No. FEB1CPHE2 2016.03

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

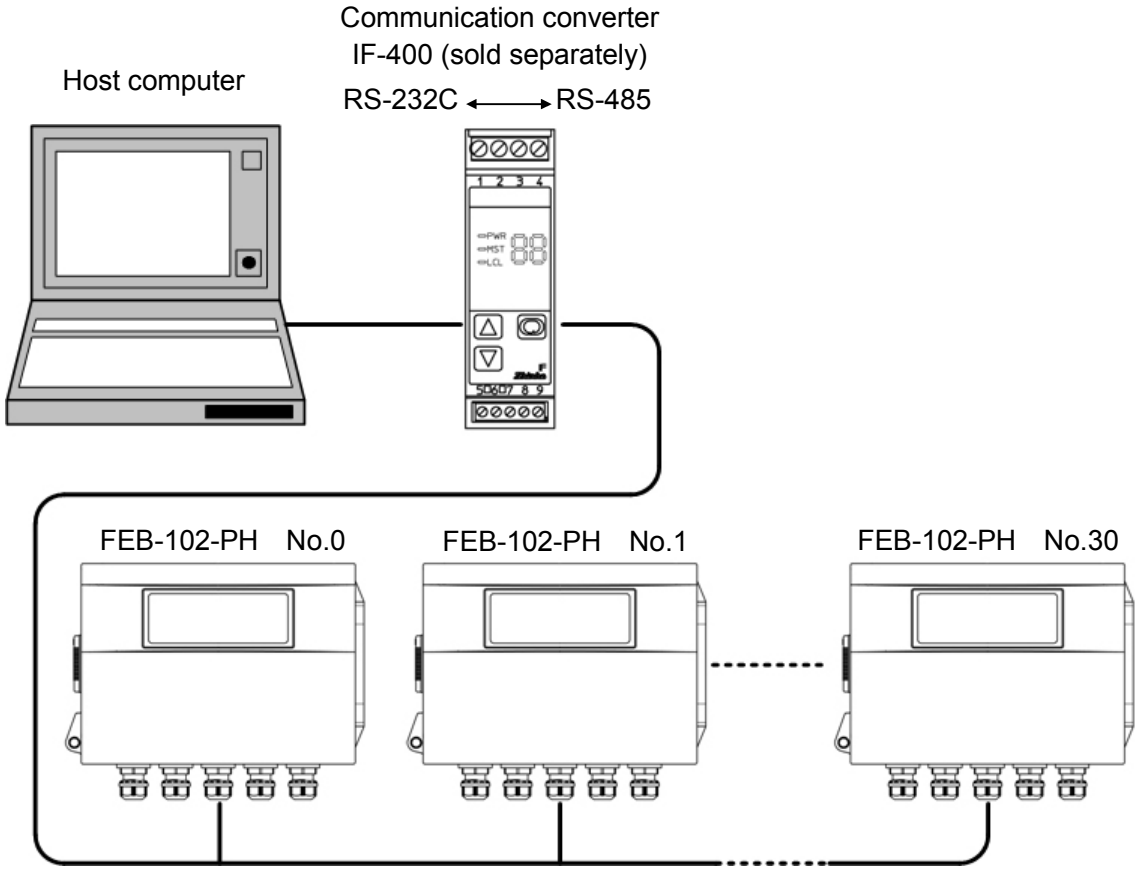
⚠ Warning

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.

1. System Configuration

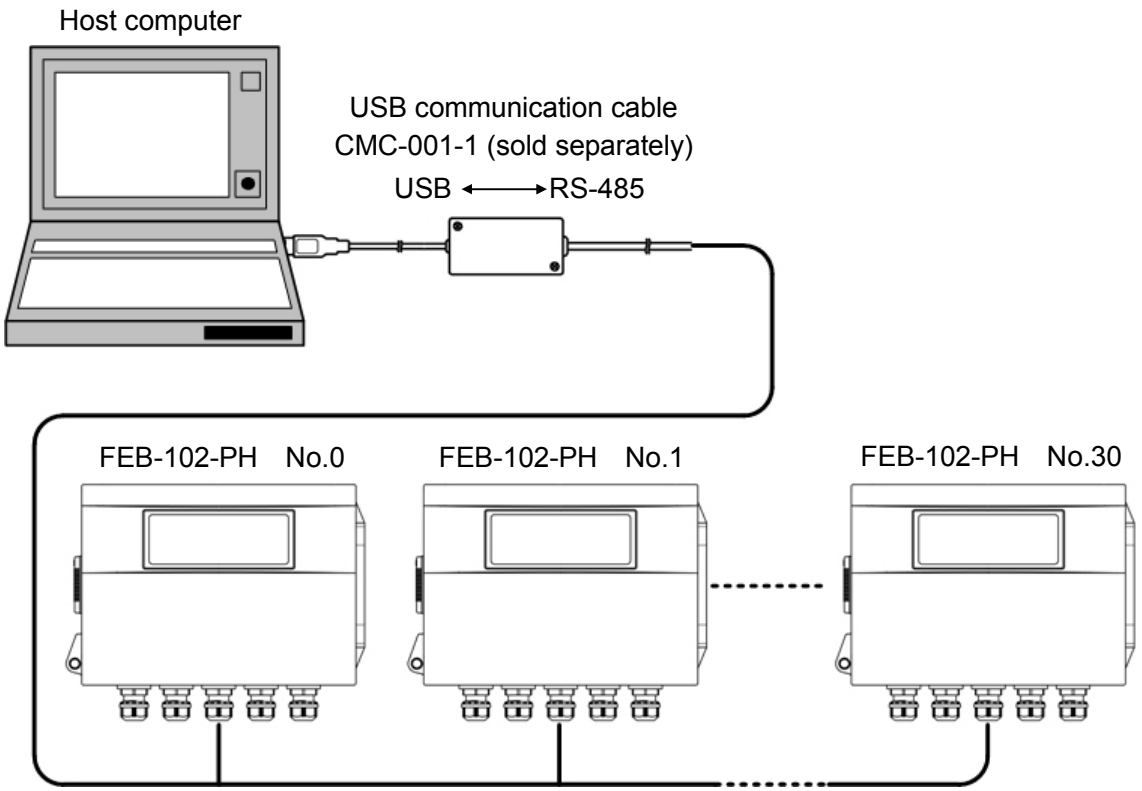
The following shows a system configuration example using the communication converter IF-400 or USB Communication Cable CMC-001-1.

