Honeywell

Ultrasonic Flow Meter Series 6
Q.Sonic®

Manual
Modbus Protocol

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Content

1 General information

1.1 About these instructions

This document describes the serial communication protocol for measured data for the following Ultrasonic Flow Meters Series 6 from Elster:

- CheckSonic Series 6
- Q.Sonic Series 6
- Vx.Sonic
- Q.Sonic-plus
- Q.Sonic-max

Information is passed in messages between the ultrasonic flow meter and a master device. A message is a data packet conforming to certain rules. The information may be measured data, a command, or a response to a command. Commands are passed from a master device to the ultrasonic flow meter, measured data and commands responses are passed from the ultrasonic flow meter to the master device.

The Ultrasonic Flow Meters Series 6 from Elster are equipped with two serial ports that can be independently configured as RS232 or RS485. On these ports the Modbus data protocol shall be implemented to allow existing equipment such as flow computers and supervisory systems to read measured data from the meter.

In addition, an alternative protocol is available where the registers are limited to 16 bits. For more information on the alternative protocol, ⇨ 7 Alternative ‘16-bits’ list (p. 26).

1.2 Relevant user documentation

Elster Gas Metering business provides the user documentations such as manuals, certificates, technical information for your UFM Series 6 meter in a ZIP file. The download information for this ZIP file is delivered with your device. Manuals referenced by this manual are included in this ZIP, such as UFM Series 6 “Safety Instructions”.

Single documents are published in the Docuthek. The documents are updated regularly.

www.docuthek.com/
Use the device series or the device type as search term:
UFM Series 6 or **Q.Sonic-max**

1.3 Limitation of liability

This manual is based on the latest information. It is provided subject to alterations. We reserve the right to change the construction and/or configuration of our products at any time without obligation to update previously shipped equipment.

The warranty conditions specified in the manufacturer's terms of delivery apply to the product. Warranty claims are excluded in the following cases:

- The repair or replacement of the equipment or parts thereof has been required by natural wear and tear, in whole or in part due to a catastrophe, or because of a defect or fault on the part of the purchaser.
- Maintenance or repair of the device or device parts has not been carried out by an authorized representative of the manufacturer, or modifications have been made to the device or device parts without prior express written consent of the manufacturer.
- No original parts are used.
- The device has been used incorrectly, carelessly, improperly or not in accordance with its nature and/or intended use.
- The product has been used with unauthorized components or peripherals such as cables, test equipment, computers, or with unauthorized voltages.

The manufacturer is not liable for incidental or consequential damages arising from breach of express or implied warranties, including property damage, and to the extent permitted by law, personal injury.

Read this manual carefully.

Read the wiring instructions carefully before starting any work.

The manufacturer accepts no liability for loss or defects resulting from failure to comply with this manual.

We reserve the right to make technical changes within the scope of optimizing the performance characteristics and continuous further development of the device.

The current warranty conditions in the General Terms and Conditions are available on our website:

process.honeywell.com/us/en/site/elster-instromet/about-us

2 OSI layer 1: The hardware layer

2.1 Introduction

The physical layer concerns both the physical and electrical interface between the user equipment and the network terminating equipment. It provides the link layer with a means of transmitting a serial bit stream between the two correspondent systems.

The ultrasonic flow meters from Elster are fitted with a serial interface software configurable as RS485 or RS232.

2.2 RS485 hardware connections

The RS485 electrical standard is used on a shielded twisted pair data link. The RS485 terminals are called ***A*** and ***B***. The following rules apply when connecting an ultrasonic flow meter to external equipment:

- RS485 devices should be connected "1:1" (or "straight through"). This means that the SPU terminal ***A*** is connected to the external equipment's terminal ***A***, and the SPU terminal ***B*** is connected to the external equipment's terminal ***B***.

