Application Engineering Bulletin

Subject: **QST30-G GCS Control Manual**	This AEB is for the following applications: ☐ **Automotive** ☐ **Industrial** ☒ **Power Generation**
Author: **Norm Jones**	
Date: **Oct, 2003**	Page 1 of 125 / AEB Number **150.06**
Engine Models included: **QST30-G**	
Fuel Systems included: **Bosch**	

Preliminary

Purpose:

The purpose of this document is to provide detailed application guidelines and recommendations for the G-Drive Control System (GCS) for the QST30-G engines. A description of the system and unique features are discussed.

Scope:

This document applies to the QST30-G engines with GCS only.

Background:

The QST30-G GCS module will provide common electronic tools (InPower) with the QSX15, QSK23/45/60/78 G-Drive engines. The GCS module provides improved engine trouble shooting and safety circuit capabilities.

The QST30 GCS Module though similar to the QSK23/45/60/78 is not interchangeable.

Instructions for the GCS Electronic control module supplied from the factory and for field up fit to the GCS Electronic control are included.

QST30-G GCS Upgrade Wiring Diagram – 4021371
-5 Ft. Extender harness - 3094140
-10 Ft. Extender harness - 3094573

QST30-G GCS Service Wiring Diagram – 4021346

QST30-G GCS Module Part Number – 4067777
Extensions harness required – WR 5010 1.5 meter length (3092195)
- WR 5011 5 meter length (4067898)
- WR 5012 12 meter length (4067899)

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About the Manual

This manual contains information needed to understand, correctly operate and maintain your Generator Drive Control System as recommended by Cummins Engine Company, Inc. Additional service literature (Operation and Maintenance, Shop Manual, Troubleshooting and Repair Manual, etc.) can be ordered by filling out and mailing the Literature Order Form located in the back of this manual.

This manual does **not** cover base engine maintenance procedures. Refer to the Operation and Maintenance Manual, Bulletin for the specific engine model for information.

This manual does **not** cover generator equipment maintenance or repair procedures. Consult the generator equipment manufacturer for specific maintenance and repair recommendations.

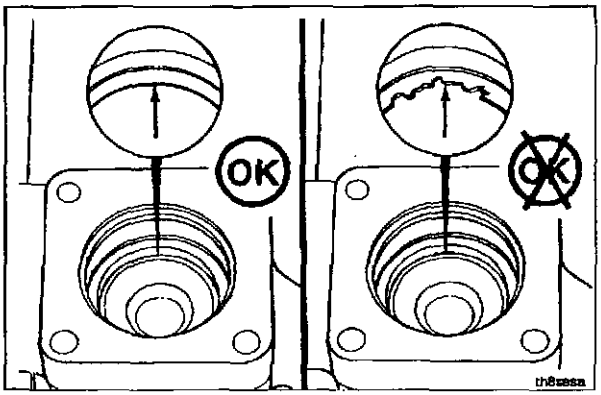
Both metric and U.S. customary values are listed in this manual. The metric value is listed first, followed by the U.S. customary in brackets.

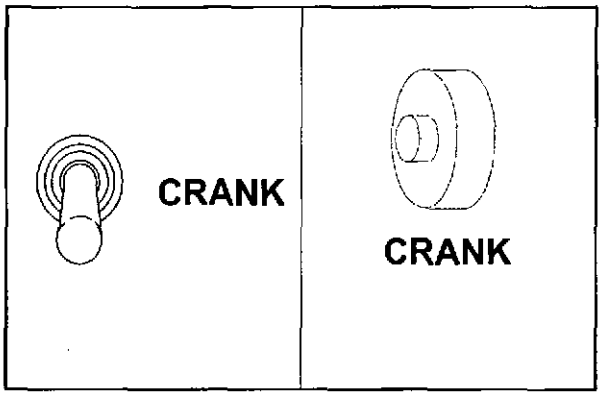
Illustrations

Some of the illustrations throughout this manual are generic and will **not** look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required and an acceptable or **not** acceptable condition.

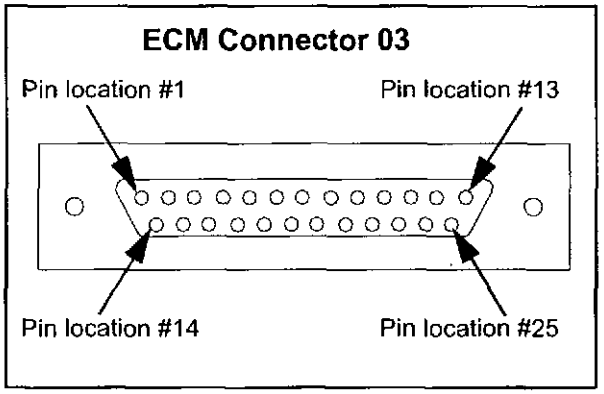
The illustrations included in this manual are intended to illustrate procedures performed or location of particular items.

The procedure performed or location of the item described will be the same even though the illustrations may vary.

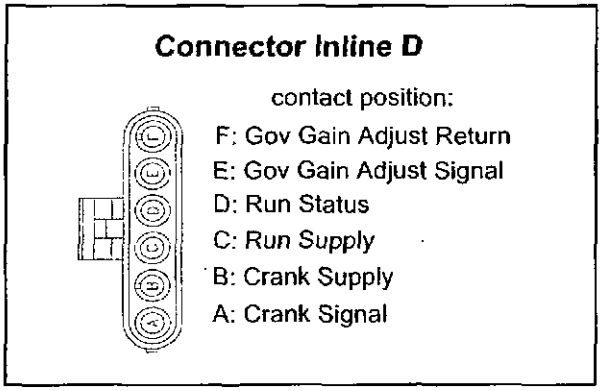




Illustrations showing connector contact positions for connections to the Electronic Control Module (ECM) are shown as viewed looking at the connector on the ECM, not the interfacing connector of the wiring harness.

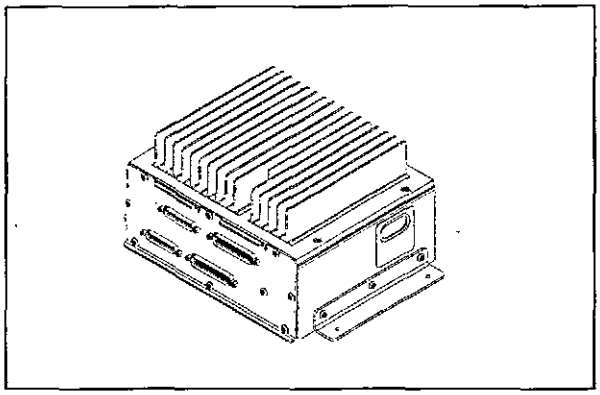


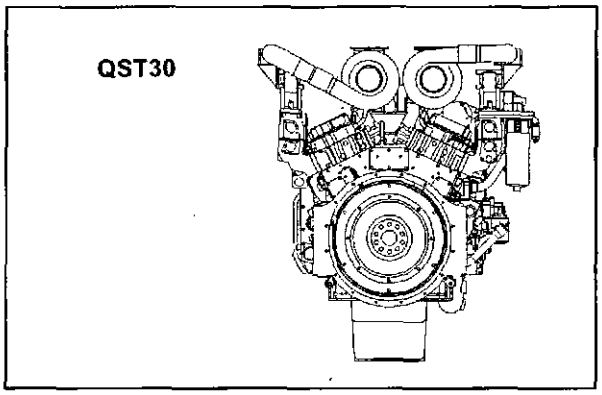
Illustrations showing connector contact positions for connections to the inline connectors of the wiring harnesses are viewed looking at the corresponding connector on the factory supplied engine or extension *wiring harness, not the connector of the interfacing* harness.



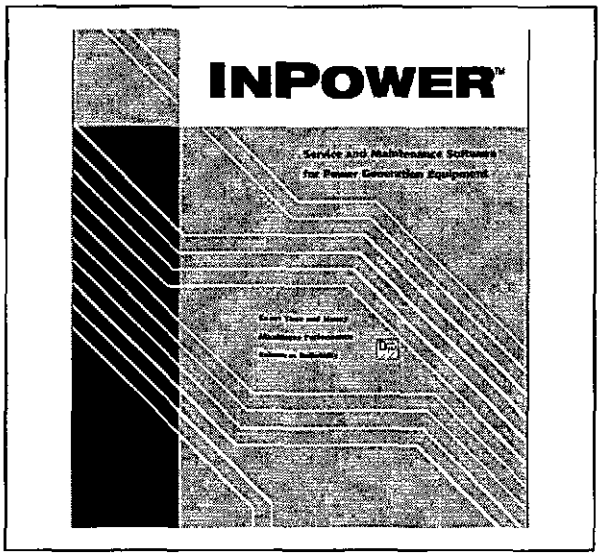
Acronyms and Abbreviations

A	Ampere
AC	Alternating Current
ABO	Area Business Organization
AEB	Application Engineering Bulletin
AMPS	Amperes
AWG	American Wire Gage
BIT	Built-In Test
B+	Battery Positive
°C	Degree Celsius
cSt	Centistokes
COM	Communication
CTS	Cooling Temperature Sensor
CW	Clockwise
CCW	Counterclockwise
CORS	Continuous Oil Replacement System
DC	Direct Current
DSR	Data Set Ready
DTR	Data Terminal Ready
ECM	Electronic Control Module
EMC	Electro-Magnetic Compatibility
EMF	Electro-Motive Force
EMI	Electro-Magnetic Interference
EPA	Environment Protection Agency
EPROM	Erasable Programmable Read Only Memory
EPS	Engine Position Sensor
E-STOP	Emergency Stop
ESS	Engine Speed Sensor
°F	Degree Fahrenheit
FSOV	Fuel Shutoff Valve
ft (FT)	Foot
GCS	Generator-Drive Control System
GND	Ground
GOEM	G-Drive Original Equipment Manufacturer
H_2O	Water
HAT	High Aftercooler Temperature
HBF	High Blowby Flow
HCT	High Coolant Temperature
HFT	High Fuel Temperature
Hg	Mercury
HIT	High Intake Manifold Temperature
HOT	High Oil Temperature
hp	Horsepower
HPI-PT	High Pressure Injection-Pressure/Time. Time is held constant while pressure is adjustable.
HPI-TP	High Pressure Injection-Time/Pressure. Pressure is held constant while time is adjustable.
Hz	Hertz
IEC	International Electrotechnical Commission
IP53	Ingress Protection - Dust-Protected & Spraying Water
IP54	Ingress Protection - Dust-Protected & Splashing Water
In	Inch
kg	Kilogram
kPa	Kilopascal
kW	Kilowatt
lb	Pound
LCL	Low Coolant Level
LCP	Low Coolant Pressure
LED	Light-Emitting Diode
LOP	Low Oil Pressure
mA	Milli-Ampere
mW	Milli-Watts
mm	Millimeter
N-m	Newton-meter
NEC	National Electric Code
NEMA	National Electric Manufacturers Association
O/M	Owner-Operator Manual
OEM	Original Equipment Manufacturer
OPS	Oil Pressure Sensor
OSS	Over Speed Sensor
PC	Personal Computer
p-p	Peak to Peak
P/N	Part Number
psi	Pounds Per Square Inch
PT	Potential Transformer
rpm(RPM)	Revolutions Per Minute
RTU	Remote Terminal Unit
RXD	Receive Data
PWM	Pulse Width Modulator
SCA	Supplemental Coolant Additive
TDC	Top Dead Center
TXD	Transmit Data
URL	Uniform Resource Locator
V	Volts
VAC	Volts-Alternating Current
VDC	Volts-Direct Current
WWW	World-Wide-Web





InPower™
Configurable Feature



Electronic Control Module

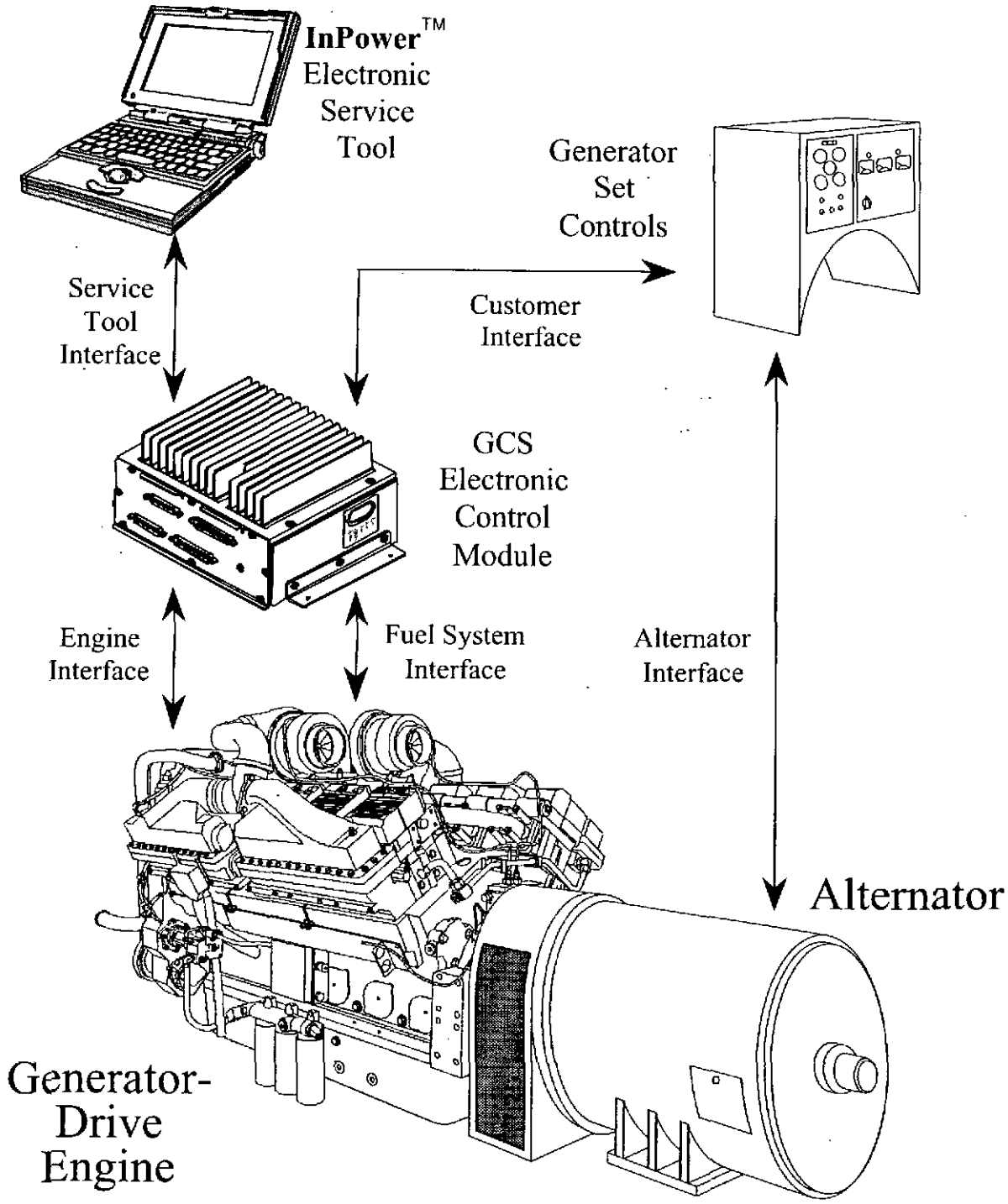
The Electronic Control Module (ECM) is the "brain" of the Generator-Drive Control System (GCS). The ECM is a state-of-the-art electronic digital control device. The primary function of the ECM is to govern the engine speed. The ECM hardware and software provides the following additional features:

- Operator Controls Interface
- Engine Monitoring using:
  - MODBUS Serial Communications Datalink
  - Meter Drivers
  - InPower™ Electronic Service Tool
- Engine Protection
- System Fault Diagnostics
- System Check-Out / Test

There are many features of the GCS that are configured using the InPower™ electronic service tool. InPower™ is a packaged software application that installs on a compatible PC. The configurable features will be discussed in this manual, however, all functions of InPower™ are not covered. Refer to the InPower™ for Generator-Drive Control System Manual for more detailed information about using InPower™. Note that the PC that has the InPower™ software installed requires a separate service cable to communicate with the ECM through the RS-232 service datalink connector on the Engine Harness.

NOTE: *All configurable features are disabled by default (the factory setting is "Disabled"). The customer must enable the features(s), using InPower™, in order to make the feature(s) operational. The steps required to enable specific configurable features are described in the respective sections of this manual.*

ECM Electronic Interfaces



ECM Hardwired Interconnections

The illustration on page 10 shows the features implemented via hardwired interconnections to the ECM, including the on-module Diagnostic LED's and the ECM mounting brackets.

This manual references the applicable ECM connectors and pins where each feature requiring a hardwired interface to the ECM is implemented. Refer to pages 27 through 31 for figures and schematics showing the external component wiring for the engine.

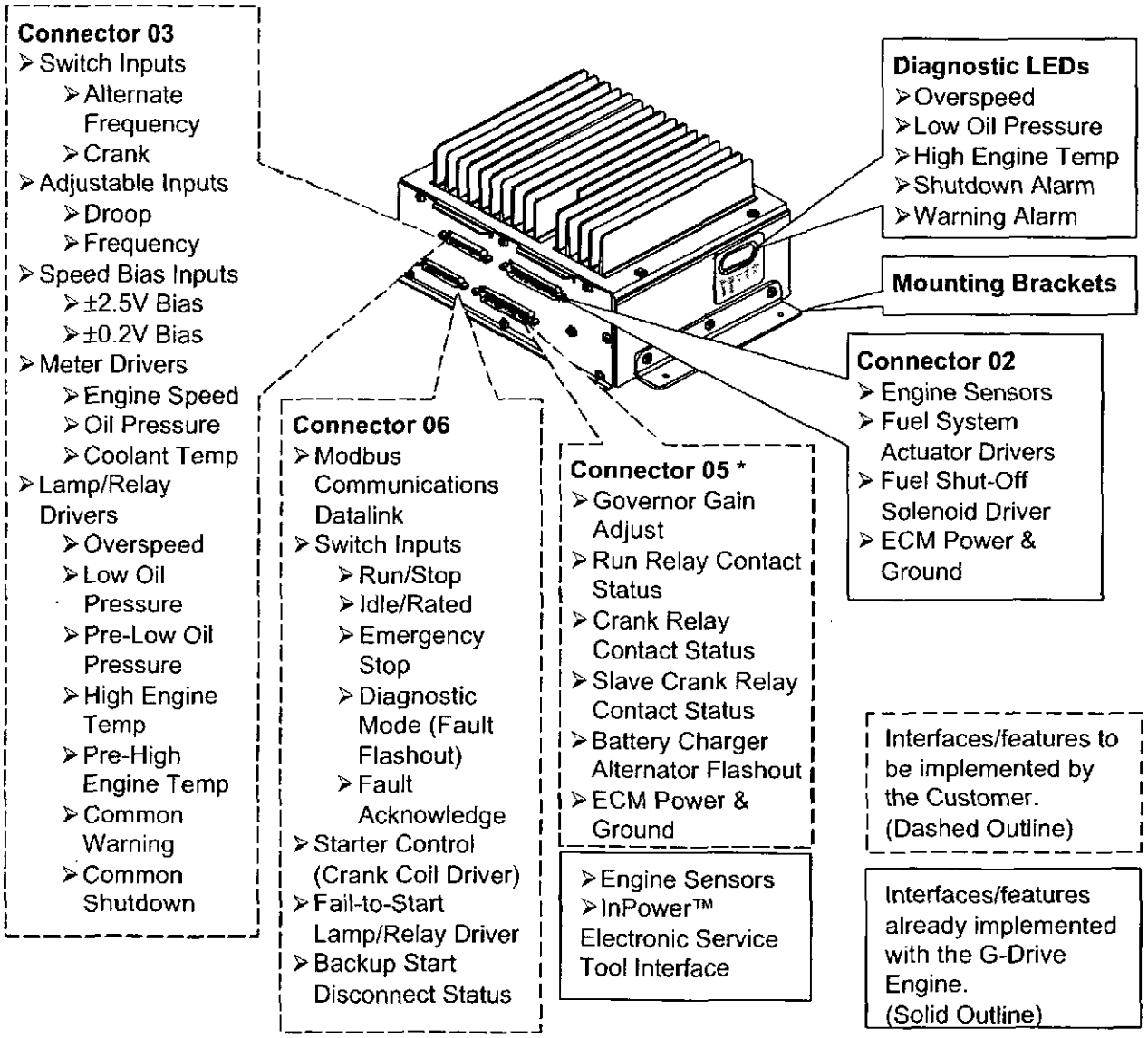
There are pins on the ECM connectors that provide an electrical ground (GND) for all hardwired interfaces requiring a ground reference or signal return path.

⚠ CAUTION ⚠

The use of the ECM ground (GND) pins is required when implementing the hardwired interfaces. The ground reference or signal path for these interfaces must not be connected directly to the battery posts or other grounding points, such as the engine block. Using the ECM GND pins is necessary to reduce the adverse effect of electrical noise on the proper operation of the electronic features.

The ***Electrical Interface Characteristics*** for the hardwired interfaces are specified in Appendix H. All customer connections to the ECM must comply with these interface specifications in order to ensure proper operation of the hardwired features.

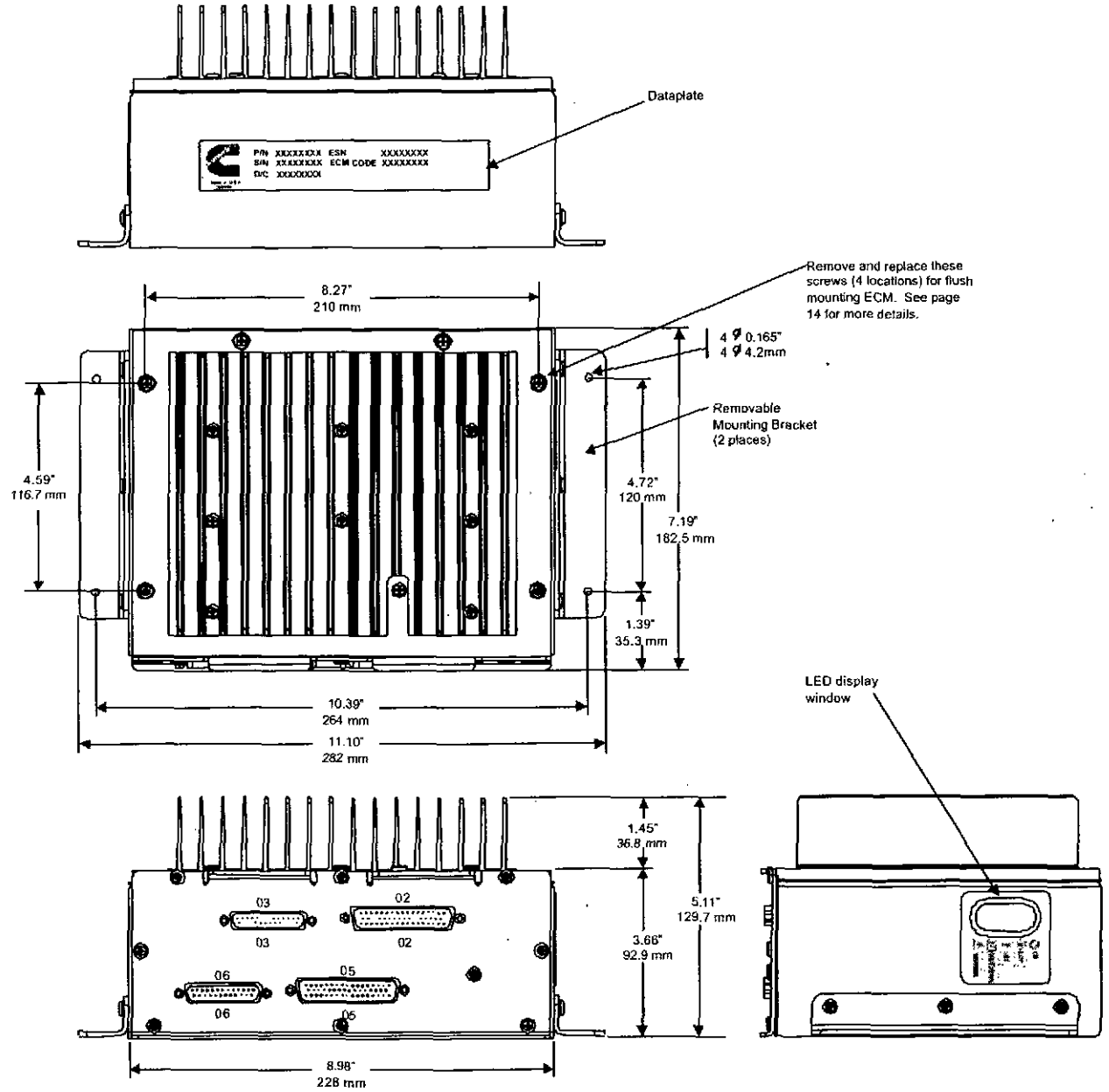
ECM Hardwired Interconnections

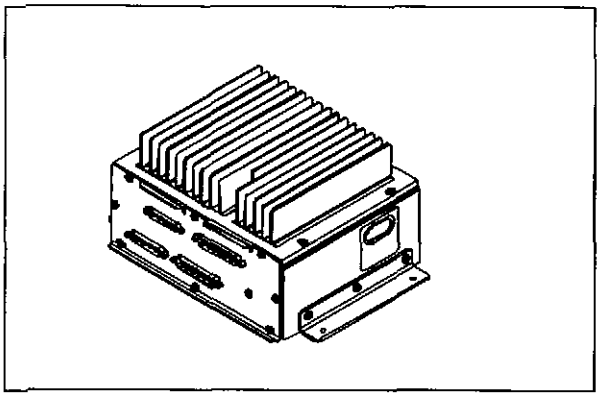


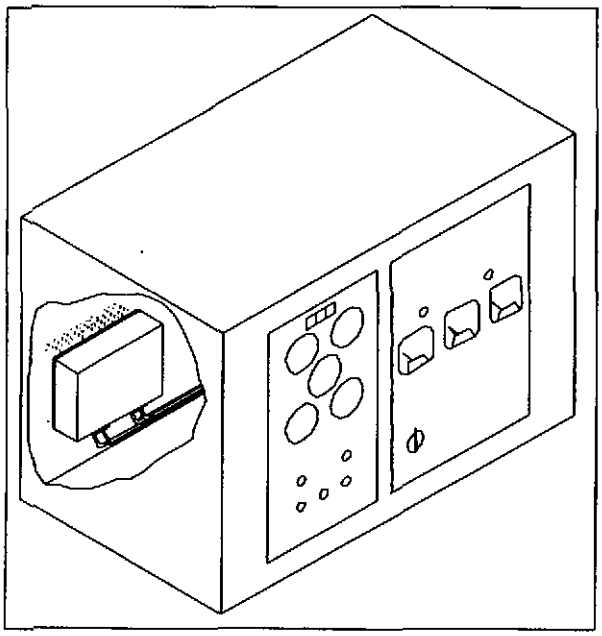
* The features of ECM Connector 05 are accessible to the customer by making the appropriate conections to Inline Connector D of the Extension Harness and Inline Connector E of the Engine Harness.

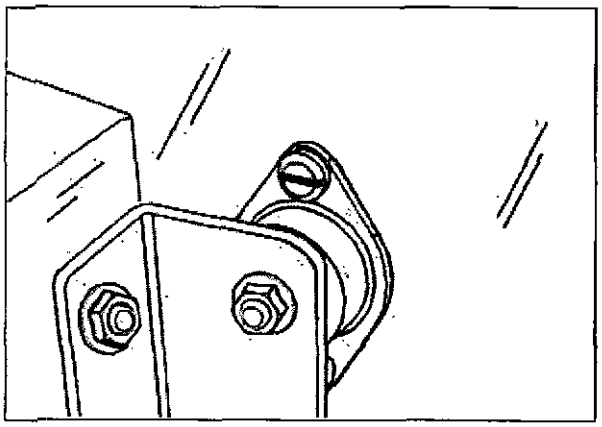
ECM Dimensions

The ECM measures 228.0 x 182.5 x 129.7mm [8.98 x 7.19 x 5.11 in.], including the heat-sink. Refer to the section "Installation" on page 14 for details and cautions before selecting a location for mounting the ECM.









Installation

⚠ WARNING ⚠

To avoid personal injury, or death, it is important that all electrical equipment be properly grounded. All metallic parts that could become energized under abnormal conditions must also be properly grounded.

The chassis of the ECM must be properly grounded to provide protection against EMI and to conduct any fault current that may be imposed on the ECM. Typical requirements for grounding are given in the National Electrical Code. All connections, wire sizes, etc., must conform to the requirements of the electrical codes in effect at the installation site.

Where to Mount the ECM

The ECM is supplied by the factory, with each engine, as a kitted part and needs to be installed by the customer.

⚠ CAUTION ⚠

*The ECM must **NOT** be mounted directly to the engine. It is the customer's responsibility to provide proper mounting and ensure that the mounting method complies with all published environmental and application requirements. See **Appendix H** listing applicable operating and environmental specifications.*

The ECM includes brackets, already attached to the ECM, for installing the ECM with the backside flush to a mounting surface. See the figure on page 16 for details of the bracket mounting hole locations and dimensions.

When the ECM mounting brackets are used to mount, the ECM to a panel or some other structure, the ECM must be adequately isolated to prevent damage due to vibration. If vibration isolators must be used to ensure compliance with the ECM vibration requirements, be sure to follow all manufacturer guidelines when selecting vibration isolators for use with the ECM installation.

***NOTE:** When vibration isolators are used, be sure that specified radial and axial load limits of the isolators are not exceeded. Be sure to provide adequate strain relief by installing clamps and allowing a sufficient bend radius on wiring harnesses.*

⚠ CAUTION ⚠

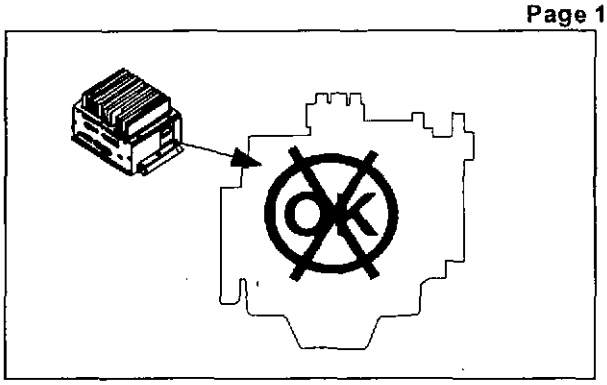
Close attention must be paid to the difference in the ambient cooling air requirements for the ECM and the heat-sink to prevent damage to the ECM. More importantly, pay attention to the maximum expected surface temperature of the heat-sink to avoid personal injury. See ***Appendix H*** *listing applicable operating and environmental specifications.*

It is important that the location of the ECM allows adequate airflow to provide proper cooling to the ECM electronics. In some instances it may be necessary to have the cooling vanes of the ECM heat sink protrude through an opening in the control panel, exposing it to ambient air. When using this means to install the ECM, an opening must be cut in the mounting surface and attachment holes drilled per the template on the following page. Four (4) mounting screws must be removed, two (2) from either side of the heat-sink base, and replaced with screws of the same thread and size but longer by the thickness of the mounting surface. The replacement screws must have the appropriate head to accommodate the holes drilled in the mounting surface (i.e. countersunk or flat).

NOTE: *The mounting brackets are not used in this configuration and can be removed, however, the bracket attachment screws* ***MUST BE REPLACED*** *in the ECM case in order to ensure proper protection against the environment (i.e. dust and water ingress).*

Make sure there is no grease or dirt on the ECM mounting surfaces. Properly tighten the 4 mounting screws per the mounting screw size/grade torque recommendations to prevent mounting failures.

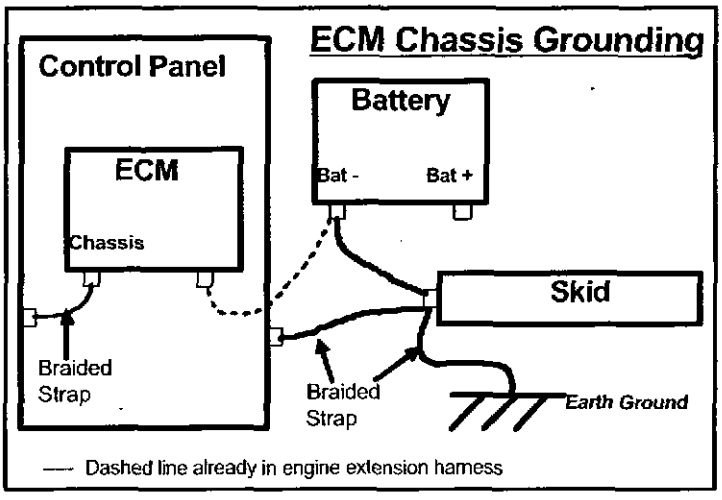
NOTE: *To comply with IP53 and NEMA-3R enclosure spray angle requirements, the ECM must be mounted with the connectors facing down. If the ECM is installed with the connectors facing sideways (heat-sink up), the customer must ensure that the installation complies with IP53 and NEMA-3R requirements. The ECM must* ***NEVER*** *be installed with the connectors facing up or with the heat-sink vanes oriented horizontally (level to the ground). The customer must also ensure that there is sufficient clearance for the wiring harnesses to be mounted to the ECM, and that the harnesses are properly supported to prevent undue stress or strain on both the harness and ECM connectors.*

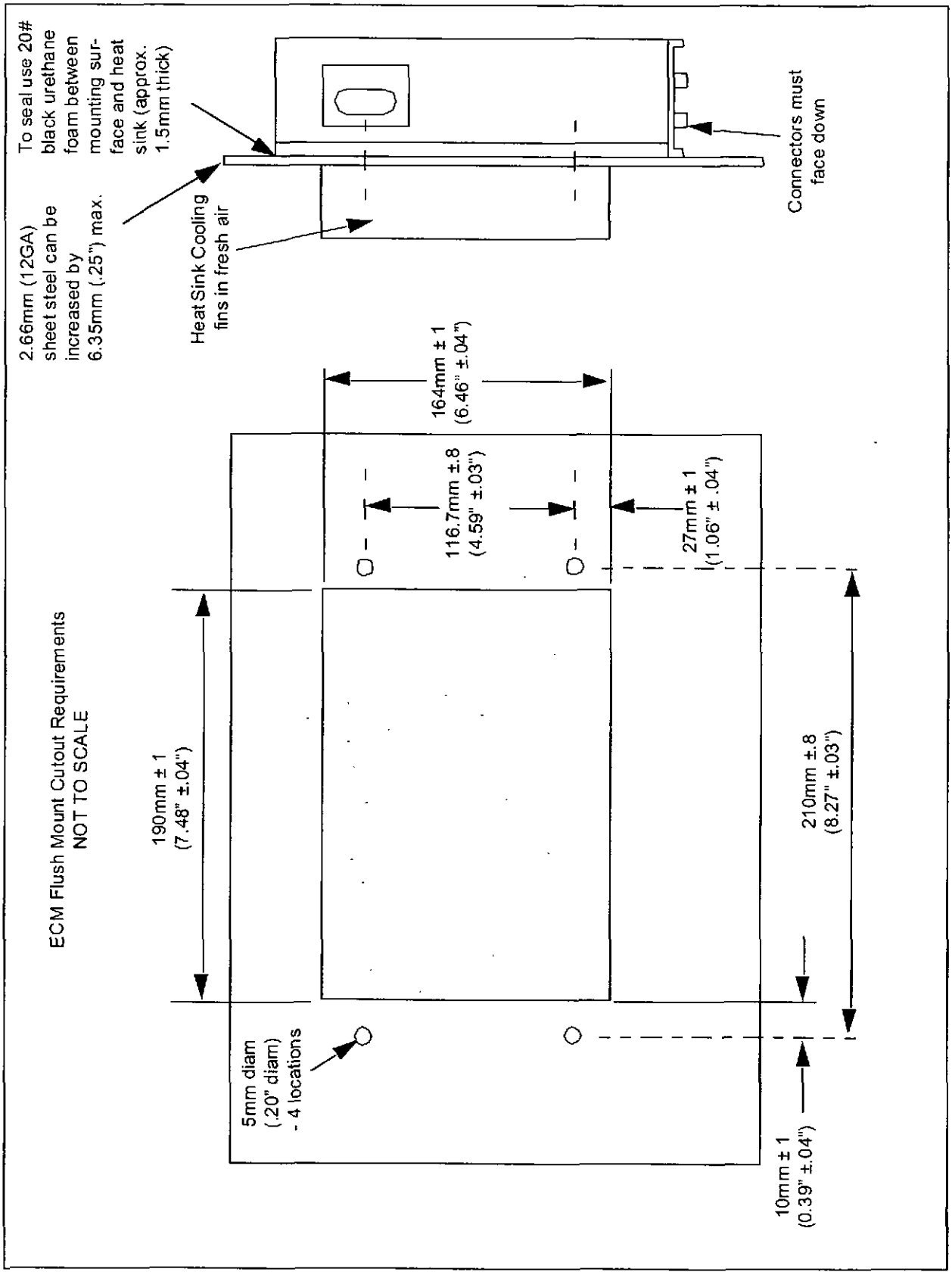


Grounding

In all applications, at the exception of Marine isolated ground systems, the ECM sheet metal enclosure (ECM Chassis Ground) must be connected to earth ground, as well as to the Battery minus terminal. The earth ground connection provides a return path for the EMI noise, such as electrostatic discharge, applied to any connector pins and diverted to the ECM enclosure by internal capacitors. The Battery minus connection to earth ground prevents system noise referenced to Battery minus from entering the ECM via the EMI capacitors.

The figure below suggests a way to implement those requirements. The ECM Battery Ground is connected to the Battery minus terminal via the extension harness and the INLINE (E) connector in the engine harness. A separate wire connects the battery minus terminal to the earth ground (the genset skid, in most cases). The ECM mounting hardware (or a separate braided strap) is used to electrically connect the ECM Chassis Ground to the control panel. A separate wire connects the control panel to the earth ground. For best performance, aim at achieving the lowest possible impedance between the ECM chassis ground and the earth ground, and an impedance of less than 3 ohms between the ECM chassis ground and the Battery minus terminal.




To seal use 20# black urethane foam between mounting surface and heat sink (approx. 1.5mm thick)
2.66mm (12GA) sheet steel can be increased by 6.35mm (.25") max.
Heat Sink Cooling fins in fresh air
Connectors must face down
164mm ± 1 (6.46" ±.04")
116.7mm ±.8 (4.59" ±.03")
27mm ± 1 (1.06" ± .04")
190mm ± 1 (7.48" ±.04")
210mm ±.8 (8.27" ±.03")
5mm diam (.20" diam) - 4 locations
10mm ± 1 (0.39" ±.04")
ECM Flush Mount Cutout Requirements
NOT TO SCALE

The customer is responsible for supplying a wiring harness(es) that interfaces with the two 25-pin ECM connectors, labeled 03 and 06, and the customer connections at Inline connectors D & E. See the ***Wiring Harnesses and Interface Connectors*** section on page 19 for further details.

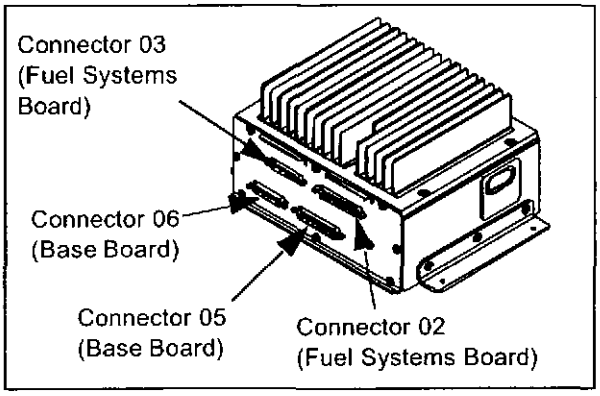
A "keying plate" is attached to the ECM on the side with the connectors. This keying plate has keyways, a polarizing feature, that mate with the backshells included with the keyed connector kits supplied by the factory with each engine. The keying feature of the 25-position connector assemblies built using the kits is designed to prevent improper connection of the customer supplied generator set interface harness to ECM connectors 03 and 06. See ***Appendix F*** for detailed instructions on how to assemble the keyed connector kit parts.

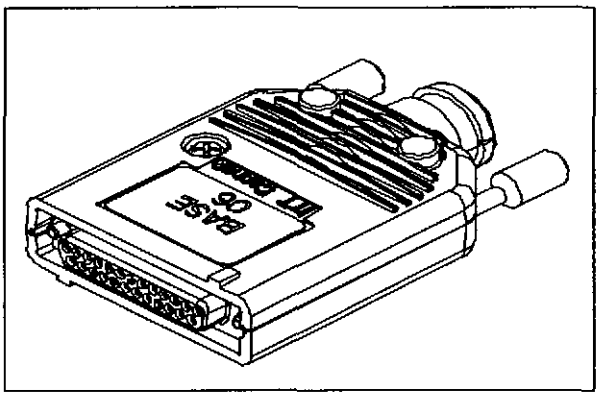
The following chart will assist in identifying the interfacing wiring harness connectors:

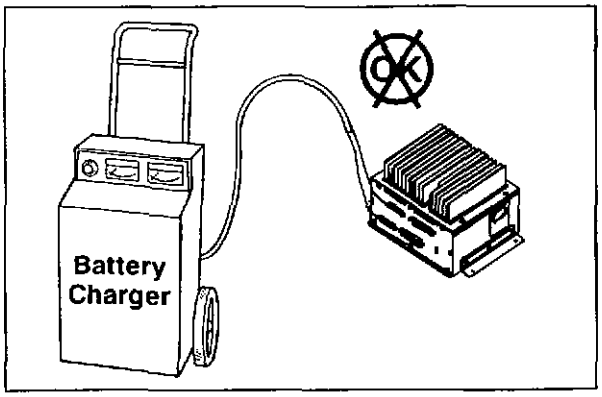
Connector Number	Keying Polarization	Label Color
06	Key A (25 position)	Green
03	Key B (25 position)	Brown
05	Key A (50 position)	Green
02	Key D (50 position)	Orange

NOTE: *When attaching the keyed connectors to the ECM, the thumbscrews should be torqued to 0.79 - 0.90 N m [7-8 in-lb].*

NOTE: *Because the connectors provided with the keyed connector kits are a high quality part using gold-plated terminals, the connectors* ***DO NOT*** *have to be coated or packed with any type of protective lubricant or anti-corrosion compound.*







Power Source

The ECM is designed to operate at a nominal 24 VDC. The ECM can operate normally within a range of 18 to 35 VDC continuous and as low as 12VDC during cranking.

⚠ CAUTION ⚠

Do not connect the ECM to a battery charger. Due to the circuitry and method of operation of the chargers, the governor will not function properly. Connect the battery charger to the battery.

⚠ CAUTION ⚠

To avoid damage to the ECM, disconnect all electrical connections to the ECM and remove the ECM from the generator set prior to using any type of welding equipment that requires electrical power to operate.

NOTE: *To prevent loss of valuable diagnostic information, such as Fault Codes and Snap-shot Data, power must be available to the ECM at all times during normal engine operation and for at least one minute following an engine shutdown.*

Sleep Mode (Low Power Consumption)

The ECM is designed to enter a low power consumption mode, also referred to as "sleep" mode, when the states of all "wake-up" inputs become inactive. When the wake-up inputs are in an inactive state the ECM will go to sleep immediately, without delay. In the sleep mode, the ECM consumes a small fraction of the normal operating power to reduce the load on the genset power supply or batteries. Although the ECM may be sleeping, it will wake-up immediately when any of the wake-up inputs become active and be ready to start and run the engine.

