



**MODBUS Message Protocol**

FOR

**MODEL FT3**

**THERMAL MASS FLOWMETER & TEMPERATURE TRANSMITTER**

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## 1. INTRODUCTION

### 1.1 Scope

This document describes the MODBUS implementation for the Fox Thermal Instruments' FT3 Mass Flow Meter based on the Modicon Modbus Protocol (PI-MBUS-300 Rev. J).

MODBUS is an application layer messaging protocol that provides client/server communications between devices. MODBUS is a request/reply protocol and offers services specified by function codes.

The size of the MODBUS Protocol Data Unit is limited by the size constraint inherited from the first MODBUS implementation on Serial Line network (max. RS485 Application Data Unit = 256 bytes). Therefore, MODBUS PDU for serial line communication = 256 – Server address (1 byte) – CRC (2 bytes) = 253 bytes.

RS-485 ADU = 253 + Server address (1 byte) + CRC (2 bytes) = 256 bytes.

For more information on MODBUS go to the web site <http://www.modbus.org/>

## 2. MODBUS PROTOCOL

### Command Request:

<Meter Address> <Function code> <Register start address high> <Register start address low>  
<Register count high> <Register count low> <CRC high><CRC low>

### Command Response:

<Meter Address> <Function code> <Data byte count> <Data register high> <Data register low> ...  
<Data register high> <Data register low> <CRC high> <CRC low>

Note: The data shown in brackets < > represent one byte of data.

## 3. FT3 COMMANDS SUPPORTED

The FT3 supports the following commands:

- 1) Function 03: Read holding registers.
- 2) Function 04: Read input register.
- 3) Function 06: Preset single register.

### 3.1 Read Holding Registers (command 03)

This command reads the basic variables from the FT3 and has the following format:

**Command Request:**

<Meter Address> <Function code=03> <Register start address high> <Register start address low>  
 <Register count high> <Register count low> <CRC high> <CRC low>

**Command Response:**

<Meter Address> <Function code=03> <Byte count> <Data high> <Data low>...  
 <Data high> <Data low> <CRC high> <CRC low>

**Table 3.1: FT3 Modbus register assignments for command 0x03**

Register Address	Modbus Address	Data type	Scaling	Comment
0x00	40001	Flow in Eng unit (low)	No	Mass flow in selected unit
0x01	40002	Flow in Eng unit (high)	No	
0x02	40003	Total (low)	No	Total in selected unit
0x03	40004	Total (High)	No	
0x04	40005	Temperature (low)	*10	Temperature in selected unit * 10
0x05	40006	Temperature (high)	*10	
0x06	40007	Elapsed time (low)	*10	Elapsed time in hours * 10
0x07	40008	Elapsed time (high)	*10	
0x08	40009	Velocity (Low)	No	Velocity in Nm/hr
0x09	40010	Velocity (high)	No	
0x0A	40011	Flow in Eng unit * 10	*10	Mass flow in selected unit * 10
0x0B	40012	Flow in Eng unit *100	*100	Mass flow in selected unit * 100
0x0C	40013	Total *100	*100	Total in selected unit * 100
0x0D	40014	Total2 (low, 2 gas curves only)	No	Total #2 for 2 gas curves
0x0E	40015	Total2 (high, 2 gas curves only)	No	Total #2 for 2 gas curves
0x0F	40016	Status	No	Status
0x10	40017	Status2	No	Status 2
0x11	40018	Spare/ Not used		
0x12	40019	Spare/ Not used		
0x13	40020	Flow in Eng Unit (float, upper 16 bits)	No	Mass flow in selected unit
0x14	40021	Flow in Eng Unit (float , lower 16 bits)	No	Mass flow in selected unit
0x15	40022	Total in Eng Unit (float, upper 16 bits)	No	Total in selected unit
0x16	40023	Total in Eng Unit (float, lower 16 bits)	No	Total in selected unit
0x17	40024	Total#2 for 2 gas curve (float, upper 16 bits)	No	Total in selected unit
0x18	40025	Total#2 for 2 gas curve (float, lower 16 bits)	No	Total in selected unit
0x19	40026	Temperature in selected unit (float, upper 16 bits)	No	Temperature in selected unit
0x1A	40027	Temperature in selected unit (float, lower 16 bits)	No	Temperature in selected unit
0x1B	40028	Elapsed time in hours (float, upper 16 bits)	No	Elapsed time in hours
0x1C	40029	Elapsed time in hours (float, lower 16 bits)	No	Elapsed time in hours
0x1D	40030	Velocity in selected unit (float, upper 16 bits)	No	Velocity in selected unit
0x1E	40031	Velocity in selected unit (float, lower 16 bits)	No	Velocity in selected unit
0x1F	40032	CAL-V Diff (float upper 16 bits)	No	CAL-V Diff
0x20	40033	CAL-V Diff (float lower 16 bits)	No	CAL-V Diff
0x21	40034	CAL-V Set (float upper 16 bits)	No	CAL-V Set
0x22	40035	CAL-V Set (float upper 16 bits)	No	CAL-V Set

