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ATC-900 Modbus Communications Guide

Rev 1.2

Instructional Booklet

Change Record.

REVISION	DATE	CHANGES
1.0	11/19/14	Initial Release
1.1	4/9/15	- Added Function Code 1 Register Numbers 1045-1049 - Redefined Function Code 3 Register Numbers 3062-3068 - Changed Data Ranges for Function Code 3 registers 3014, 3017, 3022, 3028, and 3029 - Added Note 6 for Function Code 4 to describe invalid values - Redefined Function Code 4 Register Number 6183 - Added Function Code 4 Register Number 6327 - Added Values/Bits/Codes to Tables 25, 26, 28, and 33

1. Introduction

This document is to be used as a reference to communicate with the ATC-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.

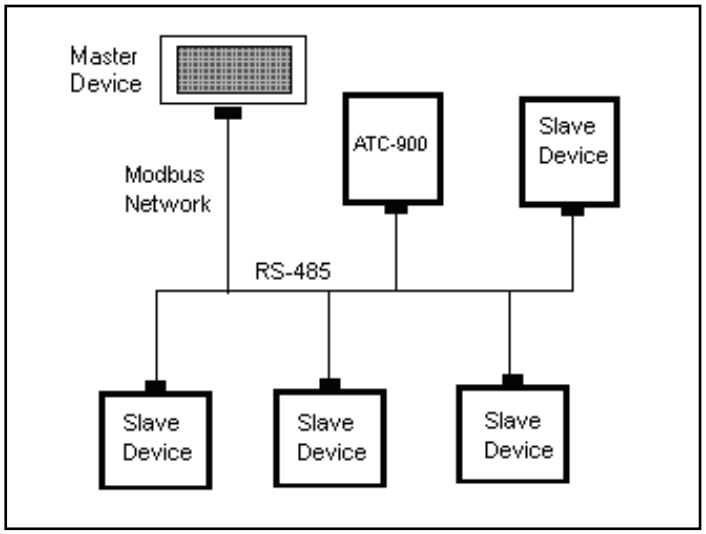

Figure 1. A Typical Modbus Network

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 ATC-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 ATC-900 supports RTU mode.

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 ATC-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 ATC-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.

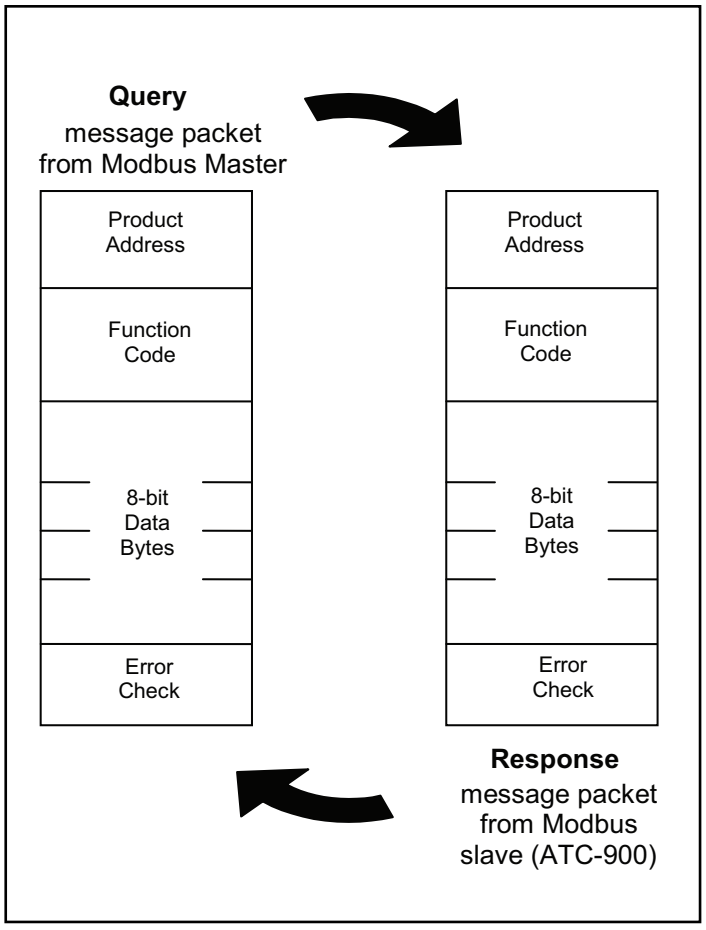

Figure 2. Modbus Master-Slave Query-Response Cycle

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 ATC-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.

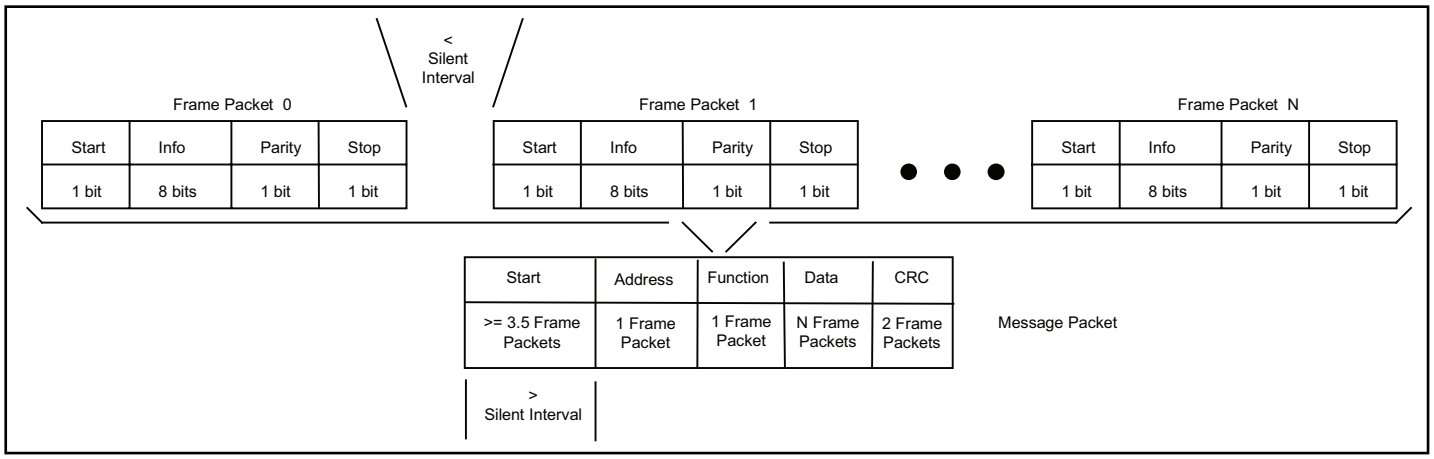

Figure 3. RTU Message Packet

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 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 ATC-900, the function code field tells the ATC-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 ATC-900 supports the function codes listed in Table 2.

When the ATC-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 ATC-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	ATC-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 ATC-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 ATC-900 to read a group of registers would have the following function code:

0000 0011 (Hexadecimal 03)

If the ATC-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 ATC-900 and it returns:

1000 0011 (Hexadecimal 83)

In addition to modifying the function code for an exception response, the ATC-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 46.

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 ATC-900 detects a CRC error, the entire message packet must be discarded. An ATC-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 ATC-900. Table 4 shows all of the possible relay and status bits available on the controller and Accessory I/O Modules. 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/Pre/User-defined Relay
Source 2 Connected	1003	3EA	Status/Pre/User-defined Relay
Source 1 Preferred	1004	3EB	Status
Source 2 Preferred	1005	3EC	Status
ATS In Test (Engine Test)	1006	3ED	Status/User-defined Relay
ATS Waiting for Sync	1007	3EE	Status/User-defined Relay
K1 Relay	1008	3EF	Pre-defined Relay
K2 Relay	1009	3F0	Pre-defined Relay
K3 Relay	1010	3F1	Pre-defined Relay
K4 Relay	1011	3F2	Pre-defined Relay
PreTransfer	1012	3F3	Status/User-defined Relay
PostTransfer	1013	3F4	Status/User-defined Relay
Alarm	1014	3F5	Status/User-defined Relay
Gen 1 Start Relay	1015	3F6	Pre/User-defined Relay
Gen 2 Start Relay	1016	3F7	Pre/User-defined Relay
Load Sequence Active	1017	3F8	Status/User-defined Relay
Engine Test Aborted	1018	3F9	Status/User-defined Relay
Non Automatic (lockout/monitor mode)	1019	3FA	Status/User-defined Relay
Emergency Inhibit	1020	3FB	Status/User-defined Relay
Selective Load Shed	1021	3FC	Status/User-defined Relay
Load Control	1022	3FD	Status/User-defined Relay
Engine Cooldown	1023	3FE	Status/User-defined Relay
Source 1 Undervoltage	1024	3FF	Status
Source 1 Overvoltage	1025	400	Status
Source 1 Voltage Unbalance	1026	401	Status
Source 1 Underfrequency	1027	402	Status
Source 1 Overfrequency	1028	403	Status
Source 1 Rotation Error	1029	404	Status
Source 1 ABC Rotation	1030	405	Status
Source 1 ACB Rotation	1031	406	Status
Source 2 Undervoltage	1032	407	Status
Source 2 Overvoltage	1033	408	Status
Source 2 Voltage Unbalance	1034	409	Status
Source 2 Underfrequency	1035	40A	Status
Source 2 Overfrequency	1036	40B	Status
Source 2 Rotation Error	1037	40C	Status
Source 2 ABC Rotation	1038	40D	Status
Source 2 ACB Rotation	1039	40E	Status
Single Phase	1040	40F	Status (Setpoint)
Transferred	1041	410	Status
Transfer Active	1042	411	Status
Bypassed	1043	412	Status/User-defined Relay
Source 2 Request	1044	413	Status/User-defined Relay
Health	1045	414	Status/User-defined Relay
Source 1 Phase Loss	1046	415	Status
Source 1 Current Unbalance	1047	416	Status
Source 2 Phase Loss	1048	417	Status
Source 2 Current Unbalance	1049	418	Status

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	04_{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 Low 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 ATC-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)
Monitor Mode - NO	2000	7CF
Timer Bypass	2001	7D0
Lockout	2002	7D1
Enable Manual Retransfer	2003	7D2
Manual Retransfer	2004	7D3
Slave In	2005	7D4
Test Engine	2006	7D5
Preferred Source	2007	7D6
Go to Emergency	2008	7D7
Emergency Inhibit	2009	7D8
ATS On Bypass	2010	7D9
Monitor Mode - NC	2011	7DA
Go to Neutral	2012	7DB
Source 2 Permit	2013	7DC

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. The inputs for modules that are not present will always show a value of "OFF".

