Connectivity to the ASCO® Power Manager Xp & 7000 Series Group 5 Controller via *Modbus*®

This design specification describes the *Modbus* communications protocol as supported by the *ASCO Power Manager Xp* and 7000 Series Group 5 Controller. It includes instructions on how to pass information into and out of the either device via the Modbus network. This publication should be used by individuals wishing to integrate either device into their facility by developing software to communicate with either device. Additional information can be found in Power Manager Xp *Operator's Manual 381333-199* and Group 5 Controller *User's Guide 381333-126*.

Modbus Protocol

Implementation Basics

The following rules define the Modbus slave implementation of the devices:

- The devices operate as slaves only (communication must be initiated by the master).
- The maximum number of bytes contained within one packet of communications is 64.

Transmission Format

Although the Modbus protocol supports both ASCII and RTU modes of transmission, only the RTU mode is implemented. Within the RTU mode, the ASCO devices support the following communication parameters:

- 8 data bits
- no parity
- 1 stop bit

Modbus RTU Packet Format

Every Modbus Packet consists of the following fields:

- Device Address Field
- Function Code Field
- Data Field
- Error Check Field

Device Address Field. This is the first byte of each Modbus RTU transmission. The device address is a number limited to the range of 0 - 247 and is associated with a single device configured with a matching address. Only the slave device whose address matches the value in this field will respond to the specified command. Device address 0 indicates a broadcast command. This means that every slave on the network will act on the command, but it will not issue any responses.

Function Code Field. This is a second byte of each transmission and represents the commanded action to the slave device (for queries from the master) or the action that was taken by the slave device (for responses from the slave). Codes between 1 and 127 are defined as Modbus RTU functions. The function codes supported by the Power Manager Xp are detailed on page 4. The function codes supported by the Group 5 Controller are detailed on page 10.

Data Field. The data field varies in length depending on whether the message is a request or a response packet. This field typically contains information required by the slave device to perform the command specified in a request packet or data being passed back by the slave device in a response packet.

Error Check Field. The error check field consists of a 16 bit (2 byte) Cyclical Redundancy Check (CRC16). It allows the receiving device to detect a packet that has been corrupted with transmission errors. Refer to *CRC-16 Algorithm* on page 2 for details.

Packet Framing and Timing

Because the Modbus RTU protocol does not define any explicit packet synchronization bytes, synchronization is accomplished implicitly with the use of silent intervals. According to the Modbus RTU standard, all messages must start with a silent interval of at least 3.5 character times. This means that every byte within a packet must precede the previous byte by fewer than 3.5 character times based on the baud rate. And every new packet of data must begin at least 3.5 character times or more after the packet that had preceded it.

In summary, the three timing intervals associated with the ASCO devices are as follows:

- Maximum time between two consecutive bytes within a packet < 3.5 character times.
- Minimum time between two consecutive packets is > 3.5 character times.
- Maximum response time from a Master request to a slave response is < 50 milliseconds.

CRC-16 Algorithm

Procedure. The algorithm essentially treats the entire data packet (less the start, stop, and, if used, parity bits) as one continuous binary number. Since we are doing a 16-bit CRC calculation, the binary number (entire packet) is multiplied by 2^{16} and then divided by the generator polynomial. In the case of the Modbus protocol, the generator polynomial is $x^{16} + x^{15} + x^2 + 1$. The 16-bit remainder of the division, which is the 16-bit CRC checksum, is then appended to the end of the packet. The resulting data packet including the 16-bit CRC checksum, when divided by the same Generator Polynomial at the receiver, will give a zero remainder if no transmission errors have occurred.

The binary value of the Generator Polynomial is **A001** hex. This is obtained by first dropping the most-significant-bit of the polynomial and then reversing the bit order. This yields 1010000000000001 or A001h.

The steps for generating the 16-bit CRC checksum are as follows:

1. Initially, load the 16-bit CRC register with the value FFFF hex.
2. Exclusive OR the 16-bit CRC register with the first data byte of the packet and store the result in the 16-bit CRC register.
3. If the Least Significant Bit (LSB) of the 16-bit CRC register is equal to one, then shift the 16-bit CRC register to the right by one bit and then Exclusive OR the result with the generator polynomial, A001 hex. Otherwise, just shift the 16-bit CRC register to the right by one bit.
4. Repeat step 3 until eight right shifts have been performed.
5. Exclusive OR the 16-bit CRC register with the next data byte of the packet.
6. Repeat steps 3-5 until all the bytes of the data packet have been used in step 5.
7. The 16-bit CRC register contains the new checksum to be appended to the end of the packet, Least Significant Byte first.

CRC-16 Pseudocode. Below is the pseudocode for generating the 16-bit CRC checksum. XOR is the Exclusive-OR function:

```
CRC16REG = FFFF hex
GENPOLY = A001 hex

FOR X = 1 to number of bytes in packet
    BEGIN
     XOR CRC16REG with the Xth data byte
     FOR Y = 1 to 8
         BEGIN
          IF [(the least-significant-bit of CRC16REG) = 1] THEN
               SHIFT CRC16REG one bit to the RIGHT
               XOR CRC16REG with GENPOLY
           OTHERWISE
                        SHIFT CRC16REG one bit to the RIGHT
         END
     NEXT Y
    END
NEXT X

The resulting CRC16REG contains the 16-bit CRC checksum
```

CRC-16 C Programming Language Example. **CRC16_checksum** is a C language function that calculates and returns the 16-bit CRC checksum of a string of characters. This is the brute force method as it consumes a lot of processing power performing numerous bit shifts. A table look-up method based on this function would be more suitable for embedded systems where processing power is at a premium. The following four parameters are passed as part of the function

1. pointer to string
2. length of string (in bytes)
3. initial CRC value
4. desired Generator polynomial

Included to make this CRC-16 function generic for any generator polynomial

continued on next page

The following C-language type definitions (typedef's) are assumed:

1. typedef unsigned int uint;
2. typedef unsigned char uchar;

The function is defined as follows:

```
uint CRC16_checksum(uchar *Buffer, uint Length, uint CRC, uint Genpoly) {

uint index;

    While (Length--) {           /* for each data byte in string */

       CRC = CRC ^ (uint) *Buffer++;     /* exclusive OR data byte */

       For (index = 0; index < 8; index++) {   /* for each of the 8 bits */
           If ((CRC & 0x0001) == 1) CRC = (CRC >> 1) ^ Genpoly;
           Else (CRC = CRC >> 1);

       } /* for statement */

    } /* while statement */

    return(CRC);
}
```

An ASCO Example. Let's assume the transmitting device desired to send the ASCII string "**ASCO**". Using an ASCII character look-up table, we have the following hexadecimal codes for each of the ASCO letters:

A = 0x65
S = 0x83
C = 0x67
O = 0x79

The transmitter would determine the 16-bit CRC checksum as follows (in C, both methods are equivalent):

CRC16_checksum("ASCO", 4, 0xFFFF, 0xA001) which returns CRC = 0xCD94
CRC16_checksum("\x65\x83\x67\x79", 4, 0xFFFF, 0xA001) which returns CRC = 0xCD94

Before sending the string, the transmitter would append the CRC checksum (in byte reverse order) to the string as follows:

"**ASCO\x94\xCD**" or the equivalent in hexadecimal notation **"\x65\x83\x67\x79\x94\xCD"**

If the receiving device received the string without any transmission errors, then doing the 16-bit CRC checksum on the entire received string would yield (again, both methods are equivalent):

CRC16_checksum("ASCO\x94\xCD", 4, 0xFFFF, 0xA001) which returns CRC = 0x0000
CRC16_checksum("\x65\x83\x67\x79\x94\xCD", 4, 0xFFFF, 0xA001) which returns CRC = 0x0000

Since the CRC checksum is equal to **zero**, the transmission is deemed valid.

Had an error been induced during the transmission, such as the ASCII character 'A' being inadvertently changed to the character 'B' (which is hexadecimal 0x66), the receiving device would determine the new checksum as:

CRC16_checksum("BSCO\x94\xCD", 4, 0xFFFF, 0xA001) which returns CRC = 0x3300
CRC16_checksum("\x66\x83\x67\x79\x94\xCD", 4, 0xFFFF, 0xA001) which returns CRC = 0x3300

Since the CRC is **NON-ZERO (0x3300),** the receiver would assume an error had occurred and discard the packet.

