FEB-102-EC□ (C5)

This manual contains instructions for communication functions of the FEB-102-EC□.
To prevent accidents arising from the misuse of this instrument, please ensure the operator receives this manual.
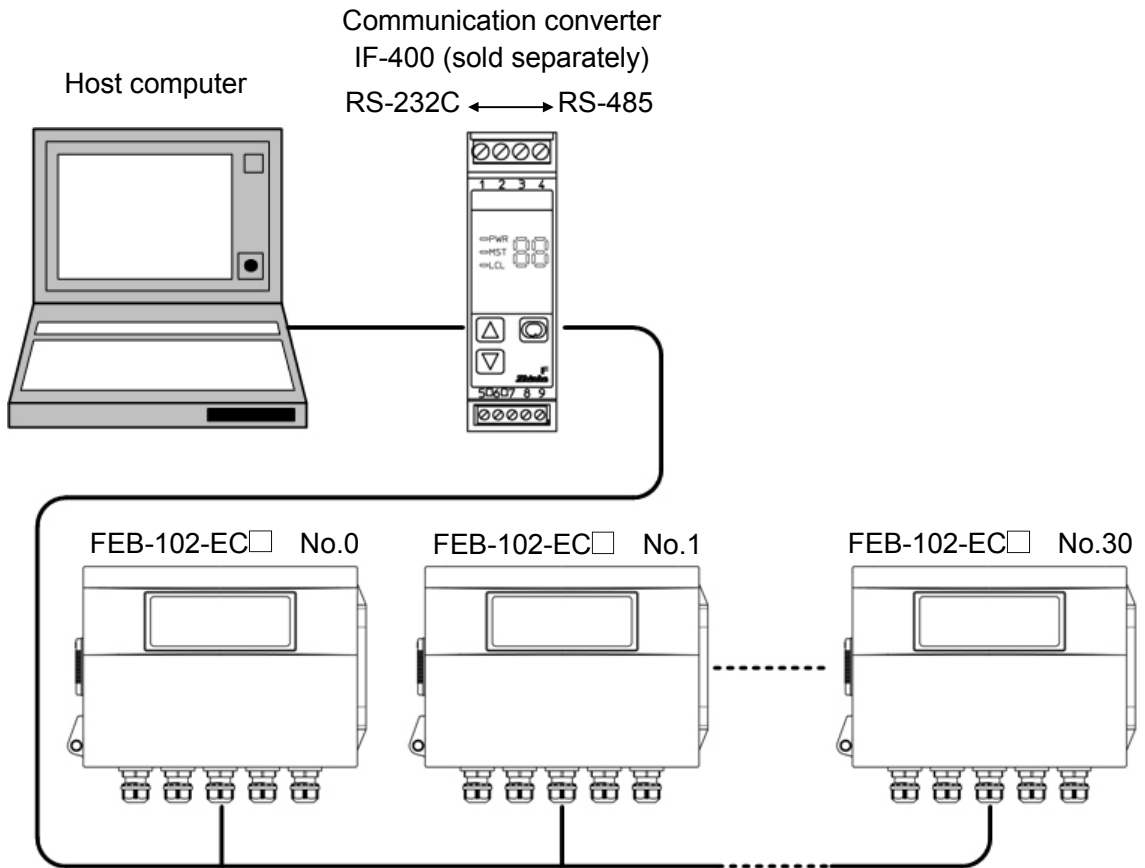

⚠ Warning

Turn the power switch of the instrument off before wiring or checking.

Working on or touching the terminal with the power switched on may result in severe injury or death due to electrical shock.
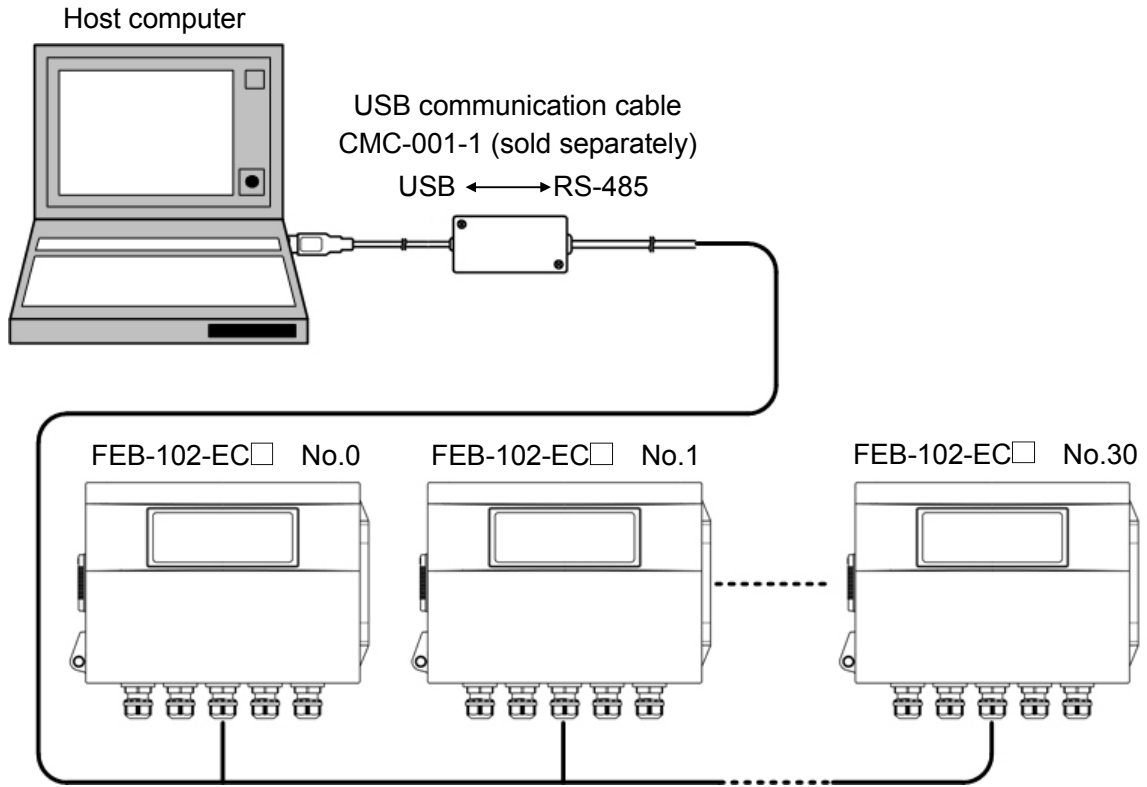
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1. System Configuration

The following shows a system configuration example using the communication converter IF-400 or USB Communication Cable CMC-001-1.

When Using the Communication Converter IF-400

(Fig. 1-1)

When Using the USB Communication Cable CMC-001-1

Host computer

USB communication cable
CMC-001-1 (sold separately)
USB ←——→ RS-485

FEB-102-EC☐ No.0   FEB-102-EC☐ No.1   FEB-102-EC☐ No.30

(Fig. 1-2)

2. Wiring

Wiring example is shown using the communication converter IF-400 or USB communication cable CMC-001-1

When using the communication converter IF-400

Connection between the communication converter IF-400 and FEB-102-EC□

By using communication cable CDM (sold separately),

Connect the cable modular jack to the IF-400 modular jack, and Y terminal ④ to FEB-102-EC□ ⑩ [YA(-)].

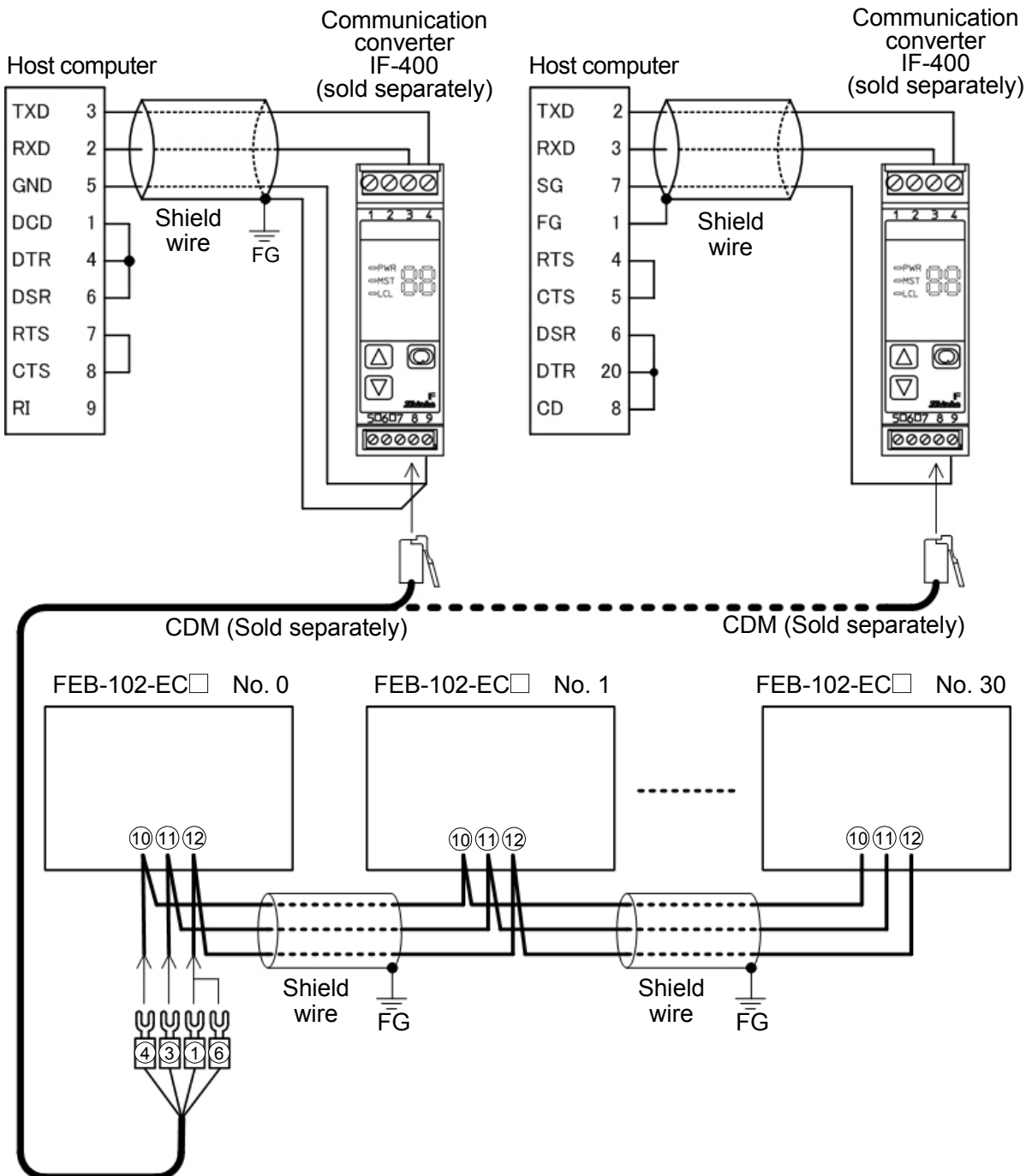Connect Y terminal ③ to FEB-102- EC□ ⑪ [YB(+)].

