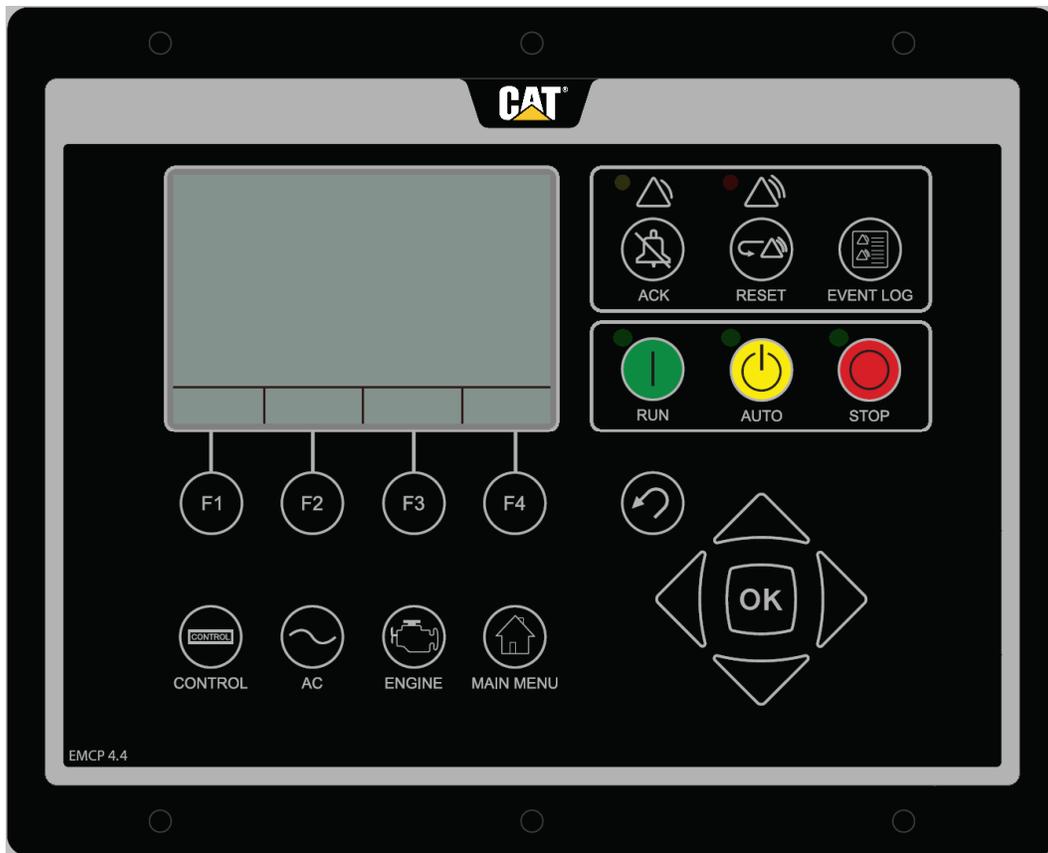


APPLICATION AND INSTALLATION GUIDE

EMCP 4 SCADA DATA LINKS



The information in this document is the property of Caterpillar Inc. and/or its subsidiaries. Any copying, distribution, transmission to others, and any use except that for which it is loaned is prohibited without written permission.

CAT, CATERPILLAR, ADEMTMA4, their respective logos, "Caterpillar Yellow" the "Power Edge" trade dress as well as corporate and product identity used herein, are trademarks of Caterpillar and may not be used without permission.

Table of Contents

1	GENERAL INFORMATION.....	1
1.1	INTRODUCTION	1
1.2	OVERVIEW OF EMCP 4 SCADA DATA LINKS	1
1.3	REFERENCES	2
1.4	GLOSSARY OF TERMS	3
2	RS-485 SCADA DATA LINK – WIRING AND CONFIGURATION.....	5
2.1	NETWORK TOPOLOGY	5
2.2	WIRING.....	6
	<i>Shielding</i>	7
	<i>Termination</i>	7
	<i>Extending Range</i>	7
2.3	SOFTWARE CONFIGURATION	7
	<i>Baud Rate</i>	7
	<i>Parity</i>	8
	<i>Slave Address</i>	8
	<i>Stop Bits</i>	8
	<i>Bias Resistors</i>	8
2.4	ERROR CHECKING	9
3	TCP/IP SCADA DATA LINK – WIRING AND CONFIGURATION	10
3.1	NETWORK TOPOLOGY	10
3.2	WIRING (INCLUDING SWITCHES, ROUTERS, ETC)	10
	<i>Crossover Cables</i>	10
3.3	SOFTWARE CONFIGURATION	11
	<i>IP Address</i>	11
	<i>Network Mask</i>	11
	<i>Default Gateway</i>	11
3.4	ERROR CHECKING	11
4	EMCP 4 SCADA COMMUNICATION	13
4.1	ADDRESSING	13
4.2	SUPPORTED FUNCTION CODES.....	13
4.3	DATA INTERPRETATION	15
	<i>Numerical data</i>	15
	<i>State-based data</i>	16
	<i>Complex data</i>	16
4.4	SECURITY	16
5	EMCP 4 SCADA DATA POINTS	19
5.1	GENERATOR AC MONITORING	19
5.2	GENERATOR POWER MONITORING.....	20
5.3	GENERATOR OTHER MONITORING	21
5.4	BUS AC MONITORING	21
5.5	GENERATOR SET STATE MONITORING AND CONTROL.....	21
5.6	ENGINE MONITORING	24
5.7	EVENT MONITORING	26
5.8	TIMERS, COUNTERS, TOTALS, AND ENERGY	28
5.9	UTILITY MONITORING	29
5.10	PROGRAMMABLE CYCLE TIMERS	30
5.11	SYSTEM INFORMATION.....	30
5.12	EMCP 4 GSC INPUTS AND OUTPUTS	31

5.13	LOAD SHED COMMAND (EMCP 4.3 AND 4.4)	33
6	TROUBLESHOOTING	34
6.1	INTERMITTENT OR NO COMMUNICATION	34
6.2	MODBUS ERRORS: EXCEPTION RESPONSES	34
6.3	DATA INVALID – OUTSIDE OF DATA RANGES	35
7	SCADA PROGRAMMING EXAMPLES	37
7.1	SIMPLE REGISTER READS	37
7.2	TWO-REGISTER DATA READS	38
7.3	READING INVALID DATA	38
7.4	SECURITY – READING AND GAINING ACCESS	39
7.5	REAL TIME CLOCK	41
7.6	READING ASCII DATA	41
7.7	READING AND SETTING VOLTAGE BIAS	42
7.8	READING ANALOG INPUTS	43
APPENDIX A	MODBUS REGISTER DATA	49
APPENDIX B	INDEX OF MODBUS REGISTERS – ALPHABETICAL	67
APPENDIX C	INDEX OF MODBUS REGISTERS – NUMERICAL	73

1 GENERAL INFORMATION

1.1 INTRODUCTION

The EMCP 4 is an advanced series of generator set control panels that monitors and controls all aspects of a generator set. It communicates within the generator set, and to Cat ET, via up to two CAN data links. For customer or site communications, the EMCP 4 features dedicated SCADA data links.

TABLE 1-1: SCADA DATA LINKS SUPPORT ACROSS THE EMCP 4 FAMILY

EMCP Level	RS-485	TCP/IP
4.1	-	-
4.2	√	-
4.3	√	√
4.4	√	√

This document details the selection, site planning, configuration, and troubleshooting of the EMCP 4 SCADA Data Links.

1.2 OVERVIEW OF EMCP 4 SCADA DATA LINKS

EMCP 4 SCADA data links are intended to provide customers an interface to monitor and control their generator set. They communicate via the Modbus protocol, which is an openly published protocol that has become a de facto standard in industrial communications over the past 30 years.

The EMCP 4 supports RS-485 and TCP/IP SCADA Data Links. There are some similarities between them. They both support networking of multiple gensets. They both require unique identifiers (called “Slave Address” in RS-485, “IP Address” in TCP/IP) to be configured in order to uniquely identify each device on the network. They both have length limitations that can be mitigated by using repeaters (repeaters in TCP/IP are built-in to gateways, bridges, hubs, and switches). However, there are also several differences.

The RS-485 SCADA Data Link runs on an RS-485 network, which is a multi-drop bus topology (see section 2.1). It uses a Modbus master-slave data link, where an EMCP 4 is considered a slave, or Remote Terminal Unit (RTU). This data link is commonly used in legacy applications, and supported either natively or via add-on cards by all major PLC platforms. It is also supported (usually via add-on network cards) by most Caterpillar Electric Power products. PCs do not natively support Modbus, but many PC software are available, either for free or for purchase. The network is RS-485, which is not supported by most personal computers. However, adapters from either RS-232 or USB are low-cost and easy to find.

The TCP/IP SCADA Data Link runs on a 10BaseT Ethernet network, which is flexible, supporting multiple topologies like bus, star, tree, etc (see section 3.1). It uses the Modbus TCP peer-to-peer data link. With the widespread use of TCP/IP networks for the internet as well as corporate networks, Modbus TCP has become quite common. However, it may be more complicated to set up, especially when connecting to an existing network. It is supported in most newer PLC platforms, but may not be available in legacy PLC systems. The network is Ethernet, which also uses a multi-drop bus topology. A contrast between RS-485 SCADA and TCP/IP SCADA data links is given in Table 1-2.

TABLE 1-2: COMPARING RS-485 VS TCP/IP SCADA DATA LINKS

Property	RS-485 SCADA	TCP/IP SCADA
Distance	4000 ft	330 ft
Speed	10-56kbps	10Mbps
Topology	bus only	bus, star, etc
Termination	required at ends	not required
Communication model	master-slave	peer-peer
Cabling	1-pair plus reference, shielded	2-pair twisted
Mean response time	120 ms	30 ms
Configuration ease	simple	complicated

1.3 REFERENCES

Modbus Application Protocol Specification
Available from www.modbus.org

Modbus over Serial Line Specification and Implementation Guide
Available from www.modbus.org

Modbus Messaging on TCP/IP Implementation Guide
Available from www.modbus.org

EMCP 4.1 and 4.2 Application and Installation Guide
LEBE0006, available from Cat PowerNet, under Products > EMCP Controls > EMCP 4

EMCP 4.3 and 4.4 Application and Installation Guide
LEBE0007, available from Cat PowerNet, under Products > EMCP Controls > EMCP 4

EMCP 3 Application Note: Reading Event Information via SCADA
Available from Cat PowerNet, under Products > EMCP Controls > EMCP 3 > A&I Information

1.4 GLOSSARY OF TERMS

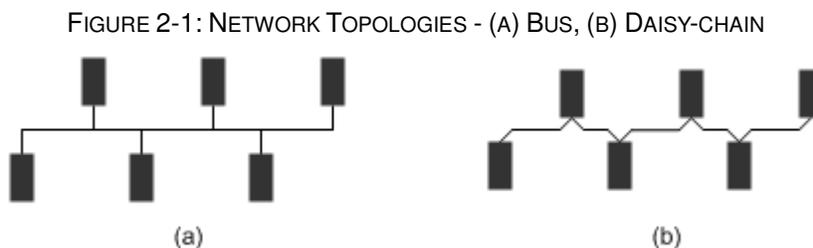
0b (e.g., 0b1001)	The prefix “0b” Indicates that the following digits represent a binary number. e.g., 0b1001 indicates 1001 binary, which is $2^3+2^0 = 9$ in decimal.
0x (e.g., 0xFE03)	The prefix “0x” indicates that the following digits and characters represent a hexadecimal number. e.g., 0xFE03 indicates FE03 hex, which is $15 \times 2^{12} + 14 \times 2^8 + 3 = 61440 + 3584 + 3 = 65027$ in decimal.
CAN	Controller Area Network. A serial communications data link with widespread use in the transportation and power generation industry. The strengths of this data link are reliable communications and plug-and-play operation. The EMCP 4 Primary Data Link and Accessory Data Link (EMCP 4.2, 4.3, and 4.4) are CAN data links. They are intended for generator set package communications only.
CRC	Cyclic Redundancy Check. This is an algorithm used to catch (and sometimes correct) transmission errors. The CRC is generated and transmitted at the source, then re-generated and compared at the target. The EMCP 4 GSC performs a 16-bit CRC check, which is often called a CRC16 algorithm.
EMCP 4	This is the new generation Caterpillar generator set control panel, consisting of a generator set control (GSC), and may have several other modules such as a voltage regulator module, annunciators, and input/output modules.
ECM	Electronic Control Module. This is a general term and can refer to any microprocessor-based module that is part of a control system. The engine ECM is an ECM dedicated to the task of engine timing and air/fuel control.
Cat ET	Caterpillar Electronic Technician. This is a software tool used for configuration and troubleshooting. It communicates with ECMs via the Primary or Accessory Data Links.
FMI	Failure Mode Indicator. The J1939 term for a failure code associated with a particular Suspect Parameter Number. For a complete list of FMI codes, refer to the Systems Operation Troubleshooting Testing and Adjusting guide.
GSC	Generator Set Controller. This is the module responsible for the overall generator protection and control functions. It is the master module on the generator set, interfacing with the user as well as the engine ECM and any other accessory modules. This unit is physically identifiable by its display screen, and a label identifying it as an EMCP 4.1, 4.2, 4.3, or 4.4 Generator Set Controller. See cover page for an image of the EMCP 4.4 GSC.
LED	Light-Emitting Diode. LEDs on the EMCP 4 include the warning, shutdown, and ECS mode indicators on the EMCP 4 GSC, as well as the status indicator on the DIO module, and all the alarm and network status indicators on the RS-485 Annunciator module.
Modbus	An openly published serial communications protocol developed by Modicon with widespread use in industry. This protocol is commonly used over RS-232, RS-485, and Ethernet TCP/IP networks. The RS-232 and RS-485 version is a master/slave protocol, whereas the TCP/IP version is a peer-to-peer protocol. The strengths of this protocol are its simplicity and low implementation cost.
NULL CHARACTER	The name for the ASCII character represented by 0x00 (1 byte of binary zeroes). This character is commonly used to mark the termination of an ASCII string.
RMS	A mathematical approach of representing a useful average for varying quantities; this is useful to indicate AC quantities.
RS-232	Officially EIA-232. A serial communications network intended for short-distance point-to-point (only between two devices) communication. Maintained by the Electronics Industries Alliance (EIA).
RS-485	Officially EIA-485. A serial communications network intended for long-distance multi-point communication. Maintained by the Electronics Industries Alliance (EIA).

SCADA	Supervisory Control And Data Acquisition. This term represents any computing system (such as a building management system, alarm panel, or control room HMI) designed to perform high-level control and monitoring over various subsystems. On the EMCP 4 GSC, we provide SCADA interfaces to allow any SCADA systems to connect and collect data about the operations of the control and the generator set(s).
RTU	Remote Terminal (or Transmitter) Unit. This term refers to a Slave device in a SCADA network that interfaces real-world objects with a system Master. The EMCP 4 GSC functions as an RTU on a SCADA system.
SPN	Suspect Parameter Number. Any parameter whose data is transmitted over a CAN network, such as the EMCP 4 Primary or Accessory Data Link. For a complete list of SPNs supported by the EMCP 4, refer to the Diagnostic Trouble Code List in the Systems Operation Troubleshooting Testing and Adjusting guide.

2 RS-485 SCADA DATA LINK – WIRING AND CONFIGURATION

2.1 NETWORK TOPOLOGY

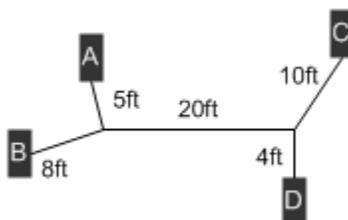
RS-485 uses a multi-drop bus topology. This means that several devices (one master and one or more RTUs) can be connected together by using “drops”, or short “T” connections, from the main bus, or trunk. Alternately, the devices can be daisy-chained together (which is effectively the same as drops of zero length). See Figure 2-1 for an illustration.



The limits on the length are 4000ft (1200m) between extreme ends, and 10ft (3m) for each drop.

Sometimes it's not clear what the “extreme ends” of the bus are. The “extreme ends” are defined by the longest distance between any two points on the bus. Look at Figure 2-2 for example. The distance from A-B is 13ft, A-C is 35ft, etc. The longest distance is from B-C at 38ft. Therefore the bus length is 38ft, and B and C are the extreme ends of the bus, and would get termination (see section 2.2 under Termination).

FIGURE 2-2: NETWORK LENGTH EXAMPLE



The RS-485 SCADA Data Link is a Master-Slave (RTU) data link. This means there is only one Master allowed, and multiple RTUs. The EMCP 4 series are all RTUs on the RS-485 SCADA Data Link. A Master may be:

- A PC running the Monitoring Software
- A PC running a customer Modbus Master/Client software
- An HMI running software such as WonderWare
- A PLC that supports Modbus¹ either natively, or via an add-on card

¹ Schneider and Modicon PLCs support Modbus Plus natively also, which is not the same as Modbus. The EMCP 4 platform does not support Modbus Plus.

2.2 WIRING

The RS-485 SCADA data link uses optically isolated half-duplex communications. It requires two twisted conductors (Rx/Tx+ and Rx/Tx-) and one reference or common conductor (REF). It is recommended to use a third conductor for the reference, instead of the shield. Therefore the RS-485 SCADA Data Link requires three conductors, plus a shield. See Table 2-1 for the pins on the EMCP 4.2, and Table 2-2 for the pins on the EMCP 4.3 and 4.4.

TABLE 2-1: RS-485 SCADA PINOUT ON EMCP 4.2

Pin #	Name	Description
3	MB-	RS-485 differential inverting line (Rx/Tx-) (A)
4	MB-REF	RS-485 reference signal
5	MB+	RS-485 differential non-inverting line (Rx/Tx+) (B)

TABLE 2-2: RS-485 SCADA PINOUT ON EMCP 4.3 AND 4.4

Pin #	Name	Description
90	MB-	RS-485 differential inverting line (Rx/Tx-) (A)
101	MB-REF	RS-485 reference signal
100	MB+	RS-485 differential non-inverting line (Rx/Tx+) (B)

Proper implementation of Modbus on EMCP 4 requires 3 conductors, plus a shield. Using a 2-wire unshielded cable is not recommended; however, if needed for low-noise environments and short distances, connect MB+ and MB- only. In cases where noise is present on the shield, improved performance may be achieved by not using the shield as a Reference. Refer to the Shielding section below.

Figures below show connections to half-duplex (also called 2-wire, Figure 2-3) and full-duplex (also called 4-wire, Figure 2-4) devices.

NOTE: Consult device documentation to verify wiring requirements.

FIGURE 2-3: POSSIBLE WIRING TO HALF-DUPLEX RS-485 DEVICE

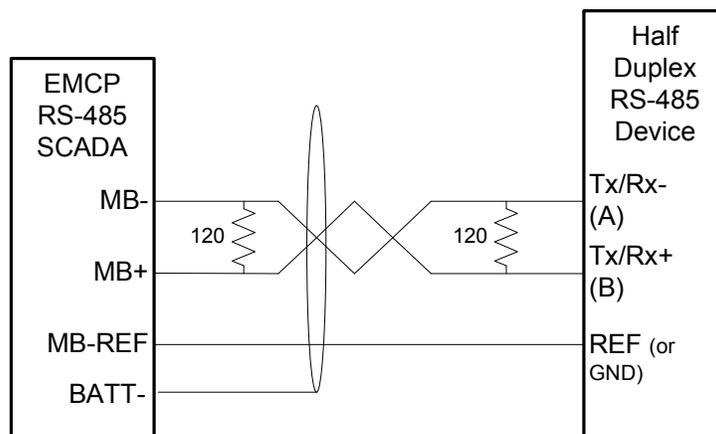
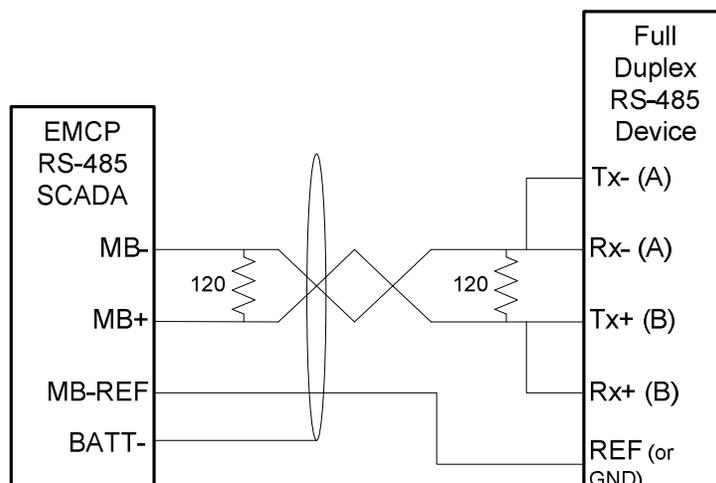


FIGURE 2-4: POSSIBLE WIRING TO FULL-DUPLEX RS-485 DEVICE



SHIELDING

It is also recommended to connect all the shields (if daisy-chaining more than two devices, you will have multiple cables) together and ground them at a **SINGLE** Battery negative point, to drain noise while preventing ground loop currents.

TERMINATION

RS-485 requires termination on the extreme ends of the bus, to prevent signal reflections. Although the communication may work properly on short buses or under certain conditions, it is good practice to always use termination. There is **NO** termination internal to the EMCP 4.

NOTE: Some devices, such as PLCs or converters, may already have termination built-in. Consult your device documentation.

EXTENDING RANGE

The RS-485 SCADA data link distance limitations may be overcome by using repeaters. However, depending on the design of the Modbus Master, the performance may decrease. The key factor here is the Modbus Master timeout, which is the amount of time the Modbus Master will wait until it thinks that the RTU (the EMCP) will not respond. Consult the documentation for your Modbus Master device for more details.

2.3 SOFTWARE CONFIGURATION

Before devices will communicate, there are some software configuration steps on the EMCP 4, on the Modbus Master, and perhaps on any other RTU device. Consult the documentation for your Modbus Master or third-party RTU device for details on configuring their setpoints. Consult the EMCP 4 Application and Installation Guide for more details on configuring setpoints via the display or ET. The EMCP 4 setpoints are located in the menu structure under CONFIGURE > ALL SETPOINTS > NETWORK > RS-485 SCADA.

BAUD RATE

The baud rate is the speed of communication. However, it will not significantly change overall system response time. The EMCP 4 supports baud rates of 9600, 14400, 19200, 28800, 38400, and 57600 baud.

The default (and recommended) baud rate is 19200. Higher rates can be used, but may be more susceptible to noise, wiring issues, improper or missing termination, etc.

The baud rate must match for all devices on the network. If any device has a different baud rate, it will not communicate, and it *may* trigger an RS-485 SCADA Data Link Fault event. Consult the EMCP 4 Application and Installation Guide for information on disabling or resetting events.

This is configured on the EMCP 4 via the setpoint “SCADA DATA LINK BAUD RATE”.

PARITY

Parity is an obsolescent error-checking mechanism. The EMCP 4 supports parity settings of ODD, EVEN, or NONE (default). This setting has no impact on system performance, noise rejection, or anything else. Some devices do not support all of these settings; the Modbus standard requires ODD parity to be supported at a minimum.

The parity must match for all devices on the network. If they do not match, the Modbus Master may see intermittent communications from the offending device.

This is configured on the EMCP 4 via the setpoint “SCADA DATA LINK PARITY”.

SLAVE ADDRESS

Slave Address is a unique identifier held by each RTU on the network. Up to 247 RTUs are allowed on a Modbus network, and each must have a unique identifier from 1 to 247. If two RTUs share the same Slave Address, the Master will most likely not be able to communicate with one or both of the RTUs. The default Slave Address for all EMCP 4 modules is 1, so this setting *must* be changed in order to set up a network with multiple EMCP 4s.

This is configured on the EMCP 4 via the setpoint “SCADA DATA LINK SLAVE ADDRESS”.

STOP BITS

Stop bits need to be configured on some devices, but not on the EMCP 4. Stop bits for other devices should be set per the following table:

Parity	Stop Bits
NONE	2
EVEN	1
ODD	1

Stop bits should be configured the same for all devices on the network. This is one of the most difficult mismatches to troubleshoot, because there is no consistent failure mode. Communication may work intermittently, or it may work only between certain devices, or all, or none. If a certain device has no configuration for stop bits, it may have a configuration for “Frame Length”. EMCP 4 frame length is always 10 bits, never 11 bits.

BIAS RESISTORS

Bias resistors are used to keep the network voltages at well-defined levels during silent times, to prevent potential false diagnostics and communication failure. They are almost always software-configured, including on the EMCP 4. This is unique from Termination resistors, which must be user-installed outside of the EMCP 4. There should only be *one* device on the network with bias resistors enabled.