2.3 RS232C hardware connections

- Equipment configured as Data Circuit-terminating Equipment (DCE) transmits data on pin 2 and receives data on pin 3.
- Equipment configured as Data Terminal Equipment (DTE) transmits data on pin 3 and receives data on pin 2.
- A standard "1:1" (or "straight through") serial cable must be used when interfacing DCE with DTE.
- A "null modem" serial cable must be used when interfacing DTE to DTE (or DCE to DCE).

3 OSI layer 2: The link layer

3.1 Introduction

The link layer builds on the physical connection and provides a reliable information transfer facility.

3.2 General characteristics

A serial data link is used with the following specifications:

- Transmission mode: asynchronous, half duplex (RS485) or full duplex (RS232C)
- Transmission rate – device type dependent:
  - Programmable: 300 to 115200.
  - Normal values are:
    4800 bps, 9600 bps (default), 19200 bps or 38400 bps
- Start bits: 1
- Data bits: 8 (LSbit first)
- Stop bits: 1
- Parity - instrument type dependent: none (default), or even.

3.3 Message format

Frame synchronization can be maintained in the Remote Terminal Unit (RTU) transmission mode only by simulating a synchronous message. The receiving device monitors the elapsed time between receipt of characters. If 3½ times elapse without a new character or completion of frame, then the device flushes the frame and assumes that the next byte received will be an address.

T3.5	Address	Function	Data	Checksum	T3.5
	8 bits	8 bits	N x 8 bits	16 bits	

Fig. 3 1: RTU Message frame format

Description of the message fields:

- The ***T3.5*** field represents the time-out limit (3½ character times) that provides frame synchronization.
- The ***Address*** field immediately follows the beginning of the frame and consists of 8 bits (1byte). These bits indicate the user assigned address of the slave device that is to receive the message sent by the attached master. Each slave will respond to a query that contains its address. When the slave sends a response, the slave address informs the master which slave is communicating. Valid addresses range from 1 to 247. Broadcast messages – which have address 0 – are not supported by Elster ultrasonic flow meters.
- The ***Function*** code field tells the addressed device which function to perform. As a standard, Elster Series 6 ultrasonic flow meters use only code 3. Herewith the current value of one or more registers is obtained.
- The high order bit in the function code field is set by the slave device to indicate abnormal responses being transmitted to the master device. Refer to ⇨ 3.4 Exception responses (p. 11) for a description of exception responses. This bit remains 0 if the message is a query or a normal response message.
- The ***Data*** field contains information needed by the addressed device to perform the specific function or it contains data collected by the device in response to a query or limits. For example, the function code tells the slave to read a holding register and the data field is needed to indicate which register to start at and how many to read.
- The ***Checksum*** field consists of 16 bits (2 bytes) which contain the CRC-16 checksum of the message. This field allows the master and slave devices to check the message for errors in the transmission. Sometimes, because of electrical noise or other interference, a message may be changed slightly while it is on its way from one unit to another. The error checking assures that the slave or master does not react to messages that have changed during transmission. This increases the safety and the efficiency of the communication system.

3.4 Exception responses

The high order bit of the function code field is set by the slave device to indicate that an abnormal response is being transmitted to the master device.

Operation errors are those involving illegal data in a message or difficulty in communicating. These errors result in an exception response. The exception response codes are listed in the following table.

Code	Name	Meaning
01	Illegal function	The message function received is not an allowable action for the device
02	Illegal data address	The address referenced in the data field is not an allowable address for the device

Table 1: Supported error codes

When a slave device detects one of these errors, it sends a response message to the master consisting of a slave address, function code, error code and error check fields:

T3.5	Address	Function	Exception	Checksum	T3.5
	8 bits	8 bits	8 bits	16 bits	

Fig. 3 2: Exception response message frame format

3.5 Bits and bytes

Bits and bytes are handled according to the following rules:

- Bits are numbered 0 through 7; bit 0 is the least significant bit (LSB), bit 7 is the most significant bit (MSB). The decimal value of bit N is 2N.
- The bits of a byte are transmitted in ascending order: LSbit first; MSbit last.

4 OSI layer 6: The presentation layer

4.1 Introduction

The presentation layer is concerned with the representation (syntax) of the data during transfer between two correspondent application layer protocol entities.

