3500B Engines Application and Installation Guide

- Electronics
- Electrical Power Supply
- Electronic Features
- Electronic Attachments
General Information

Introduction
Caterpillar’s 3500B marine engines were introduced in mid 1995. Since then, their acceptance by the marine marketplace has exceeded all expectations. This is due to their high power, superior emissions, superb fuel efficiency and long life-before-overhaul. Greater power than their predecessors results in extra productivity. 3500B engines have much better fuel efficiency than their mechanical counterparts...doing the same work for less fuel...or more work for the same fuel. Cleaner engines makes their owners better neighbors as more and more emissions rules come into effect in the first years of the new millennium. But the 3500B also have a wealth of electronic features. This manual is to help both dealer and owner understand and fully utilize those features.

Electronic Features
The 3500B is controlled by a computer rather than a governor. This gives the engine all the capabilities of a computer that can: communicate over a modem...be called on a phone or interfaced with another computer. A service man with a laptop computer can connect to the engine computer – called the engine control module (ECM) - and use the laptop to extract historical data describing how the engine has operated or upload new software which could change the way the engine reacts to its operating conditions.

The 3500B is truly an intelligent engine, protecting itself from abuse. It monitors its exhaust temperature, air cleaner restriction, jacket water temperature, altitude, aftercooler water temperature and crankcase pressure, continuously. If one of these critical parameters enters into a dangerous condition, the engine can be set to derate itself a few percent every few seconds to protect from unplanned downtime and repair expenses. Before the advent of the 3500B electronic marine engine, we used a calendar to decide when to perform maintenance. With the electronic features built into the 3500B, we use the standard, full-range, pressure transducers located both upstream and downstream of all their filters to fully utilize the life in filters, but without risking running dirty oil, fuel, or air going through the engines. Electronic 3500B engines have a self-diagnostic capability. The ability to detect unintentional grounds, shorts, and open circuits saves time during diagnosis of any engine problem. The 3500B engines’ electronics store records of past performance. This will allow troubleshooters to see if operation contributed to problems.

This manual will lead the reader through the steps to understand the differences and the advantages of computer-control.
## Minimum Electrical Requirements
for Installation of 3500B Marine Engines

<table>
<thead>
<tr>
<th>System</th>
<th>Remarks</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Supply:</strong> 3500B</td>
<td>The engine’s Electronic Control Module (ECM) needs 10 amps of 24 VDC supplied via a dedicated battery set. Interrupting this power will shut off the engine. Alternative power supplies include, but are not limited to, back-up battery sets, engine driven alternators and battery chargers.</td>
<td>See page 7-11 for details</td>
</tr>
<tr>
<td>engines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>engines must be supplied with a reliable source of direct current electricity, with a minimum of one alternative power source to provide redundancy</td>
<td></td>
</tr>
<tr>
<td><strong>Data Transmission:</strong></td>
<td>The engine’s Electronic Control Module (ECM) uses a twisted pair of wires with low capacitance over which to transmit its performance data. Use unshielded Data Link cable (P/N 143-5018) if a Data Link equal to or shorter than 30 meters or 100 feet is required. Use shielded Data Link cable (P/N 123-2376) with a Customer Communications Module, to boost the Data Link signal, in applications demanding between 30 and 457 meters or 100 to 1500 feet of Data Link. The wire path must not contain wires going to radar or radio antennas, generator output leads or battery charger’s power conductors.</td>
<td>See page 14-16 for details</td>
</tr>
<tr>
<td>pilothouse instrument</td>
<td></td>
<td></td>
</tr>
<tr>
<td>panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(only available on propulsion engines) is desired to monitor the engine, the panel must be connected via wires. The path for the wires must be free of significant electromagnetic interference</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Throttle Signal:</strong></td>
<td>Caterpillar offers a throttle signal generator to generate the required, regularly spaced, “square wave” pulses of varying width that the engine uses as a throttle signal in response to the angular movement of a lever. Several Pilot House Control Vendors offer products which also supply the PWM signal.</td>
<td>See page 36 &amp; 64 for details</td>
</tr>
<tr>
<td>The engine uses a pulse-width modulated (PWM) electronic signal to control its speed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Electrical Power Requirements

A well-designed power supply to the 3500B engine includes a 24-volt battery set, usually composed of two 12-volt batteries connected in series and capable of continuous supply of **10 amps to each engine** to drive its injectors, regardless of whether the engine is equipped with a backup ECM or not. It is important that each engine have its own set of batteries in the manner of the figure 1 sketch. Note that the following sketches are not intended to illustrate all the features or components of a fully operational system. The sketches are to illustrate specific aspects of the installation and are simplified for ease of understanding.

The engine must also have a redundant or alternative power supply to the engine to protect it from power loss because of a single component failure. The alternative power supply might be, but is not limited to, a second 24-volt battery set, a battery charger, or a separate engine-driven alternator for each engine. If a single battery charger is used to charge the batteries for more than one engine, the lines connecting the positive post of each of the batteries to the positive terminal of the battery charger must include properly oriented diodes. The diodes are to prevent an adequately charged battery discharging through a failed battery charger or a failed battery. The negative terminal of each battery set is to be connected to a single point on the metal hull or to the common ground plate on a non-metallic hull. Under no circumstances should the positive poles of each battery set be connected together. They must remain independent so a failure in any one battery does not drain the other batteries in the system.
In the application of multiple engines, it is desirable to be able to operate any engine from any set of batteries or battery charger. The sketch below illustrates the use of redundant batteries. Notice the diodes are required in the application because the battery chargers/alternators are not dedicated to a specific set of batteries.
Acceptable Voltage Range

The recommended continuous voltage range to provide power to a 3500B marine engine is 20 to 28 volts. The engine’s monitoring system will annunciate an alarm condition if the voltage falls below this range. A back-up battery set should be brought on line as soon as the primary system voltage falls outside the recommended range. Make-before-break contacts are preferred.

Many battery chargers are capable of dangerously high voltages if operated without a functioning battery to provide an electrical load. Engine operation with ECM voltage above 30 volts will damage the ECM. Engine-driven alternators include a voltage regulator and will not damage the ECM should a battery failure occur. Engine-driven alternators are to be preferred over battery chargers as a redundant power source.

The monitoring system will not function correctly below 18 volts. Engine shutdown will occur if the engine’s power supply is interrupted for more than 0.25 seconds. The engine will continue to run to as low as 12 volts. The engine is designed to handle momentary drops in system voltage to as low as 9.6 VDC. However components are not designed to operate in this mode indefinitely and continued operation at this voltage level will result in system damage. A temporary loss of power (as in one or two milliseconds when switching from primary to backup power batteries) will not effect engine operation. The engine will continue to run normally.

Current Requirements

A 3500B engine requires 10 amps of 24-volt direct current power to run. Battery chargers must be capable of providing that plus an additional 2 to 5 amps of power, over the total normal electrical load, to charge batteries, if the batteries are in a discharged state. The ECM requires 80 amps of inrush current for 2 milliseconds to initialize its injector drivers. Any engine power supply must be capable of supplying this requirement: power supplies that include batteries are capable of meeting this requirement.
## Electrical System Grounding Requirements

### Power Circuits

Proper grounding for vessel and engine electrical systems is necessary for proper performance and reliability.

**Note:** Improper grounding will cause uncontrolled and unreliable circuit paths

This can result in damage to the engine’s crankshaft main bearings, crankshaft journal surfaces or other engine components, and can cause electrical activity which may degrade the boat’s electronics and electrical communication equipment.

The engine’s alternator, starting motor and all electrical systems *MUST* be grounded to (-) Battery, and the alternator and starting motor must be electrically isolated from the engine block.

For engines which are utilizing the throttle synchronization capability, it is critical that a common ground cable be utilized between the (-) Battery connections of each engine’s battery sets. The wire should be a dedicated cable, with a diameter of 9.27 mm or more and a cross section no less than 67.4 mm² (00 AWG), to ensure proper synchronization operation.

### Ground Plate

A ground plate with a direct path to (-) Battery is permissible to use as a common ground point for the components of one engine system. The size of wire connecting an alternator’s ground terminal to a ground plate *MUST* be of adequate size to handle full alternator charging current.

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### Current Requirements

(System is nominally 24 Volts DC)

<table>
<thead>
<tr>
<th>Subsystem Component Installed by Customer</th>
<th>Continuous (Amps)</th>
<th>Intermittent (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot House Panel</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Throttle Position Sensor</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Programmable Relay</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Control Module (PRCM)</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Relay Driver Module (RDM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer Communication Module (CCM)</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Non-Electric Started engines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>supply from Batteries to Power Distribution Box</td>
<td>10</td>
<td>24 (for 2.5 sec. during actuation of Air Inlet Shutoff)</td>
</tr>
<tr>
<td>24 volt prelube pump motor</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

### Ground Cable Wire

Ground cable wire must be two wire sizes larger than other cables in the system. A ground wire can carry a lot of current. If there is resistance in the wire or any of the connections, a voltage drop can develop according to Ohm’s Law (V=IR). For sensors, this voltage drop, created on the ground wire, can cause problems in engine performance measurements.
Ground Fault Detection Equipment
Modern ground fault detection equipment will alarm on leakage currents that would have gone undetected by older incandescent lamp ground fault detection equipment. Use ground fault detection equipment whose sensitivity is adjustable to deal with the inevitable miniscule leakage currents associated with flyback diodes and modern solid state power supplies.

Ground Faults
The 3500B engine control module (ECM) is mounted in electrically insulating rubber bushings. The housing of the ECM, as shipped from the factory, is grounded to the engine block with a woven ground strap. The negative post of the input power to the ECM is grounded to the housing through a 150 kΩ resistor. That grounding resistor is to protect the ECMs electronic components from the high DC voltage imposed on the engine during its electrostatic painting process. If ground faults from this source are a problem in a specific installation, remove the ground strap between the engine block and the ECM housing. Doing so may have an effect on electromagnetic interference. See section on electromagnetic interference.

Wiring Practices
When connecting to inductive loads such as solenoids, relays, and motors, always use flyback diodes to avoid the damaging effects of transient voltage spikes.

A flyback diode allows current in a coil to decay to 0 without causing damage when the switch is opened.

