



240/241 Series Modbus

Instruction Manual

Modbus Device Specification for Models:
240-V, -VT, -VTP, -LP & 241-V, -VT, -VTP, -LP
Multivariable Mass Vortex Flow Meters



Part Number: IM240/241 Modbus, Rev. V1
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GLOBAL SUPPORT LOCATIONS: WE ARE HERE TO HELP!

CORPORATE HEADQUARTERS

5 Harris Court, Building L Monterey, CA 93940
Phone (831) 373-0200 (800) 866-0200 Fax (831) 373-4402
www.sierrainstruments.com

EUROPE HEADQUARTERS

Bijlmansweid 2 1934RE Egmond aan den Hoef
The Netherlands
Phone +31 72 5071400 Fax +31 72 5071401

ASIA HEADQUARTERS

Second Floor Building 5, Senpu Industrial Park
25 Hangdu Road Hangtouw Town
Pu Dong New District, Shanghai, P.R. China
Postal Code 201316
Phone: + 8621 5879 8521 Fax: +8621 5879 8586

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Warnings and Cautions



Warning! Agency approval for hazardous location installations varies between flow meter models. Consult the flow meter nameplate for specific flow meter approvals before any hazardous location installation.

Warning! Hot tapping must be performed by a trained professional. U.S. regulations often require a hot tap permit. The manufacturer of the hot tap equipment and/or the contractor performing the hot tap is responsible for providing proof of such a permit.

Warning! All wiring procedures must be performed with the power off.

Warning! To avoid potential electric shock, follow National Electric Code safety practices or your local code when wiring this unit to a power source and to peripheral devices. Failure to do so could result in injury or death. All AC power connections must be in accordance with published CE directives.

Warning! Do not power the flow meter with the sensor remote (if applicable) wires disconnected. This could cause over-heating of the sensors and/or damage to the electronics.

Warning! Before attempting any flow meter repair, verify that the line is de-pressurized.

Warning! Always remove main power before disassembling any part of the mass flow meter.



Caution! Before making adjustments to the device, verify the flow meter is not actively monitoring or reporting to any master control system. Adjustments to the electronics will cause direct changes to flow control settings.

Caution! All flow meter connections, isolation valves and fittings for hot tapping must have the same or higher pressure rating as the main pipeline.

Caution! Changing the length of cables or interchanging sensors or sensor wiring will affect the accuracy of the flow meter. You cannot add or subtract wire length without returning the meter to the factory for re-calibration.

Caution! When using toxic or corrosive gases, purge the line with inert gas for a minimum of four hours at full gas flow before installing the meter.

Caution! The AC wire insulation temperature rating must meet or exceed 80°C (176°F).

Caution! Printed circuit boards are sensitive to electrostatic discharge. To avoid damaging the board, follow these precautions to minimize the risk of damage:

- before handling the assembly, discharge your body by touching a grounded, metal object
- handle all cards by their edges unless otherwise required
- when possible, use grounded electrostatic discharge wrist straps when handling sensitive components

Note and Safety Information

We use caution and warning statements throughout this book to draw your attention to important information.



Warning!

This statement appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application.



Caution!

This statement appears with information that is important for protecting your equipment and performance. Read and follow all cautions that apply to your application.

Receipt of System Components

When receiving a Sierra mass flow meter, carefully check the outside packing carton for damage incurred in shipment. If the carton is damaged, notify the local carrier and submit a report to the factory or distributor. Remove the packing slip and check that all ordered components are present. Make sure any spare parts or accessories are not discarded with the packing material. Do not return any equipment to the factory without first contacting Sierra Customer Service.

Technical Assistance

If you encounter a problem with your flow meter, review the configuration information for each step of the installation, operation, and setup procedures. Verify that your settings and adjustments are consistent with factory recommendations. Installation and troubleshooting information can be found in the [240/241 Series Product Instruction Manual](#).

If the problem persists after following the troubleshooting procedures outlined in the 640S or 780S product manuals, contact Sierra Instruments by fax or by E-mail (see inside front cover). For urgent phone support you may call (800) 866-0200 or (831) 373-0200 between 8:00 a.m. and 5:00 p.m. PST. In Europe, contact Sierra Instruments Europe at +31 20 6145810. In the Asia-Pacific region, contact Sierra Instruments Asia at +86-21-58798521. When contacting Technical Support, make sure to include this information:

- The flow range, serial number, and Sierra order number (all marked on the meter nameplate)
- The software version (visible at start up)
- The problem you are encountering and any corrective action taken
- Application information (gas, pressure, temperature and piping configuration)

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Chapter 1: Modbus Communications

Applicable Flow Meter Models

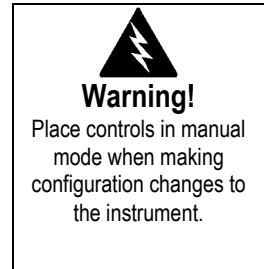
Sierra's InnovaMass® 240 and 241 Mass Vortex Flow Meters with Modbus communication protocol and firmware version 4.00.58 and above.