Connect Y terminals ① and ⑥ to FEB-102- EC□ ⑫ [COM].

Connection between FEB-102- EC□ units

By using the shield wire, connect ⑩ [YA(-)] to ⑩ [YA(-)], ⑪ [YB(+)] to ⑪ [YB(+)], and ⑫ [COM] to ⑫ [COM].

(Fig. 2-1)

When Using the USB Communication Cable CMC-001-1

Connection between the host computer and FEB-102-EC□

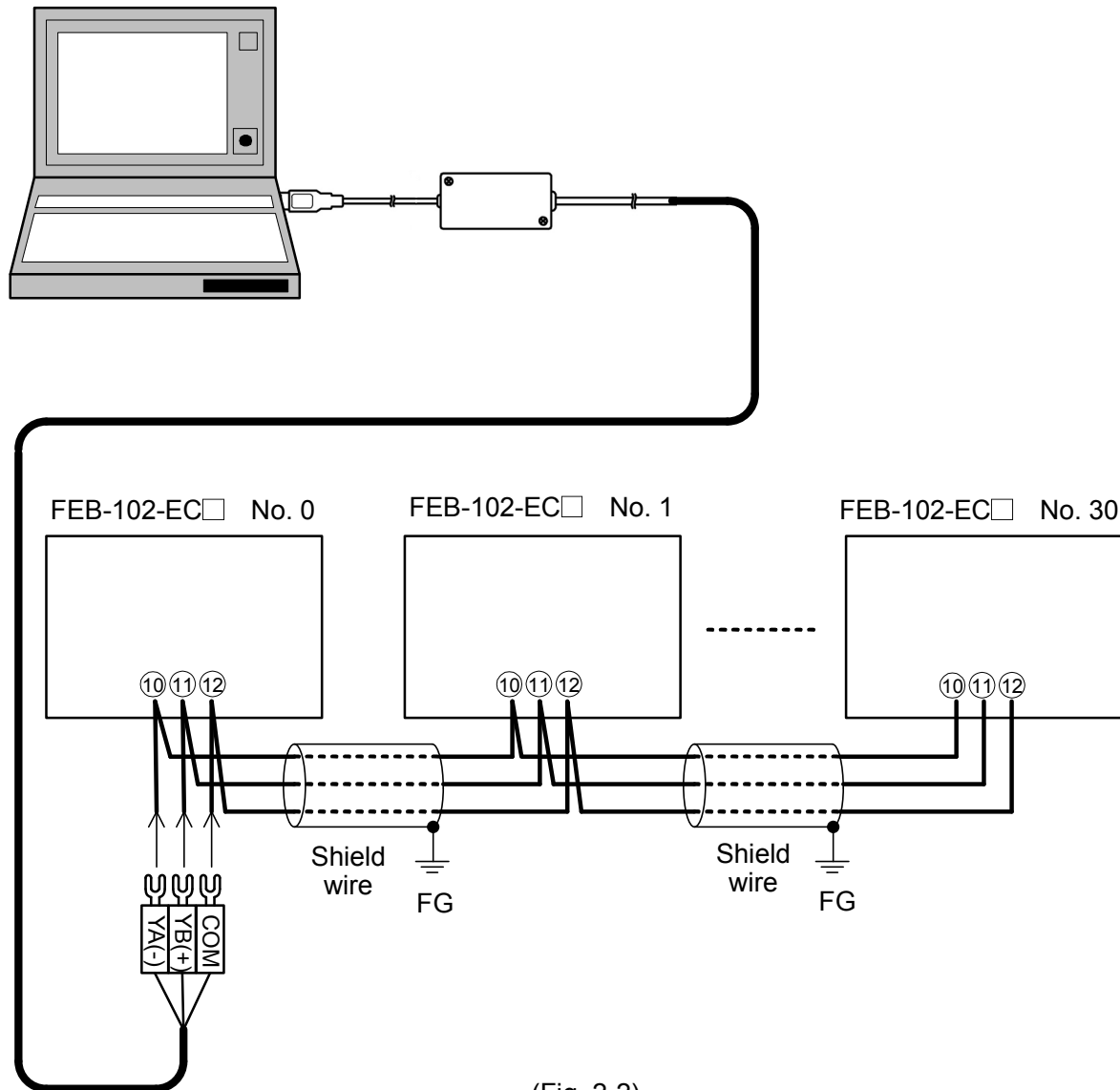By using the USB communication cable CMC-001-1 (sold separately),

Connect Y terminal [YA(-)] to FEB-102-EC□ ⑩ [YA(-)].

Connect Y terminal [YB(+)] to FEB-102-EC□ ⑪ [YB(+)].

Connect Y terminal [COM] to FEB-102-EC□ ⑫ [COM].

Connection between FEB-102-EC□ units

By using the shield wire, connect ⑩ [YA(-)] to ⑩ [YA(-)], ⑪ [YB(+)] to ⑪ [YB(+)], and ⑫ [COM] to ⑫ [COM].

(Fig. 2-2)

Shield Wire

Connect only one end of the shield to the FG terminal to avoid a ground loop. If both ends of the shield wire are connected to the FG terminal, the circuit will be closed, resulting in a ground loop. This may cause noise. Be sure to ground the FG terminal.

Recommended cable: OTSC-VB 2PX0.5SQ (made by Onamba Co., Ltd.) or equivalent (use a twisted pair cable.)

Terminator (Terminal Resistor)

Communication converter IF-400 (sold separately) has a built-in terminator.

The terminator is mounted at the end of the wire when connecting a personal computer with multiple peripheral devices. The terminator prevents signal reflection and disturbance.

Do not connect a terminator to the communication line because each FEB-102-EC□ has built-in pull-up and pull-down resistors instead of a terminator.

3. Communication Settings

Communication parameters can be set in the Communication Group.

To enter the Communication Group, follow the procedure below.

(1) **G‗pH**   Press the ⬛ MODE key once in Conductivity/Temperature Display Mode.

(2) **G‗COM**   Press the ▽ key as many times as necessary until the left characters appear.

(3) **CMSL**   Press the SET key once. The unit enters Communication Group, and "Communication protocol" appears.

(4) Set each setting items using the △ or ▽ key, and register the value with the SET key.

Character	Setting Item, Function, Setting Range	Factory Default

CMSL **NOML**	**Communication protocol**
	 • Selects communication protocol.
	 • **NOML** : Shinko protocol
	    MODA : Modbus ASCII mode
	    MODR : Modbus RTU mode
		Shinko protocol

CMNO **0**	**Instrument number** • Sets the instrument number of this unit. (The instrument numbers should be set one by one when multiple instruments are connected in Serial communication, otherwise communication is not possible.) • Setting range: 0 to 95	0

CMSP **9600**	**Communication speed**
	 • Selects a communication speed equal to that of the host computer.
	 • **9600** : 9600 bps
	    19200 : 19200 bps
	    38400 : 38400 bps
		9600 bps

CMFT **7EVN**	**Data bit/Parity**
	 • Selects data bit and parity.
	 • **8NON** : 8 bits/No parity
	    7NON : 7 bits/No parity
	    8EVN : 8 bits/Even
	    7EVN : 7 bits/Even
	    8ODD : 8 bits/Odd
	    7ODD : 7 bits/Odd
		7 bits/Even

CMST **1**	**Stop bit** • Selects the stop bit. • **1** : 1 bit **2** : 2 bits	1 bit

(5) Press the ⬛ MODE key once. The unit will revert to Conductivity/Temperature Display Mode.