NOTE: Some devices, such as PLCs or converters, may already have termination built-in. Consult your device documentation.

This is configured on the EMCP 4 via the setpoint “RS-485 BIAS RESISTOR ENABLE STATUS”.

2.4 ERROR CHECKING

Error checking in RS-485 SCADA is done via a Cyclic Redundancy Check (CRC). The CRC algorithm checks the contents of the entire message. The CRC field consists of a 16-bit value, and is appended to the end of the message. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte to be sent in the message.

The CRC value is calculated by the sending device, which appends the CRC to the message. The receiving device recalculates a CRC using the same algorithm during receipt of the message, and as it receives the CRC field, compares the calculated value to the received value. If the two values are not equal, the message is discarded.

A detailed description as well as sample code and a calculation example are given in the Modbus over Serial Line Specification and Implementation Guide.

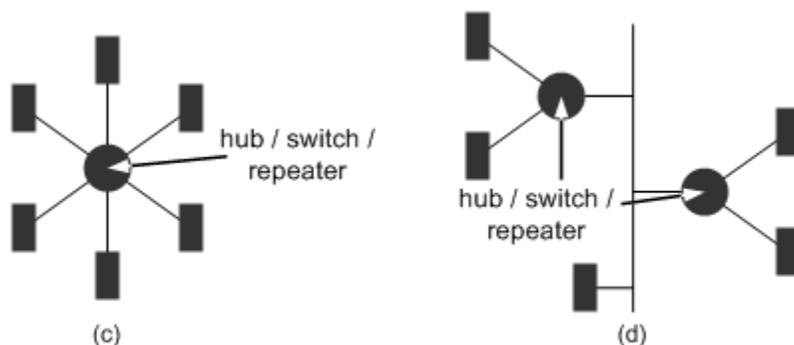
3 TCP/IP SCADA DATA LINK – WIRING AND CONFIGURATION

Ethernet TCP/IP networks are very common. However, they may be more complicated to set up, especially when connecting to an existing network. In that case, it is critical to have the support of a network administrator when connecting the EMCP 4 to the network.

3.1 NETWORK TOPOLOGY

Ethernet supports many topologies. Bus or daisy-chain is one, which is also supported by RS-485 networks. Others include star topology, and tree topology. See Figure 3-1 for an illustration of each.

FIGURE 3-1: NETWORK TOPOLOGIES - (C) STAR, (D) TREE



The limits on the length are 330ft (100m) between farthest devices unless separated by a hub, switch, or repeater. Those extend the network, and the TCP/IP data link allows for an unlimited number of such extensions.

3.2 WIRING (INCLUDING SWITCHES, ROUTERS, ETC)

The TCP/IP SCADA Data Link uses a 10BaseT connection to an Ethernet network. It requires a minimum of Category-5 (Cat5) cable, but Category-5e or Category-6 are also permitted. Connection to a network supporting 100BaseT only requires the addition of a 10/100 hub or switch between the EMCP 4 and the network. It uses four-wire communications. It requires two twisted pairs of conductors (Rx+ and Rx-, Tx+ and Tx-). See Table 3-1 for the pins on the EMCP 4.3 and 4.4.

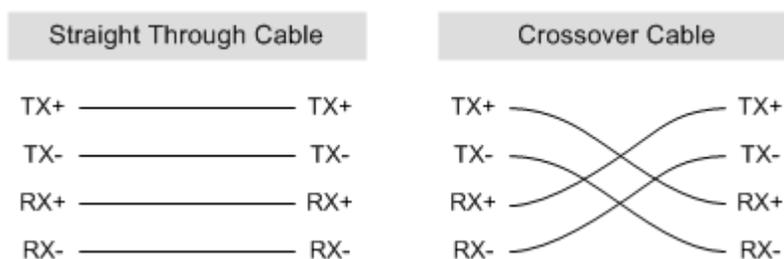
TABLE 3-1: EMCP 4.3 AND 4.4 SCADA PINOUT

Pin #	Name	Description
87	ETH1-3	Ethernet differential non-inverting transmit line (Tx+)
88	ETH1-1	Ethernet differential non-inverting receive line (Rx+)
97	ETH1-2	Ethernet differential inverting receive line (Rx-)
98	ETH1-4	Ethernet differential inverting transmit line (Tx-)

CROSSOVER CABLES

Because the receiving lines on one device need to be connected to the sending lines on another, it is possible, if connecting directly to only one device, that a crossover cable will be required. Fortunately, many PC Ethernet adapters automatically detect and internally crossover; the EMCP 4 also automatically detects and does internal crossover. If unsure, either try an Ethernet crossover cable, or consult the

device documentation. Note that a crossover cable is not required if connecting through a hub, switch, or repeater. See below for an illustration of the difference between a standard (straight through) and crossover cable.



3.3 SOFTWARE CONFIGURATION

Before devices will communicate, there are some software configuration steps on the EMCP 4 and on any other devices on the Ethernet network. Consult your network administrator for the proper or allowed settings for a shared network. Consult the EMCP 4 Application and Installation Guide for more details on configuring setpoints via the display or ET. The EMCP 4 setpoints are located in the menu structure under CONFIGURE > ALL SETPOINTS > NETWORK > TCP/IP SCADA.

IP ADDRESS

The IP address is a unique identifier for each device on an Ethernet network. The default setting for the EMCP 4 is 0.0.0.0.

NOTE: The default IP address is not valid, and **MUST** be changed before the EMCP 4 will communicate.

The TCP/IP data link on the EMCP 4 supports static IP addressing only. If connecting to a network that doesn't support (or allow) static IP, a gateway device (such as a router or switch) must be used between the EMCP 4 and the network.

NETWORK MASK

The network mask is a property of each Ethernet network. Consult your network administrator for the proper network mask to use. The default setting for the EMCP 4 is 0.0.0.0. Every device on the network should have the same network mask (although it is not absolutely required). Common values are 255.255.255.0 and 255.255.0.0.

DEFAULT GATEWAY

The default gateway is the IP address of a gateway device, if one exists on the network. If not, the default gateway can be set to any IP address; however, in that case it is important to set it to a unique IP address – one that is not addressed to any device on the network. The default setting for the EMCP 4 is 0.0.0.0. Every device on the network should have the same default gateway setting (although it is not absolutely required).

3.4 ERROR CHECKING

Error checking is usually invisible to the user in TCP/IP. It does **not** use a Cyclic Redundancy Check (CRC) like RS-485. Instead, error-checking is handled in the TCP wrapper. The TCP/IP driver checks packets for consistency, and requests the sender to re-send if there are any problems. This happens "automatically". Although this can add delays in the final receipt of the message, those delays are more

than compensated for by the high data transmission rate of 10baseT Ethernet (which is 10Mbps for EMCP 4, as opposed to 56kbps on RS-485 for EMCP 4).

4 EMCP 4 SCADA COMMUNICATION

Modbus communication consists of the client (PC, PLC, or other customer device) making requests and to read from or write to certain addresses on the server (EMCP 4). The server only responds to requests, and responds in a well-defined manner. The client must know about the addresses defined on the server; addressing is explained in section 4.1. The client requests to read from or write to certain addresses by using a set of Function Codes; section 4.2 describes the Function Codes supported by the EMCP 4.

4.1 ADDRESSING

Modbus addresses reference registers called Holding Registers that are each 2 bytes long. Larger pieces of data occupy consecutive registers, with the most significant word (pair of bytes) in the lowest address register, and the least significant word (pair of bytes) in the highest address register.

EMCP 4 Modbus addresses are described throughout this document, and are normally referenced by the name and decimal address, like this: Write Access Password (700). However, there is a different addressing model called “PDU Addressing” in which Modbus addresses for Holding Registers are in the range 40,000-49,999. For applications using PDU Addressing, simply add 40,000 to the addresses given in this document.

Modbus addresses given in this document are different from the address numbers transmitted over the data link. The address of 1 is the lowest address, but is transmitted as 0x0000. Therefore, when register addresses are given in hexadecimal, note that the decimal value must be **decreased by 1** and then converted to hex. So Write Access Password (700) is actually transmitted over the data link as 700-1 = 699 0x02BB.

4.2 SUPPORTED FUNCTION CODES

On both Modbus RTU and TCP, all communication occurs by the use of Function Codes to a set of Addresses. The addresses are all Holding Registers, and the EMCP 4 supports the following Function Codes:

- 3 (0x03) – Read Registers
- 6 (0x06) – Write Single Register
- 16 (0x10) – Write Multiple Registers

3 (0X03) – READ REGISTERS

Send this Function Code to read data, single or up to 125 consecutive registers, from the EMCP 4. Note that the query will contain the register count, while the response will contain the byte count (byte count = register count x 2). Note also that the query has a fixed length of 8 bytes, whereas the response has a variable length depending on the number of registers requested, with a minimum of 7 bytes.

TABLE 4-1: READ REGISTERS - REQUEST

Address	Fcn Code	Addr hi	Addr lo	Num hi	Num lo	CRC lo	CRC hi
Slave addr.	0x03	Starting Reg address		Number of Registers (N)		CRC16 error checking	

TABLE 4-2: READ REGISTERS - RESPONSE

Address	Fcn Code	Byte Ct	Data 1 hi	Data 1 lo
Slave addr.	0x03	N x 2	Register 1 data	
...			Data N hi	Data N lo
...		Register N data	CRC lo	CRC hi

6 (0x06) – WRITE SINGLE REGISTER

Send this Function Code to write data to a single register on the EMCP 4. Note that the EMCP 4 will attempt to write the data, and then respond with the new value in the register. If the query inadvertently attempted to write data to a Read register, an Exception response will be sent. This Function Code may be broadcast (addressed to Slave Address 0), in which case no response will be sent by any slave (EMCP 4 or otherwise).

TABLE 4-3: WRITE SINGLE REGISTER - REQUEST

Address	Fcn Code	Addr hi	Addr lo	Data hi	Data lo	CRC lo	CRC hi
Slave addr.	0x06	Reg address		Data to write		CRC16 error checking	

TABLE 4-4: WRITE SINGLE REGISTER - RESPONSE

Address	Fcn Code	Addr hi	Addr lo	Data hi	Data lo	CRC lo	CRC hi
Slave addr.	0x06	Reg address		Data written		CRC16 error checking	

16 (0x10) – WRITE MULTIPLE REGISTERS

Send this Function Code to write data to up to 123 contiguous registers on the EMCP 4. Note that the query will contain both the register count and the byte count (byte count = register count x 2). Note, also, that the query has a variable length depending on the number of registers being written, whereas the response has a fixed length of 4 bytes. The EMCP 4 will not respond with any data, only the starting address and the register count as sent in the query. If any register in this span is a Read register, the entire Write will fail, and the slave will return an Exception Response. This Function Code may be broadcast (addressed to Slave Address 0), in which case no response will be sent by any slave (EMCP 4 or otherwise).

TABLE 4-5: WRITE MULTIPLE REGISTERS - REQUEST

Address	Fcn Code	Addr hi	Addr lo	Num hi	Num lo	Byte Ct
Slave addr.	0x10	Reg address		Number of Registers (N)		N x 2
Data 1 hi	Data 1 lo	...	Data N hi	Data N lo	CRC lo	CRC hi
Register 1 data		...	Register N data		CRC16 error checking	

TABLE 4-6: WRITE MULTIPLE REGISTERS - RESPONSE

Address	Fcn Code	Addr hi	Addr lo	Num hi	Num lo	CRC lo	CRC hi
Slave addr.	0x10	Starting Reg address		Number of Registers (N)		CRC16 error checking	

4.3 DATA INTERPRETATION

In order to send data, or once data is received, it must be interpreted. A single piece of data can span multiple Modbus registers. There are a few different types of data:

- Numerical data
- State-based data
- Complex data

On PC systems, register data is converted to numbers according to predefined data types. The EMCP 4 data should always be converted to unsigned data types. The specific data type depends on the PC system architecture. For example, if UINT data type is 16-bit, then it can be used for single register reads. For data points that span 2 registers, they must use a longer data type (or calculate the value manually from two separate UINTs), such as ULONG. But again, the data types available and their length are system-specific. ULONG may be 32-bit or 64-bit or may not even be supported at all.

If converting the data manually, in order to interpret the data, first the bits must be converted to a raw number, where the number represents the decimal (base-10) representation of the raw data. Modbus data is sent most-significant-bit first and most-significant-byte first, and for data spanning multiple registers, the lowest number register is most significant. The EMCP 4 uses unsigned integer representations of all the data. Negative values for numerical data are calculated (see Numerical Data section below) by doing math operations on the unsigned integer value.

Two-register data points should be treated as 4-byte unsigned integers. Example of data received from a two-register read (spaces added for readability). Note that the response sends the lower number register first, followed by the higher number register. Therefore, the lower number register is more significant:

Binary data received (in order of receipt): 0b 0000 0000 0000 0000 0000 0110 1000 1111

Raw data in hexadecimal: 0x 0000 068F

Raw data in decimal: 1,679

The rest of the interpretation process depends on the type of data being read.

NUMERICAL DATA

Numerical data is continuous real-world measurement data, such as temperatures, levels, pressures, power, voltage, time, etc. In order to convert the bits of the received data into real-world data, the following factors must be known:

- Resolution (or scaling) – multiply the raw data by this first, to get scaled data
- Offset – add this to the scaled data to get the correct measurement data
- Data range – valid measurement data is within this range

These are given for each numerical data in Appendix A.

To troubleshoot or determine why certain data is outside of the data range, see section **Error! Reference source not found.**

STATE-BASED DATA

State-based data represents a fixed set of states, such as True, False, Run, Auto, Stop, etc. For each data point, each state must be assigned a value. The bits of the data correspond to one of those values.

A special case of state-based data is bitwise data, where each bit corresponds to a two-state value (true/false, on/off, open/closed, etc). In this case, each register could represent as many as 16 independent two-state values.

The states and their values for each state-based data are given in Appendix A.

COMPLEX DATA

Complex data is aggregate data that is actually made up of multiple pieces of data. Those pieces, in turn, can be numerical data, state-based data, or even complex data themselves. One example is time; time is made up of years, months, days, hours, minutes, and seconds. Each of those pieces of data are numerical in nature.

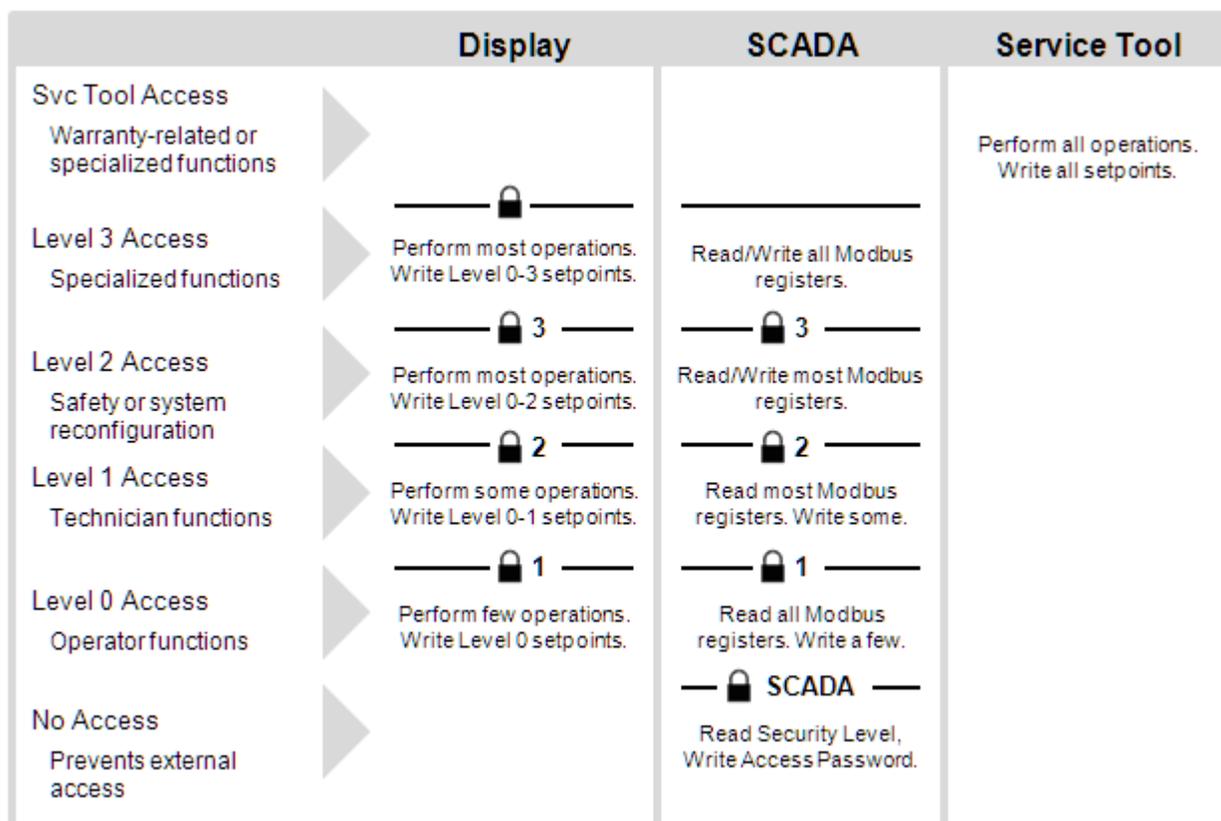
Complex data are defined in Chapter 5.

4.4 SECURITY

Security in SCADA is separate from security on the EMCP 4 display, but the access levels are parallels of each other, and the passwords are shared. Data link security uses a different set of passwords than the local security at the display. The EMCP 4 supports five levels of SCADA access, with increasing permissions. Figure 4-1 below illustrates the different security levels.

NOTE: The display and SCADA can be at different access levels at the same time.

FIGURE 4-1: EMCP 4 SECURITY LEVELS ILLUSTRATION



READING OR WRITING ASCII DATA

All passwords are numeric. They all use a string of ASCII codes with 1 byte per digit. The password entry registers are 16 bytes long. However, passwords can be different lengths, so in order to enter a shorter password, the entire register set must be the written, padding the unused bytes with the space character (0x20). All other characters are considered invalid data, and will result in a Modbus error response. Example: 12345678 = 0x 3132 3334 3536 3738 2020 2020 2020 2020.

ENTERING A SECURITY LEVEL

In order to determine the current security level, the Current Security Level (732) register must be read. If the value returned is 0xFFFF, then the level is No Access.

In order to enter any security level, the appropriate password must be written into the Write Access Password (700) register. If Level 1 and Level 2 passwords are the same, and that password is entered, Level 2 access will be granted. If the entered password doesn't match any configured passwords, there will be no change in access level.

In order to enter Level 3, the Level 3 Password Phone In Prompt (734) must be read and communicated to a factory support operator who can provide the correct password to enter. This prompt, and corresponding password, does change over time; it may be related to day, engine hours, or even number of setpoints changed. Therefore, care should be taken to avoid many other changes and to avoid delay between receiving the password and entering it.

In order to drop to a lower security level, the number of the security level must be written into the Write Current Security Level (733) register.

NOTE: If the level above the current level does not have a password configured, the EMCP 4 will automatically grant that next level of access. For example, by default there is no SCADA Password, Level 1 Password, or Level 2 Password configured; so when first powered up, Level 2 access is granted.

CHANGING PASSWORDS

The SCADA, Level 1, or Level 2 passwords can be changed by writing the new password to the SCADA Password (724), Level 1 Password (708), or Level 2 Password (716) register, as long as the appropriate access level is obtained:

- To change the Level 1 password, Level 1 access must be obtained.
- To change the SCADA or Level 2 passwords, Level 2 access must be obtained.

NOTE: The SCADA password can be a maximum of 8 digits long. The others may be as long as 16 digits.

- A password can be disabled by setting it to a single zero. The Level 3 password cannot be changed or disabled.

TIMEOUTS

There are a few timers to reset security access:

SCADA Access timeout, which resets SCADA access completely below the SCADA security level (or the lowest unprotected level) after 30 seconds without any read/write requests on the SCADA data link.

Level 1, 2, and 3 timeout, which resets the SCADA access level to level 0 (or the lowest unprotected level above level 0) after 10 minutes without any successful write requests over the SCADA data link. To prevent this fixed timer from expiring without risking affecting functions of the EMCP 4, writing to the Key Press (310) register will reset this timer.

Security-related Modbus registers:

- Key Press (310)
- Write Access Password (700)
- Level 1 Password (708)
- Level 2 Password (716)
- SCADA Password (724) – 8 ASCII digits long; leading zeroes truncated
- Current Security Level (732)
- Set Security Level (733)
- Level 3 Password Phone In Prompt (734)

An example of some of the security features is provided in Chapter 7.

5 EMCP 4 SCADA DATA POINTS

5.1 GENERATOR AC MONITORING

This is the full set of AC data as sensed at the generator output. All of the generator AC data available on the EMCP 4 display are available via Modbus. Depending on the generator configuration however, some data may not be valid. Table 5-1 details all of the variations.

TABLE 5-1: AC DATA VALID, BY WIRING CONFIGURATION

	Star	3-Wire Delta	4-Wire Delta	2-Wire 1-Phase	3-Wire 1-Phase
Gen Freq (102)	√	√	√	√	√
V _{L-L} AVG (100)	√	√	√	√	√
V _{A-B} (108)	√	√	√	√	√
V _{B-C} (109)	√	√	√	-	-
V _{C-A} (110)	√	√	√	-	-
V _{L-N} AVG (148)	√	-	√	-	√
V _A (114)	√	-	√	-	√
V _B (115)	√	-	√	-	√
V _C (116)	√	-	√	-	-
I _{AVG} (101)	√	√	√	√	√
I _A (111)	√	√	√	√	√
I _B (112)	√	√	√	√	√
I _C (113)	√	√	√	-	-

VOLTAGE DATA

- Generator Average Line-Line AC RMS Voltage (100)
- Generator Phase A Line-Line AC RMS Voltage (108)
- Generator Phase B Line-Line AC RMS Voltage (109)
- Generator Phase C Line-Line AC RMS Voltage (110)
- Generator Phase A Line-Neutral AC RMS Voltage (114)
- Generator Phase B Line-Neutral AC RMS Voltage (115)
- Generator Phase C Line-Neutral AC RMS Voltage (116)
- Generator Average Line-Neutral AC RMS Voltage (148)
- Generator Average Line-Line AC RMS Voltage Percent (163) – percent of Generator Rated Voltage (setpoint)

CURRENT (AMPS) DATA

- Generator Average AC RMS Current (101)
- Generator Phase A AC RMS Current (111)
- Generator Phase B AC RMS Current (112)
- Generator Phase C AC RMS Current (113)

- Generator Total Percent Current (174) – sum of phase currents, as a percent of generator rated current, calculated from Generator Rated Voltage (setpoint) and Generator Rated Power (setpoint)

FREQUENCY DATA

- Generator Average AC RMS Frequency (102)
- Generator Average AC RMS Frequency Percent (183)

5.2 GENERATOR POWER MONITORING

REAL POWER DATA

- Generator Total Percent Real Power (105) – percent of Generator Rated Power (setpoint)
- Generator Total Real Power (106)
- Generator Phase A Real Power (117)
- Generator Phase B Real Power (119)
- Generator Phase C Real Power (121)

APPARENT POWER DATA

- Generator Phase A Apparent Power (123)
- Generator Phase B Apparent Power (125)
- Generator Phase C Apparent Power (127)
- Generator Total Apparent Power (138)
- Generator Total Percent Apparent Power (140) – percent of Generator Rated Apparent Power (setpoint)

REACTIVE POWER DATA

- Generator Phase A Reactive Power (129)
- Generator Phase B Reactive Power (131)
- Generator Phase C Reactive Power (133)
- Generator Total Reactive Power (141)
- Generator Total Percent Reactive Power (143) – percent of generator rated reactive power, calculated from Generator Rated Power (setpoint) and Generator Rated Apparent Power (setpoint)

POWER FACTOR DATA

- Generator Overall Power Factor (103) – Chapter 7 for a programming example
- Generator Overall Power Factor Lagging (104) – indicates overall lead/lag status
- Generator Phase A Power Factor (135)
- Generator Phase B Power Factor (136)
- Generator Phase C Power Factor (137)
- Generator Phase A Power Factor Lagging (159) – indicates phase lead/lag status
- Generator Phase B Power Factor Lagging (160) – indicates phase lead/lag status
- Generator Phase C Power Factor Lagging (161) – indicates phase lead/lag status

5.3 GENERATOR OTHER MONITORING

Most of these monitoring parameters are only available if they are being received over either the Primary or Accessory Data Link (typically from either the RTD module or the Thermocouple module). Excitation data would be coming from a CDVR module.

