No.FC1CE11 2006.12

To prevent accidents arising from the use of this controller, please ensure the operator receives this manual.

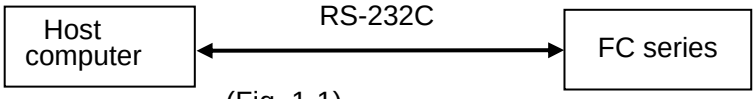
Models for Shinko protocol : FCS-23A, FCR-13A, FCR-15A, FCR-23A, FCD-13A, FCD-15A
Models for Modbus protocol : FCS-23A, FCR-13A, FCR-23A, FCD-13A

⚠ Warning

Turn the power supply to the instrument OFF before wiring or checking.
Working or touching the terminal with the power switched ON may result in severe injury or death due to Electric Shock.

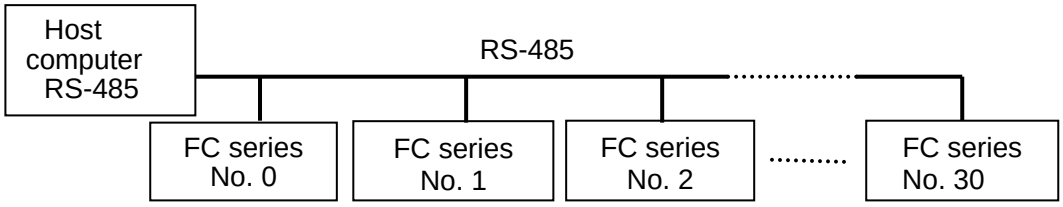
1. System configuration

RS-232C (C option)

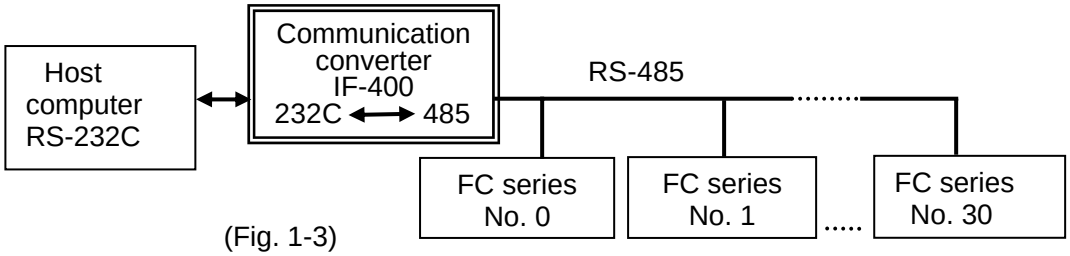


(Fig. 1-1)

RS-485 Multi-drop connection (C5 option)



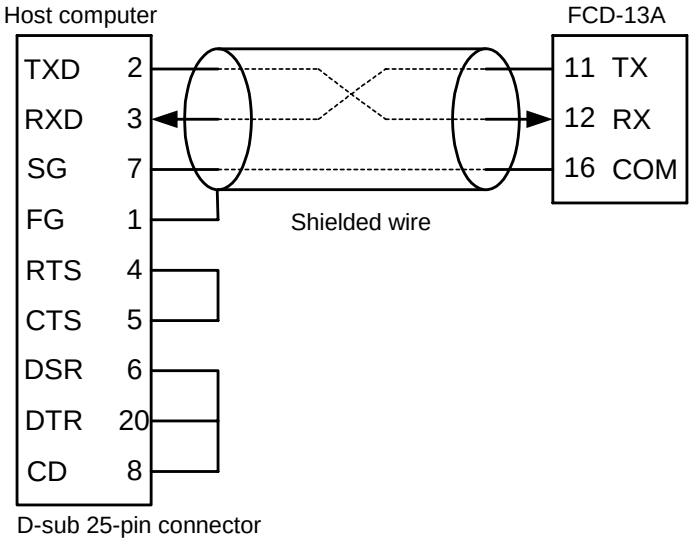
(Fig. 1-2)



(Fig. 1-3)