4. Communication Procedure

Communication starts with command transmission from the host computer (hereafter Master) and ends with the response of the FEB-102-EC☐ (hereafter Slave).
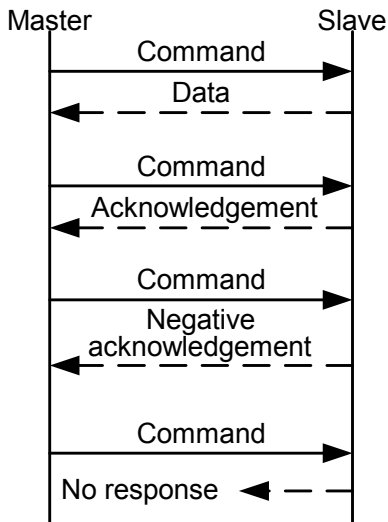
(Fig. 4-1)

- **Response with data**
  When the master sends the reading command, the slave responds with the corresponding set value or current status.
- **Acknowledgement**
  When the master sends the setting command, the slave responds by sending acknowledgement after the processing is terminated.
- **Negative acknowledgement**
  When the master sends a non-existent command or value out of the setting range, the slave returns a negative acknowledgement.
- **No response**
  The slave will not respond to the master in the following cases:
  - Global address (Shinko protocol) is set.
  - Broadcast address (Modbus protocol) is set.
  - Communication error (framing error, parity error)
  - Checksum error (Shinko protocol),
  - LRC discrepancy (Modbus ASCII mode),
  - CRC-16 discrepancy (Modbus RTU mode)

Communication Timing of the RS-485

Master Side (Take note while programming)

When the master starts transmission through the RS-485 communication line, the master is arranged so as to provide an idle status (mark status) transmission period of 1 or more characters before sending the command to ensure synchronization on the receiving side.

Set the program so that the master can disconnect the transmitter from the communication line within a 1 character transmission period after sending the command in preparation for reception of the response from the slave.

To avoid collision of transmissions between the master and the slave, send the next command after carefully checking that the master has received the response.

If a response to the command is not returned due to communication errors, set the Retry Processing to send the command again. (It is recommended to execute Retry twice or more.)

Slave Side

When the slave starts transmission through the RS-485 communication line, the slave is arranged so as to provide an idle status (mark status) transmission period of 1 or more characters before sending the response to ensure synchronization on the receiving side.

The slave is arranged so as to disconnect the transmitter from the communication line within a 1 character transmission period after sending the response.

5. Shinko Protocol

5.1 Transmission Mode

Shinko protocol is composed of ASCII codes.

Hexadecimal (0 to 9, A to F), which is divided into high order (4-bit) and low order (4-bit) out of 8-bit binary data in command is transmitted as ASCII characters.

Data format   Start bit: 1 bit
                            Data bit: 7 bits
                            Parity: Even
                            Stop bit: 1 bit

Error detection: Checksum

5.2 Command Configuration

All commands are composed of ASCII.

The data (set value, decimal number) is represented by hexadecimal numbers.

Negative numbers are represented in 2's complement.

Numerals written below the command represent the number of characters.

(1) Setting Command

Header (02H)	Address	Sub address (20H)	Command type (50H)	Data item	Data	Checksum	Delimiter (03H)
1	1	1	1	4	4	2	1

(2) Reading Command

Header (02H)	Address	Sub address (20H)	Command type (20H)	Data item	Checksum	Delimiter (03H)
1	1	1	1	4	2	1

(3) Response with Data

Header (06H)	Address	Sub address (20H)	Command type (20H)	Data item	Data	Checksum	Delimiter (03H)
1	1	1	1	4	4	2	1

(4) Acknowledgement

Header (06H)	Address	Checksum	Delimiter (03H)
1	1	2	1

(5) Negative Acknowledgement

Header (15H)	Address	Error code	Checksum	Delimiter (03H)
1	1	1	2	1

Header: Control code to represent the beginning of the command or the response. ASCII codes are used.
                             Setting command, Reading command: STX (02H) fixed
                             Response with data, Acknowledgement: ACK (06H) fixed
                             Negative acknowledgement: NAK (15H) fixed

Instrument number (Address): Numbers by which the master discerns each slave.
                             Instrument numbers 0 to 94 and Global address 95.
                             ASCII codes (20H to 7FH) are used by adding 20H to instrument numbers 0 to 95 (00H to 5FH).
                             95 (7FH) is called the Global address, which is used when the same command is sent to all the slaves connected. However, a response is not returned.

Sub address: 20H fixed

Command type: Code to discern Setting command (50H) and Reading command (20H)

Data item:	Classification of the command object.
	Composed of 4-digit hexadecimal numbers, using ASCII.
	[Refer to "7. Communication Command Table" (pp.13 to 22).]
Data:	The contents of data (set value) differ depending on the setting command.
	Composed of 4-digit hexadecimal numbers, using ASCII.
	[Refer to "7. Communication Command Table" (pp.13 to 22).]
Checksum:	2-character data to detect communication errors. (Refer to "5.3 Checksum Calculation".)
Delimiter:	Control code to represent the end of command.
	ASCII code ETX (03H) fixed
Error code:	Represents an error type using ASCII.
	1 (31H)-----Non-existent command
	2 (32H)-----Not used
	3 (33H)-----Setting outside the setting range
	4 (34H)-----Status unable to be set (e.g. During Conductivity or Temperature Calibration Mode)
	5 (35H)-----During setting mode by keypad operation

5.3 Checksum Calculation

Checksum is used to detect receiving errors in the command or data.
Set the program for the master side as well to calculate the checksum of the response data from the slaves so that communication errors can be checked.

The ASCII code (hexadecimal) corresponding to the characters which range from the address (instrument number) to that before the checksum is converted to binary notation, and the total value is calculated.
The lower one byte of the total value is converted to 2's complement, and then to hexadecimal numbers, that is, ASCII code for the checksum.
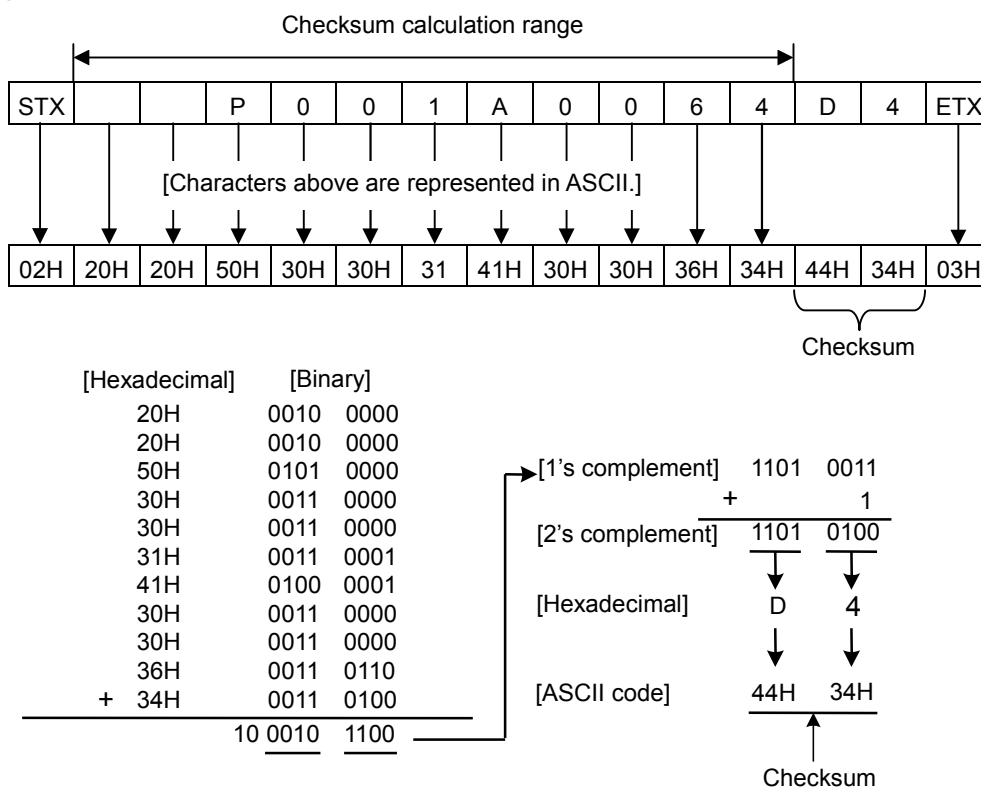
Checksum Calculation Example

Data item 001AH (EVT1 value): 1.00 (0064H)
Address (instrument number): 0 (20H)

• 1's complement: Reverse each binary bit. 0 will become 1 and vice versa.
• 2's complement: Add 1 to 1's complement.

[e.g.]

Checksum calculation range

STX		P	0	0	1	A	0	0	6	4	D	4	ETX
02H	20H	20H	50H	30H	30H	31	41H	30H	30H	36H	34H	44H	34H	03H

[Characters above are represented in ASCII.]

Checksum

[Hexadecimal]	[Binary]
20H	0010 0000
20H	0010 0000
50H	0101 0000
30H	0011 0000
30H	0011 0000
31H	0011 0001
41H	0100 0001
30H	0011 0000
30H	0011 0000
36H	0011 0110
+ 34H	0011 0100
	10 0010 1100

[1's complement] 1101 0011
            +   1
[2's complement] 1101 0100

[Hexadecimal]   D   4

[ASCII code]   44H   34H

Checksum

(Fig. 5.3-1)

6. Modbus Protocol

6.1 Transmission Mode

There are 2 transmission modes (ASCII and RTU) in Modbus protocol.

6.1.1 ASCII Mode

Hexadecimal (0 to 9, A to F), which is divided into high order (4-bit) and low order (4-bit) out of 8-bit binary data in command is transmitted as ASCII characters.

Data format   Start bit: 1 bit
                       Data bit: 7 bits
                       Parity: Even (No parity, Odd) (Selectable)
                       Stop bit: 1 bit (2 bits) (Selectable)

Error detection : LRC (Longitudinal Redundancy Check)

6.1.2 RTU Mode

8-bit binary data in command is transmitted as it is.