Supported Function Codes for Power Manager Xp

Function # 03 (03h) – Read Holding Registers

This function code allows the master to read one or more consecutive data registers from the Power Manager Xp. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 12 for details about the data register definitions of the Power Manager Xp.

The following example shows the format of a transmission between a master requesting device and the responding Power Manager Xp (slave device) at address 24. The master desires to read the four values of current, I_A, I_B, I_C, I_{AVE}, beginning at Holding register location 40021 (which is a "Data starting address" of 20 decimal or 14 hexadecimal).

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	03
Data starting address (high byte)	00
Data starting address (low byte)	14
Number of registers (high byte)	00
Number of registers (low byte)	04
CRC16 (low byte)	06
CRC16 (high byte)	04

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	03
Byte count	08
Data word #1 (high byte)	04
Data word #1 (low byte)	CE
Data word #2 (high byte)	04
Data word #2 (low byte)	D3
Data word #3 (high byte)	04
Data word #3 (low byte)	D3
Data word #4 (high byte)	04
Data word #4 (low byte)	CE
CRC16 (low byte)	36
CRC16 (high byte)	7F

The Power Manger Xp supports the following Read Holding Register addresses-decimal: 11-26, 31-48, 51-64, 71-84, 87-94, 96-125, 127-128, 130-137, 149-159. The Type of those Registers is defined as RO (Read only).

Function # 06 (06h) – Preset Single Register

This function code allows the master device to modify the contents of a single configuration register within the Power Manager Xp. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 12 for details about the about the data register definitions of the Power Manager Xp.

The Power Manager Xp currently supports the following Preset Single register addresses. If a Function #06 command is issued without one of these register addresses, the Power Manager Xp will respond with an invalid address range Exception Response (see *Exception Responses* on page 5).

Address	*Address (in hex notation)*	*Description*
40095	005E	Relay outputs (DO1-DO4)
40200	00C7	System type
40201	00C8	Source mode
40202	00C9	Potential transformer ratio (PTR)
40203	00CA	Current transformer ratio (CTR)
40204	00CB	Neutral current transformer ratio (CT4R)
40205	00CC	SCI comm. port (J5) protocol
40206	00CD	SCI comm. port (J5) baud rate
40207	00CE	SCI comm. port (J5) device address
40208	00CC	485 comm. Port (J1) protocol
40209	00CD	485 comm. Port (J1) baud rate
40210	00CE	485 comm. port (J1) device address
40211	00CF	Menu language selection
40212	00D0	Demand window size (in minutes)
40213	00D1	Demand subinterval size (fixed at 1 minute)
40214	00D2	Reset inst. & max. demand registers
40215	00D3	Reset energy registers

The following example shows the format of a transmission between a master device and the responding Power Manager Xp (slave device) at address 24. The master desires to set the System Type (Holding register 40200) to a Single Phase – 3 Wire system (data value 02). See *System Type* on page 7 for details.

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data address (high byte)	00
Data address (low byte)	C7
Data word (high byte)	00
Data word (low byte)	02
CRC16 (low byte)	BB
CRC16 (high byte)	FF

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data starting address (high byte)	00
Data starting address (low byte)	C7
Number of registers (high byte)	00
Number of registers (low byte)	02
CRC16 (low byte)	BB
CRC16 (high byte)	FF

The Power Manger Xp supports the following Preset Single Register addresses -decimal: 65-68, 95, 148, 160, and 200-215.

Function # 16 (10h) – Preset Multiple Registers

This function code allows the master device to modify the contents of consecutive configuration registers within the Power Manager Xp. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 12 for details about the data register definitions of the Power Manager Xp.

The Power Manager Xp currently supports the following Preset Multiple register ranges. If a Function #16 command is issued without one of these corresponding register ranges, the Power Manager Xp will respond with an invalid address range Exception Response (see *Exception Responses* on page 6).

Address		*Register*	*Description*	*Command String (in Hex)*
Start	*End*	*Count*		
40141	40146	6	PM Date & Time	ADDR 10 00 8C 00 06 0C ..data.. CRC_{LO} CRC_{HI}
40200	40213	14	General Settings	ADDR 10 00 C7 00 0E 1C ..data.. CRC_{LO} CRC_{HI}
40230	40235	6	Setpoint Settings	ADDR 10 00 E5 00 06 0C ..data.. CRC_{LO} CRC_{HI}
40326	40333	8	S1 Status Input #1 name	ADDR 10 01 45 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40334	40341	8	S2 Status Input #2 name	ADDR 10 01 4D 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40342	40349	8	S3 Status Input #3 name	ADDR 10 01 55 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40350	40357	8	S4 Status Input #4 name	ADDR 10 01 5D 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40358	40365	8	S5 Status Input #5 name	ADDR 10 01 65 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40366	40373	8	S6 Status Input #6 name	ADDR 10 01 6D 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40374	40381	8	S7 Status Input #7 name	ADDR 10 01 75 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40382	40389	8	S8 Status Input #8 name	ADDR 10 01 7D 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40390	40397	8	Relay Output #1 name	ADDR 10 01 85 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40398	40405	8	Relay Output #2 name	ADDR 10 01 8D 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40406	40413	8	Relay Output #3 name	ADDR 10 01 95 00 08 10 ..data.. CRC_{LO} CRC_{HI}
40414	40421	8	Relay Output #4 name	ADDR 10 01 9D 00 08 10 ..data.. CRC_{LO} CRC_{HI}

The following example shows the format of a transmission between a master requesting device and the responding Power Manager Xp (slave device) at address 24. The master desires to configure Setpoint #1 (Holding Registers 40230 – 40235).

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	10
Data starting address (high byte)	00
Data starting address (low byte)	E5
Number of registers (high byte)	00
Number of registers (low byte)	06
CRC16 (low byte)	53
CRC16 (high byte)	F5

The Power Manger Xp supports the following Preset Single Register addresses -decimal: 141-146, 200-213, 230-235, 236-319, 322-325, 326-421, and 422-433.

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	10
Data starting address (high byte)	00
Data starting address (low byte)	E5
Number of registers (high byte)	00
Number of registers (low byte)	06
Byte count	0C
Data word #1 (high byte)	00
Data word #1 (low byte)	01
Data word #2 (high byte)	03
Data word #2 (low byte)	E8
Data word #3 (high byte)	00
Data word #3 (low byte)	00
Data word #4 (high byte)	03
Data word #4 (low byte)	20
Data word #5 (high byte)	00
Data word #5 (low byte)	05
Data word #6 (high byte)	00
Data word #6 (low byte)	02
CRC16 (low byte)	D1
CRC16 (high byte)	91

Exception Responses

If the Modbus master device sends an unsupported command, attempts to read an invalid holding register, or attempts to write invalid data, the Power Manager Xp (Modbus slave) issues an exception response. The format for the exception response is as follows:

1. SLAVE ADDRESS
2. FUNCTION CODE*
   (with the most-significant-bit set to a 1)
3. ERROR CODE
4. CRC16 – low order byte
5. CRC16 – high order byte

* Note: The high order bit of the function code has been set to one to indicate an exception response has been generated.

The following table is a list of the exception codes supported by the Power Manager Xp.

Exception Response Error Codes

Error code	*Error name*	*Power Manager Xp implementation*
01	Illegal function	The slave does not support the function code contained in the master query packet.
02	Illegal data address	The slave does not support the Holding Register address referenced in the data field of the master query packet.
03	Illegal data value	The slave does not support the data referenced in the data field of the master query packet.
04	Device failure	The addresses slave is unable to perform the action requested due to an internal failure or malfunction.

The following example shows the format of a transmission between a master device and the responding Power Manager Xp (slave device) at address 24. The master device attempts to write an invalid data value (04) to the System Type holding register 40200. The Power Manager Xp slave device responds with Error code 03.

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data starting address (high byte)	00
Data starting address (low byte)	C7
Data (high byte)	00
Data (low byte)	04
CRC16 (low byte)	3B
CRC16 (high byte)	FD

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	86
Error code	03
CRC16 (low byte)	D3
CRC16 (high byte)	A6

The following example shows the format of a transmission between a master device and the responding Power Manager Xp (slave device) at address 24. The master device attempts to write to an invalid address, 40216 (0x00D7). The Power Manager Xp slave device responds with Error code 02.

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data starting address (high byte)	00
Data starting address (low byte)	D7
Data (high byte)	00
Data (low byte)	03
CRC16 (low byte)	7B
CRC16 (high byte)	FA

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	86
Error code	02
CRC16 (low byte)	12
CRC16 (high byte)	66

Configuration Register Details

System Type – Holding Register no. 40200

The system type register defines the type of system to which the Power Manager Xp is connected.

