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Ultrasonic Flow Meter For Air TRX/TRZ

MODBUS RTU Communication Specifications

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Contents

1 Overview

This specification document applies to the Ultrasonic Flow Meter For Air TRX (R) - □/5P, TRZ(R) - C/5P.

Since this document only describes the communication procedures, refer to the operation manual of the Ultrasonic Flow Meter For Air (hereafter referred to as “flow meter”) for description of operations other than communication.

The flow meter has the communication interface which equips the asynchronous serial bus interface conforming to EIA-485. This interface enables to connect up to 31 flow meters [*1] to build a networked system.

Modbus RTU Protocol is used as the communication protocol, so that measurement data and internal information of each flow meter can be acquired by issuing commands to each flow meter.

*1. The maximum number of connectable flow meters depends on the communication parameters. Refer to "3.1 Communication specifications” for the details.

2 Before Use

2.1 Connection

Connect the flow meter to the master communication device as described in the Operation Manual of the flow meter.

2.2 Setting of the items related to communication (Flow meter side)

Refer to "Section 2-2 Procedures to change settings" and "Section 2-3 Details of setting items" in the Operation Manual for the setting methods of Sections 2.2.1 through 2.2.4.

2.2.1 Flow meter setting of RTU address

Set the RTU address using the setting button of the flow meter with Item No. F19. When connecting multiple flow meters, do not use the same number.

Available addresses: 001 to 247

* "000" cannot be used.

2.2.2 Flow meter setting of communication speed (Bit rate selection)

Set the communication speed using the setting button of the flow meter with Item No. F20.

* When 115,200bps is selected, the maximum number of flow meters which can be connected is limited to 8.

2.2.3 Flow meter setting of communication protocol

Set the communication protocol using the setting button of the flow meter by selecting the number of stop bit length with Item No. F21 and parity bit with Item No. F22.

2.2.4 Setting of terminal register

Specify presence of the terminal register using the setting button of the flow meter with Item No. F23.

Normally, select “OFF”.

When connecting multiple flow meters, select “ON” only at the flow meter physically farthest from the master communication device.

2.3 Setting of the items related to communication (Master communication device side)

Set the communication speed, number of stop bit length, and parity bit to the same settings as the flow meter.

* For the data length, set it to 8 bits.

3 Communication specifications and communication timing

3.1 Communication specifications

Interface	Conforming to EIA-485
Communication method	Half-duplex
Synchronization method	Asynchronous
Maximum number of connectable flow meters	115,200bps : Up to 8 9,600bps to 57,600bps : Up to 31
Protocol	Modbus RTU
Communication speed [bps]	Selectable by parameter setting: 9,600/ 19,200/ 38,400/ 57,600/ **115,200**
Data length [bits]	8
Stop bit length [bit]	Selectable by parameter setting: **1**, 2
Parity bit	Selectable by parameter setting: No parity, odd parity, **even parity**
Sending/receiving buffer size [bytes]	100

The factory defaults are shown in **bold**.

Refer to the next section for the communication timing.

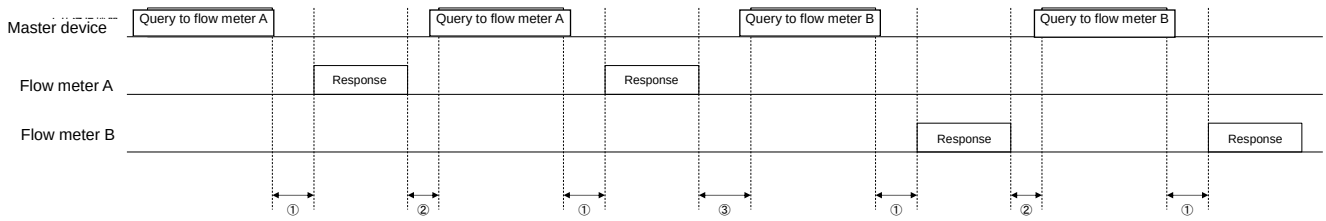
3.2 Communication timing

The response time, standby time, and communication interval depend on the communication speed and the contents of a query from the master communication device. Refer to the table <Response time and standby time> and figure <Communication timing chart> below.

<Response time and standby time>

Response time ① [ms]		9,600bps : Min 25 to max 130 19,200bps : Min 25 to max 100 38,400bps : Min 25 to max 80 57,600bps : Min 25 to max 70 115,200bps : Min 25 to max 70
Maximum standby time after response [ms]	In case of sending query to the same flow meter which responded to the master communication device ②	Common to all communication speeds: 31
Maximum standby time after response [ms]	In case of sending query to the same flow meter which responded to the master communication device ③	9,600bps : 135 19,200bps : 105 38,400bps : 85 57,600bps : 75 115,200bps : 75
Minimum communication interval		Maximum query time + response time ① (maximum value) + maximum response time + maximum standby time (② or ③)

<Communication timing chart>



(1): Prepare to receive a response within the above-described time (the minimum value of ①) after sending a query to the flow meter.

(2): Prepare time-out time to be longer than the above-described time (the maximum value of ①) after sending a query to the flow meter.

(3): In case the flow meter is only the one connected to the master communication device, after receiving a response from the flow meter, send the next query to the same flow meter after the above-described time (②) passes.

(4): In case multiple meters are connected to the master communication device, after receiving a response from any of them, send the next query after the above-described time (③) passes.

<Notes on programming>

(1): Provide some margins for the times mentioned above for safety when programing the master communication device.

(2): If a response from the flow meter cannot be received correctly after the master communication device has sent a query, it is recommended to resend the query.

4 Message frame configuration

Start	RTU address	Function code	Data	Error check code	End
Silent Interval*	1 byte	1 byte	n bytes	2 bytes	Silent Interval*

* Silent communication time for 3.5 characters or more

<RTU address>

"1" - "247" (01H - F7H) can be set for the flow meter.

The default is "1" (01H).

When a message from the master communication device is received, only the flow meter with the matching RTU address returns a response.

* Broadcast communication is not supported.

<Function code>

Each code specifies a function that the flow meter is commanded to perform.

The following function codes are available.

Code (HEX)	Function
03	Reading of parameters and flow meter information
05	Clearing of accumulated values (i.e., accumulated forward flow volume, accumulated reverse flow volume, and trip accumulated flow volume) at once. Clearing of parameters (resets parameter values)
06	Writing of a single parameter
10	Writing of multiple parameters

<Data>

Data used to perform a function code. Configuration of the data section depends on the function code. Refer to "7 Data List" for details.