- Generator Front Bearing Temperature from Data Link (149) – also called bearing #2 or right bearing
- Generator Rear Bearing Temperature from Data Link (150) – also called bearing #1 or left bearing
- Generator Phase A Winding Temperature from Data Link (151)
- Generator Phase B Winding Temperature from Data Link (152)
- Generator Phase C Winding Temperature from Data Link (153)
- Generator Rear Bearing Temperature from I/O Pin (162) – for legacy use only
- Battery Voltage (202) – measured at the input to the EMCP 4, which may be lower than the voltage at the battery terminals; see Chapter 7 for reading example
- Generator Excitation Field Voltage from Data Link (338)
- Generator Excitation Field Current from Data Link (340)

5.4 BUS AC MONITORING

Bus AC Monitoring is only available on the EMCP 4.4.

VOLTAGE DATA

- Bus Average Line-Line AC RMS Voltage (164)
- Bus Phase A Line-Line AC RMS Voltage (166)
- Bus Phase B Line-Line AC RMS Voltage (167)
- Bus Phase C Line-Line AC RMS Voltage (168)
- Bus Phase A Line-Neutral AC RMS Voltage (169)
- Bus Phase B Line-Neutral AC RMS Voltage (170)
- Bus Phase C Line-Neutral AC RMS Voltage (171)
- Bus Average Line-Neutral AC RMS Voltage (172)
- Bus Average Line-Line AC RMS Voltage Percent (173) – percentage of generator rated voltage

FREQUENCY DATA

- Bus Average AC RMS Frequency (165)

5.5 GENERATOR SET STATE MONITORING AND CONTROL

START / STOP CONTROL

- Automatic Start/Stop State (206) – engine operation state
- Bypass Cooldown (300) – command
- Engine Control Switch Position (301)
- Engine Control Switch Command (302)
- Auto Start/Stop Fuel Control Enabled (307) – status
- Dedicated Digital Input #1 (E-Stop) Active Status (612)
- Dedicated Digital Input #2 (Initiate Command) Active Status (613)
- Cooldown Duration Remaining (1054) – cooldown timer; only valid while engine is in cooldown
- Remote Initiate Command (1055) – when ECS is in Auto position, sending True commands the engine to start.

Note: Either this SCADA command OR a digital input Remote Initiate Command will start the engine – sending False to this register doesn't prevent the digital input Remote Initiate from taking effect, and vice versa.

- Emergency Stop Command (1056) – will cause the engine to immediately stop without cooling down.

Note: Either this SCADA command OR the Emergency Stop digital input will stop the engine – sending False to this register doesn't prevent the digital input from taking effect, and vice versa.

- Fuel Pump Primer Status (2087)
- Manual Fuel Priming Duration Remaining (2091) – time remaining in manual fuel priming, in seconds; only valid while engine is in fuel priming

ENGINE SPEED CONTROL

There are a few registers defined for reading and controlling the target engine speed, as well as determining whether forced idle is active and whether the engine is actually running in idle. See Chapter 7 for a programming example.

- Requested Engine Speed (1060) – speed being requested by the EMCP 4 to the engine
- Total Speed Bias Percent (1061) - Read the percentage bias being applied to the speed command output. This is a percent of 200 rpm. This will increment by 0.5% each time the Speed Adjust left or right arrow is pressed on the EMCP 4 GSC, or any time the Speed Bias Percent Increment Command (1062) is written. The min/max values for this data are $\pm 100\%$.
- Speed Bias Percent Increment Command (1062) - Increments the percentage bias being applied to the speed command output. This value gets added to the Speed Bias Percent register (the bias decreases if a negative value is written). The formula is:

$$\text{TOTAL SPEED BIAS PERCENT} = \text{TOTAL SPEED BIAS PERCENT} + \text{SPEED BIAS PERCENT INCREMENT COMMAND}$$

- Forced Idle Command Active (337)
- Low Idle State from ADEM (1263)

GENERATOR VOLTAGE CONTROL

There are a few registers defined for reading and controlling the target output voltage of the generator. See Chapter 7 for a programming example.

- Desired Genset Output Voltage (1057) – the voltage being commanded to the voltage regulator. The output voltage is limited to being RATED $\pm 40\%$. However, voltage regulators may have an even tighter range (e.g. the CDVR is RATED $\pm 15\%$). When the EMCP 4 is operating in manual voltage control mode, the formula for calculating the desired output voltage is:

$$\text{DESIRED GENSET OUTPUT VOLTAGE} = 1 + 0.4 \times (1 + \text{TOTAL_VOLTAGE_BIAS_PERCENT})$$

- Total Voltage Bias Percent (1058) – The percentage bias being applied to the voltage regulator desired genset output voltage, as a percentage of 40% of rated, The value will increment by 0.5% each time the Voltage Adjust up or down arrow is pressed on the EMCP 4 GSC, or any time the Voltage Bias Percent Increment Command (1059) is written. The min/max values for this data are:

$$\pm \text{MAXIMUM_GENERATOR_VOLTAGE_OUTPUT_BIAS_PERCENTAGE_SETPOINT} / 40\%$$

Since the setpoint is limited to 0-100%, the absolute minimum and maximum are $\pm 250\%$. Output voltage biasing is limited to $\pm 40\%$ of rated, however, and voltage regulators may have an even tighter range (the CDVR is $\pm 15\%$).

- Voltage Bias Percent Increment Command (1059) – Increments the percentage bias to be applied to the Automatic Voltage Regulator. This value gets added to the Total Voltage Bias Percent register (the bias decreases if a negative value is written). The formula is:

$$\text{TOTAL_VOLTAGE_BIAS_PERCENT} = \text{TOTAL_VOLTAGE_BIAS_PERCENT} + \text{VOLTAGE_BIAS_PERCENT_INCREMENT_COMMAND}$$

FUEL TRANSFER MONITORING

- Fuel Unload Pump Active (321) (EMCP 4.2 and 4.4 only) – status
- Fuel Load Pump Active (322) – status

DEAD BUS ARBITRATION (EMCP 4.4 ONLY)

- Arbitration Relay Active Status (DDO-01) (645)
- Bus Live Status (1070)
- Dead Bus Arbitration State (1111)

GENERATOR TO BUS SYNCHRONIZING (EMCP 4.4 ONLY)

- Generator/Bus Phase Difference (1064)
- Sync Mode Switch State (1108)

GENERATOR CIRCUIT BREAKER MONITORING AND CONTROL

- Dedicated Digital Input #3 (Gen CB Aux A) Active Status (614)
- Dedicated Digital Input #4 (Gen CB Aux B) Active Status (615)
- Gen CB Trip Command Active Status (DIDI-03) (643)
- Gen CB Close Command Active Status (DIDI-04) (644)
- Gen CB Close Active Status (DDO-02) (646)
- Gen CB Trip Active Status (DDO-03) (647)
- Generator Circuit Breaker Status (1065)

LOAD SHARING AND LOAD CONTROL (EMCP 4.4 ONLY)

- Generator Desired Power Factor (178)
- Desired Base Load (179)
- Load Share Line Total Percent kW (181)
- Load Share Line Total Percent kVAr (182)

LOAD SENSE LOAD DEMAND (EMCP 4.4 ONLY)

- Group Start Active Status (DIDI-01) (641)
- Load Sense Load Demand State (1120)

5.6 ENGINE MONITORING

SPEED

- Engine Speed (203) – actual engine speed in rpm, calculated over a minimum crankshaft angle of 720 degrees divided by the number of cylinders

FUEL

- Fuel Level (198) – independent of source (only analog input supported currently)
- Fuel Level (258) – for legacy support only; for new applications, use (198)
- Fuel Level from I/O Pin (804) – read from analog input (recommend using 198 instead)
- External Tank Fuel Level from I/O Pin (805) – read from analog input
- Engine Fuel Temperature from Data Link (246)
- Fuel Pressure from Data Link (247)

OIL

- Engine Oil Temperature (199) – independent of source; i/o pin (if configured) takes precedence over datalink
- Engine Oil Temperature from Data Link (245)
- Engine Oil Temperature from I/O Pin (800) – for legacy purposes only; for new applications, use (199)
- Engine Oil Pressure (200)
- Engine Oil Pressure from Data Link (217) – for legacy support only; for new applications, use (200)
- Engine Oil Level from I/O Pin (806) – for legacy purposes only; this will always read zero; for new applications, use Custom Parameters instead

COOLANT

- Engine Coolant Temperature (201)
- Engine Coolant Temperature from Data Link (219) – for legacy support only; for new applications, use (201)
- Engine Coolant Level from I/O Pin (807) – for legacy purposes only; this will always read zero; for new applications, use Custom Parameters instead

EXHAUST

- Cylinder #1 Exhaust Port Temperature from Data Link (221)
- Cylinder #2 Exhaust Port Temperature from Data Link (222)
- Cylinder #3 Exhaust Port Temperature from Data Link (223)
- Cylinder #4 Exhaust Port Temperature from Data Link (224)
- Cylinder #5 Exhaust Port Temperature from Data Link (225)
- Cylinder #6 Exhaust Port Temperature from Data Link (226)
- Cylinder #7 Exhaust Port Temperature from Data Link (227)
- Cylinder #8 Exhaust Port Temperature from Data Link (228)
- Cylinder #9 Exhaust Port Temperature from Data Link (229)
- Cylinder #10 Exhaust Port Temperature from Data Link (230)
- Cylinder #11 Exhaust Port Temperature from Data Link (231)
- Cylinder #12 Exhaust Port Temperature from Data Link (232)
- Cylinder #13 Exhaust Port Temperature from Data Link (233)
- Cylinder #14 Exhaust Port Temperature from Data Link (234)

- Cylinder #15 Exhaust Port Temperature from Data Link (235)
- Cylinder #16 Exhaust Port Temperature from Data Link (236)
- Cylinder #17 Exhaust Port Temperature from Data Link (237)
- Cylinder #18 Exhaust Port Temperature from Data Link (238)
- Cylinder #19 Exhaust Port Temperature from Data Link (239)
- Cylinder #20 Exhaust Port Temperature from Data Link (240)
- Exhaust Temperature (801) – independent of source
- Exhaust Temperature from Data Link (2086) – read from CAN data link
- Exhaust Manifold #1 (Left) Temperature (802) – for legacy purposes only; this will read overall exhaust temperature only; for new applications, use (241)
- Exhaust Manifold #1 (Left) Temperature from Data Link (241)
- Exhaust Manifold #2 (Right) Temperature from I/O Pin (803) – for legacy purposes only; this will read overall exhaust temperature only; for new applications, use (242)
- Exhaust Manifold #2 (Right) Temperature from Data Link (242)

INTAKE

- Intake Manifold #1 Temperature from Data Link (243)
- Intake Manifold #2 Temperature from Data Link (244)

TURBOCHARGERS

- Boost Pressure from Data Link (249)
- Turbocharger 1 Compressor Inlet Temperature (2074) – read from CAN data link
- Turbocharger 2 Compressor Inlet Temperature (2075) – read from CAN data link
- Turbocharger 3 Compressor Inlet Temperature (2076) – read from CAN data link
- Turbocharger 4 Compressor Inlet Temperature (2077) – read from CAN data link
- Turbocharger 1 Turbine Inlet Temperature (2078) – read from CAN data link
- Turbocharger 1 Turbine Outlet Temperature (2079) – read from CAN data link
- Turbocharger 2 Turbine Inlet Temperature (2080) – read from CAN data link
- Turbocharger 2 Turbine Outlet Temperature (2081) – read from CAN data link
- Turbocharger 3 Turbine Inlet Temperature (2082) – read from CAN data link
- Turbocharger 3 Turbine Outlet Temperature (2083) – read from CAN data link
- Turbocharger 4 Turbine Inlet Temperature (2084) – read from CAN data link
- Turbocharger 4 Turbine Outlet Temperature (2085) – read from CAN data link

FILTERS

- Oil Filter Differential Pressure from Data Link (251)
- Oil Filter Differential Pressure from I/O Pin (809) – for legacy purposes only; this will always read zero; for new applications, use Custom Parameters instead
- Fuel Filter Differential Pressure from Data Link (252)
- Fuel Filter Differential Pressure from I/O Pin (811) – for legacy purposes only; this will always read zero; for new applications, use Custom Parameters instead
- Air Filter 1 Differential Pressure from Data Link (253)
- Air Filter 1 Differential Pressure from I/O Pin (810) – for legacy purposes only; this will always read zero; for new applications, use Custom Parameters instead

AFTERTREATMENT

- Urea Tank Level (377) – read from CAN data link
- Main Tank Urea Level from I/O Pin (812) – read from analog input
- Aftertreatment #1 SCR Catalyst Reagent Tank #1 Temperature (378) – read from CAN data link

- Urea Injection Air Pressure (379) – read from CAN data link
- Catalyst Intake Temperature (381) – read from CAN data link
- Aftertreatment 1 SCR Catalyst Exhaust Gas Differential Pressure (382) – read from CAN data link

OTHER

- Instantaneous Fuel Consumption from Data Link (256)
- Atmospheric Pressure from Data Link (257)
- Crankcase Pressure from Data Link (248)

5.7 EVENT MONITORING

BITWISE EVENT DATA

Some of the most common events are supported as individual bits (0b1 means the event is Active, 0b0 means the event is Inactive). See Appendix A for full definition of these registers.

- Alarm Group 1.1 (342)
- Alarm Group 1.2 (343)
- Alarm Group 1 Horn (344)
- Alarm Group 2.1 (346)
- Alarm Group 2.2 (347)
- Alarm Group 2 Horn (348)
- Alarm Group 3.1 (350)
- Alarm Group 3.2 (351)
- Alarm Group 3 Horn (352)
- Alarm Group 4.1 (354)
- Alarm Group 4.2 (355)
- Alarm Group 4 Horn (356)

LEGACY EVENT LOG DATA

For legacy use only. For new applications, see “Module Event Log Data” section.

- Log Entry Index (1033)
- Log Entry (1034) – format is the same as the Module Event Log Entry (1500+) registers

MODULE EVENT LOG DATA

The EMCP 4 provides information on both internal events and those transmitted over the J1939 data link. The status of the warning and shutdown lamps on the display can be viewed, and events can be acknowledged. Events can be acknowledged individually or as a group, and the event count can be read. Details of both EMCP 4 GSC and supported additional module events can be read over SCADA.

The event log data as accessible over SCADA is very similar to the data visible on the EMCP 4 display. However, there is one significant difference: The list of events as read over SCADA is not sorted in order of event priority. Therefore, in order to find the details of any particular event, all 40 registers must first be read and the particular event must be found.

Event data in the EMCP 4 is stored in logs, where each physical module on the EMCP 4 network is assigned a separate log. To read events from a log, first the Event Log Module Selection must be set. Next, the entries can be read. Repeat for all valid logs. All modules share the same data format, which is given below the list.

- Event Log Module Selection (1498)
- Event Log Module Selection (1499)
- Module Event Log Entry 1 (1500)
- Module Event Log Entry 2 (1514)
- Module Event Log Entry 3 (1528)
- Module Event Log Entry 4 (1542)
- Module Event Log Entry 5 (1556)
- Module Event Log Entry 6 (1570)
- Module Event Log Entry 7 (1584)
- Module Event Log Entry 8 (1598)
- Module Event Log Entry 9 (1612)
- Module Event Log Entry 10 (1626)
- Module Event Log Entry 11 (1640)
- Module Event Log Entry 12 (1654)
- Module Event Log Entry 13 (1668)
- Module Event Log Entry 14 (1682)
- Module Event Log Entry 15 (1696)
- Module Event Log Entry 16 (1710)
- Module Event Log Entry 17 (1724)
- Module Event Log Entry 18 (1738)
- Module Event Log Entry 19 (1752)
- Module Event Log Entry 20 (1766)
- Module Event Log Entry 21 (1780)
- Module Event Log Entry 22 (1794)
- Module Event Log Entry 23 (1808)
- Module Event Log Entry 24 (1822)
- Module Event Log Entry 25 (1836)
- Module Event Log Entry 26 (1850)
- Module Event Log Entry 27 (1864)
- Module Event Log Entry 28 (1878)
- Module Event Log Entry 29 (1892)
- Module Event Log Entry 30 (1906)
- Module Event Log Entry 31 (1920)
- Module Event Log Entry 32 (1934)
- Module Event Log Entry 33 (1948)
- Module Event Log Entry 34 (1962)
- Module Event Log Entry 35 (1976)
- Module Event Log Entry 36 (1990)
- Module Event Log Entry 37 (2004)
- Module Event Log Entry 38 (2018)
- Module Event Log Entry 39 (2032)
- Module Event Log Entry 40 (2046)

Register 13 = Log Entry Index (for data format, see Log Entry Index parameter)

Register 12:11 = SPN/FMI

Bits 31:24 = UNUSED

Bits 23:5 = SPN

Bits 4:0 = FMI

Register 10 = Flags / Count

Bits 15:12 UNUSED

Bits 11:8 Event Status: 0b0000 = Inactive, 0b0100 = Active, 0b0101 = Present, 0b1111 = Unavailable

Bits 7:0 Occurrence Count

Register 9:8 = First Hourmeter

Resolution	Offset	Data Range
0.05 hour / bit	0 hr	0 to 210554060.75 hour

Register 7:6 = Last Hourmeter

Resolution	Offset	Data Range
0.05 hour / bit	0 hr	0 to 210554060.75 hour

Register 5:3 = First Timestamp

Byte	Resolution	Offset	Data Range
5	1 year / bit	1985 years	1985 to 2235 years
4	0.25 days / bit	0.75 days	0 to 62.5 days
3	1 month / bit	0 months	0 to 250 months
2	1 hour / bit	0 hours	0 to 250 hours
1	1 minute / bit	0 minutes	0 to 250 minutes
0	0.25 seconds / bit	0 seconds	0 to 62.5 seconds

Register 2:0 = Last Timestamp
(same format as First Timestamp)

See Chapter 7 for an example of reading and interpreting event data.

OTHER EVENT-RELATED DATA AND CONTROL

- Acknowledge All Events Command (304) – when True is sent, all events are momentarily acknowledged
- SCR System Check Required Status (319)
- System Event Count (334) – number of Present or Active events
- System Event Lamp Status (335) – status of the Red and Amber lamps on the EMCP 4 display (flashing is not distinguished from solid)
- Bell Alarm Active Status (DIDI-02) (642)
- Reset Event (1048) – in order to reset a latched event, first the condition must be gone; then the SPN and FMI of the target event must be written to this register:
 - Bits 31:24 = UNUSED, set to zeros
 - Bits 23:5 = SPN (0 to 524287)
 - Bits 4:0 = FMI (0 to 31)
- Generator Frequency within Limits (1067) – indicates whether the generator frequency is within the underfrequency shutdown and overfrequency shutdown limits
- Generator Voltage within Limits (1068) – indicates whether the generator voltage is within the undervoltage shutdown and overvoltage shutdown limits
- Bus Voltage within Limits (1069)
- Engine Protection has Shut Down Engine (1275) – indicates that the engine ECM has shut down the engine based on its protective logic, rather than based on a command from the EMCP 4

5.8 TIMERS, COUNTERS, TOTALS, AND ENERGY

ENERGY DATA

The EMCP 4 calculates real and reactive energy provided by the generator set by measuring the power provided by the generator set over the amount of time the generator set is providing the power.

- Generator Total Real Energy Exported (144) – in kilowatt-hours
- Generator Total Reactive Energy Exported (146) – in kilovar-hours

REAL TIME CLOCK

Both of these register sets share the same data format, which is given below.

- Real Time Clock (900)
- Update Real Time Clock Command (903)

Byte	Resolution	Offset	Data Range
5	1 year / bit	1985 years	1985 to 2235 years
4	0.25 days / bit	0.75 days (12:00-6:00am on day 1 = 0x01)	0 to 62.5 days
3	1 month / bit	1 month (Jan = 0x01)	0 to 250 months
2	1 hour / bit	0 hours (midnight = 0x00)	0 to 250 hours
1	1 minute / bit	0 minutes (HH:00 = 0x00)	0 to 250 minutes
0	0.25 seconds / bit	0 seconds (HH:MM:00 = 0x00)	0 to 62.5 seconds

See Chapter 7 for reading example.

SERVICE METERING

The EMCP 4 counts down to a recommended service interval, and reports the countdown in weeks, days, and hours. Service personnel can reset the service interval counter to restart the countdown at the end of a service call.

- Engine Operating Hours (204)
- Service Maintenance Interval Hours Remaining (210) – engine operating hours remaining until service is due; negative indicates that service is overdue
- Service Maintenance Interval Days Remaining (212) – calendar days remaining until service is due; negative indicates that service is overdue
- Service Maintenance Interval Weeks Remaining (299) – whole calendar weeks remaining until service is due; negative indicates that service is overdue

CRANK/START COUNTERS

The EMCP 4 provides service-related information such as the number of crank and start attempts and successes.

- Number of Crank Attempts (213)
- Number of Successful Starts (215)

5.9 UTILITY MONITORING

- Utility Total Real Power (175)
- Utility Total Reactive Power (176)
- Utility Overall Power Factor (177)

5.10 PROGRAMMABLE CYCLE TIMERS

- Programmable Cycle Timer 1 Output 3 Status (1487)
- Programmable Cycle Timer 2 Output 3 Status (1488)
- Programmable Cycle Timer 3 Output 3 Status (1489)
- Programmable Cycle Timer 4 Output 3 Status (1490)
- Programmable Cycle Timer 5 Output 3 Status (1491)
- Programmable Cycle Timer 6 Output 3 Status (1492)
- Programmable Cycle Timer 7 Output 3 Status (1493)
- Programmable Cycle Timer 1 Output 1 Status (2060)
- Programmable Cycle Timer 2 Output 1 Status (2061)
- Programmable Cycle Timer 3 Output 1 Status (2062)
- Programmable Cycle Timer 4 Output 1 Status (2063)
- Programmable Cycle Timer 5 Output 1 Status (2064)
- Programmable Cycle Timer 6 Output 1 Status (2065)
- Programmable Cycle Timer 7 Output 1 Status (2066)
- Programmable Cycle Timer 1 Output 2 Status (2067)
- Programmable Cycle Timer 2 Output 2 Status (2068)
- Programmable Cycle Timer 3 Output 2 Status (2069)
- Programmable Cycle Timer 4 Output 2 Status (2070)
- Programmable Cycle Timer 5 Output 2 Status (2071)
- Programmable Cycle Timer 6 Output 2 Status (2072)
- Programmable Cycle Timer 7 Output 2 Status (2073)

5.11 SYSTEM INFORMATION

MODULE INSTALLATION INFO

- Genset Control Online (1090) – this refers to the EMCP 4 GSC, and will always return True
- Engine Control Online (1091) – this refers to the ADEM engine ECM, and will return True only if the ADEM supports CAN communications
- Secondary Engine Control Online (1092)
- External I/O #1 Online (1093) – this refers to a Discrete I/O module configured for Instance #1
- External I/O #2 Online (1094) – this refers to a Discrete I/O module configured for Instance #2
- External I/O #3 Online (1095) – this refers to a Discrete I/O module configured for Instance #3
- External I/O #4 Online (1096) – this refers to a Discrete I/O module configured for Instance #4
- Digital AVR Online (1097) – this refers to a CDVR module
- RTD Module Online (1098)
- Thermocouple #1 Online (1099) – this refers to a Thermocouple module on the Accessory Data Link
- Thermocouple #2 Online (1100) – this refers to a Thermocouple module on the Primary Data Link
- SCR Module Online (1103) – this refers to an SCR (aftertreatment control) module

NETWORK STATUS

These registers indicate the fault status (ok or fault) of the associated networks.

- Primary Data Link Status (1140)
- Accessory Data Link Status (1141)
- RS-485 SCADA Data Link Status (1142)
- TCP/IP SCADA Data Link Status (1143)
- RS-485 Annunciator Data Link Status (1144)

OTHER

- Lamp Test Command (303) – write True to begin lamp test, False to cancel
- Control Serial Number (1276) – reads the serial number of the EMCP 4 GSC; this is the number printed on the back cover of the module; see Chapter 7 for reading example
- Software Build Version (2188)

5.12 EMCP 4 GSC INPUTS AND OUTPUTS

ANALOG INPUTS

An example of reading and interpreting analog inputs is provided in Chapter 7.