In general, relays driven by the ECM or PRCM do not need external flyback diodes since the ECM contains flyback diodes. It is good practice to maximize the distance between solenoids, relays and other electrically noisy components from engine controls or wiring.
<table>
<thead>
<tr>
<th>AWG</th>
<th>Diameter</th>
<th>Cross Section</th>
<th>Ohms / km @ 25°C</th>
<th>Ohms / km @ 105°C</th>
<th>Mass</th>
<th>kg/km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mils</td>
<td>mm²</td>
<td>cmils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 MCM</td>
<td>12.7</td>
<td>500.0</td>
<td>126.6</td>
<td>250000</td>
<td>0.138</td>
<td>0.181</td>
</tr>
<tr>
<td>4/0</td>
<td>11.7</td>
<td>460.0</td>
<td>107.4</td>
<td>212000</td>
<td>0.164</td>
<td>0.214</td>
</tr>
<tr>
<td>2/0</td>
<td>9.27</td>
<td>365.0</td>
<td>67.4</td>
<td>133000</td>
<td>0.261</td>
<td>0.341</td>
</tr>
<tr>
<td>1/0</td>
<td>8.26</td>
<td>325.0</td>
<td>53.5</td>
<td>105600</td>
<td>0.328</td>
<td>0.429</td>
</tr>
<tr>
<td>1</td>
<td>7.35</td>
<td>289.0</td>
<td>42.4</td>
<td>87700</td>
<td>0.415</td>
<td>0.542</td>
</tr>
<tr>
<td>2</td>
<td>6.54</td>
<td>258.0</td>
<td>33.6</td>
<td>66400</td>
<td>0.522</td>
<td>0.683</td>
</tr>
<tr>
<td>3</td>
<td>5.83</td>
<td>229.0</td>
<td>26.6</td>
<td>52600</td>
<td>0.659</td>
<td>0.862</td>
</tr>
<tr>
<td>4</td>
<td>5.18</td>
<td>204.0</td>
<td>21.1</td>
<td>41600</td>
<td>0.833</td>
<td>1.09</td>
</tr>
<tr>
<td>5</td>
<td>4.62</td>
<td>182.0</td>
<td>16.8</td>
<td>33120</td>
<td>1.05</td>
<td>1.37</td>
</tr>
<tr>
<td>6</td>
<td>4.11</td>
<td>162.0</td>
<td>13.3</td>
<td>26240</td>
<td>1.32</td>
<td>1.73</td>
</tr>
<tr>
<td>8</td>
<td>3.25</td>
<td>128.0</td>
<td>8.30</td>
<td>16380</td>
<td>2.12</td>
<td>2.90</td>
</tr>
<tr>
<td>10</td>
<td>2.59</td>
<td>102.0</td>
<td>5.27</td>
<td>100400</td>
<td>3.35</td>
<td>4.36</td>
</tr>
<tr>
<td>12</td>
<td>2.05</td>
<td>80.8</td>
<td>3.31</td>
<td>6530</td>
<td>5.31</td>
<td>6.95</td>
</tr>
<tr>
<td>14</td>
<td>1.63</td>
<td>64.1</td>
<td>2.08</td>
<td>4110</td>
<td>8.43</td>
<td>11.10</td>
</tr>
<tr>
<td>16</td>
<td>1.29</td>
<td>50.8</td>
<td>1.31</td>
<td>2580</td>
<td>13.4</td>
<td>17.6</td>
</tr>
<tr>
<td>18</td>
<td>1.02</td>
<td>40.3</td>
<td>0.821</td>
<td>1620</td>
<td>21.4</td>
<td>27.9</td>
</tr>
<tr>
<td>20</td>
<td>0.81</td>
<td>32.0</td>
<td>0.517</td>
<td>1.20</td>
<td>33.8</td>
<td>44.3</td>
</tr>
</tbody>
</table>
3500B Marine Engine Control Systems

The following manufacturers have successfully supplied engine speed and transmission controls for use with Caterpillar 3500B marine engines.

Vendor Home Office, Name, and Address

Mathers Controls Incorporated
675 Pease Road
Burlington, Washington 98233
United States of America
Phone: 360-757-6265
Fax: 360-757-2500

Kobelt Manufacturing Company, Ltd.
8238 129th Street
Surrey
British Columbia, Canada V3W 0A6
Phone: 604 572 3935
Fax: 604 590 8313

TD Electronics
6815 Elm Avenue
Loves Park, IL 61111-3818
Phone: 815 633-9232
Fax: 815 633-9272

Prime Mover Controls Ltd.
3600 Gilmore Way
Burnaby, British Columbia V5G 4R8
Canada
Phone: 604-433-4644
Fax: 604-433-5570

Hydraudyne Pneumatiek bv
P.O.Box 9236
3007 AE Rotterdam
The Netherlands
Phone: +31-10-4970300
Fax: +31-10-4821210

Sturdy Controls Div
1822 Carolina Beach Rd,
Wilmington, NC 28401-6599
Phone: (910)763-2500

While all the manufacturers above have successfully controlled Caterpillar 3500B marine engines, Caterpillar does not accept responsibility for successful use of products it does not sell or control.
Data Transmission

Data Link

The engine uses sets of voltage pulses in pairs of wires to communicate. Impedance of the wires, especially the capacitance aspect of the impedance, will determine the maximum wire length over which communications are practical.

Wire Specification

Caterpillar’s testing has determined the following will provide reliable Data Link communications.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor-to-conductor capacitance</td>
<td>not more than 23 picofarads per foot</td>
</tr>
<tr>
<td>Conductor-to-shield capacitance</td>
<td>not more than 44 picofarads per foot</td>
</tr>
<tr>
<td>Wire diameter</td>
<td>not less than 1.29 mm (16 AWG)</td>
</tr>
<tr>
<td>Wire data</td>
<td>Wires should be tinned, stranded and twisted</td>
</tr>
<tr>
<td>Insulation</td>
<td>Rated for 600 volts and a temperature range of –65°C to 110°C. EXANE is halogen-free and suitable for use in installations requiring premium insulation.</td>
</tr>
</tbody>
</table>

Caterpillar offers wire of the required capacitance. For Data Links less than 30 m or 100 ft in length, use part number 143-5018 - unshielded Data Link cable. For Data Links from 30 m to 457 m (100 to 1500 ft), use part number 123-2376 - shielded Data Link cable together with a Customer Communications Module (CCM). The CCM boosts the Data Link signal, making reliable communication over distances of up to 457 m or 1500 ft possible. See the section on the CCM for additional information.

Data Link Terminations:

Avoid splicing or soldering wire connections. Terminate all connections at a dedicated Data Link terminal strip to ensure engine and communications systems reliability. Locate this terminal strip to minimize the length of the Data Link wire run. Running Data Link wiring in the same raceway as high power cabling, such as generator leads, radar or radio antenna wires or any AC cabling is strictly forbidden.

Connections to Shielding of Data Transmitting Wire

Ground shielding of data transmitting wire/s at only one place. *Ground loops* will be created if the shield is grounded at both ends. Data transmitting wire shields cannot be terminated to an electrically isolated or a *floating* device. If the data transmitting wire is spliced, be sure to splice the shields together as well.
Avoid Connecting Unused Lengths of Data Transmitting Wire
It is common practice to install lengths of wire for future needs, but do not connect unused Data Link wire to the customer connection points for data transmission until the other end of the Data Link wire is connected to the remote displays. If lengths of unused wire are connected at the engine without connecting the other end of the wire to the remote displays, the capacitance of the unused wire may cause malfunction of connected equipment.

Troubleshooting Electrical Interference
Observe what happens to the interference when:

- Other devices are turned on and off
- Equipment is moved closer or further from other devices
- Different wire paths are used.
- A different or separate power source is used to power a device.

The effects of interference will be minimized or eliminated by good grounding practice. Use large wire gauges for grounds from individual devices, 9.27 mm diameter (AWG 00) or larger. Ground connections must be kept clean. Always use one common ground reference for interconnected devices. For example, since a pilothouse panel and ECM are interconnected they must share a common ground, even if they are powered by different power sources.
The 3500B engine control module (ECM) is mounted using electrically insulating rubber bushings. The housing of the ECM, as shipped from the factory, is grounded to the engine block with a woven ground strap. The negative post of the input power to the ECM is grounded to the housing through a 150 kW resistor. That grounding resistor is to protect the ECM’s electronic components from the high DC voltage imposed on the engine during its electrostatic painting process. If electromagnetic interference from this source is a problem in a specific installation, confirm the ground strap between the engine block and the ECM housing is intact and its terminals are clean and making good contact.

**Limits Number of Data Link Devices**

The number of devices on a Cat® Data Link is limited. Exceeding this number will overload the Data Link driver circuits in the devices. The most common symptom of Data Link driver circuit overload is the error message “Can Not Communicate” after an additional device is added. Some devices load the Data Link more than others. Generally, no more than 8 devices should be placed on the Data Link for reliable operation. When secondary Data Links from two or more engines are connected together, as when Engine Vision is used, that combined Data Link has an 8 device limit, not the 16 devices as would have been expected, had the secondary Data Links remained separate. Some devices load more than others, so 8 devices is an estimate. The service tool counts as one device, when connected. The 8 devices limit is for each Data Link. Primary Cat Data Link is different than the secondary Cat Data link or the ATA Data Link. Eight devices could be placed on each individual Data Link for a total of 16 devices.

**Functions of Data Links:**

<table>
<thead>
<tr>
<th>3500B Propulsion Engines Manufactured After April 1997</th>
<th>3500B Propulsion Engines Manufactured Before April 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Cat Data Link</td>
<td>Cat Data Link</td>
</tr>
<tr>
<td>• Pilot House Panel</td>
<td>• Pilot House Instrument Panel</td>
</tr>
<tr>
<td>• Cat ET and Flashing</td>
<td>• Cat ET (Not flashing software)</td>
</tr>
<tr>
<td></td>
<td>• CCM</td>
</tr>
<tr>
<td>Secondary Cat Data Link</td>
<td>ATA Data Link</td>
</tr>
<tr>
<td>• Engine Vision</td>
<td>• Software Flashing</td>
</tr>
<tr>
<td>• CCM</td>
<td></td>
</tr>
</tbody>
</table>

**Cat Data Link Protocol**

Cat Data Link is a proprietary network protocol that uses a variation of the RS-485 Wiring requirements. Since the Cat Data Link is a proprietary (closed) protocol, outside devices can only communicate to the engine network by going through the Customer Communications Module (CCM), a protocol converter that translates the protocol of the engine network and converts it an ASCII-based M5X protocol.
Connecting Programmable Relay Control Module (PRCM) to EIP

**Purpose**
To provide a communication link between the ADEM-II/EMS-II System and the PRCM. The PRCM is used by the customer to provide 25 relay outputs and six LED outputs from eight Switch Inputs and ADEM-III/EMS-II System parameters. The PRCM alone controls 7 relays and 6 LEDs. For expansion, the user can add one or two Relay Driver Modules to add an additional 9 or 18 relays. The outputs are customer programmable through a keypad and display on the PRCM.

**Value**
Provides for customized warning systems using the following ADEM-II/EMS-II System Parameters:
- ECM Active Diagnostic Present
- ECM Voltage Warning
- Engine Oil Pressure Warning
- Engine Jacket Water Temperature High Warning
- Engine Jacket Water Temperature Low Warning
- Engine Overspeed Warning
- Engine Air Inlet Restriction Warning
- Engine Exhaust Temperature High Warning
- Engine Oil Filter Differential Pressure Warning
- Engine Fuel Filter Differential Pressure Warning
- Engine Crankcase Pressure High Warning
- Engine Aftercooler Temperature High Warning
- Engine Low Coolant Level Warning
- Engine Low Fuel Level Warning
- Battery Charger Diagnostic Warning
- Marine Gear Oil Temperature High Warning
- Marine Gear Oil Pressure Low Warning
- Engine Electronic Fuel Injection Disabled
- Engine @ 100% Load Factor (i.e. in Rack Limit)
- Engine Speed above 50 rpm
- Engine Starter Overcrank
- Engine Starter Motor Relay Active
- EIP ECS Switch not in AUTO position
- Engine Power Derating Active
- Engine Power Derating Active but not for Altitude
- Engine Shutdown
- Engine Low Oil Pressure Shutdown
- Engine Jacket Water Temperature High Shutdown
- Engine Overspeed Shutdown
- Engine Crankcase Pressure High Shutdown
- Engine Aftercooler Temperature High Shutdown

**Function**
The operator will use the PRCM Keypad and Display panel to program the various input/output functions. These programmed functions will turn on/off the various LEDs and Relays. Refer to Caterpillar Publication SENR6588 Owner’s Manual, Programmable Relay Control Module for more details.
Connecting Relay and Circuit Breaker inside EIP for PRCM power control

Purpose
Provides a means to switch power to the PRCM via the four position Engine Control Switch (ECS) on the engine mounted Electronic Instrument Panel (EIP).

Value
Provides on/off control of the PRCM via the ECS and short circuit protection.

Function
The operator will install the relay, breaker and associated wiring inside the EIP using the schematic shown above. The PRCM will be turned on via the ECS in the AUTO (using a Remote Start/Stop Switch), MAN.START or STOP positions. The PRCM will be turned off via the ECS in the OFF or AUTO (using a Remote Start/Stop Switch) positions.

Note: Neither the Remote E-Stop switch or the EIP mounted E-Stop Button will remove power from the PRCM. This is done to maintain relay position status inside the PRCM in case an emergency stop is performed.
Connecting Programmable Relay Control Module (PCRM) to one or two Relay Driver Modules

**Purpose**
To provide an additional 9 or 18 relays. The outputs are customer programmable through a keypad and display on the PRCM.