<Error check code>

This code is used to detect an error (bit change) during signal transmission. The error check is performed in the CRC method. Refer to "9 Calculation of Error Check Code (CRC-16)" for details.

When the flow meter receives a message, the CRC value is calculated based on the sent message and compared with the sent CRC value. If the two CRC values do not match, an error is declared.

When the flow meter sends a message, the CRC value is calculated based on the message to send and is added to the end of the message.

5 Function codes

5.1 [Function code 03] Reading of parameters and flow meter information

The function code 03H reads parameters, and flow meter information.

The function code and data portions, which are described in "4 Message Frame Configuration," are shown below.

<Query configuration>

Function code		03H
Data	Start address	(Upper)
		(Lower)
	Number of registers	(Upper)
		(Lower)

Function code : 03H
Start address : Register address (0100H to 0117H), (0200H to 0218H)
Number of registers : Number of reading data (0001H to 0019H)
Note that the maximum number of reading data depends on register addresses.

<Response configuration>

Function code		03H
Data	Number of data bytes	Arbitrary
	Data 1	(Upper)
		(Lower)
	Data 2	(Upper)
		(Lower)
	:	
	Data N	(Upper)
		(Lower)

Function code : 03H
Number of data bytes : Number of bytes in response data
Data : Read data

Example) When reading [Address 010AH] Output pulse unit (0001H: 100L/P) and [Address 010BH] Pulse output method(0000H: 50ms):

<Query> (HEX)

Start			Silent interval
RTU address			01
Function code			03
Data	Start address	(Upper)	01
		(Lower)	0A
	Number of registers	(Upper)	00
		(Lower)	02
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

<Response> (HEX)

Start			Silent interval
RTU address			01
Function code			03
Data	Number of data bytes		04
	Data 1 (Data at address 010A)	(Upper)	00
		(Lower)	01
	Data 2 (Data at address010B)	(Upper)	00
		(Lower)	00
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

5.2 [Function code 05] Clearing of accumulated values and parameters

The function code 05H clears all accumulated values (i.e., accumulated forward flow volume, accumulated reverse flow volume, and trip accumulated flow volume) stored in the flow meter as well as resets the parameters to factory settings.

When the parameters are reset, the factory settings are used after the communication is completed.

Note that the parameters related to communication (i.e., [Addresses 0114 to 0117] RTU address, communication bit rate, stop bit length, and parity bit) are not cleared. Refer to [Address 0301H] Parameter clear on Page 29 for details.

The function code and data portions, which are described in "4 Message Frame Configuration," are shown below.

<Query configuration>

Function code		05H
Data	Start address	(Upper)
		(Lower)
	Data to change	00H
		00H

Function code : 05H
Start address : Register address (0300H to 0301H)
Data to change : 0000H (fixed)

<Response configuration>

Function code		05H
Data	Start address	(Upper)
		(Lower)
	Data to change	00H
		00H

Function code : 05H
Start address : Same as the start address of query
Data to change : 0000H (fixed)

Example) When clearing accumulated values

<Query> (HEX)

Start			Silent interval
RTU address			01
Function code			05
Data	Start address	(Upper)	03
		(Lower)	00
	Data to change	(Upper)	00
		(Lower)	00
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

<Response> (HEX)

Start			Silent interval
RTU address			01
Function code			05
Data	Start address	(Upper)	03
		(Lower)	00
	Data to change	(Upper)	00
		(Lower)	00
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

5.3 [Function code 06] Writing of a single parameter

The function code 06H changes (writes) a single parameter.

The function code and data portions, which are described in "4 Message Frame Configuration", are shown below.

<Query configuration>

Function code		06H
Data	Start address	(Upper)
		(Lower)
	Data to change	(Upper)
		(Lower)

Function code : 06H

Start address : Register address (0100H to 0117H)

Data to change : Arbitrary (Refer to "7.2.1 Parameter list" for the available range of setting for changing data.)

<Response configuration>

Function code		06H
Data	Start address	(Upper)
		(Lower)
	Data to change	(Upper)
		(Lower)

Function code : 06H
Start address : Same as the start address of query
Data to change : Same as the data to change in query

Example) When changing [Address 0100H] Display and output selection to Forward/reverse flow (0001H)

<Query> (HEX)

Start			Silent interval
RTU address			01
Function code			06
Data	Start address	(Upper)	01
		(Lower)	00
	Data to change	(Upper)	00
		(Lower)	01
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

<Response> (HEX)

Start			Silent interval
RTU address			01
Function code			06
Data	Start address	(Upper)	01
		(Lower)	00
	Data to change	(Upper)	00
		(Lower)	01
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

5.4 [Function code 10] Writing of multiple parameters

The function code 10H changes (writes) multiple consecutive parameters.

The function code and data portions, which are described in "4 Message Frame Configuration," are shown below.

<Query configuration>

Function code		10H
Data	Start address	(Upper)
		(Lower)
	Number of registers	(Upper)
		(Lower)
	Number of data bytes	Arbitrary
	Data 1	(Upper)
		(Lower)
	Data 2	(Upper)
		(Lower)
	:	
	Data N	(Upper)
		(Lower)

Function code : 10H
Start address : Register address (0100H to 0117H)
Number of registers : Number of writing data (0001H to 0018H)
Number of data bytes : Number of bytes in writing data
Data to change : Arbitrary (Refer to "7.2.1 Parameter list" for the available range of setting for changing data.)

<Response configuration>

Function code		10H
Data	Start address	(Upper)
		(Lower)
	Number of registers	(Upper)
		(Lower)

Function code : 10H
Start address : Same as the start address of query
Number of registers: Same as the number of registers of query

Example) When changing [Address 0109H] Flow-rate moving average number of times to 32 (0005H) and [Address 010AH] Output pulse unit to 100L/P (0001H)

<Query> (HEX)

Start			Silent interval
RTU address			01
Function code			10
Data	Start address	(Upper)	01
		(Lower)	09
	Number of registers	(Upper)	00
		(Lower)	02
	Number of data bytes	Arbitrary	04
	Data 1 (Flow-rate moving average number of times)	(Upper)	00
		(Lower)	05
	Data 2 (Output pulse unit)	(Upper)	00
		(Lower)	01
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

<Response> (HEX)

Start			Silent interval
RTU address			01
Function code			10
Data	Start address	(Upper)	01
		(Lower)	09
	Number of registers	(Upper)	00
		(Lower)	02
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

5.5 Communication-related parameters

When a parameter or parameters related to communication (i.e., RTU address, communication bit rate, stop bit length, and parity bit) is/are changed in a query, the response to that query is transmitted using the parameters before change, and the new parameters are used from the next communication.