0x23	40036	Spare/ Not used		
0x24	40037	Total 24 hrs, Last total record, low register	No	Tot24hrs: Last total record
0x25	40038	Total 24 hrs, Last total record, high register	No	Tot24hrs :Last total record
0x26	40039	Total 24 hrs, Current Day (0-6)	No	Tot24hrs :Current Day
0x27	40040	Total 24 hrs, Current Hour (0-23)	No	Tot24hrs: Current Hour
0x28	40041	Total 24 hrs, Record day 1 , low register	No	Tot24hrs: Record day 1
0x29	40042	Total 24 hrs, Record day 1 , high register	No	Tot24hrs: Record day 1
0x2A	40043	Total 24 hrs, Record day 2 , low register	No	Tot24hrs: Record day 2
0x2B	40044	Total 24 hrs, Record day 2 , high register	No	Tot24hrs :Record day 2
0x2C	40045	Total 24 hrs, Record day 3 , low register	No	Tot24hrs: Record day 3
0x2D	40046	Total 24 hrs, Record day 3 , high register	No	Tot24hrs :Record day 3
0x2E	40047	Total 24 hrs, Record day 4 , low register	No	Tot24hrs :Record day 4
0x2F	40048	Total 24 hrs, Record day 4 , high register	No	Tot24hrs :Record day 4
0x30	40049	Total 24 hrs, Record day 5 , low register	No	Tot24hrs: Record day 5
0x31	40050	Total 24 hrs, Record day 5 , high register	No	Tot24hrs: Record day 5
0x32	40051	Total 24 hrs, Record day 6 , low register	No	Tot24hrs :Record day 6
0x33	40052	Total 24 hrs, Record day 6 , high register	No	Tot24hrs :Record day 6
0x34	40053	Total 24 hrs, Record day 7 , low register	No	Tot24hrs :Record day 7
0x35	40054	Total 24 hrs, Record day 7 , high register	No	Tot24hrs: Record day 7
0x36	40055	Total 24 hrs, Last Total , low register	No	Tot24hrs :Last Total
0x37	40056	Total 24 hrs, Last Total , high register	No	Tot24hrs :Last Total
0x38	40057	Zero Check Mean (float, float upper 16 bits)	No	Zero Check Mean value
0x39	40058	Zero Check Mean (float, float lower 16 bits)	No	Zero Check Mean value
0x3A	40059	Zero Check Stdev (float, float upper 16 bits)	No	Zero Check Standard deviation
0x3B	40060	Zero Check Stdev (float, float lower 16 bits)	No	Zero Check Standard deviation
0x3C	40061	Zero Check Pipe Ref (float, float upper 16 bits)	No	Zero Check Pipe Reference
0x3D	40062	Zero Check Pipe Ref (float, float lower 16 bits)	No	Zero Check Pipe Reference
0x3E	40063	Zero Check Pipe Diff (float, float upper 16 bits)	No	Zero Check Pipe Difference %
0x3F	40064	Zero Check Pipe Diff (float, float lower 16 bits)	No	Zero Check Pipe Difference %
0x40	40065	Zero Check Bottle Ref (float, float upper 16 bits)	No	Zero Check Bottle Reference
0x41	40066	Zero Check Bottle Ref (float, float lower 16 bits)	No	Zero Check Bottle Reference
0x42	40067	Zero Check Bottle Diff (float, float upper 16 bits)	No	Zero Check Bottle Difference %
0x43	40068	Zero Check Bottle Diff (float, float lower 16 bits)	No	Zero Check Bottle Difference %
0x44	40069	Zero Check Test Time (integer, lower 16 bits)	No	Zero Check Test Time (sec)

*\* The data in registers with scaling must be multiplied by 10 or 100 as indicated to be scaled properly.*

Note: Registers A, B & C are provided to get more resolution for low flow and total. When the value exceeds the maximum value of the 16 bit registers, they will be frozen with all 16 bits set. It is also possible to use the velocity to calculate the flow in engineering units by using the pipe area and conversion factor for the selected unit.