Binary value	*Label*	*Description*
0 (00h)	4W_WYE	3 Phase, 4 wire WYE system
1 (01h)	3W_DELTA	3 Phase, 3 wire DELTA system
2 (02h)	3W_1PHASE	Single phase, 3 wire system
3 (03h)	2W_1PHASE	Single phase, 2 wire system

Source Mode – Holding Register no. 40201

The source mode register defines the source bus, to which the Power Manager Xp is connected. The Energy register display window changes according to the bus defined. The user can specify a normal bus connection, an emergency bus connection, a connection to the load side of the bus or no specific designation.

Binary value	*Label*	*Description*
0 (00h)	NORMAL	Normal power bus
1 (01h)	EMERGENCY	Emergency power bus
2 (02h)	LOAD	Load power bus
3 (03h)	OTHER	Any power bus with no designation on the Energy registers

When the LOAD selection is chosen, the Power Manager Xp uses the N/E INPUT status input to determine ATS switch position. Two sets of Energy registers are used; Normal energy registers & Emergency energy registers.

Potential Transformer Ratio – Holding Register no. 40202

This register defines the full-scale voltage input value for the three phases of voltage. This is based on the ratio of the external voltage transformers (PTs) connected between the Power Manager Xp and the power bus.

Range
120 to 28,200

The value of 28,200 is the ratio 235:1 (120 * 235 = 28,200). Note that if external voltage transformers are not required and subsequently not used, the ratio should be set to 120, which is 1:1.

Current Transformer Ratio – Holding Register no. 40203

This register defines the full-scale current input value for the three phases of current. This is based on the ratio of the external current transformers (CTs) connected between the Power Manager Xp and the power bus.

Range
5 to 24,000

4th Current Input Transformer Ratio – Holding Register no. 40204

This register defines the full-scale current input value for the 4th or neutral current input. This is based on the ratio of the external current transformer (CT) connected between the Power Manager Xp and the power bus.

Range
5 to 24,000

SCI Communications Port (J5) Protocol – Holding Register no. 40205

Defines the protocol of the SCI communications port.

Binary value	*Label*	*Description*
0 (00h)	ASCOBusI	ASCOBusI protocol
1 (01h)	ASCOBusII	ASCOBusII protocol
2 (02h)	ModbusRTU	ModbusRTU protocol

SCI Communications Port (J5) Baud Rate – Holding Register no. 40206

Defines the baud rate of the SCI communications port.

Binary value	*Label*	*Description*
1 (01h)	_9600	9600 bps
2 (02h)	_19_2K	19200 bps

SCI Communications Port (J5) Device Address – Holding Register no. 40207

Defines the Power Manager Xp address of the SCI communications port.

Protocol	*Allowable address range*
ASCOBusI	0-31
ASCOBusII	1-239
ModbusRTU	1-239

485 Communications Port (J1) Protocol – Holding Register no. 40208

Defines the protocol of the dedicated RS-485 communications port, if present on Power Manager Xp. ‡

Binary value	*Label*	*Description*
0 (00h)	ASCOBusI	ASCOBusI protocol
1 (01h)	ASCOBusII	ASCOBusII protocol
2 (02h)	ModbusRTU	ModbusRTU protocol

485 Communications Port (J1) Baud Rate – Holding Register no. 40209

Defines the baud rate of the dedicated RS-485 communications port, if present on Power Manager Xp. ‡

Binary value	*Label*	*Description*
1 (01h)	_9600	9600 bps
2 (02h)	_19_2K	19200 bps
3 (03h)	_38_4K	38400 bps
4 (04h)	_57_6K	57600 bps

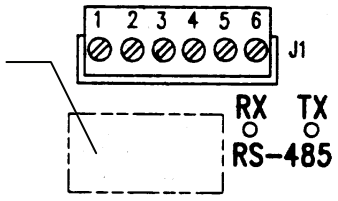
485 Communications Port (J1) Device Address – Holding Register no. 40210

Defines the Power Manager Xp address of the dedicated RS-485 communications port, if present on Power Manager Xp.‡

Protocol	*Allowable address range*
ASCOBusI	0-31
ASCOBusII	1-239
ModbusRTU	1-239

‡ Power Managers with Transducers part # 629168 (Catalog 5200T) support the RS-485 com port J1.
Data Monitors with Electronic Access Module part # 607607 Rev E or higher support the RS-485 com port J1.

Part no. 629168 or 607607 Rev. E



Language – Holding Register no. 40211

Defines the Language displayed on the liquid crystal display (LCD) interface.

Binary value	*Label*	*Description*
0 (00h)	ENGLISH	English language*

* Currently only the English language is available.

Demand Window Size – Holding Register no. 40212

Defines the length of the demand period, in minutes, used in calculating the sliding window demand values.

Range
1 to 15

Subinterval Size – Holding Register no. 40213

Defines the length of the subinterval demand period, in minutes, used in calculating the sliding window demand values. This value is fixed at 1 minute.

Range
1

Reset Demand – Holding Register no. 40214

Writing a value of 0xFFFF to this holding register clears the Minimum and Maximum KWDemand registers.

Clear Energy – Holding Register no. 40215

Writing a value of 0xFFFF to this holding register clears the Energy registers.

Status Input Names (8) – Holding Register nos. 40326-40389

Defines the name of the eight Status Inputs (S1 – S8). The name consists of sixteen ASCII characters, which are assigned two characters per register.

Register Address	*Register description (2 ASCII characters per register)*
Base	$INPUT\_NAME_{char1}$ + $INPUT\_NAME_{char2}$
Base + 1	$INPUT\_NAME_{char3}$ + $INPUT\_NAME_{char4}$
Base + 2	$INPUT\_NAME_{char5}$ + $INPUT\_NAME_{char6}$
Base + 3	$INPUT\_NAME_{char7}$ + $INPUT\_NAME_{char8}$
Base + 4	$INPUT\_NAME_{char9}$ + $INPUT\_NAME_{char10}$
Base + 5	$INPUT\_NAME_{char11}$ + $INPUT\_NAME_{char12}$
Base + 6	$INPUT\_NAME_{char13}$ + $INPUT\_NAME_{char14}$
Base + 7	$INPUT\_NAME_{char15}$ + $INPUT\_NAME_{char16}$

Relay Output Names (4) – Holding Register nos. 40390-40421

Defines the name of the four Relay Outputs (DO1 – DO4). The name consists of sixteen ASCII characters, which are assigned two characters per register.

Register Address	*Register description (2 ASCII characters per register)*
Base	$OUTPUT\_NAME_{char1}$ + $OUTPUT\_NAME_{char2}$
Base + 1	$OUTPUT\_NAME_{char3}$ + $OUTPUT\_NAME_{char4}$
Base + 2	$OUTPUT\_NAME_{char5}$ + $OUTPUT\_NAME_{char6}$
Base + 3	$OUTPUT\_NAME_{char7}$ + $OUTPUT\_NAME_{char8}$
Base + 4	$OUTPUT\_NAME_{char9}$ + $OUTPUT\_NAME_{char10}$
Base + 5	$OUTPUT\_NAME_{char11}$ + $OUTPUT\_NAME_{char12}$
Base + 6	$OUTPUT\_NAME_{char13}$ + $OUTPUT\_NAME_{char14}$
Base + 7	$OUTPUT\_NAME_{char15}$ + $OUTPUT\_NAME_{char16}$

Supported Function Codes for Group 5 Controller

Function # 03 (03h) – Read Holding Registers

This function code allows the master to read one or more consecutive data registers from the Group 5 Controller. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 18 for details about the data register definitions of the Group 5 Controller.

The following example shows the format of a transmission between a master requesting device and the responding Group 5 Controller (slave device) at address 24 (24 decimal = 18 hex).. The master desires to read the three values of voltage, NV_{AB}, NV_{BC}, NV_{CA}, I_{AVE}, beginning at Holding register location 40016 (16 decimal = 10 hexadecimal).

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	03
Data starting address (high byte)	00
Data starting address (low byte)	10
Number of registers (high byte)	00
Number of registers (low byte)	03
CRC16 (low byte)	04
CRC16 (high byte)	0E

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	03
Byte count	06
Data word #1 (high byte)	00
Data word #1 (low byte)	78
Data word #2 (high byte)	00
Data word #2 (low byte)	79
Data word #3 (high byte)	00
Data word #3 (low byte)	77
CRC16 (low byte)	B7
CRC16 (high byte)	10

The Group 5 Controller currently supports the following Read Holding Register addresses (decimal): 11-54, 100, 105-173. Maximum number of registers that can be read with a single 03H command is 12. Attempting to read more than 12 registers with a single 03H command will result in Exception Response from the Group 5 Controller.