- Spare Analog Input Percent (207) – for legacy purposes only; this will always read 0xFFFF; for new applications, use other percent registers
- Spare Analog Input Temperature (208) – for legacy purposes only; reads the temperature associated with analog input #3; for new applications, use other temperature registers
- Spare Analog Input Pressure (209) – for legacy purposes only; reads the pressure associated with analog input #3; for new applications, use other pressure registers
- Analog Input #1 Sensor Value (648) – sensor reading in Ω , V, %, or mA units
- Analog Input #2 Sensor Value (649) – sensor reading in Ω , V, %, or mA units
- Analog Input #3 Sensor Value (650) – sensor reading in Ω , V, %, or mA units
- Analog Input #4 Sensor Value (651) – sensor reading in Ω , V, %, or mA units
- Analog Input #1 Data Value (652) – converted data value, in Data Identification (setpoint) units
- Analog Input #2 Data Value (654) – converted data value, in Data Identification (setpoint) units
- Analog Input #3 Data Value (656) – converted data value, in Data Identification (setpoint) units
- Analog Input #4 Data Value (658) – converted data value, in Data Identification (setpoint) units

ANALOG OUTPUTS (EMCP 4.3 AND 4.4)

Analog outputs are supported on EMCP 4.3 and 4.4. An example of interpreting and writing analog outputs is provided in Chapter 7

- Analog Output #1 Data Value (660) – assigned data value, in Output Type (setpoint) units
- Analog Output #2 Data Value (662) – assigned data value, in Output Type (setpoint) units
- Analog Output #3 Data Value (664) – assigned data value, in Output Type (setpoint) units
- Analog Output #1 Data Command (681) – output pin reading in Ω , V, or mA units
- Analog Output #2 Data Command (683) – output pin reading in Ω , V, or mA units
- Analog Output #3 Data Command (685) – output pin reading in Ω , V, or mA units

DIGITAL INPUTS

These registers indicate whether the input pin is active or not. The EMCP 4.2 only has 6 digital inputs. The rest are supported by EMCP 4.3 and 4.4 only.

- Digital Input #1 Active Status (600)
- Digital Input #2 Active Status (601)
- Digital Input #3 Active Status (602)
- Digital Input #4 Active Status (603)
- Digital Input #5 Active Status (604)
- Digital Input #6 Active Status (605)
- Digital Input #7 Active Status (606)
- Digital Input #8 Active Status (607)

- Isolated Digital Input #1 Active Status (608)
- Isolated Digital Input #2 Active Status (609)
- Isolated Digital Input #3 Active Status (610)
- Isolated Digital Input #4 Active Status (611)

DIGITAL OUTPUTS

The status registers indicate whether the output pin is active or not. The command registers activate the output, but only if the Usage Type (setpoint) is set to SCADA Data Link. The EMCP 4.2 only has 2 digital outputs, the EMCP 4.3 has 16.

- Digital Output #1 Active Status (624)
- Digital Output #2 Active Status (625)
- Digital Output #3 Active Status (626)
- Digital Output #4 Active Status (627)
- Digital Output #5 Active Status (628)
- Digital Output #6 Active Status (629)
- Digital Output #7 Active Status (630)
- Digital Output #8 Active Status (631)
- Digital Output #9 Active Status (632)
- Digital Output #10 Active Status (633)
- Digital Output #11 Active Status (634)
- Digital Output #12 Active Status (635)
- Digital Output #13 Active Status (636)
- Digital Output #14 Active Status (637)
- Digital Output #15 Active Status (638)
- Digital Output #16 Active Status (639)
- Digital Output #17 Active Status (640)
- Digital Output #1 Command (2232)
- Digital Output #2 Command (2233)
- Digital Output #3 Command (2234)
- Digital Output #4 Command (2235)
- Digital Output #5 Command (2236)
- Digital Output #6 Command (2237)
- Digital Output #7 Command (2238)
- Digital Output #8 Command (2239)
- Digital Output #9 Command (2240)
- Digital Output #10 Command (2241)
- Digital Output #11 Command (2242)
- Digital Output #12 Command (2243)
- Digital Output #13 Command (2244)
- Digital Output #14 Command (2245)
- Digital Output #15 Command (2246)
- Digital Output #16 Command (2247)
- Digital Output #17 Command (2248)

PWM OUTPUTS (EMCP 4.3 AND 4.4)

PWM outputs are supported by the EMCP 4.3 and 4.4.

- PWM Output #1 Data Value (672) – assigned data value, in Output Type (setpoint) units
- PWM Output #2 Data Value (674) – assigned data value, in Output Type (setpoint) units
- PWM Output #1 Data Command (687) – output pin reading, in % units

- PWM Output #2 Data Command (689) – output pin reading, in % units

RELAY OUTPUTS (EMCP 4.2 ONLY)

Relay outputs are supported by the EMCP 4.2 only.

- Relay Output #1 Active Status (616)
- Relay Output #2 Active Status (617)
- Relay Output #3 Active Status (618)
- Relay Output #4 Active Status (619)
- Relay Output #5 Active Status (620)
- Relay Output #6 Active Status (621)
- Relay Output #7 Active Status (622)
- Relay Output #8 Active Status (623)
- Relay Output #1 Command (2252)
- Relay Output #2 Command (2253)
- Relay Output #3 Command (2254)
- Relay Output #4 Command (2255)
- Relay Output #5 Command (2256)
- Relay Output #6 Command (2257)
- Relay Output #7 Command (2258)
- Relay Output #8 Command (2259)

5.13 LOAD SHED COMMAND (EMCP 4.3 AND 4.4)

The active status determines whether load shed command is active, and the reset allows the command to be inactivated, but only if all of the forcing conditions are no longer present. For more information on Load Shed Command, see the EMCP 4 Application and Installation Guide.

- Load Shed Command Active Status (1129)
- Load Shed Command Reset (1130)

6 TROUBLESHOOTING

There are several categories of problems that can occur with the SCADA data links. The first is intermittent or no communication. If communication is well-established, there may be Modbus error messages, which are called Exception Responses. And finally, the EMCP 4 may return data which is outside of the valid data range.

Along with checking the physical connections and EMCP 4 software configuration, the use of a known software package to test the connection is recommended. A good choice is the EMCP 3 Monitoring Software, which is available for download from Cat PowerNet.

6.1 INTERMITTENT OR NO COMMUNICATION

There are many factors which can cause poor or no communication. Some may cause a SCADA Data Link Fault event on the EMCP 4. Others may be observed by the client only.

Certain conditions may activate a SCADA Data Link Fault event. This fault may be viewed on the EMCP 4 display, via ET, or even via Modbus (see section 5.7). The causes and troubleshooting procedure differ somewhat between data links. For the RS-485 SCADA Data Link, check the following:

- Baud rate, parity, and stop bits mismatch
- Lack of, or misplaced, termination resistors
- Incorrect wiring (MB+ and MB- switched, full-duplex device connections incorrect, etc)
- Distance from end to end too great; 1200m (4000ft) is the limit

For the TCP/IP SCADA Data Link, check the following:

- Cable disconnected after communication was established
- IP address not unique
- Subnet mask or gateway mismatch
- Incorrect wiring
- Poor shielding or no shielding (especially in noisy environments like adjacent to AC power cables or near the generator housing), or low-spec cable (anything below Cat-5)
- Distance from end to end too great; 100m (325ft) is the limit

Other symptoms may be observed at the client only. These may be indicative of poor communication or no communication:

- Wires not connected at all, or incorrectly
- Incorrect Slave Address (RS-485) or IP Address (TCP/IP) configured
- Baud rate mismatch (RS-485)
- Message timeout too short (EMCP 4 RS-485 SCADA has a maximum response time of 200ms, EMCP 4 TCP/IP SCADA has a maximum response time of 50ms)
- Multiple requests being sent from client without waiting for a response (RS-485)

6.2 MODBUS ERRORS: EXCEPTION RESPONSES

The EMCP 4 will send an Exception response if it is able to interpret the request, but there is a problem with it. The exception response is identified by a function code that is 128 (0x80) or greater. The function code is related to the function code the EMCP 4 is responding to; it's value is 128 + the Function Code for Request. There is additional data, called the exception code, within the exception response message that can help identify the problem. The different exception responses and exception codes are described below.

131 (0x83) – EXCEPTION RESPONSE TO READ REGISTERS QUERY

The exception response contains a 1-byte exception code.

Code	Reason
01	Starting or ending (starting + count) register address invalid
02	Register Count was less than 1 or greater than 125
03	Read error possibly due to some register(s) in the span not being Read registers

134 (0x86) – EXCEPTION RESPONSE TO WRITE SINGLE REGISTER QUERY

The exception response contains a 1-byte exception code.

Code	Reason
02	Register address invalid
03	Register value out of range perhaps because longer than 2 bytes
04	Write error possibly due to not being a Write register

144 (0x90) – EXCEPTION RESPONSE TO WRITE MULTIPLE REGISTERS QUERY

The exception response contains a 1-byte exception code.

Code	Reason
02	Starting or ending (starting + count) register address invalid
03	Register Count was less than 1 or greater than 123, or byte count was not (Register Count x 2)
04	Write error possibly due to some register(s) in the span not being Write registers

OTHER 128 AND ABOVE (0x80 AND ABOVE) – EXCEPTION RESPONSE TO UNSUPPORTED QUERIES

The EMCP 4 does not support any function codes not listed above in the Supported Function Codes Chapter. Such queries will return an exception response with this 1-byte exception code.

Code	Reason
01	Unsupported function code

6.3 DATA INVALID – OUTSIDE OF DATA RANGES

If the EMCP 4 returns data, the client must interpret that data correctly. For each piece of data, there is a certain range of data that is defined as valid data. See section 4.3 for explanations of data interpretation and data ranges. If the data is not within the defined valid data range, here are several possible reasons:

- The data is expected over either the Primary or Accessory Data Link, and is not being received
- The sensing inputs providing the data is detecting a fault (e.g., open circuit, short circuit)
- The EMCP 4 has determined a logical flaw with the data being detected (e.g., generator circuit breaker aux A and aux B either both closed or both open)
- The data is expected over an input, but no input is configured to provide it
- The data is expected over either the Primary or Accessory Data Link, and is being received as a fault due to problems with the module or the connection

When invalid data is suspected, the following troubleshooting steps should be followed:

1. Check whether the feature being tested is actually supported on this package
2. Check the definition of the data in this document, and determine whether the data may be unavailable due to certain conditions not having been met (e.g. cooldown duration remaining is only available while cooldown is underway)
3. Confirm that the data is actually invalid, rather than being user error. This can be done in a few different ways:
 - a. If same data is available on EMCP 4 display, check value there; invalid data should show up as asterisks (****)
 - b. If the data is available via ET from either the EMCP 4 or directly from the source device (if not the EMCP 4 GSC), connect ET and check using the Status Data option
 - c. If known working Modbus software is available, such as the EMCP 3 Monitoring Software, connect that and check the value shown (Grid Data view in the EMCP 3 Monitoring Software).
4. Once the invalid data is confirmed, determine the source of the data; the definition of that data in this document will help. Sometimes there are multiple sources (e.g., engine speed can come from either the engine ECM over the Primary Data Link, or from a magnetic pickup sensor, and the selected source must be configured as an EMCP 4 setpoint).
5. Once the source is determined, troubleshoot the sensor input(s) that generate this data. Common problems are:
 - a. Poor or incorrect wiring, including the signal reference
 - b. Mismatched sensor type (either plugging the sensor in to the wrong input, or configuring the input for a different sensor type or ma
6. Try disconnecting the sensor from the ECM and wiring separately to the sensor, or even to a duplicate sensor that is not connected into the sensor port
7. Try a new sensor, or one that is known to be working
8. If the sensor can be connected to multiple places, try connecting to a different place (such as a configurable digital or analog input on the EMCP 4), temporarily disabling the normal setting; if that works, it may indicate a hardware fault with the sensing circuit

If none of these steps resolves the issue, contact your Caterpillar technical support representative.

An example of reading invalid data is given in Chapter 7.

7 SCADA PROGRAMMING EXAMPLES

In the following examples, the EMCP 4 SCADA Data Link Slave Address setpoint is assumed to be set to 1 (0x01). The last 2 bytes (shown as “xx xx” in this Chapter) of each message consist of the CRC. The CRC is typically automatically generated and checked by SCADA communication software, and therefore is not discussed below.

These are only examples of specific conditions and the responses from the control under those conditions, and are not intended to represent the complete functionality of the control or all the possible conditions that can result in these responses. In particular, Exception Responses or all error conditions are not reflected here.

7.1 SIMPLE REGISTER READS

It is convenient to refer to these equations when converting between measured (real-world) units and raw (as sent over Modbus) data:

$$\text{MEASURED_DATA} = (\text{RAW_DATA} \times \text{RESOLUTION}) + \text{OFFSET}$$

$$\text{RAW_DATA} = (\text{MEASURED_DATA} - \text{OFFSET}) / \text{RESOLUTION}$$

BATTERY VOLTAGE

Request: 0x 01 03 00 c9 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 00 C9 = Battery Voltage
 0x 00 01 = register count (1 register)

Response: 0x 01 03 02 01 FD xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 = byte count (2 bytes – 1 register)
 0x 01 FD = 509. $509 \times 0.05 \text{ V/bit} = 25.45\text{V}$

GENERATOR OVERALL POWER FACTOR

Request: 0x 01 03 00 66 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 00 66 = Generator Overall Power Factor
 0x 00 01 = register count (1 register)

Response: 0x 01 03 02 80 00 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 = byte count (2 bytes = 1 register)
 0x 80 00 = 32768. $32768 \times (1 / 16384) - 1.0 = 1.0 \text{ PF}$

7.2 TWO-REGISTER DATA READS

Two-register data points are always treated as 4-byte unsigned integers. Take this example of reading Engine Operating Hours, registers 204-205:

Request: 0x 01 03 00 CB 00 02 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 00 CB = Engine Operating Hours
 0x 00 02 = register count (2 registers)

Response: 0x 01 03 04 00 01 12 1A xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 = byte count (4 bytes = 2 registers)
 0x 00 01 12 1A = 70,170. $70,170 \times (0.05) = 3508.5$ HRS.

An alternate approach to finding the value is to find the numeric value for each register separately, and then multiply the lower number register value by 2^{16} and then add the result to the higher number register value:

Lower register raw data in hex: 00 01
 Lower register raw data in decimal: 1

Higher register raw data in hex: 12 1A
 Higher register raw data in decimal: 4,634

$$1 \times 2^{16} + 4,634 = 65,536 + 4,634 = 70,170$$

And finally to scale with 0.05 hr / bit:

$$70,170 \times 0.05 = 3508.5 \text{ HRS.}$$

7.3 READING INVALID DATA

This example demonstrates reading data and receiving an invalid data response. See section 6.3 for more information on invalid data responses. Suppose that the Engine Oil Pressure Sensor Configuration setpoint is configured to Data Link. However, oil pressure is not being received over the data link, rather from a sensor directly connected to an analog input on the EMCP 4.

Request: 0x 01 03 00 C7 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 00 C7 = Engine Oil Pressure
 0x 00 01 = register count (1 register)

Response: 0x 01 03 02 FF FF xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)

0x 02 = byte count (2 bytes = 1 register)
 0x FF FF = 65535. $65535 \times 0.125 \text{ kPa/bit} = 8191.375 \text{ kPa}$.

But the data range for Engine Oil Pressure (200) is 0 to 8031.875 kPa (see Appendix A). Therefore this data is invalid. Now suppose the Engine Oil Pressure Sensor Configuration setpoint is changed to Sensor. If the input is configured correctly, and the oil pressure is reading correctly on the Engine Overview screen (refer to the EMCP 4 Application and Installation Guide for information on using the EMCP 4 display). Now re-reading while the engine is stopped:

Request: 0x 01 03 00 C7 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 00 C7 = Engine Oil Pressure
 0x 00 01 = register count (1 register)

Response: 0x 01 03 02 00 00 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 = byte count (2 bytes = 1 register)
 0x 00 00 = 0. $0 \times 0.125 \text{ kPa/bit} = 0 \text{ kPa}$.

This value is within the data range of 0 to 8031.875 kPa. Therefore this data is valid.

7.4 SECURITY – READING AND GAINING ACCESS

This example demonstrates setting a password, and then entering the password to gain access to a certain SCADA security level. There are also some examples given of valid versus invalid passwords.

Assume the EMCP 4 contains default values – all three user-configurable passwords (SCADA, Level 1, and Level 2) are disabled.

Read and verify the current security level (**Step 1**):

Request: 0x 01 03 02 DB 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 DB = Current Security Level

Response: 0x 01 03 02 00 02 xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 00 02 = security access level 2.

This is correct. It should be at level 2, because no passwords exist. Now, enter a level 1 password of 1, which is 0x31, and then set the SCADA password to 123, which is 0x31 32 33.

Request: 0x 01 10 02 C3 00 08 10 31 20 20 20 20 20 20 20 20 20 20 20 20 xx xx

0x 01 = slave address of EMCP 4
 0x 10 = function code (Write Registers)
 0x 02 C3 = Level 1 Password
 0x 00 08 = register count (8)

0x 10 = byte count (16)

0x 31 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 = data (1, followed by 15 spaces)

Response: 0x 01 10 02 C3 00 08 xx xx

0x 02 C3 = Level 1 Password

0x 00 08 = register count (8)

Request (**Step 3**): 0x 01 10 02 D3 00 08 10 31 32 33 20 20 20 20 20 20 20 20 20 20 20 20 xx xx

0x 01 = slave address of EMCP 4

0x 10 = function code (Write Registers)

0x 02 D3 = SCADA Password

0x 00 08 = register count (8)

0x 10 = byte count (16)

0x 31 32 33 20 20 20 20 20 20 20 20 20 20 20 20 20 = data (123, followed by 13 spaces)

Response: 0x 01 10 02 C3 00 08 xx xx

0x 02 C3 = Level 1 Password

0x 00 08 = register count (8)

Now, wait for the duration of the Level 0 Timeout, which is 10 minutes, without doing any *writes* over SCADA. Repeat **Step 1** to verify that the current security level is now zero. The response should be as follows:

Response: 0x 01 03 02 00 00 xx xx

The level is now zero. Now, disconnect from SCADA completely (i.e. no reads nor writes) for at least 30 seconds, and then reconnect. Repeating **Step 1**, the response should be as follows:

Response: 0x 01 03 02 FF FF xx xx

This is the correct response. No read or write can be done to any register since the SCADA access has timed out, with a couple of exceptions such as the Write Access Password register. Knowing the password to any level, it can be entered and therefore, be granted access to SCADA. Now, enter the SCADA password that we set in **Step 3**:

Request: 0x 01 10 02 BB 00 08 10 31 32 33 20 20 20 20 20 20 20 20 20 20 20 20 xx xx

0x 01 = slave address of EMCP 4

0x 10 = function code (Write Registers)

0x 02 BB = Write Access Password

0x 00 08 = register count (8)

0x 10 = byte count (16)

0x 31 32 33 20 20 20 20 20 20 20 20 20 20 20 20 20 = data (123, followed by 13 spaces)

Response: 0x 01 10 **02 BB 00 08** xx xx

0x 02 BB = Write Access Password

0x 00 08 = register count (8)

Again, repeat **Step 1** to verify the current security level.

Response: 0x 01 03 02 00 00 xx xx

This verifies that the SCADA password worked, and did indeed give access to level 0 security. Notice that the level did not increase to 1 or 2 because a level 1 password is set. If the level 1 password is entered, access level 2 would be granted because there is no level 2 password set.

NOTE ON SCADA PASSWORDS

Note that the SCADA password is stored as a numeric value. The password is right-justified in the field shown on the EMCP 4 display, and left-justified when set/written over SCADA. So for example, if the password is set on the EMCP 4 to be 00000020, when the security access is requested via SCADA, the value sent must be 20_____ (20 with six spaces after it), Just as with any number, leading zeros get dropped, and trailing zeros are kept (so 01 is stored as 1, but 10 is stored as 10).

Also, the first space terminates the string, so an entry of 12_3 (space between the 2 and the 3) will return an exception because only spaces (or nulls, after the first 8 bytes) are accepted after the first space.

7.5 REAL TIME CLOCK

The 1985 year offset implies that 0x14 in byte 5 translates to 20 years past 1985, or year 2005. The day offset implies that 0x1F (31) in byte 4 translates to the 8th day of the month (and the third quarter of the day – noon to 6pm). One month offset implies that 0x07 in byte 3 translates to the seventh month, July.

Zero hour offset implies that 0x00 in byte 2 translates to 12:00 midnight, and with the 24-hour format, 0x0D translates to 13:00 or 1:00 pm. Zero minute offset implies that 0x05 in byte 1 translates to 5 minutes past the hour (i.e. 12:05pm). Zero second offset implies that 0x4D (77) in byte 0 translates to 19 and a quarter seconds past the minute (i.e. 12:05:19 pm).

Therefore, 0x 4D05 0D07 1F14 is 1:05:19pm on July 8, 2005.

7.6 READING ASCII DATA

Control Serial Number: 0x04FC (1276) - 6 registers (12 bytes) long - read

Reads the serial number of the EMCP 4. This is the number that is label printed on the back cover of the control panel. For example, say the serial number is 3489B016TX, as shown in Figure Figure 7-1 below. FIGURE 7-1: SAMPLE SERIAL NUMBER FOR EMCP 4 GSC



Byte 0: Character count

Bytes 1-11: ASCII data, characters 0x30 through 0x5A valid (numbers and capital letters). String terminates with a NULL character (0x00).

Example: Reading the Control Serial Number would return the following:

0x 0A33 3438 3942 3031 3654 5800

7.7 READING AND SETTING VOLTAGE BIAS

This example demonstrates the data link commands to read setpoints, read registers, and write to registers. Furthermore, it illustrates the functionality of integration with an external Automatic Voltage Regulator.

Check the Maximum Generator Voltage Output Bias Percentage setpoint (via the EMCP 4 display, or using ET). For this example, assume that the Maximum Generator Voltage Output Bias Percentage is 20%. Read the Total Voltage Bias Percent and the Desired Genset Output Voltage before any bias is applied.

Request: 0x 01 03 04 21 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 21 = Total Voltage Bias Percent
 0x 00 01 = 1 = register count

Response: 0x 01 03 **02 7D 80** xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 7D 80 32128 251% (-251% offset) 0.0% bias

Request: 0x 01 03 04 20 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 20 = Desired Genset Output Voltage
 0x 00 01 = register count

Response: 0x 01 03 **02 01 E0** xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 01 E0 480V desired

To adjust the voltage, navigate to the Control menu and press the up arrow *ten* times, re-read the Total Voltage Bias Percent register.

Request: 0x 01 03 04 21 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 21 = Total Voltage Bias Percent
 0x 00 01 = register count

Response: 0x 01 03 **02 80 00** xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 80 00 32768 256% (-251% offset) 5.0% bias

This verifies that each key-press adjusts the percentage by 0.5% (since we did ten key-presses). Now we can check the actual voltage command that is sent to the AVR by reading the Desired Genset Output Voltage register.

Request: 0x 01 03 04 20 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 20 = Desired Genset Output Voltage
 0x 00 01 = register count

Response: 0x 01 03 **02 01 EA** xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 01 EA 490V desired

This is correct. because the Total Bias Percent represents a percentage of 40% of rated, which is 192, the overall bias percentage is 5% of 192, which is 9.6 and rounds up to 10. $480 + 10 = 490V$.

Using the Total Voltage Bias Percent Increment Command Modbus register, re-adjust the desired voltage to nominal, which is 480V. This time however, we want to *increment* the bias by -5% (negative five percent) since the current bias is 5%.

Request: 0x 01 06 04 22 7B 00 xx xx

0x 01 = slave address of EMCP 4
 0x 06 = function code (Write Register)
 0x 04 22 = Total Voltage Bias Percent Increment Command
 0x 7B 00 = $31488 \text{ (divide by 128)} = 246 \text{ (-251 offset)} \text{ -5\%}$

Response: 0x 01 06 **04 22 7B 00** xx xx

0x 04 22 – echo of address
 0x 7B 00 – echo of data

Finally, re-check the Total Voltage Bias Percent to verify that the bias has returned to zero.

Request: 0x 01 03 04 21 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 04 21 = Total Voltage Bias Percent
 0x 00 01 = register count

Response: 0x 01 03 **02 7D 80** xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 7D 80 32128 251% (-251% offset) 0.0% bias

7.8 READING ANALOG INPUTS

The EMCP 4 analog inputs are fully configurable. This means that the sensing type is configurable, as well as the usage of the analog input, as well as the scaling of the sensor reading (based on sensing type, such as voltage, current, or PWM percentage) into measured (real-world, such as a pressure in kPa) data units. The configuration of an analog input is determined by a set of setpoints. Refer to the EMCP 4 Application and Installation Guide for information on configuring and reading the configuration of analog inputs.

Over Modbus, both the sensor reading and the converted measurement data can be read. For analog input #1, the sensor reading is found in the Analog Input #1 Sensor Value (648) register, and the measurement data in Analog Input #1 Data Value (652-653) registers.