The ECM will wake-up from sleep mode whenever any one or more of the following wake-up signals are active:

* Run/Stop Switch input is set to "Run".
* Diagnostic Mode Switch input is set to "Fault Flash Out Enabled".
* Fault Acknowledge Switch input is set to "Acknowledge".
* Data Carrier Detect (DCD) on pin F of the RS232 Datalink connector is "active (the voltage is +3 to +24VDC). This active state occurs when a computer running the INPOWER service tool is connected to the engine RS232 Datalink and communicating with the ECM.

* The ECM will enter sleep mode whenever ALL wake-up signals are inactive AND there are no unacknowledged or active faults. Following is a list of conditions required for the ECM to go to sleep:
* Run/Stop Switch input is set to "Stop".
* Diagnostic Mode Switch input is set to "Fault Flash Out Disabled".
* Fault Acknowledge Switch input is set to "Not Acknowledge".
* Data Carrier Detect (DCD) input is "inactive" (the voltage is less than +3VDC). This occurs when the computer running the INPOWER service tool is no longer communicating with the ECM.
* No active faults are present and all inactive faults have been acknowledged.

Positive / Isolated Grounding

When using a grounding method other than a negative ground system, where the electrical system ground reference is not connected to Battery (-), the following items must be taken into consideration to prevent damage to the GCS or to other electrical system components:

- Optical isolation devices are recommended for interfacing to the RS-485 Modbus Communications and the RS-232 InPower Electronic Service Tool datalinks.
- Any Load Sharing / Autosynchronization equipment interfacing to the GCS must use the same grounding method or be properly isolated electrically.
- The starter, battery charging alternator, and all wiring harnesses and components (i.e. protection diodes installed to prevent damage to relay contacts or relay drivers) must be designed to operate properly when connected using the grounding method being implemented.

Wiring Harnesses and Interface Connectors

The QST30 engine is shipped with a factory mounted Engine Harness and kit containing the ECM, Extension Harness, including the mate-with connectors, contacts, and connector accessories (keyed backshells and hardware) required for interfacing with ECM connectors 03 and 06. The Extension Harness is 3.3 m [10 ft.] in length. The customer is responsible for manufacturing the harness required for interfacing with ECM connectors 03 and 06.

A wiring harness that integrates the features of Inline Connector E, and other option components pre-installed and delivered with the engine (i.e. Crank Slave Relay, Starting Motor(s), and Battery Charging Alternator) is supplied, and factory installed, when certain options are purchased with the engine. If these options are not purchased with the engine, it is the customer's responsibility to manufacture and install the required wiring harness to interface with all required engine electrical components. All published application guidelines, requirements, and practices must be strictly followed.

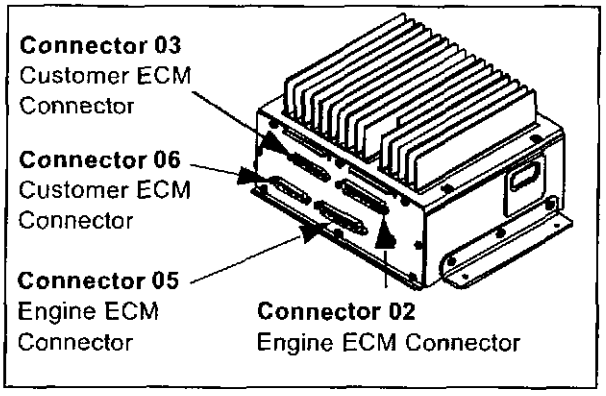
The ECM has four connectors, two 50-pin Engine ECM Connectors connectors (labeled 02 and 05), and two 25-pin Customer ECM Connectors (labeled 03 and 06). Connectors 02 & 05 are used primarily for engine control related features. Connectors 03 & 06 are used primarily for customer control related features.

The Engine ECM Connectors directly interface with the Extension Harness. In conjunction with the Extension Harness, Engine Harness, engine mounted sensors, and engine fuel system, these connectors are used to provide engine sensor information to the ECM and fueling control commands from the ECM to the engine fuel system.

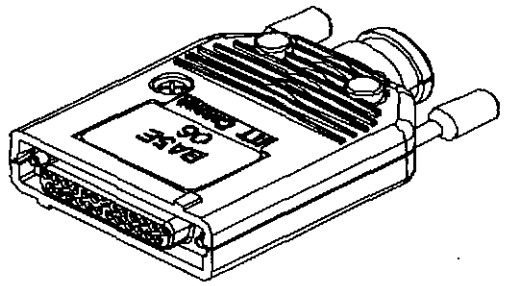
The Customer ECM connectors provide access to customer features of the ECM. It is the customer's responsibility to provide a harness that interfaces directly with these Customer ECM Connectors.

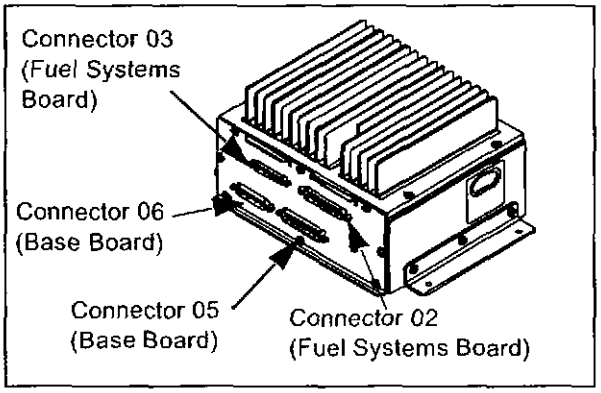
> ***NOTE:*** *The maximum length between the ECM and the location for customer feature terminations (i.e. control panel, switches, potentiometers, speed bias signals, etc.) is 15.24 m [50 ft.], with the exception of the Modbus RS-485 communications data bus.*

See the ***Modbus Communications Datalink*** section on page 84 for further details. The conductor size to be used for the customer generator set interface harness terminations to the Customer ECM Connectors is 0.5 mm^2 [20 Ga.].

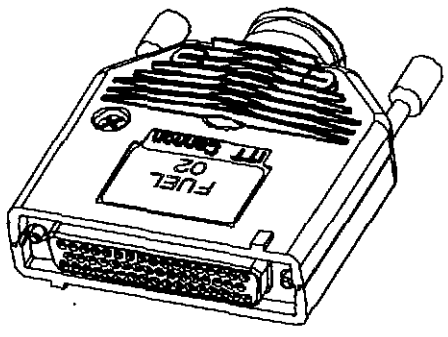


Customer ECM Connector 06





Engine ECM Connector 02



Keyed connector kits are included with each engine. The connector kits contain all of the necessary connector hardware required for the customer to interface with the two Customer ECM connectors. This includes the two 25-position mating connectors, a grommet for each connector, the necessary quantity of contacts, and the keyed connector backshells. The connector kits do not include the wires, or the hardware required to terminate the wires at the opposite end of the wiring harness (i.e. control panel terminations). See the ***Installation*** section on page 14 for further details about assembling the keyed connector kits and installing the customer supplied generator set interface harness.

The connector contacts provided in the keyed connector kits accept 0.5 mm^2 [20 Ga.] size conductor wire.

> ***NOTE:*** *The contacts included in the keyed connector kits are a non-standard part meeting high quality requirements. Substitute contacts* ***MUST NOT*** *be used.*

The connector backshells provided with the keyed connector kits have a polarized keying feature that, when properly installed on the customer generator set interface harness, prevents incorrect harness connections to the ECM.

> ***NOTE:*** *The customer is required to build the generator set interface harness using the hardware provided with the factory supplied keyed connector kits. Warranty claims related to the Customer ECM Connectors* ***WILL NOT*** *be honored unless the connector kit parts are used and assembled in accordance with the instructions supplied with the kits.*

Engine ECM Connectors

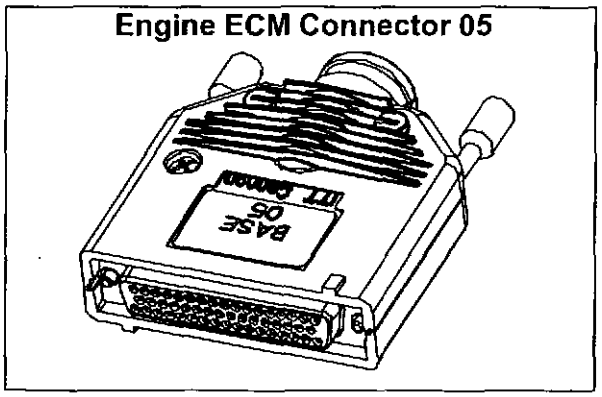
Connector 02

Engine ECM Connector 02 (Fuel System Board Connector) is a male 50-position D-subminiature plug with pins. The mate-with female connector on the Extension Harness is a 50-position D-subminiature receptacle with sockets.

Connector 05

Engine ECM Connector 05 (Base Board Connector) is a male 50-position D-subminiature plug with pins. The mate-with female connector on the Extension Harness is a 50-position D-subminiature receptacle with sockets.

> ***NOTE:*** *Both connectors 02 and 05, which are part of the factory supplied Engine Harness assembly, have a keying feature that prevents them from unintentionally being interchanged with one another.*



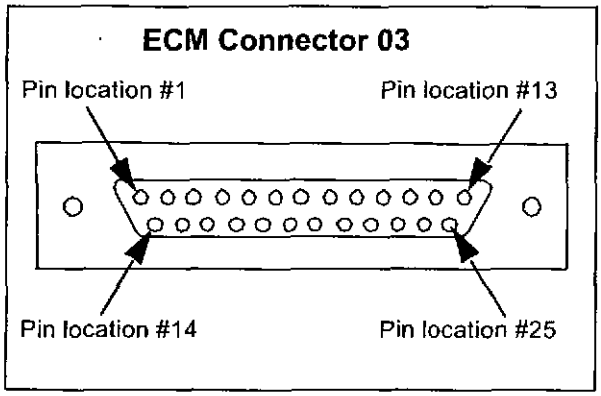
Customer ECM Connectors

Connector 03

Customer ECM Connector 03 (Fuel System Board Connector) is a male 25-position D-subminiature plug with pins. The mate-with female connector on the customer supplied generator set interface harness is a 25-position D-subminiature receptacle with sockets.

The following customer features are accessible via hardwired interface to Connector 03:

- Alternate Frequency Switch
- Crank Switch
- Droop Adjust
- Frequency Adjust
- ±2.5V Speed Bias
- ±0.2V Speed Bias
- Engine Speed, Oil Pressure and Coolant Temperature Meter Drivers
- Overspeed (OS), Low Oil pressure (LOP) and High Engine Temp (HET) Shutdown Lamp/Relay Drivers
- Pre-LOP and Pre-HET Warning Lamp/Relay Drivers
- Common Warning Lamp/Relay Driver
- Common Shutdown Lamp/Relay Driver

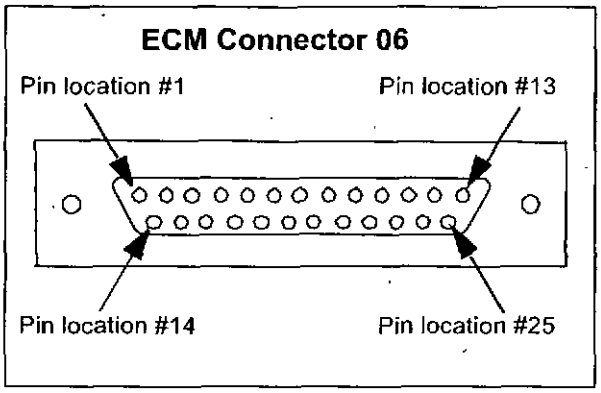


Connector 06

Customer ECM Connector 06 (Base Board Connector) is a male 25-position D-subminiature plug with pins. The mate-with female connector on the customer supplied generator set interface harness is a 25-position D-subminiature receptacle with sockets.

The following customer features are accessible via hardwired interface to Connector 06:

- Modbus RS-485 Communications Datalink
- Run/Stop Switch
- Idle/Rated Switch
- Emergency Stop Switch
- Diagnostic Mode Switch (Fault Flash Out Enable)



- Fault Acknowledge Switch
- Starter Control (Crank Relay Coil Driver)
- Fail-to-Start Lamp / Relay Driver
- Backup Start Disconnect Status

NOTE: *As mentioned prior, the factory supplied connector kits for connectors 03 and 06 include backshells with a keying feature that, when properly installed on the customer generator set interface harness, prevents them from unintentionally being interchanged with one another.*

Extension Harness

The Extension Harness provides the means for mounting the ECM off of the engine, elsewhere on the generator set or some other remote location. This is accomplished by extending the circuits from the Engine Harness Inline connectors, located near the engine's flywheel housing, to ECM Connectors 02 and 05. The Inline Connectors comply with IP54/NEMA-4 specifications.

The Extension Harness allows access to the following customer features of ECM connector 05 via hardwired interfaces to Inline Connector D:

- Inline Connector D
  - Governor Gain Adjust
  - Run Relay Contact Status
  - Crank Relay Contact Status

Engine Harness

The factory supplied Engine Harness allows access to the following customer features of ECM connector 05 (including both connectors 02 and 05 for ECM Battery (+) and GND) via hardwired interfaces to Inline Connector E and the 1-Pin Weather-Pack connector:

- Inline Connector E
  - Crank Slave Relay Coil Supply Voltage
  - Crank Slave Relay Contact Status
  - ECM Power [Battery (+)]
  - ECM Ground [GND]
  - Battery Charging Alternator Flashout

Further details discussing customer connections to each Inline Connector follow.

Inline Connectors

Inline Connector A, B and C

Inline Connectors A, B and C contain wiring for timing and fueling control actuators, the fuel shut-off solenoid driver, engine sensors, diagnostic mode enable, and service tool RS-232 communications datalink signals. Pre-wired by Cummins, OEM wiring is ***prohibited*** at these inline connectors.

⚠ CAUTION ⚠

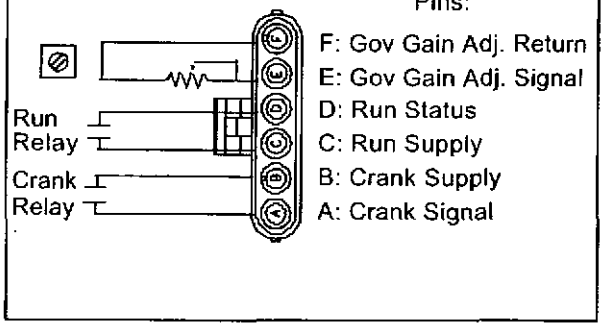
No attempt should be made to bypass existing engine sensors or actuators or to operate the engine using 3rd party governor control systems.

Inline Connector D

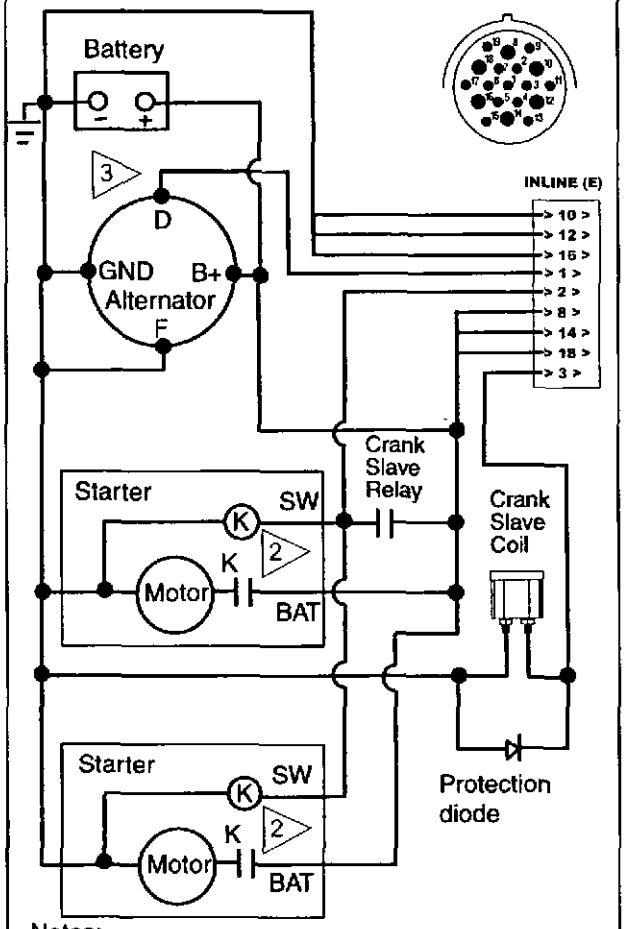
The inline connector D requires customer supplied wiring for Crank Relay contacts, Run Relay contacts, and the Governor Gain Adjust potentiometer.

NOTE: *The Run Relay contact connections are only used when the battery charging alternator requires additional energy to turn-on voltage regulation at low speeds. See the description of the Alternator Flashout feature on page 27 for further details.*

Customer Supplied Wiring for Inline D



OEM wiring for Inline E 1



Notes:

1 *Cummins offers options for purchasing a* battery charging alternator and / or starting motor(s) with the engine. If either option is purchased, the appropriate wiring harnesses are included. If the customer has not purchased either of these options and chooses to install their own electrical accessories, they must also provide the proper wiring harness that interfaces to Inline Connector E.

2 "K" indicates relay and associated contacts.

3 "D" indicates Charging Alternator Flashout Terminal

Inline Connector E

The QST30 utilizes a 19 pin inline connector for crank signal and status, Battery (+) and Ground (GND) connections.

If either the optional battery charging alternator or optional starter(s) are not purchased with the engine, the customer must supply the required wiring harness that interfaces with Inline Connector E and the customer supplied device(s).

When using a customer supplied starter or alternator the following electrical system and controls related application items must be considered:

- Starter Motor(s)
  - *Starting system voltage*
  - Case grounded or case insulated
  - Magnetic switch mounting
  - Battery cranking capacity
  - Special requirements for cold cranking (i.e. additional battery capacity)
  - Wiring and connections
    - > Cable Routing
    - > Electrical grounding/bonding
    - > Cable size (voltage drops & circuit resistance)
    - > Diode protection of relays and relay drivers

⚠ WARNING! ⚠

Due to the high Pull-In and Hold-In current draw of the typical starter motor solenoid, a magnetic switch (also called Crank Slave Relay) is required. When using a magnetic switch, a primary Crank Relay must be used to power the magnetic switch (Crank Slave Relay). A protection diode, sometimes referred to as a free-wheeling or fly-back diode, must be installed in parallel with the magnetic switch coil to prevent back-EMF from the coil causing damage to the primary Crank Relay contacts.

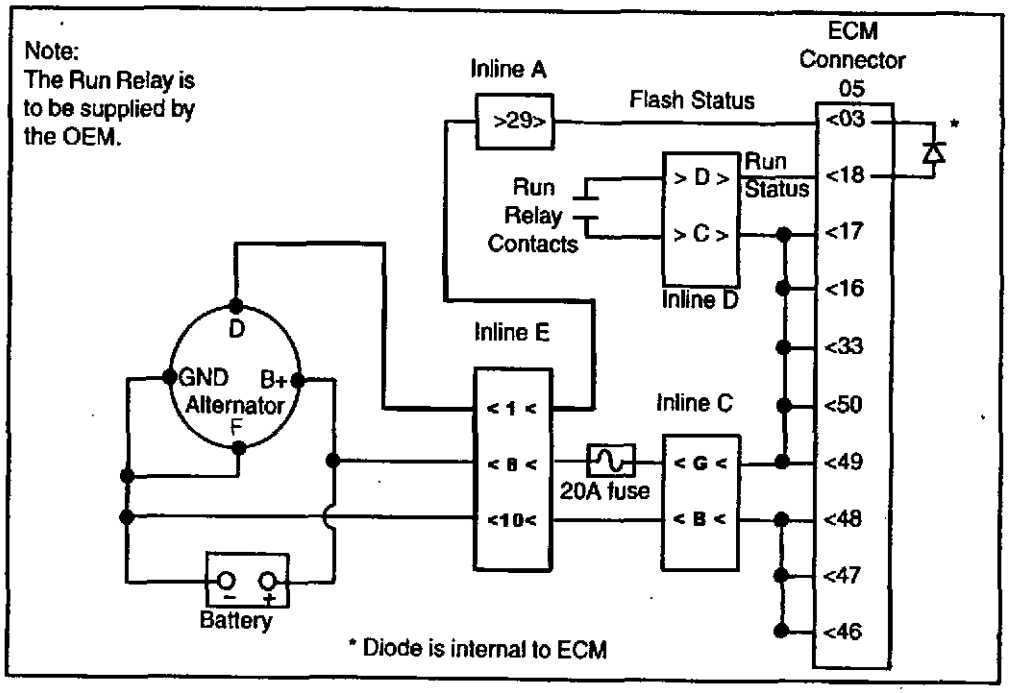
- Alternator
  - Cable Routing
  - Electrical grounding/bonding
  - Cable size (voltage drops & circuit resistance)

Battery Charging Alternator Flashout

The Alternator Flashout output provides battery power (supplied through the Run Status input on pin 18 of ECM connector 05) to the rotor windings of the battery charging alternator when the Run Relay contacts at connector Inline D (Pins C & D) are closed. The Flash Status output (Alternator Flashout output) is used on some battery charging alternators to provide the additional energy required to turn on the alternator voltage regulator at low speeds.

The customer can implement this feature by connecting the battery charging alternator flashout terminal to the appropriate pin of Inline Connector E. The contacts of a Run relay must be connected to pins C & D of Inline Connector D to supply battery power, through the ECM, to the alternator flashout terminal when the Run Relay is energized.

NOTE: *If the alternator flashout output is not used, the Run Relay contact connections to Inline Connector D* ***DO NOT*** *need to be made.*



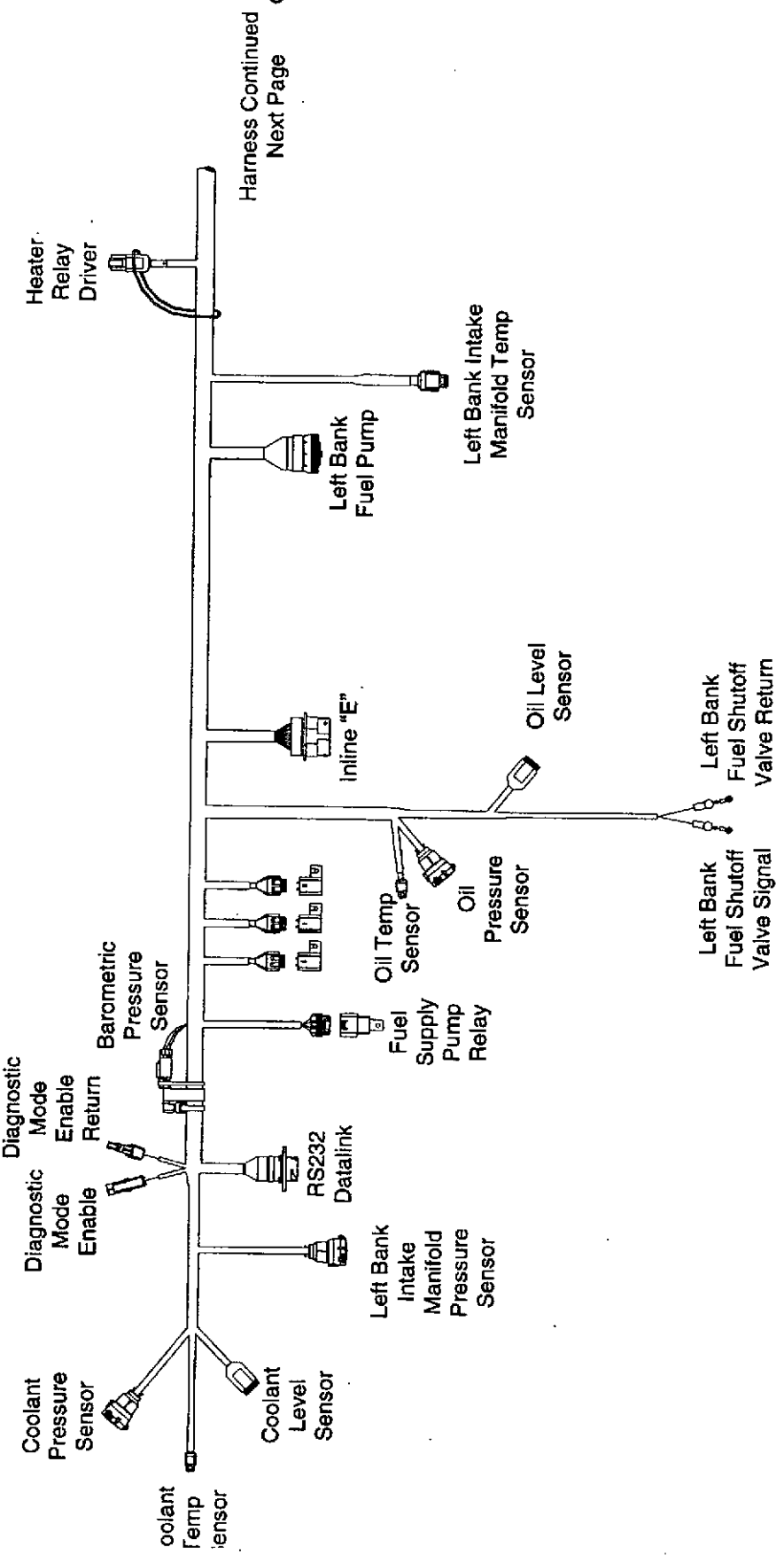
Inline Connector D & E Mating information		
Connector & Contact Position	Mate-With Part No. *	Description
Inline D	12010975	Packard Weather-Pack 6-position Shroud
A & B	12124587	3.0 mm^2 (12 AWG) Weather-Pack Male Terminal
C thru F	12089040	0.5 mm^2 (20 AWG) Weather-Pack Male Terminal
Inline E	HDP26-24-19SE	Deutsch 19-Position Connector
1 & 2	1062-16-0122	0.8 mm^2 (12 AWG) Deutsch Female Terminal
3, 8, 10, 12, 14, 16, 18	1062-12-0166	3.0 mm^2 (12 AWG) Weather-Pack Female Terminal
* For all Packard Weather-Pack terminals, use the cable seal specified on the corresponding manufacturer's drawing for each terminal.		

Inline Connector Mate-With Information

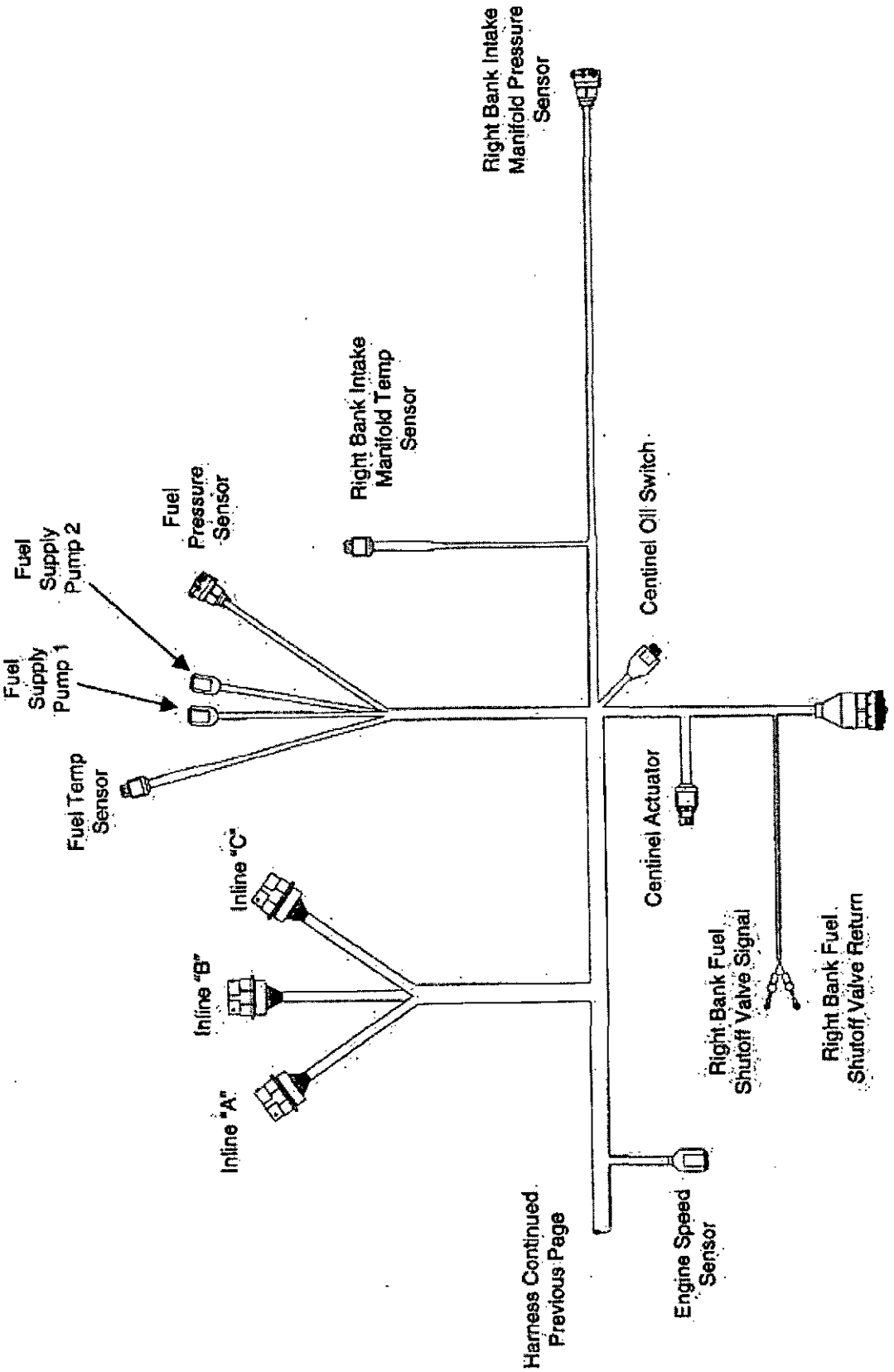
Mating connector information for Inline connectors D & E are identified at the left. Each conductor of the mating connector should use the specified terminal size and the corresponding wire conductor size.

The following pages include figures showing the various sensor connection locations on the wiring harnesses. Also included are figures, and schematic diagrams, for the optional battery charging alternator and starter system options available for purchase and use with the respective engines.

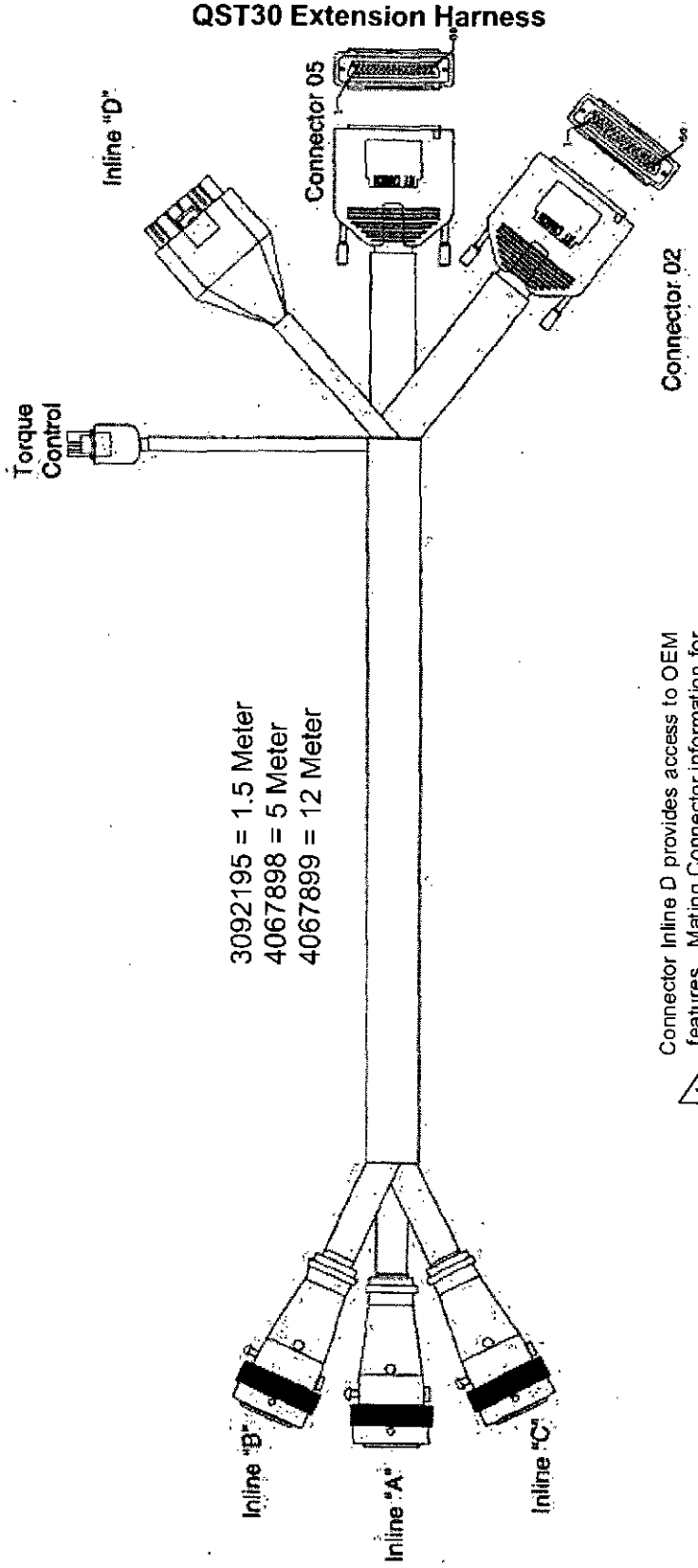
QST30 Engine Harness



QST30 Engine Harness (Continued)

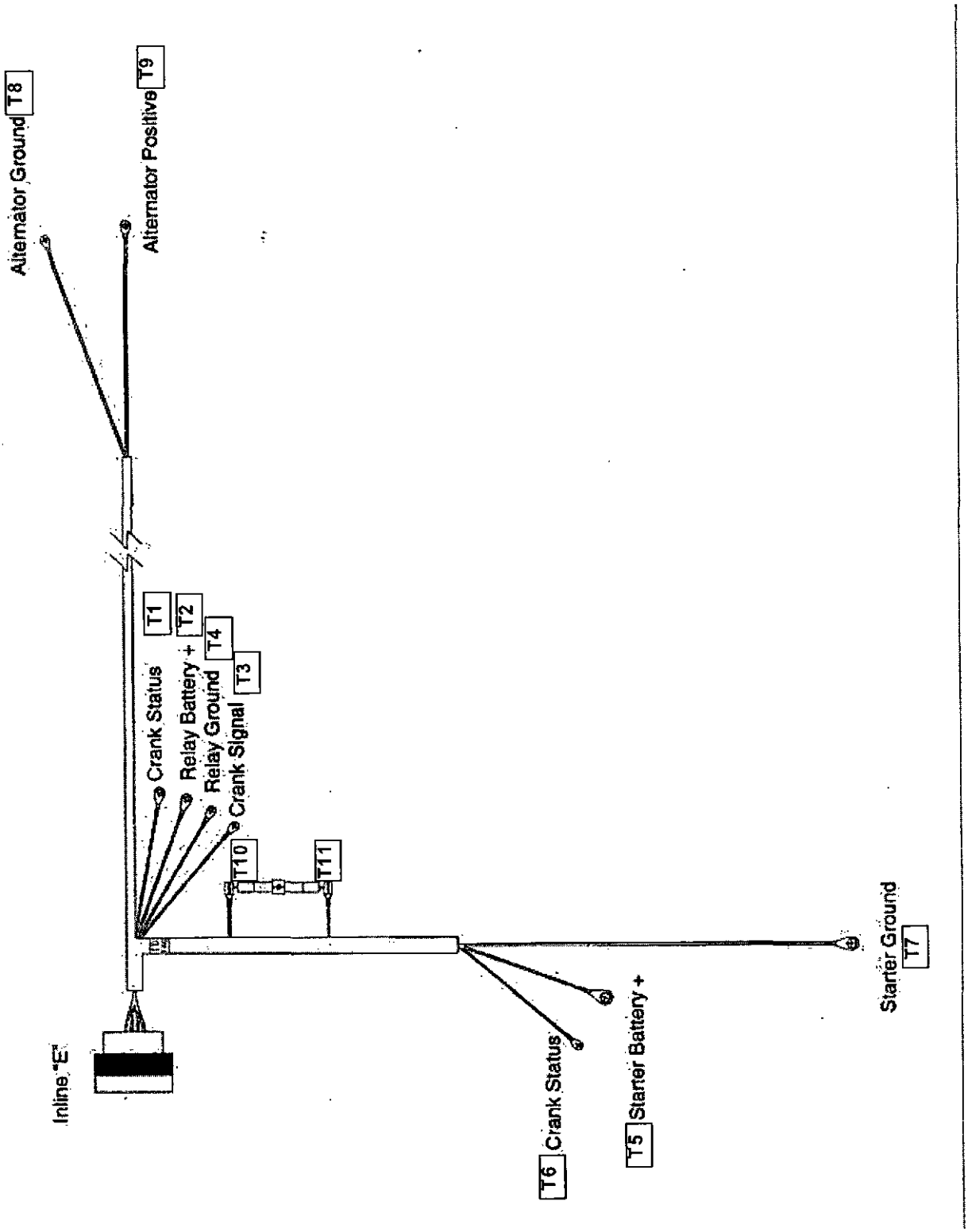


QST30 Extension Harness

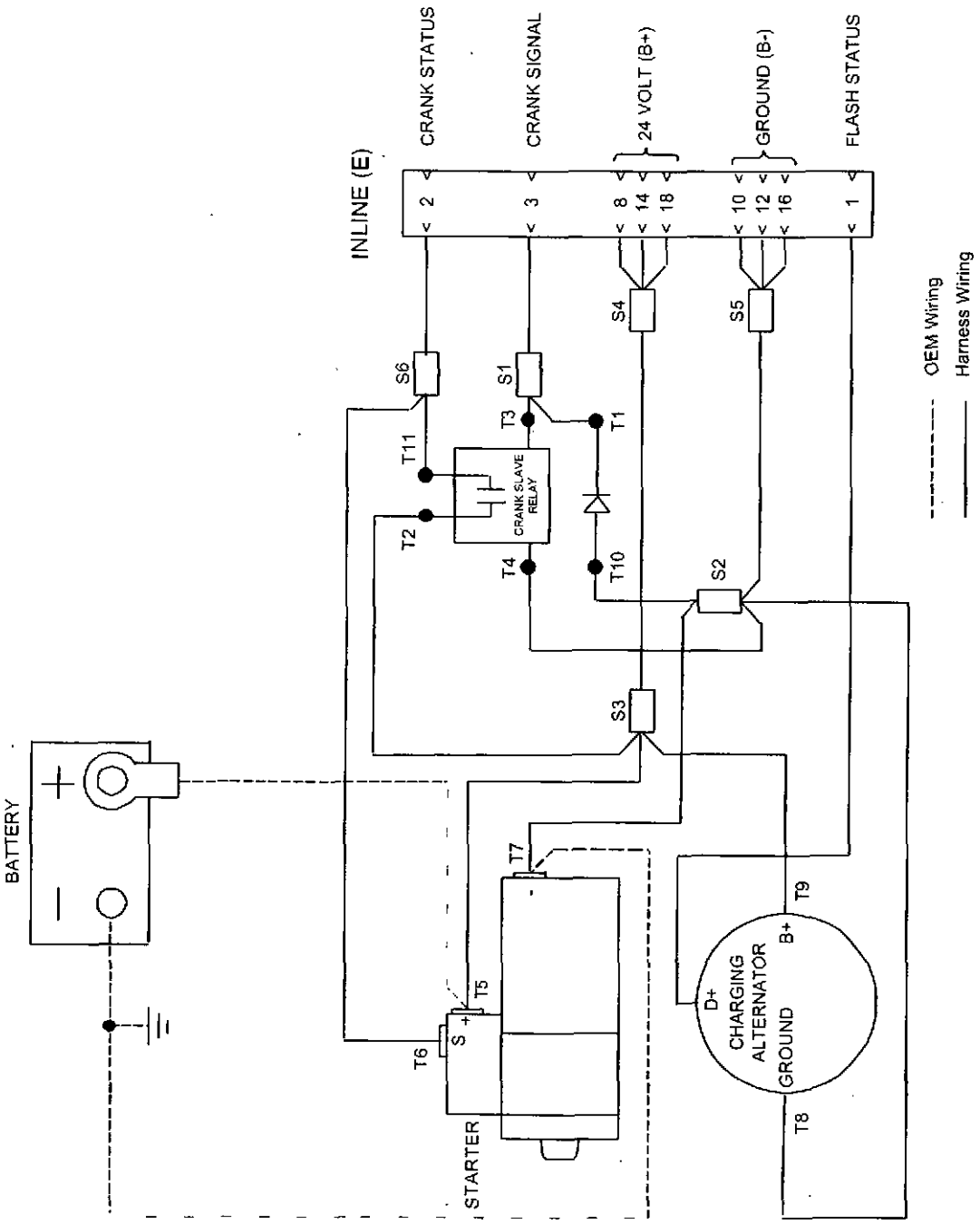


1 Connector Inline D provides access to OEM features. Mating Connector information for this connector is provided on page 28.

