GREYSTONE
ENERGY SYSTEMS INC

PM Series
Particulate Matter Transmitter
SETUP GUIDE Modbus COMMUNICATION

Modbus Requirements

- Baud Rate – Set via User Menu (9600, 19200, 38400, 57600, 76800 or 115200)
- RTU Mode only
- Parity – Set via User Menu (None, Odd, Even)
- Stop Bits – Set via User Menu (1, 2)
- CRC – Set via User Menu (A001, 1021, 8005, 8408)
- ModBus Delay – Set via User Menu (min, 50, 100, 150, 200, 250, 300, 350)
- Address – Set via User Menu (1-255)

Modbus Address	Typical Offset	Units	Data Type	Access	Notes
40001	+0	µg/m^3	Word	Read	16-bit integer, PM1.0 Particulate Mass value (0 to 1000)
40002	+1	µg/m^3	Word	Read	16-bit integer, PM2.5 Particulate Mass (0 to 1000)
40003	+2	µg/m^3	Word	Read	16-bit integer, PM4.0 Particulate Mass (0 to 1000)
40004	+3	µg/m^3	Word	Read	16-bit integer, PM10 Particulate Mass (0 to 1000)
40005	+4		Word	Read	16-bit integer, AQI Status 1 = Good, 2 = Moderate, 3 = Poor (Default = 1)
40006	+5		Word	Read	16-bit integer, PM Alarm Status 0 = Normal, 1 = Alarm (Default = 0)
40007	+6	µg/m^3	Word	R/W	16-bit integer, Analog Output Scale (500 to 1000) Resolution = 100, Default = 1000
40008	+7	µg/m^3	Word	R/W	16-bit integer, PM Alarm Setpoint (50 to 900) Resolution = 10, Default = 150
40009	+8	µg/m^3	Word	R/W	16-bit integer, PM Alarm Hysteresis (10 to 40) Resolution = 5, Default = 20
40010	+9	Minutes	Word	R/W	16-bit integer, PM Alarm Delay (0 to 10) Resolution = 1, Default = 0
40011	+10		Word	R/W	16-bit integer, Display Format 0 = AQI, 1 = µg/m^3 (Default = 1)
40012	+11		Word	R/W	16-bit integer, PM Range 1= PM1.0, 2= PM2.5, 3= PM4.0, 4= PM10 (Default 4)
40013	+12		Word	R/W	16-bit integer, PM Alarm Test 0 = Normal, 1 = Test (Default = 0)
40014	+13		Word	R/W	16-bit integer, Analog Output Direction 0 = Direct, 1 = Reverse (Default = 0)
40015	+14		Word	R/W	16-bit integer, LCD Backlight 1 = Auto, 2 = Off, 3 = On (Default = 1)

This section describes the implementation of the Modbus protocol. This device communicates on standard Modbus networks using RTU mode transmission. It operates as a slave device (address from 1 to 255) and expects a Modbus master device to transmit queries, which it will answer.

RTU Message Format

Modbus Framing	8 bit binary
Data Bits	start bits --- 1 data bits --- 8 parity bits --- none, odd or even stop bits --- 1or 2
Baud Rate	9600, 19200, 38400, 57600, 76800 or 115200
Duplex	Half duplex
Error Checking	Cyclical Redundancy Check (CRC) CRC-16 --- polynomial x16+x15+x2+x0 0x8005 or reversed version 0xA001 or CRC-CITT --- polynomial x16+x12+x5+x0 0x1021 or reversed version 0x8408
Latency	More than 3.5 characters --- minimum, 50, 100, 150, 200, 250, 300 or 350 mS

RTU Framing Support and Bit Sequences

Start	1	2	3	4	5	6	7	8	Stop	
Start	1	2	3	4	5	6	7	8	Stop	Stop
Start	1	2	3	4	5	6	7	8	Odd	Stop
Start	1	2	3	4	5	6	7	8	Even	Stop

RTU Function Codes

0x03 --- Read holding registers

Query

Slave address (0x01 to 0xFF)	Function code (0x03)	Starting address MSB	Starting address LSB	Quantity of registers MSB	Quantity of registers LSB	CRC LSB	CRC MSB

* Starting address = 0x0000 to 0xFFFF, Quantity of registers = 0x0000 to 0x007D

Response

Slave address (0x01 to 0xFF)	Function code (0x03)	Byte count 2N	Register value MSB	Register value LSB	…	CRC LSB	CRC MSB

* N= Quantity of registers

0x06 --- Write single register

Query

Slave address (0x01 to 0xFF)	Function code 0x06	Register address MSB	Register address LSB	Register value MSB	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	Function code 0x06	Register address MSB	Register address LSB	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register address = 0x0000 to 0xFFFF, Registers value = 0x0000 to 0xFFFF

Exception response

Slave address (0x01 to 0xFF)	Function code + 0x80	Exception code 0x01, 0x02 or 0x03	CRC LSB	CRC MSB

* An exception response is only returned if the CRC is correct
Exception code 01 --- illegal function, 02 --- illegal address, 03 --- illegal data value

Note that the registers may be read individually or multiple registers may be read at the same time by changing the query as shown below.

To read several registers with one query…

0x03 --- Read ALL REGISTERS

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x00 (Note 1)	0x00	0x05 (Note2)	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x0A (Note 3)	Register value MSB	Register value LSB	. . .	CRC LSB	CRC MSB

Note 1: The starting address (A) may be 0x0000 to 0x000C. The read multiple feature will read all registers from the starting address forward. If the starting address is 0x0000 then registers 40001 to 40013 can be read. If the starting address is 0x000B then registers 40012 to 40013 can be read.

