Dynasonics®
Ultrasonic Flow Meters

Transit Time Ultrasonic Flow Meters

TFX-500w Clamp-On Meter Modbus RTU Protocol

Badger Meter

TTM-UM-02764-EN-03 (May 2021)

User Manual

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SUPPORTED FEATURES

TFX-500w meters include an EIA-485 port that is selectable for Modbus RTU or BACnet MS/TP protocol. The meter can be wired on a single daisy chain network and be queried for flow rate and totalizer readings along with diagnostic and other information.

For further information on the proper installation of the transmitter, see the TFX-500w user manual.

EIA-485 port on the TFX-500w automatically detects which lines are A and B for transmitting and receiving. The hardware automatically corrects for the RS485 negative and positive connections being swapped.

WIRING

RS485 Output

The RS485 feature allows up to 126 transmitters to be placed on a single three-wire cable up to 4000 feet. All transmitters are assigned a unique numeric address that allows all of the transmitters on the cable network to be independently accessed. Either Modbus RTU or BACnet MS/TP protocol is used to interrogate the transmitters.

Flow rate and total can be monitored over the digital communications bus.

When a USB programming cable is connected, the RS485 and frequency outputs are disabled.

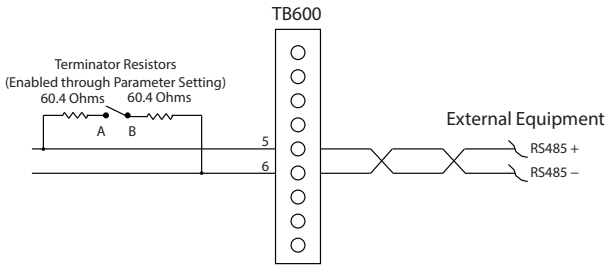

Figure 1: Typical RS485 interface

COMMUNICATION SETTINGS

To set up the meter for Modbus RTU:

1. Go to Main Menu > System Setup > Communications menu.
2. Select Modbus RTU.
3. Set the address (1…127).
4. Check that the baud rate, parity, stop bits and word order (endian) match the master device.
5. Enable the terminating resistor if the meter is the last device in the network. TFX-500w meters have a built-in resistor that can be selected through the communication setting.
6. Select the master timeout. TFX-500w meters can display a warning when the master device does not send a packet within the specified time. Setting the master timeout to 0 disables the warning.
7. Select which parameters the master device can write to:
   a. All coil outputs and read/write holding registers
   b. Coil outputs only (resets)
   c. None (read only).

REGISTERS/STARTING ADDRESS

It is important to know whether the master device uses starting addresses or registers/coils as these numbers are offset by 1. For example, holding output coil 00001 is starting address 00 (hex).

Function Codes

TFX-500w transmitters support the following function codes, as applicable:

01 (0x01 hex) Read Coils

03 (0x03 hex) Read Holding Registers

04 (0x04 hex) Read Input Registers

05 (0x05 hex) Write Single Coil

06 (0x06 hex) Write Single Register

16 (0x10 hex) Write Multiple Registers

Word Order/Endian

Each Modbus holding register represents a 16-bit integer value (2 bytes). The official Modbus standard defines Modbus as a 'big-endian' protocol where the most significant byte of a 16-bit value is sent before the least significant byte. For example, the 16-bit hex value of '1234' is transferred as '12''34'.

Beyond 16-bit values, the protocol itself does not specify how 32-bit (or larger) numbers that span over multiple registers should be handled. It is very common to transfer 32-bit values as pairs of two consecutive 16-bit registers in little-endian word order. For example, the 32-bit hex value of '12345678' is transferred as '56''78''12''34'. The register bytes are still sent in big-endian order per the Modbus protocol, but the 16-bit registers are sent in little-endian order. Alternatively, some devices store and transfer the Modbus registers in big-endian word order. For example, the 32-bit hex value of '12345678' is transferred as '12''34''56''78'.