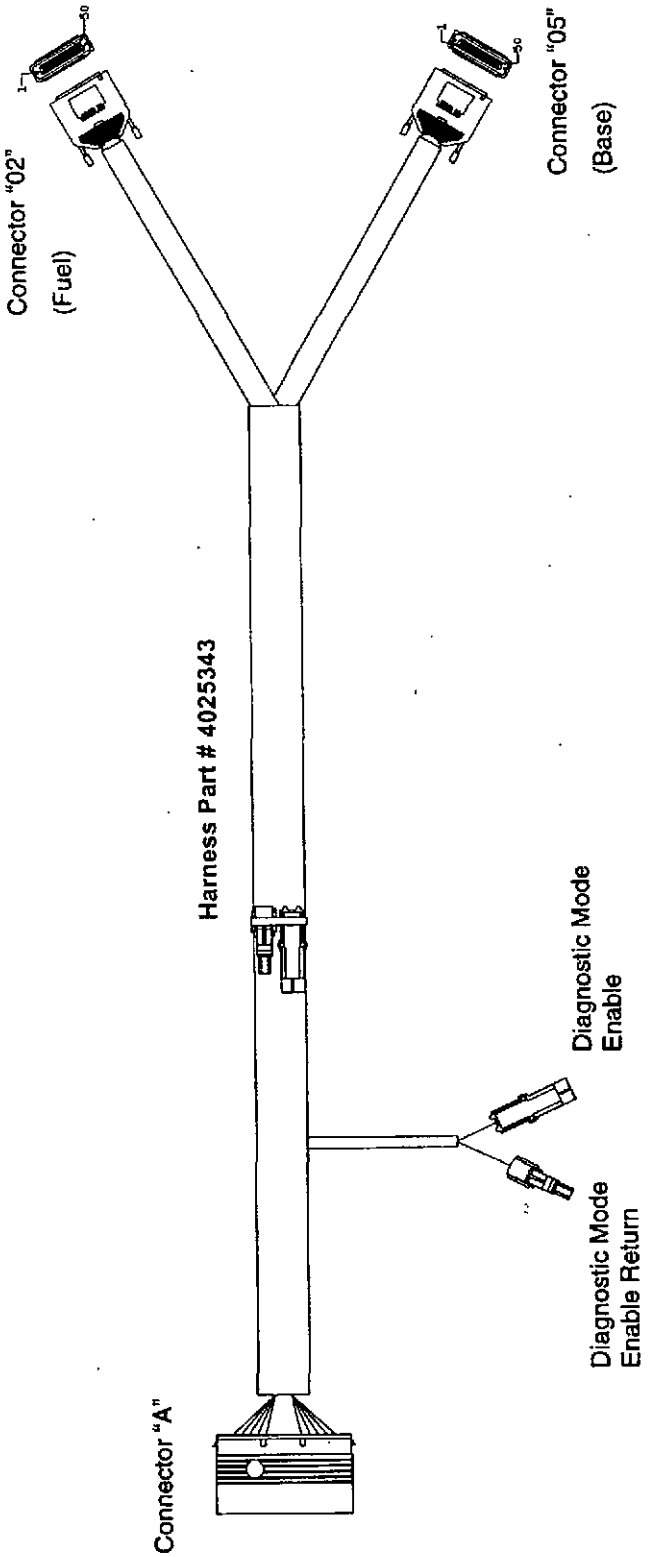
QST30 Alternator and Starter Harness



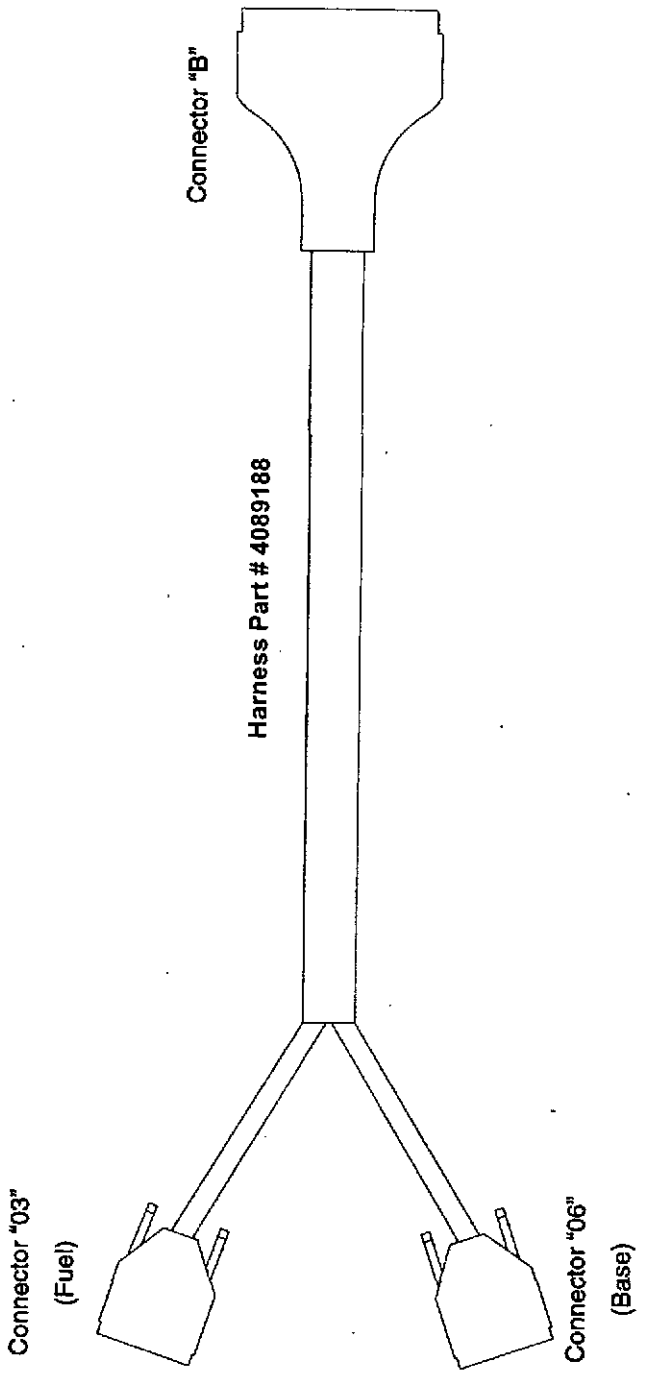
QST30 Alternator and Starter Wiring Schematic

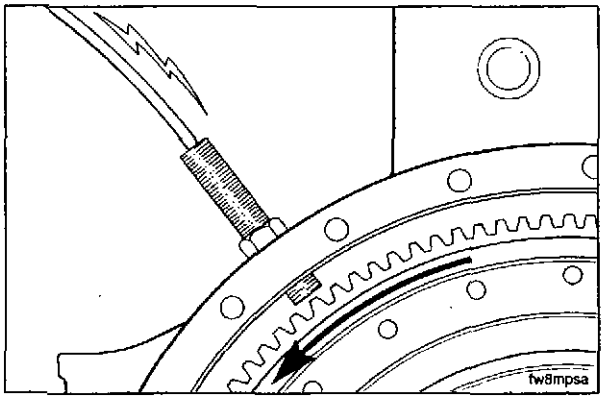


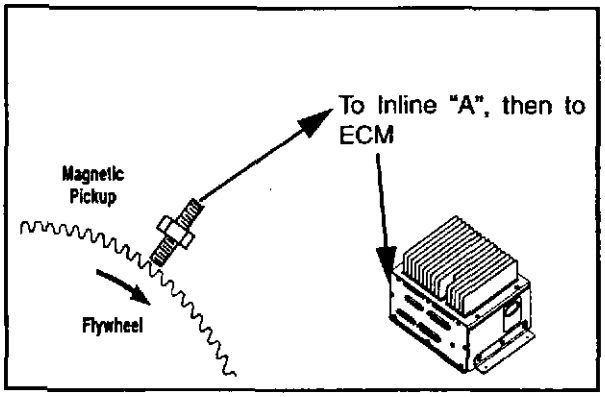
QST30 Engine Converter Harness

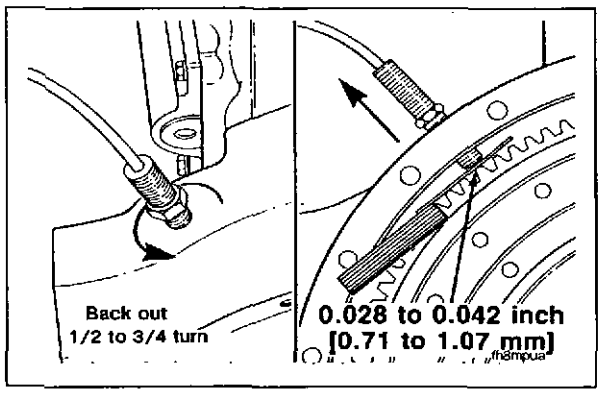


QST30 OEM Converter Harness









Magnetic Pickup Adjustment

The QST30 engine models us a magnetic pickup type sensor, an electromagnetic device, mounted in the flywheel housing for detecting engine speed. The flywheel housing is set up with two magnetic pickup hole locations. One of these two hole locations is used for the GCS speed sensor.

The GCS speed sensor is a dual-coil magnetic pickup design that has two connectors, one for each coil. Both coils must be connected to the engine harness to provide backup speed detection in the event that one of the two coils fails.

To adjust the speed sensor, ensure that a ring gear tooth is centered under the magnetic pickup hole. Rotate the flywheel if necessary.

Screw the magnetic pickup in until it contacts the targeted gear tooth. The magnetic pickup will screw in very easily; do not use excessive pressure.

NOTE: *If the magnetic pickup does not turn with finger pressure, check the hole and magnetic pickup threads. Chase threads with a tap if necessary. Using a magnet, remove any chips created by the tap.*

Back the magnetic pickup out (counterclockwise) 1/2 to 3/4 turn.

If a feeler gauge can be inserted between the magnetic pickup and the flywheel ring gear tooth, back the magnetic pickup out 0.71 to 1.07 mm [0.028 to 0.042 in.] from the gear tooth.

Tighten the jam nut on the flywheel housing. While holding the magnetic pickup, torque the jam nut to 34-47 N·m [25-35 ft-lb].

⚠ CAUTION ⚠

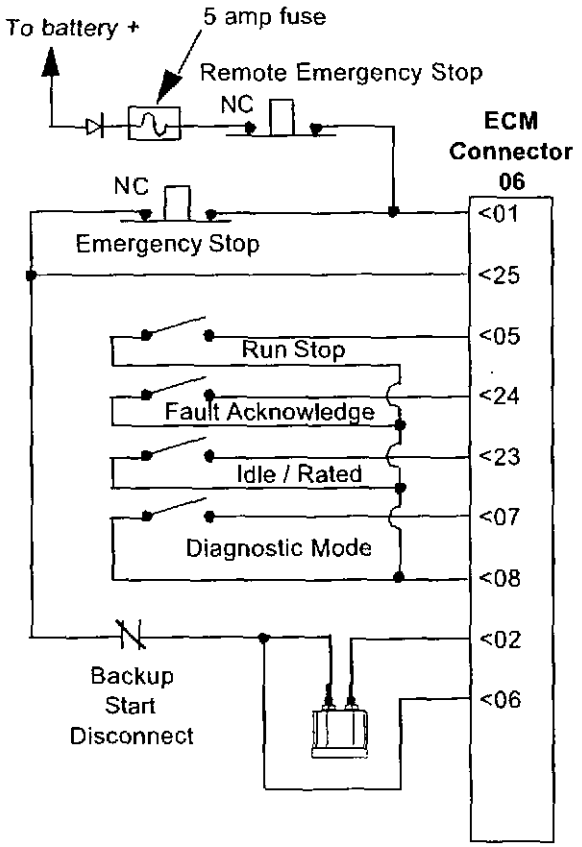
Jam nut over-torque will damage the magnetic pickup.

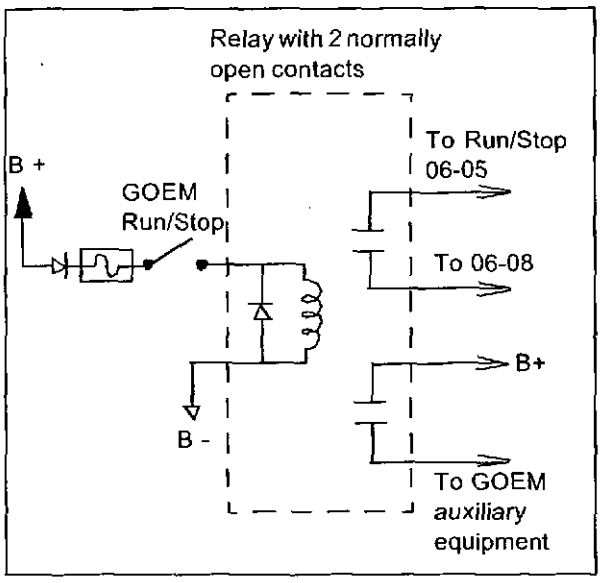
When a ring gear tooth passes the magnetic pickup, an AC voltage is induced producing the speed signal for the ECM. One cycle is induced for each gear tooth.

The speed sensor is connected to the ECM speed sensor signal and return pins via extension harness Inline connector A. The voltage generated by the speed sensor should be between 2.5 to 50 V_{p-p} under any running condition (cranking or run speeds).

If the magnetic pickup signal is less than 2.5 V_{p-p} when cranking the engine, screw the pickup in (clockwise) 1/8 to 1/4 turn.

NOTE: *One of the two magnetic pickup connectors can be disconnected in order to measure the speed sensor voltage at the sensor. Be sure to re-connect the magnetic pickup connector once all measurements have been completed.*





Run/Stop Controls

The information in this section pertains to running or stopping the engine.

Run/Stop

A Run/Stop input is provided to enable starting, running, and stopping the engine.

When used in conjunction with the Crank switch input, when the Run/Stop input is in the "Run" state, the ECM will enable the Starter Control and fueling control for starting and running the engine. See the ***Crank*** feature description on page 41 for further details.

In "Stop" state, the ECM will command the engine to stop running and inhibit starting once the engine has stopped.

To implement this feature, the customer supplies a bi-state signal, to pin 5 of ECM connector 06. Pin 8 of ECM connector 06 is used to supply an electrical signal path to GND through the ECM.

When the switch is set in the position that connects GND to the Run/Stop input, the ECM will enter the "Run" mode (GND = Run). When the switch input is set in the position that opens the circuit connection, disconnecting GND from the Run/Stop input, the ECM enters the "Stop" mode (Open = Stop).

OEM Auxiliary Equipment Control

In certain applications it may be necessary or convenient to use the remote Run/Stop switch installed at the genset control panel to activate auxiliary equipment or devices installed by the OEM.

> ***NOTE:*** *Multiple hard-wired connections to the same Run/Stop signal input and/or ECM GND* ***SHOULD NOT*** *be made. The ECM Run/Stop circuit must be isolated from other connections made to activate the operation of such auxiliary equipment/devices.*

One way this can be accomplished is by using a relay with multiple sets of contacts, each set of contacts used for switching the necessary signals for both the ECM Run/Stop circuit and the OEM auxiliary equipment/device(s).

Local Emergency Stop

The Local Emergency Stop, or Local E-Stop, feature is implemented by providing a normally-closed momentary bi-state signal, or switch, connected bewteen pins 1 and 25 of ECM connector 06. This feature provides a means to immediately shutdown the engine during an emergency condition by opening the Local E-Stop switch located at the operator panel, interrupting power to the Fuel Shut-Off Valve and fuel system actuator driver circuits of the ECM through pin 25 of ECM connector 06 (Open = E-Stop).

> ***NOTE: DO NOT** use the Emergency Stop for normal or routine shutdowns. This switch is for emergency stopping only.*

The engine Run/Stop state can also be controlled electronically using InPower™. This is accomplished by setting the *Run/Stop Command* parameter to the desired state.

> ***NOTE:** The Run/Stop electronic trim setting and switch input are both used by the ECM to determine the operating state of the engine. The electronic trim and switch input must both be set to "Run" in order for the engine to be able to start and run. If either the electronic trim or the switch input, or both, are set to "Stop" the engine will not start or run.*
>
> *If the customer prefers using the switch input as the sole means of controlling the engine operating speed, the* Run/Stop Command *parameter must be set to "Run" at all times. The* Run/Stop Command *parameter defaults to "Run" on ECM power-up.*

Remote Emergency Stop

Similar to the Local E-Stop switch, the Remote E-Stop feature is implemented by providing a normally-closed momentary bi-state signal, or switch, to pin 1 of ECM connector 06. This feature provides a means to immediately shutdown the engine during an emergency condition by opening the Remote E-Stop switch located at a location remote from the operator panel, interrupting power to the Fuel Shut-Off Valve and fuel system actuator driver circuits of the ECM through pin 25 of ECM connector 06 (Open = E-Stop).

The engine can also be electronically shutdown using the InPower™ service tool. This is accomplished by setting the *Remote E-Stop Command* parameter to "Stop".

InPower™
Configurable Feature

Run/Stop Control

InPower™ Location:

Monitor

Control

Starting / Stopping

Run/Stop Command

Remote Emergency Stop

InPower™ Location:

Monitor

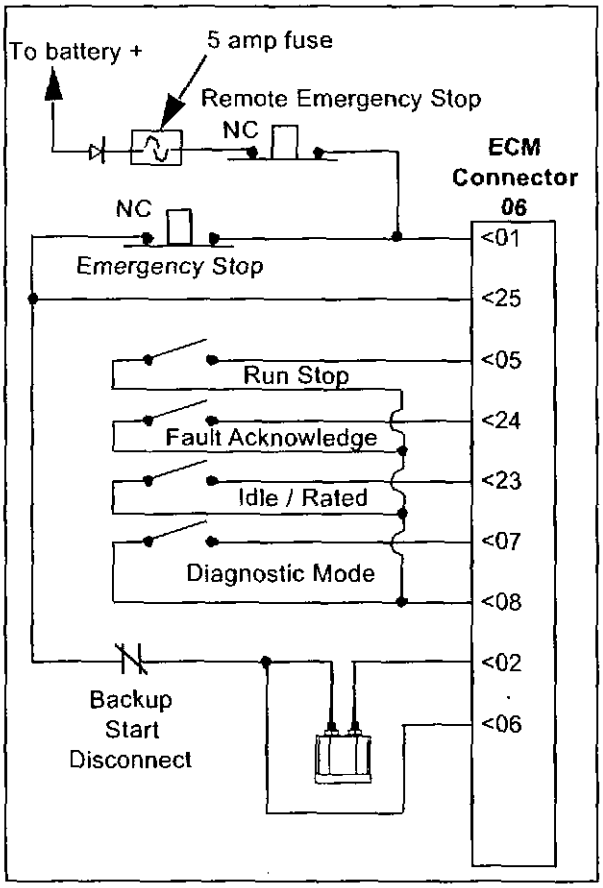
Control

Starting / Stopping

Remote E-Stop Command

⚠ WARNING ⚠

The electronic shutdown Remote E-Stop Command does not cause battery power to be physically disconnected from the ECM Fuel Shut-Off Valve and fuel system actuator driver circuits. If application requirements for the generator set dictate that emergency stopping of the engine must absolutely prevent operation of such fueling control circuits, the hard-wired Emergency Stop inputs must be used.



Starter Control

The Starter Control feature provides the means to control the engine starter solenoid and the cranking routine during engine start-up. The Starter Control cranking routine is initated based on the state of the Crank and Run/Stop switch inputs. See pages 38 and 41 describing the ***Run/Stop*** and ***Crank*** features for further details.

Following is an operational description of the GCS Starter Control feature. This description assumes that the starting circuit is connected as shown in the respective wiring schematics on page 33 and that the Emergency Stop inputs and Backup Start Disconnect are connected as shown at the left.

The Run/Stop switch must be placed in the "Run" state and the Crank Relay coil high side must be connected to Battery (+) (i.e. the Local E-Stop, Remote E-Stop and Backup Start Disconnect switches are all closed).

Engine cranking is initiated by holding the Crank switch in the "Crank" state. The Crank Coil relay driver will immediately activate the Crank Relay driver output at pin 2 of ECM connector 06, providing a signal path to GND, which energizes the Crank Relay coil. The Crank Relay will then provide power to the Crank Slave Relay (or magnetic switch) coil closing the Crank Slave Relay contacts, which in turn will supply power to the starter motor switch, causing the starter motor to engage and to begin cranking the engine.

Once the engine speed has reached a pre-programmed starter disconnect speed, the Crank Relay coil driver will open, de-energizing the Crank Relay. In turn, the Crank Slave Relay will de-energize and the starter will disengage as the engine speed continues to ramp-up to either the idle or rated speed depending upon the state of the Idle/Rated switch input. See the ***Idle/Rated Speed*** feature description on page 46 for further details.

> ***NOTE:*** *Use of the GCS Starter Control feature is not required in order to start and run the engine. If a customer supplied starting system is used, the Run/Stop switch must still be placed in the "Run" state in order to start and run the engine.*

Crank

A Crank switch input is provided to command the ECM to initiate the crank sequence to start the engine, as explained in the previous section.

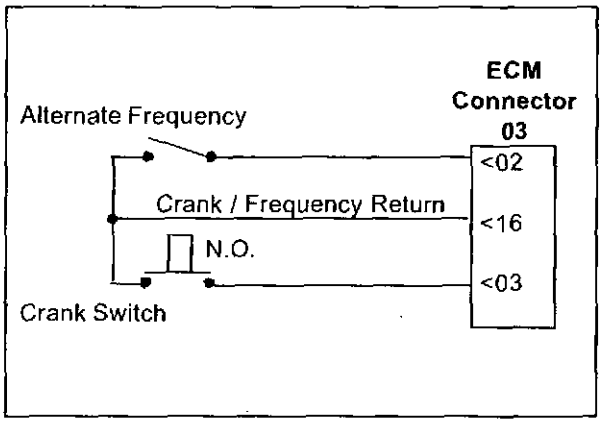
To implement this feature, the customer supplies a bi-state (normally open) signal, or switch, to pin 3 of ECM connector 03. Pin 16 of ECM connector 03 is used to provide an electrical signal path to GND through the ECM. The Crank swich input must be enabled, using InPower™, to make this feature operational. This is accomplished by setting the *Crank Switch Enable* parameter to "Enabled".

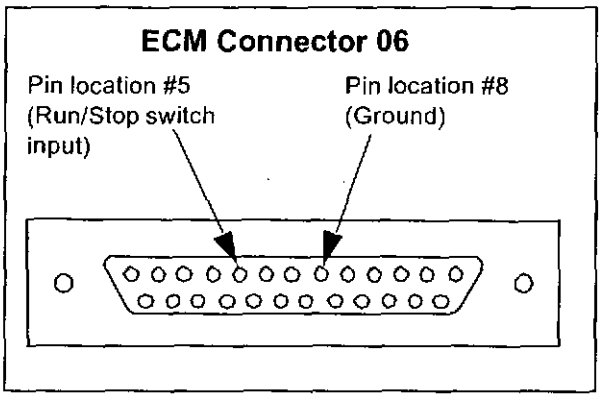
When the switch is set in the position that connects GND to the Crank input, the input is in the "Crank" state (GND = Crank).

When the switch is set in the position that opens the circuit connection, disconnecting GND from the Crank input, the input is in the "Not Crank" state (Open = Not Crank).

When the Crank switch input transitions from the "Not Crank" state to the "Crank" state while the engine is not yet running, and the Run/Stop switch is in the "Run" state, the ECM will initiate the cycle/continuous crank sequence. See the ***Cycle/Continuous Cranking*** section following for further details.

There is no effect on engine operation when the Crank switch input transitions from the "Crank" state to the "Not Crank" state once the engine has already started. If this switch transition occurs prior to the engine starting after the crank sequence has been initiated the crank sequence will cease immediately.





InPower™
Configurable Feature

Cycle/Continuous Cranking

The Starter Control feature allows the use of either cycle or continuous cranking routines which are set-up and selected using the InPower™ service tool.

The **Continuous Cranking** routine provides the capability to engage the starter only once for a configurable length of time. The *Continuous Crank Engage Time* parameter allows the user to define how long the starter will crank in an attempt to start the engine.

The **Cycle Cranking** routine provides the capability to perform a maximum of seven starting attempts with configurable starter engage and rest times. The *Cycle Crank Attempts* parameter allows the user to determine how many times the starter will attempt to start the engine. The *Cycle Crank Engage Time* parameter allows the user to define how long the starter will crank during each start attempt. The *Cycle Crank Rest Time* parameter defines how long the starter will wait, or rest, between starting attempts.

Starting Control

InPower™ Location:

Adjustments

Starting

Crank Switch Enable

Cycle / Continuous Crank Select

Continuous Crank Engage Time

Cycle Crank Attempts

Cycle Crank Engage Time

Cycle Crank Rest Time

Speed Ramping

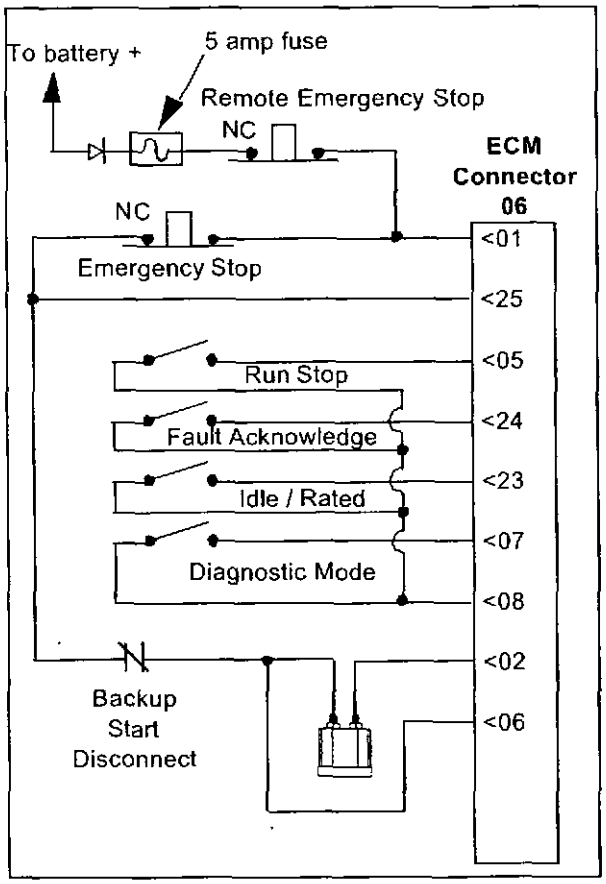
InPower™ Location:

Adjustments

Governor

Idle and Ramping

Starting to Rated Ramp Time



Starting-to-Rated Speed Ramp

During starting with the Idle/Rated Switch Input set to "Rated", the engine will ramp-up (accelerate) to rated speed at the Starting-to-Rated Speed Ramp rate.

If the ramp rate is set at or near 0 seconds, the engine speed will accelerate to achieve rated speed as quickly as possible based on the governor gain settings and the generator set performance. The user can increase or decrease the governor gain using the ***Governor Gain Adjust*** feature described on page 48.

Backup Start Disconnect

The Backup Start Disconnect is implemented by providing a bi-state switched signal, or switch, between pin 25 of ECM connector 06 and the high-side of the Crank Relay coil.

This feature provides a means to manually disengage the starter by removing power to the Crank Relay coil when the Backup Start Disconnect switch located on the operator panel is "open" (Open = Inhibit/Disengage Starter).

This feature is intended to save the starter from damage in case the Starter Control feature does not automatically disengage the starter when the engine reaches the required start disconnect speed. See the ***Starter Control*** feature description on page 40 for further details.

Backup Starting Systems

The GCS Starter Control feature can be implemented for use as either the primary or secondary starting system where backup starting control is required.

> ***NOTE:*** *If the GCS Starter Control feature is used as part of a backup starting system, it is the customer's responsibility to ensure that the GCS Starter Control feature is set-up in the correct manner to avoid interference with the proper function of either of the starting systems.*

Pre-lubrication System Integration with GCS Starter Control features

The pre-lubrication system is compatible for use with the GCS Starter Control feature. For the Starter Control feature to work properly when the pre-lubrication system is installed, the ECM Crank switch input and engine starter must be correctly wired to the pre-lubrication system switch/timer. Also, the system wiring will be different depending on the type of application for which the generator-drive engine is being used (i.e. Emergency or Non-Emergency power applications).

NOTE: In order for the GCS Starter Control feature to work properly during either a continuous or cycle cranking sequence the batteries must be adequately charged and of sufficient ampacity to provide the necessary electrical power and voltage to the pre-lube pump, starter(s) and ECM throughout the complete starting cycle. Lack of sufficient power and voltage will prevent the Pre-Lub system and Starter Control features from functioning properly.

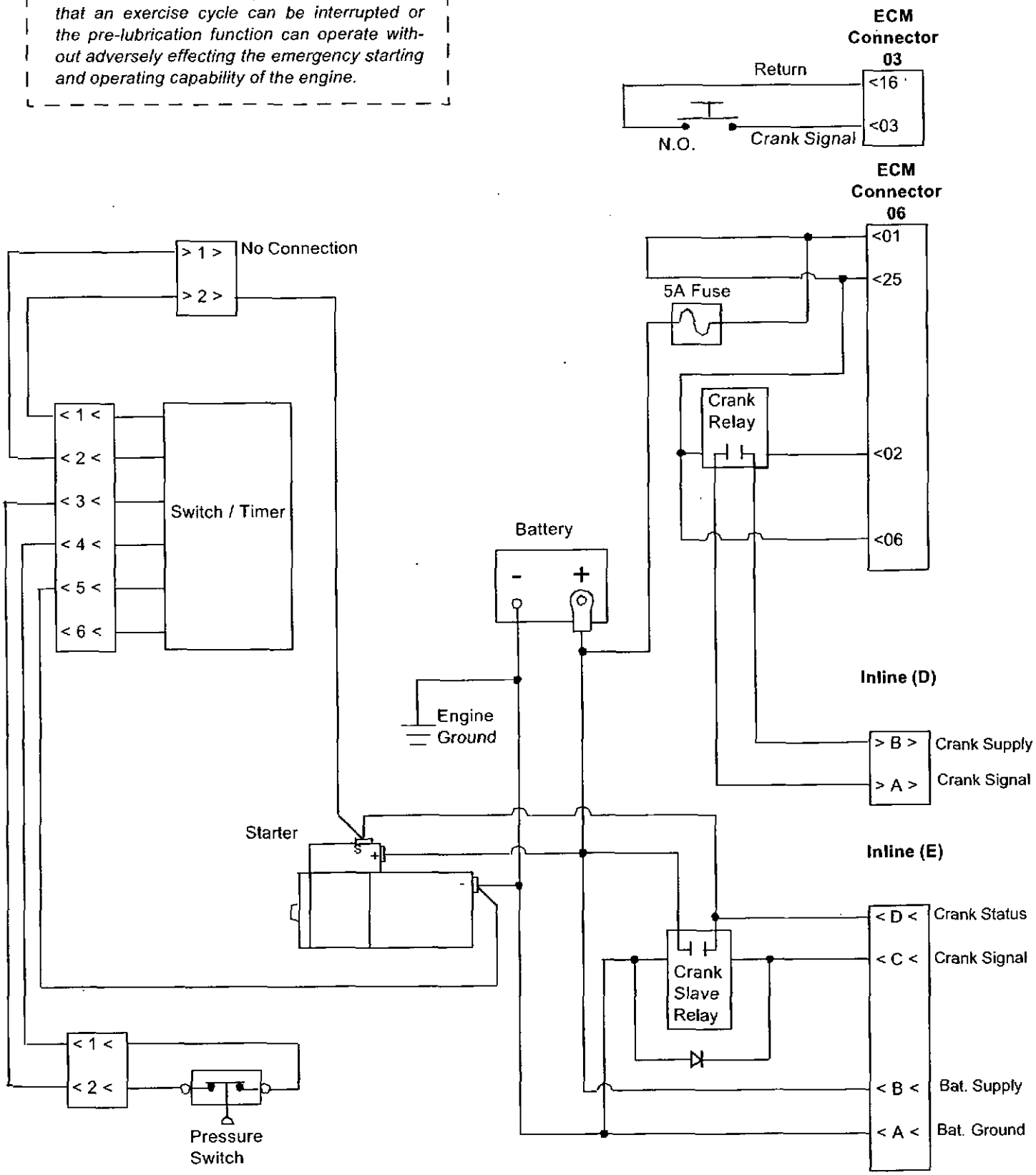
The OEM is responsible for conducting the necessary testing to ensure that the batteries, with a nominal charge, are capable of providing adequate power and voltage to the pre-lubrication pump, starter(s) and ECM.

Emergency Start Pre-Lube Cycle

When the pre-lubrication system is installed to operate in conjunction with the GCS Starter Control feature in an emergency application, where engine cranking must occur immediately upon receiving a crank command, activation of the Crank switch will initiate both the engine cranking sequence and the pre-lubrication cycle simultaneously.

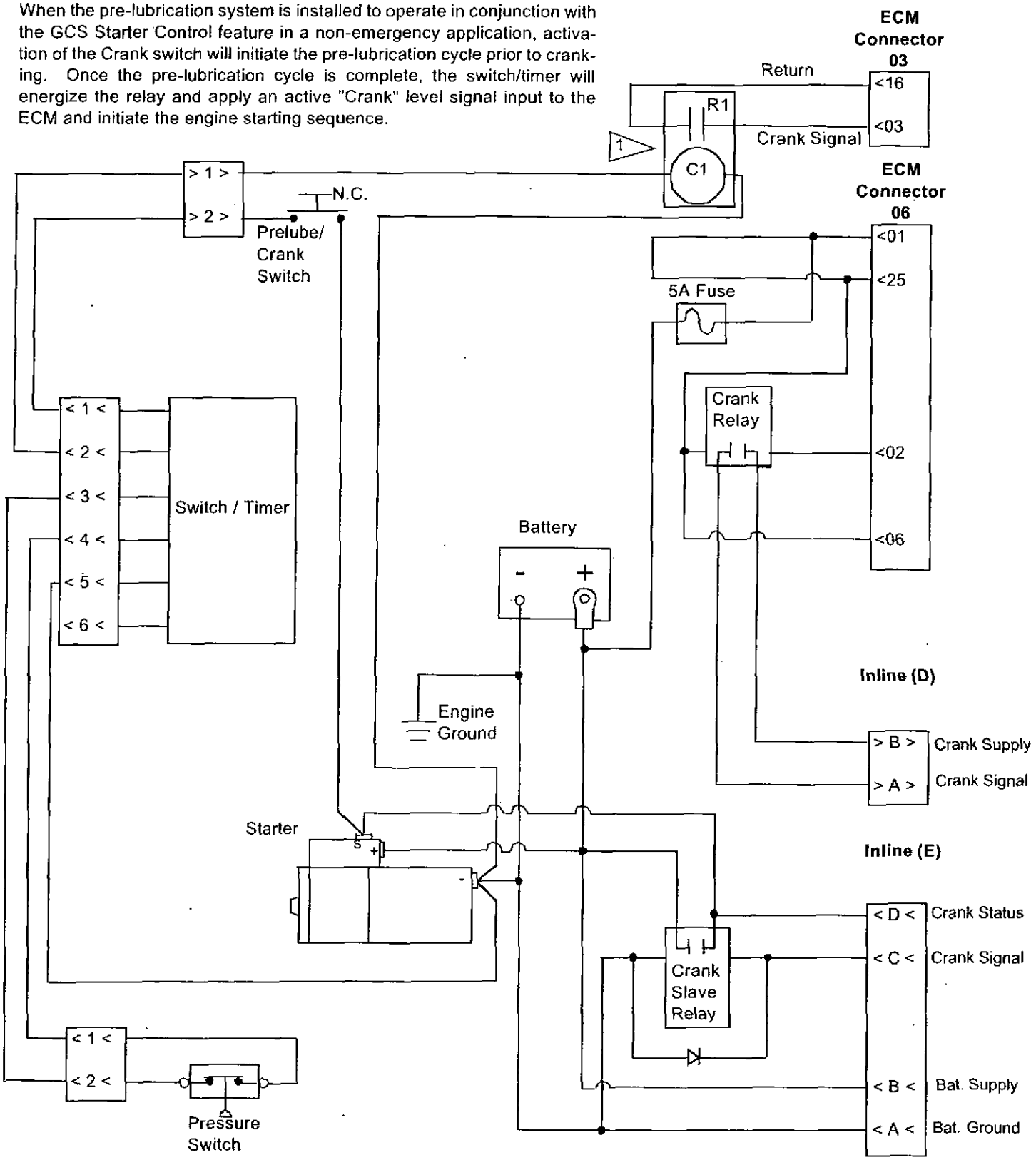
If the pre-lubrication system is used to perform pre-lubrication of the engine prior to performing an engine exercise cycle, but not prior to performing an emergency start, the OEM should revise the design as necessary to prevent the pre-lubrication function from interfering with an emergency start sequence. The design should also allow the engine to exit an exercise cycle, without stopping the engine, and immediately operate as it would normally during an emergency condition.

NOTE: The OEM is responsible for ensuring that an exercise cycle can be interrupted or the pre-lubrication function can operate without adversely effecting the emergency starting and operating capability of the engine.

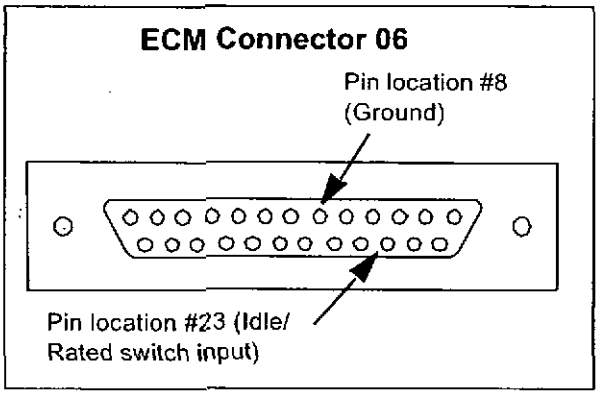


Non-Emergency Start Pre-Lube Cycle

When the pre-lubrication system is installed to operate in conjunction with the GCS Starter Control feature in a non-emergency application, activation of the Crank switch will initiate the pre-lubrication cycle prior to cranking. Once the pre-lubrication cycle is complete, the switch/timer will energize the relay and apply an active "Crank" level signal input to the ECM and initiate the engine starting sequence.



1 For the Non-Emergency starting set-up a relay must be used to convert the pre-lubrication output of the switch / timer signal to a signal level that is compatible with the ECM Crank Switch input at connector 03. It is the OEM's responsibility to install switch / timer output to Crank Switch input conversion relay.



InPower™
Configurable Feature

Idle/Rated Speed

InPower™ Location:

Monitor

Control

Starting / Stopping

Idle / Rated Command

Idle/Rated Speed

An Idle/Rated speed input is provided to allow control of the engine speed.

To implement this feature, the customer supplies a bi-state signal, or switch, to pin 23 of ECM connector 06. Pin 8 of ECM connector 06 is used to provide an electrical signal path to GND through the ECM.

When the switch is in the position that connects GND to the Idle/Rated input, the ECM enters the "Idle" speed mode (GND = Idle). Upon transition to the Idle speed mode, the generator set speed will ramp from the current speed to the idle speed. See the ***Rated-to-Idle Speed Ramp*** feature description on page 47 for further details regarding transitions from rated to idle speed.

When the switch input is set in the position that opens the circuit connection, disconnecting GND from the Idle/Rated input, the ECM enters the "Rated" speed mode (Open = Rated). Upon transition to the Rated speed mode, the generator set speed will ramp from the current speed up to the rated speed. See the ***Idle-to-Rated Speed Ramp*** feature description on page 47 for further details regarding transitions from idle to rated speed.

If the Idle/Rated switch input is set to "Rated" prior to starting the engine, the rate at which the engine will ramp-up to rated speed is determined based on the Starting-to-Rated Speed Ramp setting. See the ***Starting-to-Rated Speed Ramp*** feature description on page 42 for further details.

The Idle/Rated speed can also be controlled electronically using InPower™. This is accomplished by setting the *Idle / Rated Command* parameter to the desired state.

NOTE: *The Idle/Rated electronic trim setting and switch input are both used by the ECM to determine the operating speed of the engine. The electronic trim and switch input must both be set to "Rated" in order for the engine to operate at rated speed. If either the electronic trim or the switch input, or both, are set to "Idle" the engine will operate at idle speed.*

If the customer prefers using the switch input as the sole means of controlling the engine operating speed, the Idle / Rated Command *parameter must be set to "Rated" at all times. The* Idle / Rated Command *parameter defaults to "Rated" on ECM power-up.*

Idle Speed Adjust

The engine idle speed can be set between a minimum and maximum limit pre-programmed in the ECM. This is accomplished by setting the *Engine Idle Speed* parameter to the desired idle speed using InPower™.

Idle-to-Rated Speed Ramp

When the engine is at idle speed and the Idle/Rated switch Input state transitions from "Idle" to "Rated", the engine speed will ramp-up (accelerate) to rated speed at the Idle-to-Rated Speed Ramp rate.

If the ramp rate is set at or near 0 seconds, the engine speed will accelerate to achieve rated speed as quickly as possible based on the governor gain settings and the generator set performance. The customer can increase or decrease the governor gain using the ***Governor Gain Adjust*** feature described on page 48.

Rated-to-Idle Speed Ramp

When the engine is at rated speed and the Idle/Rated Switch Input state transitions from "Rated" to "Idle", the engine speed will ramp-down (decelerate) to idle speed at the Rated-to-Idle Speed Ramp rate.

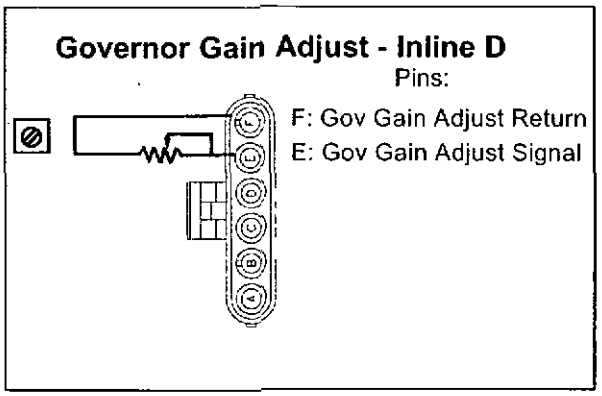
If the ramp rate is set at or near 0 seconds, the engine speed will decelerate to achieve idle speed as quickly as possible based upon the governor gain settings and the generator set performance. The customer can increase or decrease the governor gain using the ***Governor Gain Adjust*** feature described on page 48.

InPower™
Configurable Feature

Idle Speed Adjust

InPower™ Location:

Adjustments
- Governor
  - Idle and Ramping
    - ***Engine Idle Speed***
    - ***Idle to Rated Ramp Time***
    - ***Rated to Idle Ramp Time***



When using a potentiometer:

$$Gain = \left[\frac{R_{pot}}{(R_{pot} + 2870\ \Omega)} \times 15.6613\right] + 0.05$$

OR

When using a variable voltage:

$$Gain = \left[\frac{V_{in}}{3.17662\ V} \times 9.95\right] + 0.05$$

Where:

R_{pot} = Potentiometer Resistance (W)
V_{in} = Signal Input Voltage (V)

Examples:

$R_{pot} = 1336\ W$

$$Gain = \left[\frac{1336\ \Omega}{1336\Omega + 2870\Omega} \times 15.6613\right] + 0.05 = 5.025$$

$V_{in} = 1.58831\ V$

$$Gain = \left[\frac{1.58831\ V}{3.17662\ V} \times 9.95\right] + 0.05 = 5.025$$

Performance, Frequency and Droop Controls

Governor Gain Adjust

An adjustable signal input is provided to adjust the governor gain. The governor gain is adjustable from 0.05 (least amount of gain) to 10.00 (highest amount of gain).

The customer can implement the Governor Gain Adjust feature by connecting one side of a 5kΩ potentiometer to the analog ground at pin F of the Inline D connector, the other side is connected to pin E of the Inline D connector, and the wiper is also connected to pin E of the Inline D connector.

A potentiometer with a smaller resistance can be used to improve the adjustment sensitivity. Using a smaller resistance potentiometer will also decrease the adjustment range.

This feature can also be implemented by supplying a 0 to 3.177 VDC variable voltage to pin E of the Inline D connector, using pin F of the Inline D connector as a GND reference.

⚠ CAUTION ⚠

When using a variable voltage input, the voltage must not exceed 5 VDC.

The governor gain setting is directly proportional to the potentiometer resistance, or input voltage. As the resistance increases, the gain increases. The amount of gain can be calculated using the formulas shown at the right.

The Inline D connector is located on the Extension Harness. See the ***Wiring Harnesses and Interface Connectors*** section on page 21 for further details about the Extension Harness.

The governor gain can also be set by changing a trim value electronically using InPower™. Either the potentiometer or the electronic trim may be used to determine the governor gain, but not both simultaneously.

InPower™ Configurable Feature

NOTE: *A selection must be set to either "Pot" or "Trim", using InPower™, to tell the ECM whether a potentiometer is being used for this feature, or if the electronic trim governor gain setting is to be used.*

If a potentiometer is used the signal input must also be enabled, using InPower™, after the "Pot" selection is set-up.

Governor Gain Adjust

InPower™ Location:

Adjustments

Governor

Gain and Droop

Governor Gain Adjust

Governor Gain Adjust Select

⚠ CAUTION ⚠

Improper configuration or adjustment of the Governor Gain feature can cause unstable engine operation. The customer is responsible for performing any necessary system and generator set tests to ensure that this feature has been properly set-up.