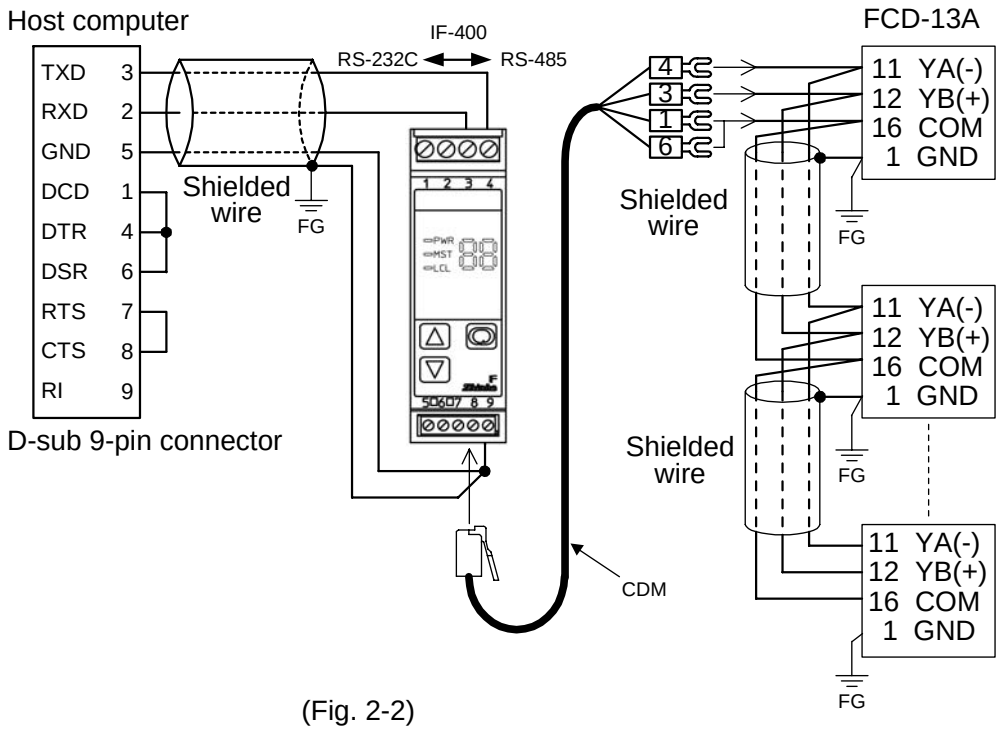
2. Wiring

RS-232C (C option)



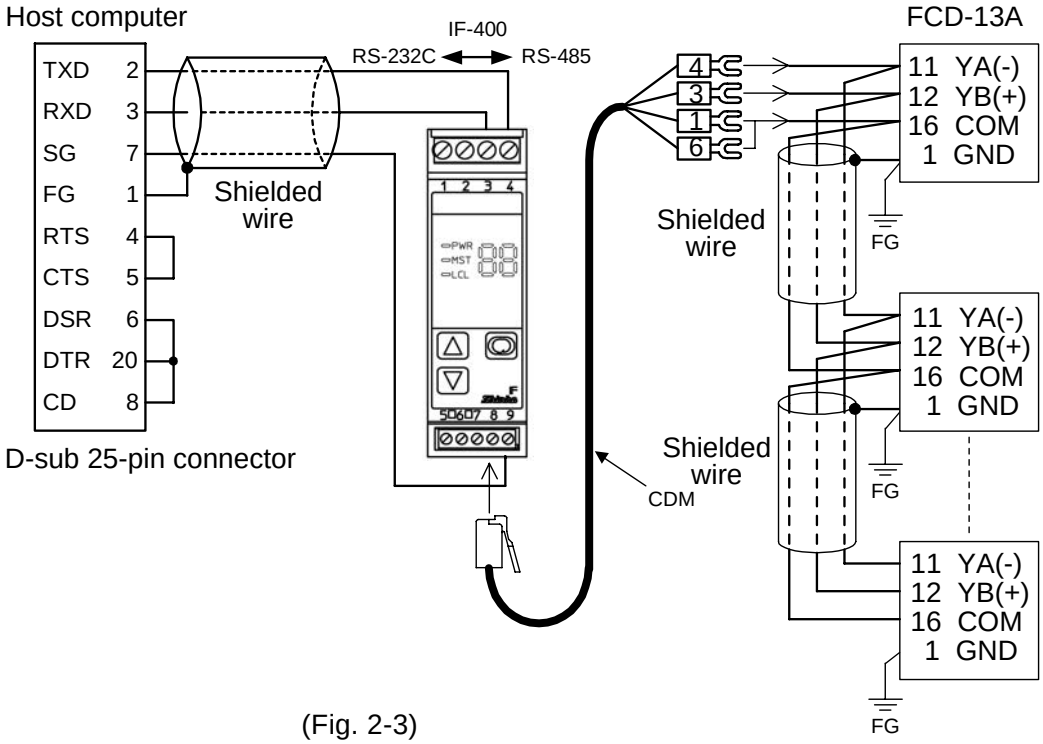
(Fig. 2-1)