Function # 06 (06h) – Preset Single Register

This function code allows the master device to modify the contents of a single configuration register within the Group 5 Controller. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 18 for details about the about the data register definitions of the Group 5 Controller.

The following example shows the format of a transmission between a master device and the responding Group 5 Controller (slave device) at address 24 (24 decimal = 18 hex). The master desires to set the time delay TDES at Holding register 40132 (132 decimal = 84 hex) to 5 seconds (data value 05).

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data address (high byte)	00
Data address (low byte)	84
Data word (high byte)	00
Data word (low byte)	05
CRC16 (low byte)	0B
CRC16 (high byte)	E9

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data address (high byte)	00
Data address (low byte)	84
Number of registers (high byte)	00
Number of registers (low byte)	05
CRC16 (low byte)	0B
CRC16 (high byte)	E9

The Group 5 Controller currently supports the following Preset Single Register addresses (decimal): 44, 101-173.

Function # 16 (10h) – Preset Multiple Registers

This function code allows the master device to modify the contents of consecutive configuration registers within the Group 5 Controller. The data registers are always 16 bit (two byte) values, transmitted high order byte first. Refer to *Register Map* on page 18 for details about the data register definitions of the Group 5 Controller.

The following example shows the format of a transmission between a master requesting device and the responding Group 5 Controller (slave device) at address 24 (24 decimal = 18 hex). The master desires to set the following parameters occupying consecutive register locations: NVDO at Holding register 40118 (118 decimal = 76 hex) to 85% (85 decimal = 55 hex), NVPU at Holding register 40119 to 90% (90 decimal = 5A hex) and NVTP at Holding register 40120 to 110% (110 decimal = 6E hex).

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	10
Data starting address (high byte)	00
Data starting address (low byte)	76
Number of registers (high byte)	00
Number of registers (low byte)	03
Byte count	06
Data word #1 (high byte)	00
Data word #1 (low byte)	55
Data word #2 (high byte)	00
Data word #2 (low byte)	5A
Data word #3 (high byte)	00
Data word #3 (low byte)	6E
CRC16 (low byte)	8A
CRC16 (high byte)	1E

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	10
Data starting address (high byte)	00
Data starting address (low byte)	76
Number of registers (high byte)	00
Number of registers (low byte)	03
CRC16 (low byte)	63
CRC16 (high byte)	DB

The Group 5 Controller currently supports the following Preset Multiple Register addresses (decimal): 44, 101-173.

Note: To access the Log Events data at Holding Register addresses 40044-40053 first the selected Log Event number has to be written into Register 40044 using Function 06H command and then the data of that Event can be read from Registers 40045-40053 using Function 03H command.

Similarly, to access the Feature F11C Schedules data at Holding Registers addresses 40112-40117, first the selected Schedule number to access (read or write) has to be written into Register 40112 using Function 06H command and then the data of that Schedule can be accessed (read or written to) at Registers 40113-40117 using Function 03H, 06H, or 10H command. The maximum number of registers that can be preset with a single 10H command is 10.

Exception Responses

If the Modbus master device sends an unsupported command, attempts to read an invalid holding register, or attempts to write invalid data, the Group 5 Controller (Modbus slave) issues an exception response. The format for the exception response is as follows:

1. SLAVE ADDRESS
2. FUNCTION CODE*
   (with the most-significant-bit set to a 1)
3. ERROR CODE
4. CRC16 – low order byte
5. CRC16 – high order byte

* Note: The high order bit of the function code has been set to one to indicate an exception response has been generated.

The following table is a list of the exception codes supported by the Group 5 Controller.

Exception Response Error Codes

Error code	*Error name*	*Group 5 Controller implementation*
01	Illegal function	The slave does not support the function code contained in the master query packet.
02	Illegal data address	The slave does not support the Holding Register address referenced in the data field of the master query packet.
03	Illegal data value	The slave does not support the data referenced in the data field of the master query packet.
04	Device failure	The addresses slave is unable to perform the action requested due to an internal failure or malfunction.

The following example shows the format of a transmission between a master device and the responding Group 5 Controller (slave device) at address 24. The master device attempts to write data word 0015H to a Read Only Register at 40016 (16 decimal = 10 hex). The Group 5 Controller slave device responds with Error code 02.

Master Transmission

Packet Format	*Example (in hex)*
Slave address	18
Function code	06
Data starting address (high byte)	00
Data starting address (low byte)	10
Data (high byte)	00
Data (low byte)	15
CRC16 (low byte)	4B
CRC16 (high byte)	C9

Slave Response

Packet Format	*Example (in hex)*
Slave address	18
Function code	86
Error code	02
CRC16 (low byte)	12
CRC16 (high byte)	66

Register Map for Power Manager Xp

The following table describes the mapping of the registers within the Power Manager Xp to Holding Registers defined in the Modbus protocol.

Note: The addresses in the format of 4xxxx follow the MODICON MODBUS protocol for point addressing. The actual address sent is the Register Address shown in the map minus the value **40001**.

Register Address	*Register Type*	Parameter Name	Parameter Description	Data Range	Units	Implemented in Firmware Version
40001-40010			Undefined			
40011	RO	V_{AN}	Phase A line to neutral voltage	0 – 59,999	Volt	FS611842-006
40012	RO	V_{BN}	Phase B line to neutral voltage	0 – 59,999	Volt	FS611842-006
40013	RO	V_{CN}	Phase C line to neutral voltage	0 – 59,999	Volt	FS611842-006
40014	RO	V_{AVE}	Line to neutral average voltage	0 – 59,999	Volt	FS611842-006
40015	RO	V_{AB}	A-B line to line voltage	0 – 59,000	Volt	FS611842-006
40016	RO	V_{BC}	B-C line to line voltage	0 – 59,000	Volt	FS611842-006
40017	RO	V_{CA}	C-A line to line voltage	0 – 59,000	Volt	FS611842-006
40018	RO	VL_{AVE}	Line to line average voltage	0 – 59,000	Volt	FS611842-006
40019	RO	VL_{UNBAL}	Line to line voltage unbalance	0 – 100%		FS611842-006
40020	RO	V_{UNBAL}	Line to neutral voltage unbalance	0 – 100%		FS611842-006
40021	RO	I_A	Phase A current	0 – 29,999	Amp.	FS611842-006
40022	RO	I_B	Phase B current	0 – 29,999	Amp.	FS611842-006
40023	RO	I_C	Phase C current	0 – 29,999	Amp.	FS611842-006
40024	RO	I_{AVE}	Average current	0 – 29,999	Amp.	FS611842-006
40025	RO	I_{UNBAL}	Current unbalance	0 – 100%		FS611842-006
40026	RO	I_N	CT4 or neutral current	0 – 29,999	Amp.	FS611842-006
40027-40030			Undefined			
40031	RO	kW_A	Active Power phase A	-29,999 to +29,999	kW	FS611842-006
40032	RO	kW_B	Active Power phase B	-29,999 to +29,999	kW	FS611842-006
40033	RO	kW_C	Active Power phase C	-29,999 to +29,999	kW	FS611842-006
40034	RO	kW_T	Active Power total	-29,999 to +29,999	kW	FS611842-006
40035	RO	$kVAR_A$	Reactive Power phase A	-29,999 to +29,999	kVAR	FS611842-006
40036	RO	$kVAR_B$	Reactive Power phase B	-29,999 to +29,999	kVAR	FS611842-006
40037	RO	$kVAR_C$	Reactive Power phase C	-29,999 to +29,999	kVAR	FS611842-006
40038	RO	$kVAR_T$	Reactive Power total	-29,999 to +29,999	kVAR	FS611842-006
40039	RO	Pf_A	Power Factor phase A	(-.99 to +1.00) * 100	Pf	FS611842-006
40040	RO	Pf_B	Power Factor phase B	(-.99 to +1.00) * 100	Pf	FS611842-006
40041	RO	Pf_C	Power Factor phase C	(-.99 to +1.00) * 100	Pf	FS611842-006
40042	RO	Pf_T	Power Factor total	(-.99 to +1.00) * 100	Pf	FS611842-006
40043	RO	kVA_A	volt-ampere Power phase A	0 – 29,999	kVA	FS611842-006
40044	RO	kVA_B	volt-ampere Power phase B	0 – 29,999	kVA	FS611842-006
40045	RO	kVA_C	volt-ampere Power phase C	0 – 29,999	kVA	FS611842-006
40046	RO	kVA_T	volt-ampere Power total	0 – 29,999	kVA	
40047			Undefined			
40048	RO	Freq.	Frequency on phase V_A	(40.00 to 80.00) * 100	Hz x 100	FS611842-006

