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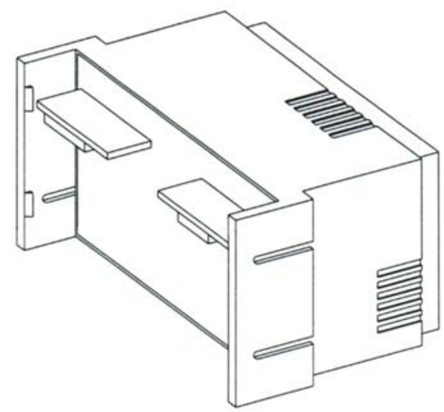
Simpson®

GIMA

MODBUS COMMUNICATIONS OPTIONS MODULE INSTRUCTION MANUAL



About this Manual

To the best of our knowledge and at the time written, the information contained in this document is technically correct and the procedures accurate and adequate to operate this instrument in compliance with its original advertised specifications.

Notes and Safety Information

This Operator's Manual contains warning headings which alert the user to check for hazardous conditions. These appear throughout this manual where applicable, and are defined below. To ensure the safety of operating performance of this instrument, these instructions must be adhered to.

⚠ Warning, refer to accompanying documents.

⚠ Caution, risk of electric shock.

Technical Assistance

SIMPSON ELECTRIC COMPANY offers assistance Monday through Friday 8:00 am to 4:30 pm Central Time. To receive assistance contact Technical Support or Customer Service at (715) 588-3311.
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SIMPSON ELECTRIC COMPANY warrants each instrument and other articles manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory or other article of equipment which shall within one (1) year after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service centers, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sales of its products.

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5 Specifications

Auxiliary Supply	
Option Module	230VAC or 110VAC 50/60Hz ±15% Automatic voltage selection when inserted into GIMA GIMA MUST be rated to match either selection.
Load	3VA Maximum
Isolation	2.5kV continuous (Supply internally wired to GIMA auxiliary mains inputs)
Mechanical (Options Module)	
Enclosure	Custom Options Enclosure . Material Mablex UL94-V-O
Dimensions **Options Unit Unfitted** **GIMA + Options**	 W=87mm x H=59mm x L=75mm 96mm x 96mm x 138mm (130mm behind panel)
Weight	Approx. 200g
Terminals	Rising Cage. 0.2 - 4.0mm² Conductors
Modbus Serial Comms	
Bus Type **RX Loading** **TX Drive**	RS422 / RS485 4/2 Wires + 0V. Half Duplex 1/4 Unit Load per Options Module 32 Unit Loads
Protocol	Modbus RTU with 16-bit CRC (JBUS compatible)
Baud RAte	4800, 9600 or 19200 user=programmable
Address	User-programmable 1-247
Speed **Reply Time** **Max Data Packet** **Command Rate**	 100ms maximum from command end to reply start Any complete table (energy, instantaneous, set-up, etc.) New command within 5ms of previous one

Contents

4.6 Modbus Diagnostics LEDs

The GIMA Options Unit uses three LEDs to aid commissioning into a Modbus system. These indicators are also useful to check continued operation of the device.

The LEDs are intelligent indicators, which are illuminated under specific conditions, as follows:

VALID COMMAND Illuminated when a host command is received, surrounded by RTU frame breaks (ref 0) with the correct Modbus address.

ERROR/EXCEPTION Illuminated when a Valid Command is received as above, but a CRC error (ref 4.4.2) or Exception Condition (ref 4.5.12) is detected.

BUS ACTIVITY Illuminated whenever changes occur on the receive- input pins of the module.

Exception Response

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	84H
EXCEPTION CODE	3	02H
CHECKSUM (High Byte)	4	42H
CHECKSUM (Low Byte)	5	C6H

EXCEPTION FUNCTION CODE

All normal function types have a most significant bit of 0 (<80 Hex). In an Exception Response, the meter sets the MSB to 1 (adds 80H to the received Function Type). The Function can therefore be used by the host to detect an Exception Response.

DATA FIELD

In an Exception Response, the data field is used only to return the type of error that occurred (**Exception Code**).

The GIMA Options Unit uses the following Exception Codes:

CODE	MEANING
1	Data out of range
2	Table and/or offset out of range for this function
3	Odd number of Integers written to Long Integers registers
9	Communications from Option Module to meter have failed

1 Description

The Modbus Options Module adds multi-drop serial communications to any standard GIMA meter. The device uses a high-speed microprocessor to extract information from the meter and interface to an industry-standard Modbus system.

Use of a dedicated communications processor ensures optimum efficiency, allowing fast access to data on systems with multiple meters. The use of Modbus protocol ensures compatibility with existing systems and/or a number of readily available software packages.

The Options Module may be configured as RS-485 or RS-232, providing 2 or 4-wire communications over distances up to 1200 meters. Data rates of 4800, 9600, or 19200 may be selected to suit system requirements.