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 9. Function Code 02 Generic Input Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
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

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 Low 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 programmable configuration information parameters. Setpoints information starts at register number 3000_{10} (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.

   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. The ATC-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	0 = ATC-900UNO 1 = ATC-900UNC 2 = ATC-900C20I 7 = ATC-900BMON 10 = ATC-900BTONI 11 = ATC-900BTONIC 14 = ATC-900C30NI 15 = ATC-900C30NIC 16 = ATC-900MVSONI 17 = ATC-900MVSONIC 18 = ATC-900MBVONI 19 = ATC-900MVBONIC 20 = ATC-900C3KONI 21 = ATC-900C3KONIC	-	-
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, 200 to 5000	1	-
Auto Clock DST Adjust	3005	BBC	0 = Disabled, 1 = Enabled	-	-
System Voltage	3006	BBD	115 (50 Hz) or 120 (60 Hz) to 600	1	V
Number of Generators	3007 HOB	BBE HOB	0 to 2	-	-
Number of Phases	3007 LOB	BBE LOB	1 or 3	-	-
Master/Slave Operation	3008	BBF	0 = Master, 1 = Slave	-	-
Sequence Check	3009 HOB	BC0 HOB	0 = Off, 1 = ABC, 2 = ACB	-	-
Preferred Source	3009 LOB	BC0 LOB	0 = None, 1 = S1, 2 = S2, 3 = External Select	-	-
Retransfer	3010 HOB	BC1 HOB	0 = Automatic, 1 = Manual, 2 = External Select	-	-
Commit to Transfer	3010 HOB	BC1 LOB	0 = No Commit, 1 = Commit	-	-
Modbus Comm. Settings	3011 HOB	BC2 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 (no Modbus!)	-	-
Modbus Address	3011 LOB	BC2 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
Number of Generators (Read-Only)	3012 HOB	BC3 HOB	See Setpoints Group 0	-	-
Style (Read-Only)	3012 LOB	BC3 LOB	See Setpoints Group 0	-	-
System Voltage (Read-Only)	3013	BC4	See Setpoints Group 0	-	-
Closed Transition Enable/Disable	3014	BC5	0 = Disable 1 = Enable with Open/In-Phase transition on sync fail 2 = Enable with Alarm on sync fail	-	-
Closed Transition Voltage Difference	3015 HOB	BC6 HOB	1% to 5% of System Voltage	1	V
Frequency Difference	3015 LOB	BC6 LOB	0 to 3	10	Hz
Closed Transition % Voltage Difference (Read-Only)	3016	BC7	1 to 5	1	%
In-Phase Transition Enable/Disable	3017	BC8	0 = Disable 1 = Enable with Open transition on sync fail 2 = Enable with Alarm on sync fail	-	-
In-Phase Transition Frequency Difference	3018	BC9	0 to 30	10	Hz
Closed/In-Phase Transition Synchronization Time-out	3019	BCA	1 to 60	1	Min.
Open Transition Load Decay Voltage Threshold	3020	BCB	0 = Disable, 2% to 30% of System Voltage	1	V
Open Transition Load Decay % Voltage Threshold (Read-Only)	3021	BCC	2 to 30	1	%
Open Transition Time Delay, neutral (TDN)	3022	BCD	0 to 600	1	Sec.

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

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Number of Generators (Read-Only)	3023	BCE	See Setpoints Group 0	1	Sec.
Time Delay, Normal to Emergency (TDNE)	3024	BCF	0 to 9,999	1	Sec.
Time Delay, Emergency to Normal (TDEN)	3025	BD0	0 to 9,999	1	Sec.
Time Delay, Pre-transfer (TDPRE)	3026	BD1	0 to 600	1	Sec.
Time Delay, Post-transfer (TDPOST)	3027	BD2	0 to 600	1	Sec.
Time Delay, Engine 1 Start (TDES1)	3028	BD3	0 to 15,540	1	Sec.
Time Delay, Engine 2 Start (TDES2)	3029	BD4	0 to 15,540	1	Sec.
Time Delay, Engine Cooldown (TDEC)	3030	BD5	0 to 9,999	1	Sec.
Time Delay, Engine Fail (TDEF)	3031	BD6	0 to 6	1	Sec.
Time Delay, Normal Disconnect (TDND)	3157	C54	0 to 10, 0xFFFF = Disabled	1	Sec.
Time Delay, Normal Reconnect (TDNR)	3158	C55	0 to 60	1	Sec.
Time Delay, Emergency Disconnect (TDED)	3157	C54	0 to 10 , 0xFFFF = Disabled	1	Sec.
Time Delay, Emergency Reconnect (TDER)	3158	C55	0 to 60	1	Sec.

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)	3032	BD7	See Setpoints Group 0	-	-
System Frequency (Read-Only)	3033	BD8	See Setpoints Group 0	-	-
Source 1 Undervoltage Dropout	3034	BD9	70% to 97% of System Voltage	1	V
Source 2 Undervoltage Dropout	3035	BDA	70% to 97% of System Voltage	1	V
Source 2 % UV Dropout (Read-Only)	3036 HOB	BDB HOB	70 to 97	1	%
Source 1 % UV Dropout (Read-Only)	3036 LOB	BDB LOB	70 to 97	1	%
Source 1 Undervoltage Pickup	3037	BDC	(dropout + 2%) to 99% of System Voltage	1	V
Source 2 Undervoltage Pickup	3038	BDD	(dropout + 2%) to 99% of System Voltage	1	V
Source 2 % UV Pickup (Read-Only)	3039 HOB	BDE HOB	(dropout% + 2) to 99	1	%
Source 1 % UV Pickup (Read-Only)	3039 LOB	BDE LOB	(dropout% + 2) to 99	1	%
Source 1 Overvoltage Dropout	3040	BDF	0 = disable, 105% to 120% of System Voltage	1	V
Source 2 Overvoltage Dropout	3041	BE0	0 = disable, 105% to 120% of System Voltage	1	V
Source 2 % OV Dropout (Read-Only)	3042 HOB	BE1 HOB	0, 105 to 120	1	%
Source 1 % OV Dropout (Read-Only)	3042 LOB	BE1 LOB	0, 105 to 120	1	%
Source 1 Overvoltage Pickup	3043	BE2	0 = disable, 103% to (dropout - 2%) of System Voltage	1	V
Source 2 Overvoltage Pickup	3044	BE3	0 = disable, 103% to (dropout - 2%) of System Voltage	1	V
Source 2 % OV Pickup (Read-Only)	3045 HOB	BE4 HOB	0, 103 to (dropout% – 2)	1	%
Source 1 % OV Pickup (Read-Only)	3045 LOB	BE4 LOB	0, 103 to (dropout% – 2)	1	%
Source 1 Underfrequency Dropout	3046	BE5	0 = Disable, 90% to 97% of Line Frequency	10	Hz
Source 2 Underfrequency Dropout	3047	BE6	0 = Disable, 90% to 97% of Line Frequency	10	Hz
Source 1 % Underfrequency Dropout (Read-Only)	3048	BE7	0, 90 to 97	1	%
Source 2 % Underfrequency Dropout (Read-Only)	3049	BE8	0, 90 to 97	1	%
Source 1 Underfrequency Pickup	3050	BE9	0 = Disable, (dropout + 10) to 99% of Line Frequency	10	Hz
Source 2 Underfrequency Pickup	3051	BEA	0 = Disable, (dropout + 10) to 99% of Line Frequency	10	Hz
Source 1 % Underfrequency Pickup (Read-Only)	3052	BEB	0 = Disable, (dropout% + 1) to 99	1	%
Source 2 % Underfrequency Pickup (Read-Only)	3053	BEC	0 = Disable, (dropout% + 1) to 99	1	%
Source 1 Overfrequency Dropout	3054	BED	0 = Disable, 103% to 110% of Line Frequency	10	Hz
Source 2 Overfrequency Dropout	3055	BEE	0 = Disable, 103% to 110% of Line Frequency	10	Hz
Source 1 % Overfrequency Dropout (Read-Only)	3056	BEF	0, 103 to 110	1	%
Source 2 % Overfrequency Dropout (Read-Only)	3057	BF0	0, 103 to 110	1	%
Source 1 Overfrequency Pickup	3058	BF1	0 = Disable, 101% of Line Frequency to (dropout - 10)	10	Hz
Source 2 Overfrequency Pickup	3059	BF2	0 = Disable, 101% of Line Frequency to (dropout - 10)	10	Hz
Source 1 % Overfrequency Pickup (Read-Only)	3060	BF3	0, 101 to (dropout% - 1)	1	%
Source 2 % Overfrequency Pickup (Read-Only)	3061	BF4	0, 101 to (dropout% - 1)	1	%
Source 2 Voltage Unbalance Dropout %	3062 HOB	BF5 HOB	0 = disable, 5 to 20	1	%
Source 1 Voltage Unbalance Dropout %	3062 LOB	BF5 LOB	0 = disable, 5 to 20	1	%
Source 2 Voltage Unbalance Pickup %	3063 HOB	BF6 HOB	0 = disable, 3 to (dropout - 2)	1	%
Source 1 Voltage Unbalance Pickup %	3063 LOB	BF6 LOB	0 = disable, 3 to (dropout - 2)	1	%
Source 2 Voltage Phase Loss Dropout %	3064 HOB	BF7 HOB	0 = disable, 20 to 60	1	%
Source 1 Voltage Phase Loss Dropout %	3064 LOB	BF7 LOB	0 = disable, 20 to 60	1	%
Source 2 Voltage Phase Loss Pickup %	3065 HOB	BF8 HOB	0 = disable, 18 to (dropout - 2)	1	%
Source 1 Voltage Phase Loss Pickup %	3065 LOB	BF8 LOB	0 = disable, 18 to (dropout - 2)	1	%
Current Unbalance/Phase Loss Dropout %	3066 LOB	BF9 LOB	0 = disable, 5 to 60	1	%
Current Unbalance/Phase Loss Enable %	3066 HOB	BF9 HOB	1 to 100 (% of maximum load current)	1	%
Current Unbalance/Phase Loss Pickup %	3067	BFA	0 = disable, 3 to (dropout - 2)	1	%
Negative Sequence Time Delay	3068	BFB	10 to 30	1	Sec.