40049-40050			Undefined			
40051	RO	$NormkWH_{IMP}$	Normal kWH Import (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40052	RO	$NormkWH_{IMP}$	Normal kWH Import (LO word)		kWH	FS611842-006
40053	RO	$NormkWH_{EXP}$	Normal kWH Export (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40054	RO	$NormkWH_{EXP}$	Normal kWH Export (LO word)		kWH	FS611842-006
40055	RO	$NormkWH_{NET}$	Normal kWH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40056	RO	$NormkWH_{NET}$	Normal kWH Net (LO word)		kWH	FS611842-006
40057	RO	$NormkVarH_{IMP}$	Normal kVarH Import (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40058	RO	$NormkVarH_{IMP}$	Normal kVarH Import (LO word)		kVARH	FS611842-006
40059	RO	$NormkVarH_{EXP}$	Normal kVarH Export (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40060	RO	$NormkVarH_{EXP}$	Normal kVarH Export (LO word)		kVARH	FS611842-006
40061	RO	$NormkVarH_{NET}$	Normal kVarH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40062	RO	$NormkVarH_{NET}$	Normal kVarH Net (LO word)		kVARH	FS611842-006
40063	RO	$NormkVAH_{NET}$	Normal kVAH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kVAH	FS611842-006
40064	RO	$NormkVAH_{NET}$	Normal kVAH Net (LO word)		kVAH	FS611842-006
40065	RW	Nom_Volt	Nominal Voltage	115-59999	Volt	AS629262-004
40066	RW	Nom_Amps	Nominal Current	0-29999	Amp.	AS629262-004
40067	RW	kW_Capacity	Nominal kW Capacity	0-24999	kW	AS629262-004
40068	RW	Nom_Freq	Nominal Freq 0– 60Hz, 1–50Hz	0 or 1		AS629262-004
40069-40070			Undefined			
40071	RO	$EmerkWH_{IMP}$	Emerg kWH Import (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40072	RO	$EmerkWH_{IMP}$	Emerg kWH Import (LO word)		kWH	FS611842-006
40073	RO	$EmerkWH_{EXP}$	Emerg kWH Export (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40074	RO	$EmerkWH_{EXP}$	Emerg kWH Export (LO word)		kWH	FS611842-006
40075	RO	$EmerkWH_{NET}$	Emerg kWH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kWH	FS611842-006
40076	RO	$EmerkWH_{NET}$	Emerg kWH Net (LO word)		kWH	FS611842-006
40077	RO	$EmerkVarH_{IMP}$	Emerg kVarH Import (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40078	RO	$EmerkVarH_{IMP}$	Emerg kVarH Import (LO word)		kVARH	FS611842-006
40079	RO	$EmerkVarH_{EXP}$	Emerg kVarH Export (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40080	RO	$EmerkVarH_{EXP}$	Emerg kVarH Export (LO word)		kVARH	FS611842-006
40081	RO	$EmerkVarH_{NET}$	Emerg kVarH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kVARH	FS611842-006
40082	RO	$EmerkVarH_{NET}$	Emerg kVarH Net (LO word)		kVARH	FS611842-006
40083	RO	$EmerkVAH_{NET}$	Emerg kVAH Net (HO word)	-1,999,999,999 to + 1,999,999,999	kVAH	FS611842-006
40084	RO	$EmerkVAH_{NET}$	Emerg kVAH Net (LO word)		kVAH	FS611842-006
40085-40086			Undefined			
40087	RO	kW_T	Active Power (Watts) total	-29,999 to +29,999	kW	FS611842-006
40088	RO	$kWDemand_T$	Instantaneous Watt Demand	-29,999 to +29,999	kW	FS611842-006
40089	RO	MaxkWDeman	Maximum Watt Demand	-29,999 to +29,999	kW	FS611842-006
40090	RO	kW_T	Active Power (Watts) total	-29,999 to +29,999	kW	FS611842-006
40091	RO	I_{AVE}	Average current	0 – 29,999	Amp.	FS611842-006
40092	RO	VL_{AVE}	Line to line average voltage	0 – 59,999	Volt	FS611842-006
40093	RO	Freq.	Frequency on phase V_A	(40.00 to 80.00) * 100	Hz x 100	FS611842-006
40094	RO	StatusInputs	8 General purpose digital inputs	Bits 0 – 7 ⇒ S1–S8		FS611842-006
40095	RW	RelayOutputs	4 General purpose digital outputs	Bits 0 – 3 ⇒ DO1–DO4		FS611842-006
40096	RO	SwitchPosition	Main & auxiliary Switch positions	0:norm & 1:emer.		FS611842-006
40097	RO	kW_T	Active Power total	-29,999 to +29,999	kW	FS611842-006

40098	RO	$kVAR_T$	Reactive Power total	-29,999 to +29,999	kVAR	FS611842-006
40099	RO	kVA_T	volt-ampere Power total	0 – 29,999	kVA	FS611842-006
40100	RO	Pf_T	Power Factor total	(-0.99 to +1.00) * 100	Pf x 100	FS611842-006
40101	RO	Freq.	Frequency on phase V_A	(40.00 to 80.00) * 100	Hz x 100	FS611842-006
40102-40107	RO	V_String	Software Version string	12 ASCII characters		FS611842-006
40108-40113	RO	SW_Date	Software build date string	12 ASCII characters		FS611842-006
40114-40119	RO	SerialNumber	Device serial number	12 ASCII characters		FS611842-006
40120-40125	RO	ModelNumber	Device model number	12 ASCII characters		FS611842-006
40126			Undefined			
40127	RO	H_STATUS	Health status word			FS611842-006
40128-Bit0	RO	SP_STATUS	Setpoint #1 Output Status Normal/Tripped	0 or 1		AS629262-004
40128-Bit1	RO	SP_STATUS	Setpoint #1 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit 2	RO	SP_STATUS	Setpoint #2 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit 3	RO	SP_STATUS	Setpoint #2 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit 4	RO	SP_STATUS	Setpoint #3 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit 5	RO	SP_STATUS	Setpoint #3 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit 6	RO	SP_STATUS	Setpoint #4 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit 7	RO	SP_STATUS	Setpoint #4 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit 8	RO	SP_STATUS	Setpoint #5 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit 9	RO	SP_STATUS	Setpoint #5 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit10	RO	SP_STATUS	Setpoint #6 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit11	RO	SP_STATUS	Setpoint #6 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit12	RO	SP_STATUS	Setpoint #7 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit13	RO	SP_STATUS	Setpoint #7 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40128- Bit14	RO	SP_STATUS	Setpoint #8 Output Status Normal/Tripped	0 or 1		AS629262-004
40128- Bit15	RO	SP_STATUS	Setpoint #8 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40129- Bit 0	RO	SP_STATUS	Setpoint #9 Output Status Normal/Tripped	0 or 1		AS629262-004
40129- Bit 1	RO	SP_STATUS	Setpoint #9 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40129- Bit 2	RO	SP_STATUS	Setpoint #10 Output Status Normal/Tripped	0 or 1		AS629262-004
40129- Bit 3	RO	SP_STATUS	Setpoint #10 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40129- Bit 4	RO	SP_STATUS	Setpoint #11 Output Status Normal/Tripped	0 or 1		AS629262-004
40129- Bit 5	RO	SP_STATUS	Setpoint #11 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40129- Bit 6	RO	SP_STATUS	Setpoint #12 Output Status Normal/Tripped	0 or 1		AS629262-004
40129- Bit 7	RO	SP_STATUS	Setpoint #12 Acknowledge State Ack/Pendg	0 or 1		AS629262-004
40129- Bit 8	RO	SP_STATUS	kW Demand Setpoint Status Normal/Trip	0 or 1		AS629262-004
40129			Not Used	Bit 9:Bit 15		
40130	RO	kW_T	Active Power (Watts) total	-29,999 to +29,999	kW	FS611842-006
40131	RO	$kWDemand_T$	Instantaneous Watt Demand	-29,999 to +29,999	kW	FS611842-006
40132	RO	MaxkWD	Maximum Watt Demand	-29,999 to +29,999	kW	FS611842-006
40133	RO	kWD_Date	Maximum Watt Demand Date	1-31		FS611842-006
40134	RO	kWD_Month	Maximum Watt Demand Month	1-12		FS611842-006
40135	RO	kWD_Year	Maximum Watt Demand Year	1-99		FS611842-006
40136	RO	kWD_Hour	Maximum Watt Demand Hour	1-23		FS611842-006
40137	RO	kWD_Minute	Maximum Watt Demand Minute	1-59		FS611842-006
40138-40140			Undefined			
40141	RW	PM_TIME	Power Manager Hours	0-23		AS629262-004