For this example, assume that the configuration is as shown:

Description	Value
 Analog Inputs	
—Analog Input #1 Signal Type	Voltage
—Analog Input #1 Signal Range	0 to 5 V
—Analog Input #1 Data Identification	Engine Oil Pressure
—Analog Input #1 Minimum Data Range	0.000
—Analog Input #1 Maximum Data Range	150.000
—Analog Input #1 Low Warning Event Threshold	30
—Analog Input #1 Low Warning Event Delay Time	10.0 sec
—Analog Input #1 Low Shutdown Event Threshold	25
—Analog Input #1 Low Shutdown Event Delay Time	10.0 sec

Also suppose that the actual oil pressure is 30 kPa. First reading the sensor value...

Request: 0x 01 03 02 87 00 01 xx xx

0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 87 = Analog Input #1 Sensor Value
 0x 00 01 = register count

Response: 0x 01 03 02 01 10 xx xx

0x 02 = byte count (2 bytes = 1 register)
 0x 01 10 = 272. 272 / 16 - 16 = 1 V.

This indicates that the sensor reading was 1 Volt. Next reading the data value...

Request: 0x:01 03 02 8B 00 02 xx xx

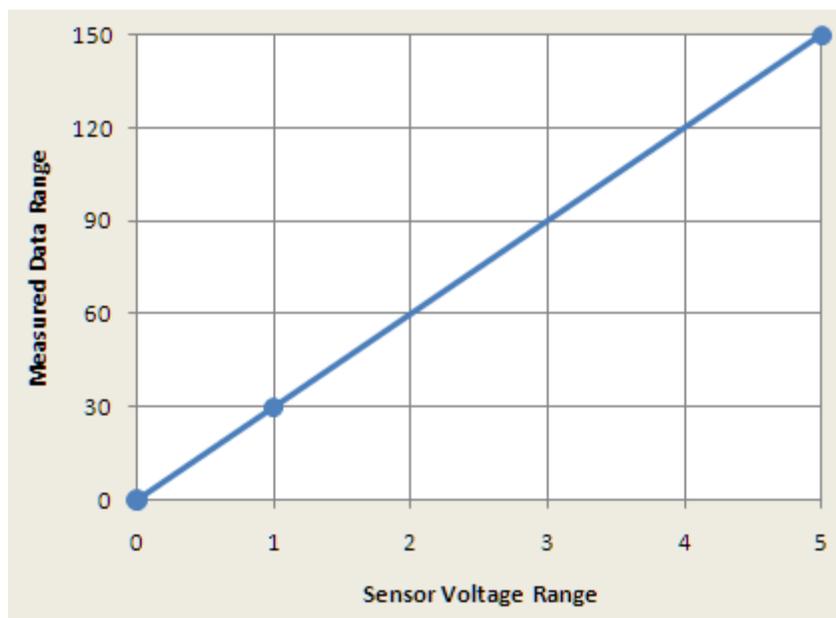
0x 01 = slave address of EMCP 4
 0x 03 = function code (Read Registers)
 0x 02 8B = Analog Input #1 Data Value
 0x 00 02 = register count

Response: 0x 01 03 04 7D 80 1E 00 xx xx

0x 04 = byte count (4 bytes = 2 registers)
 0x 7D 80 1E 00 = 2,105,548,288. 2,105,548,288 / 256 - 8,224,768 = 30 kPa.

This indicates that the data value, which is oil pressure, is 30 kPa. The below figure graphically confirms that this is correct, based on the analog input configuration.

FIGURE 7-2: RELATIONSHIP BETWEEN ANALOG INPUT SENSOR AND MEASURED VALUE



The procedure and approach to reading analog outputs is similar to that of reading analog inputs.

7.9 READING EVENT DATA

The procedure for reading event information via SCADA for the EMCP 4 is the same as for EMCP 3. Refer to the EMCP 3 Application Note: Reading Event Information via SCADA for a detailed example.

7.10 READING AND INTERPRETING ALARM GROUP DATA

Registers 342-356 contain alarm information in a simpler format than the event log information described in section 7.9. These registers contain only alarm active statuses represented by individual bits within each register. These registers also serve as indication of the alarm status of the RS-485 Annunciator modules. In fact, the RS-485 Annunciator modules are configurable to select between one of four alarm groups. Groups 1 and 2 are configurable via Cat ET, whereas Groups 3 and 4 are fixed. Likewise, the Alarm Group 1 and Alarm Group 2 registers are defined by the RS-485 Annunciator configuration in Cat ET. There is some flexibility in how to configure Alarm Groups 1 and 2 in order to read desired alarm information.

In this section, examples of both using the user-configurable and the fixed alarm groups are given. For the purpose of these examples, let's say that Alarm Group 1 is being used by existing RS-485 Annunciator modules; therefore we wish to use Alarm Group 2.

Note: the same configuration is used for configuring the SCADA Alarm Groups 1 and 2, and for RS-485 Annunciator configuration. Therefore, care should be taken to avoid misconfiguring the RS-485 Annunciator.

CONFIGURING AND READING CONFIGURABLE ALARM GROUP DATA

Suppose we wish to annunciate, and turn on an audible alarm, when we get the following alarms:

1. Low fuel level warning
2. Engine underspeed warning

3. Engine underspeed shutdown
4. Low oil pressure warning
5. High coolant temperature warning
6. High coolant temperature shutdown
7. Low battery cranking voltage warning
8. ECS not in automatic warning

First of all, note that these events must be enabled (i.e. they will show up in the event log when the event occurs) in order for them to show up in the alarm group data registers. Some of these events may not be enabled by default. Refer to the EMCP 4 Application and Installation Guide for instructions on enabling events and setting thresholds to the appropriate levels for triggering them.

A quick explanation of how the alarm group data is arranged. The data is grouped into “columns”, which indicate which column and row (LED Pair #) would be lit on the RS-485 Annunciator module. There is also a “horn” register, which indicates which row(s) would trigger a horn on the RS-485 Annunciator module. E.g., if the Alarm Group 2 Column 1 register has a 1 in the bit 2 position (defined as Row 3), then an RS-485 Annunciator module configured for Alarm Group 2 would have the third row left LED lit.

In this case, there are only eight events that we want to read. However, they can be placed in a row/column position only if the correct color LED is available for that position. For example, for row 1, column 1 is red and column 2 is amber. Therefore a shutdown event on row 1 will turn on column 1, whereas a warning event on row 1 will turn on column 2.

All event types are not valid on all row/column positions. Table 7-1 indicates which event types are available on which row/column position. Note that events with a severity level of “specific diagnostic” are available on any row/column, and events with a severity level starting with “condition exists” or “condition does not exist” indicate the color (which specifies the column) that will activate upon event activation.

TABLE 7-1: RS-485 ANNUNCIATOR EVENTS ALLOWED BY ROW/COLUMN

Row	Col 1	Col 2
1	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
2	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
3	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
4	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
5	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
6	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Green) Specific Diagnostic, Condition Exists
7	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
8	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
9	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
10	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
11	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
12	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
13	(Green) Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
14	(Green) Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists
15	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Green) Specific Diagnostic, Condition Exists
16	(Red) Shutdown, Specific Diagnostic, Condition Exists	(Amber) Warning, Specific Diagnostic, Condition Exists

One possible configuration for Alarm Group #2 is given in Figure 7-3. Note that row 6 was skipped, because it cannot contain warning-type events, whereas all the desired events included warnings.

FIGURE 7-3: CAT ET CONFIGURATION FOR ALARM GROUP 2

Select Group: ▼

LED Pair#	Trigger Condition	Severity Level	Suspect Parameter Number	Failure Mode Identifier
1	Specific Event	Low Warning	Fuel Level (Local Tank) [96]	
2	Specific Event	Low Warning or Low Shutdown	Engine Speed [190]	
3	Specific Event	Low Warning	Engine Oil Pressure [100]	
4	Specific Event	High Warning or High Shutdown	Engine Coolant Temperature [110]	
5	Specific Event	Low Warning	Cranking Voltage [4256]	
6	Disabled			
7	Specific Event	Condition Met, Amber On, Other Not Used	Generator Control Not in Automatic Start State [4007]	
8	Disabled			
9	Disabled			
10	Disabled			
11	Disabled			
12	Disabled			
13	Disabled			
14	Disabled			
15	Disabled			
16	Disabled			

This has configured the Alarm Group 2 Column 1 and Alarm Group 2 Column 2 registers as follows:

TABLE 7-2: ALARM GROUP REGISTERS CONFIGURATION

Alarm Group 2 Column 1 (346)	Alarm Group 2 Column 2 (347)
BIT 15 = not used	BIT 15 = not used
BIT 14 = not used	BIT 14 = not used
BIT 13 = not used	BIT 13 = not used
BIT 12 = not used	BIT 12 = not used
BIT 11 = not used	BIT 11 = not used
BIT 10 = not used	BIT 10 = not used
BIT 9 = not used	BIT 9 = not used
BIT 8 = not used	BIT 8 = not used
BIT 7 = not used	BIT 7 = not used
BIT 6 = not used	BIT 6 = Generator Control Not in Automatic Warning
BIT 5 = not used	BIT 5 = not used
BIT 4 = not used	BIT 4 = Low Cranking Voltage Warning
BIT 3 = High Coolant Temperature Shutdown	BIT 3 = High Coolant Temperature Warning
BIT 2 = not used	BIT 2 = Low Oil Pressure Warning
BIT 1 = Engine Underspeed Shutdown	BIT 1 = Engine Underspeed Warning
BIT 0 = not used	BIT 0 = Low Fuel Level Warning

Now reading the data:

Request: 0x 01 03 01 59 00 02 xx xx

0x 01 = slave address of EMCP 4
0x 03 = function code (Read Registers)
0x 01 59 = Alarm Group 2 Column 1
0x 00 02 = register count

Response: 0x 01 03 **04 00 02 00 21** xx xx

0x 04 = byte count (4 bytes = 2 registers)
0x 00 02 00 21 Column 1 is 0x0002 and Column 2 is 0x0021

To decode Column 1, note that 0x0002 is 0b0000000000000010, which means bit 1 (second from the end) is 1, which means Engine Underspeed Shutdown is active (see Table 7-2 above). To decode Column 2, note that 0x0021 is 0b0000000000100001, which means bits 6 and 0 (the last bit) are 1, which means Generator Control Not in Automatic Warning and Low Fuel Level Warning are active.

APPENDIX A MODBUS REGISTER DATA

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Generator Average Line-Line AC RMS Voltage	R	100	0x0063	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Average AC RMS Current	R	101	0x0064	1	0	•	•	•	Scaling: 1 A/bit, Offset: 0 A, Data range: 0 to 64255 A
Generator Average AC RMS Frequency	R	102	0x0065	1	0	•	•	•	Scaling: 1/128 Hz/bit, Offset: 0 Hz, Data range: 0 to 501.9922 Hz
Generator Overall Power Factor	R	103	0x0066	1	0	•	•	•	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Generator Overall Power Factor Lagging	R	104	0x0067	1	0	•	•	•	0 = Power factor leading 1 = Power factor lagging
Generator Total Percent kW	R	105	0x0068	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator Total Real Power	R	106	0x0069	2	0	•	•	•	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Generator Phase A Line-Line AC RMS Voltage	R	108	0x006B	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase B Line-Line AC RMS Voltage	R	109	0x006C	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase C Line-Line AC RMS Voltage	R	110	0x006D	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase A AC RMS Current	R	111	0x006E	1	0	•	•	•	Scaling: 1 A/bit, Offset: 0 A, Data range: 0 to 64255 A
Generator Phase B AC RMS Current	R	112	0x006F	1	0	•	•	•	Scaling: 1 A/bit, Offset: 0 A, Data range: 0 to 64255 A
Generator Phase C AC RMS Current	R	113	0x0070	1	0	•	•	•	Scaling: 1 A/bit, Offset: 0 A, Data range: 0 to 64255 A
Generator Phase A Line-Neutral AC RMS Voltage	R	114	0x0071	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase B Line-Neutral AC RMS Voltage	R	115	0x0072	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase C Line-Neutral AC RMS Voltage	R	116	0x0073	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Phase A Real Power	R	117	0x0074	2	0	•	•	•	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Generator Phase B Real Power	R	119	0x0076	2	0	•	•	•	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Generator Phase C Real Power	R	121	0x0078	2	0	•	•	•	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Generator Phase A Apparent Power	R	123	0x007A	2	0	•	•	•	Scaling: 1 VA/bit, Offset: -2,000,000,000 VA, Data range: -2,000,000,000 to +2,211,081,215 VA
Generator Phase B Apparent Power	R	125	0x007C	2	0	•	•	•	Scaling: 1 VA/bit, Offset: -2,000,000,000 VA, Data range: -2,000,000,000 to +2,211,081,215 VA
Generator Phase C Apparent Power	R	127	0x007E	2	0	•	•	•	Scaling: 1 VA/bit, Offset: -2,000,000,000 VA, Data range: -2,000,000,000 to +2,211,081,215 VA

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Generator Phase A Reactive Power	R	129	0x0080	2	0	•	•	•	Scaling: 1 VAr/bit, Offset: -2,000,000,000 VAr, Data range: -2,000,000,000 to +2,211,081,215 VAr
Generator Phase B Reactive Power	R	131	0x0082	2	0	•	•	•	Scaling: 1 VAr/bit, Offset: -2,000,000,000 VAr, Data range: -2,000,000,000 to +2,211,081,215 VAr
Generator Phase C Reactive Power	R	133	0x0084	2	0	•	•	•	Scaling: 1 VAr/bit, Offset: -2,000,000,000 VAr, Data range: -2,000,000,000 to +2,211,081,215 VAr
Generator Phase A Power Factor	R	135	0x0086	1	0	•	•	•	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Generator Phase B Power Factor	R	136	0x0087	1	0	•	•	•	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Generator Phase C Power Factor	R	137	0x0088	1	0	•	•	•	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Generator Total Apparent Power	R	138	0x0089	2	0	•	•	•	Scaling: 1 VA/bit, Offset: -2,000,000,000 VA, Data range: -2,000,000,000 to +2,211,081,215 VA
Generator Total Percent Apparent Power	R	140	0x008B	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator Total Reactive Power	R	141	0x008C	2	0	•	•	•	Scaling: 1 VAr/bit, Offset: -2,000,000,000 VAr, Data range: -2,000,000,000 to +2,211,081,215 VAr
Generator Total Percent Reactive Power	R	143	0x008E	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator Total Real Energy Exported	R	144	0x008F	2	0	•	•	•	Scaling: 1 kWh/bit, Offset: 0 kWh, Data range: 0 to 4,211,081,215 kWh
Generator Total Reactive Energy Exported	R	146	0x0091	2	0	•	•	•	Scaling: 1 kVArh/bit, Offset: 0 kVArh, Data range: 0 to 4,211,081,215 kVArh
Generator Average Line-Neutral AC RMS Voltage	R	148	0x0093	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Generator Front Bearing Temperature from Data Link	R	149	0x0094	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Rear Bearing Temperature from Data Link	R	150	0x0095	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Phase A Winding Temperature from Data Link	R	151	0x0096	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Phase B Winding Temperature from Data Link	R	152	0x0097	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Phase C Winding Temperature from Data Link	R	153	0x0098	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Phase A Power Factor Lagging	R	159	0x009E	1	0	•	•	•	0 = Power factor leading 1 = Power factor lagging
Generator Phase B Power Factor Lagging	R	160	0x009F	1	0	•	•	•	0 = Power factor leading 1 = Power factor lagging
Generator Phase C Power Factor Lagging	R	161	0x00A0	1	0	•	•	•	0 = Power factor leading 1 = Power factor lagging
Generator Rear Bearing Temperature from I/O Pin	R	162	0x00A1	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Generator Average Line-Line AC RMS Voltage Percent	R	163	0x00A2	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Bus Average Line-Line AC RMS Voltage	R	164	0x00A3	1	0			•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Bus Average AC RMS Frequency	R	165	0x00A4	1	0			●	Scaling: 1/128 Hz/bit, Offset: 0 Hz, Data range: 0 to 501.9922 Hz
Bus Phase A Line-Line AC RMS Voltage	R	166	0x00A5	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Phase B Line-Line AC RMS Voltage	R	167	0x00A6	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Phase C Line-Line AC RMS Voltage	R	168	0x00A7	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Phase A Line-Neutral AC RMS Voltage	R	169	0x00A8	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Phase B Line-Neutral AC RMS Voltage	R	170	0x00A9	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Phase C Line-Neutral AC RMS Voltage	R	171	0x00AA	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Average Line-Neutral AC RMS Voltage	R	172	0x00AB	1	0			●	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Bus Average Line-Line AC RMS Voltage Percent	R	173	0x00AC	1	0			●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator Total Percent Current	R	174	0x00AD	1	0	●	●	●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Utility Total Real Power	R	175	0x00AE	1	0			●	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Utility Total Reactive Power	R	176	0x00AF	1	0			●	Scaling: 1 VAr/bit, Offset: -2,000,000,000 VAr, Data range: -2,000,000,000 to +2,211,081,215 VAr
Utility Overall Power Factor	R	177	0x00B0	1	0			●	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Generator Desired Power Factor	R	178	0x00B1	1	0			●	Scaling: 1/16384 /bit, Offset: -1.0, Data range: -1.0 to 1.0
Desired Base Load	R	179	0x00B2	1	0			●	Scaling: 1 W/bit, Offset: -2,000,000,000 W, Data range: -2,000,000,000 to +2,211,081,215 W
Load Share Line Total Percent kW	R	181	0x00B4	1	0			●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Load Share Line Total Percent kVAr	R	182	0x00B5	1	0			●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator Average AC RMS Frequency Percent	R	183	0x00B6	1	0	●	●	●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Fuel Level	R	198	0x00C5	1	0	●	●	●	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Engine Oil Temperature	R	199	0x00C6	1	0	●	●	●	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Engine Oil Pressure	R	200	0x00C7	1	0	●	●	●	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Engine Coolant Temperature	R	201	0x00C8	1	0	●	●	●	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Battery Voltage	R	202	0x00C9	1	0	●	●	●	Scaling: 0.05 V/bit, Offset: 0 V, Data range: 0 to 3212.75 V
Engine rpm	R	203	0x00CA	1	0	●	●	●	Scaling: 0.125 rpm/bit, Offset: 0 rpm, Data range: 0 to 8031.875 rpm
Engine Operating Hours	R	204	0x00CB	2	0	●	●	●	Scaling: 0.05 hour/bit, Offset: 0 hr, Data range: 0 to 210554060.75 hour

Parameter Name	R/W	Holding Register	Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation	
Automatic Start/Stop State	R	206	0x00CD	1	0	•	•	•	0 = INIT 1 = PRE_CRANK 2 = STARTING 3 = RUNNING 4 = PRE_COOLDOWN 5 = COOLDOWN 6 = STOPPING 7 = STOPPED 8 = IDLING
Spare Analog Input Percent	R	207	0x00CE	1				n/a always 0xFFFF	
Spare Analog Input Temperature	R	208	0x00CF	1				Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C	
Spare Analog Input Pressure	R	209	0x00D0	1				Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa	
Service Maintenance Interval Hours Remaining	R	210	0x00D1	1	0	•	•	•	Scaling: 1 hr/bit, Offset: -32127 hr, Data range: -32127 to 32128 hr
Service Maintenance Interval Days Remaining	R	212	0x00D3	1	0	•	•	•	Scaling: 1 day/bit, Offset: -32127 days, Data range: -32127 to 32128 days
Number of Crank Attempts	R	213	0x00D4	2	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 4,211,081,215
Number of Successful Starts	R	215	0x00D6	2	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 4,211,081,215
Engine Oil Pressure from Data Link	R	217	0x00D8	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Engine Coolant Temperature from Data Link	R	219	0x00DA	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #1 Exhaust Port Temperature from Data Link	R	221	0x00DC	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #2 Exhaust Port Temperature from Data Link	R	222	0x00DD	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #3 Exhaust Port Temperature from Data Link	R	223	0x00DE	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #4 Exhaust Port Temperature from Data Link	R	224	0x00DF	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #5 Exhaust Port Temperature from Data Link	R	225	0x00E0	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #6 Exhaust Port Temperature from Data Link	R	226	0x00E1	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #7 Exhaust Port Temperature from Data Link	R	227	0x00E2	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #8 Exhaust Port Temperature from Data Link	R	228	0x00E3	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #9 Exhaust Port Temperature from Data Link	R	229	0x00E4	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #10 Exhaust Port Temperature from Data Link	R	230	0x00E5	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #11 Exhaust Port Temperature from Data Link	R	231	0x00E6	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #12 Exhaust Port Temperature from Data Link	R	232	0x00E7	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #13 Exhaust Port Temperature from Data Link	R	233	0x00E8	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #14 Exhaust Port Temperature from Data Link	R	234	0x00E9	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Cylinder #15 Exhaust Port Temperature from Data Link	R	235	0x00EA	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #16 Exhaust Port Temperature from Data Link	R	236	0x00EB	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #17 Exhaust Port Temperature from Data Link	R	237	0x00EC	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #18 Exhaust Port Temperature from Data Link	R	238	0x00ED	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #19 Exhaust Port Temperature from Data Link	R	239	0x00EE	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Cylinder #20 Exhaust Port Temperature from Data Link	R	240	0x00EF	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Exhaust Manifold #1 (Left) Temperature from Data Link	R	241	0x00F0	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Exhaust Manifold #2 (Right) Temperature from Data Link	R	242	0x00F1	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Intake Manifold #1 Temperature from Data Link	R	243	0x00F2	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Intake Manifold #2 Temperature from Data Link	R	244	0x00F3	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Engine Oil Temperature from Data Link	R	245	0x00F4	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Engine Fuel Temperature from Data Link	R	246	0x00F5	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Fuel Pressure from Data Link	R	247	0x00F6	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Crankcase Pressure from Data Link	R	248	0x00F7	1	0	•	•	•	Scaling: 1/128 kPa/bit, Offset: -250 kPa, Data range: -250 to 251.99 kPa
Boost Pressure from Data Link	R	249	0x00F8	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Oil Filter Differential Pressure from Data Link	R	251	0x00FA	1	0	•	•	•	Scaling: 0.5 kPa/bit, Offset: 0 kPa, Data range: 0 to 125 kPa
Fuel Filter Differential Pressure from Data Link	R	252	0x00FB	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Air Filter 1 Differential Pressure from Data Link	R	253	0x00FC	1	0	•	•	•	Scaling: 1/128 kPa/bit, Offset: -250 kPa, Data range: -250 to 251.99 kPa
Instantaneous Fuel Consumption from Data Link	R	256	0x00FF	1	0	•	•	•	Scaling: 0.05 L/h per bit, Offset: 0 L/h, Data range: 0 to 3212.75 L/h
Atmospheric Pressure from Data Link	R	257	0x0100	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Fuel Level	R	258	0x0101	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Service Maintenance Interval Weeks Remaining	R	299	0x012A	1	0	•	•	•	Scaling: 1 week/bit, Offset: -125 weeks, Data range: -125 to 125 weeks
Bypass Cooldown	W	300	0x012B	1	0	•	•	•	0 = FALSE 1 = TRUE
Engine Control Switch Position	R	301	0x012C	1	0	•	•	•	0 = STOP 1 = AUTO 2 = RUN
Engine Control Switch Command	W	302	0x012D	1	0	•	•	•	0 = STOP 1 = AUTO 2 = RUN
Lamp Test Command	W	303	0x012E	1	0	•	•	•	0 = FALSE 1 = TRUE

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Acknowledge All Events Command	W	304	0x012F	1	0	•	•	•	0 = FALSE 1 = TRUE
Auto Start/Stop Fuel Control Enabled	R	307	0x0132	1	0	•	•	•	0 = FALSE 1 = TRUE
Key Press	W	310	0x0135	1					0 = FALSE 1 = TRUE
SCR System Check Required Status	R	319	0x013E	1	0	•	•	•	0 = FALSE 1 = TRUE 2 = ERROR 3 = DISABLED OR NOT AVAILABLE
Fuel Unload Pump Active	R	321	0x0140	1	0	•		•	0 = FALSE 1 = TRUE 2 = ERROR 3 = DISABLED OR NOT AVAILABLE
Fuel Load Pump Active	R	322	0x0141	1	0	•	•	•	0 = FALSE 1 = TRUE 2 = ERROR 3 = DISABLED OR NOT AVAILABLE
System Event Count	R	334	0x014D	1	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 255 events
System Event Lamp Status	R	335	0x014E	1	0	•	•	•	0 = no lamp active 1 = Red lamp active 4 = Amber lamp active 5 = Amber and Red lamp active
Forced Idle Command Active	R	337	0x0150	1	0	•	•	•	0 = FALSE 1 = TRUE
Generator Excitation Field Voltage from Data Link	R	338	0x0151	1	0	•	•	•	Scaling: 0.05 V/bit, Offset: -1606.0, Data range: -1606.0 to 1606.75 V
Generator Excitation Field Current from Data Link	R	340	0x0153	1	0	•	•	•	Scaling: 0.05 A/bit, Offset: 0 A, Data range: 0 to 3212.75 A
Alarm Group 1 Column 1	R	342	0x0155	1	0	•	•	•	For all of these registers: BIT 15 = ROW 16 BIT 14 = ROW 15 BIT 13 = ROW 14 BIT 12 = ROW 13 BIT 11 = ROW 12 BIT 10 = ROW 11 BIT 9 = ROW 10 BIT 8 = ROW 9 BIT 7 = ROW 8 BIT 6 = ROW 7 BIT 5 = ROW 6 BIT 4 = ROW 5 BIT 3 = ROW 4 BIT 2 = ROW 3 BIT 1 = ROW 2 BIT 0 = ROW 1
Alarm Group 1 Column 2	R	343	0x0156	1	0	•	•	•	
Alarm Group 1 Horn	R	344	0x0157	1	0	•	•	•	
Alarm Group 2 Column 1	R	346	0x0159	1	0	•	•	•	
Alarm Group 2 Column 2	R	347	0x015A	1	0	•	•	•	
Alarm Group 2 Horn	R	348	0x015B	1	0	•	•	•	

