Modbus Protocol

Analog Input Series 2 Laureate
Digital Panel Meters & Transmitters

Now with Ethernet

Intertek
4006497

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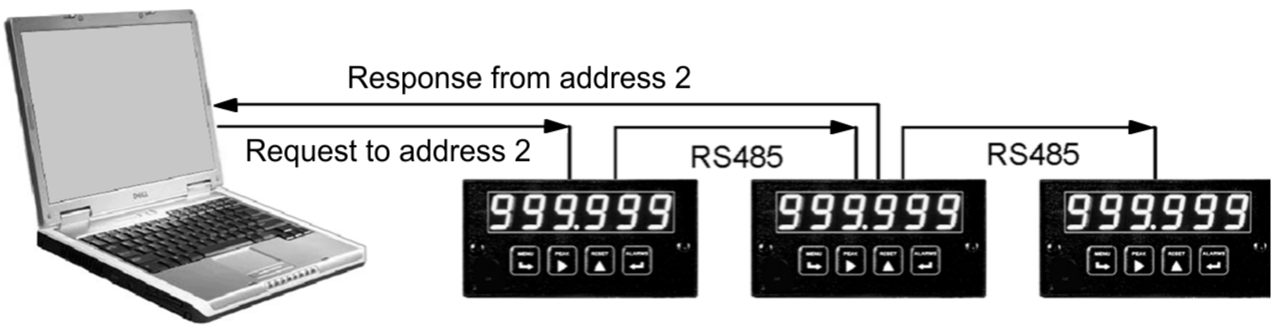
1. TABLE OF CONTENTS

2. MODBUS CONNECTION EXAMLES

1. MASTER-SLAVE ARCHITECTURE

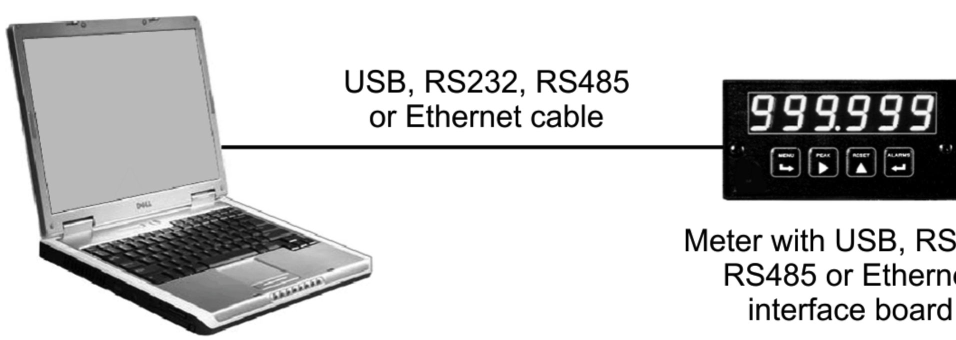
The Modbus protocol was first published by Modicon in 1979 and is now a well-established international standard. For technical details, please see Modbus over Serial Line Specification V1.0 (2002).



Master: PC, PLC or PAC

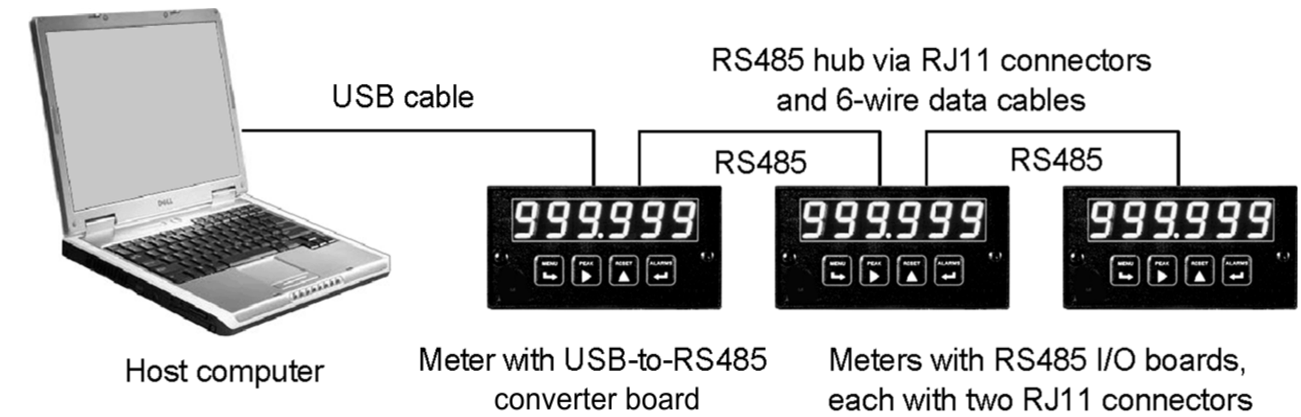
Modbus is a simple, yet flexible, request-response protocol with a master-slave architecture. The master is typically a PC, PLC or PAC, which sends out requests or commands over a serial bus or an Ethernet network and waits for a response from an addressed slave. A slave can be one of our digital panel meters, counters, timers or transmitters, or it can be an instrument from another manufacturer. Each slave needs to have an address from 1 to 247. If an addressed slave does not respond within a specified timeout, an error code is generated. There can only be up to 31 instruments on an RS485 bus for voltage loading reasons.

