1. Introduction

The MAG meter uses the standard ModBus communication protocol and supports baud rates of 1200, 2400, 4800, 9600, and 19200. Using the ModBus communication network, the host can read instantaneous flow, instantaneous velocity, and total or accumulative flow as well as other parameters.

The MAG Meter uses the following serial port parameters: 1 start bit, 8 data bits, 1 stop bit, and the none parity bit.

The MAG Meter ModBus communication ports isolation voltage is 1500V and features ESD protection. Thus it can overcome various interferences from industrial installations to ensure the reliability of the communication network.

2. MAG Meter ModBus RTU network structure and wiring

The MAG Meter's standard ModBus communication network is a bus network. It can support from 1 to 99 MAG flowmeters, or other devices, in a network installation. Note: the most distant MAG flowmeter, or device, in the network, normally requires the use of a 120 Ω matched termination resistor to connect the two sides of communication wire in parallel. The standard communication connection practice is to use a shielded twisted pair.

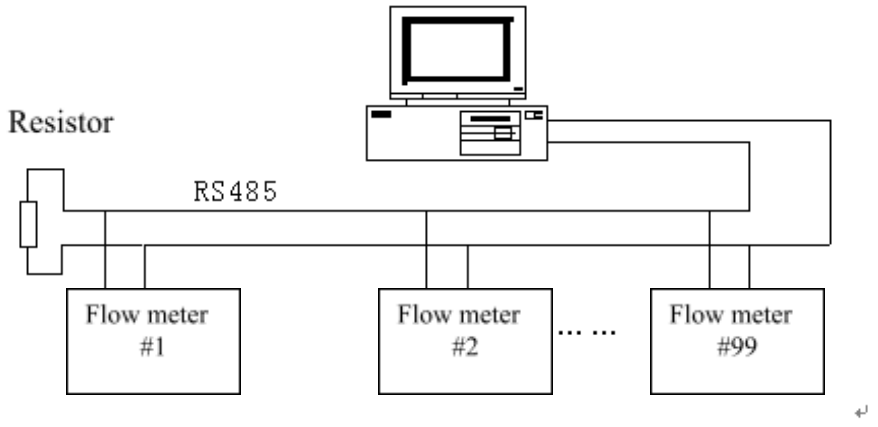

Figure-1 MAG Meter network configuration

3. ModBus RTU frame format

ModBus protocol is a master-slave communication. Communication is initiated

from the master and the slave then responds to the master's request by sending back the requested data.

The MAG Meter uses the ModBus RTU frame format (hexadecimal format). The frame format is shown below in figure2.

1) Master order frame structure

Start	Device address	Function code	Register address	Register length	CRC	Stop
T1-T2-T3-T4	8Bits	8Bits	16Bits	16Bits	16Bits	T1-T2-T3-T4

Figure-2 Master RTU message frame

2) Slave response frame structure

Start	Device address	Function code	Data	CRC	Stop
T1-T2-T3-T4	8Bits	8Bits	n 8Bits	16Bits	T1-T2-T3-T4

Figure-3 Slave RTU message frame

Note:

- T1-T2-T3-T4 is the start or stop frame. ModBus protocol requires every two frames must have a minimum 3.5 char delay as shown below in figure-4.

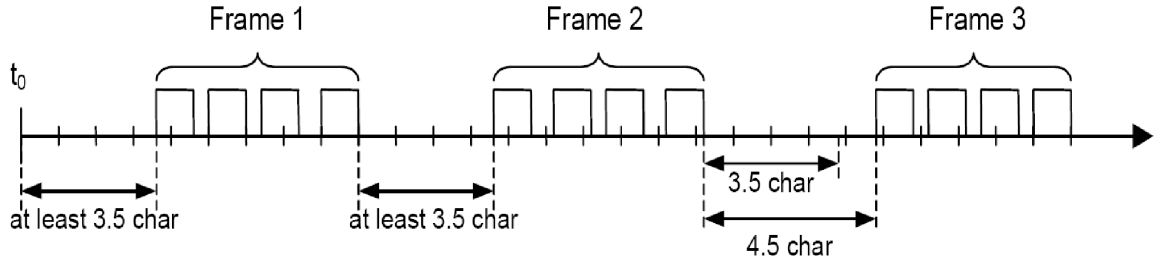

Figure-4 ModBus frame interval

- Device address: MAG meter Slave ID or communication address.
- Function code: Set by the desired ModBus protocol. The MAG Meter uses the Function code 4 which realize the collecting function through reading input register.
- Register address and register number: The start address of register to read or write.
- Slave response data: Byte number and N bytes data.

