Powering Business Worldwide

TSM-900 Modbus Communications Guide

Rev 0.5

Instructional Booklet

Description ***Page***

1. Introduction

This document is to be used as a reference to communicate with the TSM-900 Automatic Transfer Switch Controller using the Modbus protocol.

1.1 Overview

A typical Modbus network is shown in Figure 1. The network communicates using a master-slave technique. A single master device initiates all transactions, called queries, on the network. Slave devices respond to the master's queries, either by returning data or performing an action requested by the query. A query is addressed to an individual slave or broadcast to all slaves. Slave devices do not respond to a broadcast query.

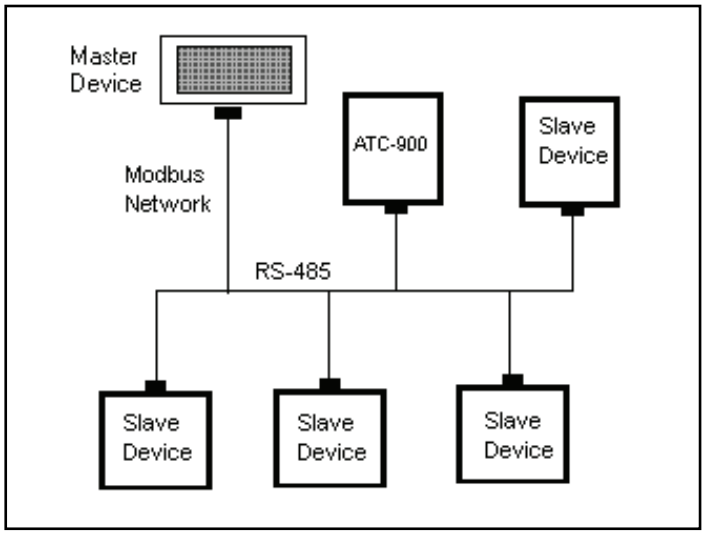

Figure 1. A Typical Modbus Network

A multi-slave device Modbus network may be implemented using a 2 wire half duplex RS 485 implementation. Various slave devices from Eaton or other Modbus compliant devices may be connected to the Modbus network. A maximum of 32 slave devices may be connected to the network at distances up to 4000 feet.

A 121 ohm terminating resistor can be added as an end of line terminator. The TSM-900 has a DIP switch on the back of the unit to switch the resistor in or out of the RS 485 receiver/transmitter circuit by the user as needed. Termination resistors are typically not needed for baud rates of 19200 and lower at distances up to 4000 feet.

The Modbus protocol specifies two transmission modes: ASCII (American Standard Code for Information Interchange) and RTU (Remote Terminal Unit). The TSM-900 will support the RTU mode of the Modbus protocol.

1.2 Definition

Character Time - The time for one character (11 bits) to be transmitted over the Modbus network at the prevailing baud rate.

CRC - Cyclical Redundancy Check.

Frame Packet - Is interchangeable with Character time.

Message Packet - A complete Modbus message made up of frame packets containing an address, function code, data field and error-checking field.

Modbus Coil - Information contained as a 1-bit quantity.

Modbus Register - Information contained as a 16-bit quantity.

Query - A Modbus message from the Modbus master to the product.

Response - A Modbus message from the product to the Modbus master.

1.3 RS-485 Connections

A 4-pin connector (J10) is provided for wiring to the RS-485 network. The following chart shows the TSM-900 J10 connector pin-out assignment.

J10	Signal
1	B (+)
2	A (-)
3	Common
4	Shield

The polarity of the A (-) and B (+) signals is very important. In the Modbus network, A (-) terminals must connect to other A (-) terminals and B (+) terminals must connect to other B (+) terminals.

Use a shielded twisted pair cable 22 AWG (0.33 mm^2) or thicker and ground the shield only at the Master device. If there is more than one Slave device cabled to the Modbus Master, tie the cable shields together but do not connect to ground at any point other than at the Master device.

Switch 1 provides a 120 ohm bus termination for the RS-485 network. In most cases, this switch should be left open. It should only be closed in cases of lengthy cable runs where communication errors are occurring (or bus analysis deems a termination is necessary), and then only if the TSM-900 is at the end of the run.

1.4 References

Modbus® is a registered trademark of Schneider Automation, Inc.

The following documents are referenced by this specification and may be necessary to properly understand this material.

02-PMP-01 "Modbus RTU Products Specification", Eaton Corp., Rev 1.02, November 2004.

PI-MBUS-300 "Modicon Modbus Protocol Reference Guide", MODICON, Inc., Industrial Automation Systems, Rev. J, June 1996. -

2. Modbus RTU Message Protocol

2.1 Modbus RTU Message Protocol

The Modbus RTU protocol is based on a technique in which a single master initiates a transaction (called a query) on the network. Every slave device connected to the network receives the Modbus query. A query is broadcast to all slaves or addressed to an individual slave. Slave devices do not respond to a broadcast query. An individually addressed slave device responds to the master query by either (1) returning data requested by the query, (2) performing an action requested by the query and returning status of that action, or (3) returning an error code.

The Query-Response Cycle between a Modbus master and slave is shown in Figure 2.

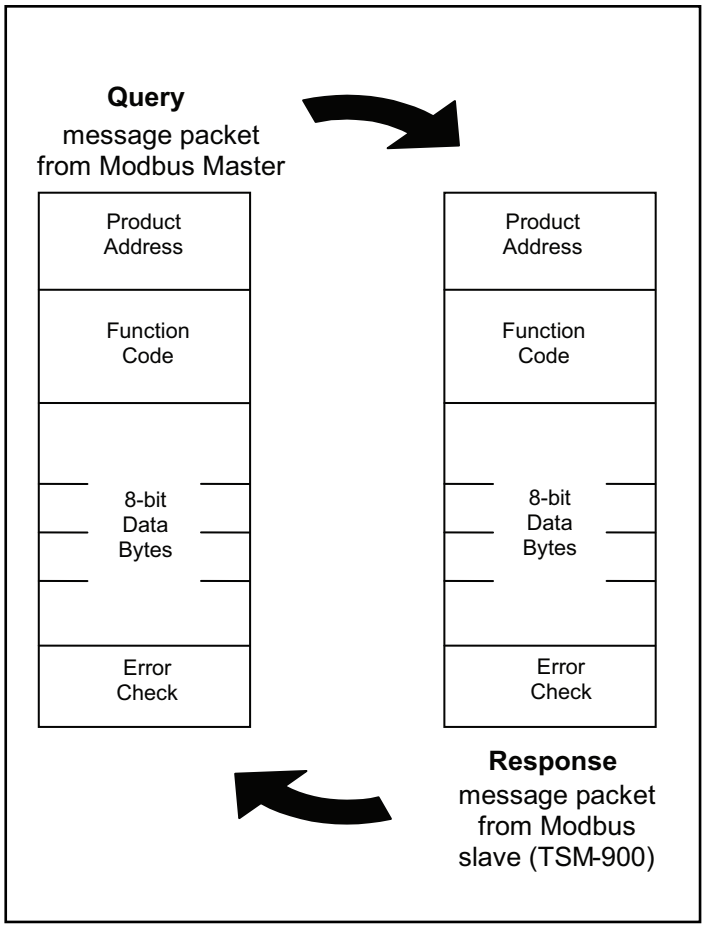

Figure 2. Modbus Master-Slave Query-Response Cycle

The address is the first byte of each Modbus transmission. Only the addressed slave device responds to a query beginning with its individual address.

The function code in the query tells the addressed slave what kind of action to perform. The data bytes contain additional information that the slave needs in order to perform the function.

For example, function code 04 queries the slave to read actual value registers and respond with the contents of those registers. The "data field" must contain the information that specifies to the slave which register to begin reading and the number of registers to read.

The "error check" field provides a method for the slave to validate the integrity of the query message contents.

The function code in a normal response from the slave is an echo of the function code from the query. The data bytes contain the information requested; i.e., register contents.

If the slave receives a query message that is in error, the function code is modified to indicate the response message is an error response. The data bytes of the response contain an exception code that describes the error.

The error check field of the response allows the master to confirm the response message contents are valid.

2.2 Modbus Message Types and Framing

The Modbus protocol defines two data exchange modes - ASCII (American Standard Code for Information Interchange) and RTU (Remote Terminal Unit). All devices (master and slaves) on a single Modbus network must communicate using the same exchange mode. ASCII transfers provide each eight-bit byte of information encoded in two ASCII characters. RTU transfers provide each eight-bit byte of information as two binary encoded four-bit hexadecimal characters.

The Eaton TSM-900 supports RTU mode. The main advantage of RTU mode is its greater character density[1], which provides for better data throughput at the same baud rate.

A RTU query or response is placed by the transmitting device into a Modbus message packet, which has a known beginning and ending point. The message packet is made up of multiple frame packets. This allows receiving devices to begin at the start of the message packet, read the address portion to determine which device is addressed[2] and to know when the message is completed. Partial messages can be detected and errors can be identified as a result.

Each RTU frame packet contains a start bit, eight data bits[3], and if parity is used, a bit for even / odd parity and one stop bit. If parity is not used, another stop bit is generally used in its place[4], thus resulting in two stop bits. Each frame packet, therefore, contains a total of 11 bits for each eight-bits of data exchanged. Each eight-bit data byte is defined as two binary encoded four-bit hexadecimal characters 0 ... 9, A ... F.

RTU message packets start with a silent interval of at least 3.5 frame packet times. This is most easily implemented as a multiple of frame packet times at the baud rate being used on the network. The silent interval between message packets is:

(3.5 frame packets) x (11 bits / frame packet) x (1 sec / baud rate).

The silent intervals for each selectable baud rate is shown in Table 1. Networked devices monitor the network bus continuously, including silent intervals.

Table 1. Silent Interval Times.

BAUD RATE (BITS / SEC)	SILENT INTERVAL (MILLISECONDS)
9600	4.01
19200	2.01

[1] Nearly twice as dense as the Modbus ASCII mode message protocol.

[2] Or if all devices are addressed in the case of a broadcast message.

[3] The least significant bit is sent first.

[4] To accommodate systems which do not incorporate a second stop bit when no parity is selected, an ideal device could be set to receive no parity and one stop bit while transmitting no parity and two stop bits.

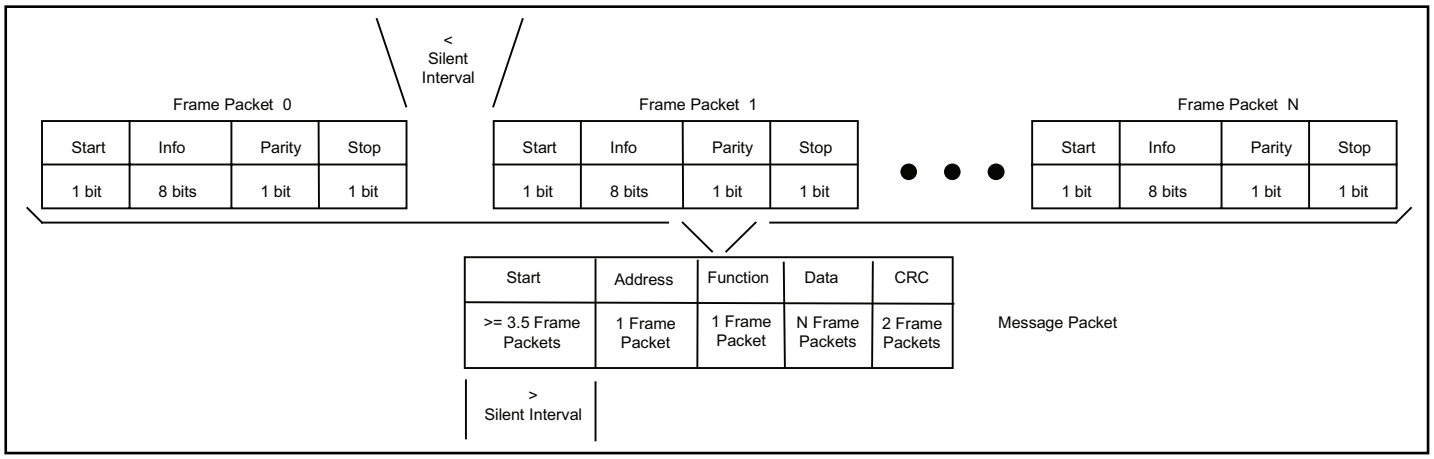

Figure 3. RTU Message Packet

Upon detecting an appropriate silent interval, all Modbus products prepare to recognize the next received byte as the address field. If the received address is the same as the address assigned to the slave, the slave receives the rest of the query from the master and responds appropriately. The slave always responds with its assigned address to the master.

The entire message packet must be transmitted as a continuous stream. If a silent interval of more than 3.5 frame times occurs before completion of the message packet, the receiving device flushes the incomplete message and assumes the next frame packet begins a new message.

If a new message begins earlier than 3.5 frame times following a previous message, the receiving device considers it a continuation of the previous message.This causes an error, as the value in the final CRC error checking field is not valid for the combined messages.

A slave device will not respond to message packets in which a computed CRC doesn't match the received CRC. A typical message packet is shown in Figure 3.

2.3 Device Addressing

The first frame packet of a message contains the eight-bit address field. Valid device addresses are in the range of 1...247[5] decimal.

A master addresses a slave by placing the slave address in the address field of the message packet. When the slave sends its response, it places its own address in the address field of the response to verify to the master the correct slave is responding.

2.4 Register Addressing

All data addresses of the registers, which are transmitted in a data field's 16-bit address contents of a Modbus message, are referenced from 0 through $FFFF_{16}$ ($65{,}535_{10}$). Therefore, the address of a register is one count less than the register number. By convention, this document will present the register number in decimal and the register address in hexadecimal. Thus, Setpoint register 3001_{10} is register address $BB8_{16}$ (i.e., 3000_{10}).

2.5 Function Codes

The frame packet following the address in a message packet contains the eight-bit function code field. When sent from a master to the TSM-900, the function code field tells the TSM-900 what action to perform. Examples include reading the ON / OFF states of a group of inputs, reading the data contents of a group of registers, reading the diagnostic status of the slave or writing to designated outputs or registers. Valid function codes from the master are 1...127 decimal. The TSM-900 supports the function codes listed in Table 2.

When the TMS-900 responds to the master, it uses the function code field to indicate either a normal (error free) response or an error condition occurred (called an exception response). For a normal response, the TSM-900 performs the requested function and simply echoes the original function code in the response message.

Table 2. Function Codes.