Table 16. Function Code 03 Group 4 Setpoints Register Definitions.

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Number of Generators (Read-Only)	3069	BFC	See Setpoints Group 0	-	-
Plant Exerciser 2 Test Mode	3070 HOB	BFD HOB	0 = Disabled, 1 = Run Unloaded, 2 = Run Loaded	-	-
Plant Exerciser 1 Test Mode	3070 LOB	BFD LOB	0 = Disabled, 1 = Run Unloaded, 2 = Run Loaded	-	-
Engine Test Mode	3071	BFE	0 = Disabled, 1 = Run Unloaded, 2 = Run Loaded	-	-
Plant Exerciser 1 Duration Timer	3072	BFF	0 to 600	1	Min.
Plant Exerciser 2 Duration Timer	3073	C00	0 to 600	1	Min.
Engine Run Timer	3074	C01	0 to 600	1	Min.
Plant Exerciser Time Delay, Normal to Emergency	3075	C02	0 to 9,999	1	Sec.
Plant Exerciser Time Delay, Emergency to Normal	3076	C03	0 to 9,999	1	Sec.
Plant Exerciser Time Delay, Engine Cooldown	3077	C04	0 to 9,999	1	Sec.
Plant Exerciser 1 Schedule Mode	3078	C05	0=daily, 1=weekly, 2=14-day, 3=28-day, 4=dates	-	-
Plant Exerciser 1 Month 1	3079 HOB	C06 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 1	3079 LOB	C06 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 2	3080 HOB	C07 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 2	3080 LOB	C07 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 3	3081 HOB	C08 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 3	3081 LOB	C08 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 4	3082 HOB	C09 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 4	3082 LOB	C09 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 5	3083 HOB	C0A HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 5	3083 LOB	C0A LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 6	3084 HOB	C0B HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 6	3084 LOB	C0B LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 7	3085 HOB	C0C HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 7	3085 LOB	C0C LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 8	3086 HOB	C0D HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 8	3086 LOB	C0D LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 9	3087 HOB	C0E HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 9	3087 LOB	C0E LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 10	3088 HOB	C0F HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 10	3088 LOB	C0F LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 11	3089 HOB	C10 HOB	1 = January to 12 = December	-	-
Plant Exerciser 1 Date 11	3089 LOB	C10 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Month 12	3090 HOB	C11 HOB	1 = January to 12 = December	-	-

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

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Plant Exerciser 1 Date 12	3090 LOB	C11 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 1 Hour	3091 HOB	C12 HOB	0 to 23	-	-
Plant Exerciser 1 Minute	3091 LOB	C12 LOB	0 to 59	-	-
Plant Exerciser 1 Day	3092	C13	1 = Sunday to 7 = Saturday	-	-
Plant Exerciser 2 Schedule Mode	3093	C14	0=daily, 1=weekly, 2=14-day, 3=28-day, 4=dates	-	-
Plant Exerciser 2 Month 1	3094 HOB	C15 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 1	3094 LOB	C15 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 2	3095 HOB	C16 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 2	3095 LOB	C16 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 3	3096 HOB	C17 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 3	3096 LOB	C17 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 4	3097 HOB	C18 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 4	3097 LOB	C18 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 5	3098 HOB	C19 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 5	3098 LOB	C19 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 6	3099 HOB	C1A HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 6	3099 LOB	C1A LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 7	3100 HOB	C1B HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 7	3100 LOB	C1B LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 8	3101 HOB	C1C HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 8	3101 LOB	C1C LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 9	3102 HOB	C1D HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 9	3102 LOB	C1D LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 10	3103 HOB	C1E HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 10	3103 LOB	C1E LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 11	3104 HOB	C1F HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 11	3104 LOB	C1F LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Month 12	3105 HOB	C20 HOB	1 = January to 12 = December	-	-
Plant Exerciser 2 Date 12	3105 LOB	C20 LOB	1 to 28, 30, or 31 (month dependent)	-	-
Plant Exerciser 2 Hour	3106 HOB	C21 HOB	0 to 23	-	-
Plant Exerciser 2 Minute	3106 LOB	C21 LOB	0 to 59	-	-
Plant Exerciser 2 Day	3107	C22	1 = Sunday to 7 = Saturday	-	-

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	3108 HOB	C23 HOB	0 to 4	-	-
Style (Read-Only)	3108 LOB	C23 LOB	See Setpoints Group 0		
Selective Load Shed Limit	3109	C24	5 to 3,000	1	KW
Local Programmable Inputs Factory Lock (Read-Only)	3110	C25	0 to 15	-	-
Accessory I/O Module Programmable Inputs Factory Lock (Read-Only)	3111	C26	0 – 65,535	-	-
Local Programmable Outputs Factory Lock (Read-Only)	3112	C27	0 to 15	-	-
Accessory I/O Module Programmable Outputs Factory Lock (Read-Only)	3113	C28	0 – 65,535	-	-
Selective Load Restore Limit	3114	C29	1 to (Selective Load Shed – 1)	1	KW
Local Input 1 Mapping	3115	C2A	Table 18	-	-
Local Input 2 Mapping	3116	C2B	Table 18	-	-
Local Input 3 Mapping	3117	C2C	Table 18	-	-
Local Input 4 Mapping	3118	C2D	Table 18	-	-
Local Output 2 Mapping	3119 HOB	C2E HOB	Table 19		
Local Output 1 Mapping	3119 LOB	C2E LOB	Table 19	-	-
Local Output 4 Mapping	3120 HOB	C2F HOB	Table 19	-	-
Local Output 3 Mapping	3120 LOB	C2F LOB	Table 19	-	-
Output 2 Load Seq. Timer	3121 HOB	C30 HOB	0 to 120	1	Sec.
Output 1 Load Seq. Timer	3121 LOB	C30 LOB	0 to 120	1	Sec.
Output 4 Load Seq. Timer	3122 HOB	C31 HOB	0 to 120	1	Sec.
Output 3 Load Seq. Timer	3122 LOB	C31 LOB	0 to 120	1	Sec.
Module 1 Input 1 Mapping	3123	C32	Table 18	-	-
Module 1 Input 2 Mapping	3124	C33	Table 18	-	-
Module 1 Input 3 Mapping	3125	C34	Table 18	-	-
Module 1 Input 4 Mapping	3126	C35	Table 18	-	-
Module 1 Output 2 Mapping	3127 HOB	C36 HOB	Table 19	-	-
Module 1 Output 1 Mapping	3127 LOB	C36 LOB	Table 19	-	-
Module 1 Output 4 Mapping	3138 HOB	C37 HOB	Table 19	-	-
Module 1 Output 3 Mapping	3138 LOB	C37 LOB	Table 19	-	-
Module 1 Output 2 Timer	3129 HOB	C38 HOB	0 to 120	1	Sec.
Module 1 Output 1 Timer	3129 LOB	C38 LOB	0 to 120	1	Sec.
Module 1 Output 4 Timer	3130 HOB	C39 HOB	0 to 120	1	Sec.
Module 1 Output 3 Timer	3130 LOB	C39 LOB	0 to 120	1	Sec.
Module 2 Input 1 Mapping	3131	C3A	Table 18	-	-
Module 2 Input 2 Mapping	3132	C3B	Table 18	-	-
Module 2 Input 3 Mapping	3133	C3C	Table 18	-	-
Module 2 Input 4 Mapping	3134	C3D	Table 18	-	-
Module 2 Output 2 Mapping	3135 HOB	C3E HOB	Table 19	-	-
Module 2 Output 1 Mapping	3135 LOB	C3E LOB	Table 19	-	-
Module 2 Output 4 Mapping	3136 HOB	C3F HOB	Table 19	-	-
Module 2 Output 3 Mapping	3136 LOB	C3F LOB	Table 19	-	-
Module 2 Output 2 Timer	3137 HOB	C40 HOB	0 to 120	1	Sec.
Module 2 Output 1 Timer	3137 LOB	C40 LOB	0 to 120	1	Sec.
Module 2 Output 4 Timer	3138 HOB	C41 HOB	0 to 120	1	Sec.
Module 2 Output 3 Timer	3138 LOB	C41 LOB	0 to 120	1	Sec.
Module 3 Input 1 Mapping	3139	C42	Table 18	-	-
Module 3 Input 2 Mapping	3140	C43	Table 18	-	-
Module 3 Input 3 Mapping	3141	C44	Table 18	-	-
Module 3 Input 4 Mapping	3142	C45	Table 18	-	-
Module 3 Output 2 Mapping	3143 HOB	C46 HOB	Table 19	-	-
Module 3 Output 1 Mapping	3143 LOB	C46 LOB	Table 19	-	-
Module 3 Output 4 Mapping	3144 HOB	C47 HOB	Table 19	-	-