Example 1) When changing the RTU address of the flow meter from 01 to 02 (HEX)

			Query	Response
Start			Silent interval	Silent interval
RTU address			01	01
Function code			06	06
Data	Start address	(Upper)	01	01
		(Lower)	14	14
	Data to change	(Upper)	00	00
		(Lower)	02	02
Error check code		(Lower)	(CRC)	(CRC)
		(Upper)	(CRC)	(CRC)
End			Silent interval	Silent interval

Response is returned with "01H."

The succeeding communications use the RTU address = 02.

Example 2) When changing the communication bit rate from 9,600bps to 115,200bps and the number of stop bits from 1 bit to 2 bits (HEX)

			Query	Response
Start			Silent interval	Silent interval
RTU address			01	01
Function code			10	10
Data	Start address	(Upper)	01	01
		(Lower)	15	15
	Number of registers	(Upper)	00	00
		(Lower)	02	02
	Number of data bytes		04	
	Data 1 (Communication bit rate)	(Upper)	00	
		(Lower)	04	
	Data 2 (Number of stop bits)	(Upper)	00	
		(Lower)	01	
Error check code		(Lower)	(CRC)	(CRC)
		(Upper)	(CRC)	(CRC)
End			Silent interval	Silent interval

Response is returned at 9,600bps with 1 stop bit.

The following communications use 115,200bps with 2 stop bits.

6 Communication Errors

6.1 Communication errors

The following table lists the communication errors defined.

Error code	Error	Details
01H	Invalid function	A function code is other than 03H, 05H, 06H, and 10H.
02H	Invalid data address	The address does not exist. Or an internal address exceeding the buffer size is assigned.
03H	Invalid data	The data value is out of the valid range.
None (no response)	Communication error other than above	Framing error, overrun error, parity error, CRC check error

6.2 Error response

The function code and data portions, which are described in "4 Message Frame Configuration," are shown below.

For an error response, the function code becomes an error function code that “1” is set to the most significant bit of the function code.

Error function code

Function code (HEX)	Error function code (HEX)
03	83
05	85
06	86
10	90

<Response configuration>

Error function code		See the table above.
Data	Error code	01H, 02H, or 03H

Example) When 0002H is set for fluid selection

Since 0002H is a data value out of the valid range, an invalid data error code 03H is returned.

<Query> (HEX)

Start			Silent interval
RTU address			01
Function code			06
Data	Start address	(Upper)	01
		(Lower)	0F
	Data to change	(Upper)	**00**
		(Lower)	**02**
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

<Response> (HEX)

Start			Silent interval
RTU address			01
Error function code			**86** ← The most significant bit of 06H is set to "1"
Data	Error code		**03**
Error check code		(Lower)	(CRC)
		(Upper)	(CRC)
End			Silent interval

6.3 Handling at the time of invalid data detection

When invalid data is detected while writing a single parameter, writing is not performed.

When invalid data is detected while writing multiple parameters, values preceding the invalid data are set but the invalid data and the values following it are not set.

The following shows an example of writing multiple addresses ([Address 010EH - 0110H]).

Example 1)

Test mode time selection : 0001H (valid data)
Fluid selection : 0011H (**invalid data**)
Analog output item selection : 0000H (valid data)

When the second of the three setting data is invalid as shown above, the first parameter (test mode time selection) is set, but the fluid selection and analog output item selection are not set because the second data (fluid selection) is invalid.

The response returned is the error code 03H for the invalid data.

Example 2)

Test mode time selection : 0003H (**invalid data**)
Fluid selection : 0001H (valid data)
Analog output item selection : 0000H (valid data)

When the first data out of three is invalid as shown above, all of the three setting data are not set.

The response returned is the error code 03H for the invalid data.

7 Data Specifications

7.1 Address and data

Data is arranged as shown below.

Address	
0000H to 00FFH	For system use
0100H to 0117H	Flow meter parameters
0118H to 01FFH	For system use
0200H to 0218H	Flow meter information
0219H to 02FFH	For system use
0300H to 0301H	Clear command
0302H to FFFFH	For system use

* System regions cannot be used.

7.2 Data list

7.2.1 Parameter list

For the listed parameters, setting and acquisition of internal information are possible. Therefore, the following function codes can be used.

Code (HEX)	Function
03	Reading of a parameter(s)
06	Writing of a single parameter
10	Writing of multiple parameters

Function code (HEX)	Address (HEX)	Area name	Parameter	Set value (Range, HEX)	Reference page for details
03 06 10	0100	Flow meter parameters	Display・output selection	0000: Forward flow 0001: Forward/reverse flow	18
	0101		Analog output FS flow-rate: Upper 2 bytes	0000 to 0001	18
	0102		Analog output FS flow-rate: Lower 2 bytes	0000 to FFFF	
	0103		State of contact output selection	0000: Normal open 0001: Normal close	18
	0104		Lower limit alarm flow-rate: Upper 2 bytes	0000 to FFFF	18
	0105		Lower limit alarm flow-rate: Lower 2 bytes	0000 to FFFF	
	0106		Upper limit alarm flow-rate: Upper 2 bytes	0000 to FFFF	19
	0107		Upper limit alarm flow-rate: Lower 2 bytes	0000 to FFFF	
	0108		Alarm judgment hysteresis width	0000 to 270F	19
	0109		Flow-rate moving average number of times	0000: 1 time 0001: 2 times 0002: 4 times 0003: 8 times 0004: 16 times 0005: 32 times 0006: 64 times	19
	010A		Output pulse unit	0000: 10L/P 0001: 100L/P 0002: 1000L/P 0003: 10000L/P	19-20
	010B		Pulse output method	0000: 50ms One-shot 0001: 100ms One-shot 0002: 125ms One-shot 0003: 250ms One-shot 0004: 500ms One-shot	20