FUNCTION CODES	ACTION	MODBUS DEFINITION	TSM-900 REGISTER GROUP
01	Read	Coil Status	Discrete outputs and Status
02	Read	Input Status	Discrete inputs
03	Read	Holding registers	Setpoints
04	Read	Input registers	Actual values
05	Write	Write single coil	Operation command
06	Write	Write single register	Setpoint / Multi-Word read configuration
08	Read/Write	Diagnostics	Diagnostic Counters
16	Write	Write multiple registers	Write Setpoints

When the TSM-900 does not perform the action associated with the function code of the message packet it returns an exception response. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to logic 1, i.e. it is defined to have a value greater than 127. For example, a message from master to TSM-900 to read a group of registers would have the following function code:

0000 0011 (Hexadecimal 03)

If the TSM-900 takes the requested action without error, it returns the same function code in its response. If an exception occurs, the requested action is not performed by the TSM-900 and it returns:

1000 0011 (Hexadecimal 83)

In addition to modifying the function code for an exception response, the TSM-900 places a unique exception code into a single byte data field of the response message. This tells the master what kind of error occurred, or the reason for the exception. Exception codes are defined in Table 50.

[5] A Modbus protocol limited range of addresses

Table 3. Default Multi-Register Fixed Point Transmission Order.

BITS 15.....8	BITS 7.....0	BITS 31.....24	BITS 23.....16	BITS 47.....40	BITS 39.....32	BITS 63.....56	BITS 55.....48
1st byte	0th byte	3rd byte	2nd byte	5th byte	4th byte	7th byte	6th byte
Register x		Register x+1		Register x+2		Register x+3	

2.6 Data Format

Each Modbus register is defined in the Modbus protocol as a 16-bit (two byte) entity. Modbus protocol defines register information to be transmitted with the high byte first, followed by the low byte.

2.7 Error-Checking Field

The error-checking field contains a 16-bit value implemented as two 8-bit bytes. The error-check value is the result of a Cyclical Redundancy Check (CRC) calculation performed on the entire contents of the message packet. Only the eight bits of data in each frame packet is applied to the CRC calculation. The start bit, parity bit and stop bits do not apply to the CRC.

The error-checking field is appended to the message packet as the last field. Opposite to data field information, the low-order byte of the CRC calculation is transmitted first, followed by the high-order byte. Thus, the high-order byte is the last byte to be sent in the message packet.

If the TSM-900 detects a CRC error, the entire message packet must be discarded. A TSM-900 detecting a CRC error in a received Modbus message does not respond to the master device.

3. Function Code Descriptions

3.1 Function Code 01 - Read Coils (Relays and Status Bits)

Function code 01 reads the ON / OFF status of various relays and status bits in the TSM-900. Table 3 shows all of the possible relay and status bits available on the controller and Accessory I/O Modules except those that are mirrors of the programmable inputs. Note that typically not all "User-Defined Output Relays" are included in a given transfer switch implementation. Unused relays will always show a value of "OFF". Similarly some status bits will not apply to all transfer switch implementations. For example status bits referencing "rotation" are not applicable to single phase systems and will always show a value of "OFF". Some Status Bits are also reflected in pre-defined and/or user-defined relays, and some pre-defined relays may also be mirrored as user-defined relays.

Table 4. Function Code 01 Relay and Status Bits Register Definitions.

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA TYPE
Source 1 Available	1000	3E7	Status/Pre/User-defined relay
Source 2 Available	1001	3E8	Status/Pre/User-defined relay
Source 1 Connected	1002	3E9	Status/User-defined relay
Source 2 Connected	1003	3EA	Status/User-defined relay
Alarm	1004	3EB	Status/User-defined relay
Transfer Test Relay	1005	3EC	Status/User-defined relay
Run-Only Test Relay	1006	3ED	Status/User-defined relay
Engine Test Aborted	1007	3EE	Status/User-defined relay
Selective Load Shed	1008	3EF	Status/User-defined relay
Load Control	1009	3F0	Status/User-defined relay
Engine Cooldown	1010	3F1	Status/User-defined relay
Source 1 External Unavailable	1011	3F2	Status
Source 1 Undervoltage	1012	3F3	Status
Source 1 Overvoltage	1013	3F4	Status
Source 1 Voltage Unbalance	1014	3F5	Status
Source 1 Phase Loss	1015	3F6	Status
Source 1 Current Unbalance	1016	3F7	Status
Source 1 Underfrequency	1017	3F8	Status
Source 1 Overfrequency	1018	3F9	Status
Source 1 Rotation Error	1019	3FA	Status
Source 1 ABC Rotation	1020	3FB	Status
Source 1 ACB Rotation	1021	3FC	Status
Source 2 External Unavailable	1022	3FD	Status
Source 2 Undervoltage	1023	3FE	Status
Source 2 Overvoltage	1024	3FF	Status
Source 2 Voltage Unbalance	1025	400	Status
Source 2 Phase Loss	1026	401	Status
Source 2 Current Unbalance	1027	402	Status
Source 2 Underfrequency	1028	403	Status
Source 2 Overfrequency	1029	404	Status
Source 2 Rotation Error	1030	405	Status
Source 2 ABC Rotation	1031	406	Status
Source 2 ACB Rotation	1032	407	Status
Single Phase	1033	408	Status (Setpoint)

Function code 01 also reads the status of the generic relays defined in Table 5, which may be mapped to the previous table's logical values. Note that Modules 1 through 4 are optional and may not be present in a given system. Also, all available outputs may not be mapped to logical outputs. Unused relays will always show a value of "OFF".

Table 5. Function Code 01 Generic Output Relay Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
Local Relay 1	1500	5DB
Local Relay 2	1501	5DC
Local Relay 3	1502	5DD
Local Relay 4	1503	5DE
Module 1 Relay 1	1504	5DF
Module 1 Relay 2	1505	5E0
Module 1 Relay 3	1506	5E1
Module 1 Relay 4	1507	5E2
Module 2 Relay 1	1508	5E3
Module 2 Relay 2	1509	5E4
Module 2 Relay 3	1510	5E5
Module 2 Relay 4	1511	5E6
Module 3 Relay 1	1512	5E7
Module 3 Relay 2	1513	5E8
Module 3 Relay 3	1514	5E9
Module 3 Relay 4	1515	5EA
Module 4 Relay 1	1516	5EB
Module 4 Relay 2	1517	5EC
Module 4 Relay 3	1518	5ED
Module 4 Relay 4	1519	5EE

The query message format for function code 01 is given in Table 6. The query specifies the starting status bit address and the quantity of status bits to be read. This example requests the Source 1 and Source 2 Available and Connected status bits.

Table 6. Read Coils (01) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	08_{16}
Function Code	01_{16}
Starting Address High Byte	03_{16}
Starting Address Low Byte	$E7_{16}$
Number of Points High Byte	00_{16}
Number of Points Low Byte	$0D_{16}$
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format for function code 01 is given in Table 7. Each status bit requested is contained in one bit of the data field. The least significant bit of the first data byte contains the status of the starting addressed status bit. Each successive status bit corresponds to the next significant bit in the data field. If the number of status bits to be returned is not a byte (8-bit) multiple, the remaining unused bits in the last data byte are set to logical zeros. The Byte Count field contains the number of data bytes being returned. A logical one indicates the ON condition while a logical zero indicates the OFF condition.

Table 7. Read Coils (01) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	08_{16}
Function Code	01_{16}
Byte Count	02_{16}
Data from Status Bits at X (e.g. 1000_{10} through 1003_{10})	03_{16}
Data from Status Bits at X+8	01_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.2 Function Code 02 - Read Discrete Inputs (Programmable Inputs Status)

Function code 02 reads the ON / OFF status of the programmable inputs in the TSM-900. "ON" means that the particular input feature is active, regardless of the open/closed state of that input. "OFF" means that it is not active. For example, Lockout is ON/active when the associated input is Open, while Test Engine is ON/active when the associated input is Closed.

Table 8 shows all of the possible programmable inputs available on the controller and accessory I/O modules. Typically, not all programmable inputs are included in a given transfer switch implementation. Unused inputs will always show a value of "OFF".

Table 8. Function Code 02 Programmable Input Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
S1 Available	2000	7CF
S2 Available	2001	7D0
On Bypass	2002	7D1
Bypass Aux S1 Switch	2003	7D2
Bypass Aux S2 Switch	2004	7D3
Gen Start	2005	7D4
Door Open	2006	7D5
General Alarm	2007	7D6
ATS Not In Auto	2008	7D7
Lockout	2009	7D8
Manual Retransfer Enable	2010	7D9
Retransfer Request	2011	7DA
Go To Emergency	2012	7DB
Emergency Inhibit	2013	7DC
Go To Neutral	2014	7DD
Bypass Timers	2015	7DE
Engine Test	2016	7DF
Engine Test Mode	2017	7E0
Test Status	2018	7E1

Function code 2 also reads the status of the generic inputs defined in Table 9, which may be mapped to the previous table's logical values. A Logic 1 indicates that the input is Open while a logic 0 indicates that the input is closed. Note that Modules 1 through 4 are optional and may not be present in a given system. Also all available inputs may not be mapped to logical inputs. Any inputs not mapped to logical inputs will show the actual state of the input, while the inputs for modules which are not present will always show a value of "OFF".

Table 9. Function Code 02 Generic Input Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)
Contact 1	2500	9C3
Contact 2	2501	9C4
Contact 3	2502	9C5
Contact 4	2503	9C6
Module 1 Contact 1	2504	9C7
Module 1 Contact 2	2505	9C8
Module 1 Contact 3	2506	9C9
Module 1 Contact 4	2507	9CA
Module 2 Contact 1	2508	9CB
Module 2 Contact 2	2509	9CC
Module 2 Contact 3	2510	9CD
Module 2 Contact 4	2511	9CE
Module 3 Contact 1	2512	9CF
Module 3 Contact 2	2513	9D0
Module 3 Contact 3	2514	9D1
Module 3 Contact 4	2515	9D2
Module 4 Contact 1	2516	9D3
Module 4 Contact 2	2517	9D4
Module 4 Contact 3	2518	9D5
Module 4 Contact 4	2519	9D6

The query message format for function code 02 is given in Table 10. The query specifies the starting address (which is always one less than the starting register number) and the quantity of binary inputs to be read.

Table 10. Read Input Status (02) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	34_{16}
Function Code	02_{16}
Starting Address High Byte	07_{16}
Starting Address Low Byte	$D0_{16}$
Number of Points High Byte	00_{16}
Number of Points Low Byte	03_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format for function code 02 is given in Table 11. Each binary input status requested is contained in one bit of the data field. The least significant bit of the first data byte contains the input status of the starting addressed input. Each successive input status bit corresponds to the next significant bit in the data field. If the number of inputs to be returned is not a byte (8-bit) multiple, the remaining unused bits in the last data byte are set to logical zeroes. The Byte Count field contains the number of data bytes being returned. A logical one indicates the ON condition while a logical zero indicates the OFF condition.

Table 11. Read Input Status (02) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	34_{16}
Function Code	02_{16}
Byte Count	01_{16}
Data from Status Bits at X (e.g. 2000_{10} through 2003_{10})	01_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.3 Function Code 03 - Read Holding Registers (Setpoints)

Function code 03, Read Holding Registers, is used to read the setpoints registers.

Setpoints registers have been reserved to hold configuration information parameters that are programmable. Setpoints information starts at register number 3000 (i.e., holding register address $BB7_{16}$)

Setpoints Notes:

1. For various functional reasons in the controller, setpoints are broken up into six groups. The six groups of setpoints and their corresponding register numbers/addresses are defined in Table 12 through Table 17. This grouping has no effect on reading setpoints via Modbus.
2. Several setpoints are repeated as "Read Only" setpoints in various groups. This does not affect reading of these setpoints, but does affect writing (Function codes 6 and 16).
3. Many setpoints are packed two to a register. These are shown in the following tables as two setpoints with the same register number/address and HOB or LOB. These are best understood in hexadecimal format where HOB indicates the upper eight bits and LOB indicates the lower eight bits of the 16-bit register. For example Group 0, register 8 is "Number of Generators and Number of Phases". A typical value for this register is 103_{16} meaning 1 generator and 3 phases. The register value in base 10 is 259.

   To convert one of these dual setpoint registers from base 10, divide the register value by 256. The answer without the decimal is the HOB setpoint value. Multiply this answer by 256 and subtract it from the original register value to determine the LOB setpoint value t.

   Again using the example above starting with a value of 259:

   259 ÷ 256 = 1.0117, so the "Number of Generators" is 1

   259 - (1 * 256) = 3, so the "Number of Phases" is 3
4. 4.The TSM-900 only supports fixed point values, thus the scale factor indicates what a decimal value has been multiplied by prior to sending out via Modbus. For example, the various frequency values have a scale factor of 10. A typical reading may be 601, which is 60.1 Hz.
5. Setpoints are written using function code 6 or 16 (10_{16}) as described in sections 3.6 and 3.8.

Table 12. Function Code 03 Group 0 Setpoints Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Language	3000 HOB	BB7 HOB	0 = English	-	-
Style (Read-Only)	3000 LOB	BB7 LOB	1 = TSM-900	-	-
CT Wiring Invert	3001 HOB	BB8 HOB	0 = Normal, 1 = Invert	-	-
Sign Convention	3001 LOB	BB8 LOB	0 = IEEE, 1 = IEEE Alternate	-	-
Line Frequency	3002	BB9	50 or 60	1	Hz
PT Ratio	3003	BBA	0 = None, 20 to 5000	10	-
CT Ratio	3004	BBB	0 = None, 100 to 5000	1	-
NTP Synchronization	3005 HOB	BBC HOB	0 = Disabled, 1 = Enabled	-	-
Auto Clock DST Adjust	3005 LOB	BBC LOB	0 = Disabled, 1 = Enabled	-	-
Time Zone Offset	3006	BBD	-760 to + 840	-	Mins.
System Voltage	3007	BBE	115 (50 Hz) or 120 (60 Hz) to 600	1	V
Sequence Check	3008 HOB	BBF HOB	0 = Off, 1 = ABC, 2 = ACB	-	-
Number of Phases	3008 LOB	BBF LOB	1 or 3	-	-
Modbus Comm. Settings	3009 HOB	BC0 HOB	Baud Rate, Stop Bits, Parity 0 = 9600 bps, 1, Even 1 = 9600 bps, 1, Odd 2 = 9600 bps, 2, None 3 = 9600 bps, 1, None 4 = 19200 bps, 1, Even 5 = 19200 bps, 1, Odd 6 = 19200 bps, 2, None 7 = 19200 bps, 1, None 8 = Disabled	-	-
Modbus Address	3009 LOB	BC0 LOB	1 - 247	-	-

Table 13. Function Code 03 Group 1 Setpoints Register Definitions.

Name	Register Number (decimal)	Register Address (hex)	Data Range	Scale Factor	Units
Line-to-Ground voltage display	3010	BC1	0 = Disabled, 1 = Enabled	-	-
Datalogging Interval	3011	BC2	1 to 120	-	Mins

Table 14. Function Code 03 Group 2 Setpoints Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
reserved for future use	3023	BCE	See Setpoints Group 0	1	Sec.