As long as the transferring and receiving device transmit the data in the same manner, it does not matter in which order the words are sent. The word order is selectable in the TFX-500w meter. This option is useful in applications where the Modbus master cannot be configured for endianness.

MODBUS REGISTERS AND COILS

Registers

Descriptive Name	Description	Network Access	Integer and Long Integer	Floating Point Single Precision 32-bit	Floating Point Double Precision 64-bit
READINGS					
Flow Rate on Screen	Flow rate displayed on home screen. Units are based on the selections for the home screen.	R	40001-40002	40601-40602	41201-41204
Velocity on Screen	Fluid velocity displayed on home screen. Units are based on the selections for the home screen.	R	40003-40004	40603-40604	41205-41208
Delta Time Filtered (ns)	Time of flight difference between upstream and downstream used to calculated the flow rate. Units are nanoseconds.	R	40005-40006	40605-40606	41209-41212
Flow Rate (gal/min)	Flow rate in gallons/minute.	R	40201-40202	40801-40802	41401-41404
Velocity (ft/sec)	Fluid velocity in feet/second.	R	40203-40204	40803-40804	41405-41408
Flow Rate (l/min)	Flow rate in liters/minute.	R	40401-40402	41001-41002	41601-41604
Velocity (m/sec)	Fluid velocity in meters/second.	R	40403-40404	41003-41004	41605-41608
TOTALS					
Net Flow Totalizer	Total volume as forward flow minus reverse flow. A negative total results when reverse flow is greater than forward flow. Units are based on the selections for the totalizer on the home screen.	R	42001-42002	42301-42302	42601-42604
Positive Flow Totalizer	Total volume of flow in forward direction. Reverse flow is not accounted for in the total. Units are based on the selections for the totalizer on the home screen.	R	42003-42004	42303-42304	42605-42608
Negative Flow Totalizer	Total volume of flow in reverse direction. Forward flow is not accounted for in the total. Units are based on the selections for the totalizer on the home screen.	R	42005-42006	42305-42306	42609-42612
Gross Flow Totalizer	Total volume of forward and reverse flow. Units are based on the selections for the totalizer on the home screen.	R	42007-42008	42307-42308	42613-42615
Totalizer Overflow Counter (Net)	Number of times the net flow total overruns.	R	42009-42010	—	—
Totalizer Overflow Counter (Positive)	Number of times the positive flow total overruns.	R	42011-42012	—	—
Totalizer Overflow Counter (Negative)	Number of times the negative flow total overruns.	R	42013-42014	—	—
Totalizer Overflow Counter (Gross)	Number of times the gross flow total overruns.	R	42015-42016	—	—
Net Flow Totalizer (gal)	Total volume as forward flow minus reverse flow. A negative total results when reverse flow is greater than forward flow.	R	42101-42102	42401-42402	42701-42704
Positive Flow Totalizer (gal)	Total volume of flow in forward direction. Reverse flow is not accounted for in the total.	R	42103-42104	42403-42404	42705-42708
Negative Flow Totalizer (ga)	Total volume of flow in reverse direction. Forward flow is not accounted for in the total.	R	42105-42106	42405-42406	42709-42712
Gross Flow Totalizer (gal)	Total volume of forward and reverse flow.	R	42107-42108	42407-42408	42713-42716
Totalizer Overflow Counter (Net)	Number of times the net flow total overruns.	R	42109-42110	—	—
Totalizer Overflow Counter (Positive)	Number of times the positive flow total overruns.	R	42111-42112	—	—
Totalizer Overflow Counter (Negative)	Number of times the negative flow total overruns.	R	42113-42114	—	—
Totalizer Overflow Counter (Gross)	Number of times the gross flow total overruns.	R	42115-42116	—	—
Net Flow Totalizer (liters)	Total volume as forward flow minus reverse flow. A negative total results when reverse flow is greater than forward flow.	R	42201-42202	42501-42502	42801-42804
Positive Flow Totalizer (liters)	Total volume of flow in forward direction. Reverse flow is not accounted for in the total.	R	42203-42204	42503-42504	42805-42808
Negative Flow Totalizer (liters)	Total volume of flow in reverse direction. Forward flow is not accounted for in the total.	R	42205-42206	42505-42506	42809-42812
Gross Flow Totalizer (liters)	Total volume of forward and reverse flow.	R	42207-42208	42507-42508	42813-42816
Totalizer Overflow Counter (Net)	Number of times the net flow total overruns.	R	42209-42210	—	—
Totalizer Overflow Counter (Positive)	Number of times the positive flow total overruns.	R	42211-42212	—	—
Totalizer Overflow Counter (Negative)	Number of times the negative flow total overruns.	R	42213-42214	—	—
Totalizer Overflow Counter (Gross)	Number of times the gross flow total overruns.	R	42215-42216	—	—