Function code (HEX)	Address (HEX)	Area name	Parameter	Set value (Range, HEX)	Reference page for details
				0005: Duty	
	010C		Flow value compensation selection	0000: No compensation (actual flow-rate) 0001: Yes (Normal) 0002: Yes (Standard)	20-21
03 06 10	010D	Flow meter parameters	Standard compensation temperature	FFF6 to 003C	21
	010E		Test mode time selection	0000: 3 min 0001: 60 min 0002: Infinite	21
	010F		Fluid selection	0000: Air 0001: Nitrogen	22
	0110		Analog output item selection	0000:Instantaneous flow-rate 0001: Pressure 0002: Temperature	22
	0111		Low flow cutoff flow-rate	0000 to 0190	22
	0112		Atmospheric pressure of the working environment	0000 to 270F	23
	0113		With or without pressure value averaging	0000: Without (1 time) 0001: With (10 times)	23
	0114		RTU address	0001 to 00F7	23
	0115		Communication bit rate	0000: 9,600bps 0001: 19,200bps 0002: 38,400bps 0003: 57,600bps 0004: 115,200bps	23
	0116		Stop bit length	0000: 1 bit 0001: 2 bits	23
	0117		Parity bit	0000: None 0001: Odd 0002: Even	23

7.2.2 Parameter description

[Address 0100H] Display・output selection

Selection of "Forward flow (0000H)" or "Forward/reverse flow (0001H)" measurement.

- Forward flow:
  The accumulated forward flow volume or trip accumulated volume is displayed on the main display.
- Forward/reverse flow:
  The accumulated forward flow volume or accumulated reverse flow volume is displayed on the main display.

The analog output value depends on this selection. Refer to [Address 0110H] Analog output item selection on Page 22 for details.

[Address 0101H, 0102H] Analog output FS (full scale) flow-rate

Setting for full scale flow-rate values of the analog output.

This setting becomes valid when [Address 0110H] Analog output item selection is set to “Instantaneous flow-rate.”

The FS flow-rate is to be in accordance with the setting of [Address 010CH] Flow value compensation selection.

The FS flow-rate value is a 4-byte data and it can be set within the range from 0 to 99999 (00000000H to 0001869FH) [m^3/h].

The address for the upper 2 bytes and the address for the lower 2 bytes are assigned separately.

[Address 0101H] Analog output FS flow-rate (upper)

[Address 0102H] Analog output FS flow-rate (lower)

Setting of the upper value only or lower value only is available. However, note that judgment of the setting available range is done as 4-byte combining the upper and the lower values together.

Example) Upper: 0000H, lower: 9876H -> Analog output FS flow-rate = 00009876H -> 39030[m^3/h]

Trying to change the upper value only to 0001H results as impossible to be set so because the value is outside the setting available range:

Analog output full scale flow-rate = 00019876H -> 104566 [m^3/h] > 99999[m^3/h]

[Address 0103H] State of contact output selection

Selection of “Normal open (0000H)” or “Normal close (0001H)” for the contact output terminal. Select “Normal open” when using a battery-driven pulse receiving instrument.

The addresses 0104H to 0108H define the thresholds of the flow meter information "Error information/Flow-rate upper/lower limit alarm".

[Address 0104H, 0105H] Lower limit alarm flow-rate

Setting of the lower limit alarm flow-rate for the upper and lower limit alarm flow-rate.

* This is a 4-byte data, similarly to the analog output FS flow-rate. The upper and lower 2 bytes can be set individually but the combined 4 bytes must be within the setting available range from -59999 to 59999 (FFFF15A1H to 0000EA5FH) [m^3/h].

[Address 0106H, 0107H] Upper limit alarm flow-rate

Setting of the upper limit alarm flow-rate for the upper and lower limit alarm flow-rate.

* This is a 4-byte data, similarly to the analog output FS flow-rate. The upper and lower 2 bytes can be set individually but the combined 4 bytes must be within the setting available range from -59999 to 59999 (FFFF15A1H to 0000EA5FH) [m^3/h].

[Address 0108H] Alarm judgment hysteresis width

Setting of the alarm judgment hysteresis width, as the flow-rate width to stop the alarm, against the set flow-rates of the upper and lower limit alarm flow-rate.

The available range is 0 to 9999 (0000H to 270FH) [m^3/h].

[Address 0109H] Flow-rate moving average number of times

Setting of the number of moving averages for the measured instantaneous flow-rate.

"No moving average (0000H)," "2 times (0001H)," "4 times (0002H)," "8 times (0003H)," "16 times (0004H)," "32 times (0005H)," and "64 times (0006H)." are selectable.

Including the instantaneous flow-rate most recently measured, flow-rate value averaged with the selected moving average number of times is displayed and outputted.

It is set to “4 times” at factory.

[Address 010AH] Output pulse unit

Selection of the output pulse unit from "10L/P(0000H)," "100L/P(0001H)," "1000L/P(0002H)", and "10000L/P(0003H).”

May not be selectable depending on the combination of the nominal diameter and settings of [Address 010BH] Pulse output method and [Address 010CH] Flow value compensation.

See the table below for details.

Nominal diameter	Pulse constant	Duty output			One-shot pulse output															
					Pulse ON width [ms]															
					Actual flow-rate					Standard compensation					Normal compensation				
		Actual flow-rate	Standard	Normal	50	100	125	250	500	50	100	125	250	500	50	100	125	250	500
25A	10		×	×					×	×	×	×	×	×	×	×	×	×	×
	100			○										×					×
	1000																		
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
32A	10		×	×				×	×	×	×	×	×	×	×	×	×	×	×
	100			○									×	×				×	×
	1000																		
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
40A	10		×	×				×	×	×	×	×	×	×	×	×	×	×	×
	100			○									×	×				×	×
	1000																		
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
50A	10		×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100			○							×	×	×	×		×	×	×	×
	1000																		
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
65A	10		×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100			○						×	×	×	×	×		×	×	×	×
	1000													×					
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
80A	10		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100		×	○					×	×	×	×	×	×	×	×	×	×	×
	1000													×					×
	10000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
100A	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100		×	×					×	×	×	×	×	×	×	×	×	×	×
	1000			○									×	×					×
	10000																		
150A	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100		×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×
	1000			○							×	×	×	×			×	×	×
	10000																		
200A	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	100		×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×
	1000			○							×	×	×	×		×	×	×	×
	10000																		

○ Factory setting
Can be set
× Cannot be set

[Address 010BH] Pulse output method

Selection of method of outputting pulses from 5 kinds of one-shot method (ON time of "50ms(0000H)," "100ms(0001H)," "125ms(0002H)," "250ms(0003H)," and "500ms(0004H)") and Duty method (0005H).