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Table 15. Function Code 03 Group 3 Setpoints Register Definitions

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
System Voltage (Read-Only)	3012	BC3	See Setpoints Group 0	-	-
System Frequency (Read-Only)	3013	BC4	See Setpoints Group 0	-	-
Source 1 Undervoltage Dropout	3014	BC5	0 = disable,70% to 97% of System Voltage	1	V
Source 2 Undervoltage Dropout	3015	BC6	0 = disable,70% to 97% of System Voltage	1	V
Source 2 % UV Dropout (Read-Only)	3016 HOB	BC7 HOB	0, 70 to 97	1	%
Source 1 % UV Dropout (Read-Only)	3016 LOB	BC7 LOB	0, 70 to 97	1	%
Source 1 Undervoltage Pickup	3017	BC8	0 = disable, (dropout + 2%) to 99% of System Voltage	1	V
Source 2 Undervoltage Pickup	3018	BC9	0 = disable, (dropout + 2%) to 99% of System Voltage	1	V

Table 15. Function Code 03 Group 3 Setpoints Register Definitions (Continued).

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Source 2 % UV Pickup (Read-Only)	3019 HOB	BCA HOB	0, (dropout% + 2) to 99	1	%
Source 1 % UV Pickup (Read-Only)	3019 LOB	BCA LOB	0, (dropout% + 2) to 99	1	%
Source 1 Overvoltage Dropout	3020	BCB	0 = disable, 105% to 120% of System Voltage	1	V
Source 2 Overvoltage Dropout	3021	BCC	0 = disable, 105% to 120% of System Voltage	1	V
Source 2 % OV Dropout (Read-Only)	3022 HOB	BCD HOB	0, 105 to 120	1	%
Source 1 % OV Dropout (Read-Only)	3022 LOB	BCD LOB	0, 105 to 120	1	%
Source 1 Overvoltage Pickup	3023	BCE	0 = disable, 103% to (dropout - 2%) of System Voltage	1	V
Source 2 Overvoltage Pickup	3024	BCF	0 = disable, 103% to (dropout - 2%) of System Voltage	1	V
Source 2 % OV Pickup (Read-Only)	3025 HOB	BD0 HOB	0, 103 to (dropout% – 2)	1	%
Source 1 % OV Pickup (Read-Only)	3025 LOB	BD0 LOB	0, 103 to (dropout% – 2)	1	%
Source 1 Underfrequency Dropout	3026	BD1	0 = Disable, 90% to 97% of Line Frequency	10	Hz
Source 2 Underfrequency Dropout	3027	BD2	0 = Disable, 90% to 97% of Line Frequency	10	Hz
Source 1 % Underfrequency Dropout (Read-Only)	3028	BD3	0, 90 to 97	1	%
Source 2 % Underfrequency Dropout (Read-Only)	3029	BD4	0, 90 to 97	1	%
Source 1 Underfrequency Pickup	3030	BD5	0 = Disable, (dropout + 10) to 99% of Line Frequency	10	Hz
Source 2 Underfrequency Pickup	3031	BD6	0 = Disable, (dropout + 10) to 99% of Line Frequency	10	Hz
Source 1 % Underfrequency Pickup (Read-Only)	3032	BD7	0 = Disable, (dropout% + 1) to 99	1	%
Source 2 % Underfrequency Pickup (Read-Only)	3033	BD8	0 = Disable, (dropout% + 1) to 99	1	%
Source 1 Overfrequency Dropout	3034	BD9	0 = Disable, 103% to 110% of Line Frequency	10	Hz
Source 2 Overfrequency Dropout	3035	BDA	0 = Disable, 103% to 110% of Line Frequency	10	Hz
Source 1 % Overfrequency Dropout (Read-Only)	3036	BDB	0, 103 to 110	1	%
Source 2 % Overfrequency Dropout (Read-Only)	3037	BDC	0, 103 to 110	1	%
Source 1 Overfrequency Pickup	3038	BDD	0 = Disable, 101% of Line Frequency to (dropout - 10)	10	Hz
Source 2 Overfrequency Pickup	3039	BDE	0 = Disable, 101% of Line Frequency to (dropout - 10)	10	Hz
Source 1 % Overfrequency Pickup (Read-Only)	3040	BDF	0, 101 to (dropout% - 1)	1	%
Source 2 % Overfrequency Pickup (Read-Only)	3041	BE0	0, 101 to (dropout% - 1)	1	%
Source 2 Voltage Unbalance Dropout %	3042 HOB	BE1 HOB	0 = disable, 5 to 20	1	%
Source 1 Voltage Unbalance Dropout %	3042 LOB	BE1 LOB	0 = disable, 5 to 20	1	%
Source 2 Voltage Unbalance Pickup %	3043 HOB	BE2 HOB	0 = disable, 3 to (dropout - 2)	1	%
Source 1 Voltage Unbalance Pickup %	3043 LOB	BE2 LOB	0 = disable, 3 to (dropout - 2)	1	%
Source 2 Voltage Phase Loss Dropout %	3044 HOB	BE3 HOB	0 = disable, 20 to 60	1	%
Source 1 Voltage Phase Loss Dropout %	3044 LOB	BE3 LOB	0 = disable, 20 to 60	1	%
Source 2 Voltage Phase Loss Pickup %	3045 HOB	BE4 HOB	0 = disable, 18 to (dropout - 2)	1	%
Source 1 Voltage Phase Loss Pickup %	3045 LOB	BE4 LOB	0 = disable, 18 to (dropout - 2)	1	%
Current Unbalance/Phase Loss Dropout %	3046 LOB	BE5 LOB	0 = disable, 5 to 60	1	%
Current Unbalance/Phase Loss Enable %	3046 HOB	BE5 HOB	1 to 100 (% of maximum load current)	1	%
Current Unbalance/Phase Loss Pickup %	3047	BE6	0 = disable, 3 to (dropout - 2)	1	%
Negative Sequence Time Delay	3048	BE7	10 to 30	1	Sec.

Table 16. Function Code 03 Group 4 Setpoints Register Definitions

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Plant Exerciser 2 Test Mode	3049 HOB	BE8 HOB	0 = Disabled 1 = Run Unloaded, 2 = Run Loaded	-	-
Plant Exerciser 1 Test Mode	3049 LOB	BE8 LOB	0 = Disabled 1 = Run Unloaded, 2 = Run Loaded	-	-
Engine Test Mode	3050	BE9	0 = Disabled 1 = Run Unloaded, 2 = Run Loaded	-	-
Engine Test Relays Config.	3051	BEA	0 = Transfer relay only for transfers 1 = Both relays for transfers	-	-
Plant Exerciser 1 Duration Timer	3052	BEB	0 to 600	1	Min.
Plant Exerciser 2 Duration Timer	3053	BEC	0 to 600	1	Min.
Engine Run Timer	3054	BED	0 to 600	1	Min.
Time Delay, Emergency Fail	3055	BEE	0 to 6	1	Sec.
Time Delay, Engine Cooldown	3056	BEF	0 to 9,999	1	Sec.
Time Delay, Normal to Emergency	3057	BF0	0 to 9,999	1	Sec.
Time Delay, Emergency to Normal	3058	BF1	0 to 9,999	1	Sec.
Plant Exerciser 1 Schedule Mode	3059	BF2	0=daily, 1=weekly, 2=14-day, 3=28-day, 4=dates	-	-
Plant Exerciser 1 Month 1	3060 HOB	BF3 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 1	3060 LOB	BF3 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 2	3061 HOB	BF4 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 2	3061 LOB	BF4 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 3	3062 HOB	BF5 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 3	3062 LOB	BF5 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 4	3063 HOB	BF6 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 4	3063 LOB	BF6 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 5	3064 HOB	BF7 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 5	3064 LOB	BF7 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 6	3065 HOB	BF8 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 6	3065 LOB	BF8 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 7	3066 HOB	BF9 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 7	3066 LOB	BF9 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 8	3067 HOB	BFA HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 8	3067 LOB	BFA LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 9	3068 HOB	BFB HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 9	3068 LOB	BFB LOB	1 to 28, 30, or 31 (month dependent)	-	-

Table 16. Function Code 03 Group 4 Setpoints Register Definitions (Continued).

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Plant Exerciser 1 Month 10	3069 HOB	BFC HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 10	3069 LOB	BFC LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 11	3070 HOB	BFD HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 11	3070 LOB	BFD LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 12	3071 HOB	BFE HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 12	3071 LOB	BFE LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Hour	3072 HOB	BFF HOB	0 to 23	-	-
Plant Exerciser 1 Minute	3072 LOB	BFF LOB	0 to 59	-	-
Plant Exerciser 1 Day	3073	C00	1 = Sunday to 7 = Saturday	-	-
Plant Exerciser 2 Schedule Mode	3074	C01	0=daily, 1=weekly, 2=14-day, 3=28-day, 4=dates	-	-
Plant Exerciser 2 Month 1	3075 HOB	C02 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 1	3075 LOB	C02 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 2	3076 HOB	C03 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 2	3076 LOB	C03 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 3	3077 HOB	C04 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 3	3077 LOB	C04 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 4	3078 HOB	C05 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 4	3078 LOB	C05 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 5	3079 HOB	C06 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 5	3079 LOB	C06 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 6	3080 HOB	C07 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 6	3080 LOB	C07 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 7	3081 HOB	C08 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 7	3081 LOB	C08 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 8	3082 HOB	C09 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 8	3082 LOB	C09 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 9	3083 HOB	C0A HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 9	3083 LOB	C0A LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 10	3084 HOB	C0B HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 10	3084 LOB	C0B LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 11	3085 HOB	C0C HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 11	3085 LOB	C0C LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 12	3086 HOB	C0D HOB	1 = January to 12 = December	-	-

Table 16. Function Code 03 Group 4 Setpoints Register Definitions (Continued).

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Plant Exerciser 2 Date 12	3086 LOB	C0D LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Hour	3087 HOB	C0E HOB	0 to 23	-	-
Plant Exerciser 2 Minute	3087 LOB	C0E LOB	0 to 59	-	-
Plant Exerciser 2 Day	3088	C0F	1 = Sunday to 7 = Saturday	-	-

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Table 17. Function Code 03 Group 5 Setpoints Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Number of Accessory I/O Modules	3089 HOB	C10 HOB	0 to 4	-	-
Style (Read-Only)	3089 LOB	C10 LOB	See Setpoints Group 0		
Selective Load Shed Limit	3090	C11	5 to 3,000	1	KW
Local Programmable Inputs Factory Lock (Read-Only)	3091	C12	0 to 15	-	-
Accessory I/O Module Programmable Inputs Factory Lock (Read-Only)	3092	C13	0 – 65,535	-	-
Local Programmable Outputs Factory Lock (Read-Only)	3093	C14	0 to 15	-	-
Accessory I/O Module Programmable Outputs Factory Lock (Read-Only)	3094	C15	0 – 65,535	-	-
Selective Load Restore Limit	3095	C16	1 to (Selective Load Shed – 1)	1	KW
Local Input 1 Mapping	3096	C17		-	-
Local Input 2 Mapping	3097	C18		-	-
Local Input 3 Mapping	3098	C19		-	-
Local Input 4 Mapping	3099	C1A		-	-
Local Output 2 Mapping	3100 HOB	C1B HOB			
Local Output 1 Mapping	3100 LOB	C1B LOB		-	-
Local Output 4 Mapping	3101 HOB	C1C HOB		-	-
Local Output 3 Mapping	3101 LOB	C1C LOB		-	-
Module 1 Input 1 Mapping	3102	C1D		-	-
Module 1 Input 2 Mapping	3103	C1E		-	-
Module 1 Input 3 Mapping	3104	C1F		-	-
Module 1 Input 4 Mapping	3105	C20		-	-
Module 1 Output 2 Mapping	3106 HOB	C21 HOB		-	-
Module 1 Output 1 Mapping	3106 LOB	C21 LOB		-	-
Module 1 Output 4 Mapping	3107 HOB	C22 HOB		-	-
Module 1 Output 3 Mapping	3107 LOB	C22 LOB		-	-
Module 2 Input 1 Mapping	3108	C23		-	-
Module 2 Input 2 Mapping	3109	C24		-	-
Module 2 Input 3 Mapping	3110	C25		-	-
Module 2 Input 4 Mapping	3111	C26		-	-
Module 2 Output 2 Mapping	3112 HOB	C27 HOB		-	-
Module 2 Output 1 Mapping	3112 LOB	C27 LOB		-	-
Module 2 Output 4 Mapping	3113 HOB	C28 HOB		-	-
Module 2 Output 3 Mapping	3113 LOB	C28 LOB		-	-
Module 3 Input 1 Mapping	3114	C29		-	-
Module 3 Input 2 Mapping	3115	C2A		-	-

Table 17. Function Code 03 Group 5 Setpoints Register Definitions (Continued).

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Module 3 Input 3 Mapping	3116	C2B		-	-
Module 3 Input 4 Mapping	3117	C2C		-	-
Module 3 Output 2 Mapping	3118 HOB	C2D HOB		-	-
Module 3 Output 1 Mapping	3118 LOB	C2D LOB		-	-
Module 3 Output 4 Mapping	3119 HOB	C2E HOB		-	-
Module 3 Output 3 Mapping	3119 LOB	C2E LOB		-	-
Module 4 Input 1 Mapping	3120	C2F		-	-
Module 4 Input 2 Mapping	3121	C30		-	-
Module 4 Input 3 Mapping	3122	C31		-	-
Module 4 Input 4 Mapping	3123	C32		-	-
Module 4 Output 2 Mapping	3124 HOB	C33 HOB		-	-
Module 4 Output 1 Mapping	3124 LOB	C33 LOB		-	-
Module 4 Output 4 Mapping	3125 HOB	C34 HOB		-	-
Module 4 Output 3 Mapping	3125 LOB	C34 LOB		-	-

Table 18. Programmable Input Definitions.

VALUE	DEFINITION
0	Disabled
1	S1 Available
2	S2 Available
3	Transfer Switch on Bypass
4	Bypass Aux S1 In
5	Bypass Aux S2 In
6	Gen Start Contact
7	Door Open
8	General Alarm
9	ATS Not In Automatic
10	Lockout
11	Enable Manual Retransfer
12	Manual Retransfer Request
13	Go To Emergency
14	Emergency Inhibit
15	Go To Neutral
16	Bypass Timers
17	Remote Engine Test
18	Engine Test Mode Select
19	Test Status
20	Remote I/O

Table 19. Programmable Output Definitions.