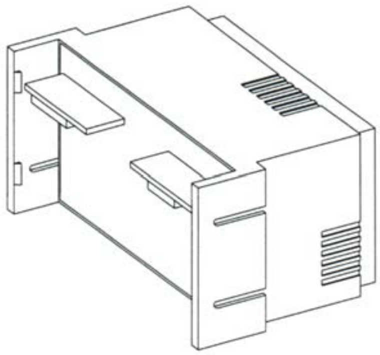

Figure 1.1. Options Module

1.1 Available Parameters

The Options Module is available in two forms.

The “Standard” unit provides access to GIMA measure parameters, which may be seen on the meter’s LCD display. Parameters not provided on a particular GIMA meter type are set to zero in the Modbus tables (refer to section 4.5).

The “All Value” unit provides access to all parameters shown in the table in section 4.5.

Both types of Options Units provide access to standard programmable meter settings, such as CT primary.

2 Connecting the Options Unit

To connect the Options Module to the GIMA:

1 Isolate all inputs/outputs to the GIMA.
2 Check the ratings on the options module and meter to ensure compatibility.
3 Use a sharp knife to remove the cutout section from the rear of the GIMA. Ensure the knife blade does not penetrate more than 3mm.
4 Insert the Options Module into the slot on the rear of the meter.
5 Slide the Module fully home until all four mounting lugs cluck into place, as shown below.

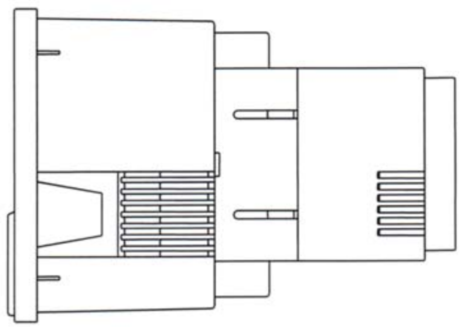

Figure 2.1. Options Module attached to GIMA

Meter Response

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	10H
TABLE NUMBER (Address High Byte)	3	0DH
TABLE OFFSET (Address Low Byte)	4	03H
NUMBER OF DATA WORDS (N) (High Byte)	5	00H
NUMBER OF DATA WORDS (N) (Low Byte)	6	03H
CHECKSUM (High Byte)	7	71H
CHECKSUM (Low Byte)	8	7CH

The reply confirms the data address and amount of data received.

4.5.12 Exception Responses

When a host sends a query to an individual meter on the network, it expects a normal response. In fact, one of four possible events may occur as a result of the query:

- If the Options Unit receives the message with no communication errors, and can handle the query, it will reply with a normal response.
- If the Options Unit does not receive the message due to a communication failure, no response will be returned and the host will eventually time-out.
- If the Options Unit receives the message but detects a communication error via its CRC, no response will be returned and the host will time-out.
- If the Options Unit receives the query with no communication errors, but cannot handle the query (out of range data or address), the response will be an Exception Response informing the host of the nature of the error.

An Exception Response differs from a normal response in its Function Code and Data Fields.

4.5.11 Function 16 Preset Multiple Registers

Description

This function allows a number of registers in a meter table to be set, by the host, in a single operation. When broadcast (address = 0), all meters on the network are addressed together, but none reply.

Host Request

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	10H
TABLE NUMBER (Address High Byte)	3	0DH
TABLE OFFSET (Address Low Byte)	4	03H
NUMBER OF DATA WORDS (N) (High Byte)	5	00H
NUMBER OF DATA WORDS (N) (Low Byte)	6	03H
NUMBER OF DATA BYTES (2N)	7	06H
DATA BYTE 1	8	00H
DATA BYTE 2	9	00H
DATA BYTE 3	10	00H
DATA BYTE 4	11	00H
DATA BYTE 5	12	00H
DATA BYTE 6	13	00H
CHECKSUM (High Byte)	14	0C
CHECKSUM (Low Byte)	15	FB

The example above simultaneously writes 00 to all three peak hold voltage registers (V1 Peak Hold = Table 13, Offset 3). The meter accessed has a Modbus ID of 25 (19H).

3 Operation

3.1 Local Communications (Meter-Options Module)

Once connected and powered up, the GIMA and Options Unit will begin communicating with each other automatically. All readings taken by the meter are sent to the Options Module each second, along with all meter program settings. The Options Module replies with confirmation of the values and any requests to alter meter settings.

The GIMA will confirm that it is correctly connected to an Options Module by illuminating the ***Options*** LED on its front panel. If for any reason the local communications fail, this LED will switch off.

3.2 Programming

The GIMA programming menu will automatically expand to include Baud Rate and Address settings when a valid Modbus Options Module is detected.

3.2.1 Setting Baud Rate

Remote serial communications speeds of 4800, 9600 or 19200 may be selected to suit external system requirements. Higher speeds will provide faster data access, while a slower speed may be required in electrically noisy environments.

Enter the programming mode on the GIMA as described in the meter's Instruction Manual. Scroll through the program settings using ↵ until the meter displays 'Baud Rate.'

1 Press △ to select the next highest available baud rate setting.
2 Press ▽ to select the next lowest available baud rate setting.
3 Press ↵ and hold for two seconds to finish.

3.2.2 Setting Meter Address

Each outstation (meter) on a multi-drop Modbus system is identified to the master by a unique address. The GIMA may be addressed anywhere in the full Modbus range of 1-247.