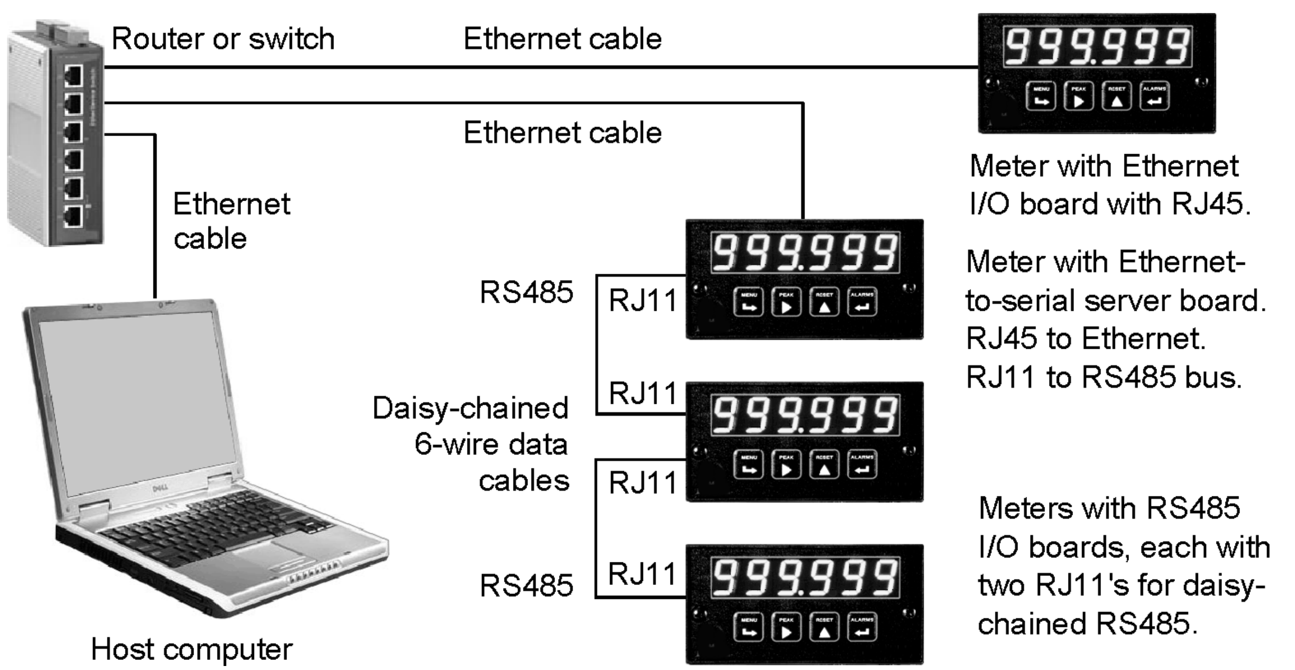
2. CONNECTION EXAMPLES

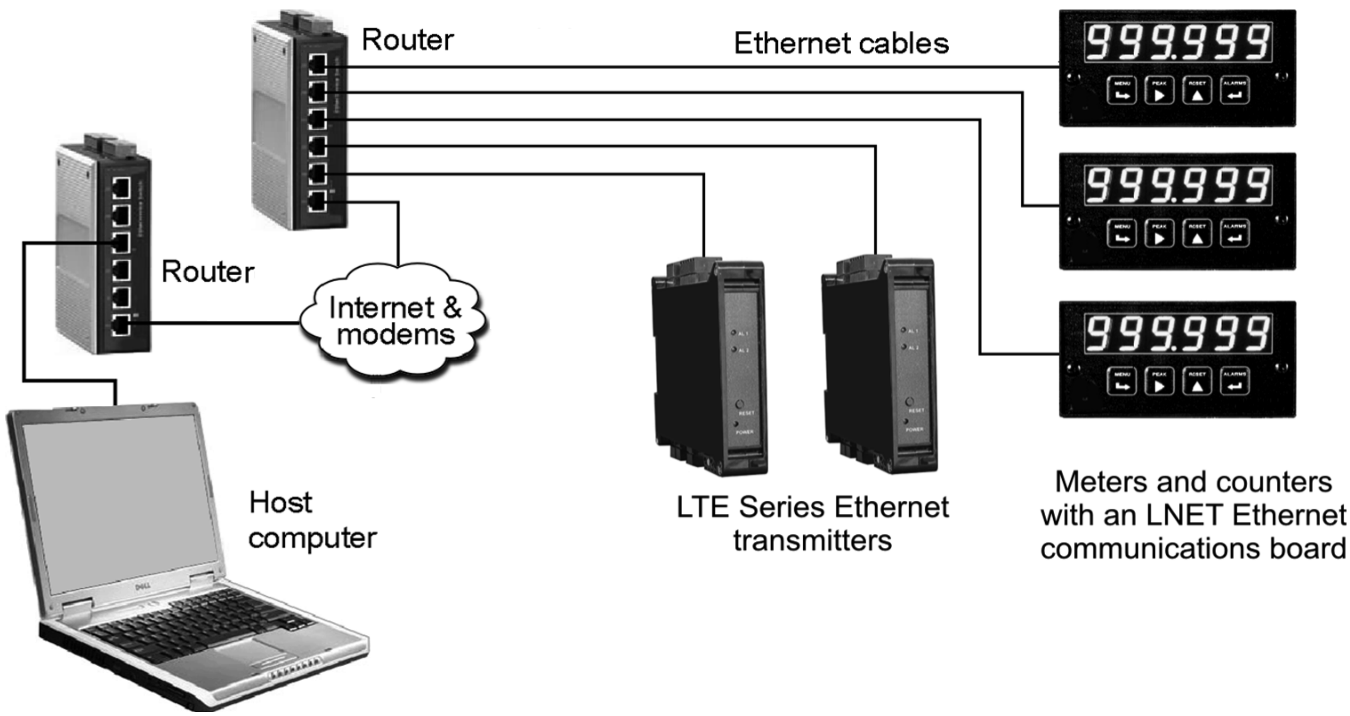


Meter with USB, RS232, RS485 or Ethernet interface board

Host computer


USB cable
RS485 hub via RJ11 connectors
and 6-wire data cables
RS485
RS485
999.999
999.999
999.999
Host computer
Meter with USB-to-RS485
converter board
Meters with RS485 I/O boards,
each with two RJ11 connectors


Router or switch
Ethernet cable
Ethernet cable
Ethernet
cable
999.999
Meter with Ethernet
I/O board with RJ45.
RS485
RJ11
RJ11
Daisy-chained
6-wire data
cables
RJ11
RJ11
RS485
Meter with Ethernet-
to-serial server board.
RJ45 to Ethernet.
RJ11 to RS485 bus.
Meters with RS485
I/O boards, each with
two RJ11's for daisy-
chained RS485.
Host computer



Router
Ethernet cables
999.999
999.999
999.999
Router
Internet &
modems
Host
computer
LTE Series Ethernet
transmitters
Meters and counters
with an LNET Ethernet
communications board

3. MODBUS PROTOCOL IMPLEMENTATION

1. OVERVIEW

This DPM Modbus manual covers our 1/8 DIN size panel-mount analog input Laureate digital panel meters and their transmitter counterparts, plus our scale meter, which is a digital panel meter with firmware additions for weighing applications. A separate Modbus manual covers our pulse input counter instruments.

The Modbus protocol is selectable with all of our communications options: Ethernet, WiFi, USB, RS485 and RS232. It is compliant with Modbus RTU or ASCII transmission modes (software selectable), as specified in Modbus over Serial Line Specification V1.0 (2002).

The Modbus protocol is embedded as a standard feature in the microcomputer firmware of Laureate meters and transmitters along with the Custom ASCII Protocol, which is a simpler text string based protocol. Laureate DIN-rail transmitters come standard with either RS232/ RS485 communications (LT series) or Ethernet communications (LTE series). Laureate 1/8 DIN size panel meters and counters require a plug-in option board for communications.

2. METER COMMUNICATION BOARDS

As of the date of this manual, available plug-in communication boards were the following:

- RS232 board (P/N L232, ordering option 1).
- RS485 board for RS485 with dual RJ11 jacks (P/N L485, ordering option 2).
- RS485 board for RS485 with dual RJ45 jacks (P/N LMOD, ordering option 4).
- USB board (P/N LUSB, ordering option 5).
- USB-to-RS485 converter board (P/N LUSB485, ordering option 6).
- Ethernet board (P/N LNET, ordering option 7).
- Ethernet-to-RS485 converter board (P/N LNET485, ordering option 8).

Our two RS485 boards (ordering options 2 and 4) use the same circuit, and both support the Modbus protocol equally. Option 2 boards with dual RJ11 jacks can be daisy-chained using our CBL03, straight-through, 6-wire data cables (not 4-wire telephone cables or crossover cables). Option 4 boards with dual RJ45 jacks cannot be daisy-chained using CBL03. With either board, the two jacks are wired in parallel to allow daisy chaining with no need for a hub.

Our USB-to-RS485 converter board allows the host meter to function as a normal meter, to be connected to a PC USB port, and also to be connected to an RS485 network with up to 31 remote meters or counters. These need to be equipped with an RS485 board with dual RJ11 connectors for daisy chaining with 6-wire CBL03 data cables.

Our Ethernet-to-RS485 converter board allows the host meter to function as a normal meter, to be connected to PC Ethernet port or an Ethernet LAN, and also to be connected to an RS485 network with up to 31 remote meters or counters. These need to be equipped with an RS485 board with dual RJ11 connectors for daisy chaining with 6-wire CBL03 data cables.

3. SERIAL COMMUNICATIONS

For serial communications (RS232, RS485 USB) to work between a sending device and receiving device, the right pins have to be connected, jumpers may have to be set, the right PC Com port has to be chosen, and the following serial parameters have to be set: baud rate, start bits, stop bits, parity. Please refer to the appropriate instrument user manuals on how to make these settings. Our Instrument Setup Software is good tool to set up and verify serial communications. Also, the address of each Slave instrument has to be set for Modbus to work.

4. ETHERNET COMMUNICATIONS

The Modbus RTU Protocol is seamlessly converted to Modbus TCP by the Ethernet Nodes in our Ethernet meters and transmitters.

Ethernet Nodes can be an LNET Ethernet board inside a meter or counter, or be the Ethernet portion of an LTE transmitter. An Ethernet Node is normally associated with one device, namely the host meter or transmitter, but it can also be associated with up to 31 remote meters or transmitters on an RS485 bus.

Our Ethernet Nodes can be connected directly to a PC via an Ethernet cable, be connected to a local PC via a LAN to which the PC is also connected, or be connected to a remote PC via the Internet. For connection via the Internet, the PC can be plugged into a local LAN, and the remote instruments can be plugged into a remote LAN. Our Ethernet Nodes and any devices attached to them via an RS485 bus will automatically be discovered by our Instrument Setup Software or Node Manager Software when the IP address of the remote router is entered, or when the IP address of any node on the remote network is entered.

Instrument Setup Software or Node Manager Software running on the host PC will automatically discover our Nodes and the device (or devices) associated with each Node. Following discovery, Instrument Setup Software can be used to set up each device (or devices) associated with a Node, for example to scale a meter or transmitter, and set setpoints. Node Manager Software cannot be used to set up devices, but it offers advanced features like sending out emails or text messages periodically or in the event of an alarm.

Our Ethernet Nodes can also be discovered and configured by using the Web Server built into each Node. To do so, use a web browser like Internet Explorer and enter the public IP address of the router or the IP address of any Node in the network.

5. MODBUS TYPES

Three Modbus protocol versions are supported by our instruments:

- **Modbus RTU**

This is the modern and most popular Modbus version for RS232, RS485 or USB serial communications. Here message frames (or packets) are transmitted in binary format (1’s and 0’s) for highest speed. Message frames are separated by a silent interval of at least 3.5 character times. If a silent interval of more than 1.5 character times occurs between two characters of a frame, the frame is considered incomplete and is discarded. The accuracy of each frame is verified by a 16-bit cyclic redundancy check (CRC).