VALUE	DEFINITION
0	Disabled
1	Source 1 Available
2	Source 2 Available
3	Transfer Switch On Bypass
4	Source 1 Connected
5	Source 2 Connected
6	Gen Start
7	Door Open
8	Alarm
9	ATS Not In Automatic
10	Lockout
11	Enable Manual Retransfer
12	Manual Retransfer Request
13	Go To Emergency
14	Emergency Inhibit
15	Go To Neutral
16	ATS In Test
17	Transfer Test Contact Status
18	Run-Only Test Contact Status
19	Engine Test Aborted
20	Selective Load Shed
21	Load Bank Control
22	Cooldown In Progress
23	Remote I/O

Table 20. Write Setpoints Status and Multi-Register Configuration Definitions.

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Write Setpoints Status (Read-Only)	3126	C35	0 = No Error 1-0xFFFF = Error while writing setpoints	-	-
Multi-Register Configuration	3500	DAB	0 = High-Order Word in Lowest Register Number 1 - 0xFFFF = Low-Order Word in Lowest Register Number	-	-

The query message format for function code 03 is given in Table 21. The query specifies the starting register address (which is always one less than the starting register number) and the quantity of registers to be read.

Table 21. Read Setpoints Registers (03) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	03_{16}
Starting Address High Byte	$0B_{16}$
Starting Address Low Byte	$B9_{16}$
Number of Registers High Byte	00_{16}
Number of Registers Low Byte	02_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format for function code 03 is given in Table 22. The contents of each 16-bit register are returned as two bytes, with the high-order byte returned first. The Byte Count field contains the number of data bytes being returned, which is calculated as two times the number of registers requested.

Table 22. Read Setpoints Registers (03) Response.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	03_{16}
Byte Count	04_{16}
Data from High Byte of Regiser X (e.g., $0BB9_{16}$)	00_{16}
Data from Low Byte of Regiser X (e.g., $0BB9_{16}$)	03_{16}
Data from High Byte of Regiser X+1 (e.g., $0BBA_{16}$)	00_{16}
Data from Low Byte of Regiser X+1 (e.g., $0BBA_{16}$)	05_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.4 Function Code 04 - Read Input Registers (Actual Values)

Actual Value registers contain dynamic information such as device status and metered values, like voltages and frequencies (Table 23), fixed information such as firmware version numbers (Table 24), and historical information such as event data (Table 25) and high-speed capture data (Table 27). Actual value registers are read-only and are accessed using function code 04.

Table 23 provides a real-time view into various metered values, statistical information, and statuses.

Note:

1. Most values are 16 bits (2 bytes) in length. However, the system counters are 32 bits (4 bytes) in length. These values are contained in two successive registers. The arrangement of the bytes in the 4-byte system counter values may be configured by setting the Multi-Register Configuration. See section 3.6.
2. The TSM-900 only supports fixed-point values, thus the scale factor indicates what a decimal value has been multiplied by prior to sending out via Modbus. For example, the various frequency values have a scale factor of 10. A typical reading may be 601, which is 60.1 Hz.
3. The time and data values are packed two bytes of data per register, indicated in the table with a colon ":" between values.
4. TOC is Time of Change, and indicates the last time that a timer/counter was updated. TOR is Time of Reset and indicates the last time that a timer/counter was reset (via front panel display interface or Modbus command).
5. A * before a register address or number indicates a break in the normal sequential numbering, typically due to new registers added after the product was released.

Table 23. Function Code 04 Actual Values (Dynamic Data) Register Definitions

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Measured Values	Source 1 V_{AB}	V	6145	1800	1	Uint16
	Source 1 V_{BC}	V	6146	1801	1	Uint16
	Source 1 V_{CA}	V	6147	1802	1	Uint16
	Source 1 V_{AG}	V	6148	1803	1	Uint16
	Source 1 V_{BG}	V	6149	1804	1	Uint16
	Source 1 V_{CG}	V	6150	1805	1	Uint16
	Source 2 V_{AB}	V	6151	1806	1	Uint16
	Source 2 V_{BC}	V	6152	1807	1	Uint16
	Source 2 V_{CA}	V	6153	1808	1	Uint16
	Source 2 V_{AG}	V	6154	1809	1	Uint16
	Source 2 V_{BG}	V	6155	180A	1	Uint16
	Source 2 V_{CG}	V	6156	180B	1	Uint16
	Source 1/ Source 2 Max Voltage Difference	V	6157	180C	1	Uint16
	Load V_{AB}	V	6158	180D	1	Uint16
	Load V_{BC}	V	6159	180E	1	Uint16
	Load V_{CA}	V	6160	180F	1	Uint16
	Load V_{AG}	V	6161	1810	1	Uint16
	Load V_{BG}	V	6162	1811	1	Uint16
	Load V_{CG}	V	6163	1812	1	Uint16
	Source 1 Frequency	Hz	6164	1813	10	Uint16
	Source 2 Frequency	Hz	6165	1814	10	Uint16
	Source 1/ Source 2 Frequency Difference	Hz	6166	1815	10	Uint16
	Load Frequency	Hz	6167	1816	10	Uint16
	Load I_A	A	6168	1817	1	Uint16
	Load I_B	A	6169	1818	1	Uint16
	Load I_C	A	6170	1819	1	Uint16
	Source 1 Voltage Unbalance	%	6171	181A	10	Uint16
	Source 2 Voltage Unbalance	%	6172	181B	10	Uint16
	Load Current Unbalance	%	6173	181C	10	Uint16
	Source 1/ Source 2 Phase Difference	Deg	6174	181D	1	Uint16
	Phase A Active Power high register	W	6175	181E	1	Int32
	Phase A Active Power low register	W	6176	181F	1	Int32
	Phase A Reactive Power high register	VAR	6177	1820	1	Int32
	Phase A Reactive Power low register	VAR	6178	1821	1	Int32
	Phase A Apparent Power high register	VA	6179	1822	1	Uint32
	Phase A Apparent Power low register	VA	6180	1823	1	Uint32
	Phase A Power Factor (Apparent)		6181	1824	100	Int16
	Phase B Active Power high register	W	6182	1825	1	Int32
	Phase B Active Power low register	W	6183	1826	1	Int32
	Phase B Reactive Power high register	VAR	6184	1827	1	Int32
	Phase B Reactive Power low register	VAR	6185	1828	1	Int32
	Phase B Apparent Power high register	VA	6186	1829	1	Uint32

Table 23. Function Code 04 Actual Values (Dynamic Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Phase B Apparent Power low register	VA	6187	182A	1	Uint32
	Phase B Power Factor (Apparent)		6188	182B	100	Int16
	Phase C Active Power high register	W	6189	182C	1	Int32
	Phase C Active Power low register	W	6190	182D	1	Int32
	Phase C Reactive Power high register	VAR	6191	182E	1	Int32
	Phase C Reactive Power low register	VAR	6192	182F	1	Int32
	Phase C Apparent Power high register	VA	6193	1830	1	Uint32
	Phase C Apparent Power low register	VA	6194	1831	1	Uint32
	Phase C Power Factor (Apparent)		6195	1832	100	Int16
	Total Active Power high register	W	6196	1833	1	Int32
	Total Active Power low register	W	6197	1834	1	Int32
	Total Reactive Power high register	VAR	6198	1835	1	Int32
	Total Reactive Power low register	VAR	6199	1836	1	Int32
	Total Apparent Power high register	VA	6200	1837	1	Uint32
	Total Apparent Power low register	VA	6201	1838	1	Uint32
	Power Factor (Apparent)		6202	1839	100	Int16
Timers	TDEC Timer	seconds	6203	183A	1	Uint16
	TDEF Timer	seconds	6204	183B	1	Uint16
	Engine Run Timer	seconds	6205	183C	1	Uint16
	S1 Negative Sequence Timer	seconds	6206	183D	1	Uint16
	S1 Negative Sequence Timer	seconds	6207	183E	1	Uint16
System Counters	Transfer Time (valid when connected to Source 2, else zero)	seconds	6208	183F	100	Uint16
	Transfer Time (always returns last transfer time)	seconds	6355	18D2	100	Uint16
	Transfer Time TOC month : date	1-12 : 1-31	6209	1840	-	Uint16
	Transfer Time TOC year : day	0-99 : 1-7	6210	1841	-	Uint16
	Transfer Time TOC hour : minute	0-23 : 0-59	6211	1842	-	Uint16
	Transfer Time TOC second : 1/100 second	0-59 : 0-99	6212	1843	-	Uint16
	Transfer Test Time high register	minutes	6213	1844	-	Uint16
	Transfer Test Time low register	minutes	6214	1845	-	Uint16
	Transfer Test TOC month : date	1-12 : 1-31	6215	1846	-	Uint16
	Transfer Test TOC year : day	0-99 : 1-7	6216	1847	-	Uint16
	Transfer Test TOC hour : minute	0-23 : 0-59	6217	1848	-	Uint16
	Transfer Test TOC second : 1/100 second	0-59 : 0-99	6218	1849	-	Uint16
	Transfer Test TOR month : date	1-12 : 1-31	6219	184A	-	Uint16
	Transfer Test TOR year : day	0-99 : 1-7	6220	184B	-	Uint16
	Transfer Test TOR hour : minute	0-23 : 0-59	6221	184C	-	Uint16
	Transfer Test TOR second : 1/100 second	0-59 : 0-99	6222	184D	-	Uint16
	Run-Only Test Time high register	minutes	6223	184E	-	Uint16
	Run-Only Test Time low register	minutes	6224	184F	-	Uint16
	Run-Only Test TOC month : date	1-12 : 1-31	6225	1850	-	Uint16
	Run-Only Test TOC year : day	0-99 : 1-7	6226	1851	-	Uint16

Table 23. Function Code 04 Actual Values (Dynamic Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Run-Only Test TOC hour : minute	0-23 : 0-59	6227	1852	-	Uint16
	Run-Only Test TOC second : 1/100 second	0-59 : 0-99	6228	1853	-	Uint16
	Run-Only Test TOR month : date	1-12 : 1-31	6229	1854	-	Uint16
	Run-Only Test TOR year : day	0-99 : 1-7	6230	1855	-	Uint16
	Run-Only Test TOR hour : minute	0-23 : 0-59	6231	1856	-	Uint16
	Run-Only Test TOR second : 1/100 second	0-59 : 0-99	6232	1857	-	Uint16
	S1 Available Time high register	minutes	6233	1858	-	Uint16
	S1 Available Time low register	minutes	6234	1859	-	Uint16
	S1 Available TOC month : date	1-12 : 1-31	6235	185A	-	Uint16
	S1 Available TOC year : day	0-99 : 1-7	6236	185B	-	Uint16
	S1 Available TOC hour : minute	0-23 : 0-59	6237	185C	-	Uint16
	S1 Available TOC second : 1/100 second	0-59 : 0-99	6238	185D	-	Uint16
	S1 Available TOR month : date	1-12 : 1-31	6239	185E	-	Uint16
	S1 Available TOR year : day	0-99 : 1-7	6240	185F	-	Uint16
	S1 Available TOR hour : minute	0-23 : 0-59	6241	1860	-	Uint16
	S1 Available TOR second : 1/100 second	0-59 : 0-99	6242	1861	-	Uint16
	S2 Available Time high register	minutes	6243	1862	-	Uint16
	S2 Available Time low register	minutes	6244	1863	-	Uint16
	S2 Available TOC month : date	1-12 : 1-31	6245	1864	-	Uint16
	S2 Available TOC year : day	0-99 : 1-7	6246	1865	-	Uint16
	S2 Available TOC hour : minute	0-23 : 0-59	6247	1866	-	Uint16
	S2 Available TOC second : 1/100 second	0-59 : 0-99	6248	1867	-	Uint16
	S2 Available TOR month : date	1-12 : 1-31	6249	1868	-	Uint16
	S2 Available TOR year : day	0-99 : 1-7	6250	1869	-	Uint16
	S2 Available TOR hour : minute	0-23 : 0-59	6251	186A	-	Uint16
	S2 Available TOR second : 1/100 second	0-59 : 0-99	6252	186B	-	Uint16
	S1 Connect Time high register	minutes	6253	186C	-	Uint16
	S1 Connect Time low register	minutes	6254	186D	-	Uint16
	S1 Connect TOC month : date	1-12 : 1-31	6255	186E	-	Uint16
	S1 Connect TOC year : day	0-99 : 1-7	6256	186F	-	Uint16
	S1 Connect TOC hour : minute	0-23 : 0-59	6257	1870	-	Uint16
	S1 Connect TOC second : 1/100 second	0-59 : 0-99	6258	1871	-	Uint16
	S1 Connect TOR month : date	1-12 : 1-31	6259	1872	-	Uint16
	S1 Connect TOR year : day	0-99 : 1-7	6260	1873	-	Uint16
	S1 Connect TOR hour : minute	0-23 : 0-59	6261	1874	-	Uint16
	S1 Connect TOR second : 1/100 second	0-59 : 0-99	6262	1875	-	Uint16
	S2 Connect Time high register	minutes	6263	1876	-	Uint16
	S2 Connect Time low register	minutes	6264	1877	-	Uint16
	S2 Connect TOC month : date	1-12 : 1-31	6265	1878	-	Uint16
	S2 Connect TOC year : day	0-99 : 1-7	6266	1879	-	Uint16
	S2 Connect TOC hour : minute	0-23 : 0-59	6267	187A	-	Uint16
	S2 Connect TOC second : 1/100 second	0-59 : 0-99	6268	187B	-	Uint16

