fully Depressed	75 to 90%

Connection details

PWM sensor 1

Sensor terminal	ECM J1 Connector Pin Assignment
Sensor +	43
Sensor signal	53
Sensor –	33

PTO mode

PTO mode has also previously been referred to as “engine speed cruise control” or “set speed control”

PTO mode cost effective way to control engine speed as for the minimum implementation it only requires buttons to raise and lower engine speed.

Another benefit is that it can be used in an application where it is necessary to control the engine speed from several different points on the machine. Likewise, it is a simple method controlling engine speed by another controller

The disadvantage of controlling speed via PTO mode is that it takes some time to ramp up or down to the required speed.

ON/OFF switch

When this switch input is open then the PTO mode cannot be engaged, and none of the other buttons will have any effect. When the switch is turned off, the memorized speed will be

Set/lower Button

When the PTO mode is on but not engaged, the first time that the set button is pressed it will save the current engine speed as the memorized speed, and the engine will try to run at this speed.

Once that a PTO speed has been engaged, if the pressed again, or if it is held down, then the engine speed will be lowered.

Raise/ Resume Button

If the resume button, is pressed before the set button, immediately after start or after switching ON the cruise control ON/OFF switch then the engine will go to the preset speed as described below.

If a the PTO mode has already been engaged by the set button, then the resume raise button can be pressed or held down to increase the speed.

After the PTO mode has been disengaged using the disengage switch described below, then pressing the Resume/Raise button will set the engine speed to the last memorized speed.

Disengage Switch

The disengage switch input is opened the engine speed will not follow the memorised speed, but will return to the next highest engine speed demand

The disengage switch may be a operator panel switch, or may be a micro switch on the brake, clutch, or other component of the application

Preset Speed

The preset speed is programmed via the service tool. A speed may be selected such that if the resume button is pressed, before the set button has been pressed, then the engine speed will jump straight to this speed.

Note: this feature will not be fully supported in the ECM or in the service tool by July 2005

PTO mode lamp

An optional lamp may be fitted. The positive terminal of the lamp is connected to the battery positive after the ignition keyswitch. The negative terminal of the lamp should be connected to pin 61 of the ECM J1 Connector

The lamp will FLASH when PTO mode is switched ON but is NOT ENGAGED. When the PTO mode is engaged then the lamp will be on SOLID when the PTO mode is ON and ENGAGED.

Example of PTO mode operation

It is recognized that the precise function of the PTO mode is difficult to understand from a written text document, especially for engineers who do not have English as their first language. The following table illustrates the operation of the PTO mode feature. In this example, the preset speed has been set on the service tool to 1800 rpm.

On/Off Switch	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
Interrupt Switch	1	1	1	1	1	1	1	1	1	Quickly open	1	Quickly open	1	1	1	1	1	1	1
Set/Lower Switch	0	0	0	0	0	0	0	0	Quick Close	0	0	0	Quick Close	Quick Close	0	0	0	0	Quick Close
Raise resume	0	0	Quick Close	0	0	0	Quick Close	Hold Close 3 secs	0	0	Quick Close	0	0	0	Hold Close 3 secs	0	Quick Close	0	Quick Close
Throttle Pedal demand	1200	1200	1200	1200	1900	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Memorised Speed	1800	1800	1800	1800	1800	1800	1820	2050	2030	2030	2030	2030	1200	1180	2430	1800	1800	1800	1800
Resulting engine speed	1200	1200	1800	1800	1900	1800	1820	2050	2030	1200	2030	1200	1200	1200	2430	1200	1200	1200	1200
Comments	PTO mode not enabled	PTO mode disenaged	PTO jumps to memorised speed		Pedal overrides PTO (max wins)		Speed raised by 20 RPM	Speed ramps up	Lowered by 20 RPM	Disengage - speed retuns to next highest demand (Throttle pedal)	Resumes to 2030	Disengage - speed retuns to next highest demand (Throttle pedal)	Sets memorised speed to current speed	Memorized speed lowered by 20RPM but now pedal is highest wins	Speed ramps up	PTO mode switched off. Preset memorised speed now	no effect as PTO mode is not enabled	PTO mode disengaged	no effect if both buttons are pressed at once

PTO mode Connection table

Function	ECM J1 Connector Pin Assignment
Set / Lower button	51
Raise / Resume button	50
ON/OFF switch	49
Disengage switch (normally closed)	52
PTO mode lamp	61

Multi Position Throttle Switch (MPTS)

Four switch inputs are available on the ECM for switched throttles. The ECM may be configured so that different combinations of switch inputs will relate to different engine speed demands. There are 16 different combinations of states of these 4 switches, although not all of these combinations need to be programmed.

If a switch combination is detected which has been configured as “Not Valid” then a fault code will be raised and the ECM will ignore the MPTS for the rest of the key cycle.

This is a very powerful and flexible feature that may be used in a number of ways. For example:

- Principal speed control method in a hydrostatic machines where engine speed is selected and then not required to be frequently changed by the operator. It is in this respect a good alternative to a hand throttle as the speeds selected on the switch. can be designed to correspond to the optimum operating speeds of hydraulic pumps. A rotary encoded 10 position switch component is available for this function. Please contact the electronic applications team for further details.
- Machine limp home speed feature. For example, if the normal throttle fails the operator could remove a fuse or a link and the engine would go to a speed that would allow the machine to be moved. In this application only one of the available 4 switch inputs would be used.
- Elevated idle. For example the OEM could increase the idle speed when work lights are switched on so that the alternator will provide sufficient current to recharge the battery. In this application only one of the available 4 switch inputs would be used.

The following table illustrates how the ECM may be configured for a 10 position rotary switch.

Multi-Position Switch Configuration Example

Switch 4	Switch 3	Switch 2	Switch 1	Switch position	Engine Speed
Open	Open	Open	Open	Not valid	800
Open	Open	Open	Closed	1	800
Open	Open	Closed	Open	3	1800
Open	Open	Closed	Closed	2	1400
Open	Closed	Open	Open	7	2050
Open	Closed	Open	Closed	6	2000
Open	Closed	Closed	Open	4	1900
Open	Closed	Closed	Closed	5	1950
Closed	Open	Open	Open	Not valid	800
Closed	Open	Open	Closed	Not valid	800
Closed	Open	Closed	Open	Not valid	800
Closed	Open	Closed	Closed	Not valid	800
Closed	Closed	Open	Open	8	2100
Closed	Closed	Open	Closed	9	2200
Closed	Closed	Closed	Open	Not valid	800
Closed	Closed	Closed	Closed	10	2350

Multi-Position Throttle Switch connections

Function	ECM J1 Connector Pin Assignment
MPTS Switch 1	52
MPTS Switch 2	51
MPTS Switch 3	50
MPTS Switch 4	49
Switch return	35

Torque Speed Control TSC1 (Speed Control Over CAN)

A special J1939 message called Torque/Speed Control #1 (TSC1) allows other electronic devices to control or to limit the engine speed. This message is explained in detail in the J1939 section of this application and installation guide

Arbitration of speed demand

In applications where there is more than one source of engine speed demand, it is necessary to arbitrate between the different demands. There are 3 methods of arbitration:

- Max Wins. The highest speed demand is the one that controls the engine. This is the default configuration
- Manual Selection switch. A switch input can be used to define which speed input has control. This is particularly useful in applications where there are 2 driver seat positions.
- Tsc1 override. As described above, the Tsc1 message over J1939 will override speed demand from any other source.

Manual Throttle Selection Switch

A switch input is available on pin 47of the ECM J1 connector, which can be configured to manually select the active speed demand channel. If the switch input is open then Speed demand 1 is selected. If the switch is closed then speed demand 2 is selected.

Cold Starting Aid.

Control of Glow Plugs by the Engine ECM

Glow plugs are fitted as standard on the 1104D and 1106D.

When the ignition keyswitch is switched ON, the engine ECM will monitor the coolant temperature and the inlet air temperature and decide whether the glow plugs are required. If so then the ECM will drive ECM connector pin 57 to ground, activating the glow plug relay.

The Glow plug relay is supplied and fitted by the OEM.

Relay, Fuse and Cable Gauge Specification

The relay coil should not draw more than 1A.and should be fitted with either a resistor or diode to suppress flyback energy (back emf) when the relay is de-energised.

As the glow plugs may be activated during cranking, when the battery voltage may be low, it is recommended that relay is specified such that it will close at a voltage of 60% of nominal battery voltage or lower.

The relay contacts should be rated to withstand the current characteristics outlined in the table below. Note that for the purpose of relay specification, the glow plugs are a purely resistive load (no inductive element).

Although the glow plugs are normally operated only for a short time, in cold ambient conditions, best practice would be to size the cable to withstand the stabilized glowplug current permenantly. This will allow for a relay which fails closed. For example a 4 Cylinder 12V application should have wire sized to carry 50A. Refer to the recommended cable sizes in the table below.

Engine:	**1104D**		**1106D**	
Supply Voltage:	**12V**	**24V**	**12V**	**24V**
Current - Initial	82A	36A	122A	54A
Current after 4 seconds	64A	29A	97A	43A
Current after 8 seconds	50A	24A	74A	36A
Recommended Fuse To SAEJ1888 (slow blow)	50	30	80	40
Recommended min cable gauge - mm^2 (SAE J1128 GLX cable)	$5mm^2$	$2mm^2$	$8mm^2$	$3mm^2$

Wait-to-Start / Start Aid active lamps

On a cold start, when the ECM decides that it is necessary for the glowplugs to be activated prior to starting, a lamp output will indicate to the operator that he needs to “wait to start”. Note that it is possible that start aids will also be used either during cranking or when the engine has started. The wait to start lamp will not be active in these conditions. For further information refer to the Lamp Output section.

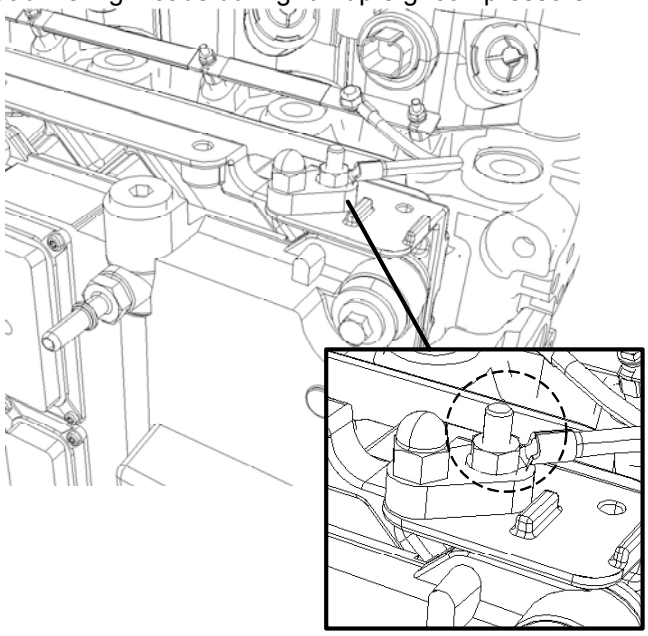
Note that the ECM will also transmit a parameter on the J1939 datalink indicating the status of the Wait to Start lamp (see section on J1939 support).