4. MAG Meter ModBus Function Codes

Table-1

Function code	name	function
01	Read coil status	reserved
02	Read input status	reserved
03	Read holding registers	reserved
04	Read input register	read real-time information
05	Strong set single coil	reserved
06	Preset single register	reserved
07	read abnormal status	reserved
08	Loopback diagnostic check	reserved
09	Program	reserved
10	Control exercise	reserved
11	Read events count	reserved
12	Read communication events record	reserved
13	Program	reserved
14	Inquire	reserved
15	Strong multi-coil set	reserved

5. MAG Meter ModBus register Addresses

Table-2

Protocol Addresses（Decimal）	Protocol Addresses（HEX）	Data format	Resister definition
4112	0x1010	Float Inverse	Instantaneous flow float representation
4114	0x1012	Float Inverse	Instantaneous velocity float representation
4116	0x1014	Float Inverse	Float representation of the flow percentage (battery-powered only)
4118	0x1016	Float Inverse	Floating representation of fluid conductivity ratio
4120	0x1018	Long Inverse	Integer part of the cumulative positive value

4122	0x101A	Float Inverse	Decimal part of the cumulative positive value
4124	0x101C	Long Inverse	Integer part of the cumulative negative value
4126	0x101E	Float Inverse	Decimal part of the cumulative negative value
4128	0x1020	Unsigned short	Instantaneous flow unit (table-3)
4129	0x1021	Unsigned short	Cumulative total units (table-4 or table-5)
4130	0x1022	Unsigned short	Upper limit alarm
4131	0x1023	Unsigned short	Lower limit alarm
4132	0x1024	Unsigned short	Empty pipe alarm
4133	0x1025	Unsigned short	System alarm

1) Data Formats

- Float format:

The MAG Meter ModBus uses IEEE754 which is a 32 bit float format. The structure is shown as follows: (Instantaneous flow as an example)

0X1010（34113）		0x1011（34114）	
BYTE1	BYTE2	BYTE3	BYTE4
S EEEEEEE	E MMMMMMM	MMMMMMMM	MMMMMMMM

S- Mantissa symbol; 1=negative, 0=positive.

E- Exponent; expressed by the difference between decimal number 127.

M- Mantissa; low 23 bits and the decimal part.

When all of the E are not “0” and “1”, the conversion formula between float and the decimal number is:

$$V = (-1)^S 2^{(E-127)}(1+M)$$

- Instantaneous flow units

Code	Unit	Code	Unit	Code	Unit	Code	Unit
0	L/S	3	M3/S	6	T/S	9	GPS
1	L/M	4	M3/M	7	T/M	10	GPM
2	L/H	5	M3/H	8	T/H	11	GPH

- Cumulative flow units

Table 4

Code	0	1	2	3
Cumulative unit	L	M3	T	USG

- Alarm

Upper limit alarm, lower limit alarm, empty pipe alarm, system alarm:

0 ------ No alarm; 1------ Alarm

6. Communication data examples

1) **Read instantaneous flow**

Master sends the command (hexadecimal numbers)

01	04	10	10	00	02	74	CE
Device address	Function code	Register high address	Register high address	Register high length	Register low length	CRC high	CRC low

Data that the master receives

01	04	04	C4	1C	60	00	2F	72
Device address	Function code	Data length	4 bytes float (instantaneous flow)				CRC high	CRC low

Float: C4 1C 60 00

1100 0100 0001 1100 0110 0000 0000 0000

float byte 1 float byte 2 float byte 3 float byte 4

S=1: if mantissa symbol is 1, it is a negative.