**Example:**

Request data register at starting address 0x0000 and specifying only 1 register:

<0x01> <0x03> <0x00> <0x00> <0x00> <0x01> <0x0a> <0x84>

**Command Response:**

<0x01> <0x03> <0x02> <xx> <xx> <CRC high> <CRC low>

Where xx xx is the data register value.

### 3.2 Read Input Register (FT3 status and status 2 command 04)

This command is used to report the FT3 status information.

**Command Request:**

<Meter Address> <Function code=04> <Register address =0> <Register address =0>  
<Register count =0> <Register count =1> <CRC high> <CRC low>

**Command Response:**

<Meter Address> <Function code=04> <Byte count=2> <Status High><Status Low>  
<CRC high> <CRC low>

The FT3 supports only reading of the FT3 status. The register address must be set to zero (Modbus Address 30001) and the register count must be set to 1.

**Table 3.2.1: Status bits definitions (Modbus Address 30001)**

Bit	Definition	Comment
0	Power up indication	Reset when out of the power up sequence
1	Flow rate reached high limit threshold	Set limit to zero to disable
2	Flow rate reached low limit threshold	Set limit to zero to disable
3	Temperature reached high limit threshold	Set limit to zero to disable
4	Temperature reached low limit threshold	Set limit to zero to disable
5	Sensor reading is out of range	Check sensor wiring
6	Velocity flow rate outside of calibration table	Check sensor wiring
7	Incorrect Settings	Check settings
8	In simulation mode	Set simulation value to 0 to disable
9	Frequency output is out of range	Check frequency output settings
10	Analog 4-20 mA for flow is out of range	Check analog output settings
11	Analog 4-20 mA for temperature is out of range	Check analog output settings
12	Busy	Check wiring from RS485 to Anybus IC
13	Bridge Shutdown	Check RTC
14	CRC error	Check parameters and reset CRC
15	Tot Error	Reset total

**Table 3.2.2: Status 2 bits definitions (Modbus Address 30002)**

Bit	Definition	Comment
0	CAL-V in progress	CAL-V in progress
1	ADC12<>ADC24 too far apart	Internal ADC calibration out of range
2	CAL-V Diff out of range	CAL-V Diff out of range
3	Curve #2 Selected (for 2 gas curve only)	Curve #2 Selected (2 gas curve only)
4	Zero Check Failed	Zero Check Failed
5	CAL-V/Zero Check Aborted	CAL-V/Zero Check Aborted

### 3.3 Preset Single Register (command 06)

This command is used to perform miscellaneous functions such as clearing the totalizer and initiating diagnostic operations. The register address is 0x0a (10 decimal, Modbus=40011) and the data to write is described on the following page.

**Command Request:**

<Meter Address> <Function code=06> <Register address high=0x00> <Register address low=0x0a>  
<Register data high=0x00> <Register data low =0x02> <CRC high> <CRC low>

**Command Response:**

<Meter Address> <Function code=06> <Register address =0x00> <Register address =0x0a>  
<Register data=0x00> <Register data =0x02> <CRC high> <CRC low>

**Reset Total:**

Address = 40011, data = 0x02

This command is used to clear the Totalizer and elapsed time registers

**Reset 24 hours Total:**

Address=40011, data = 180 (0xB4)

This command reset the 24 hours 7 days record including the day and hours counters

**Reset 24 hour time:**

Address=40011, data = 181 (0xB5)

This command reset the 24 hours day and hours counters

**24 hours Event:**

Address=40011, data = 182 (0xB6)

This command generates a 24 hours event, the same way as when the 24 hours counter rolls over.

This may be useful to record total over a shorter period.

**CAL-V Verify:**

Address=40011, data = 161 (0xA1)

This command initiates a “CAL\_V Verify. This operation may take 4 minutes to complete and will stop the meter from calculation flow. The Status2 bit D0 may be monitored to check for completion.

**Zero Check In-Pipe Verify:**

Address=40011, data = 173 (0xAD)

This command initiates a “Zero Check In-PipeVerify”. This operation does not affect flow calculations. The register 40069 may be monitored to check for completion.

