Application Note

FLOW COMPUTER / MODBUS RTU / Addressing, Wiring & Programming

Introduction

This document describes programming MODBUS RTU with SoundWater flowmeters, as well as wiring RS485 half duplex (two wire) and full duplex (four wire) networks.

Background

MODBUS RTU

MODBUS© Protocol is a messaging structure, used to establish master-slave communication between electronic devices. A MODBUS message sent from a master to a slave call a "request" contains the address of the slave, command, command data, and a check sum. A MODBUS message sent from a slave to a master is called a "response". A slave may only respond to the master, i.e., it may not initiate a request to the master. Whether request or response, the message is a packet of data bytes called an Application Data Unit (ADU). The ADU is simply a packet of bytes containing the slave id, command, command data, and check sum.

The ADU fields all have byte size requirements (shown in figure 1). The Slave Id is one byte (0-FF), Function Code is one byte (0-FF), data may be N bytes, and the check sum must be two bytes (0 - FFFF). The entire ADU size must not exceed 256 bytes.

Since Modbus protocol is just a messaging structure, it is independent of the underlying physical layer. It is traditionally implemented using TCP/IP, RS232, RS422, or RS485. SoundWater flowmeters utilize an RS485 physical layer.

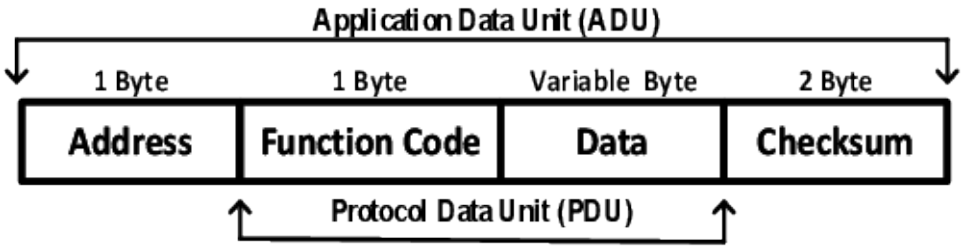


Figure I This figure displays all fields of an ADU packet.

Application Data Units (ADU)

The Master Request ADU

The request is an ADU transmitted by the master and received by the slave. It contains a byte called a function code which tells the addressed slave device what kind of action to perform. The bytes following the function code contain any additional information that the slave will need to perform the action. For example, function code 03 will request the slave to read holding registers and respond with their contents. The command's data field must then contain the information indicating to the slave which register to start at and how many registers to read. The error check field, or CRC, provides a method for the slave to validate the integrity of the message contents.

The Slave Response ADU

The response to a request is an ADU transmitted by the slave to the master. In a normal response, the function code in the response is an echo of the function code from the request. The response data bytes contain all data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the ADU contents are valid.

ADU Framing

In RTU mode, ADU packets are framed by silent intervals - which can be specified by the user via the SoundWater flowmeter display and setup menus. The silent intervals parameter is known as a timeout. After a timeout, the first field transmitted in the ADU packet is the device address, followed by the function code, data, and checksum fields. Following the last transmitted character of the check sum field, another timeout (silent interval) marks the end of the message packet. A new message can then begin after this interval.

The entire message frame must be transmitted as a continuous stream. If a timeout occurs during the message transmission, then the final CRC field will not be valid for the message, and the slave will then respond with an error code.

Transmission Mode

Controllers can be setup to communicate on standard Modbus networks using either of two transmission modes: ASCII or RTU. SoundWater products all use RTU mode, so ASCII will not be covered herein.

When controllers are setup to communicate on a Modbus network using RTU (Remote Terminal Unit) mode, each byte in a message contains two hexadecimal characters. The main advantage of this mode is that its greater character density allows better data throughput than ASCII for the same baud rate. Each message must be transmitted in a continuous stream.

The allowable characters transmitted for all fields are hexadecimal 0 ... 9, A ... F. Networked devices monitor the network bus continuously, including during the silent intervals. When the first field (the address field) is received, each device decodes it to find out if it is the addressed device.