- **Modbus ASCII**

  This is an older and now seldom used Modbus version for RS232, RS485 or USB serial communications. Here message frames are encoded into two ASCII characters 0-9, A-F, per byte to represent the hexadecimal notation of the byte. Each message begins with a colon (:) and ends with a Carriage Return / Line Feed (CRLF). The allowable time interval between characters can be set to as long as 1, 3, 5 or 10 seconds. The accuracy of each frame is verified by a 1-byte longitudinal redundancy check (LRC).

- **Modbus TCP**

  Also called Modbus TCP/IP, this is the Ethernet version of Modbus RTU. It simply embeds a standard Modbus RTU frame into a TCP frame, and the CRC redundancy check is now provided by standard Ethernet TCP/IP checksum methods. Since the frame contents are the same for Modbus RTU and Modbus TCP, this Modbus manual applies equally to both.

6. COMMUNICATION PARAMETERS

Do not use data rates above 9600 baud, even though 19200 baud is selectable.

Modbus RTU

Baud Rate ....300, 600, 1200, 2400, 4800, 9600, ~~19200~~
Data Format ....1 start bit, 8 data bits, 1 parity bit, 1 stop bit (11 bits total)
Parity ....None, Odd, Even (if None, then 2 Stop bits for 11 total)
Address..0 for broadcast, 1-247 for individual meters

Modbus ASCII

Baud Rate ....300, 600, 1200, 2400, 4800, 9600, ~~19200~~
Data Format .... 1 Start bit, 7 Data bits, 1 Parity bit, 1 Stop bit (10 bits total)
Parity ....None, Odd, Even (if None, then 2 Stop bits for 10 total)
Address..0 for broadcast, 1-247 for individual meters

7. PARAMETERS SELECTABLE VIA INSTRUMENT SETUP (IS) SOFTWARE

Serial Protocol ....Custom ASCII, Modbus RTU, Modbus ASCII
Modbus ASCII Gap Timeout .... 1 sec, 3 sec, 5 sec, 10 sec
Baud Rate ....300, 600, 1200, 2400, 4800, 9600, ~~19200~~
Parity ....No parity, 2 stop bits; odd parity,1 stop bit; even parity, 1 stop bit
Device Address ....1 to 247

8. MESSAGE FRAME CONTENT OVERVIEW

The content of each request or response includes the following:

- Device Address
- Function Code (FC)
- Register Address
- Data
- Checksum (applicable to Modbus RTU and ASCII, not TCP)

Device Address is the slave ID number. This is a decimal number from 1 to 247. Note that only up to 31 devices can be multi-dropped on an RS485 line for voltage loading reasons.

Register is a memory location for a 16-bit value, which can be read or written. Each Register has a Register Address specified as a 16-bit hexadecimal number. Our Registers are either Holding Registers in non-volatile EEPROM for setup information like scale, offset, setpoints, etc., or Input Registers in volatile RAM for measurement values or alarm status.

Coil is a memory location with a 1-bit 0 or 1 value, which can be read or written. The Modbus specification defines coils for input (sense) or output (write/force). Our Modbus coils only allow output. Each Coil is characterized by a Coil Address.

Function Code (FC) is a two-digit hexadecimal number which tells the addressed slave the type of action to perform on a Modbus register. Five function codes are recognized by our devices:

- **FC03: Read Holding Register.** A Holding Register is a read/write register, which contains setup information like scale, offset, setpoints, etc. in the form of a 16-bit value. Data is returned in hexadecimal format. Reading a Holding Register causes a meter reset.
- **FC04: Read Input Register.** An Input Register is a read-only register, which contains a 16-bit measurement value or alarm status. Data is returned in hexadecimal format. Reading an Input Register does not cause a meter reset.
- **FC05: Write/Force Single Coil.** A Single Coil is a register whose value can be a 1 or a 0. Writing a Single Coil can command a specific action, like taring a meter. For historical reasons, the word "coil" refers to a relay coil, which can be energized or de-energized on command. Writing a Single Coil does not cause a meter reset.
- **FC08: Diagnostics.** Checks communication between master and slave.
- **FC10: Write/Preset Multiple Holding Registers.** This action is used to enter setup information like scale, offset, setpoints, etc. into Holding Registers. This action causes a meter reset.

9. HI WORD & LO WORD

Register values specified by Modbus are 16-bit numbers. Our requests require the address of the Hi Word and the number of registers, which is 02, to get both the Hi Word followed by the Lo Word. Depending on the Function Code, register values can have the following formats:

2C32: Two's Complement

Hi Word (Register)	Lo Word (Register)
CCCC CCCC CCCC CCCC	CCCC CCCC CCCC CCCC

M31: Sign + Binary Magnitude

Hi Word (Register)	Lo Word (Register)
SMMM MMMM MMMM MMMM	MMMM MMMM MMMM MMMM

B16

Hi Byte	Lo Byte
0000 0000	BBBB BBBB

The letters S, C, M and B are defined as follows:

S = Sign Bit (0 = Positive, 1 = Negative)
C = Bits of 2's Complement Binary Value
M = Bits of Positive Binary Magnitude
B = Bits of Configuration Data

- For Modbus RTU, each data character (2 hex characters) consists of 8 bits (or 1 byte).
- For Modbus ASCII, each data character (2 hex characters) consists of 1 byte for each hex character.

4. FUNCTION CODE DETAILS

FC04: Read Input Registers

Reads measurement value, alarm status, peak and valley. Returns values in M31 format without a decimal point for analog input meters, scale meters and transmitters. If required for verification purposes, the decimal point setting can be read from its Holding Register by using Function Code 03 at address 00 57.

Use only the Hi Word Starting Register Address, and set the number of Registers to be read to an even number to capture the Hi Word and Lo Word as a pair. Reading a single register will cause an error. The Register Addresses are used to program the Modbus master and are in Hex for Modbus numbering systems that start at 00 01 (Base 1). Subtract 1 from each Register Address for Modbus numbering systems that start at 0000 (Base 0). Reading an Input Register does not cause a meter reset.

Why Base 1? Some Master devices (e.g., Modicon) require that the desired Register Number (Base 1) and not the actual Register Address (Base 0) be entered. The Base 1 Register Number is 1 higher than the Base 0 Register Address. Most Modbus software on the market now uses Base 1, not Base 0. However, the bytes that are transmitted on the communication line are always for Base 0.

Digital panel meters with an analog input can only display and transmit one reading, which is called Item #1. Analog input transmitters can only transmit Item #1, not display it.

Register Address Base 1	Response (M31 format)
00 02	Hi Word of Alarm status
00 03	Lo Word of Alarm status
00 04	Hi Word of Measurement value (net value for scale meter)
00 05	Lo Word of Measurement value (net value for scale meter)
00 06	Hi Word of Peak value
00 07	Lo Word of Peak value
00 08	Hi Word of Valley value (gross value for scale meter)
00 09	Lo Word of Valley value (gross value for scale meter)
00 0A	N/A
00 0B	N/A
00 0C	N/A
00 0D	N/A

FC05: Write Single Coil:

Single-bit action command to device. Does not return a value. The command output value is hex 00 FF to set, or 00 00 to reset or deactivate. The Register Addresses below are in Hex and are for Modbus numbering systems that start at 00 01 (Base 1). Subtract 1 from each Register Address for Modbus numbering systems that start at 00 00 (Base 0). Writing a Single Coil does not cause a meter reset.

Please refer to our separate Digital Panel Meter Manual for an explanation of Meter Reset, Function Reset, Tare, Meter Hold, Blank Display, and External Inputs A & B. Or call our Tech Support. These same terms (except Blank Display) also apply to our transmitters.

Register Address Base 1	Output Value		Action Command
	To Set	To Reset	
00 02	FF 00	N/A	Meter Reset (No Response)
00 03	FF 00	N/A	Function Reset (Peak, Valley, latched alarms, total)
00 04	FF 00	N/A	Latched Alarm Reset (only)
00 05	FF 00	N/A	Peak Reset
00 06	FF 00	N/A	Valley Reset
00 07	FF 00	N/A	Remote Display Reset (Counters in Remote Display Mode)
00 08	FF 00	N/A	Display Item 1 (Meters, Counters, Timers)
00 09	FF 00	N/A	Display Item 2 (Counters, Timers)
00 0A	FF 00	N/A	Display Item 3 (Counters, Timers)
00 0B	FF 00	N/A	Display Peak (Meters, Counters, Timers)
00 0C	FF 00	N/A	Display Valley (Meters except Weight, Counters, Timers)
00 0D	FF 00	00 00	Tare (Meters)
00 0E	FF 00	00 00	Meter Hold (Meters)
00 0F	FF 00	00 00	Blank Display
00 10	FF 00	00 00	Activate External Input A
00 11	FF 00	00 00	Activate External Input B

FC08: Diagnostics

Checks communications between the Master and Slave, and returns the count in the Modbus Slave counters (which are reset when the meter is reset).