Enter the programming mode on the GIMA as described in the meter's Instruction Manual. Scroll through program settings using ↵ until the meter displays 'Cube Addr.'

Figure 3.3. Setting the Modbus Address

1 Press △ to select to increment the Modbus Address.
2 Press ▽ to decrement the Modbus Address.
3 Press ↵ and hold for two seconds to finish.

4 Modbus Communication

4.1 Description

The GIMA Options Module provides a serial communications interface to external systems. This allows remote reading and programming of the meter by a host computer (e.g. PC). The output may be wired as RS-232 (full duplex) or RS-485 (half duplex).

The communication protocol used is a subset of Modicon's Modbus, enabling use of standard off-the-shelf software packages and connection to standard controllers.

4.1.1 Communication Address

Each meter on a Modbus serial communication network must be assigned a unique address between 1 and 247. This is carried out in programming mode, as described in section 3.2. If two or more meters, connected in a multi-drop network have the same address, data on the network will be corrupted and communication will fail.

4.5.10 Function 08 Loop Back Diagnostic

Description
This function provides a simple means of testing the communication network and detecting if a particular meter is present. This command is not available as a broadcast command as it requires a return data packet from the meter.

Host Request

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	08H
DIAGNOSTIC CODE (High Byte)	3	00H
DIAGNOSTIC CODE (Low Byte)	4	00H
DIAGNOSTIC DATA (High Byte)	5	03H
DIAGNOSTIC DATA (Low Byte)	6	E8H
CHECKSUM (High Byte)	7	E3H
CHECKSUM (Low Byte)	8	6DH

The example above shows a command with a Loop Back Code of 0 and Diagnostic Data of 1000 (03H E8H). The meter accessed has a Modbus ID of 15 (19H).

Meter Response

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	08H
DIAGNOSTIC CODE (High Byte)	3	00H
DIAGNOSTIC CODE (Low Byte)	4	00H
DIAGNOSTIC DATA (High Byte)	5	03H
DIAGNOSTIC DATA (Low Byte)	6	E8H
CHECKSUM (High Byte)	7	E3H
CHECKSUM (Low Byte)	8	6DH

The reply format is a copy of the command confirming its validity.

Host Request

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	06H
TABLE NUMBER (Address High Byte)	3	0EH
TABLE OFFSET (Address Low Byte)	4	00H
DATA VALUE (High Byte)	5	00H
DATA VALUE (Low Byte)	6	C8H
CHECKSUM (High Byte)	7	89H
CHECKSUM (Low Byte)	8	6CH

The example above shows a value of 200 (00H C8H), written to the CT Primary register (Data Table 14, offset 0). The meter accessed has a Modbus ID of 25 (19H).

Meter Response

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	06H
TABLE NUMBER (Address High Byte)	3	0EH
TABLE OFFSET (Address Low Byte)	4	00H
DATA VALUE (High Byte)	5	00H
DATA VALUE (Low Byte)	6	C8H
CHECKSUM (High Byte)	7	89H
CHECKSUM (Low Byte)	8	6CH

The replay format is a copy of the command confirming its validity:

Note: This Modbus command is limited to writing 2-byte data only. Long integer registers may be written, but the meter assumes sets upper bytes automatically to zero.

4.1.2 Data Format

The device uses a fixed data format for serial communications:

1 Start Bit	8 Data Bits	1 Stop Bit

The 8 data bits are always transmitted least significant bit first. This data byte is binary coded.

The baud rate is programmable as **4800, 9600 or 19200 baud**. This is carried out in programming mode as described in section 3.2.

4.2 RS-485

The RS-485 communication option enables connection of up to 128 meters on a single pair of wires (247 with repeaters). The pair is used for transmission and reception with each meter (and the host) automatically switching data direction. The host should be fitted with an RS-485 driver (or converter) capable of operation in two-wire mode (half duplex).

PC operation in RS-485 two-wire mode usually requires software control of the data direction. This controls the line drivers connected to the bus at the host serial port. This direction control requires high-speed operation and may be problematic under certain operation systems such as Windows. It is advisable to check with the software vendor before selecting RS-485 as the mode of operation.

If software data direction control is not suitable, RS-232/RS-485 converters are available for standard PCs, which carry out automatic hardware control. For more information on these, contact your distributor.
Each Modbus serial transaction is preceded by a device address allowing the host to temporarily connect with any meter on the bus. Certain commands allow the host to transmit commands or data to all meters simultaneously. These commands are known as broadcasts and use address '0.' The RS-485 standard enables reliable communication over a maximum distance of 1200 meters.

Standard line repeaters may be installed to increase the maximum distance of an RS-485 network and/or the number of devices that may be connected.

4.2.1 RS-485 Connection

It is recommended that screened twisted-pair cable be used for RS-485 connection in order to minimize signal errors due to noise. An optional third wire, connection the common (0V) at each unit, is recommended for optimum performance. The cable screen should be connected to the connector housing (ground) at the host (PC) only. To reduce cable reflections over long distances, RS-422/485 systems require line termination. This is achieved by fitting two 120Ω terminating resistors as shown in figure 4.2. One resistor should be fitted at the Host input/output buffer and the other at the buffer of the most remote device.