Governor Gain Adjust

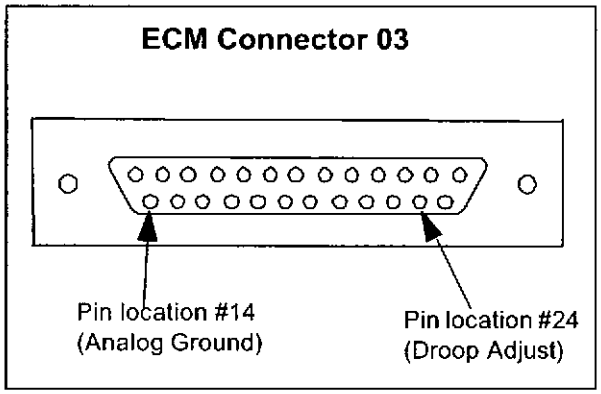
InPower™ Location:

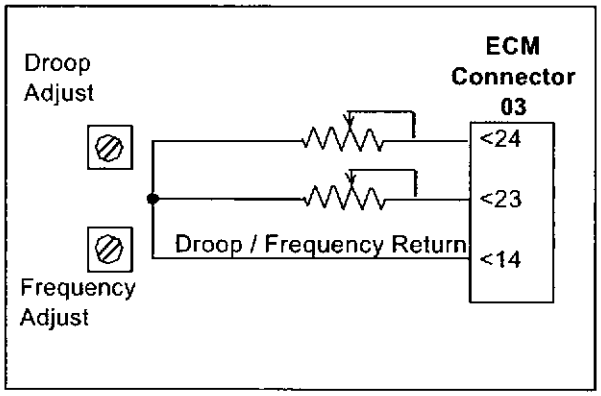
Adjustments

Features

Inputs

Governor Gain Adjust Pot Enable





$$\%Droop = \left[\frac{Rpot}{(Rpot + 2870\Omega)} * 15.74\right]$$

OR

$$\%\,Droop = \left[\frac{Vin}{3.17662} * 10\right]$$

Where:

R_{pot} = Potentiometer Resistance (W)
V_{in} = Signal Input Voltage (V)

Examples:

R_{pot} = 2500, W

$$\%\,Droop = \frac{2500}{(2500 + 2850)} \times 15.74 = 7.36\%$$

V_{in} = 1.58831 V

$$\%\,Droop = \frac{1.58831}{3.17662} \times 10.00\% = 5.00\%$$

Droop Adjust

An adjustable signal input is provided to control the governor speed droop. The speed droop is adjustable from 0 to 10%.

The customer can implement the Droop Adjust feature by connecting one side of a 5kΩ potentiometer to the analog ground at pin 14 of connector 03, the other side connected to pin 24 of connector 03, and the wiper also connected to pin 24 of connector 03.

This feature can also be implemented by supplying a 0 to 3.177 VDC variable voltage to pin 24 of ECM connector 03, using pin 14 of ECM connector 03 as a GND reference.

⚠ CAUTION ⚠

When using a variable voltage input, the voltage must not exceed 5 VDC.

The droop adjust setting is directly proportional to the potentiometer resistance, or input voltage. As the resistance increases, the droop increases. The amount of droop can be calculated using the formula shown at the left.

The speed droop can also be set by changing a trim value electronically using InPower™. Either the potentiometer or the electronic trim may be used to determine the speed droop, but not both simultaneously.

NOTE: *A selection must be set to either "Pot" or "Trim", using InPower™, to tell the ECM whether a potentiometer is being used for this feature, or if the electronic trim droop setting is to be used.*

If a potentiometer is used, the signal input must also be enabled, using InPower™, after the "Pot" selection is set-up.

⚠ CAUTION ⚠

Improper configuration or adjustment of the Droop feature can cause undesireable engine speed variation. The customer is responsible for performing any necessary system and generator set tests to ensure that this feature has been properly set-up.

InPower™
Configurable Feature

Droop Adjust

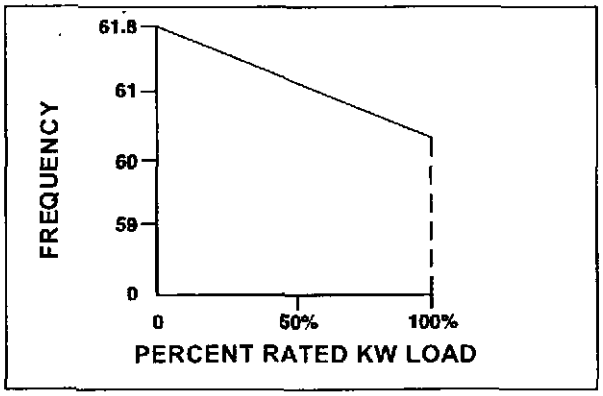
InPower™ Location:

Adjustments
Governor
Gain and Droop
Droop Adjust
Droop Adjust Select

Droop Adjust

InPower™ Location:

Adjustments
Features
Inputs
Droop Adjust Pot Enable



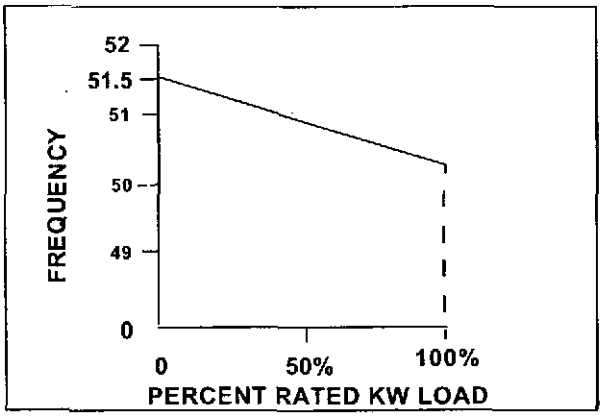
Droop engine-generator sets which are to operate at 60Hz full-load, must have the engine no-load governed speed adjusted to:

- 61.8 Hz (1854 RPM) for 3% Speed Droop
- 63.0 Hz (1890 RPM) for 5% Speed Droop

Droop engine-generator sets which are to operate at 50Hz full-load, must have the engine no-load governed speed adjusted to:

- 51.5 Hz (1545 RPM) for 3% Speed Droop
- 52.5 Hz (1575 RPM) for 5% Speed Droop

NOTE: *Speed adjustments to obtain desired no-load rated speeds must be made using the* Frequency Adjust *feature (see the Frequency Adjust section on page 56).*



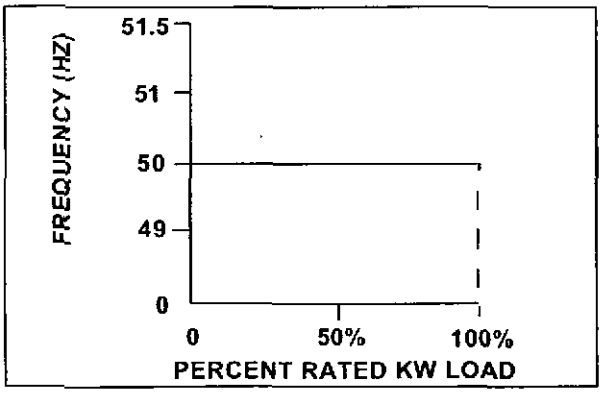
$$S_{al} = S_{nl} - \left(\left(\frac{\text{Available kW Load}}{\text{Rated kW}}\right) X \left(S_{nl}-S_{fl}\right)\right)$$

Where:
S_{al} = Speed at Available kW Load
S_{fl} = Speed at Full kW Load
S_{nl} = Speed at No Load

Example:
Available kW Load = 400
Rated kW = 500
Speed at Full kW Load = 1800
Speed at No Load = 1854
$S_{al} = 1854 - \left(\left(\frac{400}{500}\right) X (1854-1800)\right)$
S_{al} = 1811 RPM

Percent Speed Droop on the engine-generator set can be verified by noting no-load and full-load speeds and using the Speed Droop formula found at right.

When full-load kW is not available, to calculate what the Droop Governed speed should be under the available load, use this formula.



Isochronous Mode

For Isochronous Speed operation, the Droop setting needs to be set at 0%.

The Droop setting can be adjusted using the InPower™ electronic service tool, or a variable analog signal as described in the ***Droop Adjust*** section on page 50.

Dual Governing Dynamics

Some generator drive applications require different gain or droop settings for the same installation. A typical example is a Standby Generator Set which is also used for Peak shaving, which may have the following needs:

Standby or Stand Alone	Peak Shaving or Grid (Utility) Parallel
High Governor Gain – for fast transient response	Low Governor Gain – for smooth loading changes
Minimal or no Governor Speed Droop – for constant frequency at all load levels	High Governor Speed Droop – for droop method load control

As explained above, the input range for the Droop Adjust and Governor Gain Adjust signals is 0 to 3.177 volts. A 2.87kW resistor is installed within the control and is connected between each input and an internal 5 VDC power supply. This circuit design is what allows the use of a potentiometer (variable resistor) to be used to provide the voltage input. Figure 1 shows a simplified equivalent circuit for Speed Droop. Figure 2 shows a simplified equivalent circuit for Governor Gain.

As the resistance on the potentiometer is reduced the voltage provided to the corresponding signal input is reduced. The control interprets the lower voltage input as a command to use a corresponding lower gain or droop in its control algorithms. This is also explained in further detail in the ***Governor Gain Adjust*** section on page 48 and the ***Droop Adjust*** section on page 50.

Maximum Range Governor Gain and Governor Droop Implementation

Figure 3 shows a very simple method of implementing a dual Governor Droop. Figure 4 shows a very simple method of implementing a dual Governor Gain. This technique utilizes a set of "form C" relay or switch contacts (one normally open and one normally closed contact sharing a common connection) to select between two potentiometers. An advantage of this scheme is that both potentiometers can be independently set anywhere within the adjustment range.

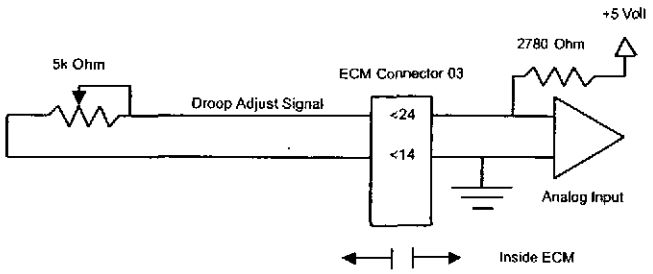


Figure 1: Simplified Equivalent Circuit for Remote Droop Adjustment

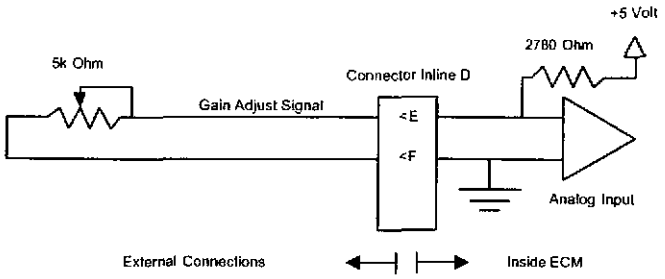


Figure 2: Simplified Equivalent Circuit for Remote Gain Adjustment

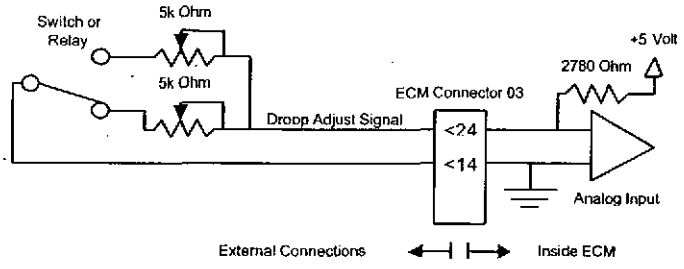


Figure 3: Maximum Range Dual Droop Implementation

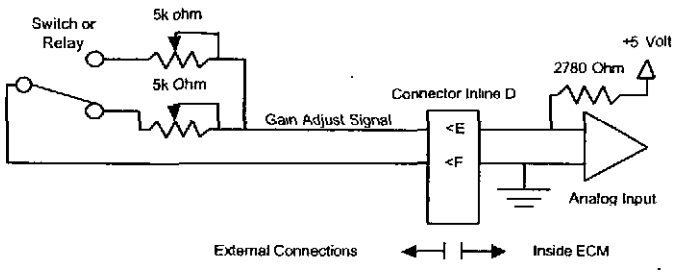


Figure 4: Maximum Range Dual Gain Implementation

A disadvantage of this scheme becomes apparent if there is a failure of either one of the relay contacts. For a failure that causes an abnormally high resistance on the enabled droop input, the control uses a default droop value of 0%. For a failure mode that causes an abnormally high resistance on the enabled gain input, the control uses a default gain value of 1.0. If the failure condition is present for more than 1 second a warning fault is detected and reported for the corresponding input. For example, suppose the normally closed contacts fail to close. When the relay or switch is in the normal mode, there is no potentiometer connected to the input. The ECM recognizes this as an abnormal condition and applies the default value in its control algorithms. After one second the ECM reports a warning fault. If this faulty behavior could cause a problem with the application, the Optimal Failure Mode Governor Gain and Droop Implementation scheme described below should be utilized.

A second disadvantage is that there will be a momentarily high or low signal provided to the input when the switch or relay changes state. Switches and relays are typically produced to perform in one of two manners: Make-before-Break and Break-before-Make.

If a Make-before-Break relay is used, the two potentiometers will be momentarily connected in parallel. The equivalent resistance is much less than either value, so the input is momentarily provided with a signal which is much less than either desired setting. If this very low signal could cause a problem with the application, then the Optimal Failure Mode Governor Gain and Droop Implementation scheme described below should be utilized.

If a Break-before-Make relay is used, then for a moment neither potentiometer is connected to the input. In this case, the control will use the corresponding droop default value (0%) or gain default value (1.0) while both sets of contacts are open. If this performance could cause a problem with the application, then the Optimal Failure Mode Governor Gain and Governor Droop Implementation scheme described below should be utilized.

Optimal Failure Mode Governor Gain and Droop Implementation

Figure 5 provides an implementation scheme for droop governing that avoids the undesirable failure mode and switch transition performance described for the previous scheme. Figure 6 is the same technique applied to the Gain input.

A single set of switch contacts is used to determine whether the signal presented to an input is determined by only one or by both of the potentiometers. The potentiometer that is always connected is termed the Limiting Potentiometer and the switch potentiometer is referred to as the Reducing Potentiometer.

The Limiting Potentiometer is always connected, so the maximum resistance (without a wire break) that is ever provided to the input is the setting of the Limiting Potentiometer. The Reducing Potentiometer is connected when the switch or relay contacts are closed. Since it is only connected in parallel with the Limiting Potentiometer, it serves to reduce the equivalent resistance when the switch or relay contact is closed. The equivalent resistance (R_{equiv}) is equal to the product of the two potentiometers' setting divided by the sum of the two potentiometers' settings:

$$R_{equiv} = (R_1 * R_2)/(R_1 + R_2),$$

where R_1 is the Reducing Potentiometer resistance in ohms, and R_2 is the Limiting Potentiometer resistance in ohms.

The formula given in this manual can be used to determine the actual gain or droop setting for various potentiometer settings. Table 1 is derived using the formula in the **Droop Adjust** section on page 50 and provides the droop adjustment range for several Potentiometer values. Table 2 is similarly derived gain ranges from the formula in the **Governor Gain Adjust** section on page 48. As the tables show, the adjustment range for the mode where the potentiometers are connected in parallel is not as wide when only the Limiting Potentiometer is connected. Note that the Second Adjustment Range is calculated assuming the Limiting Potentiometer is set to its highest value. If it is set to a lower value, the Second Adjustment Range is similarly reduced.

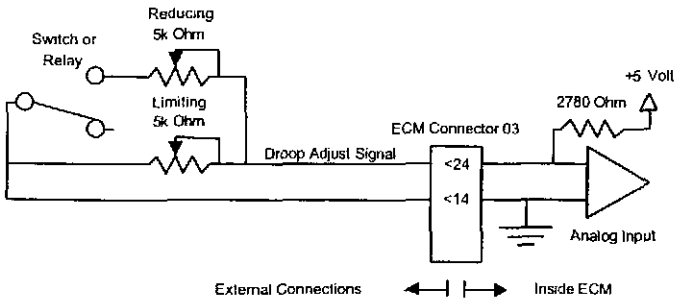


Figure 5: Sample Optimal Failure Mode Dual Droop Implementation

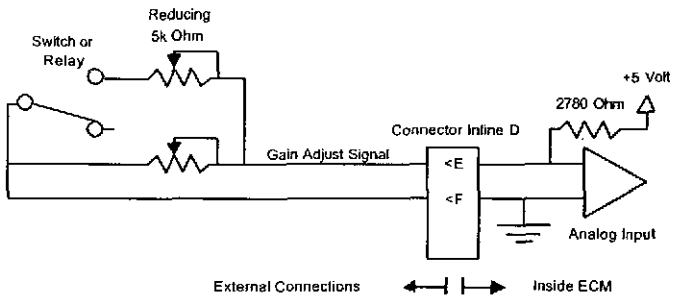


Figure 6: Sample Optimal Failure Mode Dual Gain Implementation

R_1 (Ohms)	R_2 (Ohms)	Primary (Limiting) Droop Adjustment Range	Maximum Second (Reduced) Droop Adjustment Range
500	500	0 – 1%	0 – 0.5%
500	1000	0 – 1%	0 – 0.7%
500	2000	0 – 1%	0 – 0.8%
500	5000	0 – 1%	0 – 0.9%
1000	1000	0 – 2%	0 – 1.0%
1000	2000	0 – 2%	0 – 1.3%
1000	5000	0 – 2%	0 – 1.7%
1000	10,000	0 – 2%	0 – 1.8%
2000	2000	0 – 4%	0 – 2.0%
2000	5000	0 – 4%	0 – 2.9%
2000	10,000	0 – 4%	0 – 3.3%
2000	20,000	0 – 4%	0 – 3.6%
5000	5000	0 – 10%	0 – 5.0%
5000	10,000	0 – 10%	0 – 6.7%
5000	20,000	0 – 10%	0 – 8.0%
5000	50,000	0 – 10%	0 – 9.1%

Table 1: Maximum Adjustment Ranges for Optimal Failure Mode Dual Droop Circuit

R_1 (Ohms)	R_2 (Ohms)	Primary (Limiting) Gain Adjustment Range	Maximum Second (Reduced) Gain Adjustment Range
500	500	0.05 – 2.37	0.05 – 1.30
500	1000	0.05 – 2.37	0.05 – 1.68
500	2000	0.05 – 2.37	0.05 – 1.97
500	5000	0.05 – 2.37	0.05 – 2.19
1000	1000	0.05 – 4.10	0.05 – 2.37
1000	2000	0.05 – 4.10	0.05 – 3.00
1000	5000	0.05 – 4.10	0.05 – 3.57
1000	10,000	0.05 – 4.10	0.05 – 3.82
2000	2000	0.05 – 6.48	0.05 – 4.10
2000	5000	0.05 – 6.48	0.05 – 5.25
2000	10,000	0.05 – 6.48	0.05 – 5.80
2000	20,000	0.05 – 6.48	0.05 – 6.12
5000	5000	0.05 – 10.0	0.05 – 7.34
5000	10,000	0.05 – 10.0	0.05 – 8.47
5000	20,000	0.05 – 10.0	0.05 – 9.17
5000	50,000	0.05 – 10.0	0.05 – 9.65

Table 2: Maximum Adjustment Ranges for Optimal Failure Mode Dual Gain Circuit

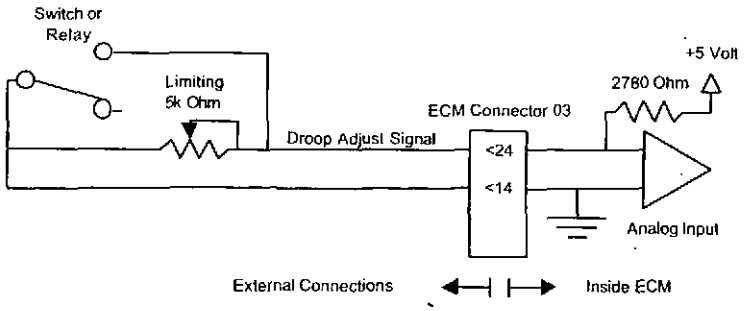


Figure 7: Sample Droop/Isochronous Switch Selection

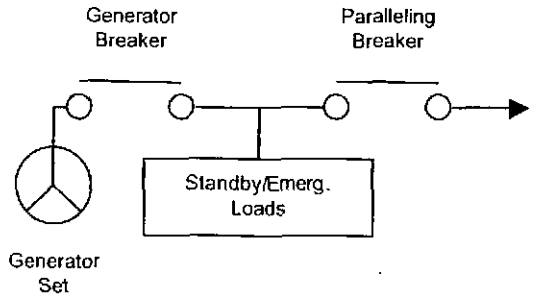


Figure 8: Sample Application One-Line Distribution Diagram

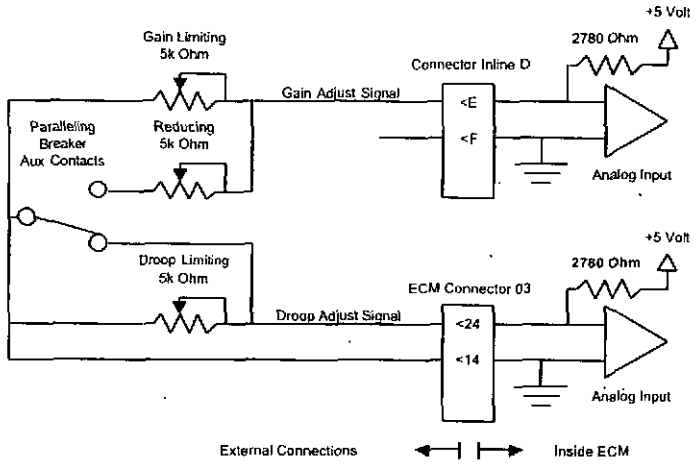


Figure 9: Sample Application Wiring

Special Case: Droop/Isochronous Switch Selection

Some applications may require the engine's operating mode to be Droop/Isochronous, based on a switch or relay contact state. Figure 7 provides a method of implementing this.

This circuit is merely a specialized case of the circuit in Figure 5 with the value of the Reducing Potentiometer set to zero Ohms. When the switch or relay contact is closed, shorting the Droop Adjust Signal at pin 24 to the signal return at pin 14, the controller's input is supplied a zero volt signal, which is interpreted as a command to control the engine with a droop value of 0%.

A Sample Application: Droop/Isochronous and Dual Gains

An example application of where the dual gain and droop / iscochronous selection is needed is a generator set which is used both as an emergency standby generator and in parallel with a utility grid for peak shaving. Figure 8 is a one-line diagram of the electrical distribution.

In this sample application, two sets of auxiliary contacts provided by the paralleling breaker are used to determine the engine's operating mode. Figure 9 shows how the remote Gain and Remote Droop inputs are wired.

When the set is operating as a standby generator set, the paralleling breaker is open. One set of auxiliary contacts commands the engine to operate in isochronous mode (droop commanded to zero) and gain set by the Limiting Potentiometer setting. This allows a responsive gain setting with no droop for the stand-alone operation.

When the set is paralleled with the utility grid, the paralleling breaker is closed. In this state the engine is commanded to operate with speed droop and a lower gain setting (defined by the equivalent resistance of the two gain potentiometers connected in parallel). The speed droop allows for manual load control and the lower gain setting provides for smooth load operation while the generator set is paralleled to the utility grid.

Frequency Adjust

An adjustable signal input is provided to adjust the generator set frequency. The frequency is adjustable within ±9Hz of the rated operating frequency.

The customer can implement the Frequency Adjust feature by connecting one side of a 5 kΩ potentiometer to the analog ground at pin 14 of connector 03, the other side connected to pin 23 of connector 03, and the wiper also connected to pin 23 of connector 03.

This feature can also be implemented by supplying a 0 to 3.177 VDC variable voltage to pin 23 of ECM connector 03, using pin 14 of ECM connector 03 as a GND reference.

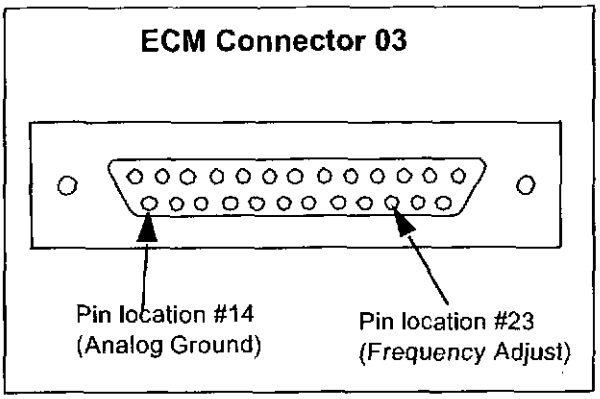
⚠ CAUTION ⚠

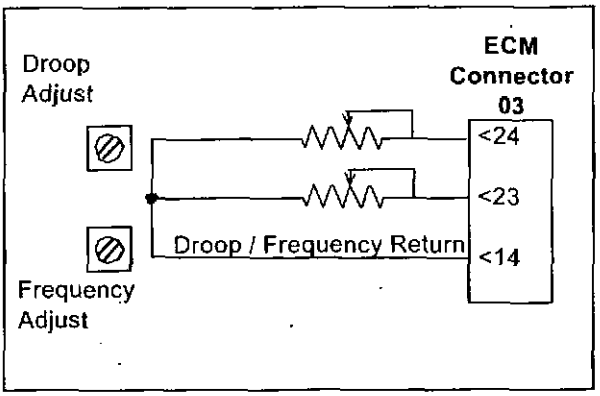
NOTE: *When using a variable voltage input, the voltage must not exceed 5 VDC.*

The frequency adjust setting is directly proportional to the potentiometer resistance, or input voltage. As the resistance increases, the frequency increases. The amount of frequency change can be calculated using the formula shown at the left.

The governor frequency is adjustable by ±9Hz using a combination of both a remote mounted potentiometer and the frequency adjustment trim which can be set using InPower™.

The potentiometer allows an adjustment range of ±3Hz, while the frequency adjustment trim allows an additional adjustment range of ±6Hz.





$$\Delta Freq = \left[\frac{Rpot}{(Rpot + 2870\Omega)} * 9.444Hz\right] - 3Hz$$

OR

$$\Delta\ Freq. = \left[\frac{V_{in}}{3.17662\ V} \times 6Hz\right] - 3Hz$$

Where:

R_{pot} = *Potentiometer Resistance (W)*
V_{in} = Signal Input Voltage (V)

Examples:

R_{pot} = *1667 W*

$$?Frequency = \left[\frac{1667}{1667 + 2870} X\ 9.444Hz\right] - 3Hz = 0.5Hz$$

V_{in} = 1.05887 V

$$?Frequency = \left[\frac{1.05887}{3.17662} X\ 6Hz\right] - 3Hz = 1Hz$$

InPower™
Configurable Feature

Frequency Adjust

InPower™ Location:

Adjustments

Governor

Frequency

Frequency Adjust

Frequency Adjust

InPower™ Location:

Adjustments

Features

Inputs

Frequency Adjust Pot Enable

NOTE: *The Frequency Adjust feature is different from the Droop Adjust and Governor Gain Adjust features in that both the potentiometer and the electronic trim can be used simultaneously. The effect of the potentiometer setting and the electronic trim setting is additive.*

For example, if the potentiometer were set to provide a +3Hz adjustment and the electronic trim where set to +4Hz, the overall frequency adjustment would be equal to +7Hz. Using another example, if the potentiometer where set to provide a -1Hz adjustment and the electronic trim where set to +6Hz, the overall frequency adjustment would be equal to +5Hz.

If a potentiometer is used, the signal input must be enabled, using InPower™. This is accomplished by setting the Frequency Adjust Pot Enable parameter to "Enabled".

⚠ CAUTION ⚠

Improper configuration or adjustment of the frequency adjust feature can cause the engine to operate at the incorrect speed. The customer is responsible for performing any necessary system and generator set tests to ensure that this feature has been properly set-up.

Alternate Frequency

An Alternate Frequency input is provided to allow selecting between one of two generator set frequency settings.

To implement this feature, the customer supplies a bi-state signal, or switch, to pin 2 of ECM connector 03. Pin 16 of ECM connector 03 is used to provide an electrical signal path to GND through the ECM.

> ***NOTE:*** *The alternate frequency selection feature is only enabled for engines that have been rated for dual speed operation. For engines rated for a single operating speed, the Alternate Frequency input is non-operational and no connection needs to be made to this input.*

> ***NOTE:*** *The ECM will use separate 50Hz and 60 Hz engine overspeed shutdown protection thresholds associated with the respective selection of the frequency determined by this switch. The dual overspeed threshold feature is dependent on the version of control software in the ECM. See the* ***Engine Protection*** *section on page 65 for further details.*

When the switch is set in the position that opens the circuit connection, disconnecting GND from the Alternate Frequency input, and the engine is not running, the ECM will transition to the "Primary" (or "Normal') frequency setting (Open = Primary/Normal). Upon engine start-up, and after being commanded to run at "rated" speed, the engine speed will ramp-up to the speed specified for the Primary frequency setting.

When the switch is set in the position that connects GND to the Alternate Frequency input, and the engine is not running, the ECM will transition to the "Secondary" (or "Alternate") frequency setting (GND = Secondary/Alternate). Upon engine start-up, and after being commanded to run at "rated" speed, the engine speed will ramp-up to the speed specified for the Secondary frequency setting.

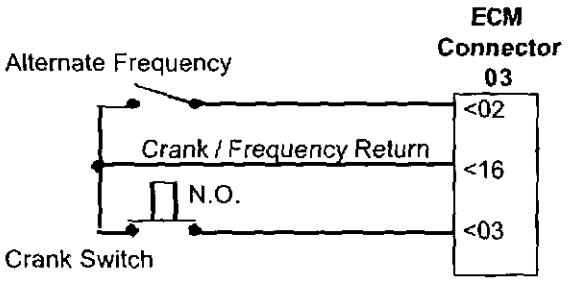
> ***NOTE:*** *If the frequency selection using the Alternate Frequency input changes while the engine is running, the selected frequency setting will not take effect until after the engine is shut down and re-started.*

The frequency settings for the Primary/Secondary states of the Alternate Frequency input can be reversed (e.g. Primary = 50Hz / Secondary = 60Hz changed to Primary = 60Hz / Secondary = 50Hz) us-

Alternate Frequency Switch

Primary

Secondary



InPower™ Configurable Feature

Alternate Frequency

InPower™ Location:

Adjustments

Governor

Frequency

Alternate Frequency Select

ing InPower™. This is accomplished by setting the *Alternate Frequency Select* parameter to either "60Hz Primary" or "50Hz Primary".

The Alternate Frequency setting can also be controlled electronically using InPower™. This is accomplished by setting the *Alternate Frequency Select* parameter to either "60Hz Only" or "50Hz Only". These settings effectively disable the Alternate Frequency switch input, by overriding the switch setting.

Load Sharing / Autosynchronization

The ECM provides two types of speed bias inputs making it compatible for use with off-the-shelf isochronous load share and synchronizing equipment (i.e. Woodward and Barber-Colman speed governing and load sharing controls).

> ***NOTE:*** *The speed bias signal and the signal return conductors must be protected from EMI by a common shield. One end of the shield must be attached to GND and the other end must be left open-ended (not attached to GND). The open-end of the shield must terminate as close as possible to the connector of the interfacing device. To accommodate grounding the shield at the ECM end of the interface a shield ground is provided at ECM connector 03, pin 20. It is highly recommended that the shield be terminated at the ECM, which provides a common low impedance shield ground point.*

The ECM provides a +5VDC (±2%) supply voltage at pin 6 of connector 03. This supply voltage is to be used as the signal reference for both the ±2.5V and ±0.2V speed bias signals. The supply is rated to provide the specified voltage at $50mV_{p-p}$ max. ripple voltage, and 25mA max. current.

±2.5V Speed Bias

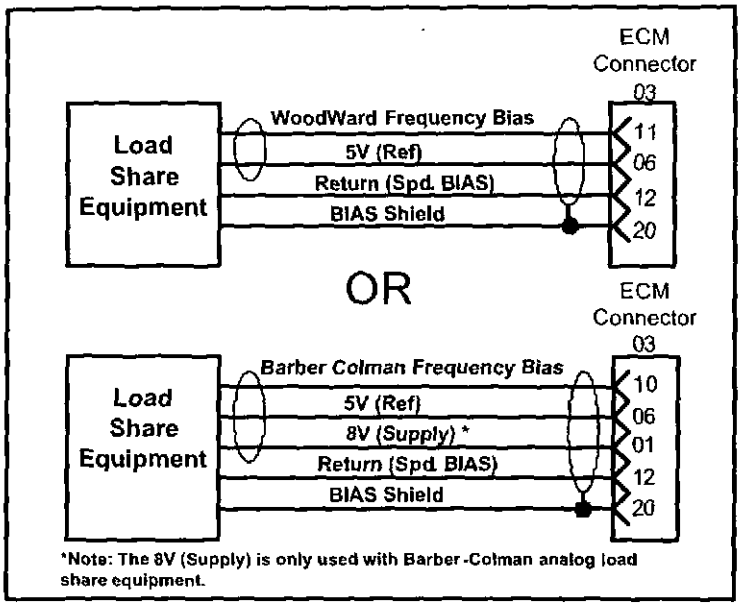
This speed bias signal input is provided for interfacing with compatible speed governing and load share controls (typically Woodward). The ECM expects a +/- 2.5V signal offset by the 5V (Ref). Therefore, the absolute value of the voltage present at 03 pin 11 in relation to ground should range from 2.5V to 7.5V. The ±2.5V speed bias signal represents a full scale speed bias control range of ±3Hz.

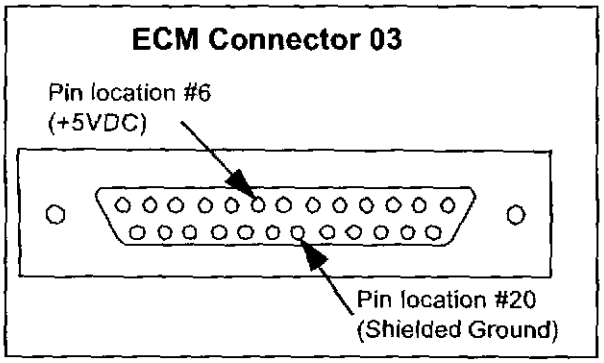
The customer can implement this feature by supplying the proper speed bias signal to pin 11 of connector 03.

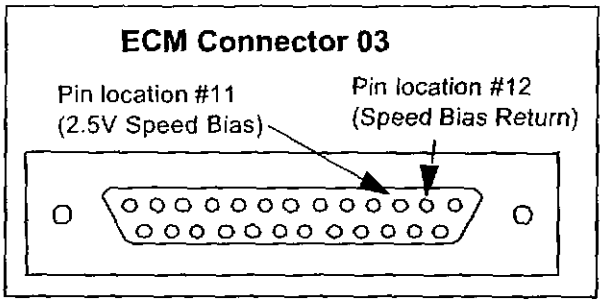
±0.2V Speed Bias

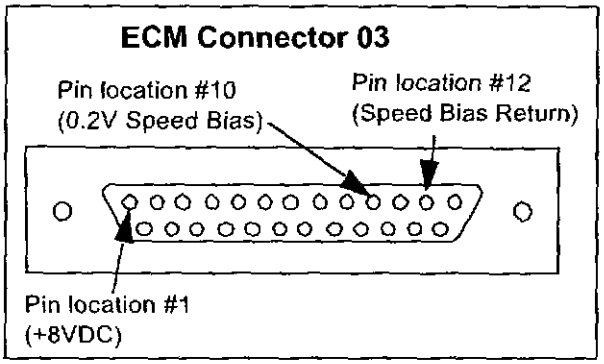
This input is provided for interfacing with the Barber-Colman DYN2 ILS control or other compatable devices. The ECM expects a +/- 0.2V signal offset by the 5V (Ref). Therefore, the absolute value of the voltage present at 03 pin 10 in relation to ground should range from 4.8V to 5.2 V. The ±0.2V speed bias signal represents a full scale speed bias control range of ±7.38Hz.

The customer can implement this feature by supplying the proper speed bias signal to pin 10 of connector 03.









InPower™
Configurable Feature

Load Sharing / Autosynchronization

InPower™ Location:

Adjustments

Features

Inputs

Frequency Bias Select

Barber Colman Frequency Bias Enable

Woodward Frequency Bias Enable

In addition to the +5VDC reference supply voltage, the ECM also provides a +8VDC (±5%) power supply at pin 1 of connector 03. This supply voltage is provided as a means to power the electronic circuits on analog load share equipment. The supply is rated to provide the specified voltage at $50mV_{p-p}$ max. ripple voltage, and 15 mA max. current.

Speed Bias Input Type

The type of speed bias input to be used is selected, using InPower™. This is accomplished by setting the *Frequency Bias Select* parameter to either "Barber Colman" or "Woodward", depending on which speed bias input is being used.

Once the type of speed bias input to be used is selected the speed bias input must be enabled, using InPower™, to make this feature operational. This is accomplished by setting either the *Barber Colman Frequency Bias Enable* parameter or *Woodward Frequency Bias Enable* parameter to "Enabled", depending on which speed bias input is being used.

NOTE: *The Load Sharing / Autosynchronization feature will not operate unless the corresponding speed bias input is enabled, and the type of speed bias selected is the same as the speed bias input being used.*

If the speed bias input is not used, the Frequency Bias Select *parameter should be set to "None".*

Engine Protection

The engine protections shown to the left are user configurable, within pre-programmed limits, using InPower™. The InPower™ software will not allow settings outside the minimum and maximum ranges established for your engine.

Abbreviations:

LOP	**Low Oil Pressure**
HOT	**High Oil Temperature**
LCL	**Low Coolant Level**
LCP	**Low Coolant Pressure**
LCT	**Low Coolant Temperature**
HCT	**High Coolant Temperature**
HFT	**High Fuel Temperature**
HIT	**High Intake Manifold Temperature**

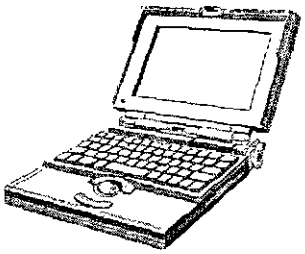
NOTE: *When the engine coolant temperature is less than the LCT Warning Threshold* ***when the engine is running****, a Common Warning will be activated to signal that a Low Coolant Temperature condition exists.*

The Engine Cold Warning Threshold is intended for use when block heaters are installed. When the engine coolant temperature is less than the Engine Cold Warning Threshold ***prior to starting the engine****, a Common Warning will be activated to signal that an Engine Cold Warning condition exists.*

Setting the Engine Cold Warning Threshold at too high a level can cause nuisance Engine Cold Warning faults. The customer is responsible for properly setting the Engine Cold Warning Threshold at the proper level, dependent upon whether block heaters are being used, or are not used.

NOTE: *ECM calibrations created from later versions of software have changed from using a single overspeed engine protection shutdown threshold for both 1500 rpm and 1800 rpm rated to using individual protection thresholds for each speed. This allows the operator to set the overspeed shutdown protection speed dependent on the engine's rated operating speed. If the software calibration that is installed in the ECM supports the dual overspeed threshold settings, both overspeed threshold parameters will appear in the InPower™ engine protection adjustments menu.*

InPower™
Configurable Feature



Engine Protection

InPower™ Location:

Adjustments

Engine Protection Adjustments

Engine Cold Warning Threshold
LOP Warning Threshold Table
LOP Shutdown Threshold Table
HOT Warning Threshold
HOT Shutdown Threshold
LCL Warning Threshold
LCL Shutdown Threshold
LCP Warning Threshold Table
LCP Shutdown Threshold Table
LCT Warning Threshold
HCT Shutdown Threshold
HCT Shutdown Threshold
HFT Warning Threshold
HFT Shutdown Threshold
HIT Warning Threshold
HIT Shutdown Threshold
Overspeed Shutdown Threshold

Dual Overspeed Thresholds

InPower™ Location:

Adjustments

Engine Protection Adjustments

Overspeed Shutdown Threshold (50 Hz)

Overspeed Shutdown Threshold (60 Hz)

InPower™ Configurable Feature

Shutdown Override

InPower™ Location:

Adjustments

Features

Shutdown Override

Shutdown Override Enable

The switch for the Low Coolant Level (LCL) engine protection is mandatory and must be installed. A customer option for this switch is available from Cummins for use with these engines. See the Cummins G-Drive Sales Handbook or contact your local Cummins distributor for further details and ordering information. Also, see the ***Miscellaneous Application Requirements and Information*** section on page 88 for further details about the Coolant Level switch.

Shutdown Override

The ECM can be configured to allow continued engine operation while most shutdown faults are active. Even when enabled, the Shutdown Override feature does not allow engine operation while overspeed or loss of engine speed faults are active, or while the ECM detects that the Local E-Stop, Remote E-Stop, or Backup Start Disconnect switches are in an "open" state. All other shutdown faults are overridden when this feature is enabled.

The Shutdown Override feature is enabled using the Cummins InPower™ electronic service tool. This is accomplished by setting the *Shutdown Override Enable* parameter to "Enabled".