When Using the Communication Converter IF-400



(Fig. 1-1)

When Using the USB Communication Cable CMC-001-1



(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-PH

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-PH ⑩ [YA(-)].

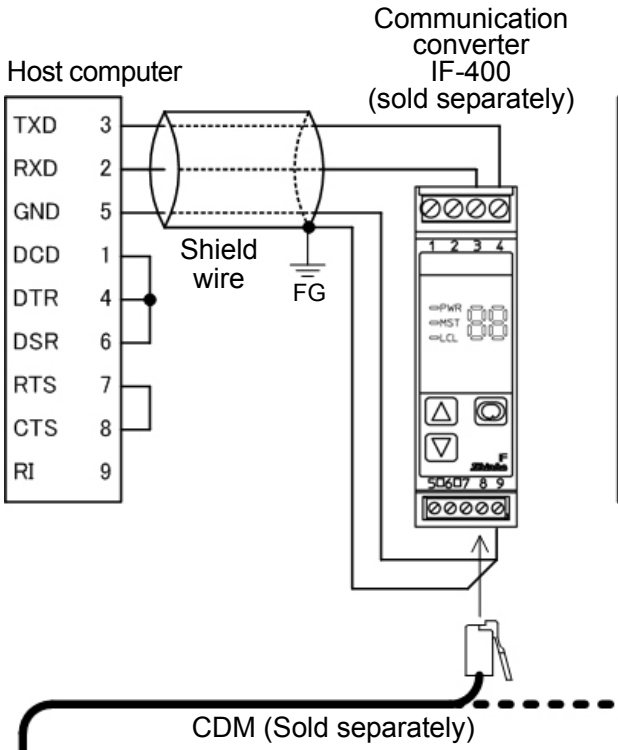
Connect Y terminal ③ to FEB-102-PH ⑪ [YB(+)].

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

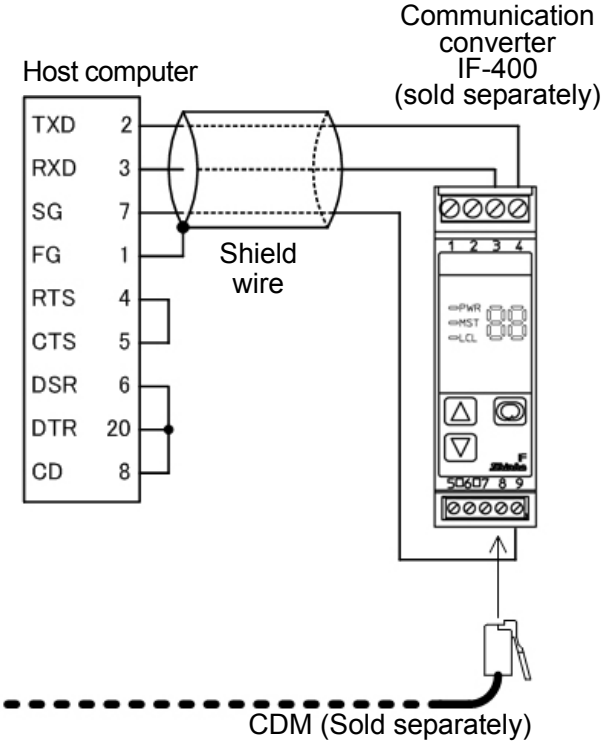
Connection between FEB-102-PH units

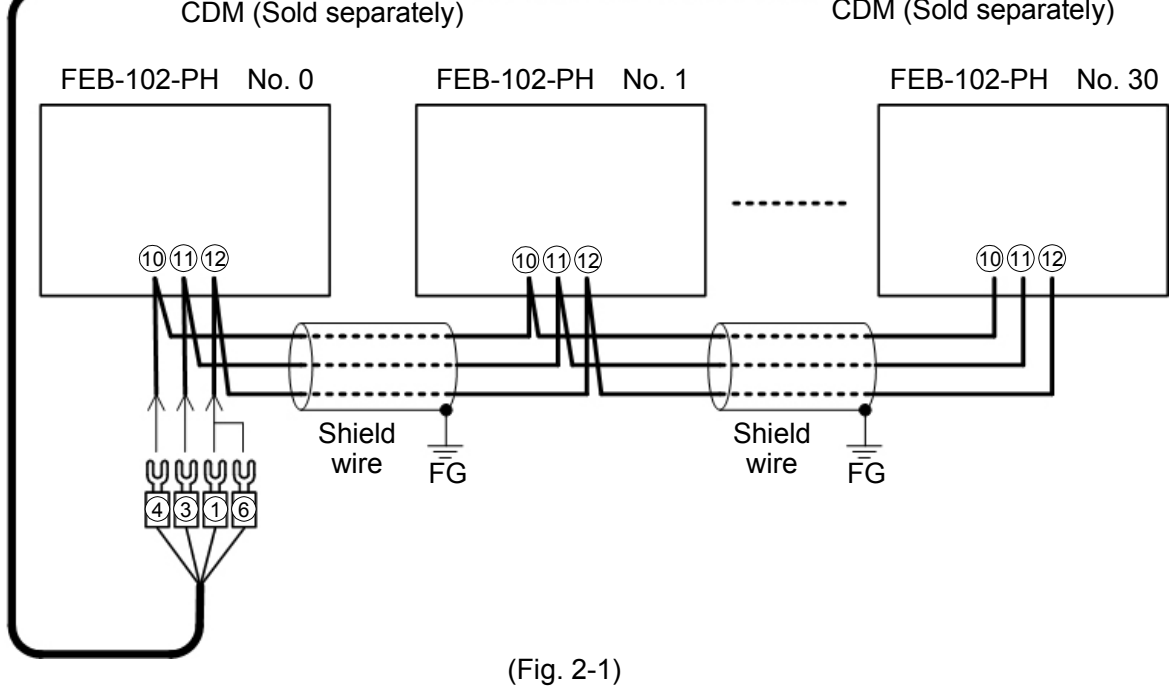
By using the shield wire, connect ⑩ [YA(-)] to ⑩ [YA(-)], ⑪ [YB(+)] to ⑪ [YB(+)], and ⑫ [COM] to ⑫ [COM].