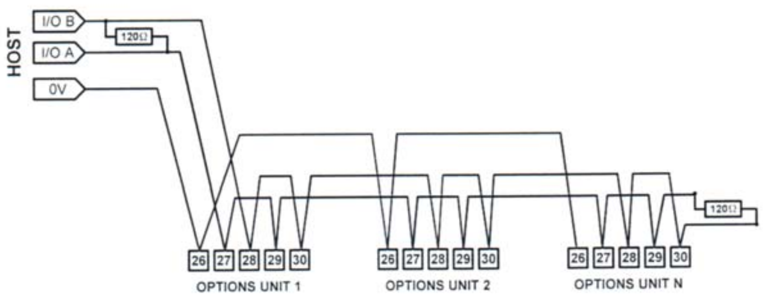

Figure 4.4. RS-485 Multi-Drop Connection

4.3 RS-422

The RS-422 communication option enables connection of up to 128 meters (247 with repeaters) on two pairs of wires (4-wire bus). One pair is used for transmission and the other for reception.

This connection is more commonly used in full duplex communications systems where host and slave can simultaneously transmit/receive data. In this instance however, the Modbus protocol itself ensures half duplex operation in RS-485 mode with data direction control. The RS-422 standard enables reliable communication over a maximum distance of 1200 meters. Standard line repeaters may be installed to increase the maximum distance of an RS-422 network and/or the number of devices that may be connected.

Meter Response

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	04H
NUMBER OF BYTES (2N)	3	06H
DATA REGISTER 1 (High Byte)	4	02H
DATA REGISTER 1 (Low Byte)	5	3AH
DATA REGISTER 2 (High Byte)	6	07H
DATA REGISTER 2 (Low Byte)	7	5CH
DATA REGISTER N (High Byte)	8	07H
DATA REGISTER N (Low Byte)	9	02H
CHECKSUM (High Byte)	10	51H
CHECKSUM (Low Byte)	11	E3H

The example shows a replay of 6 bytes (3 integers) as:

3-ph kW = 570 (02 3A Hex)
3-Ph kVA = 1884 (07 5C Hex)
3-Ph kvar = 1794 (07 02 Hex)

4.5.9 Function 06 Preset a Single Register

Description

This function allows a single integer register in a meter table to be changed by the host. This command is commonly used to program meter parameters or to reset energy registers to zero. When broadcast (address = 0), all meters on the network are addressed together, but none reply.

4.5.7 Table 16 Current and Voltage Demand

Offset	Address	Contents	Format	Bytes	Words	Access
0	4096	I1 Demand	Unsigned Int	2	1	Read Only[5]
1	4097	I2 Demand	Unsigned Int	2	1	Read Only[5]
2	4098	I3 Demand	Unsigned Int	2	1	Read Only[5]
3	4099	V1 Demand	Unsigned Int	2	1	Read Only[6]
4	4100	V2 Demand	Unsigned Int	2	1	Read Only[6]
5	4101	V3 Demand	Unsigned Int	2	1	Read Only[6]

Notes: 5. Use "Amps Scale" at Addr 2837 to convert to real Amp Demand.
6. Use "Ph Volts Scale" at Addr 2838 to convert to real Volts Demand.

The rolling demand averages of currents and voltages are available in Table 16 as unsigned integers.

Note: Tables 15 and 16 are only available in GIMA meters with software versions 1.04 or later. An invalid table exception will be returned on earlier meters.

4.5.8 Function 04 (or 03) Read Multiple Registers

Description

This function allows a number of registers from a meter table to be read in a single operation. This command is commonly used to obtain instantaneous, energy or set-up data from the meter. This command is not available as a broadcast command, as it requires a return data packet from the meter

Host Request

	BYTE	EXAMPLE
METER ADDRESS	1	19H
FUNCTION	2	04H
TABLE NUMBER (Address High Byte)	3	0BH
TABLE OFFSET (Address Low Byte)	4	00H
NO. OF WORDS (N) (High Byte)	5	00H
NO. OF WORDS (N) (Low Byte)	6	03H
CHECKSUM (High Byte)	7	B1H
CHECKSUM (Low Byte)	8	F7H

The example above shows a read of three consecutive Integers from the Instantaneous Data Table 11 (OBH), offset 0. The meter accessed has a Modbus ID of 25 (19H).

4.3.1 RS-422 Connection

It is recommended that screened 2 x twisted pair cable is used for RS-422 connection in order to minimize signal errors due to noise. An option fifth wire, connecting the common (0v) at each unit, is recommended for optimum performance. The first pair should be used for RXA and RXB and the second for TXA and TXB. The screen should be connected to the connector housing (ground) at the host only. To reduce cable reflections over long distances, RS-422 systems require line termination. This is achieved by fitting two 120Ω terminating resistors as shown in figure 4.5. One resistor should be fitted at the Host receive input buffer and the other at the receive buffer of the most remote meter.