Hex Sub Function Code	Data Sent	Response Data	Description
00 00	Any	Same	Returns Query Data (N x 2 bytes). Echo Request.
00 01	 FF 00 00 00	 FF 00 00 00	Restarts Communications. If in the Listen-Only mode, no response occurs. Takes Slave out of the Listen-Only mode and one of the following: - Clears communications event counters. - Does not clear communications event counters.
00 04	00 00	None	Forces Listen-Only. All addressed and broadcast Messages are monitored and counters are incremented, but no action is taken or response is sent. Only Sub-Function 00 01 causes removal of this Listen-Only state.
00 0A	00 00	00 00	Clears all Modbus slave counters.
00 0B	00 00	Total Message Count	Returns total number of messages detected on the bus, including those not addressed to this Slave. Excludes bad LRC/CRC, parity error or length < 3.
00 0C	00 00	Checksum Error Count	Returns total number of messages with bad LRC/CRC, parity or length < 3 errors detected on the bus including those not addressed to the Slave.
00 0D	00 00	Exception Error Count	Returns total number of Exception responses returned by the Addressed Slave or that would have been returned if not a broadcast message or if the Slave was not in a Listen-Only mode.
00 0E	00 00	Slave Message Count	Returns total number of messages, either broadcast or addressed to the Slave. Excludes bad LRC/CRC, parity or length < 3 errors.
00 0F	00 00	No Response Count	Returns total number of messages, either broadcast or addressed to the Slave, for which Slave has returned No Response, neither a normal response nor an exception response. Excludes bad LRC/CRC, parity or length < 3 errors.
00 11	00 00	Slave Busy	Returns total number of Exception Code 6 (Slave Busy) responses.

SUPPORTED EXCEPTION RESPONSE CODES

Code	Name	Error Description
01	Illegal Function	Illegal Function Code for this Slave. Only hex Function Codes 03, 04, 05, 08, 10 are allowed.
02	Illegal Data Address	Illegal Register Address for this Slave or Register length.
03	Illegal Data Value	Illegal data value or data length for the Modbus protocol.
04	Slave Device Failure	Slave device failure (eg.,device set for external gate).

FC03 (READ) & FC10 (WRITE) HOLDING REGISTER ADDRESSES

Use Hi Word starting Holding Register Addresses and an even number of Registers. The Register Addresses below apply to both FC03 and FC10, and are for Modbus numbering systems that start at 00 01 (Base 1). Subtract 1 from each Register Address for Modbus numbering systems that start at 00 00 (Base 0).

Warning: Analog input meters and transmitters reset after any setup data in Holding Registers has been read or written.

Register Address		Holding Register Name	Data Type	Scaling & Dec Point
Dec	Hex			
2	00 02	Setpoint 1 (Hi word)	2C32	Dec pt same as displayed
3	00 03	Setpoint 1 (Lo word)		
4	00 04	Setpoint 2 (Hi word)	2C32	Dec pt same as displayed
5	00 05	Setpoint 2 (Lo word)		
6	00 06	Setpoint 3 (Hi word) (not for Scale Meter)	2C32	Dec pt same as displayed
7	00 07	Setpoint 3 (Lo word) (not for Scale Meter)		
8	00 08	Setpoint 4 (Hi word) (not for Scale Meter)	2C32	Dec pt same as displayed
9	00 09	Setpoint 4 (Lo word) (not for Scale Meter)		
10	00 0A	Scale (Hi word)	2C32	* See footnote
11	00 0B	Scale (Lo word)		
12	00 0C	Offset (Hi word)	2C32	Dec pt same as displayed
17	00 11	Offset (Lo word)		
18	00 12	Lo In (Hi word)	2C32	Uses dec pt of input range
19	00 13	Lo In (Lo word)		
20	00 14	Lo Rd (Hi word)	2C32	Dec pt same as displayed
21	00 15	Lo Rd (Lo word)		
22	00 16	Hi In (Hi word)	2C32	Uses dec pt of input range
23	00 17	Hi In (Lo word)		
24	00 18	Hi Rd (Hi word)	2C32	Dec pt same as displayed
25	00 19	Hi Rd (Lo word)		
26	00 1A	Rd0 (Hi word) (tare for Scale Meter)	2C32	Dec pt same as displayed
33	00 21	Rd0 (Lo word) (tare for Scale Meter)		
34	00 22	Deviation 1 (Hi word) (SP1DIFF for Sc M)	2C32	Dec pt same as displayed
35	00 23	Deviation 1 (Lo word) (SP1DIFF for Sc M)		
36	00 24	Deviation 2 (Hi word) (SP2DIFF for Sc M)	2C32	Dec pt same as displayed
37	00 25	Deviation 2 (Lo word) (SP2DIFF for Sc M)		
38	00 26	Deviation 3 (Hi word) (not for Scale Meter)	2C32	Dec pt same as displayed
39	00 27	Deviation 3 (Lo word) (not for Scale Meter)		
40	00 28	Deviation 4 (Hi word) (not for Scale Meter)	2C32	Dec pt same as

41	00 29	Deviation 4 (Lo word) (not for Scale Meter)		displayed
42	002A	Analog Lo (Hi word)	2C32	Dec pt same as displayed
43	002B	Analog Lo (Lo word)		
44	002C	Analog Hi (Hi word)	2C32	Dec pt same as displayed
45	002D	Analog Hi (Lo word)		

* Scale = .0001 x dec value of (Hi word + Lo word)

Data Type B16

For the following, use any starting Register Address and any number of Registers.

Please refer to our separate Digital Panel Meter Manual for an explanation of the functions referred to in the table below, or call our Tech Support. These same functions also apply to our transmitters.

Register Address		Register Name	Bit Significance
Dec	Hex		
66	00 42	Alarm Config 1	Bit 0 0 = AL1 Hi Active 1 = Lo Active Bit 1 0 = AL1 Enabled, 1 = Disabled Bit 2 0 = AL2 Hi Active 1 = Lo Active Bit 3 0 = AL2 Enabled 1 = Disabled Bit 4 0 = AL1 Non-Latched 1 = Latched Bit 5 0 = AL2 Non-Latched 1 = Latched Bit 6 0 = Relay1 Active On 1 = Off Bit 7 0 = Relay2 Active On 1 = Off

67	00 43	Alarm Config 2	Bits 2:0 # Readings before Alarms 1 & 2.
			000 = 1, 001 = 2, 010 = 4, 011 = 8, 100 = 16,
			101 = 32, 110 = 64, 111 = 128
			Bit 3 AL1 0 = Deviation 1 = Hysteresis
			Bit 4 AL2 0 = Deviation 1 = Hysteresis
			Bit 5 0 = Deviation in Menu 1 = Omitted

68	00 44	Alarm Config 3 (not applicable to Scale Meter)	Bit 0 0 = AL3 Hi Active 1 = Lo Active Bit 1 0 = AL3 Enabled 1 = Disabled Bit 2 0 = AL4 Hi Active 1 = Lo Active Bit 3 0 = AL4 Enabled 1 = Disabled Bit 4 0 = AL3 Non-Latched 1 = Latched Bit 5 0 = AL4 Non-Latched 1 = Latched Bit 6 0 = Relay3 Active On 1 = Off Bit 7 0 = Relay4 Active On 1 = Off

69	00 45	Alarm Config 4 (not applicable to Scale Meter)	Bits 2:0 = # Readings before Alarm 3 & 4
			000 = 1, 001 = 2, 010 = 4, 011 = 8, 100 = 16,
			101 = 32 110 = 64 111 = 128
			Bit 3 AL3 0 = Deviation 1 = Hysteresis
			Bit 4 AL4 0 = Deviation 1 = Hysteresis

			Bit 5 0 = Deviation in Menu 1 = Omitted
70	00 46	Input Type	Lo Byte Hex value 40-4D Thermocouple JF, C, KF, KC, NF, NC, EF, EC, TF, TC, SF, SC, RF, RC 50-5C RTD pre-2009: 4-wire DIN°F, 4-wire DIN°C, 4-wire ANSI°F, 4-wire°C, 3-wire DIN°F, 3-wire DIN°C, 3-wire ANSI°F, 3-wire ANSI°C, 2-wire DIN°F, 2-wire DIN°C, 2-wire ANSI°F, 2-wire ANSI°C, Short 50-57 RTD post-2009: DIN°F, DIN°C, ANSI°F, ANSI°C, Ni°F, Ni°C, Cu°F, Cu°C, 60-64 DC 0.2V, 2V, 20V, 200V, 660V 70-73 DC 2 mA, 20 mA, 200 mA, 5A A0-A2 Ratio 0.2V, 2V, 20V 80-84 RMS 0.2V, 2V, 20V, 200V, 660V 90-93 RMS 2 mA, 20 mA, 200 mA, 5A C0-C4 Strain 20, 50, 100, 250, 500 mV D0-D4 Load Cell 20, 50, 100, 250, 500 mV E0-E4 Ohms 20, 200, 2000, 20K, 200K
71	00 47	Setup (applicable to DPM) M = Meter F = Function D = Display	Bits 3:0 Ctrl In 1 Ctrl In 2 Both Reset Hex 0 M Reset M Hold M Reset Hex 1 F Reset Pk, Vy M Reset Hex 2 M Hold Pk, Vy F Reset Hex 3 M Hold Tare M Reset Hex 4 Pk, Vy Tare FReset Hex 5 Tare M Reset M Reset Hex 6 DP2 DP3 DP5 Neither = DP1 Hex 7 DP3 DP4 DP6 Neither = DP2 Hex 8 F Reset D Blank M Reset Hex 9 M Hold D Blank M Reset Hex A Pk, Vy D Blank F Reset Hex B Tare D Blank M Reset Hex C Valley Peak F Reset Hex D Tare T Reset M Reset Bits 5:4 Hex 00 Scale using Scale, Offset Hex 01 Scale using Coordinates of 2 Points Hex 10 Scale using Reading Coordinates Bit 6 Spare Bit 7 0 = 60 Hz, 1 = 50 Hz