OEM / Operator control or override of the Glow Plugs

The ECM glow plug control strategy has been developed in a cold chamber to be suitable for the majority of applications.

There may be some applications that require a specially adapted strategy for control of the start aid. In such cases it will be necessary for the OEM or operator to control the start aid. Examples of applications that may require special starting strategies are:

- Engines in extremely cold climates that are fitted with block heaters.
- Engines that drive high loads during run up e.g. compressors.



Busbar connection point

An insulated M6 terminal post is provided for the machine harness connection to the busbar, this is located to the top right hand side of the ECM bracket. A 5.5-6 mm diameter ring terminal is required to connect the machine harness; this should be capable of handling an 80Amp current.

The existing terminal nut is used to locate both the engine-side and harness-side ring terminals to the post. A 10mm ring spanner is required to tighten the terminal nut to a torque of 6 Nm ± 2Nm.

Customers who paint their engine are required to shield the terminal post prior to painting.

Ether Cold Start Systems

Ether Cold start systems are not currently approved for use with 1106D and 1104D engines.

Operator Displays

Gauge Drivers

OEM's are increasingly selecting datalink driven intelligent displays for their applications, instead of traditional gauges and lamps directly driven from sensors or engine ECM.

If a needle type Analog gauge is required, to display an engine parameter such as engine speed, oil pressure or coolant temperature, then it is recommended that the OEM uses a gauge or display that can use the parameters broadcast by the ECM on the J1939 datalink.

As an alternative, traditional single wire gauge "senders" may be used if a suitable tapping is available. If this implementation is required, then please contact the electronic applications team to discuss requirements.

A traditional tacho signal may be obtained from the "W" terminal of the alternator, although this will not be as accurate as the value sent on the J1939 datalink.

Warning: The engine wiring harness must NEVER be modified to use the signal from the sensors connected to the engine ECM. This action would invalidate the engine warranty.

Lamp Outputs

The lamp strategy is designed to display the maximum amount of information on the minimum number of lamps.

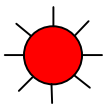
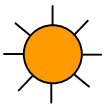
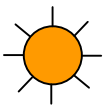
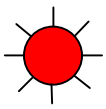
There are five lamp outputs available:

1. Red Stop Lamp
2. Amber Warning Lamp
3. Wait to Start Lamp (cold start lamp)
4. Oil Pressure lamp
5. PTO mode lamp

It is mandatory for the OEM to fit the Red Stop Lamp (1) and Amber Warning Lamp (2) unless a datalink driven intelligent display is fitted, which fulfils the specification outlined in the next section.

Lamps three, four and five are optional.

Indicator lamps Logic

	Engine Management System Related.	**Warning Lamp** (Also known as Alert Lamp)	**Shutdown Lamp** (Also known as Action Lamp)	**Lamp State**	**Description of what Lamp Status is Indicating**	**Engine State**
		 On	 On	Bulb Check	When the ignition is turned on the EMS shall illuminate each bulb for 2 seconds and extinguish them afterwards.	Key on but engine has yet to be cranked.
		 Off	 Off	No Faults Present.	With both lamps off whilst engine is running then there are no currently active warnings diagnostic's or events.	Engine is running with no detected faults.
		 On	 Off	Active Diagnostic	Should the warning lamp illuminate during engine running this indicates that an Active diagnostic (Electrical fault) is present.	Engine is running normally but has one or more faults with the engine management system.
		 On	 Flash	Derate. (Invoked by Active Diagnostic)	Should the warning lamp illuminate and the shutdown lamp flash during engine running this indicates that an Active diagnostic (Electrical fault) is present. The diagnostic is sufficiently serious to invoke engine derate.	Engine is running but has one or more Active diagnostic events that have initiated engine derate.
		 Flash	 Off	Warning (Warning only)	Should the warning lamp flash during engine running this indicates that one or more of the engine protection strategy warning values have been exceeded but not to a level that will invoke Derate or Shutdown.	Engine is running normally but has one or more monitored engine parameters outside of the acceptable range.
		 Flash	 Flash	Derate. (Warning and Derate).	Should both the Warning lamp and Shutdown lamp flash during engine running this indicates that one, or more, of the engine protection strategy values have been exceeded beyond the level required to invoke engine Derate.	Engine is running but one or more of the monitored engine parameters has gone beyond that of warning only and has now exceeded those set for engine derate.
		 On	 On	Engine Shutdown	Should both the Warning lamp and Shutdown lamp illuminate during engine running this indicates that either 1. One or more of the engine protection strategy shutdown values has been exceeded. 2. A serious Active diagnostic has been detected. **Shortly after *(time duration to be agreed)* engine will shutdown.**	Engine is either shutdown or shutdown is imminent, one or more monitored engine parameters have gone beyond that of warning or derate and have now exceeded those set for engine shutdown. Or a serious Active diagnostic has been detected

Datalink Driven Intelligent Displays

Displays may be connected to the engine ECM using J1939 datalink.

Some products that use the CDL may also be compatible. Please contact your local Applications team to confirm before selecting a CDL display.

Devices that are connected to the J1939 datalink should meet the following standard if the OEM does not intend fitting the indicator lamps, described above.

Minimum Functional Specification for J1939 display.

- The display always on when the engine is running
- The display should be line-of-sight of machine operator during machine operation
- Display of the whole J1939 fault code including Suspect Parameter Number, Failure Mode Indicator, and Occurrence number.
- Clear indication of what action, if any the operator is required to take.
- Display of engine speed
- Audible or bright lamp warning when new fault code is detected
- The scaling of any gauges (e.g. coolant temperature) should be such that the needle is not far to the right of vertical when the engine is in normal operation (this would give the impression that the engine was abnormally hot, when in fact it is running within it's design limits).

Perkins will under no circumstances change the engine J1939 implementation in order to resolve compatibility issues with gauges or displays other than those supplied directly by Perkins.

Gauge manufacturers may contact the Electronic Applications team, however for information and assistance in ensuring that their products are compatible with the engine ECM.

To support new standards and requirements Perkins may add to the fault code table. Therefore any active engine fault codes including those not recognized or referenced should be displayed. Perkins recommends that any suspect parameter number and the associated failure mode identifier are displayed.

Customer Triggered Engine Fault codes

The engine will raise fault codes (event codes) when it's design limits are exceeded. For example, for excessive coolant temperature. The fault code algorithms are carefully designed and validated so that they do not cause spurious codes when there is in fact no fault.

Some intelligent instrument clusters available on the market are also capable of raising fault codes themselves, based on the information that the engine transmits on J1939 such as "engine coolant temperature". The machine designer could set a limit that was more conservative (lower) than the warning threshold defined by Perkins. This raises the possibility that the display will say that the engine has a fault, when the engine is in fact running within its design limits. This is undesirable as it may result in a service technician being called to resolve a "problem" when in fact no problem exists. It will also cause damage to the reputation of Perkins and of the OEM.

Perkins recommend therefore, that intelligent display DO NOT have their own fault detection for engine over temperature / oil pressure etc, but that they use the fault codes generated by the engine, sent in the J1939 "Diagnostic Message#1 (DM1)".

Engine Software Features

Engine Monitoring System

Software will monitor the engine during operation and in extreme conditions make decisions to protect the engine from damage. The values of four main operating parameters are monitored Engine Coolant Temperature, Engine Oil Pressure, Intake Manifold Air Temperature and Engine Speed. The monitoring system will compare parameters predetermined as dangerous to the engine and depending on the parameter values take appropriate action. There are three levels of action Warning, De-rate and Shutdown.

General
All parameters work independently using individual threshold values and guard timers. Consequently, it is possible for more than one parameter to register a warning or de-rate condition at any one time.

Warning
Each monitored parameter has its own warning trigger threshold. A warning will be triggered when any parameter equals or exceeds its warning. In addition, for oil pressure, the trigger threshold varies with engine speed. The ECM will log these events and turn on the appropriate lamp driver.

De-rate
Each monitored parameter that uses the de-rate function has its own de-rate trigger threshold. If the de-rate threshold is equaled or exceeded by any parameter for a de-rate protection will be set active. The engine will de-rate. The ECM will log these events and turn on the appropriate lamp driver. Whilst de-rate protection is set active, the de-rate percentage may vary with parameter value

Shutdown
The engine shutdown indication lamp driver will be triggered when any parameter equals or exceeds it shutdown threshold for a time exceeding its shutdown indication guard time. Physical engine shutdown will occur only if enabled by the configurable parameter. The ECM will log these events and turn on the appropriate lamp driver.

Note: All values quoted in tables below are subject to change. Also, the percentage derate can be confusing. 100% derate does not mean that the engine has no power at all, it means that the engine will be running on a derate rating. The percentage of normal power that is available on the derate curve will depend on the rating used, but will normally be approximately 50% of nominal power

Coolant Temperature

Parameter	Temp	De-rate %
Warning	113	N/A
De-rate	114	25
	115	
	116	
	117	
	118	
	119	100
Shutdown	118	N/A

Engine Oil Pressure

Parameter	Engine Speed (rpm)	Trigger Pressure (kPa)
Warning	700	100
	900	150
	1000	175
	1200	200
Shutdown	700	100
	1200	100
	1800	100
	2400	100

* Derate thresholds will be released Jan 2005 for oil pressure.

Intake Manifold Temperature

Parameter	Temp	De-rate %
Warning	82	N/A
De-rate	86	10
	87	20
	88	30
	89	40
	90	50

Monitored Inputs for Customer Fitted Sensors

Configurable options will be available that enable the use of discrete ECM inputs to function as operator warnings and engine protection. The three options to be offered include:

	Input	State	De bounce Time (secs)	Warning/Shutdown	J1 Pin Assignment
Air Intake Restriction	SWG	Normally Open	30	Disabled or Warning	J1-47
Engine Coolant Level Low	SWG	Normally Closed	30	Disabled, Warning or Shutdown	J1-38
Water in Fuel	SWG	Normally Open	30	Disabled or Warning	44

Configurable States

The ECM may be configured to take the following action when the monitored element has reached or exceeded the predetermined limit (switched).

Disabled, the input will not be monitored.
Warning, the input will be monitored when the device is switched the warning light will illuminate and an event flagged.
Shutdown, the input will be monitored and when switched will illuminate the shutdown lamp; flag an event and shutdown the engine.

Air Filter Service Indicator – Air Intake Restriction Switch

Indicates that the air intake circuit is restricted. The switch is installed or piped to the air filter housing or air induction pipe so that it is monitoring clean filtered air (between the air filter and engine). The customer will select an appropriate restriction switch. The switch shall be connected to the engine ECM. The switch should close when the maximum permitted restriction is detected – Normally open.