**Zero Check In-Bottle Verify:**

Address=40011, data = 176 (0xB0)



This command initiates a “Zero Check In-Bottle Verify”. This operation does not affect flow calculations. The register 40069 may be monitored to check for completion.

**Switch to Curve #1:**

Address=40011, data = 170 (0xAA)

This command initiates a command to switch to gas curve 1 when configured for 2 gas curves. Make sure that the input contact is not programmed for curve switching

**Switch to Curve #2:**

**Address=40011, data = 171 (0xAB)**

This command initiates a command to switch to gas curve 2 when configured for 2 gas curves. Make sure that the input contact is not programmed for curve switching

## **4. RS-485 WIRING**

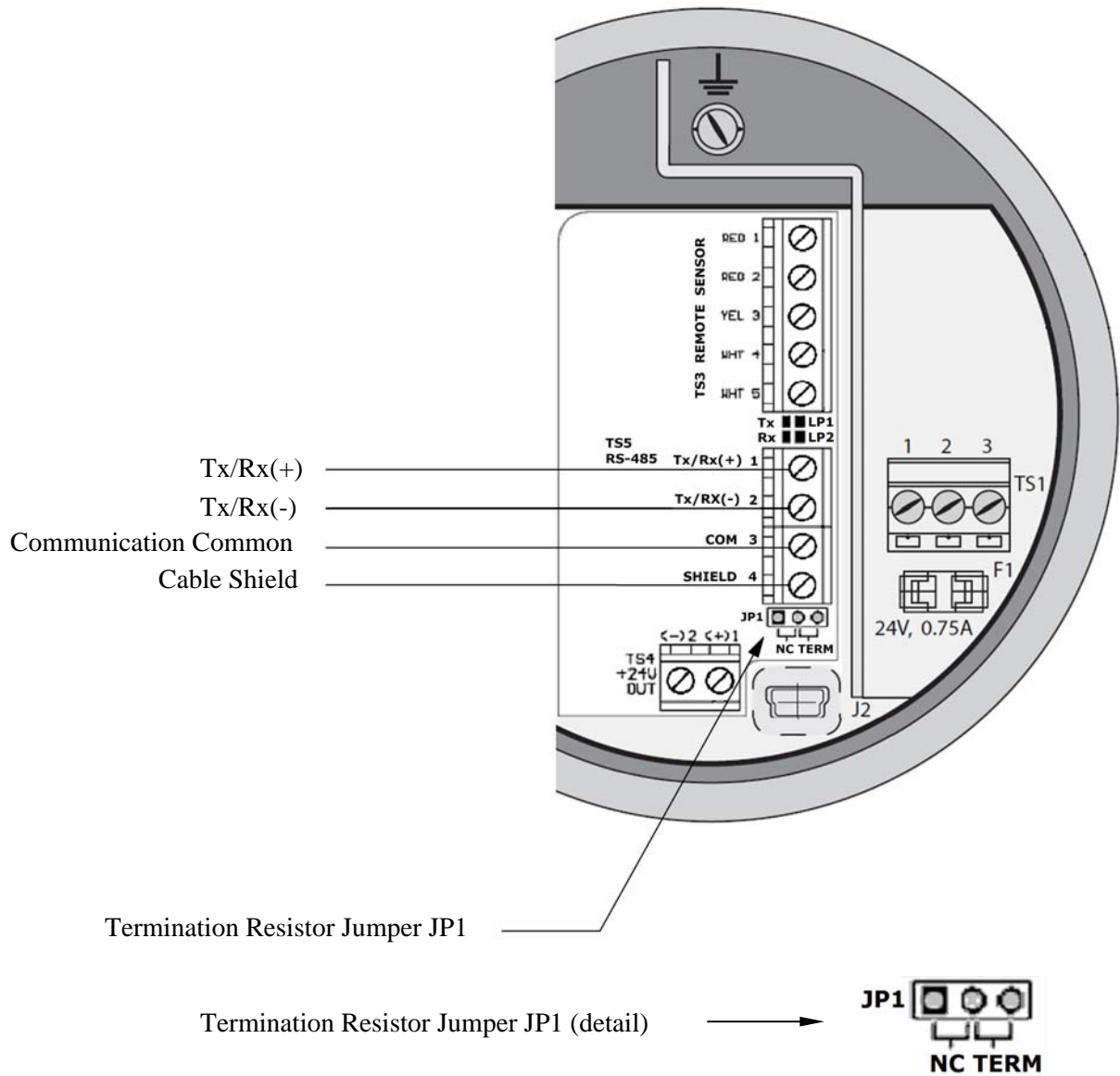
The RS-485 Modbus communication wiring connections are made to terminal block TS5 of the FT3 RS-485 board. The Tx/Rx+ signal must connect to pin 1, Tx/Rx- must connect to pin 2, communication common to pin 3, and the cable shield to pin 4 as show in Figure 4.1.