71	00 47	Setup (applicable to Scale Meter) M = Meter F = Function D = Display T = Tare	Bits 3:0 Ctrl In 1 Ctrl In 2 Both Reset Hex 0 M Reset M Hold M Reset Hex 1 F Reset Peak D M Reset Hex 2 M Hold Peak D F Reset Hex 3 M Hold Tare Tare Hex 4 Peak Tare F Reset Hex 5 M Reset Tare M Reset Hex 6 F Reset Tare M Reset Hex 7 T Reset Tare M Reset Hex 8 D Blank Tare M Reset Hex 9 M Reset D Blank M Reset Hex A F Reset D Blank M Reset Hex B D Item Tare Tare Hex C D Item D Blank F Reset Hex D M Reset D Item M Reset Hex E F Reset D Item M Reset Hex F M Hold D Item M Reset Bit 4 0 = Scale, Offset 1 = Coord of 2 Points Bit 5 0 = Peak key is Peak 1 = Peak key is Tare Bit 6 0 = 60 Hz 1 = 50 Hz Bit 7 0 = No dummy zero 1 = Dummy zero
72	00 48	Filter	Bits 3:0 Filtering Hex 0 = Auto Filter, 1 = Batch 16, 2-9 = Moving Avg, 2 = .08S, 3 = .15S, 4 = .3S, 5 = .6S, 6 = 1.2S, 7 = 2.4S, 8 = 4.8S, 9 = 9.6S, A = Unfiltered Bit 4 0 = Low Adaptive 1 = High Adaptive Bit 5 0 = Display Batch of 16 1 = Display Filtered Bit 6 0 = Peak of Unfiltered 1 = Peak of Filtered Bit 7 0 = Alarm source Unfiltered, 1 = Filtered
73	00 49	Options	Do Not Use.
74	00 4A	Serial Config 1	Bits 3:0 Time between Continuous Serial Outputs Hex 0=.017S, 1=.28S, 2=.57S, 3=1.1S, 4=2.3S, 5=4.5S, 6=9.1S, 7=18.1S, 8=36.3S, 9=1M13S, A=2M25S, B=4M50S, C=9M40S, D=19M20S, E=38M41S, F=77M21S Bits 6:4 Baud Rate 000 = 300, 001 = 600, 010 = 1200, 011 = 2400, 100 = 4800, 101 = 9600, 110 = ~~19200~~ Bit 7 0 = Send Unfiltered value, 1 = Send Filtered Val

75	00 4B	Serial Config 2	Bits 4:0 Meter Serial Address (0-31) [Non-Modbus] Hex 0 = Broadcast (01 = 1 to 0A = 10), 0F = 15, 10 = 16, 1F = 31 Bit 5 0 = Continuous Mode, 1 = Command Mode Bit 6 0 = No Alarm data with readings, 1 = Alarm data Bit 7 0 = No LF following CR, 1 = LF following CR
76	00 4C	Serial Config 3	Bits 2:0 for DPM. Data sent in serial output 0 = Reading, 1 = Peak, 2 = Valley, 3 = Rdg + Peak, 4 = Rdg + Valley, 5 = Rdg + Peak + Valley Bits 2:0 for Scale Meter 0 = Net + Gross 1 = Net only 2 = Gross only 3 = Peak only 4 = Net + Gross + Peak Bit 3 0 = Termination chars at end of all items 1 = " " at end of each item Bit 4 0 = Non-latching RTS, 1 = Latching RTS Bit 5 0 = Normal continuous serial transmission 1 = Special Start & Stop characters Bit 6 0 = Full Duplex 1 = Half Duplex
77	00 4D	Serial Config 4	Bits 1:0 00 = No Parity 01 = Odd Parity 10 = Even Parity Bits 3:2 00 = Custom ASCII 01 = Modbus RTU 10 = Modbus ASCII Bits 5:4 Modbus ASCII Gap Timeout 00 = 1S, 01 = 3S, 10 = 5S, 11 = 10S
78	00 4E	Config (applicable to DPM)	Bit 0 0 = Linear Curve 1 = Custom Curve Bit 1 0 = 2-wire RTD Read 1= 2-wire RTD Short Bits 2 0 = No Auto-tare 1 = Auto-tare Bits 4:3 Peak button display response 00 = Peak 01 = Valley 10 = Peak then Vall. 11 = Tare Bits 7:5 000 = Not Rate 001 = Rate x 0.1, 010 = Rate x 1 011 = Rate x 10, 100 = Rate x 100 101 = Rate x 1000 110 = Rate x 10000
78	00 4E	Config (applicable to Scale Meter)	Bit 1 0 = Peak of net value 1 = peak of gross value Bit 2 0 = Dribble enabled 1 = Dribble disabled Bit 3 0 = Scale & offset setup method 1 = Reading coordinates of 2 points method

79	00 4F	Lockout 1 (applicable to DPM)	0 = Enabled, 1 = Locked out Bit 0 Offset, Lo, Hi Rd Bit 1 Scale, Lo In, Hi In Bit 2 Filter Bit 3 Setup, Config, DP Bit 4 Input Type
79	00 4F	Lockout 1 (applicable to Scale Meter)	0 = Enabled, 1 = Locked out Bit 0 Count Bit 1 Setup, Config, DP Bit 2 Input Type Bit 3 Change Display Item# Bit 4 Tare Bit 5 Offset, Lo Rd, Hi Rd Bit 6 Scale, Lo, Hi In Bit 7 Filter
80	00 50	Lockout 2	Bit 0 Serial Comm Config Bit 1 Analog Out Scaling Bit 2 Alarm Setpoint Programming Bit 3 Alarm Config Bit 4 Front Panel Meter Reset Bit 5 Front Panel Function Reset Bit 6 View Setpoints Bit 7 View Peak
82	00 52	Setup 1 (not for Scale Meter)	Bits 1:0 00 = 4-1/2 Digits, 0.1 degree 01 = Slave Remote Display 10 = 4-1/2 Dig/10, 0.01 degree 11 = 3-1/2 Digits,1 degree
82	00 52	Count (applies to Scale Meter)	Bits 3:0 0 = No auto-zero band 1= 1-count zero band 2 = 2-count zero band 3 = 3-count zero band Etc. 9 = 9-count zero band Bits 6:4 0 = Count by 1 1 = Count by 2 2 = Count by 5 3 = Count by 10 4 = Count by 20 5 = Count by 50 6 = Count by 100
83	00 53	Analog Output Setup (applies to DPM)	Bit 0 0 = Source Unfiltered 1 = Filtered Bit 1 0 = Current Output 1 = Voltage Output Bits 2:1 00 = Current (0-20 mA) 10 = Curr. (4-20 mA) 01 = Voltage (0-10V) 11 = Voltage (±10V)
83	00 53	Analog Output Setup (applies to Scale Meter)	Bit 0 0 = Net Value 1 = Gross Value Bit 1 0 = Filtered 1 = Unfiltered Bits 3:2 00 = Current (0-20 mA) 10 = Curr. (4-20 mA) 01 = Voltage (0-10V) 11 = Voltage (±10V)
88	00 58	System Decimal Point	Bits 2:0 001 = ddddd. 010 = dddd.d 011 = ddd.dd 100 = dd.ddd 101 = d.dddd 110 = .ddddd
94	00 5E	Start Character	Bits 7:0 ASCII Hex Character
95	00 5F	Stop Character	Bits 7:0 ASCII Hex Character
96	00 60	Modbus Addr.	Bits 7:0 Hex value of Decimal Address from 1-255

READ ONLY (FC03) – Data Type B16

101	00 65	Analog Output DAC Type	Bits 7:0	0 = none, 1 = 1 output, unipolar (12-bit, pre 2009) 2 = 1 output, unipolar (16-bit, pre 2009) 3 = 1 output, uni or bipolar (16-bit, post 2009) 4 = 2 outputs, unipolar (16-bit, post 2009, not for Scale Meter)
102	00 66	Device Type	Bits 7:0	01 = DPM meter 02 = Scale meter 03 = Counter/timer met. 05 = DPM transmitter 06 = Scale transmitter 07 = Counter/timer transmitter
103	00 67	Revision	Bits 7:0	Hex value of Decimal Revision number
104	00 68	Overload Value	Bits 7:0	Hex overload value
105	00 69	Signal Conditioner Type	Bits 7:0	01 = DC, TC/RTD (pre 2009) 02 = RMS (pre 2009) 03 = Load Cell 22 = RMS (post 2009) 31 = TC (post 2009) 41 = RTD or Ohms (post 2009)

WRITE ONLY (FC10) – Data Type 2C32

106	00 6A	Display Data (Hi Word)	Hi word of Remote Data to be displayed.
107	00 6B	Display Data (Lo Word)	Lo word of Remote Data to be displayed.