• **D-sub 9-pin connector**



• **D-sub 25-pin connector**





(Fig. 2-1)

When Using the USB Communication Cable CMC-001-1

Connection between the host computer and FEB-102-PH

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

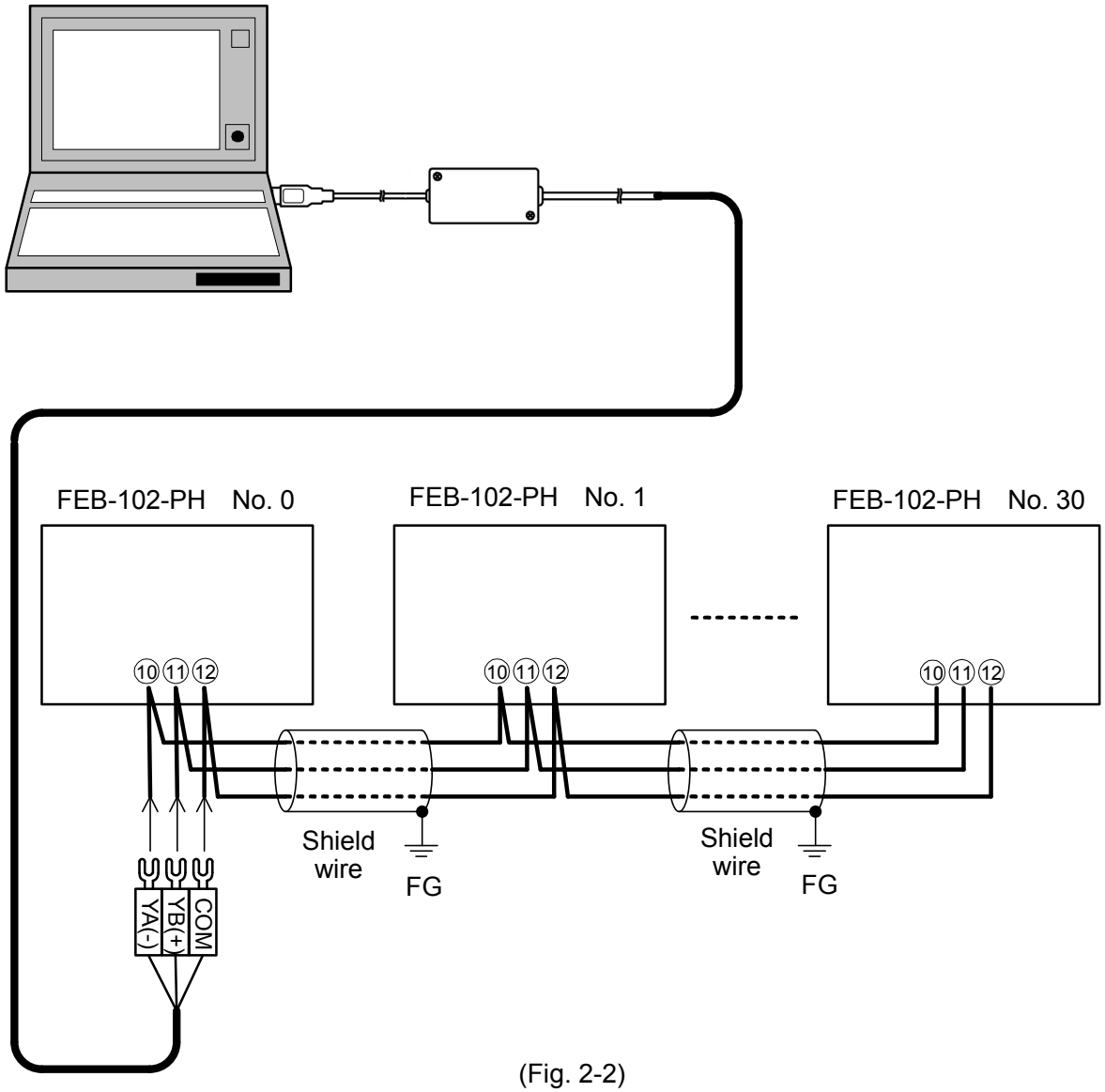
Connect Y terminal [YA(-)] to FEB-102-PH ⑩ [YA(-)].

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

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

Connection between FEB-102-PH 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-PH 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 pH-Temperature/ORP Display Mode, or Cleansing Output 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.

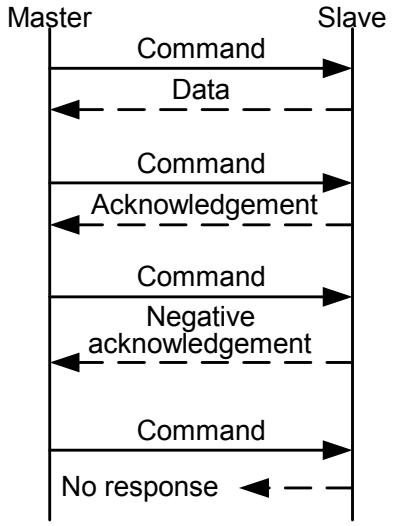
(4) Set each setting items using the △ or ▽ key, and register the value with the SET key.