Data format   Start bit: 1 bit
                   Data bit: 8 bits
                   Parity: No parity (Even, Odd) (Selectable)
                   Stop bit: 1 bit (2 bits) (Selectable)

Error detection: CRC-16 (Cyclic Redundancy Check)

6.2 Data Communication Interval

6.2.1 ASCII Mode

1 second or less

Max.1 second of interval between ASCII mode characters

6.2.1 RTU Mode

3.5 character transmission times or less

To transmit continuously, an interval between characters which consist of one message, must be within 3.5 character transmission times.

If an interval lasts longer than 3.5 character transmission times, FEB-102-EC□ assumes that transmission from the master is finished, which results in a communication error, and will not return a response.

6.3 Message Configuration

6.3.1 ASCII Mode

ASCII mode message is configured to start by Header [: (colon) (3AH)] and end by Delimiter [CR (carriage return) (0DH) + LF (Line feed) (0AH)].

Header (:)	Slave address	Function code	Data	Error check LRC	Delimiter (CR)	Delimiter (LF)

6.3.2 RTU Mode

RTU mode is configured to start after idle time is processed for more than 3.5 character transmissions, and end after idle time is processed for more than 3.5 character transmissions.

3.5 idle characters	Slave address	Function code	Data	Error check CRC-16	3.5 idle characters

6.3.3 Message Details

(1) Slave Address

Slave address is an individual instrument number on the slave side, and is set within the range 0 to 95 (00H to 5FH). The master identifies slaves by the slave address of the requested message.

The slave informs the master which slave is responding to the master by placing its own address in the response message.

Slave address 00H (Broadcast address) can identify all the slaves connected. However slaves do not respond.

(2) Function Code

The function code is the command code for the slave to undertake one of the following actions.

(Table 6.3.3-1)

Function Code	Contents
03 (03H)	Reading the set value and information from slaves
06 (06H)	Setting to slaves

The Function code is used to discern whether the response is normal (acknowledgement) or if any error (negative acknowledgement) has occurred when the slave returns the response message to the master.

When acknowledgement is returned, the slave simply returns the original function code.

When negative acknowledgement is returned, the MSB of the original function code is set as 1 for the response.

(For example, if the master sends request message setting 10H to the function code by mistake, slave returns 90H by setting the MSB to 1, because the former is an illegal function.)

For negative acknowledgement, the exception codes below are set to the data of the response message, and returned to the master in order to inform it of what kind of error has occurred. (Table 6.3.3-2)

(Table 6.3.3-2)

Exception Code	Contents
1 (01H)	Illegal function (Non-existent function)
2 (02H)	Illegal data address (Non-existent data address)
3 (03H)	Illegal data value (Value out of the setting range)
17 (11H)	Shinko protocol error code 4 [Status unable to be set. (e.g.) During Conductivity or Temperature Calibration Mode]
18 (12H)	Shinko protocol error code 5 (During setting mode by keypad operation)

(3) Data

Data differs depending on the function code.

A request message from the master is composed of a data item, amount of data, and setting data.

A response message from the slave is composed of a number of bytes, data and exception codes in negative acknowledgements. [Refer to "7. Communication Command Table" (pp.13 to 22).]

The effective range of data is -32768 to 32767 (8000H to 7FFFH).

(4) Error Check

Error check differs depending on the ASCII Mode and RTU mode.

ASCII Mode

After calculating LRC (Longitudinal Redundancy Check) from the slave address to the end of data, the calculated 8-bit data is converted to two ASCII characters, and are appended to the end of message.

How to calculate LRC

① Create a message in RTU mode.
② Add all the values from the slave address to the end of data. This is assumed as X.
③ Make a complement for X (bit reverse). This is assumed as X.
④ Add a value of 1 to X. This is assumed as X.
⑤ Set X as an LRC to the end of the message.
⑥ Convert the whole message to ASCII characters.

RTU Mode

After calculating CRC-16 (Cyclic Redundancy Check) from the slave address to the end of the data, the calculated 16-bit data is appended to the end of message in sequence from low order to high order.

How to calculate CRC-16

In the CRC-16 system, the information is divided by the polynomial series. The remainder is added to the end of the information and transmitted. The generation of a polynomial series is as follows. (Generation of polynomial series: $X^{16} + X^{15} + X^2 + 1$)

① Initialize the CRC-16 data (assumed as X) (FFFFH).

② Calculate exclusive OR (XOR) with the 1st data and X. This is assumed as X.

③ Shift X one bit to the right. This is assumed as X.

④ When a carry is generated as a result of the shift, XOR is calculated by X of ③ and the fixed value (A001H). This is assumed as X. If a carry is not generated, go to step ⑤.

⑤ Repeat steps ③ and ④ until shifting 8 times.

⑥ XOR is calculated with the next data and X. This is assumed as X.

⑦ Repeat steps ③ to ⑤.

⑧ Repeat steps ③ to ⑤ up to the final data.

⑨ Set X as CRC-16 to the end of message in sequence from low order to high order.

6.4 Message Example

6.4.1 ASCII Mode

Numerals written below the command represent the number of characters.

① **Reading [Slave address 1, Data item 0080H (Conductivity)]**

• A request message from the master

Amount of data means how many data items are to be read. It is fixed as (30H 30H 30H 31H).

Header	Slave address	Function code	Data item [0080H]	Amount of data [0001H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 30H 38H 30H)	(30H 30H 30H 31H)	(37H 42H)	(0DH 0AH)
1	2	2	4	4	2	2

• Response message from the slave in normal status [1.00 mS/cm (0064H)]

The number of response bytes means the number of bytes of data which have been read. It is fixed as (30H 32H).

Header	Slave address	Function code	Number of response bytes [02H] (30H 32H)	Data [0064H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)		(30H 30H 36H 34H)	(39H 36H)	(0DH 0AH)
1	2	2	2	4	2	2

• Response message from the slave in exception (error) status (When a data item is incorrect)

The function code MSB is set to 1 for the response message in exception (error) status (83H is returned).

The exception code 02H (Non-existent data address) is returned (error).

Header	Slave address	Function code	Exception code [02H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(38H 33H)	(30H 32H)	(37H 41H)	(0DH 0AH)
1	2	2	2	2	2

② **Setting [Slave address 1, Data item 001AH (EVT1 value) 1.00 (0064H)]**

• A request message from the master

Header	Slave address	Function code	Data item [001AH]	Data [0064H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 36H)	(30H 30H 31H 41H)	(30H 30H 36H 34H)	(37H 42H)	(0DH 0AH)
1	2	2	4	4	2	2

• Response message from the slave in normal status

Header	Slave address	Function code	Data item [001AH]	Data [0064H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 36H)	(30H 30H 31H 41H)	(30H 30H 36H 34H)	(37H 42H)	(0DH 0AH)
1	2	2	4	4	2	2

- Response message from the slave in exception (error) status (When a value out of the setting range is set.)
  The function code MSB is set to 1 for the response message in exception (error) status (86H is returned.).
  The exception code 03H (Value out of the setting range) is returned (error).

Header	Slave address	Function code	Exception code [03H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(38H 36H)	(30H 33H)	(37H 36H)	(0DH 0AH)
1	2	2	2	2	2

6.4.2 RTU Mode

Numerals written below the command represent the number of characters.

① Reading [Slave address 1, Data item 0080H (Conductivity)]

- A request message from the master
  Amount of data means how many data items are to be read. It is fixed as (0001H).

3.5 idle characters	Slave address (01H)	Function code (03H)	Data item (0080H)	Amount of data (0001H)	Error check CRC-16 (85E2H)	3.5 idle characters
	1	1	2	2	2	

- Response message from the slave in normal status [1.00 mS/cm (0064H)]
  The number of response bytes means the number of bytes of data which has been read. It is fixed as (02H).

3.5 idle characters	Slave address (01H)	Function code (03H)	Number of response bytes (02H)	Data (0064H)	Error check CRC-16 (B9AFH)	3.5 idle characters
	1	1	1	2	2	

- Response message from the slave in exception (error) status (When a data item is incorrect)
  The function code MSB is set to 1 for the response message in exception (error) status (83H is returned).
  The exception code (02H: Non-existent data address) is returned (error).

3.5 idle characters	Slave address (01H)	Function code (83H)	Exception code (02H)	Error check CRC-16 (C0F1H)	3.5 idle characters
	1	1	1	2	

② Setting (Slave address 1, Data item 001AH (EVT1 value) 1.00 (0064H)]

- A request message from the master

3.5 idle characters	Slave address (01H)	Function code (06H)	Data item (001AH)	Data (0064H)	Error check CRC-16 (A9E6H)	3.5 idle characters
	1	1	2	2	2	

- Response message from the slave in normal status

3.5 idle characters	Slave address (01H)	Function code (06H)	Data item (0008H)	Data (0064H)	Error check CRC-16 (A9E6H)	3.5 idle characters
	1	1	2	2	2	

- Response message from the slave in exception (error) status (When a value out of the setting range is set)
  The function code MSB is set to 1 for the response message in exception (error) status (86H is returned.).
  The exception code (03H: Value out of the setting range) is returned (error).