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

NAME	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	DATA RANGE	SCALE FACTOR	UNITS
Module 3 Output 3 Mapping	3144 LOB	C47 LOB	Table 19	-	-
Module 3 Output 2 Timer	3145 HOB	C48 HOB	0 to 120	1	Sec.
Module 3 Output 1 Timer	3145 LOB	C48 LOB	0 to 120	1	Sec.
Module 3 Output 4 Timer	3146 HOB	C49 HOB	0 to 120	1	Sec.
Module 3 Output 3 Timer	3146 LOB	C49 LOB	0 to 120	1	Sec.
Module 4 Input 1 Mapping	3147	C4A	Table 18	-	-
Module 4 Input 2 Mapping	3148	C4B	Table 18	-	-
Module 4 Input 3 Mapping	3149	C4C	Table 18	-	-
Module 4 Input 4 Mapping	3150	C4D	Table 18	-	-
Module 4 Output 2 Mapping	3151 HOB	C4E HOB	Table 19	-	-
Module 4 Output 1 Mapping	3151 LOB	C4E LOB	Table 19	-	-
Module 4 Output 4 Mapping	3152 HOB	C4F HOB	Table 19	-	-
Module 4 Output 3 Mapping	3152 LOB	C4F LOB	Table 19	-	-
Module 4 Output 2 Timer	3153 HOB	C50 HOB	0 to 120	1	Sec.
Module 4 Output 1 Timer	3153 LOB	C50 LOB	0 to 120	1	Sec.
Module 4 Output 4 Timer	3154 HOB	C51 HOB	0 to 120	1	Sec.
Module 4 Output 3 Timer	3154 LOB	C51 LOB	0 to 120	1	Sec.
Time Delay Normal Fail (TDNF)	3155	C62	0 to 120	1	Sec.

Table 18. Programmable Input Definitions.

VALUE	DEFINITION
0	Disabled
1	Monitor Mode - NO
2	Bypass Timer
3	Lockout
4	Enable Manual Retransfer
5	Manual Retransfer Request
6	Slave In
7	Remote Engine Test
8	Preferred Source Select
9	Go to Emergency
10	Emergency Inhibit
11	ATS on Bypass
12	Monitor Mode - NC
13	Go to Neutral
14	Sourced 2 Permit

Table 19. Programmable Output Definitions.

VALUE	DEFINITION
0	Disabled
1	Alarm
2	Source 1 Connected
3	Source 2 Connected
4	Pre/Post Transfer
5	Pre Transfer
6	Post Transfer
7	Engine 1 Start Contact Status
8	Engine 2 Start Contact Status
9	Selective Load Shed
10	Load Bank Control
11	Load Sequence
12	Emergency Inhibit On
13	ATS Not in Automatic
14	Cooldown in Progress
15	ATS in Test
16	Engine Test Aborted
17	Remote I/O
18	ATS in Bypass
19	Source 1 Available
20	Source 2 Available
21	Source 2 Request
22	Health

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.

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 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)	3155	C52	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	-	-

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

Table 22. Read Setpoints Registers (03) Response.

QUERY FIELD NAME	EXAMPLE
Slave Address	21_{16}
Function Code	03_{16}
Data from Starting Address High Byte	00_{16}
Data from Starting Address Low Byte	03_{16}
Data from Number of Registers High Byte	00_{16}
Data from Number of Registers Low Byte	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 31), and historical information such as event data (Table 32) and high-speed capture data (Table 35). 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 ATC-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 Table 23 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.
6. A value of 0xFFFF will be returned for voltage, current, and power readings that are "invalid". Reasons for invalid readings are: 3-phase parameters in single-phase systems, current/power parameters for systems with no DCT Module installed, and unreliable unbalance readings due to extremely low per-phase readings for all 3 phases.