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 pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

4. Communication Procedure

Communication starts with command transmission from the host computer (hereafter Master) and ends with the response of the FEB-102-PH (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 21).]

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 21).]

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. Automatic calibration is being performed using the Automatic electrode quality evaluation function.)
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.

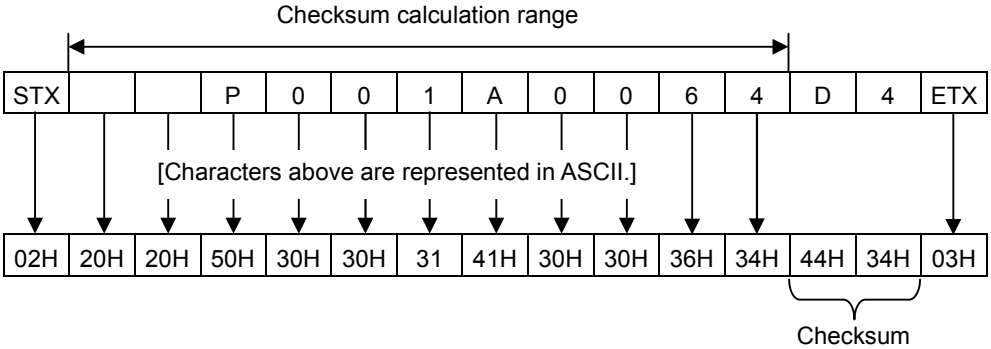
The ASCII code (hexadecimal) corresponding to the characters which range from the address (instrument number) to that before the checksum is converted to binary notation, and the total value is calculated.
The lower one byte of the total value is converted to 2’s complement, and then to hexadecimal numbers,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



[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

6.2.2 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-PH 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.) Automatic calibration is being performed using the Automatic electrode quality evaluation function.)]
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 21).]

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 (pH/ORP value)]

• 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 [When pH 1.00 (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]	Data [0064H]	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 32H)	(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 (pH/ORP value)]**

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

• Response message from the slave in normal status [When pH 1.00 (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	Function code	Number of response bytes	Data	Error check CRC-16	3.5 idle characters
	(01H)	(03H)	(02H)	(0064H)	(B9AFH)	
	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	Function code	Exception code	Error check CRC-16	3.5 idle characters
	(01H)	(83H)	(02H)	(C0F1H)	
	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	Function code	Data item	Data	Error check CRC-16	3.5 idle characters
	(01H)	(06H)	(001AH)	(0064H)	(A9E6H)	
	1	1	2	2	2	

• Response message from the slave in normal status

3.5 idle characters	Slave address	Function code	Data item	Data	Error check CRC-16	3.5 idle characters
	(01H)	(06H)	(0008H)	(0064H)	(A9E6H)	
	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	Function code	Exception code	Error check CRC-16	3.5 idle characters
	(01H)	(86H)	(03H)	(0261H)	
	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 option is 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 Electrode RTD, Temperature calibration value, pH calibration value, pH calibration Auto/Manual, Adjustment value, Span sensitivity correction 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	pH 7 calibration standard (pH meter)	0000H: JIS 0002H: US standard
50H/20H	06H/03H	0002H	2nd solution (pH meter)	0000H: pH 2 0001H: pH 4 0002H: pH 9 0003H: pH 10
50H/20H	06H/03H	0003H	pH calibration Auto/Manual (pH meter)	0000H: Automatic 0001H: Manual
50H/20H	06H/03H	0004H	pH input decimal point place (pH meter)	0000H: No decimal point 0001H: 1 digit after decimal point 0002H: 2 digits after decimal point
50H/20H	06H/03H	0005H	Moving average data amount	Set value

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0006H	Input filter time constant	Set value, Decimal point ignored.
50H/20H	06H/03H	0007H	pH input sensor correction (pH meter)	Set value, Decimal point ignored.
50H	06H	0008H	pH calibration mode (pH meter)	0000H: pH-Temperature/ORP Display Mode, or Cleansing Output Mode 0001H: Calibration mode
50H	06H	0009H	pH calibration start (pH meter)	0001H: 1st point calibration start 0002H: 1st point calibration complete 0003H: 2nd point calibration start 0004H: 2nd point calibration complete
50H/20H	06H/03H	000AH	1st point pH calibration value (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	000BH	2nd point pH calibration value (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	000CH	Input high limit (ORP meter)	Set value
50H/20H	06H/03H	000DH	Input low limit (ORP meter)	Set value
50H/20H	06H/03H	000EH	Adjustment mode (ORP meter)	0000H: pH-Temperature/ORP Display Mode or Cleansing Output Mode 0001H: Adjustment Mode
50H/20H	06H/03H	000FH	Adjustment value (ORP meter)	Set value
50H/20H	06H/03H	0010H	Span sensitivity correction mode (ORP meter)	0000H: pH-Temperature/ORP Display Mode or Cleansing Output Mode 0001H: Span sensitivity correction mode
50H/20H	06H/03H	0011H	Span sensitivity correction value (ORP meter)	Set value
50H/20H	06H/03H	0012H	Electrode RTD (pH meter)	0000H: No temperature compensation 0001H: Cu500 0002H: Pt100 0003H: Pt1000
50H/20H	06H/03H	0013H	Reference temperature (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	0014H	Temperature input decimal point place (pH meter)	0000H: No decimal point 0001H: 1 digit after decimal point
50H/20H	06H/03H	0015H	Pt100 input wire type (pH meter)	0000H: 2-wire type 0001H: 3-wire type
50H/20H	06H/03H	0016H	Cable length correction (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	0017H	Cable cross-section area (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	0018H	Temperature calibration value (pH meter)	Set value, Decimal point ignored.
50H/20H	06H/03H	0019H	EVT1 type (pH meter)	0000H: No action 0001H: pH input low limit action 0002H: pH input high limit action 0003H: Temperature input low limit action 0004H: Temperature input high limit action 0005H: Error output 0006H: Fail output 0007H: Cleansing output 0008H: pH input error alarm output
			EVT1 type (ORP meter)	0000H: No action 0001H: ORP input low limit action 0002H: ORP input high limit action 0003H: Cleansing output 0004H: ORP input error alarm output