Descriptive Name	Description	Network Access	Integer and Long Integer	Floating Point Single Precision 32-bit	Floating Point Double Precision 64-bit
HOME SCREEN UNITS					
Flow Rate Units	Flow rate units on home screen as defined in parameter settings	R	43001	—	—
Flow Rate Decimal	Number of digits after the decimal of flow rate on home screen. Use with long integer format.	R	43002	—	—
Velocity Units	Velocity units on home screen as defined in parameter settings	R	43003	—	—
Flow Total Units	Total volume units on home screen as defined in parameter settings	R	43004	—	—
Flow Total Decimal	Number of digits after the decimal of flow rate on home screen. Use with long integer format.	R	43005	—	—
SETUP					
Low Flow Cutoff	Setting to display flow rate as zero & stop totalizing when flow rate goes below this value	R/W	—	44001-44002	—
Low Signal Cutoff	Setting to display flow rate as zero & stop totalizing when signal strength goes below this value and trigger a low signal error message	R/W	44003	—	—
High Signal Cutoff	Setting to display flow rate as zero & stop totalizing when signal strength goes above this value and trigger an oversaturate error message	R/W	44004	—	—
DIAGNOSTICS - Alarms					
Active Failed Conditions	Message code corresponds to the bit (ex. F02 is bit 02)	R	45001-45007	—	—
Active Out of Specification Conditions	Message code corresponds to the bit (ex. S02 is bit 02)	R	45008-45014	—	—
Active Check Function Conditions	Message code corresponds to the bit (ex. C02 is bit 02)	R	45015-45021	—	—
Alarm History	Alarm History is a first-in-first-out buffer of 64 errors, alarms and events messages. Each message contains two registers for the index, 1 register for the Alarm/Event code type and 1 register indicating whether the alarm set or cleared. Registers 45033-45036 contain the most recent Alarm/Event message. Register 45285-45288 contains the oldest Alarm/Event message.	R	45003-45288	—	—
DIAGNOSTICS - Measurements					
Signal Strength	Indicates the strength of the ultrasonic signal	R	45501	—	—
Current Output Source	Parameter assigned to Current Output #1. [1]	R	45601	—	—
Current Output	Current in mA of Current Output #1.	R	—	45602-45603	—
Output #1 Mode	Operation mode of Digital Output #1. [1]	R	45701	—	—
Output #1 Source	Parameter assigned to Digital Output #1. [1]	R	45702	—	—
Output #1 Status	Status of Digital Output #1. [1]	R	45703	—	—
Output #2 Mode	Operation mode of Digital Output #2. [1]	R	45704	—	—
Output #2 Source	Parameter assigned to Digital Output #2. [1]	R	45705	—	—
Output #2 Status	Status of Digital Output #2. [1]	R	45706	—	—
Input Mode	Operation mode of Digital Input. [1]	R	45901	—	—
Input Active State	Indicates the voltage level to make the input active. [1]	R	45902	—	—
Input Status	Status of Digital Input. [1]	R	45903	—	—
COMMUNICATION					
Modbus Access	Modbus Access Type	R	46001	—	—
Modbus Active Timeout	Defines the maximum time that master will poll the meter. If the meter does not see any communication from the master in the time specified, a message will trigger. READ/WRITE	R/W	46002	—	—
Termination Resistor	Selection to enable or disable the internal termination resistor (RS485 devices only)	R/W	46003	—	—
IDENTIFICATION					
Tag Identification *	String setting to identify the meter	R	47001	—	—
Part Number *	Part number of the meter	R	47065	—	—
Serial Number *	Serial number of the meter	R	47129	—	—
Firmware Version *	Firmware version of the meter	R	47193	—	—
Calibration Date *	Date the meter was last calibrated at factory	R	47257	—	—
Date Code *	Date the meter was manufactured	R	47321	—	—