The presentation layer maps the application layer's abstract data types to the link layer's data units (bytes).

4.2 Abstract data types

The presentation layer recognizes the following abstract data types:

- ***Short Word***: Two bytes (16 bits) containing an integer number between 0 and 65535. Byte order: MSB first, LSB last.
- ***Long Word***: Four bytes (32 bits) containing an integer number between 0 and +4294967295. Byte order: MSB first, LSB last.

> **Tip!**
>
> When using the alternative ’16-bits list’, the Long Word is limited to 16 bits and 2 addresses are used for one register.
>
> ⇨ 7 Alternative ‘16-bits’ list (p. 26)

- ***Float:*** Four bytes containing a floating-point number (IEEE-754). Byte order: MSB first, LSB last. The bytes can be viewed as 32 contiguous bits, which can be divided into fields as follows.

MSB	Sign (1 bit)	Exponent (8 bits)	Fraction (23 bits)	LSB

Fig. 4 1: Abstract data type: Float

Where:

- ***Sign*** is a 1-bit field that contains the value **0** if the real value is positive; **1** if the real value is negative.
- ***Exponent*** is an 8-bit field that contains a value offset by 127; in other words, the actual exponent can be obtained from the exponent field by subtracting 127. An exponent field of all 0s or all 1s represents special cases. Otherwise, the real is called normalized.
- ***Fraction*** is a 23-bit field that contains the fractional part of the real value, represented in binary scientific notation. The most-significant digit of the fraction field is not actually represented, because by definition, this digit contains a value of 1 (unless the real number is 0 or denormalized).

Tip!

When using the alternative '16-bits list', the Float is limited to 16 bits and 2 addresses are used for one register.

⇨ 7 Alternative '16-bits' list (p. 26)

- ***Double Float***: Eight bytes containing a floating-point number (IEEE-754). Byte order: MSB first, LSB last. The bytes can be viewed as 64 contiguous bits, which can be divided into fields as follows:

MSB	Sign (1 bit)	Exponent (11 bits)	Fraction (52 bits)	LSB

Fig. 4 2: Abstract Data Type: Double

Where:

- ***Sign*** is a 1-bit field that contains the value 0 if the real value is positive; 1 if the real value is negative.
- ***Exponent*** is an 11-bit field that contains a value offset by 127; in other words, the actual exponent can be obtained from the exponent field by subtracting 127. An exponent

field of all 0s or all 1s represents special cases. Otherwise, the real is called normalized.

- ***Fraction*** is a 52-bit field that contains the fractional part of the real value, represented in binary scientific notation. The most-significant digit of the fraction field is not actually represented, because by definition, this digit contains a value of 1 unless the real number is 0 or deformalized.

Tip!

When using the alternative ‘16-bits list’, the Double Float is limited to 16 bits and 4 addresses are used for one register.

⇨ 7 Alternative ‘16-bits’ list (p. 26)

5 OSI layer 7: The application layer

5.1 Introduction

The application layer provides the user interface for data exchange with the ultrasonic flow meter.

5.2 Register groups

The data types presented in ⇨ 4 OSI layer 6: The presentation layer (p. 13) are assigned specific address ranges:

- **Short word** registers: n000… n199
- **Long word** registers: n200… n399
- **Floating point word** registers: n400… n599
- **Double float** registers: n600… n699
  (only for the alternative 16-bits list, ⇨ 7 Alternative '16-bits' list, p. 26)

> Where n = 0 or 1;
> higher values for n are available upon request, keeping in mind that the highest possible register is 65535.

5.2.1 Short word registers

The following table below lists the short word registers implemented in the Series 6 ultrasonic flow meters.