When using a battery-driven pulse receiving instrument, the one-shot method is recommended.

Check the specification of the pulse receiving instrument and select the most suitable ON time.

The pulse ON width for one-shot pulses has a tolerance of up to +5ms for the set value.

Set value	Range
50ms	50 to 55ms
100ms	100 to 105ms
125ms	125 to 130ms
250ms	250 to 255ms
500ms	500 to 505ms

[Address 010CH] Flow value compensation selection

Selection from "No (OFF) (0000H), "Yes (Normal) (0001H), and "Yes (Standard) (0002H)" for flow value compensation.

When the compensation is set to “Yes”, the indication of "Normal" or "Standard” above the separation line of flow meter display is turned on. And, the accumulated flow volume

indication, instantaneous flow-rate display, and output signals are to correspond to the compensated flow value.

When compensation is set to “No”, the indication of "Normal" or "Standard” above the separation line of flow meter display is turns off. And, the accumulated flow volume indication, instantaneous flow-rate display, and output signals are to correspond to the actual flow value.

When flow value compensation is set, the following settings are automatically applied:

Pulse constant : 1,000 L/P (common to one-shot and duty methods)
Pulse ON width : 50 ms (one-shot method only)

Example 1: When the standard flow value compensation is selected from no compensation (one-shot method)

Nominal diameter 25A, pulse constant **10L/P**, pulse ON width **100ms**, actual flow value

↓Selection of standard flow value compensation

Nominal diameter 25A, pulse constant **1,000L/P**, pulse ON width **50ms**, standard flow value

Example 2: When no compensation is selected from no compensation (one-shot method)

Nominal diameter 25A, pulse constant **10L/P**, pulse ON width **100ms**, actual flow value

↓ Selection of actual flow value

Nominal diameter 25A, pulse constant **1,000L/P**, pulse ON width **50ms**, actual flow value

Example 3: When the normal flow value compensation is selected from no compensation (one-shot method)

Nominal diameter 25A, pulse constant **10L/P**, Duty, actual flow value

↓Selection of normal flow value

Nominal diameter 25A, pulse constant **1,000L/P**, Duty, normal flow value

[Address 010DH] Standard compensation temperature

Setting of the temperature [°C] used as the standard when performing standard compensation.

Temperature can be set within the range from -10 to +60°C (FFF6H to 003CH) increments of 1°C units. At the time of the setting, handle this value as the data with +/- sign.

The standard compensation temperature is effective only when [Address 010CH] Flow value compensation selection is set to “Yes (Standard).”

When it is set to “No” or "Yes (Normal),” the compensation temperature can be changed but will not be reflected on flow value compensation.

[Address 010EH] Test mode time selection

Setting of the test mode effective time to "3 min (0000H)," "60 min (0001H),” or "Infinite (0002H).”

The test mode temporarily cancels the low flow cut off function to allow for simple detection of pipe leak. Refer to "3) Test mode" under "7. Operation Mode" in the Operation Manual for the details.

[Address 010FH] Fluid selection

Selection from "Air (0000H)" and "Nitrogen (0001H)."

Even if the product for air was ordered, setting this parameter to nitrogen allows for using it for nitrogen. Note that nitrogen cannot be selected for the nominal diameters 100 to 200A.

[Address 0110H] Analog output item selection

Selection from "Instantaneous flow-rate (0000H)," "Pressure (0001H)," or "Temperature (0002H)" for the analog output function.

When the instantaneous flow-rate is selected, the correlated value of the instantaneous flow-rate selected by [Address 010CH] Flow value compensation selection is output.

The analog output value depends on the setting of [Address 0100H] Display・output selection. See the table below.

		[Address 0100H] Display・output selection	
		Forward flow	Forward/reverse flow
[Address 0110H] Analog output item selection	Instantaneous flow-rate	Flow-rate 0 to +FS* Current 4 to 20 [mA] (Flow-rate 0 -> Current 4 [mA])	Flow-rate -FS to +FS* Current 4 to 20 [mA] (Flow-rate 0 -> Current 12 [mA])
	Pressure	Current depending on pressure [mA]	
	Temperature	Current depending on temperature [mA]	

*FS: Set value of [Address 0101H, 0102H] Analog output FS (full scale) flow-rate

[Address 0111H] Low flow cut off flow-rate

Setting of the low flow cut off value (Q_{cut}) to make the instantaneous flow-rate as "0m^3/h."

Use a value multiplied by 10 as the setting value. For example, when setting the value to "1.0[m^3/h]," set "1.0×10=10 (DEC)" (000A (HEX)) and the instantaneous flow-rate becomes "0[m^3/h]" when the measured instantaneous flow-rate falls within -1.0 to +1.0[m^3/h].

The Qcut value can be set within the range from 0 to Qmin (not included). The value of Qmin depends on the nominal diameter. See the table below.

Nominal diameter	Qmin [m^3/h]	Upper limit (HEX)
25A	0.7	0007
32A	1.3	000D
40A	1.6	0010
50A	3	001E
65A	4.8	0030
80A	6	003C
100A	10	0064
150A	24	00F0
200A	40	0190

The set flow-rate is the one selected with [Address 010CH] Flow value compensation.

[Address 0112H] Atmospheric pressure of the working environment

Setting of the atmospheric pressure of the working environment as an absolute pressure [kPa]. The set value is used to calculate the compensated flow value.

Use a value multiplied by 10 as the setting value. For example, when setting “101.3[kPa], set “101.3×10 = 1013 (DEC)” (03F5 (HEX)).

It is set to “101.3 [kPa]” at factory. When the flow meter is used at a high attitude, an error occurs in calculation of the compensated flow value, so set an appropriate atmospheric pressure.

See below for the relationship between the attitude and atmospheric pressure and the maximum measurement error.

(Note that this table lists reference values which may vary depending on other environmental factors.)

Altitude (m)	Atmospheric pressure (absolute pressure) (kPa)	Maximum error (%) (Set value of the atmospheric pressure of use environment: 101.3kPa Measured pressure: 0kPa (gage pressure)
0	101.3	±0.0
200	98.95	+2.4
400	96.61	+4.9
1000	89.87	+12.7

[Address 0113H] With or without pressure value averaging [kPa]

Setting of the moving average of the pressure value to "No (0000H).” or "Yes (0001H)” When "Yes” is selected, the moving average value of 10 most recently measured pressure values is used for display and output.