When using communication converter IF-400
D-sub 9-pin connector



(Fig. 2-2)

D-sub 25-pin connector



(Fig. 2-3)

Shielded wire

Connect only one side of the shielded wire to the FG or GND terminal so that current cannot flow to the shielded wire. (If both sides of the shielded wire are connected to the FG or GND terminal, the circuit will be closed between the shielded wire and the ground. As a result, current will run through the shielded wire and this may cause noise.)
Be sure to ground FG and GND terminals.
Recommended cable: OTSC-VB 2PX0.5SQ (made by Onamba Co., Ltd.) or equivalent
(Use a twisted pair cable.)

Terminator (Terminal resistor)

The terminator prevents signal reflection and disturbance.
Connect a terminator at the end of the communication cable.
The IF-400 (sold separately) is available as a communication converter.

3. Communication parameters setting

Set Communication parameters as follows. (Refer to the Instruction manual.)

(1) Instrument number setting

Set an instrument number to each of the FC series individually when communicating by connecting plural units. (Default: 0)

(2) Communication speed selection

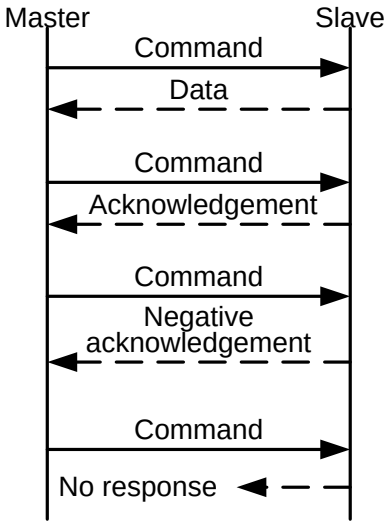
Select a communication speed for the FC series according to that of the host computer. (Default: 9600bps)

(3) Communication protocol selection (For the FCD-13A, FCR-13A, FCR-23A, FCS-23A)

Select a communication protocol. (Default: Shinko protocol)

4. Communication procedure

Communication starts with command transmission from the host computer (hereafter Master) and ends with the response of the FC series (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 the 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 as a response.
- **No response**
  The slave will not respond to the master in the following cases:
  - Global address (Shinko protocol) is set.
  - Communication error (framing error, parity error)
  - Checksum error (Shinko protocol), LRC discrepancy (Modbus)

● **Communication timing between master and slave**

Master side (Notice on programming)

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

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 the 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 figures, and ASCII codes are used for the command.

The negative numbers are represented by 2's complement.

(1) Setting command

Header (02H)	Address	Memory number	Command type (50H)	Data item	Data	Check-sum	Delimiter (03H)
1	1	1	1	4	4	2	1 ← Number of characters

(Fig. 5.2-1)

(2) Reading command

Header (02H)	Address	Memory number	Command type (20H)	Data item	Check-sum	Delimiter (03H)
1	1	1	1	4	2	1 ← Number of characters

(Fig. 5.2-2)

(3) Response with data

Header (06H)	Address	Memory number	Command type (20H)	Data item	Data	Check-sum	Delimiter (03H)
1	1	1	1	4	4	2	1 ← Number of characters

(Fig. 5.2-3)

(4) Acknowledgement

Header (06H)	Address	Check-sum	Delimiter (03H)
1	1	2	1 ← Number of characters

(Fig. 5.2-4)

(5) Negative acknowledgement

Header (15H)	Address	Error code	Check-sum	Delimiter (03H)
1	1	1	2	1 ← Number of characters

(Fig. 5.2-5)

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

Address (Instrument number): Numbers by which the master discerns each slave.
Instrument number 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 Global address, which is used when the same command is sent to all the slaves connected. However, a response is not returned.