Coolant Low Level Switch

Indicates that the engine coolant reservoir is at or has exceeded the minimum level. The sensor needs to be installed such that when coolant level is normal the sensing element is always completely immersed. Typically a device switches when the sensing element is fully immersed and when the fluid touches the body of the sensor. –Normally closed

Fuel in Water Trap Switch

Indicates that the fuel filter water trap is full. Typically a sensor is installed in the bottom of the water trap. During normal engine operation the sensor is immersed in diesel fuel. As water collects and reaches the maximum level the water enables a conductive path between electrodes. – Normally open

Engine Governor

All speed

The default governor type is an All Speed Governor, also known as a variable Speed Governor. The diagram below illustrates the torque and speed characteristics of this governor

Torque limit curve

Note that the engine may not be capable of reaching the toque fuel limit curve in some circumstances. For example, if the turbocharger is not providing the required boost pressure, then the fuel will be limited so that the engine does not emit black smoke

Droop

Droop is the variation of engine speed as load is applied. For example, if an engine has 10% droop and is running at 1500RPM without load, then as load is applied the operator will feel and hear the engine speed gradually decreasing. This is represented by the diagonal dotted lines under the torque curve in the diagram below.

When the load reaches the torque limit curve of the engine, the engine will lug back along the curve.

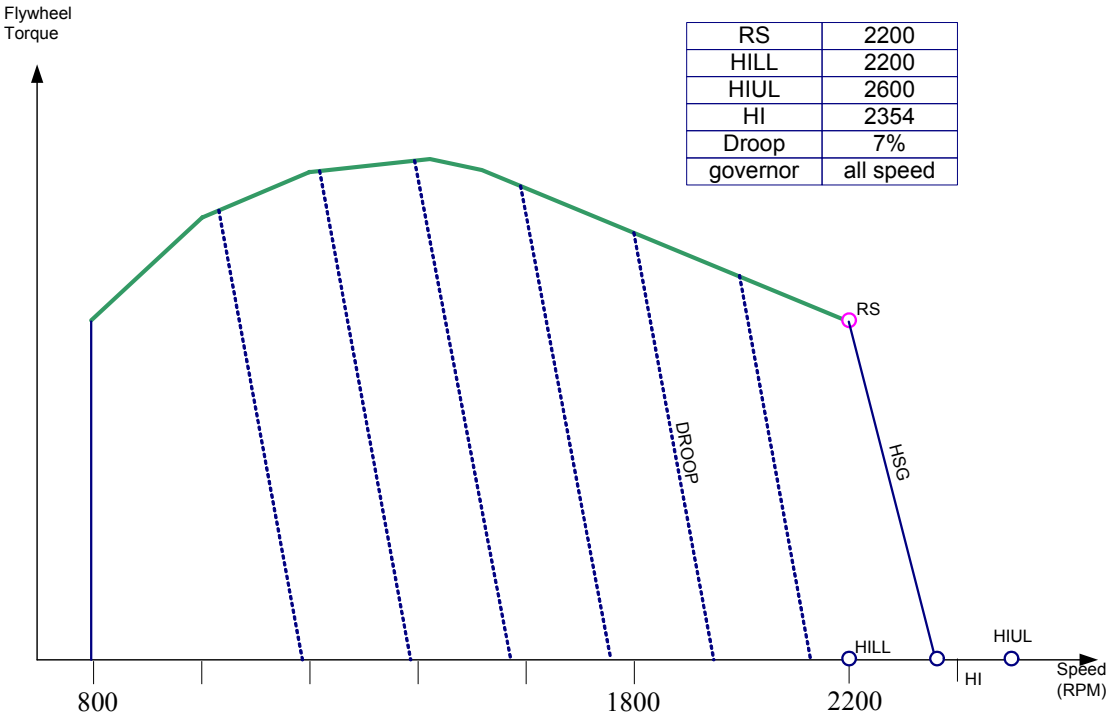
Note that droop values can be assigned to the multi-position throttle switch input, PWM accelerator pedal/lever input and the TSc1 speed demand over J1939. Droop does not apply, however to the PTO mode, which always operates isochronously (0% Droop)

High Speed Governor (Governor Run-Out)

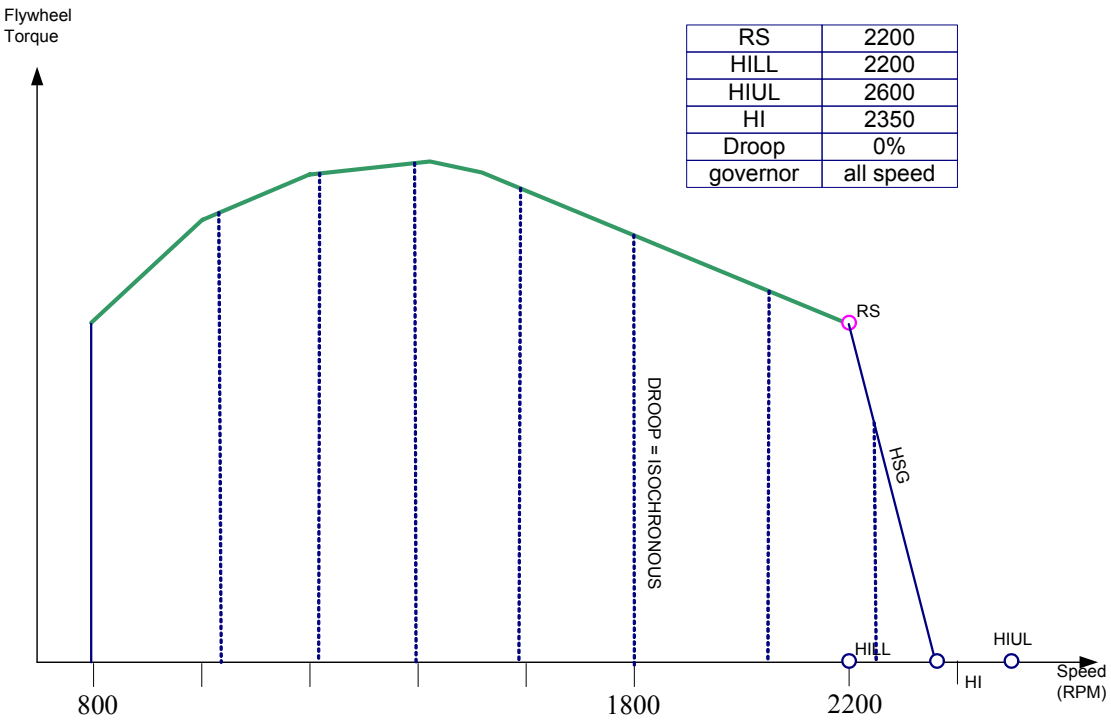
The parameter Top Engine Limit (TEL) will no longer be offered on the 1104D and 1106D engines. Flexibility is improved, however, by allowing the high idle (HI) speed to be configured. High Idle is the maximum speed that the engine will reach. Note that this is on the bare engine and when installed in an application, it may not be possible to reach this speed due to the parasitic loads of the driven equipment. The range of possible high idle speeds is defined by the parameters High Idle Lower limit (HILL) and High Idle Upper Limit. (HIUL). High Idle cannot be specified to be less than Rated Speed (RS) and the HIUL will be dependant on the mechanical limits of the engine.

The rated speed (RS) may not be changed by customer configuration.

Example Governing1 - showing droop and HSG slopes approximately equal



Example Governing 2 – Showing isochronous droop but with a shallow HSG slope



Auxillary Governor

It is possible to control the engine by the output shaft speed of another module. Perkins do not offer a speed sensor for this component, nor is there a direct speed sensor input, however this is for the following reasons:

- There are a wide variety of speeds to be measured
- Speed sensors output signals are low in amplitude and sensitive to electromagnetic interference
- The engine is often not close to the output shaft to be measured, thus resulting in poor quality speed signals

The recommended solution for this requirement is as follows

The speed measured close to the output shaft by a third party electronic control module, which would give an engine speed demand to the engine, either using by switch the PTO raise and lower buttons. The third party module could also incorporate a display and/or operator control buttons. The electronic Application team can give advise on specifying and selecting the third party electronic module for this function.

The advantage of this approach is that, although the initial cost of the additional module is higher than a direct speed input, the cost of the additional components is reasonable and the advantages in reliability and ease of commissioning outweigh the disadvantages.

Rating selection via Service Tool

Some engines will have the capability to run more than one power rating. If this is the case then the highest allowed rating may be changed via the “rating” parameter on the confitguration screen of the service tool. Note, however that the engine may not be running the highest enabled speed due to the status of the mode switches or due to requests from another electronic module on the machine over J1939 datalink.

Mode Switches

A mode is a performance characteristic in terms of power / torque, Droop and rated speed. There are up to 4 modes configurable on the 1104D and 1106D engines, and these can be selected in operation when the engine is running and on load.

The mode switches are of the Switch to Ground type and the ECM J1 pin connections are as follows:

Function	ECM - J1 connector pin assignment
Mode switch 1	46
Mode switch 2	39

The following table is an example of how the mode switches can be configured. The 2 switch inputs provide a total of four possible combinations. Two ratings have been configured such that if switch 2 is open the engine will run on the lower rating, and if the switch is closed it will run on the higher rating. Switch 1 is configured such that if it is open then the droop on throttle 1 and 2 is 10%, which may be suitable for road operation in an agricultural tractor, for example. When Switch 1 is closed, however, a tighter droop is applied which may be suitable in “field” or “work” operation

Note that the highest rating available in the mode switch feature will be defined by the “rating” parameter on the configuration screen of the service tool

Example of mode switch configuration

Switch 2	Switch 1	Mode No.	Rating	Droop (%)		
				Throttle 1	Throttle 2	Tsc1
Open	Open	1	100KW @ 2200	10	10	10
Open	Closed	2	100KW @ 2200	5	2	0
Closed	Open	3	120KW @ 2200	10	10	10
Closed	Closed	4	120 KW @ 2200	5	5	0

Rating and Droop changes requested via the J1939 datalink

It will be possible to select an alternative droop and alternative rating via the J1939 link, instead of via the hardwired switch inputs.

This feature is still in development, although the messages to be used are outlined in the J1939 datalink section of this applications and installation guide

Variable Speed Fan

A Variable Speed Fan control system will be offered as a configurable option. The engine ECM will determine the correct fan speed based on engine Intake Manifold Temperature and Coolant Temperature. Fan speed may also be controlled using J1939 data link.

Hydraulic arrangements may be controlled using a 2A PWM output.

The OEM will need to consider the following operating parameters:

Fan Speed Requirements (Max, Min)
Control Valve operating current (Max 2A)
Control Valve operating frequency

Further information concerning variable speed fan control will be available in Sep 2005

Machine Security System

Contact your local electronic applications representative for more information.

Using the ET service tool.

The latest version of ET will be required to view or modify some of the 1106D engine software parameters and features. It is important that the engineer regularly updates their service tool to ensure compatibility. In addition it is the responsibility of the engineer to confirm software release dates. During project engine development features may not be available or viewable and may be dependant later software release dates.

Datalink Support

There are 2 datalinks available for OEM connection to the engine. J1939 and Perkins Data link (CDL). It is recognized, however that other CANbus standards (higher level protocols) do exist and are used in off-highway applications, so some notes are also provided for users of those standards.

SAE J1939

The SAE J1939 standard was initially developed for the US truck and bus industry. It has been expanded and is now the most widely used datalink standard for industrial powertrains, with compliance from almost all engine manufacturers and most transmission manufacturers.