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Alarm Group 3 Column 1	R	350	0x015D	1	0	•	•	•	BIT 15 = Aftertreatment Shutdown Event Active BIT 14 = not used BIT 13 = not used BIT 12 = not used BIT 11 = not used BIT 10 = not used BIT 9 = High Battery Voltage Shutdown Event Active BIT 8 = not used BIT 7 = Low Fuel Level Shutdown or Low Gas Pressure Shutdown Event Active BIT 6 = Low Coolant Level Shutdown Event Active BIT 5 = Overspeed Shutdown Event Active BIT 4 = Low Oil Pressure Shutdown Event Active BIT 3 = not used BIT 2 = High Coolant Temperature Shutdown Event Active BIT 1 = Engine Failure to Start (Overcrank) Shutdown Event Active BIT 0 = Emergency Stop Shutdown Event Active
Alarm Group 3 Column 2	R	351	0x015E	1	0	•	•	•	BIT 15 = Aftertreatment Warning Event Active BIT 14 = Engine Running Condition Active BIT 13 = Emergency Power System Supplying Load Condition Active BIT 12 = Battery Charger AC Failure Event Active BIT 11 = Low Cranking Voltage Warning Event Active BIT 10 = Low Battery Voltage Warning Event Active BIT 9 = High Battery Voltage Warning Event Active BIT 8 = Engine Control Switch Not in Automatic Event Active BIT 7 = Low Fuel Level Warning or Low Gas Pressure Warning Event Active BIT 6 = Low Coolant Level Warning Event Active BIT 5 = not used BIT 4 = Low Oil Pressure Warning Event Active BIT 3 = Low Coolant Temperature Warning Event Active BIT 2 = High Coolant Temperature Warning Event Active BIT 1 = not used BIT 0 = Emergency Stop Diagnostic Event Active

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Alarm Group 3 Horn	R	352	0x015F	1	0	•	•	•	BIT 15 = Aftertreatment Event Horn Active BIT 14 = Engine Running Condition Horn Active BIT 13 = Emergency Power System Supplying Load Condition Horn Active BIT 12 = Battery Charger AC Failure Event Horn Active BIT 11 = Low Cranking Voltage Event Horn Active BIT 10 = Low Battery Voltage Event Horn Active BIT 9 = High Battery Voltage Event Horn Active BIT 8 = Engine Control Switch Not in Automatic Event Horn Active BIT 7 = Low Fuel Level or Low Gas Pressure Event Horn Active BIT 6 = Low Coolant Level Event Horn Active BIT 5 = Overspeed Shutdown Event Horn Active BIT 4 = Low Oil Pressure Event Horn Active BIT 3 = Low Coolant Temperature Event Horn Active BIT 2 = High Coolant Temperature Event Horn Active BIT 1 = Engine Failure to Start (Overcrank) Shutdown Event Horn Active BIT 0 = Emergency Stop Shutdown / Diagnostic Horn Active
Alarm Group 4 Column 1	R	354	0x0161	1	0	•	•	•	BIT 15 = Aftertreatment Shutdown Event Active BIT 14 = Air Shutdown Damper Closed Event Active BIT 13 = not used BIT 12 = not used BIT 11 = not used BIT 10 = not used BIT 9 = High Battery Voltage Shutdown Event Active BIT 8 = not used BIT 7 = Low Fuel Level Shutdown Event Active BIT 6 = Low Coolant Level Shutdown Event Active BIT 5 = Overspeed Shutdown Event Active BIT 4 = Low Oil Pressure Shutdown Event Active BIT 3 = not used BIT 2 = High Coolant Temperature Shutdown Event Active BIT 1 = Engine Failure to Start (Overcrank) Shutdown Event Active BIT 0 = Emergency Stop Shutdown Event Active

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Alarm Group 4 Column 2	R	355	0x0162	1	0	•	•	•	BIT 15 = Aftertreatment Warning Event Active BIT 14 = not used BIT 13 = Emergency Power System Supplying Load Condition Active BIT 12 = Battery Charger AC Failure Event Active BIT 11 = Low Cranking Voltage Warning Event Active BIT 10 = Low Battery Voltage Warning Event Active BIT 9 = High Battery Voltage Warning Event Active BIT 8 = Engine Control Switch Not in Automatic Event Active BIT 7 = Low Fuel Level Warning Event Active BIT 6 = Low Coolant Level Warning Event Active BIT 5 = not used BIT 4 = Low Oil Pressure Warning Event Active BIT 3 = Low Coolant Temperature Warning Event Active BIT 2 = High Coolant Temperature Warning Event Active BIT 1 = not used BIT 0 = Emergency Stop Diagnostic Event Active
Alarm Group 4 Horn	R	356	0x0163	1	0	•	•	•	BIT 15 = Aftertreatment Event Horn Active BIT 14 = Air Shutdown Damper Closed Event Horn Active BIT 13 = Emergency Power System Supplying Load Condition Horn Active BIT 12 = Battery Charger AC Failure Event Horn Active BIT 11 = Low Cranking Voltage Event Horn Active BIT 10 = Low Battery Voltage Event Horn Active BIT 9 = High Battery Voltage Event Horn Active BIT 8 = Engine Control Switch Not in Automatic Event Horn Active BIT 7 = Low Fuel Level Event Horn Active BIT 6 = Low Coolant Level Event Horn Active BIT 5 = Overspeed Shutdown Event Horn Active BIT 4 = Low Oil Pressure Event Horn Active BIT 3 = Low Coolant Temperature Event Horn Active BIT 2 = High Coolant Temperature Event Horn Active BIT 1 = Engine Failure to Start (Overcrank) Shutdown Event Horn Active BIT 0 = Emergency Stop Shutdown / Diagnostic Horn Active
Urea Tank Level	R	377	0x0178	1	0	•	•	•	Scaling: 0.4 %/bit, Offset: 0%, Data range: 0 to 100%
Aftertreatment #1 SCR Catalyst Reagent Tank #1 Temperature	R	378	0x0179	1	0	•	•	•	Scaling: 1 C/bit, Offset: -40 C, Data range: -40 to 210 C

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Urea Injection Air Pressure	R	379	0x017A	1	0	●	●	●	Scaling: 8 kPa/bit, Offset: 0 kPa, Data range: 0 to 2000 kPa
Catalyst Intake Temperature	R	381	0x017C	1	0	●	●	●	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Aftertreatment 1 SCR Catalyst Exhaust Gas Differential Pressure	R	382	0x017D	1	0	●	●	●	Scaling: 0.1 kPa/bit, Offset: 0 kPa, Data range: 0 to 6425.5 kPa
Digital Input #1 Active Status	R	600	0x0257	1	0	●	●	●	For all of these inputs: 0 = INACTIVE 1 = ACTIVE 3 = DISABLED
Digital Input #2 Active Status	R	601	0x0258	1	0	●	●	●	
Digital Input #3 Active Status	R	602	0x0259	1	0	●	●	●	
Digital Input #4 Active Status	R	603	0x025A	1	0	●	●	●	
Digital Input #5 Active Status	R	604	0x025B	1	0	●	●	●	
Digital Input #6 Active Status	R	605	0x025C	1	0	●	●	●	
Digital Input #7 Active Status	R	606	0x025D	1	0	●	●	●	
Digital Input #8 Active Status	R	607	0x025E	1	0	●	●	●	
Isolated Digital Input #1 Active Status	R	608	0x025F	1	0	●	●	●	
Isolated Digital Input #2 Active Status	R	609	0x0260	1	0	●	●	●	
Isolated Digital Input #3 Active Status	R	610	0x0261	1	0	●	●	●	
Isolated Digital Input #4 Active Status	R	611	0x0262	1	0	●	●	●	
Dedicated Digital Input #1 (E-Stop) Active Status	R	612	0x0263	1	0	●	●	●	For all of these dedicated inputs: 0 = INACTIVE 1 = ACTIVE
Dedicated Digital Input #2 (Initiate Command) Active Status	R	613	0x0264	1	0	●	●	●	
Dedicated Digital Input #3 (Gen CB Aux A) Active Status	R	614	0x0265	1	0			●	
Dedicated Digital Input #4 (Gen CB Aux B) Active Status	R	615	0x0266	1	0			●	
Relay Output #1 Active Status	R	616	0x0267	1	0	●			For all of these relay and digital outputs: 0 = INACTIVE 1 = ACTIVE 3 = DISABLED
Relay Output #2 Active Status	R	617	0x0268	1	0	●			
Relay Output #3 Active Status	R	618	0x0269	1	0	●			
Relay Output #4 Active Status	R	619	0x026A	1	0	●			
Relay Output #5 Active Status	R	620	0x026B	1	0	●			
Relay Output #6 Active Status	R	621	0x026C	1	0	●			
Relay Output #7 Active Status	R	622	0x026D	1	0	●			
Relay Output #8 Active Status	R	623	0x026E	1	0	●			
Digital Output #1 Active Status	R	624	0x026F	1	0	●			
Digital Output #2 Active Status	R	625	0x0270	1	0	●			
Digital Output #3 Active Status	R	626	0x0271	1	0	●			
Digital Output #4 Active Status	R	627	0x0272	1	0	●			
Digital Output #5 Active Status	R	628	0x0273	1	0	●			
Digital Output #6 Active Status	R	629	0x0274	1	0	●			
Digital Output #7 Active Status	R	630	0x0275	1	0	●			
Digital Output #8 Active Status	R	631	0x0276	1	0	●			
Digital Output #9 Active Status	R	632	0x0277	1	0	●			
Digital Output #10 Active Status	R	633	0x0278	1	0	●			

Parameter Name	R/W	Holding Register	Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Digital Output #11 Active Status	R	634	0x0279	1	0	●		
Digital Output #12 Active Status	R	635	0x027A	1	0	●		
Digital Output #13 Active Status	R	636	0x027B	1	0	●		
Digital Output #14 Active Status	R	637	0x027C	1	0	●		
Digital Output #15 Active Status	R	638	0x027D	1	0	●		
Digital Output #16 Active Status	R	639	0x027E	1	0	●		
Digital Output #17 Active Status	R	640	0x027F	1	0	●		
Group Start Active Status (DIDI-01)	R	641	0x0280	1	0			For all of these statuses: 0 = INACTIVE 1 = ACTIVE
Bell Alarm Active Status (DIDI-02)	R	642	0x0281	1	0			
Gen CB Trip Command Active Status (DIDI-03)	R	643	0x0282	1	0			
Gen CB Close Command Active Status (DIDI-04)	R	644	0x0283	1	0			
Arbitration Relay Active Status (DDO-01)	R	645	0x0284	1	0			
Gen CB Close Active Status (DDO-02)	R	646	0x0285	1	0			
Gen CB Trip Active Status (DDO-03)	R	647	0x0286	1	0			
Analog Input #1 Sensor Value	R	648	0x0287	1	0	●	●	Scaling: 1/16 /bit, Offset: -16, Data range: -16 to 3999.9375
Analog Input #2 Sensor Value	R	649	0x0288	1	0	●	●	Scaling: 1/16 /bit, Offset: -16, Data range: -16 to 3999.9375
Analog Input #3 Sensor Value	R	650	0x0289	1	0	●	●	Scaling: 1/16 /bit, Offset: -16, Data range: -16 to 3999.9375
Analog Input #4 Sensor Value	R	651	0x028A	1	0		●	Scaling: 1/16 /bit, Offset: -16, Data range: -16 to 3999.9375
Analog Input #1 Data Value	R	652	0x028B	2	0	●	●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Input #2 Data Value	R	654	0x028D	2	0	●	●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Input #3 Data Value	R	656	0x028F	2	0	●	●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Input #4 Data Value	R	658	0x0291	2	0		●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Output #1 Data Value	R	660	0x0293	2	0		●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Output #2 Data Value	R	662	0x0295	2	0		●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Output #3 Data Value	R	664	0x0297	2	0		●	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
PWM Output #1 Data Value	R	672	0x029F	2	0		●	Scaling: 1/16 %/bit, Offset: -16, Data range: -16 to 3999.9375 %
PWM Output #2 Data Value	R	674	0x02A1	2	0		●	Scaling: 1/16 %/bit, Offset: -16, Data range: -16 to 3999.9375 %

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Analog Output #1 Data Command	W	681	0x02A8	2	0		•	•	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Output #2 Data Command	W	683	0x02AA	2	0		•	•	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Analog Output #3 Data Command	W	685	0x02AC	2	0		•	•	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
PWM Output #1 Data Command	W	687	0x02AE	2	0		•	•	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
PWM Output #2 Data Command	W	689	0x02B0	2	0		•	•	Scaling: 1/256 /bit, Offset: -8,224,768, Data range: -8,224,768 to 8,224,767.99609375
Write Access Password	W	700	0x02BB	8	none	•	•	•	For all of these passwords: Each byte is comprised of one character via its ASCII code. First NULL (0x00) character terminates string.
Level 1 Password	W	708	0x02C3	8	1	•	•	•	
Level 2 Password	W	716	0x02CB	8	2	•	•	•	
SCADA Password	W	724	0x02D3	8	2	•	•	•	
Current Security Level	R	732	0x02DB	1	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 64255
Set Security Level	W	733	0x02DC	1	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 64255
Level 3 Password Phone In Prompt	R	734	0x02DD	8	0	•	•	•	Each byte is comprised of one character via its ASCII code. First NULL (0x00) character terminates string.
Engine Oil Temperature from I/O Pin	R	800	0x031F	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Exhaust Temperature	R	801	0x0320	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Left Manifold Exhaust Temperature	R	802	0x0321	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Right Manifold Exhaust Temperature from I/O Pin	R	803	0x0322	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Fuel Level from I/O Pin	R	804	0x0323	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
External Tank Fuel Level from I/O Pin	R	805	0x0324	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Engine Oil Level from I/O Pin	R	806	0x0325	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Engine Coolant Level from I/O Pin	R	807	0x0326	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Oil Filter Differential Pressure from I/O Pin	R	809	0x0328	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Air Filter 1 Differential Pressure from I/O Pin	R	810	0x0329	1	0	•	•	•	Scaling: 1/128 kPa/bit, Offset: -250 kPa, Data range: -250 to 251.99 kPa
Fuel Filter Differential Pressure from I/O Pin	R	811	0x032A	1	0	•	•	•	Scaling: 0.125 kPa/bit, Offset: 0 kPa, Data range: 0 to 8031.875 kPa
Main Tank Urea Level from I/O Pin	R	812	0x032B	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Real Time Clock	R	900	0x0383	3	0	•	•	•	see section 5.8
Update Real Time Clock Command	W	903	0x0386	3	1	•	•	•	see section 5.8

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Log Entry Index	W	1033	0x0408	1	0	•	•	•	Scaling: 1 /bit, Offset: 0, Data range: 0 to 39
Log Entry	R	1034	0x0409	14	0	•	•	•	see section 5.7
Reset Event	W	1048	0x0417	2	1	•	•	•	see section 5.7
Cooldown Duration Remaining	R	1054	0x041D	1	0	•	•	•	Scaling: 1 second/bit, Offset: 0 seconds, Data range: 0 to 64255 seconds
Remote Initiate Command	W	1055	0x041E	1	0	•	•	•	0 = FALSE 1 = TRUE
Emergency Stop Command	W	1056	0x041F	1	0	•	•	•	0 = FALSE 1 = TRUE
Desired Genset Output Voltage	R	1057	0x0420	1	0	•	•	•	Scaling: 1 V/bit, Offset: 0 V, Data range: 0 to 64255 V
Total Voltage Bias Percent	R	1058	0x0421	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Voltage Bias Percent Increment Command	W	1059	0x0422	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Requested Engine Speed	R	1060	0x0423	1	0	•	•	•	Scaling: 0.125 rpm/bit, Offset: 0 rpm, Data range: 0 to 8031.875 rpm
Total Speed Bias Percent	R	1061	0x0424	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Speed Bias Percent Increment Command	W	1062	0x0425	1	0	•	•	•	Scaling: 0.0078125 %/bit, Offset: -251 %, Data range: -251 to 250.99 %
Generator/Bus Phase Difference	R	1064	0x0427	1	0			•	Scaling: 1/128 degree/bit, Offset: -200 degrees, Data range: -200 to 301.99 degrees
Generator Circuit Breaker Status	R	1065	0x0428	1	0			•	0 = OPEN 1 = CLOSED 2 = LOCKED OUT 7 = ERROR
Generator Frequency within Limits	R	1067	0x042A	1	0	•	•	•	0 = FALSE 1 = TRUE
Generator Voltage within Limits	R	1068	0x042B	1	0	•	•	•	0 = FALSE 1 = TRUE
Bus Voltage within Limits	R	1069	0x042C	1	0			•	0 = FALSE 1 = TRUE
Bus Live Status	R	1070	0x042D	1	0			•	0 = FALSE 1 = TRUE
Genset Control Online	R	1090	0x0441	1	0	•	•	•	0 = FALSE 1 = TRUE
Engine Control Online	R	1091	0x0442	1	0	•	•	•	0 = FALSE 1 = TRUE
Secondary Engine Control Online	R	1092	0x0443	1	0	•	•	•	0 = FALSE 1 = TRUE
External I/O #1 Online	R	1093	0x0444	1	0	•	•	•	0 = FALSE 1 = TRUE
External I/O #2 Online	R	1094	0x0445	1	0	•	•	•	0 = FALSE 1 = TRUE
External I/O #3 Online	R	1095	0x0446	1	0	•	•	•	0 = FALSE 1 = TRUE
External I/O #4 Online	R	1096	0x0447	1	0	•	•	•	0 = FALSE 1 = TRUE
Digital AVR Online	R	1097	0x0448	1	0	•	•	•	0 = FALSE 1 = TRUE

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
RTD Module Online	R	1098	0x0449	1	0	•	•	•	0 = FALSE 1 = TRUE
Thermocouple #1 Online	R	1099	0x044A	1	0	•	•	•	0 = FALSE 1 = TRUE
Thermocouple #2 Online	R	1100	0x044B	1	0	•	•	•	0 = FALSE 1 = TRUE
SCR Module Online	R	1103	0x044E	1	0	•	•	•	0 = FALSE 1 = TRUE
Sync Mode Switch State	R	1108	0x0453	1	0			•	0 = OFF 1 = AUTOMATIC 2 = MANUAL 3 = CHECK
Dead Bus Arbitration State	R	1111	0x0456	1	0			•	0 = DBA DISABLED 1 = DBA ENABLED 2 = REQUESTING 3 = CAPTURING 4 = ARB CHECK 5 = CLOSE GRANTED 6 = GEN ONLINE 7 = DBA FAILURE #1 8 = DBA FAILURE #2 9 = DBA FAILURE #3 10 = FAILURE WAIT 11 = MAX FAILURES 12 = LIVE BUS 13 = BRKR CLOSED 14 = LINE FAULT #1 15 = LINE FAULT #2 16 = LINE FAULT #3 17 = DBA FAILURE #1 18 = DBA FAILURE #2 19 = DBA FAILURE #3 20 = DBA FAILURE #4
Load Sense Load Demand State	R	1120	0x045F	1	0			•	0 = LSLD OFF 1 = LSLD WAIR 2 = ANALYZING KW 3 = ARBITRATION 4 = RAMP UP 5 = LAST UNIT CHECK 6 = RAMP DOWN 7 = LSLD STANDBY
Load Shed Command Active Status	R	1129	0x0468	1	0		•	•	0 = INACTIVE 1 = ACTIVE 3 = DISABLED
Load Shed Command Reset	W	1130	0x0469	1	0		•	•	0 = FALSE 1 = TRUE
Primary Data Link Status	R	1140	0x0473	1	0	•	•	•	0 = OK 1 = FAULT
Accessory Data Link Status	R	1141	0x0474	1	0	•	•	•	0 = OK 1 = FAULT
RS-485 SCADA Data Link Status	R	1142	0x0475	1	0	•	•	•	0 = OK 1 = FAULT
TCP/IP SCADA Data Link Status	R	1143	0x0476	1	0		•	•	0 = OK 1 = FAULT 3 = DISABLED OR NOT AVAILABLE
RS-485 Annunciator Data Link Status	R	1144	0x0477	1	0	•	•	•	0 = OK 1 = FAULT

Parameter Name	R/W	Holding Register	Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation	
Low Idle State from ADEM	R	1263	0x04EE	1	0	•	•	•	0 = FALSE 1 = TRUE 2 = ERROR 3 = DISABLED OR NOT AVAILABLE
Engine Protection has Shut Down Engine	R	1275	0x04FA	1	0	•	•	•	0 = FALSE 1 = TRUE 2 = ERROR 3 = DISABLED OR NOT AVAILABLE
Control Serial Number	R	1276	0x04FB	6	0	•	•	•	Each byte is comprised of one character via its ASCII code. First NULL (0x00) character terminates string.
Programmable Cycle Timer 1 Output 3 Status	R	1487	0x05CE	1	0			•	For each programmable cycle timer output status: 0 = PCT Output 3 is currently not activated by this timer (but is configured). 1 = PCT Output 3 is currently activated by this timer. 2 = PCT Output 3 is not configured to be activated by this timer.
Programmable Cycle Timer 2 Output 3 Status	R	1488	0x05CF	1	0			•	
Programmable Cycle Timer 3 Output 3 Status	R	1489	0x05D0	1	0			•	
Programmable Cycle Timer 4 Output 3 Status	R	1490	0x05D1	1	0			•	
Programmable Cycle Timer 5 Output 3 Status	R	1491	0x05D2	1	0			•	
Programmable Cycle Timer 6 Output 3 Status	R	1492	0x05D3	1	0			•	
Programmable Cycle Timer 7 Output 3 Status	R	1493	0x05D4	1	0			•	
Event Log Module Selection	W	1498	0x05D9	1	0	•	•	•	For each module selection: 0 = GENSET CONTROL 1 = ENGINE CONTROL 2 = SECONDARY ENGINE CONTROL 3 = EXTERNAL I/O #1 4 = EXTERNAL I/O #2 5 = EXTERNAL I/O #3 6 = EXTERNAL I/O #4 7 = DIGITAL AVR 8 = RTD MODULE 9 = THERMOCOUPLE MODULE #1 10 = THERMOCOUPLE MODULE #2
Event Log Module Selection	R	1499	0x05DA	1	0	•	•	•	
Module Event Log Entry 1	R	1500	0x05DB	14	0	•	•	•	see section 5.7
Module Event Log Entry 2	R	1514	0x05E9	14	0	•	•	•	see section 5.7
Module Event Log Entry 3	R	1528	0x05F7	14	0	•	•	•	see section 5.7
Module Event Log Entry 4	R	1542	0x0605	14	0	•	•	•	see section 5.7
Module Event Log Entry 5	R	1556	0x0613	14	0	•	•	•	see section 5.7
Module Event Log Entry 6	R	1570	0x0621	14	0	•	•	•	see section 5.7
Module Event Log Entry 7	R	1584	0x062F	14	0	•	•	•	see section 5.7
Module Event Log Entry 8	R	1598	0x063D	14	0	•	•	•	see section 5.7
Module Event Log Entry 9	R	1612	0x064B	14	0	•	•	•	see section 5.7
Module Event Log Entry 10	R	1626	0x0659	14	0	•	•	•	see section 5.7
Module Event Log Entry 11	R	1640	0x0667	14	0	•	•	•	see section 5.7
Module Event Log Entry 12	R	1654	0x0675	14	0	•	•	•	see section 5.7
Module Event Log Entry 13	R	1668	0x0683	14	0	•	•	•	see section 5.7
Module Event Log Entry 14	R	1682	0x0691	14	0	•	•	•	see section 5.7