5. MESSAGE FORMATTING OVERVIEW

MA = Meter Address
FC = Function Code
RA = Register Address
NR = Number of Registers
NB = Number of bytes

DD = Data (Hex)
WW = Data (On/Off)
SF = Sub-Function
EC = Error Code
LRC = ASCII Checksum

CL = CRC Lo Byte
CH = CRC Hi Byte
CR = Carriage Return
LF = Line Feed

For more information, see the Examples later in this manual.

Modbus RTU Format

FC	Action	> 3.5 Char	Byte Number										
			1	2	3	4	5	6	7	8	9	10	11
03	Request	NoTx	MA	FC	RA	RA	NR	NR	CL	CH			
03	Response	NoTx	MA	FC	NB	DD*	DD*	CL	CH				
04	Request	NoTx	MA	FC	RA	RA	NR	NR	CL	CH			
04	Response	NoTx	MA	FC	NB	DD*	DD*	CL	CH				
05	Request	NoTx	MA	FC	RA	RA	WW	WW	CL	CH			
05	Response	NoTx	MA	FC	RA	RA	WW	WW	CL	CH			
08	Request	NoTx	MA	FC	SF	SF	WW	WW	CL	CH			
08	Response	NoTx	MA	FC	SF	SF	DD	DD	CL	CH			
10	Request	NoTx	MA	FC	RA	RA	NR	NR	NB	DD*	DD*	CL	CH
10	Response	NoTx	MA	FC	RA	RA	NR	NR	CL	CH			
Exception Response		NoTx	MA	FC +80	EC	CL	CH						

DD* = (DD DD) times NR (Number of Registers)

Modbus ASCII Format

Except for the colon, CR and LF, each column is 2 hex character bytes.
DD* = (DD DD) times NR (Number of Registers)

FC	Action	Column Number												
		1	2	3	4	5	6	7	8	9	10	11	12	13
03	Request	:	MA	FC	RA	RA	NR	NR	LRC	CR	LF			
03	Response	:	MA	FC	NB	DD*	DD*	LRC	CR	LF				
04	Request	:	MA	FC	RA	RA	NR	NR	LRC	CR	LF			
04	Response	:	MA	FC	NB	DD*	DD*	LRC	CR	LF				

05 05	Request Response	: :	MA MA	FC FC	RA RA	RA RA	WW WW	WW WW	LRC LRC	CR CR	LF LF			
08 08	Request Response	: :	MA MA	FC FC	SF SF	SF SF	WW DD*	WW DD*	LRC LRC	CR CR	LF LF			
10 10	Request Response	: :	MA MA	FC FC	RA RA	RA RA	NR NR	NR NR	NB LRC	DD* CR	DD* LF	LRC	CR	LF
Exception Response		:	MA	FC +80	EC	LRC	CR	LF						

6. SETTING YOUR INSTRUMENT TO MODBUS

1. SETTING TO MODBUS FROM THE METER FRONT PANEL

Digital panel meters with an RS232, RS485 or USB interface are shipped from the factory set to the Custom ASCII protocol and 9600 baud, no parity, 8 data bits, one stop bit. They can be set to the Modbus protocol from the front panel. They can also be reset to the Custom ASCII protocol from the front panel after they have been set to Modbus.

Press the front panel menu key repeatedly until you reach SEr_1, SEr_4 and then Addr, and make the appropriate selections. Please our Digital Panel Meter manual for all available front panel programmable features. The baud rate is set in SEr_1. The selection of Modbus RTU or Modbus ASCII in SEr_4 overrides any LF or Command Mode selections that may have been made from the front panel, since they are determined by the Modbus protocol.

MENU *Press Menu Select Key*	PEAK *Press Digit Select Key*	RESET *Press Value Select Key*
SEr 1 Fixed Parameters: No parity 8 data bits 1 stop bit	000 Output filtering	0 Send unfiltered signal 1 Send filtered signal
	000 Baud rate	0 300 baud 1 600 baud 2 1200 baud 3 2400 baud 4 4800 baud 5 9600 baud 6 19200 baud (do not use)
SEr 4 Serial Setup 4.	000 Modbus ASCII gap timeout	0 1 sec 1 3 sec 2 5 sec 3 10 sec
	000 Serial protocol	0 Custom ASCII 1 Modbus RTU 2 Modbus ASCII
	000 Parity	0 None, 2 or more stop bits 1 Odd, 1 or more stop bits 2 Even, 1 or more stop bits
Addr Modbus Address. Appears only if the Modbus protocol is selected.	000 000 000 Select digit to flash.	**247** Select 0 through 9 for flashing digit. Address range is 1 to 247.

2. SETTING TO MODBUS WITH INSTRUMENT SETUP SOFTWARE

Our transmitters, which don't have front panel buttons, can only be set to Modbus with our free Windows-based Instrument Setup (IS) software. Digital panel meters with a communications board can also be set to Modbus with IS software, as explained below.

IS software allows uploading, editing, downloading and saving of setup data, execution of commands under computer control, listing, plotting and graphing of data, and computer prompted calibration. It is also a great too verify that communications are working.

As the first step to install IS software, set User Account Control (UAC) of your version of Windows to "Never notify" so that the installation can create directories. Use Google for instructions on how to change UAC. Power down and restart your computer for the UAC change to take effect. Following installation, you may return UAC to its previous setting.

Download the file *IS3_5_4.exe* from our website, double-click on that file name to extract three files, double-click *on setup.exe*, and follow the prompts.

To launch IS software from Windows, press *Start* => *Programs* => *IS2* => *IS2*. Or click on the Windows shortcut that you may have created. Establish communications by selecting matching settings between the instrument and PC, and click on *Establish*.

Factory default communication settings are 9600 baud, Custom ASCII Protocol, no parity, 8 data bits, and 1 stop bit. You will be prompted to select a Com port. Try different selections until one works, or use *Windows Control Panel* => *Device Manager* => *Ports (COM & LPT)* => *Advanced* to assign an available Com port number to the detected meter. Once communications have been established, click on *Main Menu*.

The best way to learn IS software is to experiment with it. From the Main Menu, click on *Get Setup* to upload (or get) the existing setup data from your device. Click on *View* = > *Setup* to bring up screens which allow you to edit the setup file using pull-down menus and other selection tools. You can save your file to disk by clicking on *File* = > *Save Setup*. You can download (or put) your edited file into the device by clicking on *Put Setup*. Programmable items will only be displayed if the appropriate hardware has been detected, such as the dual relay option for meters. Pressing the *F1* key at any time will bring up detailed help information.

Once you are communication with your device using IS software, click on the *Communication* tab. In the resulting screen, select Modbus RTU, no Parity, 8 data bits, and 2 stop bits, as well as your device's desired Modbus Address, such as 1. Note the instructions on the screen on how to set up communication parameters of the Modbus Master. When done, return to the Main Menu and execute a *Put Setup* to download your setup information from the PC into your device. From that moment on, your device is a Modbus Slave.

You can use IS software for instrument setup, such as scaling and setting alarm setpoints, after your instrument has been set to a specific protocol (Modbus RTU, Modbus ASCII or Custom ASCII).

2. RESETTING TO FACTORY DEFAULT COMMUNICATIONS

If you need to your instrument to factor default communications, which include the Custom ASCII Protocol, you can do so outside of IS software. If your instrument is a meter, you can do so from the front panel, as documented in the previous manual section. If your instrument is a transmitter, place jumper E1, apply power, remove power, remove the jumper, and reapply power, as documented in the section “Main Board Jumper Settings” of your transmitter user manual.