E=10001000: Exponent is 136

M=001 1100 0110 0000 0000 0000, The mantissa is :

$$V = (-1)^1 2^{(136-127)}(1+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}+\frac{1}{512}+\frac{1}{1024})$$

= -625.5, yes, the flow can go backwards… In this example, S-Mantissa symbol = 1 which means the number is negative.

2) **Read instantaneous velocity example**

Master sends command (hexadecimal number)

01	04	10	12	00	02	D5	0E

Device address	Function code	Register high address	Register high address	Register high length	Register low length	CRC high	CRC low

Data that the master receives

01	04	04	C1	B0	80	00	A6	5F
Device address	Function code	Data length	4 bytes float (instantaneous velocity)				CRC high	CRC low

Float: C1 B0 80 00

1100 0001 1011 0000 1111 1000 0000 0000

S=1

E= 10000011

M= 011 0000 1111 1000 0000 0000

$$V = (-1)^1 2^{(131-127)}(1+\frac{1}{4}+\frac{1}{8}+\frac{1}{256})$$

= -22.0625

3) **Read cumulative, or total, flow example**

To express the 9 bits that represent the Total or cumulative value of MAG Flow meter requires extracting the integer part and decimal part of cumulative or total flow. The integer part uses a long variable and the decimal uses a float variable.

Cumulative flow is 1578m^3

Master sends command to collect the integer value of cumulative flow

01	04	10	18	00	02	F5	0C
Device address	Function code	Register high address	Register high address	Register high length	Register low length	CRC high	CRC low

Data that the master receives

01	04	04	00	00	70	71	1E	60
Device address	Function code	Data length	4 bytes float (integer value of cumulative flow)				CRC high	CRC low

Integer value of cumulative flow is 28785

Master sends command to collect the decimal value of the total or cumulative flow

01	04	10	1A	00	02	54	CC

Device address	Function code	Register high address	Register high address	Register high length	Register low length	CRC high	CRC low

Data that master receives

01	04	04	3F	00	00	00	3B	90
Device address	Function code	Data length	4 bytes float (decimal value of cumulative flow)				CRC high	CRC low

Float: 3F 00 00 00

0011 1111 0000 0000 0000 0000 0000 0000

S=0

E= 0111111 126

M= 000 0000 0000 0000 0000 0000

$V = (-1)^1 2^{(126-127)} = 0.5$ Therefore, the TOTAL of these two numbers is 28785+0.5 or the cummulative, or total flow is 28785.5

4) **Read instantaneous flow units**

Master sends 8 bytes command to read instantaneous flow unit

01	04	10	20	00	01	34	C0
Device address	Function code	Register high address	Register high address	Register high	Register low	CRC high	CRC low

7 bytes data that the master receives from slave

01	04	02	00	05	79	33
Device address	Function code	Data length	2 bytes integer (instantaneous flow unit)		CRC high	CRC low

Flow unit is M^3/H from table-3.

5) **Read the units of the total flow**

Master sends 8 bytes command to read instantaneous flow unit

01	04	10	21	00	01	65	00
Device address	Function code	Register high address	Register high address	Register high	Register low	CRC high	CRC low

7 bytes data that the master receives from slave

01	04	02	00	01	78	F0
Device address	Function code	Data length	2 bytes integer (cumulative flow unit)		CRC high	CRC low

Flow unit is M^3 from table-4.

6) Read alarm status

Master sends the following 8 byte command to read instantaneous flow unit

01	04	10	24	00	01	75	01
Device address	Function code	Register high address	Register high address	Register high length	Register low length	CRC high	CRC low

7 bytes of data that the master receives from slave

01	04	02	00	01	78	F0
Device address	Function code	Data length	2 bytes integer (alarm)		CRC high	CRC low

Empty pipe is in alarm status if status is 1.

ModBus Simple showing Slave ID 21, 19,200,n,8,1 on Function code 4 for Reg 4112 to read flow