Shinko Command Type	Modbus Function Code	Data Item		Data
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 (pH meter)	0000H: No action 0001H: pH input low limit action 0002H: pH input high limit action 0003H: Temperature input low limit action 0004H: Temperature input high limit action 0005H: Error output 0006H: Fail output 0007H: Cleansing output 0008H: pH input error alarm output
			EVT2 type (ORP meter)	0000H: No action 0001H: ORP input low limit action 0002H: ORP input high limit action 0003H: Cleansing output 0004H: ORP 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
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

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0035H	EVT3 type (pH meter)	0000H: No action 0001H: pH input low limit action 0002H: pH input high limit action 0003H: Temperature input low limit action 0004H: Temperature input high limit action 0005H: Error output 0006H: Fail output 0007H: Cleansing output 0008H: pH input error alarm output
			EVT3 type (ORP meter)	0000H: No action 0001H: ORP input low limit action 0002H: ORP input high limit action 0003H: Cleansing output 0004H: ORP 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 (pH meter)	0000H: No action 0001H: pH input low limit action 0002H: pH input high limit action 0003H: Temperature input low limit action 0004H: Temperature input high limit action 0005H: Error output 0006H: Fail output 0007H: Cleansing output 0008H: pH input error alarm output
			EVT4 type (ORP meter)	0000H: No action 0001H: ORP input low limit action 0002H: ORP input high limit action 0003H: Cleansing output 0004H: ORP 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.

Shinko Command Type	Modbus Function Code	Data Item		Data
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
50H/20H	06H/03H	0051H	Transmission output 1 type (pH meter)	0000H: pH transmission 0001H: Temperature transmission 0002H: EVT1 MV transmission 0003H: EVT2 MV transmission
			Transmission output 1 type (ORP meter)	0000H: ORP transmission 0001H: EVT1 MV transmission 0002H: 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 (pH meter)	0000H: pH transmission 0001H: Temperature transmission 0002H: EVT1 MV transmission 0003H: EVT2 MV transmission 0004H: EVT3 MV transmission
			Transmission output 2 type (ORP meter)	0000H: ORP transmission 0001H: EVT1 MV transmission 0002H: EVT2 MV transmission 0003H: 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	0057H	Number of cleansing cycles	Set value
50H/20H	06H/03H	0058H	Cleansing interval	Set value
50H/20H	06H/03H	0059H	Cleansing time	Set value
50H/20H	06H/03H	005AH	Restore time after cleansing	Set value
50H	06H	005BH	Manual cleansing mode	0001H: Manual cleansing mode
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 (pH meter)	0000H: Input value (pH, Temperature) 0001H: pH 0002H: Temperature
			Display selection (ORP meter)	0000H: No indication 0001H: EVT1 value 0002H: EVT2 value
50H/20H	06H/03H	0063H	EVT output when input errors occur	0000H: Enabled 0001H: Disabled
50H/20H	06H/03H	0064H	Display when no temperature compensation	0000H: Unlit 0001H: Reference temperature
50H/20H	06H/03H	0065H	Model selection	0000H: pH meter 0001H: ORP meter
50H	06H	007FH	Key operation change flag clearing	0001H: Clear change flag

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0102H	Transmission output 1 status when calibrating (pH meter) Transmission output 1 status in Adjustment Mode, Span Sensitivity Correction Mode (ORP meter)	0000H: Last value HOLD 0001H: Set value HOLD 0002H: Measured 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 (pH meter) Transmission output 2 status in Adjustment Mode, Span Sensitivity Correction Mode (ORP meter)	0000H: Last value HOLD 0001H: Set value HOLD 0002H: Measured value
50H/20H	06H/03H	0105H	Transmission output 2 Set value HOLD	Set value, Decimal point ignored.
50H/20H	06H/03H	0106H	EVT1 pH input error alarm EVT□ type	0000H: No action 0001H: EVT2 type 0002H: EVT3 type 0003H: EVT4 type
50H/20H	06H/03H	0107H	EVT2 pH input error alarm EVT□ type	0000H: EVT1 type 0001H: No action 0002H: EVT3 type 0003H: EVT4 type
50H/20H	06H/03H	0108H	EVT3 pH input error alarm EVT□ type	0000H: EVT1 type 0001H: EVT2 type 0002H: No action 0003H: EVT4 type
50H/20H	06H/03H	0109H	EVT4 pH input error alarm EVT□ type	0000H: EVT1 type 0001H: EVT2 type 0002H: EVT3 type 0003H: No action
50H/20H	06H/03H	010AH	EVT1 pH/ORP input error alarm span when EVT□ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	010BH	EVT1 pH/ORP input error alarm time when EVT□ output ON	Set value
50H/20H	06H/03H	010CH	EVT1 pH/ORP input error alarm span when EVT□ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	010DH	EVT1 pH/ORP input error alarm time when EVT□ output OFF	Set value
50H/20H	06H/03H	010EH	EVT2 pH/ORP input error alarm span when EVT□ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	010FH	EVT2 pH/ORP input error alarm time when EVT□ output ON	Set value
50H/20H	06H/03H	0110H	EVT2 pH/ORP input error alarm span when EVT□ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0111H	EVT2 pH/ORP input error alarm time when EVT□ output OFF	Set value
50H/20H	06H/03H	0112H	EVT3 pH/ORP input error alarm span when EVT□ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	0113H	EVT3 pH/ORP input error alarm time when EVT□ output ON	Set value