Parameter Name	R/W	Holding Register	Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Module Event Log Entry 15	R	1696 0x069F	14	0	●	●	●	see section 5.7
Module Event Log Entry 16	R	1710 0x06AD	14	0	●	●	●	see section 5.7
Module Event Log Entry 17	R	1724 0x06BB	14	0	●	●	●	see section 5.7
Module Event Log Entry 18	R	1738 0x06C9	14	0	●	●	●	see section 5.7
Module Event Log Entry 19	R	1752 0x06D7	14	0	●	●	●	see section 5.7
Module Event Log Entry 20	R	1766 0x06E5	14	0	●	●	●	see section 5.7
Module Event Log Entry 21	R	1780 0x06F3	14	0	●	●	●	see section 5.7
Module Event Log Entry 22	R	1794 0x0701	14	0	●	●	●	see section 5.7
Module Event Log Entry 23	R	1808 0x070F	14	0	●	●	●	see section 5.7
Module Event Log Entry 24	R	1822 0x071D	14	0	●	●	●	see section 5.7
Module Event Log Entry 25	R	1836 0x072B	14	0	●	●	●	see section 5.7
Module Event Log Entry 26	R	1850 0x0739	14	0	●	●	●	see section 5.7
Module Event Log Entry 27	R	1864 0x0747	14	0	●	●	●	see section 5.7
Module Event Log Entry 28	R	1878 0x0755	14	0	●	●	●	see section 5.7
Module Event Log Entry 29	R	1892 0x0763	14	0	●	●	●	see section 5.7
Module Event Log Entry 30	R	1906 0x0771	14	0	●	●	●	see section 5.7
Module Event Log Entry 31	R	1920 0x077F	14	0	●	●	●	see section 5.7
Module Event Log Entry 32	R	1934 0x078D	14	0	●	●	●	see section 5.7
Module Event Log Entry 33	R	1948 0x079B	14	0	●	●	●	see section 5.7
Module Event Log Entry 34	R	1962 0x07A9	14	0	●	●	●	see section 5.7
Module Event Log Entry 35	R	1976 0x07B7	14	0	●	●	●	see section 5.7
Module Event Log Entry 36	R	1990 0x07C5	14	0	●	●	●	see section 5.7
Module Event Log Entry 37	R	2004 0x07D3	14	0	●	●	●	see section 5.7
Module Event Log Entry 38	R	2018 0x07E1	14	0	●	●	●	see section 5.7
Module Event Log Entry 39	R	2032 0x07EF	14	0	●	●	●	see section 5.7
Module Event Log Entry 40	R	2046 0x07FD	14	0	●	●	●	see section 5.7
Programmable Cycle Timer 1 Output 1 Status	R	2060 0x080B	1	0	●	●	●	For each programmable cycle timer output status: 0 = PCT Output 1 is currently not activated by this timer (but is configured). 1 = PCT Output 1 is currently activated by this timer. 2 = PCT Output 1 is not configured to be activated by this timer.
Programmable Cycle Timer 2 Output 1 Status	R	2061 0x080C	1	0	●	●	●	
Programmable Cycle Timer 3 Output 1 Status	R	2062 0x080D	1	0	●	●	●	
Programmable Cycle Timer 4 Output 1 Status	R	2063 0x080E	1	0	●	●	●	
Programmable Cycle Timer 5 Output 1 Status	R	2064 0x080F	1	0	●	●	●	
Programmable Cycle Timer 6 Output 1 Status	R	2065 0x0810	1	0	●	●	●	
Programmable Cycle Timer 7 Output 1 Status	R	2066 0x0811	1	0	●	●	●	
Programmable Cycle Timer 1 Output 2 Status	R	2067 0x0812	1	0	●	●	●	For each programmable cycle timer output status: 0 = PCT Output 2 is currently not activated by this timer (but is configured). 1 = PCT Output 2 is currently activated by this timer. 2 = PCT Output 2 is not configured to be
Programmable Cycle Timer 2 Output 2 Status	R	2068 0x0813	1	0	●	●	●	
Programmable Cycle Timer 3 Output 2 Status	R	2069 0x0814	1	0	●	●	●	

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Programmable Cycle Timer 4 Output 2 Status	R	2070	0x0815	1	0	•	•	•	activated by this timer.
Programmable Cycle Timer 5 Output 2 Status	R	2071	0x0816	1	0	•	•	•	
Programmable Cycle Timer 6 Output 2 Status	R	2072	0x0817	1	0	•	•	•	
Programmable Cycle Timer 7 Output 2 Status	R	2073	0x0818	1	0	•	•	•	
Turbocharger 1 Compressor Inlet Temperature	R	2074	0x0819	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 2 Compressor Inlet Temperature	R	2075	0x081A	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 3 Compressor Inlet Temperature	R	2076	0x081B	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 4 Compressor Inlet Temperature	R	2077	0x081C	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 1 Turbine Inlet Temperature	R	2078	0x081D	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 1 Turbine Outlet Temperature	R	2079	0x081E	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 2 Turbine Inlet Temperature	R	2080	0x081F	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 2 Turbine Outlet Temperature	R	2081	0x0820	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 3 Turbine Inlet Temperature	R	2082	0x0821	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 3 Turbine Outlet Temperature	R	2083	0x0822	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 4 Turbine Inlet Temperature	R	2084	0x0823	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Turbocharger 4 Turbine Outlet Temperature	R	2085	0x0824	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Exhaust Temperature from Data Link	R	2086	0x0825	1	0	•	•	•	Scaling: 0.03125 C/bit, Offset: -273 C, Data range: -273 to 1735 C
Fuel Pump Primer Status	R	2087	0x0826	1	0	•	•	•	0 = Deactivate Fuel Priming 1 = Priming Active 2 = Priming Inappropriate
Manual Fuel Priming Duration Remaining	R	2091	0x082A	1	0	•	•	•	Scaling: 1 second/bit, Offset: 0 seconds, Data range: 0 to 64255 seconds
Software Build Version	R	2188	0x088B	10	0	•	•	•	Each byte is comprised of one character via its ASCII code. First NULL (0x00) character terminates string.
Digital Output #1 Command	W	2232	0x08B7	1	0	•	•	•	For each digital and relay output command: 0 = DEACTIVATE 1 = ACTIVATE
Digital Output #2 Command	W	2233	0x08B8	1	0	•	•	•	
Digital Output #3 Command	W	2234	0x08B9	1	0	•	•	•	
Digital Output #4 Command	W	2235	0x08BA	1	0	•	•	•	
Digital Output #5 Command	W	2236	0x08BB	1	0	•	•	•	
Digital Output #6 Command	W	2237	0x08BC	1	0	•	•	•	
Digital Output #7 Command	W	2238	0x08BD	1	0	•	•	•	

Parameter Name	R/W	Holding Register		Ct	Sec Lvl	4.2	4.3	4.4	Data Interpretation
Digital Output #8 Command	W	2239	0x08BE	1	0		•	•	
Digital Output #9 Command	W	2240	0x08BF	1	0		•	•	
Digital Output #10 Command	W	2241	0x08C0	1	0		•	•	
Digital Output #11 Command	W	2242	0x08C1	1	0		•	•	
Digital Output #12 Command	W	2243	0x08C2	1	0		•	•	
Digital Output #13 Command	W	2244	0x08C3	1	0		•	•	
Digital Output #14 Command	W	2245	0x08C4	1	0		•	•	
Digital Output #15 Command	W	2246	0x08C5	1	0		•	•	
Digital Output #16 Command	W	2247	0x08C6	1	0		•	•	
Digital Output #17 Command	W	2248	0x08C7	1	0			•	
Relay Output #1 Command	W	2252	0x08CB	1	0	•			
Relay Output #2 Command	W	2253	0x08CC	1	0	•			
Relay Output #3 Command	W	2254	0x08CD	1	0	•			
Relay Output #4 Command	W	2255	0x08CE	1	0	•			
Relay Output #5 Command	W	2256	0x08CF	1	0	•			
Relay Output #6 Command	W	2257	0x08D0	1	0	•			
Relay Output #7 Command	W	2258	0x08D1	1	0	•			
Relay Output #8 Command	W	2259	0x08D2	1	0	•			

APPENDIX B INDEX OF MODBUS REGISTERS – ALPHABETICAL

section	Parameter Name	#
5.11	Accessory Data Link Status	1141
5.7	Acknowledge All Events Command	304
5.6	Aftertreatment #1 SCR Catalyst Reagent Tank #1 Temperature	378
5.6	Aftertreatment 1 SCR Catalyst Exhaust Gas Differential Pressure	382
5.6	Air Filter 1 Differential Pressure from Data Link	253
5.6	Air Filter 1 Differential Pressure from I/O Pin	810
5.12	Analog Input #1 Data Value	652
5.12	Analog Input #1 Sensor Value	648
5.12	Analog Input #2 Data Value	654
5.12	Analog Input #2 Sensor Value	649
5.12	Analog Input #3 Data Value	656
5.12	Analog Input #3 Sensor Value	650
5.12	Analog Input #4 Data Value	658
5.12	Analog Input #4 Sensor Value	651
5.12	Analog Output #1 Data Command	681
5.12	Analog Output #1 Data Value	660
5.12	Analog Output #2 Data Command	683
5.12	Analog Output #2 Data Value	662
5.12	Analog Output #3 Data Command	685
5.12	Analog Output #3 Data Value	664
5.5	Arbitration Relay Active Status (DDO-01)	645
5.6	Atmospheric Pressure from Data Link	257
5.5	Auto Start/Stop Fuel Control Enabled	307
5.5	Automatic Start/Stop State	206
5.3	Battery Voltage	202
5.5	Bell Alarm Active Status (DIDI-02)	642
5.6	Boost Pressure from Data Link	249
5.4	Bus Average AC RMS Frequency	165
5.4	Bus Average Line-Line AC RMS Voltage	164
5.4	Bus Average Line-Line AC RMS Voltage Percent	173
5.4	Bus Average Line-Neutral AC RMS Voltage	172
5.5	Bus Live Status	1070
5.4	Bus Phase A Line-Line AC RMS Voltage	166
5.4	Bus Phase A Line-Neutral AC RMS Voltage	169

section	Parameter Name	#
5.4	Bus Phase B Line-Line AC RMS Voltage	167
5.4	Bus Phase B Line-Neutral AC RMS Voltage	170
5.4	Bus Phase C Line-Line AC RMS Voltage	168
5.4	Bus Phase C Line-Neutral AC RMS Voltage	171
5.5	Bus Voltage within Limits	1069
5.5	Bypass Cooldown	300
5.6	Catalyst Intake Temperature	381
5.11	Control Serial Number	1276
5.5	Cooldown Duration Remaining	1054
5.6	Crankcase Pressure from Data Link	248
4.4	Current Security Level	732
5.6	Cylinder #1 Exhaust Port Temperature from Data Link	221
5.6	Cylinder #10 Exhaust Port Temperature from Data Link	230
5.6	Cylinder #11 Exhaust Port Temperature from Data Link	231
5.6	Cylinder #12 Exhaust Port Temperature from Data Link	232
5.6	Cylinder #13 Exhaust Port Temperature from Data Link	233
5.6	Cylinder #14 Exhaust Port Temperature from Data Link	234
5.6	Cylinder #15 Exhaust Port Temperature from Data Link	235
5.6	Cylinder #16 Exhaust Port Temperature from Data Link	236
5.6	Cylinder #17 Exhaust Port Temperature from Data Link	237
5.6	Cylinder #18 Exhaust Port Temperature from Data Link	238
5.6	Cylinder #19 Exhaust Port Temperature from Data Link	239
5.6	Cylinder #2 Exhaust Port Temperature from Data Link	222
5.6	Cylinder #20 Exhaust Port Temperature from Data Link	240
5.6	Cylinder #3 Exhaust Port Temperature from Data Link	223
5.6	Cylinder #4 Exhaust Port Temperature from Data Link	224
5.6	Cylinder #5 Exhaust Port Temperature from Data Link	225
5.6	Cylinder #6 Exhaust Port Temperature from Data Link	226

section	Parameter Name	#
5.6	Cylinder #7 Exhaust Port Temperature from Data Link	227
5.6	Cylinder #8 Exhaust Port Temperature from Data Link	228
5.6	Cylinder #9 Exhaust Port Temperature from Data Link	229
5.5	Dead Bus Arbitration State	1111
5.5	Dedicated Digital Input #1 (E-Stop) Active Status	612
5.5	Dedicated Digital Input #2 (Initiate Command) Active Status	613
5.5	Dedicated Digital Input #3 (Gen CB Aux A) Active Status	614
5.5	Dedicated Digital Input #4 (Gen CB Aux B) Active Status	615
5.5	Desired Base Load	179
5.5	Desired Genset Output Voltage	1057
5.11	Digital AVR Online	1097
5.12	Digital Input #1 Active Status	600
5.12	Digital Input #2 Active Status	601
5.12	Digital Input #3 Active Status	602
5.12	Digital Input #4 Active Status	603
5.12	Digital Input #5 Active Status	604
5.12	Digital Input #6 Active Status	605
5.12	Digital Input #7 Active Status	606
5.12	Digital Input #8 Active Status	607
5.12	Digital Output #1 Active Status	624
5.12	Digital Output #1 Command	2232
5.12	Digital Output #10 Active Status	633
5.12	Digital Output #10 Command	2241
5.12	Digital Output #11 Active Status	634
5.12	Digital Output #11 Command	2242
5.12	Digital Output #12 Active Status	635
5.12	Digital Output #12 Command	2243
5.12	Digital Output #13 Active Status	636
5.12	Digital Output #13 Command	2244
5.12	Digital Output #14 Active Status	637
5.12	Digital Output #14 Command	2245
5.12	Digital Output #15 Active Status	638
5.12	Digital Output #15 Command	2246
5.12	Digital Output #16 Active Status	639
5.12	Digital Output #16 Command	2247
5.12	Digital Output #17 Active Status	640
5.12	Digital Output #17 Command	2248
5.12	Digital Output #2 Active Status	625

section	Parameter Name	#
5.12	Digital Output #2 Command	2233
5.12	Digital Output #3 Active Status	626
5.12	Digital Output #3 Command	2234
5.12	Digital Output #4 Active Status	627
5.12	Digital Output #4 Command	2235
5.12	Digital Output #5 Active Status	628
5.12	Digital Output #5 Command	2236
5.12	Digital Output #6 Active Status	629
5.12	Digital Output #6 Command	2237
5.12	Digital Output #7 Active Status	630
5.12	Digital Output #7 Command	2238
5.12	Digital Output #8 Active Status	631
5.12	Digital Output #8 Command	2239
5.12	Digital Output #9 Active Status	632
5.12	Digital Output #9 Command	2240
5.5	Emergency Stop Command	1056
5.5	Engine Control Online	1091
5.5	Engine Control Switch Command	302
5.5	Engine Control Switch Position	301
5.6	Engine Coolant Level from I/O Pin	807
5.6	Engine Coolant Temperature	201
5.6	Engine Coolant Temperature from Data Link	219
5.6	Engine Fuel Temperature from Data Link	246
5.6	Engine Oil Level from I/O Pin	806
5.6	Engine Oil Pressure	200
5.6	Engine Oil Pressure from Data Link	217
5.6	Engine Oil Temperature	199
5.6	Engine Oil Temperature from Data Link	245
5.6	Engine Oil Temperature from I/O Pin	800
5.8	Engine Operating Hours	204
5.7	Engine Protection has Shut Down Engine	1275
5.6	Engine rpm	203
5.7	Event Log Module Selection	1498
5.7	Event Log Module Selection	1499
5.6	Exhaust Manifold #1 (Left) Temperature from Data Link	241
5.6	Exhaust Manifold #2 (Right) Temperature from Data Link	242
5.6	Exhaust Temperature	801
5.6	Exhaust Temperature from Data Link	2086

section	Parameter Name	#
5.11	External I/O #1 Online	1093
5.11	External I/O #2 Online	1094
5.11	External I/O #3 Online	1095
5.11	External I/O #4 Online	1096
5.6	External Tank Fuel Level from I/O Pin	805
5.5	Forced Idle Command Active	337
5.6	Fuel Filter Differential Pressure from Data Link	252
5.6	Fuel Filter Differential Pressure from I/O Pin	811
5.6	Fuel Level	198
5.6	Fuel Level	258
5.6	Fuel Level from I/O Pin	804
5.5	Fuel Load Pump Active	322
5.6	Fuel Pressure from Data Link	247
5.5	Fuel Pump Primer Status	2087
5.5	Fuel Unload Pump Active	321
5.5	Gen CB Close Active Status (DDO-02)	646
5.5	Gen CB Close Command Active Status (DIDI-04)	644
5.5	Gen CB Trip Active Status (DDO-03)	647
5.5	Gen CB Trip Command Active Status (DIDI-03)	643
5.1	Generator Average AC RMS Current	101
5.1	Generator Average AC RMS Frequency	102
5.1	Generator Average AC RMS Frequency Percent	183
5.1	Generator Average Line-Line AC RMS Voltage	100
5.1	Generator Average Line-Line AC RMS Voltage Percent	163
5.1	Generator Average Line-Neutral AC RMS Voltage	148
5.5	Generator Circuit Breaker Status	1065
5.5	Generator Desired Power Factor	178
5.3	Generator Excitation Field Current from Data Link	340
5.3	Generator Excitation Field Voltage from Data Link	338
5.5	Generator Frequency within Limits	1067
5.3	Generator Front Bearing Temperature from Data Link	149
5.8	Generator Overall Power Factor	103
5.8	Generator Overall Power Factor Lagging	104
5.1	Generator Phase A AC RMS Current	111

section	Parameter Name	#
5.8	Generator Phase A Apparent Power	123
5.1	Generator Phase A Line-Line AC RMS Voltage	108
5.1	Generator Phase A Line-Neutral AC RMS Voltage	114
5.8	Generator Phase A Power Factor	135
5.8	Generator Phase A Power Factor Lagging	159
5.8	Generator Phase A Reactive Power	129
5.8	Generator Phase A Real Power	117
5.3	Generator Phase A Winding Temperature from Data Link	151
5.1	Generator Phase B AC RMS Current	112
5.8	Generator Phase B Apparent Power	125
5.1	Generator Phase B Line-Line AC RMS Voltage	109
5.1	Generator Phase B Line-Neutral AC RMS Voltage	115
5.8	Generator Phase B Power Factor	136
5.8	Generator Phase B Power Factor Lagging	160
5.8	Generator Phase B Reactive Power	131
5.8	Generator Phase B Real Power	119
5.3	Generator Phase B Winding Temperature from Data Link	152
5.1	Generator Phase C AC RMS Current	113
5.8	Generator Phase C Apparent Power	127
5.1	Generator Phase C Line-Line AC RMS Voltage	110
5.1	Generator Phase C Line-Neutral AC RMS Voltage	116
5.8	Generator Phase C Power Factor	137
5.8	Generator Phase C Power Factor Lagging	161
5.8	Generator Phase C Reactive Power	133
5.8	Generator Phase C Real Power	121
5.3	Generator Phase C Winding Temperature from Data Link	153
5.3	Generator Rear Bearing Temperature from Data Link	150
5.3	Generator Rear Bearing Temperature from I/O Pin	162
5.8	Generator Total Apparent Power	138
5.8	Generator Total Percent Apparent Power	140
5.1	Generator Total Percent Current	174
5.8	Generator Total Percent kW	105
5.8	Generator Total Percent Reactive Power	143

section	Parameter Name	#
5.8	Generator Total Reactive Energy Exported	146
5.8	Generator Total Reactive Power	141
5.8	Generator Total Real Energy Exported	144
5.8	Generator Total Real Power	106
5.5	Generator Voltage within Limits	1068
5.5	Generator/Bus Phase Difference	1064
5.11	Genset Control Online	1090
5.5	Group Start Active Status (DIDI-01)	641
5.6	Instantaneous Fuel Consumption from Data Link	256
5.6	Intake Manifold #1 Temperature from Data Link	243
5.6	Intake Manifold #2 Temperature from Data Link	244
5.12	Isolated Digital Input #1 Active Status	608
5.12	Isolated Digital Input #2 Active Status	609
5.12	Isolated Digital Input #3 Active Status	610
5.12	Isolated Digital Input #4 Active Status	611
4.4	Key Press	310
5.11	Lamp Test Command	303
5.6	Left Manifold Exhaust Temperature	802
4.4	Level 1 Password	708
4.4	Level 2 Password	716
4.4	Level 3 Password Phone In Prompt	734
5.5	Load Sense Load Demand State	1120
5.5	Load Share Line Total Percent kVAr	182
5.5	Load Share Line Total Percent kW	181
5.13	Load Shed Command Active Status	1129
5.13	Load Shed Command Reset	1130
5.7	Log Entry	1034
5.7	Log Entry Index	1033
5.5	Low Idle State from ADEM	1263
5.6	Main Tank Urea Level from I/O Pin	812
5.5	Manual Fuel Priming Duration Remaining	2091
5.7	Module Event Log Entry 1	1500
5.7	Module Event Log Entry 10	1626
5.7	Module Event Log Entry 11	1640
5.7	Module Event Log Entry 12	1654
5.7	Module Event Log Entry 13	1668
5.7	Module Event Log Entry 14	1682

section	Parameter Name	#
5.7	Module Event Log Entry 15	1696
5.7	Module Event Log Entry 16	1710
5.7	Module Event Log Entry 17	1724
5.7	Module Event Log Entry 18	1738
5.7	Module Event Log Entry 19	1752
5.7	Module Event Log Entry 2	1514
5.7	Module Event Log Entry 20	1766
5.7	Module Event Log Entry 21	1780
5.7	Module Event Log Entry 22	1794
5.7	Module Event Log Entry 23	1808
5.7	Module Event Log Entry 24	1822
5.7	Module Event Log Entry 25	1836
5.7	Module Event Log Entry 26	1850
5.7	Module Event Log Entry 27	1864
5.7	Module Event Log Entry 28	1878
5.7	Module Event Log Entry 29	1892
5.7	Module Event Log Entry 3	1528
5.7	Module Event Log Entry 30	1906
5.7	Module Event Log Entry 31	1920
5.7	Module Event Log Entry 32	1934
5.7	Module Event Log Entry 33	1948
5.7	Module Event Log Entry 34	1962
5.7	Module Event Log Entry 35	1976
5.7	Module Event Log Entry 36	1990
5.7	Module Event Log Entry 37	2004
5.7	Module Event Log Entry 38	2018
5.7	Module Event Log Entry 39	2032
5.7	Module Event Log Entry 4	1542
5.7	Module Event Log Entry 40	2046
5.7	Module Event Log Entry 5	1556
5.7	Module Event Log Entry 6	1570
5.7	Module Event Log Entry 7	1584
5.7	Module Event Log Entry 8	1598
5.7	Module Event Log Entry 9	1612
5.8	Number of Crank Attempts	213
5.8	Number of Successful Starts	215
5.6	Oil Filter Differential Pressure from Data Link	251
5.6	Oil Filter Differential Pressure from I/O Pin	809
5.11	Primary Data Link Status	1140
5.10	Programmable Cycle Timer 1 Output 1 Status	2060

section	Parameter Name	#
5.10	Programmable Cycle Timer 1 Output 2 Status	2067
5.10	Programmable Cycle Timer 1 Output 3 Status	1487
5.10	Programmable Cycle Timer 2 Output 1 Status	2061
5.10	Programmable Cycle Timer 2 Output 2 Status	2068
5.10	Programmable Cycle Timer 2 Output 3 Status	1488
5.10	Programmable Cycle Timer 3 Output 1 Status	2062
5.10	Programmable Cycle Timer 3 Output 2 Status	2069
5.10	Programmable Cycle Timer 3 Output 3 Status	1489
5.10	Programmable Cycle Timer 4 Output 1 Status	2063
5.10	Programmable Cycle Timer 4 Output 2 Status	2070
5.10	Programmable Cycle Timer 4 Output 3 Status	1490
5.10	Programmable Cycle Timer 5 Output 1 Status	2064
5.10	Programmable Cycle Timer 5 Output 2 Status	2071
5.10	Programmable Cycle Timer 5 Output 3 Status	1491
5.10	Programmable Cycle Timer 6 Output 1 Status	2065
5.10	Programmable Cycle Timer 6 Output 2 Status	2072
5.10	Programmable Cycle Timer 6 Output 3 Status	1492
5.10	Programmable Cycle Timer 7 Output 1 Status	2066
5.10	Programmable Cycle Timer 7 Output 2 Status	2073
5.10	Programmable Cycle Timer 7 Output 3 Status	1493
5.12	PWM Output #1 Data Command	687
5.12	PWM Output #1 Data Value	672
5.12	PWM Output #2 Data Command	689
5.12	PWM Output #2 Data Value	674
5.12	Real Time Clock	900
5.12	Relay Output #1 Active Status	616
5.12	Relay Output #1 Command	2252
5.12	Relay Output #2 Active Status	617
5.12	Relay Output #2 Command	2253
5.12	Relay Output #3 Active Status	618
5.12	Relay Output #3 Command	2254