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 2 V_{AB}	V	6148	1803	1	Uint16
	Source 2 V_{BC}	V	6149	1804	1	Uint16
	Source 2 V_{CA}	V	6150	1805	1	Uint16
	Source 1/ Source 2 Max Voltage Difference	V	6151	1806	1	Uint16
	Load V_{AB}	V	6152	1807	1	Uint16
	Load V_{BC}	V	6153	1808	1	Uint16
	Load V_{CA}	V	6154	1809	1	Uint16
	Source 1 Frequency	Hz	6155	180A	10	Uint16
	Source 2 Frequency	Hz	6156	180B	10	Uint16
	Source 1/ Source 2 Frequency Difference	Hz	6157	180C	10	Uint16
	Load Frequency	Hz	6158	180D	10	Uint16
	Load I_A	A	6159	180E	1	Uint16
	Load I_B	A	6160	180F	1	Uint16
	Load I_C	A	6161	1810	1	Uint16
	Source 1 Voltage Unbalance	%	6162	1811	10	Uint16
	Source 2 Voltage Unbalance	%	6163	1812	10	Uint16
	Load Current Unbalance	%	6164	1813	10	Uint16
	Source 1/ Source 2 Phase Difference	Deg	6165	1814	1	Uint16
	Total Active Power high register	W	6166	1815	1	Int32
	Total Active Power low register	W	6167	1816	1	Int32
	Total Reactive Power high register	VAR	6168	1817	1	Int32
	Total Reactive Power low register	VAR	6169	1818	1	Int32
	Total Apparent Power high register	VA	6170	1819	1	Uint32
	Total Apparent Power low register	VA	6171	181A	1	Uint32
	Power Factor (Apparent)		6172	181B	100	Int16
Timers	TDES Timer	seconds	6173	181C	1	Uint16
	TDNE Timer	seconds	6174	181D	1	Uint16
	TDEN Timer	seconds	6175	181E	1	Uint16
	TDEC Timer	seconds	6176	181F	1	Uint16
	TDN Timer	seconds	6177	1820	1	Uint16
	TDEF Timer	seconds	6178	1821	1	Uint16
	TDNF Timer	seconds	*6326	*18B5	1	Uint16
	TDND Timer	seconds	6327	18B6	1	Uint16
	TDNR Time	seconds	6328	18B7	1	Uint16
	TDED Timer	seconds	6329	18B8	1	Uint16
	TDER Timer	seconds	6330	18B9	1	Uint16
	Pretransfer Timer	seconds	6179	1822	1	Uint16
	Engine Run Timer	seconds	6180	1823	1	Uint16
	Sync Timer	seconds	6181	1824	1	Uint16
	Posttransfer Timer	seconds	6182	1825	1	Uint16
	S1 Unbalance/Phase Loss Timer	seconds	6183	1826	1	Uint16
	S2 Unbalance/Phase Loss Timer	seconds	*6327	*18B6	1	Uint16
System Counters	S1 Engine Run Time high register	minutes	6184	1827	-	Uint16
	S1 Engine Run Time low register	minutes	6185	1828	-	Uint16
	S1 Engine Run TOC month : date	1-12 : 1-31	6186	1829	-	Uint16
	S1 Engine Run TOC year : day	0-99 : 1-7	6187	182A	-	Uint16
	S1 Engine Run TOC hour : minute	0-23 : 0-59	6188	182B	-	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
	S1 Engine Run TOC second : 1/100 second	0-59 : 0-99	6189	182C	-	Uint16
	S1 Engine Run TOR month : date	1-12 : 1-31	6190	182D	-	Uint16
	S1 Engine Run TOR year : day	0-99 : 1-7	6191	182E	-	Uint16
	S1 Engine Run TOR hour : minute	0-23 : 0-59	6192	182F	-	Uint16
	S1 Engine Run TOR second : 1/100 second	0-59 : 0-99	6193	1830	-	Uint16
	S2 Engine Run Time high register	minutes	6194	1831	-	Unit16
	S2 Engine Run Time low register	minutes	6195	1832	-	Uint16
	S2 Engine Run TOC month : date	1-12 : 1-31	6196	1833	-	Uint16
	S2 Engine Run TOC year : day	0-99 : 1-7	6197	1834	-	Uint16
	S2 Engine Run TOC hour : minute	0-23 : 0-59	6198	1835	-	Uint16
	S2 Engine Run TOC second : 1/100 second	0-59 : 0-99	6199	1836	-	Uint16
	S2 Engine Run TOR month : date	1-12 : 1-31	6200	1837	-	Uint16
	S2 Engine Run TOR year : day	0-99 : 1-7	6201	1838	-	Uint16
	S2 Engine Run TOR hour : minute	0-23 : 0-59	6202	1839	-	Uint16
	S2 Engine Run TOR second : 1/100 second	0-59 : 0-99	6203	183A	-	Uint16
System Counters	S1 Connect Time high register	minutes	6204	183B	-	Uint16
	S1 Connect Time low register	minutes	6205	183C	-	Uint16
	S1 Connect TOC month : date	1-12 : 1-31	6206	183D	-	Uint16
	S1 Connect TOC year : day	0-99 : 1-7	6207	183E	-	Uint16
	S1 Connect TOC hour : minute	0-23 : 0-59	6208	183F	-	Uint16
	S1 Connect TOC second : 1/100 second	0-59 : 0-99	6209	1840	-	Uint16
	S1 Connect TOR month : date	1-12 : 1-31	6210	1841	-	Uint16
	S1 Connect TOR year : day	0-99 : 1-7	6211	1842	-	Uint16
	S1 Connect TOR hour : minute	0-23 : 0-59	6212	1843	-	Uint16
	S1 Connect TOR second : 1/100 second	0-59 : 0-99	6213	1844	-	Uint16
	S2 Connect Time high register	minutes	6214	1845	-	Uint16
	S2 Connect Time low register	minutes	6215	1846	-	Uint16
	S2 Connect TOC month : date	1-12 : 1-31	6216	1847	-	Uint16
	S2 Connect TOC year : day	0-99 : 1-7	6217	1848	-	Uint16
	S2 Connect TOC hour : minute	0-23 : 0-59	6218	1849	-	Uint16
	S2 Connect TOC second : 1/100 second	0-59 : 0-99	6219	184A	-	Uint16
	S2 Connect TOR month : date	1-12 : 1-31	6220	184B	-	Uint16
	S2 Connect TOR year : day	0-99 : 1-7	6221	184C	-	Uint16
	S2 Connect TOR hour : minute	0-23 : 0-59	6222	184D	-	Uint16
	S2 Connect TOR second : 1/100 second	0-59 : 0-99	6223	184E	-	Uint16
	S1 Available Time high register	minutes	6224	184F	-	Uint16
	S1 Available Time low register	minutes	6225	1850	-	Uint16
	S1 Available TOC month : date	1-12 : 1-31	6226	1851	-	Uint16
	S1 Available TOC year : day	0-99 : 1-7	6227	1852	-	Uint16
	S1 Available TOC hour : minute	0-23 : 0-59	6228	1853	-	Uint16
	S1 Available TOC second : 1/100 second	0-59 : 0-99	6229	1854	-	Uint16
	S1 Available TOR month : date	1-12 : 1-31	6230	1855	-	Uint16
	S1 Available TOR year : day	0-99 : 1-7	6231	1856	-	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
	S1 Available TOR hour : minute	0-23 : 0-59	6232	1857	-	Uint16
	S1 Available TOR second : 1/100 second	0-59 : 0-99	6233	1858	-	Uint16
	S2 Available Time high register	minutes	6234	1859	-	Uint16
	S2 Available Time low register	minutes	6235	185A	-	Uint16
	S2 Available TOC month : date	1-12 : 1-31	6236	185B	-	Uint16
	S2 Available TOC year : day	0-99 : 1-7	6237	185C	-	Uint16
	S2 Available TOC hour : minute	0-23 : 0-59	6238	185D	-	Uint16
	S2 Available TOC second : 1/100 second	0-59 : 0-99	6239	185E	-	Uint16
	S2 Available TOR month : date	1-12 : 1-31	6240	185F	-	Uint16
	S2 Available TOR year : day	0-99 : 1-7	6241	1860	-	Uint16
	S2 Available TOR hour : minute	0-23 : 0-59	6242	1861	-	Uint16
	S2 Available TOR second : 1/100 second	0-59 : 0-99	6243	1862	-	Uint16
	Tier 4 Time high register	minutes	6244	1863	-	Uint16
	Tier 4 Time low register	minutes	6245	1864	-	Uint16
System Counters	Tier 4 TOC month : date	1-12 : 1-31	6246	1865	-	Uint16
	Tier 4 TOC year : day	0-99 : 1-7	6247	1866	-	Uint16
	Tier 4 TOC hour : minute	0-23 : 0-59	6248	1867	-	Uint16
	Tier 4 TOC second : 1/100 second	0-59 : 0-99	6249	1868	-	Uint16
	Tier 4 TOR month : date	1-12 : 1-31	6250	1869	-	Uint16
	Tier 4 TOR year : day	0-99 : 1-7	6251	186A	-	Uint16
	Tier 4 TOR hour : minute	0-23 : 0-59	6252	186B	-	Uint16
	Tier 4 TOR second : 1/100 second	0-59 : 0-99	6253	186C	-	Uint16
	Load Energized Time high register	minutes	6254	186D	-	Uint16
	Load Energized Time low register	minutes	6255	186E	-	Uint16
	Load Energized TOC month : date	1-12 : 1-31	6256	186F	-	Uint16
	Load Energized TOC year : day	0-99 : 1-7	6257	1870	-	Uint16
	Load Energized TOC hour : minute	0-23 : 0-59	6258	1871	-	Uint16
	Load Energized TOC second : 1/100 second	0-59 : 0-99	6259	1872	-	Uint16
	Load Energized TOR month : date	1-12 : 1-31	6260	1873	-	Uint16
	Load Energized TOR year : day	0-99 : 1-7	6261	1874	-	Uint16
	Load Energized TOR hour : minute	0-23 : 0-59	6262	1875	-	Uint16
	Load Energized TOR second : 1/100 second	0-59 : 0-99	6263	1876	-	Uint16
	Number of Transfers		6264	1877	-	Uint16
	Number of Transfers TOC month : date	1-12 : 1-31	6265	1878	-	Uint16
	Number of Transfers TOC year : day	0-99 : 1-7	6266	1879	-	Uint16
	Number of Transfers TOC hour : minute	0-23 : 0-59	6267	187A	-	Uint16
	Number of Transfers TOC sec:1/100 sec	0-59 : 0-99	6268	187B	-	Uint16
	Number of Transfers TOR month : date	1-12 : 1-31	6269	187C	-	Uint16
	Number of Transfers TOR year : day	0-99 : 1-7	6270	187D	-	Uint16
	Number of Transfers TOR hour : minute	0-23 : 0-59	6271	187E	1	Uint16
	Number of Transfers TOR sec:1/100 sec	0-59 : 0-99	6272	187F	-	Uint16
	Number of Generator 1 Starts		6273	1880	-	Uint16
	Number of Gen 1 Starts TOC month : date	1-12 : 1-31	6274	1881	-	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
System Counters	Number of Gen 1 Starts TOC year : day	0-99 : 1-7	6275	1882	-	Uint16
	Number of Gen 1 Starts TOC hour : minute	0-23 : 0-59	6276	1883	-	Uint16
	Number of Gen 1 Starts TOC sec:1/100 sec	0-59 : 0-99	6277	1884	-	Uint16
	Number of Gen 1 Starts TOR month : date	1-12 : 1-31	6278	1885	-	Uint16
	Number of Gen 1 Starts TOR year : day	0-99 : 1-7	6279	1886	-	Uint16
	Number of Gen 1 Starts TOR hour : minute	0-23 : 0-59	6280	1887	1	Uint16
	Number of Gen 1 Starts TOR sec:1/100 sec	0-59 : 0-99	6281	1888	-	Uint16
	Number of Generator 2 Starts		6282	1889	-	Uint16
	Number of Gen 2 Starts TOC month : date	1-12 : 1-31	6283	188A	-	Uint16
	Number of Gen 2 Starts TOC year : day	0-99 : 1-7	6284	188B	-	Uint16
	Number of Gen 2 Starts TOC hour : minute	0-23 : 0-59	6285	188C	-	Uint16
	Number of Gen 2 Starts TOC sec:1/100 sec	0-59 : 0-99	6286	188D	-	Uint16
	Number of Gen 2 Starts TOR month : date	1-12 : 1-31	6287	188E	-	Uint16
	Number of Gen 2 Starts TOR year : day	0-99 : 1-7	6288	188F	-	Uint16
	Number of Gen 2 Starts TOR hour : minute	0-23 : 0-59	6289	1890	1	Uint16
	Number of Gen 2 Starts TOR sec:1/100 sec	0-59 : 0-99	6290	1891	-	Uint16
ATS Info	Primary Status		6291	1892	1	Uint16
	Secondary Status		6292	1893	1	Uint16
	Cause of Status		6293	1894	-	Uint16
	Source 1 Status		6294	1895	-	Uint16
	Source 2 Status		6295	1896	-	Uint16
	Binary Status Bits		6296	1897	-	Uint16
	Binary Status2 Bits		6297	1898	-	Uint16
	Alarm Status Bits		6298	1899	-	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
8	Alarm

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
121	Fail to Sync on Frequency
122	Fail to Sync on Voltage
131	Preferred Source
132	Plant Exercise
136	Real Time Clock
153	Monitor Mode
154	Mechanism Fault
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

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	Load Sequence Active
8	Engine 1 Run
9	Engine 2 Run
10	ATS in Test
11	Transfer in Progress
12	Single Phase
13	ATS in Bypass
14	Source 1 Preferred
15	Source 2 Preferred

Table 29. Decoding for Binary Status Register 2.

CODE	DEFINITION
0	DCT Module Detected
1	Monitor Mode
2	Go to Emergency
3	Emergency Inhibit
4	Go to Neutral
5	Automatic Retransfer
6	Slave In
7	Waiting for S2 Permit
8	S1 ABC Rotation Detected
9	S1 ACB Rotation Detected
10	S2 ABC Rotation Detected
11	S2 ACB Rotation Detected
12-15	Unused

Table 30. Decoding for Alarm Status Register.