Table 23. Function Code 04 Actual Values (Dynamic Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	S2 Connect TOR month : date	1-12 : 1-31	6269	187C	-	Uint16
	S2 Connect TOR year : day	0-99 : 1-7	6270	187D	-	Uint16
	S2 Connect TOR hour : minute	0-23 : 0-59	6271	187E	-	Uint16
	S2 Connect TOR second : 1/100 second	0-59 : 0-99	6272	187F	-	Uint16
	Load EnergizedTime high register	minutes	6273	1880	-	Uint16
	Load Energized Time low register	minutes	6274	1881	-	Uint16
	Load Energized TOC month : date	1-12 : 1-31	6275	1882	-	Uint16
	Load Energized TOC year : day	0-99 : 1-7	6276	1883	-	Uint16
	Load Energized TOC hour : minute	0-23 : 0-59	6277	1884	-	Uint16
	Load Energized TOC second : 1/100 second	0-59 : 0-99	6278	1885	-	Uint16
	Load Energized TOR month : date	1-12 : 1-31	6279	1886	-	Uint16
	Load Energized TOR year : day	0-99 : 1-7	6280	1887	-	Uint16
	Load Energized TOR hour : minute	0-23 : 0-59	6281	1888	-	Uint16
	Load Energized TOR second : 1/100 second	0-59 : 0-99	6282	1889	-	Uint16
	Tier 4 Time high register	minutes	6283	188A	-	Uint16
	Tier 4 Time low register	minutes	6284	188B	-	Uint16
	Tier 4 TOC month : date	1-12 : 1-31	6285	188C	-	Uint16
	Tier 4 TOC year : day	0-99 : 1-7	6286	188D	-	Uint16
	Tier 4 TOC hour : minute	0-23 : 0-59	6287	188E	-	Uint16
	Tier 4 TOC second : 1/100 second	0-59 : 0-99	6288	188F	-	Uint16
	Tier 4 TOR month : date	1-12 : 1-31	6289	1890	-	Uint16
	Tier 4 TOR year : day	0-99 : 1-7	6290	1891	-	Uint16
	Tier 4 TOR hour : minute	0-23 : 0-59	6291	1892	-	Uint16
	Tier 4 TOR second : 1/100 second	0-59 : 0-99	6292	1893	-	Uint16
	Number of Transfers		6293	1894	-	Uint16
	Number of Transfers TOC month : date	1-12 : 1-31	6294	1895	-	Uint16
	Number of Transfers TOC year : day	0-99 : 1-7	6295	1896	-	Uint16
	Number of Transfers TOC hour : minute	0-23 : 0-59	6296	1897	-	Uint16
	Number of Transfers TOC sec:1/100 sec	0-59 : 0-99	6297	1898	-	Uint16
	Number of Transfers TOR month : date	1-12 : 1-31	6298	1899	-	Uint16
	Number of Transfers TOR year : day	0-99 : 1-7	6299	189A	-	Uint16
	Number of Transfers TOR hour : minute	0-23 : 0-59	6300	189B	1	Uint16
	Number of Transfers TOR sec:1/100 sec	0-59 : 0-99	6301	189C	-	Uint16
	Number of Transfer Tests		6302	189D	-	Uint16
	Number of Transfer Tests TOC month : date	1-12 : 1-31	6303	189E	-	Uint16
	Number of Transfer Tests TOC year : day	0-99 : 1-7	6304	189F	-	Uint16
	Number of Transfer Tests TOC hour : minute	0-23 : 0-59	6305	18A0	-	Uint16
	Number of Transfer Tests TOC sec:1/100 sec	0-59 : 0-99	6306	18A1	-	Uint16
	Number of Transfer Tests TOR month : date	1-12 : 1-31	6307	18A2	-	Uint16
	Number of Transfer Tests TOR year : day	0-99 : 1-7	6308	18A3	-	Uint16
	Number of Transfer Tests TOR hour : minute	0-23 : 0-59	6309	18A4	1	Uint16
	Number of Transfer Tests TOR sec:1/100 sec	0-59 : 0-99	6310	18A5	-	Uint16

Table 23. Function Code 04 Actual Values (Dynamic Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Number of Run-Only Tests		6311	18A6	-	Uint16
	Number of Run-Only Tests TOC month : date	1-12 : 1-31	6312	18A7	-	Uint16
	Number of Run-Only Tests TOC year : day	0-99 : 1-7	6313	18A8	-	Uint16
	Number of Run-Only Tests TOC hour : minute	0-23 : 0-59	6314	18A9	-	Uint16
	Number of Run-Only Tests TOC sec:1/100 sec	0-59 : 0-99	6315	18AA	-	Uint16
	Number of Run-Only Tests TOR month : date	1-12 : 1-31	6316	18AB	-	Uint16
	Number of Run-Only Tests TOR year : day	0-99 : 1-7	6317	18AC	-	Uint16
	Number of Run-Only Tests TOR hour : minute	0-23 : 0-59	6318	18AD	1	Uint16
	Number of Run-Only Tests TOR sec:1/100 sec	0-59 : 0-99	6319	18AE	-	Uint16
Transfer Switch Status Information	Primary Status	Table 24	6320	18AF	1	Uint16
	Secondary Status	Table 25	6321	18B0	1	Uint16
	Cause of Status	Table 26	6322	18B1	-	Uint16
	Source 1 Status	Table 27	6323	18B2	-	Uint16
	Source 2 Status	Table 27	6324	18B3	-	Uint16
	Binary Status Bits	Table 28	6325	18B4	-	Uint16
	Binary Status2 Bits	Table 29	6326	18B5	-	Uint16
	Alarm Status Bits	Table 30	6327	18B6	-	Uint16

Table 24. Decoding for Primary Status Register.

CODE	DEFINITION
4	Alarmed
8	Starting
9	Operational
11	Locked-Out
12	Transferred
27	On Good Source

Table 25. Decoding for Secondary Status Register.

CODE	DEFINITION
1	Not Applicable
3	Test Mode
7	Powered Up Since Last Alarm Reset

Table 26. Decoding for Cause of Status Register.

CODE	DEFINITION
0	Unknown
1	Normal Operating Mode
11	Overvoltage
12	Undervoltage
15	Underfrequency
16	Overfrequency
17	Current Unbalance
18	Voltage Unbalance
39	Diagnostic Warning #1 (A/D Calibration)
68	Reverse Sequence
71	Alarm Active
74	Lockout
77	Setpoints Error
113	Calibration
132	Plant Exercise
136	Real Time Clock
153	Monitor Mode (ATS Not in Automatic)
2043	Phase Loss
2044	RAM Error
2045	Non-volatile Memory Error
2046	Watchdog
2047	ROM Error

Table 27. Decoding for Source 1 / Source 2 Status Registers.

CODE	DEFINITION
0	Normal
1	Undervoltage
2	Overvoltage
3	Underfrequency
4	Overfrequency
5	Voltage Unbalance
6	Phase Reversal
7	Phase Loss
8	Current Unbalance
9	External Available Input

Table 28. Decoding for Binary Status Register.

CODE	DEFINITION
0	Source 1 Connected
1	Source 2 Connected
2	ATS Transferred
3	Alarm
4	Source 1 Available
5	Source 2 Available
6	Rotation ACB
7	Waiting for Transfer
8	Engine Transfer Test
9	Engine Run-only Test
10	Transfer Switch in Test
11	Transfer in Progress
12	Single Phase
13	Transfer Switch in Bypass
14	Source 1 Available External Input
15	Source 2 Available External Input

Table 29. Decoding for Binary Status Register 2.

CODE	DEFINITION
0	DCT Module Detected
1	ATS Not in Automatic
2	Go to Emergency
3	Emergency Inhibit
4	Go to Neutral
5 - 15	Reserved for internal use

Table 30. Decoding for Alarm Status Register.

CODE	DEFINITION
0	Lockout
1	Engine Test Aborted
2	Generator Unavailable
3	External Alarm
4	Door Alarm
5 - 14	Reserved for Future Use
15	Infernal Controller Electronic Fault

Table 31 contains fixed data which typically does not change.

Note:

1. The ASCII strings are packed two characters per register, with the HOB in the lowest numbered register containing the leftmost character in the string, going to the LOB in the highest numbered register containing the rightmost character in the string. Unused characters are NULL (0x00) and padded on the right side of the string.
2. The Display and Gen Start firmware/revision numbers will be zero for up to 70 seconds after power-on.

Table 31. Function Code 04 Actual Values (Fixed Data) Register Definitions

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Controller Info	Product ID (TSM-900) – start	-	6228	18B7	-	ASCII
	...	-	...	...	-	ASCII
	Product ID – end	-	6331	18BA	-	ASCII
	Hardware Revision	-	6332	18BB	-	Uint16
	DSP Firmware Version : Revision	-	6333	18BC	-	Uint16
	Display Firmware Version : Revision	-	6334	18BD	-	Uint16
	Gen Start Firmware Version : Revision	-	6335	18BD	-	Uint16
	Serial Number – start	-	6336	18BF	-	ASCII
	...(8)	-	...	...	-	ASCII
	Serial Number – end	-	6345	18B8	-	ASCII
	Date Code – start	-	6346	18C9	-	ASCII
	...(2)	-	...	...	-	ASCII
	Date Code – end	-	6249	18CC	-	ASCII
	GO Number – start	-	6250	18CD	-	ASCII
	...(3)	-	...	...	-	ASCII
	GO Number – end	-	6354	18D1	-	ASCII

Table 32 contains historical event log entries. Each entry is the latest occurrence for that type of event.

Note:

1. Most values are 16 bits (2 bytes) in length. However, the Event IDs are 32 bits (4 bytes) in length. These values are contained in two successive registers. The arrangement of the bytes in the 4-byte system counter values may be configured by writing the Multi-Register Configuration. See section 3.6.
2. The Event ID is a sequential number generated by the controller at the time of an event. It can be useful for sorting or if the timestamp is ambiguous, such as if events occur during both the hour before and the hour after switching back from daylight savings time to standard time.
3. Although Table 33 shows all of the "Event Codes", each event type only uses a subset of the codes.
4. The various Input and Output events coincide with all possible programmable input and output types. Only those that are actually used will be updated.
5. The S1/S2 Unavailable Events and the Transfer Step events contain a snapshot of various voltages/currents and statuses at the time that the event occurred.

Table 32. Function Code 04 Actual Values (Event Data) Register Definitions

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Power-Up Event	Event ID low register	-	7000	1B57	-	Uint32
	Event ID high register	-	7001	1B58	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7002	1B59	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7003	1B5A	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7004	1B5B	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7005	1B5C	-	Uint16
	Event Code	Table33	7006	1B5D	-	Uint16
Setpoint Download	Same format as Power-Up Event	-	7007	1B5E	-	-
Counter/ Timer Reset	Same format as Power-Up Event	-	7014	1B65	-	-
Bypass Timer	Same format as Power-Up Event	-	7021	1B6C	-	-
Internal Alarm	Same format as Power-Up Event	-	7028	1B73	-	-
Reset Alarm	Same format as Power-Up Event	-	7035	1B7A	-	-
Plant Exercise	Same format as Power-Up Event	-	7042	1B81	-	-
Transfer Test Relay	Same format as Power-Up Event	-	7049	1B88	-	-
Run-Only Test Relay	Same format as Power-Up Event	-	7056	1B8F	-	-
S1 Avail. Input	Same format as Power-Up Event	-	7063	1B96	-	-
S2 Avail. Input	Same format as Power-Up Event	-	7070	1B9D	-	-
On Bypass Input	Same format as Power-Up Event	-	7077	1BA4	-	-
Bypass S1 Aux. Input	Same format as Power-Up Event	-	7084	1BAB	-	-
Bypass S2 Aux. Input	Same format as Power-Up Event	-	7091	1BB2	-	-
Generator Start Input	Same format as Power-Up Event	-	7098	1BB9	-	-
Door Open Input	Same format as Power-Up Event	-	7105	1BC0	-	-
General Alarm Input	Same format as Power-Up Event	-	7112	1BC7	-	-
ATS Not In Auto. Input	Same format as Power-Up Event	-	7119	1BCE	-	-
Lockout Input	Same format as Power-Up Event	-	7126	1BD5	-	-
Manual Retransfer Enable Input	Same format as Power-Up Event	-	7133	1BDC	-	-
Manual Retransfer Request Input	Same format as Power-Up Event	-	7140	1BE3	-	-
Go To Emergency Input	Same format as Power-Up Event	-	7147	1BEA	-	-
Emergency Inhibit Input	Same format as Power-Up Event	-	7154	1BF1	-	-
Go To Neutral Input	Same format as Power-Up Event	-	7161	1BF8	-	-
Bypass Timers Input	Same format as Power-Up Event	-	7168	1BFF	-	-
Engine Test Input	Same format as Power-Up Event	-	7175	1C06	-	-
Engine Test Mode Input	Same format as Power-Up Event	-	7182	1C0D	-	-
Test Status Input	Same format as Power-Up Event	-	7189	1C14	-	-
S1 Avail. Output	Same format as Power-Up Event	-	7196	1C1B	-	-
S2 Avail. Output	Same format as Power-Up Event	-	7203	1C22	-	-
Transfer Switch On Bypess Output	Same format as Power-Up Event	-	7210	1C29	-	-
S1 Conn. Output	Same format as Power-Up Event	-	7217	1C30	-	-
S2 Conn. Output	Same format as Power-Up Event	-	7224	1C37	-	-
Gen Start Output	Same format as Power-Up Event	-	7231	1C3E	-	-
Door Open Output	Same format as Power-Up Event	-	7238	1C45	-	-

Table 32. Function Code 04 Actual Values (Event Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Alarm Output	Same format as Power-Up Event	-	7245	1C4C	-	-
ATS Not In Automatic Output	Same format as Power-Up Event	-	7252	1C53	-	-
Lockout Output	Same format as Power-Up Event	-	7259	1C5A	-	-
Manual Retransfer Enable Output	Same format as Power-Up Event	-	7266	1C61	-	-
Manual Retransfer Request Output	Same format as Power-Up Event	-	7273	1C68	-	-
Go To Emergency Output	Same format as Power-Up Event	-	7280	1C6F	-	-
Emergency Inhibit Output	Same format as Power-Up Event	-	7287	1C76	-	-
Go To Neutral Output	Same format as Power-Up Event	-	7294	1C7D	-	-
ATS In Test Output	Same format as Power-Up Event	-	7301	1C84	-	-
Transfer Test Contact Status Output	Same format as Power-Up Event	-	7308	1C8B	-	-
Run-Only Test Contact Status Output	Same format as Power-Up Event	-	7315	1C92	-	-
Engine Test Aborted Output	Same format as Power-Up Event	-	7322	1C99	-	-
Selective Load Shed Output	Same format as Power-Up Event	-	7329	1CA0	-	-
Load Bank Control Output	Same format as Power-Up Event	-	7336	1CA7	-	-
Cooldown In Progress Output	Same format as Power-Up Event	-	7343	1CAE	-	-
Time Adjustment Event	Event ID low register	-	7350	1CB5	-	-
	Event ID high register	-	7351	1CB6	-	Uint32
	Old Time month : date	1-12 : 1-31	7352	1CB7	-	Uint16
	Old Time year : day	0-99 : 1-7	7353	1CB8	-	Uint16
	Old Time hour : minute	0-23 : 0-59	7354	1CB9	-	Uint16
	Old Time second : 1/100 second	0-59 : 0-99	7355	1CBA	-	Uint16
	Event Code		7356	1CBB	-	Uint16
	New Time month : date	1-12 : 1-31	7357	1CBC	-	Uint16
	New Time year : day	0-99 : 1-7	7358	1CBD	-	Uint16
	New Time hour : minute	0-23 : 0-59	7359	1CBE	-	Uint16
	New Time second : 1/100 second	0-59 : 0-99	7360	1CBF	-	Uint16