section	Parameter Name	#
5.12	Relay Output #4 Active Status	619
5.12	Relay Output #4 Command	2255
5.12	Relay Output #5 Active Status	620
5.12	Relay Output #5 Command	2256
5.12	Relay Output #6 Active Status	621
5.12	Relay Output #6 Command	2257
5.12	Relay Output #7 Active Status	622
5.12	Relay Output #7 Command	2258
5.12	Relay Output #8 Active Status	623
5.12	Relay Output #8 Command	2259
5.5	Remote Initiate Command	1055
5.5	Requested Engine Speed	1060
5.7	Reset Event	1048
5.6	Right Manifold Exhaust Temperature from I/O Pin	803
5.7	RS-485 Ann Alarm Group 1 Column 1	342
5.7	RS-485 Ann Alarm Group 1 Column 2	343
5.7	RS-485 Ann Alarm Group 1 Horn	344
5.7	RS-485 Ann Alarm Group 2 Column 1	346
5.7	RS-485 Ann Alarm Group 2 Column 2	347
5.7	RS-485 Ann Alarm Group 2 Horn	348
5.7	RS-485 Ann Alarm Group 3 Column 1	350
5.7	RS-485 Ann Alarm Group 3 Column 2	351
5.7	RS-485 Ann Alarm Group 3 Horn	352
5.7	RS-485 Ann Alarm Group 4 Column 1	354
5.7	RS-485 Ann Alarm Group 4 Column 2	355
5.7	RS-485 Ann Alarm Group 4 Horn	356
5.11	RS-485 Annunciator Data Link Status	1144
5.11	RS-485 SCADA Data Link Status	1142
5.11	RTD Module Online	1098
4.4	SCADA Password	724
5.11	SCR Module Online	1103
5.5	SCR System Check Required Status	319
5.11	Secondary Engine Control Online	1092
5.8	Service Maintenance Interval Days Remaining	212
5.8	Service Maintenance Interval Hours Remaining	210
5.8	Service Maintenance Interval Weeks Remaining	299

section	Parameter Name	#
4.4	Set Security Level	733
5.11	Software Build Version	2188
5.12	Spare Analog Input Percent	207
5.12	Spare Analog Input Pressure	209
5.12	Spare Analog Input Temperature	208
5.5	Speed Bias Percent Increment Command	1062
5.5	Sync Mode Switch State	1108
5.7	System Event Count	334
5.7	System Event Lamp Status	335
5.11	TCP/IP SCADA Data Link Status	1143
5.11	Thermocouple #1 Online	1099
5.11	Thermocouple #2 Online	1100
5.5	Total Speed Bias Percent	1061
5.5	Total Voltage Bias Percent	1058
5.6	Turbocharger 1 Compressor Inlet Temperature	2074
5.6	Turbocharger 1 Turbine Inlet Temperature	2078
5.6	Turbocharger 1 Turbine Outlet Temperature	2079
5.6	Turbocharger 2 Compressor Inlet Temperature	2075

section	Parameter Name	#
5.6	Turbocharger 2 Turbine Inlet Temperature	2080
5.6	Turbocharger 2 Turbine Outlet Temperature	2081
5.6	Turbocharger 3 Compressor Inlet Temperature	2076
5.6	Turbocharger 3 Turbine Inlet Temperature	2082
5.6	Turbocharger 3 Turbine Outlet Temperature	2083
5.6	Turbocharger 4 Compressor Inlet Temperature	2077
5.6	Turbocharger 4 Turbine Inlet Temperature	2084
5.6	Turbocharger 4 Turbine Outlet Temperature	2085
5.8	Update Real Time Clock Command	903
5.6	Urea Injection Air Pressure	379
5.6	Urea Tank Level	377
5.9	Utility Overall Power Factor	177
5.9	Utility Total Reactive Power	176
5.9	Utility Total Real Power	175
5.5	Voltage Bias Percent Increment Command	1059
4.4	Write Access Password	700

APPENDIX C INDEX OF MODBUS REGISTERS – NUMERICAL

section	#	Parameter Name
5.1	100	Generator Average Line-Line AC RMS Voltage
5.1	101	Generator Average AC RMS Current
5.1	102	Generator Average AC RMS Frequency
5.8	103	Generator Overall Power Factor
5.8	104	Generator Overall Power Factor Lagging
5.8	105	Generator Total Percent kW
5.8	106	Generator Total Real Power
5.1	108	Generator Phase A Line-Line AC RMS Voltage
5.1	109	Generator Phase B Line-Line AC RMS Voltage
5.1	110	Generator Phase C Line-Line AC RMS Voltage
5.1	111	Generator Phase A AC RMS Current
5.1	112	Generator Phase B AC RMS Current
5.1	113	Generator Phase C AC RMS Current
5.1	114	Generator Phase A Line-Neutral AC RMS Voltage
5.1	115	Generator Phase B Line-Neutral AC RMS Voltage
5.1	116	Generator Phase C Line-Neutral AC RMS Voltage
5.8	117	Generator Phase A Real Power
5.8	119	Generator Phase B Real Power
5.8	121	Generator Phase C Real Power
5.8	123	Generator Phase A Apparent Power
5.8	125	Generator Phase B Apparent Power
5.8	127	Generator Phase C Apparent Power
5.8	129	Generator Phase A Reactive Power
5.8	131	Generator Phase B Reactive Power
5.8	133	Generator Phase C Reactive Power
5.8	135	Generator Phase A Power Factor
5.8	136	Generator Phase B Power Factor
5.8	137	Generator Phase C Power Factor
5.8	138	Generator Total Apparent Power
5.8	140	Generator Total Percent Apparent Power
5.8	141	Generator Total Reactive Power
5.8	143	Generator Total Percent Reactive Power
5.8	144	Generator Total Real Energy Exported

section	#	Parameter Name
5.8	146	Generator Total Reactive Energy Exported
5.1	148	Generator Average Line-Neutral AC RMS Voltage
5.3	149	Generator Front Bearing Temperature from Data Link
5.3	150	Generator Rear Bearing Temperature from Data Link
5.3	151	Generator Phase A Winding Temperature from Data Link
5.3	152	Generator Phase B Winding Temperature from Data Link
5.3	153	Generator Phase C Winding Temperature from Data Link
5.8	159	Generator Phase A Power Factor Lagging
5.8	160	Generator Phase B Power Factor Lagging
5.8	161	Generator Phase C Power Factor Lagging
5.3	162	Generator Rear Bearing Temperature from I/O Pin
5.1	163	Generator Average Line-Line AC RMS Voltage Percent
5.4	164	Bus Average Line-Line AC RMS Voltage
5.4	165	Bus Average AC RMS Frequency
5.4	166	Bus Phase A Line-Line AC RMS Voltage
5.4	167	Bus Phase B Line-Line AC RMS Voltage
5.4	168	Bus Phase C Line-Line AC RMS Voltage
5.4	169	Bus Phase A Line-Neutral AC RMS Voltage
5.4	170	Bus Phase B Line-Neutral AC RMS Voltage
5.4	171	Bus Phase C Line-Neutral AC RMS Voltage
5.4	172	Bus Average Line-Neutral AC RMS Voltage
5.4	173	Bus Average Line-Line AC RMS Voltage Percent
5.1	174	Generator Total Percent Current
5.9	175	Utility Total Real Power
5.9	176	Utility Total Reactive Power
5.9	177	Utility Overall Power Factor
5.5	178	Generator Desired Power Factor
5.5	179	Desired Base Load
5.5	181	Load Share Line Total Percent kW

section	#	Parameter Name
5.5	182	Load Share Line Total Percent kVAr
5.1	183	Generator Average AC RMS Frequency Percent
5.6	198	Fuel Level
5.6	199	Engine Oil Temperature
5.6	200	Engine Oil Pressure
5.6	201	Engine Coolant Temperature
5.3	202	Battery Voltage
5.6	203	Engine rpm
5.8	204	Engine Operating Hours
5.5	206	Automatic Start/Stop State
5.12	207	Spare Analog Input Percent
5.12	208	Spare Analog Input Temperature
5.12	209	Spare Analog Input Pressure
5.8	210	Service Maintenance Interval Hours Remaining
5.8	212	Service Maintenance Interval Days Remaining
5.8	213	Number of Crank Attempts
5.8	215	Number of Successful Starts
5.6	217	Engine Oil Pressure from Data Link
5.6	219	Engine Coolant Temperature from Data Link
5.6	221	Cylinder #1 Exhaust Port Temperature from Data Link
5.6	222	Cylinder #2 Exhaust Port Temperature from Data Link
5.6	223	Cylinder #3 Exhaust Port Temperature from Data Link
5.6	224	Cylinder #4 Exhaust Port Temperature from Data Link
5.6	225	Cylinder #5 Exhaust Port Temperature from Data Link
5.6	226	Cylinder #6 Exhaust Port Temperature from Data Link
5.6	227	Cylinder #7 Exhaust Port Temperature from Data Link
5.6	228	Cylinder #8 Exhaust Port Temperature from Data Link
5.6	229	Cylinder #9 Exhaust Port Temperature from Data Link
5.6	230	Cylinder #10 Exhaust Port Temperature from Data Link
5.6	231	Cylinder #11 Exhaust Port Temperature from Data Link
5.6	232	Cylinder #12 Exhaust Port Temperature from Data Link
5.6	233	Cylinder #13 Exhaust Port Temperature from Data Link

section	#	Parameter Name
5.6	234	Cylinder #14 Exhaust Port Temperature from Data Link
5.6	235	Cylinder #15 Exhaust Port Temperature from Data Link
5.6	236	Cylinder #16 Exhaust Port Temperature from Data Link
5.6	237	Cylinder #17 Exhaust Port Temperature from Data Link
5.6	238	Cylinder #18 Exhaust Port Temperature from Data Link
5.6	239	Cylinder #19 Exhaust Port Temperature from Data Link
5.6	240	Cylinder #20 Exhaust Port Temperature from Data Link
5.6	241	Exhaust Manifold #1 (Left) Temperature from Data Link
5.6	242	Exhaust Manifold #2 (Right) Temperature from Data Link
5.6	243	Intake Manifold #1 Temperature from Data Link
5.6	244	Intake Manifold #2 Temperature from Data Link
5.6	245	Engine Oil Temperature from Data Link
5.6	246	Engine Fuel Temperature from Data Link
5.6	247	Fuel Pressure from Data Link
5.6	248	Crankcase Pressure from Data Link
5.6	249	Boost Pressure from Data Link
5.6	251	Oil Filter Differential Pressure from Data Link
5.6	252	Fuel Filter Differential Pressure from Data Link
5.6	253	Air Filter 1 Differential Pressure from Data Link
5.6	256	Instantaneous Fuel Consumption from Data Link
5.6	257	Atmospheric Pressure from Data Link
5.6	258	Fuel Level
5.8	299	Service Maintenance Interval Weeks Remaining
5.5	300	Bypass Cooldown
5.5	301	Engine Control Switch Position
5.5	302	Engine Control Switch Command
5.11	303	Lamp Test Command
5.7	304	Acknowledge All Events Command
5.5	307	Auto Start/Stop Fuel Control Enabled
4.4	310	Key Press
5.5	319	SCR System Check Required Status

section	#	Parameter Name
5.5	321	Fuel Unload Pump Active
5.5	322	Fuel Load Pump Active
5.7	334	System Event Count
5.7	335	System Event Lamp Status
5.5	337	Forced Idle Command Active
5.3	338	Generator Excitation Field Voltage from Data Link
5.3	340	Generator Excitation Field Current from Data Link
5.7	342	RS-485 Ann Alarm Group 1 Column 1
5.7	343	RS-485 Ann Alarm Group 1 Column 2
5.7	344	RS-485 Ann Alarm Group 1 Horn
5.7	346	RS-485 Ann Alarm Group 2 Column 1
5.7	347	RS-485 Ann Alarm Group 2 Column 2
5.7	348	RS-485 Ann Alarm Group 2 Horn
5.7	350	RS-485 Ann Alarm Group 3 Column 1
5.7	351	RS-485 Ann Alarm Group 3 Column 2
5.7	352	RS-485 Ann Alarm Group 3 Horn
5.7	354	RS-485 Ann Alarm Group 4 Column 1
5.7	355	RS-485 Ann Alarm Group 4 Column 2
5.7	356	RS-485 Ann Alarm Group 4 Horn
5.6	377	Urea Tank Level
5.6	378	Aftertreatment #1 SCR Catalyst Reagent Tank #1 Temperature
5.6	379	Urea Injection Air Pressure
5.6	381	Catalyst Intake Temperature
5.6	382	Aftertreatment 1 SCR Catalyst Exhaust Gas Differential Pressure
5.12	600	Digital Input #1 Active Status
5.12	601	Digital Input #2 Active Status
5.12	602	Digital Input #3 Active Status
5.12	603	Digital Input #4 Active Status
5.12	604	Digital Input #5 Active Status
5.12	605	Digital Input #6 Active Status
5.12	606	Digital Input #7 Active Status
5.12	607	Digital Input #8 Active Status
5.12	608	Isolated Digital Input #1 Active Status
5.12	609	Isolated Digital Input #2 Active Status

section	#	Parameter Name
5.12	610	Isolated Digital Input #3 Active Status
5.12	611	Isolated Digital Input #4 Active Status
5.5	612	Dedicated Digital Input #1 (E-Stop) Active Status
5.5	613	Dedicated Digital Input #2 (Initiate Command) Active Status
5.5	614	Dedicated Digital Input #3 (Gen CB Aux A) Active Status
5.5	615	Dedicated Digital Input #4 (Gen CB Aux B) Active Status
5.12	616	Relay Output #1 Active Status
5.12	617	Relay Output #2 Active Status
5.12	618	Relay Output #3 Active Status
5.12	619	Relay Output #4 Active Status
5.12	620	Relay Output #5 Active Status
5.12	621	Relay Output #6 Active Status
5.12	622	Relay Output #7 Active Status
5.12	623	Relay Output #8 Active Status
5.12	624	Digital Output #1 Active Status
5.12	625	Digital Output #2 Active Status
5.12	626	Digital Output #3 Active Status
5.12	627	Digital Output #4 Active Status
5.12	628	Digital Output #5 Active Status
5.12	629	Digital Output #6 Active Status
5.12	630	Digital Output #7 Active Status
5.12	631	Digital Output #8 Active Status
5.12	632	Digital Output #9 Active Status
5.12	633	Digital Output #10 Active Status
5.12	634	Digital Output #11 Active Status
5.12	635	Digital Output #12 Active Status
5.12	636	Digital Output #13 Active Status
5.12	637	Digital Output #14 Active Status
5.12	638	Digital Output #15 Active Status
5.12	639	Digital Output #16 Active Status
5.12	640	Digital Output #17 Active Status
5.5	641	Group Start Active Status (DIDI-01)
5.5	642	Bell Alarm Active Status (DIDI-02)
5.5	643	Gen CB Trip Command Active Status (DIDI-03)
5.5	644	Gen CB Close Command Active Status (DIDI-04)
5.5	645	Arbitration Relay Active Status (DDO-01)
5.5	646	Gen CB Close Active Status (DDO-02)

section	#	Parameter Name
5.5	647	Gen CB Trip Active Status (DDO-03)
5.12	648	Analog Input #1 Sensor Value
5.12	649	Analog Input #2 Sensor Value
5.12	650	Analog Input #3 Sensor Value
5.12	651	Analog Input #4 Sensor Value
5.12	652	Analog Input #1 Data Value
5.12	654	Analog Input #2 Data Value
5.12	656	Analog Input #3 Data Value
5.12	658	Analog Input #4 Data Value
5.12	660	Analog Output #1 Data Value
5.12	662	Analog Output #2 Data Value
5.12	664	Analog Output #3 Data Value
5.12	672	PWM Output #1 Data Value
5.12	674	PWM Output #2 Data Value
5.12	681	Analog Output #1 Data Command
5.12	683	Analog Output #2 Data Command
5.12	685	Analog Output #3 Data Command
5.12	687	PWM Output #1 Data Command
5.12	689	PWM Output #2 Data Command
4.4	700	Write Access Password
4.4	708	Level 1 Password
4.4	716	Level 2 Password
4.4	724	SCADA Password
4.4	732	Current Security Level
4.4	733	Set Security Level
4.4	734	Level 3 Password Phone In Prompt
5.6	800	Engine Oil Temperature from I/O Pin
5.6	801	Exhaust Temperature
5.6	802	Left Manifold Exhaust Temperature
5.6	803	Right Manifold Exhaust Temperature from I/O Pin
5.6	804	Fuel Level from I/O Pin
5.6	805	External Tank Fuel Level from I/O Pin
5.6	806	Engine Oil Level from I/O Pin
5.6	807	Engine Coolant Level from I/O Pin
5.6	809	Oil Filter Differential Pressure from I/O Pin
5.6	810	Air Filter 1 Differential Pressure from I/O Pin
5.6	811	Fuel Filter Differential Pressure from I/O Pin
5.6	812	Main Tank Urea Level from I/O Pin
5.8	900	Real Time Clock
5.8	903	Update Real Time Clock Command

section	#	Parameter Name
5.7	1033	Log Entry Index
5.7	1034	Log Entry
5.7	1048	Reset Event
5.5	1054	Cooldown Duration Remaining
5.5	1055	Remote Initiate Command
5.5	1056	Emergency Stop Command
5.5	1057	Desired Genset Output Voltage
5.5	1058	Total Voltage Bias Percent
5.5	1059	Voltage Bias Percent Increment Command
5.5	1060	Requested Engine Speed
5.5	1061	Total Speed Bias Percent
5.5	1062	Speed Bias Percent Increment Command
5.5	1064	Generator/Bus Phase Difference
5.5	1065	Generator Circuit Breaker Status
5.5	1067	Generator Frequency within Limits
5.5	1068	Generator Voltage within Limits
5.5	1069	Bus Voltage within Limits
5.5	1070	Bus Live Status
5.11	1090	Genset Control Online
5.11	1091	Engine Control Online
5.11	1092	Secondary Engine Control Online
5.11	1093	External I/O #1 Online
5.11	1094	External I/O #2 Online
5.11	1095	External I/O #3 Online
5.11	1096	External I/O #4 Online
5.11	1097	Digital AVR Online
5.11	1098	RTD Module Online
5.11	1099	Thermocouple #1 Online
5.11	1100	Thermocouple #2 Online
5.11	1103	SCR Module Online
5.5	1108	Sync Mode Switch State
5.5	1111	Dead Bus Arbitration State
5.5	1120	Load Sense Load Demand State
5.13	1129	Load Shed Command Active Status
5.13	1130	Load Shed Command Reset
5.11	1140	Primary Data Link Status
5.11	1141	Accessory Data Link Status
5.11	1142	RS-485 SCADA Data Link Status
5.11	1143	TCP/IP SCADA Data Link Status
5.11	1144	RS-485 Annunciator Data Link Status
5.5	1263	Low Idle State from ADEM

section	#	Parameter Name
5.7	1275	Engine Protection has Shut Down Engine
5.11	1276	Control Serial Number
5.10	1487	Programmable Cycle Timer 1 Output 3 Status
5.10	1488	Programmable Cycle Timer 2 Output 3 Status
5.10	1489	Programmable Cycle Timer 3 Output 3 Status
5.10	1490	Programmable Cycle Timer 4 Output 3 Status
5.10	1491	Programmable Cycle Timer 5 Output 3 Status
5.10	1492	Programmable Cycle Timer 6 Output 3 Status
5.10	1493	Programmable Cycle Timer 7 Output 3 Status
5.7	1498	Event Log Module Selection
5.7	1499	Event Log Module Selection
5.7	1500	Module Event Log Entry 1
5.7	1514	Module Event Log Entry 2
5.7	1528	Module Event Log Entry 3
5.7	1542	Module Event Log Entry 4
5.7	1556	Module Event Log Entry 5
5.7	1570	Module Event Log Entry 6
5.7	1584	Module Event Log Entry 7
5.7	1598	Module Event Log Entry 8
5.7	1612	Module Event Log Entry 9
5.7	1626	Module Event Log Entry 10
5.7	1640	Module Event Log Entry 11
5.7	1654	Module Event Log Entry 12
5.7	1668	Module Event Log Entry 13
5.7	1682	Module Event Log Entry 14
5.7	1696	Module Event Log Entry 15
5.7	1710	Module Event Log Entry 16
5.7	1724	Module Event Log Entry 17
5.7	1738	Module Event Log Entry 18
5.7	1752	Module Event Log Entry 19
5.7	1766	Module Event Log Entry 20
5.7	1780	Module Event Log Entry 21
5.7	1794	Module Event Log Entry 22
5.7	1808	Module Event Log Entry 23
5.7	1822	Module Event Log Entry 24
5.7	1836	Module Event Log Entry 25
5.7	1850	Module Event Log Entry 26
5.7	1864	Module Event Log Entry 27

section	#	Parameter Name
5.7	1878	Module Event Log Entry 28
5.7	1892	Module Event Log Entry 29
5.7	1906	Module Event Log Entry 30
5.7	1920	Module Event Log Entry 31
5.7	1934	Module Event Log Entry 32
5.7	1948	Module Event Log Entry 33
5.7	1962	Module Event Log Entry 34
5.7	1976	Module Event Log Entry 35
5.7	1990	Module Event Log Entry 36
5.7	2004	Module Event Log Entry 37
5.7	2018	Module Event Log Entry 38
5.7	2032	Module Event Log Entry 39
5.7	2046	Module Event Log Entry 40
5.10	2060	Programmable Cycle Timer 1 Output 1 Status
5.10	2061	Programmable Cycle Timer 2 Output 1 Status
5.10	2062	Programmable Cycle Timer 3 Output 1 Status
5.10	2063	Programmable Cycle Timer 4 Output 1 Status
5.10	2064	Programmable Cycle Timer 5 Output 1 Status
5.10	2065	Programmable Cycle Timer 6 Output 1 Status
5.10	2066	Programmable Cycle Timer 7 Output 1 Status
5.10	2067	Programmable Cycle Timer 1 Output 2 Status
5.10	2068	Programmable Cycle Timer 2 Output 2 Status
5.10	2069	Programmable Cycle Timer 3 Output 2 Status
5.10	2070	Programmable Cycle Timer 4 Output 2 Status
5.10	2071	Programmable Cycle Timer 5 Output 2 Status
5.10	2072	Programmable Cycle Timer 6 Output 2 Status
5.10	2073	Programmable Cycle Timer 7 Output 2 Status
5.6	2074	Turbocharger 1 Compressor Inlet Temperature
5.6	2075	Turbocharger 2 Compressor Inlet Temperature
5.6	2076	Turbocharger 3 Compressor Inlet Temperature
5.6	2077	Turbocharger 4 Compressor Inlet Temperature
5.6	2078	Turbocharger 1 Turbine Inlet Temperature

section	#	Parameter Name
5.6	2079	Turbocharger 1 Turbine Outlet Temperature
5.6	2080	Turbocharger 2 Turbine Inlet Temperature
5.6	2081	Turbocharger 2 Turbine Outlet Temperature
5.6	2082	Turbocharger 3 Turbine Inlet Temperature
5.6	2083	Turbocharger 3 Turbine Outlet Temperature
5.6	2084	Turbocharger 4 Turbine Inlet Temperature
5.6	2085	Turbocharger 4 Turbine Outlet Temperature
5.6	2086	Exhaust Temperature from Data Link
5.5	2087	Fuel Pump Primer Status
5.5	2091	Manual Fuel Priming Duration Remaining
5.11	2188	Software Build Version
5.12	2232	Digital Output #1 Command
5.12	2233	Digital Output #2 Command
5.12	2234	Digital Output #3 Command
5.12	2235	Digital Output #4 Command
5.12	2236	Digital Output #5 Command

section	#	Parameter Name
5.12	2237	Digital Output #6 Command
5.12	2238	Digital Output #7 Command
5.12	2239	Digital Output #8 Command
5.12	2240	Digital Output #9 Command
5.12	2241	Digital Output #10 Command
5.12	2242	Digital Output #11 Command
5.12	2243	Digital Output #12 Command
5.12	2244	Digital Output #13 Command
5.12	2245	Digital Output #14 Command
5.12	2246	Digital Output #15 Command
5.12	2247	Digital Output #16 Command
5.12	2248	Digital Output #17 Command
5.12	2252	Relay Output #1 Command
5.12	2253	Relay Output #2 Command
5.12	2254	Relay Output #3 Command
5.12	2255	Relay Output #4 Command
5.12	2256	Relay Output #5 Command
5.12	2257	Relay Output #6 Command
5.12	2258	Relay Output #7 Command
5.12	2259	Relay Output #8 Command