CODE	DEFINITION
0	Lockout
1	Engine Test Aborted
2	Failed to Synchronize
3	Uncommanded Breaker/Contactor Opening/Closing
4	Not Defined
5	Not Defined
6	Closed Transition Source 1 to Source 2 Failed
7	Closed Transition Source 2 to Source 1 Failed
8	In-Phase Transition Source 1 to Source 2 Failed
9	In-Phase Transition Source 2 to Source 1 Failed
10	Open Transition Source 1 to Source 2 Failed
11	Open Transition Source 2 to Source 1 Failed
12	Generator 1 Unavailable
13	Generator 2 Unavailable
14	Mechanism (Breaker/Contactor) Fault
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 (ATC-900) – start	-	6299	189A	-	ASCII
	...	-	...	...	-	ASCII
	Product ID – end	-	6302	189D	-	ASCII
	Hardware Revision	-	6303	189E	-	Uint16
	DSP Firmware Version : Revision	-	6304	189F	-	Uint16
	Display Firmware Version : Revision	-	6305	18A0	-	Uint16
	Gen Start Firmware Version : Revision	-	6306	18A1	-	Uint16
	Serial Number – start	-	6307	18A2	-	ASCII
	...	-	...	...	-	ASCII
	Serial Number – end	-	6316	18AB	-	ASCII
	Date Code – start	-	6317	18AC	-	ASCII
	...	-	...	...	-	ASCII
	Date Code – end	-	6220	18AE	-	ASCII
	GO Number – start	-	6221	18AF	-	ASCII
	...	-	...	...	-	ASCII
	GO Number – end	-	6325	18B4	-	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 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.
5. Transfer Step Events capture individual steps of a transfer. The number of steps will vary depending on the type of transfer and other factors. There are 7 step event register sets ("Transfer Step 0 Event" through "Transfer Step 6 Event") available to record a transfer, but not all will be updated for a given transfer.

   All transfers start with Transfer Step 0, with a Transfer ID assigned at the start of a particular transfer. All steps within a particular transfer have the same Transfer ID. So, when looking through Transfer Step Event Data, the Transfer ID is used to determine which steps were recorded for the latest transfer, and which may be remnants from a previous transfer. The Event Code is 0xFF for all but the final step event in a transfer.

Table 32. Function Code 04 Actual Values (Fixed 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	Table 33	7006	1B5D	-	Uint16
Setpoint Download Event	Event ID low register	-	7007	1B5E	-	Uint16
	Event ID high register	-	7008	1B5F	-	Uint16
	Event Timestamp month : date	1-12 : 1-31	7009	1B60	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7010	1B61	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7011	1B62	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7012	1B63	-	Uint16
	Event Code	Table 33	7013	1B64	-	Uint16
Counter/Timer Reset Event	Event ID low register	-	7014	1B65	-	Uint32
	Event ID high register	-	7015	1B66	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7016	1B67	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7017	1B68	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7018	1B69	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7019	1B6A	-	Uint16
	Event Code	Table 33	7020	1B6B	-	Uint16
Lockout Event	Event ID low register	-	7021	1B6C	-	Uint32
	Event ID high register	-	7022	1B6D	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7023	1B6E	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7024	1B6F	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7025	1B70	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7026	1B71	-	Uint16
	Event Code	Table 33	7027	1B72	-	Uint16
Monitor Mode Event	Event ID low register	-	7028	1B73	-	Uint32
	Event ID high register	-	7029	1B74	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7030	1B75	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7031	1B76	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7032	1B77	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7033	1B78	-	Uint16
	Event Code	Table 33	7034	1B79	-	Uint16
Retransfer Event	Event ID low register	-	7035	1B7A	-	Uint32
	Event ID high register	-	7036	1B7B	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7037	1B7C	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7038	1B7D	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7039	1B7E	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7040	1B7F	-	Uint16
	Event Code	Table 33	7041	1B80	-	Uint16
Bypass Timer Event	Event ID low register	-	7042	1B81	-	Uint32
	Event ID high register	-	7043	1B82	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7044	1B83	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7045	1B84	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7046	1B85	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7047	1B86	-	Uint16
	Event Code	Table 33	7048	1B87	-	Uint16
Internal Alarm Event	Event ID low register	-	7049	1B88	-	Uint32
	Event ID high register	-	7050	1B89	-	Uint32

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Internal Alarm Event	Event Timestamp month : date	1-12 : 1-31	7051	1B8A	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7052	1B8B	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7053	1B8C	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7054	1B8D	-	Uint16
	Event Code	Table 33	7055	1B8E	-	Uint16
Mechanism Alarm Event	Event ID low register	-	7056	1B8F	-	Uint32
	Event ID high register	-	7057	1B90	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7058	1B91	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7059	1B92	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7060	1B93	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7061	1B94	-	Uint16
	Event Code	Table 33	7062	1B95	-	Uint16
Reset Alarm Event	Event ID low register	-	7063	1B96	-	Uint32
	Event ID high register	-	7064	1B97	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7065	1B98	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7066	1B99	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7067	1B9A	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7068	1B9B	-	Uint16
	Event Code	Table 33	7069	1B9C	-	Uint16
Preferred Source Change Event	Event ID low register	-	7070	1B9D	-	Uint32
	Event ID high register	-	7071	1B9E	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7072	1B9F	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7073	1BA0	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7074	1BA1	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7075	1BA2	-	Uint16
	Event Code	Table 33	7076	1BA3	-	Uint16
Plant Exercise Event	Event ID low register	-	7077	1BA4	-	Uint32
	Event ID high register	-	7078	1BA5	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7079	1BA6	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7080	1BA7	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7081	1BA8	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7082	1BA9	-	Uint16
	Event Code	Table 33	7083	1BAA	-	Uint16
Time Adjustment Event	Event ID low register	-	7084	1BAB	-	Uint32
	Event ID high register	-	7085	1BAC	-	Uint32
	Old Time month : date	1-12 : 1-31	7086	1BAD	-	Uint16
	Old Time year : day	0-99 : 1-7	7087	1BAE	-	Uint16
	Old Time hour : minute	0-23 : 0-59	7088	1BAF	-	Uint16
	Old Time second : 1/100 second	0-59 : 0-99	7089	1BB0	-	Uint16
	Event Code	Table 33	7090	1BB1	-	Uint16
	New Time month : date	1-12 : 1-31	7091	1BB2	-	Uint16
	New Time year : day	0-99 : 1-7	7092	1BB3	-	Uint16
	New Time hour : minute	0-23 : 0-59	7093	1BB4	-	Uint16
	New Time second : 1/100 second	0-59 : 0-99	7094	1BB5	-	Uint16
S1 Unavailable Event	Event ID low register	-	7095	1BB6	-	Uint32
	Event ID high register	-	7096	1BB7	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7097	1BB8	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7098	1BB9	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7099	1BBA	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7100	1BBB	-	Uint16
	Validity bits low register	-	7101	1BBC	-	Uint16
	Validity bits high register	-	7102	1BBD	-	Uint16

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
S1 Unavailable Event	Event Code : Cause of Alarm Code	0 : Table 33	7103	1BBE	-	Uint16
	Source 1 V_{AB}	V	7104	1BBF	1	Uint16
	Source 1 V_{BC}	V	7105	1BC0	1	Uint16
	Source 1 V_{CA}	V	7106	1BC1	1	Uint16
	Source 2 V_{AB}	V	7107	1BC2	1	Uint16
	Source 2 V_{BC}	V	7108	1BC3	1	Uint16
	Source 2 V_{CA}	V	7109	1BC4	1	Uint16
	Load V_{AB}	V	7110	1BC5	1	Uint16
	Load V_{BC}	V	7111	1BC6	1	Uint16
	Load V_{CA}	V	7112	1BC7	1	Uint16
	Load I_A	A	7113	1BC8	1	Uint16
	Load I_B	A	7114	1BC9	1	Uint16
	Load I_C	A	7115	1BCA	1	Uint16
	Source 1 Frequency	Hz	7116	1BCB	10	Uint16
	Source 2 Frequency	Hz	7117	1BCC	10	Uint16
	Load Frequency	Hz	7118	1BCD	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7119	1BCE	-	Uint16
	Binary Status Bits	Table 28	7120	1BCF	-	Uint16
	Binary Status Validity Mask	0xFFFF	7121	1BD0	-	Uint16
S2 Unavailable Event	Event ID low register		7122	1BD1	-	Uint32
	Event ID high register	-	7123	1BD2	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7124	1BD3	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7125	1BD4	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7126	1BD5	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7127	1BD6	-	Uint16
	Validity bits low register	-	7128	1BD7	-	Uint16
	Validity bits high register	-	7129	1BD8	-	Uint16
	Event Code : Cause of Alarm Code	0 : Table 33	7130	1BD9	-	Uint16
	Source 1 V_{AB}	V	7131	1BDA	1	Uint16
	Source 1 V_{BC}	V	7132	1BDB	1	Uint16
	Source 1 V_{CA}	V	7133	1BDC	1	Uint16
	Source 2 V_{AB}	V	7134	1BDD	1	Uint16
	Source 2 V_{BC}	V	7135	1BDE	1	Uint16
	Source 2 V_{CA}	V	7136	1BDF	1	Uint16
	Load V_{AB}	V	7137	1BE0	1	Uint16
	Load V_{BC}	V	7138	1BE1	1	Uint16
	Load V_{CA}	V	7139	1BE2	1	Uint16
	Load I_A	A	7140	1BE3	1	Uint16
	Load I_B	A	7141	1BE4	1	Uint16
	Load I_C	A	7142	1BE5	1	Uint16
	Source 1 Frequency	Hz	7143	1BE6	10	Uint16
	Source 2 Frequency	Hz	7144	1BE7	10	Uint16
	Load Frequency	Hz	7145	1BE8	10	Uint16
	Source 1 Status : S2 Status	Table 27 : Table 27	7146	1BE9	-	Uint16
	Binary Status Bits	Table 28	7147	1BEA	-	Uint16
	Binary Status Validity Mask	0xFFFF	7148	1BEB	-	Uint16
Transfer Step 0 Event	Event ID low register	-	7149	1BEC	-	Uint32
	Event ID high register	-	7150	1BED	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7151	1BEE	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7152	1BEF	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7153	1BF0	-	Uint16