Note 2: The quantity of registers (N) may be 0x0001 to 0x000C, but must be limited to 12 – A. If the starting address (A) is set to 0x0000 then N may be 0x0001 to 0x000C. If the starting address is set to 0x000C then N may be 0x0001 to 0x0002.

Note 3: The byte count (B) will always be 2N. If the quantity of registers (N) is 0x0001 then B will be 0x02. If N is 0x0005 then B will be 0x0A.

The RTU function codes supported are shown below.

0x03 --- Read PM1.0_Concentration_Value

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x00	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 to 0x03E8, corresponding to 0 to 1000 μg/m^3

0x03 --- Read PM2.5_Concentration_Value

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x01	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 to 0x03E8, corresponding to 0 to 1000 μg/m^3

0x03 --- Read PM4.0_Concentration_Value

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x02	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 to 0x03E8, corresponding to 0 to 1000 μg/m^3

0x03 --- Read PM10_Concentration_Value

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x03	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 to 0x03E8, corresponding to 0 to 1000 μg/m^3

0x03 --- Read AQI_Status

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x04	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0001 corresponding to good status
= 0x0002 corresponding to moderate status
= 0x0003 corresponding to poor status

0x03 --- Read PM_Alarm_Status

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x05	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 corresponding to normal status
= 0x0001 corresponding to alarm status

0x03 --- Read Analog_Output_Scale

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x06	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x01F4 to 0x03E8, corresponding to 500 to 1000 µg/m^3

0x03 --- Read PM_Alarm_Setpoint

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x07	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0032 to 0x0384, corresponding to 50 to 900 µg/m^3

0x03 --- Read PM_Alarm_Hysteresis

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x08	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x000A to 0x0028, corresponding to 10 to 40 µg/m^3

0x03 --- Read PM_Alarm_Delay

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x09	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 to 0x000A, corresponding to 0 to 10 minutes

0x03 --- Read Display_Format

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x0A	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 corresponding to the AQI display format
= 0x0001 corresponding to the µg/m^3 display format

0x03 --- Read PM_Range

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x0B	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0001 corresponding to the PM1.0 range
= 0x0002 corresponding to the PM2.5 range
= 0x0003 corresponding to the PM4.0 range
= 0x0004 corresponding to the PM10 range

0x03 --- Read PM_Alarm_Test

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x0C	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 corresponding to normal status
= 0x0001 corresponding to test status

0x03 --- Read Analog_Output_Direction

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x0D	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0000 corresponding to direct output signal
= 0x0001 corresponding to reverse output signal

0x03 --- Read LCD_Backlight

Query

Slave address (0x01 to 0xFF)	0x03	0x00	0x0E	0x00	0x01	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x03	0x02	Register value 0x00	Register value LSB	CRC LSB	CRC MSB

* Register value = 0x0001 corresponding to auto mode
= 0x0002 corresponding to off mode
= 0x0003 corresponding to on mode

0x06 --- Write Analog_Output_Scale

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x06	Register value MSB	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x06	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* This register is used to change the scale of the analog output signal.
Register value = 0x01F4 to 0x03E8, corresponding to 500 to 1000 µg/m^3, resolution = 100

0x06 --- Write PM_Alarm_Setpoint

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x07	Register value MSB	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x07	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the PM alarm setpoint value.
Register value = 0x0032 to 0x0384, corresponding to 50 to 900 µg/m^3, resolution = 10

0x06 --- Write PM_Alarm_Hysteresis

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x08	Register value MSB	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x08	Register value MSB	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the PM alarm hysteresis value.
  Register value = 0x000A to 0x0028, corresponding to 10 to 40 µg/m^3, resolution = 5

0x06 --- Write PM_Alarm_Delay

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x09	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x09	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the PM alarm delay value.
  Register value = 0x0000 to 0x000A, corresponding to 0 to 10 minutes, resolution = 1

0x06 --- Write Display_Format

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x0A	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x0A	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the LCD display format.
  Register value = 0x0000 corresponding to AQI mode
  = 0x0001 corresponding to µg/m^3 mode

0x06 --- Write PM_Range

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x0B	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x0B	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the PM measurement range.

Register value = 0x0001 corresponding to PM1.0
= 0x0002 corresponding to PM2.5
= 0x0003 corresponding to PM4.0
= 0x0004 corresponding to PM10

0x06 --- Write PM_Alarm_Test

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x0C	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x0C	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to initiate a PM alarm test.

Register value = 0x0000 resets the PM alarm to normal status
= 0x0001 sets the PM alarm to alarm status (for testing purposes)

0x06 --- Write Analog_Output_Direction

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x0D	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x0D	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the analog output signal direction.

Register value = 0x0000 sets the analog output for direct operation (0-1000 µg/m^3 = 4-20 mA)
= 0x0001 sets the analog output for reverse operation (0-1000 µg/m^3 = 20-4 mA)

0x06 --- Write LCD_Backlight

Query

Slave address (0x01 to 0xFF)	0x06	0x00	0x0E	0x00	Register value LSB	CRC LSB	CRC MSB

Response

Slave address (0x01 to 0xFF)	0x06	0x00	0x0E	0x00	Register value LSB	CRC LSB	CRC MSB

* This register is used to set the LCD backlight operating mode.

Register value = 0x0001 sets the backlight mode to auto (lights during startup and menu operation only)
= 0x0002 sets the backlight mode to off (never lights)
= 0x0003 sets the backlight mode to on (always lights)

Exception response

Slave address (0x01 to 0xFF)	Function code + 0x80	Exception code * 0x01, 0x02 or 0x03	CRC LSB	CRC MSB

* An exception response is only returned if the CRC is correct

Exception code 01 --- illegal function
Exception code 02 --- illegal address
Exception code 03 --- illegal data value