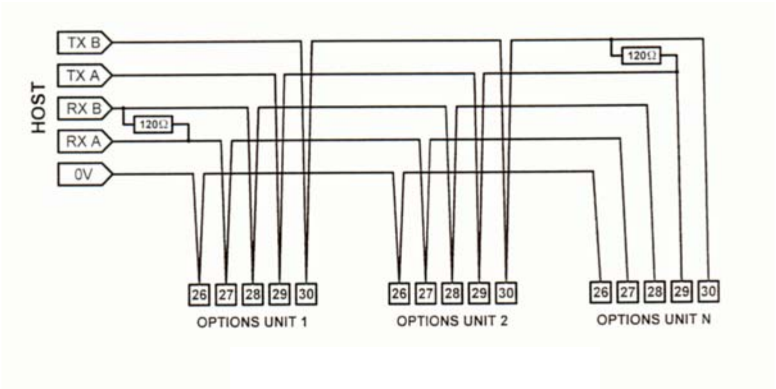

Figure 4.5. RS-422 Multi-Drop Connection

4.4 Modbus Protocol

4.4.1 An Introduction to Modbus

A communication protocol defines a set of commands and data formats that will be recognized by all compatible equipment connected on a system. The protocol effectively forms a communication language.

The GIMA Options Units utilize a subset of Modicon's Modbus standard protocol. This protocol was originally developed for use by programmable logic controllers (PLCs). It defines a set of commands for reading and/or writing data to devices connected on the bus.

Modbus is a master-slave protocol with all transaction initiated by a single host (e.g. a PC). A single transaction commences with the host transmission of a command packet followed by a slave (Options Unit) replay after a short delay for processing the command.

Command packets consist of an address, a command identifier, data and a checksum for error detection. Each slave device continually monitors the bus looking for activity. Command packets are detected by all slaves, but may be acted upon only by the device whose address matches that transmitted.

The host may transmit a **broadcast command**, which uses address '0' to contact all devices on the network. In this instance, all slaves act on the command, but none of them may reply. This type of command may be useful, for example, in synchronizing energy register reset on all meters.

The full Modbus protocol consists of many commands and modes of operation to suit a variety of controllers and applications. The GIMA Options Module utilizes only a few commands and a single transmission mode to perform many functions relevant to metering.

4.4.2 Remote Terminal Unit Transmission Mode

The RTU mode is utilized by the GIMA Options Module because it provides the most efficient throughput of data at any particular baud rate.

In RTU mode, the start and end of each message is marked by a silent period of at least 3.5 character periods (approximately 3.5ms @ 9600 baud). This is shown in the RTU message from in figure 4.6

START	ADDRESS	FUNCTION	DATA	CRC	END
SILENT PERIOD	8 BITS	8 BITS	n x 8 BITS	16 BITS	SILENT PERIOD

Figure 4.6. RTU Framing

4.5.5.1 Meter Set-up Values

Information about the GIMA' configuration is available in Table 14 as unsigned integers.

- **CT Primary** (5A - 5000A) CT Primary is displayed during meter set-up
- **PT Primary** (60V - 50000V) PT Primary as displayed during meter set-up
- **Pulse 1 Rate** (1 - 256) No. of counts of kWh register per pulse (if fitted)
- **Pulse 2 Rate** (1-256) No. of counts of kvarh register per pulse (if fitted)
- **Baud Rate** (48, 96 or 192) RS-485/422 baud rates of 4800, 9600 or 19200
- **Modbus ID** (1 - 247) Modbus meter address
- **Meter Model** A constant indentifying the product range (GIMA = 100)
- **Meter Type** (1 - 4) Refer to GIMA manual for details of meter types
- **Meter Software** Hexadecimal byte define GIMA software version (e.g. 0x0102 = Version 103)
- **V/I MD Period** Time periods (seconds/10) for current and voltage demand.

E.g. a value of six corresponds to a demand period of 60 seconds

4.5.6 Table 15 Peak Current and Voltage Demand

Offset	Address	Contents	Format	Bytes	Words	Access
0	3840	Peak I1 MD	Unsigned Int	2	1	Read/Write[5]
1	3841	Peak I2 MD	Unsigned Int	2	1	Read/Write[5]
2	3842	Peak I3 MD	Unsigned Int	2	1	Read/Write[5]
3	3843	Peak V1 MD	Unsigned Int	2	1	Read/Write[6]
4	3844	Peak V2 MD	Unsigned Int	2	1	Read/Write[6]
5	3845	Peak V3 MD	Unsigned Int	2	1	Read/Write[6]

Notes:
5. Use "Amps Scale" at Addr 2837 to convert to real Peak Amp Demand.
6. Use "Ph Volts Scale" at Addr 2838 to convert to real Peak Volts Demand.

The peak values of rolling demand averages of currents and voltages are available in Table 15 as unsigned integers.

4.5.4.2 Scaling Instantaneous/Peak Values

Instantaneous readings from the GIMA are provided as Signed Integer values with no decimal point or legend (e.g. kW or MW). Scaling factors are provided to enable conversion of the raw data to real numbers in basic unit form (amps, volts, watts, VA or var). These scaling factors are constant values calculated in the GIMA as a function of CT and PT Primary programming.