⚠ WARNING ⚠

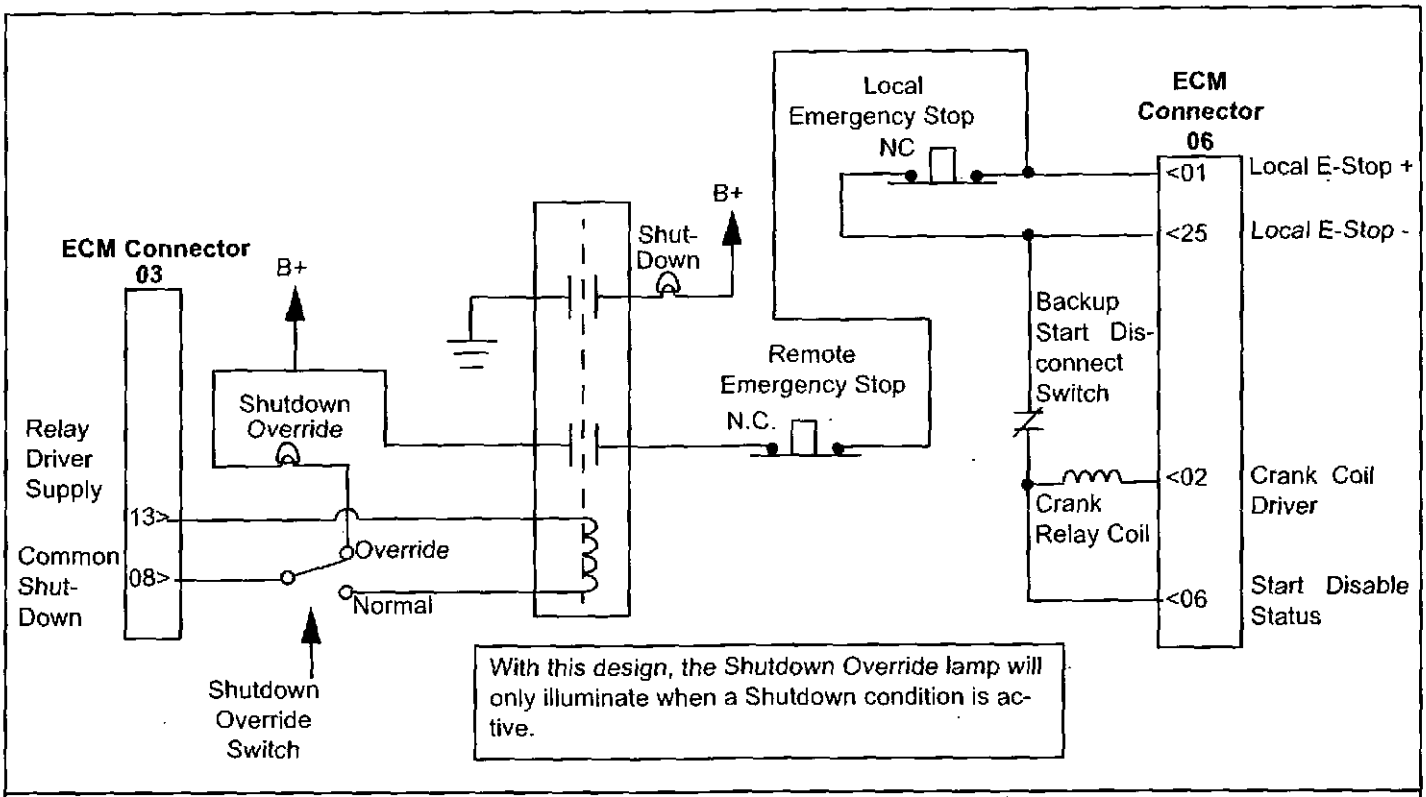
The Shutdown Override feature prevents the ECM from shutting down the engine, even when engine-damaging conditions are present. Damage done to the engine or the GCS while in Shutdown Override mode is ***NOT*** *covered by the engine warranty.*

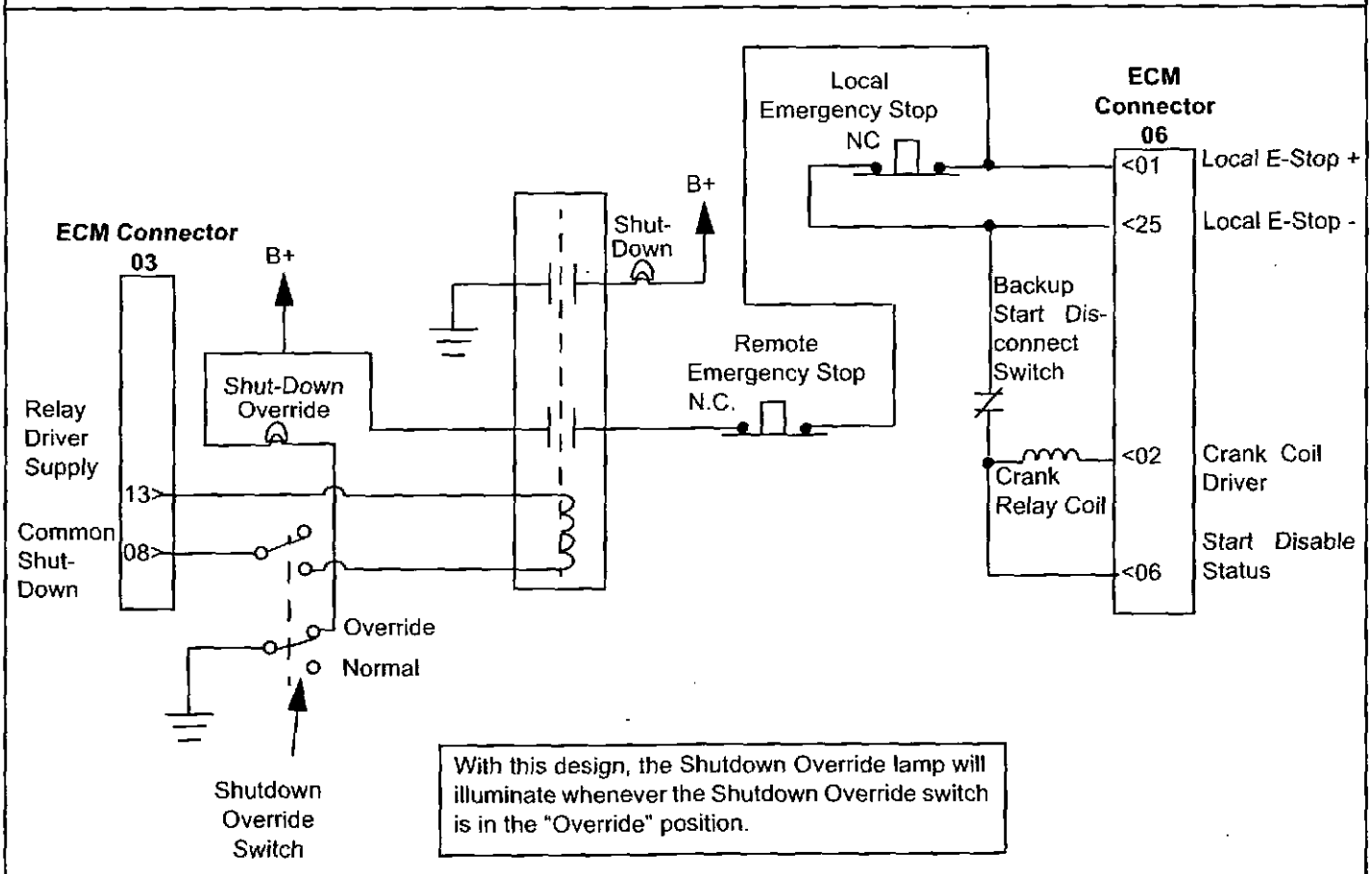
This feature should only be used in applications where engine damage is an acceptable trade-off for keeping the engine running.

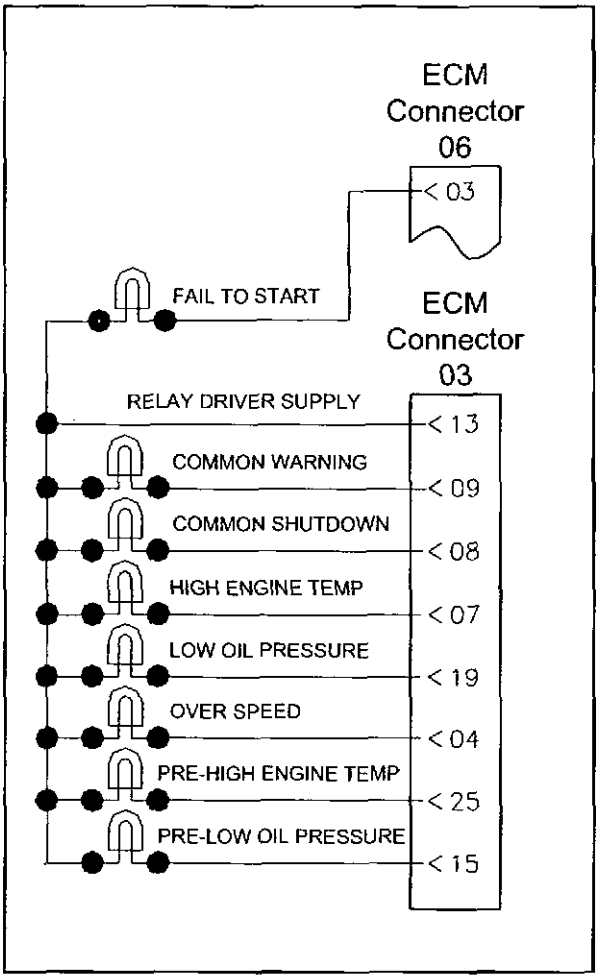
NEVER *use this feature to disable "nuisance" alarms. All alarms are to be treated as real until the root-cause is determined.*

An external switch can also be used to implement the shutdown override feature. The schematic diagrams on page 67 describe two different means to implement the external shutdown override control.

NOTE: *In order for the external Shutdown Override to operate, the Shutdown Override Enable parameter must be set to "Enabled" using InPower™.*


Local
Emergency Stop
NC
ECM
Connector
06
<01
Local E-Stop +
<25
Local E-Stop -
B+
Shut-
Down
ECM Connector
03
B+
Backup
Start Dis-
connect
Switch
Remote
Emergency Stop
N.C.
Shutdown
Override
Relay
Driver
Supply
13>
<02
Crank Coil
Driver
Crank
Relay Coil
Override
Common
Shut-
Down
08>
Normal
<06
Start Disable
Status
Shutdown
Override
Switch
With this design, the Shutdown Override lamp will only illuminate when a Shutdown condition is active.


Local
Emergency Stop
NC
ECM
Connector
06
<01
Local E-Stop +
<25
Local E-Stop -
B+
Shut-
Down
ECM Connector
03
B+
Backup
Start Dis-
connect
Switch
Remote
Emergency Stop
N.C.
Shut-Down
Override
Relay
Driver
Supply
13>
<02
Crank Coil
Driver
Crank
Relay Coil
Common
Shut-
Down
08>
Override
Normal
<06
Start Disable
Status
Shutdown
Override
Switch
With this design, the Shutdown Override lamp will illuminate whenever the Shutdown Override switch is in the "Override" position.



NOTE: *There is a small amount of leakage current (approximately 0.3mA) from the LED / Lamp drivers when the drivers are inactive, or turned "off". A suitable LED / Lamp must be selected by the OEM to prevent the LED / Lamp from dimly illuminating due to the leakage current.*

Alarm Lamp/Relay Drivers

Eight (8) output drivers are provided to annunciate that specific engine protection alarm conditions have occurred. Each output can be used to drive either a lamp or a relay. The following alarm drivers are provided:

Engine Shutdown Alarms

Drivers are provided for annunciating three Engine Shutdown Alarms for the following conditions:

- High Engine Temperature (HET)
- Low Oil Pressure (LOP)
- Overspeed (OS)

A condition that causes an HET, LOP or OS Engine Shutdown Alarm will activate the relay or lamp connected to the respective lamp/relay driver output.

Common Shutdown Alarm

A driver is provided for annunciating a Common Shutdown Alarm. The Common Shutdown Alarm activates when:

- Any Engine Shutdown Alarm condition is active
- The Local or Remote Emergency Stop Input is activated (either or both of these switches is "open")

Engine Warning Alarms

Drivers are provided for annunciating three Engine Shutdown Alarms for the following conditions:

- Pre-High Engine Temperature (HET)
- Pre-Low Oil Pressure (LOP)
- Fail-to-Start

A condition that causes a Pre-HET or Pre-LOP Engine Warning Alarm will activate the relay or lamp connected to the respective lamp/relay driver output. The Fail-to-Start output activates when the engine fails to start after the number of start attempts configured using the Cycle/Continuous Cranking feature have expired without successfully starting the engine. See the ***Cycle/Continuous Cranking*** section on page 41 for further details.

Common Warning Alarm

A driver is provided for annunciating a Common Warning Alarm. The Common Warning Alarm activates when any Engine Warning Alarm condition is active.

Each lamp/relay driver is rated to handle a maximum continuous voltage equivalent to Battery (+) and 200mA maximum continuous sink current.

The lamp/relay driver outputs are implemented by making the appropriate connections to ECM connector 03, except for the Fail-to-Start driver output, which is at ECM connector 06.

The Relay Driver Supply voltage is supplied by the ECM at pin 13 of ECM connector 03.

The lamp/relay drivers and driver supply voltage diagnostics must be enabled in order for the ECM to properly diagnose and report any lamp/relay driver faults. This is accomplished by setting the corresponding driver, or the driver supply, diagnostic parameters to "Enabled" using InPower™.

NOTE: *The ECM lamp/relay driver diagnostics are capable of detecting an open or short circuit condition. In order for the open circuit diagnostic to properly function, the lamp/relay load must draw between 2 to 200 mA current at +24 VDC. A load drawing less than 2mA will be diagnosed and reported as a driver open circuit fault. If any lamp or relay driver load draws less than 2mA, the respective driver diagnostic should be disabled to prevent nuisance open circuit faults from being reported.*

Fault Diagnostics

The following information is not intended to take the place of similar information provided in the engine Troubleshooting and Repair Manual (Cummins Bulletin No. 3666393). If there are discrepancies between the information in this manual and the information in the Troubleshooting and Repair Manual, the Troubleshooting and Repair Manual takes precedence.

Diagnostic LEDs

There are five diagnostic LEDs located on the side of the ECM that are visible through the display window. Following is a description of the condition being reported when the respective LED is illuminated:

Overspeed - this red LED indicates that an overspeed shutdown fault has occurred.

Low Oil Pressure - this red LED indicates that an engine Low Oil Pressure shutdown fault has occurred.

High Engine Temperature - this red LED indicates that a High Coolant Temperature or a High Intake Manifold Temperature shutdown fault has occurred.

Common Shutdown - this red LED indicates that a shutdown fault, other than those identified above, has occurred.

Common Warning - This yellow LED indicates that a warning fault has occurred.

InPower™
User Configurable Feature

Alarm Lamp/Relay Driver Diagnostics

InPower™ Location:

Adjustments

Features

Relay Drivers

Relay Driver Supply Diagnostic Enable

Fail to Start Driver Diagnostic Enable

Common Warning Driver Diagnostic Enable

Common Shutdown Driver Diagnostic Enable

HET Driver Diagnostic Enable

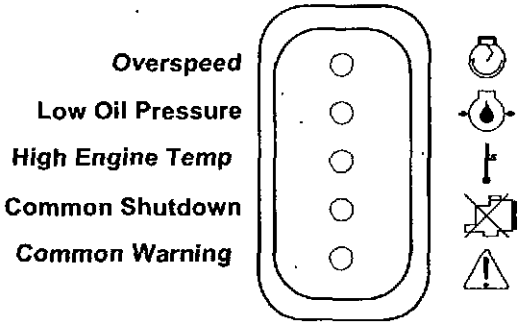
LOP Driver Diagnostic Enable

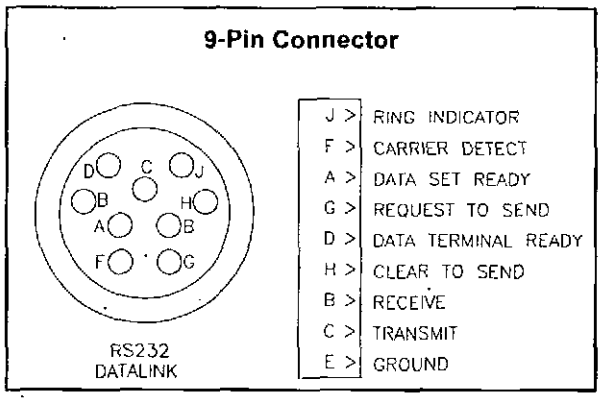
Overspeed Driver Diagnostic Enable

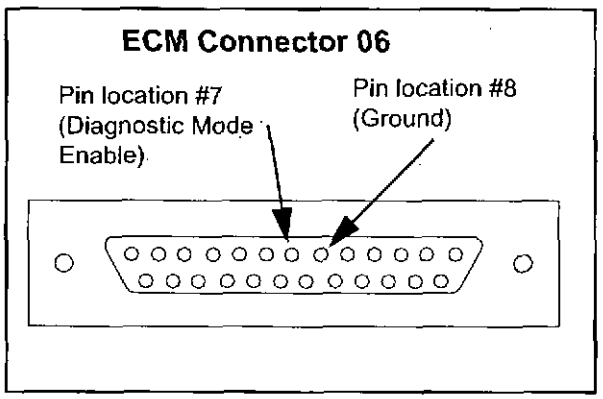
Pre-HET Driver Diagnostic Enable

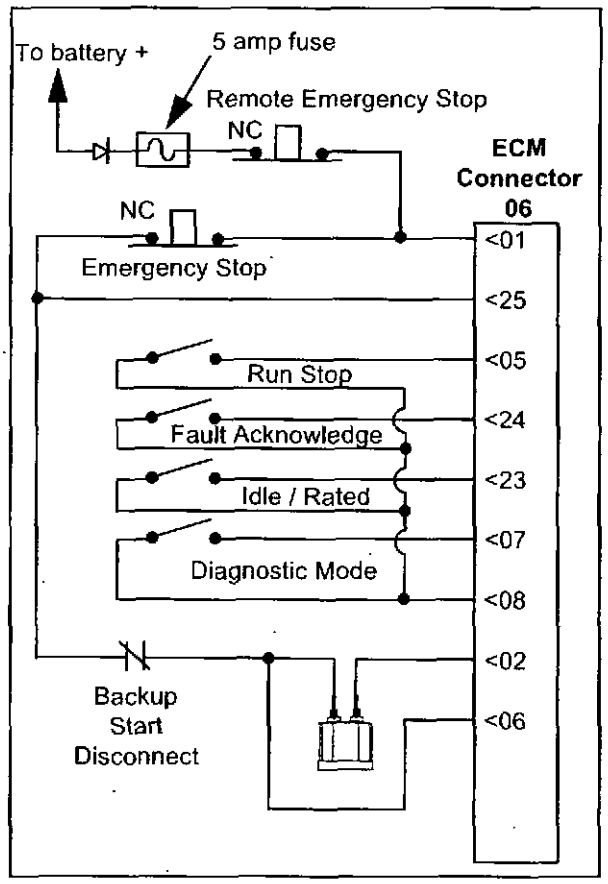
Pre-LOP Driver Diagnostic Enable

Diagnostic LED Display Window
(located on the side of the ECM)









Service Tool Interface

A 9-pin circular connector is accessible on the Engine Harness to provide a means of connecting the PC to the ECM so that the InPower™ electronic service tool can be used. Refer to the QSX15, QST30, QSK45, and QSK60 Generator-Drive Control System Troubleshooting and Repair Manual for further details.

Fault Codes

The ECM can record and report certain detectable diagnostic conditions. These conditions are recorded as fault codes, which can be used to assist in troubleshooting engine and control system failures. Refer to the QSX15, QST30, QSK45, and QSK60 Generator-Drive Control System Troubleshooting and Repair Manual for further details.

Fault codes recorded in the ECM memory can be accessed in three different ways:

- Diagnostic Mode (Fault Flash Out)
- Cummins InPower™ Electronic Service Tool
- Modbus Communications Datalink

Diagnostic Mode

A Diagnostic Mode input is provided to allow a means of placing the ECM into the diagnostic mode. When the ECM is in the diagnostic mode, fault codes are visually displayed, or "flashed out", using the Common Warning and Common Shutdown LEDs on the ECM. See the ***Fault Flash Out*** section on page 72 for further details.

To implement this feature, the customer supplies a bi-state signal, or switch, to pin 7 of ECM connector 06. Pin 8 of ECM connector 06 is used to provide an electrical signal path to GND through the ECM.

When the switch is set in the position that connects GND to the Diagnostic Mode input, the input is in the "Fault Flash Out Enabled" state (GND = Fault Flash Out Enabled).

When the switch is set in the position that opens the circuit connection, disconnecting GND from the Diagnostic Mode input, the input is in the "Fault Flash Out Inhibited" state (Open = Fault Flash Out Inhibited).

The diagnostic mode can also be enabled by removing the protective covers from the Diagnostic Mode Enable connectors on the Engine Harness, and plugging the two connectors together (the Diagnostic Mode Enable connectors are opposite genders).

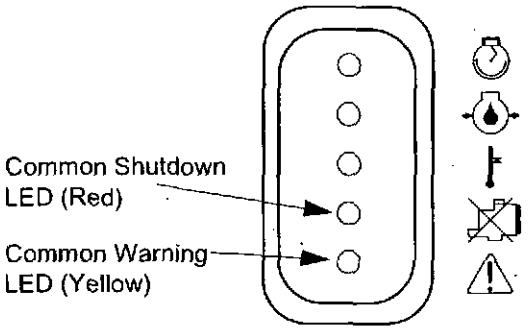
Once the diagnostic mode has been enabled, the Common Warning LED will flash once signifying the start of a new fault code, and then the fault code will flash out on the Common Shutdown LED. See the ***Fault Flash Out*** section on page 72 for further details.

> ***NOTE:*** *The Run/Stop input must be set to the "Stop" state in order to enter the Diagnostic Mode. If the Run/Stop input state changes to "Run" while the ECM is in the Diagnostic Mode, the ECM will immediately exit Diagnostic Mode and any fault flash out in process will terminate.*

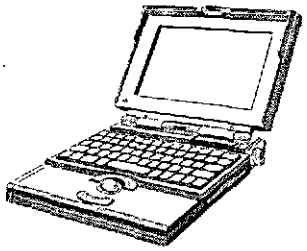
The Cummins InPower™ electronic service tool can also be used to read the fault codes. Refer to the InPower™ for Generator-Drive Control System Manual for detailed instructions on how to use InPower™ to read fault codes.

A third means of reading the fault codes is available via the Modbus communications datalink. See the ***Modbus Communications Datalink*** section on page 84 for further details.

Diagnostic LED Display Window
(located on the side of the ECM)



InPower™
User Configurable Feature



GCS Faults

InPower™ Location:

Faults

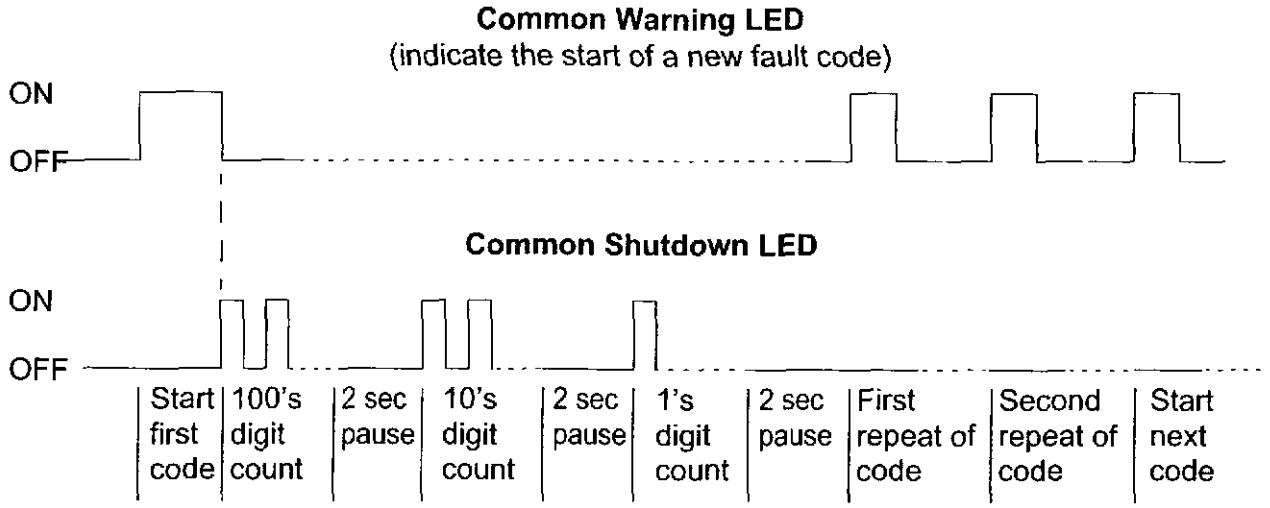
Fault Flash Out

When the ECM is in Diagnostic Mode, the Common Shutdown and Common Warning LEDs are used to display the fault codes of the currently active shutdown and warning faults.

These active fault codes are flashed out in the following method:

1. The first active fault code is flashed out 3 times consecutively.
2. If there is more than one active fault code, the process advances to the next fault and flashes out its code 3 times and so forth until all of the active faults have been displayed.
3. If the Fault Flashout mode is still active after all faults have been displayed, the process starts over again with the first active fault.
4. This cyclical display of active faults continues while Diagnostic Mode is active.

Following is a graphic depiction of the fault code flash out sequence for a 3-digit fault code:



The above example shows the LED flash-out sequence for reporting fault code 221.

Fault Acknowledge

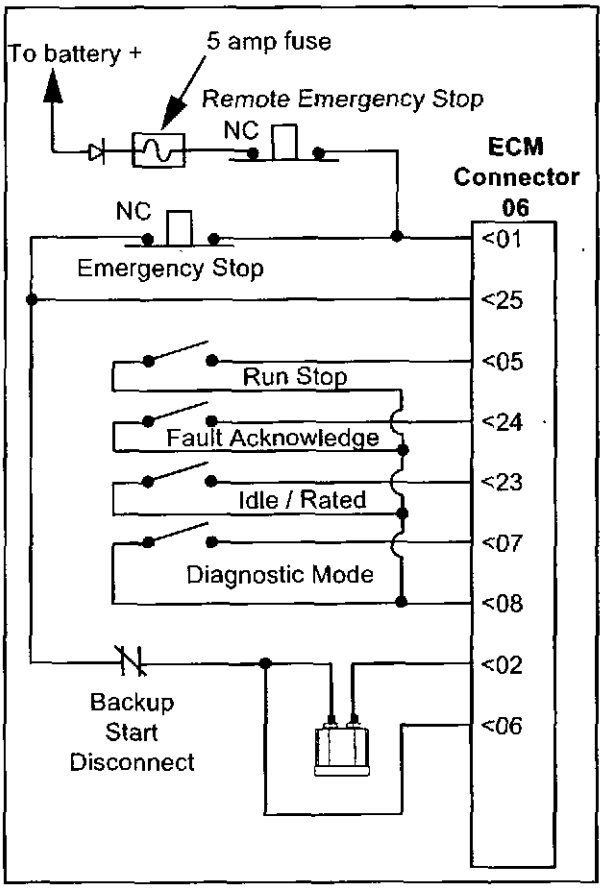
A Fault Acknowledge input is provided to allow a means of acknowledging the Common Warning and Common Shutdown lamp/relay driver outputs and Common Warning and Common Shutdown Diagnostic LED's that activate due to a fault condition. This feature is also used to acknowledge a shutdown condition and allow a re-start of the engine after it has shutdown due to an Emergency Shutdown condition.

To implement this feature, the customer supplies a normally open momentary bi-state signal, or switch, connection to pin 24 of ECM connector 06. Pin 8 of ECM connector 06 is used to supply an electrical signal path to GND through the ECM.

When the switch is actuated, momentarily connecting GND to the Fault Acknowledge input, the ECM will extinguish the indication of warning and shutdown conditions being displayed by the lamp/relay drivers and the diagnostic LED's (GND = Acknowledge, Open = Not Acknowledge).

> ***NOTE:*** *The Warning (Pre-Alarm) indications can be acknowledged when the engine is stopped or while the engine is still running. The Shutdown (Alarm) indications can only be acknowledged when the engine is stopped and the Run/Stop switch is in the "Stop" state.*
>
> *When a shutdown alarm condition is recognized by the ECM, the user must acknowledge this alarm before the engine can be re-started.*
>
> *Activation of the Fault Acknowledge input does not clear fault codes. The Cummins InPower™ Electronic Service Tool must be used to clear fault codes. Refer to the QSX15, QST30, QSK45, and QSK60 Generator-Drive Control System Troubleshooting and Repair Manual for details.*

The Fault Acknowledge feature can also be activated electronically using InPower™. This is accomplished by setting the *Fault Acknowledge Command* parameter to "Acknowledge". The ECM will automatically reset this parameter to "Not Acknowledge" after it has been activated.



InPower™
User Configurable Feature

Fault Acknowledge

InPower™ Location:

Monitor

Control

Starting / Stopping

Fault Acknowledge Command

NOTE: *Either the electronic trim, the switch input, or the MODBUS Fault Acknowledge bit can be used to acknowledge fault conditions. See the Modbus Communications Datalink section on page 84 for further information about the MODBUS communications datalink and the MODBUS Fault Acknowledge bit parameter.*

The Fault Acknowledge Command *parameter defaults to "Not Acknowledge" on ECM power-up.*

Snapshot Data

Snapshot data allows the relationship between the fault condition and the state of the ECM inputs and outputs, at the time the condition occurred, to be captured and viewed to assist in troubleshooting. When a fault code is recorded in the ECM, a "snapshot" of data is also recorded by the ECM.

The snapshot data is read using the Cummins InPower™ electronic service tool. Refer to the InPower™ for Generator-Drive Control System Manual for detailed instructions on how to use InPower™ to read snapshot data.

NOTE: *To prevent loss of valuable diagnostic information, such as Fault Codes and Snapshot Data, power must be available to the ECM at all times during normal engine operation and for at least one minute following an engine shutdown.*

System Check-Out / Test

Built-In Test

The following Built-In Tests are provided for the purpose of checking specific ECM electronic features:

- Lamp/Relay Driver Start-Up Test
- Stationary Test
- Cranking Test

The Lamp/Relay Driver Start-Up Test is automatically performed whenever the engine is started. It is also the first test conducted in the sequence of tests performed during the Stationary and Cranking Tests. The Stationary and Cranking Tests are initiated using InPower™ . This is accomplished by setting the *Built In Test Command* toggle parameter to the desired state, either "Test-Stationary" or "Test-Cranking".

When the Stationary Test is initiated the Outputs Test and Fuel Shut-Off Test, as described on page 76, will be performed sequentially.

When the Cranking Test is initiated the Outputs Test, Fuel Shut-Off Test, and Starter Test, as described on page 76, will be performed sequentially.

The Stationary, Cranking, or Fuel Rack Position tests can be aborted at any moment when commanded to do so using the Cummins InPower™ electronic service tool. This is accomplished by setting the *Built In Test Command* toggle parameter to "Test-Abort". The *Built In Test Command* toggle parameter will automatically reset to "Test-Abort" once the Stationary or Cranking Test is completed.

While conducting either the Stationary or Cranking test, the standard ECM diagnostic routines are performed. If any faults are detected during this time, the faults are recorded and reported using the means described in the ***Fault Diagnostics*** section on page 69.

InPower™
Configurable Feature

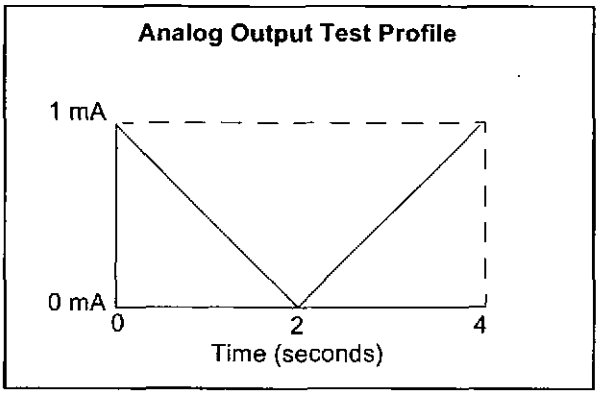
Built-In Test

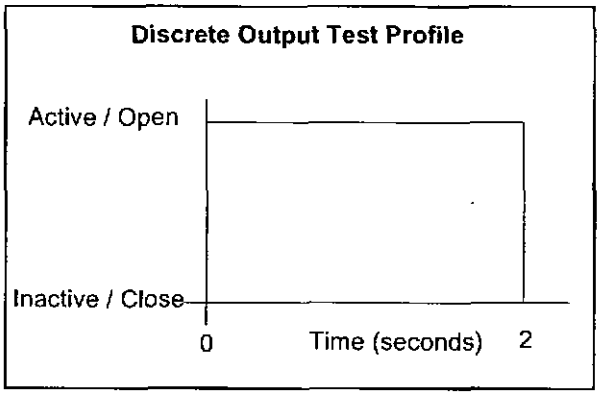
InPower™ Location:

Test

Self Test

Built In Test Command





Lamp/Relay Driver Start-Up Test

The Lamp/Relay Driver supply voltage at connector 03 is normally on when the ECM is powered. During engine start-up the ECM will turn this supply voltage off for a 1.5 second interval as a means of testing the lamps/relays driven by the supply. Any Lamp/Relay Driver output that is active during this test will extinguish/de-energize during the 1.5 second test duration.

Outputs Test

During the Outputs test all meter drivers, lamp/relay drivers and diagnostic LEDs will be exercised. The meter driver output test will respond according to the Analog Output Test Profile shown to the right. The Lamp/Relay drivers and LEDs will respond according to the Discrete Output Test Profile shown to the right. Note that the Outputs Test for the lamps/relay drivers and the LEDs are performed first, followed by the meter drivers test.

Fuel Shut-Off Test

Immediately following the Output Tests, the Fuel Shut-Off Test will be initiated. During this test, the FSO driver will respond according to the Discrete Output Test Profile shown to the right. Also, the fueling actuators are de-energized while this test is being conducted.

Starter Test

The Starter Test will be performed immediately following the Fuel Shut-Off Test, only when the Cranking Test is being performed. For this test, the Crank Relay driver output will respond to the Discrete Output Test Profile shown to the right.

⚠ WARNING ⚠

The Starter Test will cause the engine to crank for 2 seconds, although the engine will not start. All barring devices should be removed from the engine and personnel should be a safe distance away from the engine prior to initiating the Starter Test.

Fuel Rack Position Test

The Fuel Rack Position Test is used to check the fuel rack driver and position sensor circuitry. InPower™ can be used to move the fuel rack position and the results can be measured. The position test capability is emabled by setting the *Built-In Test* toggle parameter to the "Test - Manual" state.

> ***NOTE:*** *The control system will not enter the Test - Manual state if the engine is not running. If the engine is not running and the control system is in the Test - Manual, and the engine is started, it will exit the Test - Manual state immediately and discontinue the Rack Position Test.*

The Fuel Rack Position Overdrive Command #1 and Fuel Rack Position Overtide #2 parameters are used to command the desired rack position of the corresponding fuel pump while in the Test - Manual state. The Fuel Rack Position #1 and Fuel Rack Position #2 monitor parameters report the rack positions as determined by the rack position sensor of the respective pump.

Fuel Rack Position Test

InPower™ Location:

Test

Fuel System Test

Built-in Test

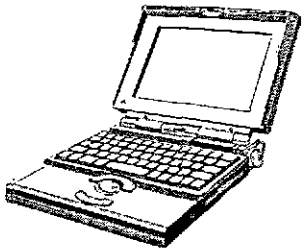
Fuel Rack Position Override Command #1

Fuel Rack Position #1

Fuel Rack Position Override Command #2

Fuel Rack Position #1

InPower™ Configurable Feature



Additional Test Capabilities

The GCS provides the following additional test capabilities. These test functions are set-up using InPower™.

> ***NOTE:*** *These tests require that the normal input/output signal levels be manually overriden by the user.*
>
> *Once testing is complete, be certain that all override enables are set back to "Disabled" to ensure that the ECM is using the actual engine sensor signals and controlling the meter and lamp/relay drivers to the actual output level/ state.*
>
> *Override enables will default back to "Disabled" when the ECM is powered off and back on.*

Meter Drivers Test

InPower™ Location:

Test
- Outputs
  - Meter Drivers
    - Coolant Temp
      - ***Coolant Temp Meter Override***
      - ***Coolant Temp Meter Override Enable***
    - Engine Speed
      - ***Engine Speed Meter Override***
      - ***Engine Speed Meter Override Enable***
    - Oil Pressure
      - ***Oil Pressure Meter Override***
      - ***Oil Pressure Meter Override Enable***

Meter Drivers

The normal analog meter driver outputs can be overriden to command a specified test output level. This is accomplished by setting the respective meter override enable command to "Enabled" and setting the override value to the desired meter output driver current.

Lamp/Relay Drivers

The state of each Alarm Lamp/Relay Driver output can be overriden individually. This is accomplished by setting the respective driver override enable command to "Enabled" and setting the override value to the desired driver output state.

Lamp/Relay Drivers Test

InPower™ Location:

Test
- Outputs
  - Relay Drivers
    - Common Shutdown
      - ***Common Shutdown Driver Override Command***
      - ***Common Shutdown Driver Override Enable***
    - Common Warning
      - ***Common Warning Driver Override Command***
      - ***Common Warning Driver Override Enable***
    - Fail to Start
      - ***Fail to Start Driver Override Command***
      - ***Fail to Start Driver Override Enable***
    - HET Shutdown
      - ***HET Driver/LED Override Command***
      - ***HET Driver/LED Override Enable***
    - LOP Shutdown
      - ***LOP Driver /LED Override Command***
      - ***LOP Driver/LED Override Enable***
    - Overspeed
      - ***Overspeed Driver/LED Override Command***
      - ***Overspeed Driver/LED Override Enable***
    - Pre-HET Warning
      - ***Pre-HET Driver Override Command***
      - ***Pre-HET Driver Override Enable***
    - Pre-LOP Warning
      - ***Pre-LOP Driver Override Command***
      - ***Pre-LOP Driver Override Enable***

Engine Protection Verification Test

InPower™ Location:

Test

Fault Simulation

Engine Protection Tests

Coolant Pressure

Coolant Pressure Override Command

Coolant Pressure Override Enable

Coolant Temp

Coolant Temp Override Command

Coolant Temp Override Enable

Fuel Temp

Fuel Temp Override Command

Fuel Temp Override Enable

Intake Manifold Temp

Intake Manifold Temp Override Command

Intake Manifold Temp Override Enable

Oil Pressure

Oil Pressure Override Command

Oil Pressure Override Enable

Oil Temp

Oil Temp Override Command

Oil Temp Override Enable

Overspeeding

Overspeed Shutdown Threshold

Engine Speed Reference Override Command

Engine Speed Reference Override Enable

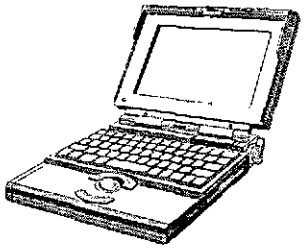
Accel Ramp for Engine Speed Override

Decel Ramp for Engine Speed Override

Engine Protection Verification

The normal sensor values used by the ECM to perform engine protection can be overriden to simulate a specified test signal level. This is accomplished by setting the respective engine sensor override enable command to "Enabled" and setting the override value to the desired sensor input level.

InPower™ Configurable Feature



Reset Fuel Consumption

InPower™ Location:

Adjustments

Reset History Counters

Fuel

Reset Fuel Consumption

Power Limiter

InPower™ Location:

Adjustments

Features

Power Limiter

Power Limiter State

Power Limiter Enable

Continuous Scale Factor

Miscellaneous Outputs / Capabilities

Reset Fuel Consumption

The ECM stores the total cumulative amount of fuel used by the engine in non-volatile memory. There is also a second fuel consumption counter, called *Fuel Consumption Since Reset*, that stores the amount of fuel consumed since this counter was last reset. The *Fuel Consumption Since Reset* counter can be reset to zero using InPower™. This is accomplished by selecting the *Reset Fuel Consumption* toggle parameter.

Power Limiter

The Power Limiter feature provides the capability to select a power limit best suited for the specific application in which the engine is being used (i.e. standy, prime, or continuous power applications). This is accomplished by setting the *Power Limiter State* parameter to the desired selection (Standy, Limited Time Prime, Unlimited Time Prime, or Continuous) using InPower™.

The Power Limiter feature must be enabled in order make the feature operational. This is accomplished by setting the *Power Limiter Enable* parameter to "Enabled" using InPower™. Once enabled, the engine power is limited by the maximum fueling that the fuel system is commanded to deliver to the engine based on limits pre-programmed in the ECM.

When the Power Limiter State is set to "Continuous" the *Continuous Scale Factor* parameter can be used to control the maximum amount of continuous power that the engine is capable of providing. This is accomplished by setting the *Continuous Scale Factor* to a value between 0 and 1, representing the percentage (between 0 and 100%) of the total engine continuous rated power capability.

> ***NOTE:*** *There is only a scale factor for use with continuous power applications. For engines used in standby or prime-time applications, the Power Limiter feature uses pre-programmed fueling limits and the Continuous Scale Factor parameter setting has no effect.*

Pre-Start Priming

The QST30 generator drive engine is equipped with an electric fuel lift pump that is controlled by the ECM. The Pre-Start Priming feature of the GCS provides a means to prime the fuel system prior to starting the

engine. When the Pre-Start Priming feature is enabled, the fuel lift pump will start the priming cycle, beginning to pump fuel when either the Run/Stop switch changes from "Stop" to "Run" or when the Crank switch input becomes active, and run for a specified period of time prior to engaging the starting system.

The reason for having either the Run/Stop switch or the Crank switch initiate the priming cycle is so that if engine cranking is not performed for a while after the Run/Stop switch has been set to "Run", the priming cycle will be performed again when Cranking is initiated to ensure the fuel system is primed for starting.

The Pre-Start Priming feature must be enabled in order to make the feature operational. This is accomplished by setting the *Pre-Start Priming Enable* paramter to "Enabled" using INPOWER™. The amount of time that the fuel lift pump wil run prior to the starting system engagement can be adjusted by setting the *Pre-Start Fuel Priming Time* parameter to the desired period.

If the Pre-Start Priming feature is not enabled, or the Pre-Start Fuel Priming Time value is set to 0 seconds when the feature is enabled, the GCS will engage the starting system immediately after the Crank switch is activated, without delay.

InPower™
Configurable Feature

Reset Fuel Consumption

InPower™ Location:

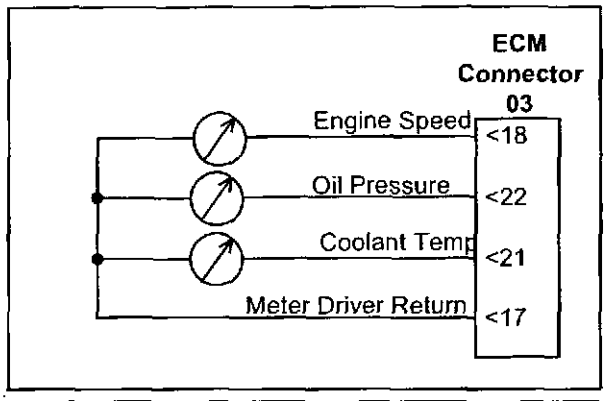
Adjustments

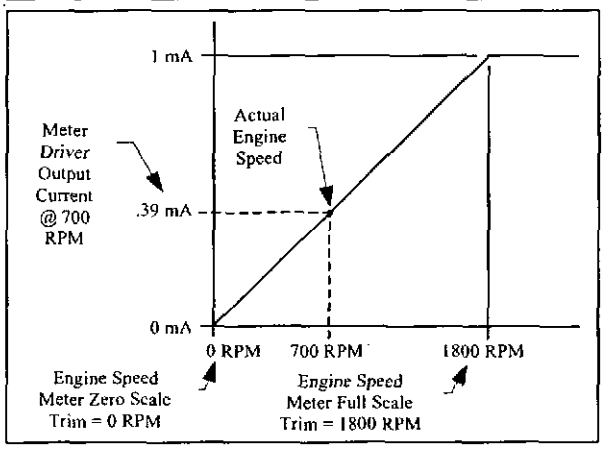
Features

Fuel Lift Pump

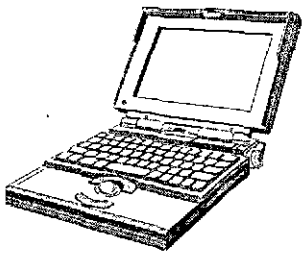
Pre-Start Priming Enable

Pre-Start Fuel Priming Time





InPower™
Configurable Feature



Analog Meter Drivers

InPower™ Location:

Adjustments

Features

Meter Drivers

Engine Speed Meter Zero Scale

Engine Speed Meter Full Scale

Oil Pressure Meter Zero Scale

Oil Pressure Meter Full Scale

Coolant Temp Meter Zero Scale

Coolant Temp Meter Full Scale

Engine Monitoring

Analog Meter Drivers

Drivers are provided for driving analog meters to monitor the following three engine parameters:

- Engine Speed
- Oil Pressure
- Coolant Temperature

These parameters can be monitored by interfacing with the respective meter driver outputs and meter driver return input of ECM connector 03.

> ***NOTE:*** *The type of meter selected for use with this feature must have a 0 to 1 mA meter movement, with an impedance not greater than 100 ohms. The lower the impedance, the higher the accuracy of the indication will be. A meter with a 50 ohm impedance will provide an accuracy of approximately 1.2%.*

The meter drivers are configured using InPower™ to set the parameter trim values for the lower and upper parameter limits corresponding to 0 and 1 mA driver current levels. For example, the figure at the left is a graph depicting the driver response when configured to monitor the Engine Speed, using 0 and 1800 RPM as the trim values.