3.5 idle characters	Slave address (01H)	Function code (86H)	Exception code (03H)	Error check CRC-16 (0261H)	3.5 idle characters
	1	1	1	2	

7. Communication Command Table

7.1 Note on Setting and Reading Commands

- The data (set value, decimal) is converted to hexadecimal numbers.
  Negative numbers are represented in 2's complement.
- When connecting multiple slaves, the address (instrument number) must not be duplicated.
- User save area 1 to 10 (0200H to 0209H) can be read or set in 1 word units.
  Effective range of data is -32768 to 32767 (8000H to 7FFFH).
- Even if EVT3 or EVT4 options are not ordered, setting or reading via software communication will be possible. However, EVT3 and EVT4 command contents will not function.
- Do not use undefined Data items. If they are used, negative acknowledgement will be returned or a random value will be written or read, resulting in malfunction.
- Modbus protocol uses Holding Register addresses. The Holding Register addresses are created as follows. A Shinko command data item is converted to decimal number, and the offset of 40001 is added. The result is the Holding Register address.
  Using Data item 001AH (EVT1 value) as an example: The Data item in the sending message is 001AH, however, the Modbus protocol Holding Register address is 40027 (26 + 40001).

(1) Setting Command

- Up to 1,000,000 (one million) entries can be stored in non-volatile IC memory.
  If the number of settings exceeds the limit, the data will not be saved. So, do not change the set values frequently via software communication. (If a value set via software communication is the same as the value before the setting, the value will not be written in non-volatile IC memory.)
- Be sure to select Lock 3 when changing the set value frequently via software communication. If Lock 3 is selected, all set values –except Sensor cell constant, Unit selection, Measurement range, RTD, Conductivity Zero adjustment value, Conductivity Span adjustment value, Temperature calibration value, Transmission output 1 Zero adjustment value, Transmission output 1 Span adjustment value, Transmission output 2 Zero adjustment value, Transmission output 2 Span adjustment value – can be temporarily changed. However, they revert to their previous value after the power is turned off because they are not saved in the non-volatile IC memory.
  Do not change setting items (EVT1, EVT2, EVT3, EVT4 types). If they are changed, they will affect other setting items.
- Setting range of each item is the same as that of keypad operation.
- When the data (set value) has a decimal point, a whole number (hexadecimal) without a decimal point is used.
- If EVT type is changed at Data item 0019H (EVT1 type), 0027H (EVT2 type), 0035H (EVT3 type) or 0043H (EVT4 type), then EVT1, EVT2, EVT3 or EVT4 value will default to 0 (zero). The output status of EVT1, EVT2, EVT3 or EVT4 will also be initialized.
- Settings via software communication are possible while in Set value lock status.
- The Instrument Numbers and Communication Speed of the slave cannot be set by the software communication. They can only be set via the keypad.
- When sending a command by Global address [95 (7FH), Shinko protocol] or Broadcast address [0 (00H), Modbus protocol], the same command is sent to all the slaves connected. However, the response is not returned.

(2) Reading Command

- When the data (set value) has a decimal point, a whole number (hexadecimal) without a decimal point is used for a response.

7.2 Setting/Reading Command

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0001H	Sensor cell constant	(FEB-102-ECH) 0000H: 1.0/cm 0001H: 10.0/cm
				(FEB-102-ECM) 0000H: 0.01/cm 0001H: 0.1/cm 0002H: 1.0/cm

Shinko Command Type	Modbus Function Code		Data Item	Data
50H/20H	06H/03H	0002H	Cell constant correction value	Set value, Decimal point ignored.
50H/20H	06H/03H	0003H	Unit selection	(FEB-102-ECH) 0000H: Conductivity (mS/cm) 0001H: Conductivity (S/m) 0002H: Seawater salinity (%) 0003H: NaCl salinity (%) 0004H: TDS conversion (g/L)
				(FEB-102-ECM) 0000H: Conductivity (μS/cm) 0001H: Conductivity (mS/m) 0002H: TDS conversion (mg/L)
50H/20H	06H/03H	0004H	Measurement range (FEB-102-ECH) Data differs depending on the selection of sensor cell constant and unit.	

When Sensor cell constant 1.0/cm is selected

Unit	Data	Measurement Range
Conductivity (mS/cm)	0000H	0.00 to 20.00 mS/cm
	0001H	0.0 to 200.0 mS/cm
	0002H	0.0 to 500.0 mS/cm
	0003H	0 to 500 mS/cm
Conductivity (S/m, mS/m)	0000H	0.000 to 2.000 S/m
	0001H	0.00 to 20.00 S/m
	0002H	0.00 to 50.00 S/m
	0003H	0.0 to 50.0 S/m
	0004H	0 to 2000 mS/m
TDS conversion (g/L)	0000H	0.0 to 20.0 g/L
	0001H	0 to 200 g/L
	0002H	0 to 500 g/L
Seawater salinity (%)	0000H	0.00 to 4.00%
NaCl salinity (%)	0000H	0.00 to 20.00%

When Sensor cell constant 10.0/cm is selected

Unit	Data	Measurement Range
Conductivity (mS/cm)	0000H	0.0 to 200.0 mS/cm
	0001H	0.0 to 500.0 mS/cm
	0002H	0 to 2000 mS/cm
Conductivity (S/m)	0000H	0.00 to 20.00 S/m
	0001H	0.00 to 50.00 S/m
	0002H	0.0 to 200.0 S/m
TDS conversion (g/L)	0000H	0 to 200 g/L
	0001H	0 to 500 g/L
	0002H	0 to 2000 g/L
Seawater salinity (%)	0000H	0.00 to 4.00%
NaCl salinity (%)	0000H	0.00 to 20.00%

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0004H	Measurement range (FEB-102-ECM) Measurement range will be fixed depending on the selection of sensor cell constant and unit. Negative acknowledgement (*) will be returned for the setting command.	

Unit	Cell Constant	Item	Measurement Range
Conductivity (μS/cm)	0.01/cm	0000H	0.00 to 20.00 μS/cm
	0.1/cm	0001H	0.0 to 200.0 μS/cm
	1.0/cm	0002H	0 to 2000 μS/cm
Conductivity (mS/m)	0.01/cm	0000H	0.000 to 2.000 mS/m
	0.1/cm	0001H	0.00 to 20.00 mS/m
	1.0/cm	0002H	0.0 to 200.0 mS/m
TDS conversion (mg/L)	0.01/cm	0000H	0.0 to 20.0 mg/L
	0.1/cm	0001H	0 to 200 mg/L
	1.0/cm	0002H	0 to 2000 mg/L

(*) Error code 1 (31H) (Shinko protocol) or Exception code 1 (01H) (Modbus protocol) will be returned.

Shinko Command Type	Modbus Function Code	Data Item	Data
50H/20H	06H/03H	0005H TDS conversion factor	Set value, Decimal point ignored.
50H/20H	06H/03H	0008H Conductivity input filter time constant	Set value, Decimal point ignored.
50H/20H	06H/03H	0009H Conductivity input sensor correction	Set value, Decimal point ignored.
50H/20H	06H/03H	000AH RTD type	0000H: Pt100 0001H: Pt1000
50H/20H	06H/03H	000BH Temperature compensation method	(FEB-102-ECH) 0000H: Temperature characteristics of NaCl 0001H: Temperature coefficient (%/℃) and randomly selected reference temperature 0002H: No temperature compensation
			(FEB-102-ECM) 0000H: Temperature characteristics of NaCl 0001H: Temperature coefficient (%/℃) and randomly selected reference temperature 0002H: Temperature characteristics of pure (deionized) water 0003H: No temperature compensation
50H/20H	06H/03H	000CH Temperature coefficient	Set value, Decimal point ignored.
50H/20H	06H/03H	000DH Reference temperature	Set value, Decimal point ignored.
50H/20H	06H/03H	000EH Decimal point place	0000H: No decimal point 0001H: 1 digit after decimal point
50H/20H	06H/03H	000FH Pt100 input wire type	0000H: 2-wire type 0001H: 3-wire type
50H/20H	06H/03H	0010H Cable length correction	Set value, Decimal point ignored.
50H/20H	06H/03H	0011H Cable cross-section area	Set value, Decimal point ignored.
50H/20H	06H/03H	0012H Temperature input filter time constant	Set value, Decimal point ignored.
50H	06H	0013H Temperature calibration mode	0000H: Conductivity/Temperature Display Mode 0001H: Temperature calibration mode
50H/20H	06H/03H	0014H Temperature calibration value	Set value, Decimal point ignored.

Shinko Command Type	Modbus Function Code		Data Item	Data
50H	06H	0015H	Conductivity calibration mode	0000H: Conductivity/Temperature Display Mode 0001H: Conductivity calibration mode Zero adjustment 0002H: Conductivity calibration mode Span adjustment
50H/20H	06H/03H	0016H	Conductivity Zero adjustment value	Set value, Decimal point ignored.
50H/20H	06H/03H	0017H	Conductivity Span adjustment value	Set value, Decimal point ignored.
50H/20H	06H/03H	0019H	EVT1 type	0000H: No action 0001H: Conductivity input low limit 0002H: Conductivity input high limit 0003H: Temperature input low limit 0004H: Temperature input high limit 0005H: Error output 0006H: Fail output 0007H: Conductivity input error alarm output
50H/20H	06H/03H	001AH	EVT1 value	Set value, Decimal point ignored.
50H/20H	06H/03H	001BH	EVT1 proportional band	Set value, Decimal point ignored.
50H/20H	06H/03H	001CH	EVT1 reset	Set value, Decimal point ignored.
50H/20H	06H/03H	001DH	EVT1 hysteresis type	0000H: Medium value 0001H: Reference value
50H/20H	06H/03H	001EH	EVT1 ON side	Set value, Decimal point ignored.
50H/20H	06H/03H	001FH	EVT1 OFF side	Set value, Decimal point ignored.
50H/20H	06H/03H	0020H	EVT1 ON delay time	Set value
50H/20H	06H/03H	0021H	EVT1 OFF delay time	Set value
50H/20H	06H/03H	0022H	EVT1 proportional cycle	Set value
50H/20H	06H/03H	0023H	EVT1 output high limit	Set value
50H/20H	06H/03H	0024H	EVT1 output low limit	Set value
50H/20H	06H/03H	0025H	Output ON time when EVT1 output ON	Set value
50H/20H	06H/03H	0026H	Output OFF time when EVT1 output ON	Set value
50H/20H	06H/03H	0027H	EVT2 type	0000H: No action 0001H: Conductivity input low limit 0002H: Conductivity input high limit 0003H: Temperature input low limit 0004H: Temperature input high limit 0005H: Error output 0006H: Fail output 0007H: Conductivity input error alarm output
50H/20H	06H/03H	0028H	EVT2 value	Set value, Decimal point ignored.
50H/20H	06H/03H	0029H	EVT2 proportional band	Set value, Decimal point ignored.
50H/20H	06H/03H	002AH	EVT2 reset	Set value, Decimal point ignored.
50H/20H	06H/03H	002BH	EVT2 hysteresis type	0000H: Medium value 0001H: Reference value
50H/20H	06H/03H	002CH	EVT2 ON side	Set value, Decimal point ignored.
50H/20H	06H/03H	002DH	EVT2 OFF side	Set value, Decimal point ignored.
50H/20H	06H/03H	002EH	EVT2 ON delay time	Set value
50H/20H	06H/03H	002FH	EVT2 OFF delay time	Set value
50H/20H	06H/03H	0030H	EVT2 proportional cycle	Set value
50H/20H	06H/03H	0031H	EVT2 output high limit	Set value
50H/20H	06H/03H	0032H	EVT2 output low limit	Set value