**Value**
Allows Customer to expand the number of engine parameters monitored through the PRCM.

**Function**
The operator will use the PRCM Keypad and Display panel to program the various input/output functions. These programmed functions will turn on/off the Relays. Refer to Caterpillar Publication SENR6588 Owner’s Manual, Programmable Relay Control Module for more details.
Connecting Relay Driver Module
to Relay Board Assembly

**Purpose**
To provide an additional 9 or 18 relays. The outputs are customer programmable through a keypad and display on the PRCM.

**Value**
Allows Customer to expand the number of engine parameters monitored through the PRCM.

**Function**
The operator will use the PRCM Keypad and Display panel to program the various input/output functions. These programmed functions will turn on/off the Relays. Refer to Caterpillar Publication SENR6588 Owner’s Manual, Programmable Relay Control Module for more details.
Connecting to Relay Contacts on Relay Board Assembly

Relay Contact Schematic Diagram

![Relay Board Assembly Diagram]

**Note:** Do not connect Relay Board Assembly terminals 1, 2, 12 or 40 to the Relay Contact circuits. The relay circuits must be kept separate from the Relay Driver Module power, ground and control signals. Also note that each common connection is fused (see schematic diagram above).

**Purpose**
To provide an additional 9 or 18 relays. The outputs are customer programmable through a keypad and display on the PRCM.

**Value**
Allows Customer to expand the number of engine parameters monitored through the PRCM.

**Function**
The operator will use the PRCM Keypad and Display panel to program the various input/output functions. These programmed functions will turn on/off the Relays. Refer to Caterpillar Publication SENR6588 Owner’s Manual, Programmable Relay Control Module for more details.
Connecting Customer Communication Module (CCM) to EIP

**Purpose**
To provide a two-way communication link between the ADEM-II System and the Operator of a Personal Computer or Programmable Logic Controller or other device with a RS-232C Port.

**Value**
Allows Customer to remotely control and monitor the engine.

**Function**
The operator will use Caterpillar supplied basic PC software to create Customer Specific Programs. The CCM software can be easily upgraded via Flash memory programming. Refer to Caterpillar Publication SEBU6874 Owner’s Manual, Customer Communication Module for more details. The following is a list of parameters that can be communicated via CCM.
**Status Parameters**

Fault Present
ECM Voltage Warning
Engine Jacket Water Temp High Warning
Engine Jacket Water Temp High Shutdown
Engine Jacket Water Temp High Derate
Engine Jacket Water Temp Low Warning
Engine Oil Pressure Low Warning
Engine Oil Pressure Low Shutdown
Engine Oil Pressure Derate
Engine Overspeed Warning
Engine Overspeed Shutdown
Air Inlet Restriction Warning
Air Inlet Restriction Derate
Exhaust Temperature Warning
Exhaust Temperature Derate
Oil Filter Differential Pressure Warning
Fuel Filter Differential Pressure Warning
Crankcase Pressure Warning
Crankcase Pressure Shutdown
Crankcase Pressure Derate
Aftercooler Water Temperature Warning
Aftercooler Water Temperature Shutdown
Aftercooler Water Temperature Derate
Fuel Injection Disabled
Engine Overcrank
Air Shut-off Relay Active
Start Motor Relay Active
Battery Charger Fault Warning (customer wired)
Engine Running
Engine At Full Load (i.e. at rack limit)
System not in Auto
High Altitude Derate
Low Engine Coolant Level Warning (if wired)
Low Fuel Level Warning (if wired)
Engine Diagnostic Active
Backup ECM Ready
Backup ECM Online
Marine Gear Oil Pressure Warning (customer wired)
Marine Gear Oil Temperature Warning (customer wired)

**Operating Parameters**

1) Engine Speed
2) Instantaneous Fuel Rate
3) Total Fuel Consumed
4) Engine Hours
5) Engine Oil Pressure
6) Engine Coolant Temperature
7) System Voltage
8) Engine Fuel Pressure
9) Exhaust Manifold Temperature (Turbine Inlet)-RH
10) Exhaust Manifold Temperature (Turbine Inlet)-LH
11) Air Inlet Restriction - RH
12) Air Inlet Restriction - LH
13) Fuel Filter Differential Pressure
14) Oil Filter Differential Pressure
15) Turbo Outlet Pressure (Boost)
16) Separate Circuit Aftercooler Coolant Temperature
17) Engine Oil Temperature (GSE Only)
18) Inlet Air Temperature (GSE Only)
19) Marine Gear Oil Pressure (if sensor installed/wired)
20) Marine Gear Oil Temperature (if sensor installed/wired)
21) Crankcase Pressure

**Control Parameters:**

1) Remote Start/Stop - EPG Only
2) Emergency Stop - EPG Only
3) Fault Reset
4) Activate Idle/Rated Speed Contact (w/EMCP 11) - EPG Only
5) Activate Circuit Breaker Shunt Trip (w/EMCP 11) - EPG Only
6) Override Cooldown Timer - EPG Only
Connecting Customer Communication Module (CCM) to a Modem

**Purpose**
To provide a two-way communication link between the CCM and a remote operator of a Personal Computer or Programmable Logic Controller or other device with a RS-232C Port.

**Value**
Allows Customer to remotely control and monitor the engine.

**Function**
The operator will use Caterpillar supplied basic PC software to create Customer Specific Programs. The CCM software can be easily upgraded via Flash memory programming. Refer to Caterpillar Publication SEBU6874 Owner’s Manual, Customer Communication Module for more details.
Connecting Customer Communication Module (CCM) to a Personal Computer

**Purpose**
To provide a two-way communication link between the CCM and an operator of a Personal Computer or Programmable Logic Controller or other device with a RS-232C Port.

**Value**
Allows Customer to control and monitor the engine from another location in close proximity to the engine.

**Function**
The operator will use Caterpillar supplied basic PC software to create Customer Specific Programs. The CCM software can be easily upgraded via Flash memory programming. Refer to Caterpillar Publication SEBU6874 Owner’s Manual, Customer Communication Module for more details.
Connecting Customer Communication Module (CCM) to a Satellite Receiver/Transmitter

**Purpose**
To provide a two-way communication link between the CCM and a remote operator of a Personal Computer or Programmable Logic Controller or other device with a RS-232C Port via Satellite.

**Value**
Allows Customer to remotely control and monitor the engine.

**Function**
The operator will use Caterpillar supplied basic PC software to create Customer Specific Programs. The CCM software can be easily upgraded via Flash memory programming. Refer to Caterpillar Publication SEBU6874 Owner’s Manual, Customer Communication Module for more details.
Connecting a Remote Start/Stop Switch to the EIP

Purpose
Provides a remote means to start, run and cooldown/stop the engine.

Note: This function is only available while the Electronic Instrument Panel (EIP) mounted Engine Control Switch (ECS) is in the AUTO (3 O’Clock) Position.

Value
Adds operator convenience. Start/Run/Stop control of the engine can be accomplished from a remote location with only 5 wires and a switch.

Function
Warning: Starting the engine when a person is working on or near the unit could result in injury or death. Always insure that no one is near the engine when it is started or whenever the Engine Control Switch (ECS) is placed in AUTO (3 O’Clock) position.

The Operator must first verify that the Remote Start/Stop Switch is set to the STOP position. The operator will secondly set the EIP mounted Engine Control Switch (ECS) to the AUTO (3 O’Clock) Position. Finally, to start/run the engine, the operator must move the Remote Start/Stop Switch to the Start/Run position. To cooldown/stop the engine the operator will move the Remote Start/Stop Switch to the Cool/Stop position. Finally, to stop the engine without cooldown the operator must move the Remote Start/Stop Switch to the Stop position.

Note: Only one Remote Start/Stop Switch is allowed per engine. The ADEM-II System will not function with more than one Remote Start/Stop Switch. For example, applications that have a Pilot House Control Panel that includes a Remote Start/Stop Switch function must not add on another Remote Start/Stop Switch to the ADEM-II System.
Connecting a Remote E-Stop Switch to the EIP

Purpose
Provides a remote means to stop the engine.

*Note:* This function is available while the Electronic Instrument Panel (EIP) mounted Engine Control Switch (ECS) is in the AUTO (3 O’Clock), MAN, START (6 O’Clock) and COOLDOWN STOP (9 O’Clock) Positions.

Value
Adds operator convenience. E-Stop control of the engine can be accomplished from a remote location with only 3 wires and a switch.

Function
*Note:* Emergency Shutoff controls are for EMERGENCY use ONLY. DO NOT use Emergency shutoff devices or controls for normal stopping procedure. Refer to the Engine Stopping section of Caterpillar Publication SEBU6917 for normal stopping procedures.

The Remote E-Stop Switch is used to shut down the engine during an emergency situation by signaling the ECM to disable fuel injection, and actuate both air shutoffs if present and enabled for use via the ET Service Tool.

*Note:* The EIP mounted Emergency Stop push button has a protective cover around it to prevent inadvertent operation. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.
Connecting a Coolant Level Sensor to the EIP

**Purpose**
Provide a Low Coolant Level indication to the operator.

**Value**
Adds a monitoring function to aid the operator in maintaining proper coolant volume in the engine and thereby preventing engine overheating.

**Function**
The operator will use the EMS-II LED corresponding to Low Coolant Level indication on the Electronic Instrument Panel (EIP) to monitor low coolant level in the Radiator (Gen sets) or Expansion Tank (Marine). Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details. Low coolant level will have a negative impact on engine life.

*Note:* Using this Sensor, the operator can also receive an Engine Low Coolant Level Warning indication via the PRCM.
Connecting a Fuel Level Switch to the EIP

**Purpose**
To provide a Low Fuel Level indication to the operator.

**Value**
Aids the operator in preventing unexpected engine shutdown because of an empty fuel supply tank.

**Function**
The operator will use the EMS-II LED corresponding to Low Fuel Level indication on the Electronic Instrument Panel (EIP) to monitor low fuel level in the supply tank. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.

*Note: Using this Switch, the operator can also receive an Engine Low Fuel Level Warning indication via the PRCM.*
Connecting a 4-20 mA Convertor for Throttle Input to Engine Electronic Control System (Marine Propulsion Only)

**Purpose**
Provides an isolated interface between industry standard 4-20 mA analog input signal and the Caterpillar Standard Pulse Width Modulated format.

**Value**
Eliminates the need for customer to custom design pulse width modulated driver modules.

**Function**
Converts 4-20 mA throttle signal to Caterpillar Standard Pulse Width Modulated format.
Throttle and Engine Synchronization System for Dual Engine control (Marine Propulsion Only)

**Purpose**
To link the engine controls of both engines to a single throttle.

**Value**
Adds operator convenience, vessel control and is a standard practice in marine applications.

**Function**
The operator will use the Synchronization Switch to transfer the control of both engines to a single throttle lever. The Electronic Control Module (ECM) will then control engine speed from the Master throttle lever. Engine synchronization can be transferred to either the PORT or STARBOARD (STBD) throttle.

The Operator will set the Synchronization Switch and then adjust the throttles to bring the engine speeds within 50 rpm of each other. The Engine controls will detect if and when the engine speeds are within 50 rpm of one another and then lock onto the Master throttle for engine speed control.

**Note:** Synchronization can only occur when both engine speeds are within 50 rpm of each other. Likewise, unsynchronization can only occur when both engine speeds are within 50 rpm of each other.
Throttle and Engine Synchronization System for Triple Engine Control by CENTER Throttle
(Marine Propulsion Only)
**Purpose**
To link the engine controls of all three engines to a single throttle.

**Value**
Adds operator convenience, vessel control and is a standard practice in marine applications.

**Function**
The operator will use the Throttle Synchronization Switch to transfer the control of all three engines to the center throttle lever. The Electronic Control Module (ECM) of each engine will then govern engine speed from the center Engine throttle signal.