[Address 0114H] - [Address 0117H] are the configuration items related to communication.
If these items are changed, change the settings of the master communication device also in accordance with the changed settings.

[Address 0114H] RTU address

Setting of the flow meter RTU address.

The RTU address can be set within the range from 001 to 247 (0001H - 00F7H).

[Address 0115H] Communication bit rate

Setting of the communication bit rate to "9,600bps (0000H),” "19,200bps (0001H),” "38,400bps (0002H),” "57,600bps (0003H),” or "115,200bps (0004H).”

[Address 0116H] Stop bit length

Setting of the number of stop bits to "1 bit (0000H)” or "2 bits (0001H).”

[Address 0117H] Parity bit

Selection of the parity bit from "None (0000H)," "Odd (0001H)," and "Even (0002H)."

7.2.3 Flow meter information and clearing

The internal flow meter information can be acquired. The following function codes can be used for this purpose.

Code (HEX)	Function
03	Reading of parameters

The function code listed below can be used to clear the parameters.

Code (HEX)	Function
05	Clearing of accumulated values and parameters

Function code (HEX)	Address (HEX)	Area name	Function	Reference page
03	0200	Flow meter information	Instantaneous flow-rate (upper 2 bytes)	26
	0201		Instantaneous flow-rate (lower 2 bytes)	
	0202		Pressure (2 bytes)	26
	0203		Temperature (2 bytes)	26
	0204		Accumulated forward flow volume ① (upper 2 bytes of 6-byte data)	26-27
	0205		Accumulated forward flow volume ① (middle 2 bytes of 6-byte data)	
	0206		Accumulated forward flow volume ① (lower 2 bytes of 6-byte data)	
	0207		Accumulated reverse flow volume ① (upper 2 bytes of 6-byte data)	26-27
	0208		Accumulated reverse flow volume ① (middle 2 bytes of 6-byte data)	
	0209		Accumulated reverse flow volume ① (lower 2 bytes of 6-byte data)	
	020A		Trip accumulated volume ① (upper 2 bytes of 6-byte data)	26-27
	020B		Trip accumulated volume ① (middle 2 bytes of 6-byte data)	
	020C		Trip accumulated volume ① (lower 2 bytes of 6-byte data)	
	020D		Error information: Ultrasonic measurement failure (2 bytes)	27
	020E		Error information: Temperature measurement failure (2 bytes)	27
	020F		Error information: Pressure measurement failure (2 bytes)	27
	0210		Error information: Power supply voltage drop (2 bytes)	27
	0211		Error information: Upper/ lower flow-rate limit failure (2 bytes)	27

	0212		Nominal diameter information	27-28
	0213		Accumulated forward flow volume ② (upper 2 bytes of 4-byte data)	28-29
	0214		Accumulated forward flow volume ② (lower 2 bytes of 4-byte data)	
	0215		Accumulated reverse flow volume ② (upper 2 bytes of 4-byte data)	
	0216		Accumulated reverse flow volume ② (lower 2 bytes of 4-byte data)	
	0217		Trip accumulated volume ② (upper 2 bytes of 4-byte data)	
	0218		Trip accumulated volume ② (lower 2 bytes of 4-byte data)	
05	0300	Clear	Accumulated value clear	29
	0301		Parameter clear (Setting of initial values)	29

[Address 0200H, 0201H] Instantaneous flow-rate

Instantaneous flow-rate in accordance with [Address 010CH] flow value compensation selection. Responds with +/-signed 4-byte data, multiplied by 100.

The 4-byte data can be read in the upper and lower 2 bytes separately.

(Example) When the instantaneous flow-rate is 123.45[m^3/h] (123.45×100=12345 (DEC), 00003039 (HEX))

- Upper 2 bytes of read data : 0000H
- Lower 2 bytes of read data : 3039H
- 4 bytes of read data : 00003039H

[Address 0202H] Pressure [kPa]

Responds with unsigned 2-byte data, multiplied by 10.

(Example) When the pressure is 123.4 [kPa] (123.4×10=1234 (DEC), 04D2 (HEX))

- Read data: 04D2H

[Address 0203H] Temperature [°C]

Responds with signed 2-byte data, multiplied by 10.

(Example) When the temperature is -9.4 [°C] (-9.4×10=-94 (DEC), FFA2 (HEX))

- Read data: FFA2H

[Address 0204H, 0205H, 0206H] Accumulated forward flow volume ① 6-byte data
[Address 0207H, 0208H, 0209H] Accumulated reverse flow volume ① 6-byte data
[Address 020AH, 020BH, 020CH] Trip accumulated volume ① 6-byte data

Accumulated flow volume depending on [Address 010CH] flow value compensation selection. Responds with unsigned 6-byte data, multiplied by 1 to 100.

The 6-byte data can be read in the upper, middle, and lower 2 bytes separately.

Note that the multiplier varies depending on [Address 010CH] Flow value compensation selection. See the table below.

	Nominal diameter	
	25 to 80A	100 to 200A
Normal and standard compensation	Value multiplied by 10 hex: 003B 9AC9 FFFFH dec: 255,999,999,999	Value multiplied by 1 hex: 0254 0BE3 FFFFH dec: 2,559,999,999,999
No compensation	Value multiplied by 100 hex: 0254 0BE3 FFFFH dec: 2,559,999,999,999	Value multiplied by 1 hex: 0254 0BE3 FFFFH dec: 2,559,999,999,999

Each accumulated volume can be read without regard to the setting of [Address 0100H] Display・ output selection. For example, the trip accumulated volume can be read when the forward/reverse flow-rate is selected for display and output.

Example) When the read value is 0000075BCD15H

	Accumulated forward flow volume, trip accumulated volume	Accumulated reverse flow volume
[Valued multiplied by 1]	123456789	-123456789
[Valued multiplied by 10]	12345678.9	-12345678.9
[Valued multiplied by 100]	1234567.89	-1234567.89

Even when the accumulated value display overflows, the true accumulated flow volume is read.

Example) When the read value is 00086B76CF28H

	Accumulated forward flow volume	Trip accumulated volume	Accumulated reverse flow volume
[Valued multiplied by 1]	3***6162686760***	36***162686760***	- 36***162686760***
[Valued multiplied by 10]	3***616268676.0***	36***16268676.0***	- 36***16268676.0***
[Valued multiplied by 100]	3***61626867.60***	36***1626867.60***	- 36***1626867.60***

*Italic and underscored figures are displayed.