Summary of Key J1939 Application Issues

This is a summary of some of the 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.

Physical layer

- The data rate is 250 KBits/sec
- Twisted pair cable, of a 120Ohm 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. Unshielded-twisted pair cable is used by some machine manufacturers, however (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 40m
- The terminating resistors should not be contained in Network Nodes
- Network nodes are connected to the bus via stubs of maximum recommended length 1 meter.

Network Layer

- J1939 recommends a bit sample point of 87% . This relatively late sample point gives best compromise for immunity to noise and propagation delay. It does restrict the size of the software jump width (SJW), however.
- All nodes should have the same bit timing
- Accurate bit timing is essential (4μs +/- 0.2%)
- It is recommended that the average bus load is not greater than 40%
- 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 0. It will not change it's address in the arbitration process described in J1939-81
- The multi-7packet protocol (described in J1339-21) is used for sending messages with more than 8 bytes of data. In the Perkins 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 20ms but it will only send "hours run " information if another node requests it.

Application Layer

- The messages (PGN's)supported by Perkins ECM are only a subset of the messages described in J1939-71 and J1939-73

- Some PGN's 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 or invalid information is sent as FE.

J1939 Supported Parameters Quick reference SummaryTable

Section of SAE J1939 Document	PGN (decimal)	PGN (Hexidecimal)	PGN description	Parameter *(parameters in italics are proposed but may not yet be available / fully validated)*	Receive / Transmit
71	0	0	**Torque Speed Control (Tsc1)**		r
71				*Requested Torque / Torque Limit*	
71				Requested Speed / Speed Limit	
71				Override Control Modes	
71	57344	E000	**Cab Message 1 (CM1)**		r
71				*Requested Percent Fan Speed*	
71	61441		**Electronic Brake Controller 1**		
71				*Auxillary Engine Shutdown Switch*	
71	61443	F003	**EEC2**		t
71				Percent load at current speed	
71				Accelerator Pedal 1 Low Idle Switch	
71				Accelerator Pedal 2 Low Idle Switch	
71				Accelerator Pedal Position 1	
71				Accelerator Pedal Position 2	
71				Engine Speed	
71				*Engine Retarder Torque Mode*	
71				Actual Engine Percent Torque	
71	65174	FE96	**TurboWastegate**		t
71				Turbo1 Wastegate Drive	
71			**Fan Drive**		t
71				*Fan Drive States*	
71				*Estimated Percent Fan Speed*	
71	65241	FED9	**Aux Discrete IO State**		t
71				Aux IO discrete channel_1	
71				Aux IO discrete channel_2	
71				Aux IO discrete channel_3	
71				Aux IO discrete channel_4	
71				Aux IO discrete channel_5	
71				Aux IO discrete channel_6	
71				Aux IO discrete channel_7	
71				Aux IO discrete channel_8	
71				Aux IO discrete channel_9	
71				Aux IO discrete channel_10	
71				Aux IO discrete channel_11	
71				Aux IO discrete channel_12	
71				Aux IO discrete channel_13	
71				Aux IO discrete channel_14	
71				Aux IO discrete channel_15	
71				Aux IO discrete channel_16	
71				Aux IO Analog channel_1	
71				Aux IO Analog channel_2	

Section of SAE J1939 Document	PGN (decimal)	PGN (Hexidecimal)	PGN description	Parameter *(parameters in italics are proposed but may not yet be available / fully validated)*	Receive / Transmit
71	65242	FEDA	**Software Identification**		t
71				*Software Identification*	
71				*Number of software ID fields*	
71	65243	FEDB	**Engine Fluid Level_Pressure_2**		t
71				Injector Metering Rail1 Pressure	
71	65247	FEDF	**EEC3**		t
71				Engine Desired Operating Speed	
71	65251	FEE3	**EngineConfig**		t
71				*Engine Speed At Idle Pt1*	
71				*Percent Torque At Idle Pt1*	
71				*Engine Speed At Pt2*	
71				*Percent Torque At Pt2*	
71				*Engine Speed At Pt3*	
71				*Percent Torque At Pt 3*	
71				*Engine Speed at pt4*	
71				*Percent Torque at pt4*	
71				*Engine Speed at pt5*	
71				*Percen Torque at pt5*	
71				*Engine speed at high idle pt6*	
71				*Reference Engine Torque*	
71	65252	FEE4	**Shutdown**		t
71				Wait To Start Lamp	
71	65253	FEE5	**Engine Hours Revolutions**		t
71				*Total Engine Hours*	
71			**FuelConsumption**		t
71				*Total Fuel Used*	
71	65259	FEEB	**Component Identifier**		t
71				*Make*	
71				*Model*	
71				*Serial Number*	
71				*Unit Number*	
71	65260	FEEC	**Vehicle Identification**		t
71				*Vehicle Identification Number*	
71	65262	FEEE	**Engine Temp**		t
71				Engine Coolant Temperature	
71			**EngineFluidLevel_Pressure**		t
71				Engine Oil Pressure	
71	65264	FEF0	**Power Take Off Info (PTO)**		t
71				*PTO Set Switch*	
71				*PTO resume Swich*	
71				*PTO Enable Switch*	
71				*PTO coast / Decelerate Switch*	
71				*PTO accelerate Switch*	
71	65266	FEF2	**Fuel Economy**		t
71				*Fuel Rate*	

Section of SAE J1939 Document	PGN (decimal)	PGN (Hexidecimal)	PGN description	Parameter *(parameters in italics are proposed but may not yet be available / fully validated)*	Receive / Transmit
71	65270	FEF6	**InletExhaustCond**		t
71				Intake Manifold Temp	
71				Boost Pressure	
71				*Air Inlet pressure*	
71	65165	FE8D	**VehicleElectricalPower**		t
71				*Electrical Potential*	
71				*Battery Potential Switched*	
71a	64967	FDC7	**Off highway engine control selection state**		
71a				*Alternate Rating Select State*	
71a				*Alternate Droop Accelerator 1 Select State*	
71a				*Alternate Droop Accelerator 2 Select State*	
71a				*Alternate Droop Remote Accelerator Select State*	
71a	64971	FDCB	**Off highway engine control selection (OHECS)**		
71a				*Alternate Rating Select*	
71a				*Alternate Droop Accelerator 1 Select*	
71a				*Alternate Droop Accelerator 2 Select*	
71a				*Alternate Droop Remote Accelerator*	
73	*	*	**DM1 (active codes)**		t
73				Protect Lamp Status	
73				Amber Lamp Status	
73				Red Lamp Status	
73				Spn	
73				Fmi	
73				Oc	
73				Spn Conversion Method	
73	*	*	**DM2 (logged codes)**		t
73				*Protect Lamp Status*	
73				*Amber Lamp Status*	
73				*Red Lamp Status*	
73				*Spn*	
73				*Fmi*	
73				*Oc*	
73				*Spn Conversion Method*	
73	*	*	**DM3 (request to clear logged codes)**		r
73				*Request To Clear Logged Fault Codes*	
21	*	*	**Transport Protocol (TP_DT)**		t/r
21				TP_DT	
21	*	*	**Transport protocol (TP_CM)**		t/r
21				BAM and RTS	
21	*	*	**Acknowledge (ACK and NACK)**		t
21				PGN number	
21				Control Byte	
21	*	*	**Request PGN**		r

Section of SAE J1939 Document	PGN (decimal)	PGN (Hexidecimal)	PGN description	Parameter *(parameters in italics are proposed but may not yet be available / fully validated)*	Receive / Transmit
21				Requested PGN	

J1939 Parameters – Detailed Descriptions

Note: The PGN numbers are written in some documents in decimal form (e.g.61444). This document will use the Hexidecimal form (e.g. F004) as it is easier to remember and simpler to decode when using tools to analyse traffic on the CAN J1939 bus.

Torque Speed Control (TSC1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
0C 00 00 xx	10	000000	3	0	0	See notes	00

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
	X	**Override Control Mode (spn 695)**	1	1	2						
	X	Override Disabled				00					
	X	Speed Control				01					
		Torque Control				10					
	X	Speed/Torque Limit Control				11					
		Requested Speed Control Conditions (spn 696)		3	2						
	X	**Override Control Mode Priority (spn 897)**		5	2						A
	X	Highest Priority				00					A
	X	High Priority				01					A
	X	Medium Priority				10					A
	X	Low Priority				11					A
		Not Defined		7..8							
	X	**Requested Speed / Speed Limit (spn 898)**	2	1	16		Rpm	0.125	0	8032	
	X	**Requested Torque / Torque Limit**	4	1	8		%	1	-125	+125	B

The Torque/Speed Control #1 (TSC1) PGN allows other electronic devices to control the engine speed.

Although originally designed by the SAE for truck applications as a temporary means for the transmission to override engine speed during gearshifts, this PGN is now widely used as a permanent means of controlling the engine speed. It 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 ECM to ensure that this is so and to perform the necessary risk assessment validation of the software of electronic modules on the application that are transmitting TSC1 speed demand messages to the engine.

TSC1 Configuration

Tsc1 will always be available (it does not need to be configured to be ENABLED in the service tool)

In addition, Tsc1 may be configured to be a “continuous speed limit/ request”. In this case the

- TSC1 –Transient Engine Speed Limit / Request
- TSC1 - Continuous Speed Limit / Request

In addition to these options, it is also possible to specify what droop value applies to the engine speed request. This will operate in the same was as for the direct analogue / PWM and throttle position switch inputs.

TSC1 as Transient Speed Limit / Request
The ECM will allow other modules to request or limit engine speed for any period. The TSC1 message will override any other speed demand such as PWM throttle pedal.

End of Transmission – fault detection
The ECM needs to differentiate between the end of a transmission by another controller and an intermittent failure. The ECM expects, therefore, that when a controller no longer wished to demand engine speed then it will terminate with at least one message with the control override bits set to 00. If the engine sees that TSC1 messages have stopped, for 90ms, but have not been terminated correctly then the ECM will recognize this as a fault and will not accept any speed demand requests for the remainder of the key cycle.TSC1 as Permanent speed demand

Source address requirements
The ECM will accept messages from modules with any source address (i.e. TSC1 messages do not necessarily have to be sent by the transmission). The destination address does have to be 00 for the messages to be accepted by the engine however.

TSC1 as Continuous Speed Limit / Request
If TSC1 is to be the primary means of controlling the engine speed or as a method of continuously limiting engine speed, then the ECM may be configured to
raise a fault code if a valid Tsc1 message is not received by the time that engine speed reaches 500rpm of the keyswitch being turned on. This will allow for the normal start up time of other electronic modules.

TSC1 - Feature Summary Table

Function	**TSC1 – Transient (default)**	**TSC1 – Continuous**
Speed request	Yes	Yes
Speed limit	Yes	Yes
Torque request	No	No
Torque Limit (temporary)	Yes	Yes
Fault Detection – 90ms Timeout	Yes	Yes
Fault Detection – Message present at start	No	Yes
Accepts TSC1 messages from several sources simultaneously	No	No

Note A: The ECM does not prioritize or arbitrate between speed request or limits from more than one source and so this situation may result in erratic engine operation. The OEM must ensure that TSC1 messages are not sent from more than one source at a time.