Address	Measured value	Unit	Meaning
n000	InstrumentType	–	Flow meter identification code [1]
n001	NumPaths	–	Number of acoustic paths [1]

[1] ⇨ Table 3: Meter Identification (p. 18)

<table>
<tr><td>n002</td><td>SequenceNum LO</td><td>–</td><td>Measurement interval sequence number: ‘Low-order’ bytes</td></tr>
<tr><td>n003</td><td>SequenceNum HO</td><td>–</td><td>Measurement interval sequence number: ‘High-order’ bytes</td></tr>
<tr><td>n004</td><td>SampleRate</td><td>–</td><td>Number of acquired samples (elementary measurements)</td></tr>
<tr><td>n005…n012</td><td>ValidSamples:
L1…L8</td><td>–</td><td>Number of valid samples of path 1…8</td></tr>
<tr><td>n013…n028</td><td>AgcLevel:
Trd L1A…L8B</td><td>–</td><td>Gain required on the received pulses for proper measurement. Transducers: 1A, 1B, 2A, 2B … 8A, 8B</td></tr>
<tr><td>n029…n044</td><td>SNR:
Trd L1A…L8B</td><td>–</td><td>Signal Noise Ratio (in dB) of transducer: 1A, 1B, 2A, 2B … 8A, 8B</td></tr>
<tr><td>n045</td><td>OperationalStatus</td><td>–</td><td>Operational Status of the Flow Meter:
<table>
<tr><th>Hex Value
(Dec value)</th><th>Description</th></tr>
<tr><td>0x000 (0)</td><td>OK: Measurement data is reliable</td></tr>
<tr><td>0x001 (1)</td><td>Reduced Accuracy</td></tr>
<tr><td>0x002 (2)</td><td>Error – Non Fiscal: Specific paths in error resulting in non-fiscal measurement</td></tr>
<tr><td>0x004 (4)</td><td>Error – No Measurement: All paths in error</td></tr>
<tr><td>0x008 (8)</td><td>Error – Non fiscal high swirl: Potential accuracy issue due to high swirl & high velocity</td></tr>
<tr><td>0x010 (16)</td><td>Security:
Security switch is open</td></tr>
</table></td></tr>
<tr><td>n046</td><td>Status2
(C/R-status)</td><td>–</td><td>(Reserved for future use: Operational status of the optional inputs)</td></tr>
<tr><td>n047…n199</td><td>(undefined)</td><td>–</td><td>Undefined registers always return zero ()</td></tr>
</table>

Table 2: Short Word Registers

The meter identification code with the corresponding number of paths are registered:

Meter Name	Meter identification code	Number of Paths
CheckSonic Series 6	61	1
CheckSonic-2 Series 6	62	2
Q.Sonic-3 Series 6	63	3
Placeholder for future use	64	4
Q.Sonic-5 Series 6	65	5
Q.Sonic-plus	66	6
Q.Sonic-max	68	8
Vx.Sonic 6P	70	6
Vx.Sonic 3P	71	3

Table 3: Meter Identification

5.2.2 Long word registers

The following table lists the long word registers implemented in the Series 6 ultrasonic flow meters.

Address	Measured Value	Unit	Meaning
n200…n207	Diabits: L1…L8	–	Reserved for diagnostic information of path 1…8 [2]
n208	ForwardVolume	m^3	Accumulated actual volume ‘forward’: 8-digit counter

[2] ⇨ Table 5: Diagnostic Bits (p. 20)

n209	ReverseVolume	m^3	Accumulated actual volume ‘reverse’: 8-digit counter
n210	ForwardAlarmVolume	m^3	Accumulated actual error volume ‘forward’: 8-digit counter
n211	ReverseAlarmVolume	m^3	Accumulated actual error volume ‘reverse’: 8-digit counter
n212	Checksum1	–	Program (≙ firmware ROM) checksum
n213	Checksum2	–	Parameter set-up checksum
n214…n399	*(undefined)*	–	Undefined registers always return zero (0)

Table 4: Long Word Registers

The Diagnostic bits (Diagbits) are reserved diagnostic information of each path:

Hex Value	Dec value	Short Description	Meaning
0x000	0	No error	No Error
0x001	1	No_Pulse_A	TA: received signal stat under threshold (signal too small)
0x002	2	Pulse_Clip_A	TA: crossing clip threshold (signal too big)
0x004	4	Criterion_A	TA: pulse ratios error
0x008	8	SNR_A	TA: Signal to Noise ratio too low

Hex Value	Dec value	Short Description	Meaning
0x010	16	No_Pulse_B	TB: received signal stat under threshold (signal too small)
0x020	32	Pulse_Clip_B	TB: crossing clip threshold (signal too big)
0x040	64	Criterion_B	TB: pulse ratios error
0x080	128	SNR_B	TB: Signal to Noise ratio too low
0x100	256	VoS_range	Velocity of Sound out of range
0x200	512	VoG_range	Velocity of Gas out of range
0x400	1024	Ping_reject	Acceleration Error
0x800	2048	Performance_ Low	Performance too low
0x1000	4096	Path Substitution	A per-path gas velocity value was calculated by substitution
0x2000	8192	WGF_VoS	VoS ratio or VoS standard deviation out of range
0x4000	16384	WGF_VoG	VoG ratio out of range
0x8000	32768	Std_dev_hi_A	TA: standard deviation exceeds threshold
0x10000	65636	Std_dev_hi_B	TB: standard deviation exceeds threshold
0x20000	131072	DSP_Error	Error (or inconsistency) in internal (DSP) parameters
0x40000	262144	Tracking Active	Seeking signal

Table 5: Diagnostic Bits

5.2.3 Floating point registers

The following table lists the floating-point registers implemented in the UFM Series 6:

Address	Measured value	Unit	Meaning
n400	Speed of Sound	m/s	Speed of Sound (N-path average)
n401	Velocity of Gas	m/s	Velocity of Gas (N-path average)
n402	Pressure	kPa	Absolute pressure *(Reserved for future use)*
n403	Temperature	K	Absolute temperature *(Reserved for future use)*
n404	QLine	m^3/h	Volume flow at line conditions (≙ actual flow)
n405	QBase	Nm^3/h	Volume flow at base/ reference conditions (≙ corrected volume flow) *(Reserved for future use)*
n406…n413	Cpp: L1…L8	m/s	Speed of Sound per acoustic path (L1…L8)
n414…n421	Vpp: L1…L8	m/s	Velocity of Gas per acoustic path (L1…L8)
n422	Tspare	–	*(Reserved for future use)*
n423	Swirl angle	Degrees	Swirl angle estimation from the swirl paths
n424	Meter factor	Pulse/ m^3/h	Meter factor *(Reserved for future use)*

n425…n599	Undefined	–	Undefined registers always return zero (0)

Table 6: Floating Point Register

6 Examples

6.1 Example 1

Read long word register #200 (SequenceNum) from device #1. The query and response data streams are shown below.

Query

T3.5	Address	Function	Start Reg	# of Regs	Check sum	T3.5
	01	03	00 C8	00 01	05 F4	

Response

T3.5	Address	Function	Byte Count	Register Contents	Check sum	T3.5
	01	03	04	00 00 04 07	B9 31	

Notes

- Query and response data are shown as hexadecimal values
- Returned register value:
  SequenceNum = 1031 (hex: 00 00 04 07)

6.2 Example 2

Read short word registers #4 through #7 (SampleRate, ValidSamples (L1), ValidSamples(L2), ValidSamples (L3)) from device #1. The query and response data streams are shown below.

Query

T3.5	Address	Function	Start Reg	# of Regs	Check sum	T3.5
	01	03	00 04	00 04	05 C8	

Response

T3.5	Address	Function	Byte Count	Register Contents	Check sum	T3.5
	01	03	08	00 0F 00 0E 00 0D 00 0C	92 D0	

Notes

- Query and response data are shown as hexadecimal values.
- Returned register values:
  - SampleRate = 15 (hex: 00 0F)
  - ValidSamples (L1) = 14 (hex: 00 0E)
  - ValidSamples (L2) = 13 (hex: 00 0D)
  - ValidSamples (L3) = 12 (hex: 00 0C)

6.3 Example 3

Read floating-point register #400 (Speed of Sound) from device #16. The query and response data streams are shown below.