[Address 020DH] Error information: Ultrasonic measurement failure

This item reads the status of ultrasonic measurement (flow measurement).

Failure: Responds FFFFH. Normal: Responds 0000H.

[Address 020EH] Error information: Abnormal temperature

This item reads the temperature status.

Failure: Responds FFFFH. Normal: Responds 0000H.

[Address 020FH] Error information: Pressure measurement failure

This item reads the status of pressure measurement.

Failure: Responds FFFFH. Normal: Responds 0000H.

[Address 0210H] Error information: Power supply voltage drop

This item reads the status of the power supply voltage.

Note that when the power supply voltage is too low so that the status is as a power failure, the communication function of the flow meters is stopped. Therefore, "Power supply voltage normal: 0000H" can only be responded.

[Address 0211H] Error information: Upper and lower flow-rate limits failure

This item reads the status of the instantaneous flow-rate values.

It is the judged result based on the settings of [Address 0104H, 0105H] Lower limit alarm output flow-rate, [Address 0106H, 0107H] Upper limit alarm output flow-rate, and [Address 0108H] Alarm judgment hysteresis width.

Failure: Responds FFFFH. Normal: Responds 0000H.

[Address 0212H] Nominal diameter information

This item reads the nominal diameter of the flow meter.

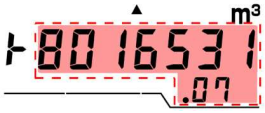
The table below lists relationship between the nominal diameters and read data.

Read data (HEX)	Nominal diameter
0000	25A
0001	32A
0002	40A
0003	50A
0004	65A
0005	80A
0006	100A

0007	150A
0008	200A

[Address 0213H, 0214H] Accumulated forward flow volume ② 4-byte data
[Address 0215H, 0216H] Accumulated reverse flow volume ② 4-byte data
[Address 0217H, 0218H] Trip accumulated volume ② 4-byte data
[Address 010CH] Accumulated flow volume depending on flow value compensation selection
Responds with unsigned 4-byte data, enclosed by dashed line shown in the figure in the table below (⬚), multiplied by 1 to 100.

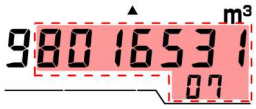
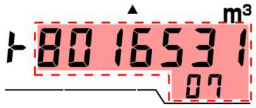
1) Nominal diameter 25 to 80A, no flow value compensation

	Display example	Read value
Accumulated forward flow volume		9-digit display value multiplied by 100 2FC84173H(8016531.07 multiplied by 100) Read value (max) hex: 3B9AC9FFH dec: 999,999,999
Trip accumulated volume		9-digit display value multiplied by 100 2FC84173H(8016531.07 multiplied by 100) Read value (max) hex: 3B9AC9FFH dec: 999,999,999
Accumulated reverse flow volume		9-digit display value multiplied by 100 2FC84173H(8016531.07 multiplied by 100) Read value (max) hex: 3B9AC9FFH dec: 999,999,999

2) Nominal diameter 25 to 80A, with flow value compensation

	Display example	Read value
Accumulated forward flow volume		9-digit display value multiplied by 10 3A6C22C5H(98016531.7 multiplied by 10) Read value (max) hex: 3B9AC9FFH dec: 999,999,999
Trip accumulated volume		8-digit display value multiplied by 10 04C739C5H(8016531.7 multiplied by 10) Read value (max) hex: 05F5E0FFH dec: 99,999,999
Accumulated reverse flow volume		8-digit display value multiplied by 10 04C739C5H(8016531.7 multiplied by 10) Read value (max) hex: 05F5E0FFH dec: 99,999,999

3) Nominal diameter 100 to 200A

	Display example	Read value
Accumulated forward flow volume		9-digit display value multiplied by 1 2FC84173H(801653107 multiplied by 1) Read value (max) hex: 3B9AC9FFH dec: 999,999,999
Trip accumulated volume		9-digit display value multiplied by 1 2FC84173H(801653107 multiplied by 1) Read value (max) hex: 3B9AC9FFH dec: 999,999,999
Accumulated reverse flow volume		9-digit display value multiplied by 1 2FC84173H(801653107 multiplied by 1) Read value (max) hex: 3B9AC9FFH dec: 999,999,999

The 4-byte data can be read in the upper and lower 2 bytes separately.

Note that the multiplier varies depending on the nominal diameter and the setting of [Address 010CH] Flow value compensation selection. See the example above.

[Address 0300H] Accumulated value clear

Clearing of the accumulated forward flow volume, accumulated reverse flow volume, and trip accumulated flow volume to "0" at once.

Setting data is only cleared by a clear command of “0000H.”

Note that any of the accumulated forward flow volume, accumulated reverse flow volume, and trip accumulated flow volume cannot be cleared individually.

However, the trip accumulated volume can be cleared using the setting button of the flow meter. Refer to "1) Measurement mode" under "7. Operation Mode" in the Operation Manual for the details.

[Address 0301H] Parameter reset

Resetting of the parameters [Address 0100H] to [Address 0113H] to the factory settings. Setting data is only cleared by a clear command of “0000H.”

Refer to "8 Factory Setting List” for the factory defaults.

Note that the pulse output unit is reset to 1,000L/P.