Programming Setup

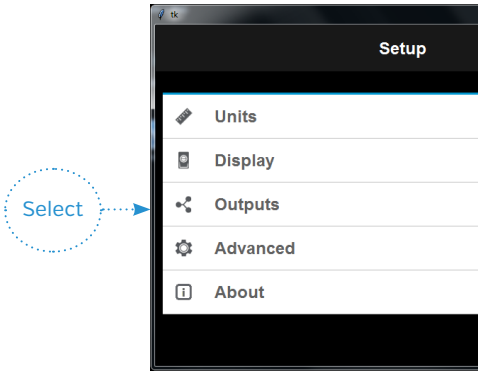
Units Selection

Measurement units default to the following: flowrate (gallons/min), totalizer (gallons), velocity (ft/sec), and temperatue (F). For selecting another type of unit, write the units selection code (see "Units Selection Codes") to the corresponding unit selection register (see the "Addressing").

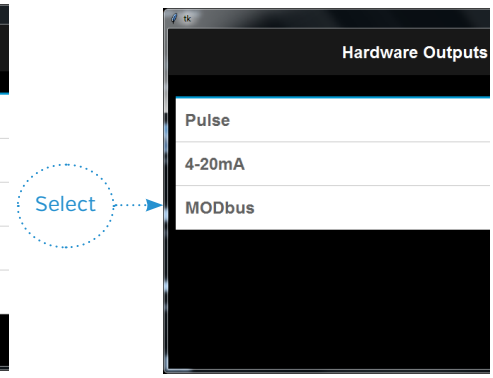
Ports Settings & Slave Identification

Port Settings for the MODBUS physical layer (RS 485) may be configured from the flowmeter's display (user interface) by navigating to the MODBUS setup menu. Configuration options include slave ID, timeout, baud rate, parity, stop bits, and data bits. Image one below, displays the "Setup" view. From Setup view, simply select the item labeled "Outputs" to navigate to the "Outputs" view (image two). Next, select the item labeled "MODBUS" to navigate to the "MODBUS" view (image three) where the MODBUS physical layer may be configured. Simply select any MODBUS menu item and select the desired configuration from a list of options.

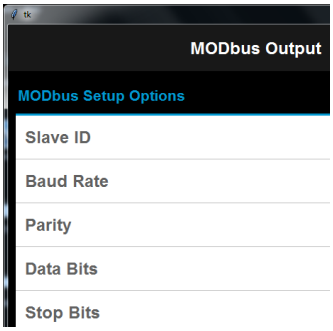
1 Setup View



2 Output Options View



3 MODBUS View



Addressing

Register Address Table (for use with function codes 03, 04, & 16)

Table 1 lists all readable registers for SoundWater flowmeters. A readable address may be read to by issuing an ADU with function code 03. A writable address may be written to by issuing an ADU with function code 16. Each register is associated with a two byte address. The Response ADU contains a data field with a four byte floating point number. Each register is a two byte data value. To read a complete data value from a flowmeter, the number registers read must be two, which would return the complete four byte floatiung point number (See the Examples section below).

(addressing for firmware version 3.17+, 2021)

Address	Number of Registers	Data Bytes	Data Type	Access	Description
0001	1	2	Float	read	Echo/Ping
0005	2	4	Float	read	Flow rate FMA
0007	2	4	Float	read	Flow rate FMB
0023	2	4	Float	read	Flow velocity FMA
0025	2	4	Float	read	Flow velocity FMB
0041	2	4	Float	read	Flow volume Net FMA
0042	2	4	Float	read	Flow volume Net FMB
0059	2	4	Float	read	Flow volume Fwd FMA
0061	2	4	Float	read	Flow volume Fwd FMB
0077	2	4	Float	read	Flow volume Rev FMA
0079	2	4	Float	read	Flow volume Rev FMB
0095	2	4	Float	read	Percent signal loss (sand detection etc.) FMA
0097	2	4	Float	read	Percent signal loss (sand detection etc.) FMB
0203	2	4	Float	read	Temperature FMA
0205	2	4	Float	read	Temperature FMB
0221	2	4	Float	read	Liquid sound speed FMA
0223	2	4	Float	read	Liquid sound speed FMB
0239	1	2	WORD	read/write	Flow rate unit selection (default gal/min).
0240	1	2	WORD	read/write	Velocity unit selection (default ft/sec).
0241	1	2	WORD	read/write	Totalizer unit selection (default gallons).
0243	1	2	WORD	read/write	Temperature unit selection (default F).