Table 32. Function Code 04 Actual Values (Event Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Source 1 Unavailable Event	Event ID low register	-	7361	1CC0	-	Uint32
	Event ID high register	-	7362	1CC1	-	Uint32
	Event Time Stamp month : date	1-12 : 1-31	7363	1CC2	-	Uint16
	Event Time Stamp year : day	0-99 : 1-7	7364	1CC3	-	Uint16
	Event Time Stamp hour : minute	0-23 : 0-59	7365	1CC4	-	Uint16
	Event Time Stamp second : 1/100 second	0-59 : 0-99	7366	1CC5	-	Uint16
	Validity bits low register	-	7367	1CC6	-	Uint16
	Validity bits high register	-	7368	1CC7	-	Uint16
	Event Code : Cause of Alarm Code	0 :	7369	1CC8	-	Uint16
	Source 1 V_{AB}	V	7370	1CC9	1	Uint16
	Source 1 V_{BC}	V	7371	1CCA	1	Uint16
	Source 1 V_{CA}	V	7372	1CCB	1	Uint16
	Source 2 V_{AB}	V	7373	1CCC	1	Uint16
	Source 2 V_{BC}	V	7374	1CCD	1	Uint16
	Source 2 V_{CA}	V	7375	1CCE	1	Uint16
	Load V_{AB}	V	7376	1CCF	1	Uint16
	Load V_{BC}	V	7377	1CD0	1	Uint16
	Load V_{CA}	V	7378	1CD1	1	Uint16
	Load I_A	A	7379	1CD2	1	Uint16
	Load I_B	A	7380	1CD3	1	Uint16
	Load I_C	A	7381	1CD4	1	Uint16
	Source 1 Frequency	Hz	7382	1CD5	10	Uint16
	Source 2 Frequency	Hz	7381	1CD4	10	Uint16
	Load Frequency	Hz	7382	1CD5	10	Uint16
	Source 1 Status : Source 2 Status	:	7383	1CD6	-	Uint16
	Binary Status Bits		7384	1CD7	-	Uint16
	Binary Status Validity Mask	0xFFFF	7385	1CD8	-	Uint16
S2 Unavailable Event	Same format as Source 1 Unavailable Event		7386	1CD9	-	-

Table 32. Function Code 04 Actual Values (Event Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Event ID low register	-	7387	1CDA	-	Uint32
	Event ID high register	-	7388	1CDB	-	Uint32
	Event Time Stamp month : date	1-12 : 1-31	7389	1CDC	-	Uint16
	Event Time Stamp year : day	0-99 : 1-7	7390	1CDD	-	Uint16
	Event Time Stamp hour : minute	0-23 : 0-59	7391	1CDE	-	Uint16
	Event Time Stamp second : 1/100 second	0-59 : 0-99	7392	1CDF	-	Uint16
	Validity bits low register	-	7393	1CE0	-	Uint16
	Validity bits high register	-	7394	1CE1	-	Uint16
	Event Code		7395	1CE2	-	Uint16
	Source 1 V_{AB}	V	7396	1CE3	1	Uint16
	Source 1 V_{BC}	V	7397	1CE4	1	Uint16
	Source 1 V_{CA}	V	7398	1CE5	1	Uint16
	Source 2 V_{AB}	V	7399	1CE6	1	Uint16
	Source 2 V_{BC}	V	7400	1CE7	1	Uint16
Transfer Connected to Source 1 Event	Source 2 V_{CA}	V	7401	1CE8	1	Uint16
	Load V_{AB}	V	7402	1CE9	1	Uint16
	Load V_{BC}	V	7403	1CEA	1	Uint16
	Load V_{CA}	V	7404	1CEB	1	Uint16
	Load I_A	A	7405	1CEC	1	Uint16
	Load I_B	A	7406	1CED	1	Uint16
	Load I_C	A	7407	1CEE	1	Uint16
	Source 1 Frequency	Hz	7408	1CEF	10	Uint16
	Source 2 Frequency	Hz	7409	1CF0	10	Uint16
	Load Frequency	Hz	7410	1CF1	10	Uint16
	Source 1 Status : Source 2 Status	:	7411	1CF2	-	Uint16
	Binary Status Bits		7441	1D10	-	Uint16
	Binary Status Validity Mask	0xFFFF	7471	1D2E	-	Uint16
	Transfer ID	-	7501	1D4C	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7502	1D4D	-	Uint16
	Spare	-	7503	1D4E	-	Uint16
Transfer To Neutral Event	Same format as Transfer Connected to Source 1 Event	-	7504	1D4F	-	-
Transfer To Parallel Event	Same format as Transfer Connected to Source 1 Event	-	7505	1D50	-	-
Transfer Connected to Source 2 Event	Same format as Transfer Connected to Source 1 Event	-	7506	1D51	-	-
	Event ID low register	-	7507	1D52	-	Uint32
	Event ID high register	-	7508	1D53	-	Uint32
	Event Time Stamp month : date	1-12 : 1-31	7509	1D54	-	Uint16
	Event Time Stamp year : day	0-99 : 1-7	7510	1D55	-	Uint16
Transfer Time Event	Event Time Stamp hour : minute	0-23 : 0-59	7511	1D56	-	Uint16
	Event Time Stamp second : 1/100 second	0-59 : 0-99	7512	1D57	-	Uint16
	Event Code		7513	1D58	-	Uint16
	Transfer Time (milliseconds)		7514	1D59		Uint16

Table 33. Decoding for Event Code

CODE	DEFINITION
0	Controller Powered Up, All OK
1	Controller Powered Up, Real Time Clock Failed to Power Up Properly.
2	Setpoints Downloaded (Front Cover or Modbus Port)
3	Real Time Clock adjusted (More than 1 Minute Change)
4	Generator Transfer Test Timer/Counter was Reset
5	Generator Run-Only Test Timer/Counter was Reset
6	Source 1 Available Timer/Counter was Reset
7	Source 2 Available Timer/Counter was Reset
8	Source 1 Connected Timer/Counter was Reset
9	Source 2 Connected Timer/Counter was Reset
10	Load Energized Timer/Counter was Reset
11	Number of Transfers Counter was Reset
12	Number of Generator Transfer Tests Counter was Reset
13	Number of Generator Run-Only Tests Counter was Reset
14	Transfer Timers were Manually Bypassed
15	Source 1 became Available
16	Source 2 became Available
17	Source 1 went Unavailable
18	Source 2 went Unavailable
19	Internal Controller Alarm
20	Manual Alarm Reset Occurred
21	Engine Run Test Requested (Front Panel)
22	Engine Run Test Completed Properly
23	Engine Run Test Failed (Generator Failed)
24	Engine Run Test Aborted (Manual Abort or Other Source Failed)
25	Transferred to Source 2
26	Transferred to Source 1
27	Transferred to Neutral (load disconnected from both sources)
28	Transferred to Parallel (load connected to both sources)
29	Tier 4 Timer/Counter was Reset
30	Engine Run Test Requested (Programmable Input)
31	Engine Run Test Requested (Modbus Port)
32	Plant Exercise 1
33	Plant Exercise 2
34	Transfer Time Complete
35	Transfer Test Relay On
36	Run-Only Test Relay On
37	Transfer Test Relay Off
38	Run-Only Test Relay Off
39	Source 1 Available Input On
40	Source 2 Available Input On
41	Transfer Switch On Bypass Input On
42	Bypass Source 1 Auxiliary Input On
43	Bypass Source 2 Auxiliary Input On
44	Generator Start Input On
45	Door Open Input On
46	General Alarm Input On
47	ATS Not In Automatic Input On
48	Lockout Input On

Table 33. Decoding for Event Code (Continued).

CODE	DEFINITION
49	Manual Retransfer Enable Input On
50	Manual Retransfer Request Input On
51	Go To Emergency Input On
52	Emergency Inhibit Input On
53	Go To Neutral Input ON
54	Bypass Timers Input On
55	Engine Test Input On
56	Engine Test Mode Input On
56	Test Status Input On
58	Remote I/O Input On
59	Source 1 Available Input Off
60	Source 2 Available Input Off
61	Transfer Switch On Bypass Input Off
62	Bypass Source 1 Auxiliary Input Off
63	Bypass Source 2 Auxiliary Input Off
64	Generator Start Input Off
65	Door Open Input Off
66	General Alarm Input Off
66	ATS Not In Automatic Input Off
68	Lockout Input Off
69	Manual Retransfer Enable Input Off
70	Manual Retransfer Request Input Off
71	Go To Emergency Input Off
72	Emergency Inhibit Input Off
73	Go To Neutral Input Off
74	Bypass Timers Input Off
75	Engine Test Input Off
76	Engine Test Mode Input Off
77	Test Status Input Off
78	Remote I/O Input Off
79	Source 1 Available Output On
80	Source 2 Available Output On
81	Transfer Switch On Bypass Output On
82	Source 1 Connected Output On
83	Source 2 Connected Output On
84	Generator Start Output On
85	Door Open Output On
86	General Alarm Output On
87	ATS Not In Automatic Output On
88	Lockout Output On
89	Manual Retransfer Enable Output On
90	Manual Retransfer Request Output On
91	Go To Emergency Output On
92	Emergency Inhibit Output On
93	Go To Neutral Output ON
94	Engine Test Mode Output On
95	Transfer Test Output On
96	Run-Only Test Output On
97	Engine Test Aborted Output On
98	Selective Load Shed Output On

Table 33. Decoding for Event Code (Continued).

CODE	DEFINITION
99	Load Control Output On
100	Generator Cooldown Output On
101	Remote I/O Output On
102	S1 Available Output Off
103	S2 Available Output Off
104	Transfer Switch On Bypass Output Off
105	Source 1 Connected Output Off
106	Source 2 Connected Output Off
107	Generator Start Output Off
108	Door Open Output Off
109	General Alarm Output Off
110	ATS Not In Automatic Output Off
111	Lockout Output Off
112	Manual Retransfer Enable Output Off
113	Manual Retransfer Request Output Off
114	Go To Emergency Output Off
115	Emergency Inhibit Output Off
116	Go To Neutral Output OFF
117	Engine Test Mode Output Off
118	Transfer Test Output Off
119	Run-Only Test Output Off
120	Engine Test Aborted Output Off
121	Selective Load Shed Output Off
122	Load Control Output Off
123	Generator Cooldown Output Off
124	Remote I/O Output Off
0xFF	No Event Code (error occurred)

Table 34 contains high-speed capture data. The data is sampled continuously every 20ms and written into a "circular buffer" so that historical data is always available. When a transfer occurs an additional 100 samples are taken (2 seconds worth), then all 200 samples (4 seconds worth) of the data is stored in non-volatile memory. There are two sets of high-speed data that are alternated for each new transfer event..

Note:

1. Most values are 16 bits (two bytes) in length. However, the Event IDs are 32 bits (4 bytes) in length. These values are contained in two successive registers. The arrangement of the bytes in the 4-byte system counter values may be configured by writing the Multi-Register Configuration. See section 3.6.
2. The Event ID of the samples will always match the Event ID of the Transfer that triggered storage of the samples.
3. The time stamp is the time of the first data point, which is ideally two seconds earlier than the time stamp of the associated Transfer Event.
4. Because the data is continuously written into a circular buffer, the "Next Sample" value from the Transfer Event is used to determine which sample is the first data point. This counter starts at 0, which corresponds to the first sample and goes through 199, which corresponds to the 200th sample. As an example, a Next Sample Value of 40, would mean that the 41st data point is the first (oldest) sample, the 200th data point is the 160th sample, the 1st data point is the 161st sample, and the 40th data point is the last (newest) sample..
5. If for some reason (such as a power failure) less than 100 samples are taken after the transfer step event, the "Post Transfer Counter" value from the Transfer Step x Event shows how many samples occurred before the transfer. As an example, a value of 150 would mean the first 150 samples (3 seconds worth) occurred before the transfer step, and the last 50 samples (1 seconds worth) occurred after the step event..

Table 34. Function Code 04 Actual Values (Hi-Speed Capture Data) Register Definitions.

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Event ID low register	-	8000	1F3F	-	Uint32
	Event ID high register	-	8001	1F40	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	8002	1F41	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	8003	1F42	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	8004	1F43	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	8005	1F44	-	Uint16
	Source 1 V_{AB} Sample 1	V	8006	1F45	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{AB} Sample 200	V	8205	200C	1	Uint16
	Source 1 V_{BC} Sample 1	V	8206	200D	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{BC} Sample 200	V	8405	20D4	1	Uint16
	Source 1 V_{CA} Sample 1	V	8406	20D5	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{CA} Sample 200	V	8605	219C	1	Uint16
	Source 2 V_{AB} Sample 1	V	8606	219D	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{AB} Sample 200	V	8805	2264	1	Uint16
	Source 2 V_{BC} Sample 1	V	8806	2265	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{BC} Sample 200	V	9005	232C	1	Uint16
	Source 2 V_{CA} Sample 1	V	9006	232D	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{CA} Sample 200	V	9205	23F4	1	Uint16
	Load V_{AB} Sample 1	V	9206	23F5	1	Uint16
High-Speed Samples 0	...	V	...	...	1	Uint16
	Load V_{AB} Sample 200	V	9405	24BC	1	Uint16
	Load V_{BC} Sample 1	V	9406	24BD	1	Uint16
	...	V	...	...	1	Uint16
	Load V_{BC} Sample 200	V	9605	2584	1	Uint16
	Load V_{CA} Sample 1	V	9606	2585	1	Uint16
	...	V	...	...	1	Uint16
	Load V_{CA} Sample 200	V	9805	264C	1	Uint16
	Load I_A Sample 1	A	9806	264D	1	Uint16
	...	A	...	...	1	Uint16
	Load I_A Sample 200	A	10005	2714	1	Uint16
	Load I_B Sample 1	A	10006	2715	1	Uint16
	...	A	...	...	1	Uint16
	Load I_B Sample 200	A	10205	27DC	1	Uint16
	Load I_C Sample 1	A	10206	27DD	1	Uint16
	...	A	...	...	1	Uint16
	Load I_C Sample 200	A	10405	28A4	1	Uint16
	Source 1 Frequency Sample 1	Hz	10406	28A5	10	Uint16
	...	Hz	...	...	10	Uint16
	Source 1 Frequency Sample 200	Hz	10605	296C	10	Uint16
	Source 2 Frequency Sample 1	Hz	10606	296D	10	Uint16
	...	Hz	...	...	10	Uint16
	Source 2 Frequency Sample 200	Hz	10805	2A34	10	Uint16
	Load Frequency Sample 1	Hz	10806	2A35	10	Uint16
	...	Hz	...	...	10	Uint16
	Load Frequency Sample 200	Hz	11005	2AFC	10	Uint16

Table 34. Function Code 04 Actual Values (Hi-Speed Capture Data) Register Definitions. (Continued)