7. USING DIAGNOSTIC TOOL QMODMASTER

0. ABOUT QMODMASTER

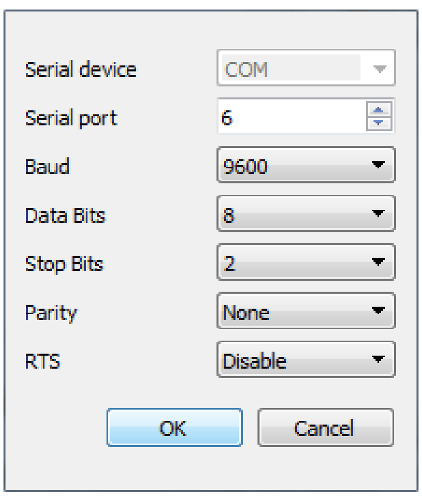
qModMaster.exe is a freeware Windows program which allows a PC to serve as a Modbus Master. It is an easy-to-use tool to verify communications, send requests to Modbus Slaves, and view their responses. It works well with Base 0, not Base 1, so use it only with Base 0 and subtract 1 from the Register addresses listed in this manual. Download qModMaster from SourceForge: https://sourceforge.net/projects/qmodmaster/files/latest/download

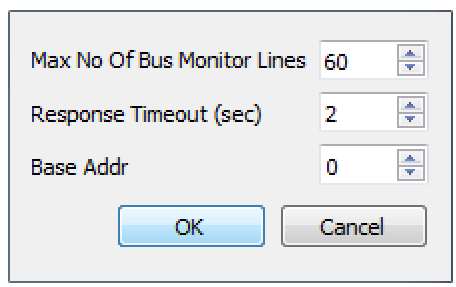
Click on the downloaded file and install it in a directory of your choice. Create a desktop icon from the installed executable. Before using qModMaster, ensure that your meter or transmitter has been set to Modbus RTU as explained in the preceding section of this manual.

1. EXAMPLE 1: READ A PANEL METER WITH QMODMASTER

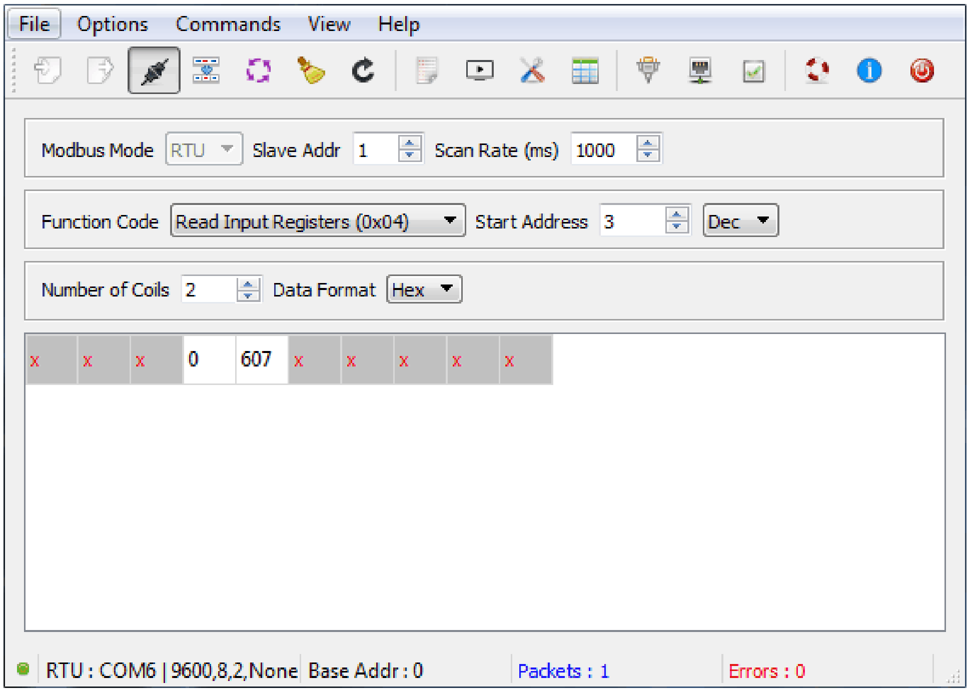
Get the reading from a digital panel meter that displays 1.543 Volts. Use Modbus RTU, Base 0, Slave Address 1, and Com port 6 (as verified by Device Manager).

Step 1. Under *Options*, select *Modbus RTU*. This will open *Modbus RTU Settings*, where you can enter your Serial port. From *Options* go to *Settings*, and select *Base Addr. 0* (for Base 0).





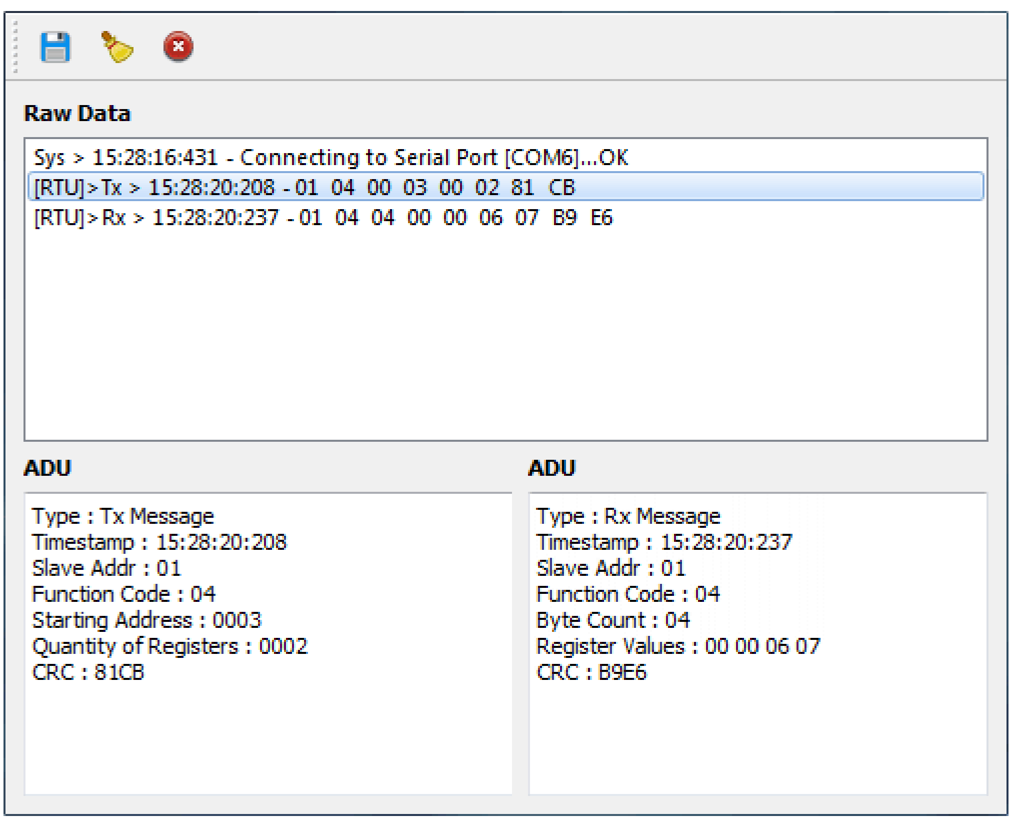
Step 2. In the main window below, set *Function Code* to FC04 for Read Input Register. Set *Start Address* 00 03 (hex), which is the Hi Word of the measurement value with Base 0. Set *Number of Registers* (or *Number of Coils*) to 2, since the Hi Word and Lo Word need to be read as a pair. In this example, we have specified that we want the data format to be in Hex. The main window immediately shows the Hi Word value as 0 and the Lo Word value as 607. Hex 607 is the same as Decimal 1543. This is 1543 counts without a decimal point for the 1.543 Volts displayed by the meter.



Step 3. Click on *View* => *Bus Monitor*. This will open the Bus Monitor window.

Step 4. In the main Window, click twice on *Commands* => *Connect*, and check the Bus Monitor to verify that your communication and Modbus settings are …*OK*.

Step 5. In the main Window, click on *Commands* => *Read/Write* to send your Modbus request and receive your meter's response.

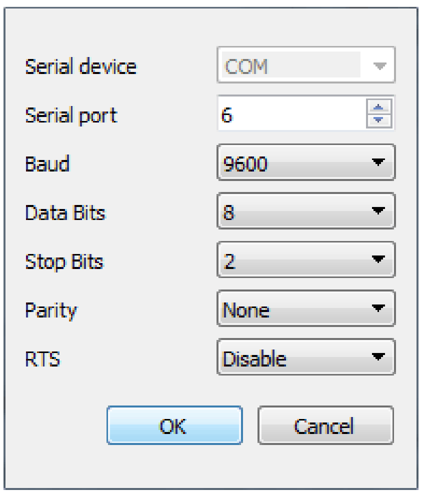


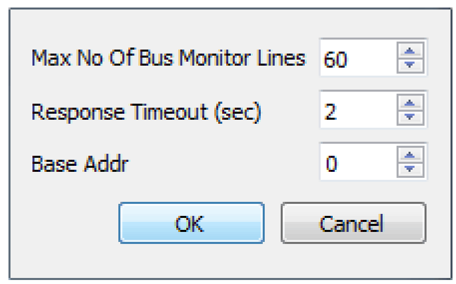
The Raw Data window of the Bus Monitor shows the ASCII characters that were sent (Tx) and received (Rx). For information on each group of characters, click on the Tx and Rx rows under Raw Data, and details will be shown in the ADU (Application Data Unit) window for either Tx or Rx. The returned Register Values for the reading are 00 00 06 07. Hex 607 is the same as Decimal 1543. This is the 1.543 Volts displayed by the meter in counts without the decimal point.