40142	RW	PM_TIME	Power Manager Minutes	0-59		AS629262-004
40143	RW	PM_DATE	Power Manager Year	0-99		AS629262-004
40144	RW	PM_DATE	Power Manager Month	1-12		AS629262-004
40145	RW	PM_DATE	Power Manager Day of Month	1-31		AS629262-004
40146	RW	PM_DATE	Power Manager Day of Week (0-S, 1-M, etc)	1-6		AS629262-004
40147			Undefined			
40148-Bit 0	WO	SP_ACK	Setpoint #1 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 1	WO	SP_ACK	Setpoint #2 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 2	WO	SP_ACK	Setpoint #3 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 3	WO	SP_ACK	Setpoint #4 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 4	WO	SP_ACK	Setpoint #5 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 5	WO	SP_ACK	Setpoint #6 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 6	WO	SP_ACK	Setpoint #7 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 7	WO	SP_ACK	Setpoint #8 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 8	WO	SP_ACK	Setpoint #9 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit 9	WO	SP_ACK	Setpoint #10 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit10	WO	SP_ACK	Setpoint #11 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit11	WO	SP_ACK	Setpoint #12 Output Alarm Acknowledge	0 or 1		AS629262-004
40148- Bit12			Not Used			
40148- Bit13			Not Used			
40148- Bit14			Not Used			
40148- Bit15			Not Used			
40149	RO	Event _LOG	Number of Unread Event Log Entries	0-99		AS629262-004
40150	RO	Event _LOG#	Event Number (0 – The Latest One)	0-255		AS629262-004
40151	RO	Event_Year	Event Year	0-99		AS629262-004
40152	RO	Event _Month	Event Month	1-12		AS629262-004
40153	RO	Event _Day	Event Month Day	1-31		AS629262-004
40154	RO	Event _Week	Event Week Day	0-6		AS629262-004
40155	RO	Event _Hour	Event Hour	0-23		AS629262-004
40156	RO	Event _Minute	Event Minute	0-59		AS629262-004
40157	RO	Event _Second	Event Second	0-59		AS629262-004
40158	RO	Event _Event	Event Parameter: 1-kW Prealarm, 2-kW Alarm, 3-Over Voltage, 4-Under Voltage, 5-OverFrequency, 6-UnderFrequency, 7-Reverse Power, 8-Reverse VARs, 9-Reverse Current, 10-Negative Sequence Current, 11-Negative Sequence Voltage, 12-Input#1, 13-Input#2, 14-Input#3,	1-22		AS629262-004

			15-Input#4, 16-Input#5, 17-Input#6, 18-Input#7, 19-Input#8, 20-Input#9(switch position), 21-None, 22-KW Demand			
40159	RO	Event _Cause	Event Cause: 0-Reset, 1-Tripped, 2-Acknowled	0-2		AS629262-004
40160-Bit 0	R	Device 86	Device 86 Enable status	0-Disabled or 1-Enabled		AS629262-004
	W		Device 86 Disable	0-No change or 1-Disable		
40160-Bit 1	R	Device 86	Device 86 State status	0-Normal or 1-Tripped		AS629262-004
	W		Device 86 Enable	0-No change or 1-Enable		
40160-Bit 2	R	Device 86	Device 86 Reset status	0-Ready or 1-Not ready		AS629262-004
	W		Device 86 Reset	0-No change or 1-Reset		
40161			Undefined			
40162	RW	select_setup#	Select a setup log number to view	0-49		AS629262-019
40163	RO	setup_year	Setup log date stamp: year	0-99		AS629262-019
40164	RO	setup_month	Setup log date stamp: month	1-12		AS629262-019
40165	RO	setup_date	Setup log date stamp: date	1-31		AS629262-019
40166	RO	setup_hour	Setup log time stamp: hour	0-23		AS629262-019
40167	RO	setup_minute	Setup log time stamp: minute	0-59		AS629262-019
40168	RO	setup_feature	Setup log feature: 1-Setpoint related: Parameter, trip, dropout, reset, pickup, TDtrip, TDreset, output. 2-Nominal settings related: Voltage, current, frequency, kw capacity.	0-11 range 1-(0-7) for setpoint 2-(8-11) for nominals		AS629262-019
40169	RO	setup_sp	Setup log sepoint number	0-11 setpoint #		AS629262-019
40170	RO	setup_param	Setup log parameter: 0-No parameter 1-kW Prealarm, 2-kW Alarm, 3-Over Voltage, 4-Under Voltage, 5-OverFrequency, 6-UnderFrequency, 7-Reverse Power, 8-Reverse VARs, 9-Reverse Current, 10-Negative Sequence Current, 11-Negative Sequence Voltage, 12-Input#1, 13-Input#2, 14-Input#3, 15-Input#4, 16-Input#5,	0-20		AS629262-019

			17-Input#6, 18-Input#7, 19-Input#8, 20-Switch position input			
40171	RO	setup_from	Setup log recorded from: 0-keypad, 1-serial	0-1		AS629262-019
40172	RO	setup_old	Setup log old parameter value			AS629262-019
40173	RO	setup_new	Setup log new parameter value			AS629262-019
40174-40175			Undefined			
40176	RO	EngineRunEnab	Engine timer enable	0-Disable or 1-Enable		AS629262-019
40177	RO	RunTimer	Engine Timer: hour	0-65535		AS629262-019
40178	RO	RunTimerMin	Engine Timer: minute	0-59		AS629262-019
40179	WO	ClearEngineCnt	Clear engine counter			AS629262-019
40180			Undefined			
40181	RW	select_event#	Select an event log number to view	0-99		AS629262-019
40182	RO	event_year	Event log date stamp: year	0-99		AS629262-019
40183	RO	event_month	Event log date stamp: month	1-12		AS629262-019
40184	RO	event_date	Event log date stamp: date	1-31		AS629262-019
40185	RO	event_day	Event log date stamp: day	0-6 (Mon-Sun)		AS629262-019
40186	RO	event_hour	Event log time stamp: hour	0-23		AS629262-019
40187	RO	event _minute	Event log time stamp: minute	0-59		AS629262-019
40188	RO	event_second	Event log time stamp: second	0-59		AS629262-019
40189	RO	event_event	Event log parameter: (see list on register 40158)	1-22		AS629262-019
40190	RO	event_cause	Event cause: 0-Reset, 1-Tripped, 2-Acknowled	0-2		AS629262-019
40191			Undefined			
40192	WO	clear_event_log	Register to clear event log database			AS629262-019
40193-40199			Undefined			
40200	RW	$TYPE_{SYSTEM}$	System Type			FS611842-006
40201	RW	$MODE_{SOURCE}$	Source Mode			FS611842-006
40202	RW	PTR	Potential Transformer Ratio			FS611842-006
40203	RW	CTR	Current Transformer Ratio			FS611842-006
40204	RW	CT4R	4th Current Input Transformer Ratio			FS611842-006
40205	RW	$PROTOCOL_{SCI}$	SCI comm. port (J5) protocol			FS611842-006
40206	RW	$BAUD_{SCI}$	SCI comm. port (J5) baud rate			FS611842-006
40207	RW	$ADDR_{SCI}$	SCI comm. port (J5) device address			FS611842-006
40208	RW	$PROTOCOL_{485}$	485 comm. port (J1) protocol			FS611842-006
40209	RW	$BAUD_{485}$	485 comm. port (J1) baud rate			FS611842-006
40210	RW	$ADDR_{485}$	485 comm. port (J1) device address			FS611842-006
40211	RW	$TYPE_{LANG}$	Language selection			FS611842-006
40212	RW	Window_Size	Demand Window size (in minutes)		min.	FS611842-006
40213	RW	Subintl_Size	Demand Subinterval size (fixed at 1 minute)		min.	FS611842-006
40214	WO	Reset_Demand	Resets Inst. & Max. demand registers			FS611842-006
40215	WO	Clear_Energy	Clears Energy registers to 0			FS611842-006
40216-40229			Undefined			
40230-40235	RW	SETPOINT	Setpoint configuration settings			
40236-40242 40236	RW RW	$SETPOINT_1$ #I	Setpoint#1 Configuration Settings: Setpoint Number	 0-11		AS629262-004