Memory number: Set value memory number (1 to 7)
Zero (0) is set to the data item which has no relation to the Set value memory.
The numbers (20H to 27H) are used by adding 20H of bias.

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

Data item : Data classification of the command object
Composed of hexadecimal 4 digits (Refer to the Communication command table.)

Data : The contents of data (set value) differ depending on the setting command.
Composed of hexadecimal 4 digits (Refer to the Communication command table.)

Checksum : 2-character data to detect communication errors (Refer to 5.3 Checksum calculation.)

Delimiter : Control code to represent the end of command
03H fixed

Error code : Represents an error type. Composed of hexadecimal 1 digit.
0 (30H)---- Unknown error
1 (31H)-----Non-existent command
2 (32H)-----Not used
3 (33H)-----Set value out of the setting range
4 (34H)-----Unsettable status (e.g. AT is performing)
5 (35H)-----During setting mode by keypad operation

5.3 Checksum calculation

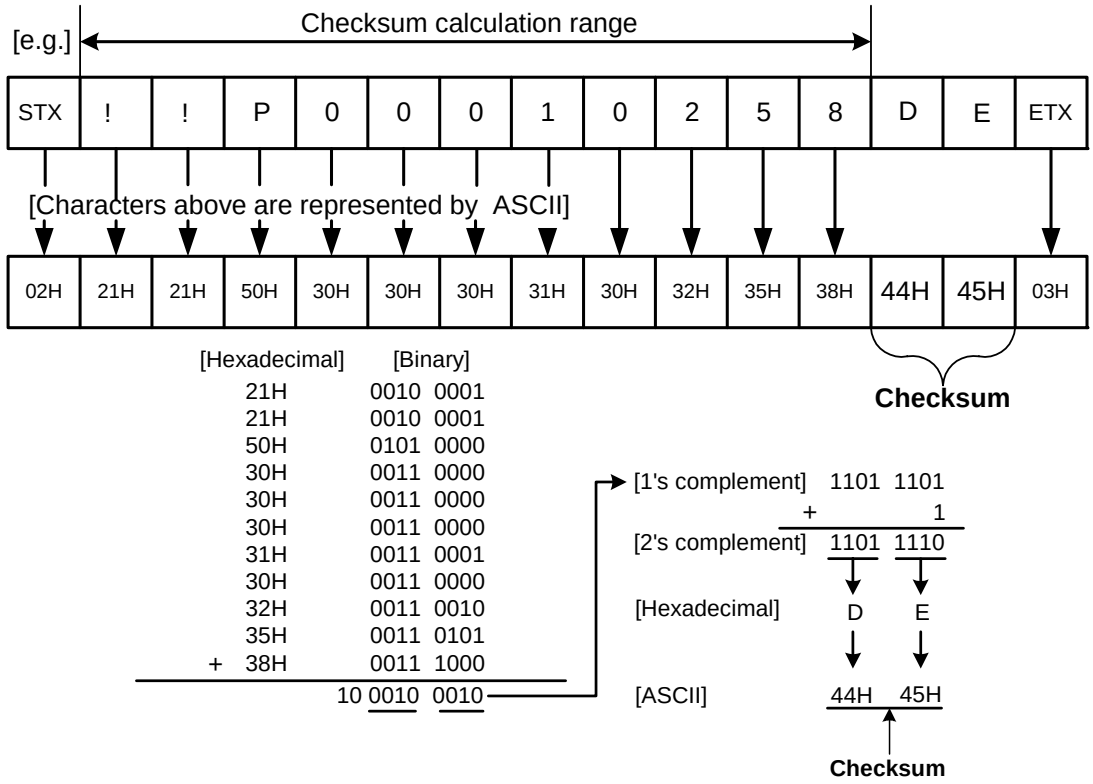
Checksum is used to detect receiving errors in the command or data.
Set the program for the master side as well to calculate the checksum of the response data from the slaves so that the communication errors can be checked.

The ASCII code (hexadecimal) corresponding to the characters which range from the address to that before the checksum is converted to binary notation, and the total value is calculated.
The lower 2-digits of the total value are converted to 2's complements and then to hexadecimal figures, that is, ASCII code for the checksum.