* Represented as a variable length ASCII string with NULL terminator.

Coils

Descriptive Name	Description	Network Access	Coil
ACTIONS			
Reset Totalizers	Resets all flow totals in meter to zero	W	00001
Unlatch Alarms	Unlatches outputs in alarm latched state	W	00002
Clear Alarm History	Clears all errors, alarms and event codes from alarm history	W	00003
Reboot Device	Reboots the meter	W	00004

ENUMERATIONS

Parameter	Enumeration	Value
UNITS OF MEASURE		
Flow Rate Units	Liters per second	0
	Liters per minute	1
	Liters per hour	2
	Cubic meters per second	3
	Cubic meters per minute	4
	Cubic meters per hour	5
	Cubic feet per second	6
	Cubic feet per minute	7
	Cubic feet per hour	8
	Gallons per second	9
	Gallons per minute	10
	Gallons per hour	11
	Mega gallons per day	12
	United Kingdom gallons per second	13
	United Kingdom gallons per minute	14
	United Kingdom gallons per hour	15
	Barrels per minute	18
	Mega United Kingdom gallons per day	19
	Barrels per day	20
	Acre feet per day	21
	Fluid barrels per day	22
	Imperial barrels per day	23
Velocity Units	Meters per second	0
	Feet per hour	11
Flow Total Units	Liters	0
	Hectoliters	1
	Cubic meters	2
	Cubic feet	3
	Gallons	4
	Mega gallons	5
	United Kingdom gallons	6
	Acre feet	9
	Oil barrel	10
	Mega United Kingdom gallons	11
	Liquid barrel	12
	Feet	13
	Meters	14
	Kilograms	15

Parameter	Enumeration	Value
INPUTS/OUTPUTS		
Current Output Source	Disabled	0
	Flow rate	1
	Velocity	2
	Signal strength	3
	Test mode	7
Digital Output Mode	Disabled	0
	Frequency	1
	Pulse totalizer	2
	Direction status	3
	Mode alarm	4
Digital Output Source	Disabled	0
	Flow rate	1
	Velocity	2
	Test mode	3
Digital Output Status	Off	0
	On	1
	Frequency	2
	Pulse	3
	Disabled	4
Input Mode	Disabled	0
	Reset flow total	1
	Unlatch alarm	2
Input Active State	Active high	0
	Active low	1
Input Status	Inactive	0
	Active	1
COMMUNICATION		
Termination Resistor	Disabled	0
	Enabled	1
ACTIONS		
Reset Totalizers	Disabled	0
	Enabled	1
Unlatch Alarms	Disabled	0
	Enabled	1
Clear Alarm History	Disabled	0
	Enabled	1
Reboot Device	Disabled	0
	Enabled	1

ALARM EVENT CODES

Alarm ID	Unique Alarm Identifier
1 = F01	Bootloader Error
2 = F02	Electronic Error Watchdog
3 = F03	Electronic Error Voltage
10 = F10	Low Signal
11 = F11	High Signal
101 = S01	Electronic Error Watchdog Warning
102 = S02	Default Failed
110 = S10	mA Too High
120 = S20	Freq High (Output #1)
121 = S21	Freq High (Output #2)
130 = S30	Pulse High (Output #1)