Modbus Communications Datalink

The ECM contains data that can be read using a remote device communicating with the ECM via Modbus protocol on a two-wire half-duplex RS-485 serial communications bus. In this arrangement, the remote device is the master, and the ECM is a slave, supplying data to the master when requested. For further details refer to the Modbus master-slave technique described in the Modbus Protocol Reference Guide (Modicon Document No. PI-MBUS-300). The Modbus Protocol Reference Guide can be found on the World-Wide-Web (WWW) at the Schneider Automation Inc. web-site. The document is accessible on-line using Universal Resource Locator (URL):

http://www.modicon.com/techpubs/techpubnew/pi_mbus_300.pdf

The following engine and ECM information can be monitored using the Modbus datalink:

Engine Sensor Parameters
- Fuel Rack Position (Left & Right Banks)
- Engine Speed
- Coolant Temperature
- Oil Pressure
- Barometric Pressure
- Intake Manifold Pressure (Left & Right Banks)
- Intake Manifold Temperature (Left & Right Banks)
- Coolant Pressure
- Fuel Supply Pressure
- Oil Temperature
- Fuel Temperature
- Coolant Level
- CENTINEL Oil Make-Up Tank Level

Switch Input States
- Idle/Rated
- Run/Stop
- Remote Emergency Stop

Adjustable Input Settings
- Frequency Adjust Pot
- Droop Adjust Pot
- Governor Gain Adjust Pot

Speed Bias Inputs
- ±0.2V Speed Bias Signal
- ±2.5V Speed Bias Signal

Lamp/Relay Driver States
- Common Shutdown
- Common Warning

Actuator Driver States
- Fuel Shut-Off Solenoids

Fault/Diagnostic Data
- Active Warning Fault Events
- Active Shutdown Fault Events
- Most Recent Fault Events

Other GCS/ECM Data

- Battery Voltage
- Operator Interface Mode
- Engine Running Time
- ECM On-Time
- Base Frequency
- Base Speed
- Final Speed Reference
- Estimated Torque
- Load Profile Monitor
- Fuel Consumption Rate
- Cumulative Fuel Consumption

The customer can implement the RS-485 physical interface by connecting the shielded twisted-pair serial communications bus wires RS485+ and RS485- (pins 21 and 18 respectively) and the bus shield (pin 20) of ECM connector 06.

The Modbus operates at a communications rate of 9600 baud. At this data rate, the maximum specified bus length of 4000 ft. [1219m] can be achieved. If the ECM is connected at either end of the communications bus, Term 1 and Term 2 (pins 22 and 19 respectively) of ECM connector 06 are to be jumpered by shorting these two pins together. If the ECM is not connected at either end of the bus, Term 1 and Term 2 should be left unconnected.

For further details regarding RS-485 implementation and applications, refer to Electronic Industries Association Standard EIA-485, "Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multi-Point Systems". Additional information can be found on the WWW at the B&B Electronics Manufacturing Company website. Refer to the "RS-422 and RS-485 Application Note" accessible on-line using URL:

http://www.bb-elec.com/bb-elec/literature/tech/485appnote.pdf

The information following provides specific details required to implement the digital portion of the Modbus Interface. Please refer to Modicon's Modbus Protocol Reference Guide for further details not inlcuded in this manual

The Modbus interface supports the Remote Terminal Unit (RTU) mode message framing only. The communications parameters are set at 1 start bit, 8 data bits, no parity and 2 stop bits. The ECM slave device address is 1.

Modbus register data available for all engine models is defined in Appendix A. Appendix B defines the register data available for only the QSX15 model engine. Appendix C defines the register data available for only the QSK45 and QSK60 model engines. Modbus register parameters are identified as either Signed (S) or Unsigned (U) in the Type column of the respective tables. Where signed values are used, the value is a 16-bit 2's complement number. The maximum amount of register data the ECM can return in a slave response is 16 registers. The maximum length of the entire message must not exceed 256 bytes.

Appendix D defines the bit data available via the Modbus for all engine models. The maximum amount of bit data the ECM can return in a slave response is 32 bits (specified as "inputs", per the Modbus Protocol Reference Guide). The maximum length of the entire message must not exceed 256 bytes.

Supported Modbus exception codes are defined in Appendix C, and supported diagnostic sub-functions are defined in Appendix D.

First Time Engine Start

Prior to starting the engine for the first time the following Engine Check and Functional Test procedures should be performed.

Engine Check

Perform the following checks:

- Verify nominal battery voltage
- Verify there are no active faults
- Using InPower™, verify the following critical sensors are indicating a normal value (with engine not running)
  - Boost Pressure
  - Fuel Pressure
  - Oil Pressure
  - Coolant Temperature
- Manually check that the Oil Level is normal
- Manually check that the Coolant level is normal

If any problems or abnormal conditions are observed, perform any necessary troubleshooting and repairs prior to performing the following functional test.

Control System Functional Test

Perform the following control system tests in the sequence shown. Verify by observation that the expected system/engine response occurs during each test. These tests are described in detail in the ***Built-In Test*** section on page 75 of this manual.

- Stationary Test
- Cranking Test

If any test fails to produce the expected result, perform any necessary troubleshooting and repairs prior to attempting to start the engine for the first time.

Engine Starting

Prior to starting the engine for the first time, the ***Engine Check*** and ***Control System Functional Test*** procedures described on page 86 should be performed.

To start the engine, the Run/Stop input must be set to the "Run" state first. Then to engage the starter and crank the engine, the Crank input must be held in the "Crank" state until the engine starts and is running on its own power. The control system will automatically disengage the starter once the engine speed has increased above a pre-programmed starter disconnect speed. If the starter fails to automatically disengage, the Backup Start Disconnect switch should be used to disengage the starter. See the ***Backup Start Disconnect*** section on page 42 for details.

The control system is designed so that it can be programmed by the customer to prevent damage to the starter due to over-cranking. The maximum cranking time can be programmed using InPower. See the ***Cycle/Continuous Cranking*** section on page 41 for details. When the specified crank engage time has been achieved, the control system will automatically disengage the starter.

Miscellaneous Application Requirements and Information

Customer Supplied Coolant Level Switch

The Engine Harness has a provision for installing a customer supplied Coolant Level Switch. The Coolant Level Switch interface connector on the harness is a Deutsch 4-position connector (Deutsch P/N DT06-4S with a P/N W4S wedge insert) using 0.969 - 1.442 mm^2 sockets (16-18 AWG; Deutsch P/N 1062-16-0122).

A Coolant Level Switch that is compatible for use with the engine can be purchased from Cummins. See the Cummins G-Drive Sales Handbook or contact your local Cummins distributor for further details and ordering information.

> ***NOTE:*** *Use of the Coolant Level Switch is mandatory and must be installed. The customer is responsible for performing a test to ensure that this feature is set-up correctly and that a low coolant level is being properly detected and reported.*

CENTINEL™ Continuous Oil Replacement System (CORS)

The CENTINEL™ CORS feature, when used in conjunction with a CORS oil burn/make-up valve and an oil make-up tank, blends used engine oil with diesel fuel and provides fresh oil to the engine. The blend rate, the rate at which used oil is added to the fuel to be burnt during combustion and fresh oil is added back to the oil sump, is controlled by the CORS feature algorithm based on the engine's operating duty cycle. Refer to the appropriate sections of the CENTINEL™ Master Repair Manual (Cummins Bulletin No. 3666231) for further details about the "Burn with make-up" system installation and operation.

There is also a "Burn-only" version of the CENTINEL™ system that does not use a make-up oil tank. This version requires that the operator add oil to the engine at regular intervals since there is no fresh oil supply to make-up the engine oil that is burned.

NOTE: *The burn-only version uses the same engine wiring harness that has the make-up tank oil level sensor connection, but it is not connected to the make-up tank oil level sensor. To prevent nuisance low oil level faults in the burn-only system, the make-up oil level sensor connector on the wiring harness must be jumpered. Refer to the appropriate sections of the CENTINEL™ Master Repair Manual (Cummins Bulletin No. 3666231) for further details about the "Burn-only" system installation and operation.*

The factory default for the *CORS User Trim Enable* setting is dependent upon whether the customer has ordered the CENTINEL CORS option with the engine. If the option was ordered, the CORS valve will be installed on the engine during manufacture and the ECM trim setting for the CENTINEL CORS feature will be enabled, otherwise, the trim setting will be disabled. See the Cummins G-Drive Sales Handbook or contact your local Cummins distributor for further details and ordering information.

Centinel™ Continous Oil Replacement System (CORS) InPower™ Location:

Adjustments

Features

CORS

CORS User Trim Enabe

Oil Changed

NOTE: *Engines built prior to the availability of the CENTINEL CORS feature will not have the necessary calibration and/or engine wiring harness connectors to work with the CENTINEL oil burn/make-up valve. See the Cummins G-Drive Sales Handbook or contact your local Cummins distributor for further details and ordering information.*

The CENTINEL CORS MUST NOT be installed on engines that are to be operated in California and other locations where regulatory agencies have restricted the use of such oil burning systems.

When there is a CENTINEL CORS failure or the make-up oil tank level sensor detects that the oil in the make-up tank is low, the ECM will inhibit the oil burn/make-up cycling of the valve and the appropriate fault will be reported.

The ECM will maintain a count of missed oil burn/make-up cycles, or pulses, while a CENTINEL CORS fault is active. If the cause of the fault is repaired in a timely manner the ECM will re-activate the valve and increase the blend rate to catch up with the amount of fresh oil that was missed, until the proper amount of fresh oil has been replaced. If the fault persists too long the CORS can not catch-up even if the fault were to be repaired and the ECM will report a specific fault requiring an oil change be performed to completely replace the engine oil with fresh oil.

If an oil change is required due to an extended CORS fault condition, after the oil change has been accomplished it is necessary for the operator to reset the number of missed pulses in order for the CORS feature to function normally. This is accomplished using InPower™ by setting the *Oil Changed* parameter to "Reset". The ECM will automatically set this parameter back to "Not Reset" after it has been Reset indicating that the number of missed pulses has been reset.

Differences Between the GCS and FCG Systems

Installation Differences

There are several controller installation and design specification differences between the "old" ***G-Drive Fuel Control Governor (FCG)*** module and the "new" ***G-Drive Control System (GCS)*** module that must be considered by the OEM.

Engine Harness and OEM Connections

The G-Drive Fuel Control Governor (FCG) module and the G-Drive Control System (GCS) module use two different types of connector systems.

The FCG module has two 40-pin Deutsch connectors, Connector A and Connector B respectively. Connections between the engine harness and the control module are made using a factory supplied wiring harness that mates with Connector A of the module. The OEM is responsible for building the wiring harness to access the features available by wiring to Connector B. Further details are described in the QST30 Generator Drive Fuel Control Governor application manual, Cummins Bulletin #3666323.

The GCS module has two 50-position D-Sub connectors (Connectors 02 and 05) and two 25-position D-Sub connectors (Connectors 03 and 06). Connections between the engine harness and the control module are made using a factory supplied wiring harness that mates with the two 50-position D-Sub connectors, Connectors 02 and 05. The OEM is responsible for building the wiring harness to access the features available by wiring to the two 25-position D-Sub connectors, Connectors 03 and 06. The mating connectors and associated parts are supplied with the engine to be used in the manufacture of the

OEM wiring harness to these two 25-position connectors. See the ***Installation*** section on page 14 for further details.

Module Orientation

The Generator Drive Control System (GCS) module is required to be installed with the connectors facing down and the cooling fins of the heat-sink oriented vertically in order to comply with IP53/NEMA-3R requirements and provide adequate cooling for the module. See the ***Installation*** section on page 14 for further details.

Specification Similarities and Differences

The following tables provide a listing of both the similarities and differences between the GCS and FCG module design specifications. The differences may require that the OEM make changes to accommodate the new GCS control module. The "QST30 GCS Vs FCG Differences" table provides an application recommendation or guideline in the last column of the table. The OEM is responsible for ensuring their installation and design meets the intent of each recommendation and guideline.

QST30 GCS Vs FCG Similarities

Specification	NEW G-Drive Control System (GCS) module (Ref. Cummins Bulletin #4000195)	OLD Generator Drive Fuel Control Governor module (Ref. Cummins Bulletin #3666323)	Comments
Governor Mode	Isochronous to 10% Droop	Isochronous to 10% Droop	
Operating Voltage Range	+18 to +35VDC (+12VDC Minimum during engine starting)	22.0 to 34.0 VDC; 24 VDC Recommended	The GCS module has a wider Operating Voltage Range.
Ground Polarity	Negative Ground (Convertible to Positive or Isolated Ground)	(-) Negative	The GCS module is compatible for use with a Positive or Isolated Ground as well as a Negative Ground system.
Relative Humidity	0-95% non-condensing	0-95% non-condensing	
Case Metal	Sheet Steel - Housing Aluminum - Heat Sink	Die Cast Aluminum	The difference in package metal is not a significant difference with regard to the application or installation of the module providing all other application guidelines and installation recommendations are followed.
Voltage Surge Protection	per EN61000-4-5 and +63VDC supply surge voltage	80 VDC, 10mS transient	There is nothing that changes with the installation or application due to the difference in module surge protection.
Reverse Polarity Protection	+28VDC Maximum	Yes	The GCS module is capable of withstanding an applied reverse voltage of +28VDC.
High Voltage Protection	+35VDC Maximum Continuous	35VDC for 24 hours continuous	The GCS module is capable of withstanding a continuous applied voltage of +35VDC.

QST30 GCS Vs FCG Differences

Specification	NEW G-Drive Control System (GCS) module (Ref. Cummins Bulletin #4000195)	*OLD* Generator Drive Fuel Control Governor module (Ref. Cummins Bulletin #3666323)	Application Recommendation/Guideline
Nominal Operating Current	8.0A @ +24VDC	3.5A @ 24VDC	Battery power supply and return cables must be sized appropriately for the *larger current demand of* the GCS module.
Maximum Operating Current	10A @ +24VDC	4.5A @ 24VDC	
Quiescent Current Draw	60mA (nominal) - Sleep Mode 350mA (nominal) - Ready Mode [ECM On & Engine *Running*]	30mA	
Ambient Operating Temperature	Module Housing Temperature: -40 to 158 deg. F [-40 to 70 deg. C] Module Heat Sink Temperature: -40 to 140 deg. F [-40 to 60 deg. C]	-40 to 185 deg. F [-40 to 85 deg. C]	The GCS module must be installed where the maximum operating temperatures are not exceeded. This may require that the installation be changed to provide an adequate cooling environment.
Storage Temperature	-67 to 176 deg. F *[-55 to 80 deg. C]*	-40 to 185 deg. F *[-40 to 85 deg. C]*	The storage temperature *range for the GCS module* is not as wide. Storing a GCS module may require different provisions in order to comply with the *storage temperature* requirements.
Dimensions	228 mm x 182.5 mm x 129.7 mm [8.98 in. x 7.19 in. x 5.11in.]	204 mm x 227 mm x 46 mm [8.0 in. x 8.9 in. x 1.8 in.]	Although the depth of the GCS module is not as great, both the height and width of the GCS module are greater. The GCS module mounting holes are located differently.

NOTE: *These differences may require the OEM make changes to accomodate the new GCS control module.*

QST30 GCS Vs FCG Differences (continued)

Specification	NEW G-Drive Control System (GCS) module (Ref. Cummins Bulletin #4000195)	OLD Generator Drive Fuel Control Governor module (Ref. Cummins Bulletin #3666323)	Application Recommendation/Guideline
			These differences require that the installation be changed to accommodate the mounting and space requirements of the GCS module.
Weight	4.15 kg [9.16 lbs]	2.7 kg [6.0 lbs]	The GCS module is heavier. This may require that the installation be changed to accommodate the heavier weight.
Hard-Wired OEM Interfaces	See ***OEM Wiring Changes*** section below for further details.		

NOTE: *These differences may require the OEM make changes to accomodate the new GCS control module.*

Field Conversion of a GCS Module to an Engine Currently Using the FCG Module

An existing engine that uses the FCG can be converted so that it will operate using the new GCS module. The following application information provides specific details about the conversion process. All applicable recommendations and guidelines in the last column of the "QST30 GCS Vs FCG Differences" on page 93 ***must*** be followed. The OEM is responsible for ensuring their installation and design meets the intent of each recommendation and guideline.

Field Conversion Parts and Instructions

Cummins Parts Announcement TBD includes specific information about the parts available for purchase that are needed and instructions to upfit a GCS module to a genset currently using the FCG module. The OEM or customer should obtain a copy of the Parts Announcement and read it prior to making any design or installation changes required to upfit the genset with a GCS module. Pages 34 and 36 are diagrams of the Engine Converter and OEM Converter Harness available for converting an existing engine. See the Parts Announcement for further details.

OEM Wiring Changes

Due to design differences between the GCS and FCG modules the OEM wiring will need to change if certain features of the FCG used in the current genset control system are to operate properly once the GCS module is upfit to the genset.

Diagnostic Mode Connectors

This diagnostic shorting plug on the engine harness is removed to power the FCG module allowing service tool communications with the module when the Run Switch is off. The diagnostic shorting plug on the engine harness is not used with the GCS module. Instead, the OEM adapter harness has two 1-pin, opposite gender weather-pack connectors that are used to initiate the diagnostic mode of the GCS module. When the two 1-pin connectors are plugged into one another, the GCS module will enter diagnostic mode while the engine is not running (the Run/ Stop switch is set to "Stop").

While in diagnostic mode, the Common Warning and Common Shutdown LED's on the side of the ECM will flash-out a sequence indicating which faults are active. Diagnostic mode terminates when the plug is disconnected from the mating connector or when the engine starts and the diagnostic mode connectors are still plugged into one another. See the ***Diagnostic Mode*** section on Page 70 if this manual for further details.

Also, the analog Rack Position Voltages are not output from the GCS module to the Diagnostic Connector of the Engine Harness, but are available for monitoring electronically using the INPOWER™ service tool.

Run/Stop Switch

The Run Signal input of the FCG requires that one terminal of the Run/Stop switch be connected to B+. The B+ connection from the Run/Stop switch must be disconnected from B+ and connected to engine ground in order to work properly with the GCS module Run/Stop switch input.

Common Warning and Alarm Drivers

The Common Alarm Shutdown Relay and Common Warning Relay outputs are replaced by low side drivers (Active = Ground, Inactive = Open) in the GCS module. This requires that the OEM interface to these connections be changed so that the load on these low-side drivers is no greater than 200 mA at +24 VDC for each driver output. The OEM may need to install external relays in order to comply with the driver rating limitations of the GCS module.

Speed Adjust Potentiometer

Due to the difference in the circuitry that processes the Speed Adjust input potentiometer signal, the potentiometer connections to the GCS module must be checked to insure that the adjustment results in the desired speed response (i.e. clockwise adjustment = increase speed & counter-clockwise adjustment = decrease speed). If the response is opposite than the desired response, the circuits to the end terminals of the potentiometer will need to be reversed.

Emergency Stop

If an Emergency Stop switch is required for the application, the switch must be wired so that the activation of the Normally-Closed switch interrupts Battery (+) power to both pins 1 and 25 of GCS ECM Connector 06. The normal state of the switch (closed) applies constant Battery (+) power to these two pins. If an Emergency Stop Switch is not used, Battery (+) power ***must*** be connected to both of these two pins in order for the system to control engine fueling. The engine will not run unless there is power to both pins. The circuit must also be protected using a 5A fuse and a reverse-current protection diode, whether an Emergency Stop switch is installed or not.

Appendix A: Modbus Register Data[1]

Parameter	Function Code	Register Address (Decimal)	Total number of bytes	Read/ Write	Scaling	Type	Eng Units	Range
Engine Speed	04	30001	2	Read Only	8	S	rpm	≥ 0
Coolant Temperature	04	30002	2	Read Only	64	S	°F	-40 to 302
Oil Pressure	04	30003	2	Read Only	64	S	psia	0 to 120
Battery Voltage	04	30004	2	Read Only	64	S	volts	0 to 40
Frequency Adjust Pot	04	30005	2	Read Only	80	S	Hz	-3 to 3
Droop Adjust Pot	04	30006	2	Read Only	256	S	%	0 to 10
Barometric Pressure	04	30007	2	Read Only	64	S	In. Hg	13.2 to 32.6
Engine Running Time	04	30008-30009	4	Read Only	10	U	sec	0 to 200,000,000
ECM On Time	04	30010-30011	4	Read Only	1	U	sec	0 to 789,000,000
Base Frequency	04	30012	2	Read Only	80	U	Hz	50 to 60
Base Speed	04	30013	2	Read Only	8	U	rpm	1000 to 3600
Final Speed Reference	04	30014	2	Read Only	8	U	rpm	≥ 0
Estimated Torque	04	30015	2	Read Only	1	S	lb.-ft.	0 to 11,952
±0.2V Speed Bias	04	30016	2	Read Only	80	S	Hz	± 7.38
±2.5V Speed Bias	04	30017	2	Read Only	80	S	Hz	± 3
Fuel Consumption Rate	04	30018	2	Read Only	100	U	Gal./Hr.	0 to 600
Cumulative Fuel Consumption	04	30019 to 30020	4	Read Only	100	U	Gal.	0 to 10,000,000
Governor Gain Adjust Pot	04	30021	2	Read Only	256	U	N/A	0.05 to 10.0

1. The maximum amount of data the ECM can return in response to a Read Input Registers request (Function Code 04) is 16 registers. The maximum length of an entire message must not exceed 256 bytes.

Parameter	Function Code	Register Address (Decimal)	Total number of bytes	Read/ Write	Scaling	Type	Eng Units	Range
Active Warning Fault Events List[a]	04	30033-30048	32 (total)	Read Only				
Fault Code			*2 each*		*1*	*U*	*N/A*	*0 to 9999*
Active Shutdown Fault Events List[a]	04	30049-30064	32	Read Only				
Fault Code			*2 each*		*1*	*U*	*N/A*	*0 to 9999*
Most Recent Fault Events List[b]	04	30065-30316	504 (total)	Read Only				
Fault Code			*2 each*		*1*	*U*	*N/A*	*0 to 9999*
Fault Count			*2 each*		*1*	*U*	*N/A*	*0 to 65535*
Time Stamp (last occurrence, ECM on time)			*4 each*		*1*	*U*	*sec*	*0 to 789,000,000*
Time Stamp (last occurrence, engine running time)			*4 each*		*10*	*U*	*sec*	*0 to 200,000,000*
Fuel Rack Position (Left Bank)	04	30545	2	Read Only	128	S	mm	-5.79 to 23.3
Fuel Rack Position (Right Bank)	04	30546	2	Read Only	128	S	mm	-5.79 to 23.3
Intake Manifold Pressure (Left Bank)	04	30547	2	Read Only	64	S	psia	0 to 153
Intake Manifold Pressure (Right Bank)	04	30548	2	Read Only	64	S	psia	0 to 153
Intake Manifold Temperature (Left Bank)	04	30549	2	Read Only	64	S	°F	-40 to 302
Intake Manifold Temperature (Right Bank)	04	30550	2	Read Only	64	S	°F	-40 to 302
Coolant Pressure	04	30551	2	Read Only	64	S	psia	0 to 75
Oil Temperature	04	30552	2	Read Only	64	S	°F	-40 to 302
Fuel Supply Pressure	04	30553	2	Read Only	64	S	psia	0 to 75
Fuel Temperature	04	30554	2	Read Only	64	S	°F	-40 to 302

a. The Active Warning and Active Shutdown Fault Events Lists each consist of 16 Fault Codes.

b. The Most Recent Fault Events List consists of 42 records of fault data. Each record consists of 12 bytes containing data for the Fault Code. Fault Code, Fault Count, ECM On-Time Time Stamp, and Engine Running Time Stamp. The Fault Count is the number of occurences for the respective Fault Codes.

Parameter	Function Code	Register Address (Decimal)	Total number of bytes	Read/ Write	Scaling	Type	Eng Units	Range
Load Profile Monitor[a] (50Hz Log)	04	30317-30336	40 (Total)	Read Only				
Range #1 (0% to 10% load)	*04*	*30317-30318*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #2 (> 10% to 20% load)	*04*	*30319-30320*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #3 (>20% to 30% load)	*04*	*30321-30322*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #4 (> 30% to 40% load)	*04*	*30323-30324*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #5 (> 40% to 50% load)	*04*	*30325-30326*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #6 (> 50% to 60% load)	*04*	*30327-30328*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #7 (> 60% to 70% load)	*04*	*30329-30330*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #8 (> 70% to 80% load)	*04*	*30331-30332*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #9 (> 80% to 90% load)	*04*	*30333-30334*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #10 (> 90% to 100% load)	*04*	*30335-30336*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*

a. The Load Profile Monitor is a record consisting of percentile Ranges #1 through #10. Each range consists of 4 bytes designating the amount of time (in minutes) that the engine has been operating in the respective load range.

Parameter	Function Code	Register Address (Decimal)	Total number of bytes	Read/ Write	Scaling	Type	Eng Units	Range
Load Profile Monitor[a] (60Hz Log)	04	30337-30356	40 (Total)	Read Only				
Range #1 (0% to 10% load)	*04*	*30337-30338*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #2 (> 10% to 20% load)	*04*	*30339-30340*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #3 (>20% to 30% load)	*04*	*30341-30342*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #4 (> 30% to 40% load)	*04*	*30343-30344*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #5 (> 40% to 50% load)	*04*	*30345-30346*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #6 (> 50% to 60% load)	*04*	*30347-30348*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #7 (> 60% to 70% load)	*04*	*30349-30350*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #8 (> 70% to 80% load)	*04*	*30351-30352*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #9 (> 80% to 90% load)	*04*	*30353-30354*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*
Range #10 (> 90% to 100% load)	*04*	*30355-30356*	*4 each*		*10*	*U*	*min*	*0 to 200,000,000*

a. The Load Profile Monitor is a record consisting of percentile Ranges #1 through #10. Each range consists of 4 bytes designating the amount of time (in minutes) that the engine has been operating in the respective load range.

Appendix B - Modbus Bit Data[1]

Switch Name	Function Code	Coil/Input Address (Decimal)	Total number of bits	Read/Write	States
Shutdown Override	01 (Read) 05 (Write)	00001	1	Read / Write	Enabled = 1 Disabled = 0
Fault Acknowledge[a]	01 (Read) 05 (Write)	00002	1	Read / Write	Acknowledge = 1 Not Acknowledge = 0
Idle/Rated Switch State	02	10001	1	Read Only	Rated =1, Idle = 0
Run/Stop Switch State	02	10002	1	Read Only	Run =1, Stop = 0
Remote Emergency-Stop Input	02	10003	1	Read Only	Stop =1, Not Stop =0
Coolant Level Switch State[b]	02	10004	1	Read Only	Low =1, Normal =0
Common Shutdown Lamp/Relay Driver Command	02	10005	1	Read Only	Driver On =1 Driver Off =0
Common Warning Lamp/Relay Driver Command	02	10006	1	Read Only	Driver On =1 Driver Off =0
Fuel Shut-off Valve Driver State	02	10007	1	Read Only	Driver On =1 Driver Off =0
Operator Interface Mode	02	10008 - 10011	4	Read Only	See Table Below
CENTINEL Oil Make-Up Tank Level	02	10012	1	Read Only	Low Oil Level = 1 Not Low Oil Level = 0

a. The Fault Acknowledge command is a momentary signal and should be held in the "acknowledge" state for no longer than 0.5 seconds when acknowledging a fault condition.

b. The Coolant Level Switch is to be supplied by the customer. The control system must be set -up to read the Coolant Level Switch signal. See the ***Customer Supplied Coolant Level Switch*** section on page 101 for further details.

Bit No.	B	A	9	8
Off	0	0	0	0
Ready	0	0	0	1
Fault Flashout	0	0	1	0
Non-Running Test	0	0	1	1
Starting	0	1	0	0
Idle	0	1	0	1
Rated	0	1	1	0
Normal Stop	0	1	1	1
Emergency Stop	1	0	0	0
Watchdog Test	1	0	0	1

1. The maximum amount of data the ECM can return in response to: i) a Read Coil Status request (Function Code 01) is 32 coils, ii) a Force Single Coil request (Function Code 05) is 1 coil, or iii) a Read Input Status request (Function Code 02) is 32 inputs. The maximum length of an entire message must not exceed 256 bytes.

Appendix C - Supported Modbus Exception Codes

Code	Name	Description
01	Illegal Function	The function code received is not valid
02	Illegal Data Address	The data address received in the query is not a valid address
03	Illegal Data Value	A value contained in the query data field is not a valid value for the slave

Appendix D - Supported Modbus Diagnostics

Sub-Function Code	Name	Description
00	Return Query Data	The data passed in the query data field is to be returned (looped back) in the response. The entire response message should be identical to the query.
01	Restart Communications Option	The slave's peripheral port is to be initialized and restarted, and all of its communications event counters are to be cleared. If the port is currently in Listen Only Mode, no response is returned. If the port is not currently in Listen Only Mode, a normal response is returned.
04	Force Listen Only Mode	Forces the ECM into Listen Only Mode. This isolates it from the other devices on the network, allowing them to continue communicating without interruption from the addressed slave. No response is returned. The only function that will be processed after this mode is entered will be the Restart Communications Option function (function code 08, subfunction 01)
10	Clear Counters and Diagnostic Register	Clears all counters and the diagnostic register.
11	Return Bus Message Count	The response data field returns the quantity of messages that the slave has detected on the communications system, since its last restart, clear counters operation, or power up.
12	Return Bus Communication Error Count	The response data field returns the quantity of CRC errors encountered by the ECM since the its last restart, clear counters operation, or power-up.
13	Return Bus Exception Error Count	The response data field returns the quantity of Modbus exception responses returned by the ECM since the its last restart, clear counters operation, or power-up.
14	Return Slave Message Count	The response data field returns the quantity of messages addressed to the ECM, or broadcast, that the ECM has processed since its last restart, clear counters operation, or power-up.
15	Return Slave No Response Count	The response data field returns the quantity of messages addressed to the ECM for which it did not return a response (neither a normal response nor an exception response), since its last restart, clear counters operation, or power-up

Appendix E - Electronic Device Usage

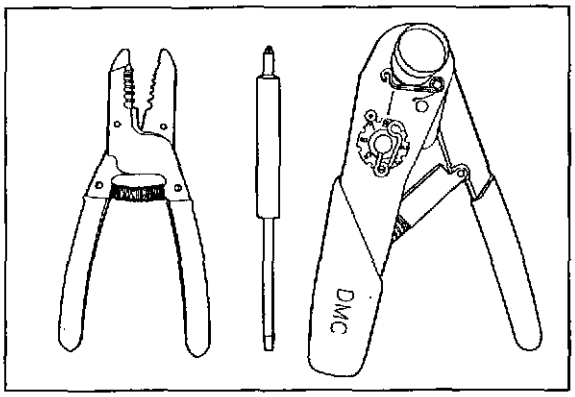
Device Type/Description	*Comments*
Sensors	
Fuel Rack Position	Both left & right bank rack positions
Barometric Pressure	
Coolant Level	**INSTALLATION OF THE COOLANT LEVEL SENSOR IS MANDATORY.** Provisions are in QST30 wiring harnesses to connect customer supplied sensor.
Coolant Pressure	
Coolant Temperature	
Engine Speed Sensor (ESS)	Sensor has redundant main/backup coils (both are wired to the ECM)
Fuel Supply Pressure	
Fuel Temperature	
Intake Manifold Pressure	Both left & right bank pressures
Intake Manifold Temperature	Both left & right bank temperatures
Oil Pressure	
Oil Temperature	
CENTINEL Continuous Oil Replacement System Oil Make-Up Tank Level	
Switch Inputs	
Run/Stop	
Idle/Rated	
Crank	
Alternate Frequency	
Diagnostic Mode	
Fault Acknowledge	
Control/Service/Safety Discrete Inputs	
Emergency Stop (Local & Remote)	
Run Relay Contact Status	
Crank (Slave) Relay Contact Status	
Backup Start Disconnect Status	
Diagnostic Mode Enable	Two one-pin connectors (opposite gender) are plugged together to enable Diagnostic Mode
Adjustable Inputs	
Governor Gain	
Speed Droop	
Frequency	
Speed Bias/Synchronizing/ *Fuel Governing Inputs*	
+/- 0.2V Signal	For use with Barber-Colman compatible governing and load share equipment
+/- 2.5V Signal	For use with Woodward compatible governing and load share equipment
Torque Control Signal	For use with Un-interruptable Power Supply (UPS) system applications

Device Type/Description	Comments
Drivers	
Lamp/Relay Drivers	
Common Warning	
Common Shutdown	
High Engine Temperature	
Low Oil Pressure	
Overspeed	
Pre-High Engine Temperature	
Pre-Low Oil Pressure	
Fail-to-Start	
Meter Drivers	
Engine Speed	
Oil Pressure	
Coolant Temperature	
Actuator Drivers	
Fuel Pump Rack	Both left & right fuel pump racks
Fuel Shut-Off Valve Solenoid	Both left & right bank FSO's
Starter Control (Crank Coil Relay)	
Fuel Lift Pump	
CENTINEL Continuous Oil Replacement Valve	
Miscellaneous Outputs	
Battery Charging Alternator Field Flash Out	
Serial Communications Datalinks	
RS-232 Datalink (Service Tool Interface)	
MODBUS RS-485 Datalink (Customer Interface)	

Appendix F - Keyed Connector Backshell Assembly Instructions

Each keyed connector kit includes the following parts:

- Keyed Backshell
  (2 halves – includes color-coded connector identification label on each half)
- Backshell Fastening Screws (Qty. 2)
- Thumbscrews (Qty. 2)
- Wiring Harness Strain Relief Clamp (Qty. 1)
- Strain Relief Clamp Fastening Screws (Qty. 2)
- Connector Grommet Seal (Qty. 1)
- Connector Terminals (Qty. 30)
- Sealing Plugs (Qty. 30)
- Terminal Insertion/Extraction Tool (Qty. 1)

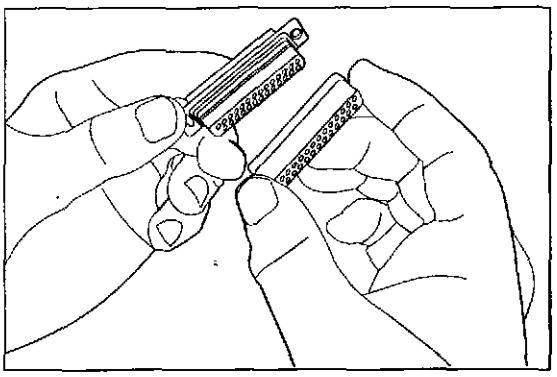


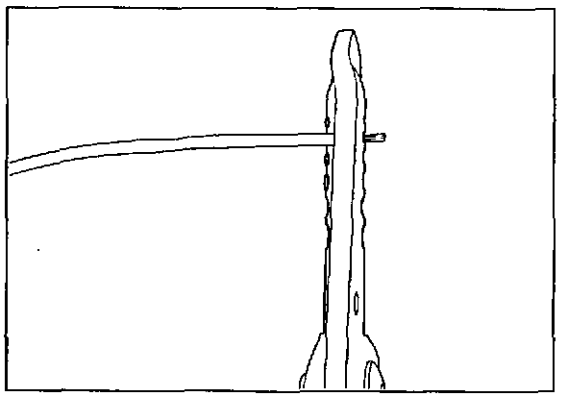
Required tools (not included in kit):

- Wire Strippers
- Standard Screwdriver
- Terminal Crimp Tool (and required accessories, i.e. positioner)

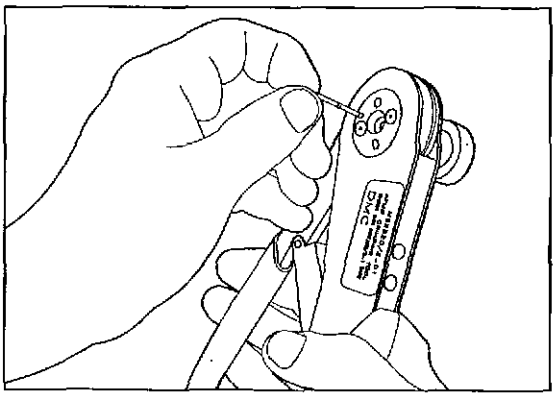
Following are the instructions explaining how to assemble the 25-position connector together with the *wiring harness and the keyed connector backshell.*

1. Position the connector grommet seal on the *backside of the connector (the side that the harness* conductors will be terminated to at the connector).



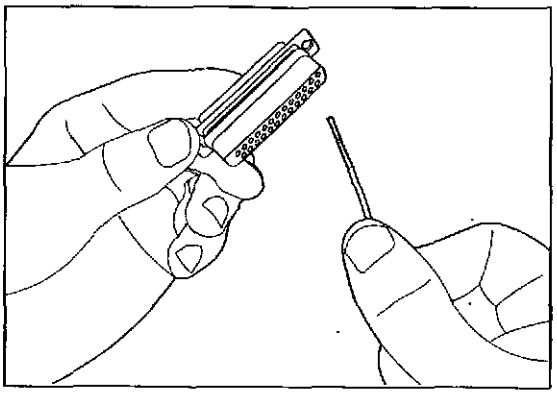


2. Strip 4.3 to 5.1 millimeters (0.17 to 0.20 inches) of insulation from the ends of the wire harness conductors.



3. Using the appropriate terminal crimping apparatus, crimp the connector terminals onto the stripped, bare ends of the wire harness conductors. Use a crimp tool with frame style M22520/2-01 per MIL-C-22520, or equivalent. A hand-held or pneumatic crimp tool can be purchased from Daniels Manufacturing Corporation (P/N AFM8 for hand-held, P/N WA27F for pneumatic) along with the terminal positioner (Part No. K13-1 for use with 0.5 mm^2 [20 AWG] terminals).

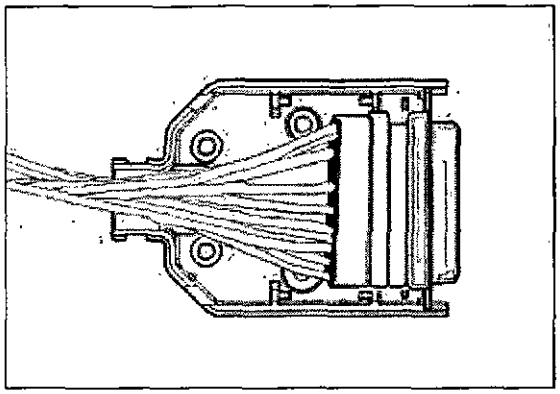
> ***NOTE:*** *Carefully read and follow all of the manufacturer's instructions for the specific crimp tool being used for this procedure. The AFM8 crimp tool from Daniels Manufacturing Corporation requires that the correct positioner be used and that the crimp tool selector knob is adjusted to the correct setting for the terminal size being used.*



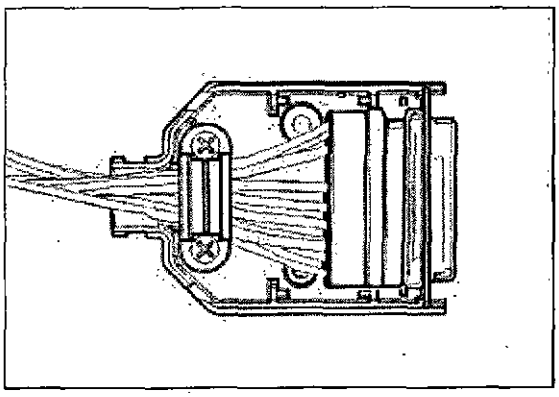
4. Once all conductors to be used are crimped onto connector terminals, insert each terminal into the correct cavity of the connector. Because the grommet seal is covering the connector, each terminal will first have to be inserted through the corresponding cavity of the grommet seal. The terminal can be installed by using a small amount of pressure to push the terminal into the connector cavity. There will be a quiet "click" or "snap" sound when the detents in the connector cavity engage, indicating that the terminal is properly seated in the connector cavity.

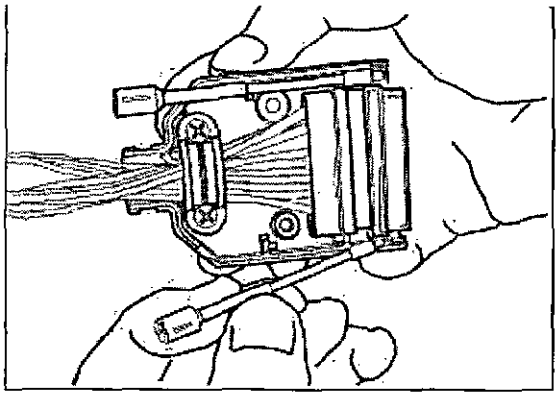
> ***NOTE:*** *If for any reason a terminal must be extracted from a connector cavity after it has already been installed, use the extraction tool provided in the kit to do so. The terminals are a rear-side removal type.*

5. The grommet seal must have a sealing plug inserted in the unpopulated cavity positions in order to provide adequate protection against debris and water intrusion. Insert a sealing plug into each open cavity position on the back (exposed) side of the grommet.
6. Ensure that all terminals are properly seated into each of the connector cavities. Applying a small amount of force to try and pull the harness conductor attached to the terminal out of the connector cavity can check this. If the terminal is improperly seated, it should easily pullout of the connector cavity. If the terminal is properly seated, there should be resistance when pulling on the conductor and the terminal will remain seated in the connector cavity.
7. When all harness conductors have been inserted into the connector and properly seated, place the connector into one half of the keyed backshell, laying the harness bundle as shown in the diagram.

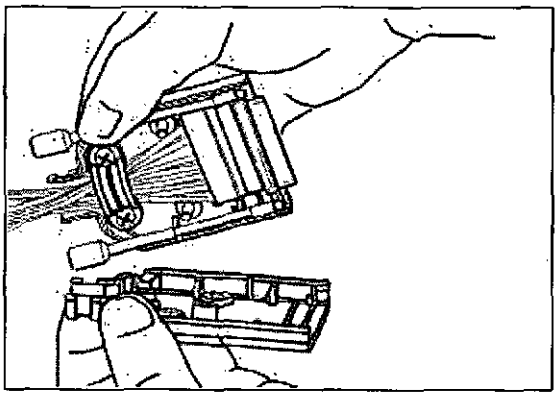


8. Place the strain relief clamp over the harness bundle and attach it to the backshell half using the two strain relief clamp screws provided.

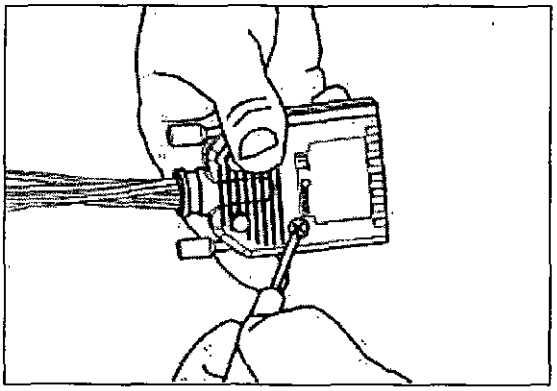


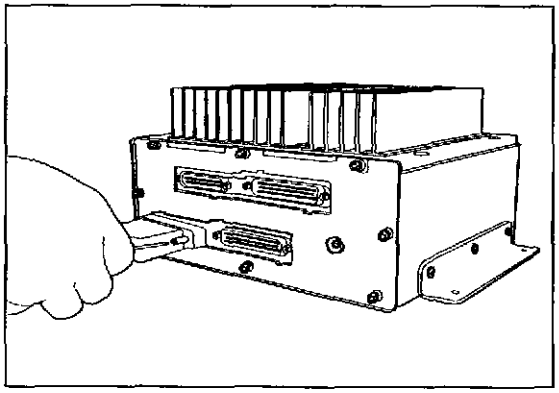


9. Place the two thumbscrews into the proper locations of the backshell half.



10. Finally, place the second half of the backshell in place, fitting it to the first half of the backshell to cover the exposed grommet seal and harness strain relief clamp and fasten the two backshell halves together using the two backshell fastening screws provided.





NOTE: *When attaching the keyed connectors to the ECM, the thumbscrews should be torqued to 0.79 - 0.90 N m (7-8 in.-lbs.).*

Appendix G - Component Manufacturers' Addresses

NOTE: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers can be contacted directly for any specifications **not** covered in this manual.