Shinko Command Type	Modbus Function Code	Data Item		Data
50H/20H	06H/03H	0114H	EVT3 pH/ORP input error alarm span when EVT□ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0115H	EVT3 pH/ORP input error alarm time when EVT□ output OFF	Set value
50H/20H	06H/03H	0116H	EVT4 pH/ORP input error alarm span when EVT□ output ON	Set value, Decimal point ignored.
50H/20H	06H/03H	0117H	EVT4 pH/ORP input error alarm time when EVT□ output ON	Set value
50H/20H	06H/03H	0118H	EVT4 pH/ORP input error alarm span when EVT□ output OFF	Set value, Decimal point ignored.
50H/20H	06H/03H	0119H	EVT4 pH/ORP input error alarm time when EVT□ output OFF	Set value
50H/20H	06H/03H	011AH	pH/ORP input error alarm time unit	0000H: Seconds 0001H: Minutes
50H	06H	011BH	Transmission output 1 adjustment mode	0000H: pH-Temperature/ORP Display Mode, or Cleansing Output 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: pH-Temperature/ORP Display Mode, or Cleansing Output 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.
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

<table>
<tr><th>Shinko Command Type</th><th>Modbus Function Code</th><th colspan="2">Data Item</th><th>Data</th></tr>
<tr><td>20H</td><td>03H</td><td>0080H</td><td>pH/ORP value</td><td>pH/ORP value,
Decimal point ignored.</td></tr>
<tr><td rowspan="2">20H</td><td rowspan="2">03H</td><td rowspan="2">0081H</td><td colspan="2">Status flag 1
0000 0000 0000 0000
2^{15} to 2^{0}
(pH meter)
2^{0} digit: Response speed error 0: Normal 1: Error
2^{1} digit: Electrode sensitivity error 0: Normal 1: Error
2^{2} digit: Asymmetry potential error 0: Normal 1: Error
2^{3} digit: Standard solution error 0: Normal 1: Error
2^{4} digit: pH 10 solution temperature error 0: Normal 1: Error
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: pH measurement value has exceeded pH 14.00
0: Normal 1: Exceeding pH 14.00
2^{10} digit: pH measurement value is less than pH 0.00
0: Normal 1: Less than pH 0.00
2^{11} digit: Unit status 0: pH-Temperature/ORP Display Mode, or Cleansing Output Mode
1: Setting mode
2^{12}, 2^{13} digits: Calibration status flag
<table>
<tr><th>2^{13}</th><th>2^{12}</th><th>Status</th></tr>
<tr><td>0</td><td>0</td><td>Standby</td></tr>
<tr><td>0</td><td>1</td><td>During the 1st point calibration</td></tr>
<tr><td>1</td><td>0</td><td>During the 2nd point calibration</td></tr>
<tr><td>1</td><td>1</td><td>Calibration complete</td></tr>
</table>
2^{14} digit: Not used (Always 0)
2^{15} digit: Change in key operation 0: No 1: Yes</td></tr>
<tr><td colspan="2">(ORP meter)
2^{0} to 2^{8} digit: Not used (Always 0)
2^{9} digit: ORP measured value has exceeded 2000 mV
0: Normal 1: Exceeding 2000 mV
2^{10} digit: ORP measured value is less than -2000 mV
0: Normal 1: Less than -2000 mV
2^{11} digit: Unit status
0: pH-Temperature/ORP Display Mode, or Cleansing Output Mode
1: Setting mode
2^{12} digit: Adjustment status flag
0: pH-Temperature/ORP Display Mode, or Cleansing Output Mode
1: Adjustment Mode
2^{13} digit: Span sensitivity correction status flag
0: pH-Temperature/ORP Display Mode, or Cleansing Output Mode
1: Span Sensitivity Correction Mode
2^{14} digit: Not used (Always 0)
2^{15} digit: Change in key operation 0: No 1: Yes</td></tr>
<tr><td>20H</td><td>03H</td><td>0084H</td><td>EVT1 MV</td><td>MV, Decimal point ignored.</td></tr>
<tr><td>20H</td><td>03H</td><td>0085H</td><td>EVT2 MV</td><td>MV, Decimal point ignored.</td></tr>
</table>

<table>
<tr><th>Shinko Command Type</th><th>Modbus Function Code</th><th colspan="2">Data Item</th><th>Data</th></tr>
<tr><td>20H</td><td>03H</td><td>0086H</td><td>EVT3 MV</td><td>MV, Decimal point ignored.</td></tr>
<tr><td>20H</td><td>03H</td><td>0087H</td><td>EVT4 MV</td><td>MV, Decimal point ignored.</td></tr>
<tr><td>20H</td><td>03H</td><td>0090H</td><td>Temperature</td><td>Temperature, Decimal point ignored.</td></tr>
<tr><td>0H</td><td>03H</td><td>0091H</td><td colspan="2">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} digit: EVT1 output flag (*) 0: OFF 1: ON
2^{5} digit: EVT2 output flag (*) 0: OFF 1: ON
2^{6} digit: EVT3 output flag (*) 0: OFF 1: ON
2^{7} digit: EVT4 output flag (*) 0: OFF 1: ON
2^{8} digit: Cleansing action (Cleansing time)
0: Programmed action
1: During cleansing time
2^{9} digit: Cleansing action (Restore time after cleansing)
0: Programmed action
1: During restore time after cleansing
2^{10} digit: Manual cleansing action
0: No manual cleansing action
1: During manual cleansing action
2^{11} to 2^{12} digits: Transmission output 1 adjustment status flag
<table>
<tr><th>2^{12}</th><th>2^{11}</th><th>Status</th></tr>
<tr><td>0</td><td>0</td><td>pH-Temperature/ORP Display Mode,
or Cleansing Output Mode</td></tr>
<tr><td>0</td><td>1</td><td>During Transmission output 1 Zero adjustment in
Transmission output 1 adjustment mode</td></tr>
<tr><td>1</td><td>0</td><td>During Transmission output 1 Span adjustment in
Transmission output 1 adjustment mode</td></tr>
</table>
2^{13} to 2^{14} digits: Transmission output 2 adjustment status flag
<table>
<tr><th>2^{14}</th><th>2^{13}</th><th>Status</th></tr>
<tr><td>0</td><td>0</td><td>pH-Temperature/ORP Display Mode,
or Cleansing Output Mode</td></tr>
<tr><td>0</td><td>1</td><td>During Transmission output 2 Zero adjustment in
Transmission output 2 adjustment mode</td></tr>
<tr><td>1</td><td>0</td><td>During Transmission output 2 Span adjustment in
Transmission output 2 adjustment mode</td></tr>
</table>
2^{15} digit: Not used (Always 0)</td></tr>
<tr><td>20H</td><td>03H</td><td>0100H</td><td>Zero indication</td><td>Indicated value, Decimal point ignored.</td></tr>
<tr><td>20H</td><td>03H</td><td>0101H</td><td>Span indication</td><td>Indicated value, Decimal point ignored.</td></tr>
</table>