Shinko Command Type	Modbus Function Code		Data Item	Data
50H/20H	06H/03H	0033H	Output ON time when EVT2 output ON	Set value
50H/20H	06H/03H	0034H	Output OFF time when EVT2 output ON	Set value
50H/20H	06H/03H	0035H	EVT3 type	0000H: No action 0001H: Conductivity input low limit 0002H: Conductivity input high limit 0003H: Temperature input low limit 0004H: Temperature input high limit 0005H: Error output 0006H: Fail output 0007H: Conductivity input error alarm output
50H/20H	06H/03H	0036H	EVT3 value	Set value, Decimal point ignored.
50H/20H	06H/03H	0037H	EVT3 proportional band	Set value, Decimal point ignored.
50H/20H	06H/03H	0038H	EVT3 reset	Set value, Decimal point ignored.
50H/20H	06H/03H	0039H	EVT3 hysteresis type	0000H: Medium value 0001H: Reference value
50H/20H	06H/03H	003AH	EVT3 ON side	Set value, Decimal point ignored.
50H/20H	06H/03H	003BH	EVT3 OFF side	Set value, Decimal point ignored.
50H/20H	06H/03H	003CH	EVT3 ON delay time	Set value
50H/20H	06H/03H	003DH	EVT3 OFF delay time	Set value
50H/20H	06H/03H	003EH	EVT3 proportional cycle	Set value
50H/20H	06H/03H	003FH	EVT3 output high limit	Set value
50H/20H	06H/03H	0040H	EVT3 output low limit	Set value
50H/20H	06H/03H	0041H	Output ON time when EVT3 output ON	Set value
50H/20H	06H/03H	0042H	Output OFF time when EVT3 output ON	Set value
50H/20H	06H/03H	0043H	EVT4 type	0000H: No action 0001H: Conductivity input low limit 0002H: Conductivity input high limit 0003H: Temperature input low limit 0004H: Temperature input high limit 0005H: Error output 0006H: Fail output 0007H: Conductivity input error alarm output
50H/20H	06H/03H	0044H	EVT4 value	Set value, Decimal point ignored.
50H/20H	06H/03H	0045H	EVT4 proportional band	Set value, Decimal point ignored.
50H/20H	06H/03H	0046H	EVT4 reset	Set value, Decimal point ignored.
50H/20H	06H/03H	0047H	EVT4 hysteresis type	0000H: Medium value 0001H: Reference value
50H/20H	06H/03H	0048H	EVT4 ON side	Set value, Decimal point ignored.
50H/20H	06H/03H	0049H	EVT4 OFF side	Set value, Decimal point ignored.
50H/20H	06H/03H	004AH	EVT4 ON delay time	Set value
50H/20H	06H/03H	004BH	EVT4 OFF delay time	Set value
50H/20H	06H/03H	004CH	EVT4 proportional cycle	Set value
50H/20H	06H/03H	004DH	EVT4 output high limit	Set value
50H/20H	06H/03H	004EH	EVT4 output low limit	Set value
50H/20H	06H/03H	004FH	Output ON time when EVT4 output ON	Set value
50H/20H	06H/03H	0050H	Output OFF time when EVT4 output ON	Set value

Shinko Command Type	Modbus Function Code		Data Item	Data
50H/20H	06H/03H	0051H	Transmission output 1 type	0000H: Conductivity transmission 0001H: Temperature transmission 0002H: EVT1 MV transmission 0003H: EVT2 MV transmission
50H/20H	06H/03H	0052H	Transmission output 1 high limit	Set value, Decimal point ignored.
50H/20H	06H/03H	0053H	Transmission output 1 low limit	Set value, Decimal point ignored.
50H/20H	06H/03H	0054H	Transmission output 2 type	0000H: Conductivity transmission 0001H: Temperature transmission 0002H: EVT1 MV transmission 0003H: EVT2 MV transmission 0004H: EVT3 MV transmission
50H/20H	06H/03H	0055H	Transmission output 2 high limit	Set value, Decimal point ignored.
50H/20H	06H/03H	0056H	Transmission output 2 low limit	Set value, Decimal point ignored.
50H/20H	06H/03H	0060H	Set value lock	0000H: Unlock 0001H: Lock 1 0002H: Lock 2 0003H: Lock 3
50H/20H	06H/03H	0061H	Display selection	0000H: Input value (Conductivity, Temperature) 0001H: Conductivity 0002H: Temperature
50H/20H	06H/03H	0063H	EVT output when input errors occur	0000H: Enabled 0001H: Disabled
50H/20H	06H/03H	0064H	Temperature Display when no temperature compensation	0000H: Unlit 0001H: Reference temperature 0002H: Measurement value
50H	06H	007FH	Key operation change flag clearing	0001H: Clear change flag
50H/20H	06H/03H	0102H	Transmission output 1 status when calibrating	0000H: Last value HOLD 0001H: Set value HOLD 0002H: Measurement value
50H/20H	06H/03H	0103H	Transmission output 1 Set value HOLD	Set value, Decimal point ignored.
50H/20H	06H/03H	0104H	Transmission output 2 status when calibrating	0000H: Last value HOLD 0001H: Set value HOLD 0002H: Measurement value
50H/20H	06H/03H	0105H	Transmission output 2 Set value HOLD	Set value, Decimal point ignored.
50H/20H	06H/03H	0106H	EVT1 conductivity input error alarm EVT☐ type	0000H: No action 0001H: EVT2 type 0002H: EVT3 type 0003H: EVT4 type
50H/20H	06H/03H	0107H	EVT2 conductivity input error alarm EVT☐ type	0000H: EVT1 type 0001H: No action 0002H: EVT3 type 0003H: EVT4 type
50H/20H	06H/03H	0108H	EVT3 conductivity input error alarm EVT☐ type	0000H: EVT1 type 0001H: EVT2 type 0002H: No action 0003H: EVT4 type

Shinko Command Type	Modbus Function Code		Data Item	Data
50H/20H	06H/03H	0109H	EVT4 conductivity input error alarm EVT☐ type	0000H: EVT1 type 0001H: EVT2 type 0002H: EVT3 type 0003H: No action
50H/20H	06H/03H	010AH	EVT1 conductivity input error alarm span when EVT☐ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	010BH	EVT1 conductivity input error alarm time when EVT☐ output ON	Set value
50H/20H	06H/03H	010CH	EVT1 conductivity input error alarm span when EVT☐ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	010DH	EVT1 conductivity input error alarm time when EVT☐ output OFF	Set value
50H/20H	06H/03H	010EH	EVT2 conductivity input error alarm span when EVT☐ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	010FH	EVT2 conductivity input error alarm time when EVT☐ output ON	Set value
50H/20H	06H/03H	0110H	EVT2 conductivity input error alarm span when EVT☐ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0111H	EVT2 conductivity input error alarm time when EVT☐ output OFF	Set value
50H/20H	06H/03H	0112H	EVT3 conductivity input error alarm span when EVT☐ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	0113H	EVT3 conductivity input error alarm time when EVT☐ output ON	Set value
50H/20H	06H/03H	0114H	EVT3 conductivity input error alarm span when EVT☐ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0115H	EVT3 conductivity input error alarm time when EVT☐ output OFF	Set value
50H/20H	06H/03H	0116H	EVT4 conductivity input error alarm span when EVT☐ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	0117H	EVT4 conductivity input error alarm time when EVT☐ output ON	Set value
50H/20H	06H/03H	0118H	EVT4 conductivity input error alarm span when EVT☐ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0119H	EVT4 conductivity input error alarm time when EVT☐ output OFF	Set value
50H/20H	06H/03H	011AH	Conductivity input error alarm time unit	0000H: Seconds 0001H: Minutes
50H	06H	011BH	Transmission output 1 adjustment mode	0000H: Conductivity/Temperature Display Mode 0001H: Transmission output 1 Zero adjustment mode 0002H: Transmission output 1 Span adjustment mode
50H/20H	06H/03H	011CH	Transmission output 1 Zero adjustment value	Set value, Decimal point ignored.
50H/20H	06H/03H	011DH	Transmission output 1 Span adjustment value	Set value, Decimal point ignored.
50H	06H	011EH	Transmission output 2 adjustment mode	0000H: Conductivity/Temperature Display Mode 0001H: Transmission output 2 Zero adjustment mode 0002H: Transmission output 2 Span adjustment mode
50H/20H	06H/03H	011FH	Transmission output 2 Zero adjustment value	Set value, Decimal point ignored.
50H/20H	06H/03H	0120H	Transmission output 2 Span adjustment value	Set value, Decimal point ignored.