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 01895-833633

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 01744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 01908-66001

C.E. Niehoff & Co.
2021 Lee Street
Evanston, Il 60202
Telephone: (708) 866-6030

Delco-Remy America
2401 Columbus Avenue
Anderson, In 46018
Telephone: (317) 646-3528

Leece-Neville Corp.
400 Main Street
Arcade, NY 14009
Telephone: (716) 482-1700

Coolant Level Switches

Robertshaw Controls Company
P.O. Box 400
Knoxville, TN 37901
Telephone: (216) 885-1773

Connnector Contact Crimp Tools & Accessories

Daniels Manufacturing Corp.
526 Thorpe Rd.
Orlando, FL 32824
Telephone: (407) 855-6161

Connnector Contact Insertion & Removal Tools

Aiconics, Inc.
13100 Kirkham Way #206
Poway, CA 92064
Telephone: (858) 513-2115

Electric Starting Motors

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 01744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 01908-66001

Delco-Remy America
2401 Columbus Avenue
Anderson, IN 46018
Telephone: (317) 646-3528

Leece-Neville Corp.
400 Main Street
Arcade, NY 14009
Telephone: (716) 482-1700

Nippondenso Inc.
2477 Denso Drive
P.O. Box 5133
Southfield, MI 48086
Telephone: (313) 350-7500

Electronic Switches

Cutler-Hammer Products
Eaton Corporation
4201 N. 27th Street
Milwaukee, WI 53216
Telephone: (414) 449-6600

Electronic Switches (continued)

Cutler-Hammer Products
Eaton Corporation
4201 N. 27th Street
Milwaukee, WI 53216
Telephone: (414) 449-6600

Gauges

A.I.S.
Dyffon Industrial Estate
Ystrad Mynach
Hengoed
Mid Glamorgam
CF8 7XD
Telephone: 01443-812791

Yokogawa Electric Corporation
9-32
Nakacho 2-chome Musashino-shi
Tokyo, 180-8750
Japan
Telephone: 81-422-52-5535

Grasslin U.K. Ltd.
Vale Rise
Tonbridge
Kent
TN9 1TB
England
Telephone: 01732-359888

Icknield Instruments Ltd.
Jubilee Road
Letchworth
Herts
England
Telephone: 04626-5551

Superb Tool and Gauge Co.
21 Princip Street
Birmingham
B4 61E
England
Telephone: 021-359-4876

Gauges (continued)

Kabi Electrical and Plastics
Cranborne Road
Potters Bar
Herts
EN6 3JP
England
Telephone: 01707-52444

Datcom Instruments
P.O. Box 128
East Petersburg, PA 17520
Telephone: (717) 569-5713

Rochester Gauges, Inc.
11616 Harry Hines Blvd.
P.O. Box 29242
Dallas, TX 75229

Crompton Instruments Ltd.
Freebournes Road
Withan Essex
CM8 3AH
England
Telephone: 44(0) 1376 512601

In-Line Connectors

Pioneer-Standard Electronics, Inc.
5440 Neiman Parkway
Solon, OH 44139
Telephone: (216) 349-1300

Deutsch
Industrial Products Division
37140 Industrial Avenue
Hemet, CA 92343
Telephone: (714) 929-1200

Ladd Industries, Inc.
4849 Hempstead Station Drive
Kettering, OH 45429
Telephone: (937) 438-2646
(800)223-1236

Load Share/ Synchronizing Controls

Woodward Governors Ltd.
P.O. Box 15
663 / 664 Ajax Avenue
Slough
Bucks
SL1 4DD
England
Telephone: 01753-26835

Load Share/ Synchronizing Controls (continued)

Woodward Governor Co.
P.O. Box 1519
Fort Collins, CO 80522
Telephone: (303) 482-5811
(800) 523-2831

Barber Colman Co.
1354 Clifford Avenue
Loves Park, IL 61132
Telephone: (815) 637-3000

United Technologies
Diesel Systems
1000 Jorie Blvd.
Suite 111
Oak Brook, IL 69521
Telephone: (312) 325-2020

Appendix H - Operating, Electrical & Environmental Specifications

Operation

Governor Mode	Isochronous to 10% Droop
Governor Gain Adjust	0.05 to 10.00
Frequency Adjust Range	±9Hz (±3Hz Using External Pot, ±6Hz Using InPower™)
Speed Bias Reference Voltage	+5VDC (±2%); 50mV$_{(p-p)}$ Max. Ripple
±2.5V Speed Bias Signal	5.0V ± 2.5V (±3Hz full scale)
±0.2V Speed Bias Signal	5.0V ± 0.2V (±7.38Hz full scale)
Minimum Mag Pickup Speed Signal Input	1.5V$_{p-p}$ @ 200 rpm, 6.5V$_{p-p}$ @ 1800 rpm

Power

Nominal Operating Voltage	+24VDC
Operating Voltage Range	+18 to +35VDC (+12VDC Minimum during engine starting)
Maximum Continuous Voltage	+35VDC
Ground Polarity	Negative Ground (Convertible to Positive or Isolated Ground; See the ***Positive/Isolated Grounding*** section on page 20 for further details)
Nominal Operating Current	8.0 A @ +24VDC
Maximum Operating Current	10.0A @ +24VDC
Sleep Mode Operating Current	60mA (nominal)
Ready Mode Operating Current [ECM On & Engine Not Running]	350mA (nominal)

Environmental

Ambient ECM Housing Operating Temp.	-40° to158°F [-40° to 70°C]
Ambient ECM Heat Sink Operating Temp.	-40° to 140°F [-40° to 60°C]
Maximum ECM Heat Sink Surface Temperature	167°F [75°C] @ 140° F [60°C] ambient air temperature
Storage Temperature	-67° to 176°F [-55° to 80°C]
Vibration Limits	20-100Hz, 93.6mm/sec; 100-200Hz, 6g
Relative Humidity	0-95% Non-Condensing
Salt Fog Resistant	150 Hours, 5% salt @ 95°F
Radiated Immunity	per ENV50140, 10V/m
Conducted Susceptibility	per ENV 50141, 10V/m
Radiated Emissions	per EN55011
Electrical Fast Transient (EFT)	per EN61000-4-4 (Level 3)
Mounting (Off engine)	IP53/NEMA-3R (with connectors facing down)

Physical

Dimensions (Including Heat Sink;	228.0 mm X 182.5 mm X 129.7 mm
excluding mounting brackets)	(8.98 in. X 7.19 in. X 5.11 in.)
Weight	4.15 kg [9.16 lbs.]
Housing Metal	Sheet Steel
Heat Sink Metal	Aluminum

Protection

Voltage Surge Protection	per EN61000-4-5 and +63 V DC supply surge voltage
Reverse Polarity Protection	+28VDC Maximum
High Voltage Protection	+35VDC Maximum Continuous
Electrostatic Discharge (ESD)	per EN61000-4-2 (8kV direct contact, 15kV air discharge)

Standards Compliance

CE	Low Voltage Directive (73/23/EEC), EN50081-2, EN50082-2
NEMA	3R (ECM Housing)
IEC	IP53 (ECM Housing), IP54 (Harness Inline Connectors)
CSA[1]	C282-M (1989)
NFPA[1]	76A

Electrical Interface Characteristics

Lamp/Relay Driver Supply

Supply Voltage	+24VDC Nominal, +35VDC Maximum
Maximum Supply Current	1.5A
Maximum Supply Impedance	0.5Ω

Lamp/Relay Drivers

Driver Type	Low-Side (switched GND/Open)
Driver Voltage Rating	+24VDC Nominal, +35VDC Maximum
Maximum Sink Current (Driver On)	200mA
Maximum Leakage Current (Driver Off)	0.3mA
Maximum Driver Impedance (Driver On)	1Ω
Open Circuit Fault Current (Driver On)	< 2mA (See ***Alarm Lamp/Relay Drivers*** section on page 79 for further details.)

1. The Generator-Drive Control System is suitable for use with generator products intended to comply with the specified standards.

Electrical Interface Characteristics (Continued)

Analog Meter Drivers

Output Current	0 to 1 mA
Maximum Meter Load Impedance	100Ω
Output Accuracy (@ 100Ω meter load)	< ±0.5% of Full Scale
Output Resolution (@ 100Ω meter load)	< 0.5% of Full Scale

Analog (Adjustable) Inputs

Nominal Input Voltage Adjustment Range	0 to 3.177VDC
Maximum Input Voltage	5VDC
Maximum Potentiometer Resistance	5KΩ ± 5%

Remote Potentiometer Specifications (Recommended)

Resistance	5KΩ ± 5%
Linearity	0.25%
Travel	360° x 10
Power Rating	2.5mW minimum @ 70 °C [158 °F]
Insulation Rating	1000MΩ @ 500VDC
Dielectric Strength	100V RMS
Operating Temperature	-55° to 105°C [-67° to 221 °F]

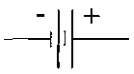
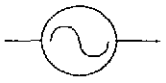
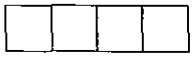
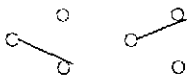
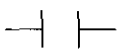
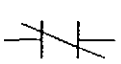
Speed (Frequency) Bias Reference & Voltage Supply

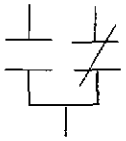
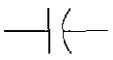
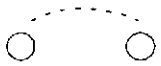
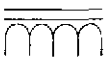
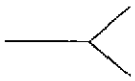
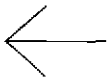
5VDC Reference Voltage	+5VDC ± 2%; 50mV$_{p-p}$ Maximum ripple voltage; 25mA Maximum Current
8VDC Supply Voltage	+8VDC ± 5%; 50mV$_{p-p}$ Maximum ripple voltage; 15mA Maximum Current

Switch Inputs

Maximum Source Current	100mA (when input is connected to signal GND return)
Input Voltage(measured @ signal input)	+5VDC when ECM is in Sleep Mode or B+ (approx. 24VDC) when ECM is not in Sleep Mode
Switching Threshold	+2.5VDC

Appendix I - Electrical Symbols

Name	Symbol
Battery	
Alternator (Frequency Source)	
Resistor	
Variable Resistor (Potentiometer) — 3 Terminal Device	
Variable Resistor (Potentiometer) — 2 Terminal Device	
Terminal Strip	
Switches:	
(N.O.) Normally Open	
(N.C.) Normally Closed	
Transfer	
Transfer 3 position	
Relay Contact:	
(N.O.) Normally Open	
(N.C.) Normally Closed	

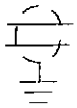
Name	Symbol
Transfer	
Capacitor	
Fuse	
Circuit Breaker	
Jumper Wire	
Coil	
Magnetic Core	
Transformer	
Variable Reluctance Magnetic Pickup	
Female Contact	
Male Contact	

Name **Symbol**

Shields:

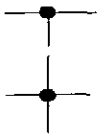
Shielded Wire

Shielded Pair



Crossing of Conductors (wires) not Connected

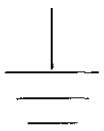
Junction of Connected *Conductors (wires)*



Grounded
Chassis or Frame
Connection

Conducting connection to a chassis or frame, of equivalent chassis connection of a printed wiring board. The chassis or frame (or equivalent chassis connection of a printed wiring board) may be at a different potential than the earth or structure in which this chassis or frame (or printed wiring board) is mounted.

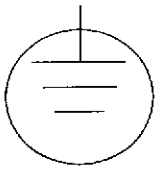
Direct Conducting Connection to Circuit Return



Conducting connection to a structure that services a function similar to that of an earth ground (that is, a structure such as a frame of an air, space or land vehicle that is not conductively connected to earth.)

Name **Symbol**

Earth Safety Ground



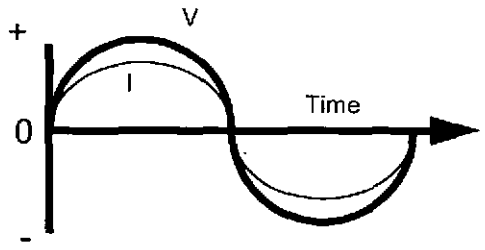
** This symbol may be used in place of symbol for direct conducting connection to circuit *return to indicate a ground* connection having a specified protective function (e.g., for protection against electrical shock in case of a fault).

** *Ref. Electrical and Electronics* Graphic Symbols and abbreviated name.

Glossary of Power Terms

A.C. -- See Alternating Current.

Alternating Current -- Electrical current which repeatedly varies from zero to a positive maximum value to zero to a negative maximum value and back to zero at a periodic rate. Since the applied voltage continually reverses polarity, the resultant current flow alternates in direction within the circuit.



Alternating Current = I
Applied Voltage = V

AMP -- An abbreviation for the term Ampere.

Ampere -- The unit of measure of electrical current flow. One ampere of current will flow when one volt of electrical potential is applied across one ohm of resistance.

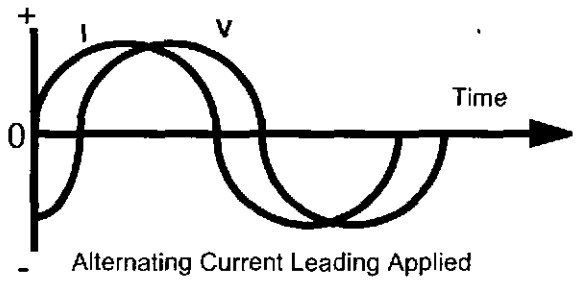
Auto-Transformer -- A transformer of single coil construction in which both the primary and secondary connections are made on the same coil but use different taps.

Bi-State -- Refers to the type of eletrical device, or the signal supplied by such a device, that has two discrete and mutually exclusive states. For example, a two-position toggle switch is a bi-state switching device that is either 'open' or 'closed'.

B- -- Symbol used to designate the negative polarity of a D.C. voltage supply.

B+ -- Symbol used to designate the positive polarity of a D.C. voltage supply.

Capacitance -- The property of a device which resists changes in voltage. In an A.C. circuit, a capacitive load will cause the voltage to lag behind the current flow. Stated more conventionally, the current leads the applied voltage. A capacitive load is, therefore, a leading power factor load (see Power Factor).



Alternating Current Leading Applied Voltage Caused by Capacitive Load

Capacitor -- A device possessing the property of capacitance. A typical capacitor consists of two conducting surfaces separated by an insulating material. A capacitor stores electrical energy, blocks the flow of D.C. and permits the flow of A.C. to a degree largely dependent on the capacitance and the frequency of the applied A.C.

Circuit -- An electrical path through which an electric current may flow from a voltage supply to a load and return. A closed or complete circuit is one where current is flowing. An open circuit is where the path has been disrupted, such as an open switch or circuit breaker, thus stopping current flow.

Circuit Breaker -- A protective device for opening a circuit where current flow exceeds a predetermined value.

Circulating Current -- Also called Cross Current. Current which flows between paralleled generators, most apparent with no external load on the paralleled generators. Circulating current is caused (1) by unequal excitation of the generators (reactive current, which may be reduced by changing the voltage regulator adjustment or connections); and (2) by unequal power from the engines that are driving the generators real current (and power) which can be eliminated by governor adjustments.

Conductor -- A wire cable, bus, or other device intended to distribute current from the supply to the load. Technically, a conductor is any device which will permit the flow of current.

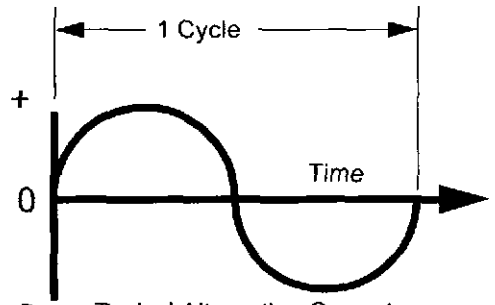
Contactor -- A device for opening and closing an electric circuit. Contactors are normally used in motor circuits where large amounts of current are controlled.

Cross Current -- *See Circulating Current.*

Cross Current Compensation -- A term, no longer approved, for a circuit arrangement that made paralleled generators share the reactive component of load current in proportion to the generator ratings. The circuit arrangement could also essentially eliminate the reactive component of circulating current flowing between paralleled generators (See Reactive Differential (Cross Current) Compensation and Reactive Droop Compensation).

Current (Electrical, Symbol I) -- The rate of transfer of electricity from one point to another. Current is usually a movement of electrons, but may also be a movement of positive ions, negative ions, or holes. Current is usually measured in amperes.

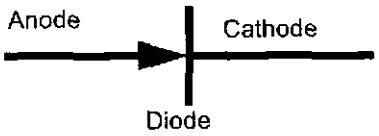
Cycle 00 -- A complete set of events before repetition occurs. In alternating current or voltage, a cycle starts at zero, continues to a maximum positive value returns to zero, continues to a maximum negative value, and is completed at zero.



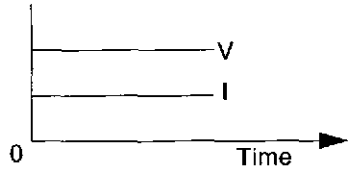
Typical Alternating Current or Voltage Cycle

D.C. -- *See Direct Current.*

Diode -- A two terminal solid-state device which permits current to flow in one direction, but not in the other. In alternating current circuits, a diode will permit one half cycle to flow but will resist the flow of the opposite half cycle of current. Thus, alternating current is converted to direct current by a diode.



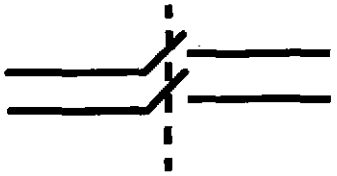
Direct Current (D.C.) -- An electric current that flows in one direction only. Conventional direct current is defined as flowing from positive to negative in the circuit outside the source (example: a battery or combination of diodes). Conventional current flows in the direction of the arrow through a diode. Electron flow and U.S. Navy designated current flow in the opposite direction.



Direct Current I
Applied Voltage V

Distribution Panel -- A control panel containing circuit breakers, transfer switches, and other control devices which distribute the electrical power, such as from a generator set to the loads.

Double Pole Switch -- A switch which has two sets of contacts which operate on two independent circuits at the same time.



Typical Double Pole Switch Shown as a Single Throw Type in the "Off" Position

E -- Symbol used to represent electrical potential (voltage).

Earth Ground -- An intentional connection made between the earth and the metallic frame of electrical equipment as a means to eliminate possible voltage hazards to personnel. Earth Ground also serves, in some cases, to reduce electrical interference in sensitive circuits such as television and radio equipment.

EMI -- An abbreviation for the term electromagnetic interference which is sometimes caused by SCR type devices and evident in radio and television operation.

Energy -- The capability of performing work.

Frequency -- The number of complete cycles of alternation current per unit of time. Typically, frequency is expressed in cycles per second or Hertz (HZ).

Frequency Droop -- A decrease in steady state frequency output of a generator caused by an increase in load. This decrease in frequency from the no load frequency is expressed as a percentage of the full load frequency or:

$$\%F_{Droop} = \frac{(F_{NL} - F_{FL}) \times 100}{F_{FL}}$$

Where: $\%F_{Droop}$ = *Percent Frequency Droop*
F_{NL} = *No Load Frequency*
F_{FL} = *Full Load Frequency*

A three percent frequency droop may be used to provide governor stability and for load sharing between paralleled generator sets.

Frequency Meter -- An instrument deigned to measure the frequency of an alternation current system.

Gain -- The increase in signal power that is produced by an amplifier, usually given as the ratio of output to input voltage, current, or power. In generator set systems, a low gain setting on the electric governor or voltage regulator provides a relatively small signal to correct variations of frequency or voltage. The frequency and/or voltage may wander or be slow in recovering to stable conditions after a load change. A high gain setting provides a relatively large signal to correct variations of frequency and/or voltage. If the gain is set too high, the electric governor or voltage regulator may over-correct. This may produce unacceptable hunting of the frequency and/or voltage.

Gate -- The third terminal of an SCR to which a voltage must be applied before the SCR will conduct.

Governor -- A device which controls engine speed and thus the generator output frequency.

Ground -- A connection, either accidental or intentional, between an electrical potential and the earth or some conducting body serving in place of the earth.

Heat Sink -- A device which absorbs heat from electrical devices such as diodes and SCR's and dissipates the heat to the surrounding air.

Hertz -- A term equivalent to cycles per second (See Frequency).

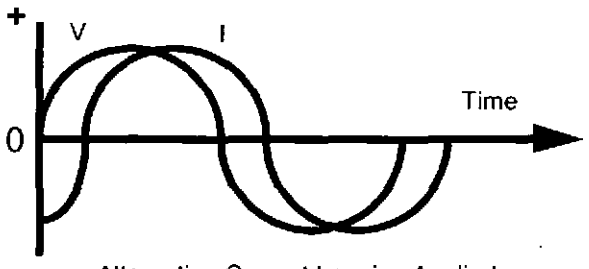
Hunting -- Oscillation in frequency or in voltage where steady state conditions are not reached, particularly after a load transient change.

I -- Symbol used to represent current.

Impedance -- The opposition to the flow of alternating current.

Induced Voltage -- The voltage which is produced by relative motion between a wire and a magnetic field.

Inductance -- The property of a device which resists changes in current. In an A.C. circuit, an inductive load will cause the current to lag behind the applied voltage. Stated more conventionally, the current lags the applied voltage. An inductive load is therefore a lagging power factor load (see Power Factor).



Alternating Current Lagging Applied Voltage Caused by Inductive Load

Inductor -- A device possessing the property of inductance. An inductor stores electrical energy, passes D.C., and opposes the flow of A.C. to a degree largely dependent on the inductance and the frequency of the applied A.C. A typical inductor consists of a coil of wire.

In Phase -- Alternating currents or voltages are in phase with respect to each other if they cross through zero and reach their positive and negative maximum values together.

Insulation -- A non-conductive material such as rubber or plastic intended to prevent current from flowing. Technically, insulation is any material which stops the flow of current.

Isochronous -- As it applies to engine governors, maintaining constant steady state speed regardless of the load within the rating of the engine. Thus, a generator set is said to be isochronous if the frequency remains the same regardless of load.

Normally Closed (Symbol N.C.) -- As applied to a magnetically operated device such as a valve or the contacts of a relay, Normally Closed indicates that the valve or the relay contacts are closed when no power is supplied to the operating magnet.

Normally Open (Symbol N.O.) -- As applied to a magnetically operated device such as a valve or the contacts of a relay, Normally Open indicates that the valve or the relay contacts are open when no power is supplied to the operating magnet.

Ohm -- The unit of measure of electrical resistance. One ohm of resistance will allow a current of one ampere to flow with an applied potential of one volt.

Ohmmeter -- An instrument for measuring electrical resistance.

Ohm's Law -- A fundamental law expressing the relationship between voltage, current, and resistance in electrical circuits. The law states that E = IR or voltage is equal to current times resistance.

Open Circuit -- 1) A circuit that does not provide a complete path for the flow of current. 2.) A condition of an electrical circuit caused by the breaking of continuity of one or more conductors of the circuit; often an undesired condition. 3) An arrangement of conductors and equipment that depends upon lack of continuity for operation, as open-circuit telegraphy; a circuit in which continuity is incomplete or interrupted.

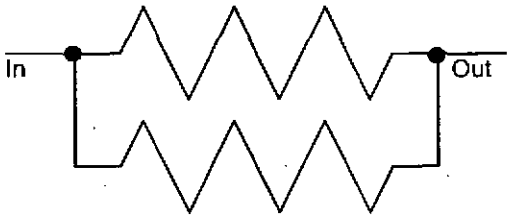
Oscillogram -- The permanent record produced by an oscillograph, or a photograph of the trace produced by an oscilloscope.

Oscillograph -- A measurement device for determining waveform by recording the instantaneous values of a quantity such as voltage as a function of time.

Oscilloscope -- An instrument primarily for making visible the instantaneous value of one or more rapidly varying electrical quantities as a function of time or of another electrical or mechanical quantity.

Oscilloscope Dual Beam -- An oscilloscope in which the cathode-ray tube produces two separate electron beams that may be individually or jointly controlled.

Parallel Connection -- An electrical connection in which the input of one element is connected to the input of another element. The output connections are similarly connected together thus providing two or more paths for current to flow.



Parallel Connection

Parallel Operation -- The method by which two or more generators having the same voltage and frequency characteristics are connected to a common load.

Permanent Magnet Generator -- A generator which uses permanent magnets to create a magnetic field. As applied to Cummins Generators; a permanent magnet generator, within the main generator, supplies the power to the voltage regulator which in turn supplies the power to the exciter field. The permanent magnet generator still supplies power during a short circuit of the main generator. This permits the main generator to sustain high short circuit currents. The output of the permanent magnet generator is electrically isolated from the main generator output and is not adversely affected by main generator output waveform distortion such as from SCR type loads.

PMG -- See Permanent Magnet Generator.

Polarity -- An electrical term which indicates the direction in which current flows in a conductor. In a direct current system, current flows in the same direction. In an alternating current system, current changes direction as the polarity of the A.C. voltage source changes.

Potential -- Another term to indicate voltage.

Potential Difference -- The difference in voltage between two points in a circuit.

Power -- Defined as the rate of performing work. Mechanical power is measured in horsepower or kilowatts. Electrical power is measured in kilowatts.

Power Factor -- The ratio of the true power (KW) requirements of a load to the apparent power (KVA) requirements of a load. The combined loads applied to a power source may have a resistive, capacitive, or inductive effect.

Resistive loads such as incandescent lighting or resistive heating elements cause no shift in the voltage/current wave forms and are, therefore, unity (1.0) power factor loads.

Inductive and capacitive loads, however, cause the voltage and current waveforms to shift with respect to one another. These types of loads are commonly called power factor loads (i.e., the power factor is less than 1.0).

See INDUCTANCE and CAPACITANCE for more information.

Power factor is frequently multiplied by 100 and expressed as a percentage.
The formula for power factor is:

$$Power\ Factor = \frac{True\ Power\ (KW)}{Apparent\ power\ (KVA)}$$

R -- Symbol used to represent resistance.

Reactive Differential (Cross Current) Compensation -- A circuit arrangement for operating generators in parallel with no generator voltage droop. Reactive Differential Compensation is accomplished by a differential interconnection of the secondaries of the generator current transformers used for Reactive Droop Compensation. This arrangement is not often used and is very difficult to set up when paralleling generators of different capacities.

Reactive Droop Compensation -- A circuit arrangement that creates a droop in generator output voltage that is proportional to the reactive load current. This circuit arrangement makes the paralleled generators share the reactive component of the load current in proportion to the generator ratings. It also can essentially eliminate the reactive component of circulating current which may flow between paralleled generators. The Reactive Droop Compensation arrangement is commonly called the Generator Paralleling Module.

Relay -- An electromechanical device having a magnetic coil which, when energized, opens or closes several sets of contacts.

Resistance -- Opposition to the flow of current.

Resistor (Symbol R) -- A device or component designed to have a definite amount of resistance. Resistors are used in circuits to limit current flow or to provide a voltage drop.

Resistor, Fixed -- A component which is used to control voltage and current by introducing a constant resistance of known value into the circuit.

Resistor, Variable -- Similar to a fixed resistor except the resistance value can be adjusted. The voltage adjust rheostat is a variable resistor.

Rheostat -- A variable resistor.

Series Connection -- An electrical connection in which the input of one element is connected to the output of another element providing only one path for current to flow.

Series Connection

Short Circuit -- An abnormal connection (including an arc) of relatively low resistance, whether made accidentally, or intentionally, between two points of different potential in a circuit. Equipment, not protected by fuse or circuit breakers, may be damaged by a short circuit.

Shunt Trip -- An electromechanical device which, when energized, trips the main line circuit breaker.

Single Pole Switch -- A switch which has only one set of contacts.

Typical Single Pole Switch Shown as a Single Throw Type in the "Off" Position

Single Throw Switch -- A switch which opens a set of contacts in one switch position and closes the contacts in the other position.

Typical Single Throw Switch Shown as a Single Pole Type in the "Off" Position

Speed Droop -- A decrease in steady state speed of an engine due to an increase in applied load. This decrease in speed from the no load speed is expressed as a percentage of full load speed or:

$$\%S_{Droop} = \frac{(S_{NL} - S_{FL}) \times 100}{S_{FL}}$$

Where: $\%S_{Droop}$ = *Percent Speed Droop*
S_{FL} = *Full Load Speed*
S_{NL} = *No Load Speed*

Solenoid -- An electromechanical device which when energized, acts on a movable core or plunger in the center of the energizing coil to perform mechanical work.

Solid-State -- A term which applies to electronic devices which are constructed using semiconductor material. Such devices include transistors, SCR's, and diodes.

Stability -- Freedom from undesired variations or oscillation. In generator set systems, the generator set is stable if it can maintain or quickly re-establish steady state conditions of voltage and frequency after a sudden load change.

Surge Suppressor -- A device capable of conducting current in either direction in the presence of high transient voltages thus protecting devices that could otherwise be damaged.

Synchronism -- The condition where two or more generators are operating at the same frequency and output voltage and are in phase with one another.

Synchronizing -- The procedure of matching the frequency, phase rotation, voltage, and phase relationship of one generator to another for purposes of paralleling the units onto a common bus.

Synchronous -- A generator whose output frequency is directly related (proportional) to the speed of the engine driving the generator.

Tachometer -- An instrument for measuring the rate of rotation expressed in revolutions per minute.

Temperature Drift -- A change in the value of a component caused by changes in operating temperature.

Terminal -- A mechanical device for making electrical connections.

Thyristor (SCR) -- A Silicon-Controlled Rectifier is a structure with an external connection (gate) to one of the inter layer. With no gate current, the SCR characteristic is that of a four-level diode.

Transformer -- Frequently, a device using a laminated iron core with a primary and secondary winding. A transformer changes some level of input (primary) voltage or current to a proportional output (secondary) voltage or current (see Current Transformer and Potential Transformer).

Transient -- A temporary change from the steady state conditions.

V -- Symbol used to represent voltage.

Volt -- The unit of measure of electrical potential (voltage). One volt of electrical potential will force a current of one ampere to flow through a resistance of one ohm.

Voltage -- Electrical potential or pressure which forces current to flow through a circuit.

Voltage Dip -- A temporary reduction in voltage generally resulting from an increase in load.

Voltage Droop -- A decrease in steady state voltage of a generator due to an increase in load applied. This decrease in voltage from the no load voltage is expressed as a percentage of the full load voltage or

$$\%V_{Droop} = \frac{(V_{NL} - V_{FL}) \times 100}{V_{FL}}$$

Where: $\%V_{Droop}$ = *Percent Voltage Droop*
V_{NL} = *No Load Voltage*
V_{FL} = *Full Load Voltage*

Voltage Droop Compensation -- A system which permits paralleled generators to share the currents of a load in proportion to the generator set ratings.

Voltage Regulator -- A device which controls the voltage output of a generator at a preset value regardless of the amount of load applied.

Voltmeter -- An instrument designed to measure electrical potential or voltage.

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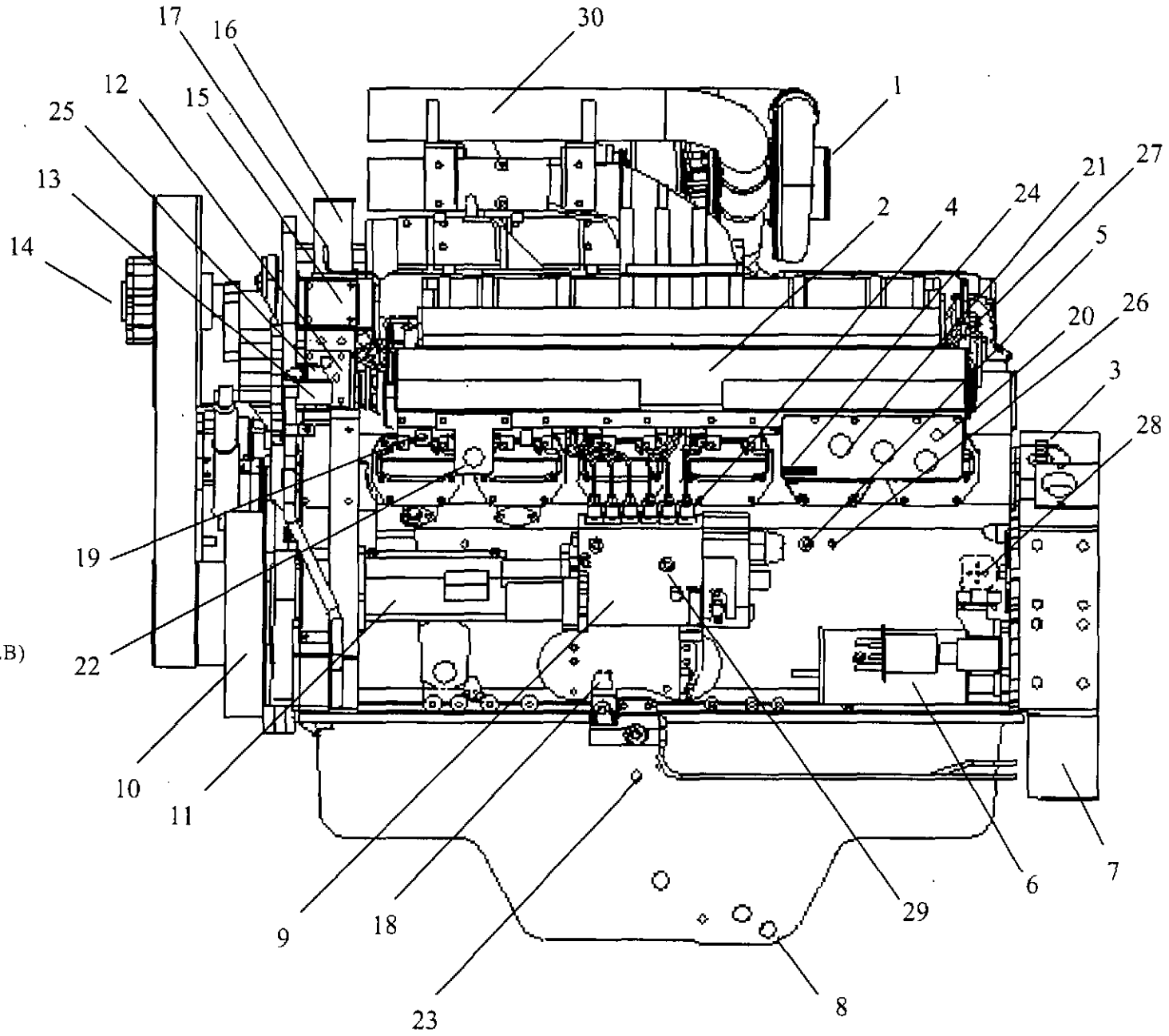
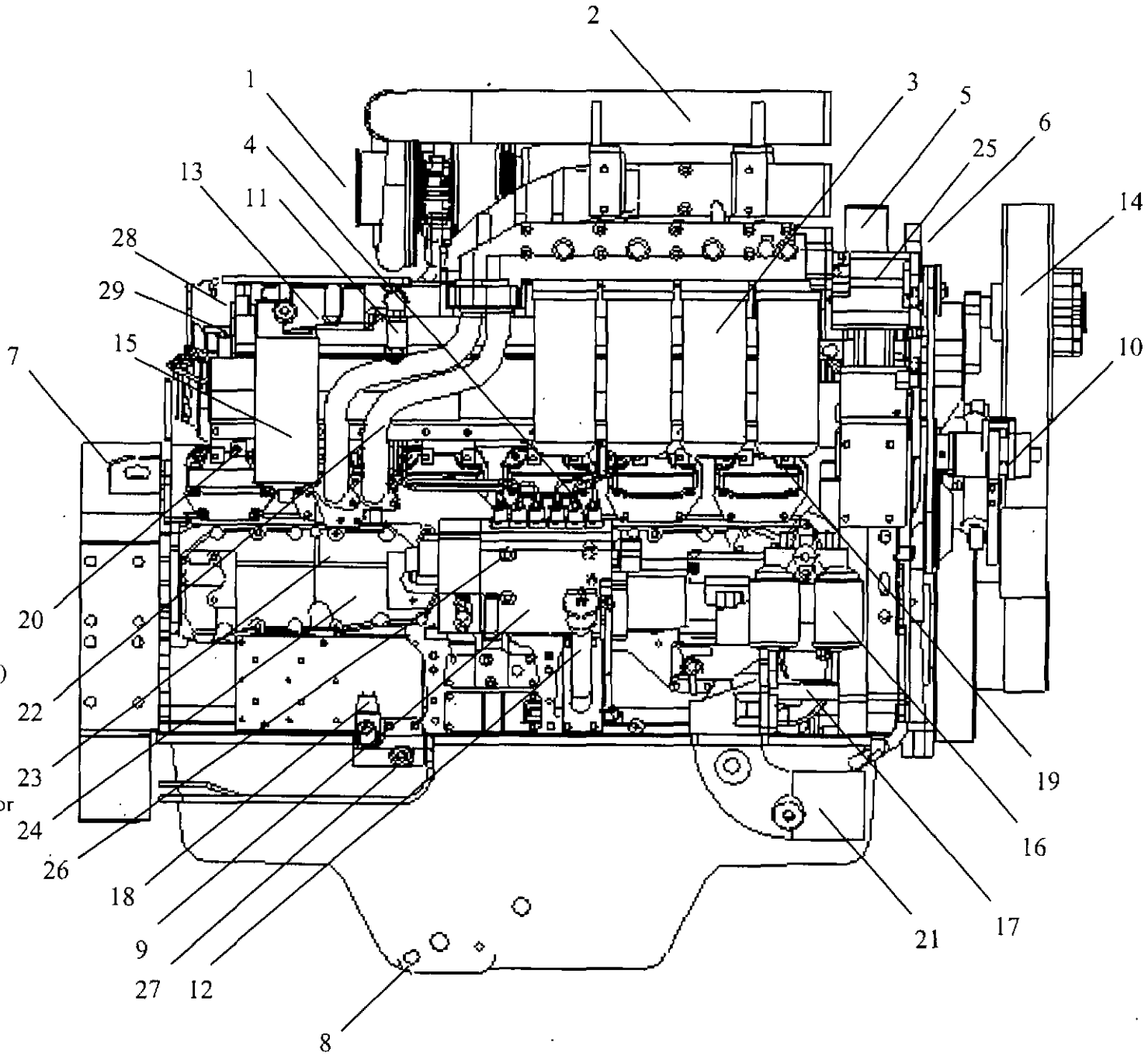
LEFT SIDE VIEW

1. Turbocharger Inlet Connection
2. Aftercooler Housing/Intake Manifold
3. Engien Speed Sensor
4. High-Pressure Fuel Supply Lines
5. Oil Pressure Sensor
6. Starter
7. Flywheel Housing
8. Oil Drain Port
9. Fuel Injection Pump (LB)
10. Vibration Damper
11. Fuel Pump Drive Housing
12. Coolant Temperature Sensor
13. Crankcase Breather
14. Fan Hub
15. Thermostat Housing
16. Coolant Outlet Connection
17. Coolant Vent Tube
18. Fuel Shutoff Valve Solenoid (LB)
19. Intake Manifold Pressure Sensor (LB)
20. Intake Manifold Temperature Sensor (LB)
21. INLINE Connectors
22. Datalink Connector
23. Oil Level Sensor (Optional)
24. Ambient Air Pressure Sensor
25. Coolant Pressure Sensor
26. Oil Temperature Sensor
27. Heater Connector
28. Starter Solenoid
29. Overflow Valve
30. ATA Crossover Connection



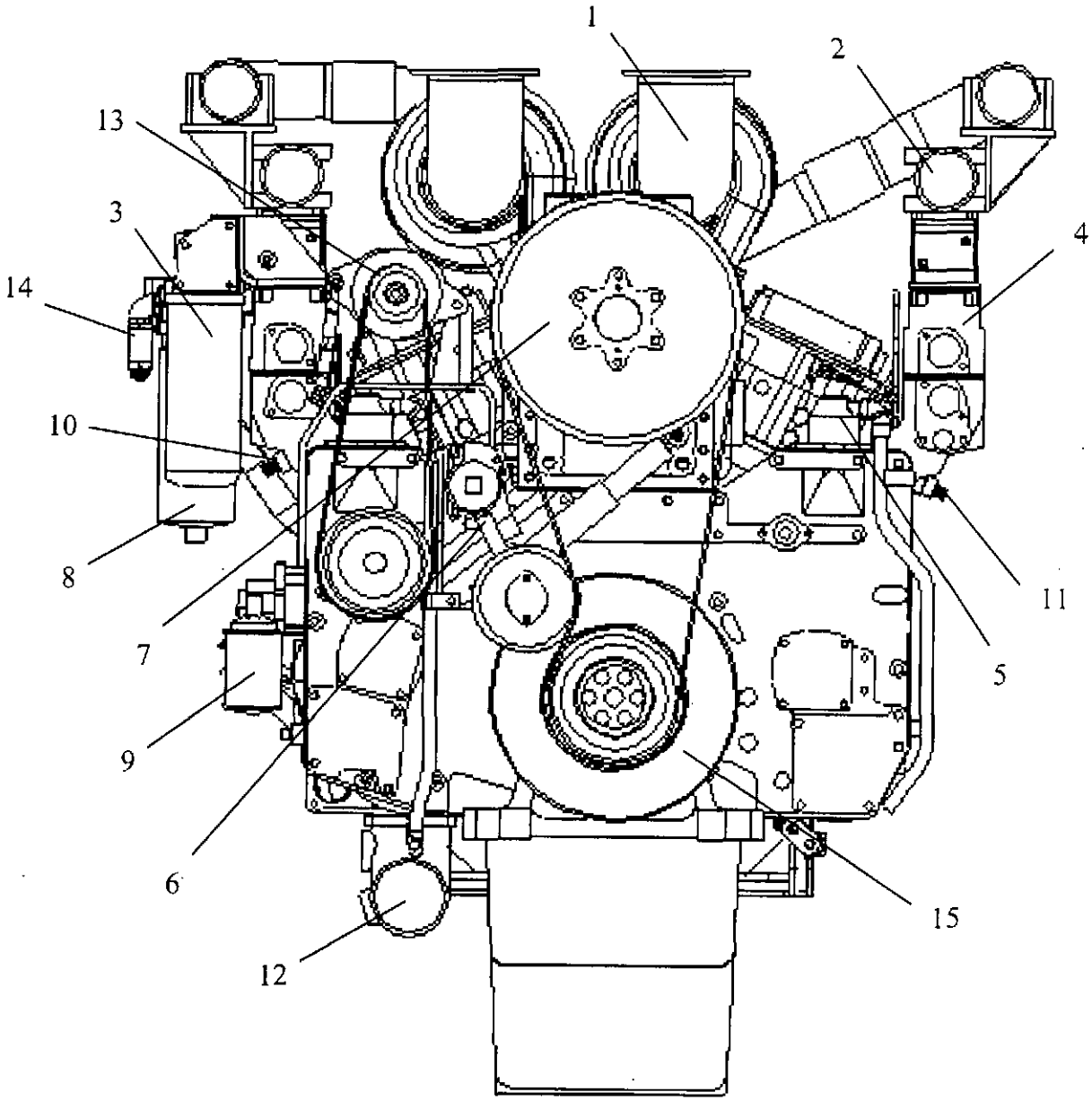
RIGHT SIDE VIEW

1. Turbocharger Inlet Connection
2. ATA Crossover Connection
3. Combo Lube Oil Filters
4. High-Pressure Fuel Lines
5. Coolant Outlet Connection
6. Lifting Bracket
7. Flywheel Housing
8. Oil Drain Port
9. Fuel Injection Pump (RB)
10. Fan Belt Idler Assembly
11. Fuel Inlet Fitting
12. Oil Filler Tube
13. Fuel Supply Pump Housing
14. Fan Hub
15. Fuel Filter
16. Coolant Additive
17. Coolant Pump
18. Fuel Shutoff Valve Solenoid (RB)
19. Intake Manifold Pressure Sensor (RB)
20. Intake Manifold Temperature Sensor (RB)
21. Coolant Inlet Connection
22. Oil Transfer Tubes
23. Centinel Driver Connector
24. Centinel Oil Tank Level Switch Connector
25. Alternator
26. Overflow Valve
27. Fuel Outlet Fitting
28. Fuel Supply Pressure Sensor
29. Fuel Temperature Sensor