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	Source 1 Status Sample 1	-	11006	2AFD	-	Uint16
	...	-	...	...	-	Uint16
	Source 1 Status Sample 200	-	11205	2BC4	-	Uint16
	Source 2 Status Sample 1	-	11206	2BC5	-	Uint16
	...	-	...	...	-	Uint16
	Source 2 Status Sample 200	-	11405	2C8C	-	Uint16
High-Speed Samples 1	Event ID low register	-	12000	2EDF	-	Uint32
	Event ID high register	-	12001	2EE0	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	12002	2EE1	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	12003	2EE2	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	12004	2EE3	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	12005	2EE4	-	Uint16
	Source 1 V_{AB} Sample 1	V	12006	2EE5	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{AB} Sample 200	V	12205	2FAC	1	Uint16
	Source 1 V_{BC} Sample 1	V	12206	2FAD	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{BC} Sample 200	V	12405	3074	1	Uint16
	Source 1 V_{CA} Sample 1	V	12406	3075	1	Uint16
	...	V	...	...	1	Uint16
	Source 1 V_{CA} Sample 200	V	12605	313C	1	Uint16
	Source 2 V_{AB} Sample 1	V	12606	313D	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{AB} Sample 200	V	12805	3204	1	Uint16
	Source 2 V_{BC} Sample 1	V	12806	3205	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{BC} Sample 200	V	13005	32CC	1	Uint16
	Source 2 V_{CA} Sample 1	V	13006	32CD	1	Uint16
	...	V	...	...	1	Uint16
	Source 2 V_{CA} Sample 200	V	13205	3394	1	Uint16
	Load V_{AB} Sample 1	V	13206	3395	1	Uint16
	...	V	...	...	1	Uint16
	Load V_{AB} Sample 200	V	13405	345C	1	Uint16
	Load V_{BC} Sample 1	V	13406	345D	1	Uint16
	...	V	...	...	1	Uint16
	Load V_{BC} Sample 200	V	13605	3524	1	Uint16
	Load V_{CA} Sample 1	V	13606	3525	1	Uint16
	...	V	...	...	1	Uint16
	Load V_{CA} Sample 200	V	13805	35EC	1	Uint16
	Load I_A Sample 1	A	13806	35ED	1	Uint16
	...	A	...	...	1	Uint16
	Load I_A Sample 200	A	14005	36B4	1	Uint16
	Load I_B Sample 1	A	14006	36B5	1	Uint16
	...	A	...	...	1	Uint16
	Load I_B Sample 200	A	14205	377C	1	Uint16
	Load I_C Sample 1	A	14206	377D	1	Uint16
	...	A	...	...	1	Uint16
	Load I_C Sample 200	A	14405	3844	1	Uint16
	Source 1 Frequency Sample 1	Hz	14406	3845	10	Uint16
	...	Hz	...	...	10	Uint16
	Source 1 Frequency Sample 200	Hz	14605	390C	10	Uint16
	Source 2 Frequency Sample 1	Hz	14606	390D	10	Uint16

Table 34. Function Code 04 Actual Values (Hi-Speed Capture Data) Register Definitions. (Continued)

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
	...	Hz	...	...	10	Uint16
	Source 2 Frequency Sample 200	Hz	14805	39D4	10	Uint16
	Load Frequency Sample 1	Hz	14806	39D5	10	Uint16
	...	Hz	...	...	10	Uint16
	Load Frequency Sample 200	Hz	15005	3A9C	10	Uint16
	Source 1 Status Sample 1	-	15006	3A9D	-	Uint16
	...	-	...	...	-	Uint16
	Source 1 Status Sample 200	-	15205	3B64	-	Uint16
	Source 2 Status Sample 1	-	15206	3B65	-	Uint16
	...	-	...	...	-	Uint16
	Source 2 Status Sample 200	-	15405	3C2C	-	Uint16

Table 35. Function Code 04 Actual Values (Logging Data) Register Definitions

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Data Log 1 (Oldest interval)	Time of Log month : date	1-12 : 1-31	20,000	4E1F	-	Uint16
	Time of Log year : day	0-99 : 1-7	20,001	4E20	-	Uint16
	Time of Log hour : minute	0-23 : 0-59	20,002	4E21	-	Uint16
	Time of Log second : 1/100 second	0-59 : 0-99	20,003	4E22	-	Uint16
	Source 1 V_{AB}	V	20,004	4E23	1	Uint16
	Source 1 V_{BC}	V	20,005	4E24	1	Uint16
	Source 1 V_{CA}	V	20,006	4E25	1	Uint16
	Source 1 Frequency	Hz	20,007	4E26	10	Uint16
	Source 2 V_{AB}	V	20,008	4E27	1	Uint16
	Source 2 V_{BC}	V	20,009	4E28	1	Uint16
	Source 2 V_{CA}	V	20,010	4E29	1	Uint16
	Source 2 Frequency	Hz	20,011	4E2A	10	Uint16
	Load V_{AB}	V	20,012	4E2B	1	Uint16
	Load V_{BC}	V	20,013	4E2C	1	Uint16
	Load V_{CA}	V	20,014	4E2D	1	Uint16
	Load Frequency	Hz	20,015	4E2E	10	Uint16
	Load I_A	A	20,016	4E2F	1	Uint16
	Load I_B	A	20,017	4E30	1	Uint16
	Load I_C	A	20,018	4E31	1	Uint16
	Total Active Power high register	W	20,019	4E32	1	Int32
	Total Active Power low register	W	20,020	4E33	1	Int32
	Total Reactive Power high register	VAR	20,021	4E34	1	Int32
	Total Reactive Power low register	VAR	20,022	4E35	1	Int32
	Total Apparent Power high register	VA	20,023	4E36	1	Uint32
	Total Apparent Power low register	VA	20,024	4E37	1	Uint32
	Power Factor (Apparent)		20,025	4E38	100	Int16
Data Log 2	Same Format as Data Log 1	-	20,026	4E39	-	-
Data Log 3	Same Format as Data Log 1	-	20,052	4E37	-	-
...(145)	Same Format as Data Log 1	-	-	-	-	-
Data Log 149	Same Format as Data Log 1	-	23,848	5D27	-	-
Data Log 150 (Newest)	Same Format as Data Log 1	-	23,874	5D41	-	-

Table 36. Function Code 04 Actual Values (Statistical Data) Register Definitions

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Source 1 Max/ Min Statistics	Time of S1 Statistics Cleared month : date	1-12 : 1-31	25,000	61A7	-	Uint16
	Time of S1 Statistics Cleared year : day	0-99 : 1-7	25,001	61A8	-	Uint16
	Time of S1 Statistics Cleared hour : minute	0-23 : 0-59	25,002	61A9	-	Uint16
	Time of S1 Stats Cleared sec. : 1/100 sec.	0-59 : 0-99	25,003	61AA	-	Uint16
	Time of Source 1 V_{AB} Max month : date	1-12 : 1-31	25,004	61AB	-	Uint16
	Time of Source 1 V_{AB} Max year : day	0-99 : 1-7	25,005	61AC	-	Uint16
	Time of Source 1 V_{AB} Max hour : minute	0-23 : 0-59	25,006	61AD	-	Uint16
	Time of Source 1 V_{AB} Max sec. : 1/100 sec.	0-59 : 0-99	25,007	61AE	-	Uint16
	Source 1 V_{AB} Max	V	25,008	61AF	1	Uint16
	Time of Source 1 V_{AB} Min month : date	1-12 : 1-31	25,009	61B0	-	Uint16
	Time of Source 1 V_{AB} Min year : day	0-99 : 1-7	25,010	61B1	-	Uint16
	Time of Source 1 V_{AB} Min hour : minute	0-23 : 0-59	25,011	61B2	-	Uint16
	Time of Source 1 V_{AB} Min sec. : 1/100sec.	0-59 : 0-99	25,012	61B3	-	Uint16
	Source 1 V_{AB} Min	V	25,013	61B4	1	Uint16
	Source 1 V_{BC} Max/Min	date/time/V	25,014	61B5	1	Uint16
	Source 1 V_{CA} Max/Min	date/time/V	25,024	61BF	1	Uint16
	Source 1 V_{AN} Max/Min	date/time/V	25,034	61C9	1	Uint16
	Source 1 V_{BN} Max/Min	date/time/V	25,044	61D3	1	Uint16
	Source 1 V_{CN} Max/Min	date/time/V	25,054	61DD	1	Uint16
	Source 1 Vunbalance. Max/Min	date/time/%	25,064	61E7	10	Uint16
	Source 1 Freq. Max/Min	date/time/Hz	25,074	61F1	10	Uint16
Source 2 Max/ Min Statistics	Time of Source 2 Statistics Cleared	date/time	25,084	61FB	-	Uint16
	Source 2 V_{AB} Max/Min	date/time/V	25,088	61FF	1	Uint16
	Source 2 V_{BC} Max/Min	date/time/V	25,098	6209	1	Uint16
	Source 2 V_{CA} Max/Min	date/time/V	25,108	6213	1	Uint16
	Source 2 V_{AN} Max/Min	date/time/V	25,118	621D	1	Uint16
	Source 2 V_{BN} Max/Min	date/time/V	25,128	6227	1	Uint16
	Source 2 V_{CN} Max/Min	date/time/V	25,138	6231	1	Uint16
	Source 2 Vunbalance. Max/Min	date/time/%	25,148	623B	10	Uint16
	Source 2 Freq. Max/Min	date/time/Hz	25,158	6245	10	Uint16
Load Max/Min Statistics	Time of Load Statistics Cleared	date/time	25,168	624F	-	Uint16
	Load V_{AB} Max/Min	date/time/V	25,172	6253	1	Uint16
	Load V_{BC} Max/Min	date/time/V	25,182	625D	1	Uint16
	Load V_{CA} Max/Min	date/time/V	25,192	6267	1	Uint16
	Load V_{AN} Max/Min	date/time/V	25,202	6271	1	Uint16
	Load V_{BN} Max/Min	date/time/V	25,212	627B	1	Uint16
	Load V_{CN} Max/Min	date/time/V	25,222	6285	1	Uint16
	Load Freq. Max/Min	date/time/Hz	25,232	628F	10	Uint16

Table 36. Function Code 04 Actual Values (Statistical Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Load Current Max/Min Statistics	Time of Load Current Statistics Cleared	date/time	25,242	6299	-	Uint16
	Load Ia Max/Min	date/time/A	25,246	629D	1	Uint16
	Load Ib Max/Min	date/time/A	25,256	62A7	1	Uint16
	Load Ic Max/Min	date/time/A	25,266	62A1	1	Uint16
	Load Iunbalance Max/Min	date/time/%	25,276	62BB	10	Uint16
Phase and Total Power Max/Min Statistics	Time of Load Total Power Statistics Cleared	date/time	25,286	62C5	-	Uint16
	Load Total Active Power Max/Min	date/time/W	25,290	62C9	1	Int32
	Load Total Reactive Power Max/Min	date/time/ VAR	25,302	62D5	1	Int32
	Load Total Apparent Power Max/Min	date/time/VA	25,314	62E1	1	Uint32
	Load Total Power Factor Max/Min	date/time/PF	25,326	62ED	100	Int16
	Time of Load Phase A Power Stats Cleared	date/time	25,336	62F7	-	Uint16
	Load Phase A Active Power Max/Min	date/time/W	25,340	62FB	1	Int32
	Load Phase A Reactive Power Max/Min	date/time/ VAR	25,352	6307	1	Int32
	Load Phase A Apparent Power Max/Min	date/time/VA	25,364	6313	1	Uint32
	Load Phase A Power Factor Max/Min	date/time/PF	25,376	631F	100	Int16
	Time of Load Phase B Power Stats Cleared	date/time	25,386	6329	-	Uint16
	Load Phase B Active Power Max/Min	date/time/W	25,390	632D	1	Int32
	Load Phase B Reactive Power Max/Min	date/time/ VAR	25,402	6339	1	Int32
	Load Phase B Apparent Power Max/Min	date/time/VA	25,414	6345	1	Uint32
	Load Phase B Power Factor Max/Min	date/time/PF	25,426	6351	100	Int16
	Time of Load Phase C Power Stats Cleared	date/time	25,436	635B	-	Uint16
	Load Phase C Active Power Max/Min	date/time/W	25,440	635F	1	Int32
	Load Phase C Reactive Power Max/Min	date/time/ VAR	25,452	636B	1	Int32
	Load Phase C Apparent Power Max/Min	date/time/VA	25,464	6377	1	Uint32
	Load Phase C Power Factor Max/Min	date/time/PF	25,476	6383	100	Int16
Demand Data	Time of Demand Data Start month : date	1-12 : 1-31	25,486	638D	-	Uint16
	Time of Demand Data Start year : day	0-99 : 1-7	25,487	638E	-	Uint16
	Time of Demand Data Start hour : minute	0-23 : 0-59	25,488	638F	-	Uint16
	Time of Demand Data Start sec. : 1/100 sec.	0-59 : 0-99	25,489	6390	-	Uint16
	Time of Demand Data End month : date	1-12 : 1-31	25,490	6391	-	Uint16
	Time of Demand Data End year : day	0-99 : 1-7	25,491	6392	-	Uint16
	Time of Demand Data End hour : minute	0-23 : 0-59	25,492	6393	-	Uint16
	Time of Demand Data End sec. : 1/100 sec.	0-59 : 0-99	25,493	6394	-	Uint16
	Load I_A Demand	A	25,494	6395	1	Uint16
	Load I_B Demand	A	25,495	6396	1	Uint16
	Load I_C Demand	A	25,496	6397	1	Uint16
	Total Active Power Demand high register	W	25,497	6398	1	Int32
	Total Active Power low Demand register	W	25,498	6399	1	Int32
	Total Reactive Power Demand high register	VAR	25,499	639A	1	Int32
	Total Reactive Power Demand low register	VAR	25,500	639B	1	Int32