40237	RW	Parameter	Setpoint Parameter	0-20		
40238	RW	High_limit	Setpoint Trip Level	0-500		
40239	RW	TD_Operate	Setpoint Trip Time Delay	0-600		
40240	RW	Low_Limit	Setpoint Reset Level	0-500		
40241	RW	TD_Release	Setpoint Reset Time Delay	0-600		
40242-Bit0-3	RW	Output	Setpoint Digital Output :DO1 To DO4	0 or 1		
40242-Bit 4	RW	--	Output No Acknowledg/Acknowledg	0 or 1		
40242-Bit 5	RW	--	Output Status Normal/Tripped	0 or 1		
40242-Bit 6	RW	--	Previous Acknowledge/Pending	0 or 1		
40242-Bit 7	RW	--	Present Acknowledge/Pending	0 or 1		
40243-40249	RW	$SETPOINT_2$	Setpoint#2 Configuration Settings	Same Setting as SP#1		AS629262-004
40250-40256	RW	$SETPOINT_3$	Setpoint#3 Configuration Settings	Same Setting as SP #1		AS629262-004
40257-40263	RW	$SETPOINT_4$	Setpoint#4 Configuration Settings	Same Setting as SP #1		AS629262-004
40264-40270	RW	$SETPOINT_5$	Setpoint#5 Configuration Settings	Same Setting as SP #1		AS629262-004
40271-40277	RW	$SETPOINT_6$	Setpoint#6 Configuration Settings	Same Setting as SP #1		AS629262-004
40278-40284	RW	$SETPOINT_7$	Setpoint#7 Configuration Settings	Same Setting as SP #1		AS629262-004
40285-40291	RW	$SETPOINT_8$	Setpoint#8 Configuration Settings	Same Setting as SP #1		AS629262-004
40292-40298	RW	$SETPOINT_9$	Setpoint#9 Configuration Settings	Same Setting as SP #1		AS629262-004
40299-40305	RW	$SETPOINT_{10}$	Setpoint#10 Configuration Settings	Same Setting as SP #1		AS629262-004
40306-40312	RW	$SETPOINT_{11}$	Setpoint#11 Configuration Settings	Same Setting as SP #1		AS629262-004
40313-40319	RW	$SETPOINT_{12}$	Setpoint#12 Configuration Settings	Same Setting as SP #1		AS629262-004
40320-40321			Undefined			
40322-40325	RW	PM-Name	Power Manager Name	8 ASCII chars		AS629262-004
40326-40333	RW	$Status_1$_Name	S1 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40334-40341	RW	$Status_2$_Name	S2 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40342-40349	RW	$Status_3$_Name	S3 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40350-40357	RW	$Status_4$_Name	S4 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40358-40365	RW	$Status_5$_Name	S5 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40366-40373	RW	$Status_6$_Name	S6 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40374-40381	RW	$Status_7$_Name	S7 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40382-40389	RW	$Status_8$_Name	S8 Status Input name	15 chars+ 1 byte eng. alarms		FS611842-006
40390-40397	RW	$Relay_1$_Name	DO1 Relay Output name	15 chars+ 1 byte eng. alarms		FS611842-006
40398-40405	RW	$Relay_2$_Name	DO2 Relay Output name	15 chars+ 1 byte eng. alarms		FS611842-006
40406-40413	RW	$Relay_3$_Name	DO3 Relay Output name	15 chars+ 1 byte eng. alarms		FS611842-006
40414-40421	RW	$Relay_4$_Name	DO4 Relay Output name	15 chars+ 1 byte eng. alarms		FS611842-006
40422-40431	RW	PM-Location	Power Manager Location	20 ASCII chars		AS629262-004
40432			Undefined			

Register Map for Group 5 Controller

The following table describes the mapping of the registers within the Group 5 Controller to Holding Registers defined in the Modbus protocol.

Note: The addresses in the format of 4xxxx follow the MODICON MODBUS protocol for point addressing. The actual address sent is the Register Address shown in the map minus the value **40001**.

Real Time Data Registers

Register Address	Register Type	Parameter Name	Parameter Description	Data Range	Units	Implemented in Firmware Version
40001- 40011			Undefined			
40012	RO	PHASE_0	Phase Shift between Normal & Emergency	-1800 – 1800	deg x 10	607540-023
40013	RO	NFRQ_0	Normal Frequency	0 – 7000	Hz x 100	607540-023
40014	RO	EFRQ_0	Emergency Frequency	0 – 7000	Hz x 100	607540-023
40015-Bit 0	RO	I_MAIN_ON_N	Main on Normal	Boolean		607540-023
40015-Bit 1	RO	I_MAIN_ON_E	Main on Emergency	Boolean		607540-023
40015-Bit 2	RO	I_AUX_ON_N	Auxiliary on Normal	Boolean		607540-023
40015-Bit 3	RO	I_AUX_ON_E	Auxiliary on Emergency	Boolean		607540-023
40015-Bit 4	RO	N.SrcAvl	Normal Source Available	Boolean		607540-023
40015-Bit 5	RO	E.SrcAvl	Emergency Source Available	Boolean		607540-023
40016-Bit 0	RO	STATPHR.NABC	Normal Phase Rotation is ABC	Boolean		607540-023
40016-Bit 1	RO	STATPHR.NCBA	Normal Phase Rotation is CBA	Boolean		607540-023
40016-Bit 2	RO	STATPHR.EABC	Emergency Phase Rotation is ABC	Boolean		607540-023
40016-Bit 3	RO	STATPHR.ECBA	Emergency Phase Rotation is CBA	Boolean		607540-023
40016-Bit 4	RO	XRQ_F11C_LX	Engine Exerciser with Load Active	Boolean		607540-023
40016-Bit 5	RO	not used	not used	Boolean		607540-023
40016-Bit 6	RO	I_F17_ON	External F17 is Active	Boolean		607540-023
40017	RO	NV_AB	Normal Voltage Phase AB	0 to 28200	Volt	607540-023
40018	RO	NV_BC	Normal Voltage Phase BC	0 to 28200	Volt	607540-023
40019	RO	NV_CA	Normal Voltage Phase CA	0 to 28200	Volt	607540-023
40020	RO	NVUnblCur	Normal Voltage Unbalance	0 to 99 %	Volt	607540-023
40021	RO	EV_AB	Emergency Voltage Phase AB	0 to 28200	Volt	607540-023
40022	RO	EV_BC	Emergency Voltage Phase BC	0 to 28200	Volt	607540-023
40023	RO	EV_CA	Emergency Voltage Phase CA	0 to 28200	Volt	607540-023
40024	RO	EVUnblCur	Emergency Voltage Unbalance	0 to 99 %	Volt	607540-023
40025	RO	I_NOM_V	Nominal Voltage	0 to 15 (Note 1)	Volt	607540-023
40026-Bit 0	RO	I_FRQ_60	Nominal Frequency	Bool (60-50 Hz)		607540-023
40026-Bit 1	RO	I_N3PHASE	Normal Source 3 Phase sensing	Boolean		607540-023
40026-Bit 2	RO	I_E3PHASE	Emergency Source 3 Phase sensing	Boolean		607540-023
40026-Bit3-4	RO	TSType	Transfer Switch Type (CTTS, OTTS,DTTS)	0 to 3 (Note 2)		607540-023
40026-Bit 5	RO	TSBypass	Transfer Switch Bypass or not	Boolean		607540-023
40026-Bit 6	RO	ATS/DualBreaker	Transfer Switch or Dual Breaker	Boolean		607540-033
40027	RO	TSAmp	Transfer Switch Amp rating	0 to 15 (Note 3)		607540-023
40028-40033	RO	LCD_CP_VER	Control Panel Software version	10 char. string		607540-023
40034-40039	RO	LCD_CP_DATE	Control Panel Software date	10 char. string		607540-023
40040-Bit 0	RO	OPSave.b.ATSLout	Transfer Switch Locked Out	Boolean		607540-023