Note B: Support for the “Torque limiting” aspect of TSC1 has been added, although this may only be used for temporary conditions, such as during a gear change.

Cab Message 1 (CM1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18E000xx	1000	E000	6	0	0	-	00

Not currently supported. This PGN may be used in applications where then engine ECM controls the speed of a fan (e.g. electronically controlled viscous fan or hydraulic fan). The parameter Requested Percent Fan Speed (SPN 986) will be sent to the engine to another module (e.g. air conditioning or hydraulic oil temperature) to communicate its need for cooling.

Will be implemented if referenced in Fan Control document (not available for job 1)

Electronic Brake Controller 1 (EBC1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18F00100	100	F001	6	0	0	-	00

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
	X	Auxillary Engine Shutdown Switch (970)	4	5	2						

This message may be sent to the engine to request it to stop running, without turning off the ignition keyswitch. This will be a normal stop and is not expected to be a safety related fail safe stop function.

Electronic Engine Controller 2 (EEC2)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
0C F0 03 00	50	00F003	3	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Accelerator Pedal Low Idle Switch 1 (spn 558)**	1	1	2						C
X		Accelerator pedal not in low idle condition				00					
X		Accelerator pedal in low idle condition				01					
X		Error indicator				10					
X		Not available or not installed				11					
		Accelerator Pedal Kickdown Switch		3	2						
X		**Accelerator Pedal Low Idle Switch 2 (spn 2970)**	1	7	2						A
X		Accelerator pedal not in low idle condition				00					
X		Accelerator pedal in low idle condition				01					
X		Error indicator				10					
X		Not available or not installed				11					
X		**Accelerator Pedal Position 1 (spn 91)**	2	1	8		%	.4	0	100	
X		**Percent Load at Current Speed (spn 92)**	3	1	8		%	1	0	125	B
		Remote Accelerator	4	1	8						
X		**Accelerator Pedal Position 2 (spn 29)**	5	1	8		%	.4	0	100	A,

Note A: Accelerator pedal low idle 2 and accelerator pedal position 2 are new parameters only recently defined by The SAE. The start byte / bit of accelerator pedal low idle switch 2 is still to be defined.

Note B: Percent load at current speed. Parameter is not accurate at low loads nor during transient conditions.

Note C: When there is discrepancy between the pedal position and the idle validation switch position, then the Accelerator Pedal Low Idle Switch parameter will be transmitted as 102 (error) and the accelerator pedal position will be transmitted as FE16 (error). If however, a pedal is not configured, then it will be sent as not supported. This will apply to both accelerator 1 and accelerator 2. Note also that the name “accelerator pedal” is not always accurate for off highway machines. Accelerator pedal 1 refers to any pedal, lever or other device that uses either the Analogue 1 or PWM throttle 1 input. Likewise, Accelerator pedal position 2 refers to any device that uses the analogue throttle 2 input.

Electronic Engine Controller 1 (EEC1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
0C F0 04 00	20	00F004	3	0	0	00	

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Engine Torque Mode	1	1	4						B
X		Low Idle Governor				0000					B
X		Accelerator Pedal 1				0001					B
		Cruise Control				0010					
X		PTO Governor				0011					B
		Road Speed Governing				0100					
		ASR Control				0101					
X		Transmission Control				0110					B
		ABS Control				0111					
X		Torque Limiting				1000					B
X		High Speed Governor				1001					B
		Brake System				1010					
		Not defined (1011 – 1101)									
		Other				1110					
		Not available				1111					
		Not Defined		5..8							
		Drivers Demand Engine - Percent Torque	2	1	8		%	1			
X		**Actual Engine - Percent Torque**	3	1	8		%	1			
X		**Engine Speed**	4	1	16		rpm	.125			
		Source Address of Controlling Device for Engine Control	6	1	8		None	1	0	253	
		Engine Starter Mode	7	1	4						

Note A: The J1939 standard describes the frequency of transmission of this PGN as engine speed dependant. The ECM actually transmits the message every 20ms, however, irrespective of engine speed

Engine torque mode - is not currently available although it intended to be supported in future software. Please contact an Electronic Applications engineer before using this parameter.

Turbocharger Wastegate (TCW)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination

18FE9600	100	FE96	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Turbocharger 1 Wastegate Drive (spn 1188)**	1	1	8		%	0.4	0	100	A
		Turbocharger 2 Wastegate Drive	2	1	8						
		Turbocharger 3 Wastegate Drive	3	1	8						
		Turbocharger 4 Wastegate Drive	4	1	8						
		Turbocharger Wastegate Act Control Pressure	5	1	8						

Note A: The J1939 specification states that " Position of the wastegate drive. A value of 0% represents fully closed and a value of 100% represents fully open". The implementation, however is that this value directly equates to the PWM duty cycle of the wastegate drive.

Fan Drive (FD)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FEBD00	1000	FEBD	6	0	0	00	-

Not currently supported. This PGN may be used in applications where then engine ECM controls the speed of a fan (e.g. electronically controlled viscous fan or hydraulic fan). The parameter Estimated Percent Fan Speed (spn 975) will be used by the engine to give feedback of the current fan speed conditions to other modules on the application. In addition the parameter Fan Drive State (spn 977) will give the status of which parameter is controlling the fan speed: Engine Coolant Temperature, Engine Air Temperature, or a fan speed request via J1939.

XX OL: Check that this is referenced n the fan specification – if so then will be supported in june 05 dev software (post job 1 production)

Auxillary Discrete IO state (AUXIO)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FED900	Note A	FED9	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Auxiliary I/O #04 (spn 704)**	1	1	2						B
X		**Auxiliary I/O #03 (spn 703)**	1	3	2						B
X		**Auxiliary I/O #02 (spn 702)**	1	5	2						B
X		**Auxiliary I/O #01 (spn 701)**	1	7	2						B
X		**Auxiliary I/O #08 (spn 708)**	2	1	2						B
X		**Auxiliary I/O #07 (spn 707)**	2	3	2						B
X		**Auxiliary I/O #06 (spn 706)**	2	5	2						B
X		**Auxiliary I/O #05 (spn 705)**	2	7	2						B
		Auxiliary I/O #12 (spn 712)	3	1	2						B
X		**Auxiliary I/O #11 (spn 711)**	3	3	2						B
X		**Auxiliary I/O #10 (spn 710)**	3	5	2						B

X		**Auxiliary I/O #09 (spn 709)**	3	7	2						B
		Auxiliary I/O #16 (spn 716)	4	1	2						B
		Auxiliary I/O #15 (spn 715)	4	3	2						B
X		**Auxiliary I/O #14 (spn 714)**	4	5	2						B
X		**Auxiliary I/O #13 (spn 713)**	4	7	2						B
X		**Auxiliary I/O Channel #1 (spn 1083)**	5,6	1	16				0	64255	C
X		**Auxiliary I/O Channel #2 (spn 1084)**	7,8	1	16				0	64255	C

Note A: The message will be sent at a frequency of 100ms, and additionally when any of the supported switch inputs (spn's 701 through 716) change state

This PGN will be used to transmit the status of all the customer side switch inputs, and two of the analogue voltage inputs of the ECM, irrespective of whether the input is used by the ECM for an application software feature.

The machine designer can use the spare inputs of the ECM, therefore, as additional input channels for non engine systems

Note B: Each of the switch inputs is transmitted as 00 if it the switch is open (or not connected) and 01 if it is closed.

The 2 "SWB" inputs below are "switch to battery", meaning that when battery voltage is applied to the pin then it will be "closed". All the other switch inputs are switch to ground, which means that when an input is at ground potential it will be "closed"

Note C: The analogue channels are scaled at 0.955Volts per bit with a 0.5V offset. For example a voltage of 2.5Voltages would be transmitted as (2.5volts – 0.5 v offset)/0.000955 volts/bit = 2094_{10} or $82E_{16}$

Table of Input pins to SPN's

Input name	ECM J1 Connector Pin	J1939 SPN
SWG1	52	701
SWG2	51	702
SWG3	50	703
SWG4	49	704
SWG5	48	705
SWG6	47	706
SWG7	46	707
SWG8	45	708
SWG9	44	709
SWG10	39	710
SWG11	38	711
SWB1	37	713
SWB2	38	714
AIN_ACT5	55	1083
AIN_ACT4	56	1084

Software Identification (SOFT)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FEDA00	On Req	FEDA	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Number of software identification fields (spn 965)**	1	1	8				1	255	A
X		**Software Identification (spn 234)**	2	1	N		ASCII				B

Note A: The number of software identification fields will be transmitted as “02”
Note B: The software identification is ASCII text, with the fields delimited by a “*”

ASCII code as follows:
02 SWPN:1234556701*SWDT:MAY05*

Software part number (SWPN) will be of the form 123456701
Software release date (SWDT) will be of the form MAY05

Note that as this PGN has more than 8 bytes of data then the transport protocol will be used as described below.

Engine Fluid Level / Pressure 2 (EFL/P2)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FEDB00	500	FEDB	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Injector Control Pressure	1	1	16						
X		**Injector Metering Rail 1 Pressure (spn157)**	3	1	16		Mpa	1/256Mpa/Bit	0	251	
		Injector Timing Rail 1 Pressure	5	1	16						
		Injector Metering Rail 2 Pressure	7	1	16						

Electronic Engine Controller 3 (EEC3)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE DF 00	250	FEDF	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Nominal friction – Percent Torque	1	1	8		%	1	-125	+125	
X		**Engine´s Desired Operating Speed (spn 515)**	2	1	16		Rpm	.125	0	8031	A
		Engine´s Operating Speed Asymmetry Adjustment	4	1	8		Ratio		0	250	

Note A: Engine desired operating speed will be the speed at which the engine would run if all load were removed and current speed demand conditions maintained.

This is not the same as the implementation for tier 2 product but the change has been implemented to make the parameter more relevant to customers who need to determine how far and how rapidly the engine is lugging back. One effect will be that in many applications where there are high parasitic loads, the engine speed will never actually reach it's desired operating speed.