● **Checksum calculation example**

Address (instrument number): 1 (21H)
Memory number: 1 (21H)
SV: 600℃ (0258H)

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



5.4 Command table (Shinko protocol)

When the data (set value) has a decimal point, remove the decimal point and represent it as a whole number, then express it in hexadecimal figures.

Memory Number	Command type	Data item		Data
1 to 7	20H/50H	0001H	SV or step SV	Set value (Decimal point ignored)
0	20H/50H	0002H	Set value memory number or step number	Selected value
0	20H/50H	0003H	AT Perform/Cancel	0000H: Cancel 0001H: Perform
1 to 7	20H/50H	0004H	OUT1 proportional band	Set value (Decimal point ignored)
1 to 7	20H/50H	0005H	OUT2 proportional band (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
1 to 7	20H/50H	0006H	Integral time	Set value
1 to 7	20H/50H	0007H	Derivative time	Set value
0	20H/50H	0008H	OUT1 proportional cycle (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value
0	20H/50H	0009H	OUT2 proportional cycle (For FCD-13A, FCR-13A, FCR-23A)	Set value
0	20H/50H	000AH	Manual reset (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
1 to 7	20H/50H	000BH	A1 value	Set value (Decimal point ignored)
1 to 7	20H/50H	000CH	A2 value (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
1 to 7	20H/50H	000DH	A3 value (For FCD-13A, FCD-15A)	Set value (Decimal point ignored)
1 to 7	20H/50H	000EH	A4 value (For FCD-13A, FCD-15A)	Set value (Decimal point ignored)

0	20H/50H	000FH	Heater burnout alarm (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
0	20H/50H	0010H	Loop break alarm time	Set value
0	20H/50H	0011H	Loop break alarm span	Set value (Decimal point ignored.)
0	20H/50H	0012H	Set value lock (If Lock 3 is selected, the set data will not saved in the memory. By turning the power off, the set values return to the previous one)	0000H: Unlock 0001H: Lock 1 0002H: Lock 2 0003H: Lock 3
0	20H/50H	0013H	SV high limit	Set value (Decimal point ignored)
0	20H/50H	0014H	SV low limit	Set value (Decimal point ignored)
0	20H/50H	0015H	Sensor correction value	Set value (Decimal point ignored)
1 to 7	20H/50H	0016H	Overlap band/Dead band (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
0	20H/50H	0017H	Remote/Local (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	0000H: Local 0001H: Remote
0	20H/50H	0018H	Scaling high limit	Set value (Decimal point ignored)
0	20H/50H	0019H	Scaling low limit	Set value (Decimal point ignored)
0	20H/50H	001AH	Decimal point place (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	0000H: XXXX (No decimal point) 0001H: XXX.X (1 digit after the decimal point) 0002H: XX.XX (2 digits after the decimal point) 0003H: X.XXX (3 digits after the decimal point)
0	20H/50H	001BH	PV filter time constant	Set value (Decimal point ignored)
1 to 7	20H/50H	001CH	OUT1 high limit (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
1 to 7	20H/50H	001DH	OUT1 low limit (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
0	20H/50H	001EH	OUT1 ON/OFF action hysteresis (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
0	20H/50H	001FH	OUT2 action mode (For FCD-13A, FCR-13A, FCR-23A)	0000H: Air cooling (Linear characteristic) 0001H: Oil cooling (1.5th power of the linear) 0002H: Water cooling (2nd power of the linear)
1 to 7	20H/50H	0020H	OUT2 high limit (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
1 to 7	20H/50H	0021H	OUT2 low limit (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
0	20H/50H	0022H	OUT2 ON/OFF action hysteresis (For FCD-13A, FCR-13A, FCR-23A)	Set value (Decimal point ignored)
0	20H/50H	0023H 0024H	A3 type (For FCD-13A, FCD-15A) A4 type (For FCD-13A, FCD-15A)	0000H: No alarm 0001H: High limit alarm 0002H: High limit alarm with standby 0003H: Low limit alarm 0004H: Low limit alarm with standby 0005H: H/L limits alarm 0006H: H/L limits alarm with standby 0007H: H/L limit range alarm

