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SPM/SPC Series Modbus Communication Protocol

Note: The hexadecimal numbers in the following description are represented by XXXXH or XXH.

1. MODBUS-RTU Standard Communication Format

This communication uses MODBUS RTU mode, message frame as below:

Slave address	Function code	Data area	CRC Check (Cyclic Redundancy Check)	
1 Byte	1 Byte	0 or up to 252 bytes	2 Bytes	
			CRC low	CRC high

(1) **Slave address**: Host control peristaltic pump address No.. The pump address No. should not be same when they are in the same 485 line. The address No. range is 1~32, 0 means broadcast.

(2) **Function code**: This protocol uses two public function codes defined by the MODBUS protocol.

   03H: Read the contents of holding register.

   06H: Write a word to the holding register.

   10H: Write a long type to the holding register.

(3) **Data area**: The specific information commands that the syringe pump needs to execute, such as start /stop, reversing, acceleration and deceleration, etc.

(4) **CRC Check:** CRC code is 2 bytes, 16 check codes. Use CRC-16 (which used in American binary synchronous system).

   Polynomial: $G(X)=X16+X15+X2+1$**. See Appendix 1 for CRC check C language code**

2. Communication Settings

(1) Communication Baud Rate: **1200,2400,4800,9600 for option**

(2) **Byte Structure**: 1 start bit + 8 data bits + 1 parity bit + 1 stop bit

(3) **Bit sequence transmission order**: Least Significant Bit (LSB)...Most Significant Bit (MSB)

Start	1	2	3	4	5	6	7	8	Check	Stop

(4) Data transfer format:

Integer type (2 bytes)

Data: Second byte   First byte

Send: Second byte   First byte

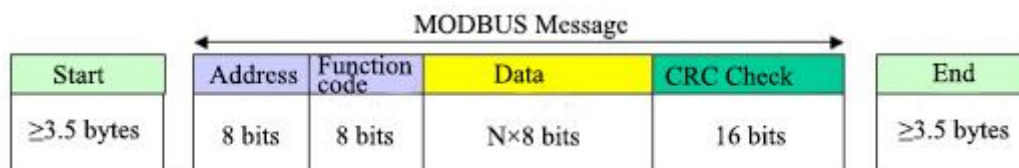Example: 1234H   Send 12H   34H

Float type (4 bytes)

Data: Forth byte   Third byte   Second byte   First byte

**Send: Second byte   First byte   Forth byte   Third byte**

Example: 8.9   Send 41H   0EH   66H   66H

3. Modbus Message RTU Frame Format

In RTU mode, message frames are distinguished by idle intervals of at least 3.5 character times. As shown below:

The entire message frame must be sent in a continuous stream of characters. If the idle interval between two characters is greater than 1.5 character time, the message frame is considered incomplete and should be discarded by the receiving node. As shown below:
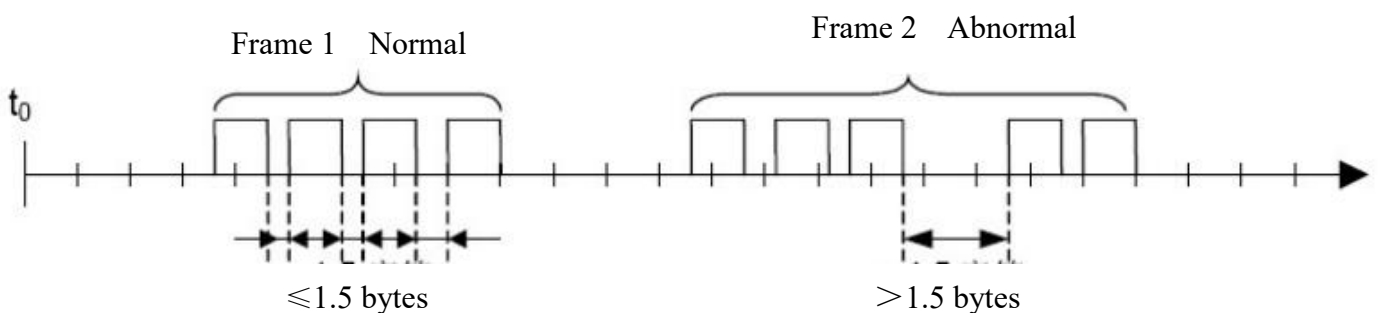
4. Abnormal Response

When the master sends the request data, the slave needs to respond abnormally when the data is abnormal. If the address code sent by the master is wrong, there is no such address code in the slave or

the CRC check of the data received by the slave is wrong, the slave returns no abnormal code, and the master needs to have a super response mechanism.