Byte & Word Ordering

All data is stored in memory with Big Endian Byte order, and Little Endian Word order. Typically, this means that for four byte data (floats, or ints) the modbus master should have the option selected to "word swap", i.e., word data are ordered as Little Endian.

Units Selection Codes

This table lists the codes used to specify measurement units. Use function code 16 to write any of these selections to the corresponding unit selection register address.

FLOW RATE (english)

0 gallons/sec	8 gallons x1M/sec	16 acre ft (US)/sec	24 barrel (Petro.)/sec
1 gallons/min	9 gallons x1M/min	17 acre ft (US)/min	25 barrel (Petro.)/min
2 gallons/hr	10 gallons x1M/hr	18 acre ft (US)/hr	26 barrel (Petro.)/hr
3 gallons/day	11 gallons x1M/day	19 acre ft (US)/day	27 barrel (Petro.)/day
4 gallons x1k/sec	12 cu. ft/sec	20 acre inch (US)/sec	28 barrel (liquid)/sec
5 gallons x1k/min	13 cu. ft/min	21 acre inch (US)/min	29 barrel (liquid)/min
6 gallons x1k/hr	14 cu. ft/hr	22 acre inch (US)/hr	30 barrel (liquid)/hr
7 gallons x1k/day	15 cu. ft/day	23 acre inch (US)/day	31 barrel (liquid)/day

FLOW RATE (metric)

32 cu. cm/sec	36 liters/sec	40 mega liters/sec	44 cu. meter/sec
33 cu. cm/min	37 liters/min	41 mega liters/min	40 cu. meter/min
34 cu. cm/hr	38 liters/hr	42 mega liters/hr	41 cu. meter/hr
35 cu. cm/day	39 liters/day	43 mega liters/day	42 cu. meter/day

VELOCITY (english)

0 ft/sec	2 ft/hr	4 in/sec	6 in/hr
1 ft/min	3 ft/day	5 in/min	7 in/day

VELOCITY (metric)

8 mm/sec	13 cm/min	18 m/hr
9 mm/min	14 cm/hr	19 m/day
10 mm/hr	15 m/day	
11 mm/day	16 m/sec	
12 cm/sec	17 m/min	

TOTALIZER (english)

0 gallons	2 gallons x1M	4 acre ft (US)	6 barrel (Petro.)
1 gallons x1k	3 cu. ft	5 acre inch (US)	7 barrel (liquid)

TOTALIZER (metric)

8 cu. cm	9 liters	10 mega liters	11 cu. meter

Examples

Reading Registers (function code 03)

This first example below displays the request and reponse ADU's for reading flow rate from a flowmeter. In this case the slave ID of the flowmeter was programmed as 0x01. The flow rate returned has a value of 122.8 when converted to a floating point number. Note that units may be setup from the flowmeter display and setup menus (See the User Instruction Manual for either *Orcas SP* or *Camano* for more detail regarding menu navigation and setup).

	Slave ID	Func Code	Start Address (flow rate)	Num Registers	Check Sum (CRC)
Request:	[0x01]	[0x03]	[0x00][0x16]	[0x00][0x02]	[0x25][0xCF]

	Slave ID	Func Code	Num Data Bytes	Data Bytes	Check Sum (CRC)
Response:	[0x01]	[0x03]	[0x04]	[0x42][0xF5][0xA4][0x23]	[0xC5][0x60]

Writing Registers (function code 16)

This first example below displays the request and reponse ADU's for writing the flow rate units selection. In this case the slave ID of the flowmeter was programmed as 0x01. The desired flow rate unit is gallons per minute (see Units Selection Codes above).