				0008H: H/L limit range alarm with standby 0009H: Process high alarm 000AH: Process high alarm with standby 000BH: Process low alarm 000CH: Process low alarm with standby
0	20H/50H	0025H	A1 hysteresis	Set value(Decimal point ignored)
0	20H/50H	0026H	A2 hysteresis (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
0	20H/50H	0027H	A3 hysteresis (For FCD-13A, FCD-15A)	Set value (Decimal point ignored)
0	20H/50H	0028H	A4 hysteresis (For FCD-13A, FCD-15A)	Set value (Decimal point ignored)
0	20H/50H	0029H	A1 action delayed timer	Set value
0	20H/50H	002AH	A2 action delayed timer (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value
0	20H/50H	002BH	A3 action delayed timer (For FCD-13A, FCD-15A)	Set value
0	20H/50H	002CH	A4 action delayed timer (For FCD-13A, FCD-15A)	Set value
0	20H/50H	002DH	External setting input high limit (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	Set value (Decimal point ignored)
0	20H/50H	002EH	External setting input low limit (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	Set value (Decimal point ignored)
0	20H/50H	002FH	Transmission output mode (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	0000H: PV transmission 0001H: SV transmission 0002H: MV transmission
0	20H/50H	0030H	Transmission output high limit (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	Set value (Decimal point ignored)
0	20H/50H	0031H	Transmission output low limit (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	Set value (Decimal point ignored)
0	20H/50H	0032H	Indication selection when control output is OFF	0000H: OFF indication 0001H: No indication 0002H: PV indication
0	20H/50H	0033H	SV rise rate	Set value (Decimal point ignored)
0	20H/50H	0034H	SV fall rate	Set value (Decimal point ignored)
0	20H/50H	0035H	Fixed value control/Program control	0000H: Fixed value control 0001H: Program control
1 to 7	20H/50H	0036H	Step (1 to 7) time	Set value (Decimal point ignored) Converted to minutes, then to hexadecimal figures. (See “Data” on p.14)
0	20H/50H	0037H	Control output OFF function	For fixed value control: 0000H: ON 0001H: OFF For program control: 0000H: STOP 0001H: RUN
0	20H/50H	0038H	Auto/Manual control (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	0000H: Automatic control 0001H: Manual control
0	20H/50H	0039H	Manual MV (manipulated variable) (For FCD-13A, FCD-15A, FCR-13A, FCR-23A, FCR-15A)	• Settable only in the Manual mode. • The setting range depends on OUT1(OUT2) high and low limit values. • Set value(Decimal point ignored)

1 to 7	20H/50H	003AH	Open/Closed dead band (For FCD-15A, FCR-15A)	Set value
0	20H/50H	003BH	Open output time (For FCD-15A, FCR-15A)	Set value
0	20H/50H	003CH	Closed output time (For FCD-15A, FCR-15A)	Set value
0	20H/50H	003DH	MV computation cycle setting (For FCD-15A, FCR-15A)	Set value
0	20H/50H	003EH	Infrared emissivity (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	Set value (Decimal point ignored)
0	20H/50H	003FH	Control output OFF function selection for excess input (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	0000H: Disabled 0001H: Enabled
0	20H/50H	0040H	A1 action Energized/Deenergized (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	0000H: Energized 0001H: Deenergized
0	20H/50H	0041H	A2 action Energized/Deenergized (For FCD-13A, FCR-13A, FCR-23A, FCS-23A)	0000H: Energized 0001H: Deenergized
0	20H/50H	0042H	A3 action Energized/Deenergized (For FCD-13A, FCD-15A)	0000H: Energized 0001H: Deenergized
0	20H/50H	0043H	A4 action Energized/Deenergized (For FCD-13A, FCD-15A)	0000H: Energized 0001H: Deenergized
0	20H	0080H	PV	PV (Decimal point ignored)
0	20H	0081H	OUT1 MV (manipulated variable)	OUT1 MV (Decimal point ignored)
0	20H	0082H	OUT2 MV (manipulated variable) (For FCD-13A, FCR-13A, FCR-23A)	OUT2 MV (Decimal point ignored)
0	20H	0083H	Current SV during program control	Current SV (Decimal point ignored)
0	20H	0084H	Remaining time during program control	Remaining time (Decimal point ignored) Converted to minutes, then to hexadecimal figures. (See “Data” on p.14)
0	20H	0085H	Status flag	0000 0000 0000 0000 2^{15} to 2^{0} 2^{0} digit: OUT1 (Control output 1) 0: OFF, 1: ON 2^{1} digit: OUT2 (Control output 2) 0: OFF, 1: ON 2^{2} digit: A1 output 0: OFF, 1: ON 2^{3} digit: A2 output 0: OFF, 1: ON 2^{4} digit: A3 output 0: OFF, 1: ON 2^{5} digit: A4 output 0: OFF, 1: ON 2^{6} digit: Heater burnout alarm output 0: OFF, 1: ON 2^{7} digit: Loop break alarm output 0: OFF, 1: ON 2^{8} digit: Overscale 0: OFF, 1: ON 2^{9} digit: Underscale 0: OFF, 1: ON 2^{10} to 2^{15} digit: Not used. Always 0
0	20H	0086H	Selected Set value memory number (running step number)	Selected value