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Transfer Step 0 Event	Event Timestamp second : 1/100 second	0-59 : 0-99	7154	1BF1	-	Uint16
	Validity bits low register	-	7155	1BF2	-	Uint16
	Validity bits high register	-	7156	1BF3	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7157	1BF4	-	Uint16
	Source 1 V_{AB}	V	7158	1BF5	1	Uint16
	Source 1 V_{BC}	V	7159	1BF6	1	Uint16
	Source 1 V_{CA}	V	7160	1BF7	1	Uint16
	Source 2 V_{AB}	V	7161	1BF8	1	Uint16
	Source 2 V_{BC}	V	7162	1BF9	1	Uint16
	Source 2 V_{CA}	V	7163	1BFA	1	Uint16
	Load V_{AB}	V	7164	1BFB	1	Uint16
	Load V_{BC}	V	7165	1BFC	1	Uint16
	Load V_{CA}	V	7166	1BFD	1	Uint16
	Load I_A	A	7167	1BFE	1	Uint16
	Load I_B	A	7168	1BFF	1	Uint16
	Load I_C	A	7169	1C00	1	Uint16
	Source 1 Frequency	Hz	7170	1C01	10	Uint16
	Source 2 Frequency	Hz	7171	1C02	10	Uint16
	Load Frequency	Hz	7172	1C03	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7173	1C04	-	Uint16
	Binary Status Bits	Table 28	7174	1C05	-	Uint16
	Binary Status Validity Mask	0xFFFF	7175	1C06	-	Uint16
	Transfer ID	-	7176	1C07	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7177	1C08	-	Uint16
	Spare	-	7178	1C09	-	Uint16
Transfer Step 1 Event	Event ID low register	-	7179	1C0A	-	Uint32
	Event ID high register	-	7180	1C0B	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7181	1C0C	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7182	1C0D	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7183	1C0E	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7184	1C0F	-	Uint16
	Validity bits low register	-	7185	1C10	-	Uint16
	Validity bits high register	-	7186	1C11	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7187	1C12	-	Uint16
	Source 1 V_{AB}	V	7188	1C13	1	Uint16
	Source 1 V_{BC}	V	7189	1C14	1	Uint16
	Source 1 V_{CA}	V	7190	1C15	1	Uint16
	Source 2 V_{AB}	V	7191	1C16	1	Uint16
	Source 2 V_{BC}	V	7192	1C17	1	Uint16
	Source 2 V_{CA}	V	7193	1C18	1	Uint16
	Load V_{AB}	V	7194	1C19	1	Uint16
	Load V_{BC}	V	7195	1C1A	1	Uint16
	Load V_{CA}	V	7196	1C1B	1	Uint16
	Load I_A	A	7197	1C1C	1	Uint16
	Load I_B	A	7198	1C1D	1	Uint16
	Load I_C	A	7199	1C1E	1	Uint16
	Source 1 Frequency	Hz	7200	1C1F	10	Uint16
	Source 2 Frequency	Hz	7201	1C20	10	Uint16
	Load Frequency	Hz	7202	1C21	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7203	1C22	-	Uint16
	Binary Status Bits	Table 28	7204	1C23	-	Uint16

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Transfer Step 1 Event	Binary Status Validity Mask	0xFFFF	7205	1C24	-	Uint16
	Transfer ID	-	7206	1C25	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7207	1C26	-	Uint16
	Spare	-	7208	1C27	-	Uint16
Transfer Step 2 Event	Event ID low register	-	7209	1C28	-	Uint32
	Event ID high register	-	7050	1C29	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7211	1C2A	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7212	1C2B	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7213	1C2C	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7214	1C2D	-	Uint16
	Validity bits low register	-	7215	1C2E	-	Uint16
	Validity bits high register	-	7216	1C2F	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7217	1C30	-	Uint16
	Source 1 V_{AB}	V	7218	1C31	1	Uint16
	Source 1 V_{BC}	V	7219	1C32	1	Uint16
	Source 1 V_{CA}	V	7220	1C33	1	Uint16
	Source 2 V_{AB}	V	7221	1C34	1	Uint16
	Source 2 V_{BC}	V	7222	1C35	1	Uint16
	Source 2 V_{CA}	V	7223	1C36	1	Uint16
	Load V_{AB}	V	7224	1C37	1	Uint16
	Load V_{BC}	V	7225	1C38	1	Uint16
	Load V_{CA}	V	7226	1C39	1	Uint16
	Load I_A	A	7227	1C3A	1	Uint16
	Load I_B	A	7228	1C3B	1	Uint16
	Load I_C	A	7229	1C3C	1	Uint16
	Source 1 Frequency	Hz	7230	1C3D	10	Uint16
	Source 2 Frequency	Hz	7231	1C3E	10	Uint16
	Load Frequency	Hz	7232	1C3F	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7233	1C40	-	Uint16
	Binary Status Bits	Table 28	7234	1C41	-	Uint16
	Binary Status Validity Mask	0xFFFF	7235	1C42	-	Uint16
	Transfer ID	-	7236	1C43	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7237	1C44	-	Uint16
	Spare	-	7238	1C45	-	Uint16
Transfer Step 3 Event	Event ID low register	-	7239	1C46	-	Uint32
	Event ID high register	-	7240	1C47	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7241	1C48	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7242	1C49	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7243	1C4A	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7244	1C4B	-	Uint16
	Validity bits low register	-	7245	1C4C	-	Uint16
	Validity bits high register	-	7246	1C4D	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7247	1C4E	-	Uint16
	Source 1 V_{AB}	V	7248	1C4F	1	Uint16
	Source 1 V_{BC}	V	7249	1C50	1	Uint16
	Source 1 V_{CA}	V	7250	1C51	1	Uint16
	Source 2 V_{AB}	V	7251	1C52	1	Uint16
	Source 2 V_{BC}	V	7252	1C53	1	Uint16
	Source 2 V_{CA}	V	7253	1C54	1	Uint16
	Load V_{AB}	V	7254	1C55	1	Uint16
	Load V_{BC}	V	7255	1C56	1	Uint16
	Load V_{CA}	V	7256	1C57	1	Uint16

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Transfer Step 3 Event	Load I_A	A	7257	1C58	1	Uint16
	Load I_B	A	7258	1C59	1	Uint16
	Load I_C	A	7259	1C5A	1	Uint16
	Source 1 Frequency	Hz	7260	1C5B	10	Uint16
	Source 2 Frequency	Hz	7261	1C5C	10	Uint16
	Load Frequency	Hz	7262	1C5D	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7263	1C5E	-	Uint16
	Binary Status Bits	Table 28	7264	1C5F	-	Uint16
	Binary Status Validity Mask	0xFFFF	7265	1C60	-	Uint16
	Transfer ID	-	7266	1C61	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7267	1C62	-	Uint16
	Spare	-	7268	1C63	-	Uint16
Transfer Step 4 Event	Event ID low register	-	7269	1C64	-	Uint32
	Event ID high register	-	7050	1C65	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7271	1C66	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7272	1C67	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7273	1C68	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7274	1C69	-	Uint16
	Validity bits low register	-	7275	1C6A	-	Uint16
	Validity bits high register	-	7276	1C6B	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7277	1C6C	-	Uint16
	Source 1 V_{AB}	V	7278	1C6D	1	Uint16
	Source 1 V_{BC}	V	7279	1C6E	1	Uint16
	Source 1 V_{CA}	V	7280	1C6F	1	Uint16
	Source 2 V_{AB}	V	7281	1C70	1	Uint16
	Source 2 V_{BC}	V	7282	1C71	1	Uint16
	Source 2 V_{CA}	V	7283	1C72	1	Uint16
	Load V_{AB}	V	7284	1C73	1	Uint16
	Load V_{BC}	V	7285	1C74	1	Uint16
	Load V_{CA}	V	7286	1C75	1	Uint16
	Load I_A	A	7287	1C76	1	Uint16
	Load I_B	A	7288	1C77	1	Uint16
	Load I_C	A	7289	1C78	1	Uint16
	Source 1 Frequency	Hz	7290	1C79	10	Uint16
	Source 2 Frequency	Hz	7291	1C7A	10	Uint16
	Load Frequency	Hz	7292	1C7B	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7293	1C7C	-	Uint16
	Binary Status Bits	Table 28	7294	1C7D	-	Uint16
	Binary Status Validity Mask	0xFFFF	7295	1C7E	-	Uint16
	Transfer ID		7296	1C7F	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7297	1C80	-	Uint16
	Spare		7298	1C81	-	Uint16
Transfer Step 5 Event	Event ID low register		7299	1C82	-	Uint32
	Event ID high register		7300	1C83	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7301	1C84	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7302	1C85	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7303	1C86	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7304	1C87	-	Uint16
	Validity bits low register	-	7305	1C88	-	Uint16
	Validity bits high register	-	7306	1C89	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7307	1C8A	-	Uint16