8 Factory Setting List

Function code (HEX)	Address (HEX)	Area name	Function	Data	(HEX)
03 06 10	0100	Parameter	Display・output selection	Forward flow:	0000
	0101		Analog output FS flow-rate: Upper 2 bytes	25A: 300[m^3/h] 32A: 600 40A: 700 50A: 1200	0000012C 00000258 000002BC 000004B0
	0102		Analog output FS flow-rate: Lower 2 bytes	65A: 2000 80A: 2500 100A: 5000 150A: 10000 200A: 20000	000007D0 000009C4 00001388 00002710 00004E20
	0103		State of contact output	Normal open	0000
	0104		Lower limit alarm flow-rate: Upper 2 bytes	0 [m^3/h]	00000000
	0105		Lower limit alarm flow-rate: Lower 2 bytes		
	0106		Upper limit alarm flow-rate: Upper 2 bytes	59999 [m^3/h]	0000EA5F
	0107		Upper limit alarm flow-rate: Lower 2 bytes		
	0108		Alarm threshold hysteresis width	0 [m^3/h]	0000
	0109		Flow-rate moving average number of times	4 times	0002
	010A		Output pulse unit	25 to 80A : 100L/P 100 to 200A: 1000L/P Parameter reset: 1000L/P	0001 0002 0002
	010B		Pulse output method	Duty	0005
	010C		Flow value compensation selection	Yes (normal compensated flow-rate)	0001
	010D		Standard compensation temperature	20°C	0014
	010E		Test mode time selection	3 min	0000
	010F		Fluid selection	Air	0000
	0110		Analog output item selection	Flow-rate	0000
	0111		Low flow cut off	25A: 0.1[m^3/h] 32A: 0.2 40A: 0.2 50A: 0.4 65A: 0.6 80A: 0.8 100A: 2.6 150A: 5.0 200A: 9.0	0001 0002 0002 0004 0006 0008 001A 0032 005A
	0112		Atmospheric pressure of the working environment	101.3kPa (10 times)	03F5
	0113		With or without pressure value averaging	With	0001
	0114		RTU address	01	0001
	0115		Bit rate	115,200bps	0004
	0116		Stop bit length	1 bit	0000
	0117		Parity bit	Even	0002

9 Calculation of Error Check Code (CRC-16)

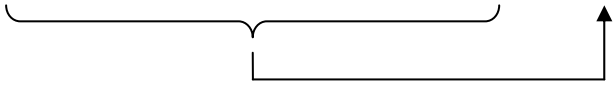
9.1 Overview

The Modbus RTU protocol includes an error check code based on the CRC method in each message. The error check code is composed of 16 bits and calculated and added to the message by the transmitting party. The receiving party calculates the CRC valued from the received message, and compares the calculated value with the error check code added to the message. If the two CRC values do not match, an error is declared.

CRC calculation is performed on the leading RTU address through the end of the data. Note that only eight bits of each character are used and CRC is not applied to the start, stop, and parity bits.

When the error check code is added to the message, the lower byte of the calculation result is added first, followed by the upper byte.

Start	RTU address	Function code	Data	Error check code	End
Silent Interval	1 byte	1 byte	n bytes	2 bytes	Silent Interval



9.2 Calculation procedure

① Initializes the CRC code to “FFFFH.”

② Calculates XOR (exclusive OR) between the lower byte of the CRC code and the first character of the message, and stores the result in the CRC code.

③ Proceeds to ④ if the least significant bit of the CRC code is “1.”
Proceeds to ⑤ if the least significant bit of the CRC code is “0.”

④ Shifts the CRC code to the right by one bit, calculates XOR with the generating polynomial A001H, and stores the result in the CRC code. Proceeds to ⑥.

⑤ Shifts the CRC code by one bit. Proceeds to ⑥.

⑥ Repeats steps ③ and ④ or step ⑤ until the CRC code has been shifted by eight bits.

⑦ Repeats steps ② to ⑥ for the second and succeeding characters to apply CRC to every character within the calculation range.

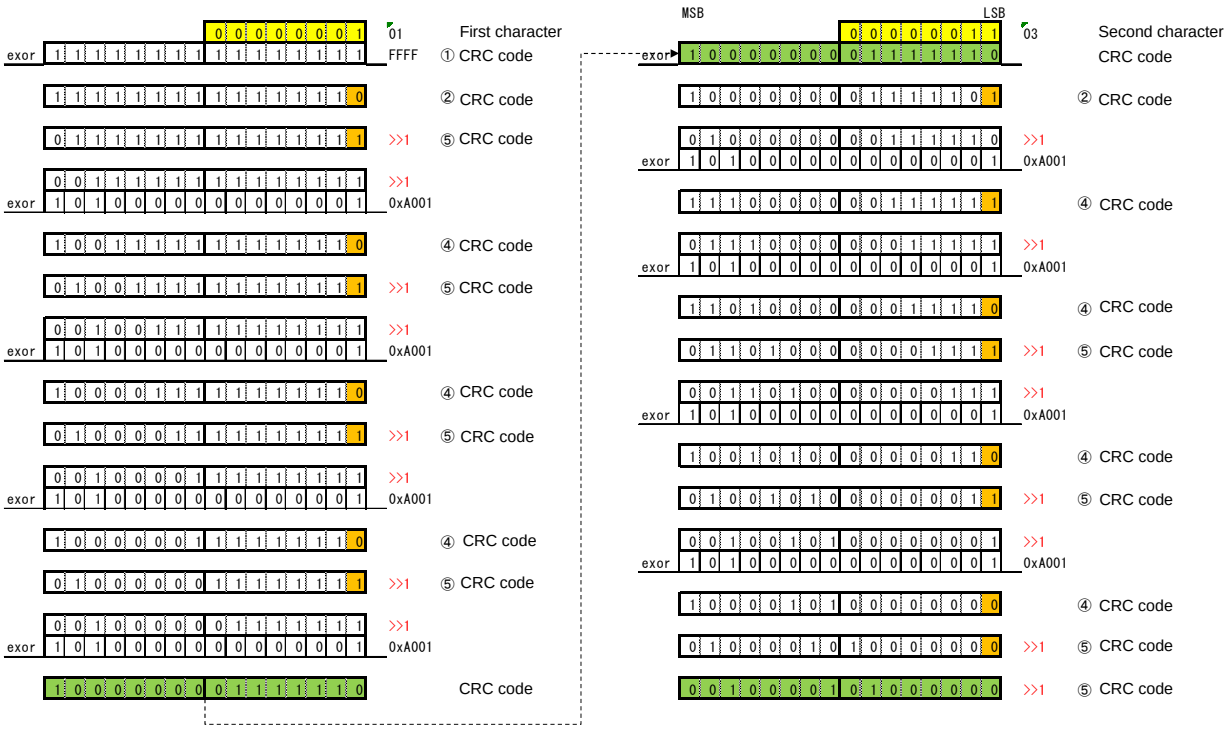
⑧ The value finally left in the CRC code is used as the error check code.

<Calculation example>

When the message is “01 03 02 01 09” (HEX), the CRC code is “D279H.” Since the lower byte of the calculation result is added to the message first, data to be transmitted is “01 03 02 01 09 79 D2.”

[Details]

Calculation for the first and second characters (“01” and “03”) are illustrated below.



Calculation continues with the third through fifth characters and the CRC code is calculated as “D279H.”