Overview

This document describes the implementation of the Modbus communication protocol for use in monitoring common process variables in the Sierra InnovaMass Vortex flow meter. The physical layer utilizes the half-duplex RS-485 port, and the Modbus protocol.

Reference Documents

The following documents are available online from www.modbus.org.



Modbus Application Protocol Specification V1.1 b3

Modbus Over Serial Line Specification & Implementation Guide V1.0 2

Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. J

Wiring

An RS485 daisy chained network configuration as depicted below is recommended. Do not use a star, ring, or cluster arrangement. Consult your RS-485 master's documentation about the need for termination, pull-up and pull-down resistors.

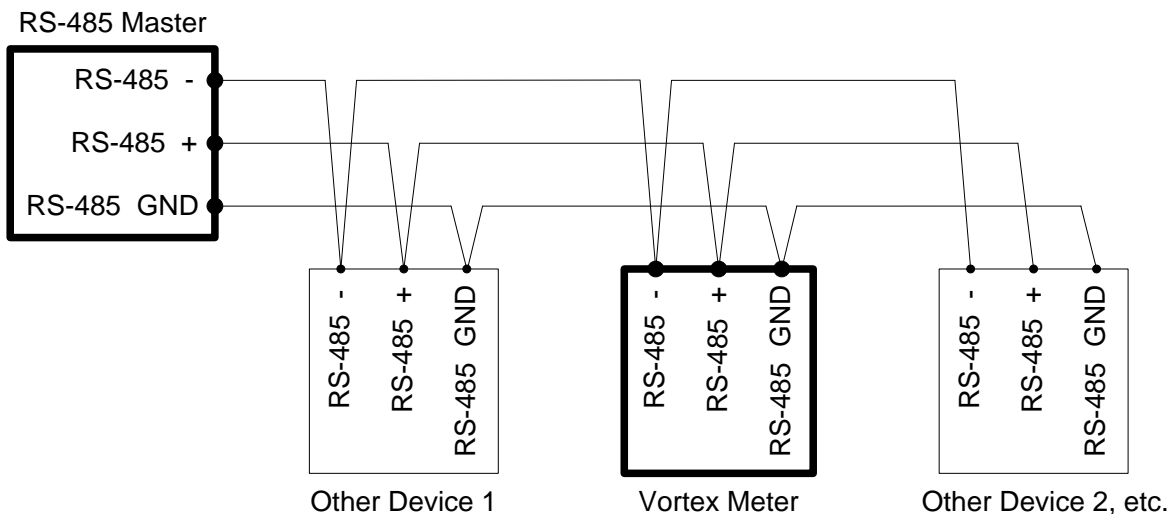


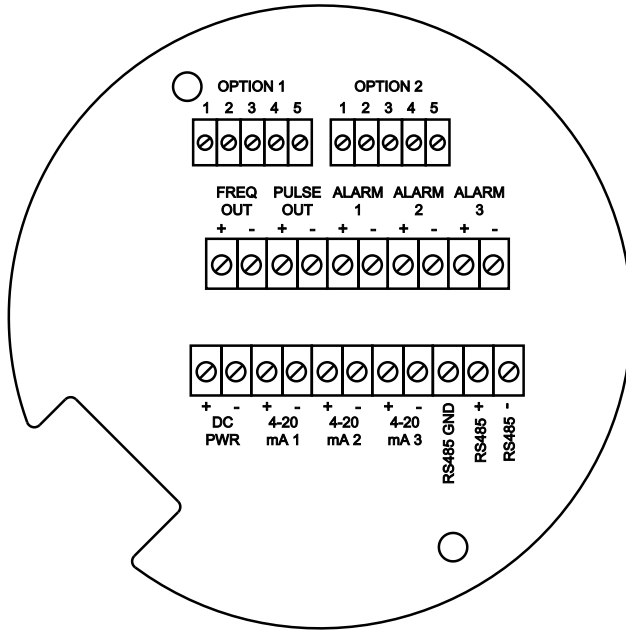
Figure 1: RS-485 Wiring (Modbus)