6. Modbus protocol (Not available for FCR-15A, FCD-15A)

6.1 Modbus message framing

Modbus protocol has 2 transmission modes (ASCII and RTU), and all commands are made up of ASCII codes since the FC series (slave) runs on the ASCII mode.
Data (set value, decimal number) is converted to hexadecimal figures, and ASCII codes are used.
Negative numbers are represented by 2's complement.

In ASCII mode, messages start with a colon (: 3AH) character, and end with a carriage return-line feed (CRLF) pair (0DH and 0AH).
Intervals of up to one second can elapse between characters within the message.
If a greater interval occurs, the receiving device assumes an error has occurred.
A typical message frame of the slave is shown in (Table 6.1-1).
(Table 6.1-1)

Header (:)	
Slave address	
Function code	
Data	Address
	Number of data or data
Error check (LRC)	
Delimiter (CR•LF)	

6.2 Slave address

Slave addresses are represented by two ASCII characters.
Slave address (instrument number): 0 to 95 (00H to 5FH)
Slave address (instrument number) is set to the FC series in the range of 0 to 95 (00H to 5FH) beforehand by the key operation.
A master addresses a slave by placing the slave address in the address field of the message.
When the slave sends its response, it places its own slave address in this address field of the response to let the master know which slave is responding.
Address 0 slave receives a message and returns the response message ignoring the broadcast address [0 (00H)] since slaves are not supported by the broadcast address.

6.3 Function code

Function code is represented by two ASCII characters.
When the message is transmitted from the master to the slaves, function code field tells the slave what kind of action to perform.

Function code	Contents
03 (03H)	Reading the set value and information from slaves (Only one piece of data can be read.)
06 (06H)	Setting to slaves (Only one piece of data can be written.)

When the slave responds to the master, function code field is used to indicate if it is a normal response or if an error has occurred.
For a normal response, the slave simply echoes the original function code.
For an exception response, the slave returns the value by adding 1 to the most significant bit of the original function code.
This tells the master what kind of error occurred by adding the exception code to the response.

Exception code	Contents
0 (00H)	Reserve (Normal or undefined)
1 (01H)	Illegal function (Non-existent function)
2 (02H)	Illegal data address (Non-existent data address)
3 (03H)	Illegal data value (Set value out of the range)

6.4 Data field

Data field consists of the address and number of data, and is represented by four ASCII characters.
A request message from the master is composed of address, number of data or data.
A response message from the slave is composed of number of bytes, data and exception code in negative acknowledgement.
Effective range of data is –32768 to 32767 (8000H to 7FFFH).

6.5 Error check field

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 the message.

[Error checking methods]

The LRC is applied to the entire message.
Both the character check and message frame check are calculated in the master device, and applied to the message contents before transmission.
(The slave device checks each character and the entire message frame during reception.)
The master is configured by the user to wait for a predetermined timeout interval before aborting the transaction. This interval is set to be long enough for any slave to respond normally.
If the slave detects a transmission error, the message will not be valid. The slave will not construct a response to the master. Thus the timeout will expire and allow the master's program to handle the error. The message addressed to a nonexistent slave device will also cause a timeout.

[LRC checking]

The LRC field checks the contents of the message, excluding the beginning colon and ending CR•LF pair. It is applied regardless of any parity check method used for the individual characters of the message. The LRC field is one byte, containing an eight-bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The receiving device calculates an LRC during reception of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error message is returned.

How to calculate LRC

The LRC is calculated by adding together successive eight-bit bytes of the message (excluding the beginning colon and ending CR•LF), discarding any carries, and then is calculated by two's compliment of the result.