Query

T3.5	Address	Function	Start Reg	# of Regs	Check sum	T3.5
	16	03	01 90	00 01	86 FC	

Response

T3.5	Address	Function	Byte Count	Register Contents	Check sum	T3.5
	16	03	04	43 D2 C0 00	78 8F	

Notes

- Query and response data are shown as hexadecimal values.
- Returned register values:
  SpeedOfSound = 421.5 (hex: 43 D2 C0 00)

7 Alternative ‘16-bits’ list

7.1 Alternative ‘16-bits’ short word registers

The alternative ’16-bits’ short word list is the same as the standard Modbus.

⇨ Table 2: Short Word Registers (p. 17)

7.2 Alternative ‘16-bits’ long word registers

The following table lists the long word registers for the alternative ‘16-bits’ list. Each register uses 2 addresses.

Address	Measured Value	Units	Meaning
n200…n215	Diabits: L1…L8	–	Reserved for diagnostic information of path 1…8 [3]
n216	ForwardVolume	m^3	Accumulated actual volume ‘forward’: 8-digit counter
n218	ReverseVolume	m^3	Accumulated actual volume ‘reverse’: 8-digit counter
n220	ForwardAlarmVolume	m^3	Accumulated actual error volume ‘forward’: 8-digit counter
n222	ReverseAlarmVolume	m^3	Accumulated actual error volume ‘reverse’: 8-digit counter
n224	Checksum1	–	Program (≙ firmware ROM) checksum

[3] ⇨ Table 6: Diagnostic Bits (p. 20)

n226	Checksum2	–	Parameter set-up check-sum
n228…n399	Undefined	–	Undefined registers always return zero (0)

Table 7: Long Word Registers, alternative 16-bits list

7.3 Alternative ‘16-bits’ floating-point registers

The following table lists the floating-point registers for the alternative ’16-bits’ list. Each register uses two addresses.

Address	Measured value	Units	Meaning
n400	Speed of Sound	m/s	Speed of Sound (N-path average)
n402	Velocity of Gas	m/s	Velocity of Gas (N-path average)
n404	Pressure	kPa	Absolute pressure *(Reserved for future use)*
n406	Temperature	K	Absolute temperature *(Reserved for future use)*
n408	QLine	m^3/h	Volume flow at line conditions (≙ actual flow)
n410	QBase	Nm^3/h	Volume flow at base/ reference conditions (≙ corrected volume flow) *(Reserved for future use)*
n412…n426	Cpp: L1…L8	m/s	Speed of Sound per acoustic path (L1…L8)
n428…n442	Vpp: L1…L8	m/s	Velocity of Gas per acoustic path (L1…L8)

n444	Tspare	-	*(Reserved for future use)*
n446	Swirl Angle	Degrees	Swirl angle estimation from the swirl paths
n448	Meter Factor	Pulse/ m^3/h	Meter factor
n450…n599	Undefined	-	Undefined registers always return zero (0)

Table 8: Floating Point Register, alternative 16-bits list

7.4 Alternative ‘16-bits’ double float registers

The following table lists the double float registers for the alternative ‘16-bits‘ list. Each register uses 4 addresses.

Address	Measured value	Units	Meaning
n600… n628	Transit time A to B: L1 … L8	s	The pulse transit time per acoustic path from transducer A to transducer B
n632… n660	Std Dev: Transit time A to B: L1 … L8	s	The standard deviation of the pulse transit time per acoustic path from transducer A to transducer B
n664… n692	Transit time B to A: L1 … L8	s	The pulse transit time per acoustic path from transducer B to transducer A
n696… n724	Std Dev: Transit time B to A: L1 … L8	s	The standard deviation of the pulse transit time per acoustic path from transducer B to transducer A
n728…n799	Undefined	–	Undefined registers always return zero (0)

Table 9: Double Float Registers, alternative 16-bits list

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