### **4.1 RS-485 Termination Resistor**

Connect a termination resistor across the receive/transmit signals of the last device on the RS-485 communication line. To connect the 121ohm termination resistor on the FT3, set jumper JP1 to the TERM position.

Disconnect the termination resistor on all other external RS-485 devices. The termination resistor of the FT3 is disconnected by setting jumper JP1 to the NC (Not Connected) position. See figure 4.1.

Figure 4.1: RS-485 Wiring and Termination Resistor Configuration



## 5. PROGRAMMING USING THE LOCAL DISPLAY

### 5.1 Entering the programming mode

To enter the programming mode, press the F1 or F2 keys repeatedly in the normal running mode until the following screen is displayed.

SET PARAMETERS ?			
No			Yes
F1	F2	F3	F4

Press **YES (F4)** and the following screen will prompt the user to enter the password if enabled:

PASWD:_			
UP	DN	NXT	OK
F1	F2	F3	F4

Enter the correct password (Note: the default password for Level 1 is 1234).

PASWD=_			
UP	DN	NXT	OK
F1	F2	F3	F4

Press the **UP (F1)** or **DN (F2)** keys to scroll to a new digit or character. The cursor indicates the selected digit. Press **NXT (F3)** to select the next digit and **OK (F4)** to accept the entry.

Note: If the **UP (F1)** or **DN (F2)** keys are held down for more than 1 second, new digits will be selected at an increasing rate.

If an incorrect password is entered, the message “Wrong Password” will be displayed for a few seconds and then return to the programming entry screen. If the password is accepted, the following screen will be displayed:

SET PARAMETERS			
I/O	FLO	DSP	EXIT
F1	F2	F3	F4

This is the base screen of the programming mode.

Note: If the programming mode must be exited, press **EXIT (F4)** repeatedly until the “Normal Mode” screen is displayed.

## 5.2 Communication Protocol and Parameters

To program the communication parameters, press **I/O (F1)** key from the base screen of the programming mode.

SET I/O			
I/O	FEQ	420	EXIT
F1	F2	F3	F4

Then press **I/O (F1)** again:

SET I/O			
COM	CTC		EXIT
F1	F2	F3	F4

Then press **COM (F1)** to select communication parameters

Set Bus protocol:

Bus=Modbus			
NXT			OK
F1	F2	F3	F4

Press **NXT (F1)** repeatedly until the correct selection is shown and then press **OK (F4)** to accept the setting.

Selections are: “Modbus”  
 “HART”  
 “None”

Set Baud Rate communication parameter:

Baud=9600			
NXT			OK
F1	F2	F3	F4

Press **NXT (F1)** repeatedly until the correct Baud Rate is shown and then press **OK (F4)** to accept the setting.

Selections are: “19200”  
 “9600”  
 “4800”  
 “2400”  
 “1200”

Parity=EVEN	
NXT	OK

F1	F2	F3	F4
----	----	----	----

Press **NXT (F1)** repeatedly until the correct Parity is displayed and press **OK (F4)** to accept the setting.

Selections are: “NONE”  
 “ODD”  
 “EVEN”

Set Unit Address:

Address=01	
CHG	OK

F1	F2	F3	F4
----	----	----	----

Press **CHG (F1)** key to change the Modbus communication Address.

Address=01			
UP	DN	NXT	OK

F1	F2	F3	F4
----	----	----	----

Press the **UP (F1)** or **DN (F2)** keys to select the value for the Modbus Address. The cursor points to the selected digit. Press **NXT (F3)** to select the next digit and **OK (F4)** to accept the entry.

Note: If the **UP (F1)** or **DN (F2)** keys are held down for more than 1 second, new digits will be selected at an increasing rate.

It is very important that there are not two devices with the same Modbus address. To avoid conflicts, each Modbus slave must have a unique address. Range is from 1 to 247.

Note: Power to the FT3 must be cycled off and on for new Modbus settings to take effect.