Pin Labeling (among devices)

“RS-485 -” = “A” = “TxD-/RxD-” = “Inverting pin”

“RS-485 +” = “B” = “TxD+/RxD+” = “Non-Inverting pin”

“RS-485 GND” = “GND” = “G” = “SC” = “Reference”



240/241 Pins	Rs485 Labeling Synonyms
RS485 -	A, TxD-/RxD-, Inverting pin
RS485 +	B, TxD+/RxD+, Non-Inverting pin
RS485 GND	GND, G, SC, Reference

Figure 1: DC Wiring Terminals

Menu Items

The following menu items are in the display, DD option Output Menu and allow selection and control of the Modbus communication protocol.

Address

When the Modbus protocol is selected, the Modbus address is equal to the user programmable device address if it is in the range 1...247, in accordance with the Modbus specification. If the device address is zero or is greater than 247, then the Modbus address is internally set to 1.

Comm Protocol

The Comm Protocol menu allows selection of “Modbus RTU Even,” “Modbus RTU Odd,” or “Modbus RTU None2,” or “Modbus RTU None1,” (non-standard Modbus) with Even, Odd and None referring to the parity selection. When even or odd parity is selected, the unit is configured for 8 data bits, 1 parity bit and 1 stop bit; with no parity, the number of stop bits is 1 (non-standard) or 2. When changing the

protocol, the change is made as soon as the Enter key is pressed.

Modbus Units

The Modbus Units menu is to control what units, where applicable, the meter's variables will be displayed in. Internal – these are the base units of the meter, °F, psia, lbm/sec, ft³/sec, Btu/sec, lbm/ft³ Display – variables are displayed in user selected display unit.

Modbus Order

The byte order within registers and the order in which multiple registers containing floating point or long integer data are transmitted may be changed with this menu item. According to the Modbus specification, the most significant byte of a register is transmitted first, followed by the least significant byte. The Modbus specification does not prescribe the order in which registers are transmitted when multiple registers represent values longer than 16 bits. Using this menu item, the order in which registers representing floating point or long integer data and/or the byte order within the registers may be reversed for compatibility with some PLCs and PC software.

The following four selections are available in this menu; when selecting an item, the protocol is changed immediately without having to press the Enter key.

0-1:2-3	Most significant register first, most significant byte first (default)
2-3:0-1	Least significant register first, most significant byte first
1-0:3-2	Most significant register first, least significant byte first
3-2:1-0	Least significant register first, least significant byte first

Note that all of the registers are affected by the byte order, including strings and registers representing 16-bit integers; the register order only affects the order of those registers representing 32-bit floating point and long integer data, but does not affect single 16-bit integers or strings.

Modbus Protocol

The Modbus RTU protocol is supported in this implementation. Supported baud rates are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200. The default baud rate is 19200 baud. Depending upon the Modbus protocol selected, data are transmitted in 8-bit data frames with even or odd parity and 1 stop bit, or no parity and 2 or 1 (non-standard) stop bits.

The current Modbus protocol specification does not define register usage, but there is an informal register numbering convention derived from the original (now obsolete) Modicon Modbus protocol specification, and used by many vendors of Modbus capable products.

Registers	Usage	Valid Function Codes
00001–09999	Read/write bits ("coils")	01 (read coils) 05 (write single coil) 15 (write multiple coils)
10001–19999	Read-only bits ("discrete inputs")	02 (read discrete inputs)

30001–39999	Read-only 16 bit registers ("input registers"), IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 04 (read input registers)
40001–49999	Read/write 16-bit registers ("holding registers"), IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 06 (write single register) 16 (write multiple registers)

Each range of register numbers maps to a unique range of addresses that are determined by the function code and the register number. The address is equal to the least significant four digits of the register number minus one, as shown in the following table.

Registers	Function Codes	Data Type and Address Range
00001-09999	01, 05, 15	Read/write bits 0000-9998
10001-19999	02	Read-only bits 0000-9999
30001-39999	03, 04	Read-only 16-bit registers 0000-9998
40001-49999	03, 06, 16	Read/write 16-bit registers 0000-9998

Register Definitions

The meter serial number and those variables that are commonly monitored (mass, volume and energy flow rates, total, pressure, temperature, density, viscosity, Reynolds number, and diagnostic variables such as frequency, velocity, gain, amplitude and filter setting) are accessible via the Modbus protocol. Long integer and floating point numbers are accessed as pairs of 16-bit registers in the register order selected in the Modbus Order menu. Floating point numbers are formatted as single precision IEEE 754 floating point values.