To convert raw data to real numbers:

$$R = I \times 10^{(K-3)}$$

Where **I** = Integer number
K = Relevant Scaling Factor
R = Real number result

Example:

If the meter is programmed with CT Primary = 50A and PT Primary = 415V:
The meter displays would be scaled as : 50.00A, 240.0V, 415.7VLL, 36.00kW.
Scaling factors would be as
I Scale = 1, Vph Scale = 2, VLL Scale = 2, P Scale = 4.
Integer Values would be transmitted as: 5000, 2400, 4157, and 3600.
Amps would be calculated as 5000 x $10^{(1-3)}$ = 5000/100 = 50.00A.
Phase Volts would be calculated as 2400 x $10^{(2-3)}$ = 2400/10 = 240.0V.
Line Volts would be calculated as 4157 x $10^{(2-3)}$ = 4157/10 = 415.7V.
3-Ph Power would be calculated as 3600 x $10^{(4-3)}$ = 3600 x 10 = 36000W.

4.5.5 Table 14 Meter Set-up

Offset	Address	Contents	Format	Bytes	Words	Access
0	3584	CT Primary	Unsigned Int	2	1	Read/Write[9]
1	3585	PT Primary	Unsigned Int	2	1	Read/Write[9]
2	3586	Pulse 1 Rate	Unsigned Int	2	1	Read/Write[9]
3	3587	Pulse 2 Rate	Unsigned Int	2	1	Read/Write[9]
4	3588	Baud Rate	Unsigned Int	2	1	Read/Write[9]
5	3589	Modbus ID	Unsigned Int	2	1	Read/Write[9]
6	3590	Meter Model	Unsigned Int	2	1	Read Only
7	3591	Meter Type	Unsigned Int	2	1	Read Only
8	3952	Meter Software	Unsigned Int	2	1	Read Only
9	3593	V/I MD Period	Unsigned Int	2	1	Read/Write[9]

Notes: 9. Values in Table 14 may not be written using Command 16.

The host initiates all transactions. Slave devices continuously monitor the network, looking for messages framed by silent periods. The first character detected, after a silent period, is assumed to be an address byte and is compared to the meter's internal address (zero for broadcasts). An addressed slave reads the remainder of the message and acts upon it as required.

A slave tests the message to determine its validity and uses the transmitted checksum (CRC) to detect communication errors. A slave will only act on valid messages, received without error, specifically addressed to it.

ADDRESS

Valid Modbus addresses are in the range 0-247. Individual devices may be assigned addresses in the range 1-247. Address 0 is retained for broadcast commands which are handled by all slaves. When a slave responds to a command, it places its own address in the replay message.

FUNCTION

The functions code is a single byte, telling the device what type of operation to perform. Valid Modbus codes are in the range 1-255 decimal, but the GIMA Options Module handles only a small subset of these as summarized below.

Function Code	Operation	Broadcast
03	Read Multiple Registers	No
04	Read Multiple Registers	No
06	Preset a Single Register	Yes
08	Loop Back Diagnostic	No
16	Preset Multiple Registers	Yes

Figure 4.7. Function Code Summary

DATA FIELD

Data from the host contains additional information for the remote device specific to the command. For example, the data field may specify which meter readings are required or new values for energy registers. Data from a slave may contain meter readings or other information requested by the host. The slave also uses the data field to send error codes.

The size of the data field varied depending on command type and usage. The data format may also vary from one command to another to suit the application. Instantaneous readings, for example, are transmitted as 2-byte Integers, whereas energy readings are formatted as 4-byte Long Integers. Data is always transmitted with the most significant byte first. Data formatting is described in more detail in the following sections.

4.4.3 Cyclic Redundancy Check

A 16-bit CRC field is tagged on to the end of all messages. This filed is the result of a CRC calculation performed on the message contents. The CRC field is used by the host and receiving devices alike to determine the validity of the entire message string. A receiving device recalculates the CRC and compares it to the value contained in the message. A slave device ignores a message if the two values do not match.

NOTE: Use of the CRC is essential when communication in noisy environments to reduce the effects of erroneous bit errors. The meter will not reply to commands with a CRC in error and the host should retransmit the command after a predetermined time-out period. If the host receives a string with a CRC in error, the transaction should be re-initiated.

The CRC is calculated no all bytes of a message from the address to the last data byte inclusively. Each bit of the message is processed through the CRC calculation starting with the first bit of the address. The Modbus standard method of CRC calculation requires reversal of the data bytes as they are fed serially through the bit processing routines. A simpler method involves swapping the low and high order bytes of the CRC integer at the end of the calculation. This is shown in the following routine.

1 Load a 16-bit register (CRC Register) with FFFF Hex. (all1's).
2 Exclusive-OR the first eight bits of the message with the low-order byte of the CRC register. Put the result in the CRC register.
3 Shift the CRC register one bit to the right (divide by two), filling the MSB with a zero.
4 If the bit shifted out in three is a one, Exclusive-OR the CRC register with the value A001 Hex.
5 Repeat steps 3 and 4 until eight shifts have been performed and the bits tested. A single byte has thus been processed.
6 Repeat steps 2 to 5 using the next eight-bit byte of the message until all bytes have been processed.
7 The final contents of the CRC register are tagged on to the end of the message with the most significant byte first.
8 Swap the low and high order bytes of the integer result.