40040-Bit 1	RO	OPSave.b.XtdPrlAl	CTTS extended parallel alarm	Boolean		607540-023
40040-Bit 2	RO	OPSave.b.SyncFail	CTTS failure to synch alarm	Boolean		607540-023
40040-Bit 3	RO	DTTSLoadDisc	DTTS Load Disconnect	Boolean		607540-023
40040-Bit 4	RO	I_EXT_PLOCK_ON	External parameter lock is active	Boolean		607540-023
40040-Bit 5	RO	Relay.NR	Engine running	Boolean		607540-023
40040-Bit 6	RO	NBrkrTipped	Normal Breaker Tripped	Boolean		607540-033
40040-Bit 7	RO	EBrkrTipped	Emergency Breaker Tripped	Boolean		607540-033
40041	RO	CPState	Control Panel State	0 to 255 (Note 4)		607540-023
40042	RO	CPStateData	Control Panel Status State Data (→lookup table)	0 to 65535(Note 4)		607540-023
40043-Bit 0	RO	F.F6BOn	Feature 6B	Boolean		607540-023
40043-Bit 1	RO	F.F6COn	Feature 6C	Boolean		607540-023
40043-Bit 2	RO	I_F17_ON	Feature 17	Boolean		607540-023
40043-Bit 3	RO	not used	not used	Boolean		607540-023
40043-Bit 4	RO	F.F29On	Feature 29	Boolean		607540-023
40043-Bit 5	RO	F.F30On	Feature 30	Boolean		607540-023
40043-Bit 6	RO	F.F34AOn	Feature 34A	Boolean		607540-023
40043-Bit 7	RO	F.F34BOn	Feature 34B	Boolean		607540-023
40044-Bit 0	RO	F.F89On	Feature 89	Boolean		607540-023
40044-Bit 1	RO	F.CTBypsOn	Feature CT Bypass	Boolean		607540-023
40044-Bit 2	RO	I_ALARM_RST	Feature Alarm Reset	Boolean		607540-023
40044-Bit 3	RO	I_F6D_MAN_ON	Feature 6D	Boolean		607540-023
40044-Bit 4	RO	F.F5On	Feature 5	Boolean		607540-023
40044-Bit 5	RO	I_F5F6Z_ON	Feature 6Z	Boolean		607540-023
40044-Bit 6	RO	F.SComF17Off	Feature 34T	Boolean		607540-023
40045	RW	LogNum	Event number	0 to 99		607540-023
40046	RO	LogYear	Event year	0 to 99		607540-023
40047	RO	LogMonth	Event month	1 to 12		607540-023
40048	RO	LogDayM	Event day of month	1 to 31		607540-023
40049	RO	LogDayW	Event day of week	0 to 6		607540-023
40050	RO	LogHour	Event hour	0 to 23		607540-023
40051	RO	LogMin	Event minute	0 to 59		607540-023
40052	RO	LogSec	Event second	0 to 59		607540-023
40053	RO	LogType	Event type	1 to 11 (Note 5)		607540-023
40054	RO	LogCause	Event cause	1 to 23 (Note 6)		607540-023
40055-Bit0-6	RO	LogEntNr	Number of entries in the control panel event log	0 to 99		607540-023
40056-40100			Undefined			
40101-Bit0-5	RO	SlcMode	Soft Load Controller mode	0 to 3 (Note 7)		607540-023
40101-Bit 6	RO	SlcStat.NBrOpn	SLC Normal Breaker status	Boolean		607540-023
40101-Bit 7	RO	SlcStat.EBrOpn	SLC Emergency Breaker status	Boolean		607540-023

Note 1

Nominal Voltage

Data	*Voltage*
0	115V
1	120V
2	208V
3	220V
4	230V
5	240V
6	277V
7	380V
8	400V
9	415V
10	440V
11	460V
12	480V
13	550V
14	575V
15	600V

Note 2

Switch Type

Data	*Switch Type*
0	OTTS
1	DTTS
2	CTTS
3	OTTS

Note 7

SLC Mode

Data	*SLC Mode*
0	No SLC
1	Islanding
2	Parallel Base Load
3	Import/Export

Note 3

Switch Amp Rating

Data	*Amp Rating*
0	30A
1	70A
2	100A
3	150A
4	260A
5	400A
6	600A
7	800A
8	1000A
9	1200A
10	1600A
11	2000A
12	3000A
13	4000A
14	OTHER
15	OTHER

Note 5

Event Type

Data	*Event Type*
1	Engine Start
2	Transfer N>E
3	Transfer E>N
4	Engine Stop
5	Emerg Acceptable
6	Emerg Not Accept.
7	Normal Acceptable
8	Normal Not Accept.
9	Transfer Abort
10	Breaker Trip
11	YY Primary Fail

Note 6

Event Cause

Data	*Event Cause*
1	Load Shed
2	Normal Fail
3	Manual Transfer
4	Test 5
5	Test 17
6	Communication
7	Engine Exerciser
8	Emergency Fail
9	Normal Under Voltage
10	Normal Over Voltage
11	Normal Under Frequency
12	Normal Over Frequency
13	Normal Phase Rotation
14	Normal Voltage Unbal.
15	Emerg. Under Voltage
16	Emerg. Over Voltage
17	Emerg. Under Frequency
18	Emerg. Over Frequency
19	Emerg. Phase Rotation
20	Emerg. Voltage Unbal.
21	Feature 6
22	Normal Breaker
23	Emergency Breaker

Note 4 - Look Up Table For Control Panel State & State Data

State	*TS Position*	*State Description*	*State Data*	*G5 state*
00	N	load on N, N ok	if 11C without load is running, then time left in minutes, else null	0
01	N	timer 1C (TDES) running	time left in seconds	1
02	N	waiting for E acceptable	null	2
03	N	transfer to E inhibited by F6Z	null	3
04	N	transfer to E inhibited by F34B	null	4
05	N	timer 2B (TDNE) running	time left in seconds	5
06	N	timer 31F (N to E pre transfer signal) running	time left in seconds	6
07	N	in phase monitor time delay (OTTS N to E transfer)	time left in seconds	7
08	N	waiting for in phase (OTTS N to E transfer)	phase difference in degrees x 10	8
09	N	in phase monitor time delay with load shed (OTTS N to E transfer)	time left in seconds	71
10	N	waiting for in phase with load shed (OTTS N to E transfer)	phase difference in degrees x 10	72
11	N	in sync monitor time delay (CTTS N to E transfer)	time left in seconds	12
12	N	waiting for in sync (CTTS N to E transfer)	phase difference in degrees x 10	13
13	N	sources paralleled (CTTS N to E transfer)	null	15
14	N	load disconnected CT bypass (CTTS N to E transfer)	time left in seconds	20
15	N	load disconnected (DTTS N to E transfer)	time left in seconds	23
16	E	N to E load shed is active	null	90,91
17	E	timer 31M (N to E post transfer signal) running	time left in seconds	27
18	E	load on E waiting for removal of transfer requests	if 11C with load is running, then time left in seconds else null	28
19	E	timer 3A (TDEN) running	time left in seconds	29
20	E	transfer to N inhibited by G6C	null	30
21	E	transfer to N inhibited by F34A	null	31
22	E	timer 31G (E to N pre transfer signal) running	time left in seconds	33
23	E	in phase monitor time delay (OTTS E to N transfer)	time left in seconds	35
24	E	waiting for in phase (OTTS E to N transfer)	phase difference in degrees x 10	36
25	E	in phase monitor time delay with load shed (OTTS E to N transfer)	time left in seconds	94

26	E	waiting for in phase with load shed (OTTS E to N transfer)	phase difference in degrees x 10	95
27	E	in sync monitor time delay (CTTS E to N transfer)	time left in seconds	39
28	E	waiting for in sync (CTTS E to N transfer)	phase difference in degrees x 10	40
29	E	sources paralleled (CTTS E to N transfer)	null	42
30	E	load disconnected CT bypass (CTTS E to N transfer)	time left in seconds	47
31	E	load disconnected (DTTS N to E transfer)	time left in seconds	51
32	N	E to N load shed is active	null	114, 115
33	N	timer 31N (E to N post transfer signal) running	time left in seconds	55
34	N	timer 2E (TDEC) running	time left in seconds	57
35	N	timer 1C (TDES) while timer 2E (TDEC) running	time left in seconds	58
36	?	power up inhibit	1 if sources not acceptable, 2 if TS position unknown, 3 if transfer inhibit signal	119
255	-	transition state (maintain last state)	null	-