*Note: Engine synchronization can not be transferred to either the port or starboard (STBD) throttle control. Engine speeds can only be synchronized to the center throttle control.*

The Operator will set the Synchronization Switch and then adjust the port and starboard throttles to bring their engine speeds to within 50 rpm of the center engine. The Engine controls will detect if and when the port and starboard engine speeds are within 50 rpm of the center engine and then “lock” onto the center throttle for engine speed control.

*Note: Synchronization can only occur when all engine speeds are within 50 rpm of one another. Likewise, unsynchronization can only occur when all engine speeds are within 50 rpm of one another.*
Throttle and Engine Synchronization System for Triple Engine Control by Port Throttle (Marine Propulsion Only)

Electronic Instrument Panel

Center Throttle

Throttle Synchronization Switch

Open for INDEPENDENT Throttle control.

Close 1 to 2 and 3 to 4 for PORT Throttle control.
Throttle Position Sensor Calibration
(Marine Propulsion Only)

Inspect Throttle Linkage
Inspect the Throttle linkage for:

- Loose, bent, broken, missing, worn components.

Also, inspect for interface with the linkage or return spring.

Throttle linkage should work smoothly without excessive drag, and return to low idle position without assistance in less than one second.

Adjustment at Low Idle Stop Position (Minimum Throttle)
The calibration of the throttle position sensor requires the use of an IBM PC compatible Laptop Computer “/Communication Adapter and Caterpillar ET Software”. Run ET and from the first screen Click on the Service pull-down menu.

- Turn ECS (Engine Control Switch) to off position.
- Connect to the ECAP or ET System.

Adjust the throttle linkage, with the throttle at LOW IDLE position, until:

- The Duty Cycle reading (display) is between 5% and 10%.

Note: After adjustment, a slight movement OFF (away from) the LOW IDLE linkage stop should increase the Duty Cycle reading.

When properly adjusted, the rotary disc should be positioned as shown in Illustration 1 when the throttle is in the low idle position.

Adjustment at High Idle Stop Position (Maximum Throttle)
Adjust the throttle linkage, with the throttle at low idle position, until:

- The Duty Cycle reading (display) is between 90% and 95%.

When properly adjusted, the rotary disc should be positioned as shown in Illustration 2 when the throttle is in the high idle position.

Repeat the adjustment at low idle position to verify that the low idle stop is still properly adjusted.
Purpose
To provide Throttle Position Sensor redundancy.

Value
Adds operator convenience. If diagnostic problem is identified on Primary Throttle then simply select the Backup Throttle via the Throttle Selection Switch.

Function
The operator will use a switch to transfer the control of the engine to the Backup Throttle Position Sensor. The Electronic Control Module (ECM) will then control engine speed from the Backup Throttle lever.
Connecting Premium Pilot
House Panel w/Switches to EIP
(Marine Propulsion Only)

**Purpose**
To provide engine monitoring information and start/stop Control to the Pilot House.

**Value**
Provides for monitoring of the following information:

**Warning Indicator Lights**
1. Shutdown/Diagnostic
2. System Voltage
3. Overspeed
4. Low Transmission Oil Pressure
5. High Transmission Oil Temperature
6. Low Oil Pressure
7. High Coolant Temperature
8. Low Coolant Temperature
9. Low Coolant Level
10. Low Fuel Level

**Gauges**
11. Engine Oil Pressure
12. Engine Coolant Temperature
13. Marine Gear Oil Pressure
14. Marine Gear Oil Temperature
15. Left Hand Exhaust Manifold Temperature
16. Right Hand Exhaust Manifold Temperature
17. Turbo Outlet Pressure (Boost)
18. Aftercooler Temperature
19. Tachometer

**LCD Display**
20. Engine Speed in RPM
21. Instantaneous Fuel Consumption
22. Percent Load
23. Engine Hours
24. Active Gauge Value

**Function**
The operator will use a Selector Switch to start/stop the engine, a Scroll Switch to access the various LCD and LCD/Gauge functions, a dimmer knob to darken/lighten the backlighting, a “mushroom” switch for emergency stop and lastly two lights to monitor Back-Up Engine Control ready and active.
Connecting Basic Pilot House Panel w/Switches to EIP (Marine Propulsion Only)

Purpose
To provide basic engine monitoring information and start/stop Control to the Pilot House.

Value
Provides for monitoring of the following information:

Warning Indicator Lights
1. Shutdown/Diagnostic
2. System Voltage
3. Overspeed
4. Low Transmission Oil Pressure
5. High Transmission Oil Temperature
6. Low Oil Pressure
7. High Coolant Temperature
8. Low Coolant Temperature
9. Low Coolant Level
10. Low Fuel Level

Gauges
11. Engine Oil Pressure
12. Engine Coolant Temperature
13. Marine Gear Oil Pressure
14. Marine Gear Oil Temperature
15. Tachometer

LCD Display
16. Engine Speed in rpm
17. Instantaneous Fuel Consumption
18. Percent Load
19. Engine Hours
20. Active Gauge Value

Function
The operator will use a Selector Switch to start/stop the engine, a Scroll Switch to access the various LCD and LCD/Gauge functions, a dimmer knob to darken/lighten the backlighting, a “mushroom” switch for emergency stop and lastly two lights to monitor Back-Up Engine Control ready and active.
Connecting Basic Pilot House Panel w/o Switches to EIP (Marine Propulsion Only)

**Purpose**
To provide basic engine monitoring information to the Pilot House.

**Value**
Provides for monitoring of the following information:

**Warning Indicator Lights**
1. Shutdown/Diagnostic
2. System Voltage
3. Overspeed
4. Low Transmission Oil Pressure
5. High Transmission Oil Temperature
6. Low Oil Pressure
7. High Coolant Temperature
8. Low Coolant Temperature
9. Low Coolant Level
10. Low Fuel Level

**Gauges**
11. Engine Oil Pressure
12. Engine Coolant Temperature
13. Marine Gear Oil Pressure
14. Marine Gear Oil Temperature
15. Tachometer

**LCD Display**
16. Engine Speed in rpm
17. Instantaneous Fuel Consumption
18. Percent Load
19. Engine Hours
20. Active Gauge Value

**Function**
The operator will use the Scroll Switch to access the various LCD and LCD/Gauge functions and a dimmer knob to darken/lighten the backlighting.

**Note:** To select, use scale on the display panel, connect a wire from batt (-) to pin 20 of the 40 pin connector at the back of the display panel EMS Module. For Metric scale remove the wire.
Using CCM as a Cat Data Link
Signal Booster

**Purpose**
To provide a boosted Cat Data Link signal.

**Value**
Allows Customer to remotely control and monitor the engine at distances beyond the standard 30 m (100 ft) Data Link limit.

**Function**
The limitation on the distance to mount Pilot House Panel and PRCM components is currently 30 m (100 ft). A CCM can be added to the system to allow the devices to be installed up to 455 m (1500 ft). from the engine. The CCM acts as a constant current source to overcome the impedance of extended length of communication link wire.

The illustration on the following page shows a sample installation using multiple Pilot House Panels. The CCM may be connected wherever it is convenient to do so, and does not necessarily need to be in series with the panel or PRCM. Segment length may vary and does not necessarily need to be in equal proportions between modules. The sum of all segments must be less than or equal to 455 m (1500 ft).
General CCM Installation Information
When a CCM is installed, these requirements must be met:

- The environmental, mounting, wiring, and cable specifications must be met.
- The connections diagrams must be followed.

Specifications
- The ambient operating temperature range is from -40°C to +70°C (-40°F to +158°F).
- The storage temperature range is from -40°C to +85°C (-40°F to +185°F).
- The unit must be protected from direct contacts with liquids (splash-proof). If sealing is required, the CCM must be in a water-tight enclosure.

Mounting
Locate the CCM on a desk or shelf. The rubber feet on the bottom of the CCM can also be removed to allow panel mounting.

Note: Do not mount the CCM on an engine or within an engine mounted enclosure. It is not designed for this environment.

General Wire and Cable Specifications
The following specifications for wire and cable is given to reduce voltage drops over long runs of wire and to reduce EMI/RFI interference.

- The wires connected to B+ and B- on the CCM must be at least 16 AWG.
- Maximum Cat Data Link cable and ± B wire length is 455 m (1500 ft.), including wire runs between any multiple panels.
- No terminations or splices allowed on the above wires, except as noted in the connection diagrams.
- The cable connected to Cat Data Link ± must be 16 AWG, shielded twisted pair cable. Use 123-2376 Electric Cable, Belden 8719 Cable, or equivalent.
Connecting a Marine Gear Oil Pressure Sensor to the EIP (Marine Propulsion Only)

Purpose
To provide a Marine Gear Oil Pressure indication to the operator.

Value
Aids the operator in maintaining proper Marine Gear Oil Pressure.

Function
The operator will use the EMS-II Gauges on the Electronic Instrument Panel (EIP) to monitor Marine Gear Oil Pressure. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.

Note: Using this Sensor, the operator can also receive a Marine Gear Oil Pressure Low Warning indication via the PRCM.
Connecting a Marine Gear Oil Temperature Sensor to the EIP (Marine Propulsion Only)

Purpose
To provide a Marine Gear Oil Temperature indication to the operator.

Value
Aids the operator in maintaining proper Marine Gear Oil Temperature.

Function
The operator will use the EMS-II Gauges on the Electronic Instrument Panel (EIP) to monitor Marine Gear Oil Temperature. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.

Note: Using this Sensor, the operator can also receive a Marine Gear Oil Temperature High Warning indication via the PRCM.
Connecting a Danfoss (or similar) Shutdown Switch to the EIP for use with PHP with Start/Stop and E-Stop Switches (Marine Propulsion Only)

**Purpose**
Provides a means to stop the engine via a remote dry contact switch.

**Value**
Provides shutdown function interface for the operator to allow the use of dry contact switches to shutdown the engine for conditions defined by the operator for engine/vessel protection.

**Function**
*Note: Emergency Shutoff controls are for EMERGENCY use ONLY. DO NOT use Emergency shutoff devices or controls for normal stopping procedure. Refer to the Engine Stopping section of Caterpillar Publication SEBU6917 for normal stopping procedures.*

The Shutdown Switch is used to shut down the engine during an emergency situation or condition by signaling the ECM disable fuel injection, and actuate both air shutoffs if present and enabled for use via the ET Service Tool. The marine engine ECM monitoring system does not currently allow for engine shutdowns, except for engine overspeed shutdown.

*Note: All air shutoff devices must be reset to open before operating ther engine.*

Low oil pressure and high jacket water temperature Danfoss contactors are available through the Price List. However, other manufacturer switches may be utilized, as well as additional switches for other desired parameters.

The momentary or time delay switch serves two basic purposes. First, it is required during start-up for a low oil pressure switch as an override until engine oil pressure builds up sufficiently. A time delay of 8-9 seconds would provide acceptable performance. Second, a momentary switch would provide a means for override of any switch shutdown condition for emergency engine operation or troubleshooting.

If more than one shutdown switch is utilized, the switches must be connected in series on the 99–BR wire.

This shutdown switch wiring instruction is not intended to meet Unattended Machinery Space marine society certification requirements. If this criteria must be met, please contact the factory for further instruction.
Connecting a Woodward Loadshare Module to the EIP (Generator Sets Only)

**Purpose**
To provide a means of sharing load with multiple generator sets.

**Value**
Allows Woodward Loadshare Module to control engine speed.

**Function**
The operator will use the Woodward Loadshare Module’s PWM OUTPUT SIGNALS (+) and (-) to provide a Desired Engine Speed signal to the ADEM-II ECM. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.