Engine Configuration (EC)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
See Note A	See Note B	FEE3	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Engine Speed at Idle, Point 1 (spn 118)**	1	1	16		Rpm	0.125	0	8031	
X		**Percent Torque at Idle, Point 1 (spn 539)**	3	1	8		%	1	-125	+125	
X		**Engine Speed at Point 2 (spn 528)**	4	1	16		Rpm	0.125	0	8031	D
X		**Percent Torque at Point 2 (spn 540)**	6	1	8		%	1	-125	+125	D
X		**Engine Speed at Point 3 (spn 529)**	7	1	16		Rpm	0.125	0	8031	
X		**Percent Torque at Point 3 (spn 541)**	9	1	8		%	1	-125	+125	
X		**Engine Speed at Point 4 (spn 530)**	10	1	16		Rpm	0.125	0	8031	
X		**Percent Torque at Point 4 (spn 542)**	12	1	8		%	1	-125	+125	
X		**Engine Speed at Point 5 (spn 531)**	13	1	16		Rpm	0.125	0	8031	
X		**Percent Torque at Point 5 (spn 543)**	15	1	8		%	1	-125	+125	
X		**Engine Speed at High Idle, Point 6 (spn 532)**	16	1	16		Rpm	0.125	0	8031	D
		Gain (KP) of the Endspeed Governor	18	1	16		%/rpm	0.0007813	0	50.2	
X		**Reference Engine Torque (spn 544)**	20	1	16		Nm	1	0	64255	C
		Maximum Momentary Engine Override Speed, Point 7	22	1	16		Rpm	0.125	0	8031	
		Maximum Momentary Override Time Limit	24	1	8		S	0.1	0	25	
		Requested Speed Control Range Lower Limit	25	1	8		Rpm	10	0	2500	
		Requested Speed Control Range Upper Limit	26	1	8		Rpm	10	0	2500	
		Requested Torque Control Range Lower Limit	27	1	8		%	1	-125	+125	
		Requested Torque Control Range Upper Limit	28	1	8		%	1	-125	125	

This PGN defines several points on the torque curve (rating) that is active in the engine. The values will change if a different torque curve is selected or to reflect if the engine is derating e.g. due to excessive engine temperature.

Note A: As this PGN is more than 8 bytes long, it will always be transmitted via the transport protocol

Note B: This PGN is sent every 5 seconds but also whenever there is a change in active torque limit map.

Note C: Engine reference torque is the advertised bare engine torque of the highest “enabled” rating in the box. That is the highest rating that can be selected via mode switches or J1939, whilst the engine is running.

Note D: As both point 2 and point 6 are supported, and Gain (Kp) of Endspeed Governor is not, the support of this message conforms to Engine Configuration Characteristic Mode 1 as described in the J1939-71 specification

Shutdown (SHUTDOWN)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE E4 00	1000	FEE4	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Idle shutdown has shut down engine	1	1	2						
		Idle shutdown driver alert mode		3	2						
		Idle shutdown timer override		5	2						
		Idle shutdown timer state		7	2						
		Idle shutdown timer function		7	2						
		A/C high pressure fan switch	3	1	2						
		Refrigerant low pressure switch		3	2						
		Refrigerant high pressure switch		5	2						
X		**Wait to start lamp (spn 1081)**	4	1	2						
X		Off				00					
X		On				01					
		Engine protection system has shut down engine	5	1	2						
		Engine protection system approaching shutdown		3	2						
		Engine protection system timer override		5	2						
		Engine protection system timer state		7	2						
		Engine protection system configuration		7	2						

Engine Hours / Revolutions (HOURS)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE E5 00	1000 Note A	FEE5	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Total engine hours (spn 247)**	1	1	32		Hr	.05	0	210,554,060	
		Total engine revolutions	5	1	32		Rev	1000	0	4,211,081,215,000	

Note A: The SAE defines this PGN as being sent on request. There are some gages and displays on the market however, which require this to be broadcast. This message will be broadcast at a low update rate, therefore, to ensure compatibility with these devices.

Fuel Consumption

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE E9 00	On Req	00FEE9	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Trip fuel	1	1	32		L	.5	0	2,105,540,607	
X		**Total fuel used (spn 250)**	5	1	32		L	.5	0	2,105,540,607	

Note A: This parameter is not a direct measurement. It is calculated from standard test fuel at standard test temperatures. The characteristics of most fuels in the field will differ from the test fuel, particularly at very high or very low temperatures. It is recommended, therefore, that this value is taken to be an indication only of the fuel used by an engine.

Component ID (CI)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE EB 00	On Req	00FEEB	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Make (spn 586)**					ASCII	None			A
X		**Model (spn 587)**					ASCII	None			A
X		**Serial Number (spn 588)**					ASCII	None			A
		Unit Number (spn 233)					ASCII	None			

Note A: All these parameters are supported as ASCII text delimited by "*"

"Make" will be transmitted as "CTRPL"
"Model" will be transmitted in the form "1106D" or "1104D" or "1104D" or "1106D"
"Serial Number" will be the engine serial number as marked on the nameplate of the engine

Vehicle Identification (VI)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FEEC00	On Req	FEEC		0	0	00	-

This PGN may be requested from the ECM but currently the message will simply contain the ASCII text "NOT PROGRAMMED".

Engine Temperature (ET1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE EE 00	1000	FEEE	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Engine Coolant Temperature (spn 110)**	1	1	8		deg C	1	-40	210	
		Fuel Temperature	2	1	8		deg C	1	-40	210	
		Engine Oil Temperature	3	1	16		deg C	.03125	-273	1735	
		Turbo Oil Temperature	5	1	16		deg C	.03125	-273	1735	
		Engine Intercooler Temperature	7	1	8		deg C	1	-40	210	
		Engine Intercooler Thermostat Opening	8	1	8		%	.4	0	100	

Engine Fluid Level / Pressure (EFL/P1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE EF 00	500	FEEF	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Fuel Delivery Pressure	1	1	8		KPA	4	0	1000	
		Extended Crankcase Blow-by Pressure	2								
		Engine Oil Level	3	1	8		%	.4	0	100	
X		**Engine Oil Pressure (spn 100)**	4	1	8		KPA	4	0	1000	
		Crankcase Pressure	5	1	16						
		Coolant Pressure	7	1	8		KPA	2	0	500	
		Coolant Level	8	1	8		%	.4	0	100	

PTO information (PTO)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FEF000	100	FEF0	6	0	0	00	-

Sen	Rec	Parameter name	Byt	Bit	Len	Sta	Uni	Resolution (unit/bit)	Range	Not

d	e i v e		e		g t h	t e	t s		Min	Max	e
		Power Takeoff Oil Temperature (spn 90)	1	1	8						
		Power Takeoff Speed (spn 186)	2	1	16						
		Power Takeoff Set Speed (spn 187)	4	1	16		Rpm	Rpm	0	8031	
X		**PTO Enable Switch (spn 980)**	6	1	2						
		Remote PTO preprogrammed Speed Control Switch (spn 979)	6	3	2						
		Remote PTO variable Speed Control Switch (spn 978)	6	5	2						
X		**PTO set switch (spn 984)**	7	1	2						A
X		**PTO Coast / Decelerate Switch (spn 983)**	7	3	2						A
X		**PTO Resume Switch (spn 982)**	7	5	2						A
X		**PTO Accelerate Switch (spn 981)**	7	7	2						A

Note A: Some of the PTO mode switch inputs on the ECM have dual functions. For example, one button provides both SET and LOWER functions and another button provides both RAISE and RESUME functions. When the SET/LOWER button is pressed, both SPN 984 and SPN 938 will go to the active state, for at least one message transmission.

Similarly, when the RAISE/RESUME button is pressed then both SPN 982 and SPN 981 will go to the active state.

Fuel Economy (LFE)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE F200	100	FEF2	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Fuel Rate (spn 183)**	1	1	16		L/hr	.05	0	3212	A
		Instantaneous Fuel Economy	3	1	16		km/kg	1/512	0	125.5	
		Average Fuel Economy	5	1	16		km/kg	1/512	0	125.5	
		Throttle Position	7	1	8		%	.4	0	100	

Note A: This parameter is not a direct measurement.. It is recommended, therefore, that this value is taken to be an indication only of the fuel quantity injected

Inlet / Exhaust Conditions (IC)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE F6 00	500	FEF6	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Particulate Trap Inlet Pressure	1	1	8		kPa	.5	0	125	
X		**Boost Pressure**	2	1	8		kPa	2	0	500	B
X		**Intake Manifold Temperature**	3	1	8		deg C	1	-40	210	
X		**Air Inlet Pressure**	4	1	8		kPa	2	0	500	A
		Air Filter Differential Pressure	5	1	8		kPa	.05	0	12.5	
		Exhaust Gas Temperature	6	1	16		deg C	.03125	-273	1735	
		Coolant Filter Differential Pressure	8	1	8		kPa	.5	0	125	

Note A: Inlet air pressure will be supported as the absolute pressure as measured by the inlet manifold pressure sensor.

Note B: Boost pressure will be calculated from inlet manifold temperature. Boost pressure will never be transmitted as a negative number, even though a slight depression at the inlet is possible for some engines when running at low idle speed.

Vehicle Electrical Power (VEP)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18 FE F7 00	1000	FEF7	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Net Battery Current	1	1	16		Amp	1	-125	125	
		Alternator Potential (Voltage)	3	1	16		V	.05	0	3212	
X		**Electrical Potential (Voltage)**	5	1	16		V	.05	0	3212	A
X		**Battery Potential (Voltage), Switched**	7	1	16		V	.05	0	3212	A

Note A: Electrical potential and battery potential parameters are both supported with the same value, which is the voltage measured between the battery (+) and battery (-) terminals of the ECM

Operator Primary Intermediate Speed (ISCS)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FDC800	1000	FDC8	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
X		**Operator Primary Intermediate Speed Select State (spn 2892)**	1	1	4						
		Intermediate speed not requested				0000					A
X		Logical Position 1				0001					
X		Logical Position 2				0010					
X		Logical Position 3				0011					
X		Logical Position 4				0100					
X		Logical Position 5				0101					
X		Logical Position 6				0110					
X		Logical Position 7				0111					
X		Logical Position 8				1000					
X		Logical Position 9				1001					
X		Logical Position 10				1010					
X		Logical Position 11				1011					
X		Logical Position 12				1100					
X		Logical state 13, 14, 15 or 16				1101					B
		Reserved				1110					
X		Not available				1111					C

This PGN is used to describe the logical state of the throttle position switch input (also known as multi-position throttle switch).

Note A: “intermediate speed not requested” state is not supported. Note however, that on most applications where throttle position switch is used, logical position 1 will be all four switches in the open position and will equate to engine idle.

Note B: There are only 13 states available but 16 possible combinations of the 4 switch inputs. No known application has used more than 10 states however, or is expected to use more than 10 states in the future, so this is not envisaged that this will cause a problem. If 16 states are use then logical states 14, 15 and 16 will be transmitted as 13.

Note C: If the throttle position switch is not configured on an application then the ECM will send 1111_2 not available.

Off highway engine control selection (OHECS)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18FDCBxx	500	FDCB	6	0	0	-	00

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Auxillary Governor Switch	1	1	2						
		Multi-Unit Synch On/Off switch	1	3	2						
		Alternate Low Idle Switch	1	5	2						
	X	**Alternate Rating Select**	2	1	8						A
	X	**Alternate Droop Accelerator 1 select**	3	1	4						
	X	Accel 1-Default Droop (default)				0000					
	X	Accel 1 –Alternate Droop 1 through 10 = 1% through 10%				0001 - 1010					
		Accel 1 –Alternate Droop 11 (Isochornous)				1011					
		Error				1110					
	X	Not Available				1111					
	X	**Alternate Droop Accelerator 2 Select**	3	5	4						
	X	Accel 12-Default Droop (default)				0000					
	X	Accel 2 –Alternate Droop 1 through 10 = 1% through 10%				0001 - 1010					
		Accel 2 –Alternate Droop 11 (Isochornous)				1011					
		Error				1110					
	X	Not Available				1111					
	X	**Alternate Droop Remote Accelerator Select**	4	1	4						
	X	Remote Accel-Default Droop (default)				0000					
	X	Remote Accel –Alternate Droop 1 through 10 = 1% through 10%				0001 - 1010					
		Remote Accel Alternate Droop 11 (Isochornous)				1011					
		Error				0011					
	X	Not Available				0100					
		Alternate Droop Auxillary Input Select	4	5	4						

This PGN may be sent to the engine to demand an alternative rating or droop, in a similar way to the hardwired “mode switches”. The J1939 request will have precedence over the hard wired switch inputs to the ECM.