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

CATEGORY	NAME	UNITS OR VALUE LIMITS	REGISTER NUMBER (DEC)	REGISTER ADDRESS (HEX)	SCALE FACTOR	FORMAT
Transfer Step 5 Event	Source 1 V_{AB}	V	7308	1C8B	1	Uint16
	Source 1 V_{BC}	V	7309	1C8C	1	Uint16
	Source 1 V_{CA}	V	7310	1C8D	1	Uint16
	Source 2 V_{AB}	V	7311	1C8E	1	Uint16
	Source 2 V_{BC}	V	7312	1C8F	1	Uint16
	Source 2 V_{CA}	V	7313	1C90	1	Uint16
	Load V_{AB}	V	7314	1C91	1	Uint16
	Load V_{BC}	V	7315	1C92	1	Uint16
	Load V_{CA}	V	7316	1C93	1	Uint16
	Load I_A	A	7317	1C94	1	Uint16
	Load I_B	A	7318	1C95	1	Uint16
	Load I_C	A	7319	1C96	1	Uint16
	Source 1 Frequency	Hz	7320	1C97	10	Uint16
	Source 2 Frequency	Hz	7321	1C98	10	Uint16
	Load Frequency	Hz	7322	1C99	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7323	1C9A	-	Uint16
	Binary Status Bits	Table 28	7324	1C9B	-	Uint16
	Binary Status Validity Mask	0xFFFF	7325	1C9C	-	Uint16
	Transfer ID	-	7326	1C9D	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7327	1C9E	-	Uint16
	Spare	-	7328	1C9F	-	Uint16
Transfer Step 6 Event	Event ID low register	-	7329	1CA0	-	Uint32
	Event ID high register	-	7050	1CA1	-	Uint32
	Event Timestamp month : date	1-12 : 1-31	7331	1CA2	-	Uint16
	Event Timestamp year : day	0-99 : 1-7	7332	1CA3	-	Uint16
	Event Timestamp hour : minute	0-23 : 0-59	7333	1CA4	-	Uint16
	Event Timestamp second : 1/100 second	0-59 : 0-99	7334	1CA5	-	Uint16
	Validity bits low register	-	7335	1CA6	-	Uint16
	Validity bits high register	-	7336	1CA7	-	Uint16
	Transfer Step Code : Event Code	Table 34 : Table 33	7337	1CA8	-	Uint16
	Source 1 V_{AB}	V	7338	1CA9	1	Uint16
	Source 1 V_{BC}	V	7339	1CAA	1	Uint16
	Source 1 V_{CA}	V	7340	1CAB	1	Uint16
	Source 2 V_{AB}	V	7341	1CAC	1	Uint16
	Source 2 V_{BC}	V	7342	1CAD	1	Uint16
	Source 2 V_{CA}	V	7343	1CAE	1	Uint16
	Load V_{AB}	V	7344	1CAF	1	Uint16
	Load V_{BC}	V	7345	1CB0	1	Uint16
	Load V_{CA}	V	7346	1CB1	1	Uint16
	Load I_A	A	7347	1CB2	1	Uint16
	Load I_B	A	7348	1CB3	1	Uint16
	Load I_C	A	7349	1CB4	1	Uint16
	Source 1 Frequency	Hz	7350	1CB5	10	Uint16
	Source 2 Frequency	Hz	7351	1CB6	10	Uint16
	Load Frequency	Hz	7352	1CB7	10	Uint16
	Source 1 Status : Source 2 Status	Table 27 : Table 27	7353	1CB8	-	Uint16
	Binary Status Bits	Table 28	7354	1CB9	-	Uint16
	Binary Status Validity Mask	0xFFFF	7355	1CBA	-	Uint16
	Transfer ID	-	7356	1CBB	-	Uint16
	Next Sample : Post Transfer Counter	0-199 : 0-100	7357	1CBC	-	Uint16
	Spare	-	7358	1CBD	-	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	Source 1 Engine Run Timer/Counter was Reset
5	Source 2 Engine Run 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	Lockout Alarm Occurred
13	Enter Monitor Mode
14	Exit Monitor Mode
15	Manual Retransfer Initiated
16	Transfer Timers were Manually Bypassed
17	Source 1 Became Available
18	Source 2 Became Available
19	Source 1 Went Unavailable
20	Source 2 Went Unavailable
21	Internal Controller Alarm
22	Manual Alarm Reset Occurred (Front Panel)
23	Preferred Source Changed
24	Engine Run Test Requested (Front Panel)
25	Engine Run Test Completed Properly
26	Engine Run Test Failed (Generator Failed)
27	Engine Run Test Aborted (Manual Abort or Other Source Failed)
28	Open Transfer to Source 2 Completed Properly
29	Open Transfer to Source 1 Completed Properly
30	In-Phase Transfer to Source 2 Completed Properly
31	In-Phase Transfer to Source 1 Completed Properly
32	Closed Transfer to Source 2 Completed Properly
33	Closed Transfer to Source 1 Completed Properly
34	Open Transfer to Source 2 Failed
35	Open Transfer to Source 1 Failed
36	In-Phase Transfer to Source 2 Failed
37	In-Phase Transfer to Source 1 Failed
38	Closed Transfer to Source 2 Failed
39	Closed Transfer to Source 1 Failed
40	Transfer Aborted
41	Transfer Due to Emergency Inhibit Input
42	Mechanism Failed to Open or Close
43	Tier 4 Timer/Counter was Reset
44	Number of Generator 1 Starts Counter was Reset
45	Number of Generator 2 Starts Counter was Reset
46	Transfer Due to Go to Neutral Input
47	Un-Commanded (Manual) Transfer Detected
48	Engine Run Test Requested (Programmable Input)
49	Engine Run Test Requested (Modbus Port)
50	Plant Exercise 1
51	Plant Exercise 2
0xFF	No Event Code (for interim transfer step events)

Table 34. Decoding for Transfer Step Code.

CODE	DEFINITION
0	Undervoltage
1	Overvoltage
2	Underfrequency
3	Overfrequency
4	Voltage Unbalance
5	Phase Reversal
6	Preferred Source Available
7	Go to Emergency
8	Emergency Inhibit
9	Gen Start Contacts Closed
10	Source 1 Available
11	Source 2 Available
12	Transfer to Neutral Initiated
13	Transfer to Neutral Complete
14	Transfer to Source 2 Initiated
15	Transfer to Source 2 Complete
16	Transfer to Source 1 Initiated
17	Transfer to Source 1 Complete
18	In-phase Transition to S2 Initiated
19	In-phase Transition to S2 Complete
20	In-phase Transition to S1 Initiated
21	In-phase Transition to S1 Complete
22	Closed Transition to S2 Initiated
23	Closed Transition to S2 Complete
24	Closed Transition to S1 Initiated
25	Closed Transition to S1 Complete
26	Transfer to Neutral Failed
27	Transfer to S2 Failed
28	Transfer to S1 Failed
29	In-phase Transition to S1 Failed - Angle
30	In-phase Transition to S1 Failed - Frequency
31	In-phase Transition to S2 Failed - Angle
32	In-phase Transition to S2 Failed - Frequency
33	Closed Transition to S1 Failed - Angle
34	Closed Transition to S1 Failed - Frequency
35	Closed Transition to S1 Failed - Voltage
36	Closed Transition to S2 Failed - Angle
37	Closed Transition to S2 Failed - Frequency
38	Closed Transition to S2 Failed - Voltage
39	Generator Unavailable
40	Engine Test Transfer
41	Lockout
42	Go to Neutral
43	Phase Loss
44	Current Unbalance

Table 35 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 the first transfer step occurs (Initial Samples) and when the last transfer step occurs (Final Samples), 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.

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 of the initial samples will always match the Event ID of the Transfer Step 0 Event. The Event ID of the Final Samples will match the Event ID of the final transfer step of the latest transfer.
3. The timestamp is the time of the first data point, which is ideally two seconds earlier than the timestamp of the associated Transfer Step x Event.
4. Because the data is continuously written into a circular buffer, the "Next Sample" value from the Transfer Step x 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 second worth) occurred after the step event.

Table 35. 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
Initial Samples	...	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 35. 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
Initial Samples	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
Final Samples	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 35. 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
Final Samples	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

The query message format for function code 04 in given in Table 36. 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 36. 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 37. 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 37. 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 ATC-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 ATC-900 responds with an exception code (01 - ILLEGAL FUNCTION). The register numbers/addresses of all possible programmable relays are shown in Table 38. Note that Modules 1 through 4 are optional and may not be present in a given system.

Table 38. 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 39 contains the registers associated with the Operation Commands supported by the ATC-900.

Table 39. Function Code 05 Operation Command Register Definitions.

NAME	REGISTER NUMBER (DECIMAL)	REGISTER ADDRESS (HEXADECIMAL)
Reset Number of Transfers	5000	1387
Reset S1 Available Time	5001	1388
Reset S1 Connect Time	5002	1389
Reset S1 Engine Run Time	5003	138A
Reset S2 Available Time	5004	138B
Reset S2 Connect Time	5005	138C
Reset S2 Engine Run Time	5006	138D
Reset Load Energized Time	5007	138E
Reset Tier 4 Timer	5008	138F
Reset Number of Generator 1 Starts	5009	1390
Reset Number of Generator 2 Starts	5010	1391
Reset Alarms	5011	1392
Initiate ATS Test	5012	1393
Cancel ATS Test	5013	1394
Bypass TDNE/TDEN	5014	1395
Manual Retransfer	5015	1396
Go To Emergency	5016	1397
Cancel Go To Emergency	5017	1398

The query message format for function code 05 is given in Table 40. This example is for initiating an ATS Test.

Table 40. 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	93_{16}
Coil High Byte	FF_{16}
Coil 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 41.

Table 41. 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	93_{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 42. Multi-Register Configuration = 0.

REGISTER X		REGISTER X + 1	
Byte 3	Byte 2	Byte 1	Byte 0
Bits 31...24	Bits 23...16	Bits 15...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 43. 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 (ATC-900 Diagnostic Counters Commands)

Function code 08 is used to read and clear the Diagnostic Counters related to Modbus communications as detailed in Table 44.

Table 44. 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 45.

Table 45. 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 46.

Table 46. 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 (Write 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 47 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.

The response message format is given in Table 48. The response echoes the starting register address and the number of setpoint registers from the query message.

Table 47. 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, Engine Fail) High Byte	00_{16}
Register Value (Time Delay, Engine Fail) Low Byte	07_{16}
Error Check Low Byte	CRC Low
Error Check High Byte	CRC High

Table 48. Write Setpoints (16) Response.

RESPONSE FIELD NAME	EXAMPLE
Slave Address	42_{16}
Function Code	10_{16}
Starting Register Value (No. of Gens) Address High Byte	$0B_{16}$
Starting Register Value (No. of Gens) 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 ATC-900 will return an exception code. The exception codes are shown in Table 49.

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 49. Exception Codes.

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

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