*Note:* The 9X-9591 Speed Control inside of the Electronic Instrument Panel (EIP) must be removed if present and the “F702-GN” wire connected to the “S” Terminal of the 9X-9591 must then be connected to Pin-36 of the 40-Pin Customer Connector.
Connecting a Speed Adjust Potentiometer to the EIP (Generator Sets Only)

**Purpose**
To provide a means of controlling engine speed on Generator Sets using the 9X-9591 Speed Control.

**Value**
Allows the operator to adjust the 9X-9591 Speed Control’s Desired Engine Speed Pulse Width Modulated (PWM) output signal. The 9X-9591 Speed Control resides inside the Electronic Instrument Panel (EIP). Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details.

**Function**
The operator will use the Speed Adjust Potentiometer to vary the Desired Engine Speed PWM signal’s pulse width. This signal is inputted to the ADEM-II ECM which in turn governs Actual Engine Speed.
Connecting an Air Inlet Temperature Sensor to the EIP (Generator Sets Only)

**Purpose**
To provide temperature measurement of the intake air prior to entering the cylinder head.

**Value**
Aids detection of degraded aftercooler performance, and high ambient air temperatures or poor air ventilation in the area immediately next to engine air filters.

**Function**
The operator will use the EMS-II Gauges on the Electronic Instrument Panel (EIP) to monitor inlet air temperature. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details. Temperatures 30°C (86°F) greater than Aftercooler Water Temperature will have a negative impact on engine performance.
Connecting an Engine Oil Temperature Sensor to the EIP (Generator Sets Only)

**Purpose**
To provide temperature measurement of the engine oil before filtering.

**Value**
Aids detection of degraded oil cooler performance.

**Function**
The operator will use the EMS-II Gauges on the Electronic Instrument Panel (EIP) to monitor oil temperature. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details. Temperatures greater than 107°C (225°F) will have a negative impact on engine life.
Connecting a Battery Charger Fault Switch to the EIP (Generator Sets Only)

Purpose
To provide a means of indicating a failing battery charger to the operator.

Value
Allows the operator to prevent an undesired engine shutdown caused by a battery charger failure.

Function
The operator will use the EMS-II System Voltage warning LED on the Electronic Instrument Panel (EIP) to monitor the battery charger. Refer to SENR6587 Service Manual, 3500B Electronic Instrument Panel for more details. If a battery charger failure occurs, the ADEM-II ECM will continue to govern the engine down to a minimum battery voltage of 10 Volts DC.

Note: If the engine has been shut down, and a restart is needed, and the battery voltage is below 14.4 Volts DC with the ADEM-II system powered but prior to Cranking the starters then the engine may not restart. This is because the ECM Relay (ECMR) inside of the Electronic Instrument Panel (EIP) has a minimum pull-in voltage of 14.4 Volts DC. The relay's contacts supply (+) Battery voltage to the ECM. If the relay contacts do not close then the ECM will not power-up. The relay's minimum hold-in voltage is 7.0 Volts DC.

Note: Using this Switch, the operator can also receive a Battery Charger Diagnostic Warning indication via the PRCM.
Adding Circuits Inside EIP for CCM Power Control (Gen Set and Marine Auxiliary Applications Only)

**Purpose**
To provide a means to switch power to the CCM (Customer Communication Module) via the four position Engine Control Switch (ECS) on the engine mounted Electronic Instrument Panel (EIP).

**Value**
Provides on/off control of the CCM via the ECS and short circuit protection.

**Function**
The operator will install the wiring inside the EIP using the schematic shown above. The CCM will be turned on via the ECS in the AUTO (using a Remote Start/Stop Switch), MAN.START or STOP positions. The CCM will be turned off via the ECS in the OFF or AUTO (using a Remote Start/Stop Switch) positions.

**Note:** Using the Remote E-Stop switch function will not remove power from the CCM. Using the EIP mounted E-Stop Button will remove power from the CCM.
Connecting Customer Communication Module (CCM) to an Engine Vision Display (Marine Propulsion Only)

Purpose
To provide a two-way communication link between the CCM and the Engine Vision Display.

Value
Allows Customer to remotely monitor the engine.

Function
The operator will use Caterpillar supplied basic PC software to create Customer Specific Programs. The CCM software can be easily upgraded via Flash memory programming. Refer to Caterpillar Publication SEBU6874 Owner's Manual, Customer Communication Module for more details.
Programmable Droop
(An option for use with shaft generators)

When Used
This feature is used in applications of propulsion engines that demand engine operation in isochronous mode or in droop mode. This feature allows the user to program the droop percentage via the Caterpillar ET service tool. Droop will cause the engine speed to slow as load increases. The amount that the engine speed slows depends on the amount of droop programmed and the amount of load on the engine. Programmable droop will be compatible with all ratings of propulsion engines (dual engine control modules). High idle is that speed at which the engine will run at full throttle with no load. High idle may be calculated from the droop percentage and the rated engine speed according to the following formula.

\[
\text{High Idle} = [100 + \% \text{Droop/100}] \\
\times [\text{Rated Engine Speed}]
\]

Description
It is not recommended that the 3500B marine propulsion engine be coupled to generators for the sole purpose of electric power generation. This is due to fundamental differences in the turbochargers, fuel injectors and software of the marine propulsion engines versus the analogous components of an electric power or marine auxiliary engine. However, in certain applications it may be desirable or required by ship design to use a shaft generator either from a power take off on the marine gear or coupled directly to the front of the marine propulsion engine. When coupling a shaft generator to a marine propulsion engine it is critically important that the installer complete a torsional vibration analysis. In these installations temporary or long duration load sharing with other shipboard auxiliary engines may be required. This can be accomplished with the programmable droop parameter found in the configuration screen of Cat ET. The droop value can be programmed from 2.5 to 8% in 0.1% increments. Setting the droop value equal to 0 will result in isochronous operation (this is the factory default setting).

Normal operation of the marine propulsion engine uses isochronous response from low idle to rated speed, and a non-adjustable 8% droop from high idle to rated speed.
The series of ET screens that follow illustrate the process of setting the programmable droop feature. The first one shows the location and format of the percent droop line in ET.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
<th>ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Droop Value</td>
<td>0 or some between 25 and 80 (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Droop Value</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The next screen shows the range of droop values that are available.

Notice! Value must be 0 or some between 25 and 80 (% droop X 10). Any value outside these limits will be refused and CAT ET will enter 0% (the default value).

The next screen offers the option of confirming the droop that was entered.

If yes is chosen, the droop of the engine will remain at the chosen value.
Load Feedback

When Used
Load feedback is used in applications when the engine speed must be adjusted in response to the engine load. An example might be an engine driving a controllable pitch propeller (CPP). Using this feature can automatically prevent potentially dangerous engine overload by reducing propeller pitch in response to the load feedback signal.

Description:
The engine’s Electronic Control Module (ECM) produces an electronic signal that is proportional to the engine load. 3500B engines do not have a physical rack, but the electronic equivalent of the familiar concept of fuel rack position (injection duration) is used in the service tools and in the discussion below.

If the engine is operated below rated speed, the percent load is calculated using the following formula:

\[
\text{Percent Load} = \frac{\text{Current Fuel (Rack) Position - Idle Fuel Position}}{\text{Max. Allowable Fuel (Rack) Position (At this speed) - Idle Fuel Position}}
\]

If the engine is operated above rated speed, the percent load is calculated with the formula shown below.

\[
\text{Percent Load} = \frac{\text{Current Fuel (Rack) Position - Idle Fuel Position}}{\text{Max. Allowable Fuel (Rack) Position (At Rated Speed) - Idle Fuel Position}}
\]

Idle Fuel Position should be set to 5.0mm.

This signal has an error of as much as ± 10%.

Notice from the 3516B performance curve below that the percent load calculation is closely related to the engine speed. On the curve, there are two operating points illustrated by way of example. Assume, in the case illustrated by the shorter brackets on the left side of the curve that the engine is operating at a rack position shown by the shorter of the two brackets. The maximum allowable rack position, for that speed, is illustrated by the longer of the two brackets. The percent load (ratio of the two rack positions) is approximately 0.60 or 60%.

The taller pair of brackets on the right side of the curve illustrates a load percent of approximately 90+% since the engine is running at a very high percentage of its maximum rack position – as illustrated by the two longer brackets.
Load Feedback Signal

40 Pin Customer Connector
(Premium Wiring and Standard Wiring)

Load Feedback (+)

Load Feedback (-)
19 or 20 or 21

0-200 mA

25 ohm
5 watt
1% resistor

Note: Isolated input to output, input to power and output to power

4-20 mA

Voltage to Current Converter

0-5 volts

Control

In

Out

Such as Phoenix MCR-C-UI/UI-DCI
Torque Limit

When Used
This feature is used in applications where it is desirable to limit the torque rise of the engine. Examples include:

- In repowering vessels that were originally powered by lower powered engines and with gears and shafts sized to the lower powered engines, it is desirable to limit the torque rise of the new engine to protect the marine gear and shafting until such time as they can be replaced. Torque limit will be very useful in this instance.

- Some equipment demands the power characteristics of mechanically governed engines. Electronic engines generally have very high torque rise, as described in the graph below. If successful operation depends on the power characteristics of mechanically governed engines (where the power is a maximum only at rated speed and where power decreases at both higher and lower speeds from rated speed), the torque limit feature can restore to the electronic engine the power characteristic of mechanically governed engines.

This feature allows the technician who sets up the engines with “ET”, the electronic service tool, to set the maximum torque to any level of torque from rated-torque-at-rated-power-and-speed up to peak torque.

Instructions
The Overspeed Verify switch (see Internal Instrument Panel Switches section) has a dual function. When torque limit is desired, the overspeed verify switch is removed and the wires leading to it are spliced together. With the engine shut down and the wires leading to the overspeed verify switch securely spliced together, Cat Electronic Technician (ET) should be connected and the configuration screen selected. Set the parameter OVS-TLS SELECT to the ON position to enable torque rise limit. The configuration screen must be exited and then re-entered. There will now be a numerical torque value displayed, in the chosen units of torque, at the TLS option near the bottom of the configuration screen. Select this value and edit the torque value to the desired value.

Note: The torque value can be programmed to any value between the engines rated torque value and the maximum torque value. ET will not accept torque values below rated torque. Consult TMI for these minimum (rated torque) values at your rating. Save and exit ET. The engine’s torque will remain limited to the value entered at ET’s configuration screen so long as the wires which previously lead to the overspeed verify switch remain spliced.
The following ET screens further illustrate the process of enabling Torque Limit. The first one shows the initial torque limit of the engine. The engine is set for full torque rise as it comes from the factory. If torque limit is desired, the torque shown in the initial screen must be reduced to the desired level.

---

The new torque level must be entered on the next screen. That level must be between the standard peak torque and the torque at rated power. See performance data for the specific rating for the peak torque and torque-at-rated-power values.

---

Notice! Value must be between maximum torque and torque at rated RPM
This screen demands confirmation of the new torque limit. Choosing yes will cause the engine to limit its peak torque to the value chosen.

The next screen illustrates the toggling of the Overspeed Verify Switch - Torque Limit Switch (OVS-TLS) function from Overspeed Verify to Torque Limit.

Notice! Selecting “ON” changes the function of the switch input to Torque Limit Switch

In summary; using ET enter the value to which torque is to be limited. Select ON on the OVS-TLS configuration parameter. When necessary, enable the overspeed verify function by reinstalling the overspeed verify switch and selecting ON in the Overspeed Verify parameter to check the overspeed protection system.
Engine Control Module Changes

(VERSION C TO VERSION D)

Differences between the Version C and Version D ECM

In April 1997, the 3500B electrical system changed to add the new features in the following table.

<table>
<thead>
<tr>
<th>Feature or component</th>
<th>Engines Shipped Before April 97</th>
<th>Engines Shipped After April 97</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine ECM</td>
<td>7X-6321</td>
<td>176-7503 or 130-7481</td>
</tr>
<tr>
<td>Data Links Supported</td>
<td>Primary CAT</td>
<td>Primary CAT</td>
</tr>
<tr>
<td>Engine Monitoring System Options</td>
<td>Warning Derate</td>
<td>Warning Derate Shutdown</td>
</tr>
<tr>
<td>Engine Protection Override Switch (EPOS)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Cold Cylinder Cutout</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Engine Vision Support</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

See serial number break list on page ____. 