Table 36. Function Code 04 Actual Values (Statistical Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Demand Data Cont.	Total Apparent Power Demand high register	VA	25,501	639C	1	Uint32
	Total Apparent Power Demand low register	VA	25,502	639D	1	Uint32
	Power Factor (Apparent) Demand		25,503	639E	100	Int16
Peak Demand Data	Time of Peak Demand Cleared month : date	1-12 : 1-31	25,504	639F	-	Uint16
	Time Peak Demand Cleared year : day	0-99 : 1-7	25,505	63A0	-	Uint16
	Time of Peak Demand Cleared hour : minute	0-23 : 0-59	25,506	63A1	-	Uint16
	Time of Peak Demand Cleared sec. : 1/100 sec.	0-59 : 0-99	25,507	63A2	-	Uint16
	Time of Load I_A Peak Demand month : date	1-12 : 1-31	25,508	63A3	-	Uint16
	Time of Load I_A Peak Demand year : day	0-99 : 1-7	25,509	63A4	-	Uint16
	Time of Load I_A Peak Demand hour : minute	0-23 : 0-59	25,510	63A5	-	Uint16
	Time of Load I_A Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,511	63A6	-	Uint16
	Load I_A Peak Demand	A	25,512	63A7	1	Uint16
	Time of Load I_B Peak Demand month : date	1-12 : 1-31	25,513	63A8	-	Uint16
	Time of Load I_B Peak Demand year : day	0-99 : 1-7	25,514	63A9	-	Uint16
	Time of Load I_B Peak Demand hour : minute	0-23 : 0-59	25,515	63AA	-	Uint16
	Time of Load I_B Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,516	63AB	-	Uint16
	Load I_B Peak Demand	A	25,517	63AC	1	Uint16
	Time of Load I_C Peak Demand month : date	1-12 : 1-31	25,518	63AD	-	Uint16
	Time of Load I_C Peak Demand year : day	0-99 : 1-7	25,519	63AE	-	Uint16
	Time of Load I_C Peak Demand hour : minute	0-23 : 0-59	25,520	63AF	-	Uint16
	Time of Load I_C Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,521	63B0	-	Uint16
	Load I_C Peak Demand	A	25,522	63B1	1	Uint16
	Time of Total Active Power Peak Demand month : date	1-12 : 1-31	25,523	63B2	-	Uint16
	Time of Total Active Power Peak Demand year : day	0-99 : 1-7	25,524	63B2	-	Uint16
	Time of Total Active Power Peak Demand hour : minute	0-23 : 0-59	25,525	63B4	-	Uint16
	Time of Total Active Power Peak Demand Sec. : 1/100 sec.	0-59 : 0-99	25,526	63B5	-	Uint16
	Total Active Power Peak Demand high register	W	25,527	63B6	1	Int32
	Total Active Power Peak Demand Low register	W	25,528	63B7	1	Int32
	Time of Total Reactive Power Peak Demand month : date	1-12 : 1-31	25,529	63B8	-	Uint16
	Time of Total Reactive Power Peak Demand year : day	0-99 : 1-7	25,530	63B9	-	Uint16
	Time of Total Reactive Power Peak Demand hour : minute	0-23 : 0-59	25,531	63BA	-	Uint16
	Time of Total Reactive Power Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,532	63BB	-	Uint16
	Total Reactive Power Peak Demand high register	VAR	25,533	63BC	1	Int32
	Total Reactive Power Peak Demand Low register	VAR	25,534	63BD	1	Int32
	Time of Total Apparent Power Peak Demand month : date	1-12 : 1-31	25,535	63BE	-	Uint16
	Time of Total Apparent Power Peak Demand year : day	0-99 : 1-7	25,536	63BF	-	Uint16
	Time of Total Apparent Power Peak Demand hour : minute	0-23 : 0-59	25,537	63C0	-	Uint16
	Time of Total Apparent Power Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,538	63C1	-	Uint16
	Total Apparent Power Peak Demand high register	VA	25,539	63C2	1	Uint32
	Total Apparent Power Peak Demand Low register	VA	25,540	63C3	1	Uint32
	Time of Total Power Factor Peak Demand month : date	1-12 : 1-31	25,541	63C4	-	Uint16
	Time of Total Power Factor Peak Demand year : day	0-99 : 1-7	25,542	63C5	-	Uint16

Table 36. Function Code 04 Actual Values (Statistical Data) Register Definitions (Continued).

CATEGORY	NAME	UNITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Peak Demand Data (cont.)	Time of Total Power Factor Peak Demand hour : minute	0-23 : 0-59	25,543	63C6	-	Uint16
	Time of Total Power Factor Peak Demand sec. : 1/100 sec.	0-59 : 0-99	25,544	63C7	-	Uint16
	Total Power Factor Peak Demand		25,545	63C8	100	Int16

The query message format for function code 04 in given in Table 37. The query specifies the starting register address (which is always one less than the starting register number) and the quantity of registers to be read.

Table 37. Read Actual Value Registers (04) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	04_{16}
Starting Address High Byte	20_{16}
Starting Address Low Byte	02_{16}
Number of Registers High Byte	00_{16}
Number of Registers Low Byte	02_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format is given in Table 38. The contents of each 16-bit register are returned as two bytes, with the high-order byte returned first. The Byte Count field contains the number of data bytes being returned, which is calculated as two times the number of registers requested.

Table 38. Read Actual Value Registers (04) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	04_{16}
Byte Count	04_{16}
Data from High Byte of Register X (e.g., 2002_{16})	02_{16}
Data from Low Byte of Register X (e.g., 2002_{16})	58_{16}
Data from High Byte of Register X + 1 (e.g., 2003_{16})	01_{16}
Data from Low Byte of Register X + 1 (e.g., 2003_{16})	$2C_{16}$
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.5 Function Code 05 - Write Single Coil (Programmable Outputs and Operation Commands)

Function code 05 executes a Write Coil Command to control the programmable output relays of the TSM-900 by sending the Coil Value (0xFF00 for coil ON, 0x0000 for coil OFF) to the appropriate register address.

Note: The programmable output must be mapped to "Remote I/O" (via Group 5 setpoints), otherwise the command is ignored and the TSM-900 responds with an exception code (01 - ILLEGAL FUNCTION). The register numbers/addresses of all possible programmable relays are shown in Table 39. Note that Modules 1 through 4 are optional and may not be present in a given system.

Table 39. Function Code 05 Programmable Relay Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
Write Local Relay 1	5500	157B
Write Local Relay 2	5501	157C
Write Local Relay 3	5502	157D
Write Local Relay 4	5503	157E
Write Module 1 Relay 1	5504	157F
Write Module 1 Relay 2	5505	1580
Write Module 1 Relay 3	5506	1581
Write Module 1 Relay 4	5507	1582
Write Module 2 Relay 1	5508	1583
Write Module 2 Relay 2	5509	1584
Write Module 2 Relay 3	5510	1585
Write Module 2 Relay 4	5511	1586
Write Module 3 Relay 1	5512	1587
Write Module 3 Relay 2	5513	1588
Write Module 3 Relay 3	5514	1589
Write Module 3 Relay 4	5515	158A
Write Module 4 Relay 1	5516	158B
Write Module 4 Relay 2	5517	158C
Write Module 4 Relay 3	5518	158D
Write Module 4 Relay 4	5519	158E

Function code 05 is also used to execute Operation Commands by sending the value of 0xFF00 to the appropriate register address. These commands are used to clear various historical counters/timers and to provide some remote control capabilities of the ATS. Table 40 contains the registers associated with the Operation Commands supported by the TSM-900.

Table 40. Function Code 05 Operation Command Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
Reset Number of Transfers	5000	1387
Reset Number of Transfer Tests	5001	1388
Reset Number of Run-Only Tests	5002	1389
Reset S1 Available Time	5003	138A
Reset S1 Connect Time	5004	138B
Reset S2 Available Time	5005	138C
Reset S2 Connect Time	5006	138D
Reset Load Energized Time	5007	138E
Reset Tier 4 Timer	5008	138F
Reset Transfer Test Time	5009	1390
Reset Run-Only Test Time	5010	1391
Reset Source 1 Voltage/Frequency min/max	5011	1392
Reset Source 2 Voltage/Frequency min/max	5012	1393
Reset Load Voltage/Frequency min/max	5013	1394
Reset Load Current min/max	5014	1395
Reset Total Power min/max	5015	1396
Reset Phase A Power min/max	5016	1397
Reset Phase B Power min/max	5017	1398
Reset Phase C Power min/max	5018	1399
Reset Peak Demand Current/Power/PF	5019	139A
Reset Alarms	5020	139B
Initiate ATS Test	5021	139C
Cancel ATS Test	5022	139D
Bypass TDNE/TDEN	5023	139E

The query message format for function code 05 is given in Table 41. This example is for initiating an ATS Test.

Table 41. Operation Command (05) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	34_{16}
Function Code	05_{16}
Operation Register Address High Byte	13_{16}
Operation Register Address Low Byte	$8F_{16}$
Coil Value High Byte	FF_{16}
Coil Value Low Byte	00_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format for function code 05 is an echo to the query as shown in Table 42.

Table 42. Operation Command (05) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	34_{16}
Function Code	05_{16}
Operation Address Register High Byte	13_{16}
Operation Address Register Low Byte	$8F_{16}$
Execute Command High Byte	FF_{16}
Execute Command Low Byte	00_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.6 Function Code 06 - Write Single Register (Setpoint Data and Multi-Register Configuration)

Function code 06 is used to write a single setpoint register as defined in Table 12 through Table 17.

Note:

1. As noted in Section 3.3, many setpoints are packed two setpoints per register, in which case both setpoints will be written with a single register write.
2. The controller checks the validity of all setpoints and only stores valid values. After writing a setpoint, the same setpoint can be read back to verify that it was accepted by the controller, or the "Write Setpoints Status" register (shown in Table 20) can be read.

Function code 06 is also used to write the Multi-Register Configuration register (Table 20), which determines the order of words when transmitting 32-bit (two-word) values.

When the value is equal to 0 (factory default), the order is: high-order (most-significant) word in the first register space, and the low-order (least-significant) word in the second register space. This order is required for proper handling by the Power Xpert Gateway:

Table 43. Multi-Register Configuration = 0.

REGISTER X		REGISTER X + 1	
Byte 3	Byte 2	Byte 1	Byte 0
Bits 31...24	Bits 23...16	Bits 1 5...8	Bits 7...0

When the value is not equal to 0, the order is: low-order (least-significant) word in the first register space, and the high-order (most-significant) word in the second register space:

Table 44. Multi-Register Configuration = 1.

REGISTER X		REGISTER X + 1	
Byte 1	Byte 0	Byte 3	Byte 2
Bits 15...8	Bits 7...0	Bits 31...24	Bits 23...16

For each word, the most-significant byte is always transmitted first. Within a byte, the least-significant bit is always transmitted first.

3.7 Function Code 08 - Diagnostics (TSM-900 Diagnostic Counters Commands)

Function code 08 is used to read and clear the Diagnostic Counters related to Modbus communications as detailed in Table 45.

Table 45. Diagnostics Sub-Function Decoding.

NAME	SUB-FUNCTION CODE
Return Query Data	00_{16}
Clear Counters	$0A_{16}$
Return Bus Message Count	$0B_{16}$
Return Bus Communication Error Count	$0C_{16}$
Return Bus Exception Error Count	$0D_{16}$
Return Slave Message Count	$0E_{16}$
Return Slave No Response Count	$0F_{16}$
Return Slave NAK Count	10_{16}
Return Slave Busy Count	11_{16}
Return Bus Character Overrun Count	12_{16}

The query message format for function code 08 is given in Table 46.

Table 46. Diagnostics (05) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	08_{16}
Sub-function Code High Byte	00_{16}
Sub-function Code Low Byte	$0B_{16}$
Data High Byte	xx_{16}
Data Low Byte	xx_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The query response format for function code 08 is given in Table 47.

Table 47. Diagnostics (05) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	08_{16}
Sub-function Code High Byte	00_{16}
Sub-function Code Low Byte	$0B_{16}$
Data High Byte	$A3_{16}$
Data Low Byte	14_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

Note: For a Clear Counters sub-function (sub-function code 0A16), the response data should echo the sent data.

3.8 Function Code 16 - Write Multiple Registers (Setpoints)

Function code 16 writes the setpoints registers.

Setpoints registers have been reserved to hold configuration information parameters that are programmable. Setpoints information starts at register number 3000 (i.e., holding register address $BB7_{16}$). Section 3.3 describes reading of setpoints and provides additional notes that aren't repeated here.

Note:

1. Each setpoint is verified by the controller to be within the valid range as shown in Table 12 through Table 17. An invalid value of any setpoint within a setpoint group will cause all values within that group to be discarded. When writing large numbers of setpoints that span multiple groups, it is possible to have some setpoints saved (where all setpoints in a particular group are valid) while others are discarded (due to one or more invalid setpoints within another particular group).
2. Setpoints designated as Read Only must be written exactly as read. Any attempted change of a Read Only value within a group will cause all setpoints being written to that group to be discarded.
3. The "Write Setpoints Status" register shown in Table 20 can be read as a quick indication that all setpoint changes were accepted (value is zero). A non-zero value will require investigation into which setpoint value was incorrect.
4. Validation of setpoints and writing to non-volatile memory takes additional processing time, therefore when writing large numbers of setpoints it may be necessary to increase the maximum timeout waiting for a response from the controller.

Table 48 shows an example of a Write Multiple Registers message to program all Group 2 setpoints. The message specifies the starting register address (BCE_{16}), the number of registers to be written to (09_{16}), and the setpoint data values of the registers. The setpoint values for each 16-bit register are transmitted as two bytes, with the high-order byte transmitted first.

Table 48. Write Setpoints (16) Query.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	16_{16}
Starting Address High Byte	$0B_{16}$
Starting Address Low Byte	CE_{16}
Number of Registers High Byte	00_{16}
Number of Registers Low Byte	09_{16}
Register Value (Number of Generators) High Byte	00_{16}
Register Value (Number of Generators) Low Byte	01_{16}
Register Value (Time Delay, Normal to Emergency) High Byte	00_{16}
Register Value (Time Delay, Normal to Emergency) Low Byte	00_{16}
Register Value (Time Delay, Emergency to Normal) High Byte	00_{16}
Register Value (Time Delay, Emergency to Normal) Low Byte	$1E_{16}$
Register Value (Time Delay, Pre-transfer) High Byte	00_{16}
Register Value (Time Delay, Pre-transfer) Low Byte	$1E_{16}$
Register Value (Time Delay, Post-transfer) High Byte	00_{16}
Register Value (Time Delay, Post-transfer) Low Byte	$1E_{16}$
Register Value (Time Delay, Engine 1 Start) High Byte	00_{16}
Register Value (Time Delay, Engine 1 Start) Low Byte	$1E_{16}$
Register Value (Time Delay, Engine 2 Start) High Byte	00_{16}
Register Value (Time Delay, Engine 2 Start) Low Byte	$1E_{16}$
Register Value (Time Delay, Engine Cooldown) High Byte	00_{16}
Register Value (Time Delay, Engine Cooldown) Low Byte	$1E_{16}$
Register Value (Time Delay, Emergency Fail) High Byte	00_{16}
Register Value (Time Delay, Emergency Fail) Low Byte	07_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

The response message format is given in Table 49. The response echoes the starting register address and the number of setpoint registers from the query message.

Table 49. Write Setpoints (16) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	42_{16}
Function Code	10_{16} (16_{10})
Starting Register Value (TDES) Address High Byte	$0B_{16}$
Starting Register Value (TDES) Address Low Byte	CE_{16}
Number of Registers High Byte	00_{16}
Number of Registers Low Byte	09_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

3.9 Exception Codes

Under certain circumstances, the TSM-900 will return an exception code. The exception codes are shown in Table 50.

Note: As per the Modbus specification, error code 0x03 for Invalid Data indicates that something about the Modbus message is incorrect (for example an invalid byte count), but is not used to show that the controller doesn't accept the data embedded in a valid message (for example an invalid setpoint).

Table 50. Exception Codes.

EXCEPTION CODE (HEX)	DESCRIPTION
01	Invalid Function
02	Invalid Register
03	Invalid Data

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