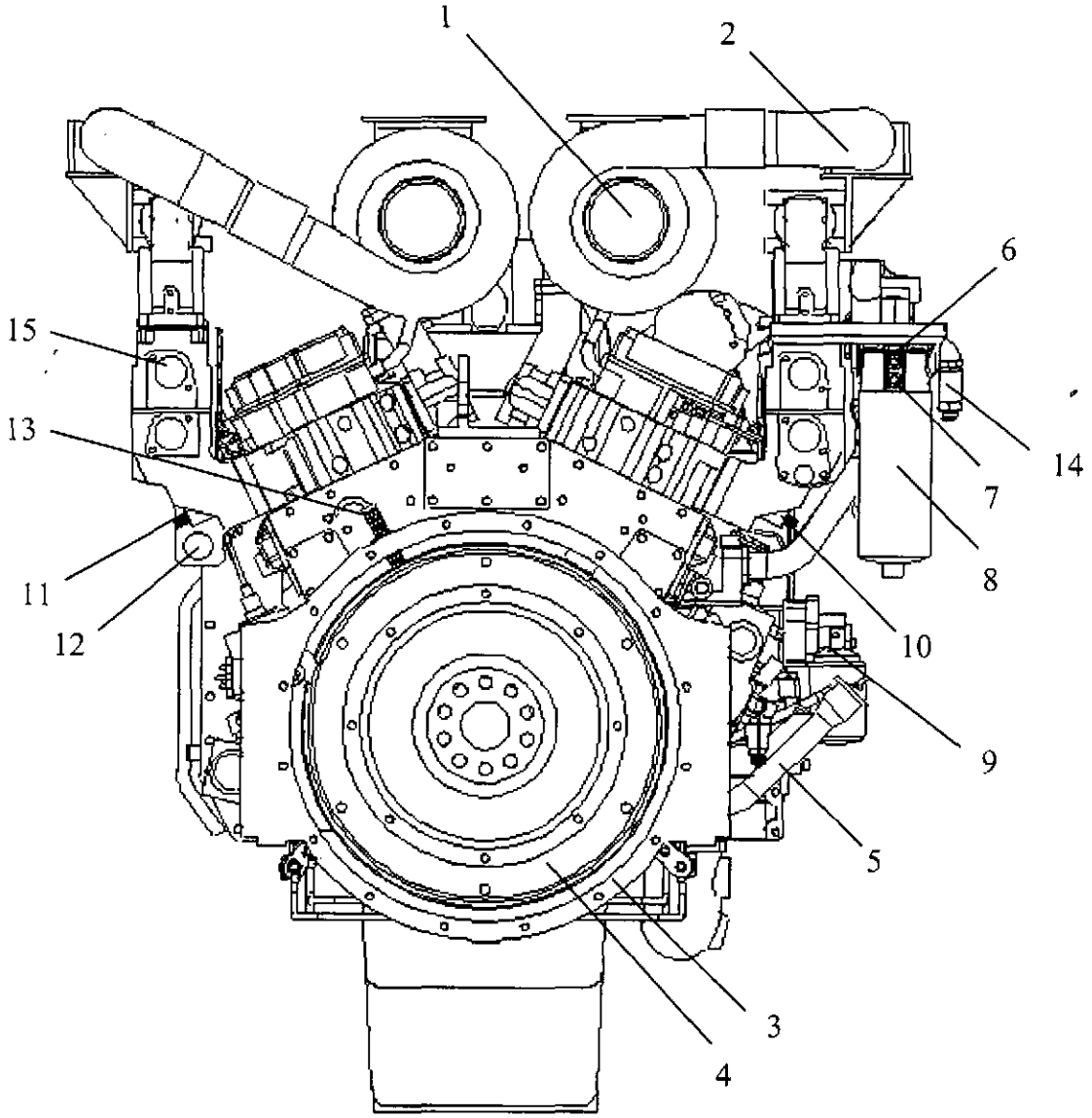
FRONT VIEW

1. Turbocharger Exhaust Connection
2. ATA Crossover Connection
3. Combo Lube Oil Filters
4. Aftercooler Housing/Intake Manifold
5. Crankcase Breather
6. Fan Belt Idler Assembly
7. Fan Hub
8. Fuel Filter
9. Coolant Additive
10. Intake Manifold Pressure Sensor (RB)
11. Intake Manifold Pressure Sensor (LB)
12. Coolant Inlet Connection
13. Alternator
14. Fuel Inlet Fitting
15. Vibration Damper



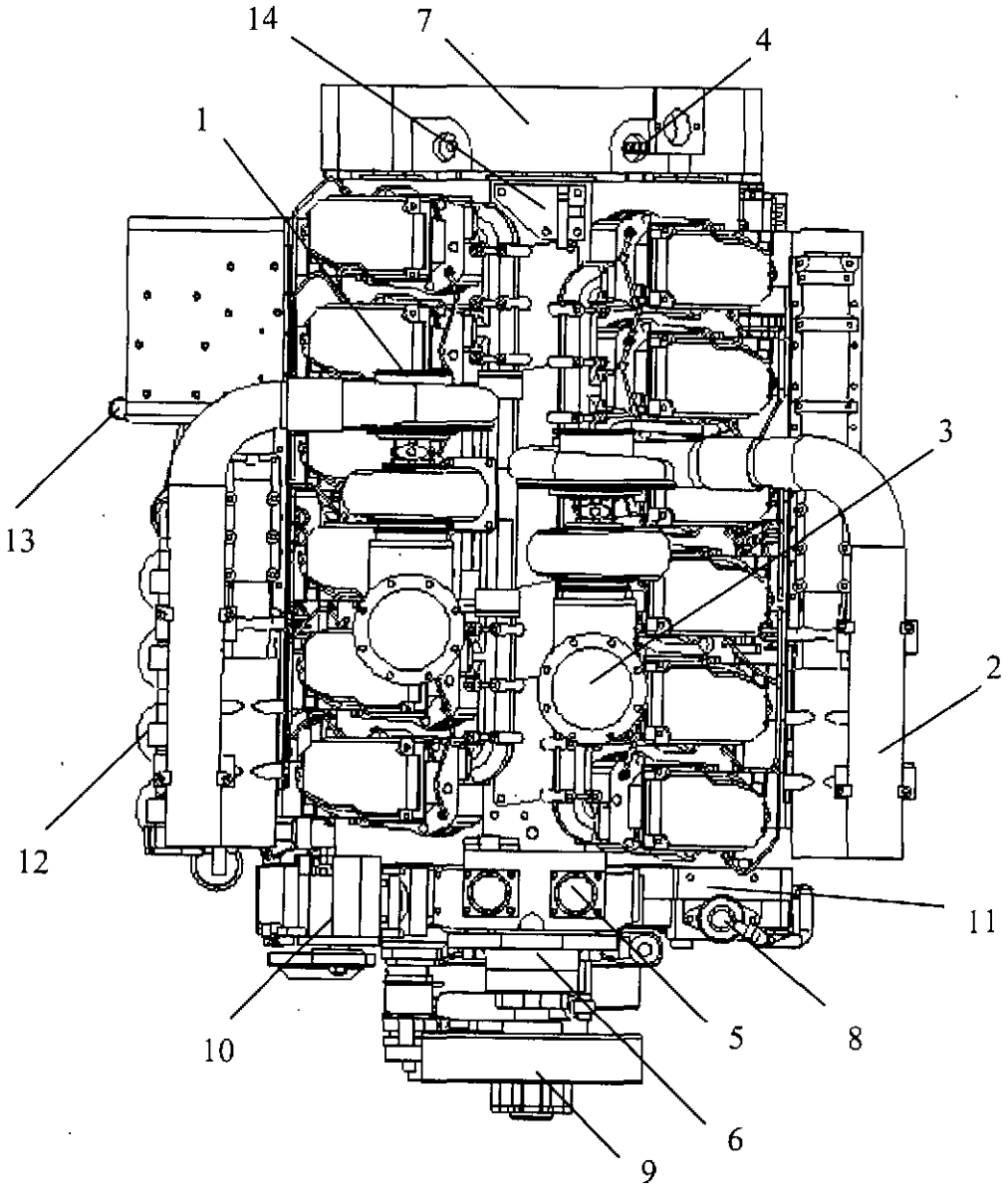
REAR VIEW

1. Turbocharger Inlet Connection
2. ATA Crossover Tube
3. Flywheel Housing
4. Flywheel
5. Oil Filler Tube
6. Fuel Supply Pressure Sensor
7. Fuel Temperature Sensor
8. Fuel Filter
9. Coolant Additive
10. Intake Manifold Temperature Sensor (RB)
11. Intake Manifold Temperature Sensor (LB)
12. Inline-E Connector
13. Speed Sensor
14. Fuel Inlet Fitting
15. Aftercooler Housing/Intake Manifold



TOP VIEW

1. Turbocharger Inlet Connection
2. ATA Crossover Connection
3. Exhaust Outlet Connection
4. Speed Sensor
5. Coolant Outlet Connection
6. Front Lifting Bracket
7. Flywheel Housing
8. Crankcase Breather
9. Fan Hub
10. Alternator
11. Coolant Level Switch Connector
12. Combo Lube Oil Filters
13. Fuel Inlet Fitting
14. Rear Lifting Bracket



RED	DC VOLTAGE
BLUE	INPUT SIGNALS
BLACK	GROUNDS, SHIELDS AND RETURNS
PURPLE	OUTPUT SIGNALS
GREEN	DATA LINKS
REPRESENTS FEMALE PIN	<
REPRESENTS MALE PIN	>

NOTE: SOME OF THE CIRCUITS SHOWN HERE WILL NOT BE ACTIVE IN ALL APPLICATIONS. CONSULT THE EQUIPMENT MANUFACTURER'S LITERATURE TO DETERMINE WHICH CIRCUITS ARE USED.

OEM RESPONSIBILITY

GENERATOR INTERFACE HARNESS

D-SUB CONNECTOR 03

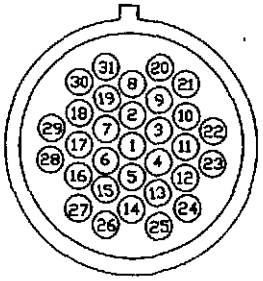
FAIL TO START <13
RELAY DRIVER SUPPLY
COMMON WARNING <09
COMMON SHUTDOWN <08
HIGH ENGINE TEMP <07
LOW OIL PRESSURE <19
OVER SPEED <04
PRE-HIGH ENGINE TEMP <25
PRE-LOW OIL PRESSURE <15
DROOP ADJUST
DROOP ADJUST SIGNAL <24
FREQUENCY ADJUST
FREQUENCY ADJUST SIGNAL <23
DROOP / FREQUENCY RETURN <14
ALTERNATE FREQUENCY
ALTERNATE FREQUENCY SIGNAL <02
CRANK/FREQUENCY RETURN <16
CRANK SWITCH
NO
CRANK SWITCH SIGNAL <03
ENGINE SPEED METER
ENGINE SPEED <18
OIL PRESSURE METER
OIL PRESSURE <22
COOLANT TEMPERATURE METER
COOLANT TEMPERATURE <21
METER DRIVER RETURN <17
WOODWARD FREQUENCY BIAS <11
COMMON RETURN <12
BARBER COLMAN FREQUENCY BIAS SIGNAL <10
SHIELD GROUND <20
8V SUPPLY FOR BARBER COLMAN <01
5V (REF) FOR BARBER COLMAN & WOODWARD <06

GENERATOR INTERFACE HARNESS

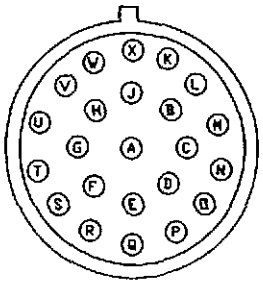
D-SUB CONNECTOR 06

FAIL TO START <03
5A FUSE
NC
EMERGENCY STOP <01
NC
EMERGENCY STOP <25
RUN / STOP <05
NO
FAULT ACKNOWLEDGE <24
IDLE/RATED <23
DIAGNOSTIC MODE <07
COMMON RETURN <08
RS-485/ MOD BUS INTERFACE
TERM 1 <22
TERM 2 <19
RS485+ <21
RS485- <18
GND <20
NC
BACKUP START DISCONNECT <06
CRANK RELAY
CRANK SIGNAL <02

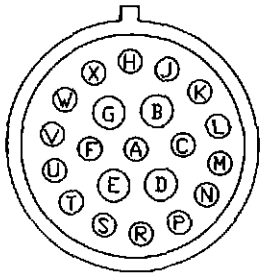
INLINE A



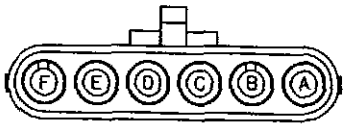
INLINE B



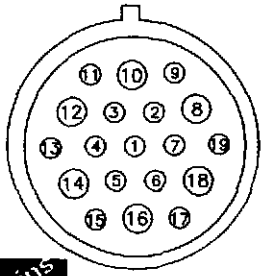
INLINE C



INLINE D



INLINE E



BATTERY

STARTER

S

+

-

CRANK SLAVE RELAY

D
CHARGING ALTERNATOR
GROUND
B+

GOVERNOR GAIN ADJUST

RUN RELAY

INI

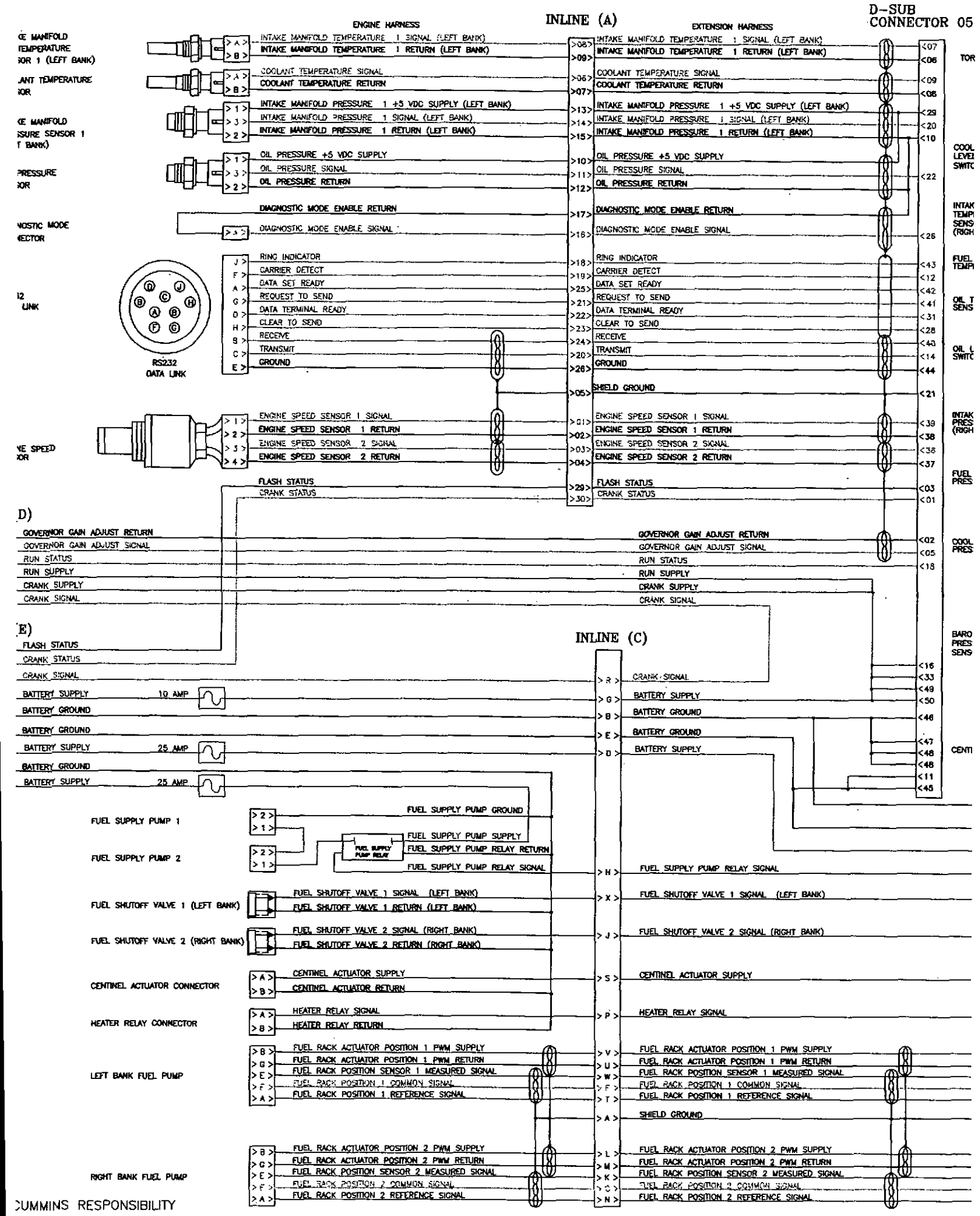
INI

QST30 Generator Drive Control System Wiring Diagram

Bulletin 4021346

Cummins Engine Company, Inc.

OEM RESPONSIBILITY


ENGINE HARNESS
INLINE (A)
EXTENSION HARNESS
D-SUB CONNECTOR 05
INTAKE MANIFOLD TEMPERATURE 1 SIGNAL (LEFT BANK)
INTAKE MANIFOLD TEMPERATURE 1 RETURN (LEFT BANK)
COOLANT TEMPERATURE SIGNAL
COOLANT TEMPERATURE RETURN
INTAKE MANIFOLD PRESSURE 1 +5 VDC SUPPLY (LEFT BANK)
INTAKE MANIFOLD PRESSURE 1 SIGNAL (LEFT BANK)
INTAKE MANIFOLD PRESSURE 1 RETURN (LEFT BANK)
OIL PRESSURE +5 VDC SUPPLY
OIL PRESSURE SIGNAL
OIL PRESSURE RETURN
DIAGNOSTIC MODE ENABLE RETURN
DIAGNOSTIC MODE ENABLE SIGNAL
RING INDICATOR
CARRIER DETECT
DATA SET READY
REQUEST TO SEND
DATA TERMINAL READY
CLEAR TO SEND
RECEIVE
TRANSMIT
GROUND
RS232 DATA LINK
ENGINE SPEED SENSOR 1 SIGNAL
ENGINE SPEED SENSOR 1 RETURN
ENGINE SPEED SENSOR 2 SIGNAL
ENGINE SPEED SENSOR 2 RETURN
SHIELD GROUND
FLASH STATUS
CRANK STATUS
GOVERNOR GAIN ADJUST RETURN
GOVERNOR GAIN ADJUST SIGNAL
RUN STATUS
RUN SUPPLY
CRANK SUPPLY
CRANK SIGNAL
INLINE (C)
BATTERY SUPPLY 10 AMP
BATTERY GROUND
BATTERY SUPPLY 25 AMP
BATTERY GROUND
BATTERY SUPPLY 25 AMP
FUEL SUPPLY PUMP 1
FUEL SUPPLY PUMP 2
FUEL SUPPLY PUMP GROUND
FUEL SUPPLY PUMP SUPPLY
FUEL SUPPLY PUMP RELAY RETURN
FUEL SUPPLY PUMP RELAY SIGNAL
FUEL SUPPLY PUMP RELAY
FUEL SHUTOFF VALVE 1 (LEFT BANK)
FUEL SHUTOFF VALVE 1 SIGNAL (LEFT BANK)
FUEL SHUTOFF VALVE 1 RETURN (LEFT BANK)
FUEL SHUTOFF VALVE 2 (RIGHT BANK)
FUEL SHUTOFF VALVE 2 SIGNAL (RIGHT BANK)
FUEL SHUTOFF VALVE 2 RETURN (RIGHT BANK)
CENTINEL ACTUATOR CONNECTOR
CENTINEL ACTUATOR SUPPLY
CENTINEL ACTUATOR RETURN
HEATER RELAY CONNECTOR
HEATER RELAY SIGNAL
HEATER RELAY RETURN
LEFT BANK FUEL PUMP
FUEL RACK ACTUATOR POSITION 1 PWM SUPPLY
FUEL RACK ACTUATOR POSITION 1 PWM RETURN
FUEL RACK POSITION SENSOR 1 MEASURED SIGNAL
FUEL RACK POSITION 1 COMMON SIGNAL
FUEL RACK POSITION 1 REFERENCE SIGNAL
SHIELD GROUND
RIGHT BANK FUEL PUMP
FUEL RACK ACTUATOR POSITION 2 PWM SUPPLY
FUEL RACK ACTUATOR POSITION 2 PWM RETURN
FUEL RACK POSITION SENSOR 2 MEASURED SIGNAL
FUEL RACK POSITION 2 COMMON SIGNAL
FUEL RACK POSITION 2 REFERENCE SIGNAL

D-SUB
CONNECTOR 02

ENGINE HARNESS

EXTENSION HARNESS

INLINE (B)
23-PIN

NTROL CONNECTOR
TORQUE CONTROL SIGNAL
TORQUE CONTROL RETURN

COOLANT LEVEL +5 VDC SUPPLY
COOLANT LEVEL LOW SIGNAL
COOLANT LEVEL HIGH SIGNAL
COOLANT LEVEL RETURN

OLD
INTAKE MANIFOLD TEMPERATURE SENSOR 2 SIGNAL (RIGHT BANK)
INTAKE MANIFOLD TEMPERATURE SENSOR 2 RETURN (RIGHT BANK)

SENSOR
FUEL SUPPLY TEMPERATURE SIGNAL
FUEL SUPPLY TEMPERATURE RETURN

URE
OIL TEMPERATURE SIGNAL
OIL TEMPERATURE RETURN

OIL LEVEL HIGH SIGNAL
OIL LEVEL LOW
OIL LEVEL +5 VDC SUPPLY
OIL LEVEL RETURN

OLD
NSOR 2
INTAKE MANIFOLD PRESSURE SENSOR 2 +5 VDC SUPPLY BANK)
INTAKE MANIFOLD PRESSURE SENSOR 2 SIGNAL (RIGHT BANK)
INTAKE MANIFOLD PRESSURE SENSOR 2 RETURN (RIGHT BANK)

NSOR
FUEL SUPPLY PRESSURE +5 VDC SUPPLY
FUEL SUPPLY PRESSURE SIGNAL
FUEL SUPPLY PRESSURE RETURN

NSOR
COOLANT PRESSURE +5 VDC SUPPLY
COOLANT PRESSURE SIGNAL
COOLANT PRESSURE RETURN

BAROMETRIC AIR PRESSURE +5 VDC SUPPLY
BAROMETRIC AIR PRESSURE SIGNAL
BAROMETRIC AIR PRESSURE RETURN

. LEVEL CONNECTOR
CENTINEL OIL LEVEL SENSOR RETURN
CENTINEL OIL LEVEL SENSOR SIGNAL

TORQUE CONTROL SIGNAL			<40
TORQUE CONTROL RETURN			
COOLANT LEVEL +5 VDC SUPPLY	>4>	<G<	COOLANT LEVEL +5 VDC SUPPLY <01
COOLANT LEVEL LOW SIGNAL	>3>	<F<	COOLANT LEVEL LOW SIGNAL <37
COOLANT LEVEL HIGH SIGNAL	>2>	<E<	COOLANT LEVEL HIGH SIGNAL <35
COOLANT LEVEL RETURN	>1>	<D<	COOLANT LEVEL RETURN <21
INTAKE MANIFOLD TEMPERATURE SENSOR 2 SIGNAL (RIGHT BANK)		<H<	INTAKE MANIFOLD TEMPERATURE SENSOR 2 SIGNAL (RIGHT BANK) <29
INTAKE MANIFOLD TEMPERATURE SENSOR 2 RETURN (RIGHT BANK)		<J<	INTAKE MANIFOLD TEMPERATURE SENSOR 2 RETURN (RIGHT BANK)
FUEL SUPPLY TEMPERATURE SIGNAL		<K<	FUEL SUPPLY TEMPERATURE SIGNAL <22
FUEL SUPPLY TEMPERATURE RETURN		<L<	FUEL SUPPLY TEMPERATURE RETURN
OIL TEMPERATURE SIGNAL		<M<	OIL TEMPERATURE SIGNAL <31
OIL TEMPERATURE RETURN		<N<	OIL TEMPERATURE RETURN <28
			SHIELD GROUND <08
OIL LEVEL HIGH SIGNAL	>2>	<O<	OIL LEVEL HIGH SIGNAL <26
OIL LEVEL LOW	>3>	<P<	OIL LEVEL LOW <19
OIL LEVEL +5 VDC SUPPLY	>4>		
OIL LEVEL RETURN	>1>		
INTAKE MANIFOLD PRESSURE SENSOR 2 +5 VDC SUPPLY BANK)			
INTAKE MANIFOLD PRESSURE SENSOR 2 SIGNAL (RIGHT BANK)		<Q<	INTAKE MANIFOLD PRESSURE SENSOR 2 SIGNAL (RIGHT BANK) <36
INTAKE MANIFOLD PRESSURE SENSOR 2 RETURN (RIGHT BANK)			
FUEL SUPPLY PRESSURE +5 VDC SUPPLY		<C<	VSENSOR B +5 VDC SUPPLY <43
FUEL SUPPLY PRESSURE SIGNAL		<R<	FUEL SUPPLY PRESSURE SIGNAL <20
FUEL SUPPLY PRESSURE RETURN			
COOLANT PRESSURE +5 VDC SUPPLY		<B<	VSENSOR A +5 VDC SUPPLY <30
COOLANT PRESSURE SIGNAL		<S<	COOLANT PRESSURE SIGNAL <09
COOLANT PRESSURE RETURN			
BAROMETRIC AIR PRESSURE +5 VDC SUPPLY			
BAROMETRIC AIR PRESSURE SIGNAL		<T<	BAROMETRIC AIR PRESSURE SIGNAL <27
BAROMETRIC AIR PRESSURE RETURN		<A<	VSENSOR RETURN <02
CENTINEL OIL LEVEL SENSOR RETURN			
CENTINEL OIL LEVEL SENSOR SIGNAL		<U<	CENTINEL OIL LEVEL SENSOR SIGNAL <41

BATTERY GROUND	<10
	<11
BATTERY GROUND	<13
	<15
	<48
BATTERY SUPPLY	<16
	<17
	<33
	<49
	<50
FUEL SUPPLY PUMP RELAY SIGNAL	<42
FUEL SHUTOFF VALVE 1 SIGNAL (LEFT BANK)	<03
FUEL SHUTOFF VALVE 2 SIGNAL (RIGHT BANK)	<14
CENTINEL ACTUATOR SUPPLY	<06
HEATER RELAY SIGNAL	<18
FUEL RACK ACTUATOR POSITION 1 PWM SUPPLY	<12
	<34
FUEL RACK ACTUATOR POSITION 1 PWM RETURN	<32
FUEL RACK POSITION SENSOR 1 MEASURED SIGNAL	<38
FUEL RACK POSITION 1 COMMON SIGNAL	<05
FUEL RACK POSITION 1 REFERENCE SIGNAL	<39
SHIELD GROUND	<04
FUEL RACK ACTUATOR POSITION 2 PWM SUPPLY	<08
	<45
	<47
FUEL RACK ACTUATOR POSITION 2 PWM RETURN	<44
FUEL RACK POSITION SENSOR 2 MEASURED SIGNAL	<46
FUEL RACK POSITION 2 COMMON SIGNAL	<25
FUEL RACK POSITION 2 REFERENCE SIGNAL	<23
	<24

Specifications

Electronic Components

⚠ WARNING ⚠

This diagram is provided as a diagnostic tool for trained, experienced technicians only. Improper troubleshooting or repair can result in severe personal injury or death or property damage. See important instructions in service manual.

ELECTRICAL SPECIFICATIONS

DATA LINK

Transmit wire to receive wire (loaded)
- 5.0 to 15.0 VDC

Transmit wire to receive wire (unloaded)
- OK if less than 25.0 VDC

ALL CONTINUITY CHECKS
- OK (no open circuit) if less than 10 Ω

5-VDC POWER SUPPLY

@ ECM
- 4.75 to 5.25 VDC

ECM CONNECTOR
- Retaining capscrew torque = 1 N•m [9 in-lb]

SHORT CIRCUIT TO EXTERNAL VOLTAGE
- OK if less than 1.5 VDC

ALL SHORTS TO GROUND

ESS circuits
- OK (no short circuit) if more than 10M Ω

All other circuits
- OK (no short circuit) if more than 100k Ω

SENSOR SPECIFICATIONS

NOTE: To convert to gauge pressure on all psia pressure sensors subtract the barometric pressure from the absolute pressure.

INTAKE MANIFOLD/COOLANT PRESSURE SENSOR
Torque = 14 N•m [124 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
0	0	0 to 0.5
103	15	1.26 to 1.34
207	30	2.06 to 2.14
310	45	2.86 to 2.94
414	60	3.66 to 3.74
517	75	4.46 to 4.56

BAROMETRIC (AMBIENT) AIR PRESSURE SENSOR
Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure (psia)	Voltage (VDC)
45	6.5	0.44 to 0.56
55	8.0	1.07 to 1.19
69	10.0	1.91 to 2.03
83	12.0	2.74 to 2.88
96	14.0	3.60 to 3.72
110	16.0	4.44 to 4.56

ALL TEMPERATURE SENSORS
Torque = 15 N•m [133 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ω)
0	32	30K to 36K
25	77	9K to 11K
50	122	3K to 4K
75	167	1350 to 1500
100	212	600 to 675

OIL AND FUEL PRESSURE SENSOR
Torque = 14 N•m [124 in-lb]

Pressure (kPa)	Pressure (psia)	Voltage (VDC)
0	15	0.92 to 1.08
207	30	1.42 to 1.58
414	60	2.42 to 2.58
621	90	3.42 to 3.58
827	120	4.42 to 4.58

ENGINE SPEED SENSOR
Torque = 34 to 47 N•m [25 to 35 ft-lb]
First Coil Resistance = 750 to 1100 Ω
Second Coil Resistance = 1100 to 1500 Ω

FUEL SHUTOFF
Resistance = 28 to 32 Ω

RACK ACTUATOR
Coil Resistance = 0.5 to 1.5 Ω

RACK POSITION SENSOR
Resistance Value = 17 to 23 Ω (between pins for Rack Position Measure signal and common signal and between pins Rack Position Reference signal and common signal)

QST30 FAULT CODE INFORMATION

FAULT CODE	LAMP ACTION	REASON	EFFECT (Only when fault code is active)
111	Shutdown	Engine Control Module - Critical internal failure.	Engine will **not** start.
115	Shutdown	Engine Speed/Position Sensor Circuit - Lost both of two signals from the magnetic pickup sensor.	Engine is shut down and can **not** be run.
121	Warning	Engine Speed/Position Sensor Circuit - Lost one of two signals from the magnetic pickup sensor.	No action is taken by the ECM.
122	Warning	Intake Manifold Pressure Sensor #1 Circuit - Shorted high (left bank).	No action is taken by the ECM. Possible loss of performance.
123	Warning	Intake Manifold Pressure Sensor #1 circuit - Shorted low (left bank).	No action is taken by the ECM. Possible loss of performance.
128	Warning	Intake Manifold Pressure Sensor #2 circuit - Shorted high (right bank).	No action is taken by the ECM. Possible loss of performance.
129	Warning	Intake Manifold Pressure Sensor #2 Circuit - Shorted low (right bank).	No action is taken by the ECM. Possible loss of performance.
135	Warning	Engine Oil Pressure Sensor Circuit - Shorted high.	No engine protection for oil pressure.
141	Warning	Engine Oil Pressure Sensor Circuit - Shorted low.	No engine protection for oil pressure.
143	Warning	Engine Oil Pressure Low - Warning. Voltage signal indicates oil pressure has dropped below the warning threshold for low oil pressure.	Calibration-dependent engine shut down occurs, or no action taken by ECM. Pre-Low oil pressure relay driver is energized.
144	Warning	Engine Coolant Temperature Sensor Circuit - Shorted high.	No engine protection for coolant temperature. Possible white smoke.
145	Warning	Engine Coolant Temperature Sensor Circuit - Shorted low.	No engine protection for coolant temperature. Possible white smoke.
146	Warning	Engine Coolant Temperature High - Warning. Voltage signal indicates coolant temperature has exceeded above the warning threshold for high coolant temperature.	Calibration-dependent engine shut down occurs, or no action is taken by ECM. Pre-High engine temperature relay driver is energized.
151	Shutdown	Engine Coolant Temperature High - Critical. Voltage signal indicates coolant temperature has exceeded the shutdown threshold for high coolant temperature.	Engine will shut down. High engine temperature relay driver is energized.
152	Warning	Engine Coolant Temperature Low - Warning. Voltage signal indicates coolant temperature has dropped below the warning threshold for low coolant temperature.	No action is taken by ECM. Possible hard starting.
153	Warning	Intake Manifold Temperature Sensor #1 Circuit - Shorted high (left bank).	No engine protection for intake manifold temperature. Possible smoke at engine start-up and no-load operation.
154	Warning	Intake Manifold Temperature Sensor #1 Circuit - shorted low (left bank).	No engine protection for intake manifold temperature. Possible smoke at engine start-up and no-load operation.
155	Shutdown	Intake Manifold Temperature #1 High - Critical. Voltage signal indicates intake manifold temperature has exceeded the shutdown threshold for high intake manifold temperature (left bank).	Engine will shut down. High engine temperature relay driver is energized.
159	Warning	Intake Manifold Temperature Sensor #2 circuit - Shorted high (right bank).	No engine protection for intake manifold temperature. Possible smoke at engine start-up and no-load operation.
161	Warning	Intake Manifold Temperature Sensor #2 Circuit - Shorted low (right bank).	No engine protection for intake manifold temperature. Possible smoke at engine start-up and no-load operation.
166	Warning	Rack Position Sensor #1 Circuit - Shorted high (left bank).	No action is taken by the ECM. Engine could possibly run rough.

FAULT CODE	LAMP ACTION	REASON	EFFECT (Only when fault code is active)
167	Warning	Rack Position Sensor #1 Circuit - Shorted low (left bank).	No action is taken by the ECM. Engine could possibly run rough.
168	Warning	Rack Actuator Position #1 Circuit - Open circuit (left bank).	Engine will shut down.
169	Warning	Rack Actuator Position #1 Circuit - Short circuit (left bank).	Engine will shut down.
171	Warning	Fuel rack actuator position 1 circuit - data incorrect (left bank).	Performance could possibly be sluggish or slow to respond.
174	Warning	Rack Actuator Position #2 Circuit - Data incorrect (right bank).	Performance could possibly be sluggish or slow to respond.
179	Warning	Rack Position Sensor #2 Circuit - Shorted high (right bank).	No action is taken by the ECM. Engine could possibly run rough.
181	Warning	Rack Position Sensor #2 Circuit - Shorted low (right bank).	No action is taken by the ECM. Engine could possibly run rough.
182	Warning	Rack Actuator Position #2 Circuit - Short circuit (right bank).	Engine will shut down.
183	Warning	Rack Actuator Position #2 Circuit - Open circuit (right bank).	Engine will shut down.
197	Warning	Engine Coolant Level Low - Warning. Voltage signal indicates low radiator coolant level.	No action is taken by the ECM. Fault Code 146, 151, 228, and/or 233 could possibly also be logged.
212	Warning	Engine Oil Temperature Sensor Circuit - Shorted high.	No engine protection for oil temperature.
213	Warning	Engine Oil Temperature Sensor Circuit - Shorted low.	No engine protection for oil temperature.
214	Shutdown	Engine Oil Temperature High - Critical. Voltage signal indicates oil temperature has exceeded the shutdown threshold for high oil temperature.	Engine will shut down.
219	Warning	Engine Oil Level #2 (remote) Low - Maintenance. Low oil level is detected in the remote oil reservoir used in the Centinel™ system.	Centinel™ system is disabled.
221	Warning	Barometric Ppressure Sensor Circuit - Shorted high.	No action is taken by the ECM. Possible loss of performance.
222	Warning	Barometric Pressure Sensor Circuit - Shorted low.	No action is taken by the ECM. Possible loss of performance.
223	Warning	Engine Oil Burn Valve Solenoid Circuit - Shorted low. The Centinel™ actuator circuit is open or shorted.	ECM turns off the Centinel™ actuator supply voltage, and the Centinel™ system is disabled.
228	Shutdown	Engine Coolant Pressure Low - Critical. Voltage signal indicates coolant pressure has dropped below the shutdown threshold for low coolant pressure.	Engine will shut down.
231	Warning	Engine Coolant Pressure Sensor Circuit - Shorted high.	No engine protection for coolant pressure.
232	Warning	Engine Coolant Pressure Sensor Circuit - Shorted low.	No engine protection for coolant pressure.
233	Warning	Engine Coolant Pressure Low - Warning. Voltage signal indicates coolant pressure has dropped below the warning threshold for low coolant pressure.	Calibration-dependent engine shutdown occurs, or no action is taken by the ECM.
234	Shutdown	Engine Speed High - Critical. Voltage signal indicates engine speed has exceeded the shutdown threshold for engine overspeed.	Engine will shutdown. Overspeed relay driver is energized.
235	Shutdown	Engine Coolant Level Low - Critical. Voltage signal indicates very low radiator coolant level.	Engine will shut down.
253	Shutdown	Engine Oil Level #1 Low - Critical. Voltage signal indicates very low lubricating oil level in the engine.	Engine will shut down.

FAULT CODE	LAMP ACTION	REASON	EFFECT (Only when fault code is active)
254	Shutdown	Fuel Shutoff Valve Circuit - Shorted low. Low voltage detected at the fuel shutoff valve signal pin, or the resistance of the solenoid has dropped below specified threshold.	Engine will shut down.
261	Warning	Fuel Temperature High - Warning. Voltage signal indicates fuel temperature has exceeded the warning threshold or high fuel temperature.	Calibration-dependent engine shut down occurs, or no action is taken by the ECM.
263	Warning	Fuel Temperature Sensor Circuit - Shorted high.	No engine protection for fuel temperature.
265	Warning	Fuel Temperature Sensor Circuit - Shorted low.	No engine protection for fuel temperature.
266	Shutdown	Fuel Temperature High - Critical. Voltage signal indicates fuel temperature has exceeded the shutdown threshold for high fuel temperature.	Engine will shut down.
343	Warning	Engine Control Module - Warning internal hardware failure. Error internal to the ECM.	No action is taken by the ECM. Possible loss of performance.
415	Shutdown	Engine Oil Pressure Low - Critical. Voltage signal indicates oil pressure has dropped below the shutdown threshold for low oil pressure.	Engine will shut down. Low oil pressure relay driver is energized.
421	Warning	Engine Oil Temperature High - Warning. Voltage signal indicates oil temperature has exceeded the warning threshold for high oil temperature.	Calibration-dependent engine shut down occurs, or no action is taken by the ECM.
422	Warning	Engine Coolant Level Sensor Circuit - Data incorrect. Voltage detected simultaneously on both the coolant level high and low signal pins - or - no voltage detected on either pin.	No engine protection for coolant level.
471	Warning	Engine Oil Level #1 Low - Warning. Voltage signal indicates low lubricating oil level in the engine.	Calibration-dependent engine shut down occurs, or no action taken by the ECM.
488	Warning	Intake Manifold Temperature #1 High - Warning. Voltage signal indicates intake manifold temperature has exceeded the warning threshold for high intake manifold temperature.	Calibration-dependent engine shut down occurs, or no action is taken by the ECM. Pre-High engine temperature relay driver is a energized.
581	Warning	Fuel Supply Pump Pressure Sensor Circuit - Shorted high.	No action taken by the ECM. Possible loss of performance.
582	Warning	Fuel Supply Pump Pressure Sensor Circuit - Shorted low.	No action taken by the ECM. Possible loss of performance.
1211	Shutdown	Fuel Shutoff Valve #1 Circuit - Root cause **not** know (left bank).	Engine will shut down.
1212	Shutdown	Fuel Shutoff Valve #2 Circuit - Root cause **not** known (right bank).	Engine will shut down.
1411	Warning	Generator Output Frequency Potentiometer - Shorted high.	The frequency adjustment feature will be disabled and a default value of zero will be used. Possible loss of performance.
1412	Warning	Droop Adjust Potentiometer - Shorted high.	The droop adjustment feature will be disabled and a default value of zero will be used. Possible loss of performance.
1413	Shutdown	Controller Configuration Error.	Engine will **not** start.
1416	Warning	Fail to Shutdown.	The operator has enabled the user-engaged engine shutdown override feature. No engine protection features are working.
1417	Warning	Controller will **not** Powerdown.	The ECM can not power down from some unknown condition. Possible drain on battery.

FAULT CODE	LAMP ACTION	REASON	EFFECT (Only when fault code is active)
1418	Warning	Gain Adjust Potentiometer - Shorted high.	The gain adjustment feature will be disabled and a default value of zero will be used. Possible loss of performance.
1424	Warning	Relay High Side Driver Diagnostic has detected an error.	The user interface panel lamps will **not** function correctly. No action is taken by the ECM.
1425	Warning	Common Shutdown Relay Driver Diagnostic has detected an error.	The shutdown panel lamp will **not** function correctly. No action is taken by the ECM.
1426	Warning	Common Warning Relay Driver Diagnostic has detected an error.	The warning panel lamp will **not** function correctly. No action taken by the ECM.
1427	Warning	Overspeed (OS) Relay Driver Diagnostic has detected an error.	The overspeed panel lamp will **not** function correctly. No action taken by the ECM.
1428	Warning	Low Oil Pressure (LOP) Relay Driver Diagnostic has detected an error.	The low oil pressure lamp will **not** function correctly. No action is taken by the ECM.
1429	Warning	High Engine Temperature (HET) Relay Driver Diagnostic has detected an error.	The high engine temperature panel lamp will **not** function correctly. No action is taken by the ECM.
1431	Warning	Pre-Low Oil Pressure Relay Driver diagnostic has detected an error.	The Pre-Low oil pressure panel lamp will **not** function correctly. No action is taken by the ECM.
1432	Warning	Pre-High Engine Temperature Relay Driver Diagnostic has detected an error.	The Pre-High engine temperature panel lamp will **not** function correctly. No action is taken by the ECM.
1433	Shutdown	Operator Interface Mode Transition to Emergency Stop (due to E-Stop).	Engine will shut down and will **not** restart until the emergency stop switch has been reset.
1434	Shutdown	Operator Interface Mode Transition to Emergency Stop (due to remote E-Stop).	Engine will shut down and will **not** restart until the remote emergency stop switch has been reset.
1435	Warning	Engine Cold - Potential starting problem.	No action is taken by the ECM. Possible hard starting.
1438	Warning	Fail to Crank.	No action is taken by the ECM, although the engine will **not** start.
1443	Shutdown	Battery #1 Voltage Low - Critical. Battery is dead.	Engine will **not** start.
1473	Shutdown	The ECM Watchdog has failed.	Engine will shutdown.
1479	Warning	Fail to Start Relay Driver Diagnostic has detected an error.	The fail to start panel lamp will **not** function correctly. No action is taken by the ECM.
2297	Warning	Fuel Supply Pump Driver Diagnostic has detected an error.	Priming pump is disabled. Possible loss of performance.
2974	Warning	Rack Position Sensor #1 Circuit - Shorted high.	No action is taken by ECM. Engine could possibly run rough.
2975	Warning	Rack Position Sensor #2 Circuit - Shorted high.	No action is taken by ECM. Engine could possibly run rough.

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