(*) EVT□ output flag:

When **CLEG** (Cleansing output) is selected in [EVT□ type]: The EVT□ output flag sets to 1 (ON).

If any item other than **CLEG** (Cleansing output) is selected:

When EVT□ output is turned ON: The EVT□ output flag sets to 1 (ON).

When EVT□ output is turned OFF: The EVT□ output flag sets to 0 (OFF).

7.4 pH Calibration, ORP Calibration and Transmission Output Adjustment via Communication Command

7.4.1 pH Calibration

Like a keypad operation, there are also 2 methods in pH calibration via communication command: Automatic Calibration and Manual Calibration

(1) Automatic Calibration

Automatic Calibration is performed in sequence from the 1st standard solution pH 7 (JIS or US standard), which is selected at Data item 0001H (pH 7 calibration standard), and then the 2nd solution [pH 2, pH 4, pH 9, pH 10 (JIS)] selected at Data item 0002H (2nd solution).
pH value (based on JIS Z8802) at each temperature of pH standard solution is automatically calculated.

The following outlines the procedure for Automatic calibration.

• The 1st Point Automatic Calibration

① Immerse the pH Combined Electrode Sensor in the 1st standard solution (pH 7).
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 sensor is being immersed in the solution currently calibrated.
After that, immerse the sensor in the 1st point standard solution (pH 7).

② Set Data item 0008H (pH calibration mode) to 0001H.
The unit proceeds to pH calibration mode.

③ Set Data item 0009H (pH calibration start) to 0001H.
The 1st point automatic calibration starts.

④ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 01 (During the 1st point calibration) will be returned during automatic calibration.
Automatic calibration is performed using the Automatic electrode quality evaluation function.

⑤ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 00 (Standby) will be returned after automatic calibration is complete.

⑥ Set 0009H (pH calibration start) to 0002H.
The 1st point automatic calibration is completed, and the unit moves to the 2nd point automatic calibration mode.

• The 2nd Point Automatic Calibration

① Rinse the electrode, then immerse the pH Combined Electrode Sensor in the 2nd standard solution.

② Set the Data item 0009H (pH calibration start) to 0003H.
Automatic calibration for the 2nd point starts.

③ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 10 (During the 2nd point calibration) will be returned during automatic calibration.
Automatic calibration is performed using the Automatic electrode quality evaluation function.

④ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 11 (Calibration complete) will be returned after automatic calibration is completed.

⑤ Set Data item 0009H (pH calibration start) to 0004H.
Automatic calibration for the 2nd point is complete.

⑥ Set Data item 0008H (pH calibration mode) to 0000H.
The pH automatic calibration is complete, and the unit will revert to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

(2) Manual Calibration

When there is a difference of pH 2 or more, Manual calibration can be performed using the randomly selected 2 kinds of solution.

The following outlines the procedure for Manual calibration.

• The 1st Point Manual Calibration

① Immerse the pH Combined Electrode Sensor in the 1st standard solution.
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 sensor is being immersed in the solution currently calibrated.
After that, immerse the sensor in the 1st point standard solution.

② Set Data item 0008H (pH calibration mode) to 0001H.
③ Set Data item 0009H (pH calibration start) to 0001H.
Manual calibration for the 1st point starts.
④ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 01 (During the 1st point calibration) will be returned during manual calibration.
⑤ Set the 1st point pH calibration value at Data item 000AH (1st point pH calibration value).
⑥ Set Data item 0009H (pH calibration start) to 0002H.
Manual calibration for the 1st point is complete, and the unit enters the 2nd point manual calibration mode.
⑦ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 00 (Standby) will be returned after manual calibration is complete.