Function code field: The abnormal response function code is the normal response function code +80H.

Data field: Return abnormal code, defined as below:

Abnormal code Definition

Code	Name	Meaning
01H	Illegal function code	The function code received by the syringe pump is a function code other than 03H/06H/10H
02H	Invalid data address	This abnormal code indicates that the register address received by the syringe pump is an unallowable value.
03H	Invalid data value	The written data does not fit the running range.
06H	The slave device (syringe pump) is busy	The current state of the syringe pump conflicts with the received command and cannot complete the command.

Note: 1. The syringe pump only receive Modbus commands when the controller is in main interface, in other interface will not receive commands.

2. Only independent pump unit receive Modbus commands, Logic pump unit will not receive commands.

5. Holding Register Address and Content

Address (Decimal)	Name	Range	Data Type
0010	All start	1: start 0: stop 2:pause	unsigned short int (2 bytes)

Note: This register address is all start/stop of all independent units within a controller address.

Basic Parameter Setting

Address (Decimal)	Name	Range	Data Type
n000	Syringe	Check Chart 1 for relative parameters	unsigned short int（2 bytes)

		manufacturer		
n001	Syringe size	Check Chart 1 for relative parameters	unsigned short int（2 bytes)
n002	Custom switch	1: Customize syringe 0: Built-in manufacturers	unsigned short int（2 bytes)
n003	Start/stop control	1: start　0: stop　　2: pause	unsigned short int（2 bytes)
n004	Working mode	0: withdraw　　　　　1: infuse 2: withdraw- infuse 3: infuse- withdraw	unsigned short int（2 bytes)
n005	Repeat numbers	0-9999 times　　　　0 is unlimited	unsigned short int（2 bytes）
n006	Fast forward	1:start fast forward 　0: stop fast forward	unsigned short int（2 bytes）
n007	Fast backward	1: start fast backward 0: stop fast backward	unsigned short int（2 bytes）
n008	Delay start time	0-9999min	Float　　（4 bytes)（Only for SPM）
n010	First group volume	0.1-99999 uL	Float　　　　　　（4 bytes）
n012	First group run time	0.1-99999（s）	Float　　　　　　（4 bytes）
n014	Pause time	0.1-9999（s）	Float　　　　　　（4 bytes）
n016	Second group volume	0.1-99999 uL	Float　　　　　　（4 bytes）
n018	Second group run time	0.1-99999（s）	Float　　　　　　（4 bytes）
n020	Cycle pause time	0.1-9999（s）	Float　　　　　　（4 bytes）
n022	Back distance	0.01—5mm	Float　　　　　　（4 bytes）
n024	Choose custom group	0: first group　　　　1: second group 2：third group　　　　3：forth group	unsigned short int（2 bytes）

Note:

(1) The fast forward and fast backward function only valid when the pump unit in stop status, or return error.

(2) When the parameter setting of independent working mode exceeds the set number of allocated groups, the setting is invalid and an error is returned. For example: The allocated group is group 1 (withdraw mode or infuse mode), and it is invalid when any one of the register addresses 1016-1020 is set.

(3) Please set the register parameters separately according to the chart. One command can not set multiple registers continuously.

(4) The range of n is 1-8, represent 8 units under one controller respectively.

(5) n024 choose custom group, SPM can select 0, 1, 2, 3 four groups, SPC can select 0, 1, 2 three groups.

(6) In n003 protocol, SPC does not have pause function, SPM has pause function.

(7) Delay start only can be used for SPM series, unit is minute, can not change.