Alarm ID	Unique Alarm Identifier
131 = S31	Pulse High (Output #2)
140 = S40	High Flow (Output #1)
141 = S41	High Flow (Output #2)
145 = S45	Low Flow (Output #1)
146 = S46	Low Flow (Output #2)
150 = S50	Totalizer Overflow
160 = S60	Modbus Timeout
201 = C01	Current Test
210 = C10	Frequency Test (Output #1)
211 = C11	Pulse Test (Output #1)
212 = C12	Switch Test (Output #1)

Alarm ID	Unique Alarm Identifier
220 = C20	Frequency Test (Output #2)
221 = C21	Pulse Test (Output #2)
222 = C22	Switch Test (Output #2)
230 = C30	Simulation Mode
301 = I01	Power On
311 = I11	Zero
312 = I12	Factory Calibration
313 = I13	Field Calibration
321 = I21	Firmware Changed
331 = I31	Flow Total Reset

TROUBLESHOOTING

Code	Description	Recommended Action
S60 MODBUS TIMEOUT Modbus master device communication packet.	Check master device poll rate and offline status.	Check the recommended actions listed for no communication symptom. If the master device communicates less frequently, change the Master Timeout to a larger time period.

Symptoms	Possible Causes	Recommended Action
No communication	Transmit and receive are wired incorrectly.	Check the network wiring from the meter.
	Baud rate does not match master.	Check the baud rate of the master and ensure the baud rate of the meter matches the master. The master is often a PLC or BAS. If it does not match, change the Baud Rate setting in the Modbus RTU Communication menu.
	Parity and stop bits do not match the master.	Check that the settings are compatible with the master. If it does not match, change the Parity or Stop Bit setting in the Modbus RTU Communication menu.
	Slave address is not unique. Another device is on the network with the same address.	Check the addresses of the other devices on the network. Check that the slave address is not 1.
	Cable is not terminated properly.	For Modbus RTU on EIA-485 network, devices can be daisy chained together. The two devices on the end of the chain need to have terminated resistors. Terminating resistors can be enabled through the Modbus RTU Communication menu.
	Cable or chain longer than 4000 feet.	For Modbus RTU on EIA-485 network, the full length of the network cannot exceed 4000 feet. Check the length of the cabling.
Intermittent communication	Cable is not properly shielded.	Communication cables must have shielding to protect the quality of the communication signals from electro-magnetic interference (EMI). Check that the cable has a shield. Typically, one end of the shield drain is connected to a clean ground to dissipate EMI and prevent ground loops. However, depending on the ground quality, cable length and type of interference, other methods can be employed.
	Cable routed near power cables such a variable frequency drives.	Cables carrying high currents cause a high degree of electro-magnetic interference that can interfere with the quality of the communication signals. Route signal cables away from power cables.
	Cable is not terminated properly.	For Modbus RTU on EIA-485 network, devices can be daisy chained together. The two devices on the end of the chain need to have terminated resistors. Terminating resistors can be enabled through the Modbus RTU Communication menu.
	Cable or chain longer than 4000 feet.	For Modbus RTU on EIA-485 network, the full length of the network cannot exceed 4000 feet. Check the length of the cabling.
Unable to read specific parameters correctly	Word order (endian) or data type/format	In Modbus RTU, floating point, long integers and string character registers may have the word order (endian) swapped. Check the data type and endian of the master and verify that the register in the meter matches the matches. If it does not match, change the Word Order setting in the Modbus RTU Communication menu.
Unable to write specific parameters	Transmitter is set up for read only or is set up for read and write only to resets	These settings are commonly used to prevent accidental or unauthorized changes to the a device over a network. Check the Access setting in the Modbus RTU menu.
	Word order (endian) or data type/format	In Modbus RTU, floating point, long integers and string character registers may have the word order (endian) swapped. Check the data type and endian of the master and verify that the register in the meter matches the matches. If it does not match, change the Word Order setting in the Modbus RTU Communication menu.

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