The flow rate, temperature, pressure, and density variables may be accessed as either the flow meter internal base units or in the user-programmed display units, which is determined by the programming of the display, DD option Output Menu's "Modbus Units" item. The display units strings may be examined by accessing their associated registers. Each of these units string registers contain 2 characters of the string, and the strings may be 2 to 12 characters in length with unused characters set to zero. Note that the byte order affects the order in which the strings are transmitted. If the Modbus Order menu (see page 2) is set to 0-1:2-3 or 2-3:0-1, then the characters are transmitted in the correct order; if set to 1-0:3-2 or 3-2:1-0, then each pair of characters will be transmitted in reverse order.

Registers	Variable	Data Type	Units	Function Code	Addresses
65100-65101	Serial number	unsigned long	—	03, 04	
30525-30526	Totalizer	unsigned long	display units*	03, 04	524-525
32037-32042	Totalizer units	string	—	03, 04	2036-2041
30009-30010	Mass flow	float	display units*	03, 04	8-9
30007-30008	Volume flow	float	display units*	03, 04	6-7
30005-30006	Pressure	float	display units*	03, 04	4-5
30001-30002	Temperature	float	display units*	03, 04	0-1
30029-30030	Velocity	float	ft/sec	03, 04	28-29
30015-30016	Density	float	display units*	03, 04	14-15
30013-30014	Viscosity	float	cP	03, 04	12-13
30031-30032	Reynolds number	float	—	03, 04	30-31
30025-30026	Vortex frequency	float	Hz	03, 04	24-25
34532	Gain	char	—	03, 04	4531
30085-30086	Vortex amplitude	float	Vrms	03, 04	84-85
30027-30028	Filter setting	float	Hz	03, 04	26-27

The following registers are available with the energy meter firmware:

Registers	Variable	Data Type	Units	Function Code	Addresses
30527-30528	Totalizer #2	unsigned long	display units*	03, 04	526-527
32043-32048	Totalizer #2 units	string	—	03, 04	2042-2047
30003-30004	Temperature #2	float	display units*	03, 04	2-3
30011-30012	Energy flow	float	display units*	03, 04	10-11

The following registers contain the display units strings:

Registers	Variable	Data Type	Units	Function Code	Addresses
32007-32012	Volume flow units	string	—	03, 04	2006-2011
32001-32006	Mass flow units	string	—	03, 04	2000-2005
32025-32030	Temperature units	string	—	03, 04	2024-2029
32019-32024	Pressure units	string	—	03, 04	2018-2023
32031-32036	Density units	string	—	03, 04	2030-2035
32013-32017	Energy flow units	string	—	03, 04	2012-2017

Function codes 03 (read holding registers) and 04 (read input registers) are the only codes supported for reading these registers, and function codes for writing holding registers are not implemented. We recommend that the floating point and long integer registers be read in a single operation with the number of registers being a multiple of two. If these data are read in two separate operations, each reading a single 16-bit register, then the value will likely be invalid.

The floating point registers with values in display units are scaled to the same units as are displayed, but are instantaneous values that are not smoothed. If display smoothing is enabled (non-zero value entered in the

Display TC item in the Display Menu), then the register values will not agree exactly with the displayed values.

Exception Status Definitions

The Read Exception Status command (function code 07) returns the exception status byte, which is defined as follows. This byte may be cleared by setting “coil” register #00003 (function code 5, address 2, data = 0xff00).

Bit(s)	Definition
0-1	Byte order (see Modbus Order on page 2) 0 = 3-2:1-0 1 = 2-3:0-1 2 = 1-0:3-2 3 = 0-1:2-3
2	Temperature sensor fault
3	Pressure sensor fault
4	A/D converter fault
5	Period overflow
6	Pulse overflow
7	Configuration changed

Discrete Input Definitions

The status of the three alarms may be monitored via the Modbus Read Discrete Input command (function code 02). The value returned indicates the state of the alarm, and will be 1 only if the alarm is enabled and active. A zero value is transmitted for alarms that are either disabled or inactive,

Registers	Variable	Function Code	Address
10001	Alarm #1 state	02	0
10002	Alarm #2 state	02	1
10003	Alarm #3 state	02	2

Control Register Definitions

The only writeable registers in this implementation are the Reset Exception Status, Reset Meter and Reset Totalizer functions, which are implemented as ”coils” which may be written with the Write Single Coil command (function code 05) to address 8 through 10, respectively, (register #00009 through #00011). The value sent with this command must be either 0x0000 or 0xff00, or the meter will respond with an error message; the totalizer will be reset or exception status cleared only with a value of 0xff00.