4.5.3 Table 12 Additional Instantaneous Values

Offset	Address	Contents	Format	Bytes	Words	Access
0	3072	Phase 1 kVA	Signed Int	2	1	Read[4]
1	3073	Phase 2 kVA	Signed Int	2	1	Read[4]
2	3074	Phase 3 kVA	Signed Int	2	1	Read[4]
3	3075	Phase 1 kvar	Signed Int	2	1	Read[4]
4	3076	Phase 2 kvar	Signed Int	2	1	Read[4]
5	3077	Phase 3 kvar	Signed Int	2	1	Read[4]

Notes: 4. Use "Power Scale" at address 2840 to convert to real W, VA or var.

4.5.4 Table 13 Peak Values

Offset	Address	Contents	Format	Bytes	Words	Access
0	3328	PK Hold I1	Signed Int	2	1	Read/Write[5]
1	3329	PK Hold I2	Signed Int	2	1	Read/Write[5]
2	3330	PK Hold I3	Signed Int	2	1	Read/Write[5]
3	3331	PK Hold V1	Signed Int	2	1	Read/Write[6]
4	3332	PK Hold V2	Signed Int	2	1	Read/Write[6]
5	3333	PK Hold V3	Signed Int	2	1	Read/Write[6]
6	3334	Peak kW MD	Signed Int	2	1	Read/Write[7,8]
7	3335	MD Period	Signed Int	2	1	Read/Write[8]
8	3336	kW MD	Signed Int	2	1	Read Only

Notes:
5. Use "Amps Scale" at address 2837 to convert to real peak hold amps.
6. Use "Ph Volts Scale" at address 2838 to convert to real peak hold volts.
7. Use "Power Scale" at address 2840 to convert to real peak W MD.
8. Peak kW MD & MD Period may not be written using Command 16.

4.5.4.1 Instantaneous/Peak Values

Instantaneous and peak measurements available for display on a GIMA are stored in Modbus Table 11-13 as Signed Integers. Parameters not available on an individual meter are returned as zero. Negative values are used for per phase/system kvar and PF readings to represent capacitive loads. All other values will be returned as positive integers.

4.5.2 Table 11 Instantaneous Meter Values

Offset	Address	Contents	Format	Bytes	Words	Access
0	2816	kW 3-Ph	Signed Integer	2	1	Read Only[4]
1	2817	kVA 3-Ph	Signed Integer	2	1	Read Only[4]
2	2818	kvar 3-Ph	Signed Integer	2	1	Read Only[4]
3	2819	PF 3-Ph	Signed Integer	2	1	Read Only
4	2820	Frequency	Signed Integer	2	1	Read Only
5	2821	Phase 1 Volts	Signed Integer	2	1	Read Only[2]
6	2822	Phase 1 Amps	Signed Integer	2	1	Read Only[1]
7	2823	Phase 1 kW	Signed Integer	2	1	Read Only[4]
8	2824	Phase 2 Volts	Signed Integer	2	1	Read Only[2]
9	2825	Phase 2 Amps	Signed Integer	2	1	Read Only[1]
10	2826	Phase 2 kW	Signed Integer	2	1	Read Only[4]
11	2827	Phase 3 Volts	Signed Integer	2	1	Read Only[2]
12	2828	Phase 3 Amps	Signed Integer	2	1	Read Only[1]
13	2829	Phase 3 kW	Signed Integer	2	1	Read Only[4]
14	2830	Phase 1 PF	Signed Integer	2	1	Read Only
15	2831	Phase 2 PF	Signed Integer	2	1	Read Only
16	2832	Phase 3 PF	Signed Integer	2	1	Read Only
17	2833	Ph1-Ph2 Volts	Signed Integer	2	1	Read Only[3]
18	2834	Ph2-Ph3 Volts	Signed Integer	2	1	Read Only[3]
19	2835	Ph3-Ph1 Volts	Signed Integer	2	1	Read Only[3]
20	2836	Neutral Current	Signed Integer	2	1	Read Only[1]
21	2837	Amps Scale	Signed Integer	2	1	Read Only
22	2838	Ph Volts Scale	Signed Integer	2	1	Read Only
23	2839	Ln Volts Scale	Signed Integer	2	1	Read Only
24	2840	Power Scale	Signed Integer	2	1	Read Only

Notes:
1. Use “Amps Scale” at address 2837 to convert to real amps.
2. Use “Ph Volts Scale” at address 2838 to convert to real volts.
3. Use “Ln Volts Scale” at address 2839 to convert to real volts.
4. Use “Power Scale” at address 2840 to convert to real W, VA or var.