Version C Data Link Description

The Version C Engine Control Module (ECM) has a primary Cat Data Link and a secondary Data Link which uses American Trucking Association (ATA) Data Link protocol. The Cat Data Link is used for communication between the ECM’s and other Caterpillar microprocessor based electronic display modules. The secondary ATA link is used for flashing new software to the ECM with the Caterpillar Electronic Technician Software Service Tool. Version C does not support Engine Vision. See Fig. 1 for Version C’s Data Link Architecture.

Version D Data Link Description

The Version D ECM has the same primary Cat Data Link as the Version C ECM, but its secondary Data Link uses the same protocol as the primary Data Link – Cat Data Link Protocol, instead of the ATA. The primary is used for flashing the ECM and the secondary is used for communication between the ECM’s and other Caterpillar microprocessor based electronic display modules such as the Engine Vision Interface Module (EVIM) and Global Positioning System Interface Module (GPSIM).

Attachments for the Version D ECM

The Version D ECM is capable of using the Caterpillar electronic monitoring system, Engine Vision. Engine Vision requires the use of an adapter called an Engine Vision Interface Module (EVIM). The Global Positioning System Interface Module (GPSIM) allows a Global Positioning System receiver to transmit data to the Cat Data Link. See Fig. 2 for Version D’s Data Link Architecture.

A conversion procedure is available. Contact 3500 Customer Service for more information or see REHS0863 for details.
VERSION D DATA LINK ARCHITECTURE

Back-up ECM (Marine Propulsion Only)

Version D
Back-up ECM
J1 Conn

Version D
Primary ECM
J1 Conn

05 14
Engine Monitoring System

19 20
Programmable Relay Control Module

D E
Service Tool

Customer Communication Module (CCM)

Data -
Data +

9 Primary CatDataLink +
3 Primary CatDataLink -

7 Secondary CatDataLink +
1 Secondary CatDataLink -

893-GN
892-BR

NOT USED
NOT USED

J981-WH
J982-OR

893-GN
892-BR

9 Primary CatDataLink +
3 Primary CatDataLink -

7 Secondary CatDataLink +
1 Secondary CatDataLink -

Programmable Relay Control Module

Service Tool

Engine Monitoring System

Customer Communication Module (CCM)
Serial Number Breaks Between
VERSION C AND VERSION D

Engines built with serial numbers higher than those listed in the table below were built with the Version D Engine Control Module.

<table>
<thead>
<tr>
<th>Marine Engine Model</th>
<th>First Version D Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>3508B DITA SCAC AUX</td>
<td>3DM00093</td>
</tr>
<tr>
<td>3512B DITA SCAC AUX</td>
<td>8EM00258</td>
</tr>
<tr>
<td>3516B DITA SCAC AUX</td>
<td>9AN00121</td>
</tr>
<tr>
<td>3508B DITA JWAC AUX</td>
<td>3DW00001</td>
</tr>
<tr>
<td>3512B DITA JWAC AUX</td>
<td>1PW00001</td>
</tr>
<tr>
<td>3516B DITA JWAC AUX</td>
<td>2FW00001</td>
</tr>
<tr>
<td>3508B DITA SWAC PROP</td>
<td>2BM00123</td>
</tr>
<tr>
<td>3512B DITA SWAC PROP</td>
<td>7HM00174</td>
</tr>
<tr>
<td>3508B DITA SCAC PROP</td>
<td>7SM00077</td>
</tr>
<tr>
<td>3512B DITA SCAC PROP</td>
<td>4TN00096</td>
</tr>
<tr>
<td>3516B DITA SWAC PROP</td>
<td>8CN00144</td>
</tr>
<tr>
<td>3516B DITA SCAC PROP</td>
<td>8KN00143</td>
</tr>
<tr>
<td>3508B DITA JWAC PROP</td>
<td>1TW00001</td>
</tr>
<tr>
<td>3512B DITA JWAC PROP</td>
<td>2GW00001</td>
</tr>
<tr>
<td>3516B DITA JWAC PROP</td>
<td>3CW00001</td>
</tr>
<tr>
<td>3516B HIGH DISP DITA SCAC PROP</td>
<td>4BW00001</td>
</tr>
<tr>
<td>3512B HIGH DISP DITA SCAC PROP</td>
<td>2EZ00001</td>
</tr>
<tr>
<td>3508 DITA JW EUI AUX</td>
<td>3TS00001</td>
</tr>
<tr>
<td>3512 DITA JW EUI AUX</td>
<td>3WS00001</td>
</tr>
<tr>
<td>3516 DITA JW EUI AUX</td>
<td>3XS00001</td>
</tr>
<tr>
<td>3508 DITA JW EUI PROP</td>
<td>3PS00001</td>
</tr>
<tr>
<td>3512 DITA JW EUI PROP</td>
<td>3RS00001</td>
</tr>
<tr>
<td>3516 DITA JW EUI PROP</td>
<td>3SS00001</td>
</tr>
</tbody>
</table>
Throttle Position Sensor

Where Used
The Throttle Position Sensor is used to provide an engine throttle signal. Some control system suppliers are able to provide usable engine throttle signals directly without using the Cat Throttle Position Sensor.

Description:
The Throttle Position Sensor converts rotational motion into a variable-duty-cycle, pulse-width-modulated signal. The duty cycle of the signal determines the desired speed of the 3500B propulsion engine.

PWM Definition
The 3500B marine engines a series of evenly-spaced voltage pulses, emits at the rate of 500 pulses per second as a throttle signal (to convey the pilot’s desired engine speed). The voltage pulses can be varied in their width. This width variability, changing the duty cycle of the signal, gives the signal its ability to convey information. When the pulses are very short (low duty cycle), the engine throttle signal is for a slow engine speed. When the pulses are very wide (high duty cycle), the engine throttle signal indicates a fast engine speed. These signals are called Pulse-Width-Modulated (PWM).

PWM signals are generally resistant to problems associated with ground faults, excessive capacitance and voltage fluctuations. These make a PWM signal ideally suited as a throttle signal.

Notice that even though the frequency (wavelength) of the voltage pulses shown below are constant, their width varies. It is that width variation the engine uses to determine its desired speed.
Programmable Relay Control Module

Where Used

The PRCM is most often used to drive alarm lights/horns in response to alarm conditions detected by the engine’s control and monitoring system. The following system parameters may be annunciated using the PRCM.

<table>
<thead>
<tr>
<th>Description</th>
<th>high crankcase pressure high aftercooler water temperature low coolant level low fuel level battery charger low voltage high marine gear oil temperature low marine gear oil temperature disabled fuel injection engine at 100% load engine speed above 50 rpm active starter motor relay power derate active power derate active, but not for altitude shutdown because of low oil pressure shutdown because of overspeed shutdown because of high aftercooler temp</th>
</tr>
</thead>
</table>

• Ambient operating temperature range: -40 to +70°C (-40 to +158°F)

• Voltages: The operating voltage range is from 15 to 45 volts DC. The Relay Driver Module is designed to only operate when powered by 24 or 32 volts DC battery systems.

• Relays: The relay coils draw 20 mA at 24 VDC. Three relays provide normally open and normally closed contacts. Four relays provide normally open contacts only. The relay contacts are silver flashed, fuse protected, and rated for 10 amps at 28 VDC.

• The PRCM case is electrically isolated from its internal circuitry.

• All inputs and outputs are protected against shorts to + or – Battery. Exceptions are terminals 2, 13 and 14 on the relay driver module which are not fused and therefore are not protected from short circuits to + or – battery.

• The PRCM is capable of operating with or without an earth ground.

• The PRCM must share common ground with the optional relay driver modules and relay boards.

• The PRCM is intended to be located in an instrument panel or on a shelf.
For more details, see Owners Manual, Programmable Relay Control Module.
General Alarm Relay

When Used
The General Alarm Relay is a relay contained within the engine-mounted instrument panel (EIP) of propulsion engines equipped with the standard engine wiring harness. The General Alarm Relay is not a feature of marine auxiliary engines. It provides dry, voltage-free, contacts with which an alarm annunciation system may be controlled. It will change state (go from normally open to closed or go from normally closed to open) in the event of a potentially dangerous condition with engine performance or if there is a failure of some portion of the engine’s electronics system. It is important to define some terms used in understanding the function of the General Alarm Relay.

- **Events** are situations where the engine’s performance parameters (exhaust temperature, jacket water temperature and oil pressure to name a few) are outside limits set for the rating and application. Active Events are occurring at the current moment, while Logged Events have occurred at some time in the past. Logged events are saved within the ECM along with the engine service meter reading at the time of the event.

- **Diagnostics** are warnings of failure of some electrical engine component. They may indicate a short circuit, unintentional ground, open circuit or improper response of an engine performance transducer or sensor. As with events, diagnostics may be active or logged.

- In the presence of active events of a potentially catastrophic nature, the engine may automatically shut off. In the presence of active events of a somewhat lesser importance, the engine may automatically lower its power output up to 25% for each parameter out of its safe range. This is called Derating. In the presence of still less important active events, the engine may issue a warning via its monitoring system. The performance parameter levels at which shut off, derate and warning occur are set at the factory.

The General Alarm Relay will actuate on the presence of Active Events or Diagnostics.

**Description:**
The General Alarm Relay contacts are rated for 20 amps at 24 volts DC.
The General Alarm Relay energizes when:
There is a dangerous condition with the engine performance - or -
There is a failure in some portion of the engine’s electronics systems.
Switches Inside the Engine Mounted Instrument Panel

Inside the electronic instrument panel are several switches. Depending on the engine configuration, they may include the following:

- Engine Protection Override Switch
- Manual Starter Switch
- Overspeed Verify Switch
- Prelube Override Switch

**Manual Starter Crank Switch** allows the operator to crank the engine using the engine starters and overriding any other control or protection systems. Therefore, the starters can be engaged even when the engine control switch is in the OFF position or when the ECM has completed the cycle crank sequence. The manual starter crank switch is intended to be used for system troubleshooting and engine maintenance. Do not use the manual starter crank switch for normal operation of the engine.

**Overspeed Verify Switch** allows the operator to verify that the overspeed protection system is working as desired. When the switch is activated, the ECM will perform an engine overspeed shutdown (if the Engine Monitoring System is programmed for this action) at 75% of the engine overspeed trip point. The overspeed verify switch is intended to be used for troubleshooting and verification of engine protection systems.

**Prelube Override Switch** allows the operator to override the prelube pump sequence at the beginning of the cycle crank sequence during engine start-up (if there is an attached prelube pump as part of the engine system). When the prelube override switch is activated, the ECM will not initiate an engine prelube prior to cranking the engine: the ECM will immediately begin to crank the engine without prelubing. The prelube override switch is intended to be used for troubleshooting and to provide for immediate engine starting during emergency situations. The prelube override switch is present only if the prelube pump attachment is part of the engine package.

**Engine Protection Override Switch** is used in circumstances where it is absolutely necessary to continue to operate an engine, even though that engine may be seriously damaged or destroyed by continued operation. An example might be during a storm at sea where loss of engine power might result in loss of the vessel and the crew. In any case, the decision to continue to operate a crippled engine must be that of the ship’s master. The engine protection override switch gives the ship’s master that option. If an engine is operating and a fault occurs; the operator may move the switch from the normal to the override position. In the override position, the engine will not shutoff, regardless of alarms or faults. If an engine has already shutoff, because of a fault, the engine may be restarted, without protection, by moving the switch from the normal to the override position.

If the engine is equipped with the standard wiring harness, the adjacent photos describe the location of the switches.
Inside the black, engine-mounted instrument box (on the side of the engine), the switches are in the upper left corner.

If the engine is equipped with the Premium Wiring Harness, the adjacent photos describe the switches' location.