Error Responses

If an error is detected in the message received by the unit, the function code in the response is the received function code with the most significant bit set, and the data field will contain the exception code byte, as follows:

Exception Code	Description
01	Invalid function code — function code not supported by device
02	Invalid data address — address defined by the start address and number of registers is out of range
03	Invalid data value — number of registers = 0 or >125 or incorrect data with the Write Single Coil command

If the first byte of a message is not equal to the unit's Modbus address, if the unit detects a parity error in any character in the received message (with even or odd parity enabled), or if the message CRC is incorrect, the unit will not respond.

Command Message Format

The start address is equal to the desired first register number minus one. The addresses derived from the start address and the number of registers must all be mapped to valid defined registers, or an invalid data address exception will occur.

Device Address 8 bits, 1...247	Function Code 8 bits	Start Address 16 bits, 0...9998	N = Number of Registers 16 bits, 1...125	CRC 16 bits
-----------------------------------	-------------------------	------------------------------------	---	----------------

Normal Response Message Format

Device Address 8 bits, 1...247	Function Code 8 bits	Byte Count = 2 x N 8 bits	Data (N) 16-bit registers	CRC 16 bits
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Exception Response Message Format

Device Address 8 bits, 1...247	Function Code + 0x80 8 bits	Exception Code 8 bits	CRC 16 bits
-----------------------------------	--------------------------------	--------------------------	----------------

Examples

Read the exception status byte from the device with address 1:

```
01 07 41 E2
```

```
01 Device address
07 Function code, 04 = read exception status
```

A typical response from the device is as follows:

```
01 07 03 62 31
```

```
01 Device address
07 Function code
03 Exception status byte
62 31 CRC
```

Request the first 12 registers from device with address 1:

```
01 04 00 00 00 0C F0 0F
```

```
01 Device address
04 Function code, 04 = read input register
00 00 Starting address
00 0C Number of registers = 12
F0 0F CRC
```

A typical response from the device is as follows: *note these are the older register definitions

```
01 04 18 00 00 03 E8 00 00 7A 02 6C 62 00 00 41 BA 87 F2 3E BF FC 6F 42 12 EC 8B 4D D1
```

```
01 Device address
04 Function code
18 Number of data bytes = 24
00 00 03 E8 Serial number = 1000 (unsigned long)
00 00 7A 02 Totalizer = 31234 lbm (unsigned long)
6C 62 00 00 Totalizer units = "lb" (string, unused characters are 0)
41 BA 87 F2 Mass flow rate = 23.3164 lbm/sec (float)
3E BF FC 6F Volume flow rate = 0.3750 ft3/sec (float)
42 12 EC 8B Pressure = 36.731 psia (float)
4D D1 CRC
```

An attempt to read register(s) that don't exist

```
01 04 00 00 00 50 F1 D2
```

```
01 Device address
04 Function code 4 = read input register
00 00 Starting address
00 50 Number of registers = 80
F0 36 CRC
```

results in an error response as follows:

```
01 84 02 C2 C1
```

```
01 Device address
84 Function code with most significant bit set indicates error response
02 Exception code 2 = invalid data address
C2 C1 CRC
```

Request the state all three alarms:

```
01 02 00 00 00 03 38 0B
```

```
01 Device address
02 Function code 2 = read discrete inputs
00 00 Starting address
00 03 Number of inputs = 3
38 0B CRC
```

and the unit responds with:

```
01 02 01 02 20 49
```

```
01 Device address
02 Function code
01 Number of data bytes = 1
02 Alarm #2 on, alarms #1 and #3 off
20 49 CRC
```

To reset the totalizer:

```
01 05 00 00 FF 00 8C 3A
```

```
01 Device address
05 Function code 5 = write single coil
00 09 Coil address = 9
FF 00 Data to reset totalizer
8C 3A CRC (not the correct CRC EJS-02-06-07)
```

The unit responds with an identical message to that transmitted, and the totalizer is reset. If the “coil” is turned off as in the following message, the response is also identical to the transmitted message, but the totalizer is not affected.

```
01 05 00 00 00 00 CD CA
```

```
01 Device address
05 Function code 5 = write single coil
00 00 Coil address = 0
00 00 Data to “turn off coil” does not reset totalizer
CD CA CRC
```