An implementation of the CRC calculation in C code is show below.

```
unsigned int check_sum(unsigned char *buff, char start, char bytes)
{
    Char byte_cnt,bit_cnt;     /* loop counters */
    unsigned int crc_reg;      /* Result register */
    unsigned int CRCHi, CRCLO;/*Low and high order bytes of the crc*/

    crc_reg = 0xFFFF;                /* Set the CRC register to all 1's */

    /* Repeat for each byte of sub string  */
    for(byte_cnt=start; byte_cnt<(bytes+start); byte_cnt++)
      {
      crc_reg = crc_reg ^ (Unsigned int)buff[byte_cnt]; /*EXOR CRC & Next Byte*/

      /* Test each bit of the CRC */
      for(bit_cnt=0; bit_cnt<8; bit_cnt++)
        {
        if(crc_reg & 0x0001)
          {
          crc_reg = crc_reg >>1;  /* IF LSB=1 EXOR CRC with A001H*/
          crc_reg = crc_reg ^ 0Xa001;     /* Then shift CRC toward LSB */
          }
        else crc_reg = crc_reg>>1;     /* ELSE Shift CRC towards LSB */
        }
      }
    CRCLo=crc_reg>>8; /*Swap the low and high order bytes of the crc result*/
    CRCHi=crc_reg<<8;
    crc_reg = CRCLo+CRCHi;
    return crc_reg;                     /*Final CRC register Result */
    }
```

4.5 Options Module Data Tables

Data in the GIMA Options Module is arranged in several tables for convenience. Individual tables contain like information. Table data may be read only (e.g. instantaneous readings) or read/write access (e.g. CT primary). Data in each table is pointed to in a Modbus command by two consecutive data address bytes. The first byte defines the table number and the second byte the offset of the data in the table. For example, ‘address 2,1’ would access Table 2, Entry 1 (3-phase kWh). The Modbus standard defines data addresses using a 16-bit integer. In the case of the GIMA Options Module, the high byte of this integer represents the table number and the low byte the offset. A Modbus integer address may be calculated as:

Modbus Data Address = (256 x Table No) + Table Offset

SIGNED INTEGER
Signed Integers are 16-bit values transmitted as two 8-bit bytes. The most significant byte is always transmitted first. These values vary in the range -32767 to +32767 although some registers have a limited range of acceptable values. The most significant bit defines the sign, zero indication positives.

UNSIGNED INTEGER
Unsigned Integers are 16-bit values transmitted as two 8-bit bytes. The most significant byte is always transmitted first. These values vary in the range 0 to 65535, although some registers have a limited range of acceptable values.

UNSIGNED LONG INTEGERS (Unsigned Long)
Unsigned long integers are 32-bit values transmitted as four 8-bit bytes. The most significant byte is always transmitted first. These values vary in the range 0 to 4294967295, although energy registers in the GIMA have a limited range: 0 to 999999.

4.5.1 Table 2 Accumulated Energy Readings

Offset	Address	Contents	Format	Bytes	Words	Access
0	512	Energy Scale Hi	Unsigned Long	4	2	Read Only
1	513	Energy Scale Lo				
2	514	kWh Hi	Unsigned Long	4	2	Read/Write
3	515	kWh Lo				
4	516	kVAh Hi	Unsigned Long	4	2	Read/Write
5	517	kVAh Lo				
6	518	kvarh (Ind) Hi	Unsigned Long	4	2	Read/Write
7	519	kvarh (Ind) Lo				
8	520	kvarh (Cap) Hi	Unsigned Long	4	2	Read/Write
9	521	Kvarh (Cap) Lo				

4.5.1.1 Energy Registers
Energy registers available for display on a GIMA are stored in Modbus Table 2 as unsigned long integers. Registers not available on an individual meter are returned as zero.

4.5.1.2 Writing to Energy Registers
Function 6 or 16 may be used to write to the energy registers in Table 2. Function 6 allows access to the upper and lower integers of the 4-byte long individually. Upper integers have a maximum write value of 0x00F, preventing out-of-range data from being sent to the GIMA.

Function 16 may be used to access a number of long integers using a single command. This is most useful for setting all registers to 0 simultaneously. Valid commands must send an even number of integers (2 integers per long) starting at an even address in Table 2 (start of a register). Failure to follow these basic rules will result in an exception response (ref. section 4.5.12).

4.5.1.3 Energy Scaling
Energy readings from the GIMA are stored as unsigned long integer values with no decimal point of legends (e.g. kWh or MWh). A single scaling factor is provided to enable conversion of the raw data to real numbers in basic unit form (Wh, Vah or varh). The scaling factor is a constant value calculated in the GIMA as a function of CT and PT Primary programming. To convert raw data to real numbers:

$$E = L \times 10^{(K-3)}$$

Where:
L = Long Integer number
K = Energy Scaling Factor
E = Scaled Energy Result

Example:
If the meter is programmed with CT Primary = 50A, and PT Primary = 415V, the meter displays would be 99999.9 kWh, 99999.9 kVAh and 99999.9 kvarh. The Energy Scaling Factor would be transmitted as 999999.
Wh would be calculated at $999999 \times 10^{(5-3)} = 999999 \times 100 = 99999900$Wh
VAh would be calculated at $999999 \times 10^{(5-3)} = 999999 \times 100 = 99999900$VAh
varh would be calculated at $999999 \times 10^{(5-3)} = 999999 \times 100 = 99999900$varh