Note the opened lid of the engine-mounted instrument box. The set of switches is at the outside right corner of the box's cover.
Cat Engine Vision
(An optional attachment)

Description:
The Engine Vision System displays current engine and transmission data, trip data, historical data, maintenance and diagnostic information, and troubleshooting information. It can also interface with vessel global positioning systems to display vessel position and speed. A single Engine Vision System can simultaneously display data for up to three engines. Each engine’s ECM is connected via Cat Data Link and the Engine Vision Interface Module to Engine Vision. Touch screen technology provides fast, easy access to desired information.

- Function keys mounted on the housing below the screen provide additional access to desired information
- The high resolution, multi-colored LCD screen provides superior readability in all lighting conditions
- Displays current engine operating parameters
- Continually updates engine historical data
- Global positioning display with GPS Interface Module
- Graphic displays of critical operating parameters
- Trip and lifetime totals for engine operating hours, load factors, and fuel rates
- Diagnostic information
- Maintenance information

For further reference see the following:
- Installation Guide SENR 5002-02
- Engine Vision 4.0 Software LERM8401-02
- Engine Vision Operator's Guide LEKM8504-01
ECM Data/Histograms

The 3500B Marine Engine collects and stores operational and performance information within its Engine Control Module (ECM). The data is stored in the form of Histograms. The histograms graphically display the percentage of total operating time spent at various:

- Engine Speeds
- Percent of Engine Loads
- Right Exhaust Manifold Temperatures
- Left Exhaust Manifold Temperatures

See the charts below for examples.

These charts are available for download from engine’s ECM using the Electronic Technician (ET) Service Tool. The charts are extremely useful for confirmation of proper engine rating level. They can also be used, by comparing a histogram taken at one point in time to the same histogram taken later, to compare the way various operators use the engine and vessel. If the ECM is replaced, the histogram data will be lost.
Shutdown Notify Relay

Where Used:
In circumstances where it is desirable to provide an electrical signal that the engines is not ready for work, the shutdown notify relay can be used. The Shutdown Notify Relay has both normally open and normally closed contacts and is energized when fuel injection is disabled, engine speed is less than the speed at which the starting motors are de–energized or the starting switch is turned off. It could be used to disengage equipment and notify the operator if there is an engine shutdown.

Description
The relay will be energized if any of the following occurs:

- Engine is shutdown by the engine protection system
- The Remote Start-Stop switch is switched to the Stop position when the Engine Control Switch (ECS) is in the Auto position.
- The Remote E-Stop switch is activated.
- The Customer Communication Module has requested a normal shutdown.
- The Customer Communication Module has requested a Emergency (E-Stop) shutdown.
- The Overspeed Verify feature has caused a shutdown.
- The Engine Control Switch (ECS) is placed on the STOP or OFF position.
- Personality Module Interlock occurs. This condition will prevent engine from running because incorrect software was loaded into the Engine Control Module (ECM).
- Engine speed drops below Crank Terminate speed. This would normally happen if the engine ran out of fuel.
Wiring Diagram
Customer Communication Module
Installation Requirements

When a Customer communication Module (CCM) is installed, these requirements must be met:

- The battery voltage input requirements are from 15 to 45 volts DC (24 or 32 volt DC Nominal Power).

- Battery (±) power dissipation is approximately 3.0 watts at 24 volts.

- The battery sets of multiple engines must share a common ground [Battery (-)].

- Multiple engines must use diodes to prevent power sharing between units. See CCM Wiring Connections for Multiple Engines. When multiple engines are to be connected to the CCM, junction boxes must be installed as shown in the following illustration. This allows for any engine to be disconnected for service or maintenance without power interruption to the CCM or the other engines.

CCM Wiring Connections for Multiple Engines

1-Junction box for unit 2, 2-Junction box for unit 1, 3-CCM

**Note A:** Ground shield in one location only, as near as possible to battery negative.

**Note B:** Diode is necessary when connecting multiple engines.

**Note C:** Battery positive and negative are to be taken from the 24 pin customer connector located on the bottom of the engine mounted Electronic Instrument Panel (EIP).
The Customer communication Module (CCM) provides a two-way communication link between the engine and its electronic control module (ECM) and some host device, such as a personal computer (PC), a programmable logic controller (PLC) or any other device with an RS-232C port. The operator of the host device is able to remotely monitor or program the engine in much the same way an operator does from the panel. The host device can connect directly to the CCM or remotely, by means of two modems. CCM compatible software is available from Caterpillar Inc. for use with a PC (See Caterpillar CCM PC for Windows: Getting Started Manual, included with the software package, for more information on the PC software). The CCM can also be used with vendor-supplied software. The serial data format is provided in the CCM Owners Manual (See SEBU6874-04 for installation instructions) to help a user program their device to communicate with the CCM. Refer to the RS-232C M5X Communication Protocol and the Parameter Identifiers (PID) section in the owners manual for additional information.

Environmental Specifications

- The ambient operating temperature range is from -40° to +70°C (-40° to 158°F)
- The unit must be protected from direct contact with liquids (splash proof). If sealing the unit is required, the CCM must be in a watertight enclosure.
Mounting

The CCM can be located on a desk or shelf. The rubber feet on the bottom of the CCM can also be removed to allow panel mounting. Do not mount the CCM on the engine, or within the engine-mounted instrument panel. It is not designed for this environment.

CCM Battery (Internal)

The CCM contains a battery (current part number 101-1785) that supplies power for internal memory whenever the CCM power is turned off. The battery can be expected to last for 5 years.

In marine applications, the CCM has the ability to communicate with up to 3 engines. The CCM identifies each engine by its Module Identifier (MID). Each engine connected to a CCM must have a unique MID.

Version C of the ECM has a primary Data Link for use with the CCM. This Data Link is called the Cat Data Link. The MID of this ECM is a fixed value. Because each ECM must have a unique MID as mentioned previously, the CCM can only be connected to one Version C ECM on the Cat Data Link.

Version D of the ECM has the same primary Data Link (Cat Data Link) as Version C with a fixed MID value. In addition, Version D also has a secondary Data Link (Secondary Cat Data Link) for use with the CCM. The secondary Cat Data Link has a programmable MID value (up to 3 different values).

To determine if your engine has a Version C or Version D ECM, see the serial number break table in the section entitled Engine Control Module Changes (Version C to Version D).

There is a maximum of one CCM per Data Link.

There is a maximum of one CCM per engine.
General Wire and Cable Specifications
The following specifications for wire and cable is given to minimize voltage drops over long runs of wire and to minimize both Electromagnetic and Radio Frequency Interference (EMI/RFI).

- Do not run Data Link wiring in the same raceway as high power cables, such as generator leads or any alternating current cabling.

- The wires connected to (+) Battery and (-) Battery on the CCM must be at least 16 AWG.

- Maximum Cat Data Link cable and (±) Battery wire length is 455 m (1500 ft), including wire runs between any multiple engines when a CCM is present. A system that does not include a CCM is limited to a maximum wire length of 30.5 m (100 ft).

- Maximum total wire length of the RS-323C cable is 15 m (50 ft).

Conformance to the European Economic Community (EEC) 336 Directive demands the RS-232C cable be shielded.

- No terminations or splices are allowed on the above wires, except as noted on the connection diagrams.

- The cable connected to the (±) Cat Data Link must be a 16 AWG, shielded twisted pair cable. Use 123-2376 Electric Cable, Belden 8719 Cable, or equivalent.

<table>
<thead>
<tr>
<th>CAT DATA LINK CABLE SPECIFICATIONS - RESISTANCE AND CAPACITANCE</th>
<th>Parameter Being Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C to C$^1$</td>
</tr>
<tr>
<td>Nominal Capacitance per meter (foot)</td>
<td>75 pF</td>
</tr>
<tr>
<td>(23 pF)</td>
<td>(44 pF)</td>
</tr>
<tr>
<td>Total Nominal Capacitance 455 m (1500 ft)</td>
<td>0.035 μF</td>
</tr>
<tr>
<td>Nominal Resistance per m (ft) at 20°C (68°F)</td>
<td>—</td>
</tr>
<tr>
<td>(4.27 mΩ)</td>
<td>—</td>
</tr>
<tr>
<td>Total Nominal Resistance 455 m (1500 ft) at 20°C (68°F)</td>
<td>—</td>
</tr>
</tbody>
</table>

$^1$ C to C = Conductor to conductor. C to S = Conductor to shield. SCSR = Single conductor series resistance (16 AWG, 19/29 stranding)
RS-232C Cable Requirements

The CCM is classed as Data Terminal Equipment (DTE) for RS-232C communication.

- The CCM RS-232C connector is a standard 25-pin D-shell connector with pins.
- The RS-232C cable must be shielded.
- When connected to other DTE devices, such as personal computers, a Null Modem cable or adapter is required to connect the two devices.
- When the CCM is connected to Data Communication Equipment (DCE), such as modems, printers or terminals, no Null Modem cable or adapter should be used.

### RS-232C PIN DEFINITIONS

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Data Transmit (TX)</td>
</tr>
<tr>
<td>3</td>
<td>Data Receive (RX)</td>
</tr>
<tr>
<td>7</td>
<td>Ground</td>
</tr>
<tr>
<td>8</td>
<td>Data Carrier Detect (DCD)</td>
</tr>
<tr>
<td>20</td>
<td>Data Terminal Ready (DTR)</td>
</tr>
</tbody>
</table>

RS-232C Communication Protocol for Customized Systems

As purchased, the CCM comes with Windows compatible software that utilizes M5X protocol to all the CCM to communicate with a remote personal computer. In some installations, the user will require customized software when a host device other than a personal computer [such as a programmable logic controller (PLC)] is used or when the application requires enhancements to the PC software provided.

The CCM communicates with the host computer via a standard RS-232C serial Data Link. This serial Data Link uses M5X protocol to send and receive data. The M5X commands allow the user to periodically request a broadcast of multiple engine parameters for monitoring by the host device. Single parameter read-and-write commands allow the user to control the engine from the host device.

The Remote PC software creates up to eight lists that are stored in non-volatile memory in the CCM. These lists contain multiple engine parameters that are broadcast to the host device from the CCM through the RS-232C network. The engine parameters are given a unique parameter identifier (PID).

Most Caterpillar electronic systems using the CCM with provide 40-50 parameters every second (1200 - 19,200 Baud) to a remote computer system through the RS-232C connection, but other limits may be encountered. When connecting through a modem operating as less than 4800 baud, the throughput will be reduced. For example, using a cellular phone connection operating a 2400-baud reduces the throughput to 29 parameters per second. In applications that use several other modules, such as multiple remote pilothouse instrument panels, and/or programmable relay control modules, the throughput can be reduced to 40 parameters per second. To optimize data transfer and minimize communication loading, stable parameters like hour meters, temperatures, and diagnostics should be requested less frequently. Parameters that are more dynamic such as engine speed and oil pressure can be requested more frequently. Use good design judgment to determine the update rate of individual parameters.
Initializing Communication

The initialization procedure differs depending on the type of connection. It is necessary to ensure proper communication between the CCM and the host computer.

When modems are installed between the CCM and the host computer, the complexity of the communication network is greatly increased. This is because there are several more possibilities for error when modems and phone lines are used. For this reason, it is recommended to begin the initialization of modem communication by making a direct connection between the host computer and the CCM. This will enable the user to become familiar with the PC software and verify proper operation of the engine while at the engine. This is illustrated below.

Make sure all the components are ready: the personal computer, RS-232C cables (See RS-232C Cable Requirements section of the CCM Owners Manual) and the software CCM PC For Windows is installed on the PC. In the following steps, the PC should be turned OFF before connecting or disconnecting cables to the serial ports.

- Install the CCM with all wiring attached. Refer to Wiring Connections and Battery Power and General Wire and Cable Specifications

- Determine the communications parameters to be used in the installation. The factory default parameters stored in the CCM are 9600 serial port communication rate (bits per second or bps), no parity, 8 data bits and 1 stop bit. These parameters will work well in most installations.