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0121H	EVT1 cycle variable range	Set value, Decimal point ignored.
50H/20H	06H/03H	0122H	EVT2 cycle variable range	Set value, Decimal point ignored.
50H/20H	06H/03H	0123H	EVT3 cycle variable range	Set value, Decimal point ignored.
50H/20H	06H/03H	0124H	EVT4 cycle variable range	Set value, Decimal point ignored.
50H/20H	06H/03H	0125H	EVT1 cycle extended time	Set value
50H/20H	06H/03H	0126H	EVT2 cycle extended time	Set value
50H/20H	06H/03H	0127H	EVT3 cycle extended time	Set value
50H/20H	06H/03H	0128H	EVT4 cycle extended time	Set value
50H/20H	06H/03H	0200H	User save area 1	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0201H	User save area 2	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0202H	User save area 3	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0203H	User save area 4	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0204H	User save area 5	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0205H	User save area 6	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0206H	User save area 7	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0207H	User save area 8	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0208H	User save area 9	-32768 to 32767 (8000H to 7FFFH)
50H/20H	06H/03H	0209H	User save area 10	-32768 to 32767 (8000H to 7FFFH)

7.3 Read Only Command

Shinko Command Type	Modbus Function Code	Data Item		Data
20H	03H	0080H	Conductivity	Conductivity, Decimal point ignored.
20H	03H	0081H	Status flag 1 0000 0000 0000 0000 2^{15}　　　　to　　　　2^0 2^0 digit: Not used (Always 0) 2^1 digit: Not used (Always 0) 2^2 digit: Not used (Always 0) 2^3 digit: Not used (Always 0) 2^4 digit: Not used (Always 0) 2^5 digit: Temperature sensor burnout 　　　　　　　　0: Normal　　　1: Burnout 2^6 digit: Temperature sensor short-circuited 　　　　　　　　0: Normal　　　1: Short-circuited 2^7 digit: Outside temperature compensation range: Exceeding 110.0℃ 　　　　　　　　0: Normal　　　1: Exceeding 110.0℃ 2^8 digit: Outside temperature compensation range: Less than 0.0℃ 　　　　　　　　0: Normal　　　1: Less than 0.0℃ 2^9 digit: Conductivity measured value, salinity (FEB-102-ECH), or TDS conversion is outside the measurement range (high limit) 　　　　　　　　0: Normal　　　1: Outside the range (high limit) 2^{10} digit: Conductivity measured value, salinity (FEB-102-ECH), or TDS conversion is outside the measurement range (low limit) 　　　　　　　　0: Normal　　　1: Outside the range (low limit) 2^{11} digit: Unit status　　0: Conductivity/Temperature Display Mode 　　　　　　　　1: Setting mode 2^{12}, 2^{13} digits: Conductivity calibration status flag | 2^{13}	2^{12}	Status
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0	0	Conductivity/Temperature Display mode
0	1	During Zero adjustment in Conductivity calibration mode
1	0	During Span adjustment in Conductivity calibration mode | 2^{14} digit: Not used (Always 0) 2^{15} digit: Change in key operation　　0: No　　1: Yes		
20H	03H	0084H	EVT1 MV	MV, Decimal point ignored.
20H	03H	0085H	EVT2 MV	MV, Decimal point ignored.
20H	03H	0086H	EVT3 MV	MV, Decimal point ignored.
20H	03H	0087H	EVT4 MV	MV, Decimal point ignored.

Shinko Command Type	Modbus Function Code	Data Item		Data
20H	03H	0090H	Temperature	Temperature, Decimal point ignored.
20H	03H	0091H	Status flag 2 0000 0000 0000 0000 2^{15}　　　　to　　　　2^0 2^0 digit: EVT1 output　　　0: OFF　　1: ON 2^1 digit: EVT2 output　　　0: OFF　　1: ON 2^2 digit: EVT3 output　　　0: OFF　　1: ON 2^3 digit: EVT4 output　　　0: OFF　　1: ON 2^4, 2^5 digits: Transmission output 1 adjustment status flag	

2^4, 2^5 digits: Transmission output 1 adjustment status flag

2^5	2^4	Status
0	0	Conductivity/Temperature Display Mode
0	1	During Transmission output 1 Zero adjustment in Transmission output 1 adjustment mode
1	0	During Transmission output 1 Span adjustment in Transmission output 1 adjustment mode

2^6, 2^7 digits: Transmission output 2 adjustment status flag

2^7	2^6	Status
0	0	Conductivity/Temperature Display Mode
0	1	During Transmission output 2 Zero adjustment in Transmission output 2 adjustment mode
1	0	During Transmission output 2 Span adjustment in Transmission output 2 adjustment mode

2^8 to 2^{11} digits: Not used (Always 0)

2^{12}, 2^{13} digits: Temperature calibration status flag

2^{13}	2^{12}	Status
0	0	Conductivity/Temperature Display Mode
0	1	During Temperature calibration mode

2^{14}, 2^{15} digits: Not used (Always 0)

7.4 Conductivity Calibration, Temperature Calibration and Transmission Output Adjustment via Communication Command

7.4.1 Conductivity Calibration

Cell constant may vary due to deterioration of the 4-electrode/2-electrode conductivity sensor.
To correct the varied cell constant, calibration must be performed.
Calibrate Conductivity Zero adjustment first, followed by Conductivity Span adjustment.

The following outlines the procedure for conductivity calibration.

(1) Conductivity zero adjustment
① When selecting Last value HOLD (0000H) at Data item 0102H (Transmission output 1 status when calibrating) or at Data item 0104H (Transmission output 2 status when calibrating), select it while the 4-elctrode/2-elctrode conductivity sensor is being immersed in the solution currently calibrated.
After that, immerse the sensor in the 1st point standard solution (pH 7).
② At this stage, do not immerse the 4-elctrode conductivity sensor in the standard solution.
③ Set Data item 0015H (Conductivity calibration mode) to 0001H.
The unit moves to Conductivity calibration Zero adjustment mode.
④ Set the Conductivity Zero adjustment value at Data item 0016H (Conductivity Zero adjustment value) so that conductivity becomes 0 (zero).
When conductivity is 0 (zero), it is not necessary to adjust.
⑤ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 01 (During Zero adjustment in Conductivity calibration mode) will be returned.
⑥ Set Data item 0015H (Conductivity calibration mode) to 0000H.
Conductivity Zero adjustment is complete, and the unit will revert to Conductivity/Temperature Display mode.

(2) Conductivity span adjustment
① Immerse the 4-elctrode conductivity sensor in the standard solution.
② Set Data item 0015H (Conductivity calibration mode) to 0002H.
The unit moves to Conductivity calibration Span adjustment mode.
③ Set the Conductivity Span adjustment value at Data item 0017H (Conductivity Span adjustment value), while checking the conductivity.
④ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 10 (During Span adjustment in Conductivity calibration mode) will be returned.
⑤ Set Data item 0015H (Conductivity calibration mode) to 0000H.
Conductivity Span adjustment is complete, and the unit will revert to Conductivity/Temperature Display mode.

If Conductivity calibration cannot be performed while in Conductivity calibration mode due to temperature compensation error, Conductivity measured value error, etc., Error code 1 (Burnout, Short-circuited, etc.) will be returned after 2^5 to 2^{10} digits are read at Data item 0081H.
To cancel the error code, set Data item 0015H (Conductivity calibration mode) to 0000H.
The unit will revert to Conductivity/Temperature Display Mode.

If Conductivity Zero/Span adjustment value is set at Data item 0016H (Conductivity Zero adjustment value) or 0017H (Conductivity Span adjustment value) in Conductivity/Temperature Display Mode, the following error code will be returned.
• Shinko protocol: Error code 34H
• Modbus protocol: Exception code 11H

7.4.2 Temperature Calibration

Temperature calibration is performed by setting temperature calibration value.

When a sensor cannot be set at the exact location where measurement is desired, the resulting measured temperature may deviate from the temperature in the desired location. In this case, the desired temperature can be set for the desired location by setting a temperature calibration value. However, it is effective within the input rated range regardless of the temperature calibration value.

Temperature after temperature calibration= Current temperature + (Temperature calibration value)

(e.g.) When current temperature is 23.5℃,
When temperature calibration value is set to 1.5℃: 23.5 + (1.5) = 25.0℃
When temperature calibration value is set to -1.5℃: 23.5 + (-1.5) = 22.0℃

The following outlines the procedure for Temperature calibration.

① Set Data item 0013H (Temperature calibration mode) to 0001H. The unit moves to Temperature Calibration mode.
② Set the Temperature calibration value at Data item 0014H (Temperature calibration value).
③ If 2^{13}, 2^{12} digits are read at Data item 0091H, 01 (During Temperature calibration mode) will be returned.
④ Set Data item 0013H (Temperature calibration mode) to 0000H.
Temperature calibration is complete, and the unit will revert to Conductivity/Temperature Display mode.

If Temperature calibration cannot be performed while calibrating temperature due to input error, calibration value error, etc., Error code 1 (Burnout, Short-circuited, etc.) will be returned after 2^5 to 2^8 digits are read at Data item 0081H.
To cancel the error code, set Data item 0013H (Temperature calibration mode) to 0000H.
The unit will revert to Conductivity/Temperature Display Mode.