When the ECM receives this PGN, it will switch to the alternate ratings/alternate droop settings requested. It will remain in this new state until either another message is received with a different ratin / droop request, or until the key switch is cycled

Note A: Ratings 1 to n are populated with all the ratings available in the ECM with “1” being the lowest and “n” being the highest rating. If the ECM receives the “0” then the rating value entered through the mode selection switches should be used.

Off highway Engine control selection state (OHCSS)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination

18FDC700	500	FDC7	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Auxillary Governor State	1	1	2						
		Multi-Unit Synch State	1	3	2						
		Alternate Low Idle Select State	1	5	2						
X		Alternate Rating Select State	2	1	8						
X		Alternate Droop Accelerator 1 Select State	3	1	4						
X		Alternate Droop Accelerator 2 Select State	3	5	4						
X		Alternate Droop Remote Accelerator Select State	4	1	4						
		Alternate Droop Auxillary Input Select State	4	5	4						

This PGN is intended for the ECM to provide Feedback on the OHECS messages described above

Section 73 - Diagnostic Layer

Active Diagnostics Trouble Codes (DM1)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
See Note A	See note B	00FECA	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Malfunction indicator lamp									C
		Protect lamp									C
		Stop lamp									C
		Warning lamp									C
X		**SPN**									
X		**FMI**									
X		**Occurrence Count**									
X		**SPN conversion method**									

Note A: If a single fault code is present then DM1 will be sent as single message with the identifier 18FECA00. If there is more than one fault code present then the DM1 message will be longer than 8 bytes thus the transport protocol (BAM) will be used to send the message.

This is different from tier 2 functionality where the transport protocol is used to send all DM1 messages, even if only one fault code is active

Note B: A DM1 message is sent when a new active fault is detected, and approximately every 1second after that. The DM1 message is not sent if there are no active fault codes.

Note C: This is not supported as per J1939 – Implementation is supported as follows: Diagnostic and Event codes have been split into 3 categories of severity called “Warning Category Indicators (WCI)” .

The lowest level (Level 1) is used for “warning” level faults, such as when engine design limits for temperature have been reached, or for a sensor short circuit.

The highest level (Level 3) is used for events where the severity merits the machine and the engine being immediately stopped.

Level 2 is an intermediate level used particularly for events or diagnostic which cause an engine derate

The status lamps in the DM1 message will be switched on according to the following table:

WCI	Protect Lamp	Warning Lamp	Shutdown Lamp
1	ON	OFF	OFF
2	ON	ON	OFF
3	ON	ON	ON

Previously Active Diagnostic Trouble Codes (DM2)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
See note A	On Req	FECB	6	0	0	00	-

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
		Malfunction indicator lamp									A
		Protect lamp									A
		Stop lamp									A
		Warning lamp									A
X		**SPN**									
X		**FMI**									
X		**Occurrence Count**									
X		**SPN conversion method**									

Note A: Lamp support as per DM1

Diagnostic Data Clear / Reset of Previously Active DTCs (DM3)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
See Note A	On req	FECC	6	0	0	-	00

Send	Receive	Parameter name	Byte	Bit	Length	State	Units	Resolution (unit/bit)	Range		Note
									Min	Max	
	X	**Request to clear fault codes**									B

Note A: This message is sent as a request PGN.

Note B: when the ECM receives a DM3 message then 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.

Supported Parameters – Section 21 - Detailed Descriptions

Transport Protocol – Connection Management (TP.CM_BAM))

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
1CECFF00	-	EC00	7	0	0	-	-

Support as per J1939 – 21. Note that this mechanism is used principally as a multipacket protocol for sending messages larger than 8 bytes of data for example to send diagnostic messages DM1 and DM2 or for the Engine Configuration PGN. This uses the Broadcast Announce Message (BAM) as shown in the example below:

Transport Protocol – Data Transfer (TP.DT)

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
1CEBFF00	See note A	EB00	7	0	0	-	-

Note A: 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.

Proprietary A

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18EF00xx	-	EF00	6	0	0	-	-

This message is used for communication between the ECM and the service tool. **It must not be used by any other electronic system on the machine, as this may cause unpredictable operation when the service tool is connected.**

Acknowledge

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18E8xxxx	-	E800	6	0	0	-	-

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

Request PGN

Identifier	Rate (msec)	PGN	Default Priority	R1	DP	Source	Destination
18EA00xx	-	EA00	6	0	0	-	00

Supported 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 then it must send a Request PGN for the Engine Hours/ Revolutions PGN

Supported Parameters – Section 81 Network Management - Detailed Descriptions

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.

Most off-highway machines do not implement this section of the specification. If further information on this subjected is required, however, then please contact the Electronic Applications Team Directly

Perkins Data Link

For industrial engines, the Perkins Datalink (CDL) is principally used for service tool support. If an application does have a requirement to communicate with another system on CDL, for example with a Perkins transmission or a display, then please contact your local applications team for further information.

Other Datalink Standards

CANopen

CANopen may become a popular choice of CAN higher level protocol in off-highway machines which 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 CAN open to J1939 gateway may be obtained from the the website of “CAN in Automation (CIA)” .

OEM Proprietary CAN standards

It is accepted that the J1939 standard cannot meet all the diverse needs of the many specialised 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, then the machine designer should consider the use of a CAN gateway to isolate the proprietary messages from the J1939 bus.

The risk of OEM defined messages is that they will clash with some of the J1939 standard messages.

List of Appendices

- **Appendix 1 - ECM J1 Connector Terminal Assignments**
- **Appendix 2 – Electronic Options Selection Form**
- **Appendix 3 - List of Diagnostic and Event Codes**

Appendix 1 - ECM J1 Connector Terminal Assignments

Pin No.	Description	Preferred Function	Alternative Function
1	Battery (-)	Battery –ve	N/A
2	Battery (-)	Battery –ve	N/A
3	Battery (-)	Battery –ve	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	Battery (+)	Battery +ve	N/A
8	Battery (+)	Battery +ve	N/A
9	- Battery	Battery –ve	N/A
10	- Battery	Battery –ve	N/A
11	DF_PWM 1 Shield	N/A	N/A
12	DF_PWM 1-	N/A	N/A
13	DF_PWM 1+	N/A	N/A
14	N/A	N/A	N/A
15	Battery (+)	Battery +ve	N/A
16	Battery (+)	Battery +ve	N/A
17	N/A	N/A	N/A
18	N/A	N/A	N/A
19	N/A	N/A	N/A
20	CAN (+)	SAE J1939 CAN DL +	N/A
21	CAN (-)	SAE J1939 CAN DL -	N/A
22	CAN A Shield	CAN Shield	N/A
23	CDL (+)	PDL +	N/A
24	CDL (-)	PDL -	N/A
25	N/A	N/A	N/A
26	N/A	N/A	N/A
27	N/A	N/A	N/A
28	N/A	N/A	N/A
29	N/A	N/A	N/A
30	N/A	N/A	N/A
31	PWM_2A Return 1	N/A	N/A
32	PWM_2A Driver 1	N/A	N/A
33	VS_RET	Sensor 0V return	N/A
34	VS_RET	Sensor 0V return	N/A
35	SWG_ RET	Switch return	N/A
36	SWB 2	N/A	N/A
37	SWB 1	N/A	N/A
38	SWG 11	Coolant Level Switch	N/A
39	SWG 10	Mode switch 2	N/A
40	SWK_0	Ignition switch input	N/A
41	VS_5_200mA	Sensor 5V supply	N/A
42	VS_5_200mA	Sensor 5V supply	N/A

43	VS_8_100mA	PWM Throttle Sensor 8V supply	N/A
44	SWG 9	Throttle 2 IVS	Fuel Water Trap Monitor
45	SWG 8	Throttle 1 IVS	N/A
46	SWG 7	Mode switch 1	N/A
47	SWG 6	Throttle Arbitration Switch	Air Filter Restriction
48	SWG 5	Remote Shutdown Switch (NO)	N/A
49	SWG 4	PTO mode disengage (NC)	MPTS4
50	SWG 3	PTO mode raise/ Resume	MPTS3
51	SWG 2	PTO mode Set/Lower	MPTS2
52	SWG 1	PTO mode ON/OFF	MPTS1
53	AIN_ACT/PWM_I 1	PWM throttle input	N/A
54	AIN_ACT 7	Throttle 1 Analog input	N/A
55	AIN_ACT 5	Throttle 2 Analog input	N/A
56	AIN_ACT 4	N/A	N/A
57	DOUT_1A 1	Start aid control	N/A
58	DOUT_0.3A 10	N/A	N/A
59	DOUT_0.3A 9	Warning Lamp	N/A
60	DOUT_0.3A 8	Shutdown Lamp	N/A
61	DOUT_0.3A 4	PTO mode lamp	N/A
62	DOUT_0.3A 3	Low oil pressure lamp	N/A
63	DOUT_0.3A 2	Wait to Start Lamp	N/A
64	DOUT_0.3A 1	N/A	N/A

Appendix 2 - Electronic Options Selection Form

The latest copy of this form is found in the Engine Sales Manual. It is replicated in this document for illustration and for convenience.

At the time of customer order, the customer needs to make certain decisions about how the engine is configured. This configuration is done in the factory, although most items can also be adjusted in the field using the service tool.