- Load the CCM PC for Windows software into the PC.

- Go to the Data Link pull-down menu, select Select ECM, CCM. Select the Utilities pull-down menu and select CCM Configuration. Set up the communication parameters of the CCM to match those in Step 2.

- Go to the Phone Book pull-down menu and select Add or Edit. Set up the communication parameters of the PC to match those in Step 2.

- The ECM of each engine must be programmed with the correct engine number to identify them to the CCM. The ECM is programmed to Engine Number 1 at the factory.

- After the CCM and the PC are all properly connected, see the CCM PC software Users Manual for instruction on monitoring and controlling the engine remotely.
Two conditions must be met before the ECM will allow control (starting and stopping) by the CCM. The Engine Control Switch (ECS) must be in AUTO position and the remote initiate contacts must be open (no other remote start signal receivable). The engine may be monitored with the ECS in any position.

To connect using modems follow the instructions following the illustration below:

![Diagram of CCM/Host Computer Remote Connection with Modems]

1. **Install the CCM with all wiring attached.**
2. **Determine the communication parameters to be used in the installation.** The factory default parameters stored in the CCM are 9600 serial port communication rate (bits per second or bps), no parity, 8 data bits and 1 stop bit. These parameters will work well in most installations.
   
   **Note:** RS-232C serial port communication rate is often referred to as DTE speed or bits per second (bps). The phone port communication rate of the modems is often referred to as DCE speed or bps.
3. **Using the proper cable, connect the RS-232C port of the answering modem directly to the RS-232C port of the PC.** This connection is temporary and must be done to set up the answering modem.
4. **Using the terminal emulator on the PC, set the serial RS-232C port for the communication parameters determined in Step 2.**
5. **Several commands must be sent to the answering modem that set the communication parameters to the proper values.** The examples given are Hayes AT commands and are for illustration purposes only. Actual command sets vary widely between modem manufacturers. Consult the manual for the modem. If desired, enter the proper command for the particular modem in the blank **User's Modem Command** column of the chart on the following page.
   
   **Note:** In the following AT commands, the symbol “0” indicates the number zero.
This completes the setup of the answering modem.

6. Disconnect the PC from the answering modem. Temporarily connect the PC directly to the CCM.

7. Load CCM PC for Windows software into the PC.

8. Go to the Data Link pull-down menu, select Select ECM, CCM. Select the Utilities pull-down menu and select CCM Configuration. Set up the communication parameters of the CCM to match those chosen in Step 2.

9. Go to the Phone Book pull-down menu and select Add or Edit. Set up the communication parameters of the PC to match those chosen in Step 2.
10. The ECM of each engine must be programmed with the correct engine number to identify them to the CCM. The ECM is programmed to Engine Number 1 at the factory.

11. Disconnect the PC from the CCM. Connect the PC, modems and CCM. Make sure the answering modem and the CCM are both powered up (turned ON) and that they are connected by the proper RS-232C cable.

12. Turn OFF (power down) the CCM (remove the wire connected to the Battery + terminal of the CCM) and then turn ON (power up) the CCM (reconnect the wire on the Battery + terminal). During this step, make sure that the CCM remains powered up for a minimum of 30 seconds. The CCM sends commands at power up that set the DTE speed of the answering modem to the same as that of the CCM.

13. After the CCM, the modems and the PC are all properly connected, refer to the CCM PC for Windows Users Manual for instruction on monitoring the engine remotely. If desired, the PC and the originating modem can be connected to a local phone line at the same site as the engine/s, CCM and answering modem, to make certain of proper communication before attempting remote monitoring.
Monitoring System Providers

The following suppliers have worked with the Caterpillar factory and have had one or more versions of their equipment confirmed compatible with the 3500B.

Vendor Home Office
Name and Address

MACSEA Ltd.
163 Water Street
Stonington, CT 06378
Phone: 860 535 3885
Fax: 860 535 3357
Kevin Logan
President

Monico, Inc.
Mail: P.O. Box 90189
Austin, Texas 78709-0189
Street: 7500 Highway 71 West
Suite 104
Austin Texas 78735
Phone: 512 288 0195
Fax: 512 301 2724
Larry Peterson
President

ServoWatch Systems
Drakes Lane Ind. Est.
Boreham
Chelmsford, Essex CM3 3BE
United Kingdom
Phone: 44 1245 360019
Fax: 44 1245 362129
Steve Smith
Director

Techsol
Electrotechnique Industrielle et Maritime
127, rue Goyette
Beauport, Quebec
Phone: 418 666 5619
Fax: 418 666 5482
Claude Messiaen
President

DMP–Member of the Radio Zeeland Group DMP International B.V.
Industrieweg 17
P.O. Box 1070, 4530 GB terneuzen
The Netherlands
Phone: 31 115 630 400
Fax: 31 115 630 500
William Bloomart
President
Demonstration of the 3500B Engine Monitoring System

Method to Demonstrate 3500B Protection and Monitoring System to Customers and Society Surveyors

- Use a 10k potentiometer to simulate analog sensors

- Use a 3E-7700 Throttle Position Sensor to simulate digital PWM sensors

- Engine overspeed condition must be simulated using the 75% overspeed verify switch on the Electronic Instrument Panel. A true engine overspeed condition should never be attempted. A square wave signal generator or throttle position sensor cannot be used to simulate the speed/timing sensor due to the unique tooth pattern on the gear read by the sensor.

- Refer to the following chart to determine which method should be used to simulate the different sensor types and part numbers.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Sensor Type</th>
<th>Simulate With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbo Outlet (Boost) Pressure</td>
<td>Analog</td>
<td>10k Potentiometer</td>
</tr>
<tr>
<td>Oil and Fuel Pressure</td>
<td>Analog</td>
<td>10k Potentiometer</td>
</tr>
<tr>
<td>Atmospheric, Crank Case, and Inlet Air Restriction Pressure</td>
<td>Analog</td>
<td>10k Potentiometer</td>
</tr>
<tr>
<td>Coolant and Aftercooler Temperature</td>
<td>Analog</td>
<td>10k Potentiometer</td>
</tr>
<tr>
<td>Exhaust Temperature</td>
<td>Digital PWM</td>
<td>3E-7700 8V Throttle Position Sensor</td>
</tr>
<tr>
<td>Marine Gear Oil Pressure</td>
<td>Digital PWM</td>
<td>3E-7700 8V Throttle Position Sensor</td>
</tr>
<tr>
<td>Marine Gear Oil Temperature</td>
<td>Digital PWM</td>
<td>3E-7700 8V Throttle Position Sensor</td>
</tr>
<tr>
<td>Speed/Timing</td>
<td>Digital</td>
<td>Overspeed Verify Switch</td>
</tr>
</tbody>
</table>

Procedure for using 10k potentiometer to simulate analog sensors

Note: Factory passwords may be needed to clear any events logged during this demonstration.

- Attach an 8T-8731 3-pin Deutsch connector to the 10k potentiometer.

- Solder three leads approximately 3 feet in length to the three lugs on the potentiometer

- Attach the 8T-8731 3-pin Deutsch connector to the other end of these three leads

- Pin C of the Deutsch connector should be connected to the wiper on the potentiometer. The wiper is usually the center lug.

- Pins A and B of the Deutsch connector should be connected to the other 2 leads. These two pins can be connected in either order as long as Pin C is connected to the wiper.

  Note: The way pins A and B are connected to the potentiometer will determine whether clockwise or counter-clockwise rotation results in raising or lowering of the parameter being simulated

- Disconnect the sensor to be simulated from the engine wiring harness

- Connect the 10k potentiometer in place of the sensor

- Demonstrate changing conditions and sensor short and open circuit diagnostics

  - With the engine OFF and the engine control switch in the COOLEDOWN/STOP position, rotate the potentiometer back and forth. Use ET status screen to watch the value of the sensor being simulated change.

  - If the potentiometer is rotated fully in one direction either a short or open circuit diagnostic will be generated after several seconds
• If the potentiometer is rotated fully in the opposite direction the opposite diagnostic will be generated.

• Some diagnostics such as 273-00, “Turbocharger Compressor Outlet Pressure Above Normal,” may be logged even with the potentiometer in the middle of its range.

**Demonstrate an engine de-rate or shutdown**

- The protection and monitoring system must be enabled using ET. Refer to the Troubleshooting guide for instructions on how to set these parameters.

- Rotate the potentiometer to the center of its range.

- Start the engine and allow it to warm up. The engine must be running for this portion of the demonstration.

- While monitoring the status of the sensor being simulated using ET, slowly rotate the potentiometer until the status screen shows a sensor reading that will cause a de-rate condition. This point will vary according to the sensor being simulated and the parameter values programmed into the protection and monitoring system.

- After a delay time of several seconds the de-rate flag should appear at the top of the ET status screen. The delay time required to cause a de-rate will vary according to the times programmed into the protection and monitoring system.

- A shutdown will occur if the condition being simulated persists. Refer to the Operation and Maintenance manual for specific conditions required for a de-rate or shutdown.

**Note:** If the potentiometer is rotated too far an active open or short circuit diagnostic will be generated. This will cause the protection and monitoring feature associated with that sensor to be DEACTIVATED.

**Note:** 3500B Marine Propulsion engines built prior to April 97 do not have an engine shutdown override switch. Due to safety concerns the engine shutdowns were removed from the engine software to prevent engine shutdowns that could not be overridden in an emergency. Therefore, if demonstrating the engine protection and monitoring system on one of these engines only de-rates will be possible.

If desired, the engine de-rate % can be viewed on an ET status screen.

**Note:** Some parameters in the 3500B Protection and Monitoring system do not cause an engine de-rate. Refer to the Operation and Maintenance guide or Troubleshooting guide for information regarding specific parameters.

- De-rate and shutdown events can be viewed in the logged events screen on ET.

- After finishing the demonstration, re-connect all wiring and sensors to original condition and clear any logged codes or events. Then allow the ECM to auto calibrate the sensors. Do this by rotating the engine control switch to START, STOP, or AUTO position for at least 5 seconds while the engine is not running.

The procedure for using throttle position sensor to simulate digital PWM sensors is the same except that the 3E-7700 throttle position sensor is used instead of the 10k potentiometer.
Electronic Technician (ET)
(A software tool for use with Caterpillar electronic engines)

Where Used:
Electronic Technician (ET) is a tool, allowing the user to:

- Flash new engine software on an engine, changing or modifying its rating and/or its operating characteristics
- Examine the engine’s history by downloading histograms
- Determine if there are or have been any engine fault or diagnostic messages
- Observe the engine’s performance
- Perform sea trials
- Initially set up the engine, customizing its parameters to the owner’s specific needs or desires

ET allows the operator to:

- Display parameter status
- View active diagnostics
- View and clear logged diagnostics
- View events where irregularities occurred and where logged by the ECM
- Perform diagnostic tests
- Perform calibrations
- Retrieve engine totals for fuel used

- An on-line help system is available.

For additional help, contact the PC Hotline:
USA and Canada – 800 765 0999
Other countries – 309 675 0999
Fax: 309 675 0725
e-mail: ssschelp@cat.com

Description:
To use Electronic Technician, the user must have:

- A IBM-PC compatible, laptop computer which contains a Pentium 133 MHz processor with no less than 24 Mb of random access memory.
- Microsoft Windows
- A Single User License for ET Ver. 1.4 or later. This is the main ET program.
- A data subscription for all engines and machines.
- A communications adapter group
- A RS-232 Connector Cable. This connects the PC to the Communications Adapter.
- A Connector Cable (Unicable) to connect the ECM to the Communications Adapter.

Versions of Electronic Technician
There are two versions of Electronic Technician: one for dealer technicians and another for use by engine owners and operators.

A brochure describing the dealer version has the form number NEDG6013. A brochure describing the engine owner/operator version has the form number NEDG6015.

Form number NEDG6013 has all of the ordering information for the dealer and engine owners and operators versions.