Calibration Setting Parameters

Address（Decimal）	Name	Range	Data Type
n100	Test start	1: start 0: stop	unsigned short int（2 bytes）
n101	Actual volume	0-99999 uL	float （4 bytes）
n103	Reset	1：Reset calibration	unsigned short int（2 bytes）
n104	Micro adjust	1：Increase 0：Decrease	unsigned short int（2 bytes）
n105	Choose group	0-1	unsigned short int（2 bytes）

Appendix: Chart 1

Syringe Manufacturer	Manufacturer Code	Syringe Code	Syringe Size	Syringe Diameter（mm）
Air-Tite（塑料）	00	0	1cc	4.70
		1	2.5cc	9.70
		2	5.0cc	12.48
		3	10cc	15.89
		4	20cc	20.00
		5	30cc	22.50
		6	50cc	28.90
Becton Dickinson Plastipak	01	0	1cc	4.70
		1	3cc	8.59
		2	5cc	11.99
		3	10cc	14.48
		4	20cc	19.05
		5	30cc	21.59
		6	60cc	26.60
Becton Dickson Glass	02	0	0.5cc	4.64
		1	1cc	4.64
		2	2.5cc	8.66
		3	5cc	11.86
		4	10cc	14.34
		5	20cc	19.13
		6	30cc	22.70
		7	60cc	28.60
Hamilton	03	0	10ul	0.46
		1	25ul	0.73
		2	50ul	1.03
		3	100ul	1.46
		4	250ul	2.30

		5	500ul	3.26
		6	1ml	4.61
		7	2.5ml	7.28
		8	5ml	10.30
		9	10ml	14.57
		10	25ml	23.03
		11	50ml	32.57
Popper&Sons	04	0	0.25ml	3.45
		1	0.5ml	3.45
		2	1ml	4.50
		3	2ml	8.92
		4	3ml	8.99
		5	5ml	11.70
		6	10ml	14.70
		7	20ml	19.58
		8	30ml	22.70
		9	50ml	29.00
Ranfac	05	0	2cc	9.12
		1	5cc	12.34
		2	10cc	14.55
		3	20cc	19.86
		4	30cc	23.20
		5	50cc	27.60
Scientific Glass Engineering	06	1	25ul	0.73
		2	50ul	1.03
		3	100ul	1.46
		4	250ul	2.30
		5	500ul	3.26
		6	1ml	4.61
		7	2.5ml	7.28
		8	5ml	10.30
		9	10ml	14.57
Sherwood-Monojet plastic	07	0	1cc	4.65
		1	3cc	8.94
		2	6cc	12.70
		3	12cc	15.90
		4	20cc	20.40
		5	35cc	23.80
		6	50cc	26.60
Terumo	08	0	1cc	4.73
		1	3cc	9.00
		2	5cc	13.04
		3	10cc	15.79
		4	20cc	20.18
		5	30cc	23.36

		6	60cc	29.45
Unimetrics	09	0	10ul	0.46
		1	25ul	0.73
		2	50ul	1.03
		3	100ul	1.46
		4	250ul	2.30
		5	500ul	3.26
		6	1000ul	4.61

6. Send Data Format

unsigned short int format

Syringe pump address	Function code	Register address		Data (unsigned short int)		CRC Check	
	06H	Address H	Address L	Data H	Data L	L	H

Float format

Syringe pump address	Function code	Register address		Register number		Byte number	Data（Float）				CRC Check	
	10H	H	L	00H	02H	04H	L1	L2	H1	H2	L	H

(1) Set syringe pump start/stop

Syringe pump address is 1, set the pump unit 1 start, number is 1003H

Send: 01 06 03 EB 00 01 38 7A

Return: 01 06 03 EB 00 01 38 7A

(2) Set the infuse volume

Syringe pump address is 1, set the pump unit 1 infuse volume 8.9uL, number is 1010H

Send: 01 10 03 F2 00 02 04 41 0E 66 66 B7 B7

Return: 01 10 03 F2 00 02 04 4F 4B

7. Appendix 2 -----CRC check C language code

The process of generating the CRC is :

(1) Load a 16-bit register with FFFF hex (all ones). Call it the CRC register.

(2) XOR the first 8-bit byte of the message with the low byte of the 16-bit CRC register and place the result in the CRC register.

(3) Shift the CRC register right by 1 bit (towards the LSB), filling the MSB with zeros. Extract and check the LSB.

(4) (If LSB is 0): Repeat step 3 (another shift).

(5) Repeat steps 3 and 4 until you have completed 8 shifts. When this is done, the full operation on the 8-bit byte is done.

(6) Repeat steps 2 through 5 for the next byte in the message, continuing until all messages have been processed.

(7) The final content in the CRC register is the CRC value.

(8) When placing a CRC value in a message, as described below, the high and low bytes must be swapped.