2. EXAMPLE 2: CHANGE A PANEL METER RELAY SETPOINT WITH QMODMASTER

Change the Alarm 1 setpoint to 1.500 Volts. Use Modbus RTU, Base 0, Slave Address 1, and Com port 6 (same as for Example 1).

Step 1. Under *Options*, select *Modbus RTU*. This will open *Modbus RTU Settings*, where you can enter your Serial port. From *Options* go to *Settings*, and select *Base Addr. 0* (for Base 0).



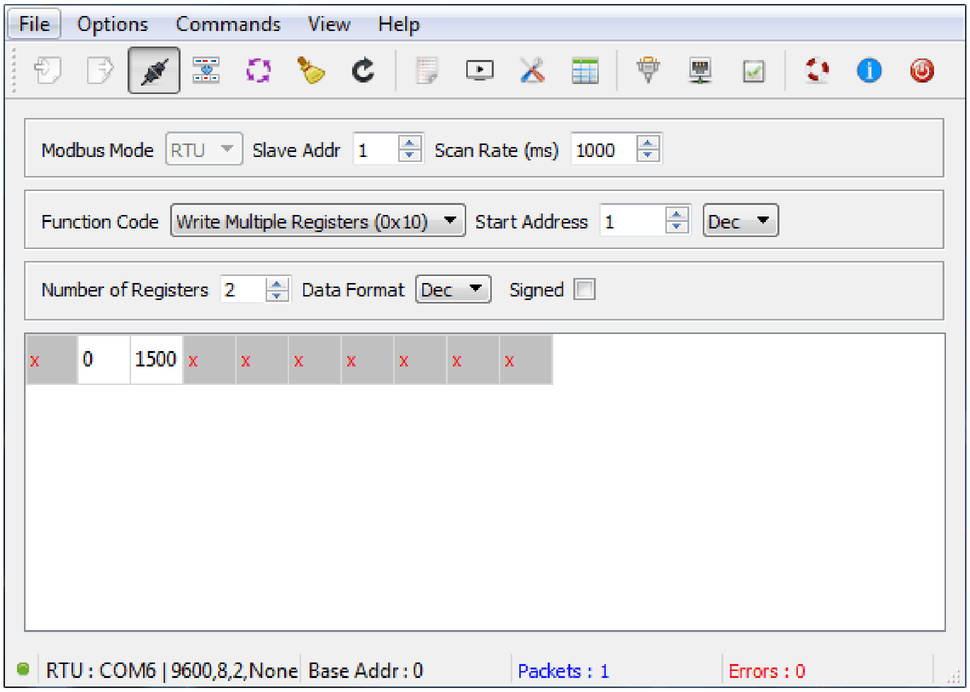


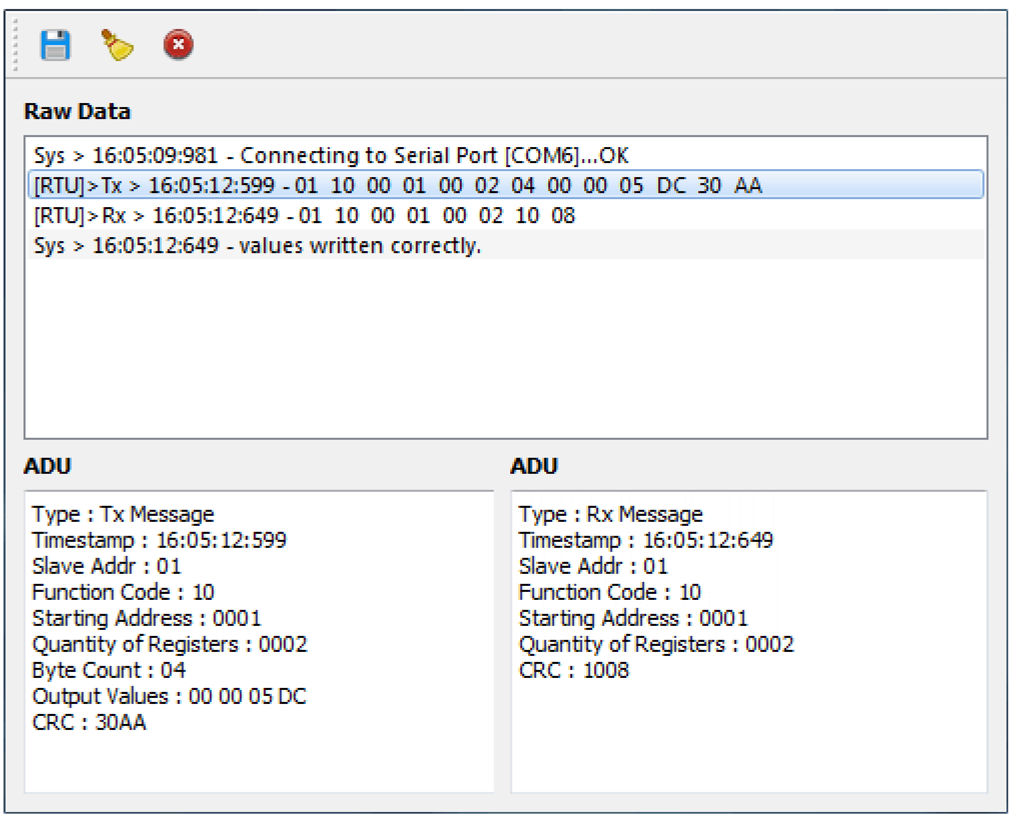
Step 2. In the main window, set *Function Code* to FC10 for *Write Multiple Registers (0x10)*. Set *Start Address* 00 01 (decimal or hex), which is the Hi Word of the Alarm 1 setpoint. Set *Number of Registers* to 2, since the Hi Word and Lo Word need to be set as a pair. In this example we have specified that we want the data format to be in Decimal. Enter the Hi Word as 0000 and the Lo Word as 1500 counts without a decimal point.

Step 3. Click on *View* => *Bus Monitor*. This will open the Bus Monitor window.

Step 4. In the main Window, click twice on *Commands* => *Connect*, and check the Bus Monitor to verify that your communication and Modbus settings are …*OK*.

Step 5. In the main Window below, click on *Commands* => *Read/Write* to send your Modbus request and receive your meter's response.





The Raw Data window of the Bus Monitor shows the ASCII characters that were sent (Tx) and received (Rx). For information on each group of characters, click on the Tx and Rx rows, and details will be shown in the ADU (Application Data Unit) window for either Tx or Rx. Note that the Output Values are 00 00 05 DC. Hex 5DC is the same as Decimal 1500. This is the desired Alarm 1 setpoint of 1.500 Volts in counts without the decimal point.

3. OTHER EXAMPLES FOR DEVICE ADDRESS 01, NO PARITY

Shown in the table below are the physical bytes on the communication line. These are always with Base 0.

Example	Action	Modbus RTU	Modbus ASCII
		Ser_4 = 010 Addr = 001	**Ser_4 = 020 Addr = 001**
Restart Communications*	Request Response	010800010000**B1CB** 010800010000**B1CB**	:010800010000**F6**crlf :010800010000**F6**crlf
Meter Reset	Request Response	01050001FF00**DDFA** None	:01050001FF00**FA**crlf None
Digital Reading = +25.18	Request Response	010400030002**81CB** 010404000009D6**7C4A**	:010400030002**F6**crlf :010404000009D6**18**crlf
Write Setpoint 1 = +37.00	Request Response	01100001000204000000E74**3624** 011000010002**1008**	:01100001000204000000E74**66**crlf :011000010002**EC**crlf
Read Setpoint 1 = +37.00	Request Response	010300010002**95CB** 01030400000E74**FE74**	:010300010002**F9**crlf :01030400000E74**76**crlf

* Suggested as first message after power-up. If device is in Listen-Only mode, no response is returned.

Bolded characters:

With Modbus RTU, last 4 characters indicate the CRC, which is added automatically by the device with RS232, RS485 or USB communications.

With Modbus ASCII, last 2 characters indicate the LRC, which is added automatically by the device with RS232, RS485 or USB communications.