	Slave ID	Func Code	Start Address	Num Registers	Num Bytes	Data Bytes	Check Sum
Request:	[0x01]	[0x51]	[0x00][0x07]	[0x00][0x01]	[0x02]	[0x00][0x01]	[0xA3][0xD8]

	Slave ID	Func Code	Start Address	Num Registers	Check Sum (CRC)
Response:	[0x01]	[0x10]	[0x00][0x07]	[0x00][0x01]	[0xB0][0x08]

Error Handling

This last example below shows the requese and response ADU when an error occurs. In this particular example the request ADU contains a command to read the flowmeter totalized volume. However, the request ADU's function code is invalid (i.e., it is not a function code that is listed in Table 1). The slave responds by echoing the function code, and also places an error code in the data field. To signify an error response ADU, the highest bit in the function code is set.

	Slave ID	Func Code	Start Address (flow rate)	Num Registers	Check Sum (CRC)
Request:	[0x01]	[0x01]	[0x00][0x16]	[0x00][0x02]	[0x5C][0x0F]

	Slave ID	Func Code	Error Code	Check Sum (CRC)
Response:	[0x01]	[0x81]	[0x01]	[0x8A][0x15]

Note that the high bit in the response function code is set to signify an effor. Also, note the error code 0x01 is an "invalid function code" as shown in Table 3 "Error Code Table."

Hardware Wiring

SoundWater Flowmeters may be wired to RS485 MODBUS RTU networks. *Cypress* may ONLY be wired as two wire (half duplex). Wiring diagrams for half duplex (two wire), and full duplex converted to half duplex (four wire converted to two wire) are shown below.

Two Wire Networks (Half Duplex)

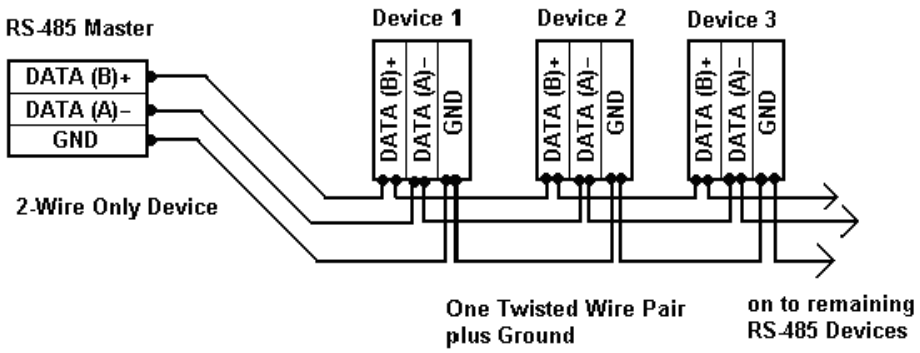


Fig. 1
2-Wire RS-485 Connections

Two Wire Converted Networks (Full to Half Duplex)

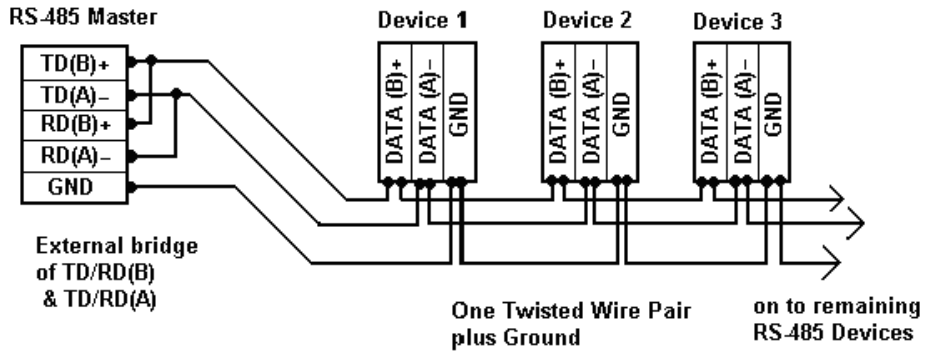


Fig. 3
2-Wire RS-485 Connections