If Temperature calibration value is set at Data item 0014H (Temperature calibration value) in Conductivity/Temperature Display Mode, the following error code will be returned.
Shinko protocol: Error code 34H
Modbus protocol: Exception code 11H

7.4.3 Transmission Output 1 Adjustment

Fine adjustment of Transmission output 1 is performed.

This instrument is adjusted at the factory, however, differences may occur between the indication value of the connected equipment (recorders, etc.) and output value of this instrument.

In this case, perform Transmission output 1 Zero adjustment and Span adjustment.

The following outlines the procedure for Transmission output 1 adjustment.

① Set Data item 011BH (Transmission output 1 adjustment mode) to 0001H.
   The unit moves to Transmission output 1 Zero adjustment mode.
   If 2^5, 2^4 digits are read at Data item 0091H (Status flag 2), 01 (During Transmission output 1 Zero adjustment in Transmission output 1 adjustment mode) will be returned.

② Set the Transmission output 1 Zero adjustment value at Data item 011CH (Transmission output 1 Zero adjustment value), while viewing the value indicated on the connected equipment (recorders, etc.).
   Setting range: ±5.00% of Transmission output span

③ Set Data item 011BH (Transmission output 1 adjustment mode) to 0002H.
   The unit moves to Transmission output 1 Span adjustment mode.
   If 2^5, 2^4 digits are read at Data item 0091H (Status flag 2), 10 (During Transmission output 1 Span adjustment in Transmission output 1 adjustment mode) will be returned.

④ Set the Transmission output 1 Span adjustment value at Data item 011DH (Transmission output 1 Span adjustment value), while viewing the value indicated on the connected equipment (recorders, etc.).
   Setting range: ±5.00% of Transmission output span

⑤ Repeat steps ① to ④ if necessary.

⑥ To finish the Transmission output 1 adjustment, set Data item 011BH (Transmission output 1 adjustment mode) to 0000H.
   The unit reverts to Conductivity/Temperature Display Mode.

7.4.4 Transmission Output 2 Adjustment

Fine adjustment of Transmission output 2 is performed.

This instrument is adjusted at the factory, however, differences may occur between the indication value of the connected equipment (recorders, etc.) and output value of this instrument.

In this case, perform Transmission output 2 Zero adjustment and Span adjustment.

The following outlines the procedure for Transmission output 2 adjustment.

① Set Data item 011EH (Transmission output 2 adjustment mode) to 0001H.
   The unit moves to Transmission output 2 Zero adjustment mode.
   If 2^7, 2^6 digits are read at Data item 0091H (Status flag 2), 01 (During Transmission output 2 Zero adjustment in Transmission output 2 adjustment mode) will be returned.

② Set the Transmission output 2 Zero adjustment value at Data item 011FH (Transmission output 2 Zero adjustment value), while viewing the value indicated on the connected equipment (recorders, etc.).
   Setting range: ±5.00% of Transmission output span

③ Set Data item 011EH (Transmission output 2 adjustment mode) to 0002H.
   The unit moves to Transmission output 2 Span adjustment mode.
   If 2^7, 2^6 digits are read at Data item 0091H (Status flag 2), 10 (During Transmission output 2 Span adjustment in Transmission output 2 adjustment mode) will be returned.

④ Set the Transmission output 2 Span adjustment value at Data item 0120H (Transmission output 2 Span adjustment value), while viewing the value indicated on the connected equipment (recorders, etc.).
   Setting range: ±5.00% of Transmission output span

⑤ Repeat steps ① to ④ if necessary.

⑥ To finish the Transmission output 2 adjustment, set Data item 011EH (Transmission output 2 adjustment mode) to 0000H.
   The unit reverts to Conductivity/Temperature Display Mode.

7.5 Notes on Programming Monitoring Software

7.5.1 How to speed up the scan time

When monitoring multiple units of FEB-102-EC□, set the program so that the requisite minimum pieces of data such as Data item 0080H (Conductivity), Data item 0090H (Temperature), Data item 0081H (Status flag 1), Data item 0091H (Status flag 2) can be read. For other data, set the program so that they can be read only when their set value has been changed. This will speed up the scan time.

7.5.2 How to read the set value changes made by the front keypad operation

If any set value is changed by keypad operation, the FEB-102-EC□ will set [0081H (Status flag 1) 2^{15}: Change in key operation] to 1 (Yes).
There are 2 methods of reading the set value changes made by the front keypad.

(1) Reading method 1

① On the monitoring software side, check that [0081H (Status flag 1) 2^{15}: Change in key operation] has been set to 1 (Yes), then read all set values.

② Clear [0081H (Status flag 1) 2^{15}: Change in key operation], by setting Data item 007FH (Key operation change flag clearing) to 0001H (Clear change flag).
If 007FH (Key operation change flag clearing) is set to 0001H (Clear change flag) during setting mode of the instrument, Error code 5 (35H, Shinko protocol) or Exception Code 18 (12H, Modbus protocol) will be returned as a negative acknowledgement. And [0081H (Status flag 1) 2^{15}: Change in key operation] cannot be cleared.
Set a program so that all set values can be read when a negative acknowledgement is returned.

③ Read all set values again after acknowledgement is returned.

(2) Reading method 2

① On the monitoring software side, check that [0081H (Status flag 1) 2^{15}: Change in key operation] has been set to 1 (Yes), then set 007FH (Key operation change flag clearing) to 0001H (Clear change flag).

② Set the program depending on acknowledgement or negative acknowledgement as follows.
When acknowledgement is returned:
    Consider it as settings completed, and read all set values.
When Error code 5 (35H, Shinko protocol) or Exception code 18 (12H, Modbus protocol) is returned as a negative acknowledgement:
    Consider it as still in setting mode, and read the requisite minimum pieces of data such as 0080H (Conductivity), 0090H (Temperature), 0081H (Status flag 1), 0091H (Status flag 2), then return to step ①.

Thus, programs which do not affect the scan time can be created using the methods described above, even if set values on the monitoring software will not be updated until settings are complete.

7.5.3 Note when sending all set values at one time

• When changing EVT type at Data item 0019H (EVT1 type), 0027H (EVT2 type), 0035H (EVT3 type), 0043H (EVT4 type), the EVT1 to EVT4 values will default to 0 (zero).
The EVT output status will also be initialized.

First, send the EVT1, EVT2, EVT3, EVT4 type, then send the EVT1, EVT2, EVT3, EVT4 value
at Data item 001AH (EVT1 value), 0028H (EVT2 value), 0036H(EVT3 value) and 0044H (EVT4 value).

8. Specifications

Serial communication		The following operations can be carried out from an external computer. (1) Reading and setting of various set values (2) Reading of the conductivity, salinity conversion, temperature, or its status (3) Function change, adjustment (4) Reading and setting of user save area
	Cable length	1.2 km (Max.), Cable resistance: Within 50 Ω (Terminators are not necessary, but if used, use 120 Ω or more on one side.)
	Communication line	EIA RS-485
	Communication method	Half-duplex communication
	Communication speed	9600, 19200, 38400 bps (Selectable by keypad)
	Synchronization	Start-stop synchronization
	Code form	ASCII, Binary
	Communication protocol	Shinko protocol, Modbus ASCII, Modbus RTU (Selectable by keypad)
	Data bit/Parity	8-bits/No parity, 7-bits/No parity, 8-bits/Even, 7-bits/Even, 8-bits/Odd, 7-bits/Odd (Selectable by keypad)
	Stop bit	1 bit, 2 bits (Selectable by keypad)
	Error correction	Command request repeat system
	Error detection	Parity check, Checksum (Shinko protocol), LRC (Modbus protocol ASCII), CRC-16 (Modbus protocol RTU)
	Data format	(see table below)

Communication Protocol	Shinko Protocol	Modbus ASCII	Modbus RTU
Start bit	1	1	1
Data bit	7	7	8
Parity	Even	Even (No parity, Odd) Selectable	No parity (Even, Odd) Selectable
Stop bit	1	1 (2) Selectable	1 (2) Selectable

9. Troubleshooting

Check that power is being supplied to the master and slave that customers use. If communication failure still occurs, check the following.

Problem	Possible Cause	Solution
Communication failure	Communication cable is not securely connected/disconnected or defective.	Check the communication cable and connector.
	Incorrect wiring of the communication cable and connector	Check the communication cable and connector.
	Imperfect contact between the communication cable and the connector or communication connector and instrument port	Check the communication cable and connector.
	Communication speed of the slave does not match that of the master.	Check the communication speed of the slave and master.
	The data bit, parity and stop bit of the master do not correspond to those of the slave.	Check the data bit, parity and stop bit of the master and the slave.
	The instrument number (address) of the slave does not correspond to that of the command.	Check the instrument number (address) of the slave and command.
	The instrument numbers (addresses) are duplicated in multiple slaves.	Check the instrument numbers (addresses) of the slave.
	Make sure that the program is appropriate for the transmission timing.	Check the program.
Although communication is occurring, the response is negative acknowledgement.	A non-existent command code has been sent.	Check the command code.
	The setting command data exceeds the setting range of the slave.	Check the setting range of the slave.
	The FEB-102-EC□ cannot be set while calibration is being performed. Refer to Sections 7.4.1 Conductivity Calibration and 7.4.2 Temperature Calibration (pp.23, 24).	Check the slave status.
	The FEB-102-EC□ is in front keypad operation setting mode.	Return the unit to Conductivity/Temperature Display Mode.

For all other malfunctions, please contact our main office or dealers.