• The 2nd Point Manual Calibration

① Rinse the electrode, then immerse the pH Combined Electrode Sensor in the 2nd standard solution.
② Set Data item 0009H (pH calibration start) to 0003H.
Manual calibration for the 2nd point starts.
③ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 10 (During the 2nd point calibration) will be returned during manual calibration.
④ Set the 2nd point pH calibration value at Data item 000BH (2nd point pH calibration value).
⑤ Set Data item 0009H (pH calibration start) to 0004H.
Manual calibration for the 2nd point will be complete.
⑥ If 2^{13}, 2^{12} digits are read at Data item 0081H (Status flag 1), 11 (Calibration complete) will be returned after manual calibration is complete.
⑦ Set Data item 0008H (pH calibration mode) to 0000H.
The pH manual calibration is complete, and the unit will revert to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

(3) Error Code during pH Calibration

During pH calibration, if pH calibration cannot be performed due to unstable pH input, temperature compensation error, etc., the “Error code 1 (Error, Burnout, Short-circuited, etc.)” will be returned after 2^0 digit to 2^{10} digit are read at Data item 0081H (Status flag 1).
To release the Error code, set Data item 0008H (pH calibration mode) to 0000H.
The unit will return to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

If Data item 0009H (pH calibration start) is set during pH calibration of the 1st or 2nd point, the following error code will be returned:
Shinko protocol: Error code 34H
Modbus protocol: Exception code 11H

7.4.2 ORP Calibration

Like a keypad operation, there are also 2 methods in ORP calibration via communication command: Adjustment Mode and Span Sensitivity Correction Mode

(1) Adjustment mode

When using a brand-new sensor, please calibrate in Adjustment Mode.

By setting the adjustment value, calibrates ORP value indicated on the instrument to read 260 mV (at 20℃) when immersing the ORP Combined Electrode Sensor in the standard solution (Quinhydrone potential difference 260 mV).

The following outlines the procedure for calibration.

① When selecting Last value HOLD (0000H) at Data item 0102H (Transmission output 1 status in Adjustment Mode, Span Sensitivity Correction Mode) or at Data item 0104H (Transmission output 2 status in Adjustment Mode, Span Sensitivity Correction Mode), select it while the sensor is being immersed in the solution currently calibrated.

② Set Data item 000EH (Adjustment mode) to 0001H.
The unit enters Adjustment Mode.
③ Immerse the ORP Combined Electrode Sensor in the standard solution (Quinhydrone potential difference 260 mV).
④ Set an adjustment value at Data item 000FH (Adjustment value) so that the ORP value is approximately 260 mV (at 20℃).
For other temperature and electrical potentials, refer to the temperature characteristics of your standard solution.
If 2^{12} digit is read at Data item 0081H, 1 (Adjustment Mode) will be returned.
⑤ Set Data item 000EH (Adjustment mode) to 0000H.
Adjustment mode is complete, and the unit reverts to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.
If 2^{12} digit is read at Data item 0081H, 0 (pH-Temperature/ORP Display Mode, or Cleansing Output Mode) will be returned.

In Adjustment Mode, if adjustment cannot be performed due to errors (e.g. ORP value is outside the measurement range), Error code 1 (Exceeding 2000 mV, Less than -2000 mV) will be returned after 2^9 to 2^{10} digits are read at Data item 0081H (Status flag 1).
To cancel the error code, set Data item 000EH (Adjustment mode) to 0000H.
The unit will return to pH-Temperature/ORP Display mode or Cleansing Output mode.

(2) Span Sensitivity Correction mode

When calibrating periodically, please calibrate in Span Sensitivity Correction Mode.

By setting the Span sensitivity correction value in percentage, calibrates ORP value indicated on the unit to read 260 mV (at 20℃) when immersing the ORP Combined Electrode Sensor in the standard solution (Quinhydrone potential difference 260 mV).

The following outlines the procedure for calibration.

① When selecting Last value HOLD (0000H) at Data item 0102H (Transmission output 1 status in Adjustment Mode, Span Sensitivity Correction Mode) or at Data item 0104H (Transmission output 2 status in Adjustment Mode, Span Sensitivity Correction Mode), select it while the sensor is being immersed in the solution currently calibrated.
② Set Data item 0010H (Span sensitivity correction mode) to 0001H.
The unit enters Span Sensitivity Correction mode.
③ Immerse the ORP Combined Electrode Sensor in the standard solution (Quinhydrone potential difference 260 mV).
④ Set an adjustment value at Data item 0011H (Span sensitivity correction value) so that the ORP value can be approximately 260 mV (at 20℃).
For other temperature and electrical potentials, refer to the temperature characteristics of your standard solution.
If 2^{13} digit is read at Data item 0081H, 1 (Span Sensitivity Correction Mode) will be returned.
⑤ Set Data item 0010H (Span Sensitivity Correction Mode) to 0000H.
Span Sensitivity Correction mode is complete, and the unit reverts to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.
If 2^{13} digit is read at Data item 0081H, 0 (pH-Temperature/ORP Display Mode, or Cleansing Output Mode) will be returned.

In Span Sensitivity Correction Mode, if span sensitivity correction cannot be performed due to errors (e.g. ORP value is outside of the measurement range), Error code 1 (Exceeding 2000 mV, Less than -2000 mV) will be returned after 2^9 to 2^{10} digits are read at Data item 0081H (Status flag 1).
To cancel the Error code, set Data item 0010H (Span Sensitivity Correction Mode) to 0000H.
The unit will return to pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

7.4.3 Transmission Output 1 Adjustment

Fine adjustment of Transmission output 1 is performed.
This ORP meter 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^{12}, 2^{11} 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^{12}, 2^{11} 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 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 pH-Temperature/ORP Display Mode, or Cleansing Output Mode.

7.4.4 Transmission Output 2 Adjustment

Fine adjustment of Transmission output 2 is performed.
This ORP meter 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^{14}, 2^{13} 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^{14}, 2^{13} 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 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 pH-Temperature/ORP Display Mode, or Cleansing Output 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-PH, set the program so that the requisite minimum pieces of data such as Data item 0080H (pH/ORP value), 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-PH 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 (pH/ORP value), 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 EVT type is changed 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 set at Data item 001AH (EVT1 value), 0028H (EVT2 value), 0036H(EVT3 value) and 0044H (EVT4 value).

8. Specifications

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

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 NAK (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-PH cannot be set while calibration is being performed using the Automatic electrode quality evaluation function.	Check the slave status.
	The FEB-102-PH is in the front keypad operation setting mode.	Return the unit to pH-Temperature/ ORP Display Mode, or Cleansing Output Mode.

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

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