Electronic Option Selection Template *figure -1*

Completed by.		**Phone Number**		*Date*	
Approved by.		***Phone Number***		*Date*	
SPES or List Number		***SPES Iss level***		***Application type***	

Option Group			Ref.	Input	Description
Ref Only	**Rating / Rating Set**		**1**		**Select from Rating / Rating sets presented.** (Can be single power curve/rating point or multiple power curve/rating point).
Feature Options	**Idle Speed**		**2**		**Numerical Value –** 10-rpm increments. (Default = 750) Range 700-1200rpm to the nearest
	High Idle		**3**		**Numerical Value –** (Range =lowest Selected 2000 to 2900rpm in 20 rpm increments. *(Note Speed **must** be specified there is no default Value)*
	Engine Monitoring		**4**		**Option selection -**1,2 or 3 (Default = 2)
	Start Aid Enabled		**5**		**Option selection -** Y, N (Default = N)
	PTO Mode	**PTO Mode**	**6**		**Option selection -** Y, N (Default = N)
		Ramp Rate	**7**		**Numerical Value -** Range 20rpm/sec to 600rpm/sec to the nearest 20rpm/sec. (Default = 400)
		Step Size	**8**		**Numerical Value** - Range 10 rpm/step to 200 rpm/step to the nearest 10rpm. (Default =10rpm per step).
		Preset Speed	**9**		**Numerical Value** – Range 700-2500 to the nearest 50 rpm. (Default = idle speed).
	Limp Home Speed		**10**		**Numerical Value –** range 700 rpm to 1800 rpm to the nearest 50rpm. (Default = 1200rpm)
Operator Demand	**Speed Demand 1 Option selection** (Not Used, Analogue, PWM, Multi Position Switch), One selection only		**11**		**Not Used** (Default) *If "not used" selected go to Speed Demand 2.*
			12		**Analogue (**work across and down). Diagnostic control Limit (%) 1A
			13		**PWM** (work across and down). Diagnostic control Limit (%) 2A; Lower Position Limit (%) 1B
			14		**Multi Position Switch** (For each switch position complete one row in the table). Lower Position Limit (%) 2B; Initial Lower Position (%) 1C
			15		Switch Combination (Open or Closed x4 example "OCCO") Up to 16 combinations available. Speed Demand Value: **Coarse** / **Fine**. Initial Position Limit (%) 2C; Idle Validation (Yes, No) 1D. Lower Dead Zone (%) 2D; Idle Validation Min Threshold (%) 1E. Upper Dead Zone (%) 2E; Idle Validation Max Threshold (%) 1F. Initial Upper Position (%) 2F; Lower Dead Zone (%) 1G

								Upper Position Limit (%)	2G	Upper Dead Zone (%)	1H
								Diagnostic Upper Limit (%)	2H	Initial Upper Position (%)	1I
										Upper Position Limit (%)	1J
										Diagnostic Upper Limit (%)	1K

	Speed Demand 2 Option selection Select one only of the following - Not Used, Analogue, PWM, and Multi Position Switch. Note – If Multi Position Switch already selected this is not available on speed demand 2.	**16**		**Not Used**	*If "not used" selected go to Operator Selections 1.*						
		17		**Analogue** (work across and down).				Diagnostic control Limit (%)	2A		
								Lower Position Limit (%)	2B		
		18		**Multi Position Switch** (For each switch position complete one row in the table). Up to 16 combinations available.				Initial Lower Position (%)	2C		
								Idle Validation (Yes, No)	2D		
		19		Switch Combination (Open or Closed x4 O or C example "OCCO" Switch Position Number (1-16)	Speed Demand Value (Select from those Presented)			Idle Validation Min Threshold (%)	2E		
					Coarse	**Fine**		Idle Validation Max Threshold (%)	2F		
								Lower Dead Zone (%)	2G		
								Upper Dead Zone (%)	2H		
								Initial Upper Position (%)	2I		
								Upper Position Limit (%)	2J		
								Diagnostic Upper Limit (%)	2K		
Operator Selections 1	**Torque Speed Control "Fault Handling only"**	**20**		**Option selection** (N or Y) Default is not required "N". Please note – This selection *ONLY* turns on or off the fault message function of CAN speed demand (TSC1) therefore only required where TSC1 is primary throttle. TSC1 is always available, i.e. not switch-able.							
	Arbitration Method.	**21**		**Option selection** (Highest wins "1" or Manual "2". Default is Highest Wins "1")							
	Remote Shutdown	**22**		**Option selection** (N or Y) Default is not required "N"							
	Coolant Level Switch Input.	**23**		**Option selection** (N or Y) Default is not required "N"							
	Air Inlet Restriction Switch Input.	**24**		**Option selection** (N or Y) Default is not required "N"							
	Water in Fuel Indicator	**25**									

Additional features being developed available September 05.

	Demand Fan (Variable Speed Fan)	**26**			**Option selection** (N or Y) Default is not required "N"					
Operator Selections 2	**Mode Selection**	**27**	Mode Switch Position		**Valid Switch Combination**	**Curve Selected** (From those presented**)**	**Selected Speed** (From those presented**)**	**Droop for Speed 1** (%, 0 -10)	**Droop for Speed 2** (%, 0 -10)	**Droop for TSC** (%, 0 - 10)
			2	**1**						
			Open	Open						
			Open	Closed						
			Closed	Open						
			Closed	Closed						

Appendix 3 – List of Diagnostic and Event codes

Note that in some cases there are differences in the codes which are transmitted on the J1939 bus and those that are transmitted on the CDL bus (those normally viewed on the service tool)

Type	CID/EID	J1939 SPN	FMI	Lamp Flash Code [future]	Component	Description
Diagnostic	91	91	2	154	Throttle Position Sensor	data erratic intermittent or incorrect
Diagnostic	91	91	3	154	Throttle Position Sensor	Voltage above normal or shorted high
Diagnostic	774	91	3	155	Secondary throttle position sensor	Voltage above normal or shorted high
Diagnostic	91	91	4	154	Throttle Position Sensor	Voltage below normal or shorted low
Diagnostic	774	91	4	155	Secondary throttle position sensor	Voltage below normal or shorted low
Diagnostic	91	91	8	154	Throttle Position Sensor	abnormal frequency, pulse width, or period
Diagnostic	774	91	8	155	Secondary throttle position sensor	abnormal frequency, pulse width, or period
Diagnostic	91	91	12	154	Throttle Position Sensor	Bad Device or component
Diagnostic	774	91	12	155	Secondary throttle position sensor	Bad Device or component
Diagnostic	100	100	3	157	Engine Oil pressure Sensor	voltage above normal or shorted high
Diagnostic	100	100	4	157	Engine Oil pressure Sensor	voltage below normal or shorted low
Diagnostic	100	100	10	157	Engine Oil pressure sensor	Engine oil pressure sensor 5V supply connection open circuit
Event	360	100	17	n/a	Engine Oil pressure sensor	low oil pressure - WARNING
Event	360	100	18	n/a	Engine Oil pressure sensor	Low oil Pressure - DERATE
Event	360	100	1	n/a	Engine Oil pressure sensor	Low Oil Pressure - SHUTDOWN
Event	539	105	15	n/a	Inlet Manifold Air Temp Sensor	High Intake manifold temperature - WARNING
Event	539	105	16	n/a	Inlet Manifold Air Temp Sensor	High Intake manifold temperature - DERATE
Diagnostic	172	105	3	133	Inlet Manifold Air Temp Sensor	voltage above normal or shorted high
Diagnostic	172	105	4	133	Inlet Manifold Air Temp Sensor	voltage below normal or shorted low
Diagnostic	1785	106	3	135	Inlet Manifold Pressure Sensor	voltage above normal or shorted high
Diagnostic	1785	106	4	135	Inlet Manifold Pressure Sensor	voltage below normal or shorted low
Diagnostic	1785	106	10	135	Inlet Manifold Pressure Sensor	Inlet Manifold Pressure Sensor 5V supply connection open circuit
Event	361	110	15	n/a	Engine Coolant Temp Sensor	High coolant temp - WARNING
Event	361	110	16	n/a	Engine Coolant Temp Sensor	High coolant temp - DERATE
Diagnostic	110	110	3	169	Engine Coolant Temp Sensor	voltage above normal or shorted high
Event	361	110	0	n/a	Engine Coolant Temp Sensor	High coolant temp - SHUTDOWN

Diagnostic	110	110	4	169	Engine Coolant Temp Sensor	voltage below normal or shorted low
Diagnostic	1797	157	3	n/a	Fuel Rail pressure sensor	Voltage above normal or shorted high
Diagnostic	1797	157	4	n/a	Fuel Rail pressure sensor	Voltage below normal or shorted low
Diagnostic	1834	158	2	439	Keyswitch	data erratic, intermittent, or incorrect
Diagnostic	168	168	0	422	ECM battery power	Excessive battery power
Diagnostic	168	168	1	422	ECM battery power	Low battery power
Diagnostic	168	168	2	422	ECM battery power	intermittent
Diagnostic	190	190	8	141	Speed/Timing sensor	abnormal signal frequency
Event	362	190	15	n/a	Engine Speed	Engine Overspeed - WARNING
Diagnostic	91	558	2	154	Throttle Position Sensor	Idle validation switch
Diagnostic	774	558	2	155	Secondary throttle position sensor	data erratic, intermittent, or incorrect
Diagnostic	268	630	2	527	Customer or system parameters	data incorrect
Diagnostic	253	631	2	415	Engine software	data incorrect
Diagnostic	247	639	9	514	SAE J1939 data link	Abnormal update
Diagnostic	526	646	5	177	Turbo Wastegate	Solenoid Current Low
Diagnostic	526	646	6	177	Turbo Wastegate	Solenoid Current High
Diagnostic	526	1188	7	177	Turbo Wastegate	Turbo Wastegate not responding
Diagnostic	1	651	5	n/a	Cylinder #1 Injector	Injector Current Low
Diagnostic	1	651	6	n/a	Cylinder #1 Injector	Injector Current High
Diagnostic	1	651	7	n/a	Cylinder #1 Injector	Injector not reponding
Diagnostic	2	652	5	n/a	Cylinder #2 Injector	Injector Current Low
Diagnostic	2	652	6	n/a	Cylinder #2 Injector	Injector Current High
Diagnostic	2	652	7	n/a	Cylinder #2 Injector	Injector not reponding
Diagnostic	3	653	5	n/a	Cylinder #3 Injector	Injector Current Low
Diagnostic	3	653	6	n/a	Cylinder #3 Injector	Injector Current High
Diagnostic	3	653	7	n/a	Cylinder #3 Injector	Injector not reponding
Diagnostic	4	654	5	n/a	Cylinder #4 Injector	Injector Current Low
Diagnostic	4	654	6	n/a	Cylinder #4 Injector	Injector Current High
Diagnostic	4	654	7	n/a	Cylinder #4 Injector	Injector not reponding
Diagnostic	5	655	5	n/a	Cylinder #5 Injector	Injector Current Low
Diagnostic	5	655	6	n/a	Cylinder #5 Injector	Injector Current High
Diagnostic	5	655	7	n/a	Cylinder #5 Injector	Injector not reponding
Diagnostic	6	656	5	n/a	Cylinder #6 Injector	Injector Current Low
Diagnostic	6	656	6	n/a	Cylinder #6 Injector	Injector Current High
Diagnostic	6	656	7	n/a	Cylinder #6 Injector	Injector not reponding
Diagnostic	41	678	3	517	8V DC supply	ECM 8V DC supply – voltage above normal or shorted high
Diagnostic	41	678	4	517	8V DC supply	ECM 8V DC supply – voltage below normal or shorted low
Diagnostic	342	723	8	142	Secondary Engine Speed Sensor	abnormal signal frequency
Diagnostic	262	1079	3	516	5V sensor DC supply	voltage above normal or shorted high
Diagnostic	262	1079	4	516	5V sensor DC supply	voltage below normal or shorted low
Diagnostic	261	637	11	143	Primary to secondary speed sig	calibration fault
Diagnostic	1779	1347	5	162	Fuel Rail Pump	Output current low
Diagnostic	1779	1347	6	162	Fuel Rail Pump	Output current high
Diagnostic	1779	1347	7	162	Fuel Rail Pump	Not responding
Diagnostic	2246	676	5	199	Glow Plug Start Aid relay	Current Low
Diagnostic	2246	676	6	199	Glow Plug Start Aid relay	Current High