6.6 Example of transmitting message

(1) Reading of SV and status (Address 1, Memory number 1, SV)

• A request message from the master

Header	Slave address	Function code	Address	Number of data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 30H 30H 30H)	(30H 30H 30H 31H)	(46H 42H)	(0DH 0AH)
1	2	2	4	4	2	2

(Fig. 6.6-1) Number of characters

• Response message from the slave in normal status (When SV is 600℃)

Slave address, function code, number of data, etc are represented by hexadecimal value, and replaced to the messages character by character.
There are two response bytes since it is 16-bit data per channel.
For the message, it becomes 4 times the number of characters since one character is composed of 4 bits.
(*1: "30H 34H" for the actual instrument)

Header	Slave address	Function code	Number of response byte *1	Data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 34H)	(30H 32H 35H 38H)	(39H 45H)	(0DH 0AH)
1	2	2	2	4	2	2

(Fig. 6.6-2) Number of characters

(2) Reading of set value and status (Address 1, PV)

• A request message from the master

Header	Slave address	Function code	Address	Number of data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 30H 39H 39H)	(30H 30H 30H 31H)	(36H 32H)	(0DH 0AH)
1	2	2	4	4	2	2

(Fig. 6.6-3) Number of characters

• Response message from the slave in normal status (When PV is 600℃)

Slave address, function code, number of data, etc are represented by hexadecimal value, and replaced to the messages character by character.
There are two response bytes since it is 16-bit data per channel.
For the message, it becomes 4 times the number of characters since one character is composed of 4 bits.
(*1: "30H 34H" for the actual instrument)

Header	Slave address	Function code	Number of response byte *1	Data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 33H)	(30H 34H)	(30H 32H 35H 38H)	(39H 45H)	(0DH 0AH)
1	2	2	2	4	2	2

(Fig. 6.6-4) Number of characters

• **Response message from the slave in exception (error) status (data item mistaken)**

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

Number of characters

(Fig. 6.6-5)

The slave returns the error contents to the master by adding 1 (binary) to the most significant bit of function code.

(3) Setting to the slave (Address 1, Memory number 1, SV is set to 600℃)

• **A request message from the master**

Header	Slave address	Function code	Data item	Data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 36H)	(30H 30H 30H 30H)	(30H32H35H 38H)	(39H 46H)	(0DH 0AH)
1	2	2	4	4	2	2

Number of characters

(Fig. 6.6-6)

• **Response message from the slave in normal status**

Slave address, function code, number of data, etc are represented by hexadecimal value, and replaced to the messages character by character.

Header	Slave address	Function code	Data item	Data	Error check LRC	Delimiter
(3AH)	(30H 31H)	(30H 36H)	(30H 30H 30H 30H)	(30H32H 35H 38H)	(39H 46H)	(0DH 0AH)
1	2	2	4	4	2	2

Number of characters

(Fig. 6.6-7)

• **Response message from the slave in exception (error) status (When "set value out of the range" is set.)**

The slave returns the error contents to the master by adding 1 (binary) to the most significant bit of function code.

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

Number of characters

(Fig. 6.6-8)

6.7 Command table (Modbus protocol)

R: Reading, W: Writing (setting)

Address	Contents		R/W	Data
0000H to 0006H	SV or step SV	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0007H to 000DH	OUT1 proportional band	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
000EH to 0014H	OUT2 proportional band (For FCD-13A, FCR-13A, FCR-23A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0015H to 001BH	Integral time	Corresponds to memory 1 to 7	R/W	Set value
001CH to 0022H	Derivative time	Corresponds to memory 1 to 7	R/W	Set value
0023H to 0029H	Alarm 1 (A1) value	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
002AH to 0030H	Alarm 2 (A2) value	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0031H to 0037H	Alarm 3 (A3) value (For FCD-13A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0038H to 003EH	Alarm 4 (A4) value (For FCD-13A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
003FH to 0045H	Overlap/Dead band (For FCD-13A, FCR-13A, FCR-23A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0046H to 004CH	OUT1 high limit	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
004DH to 0053H	OUT1 low limit	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0054H to 005AH	OUT2 high limit (For FCD-13A, FCR-13A, FCR-23A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
005BH to 0061H	OUT2 low limit (For FCD-13A, FCR-13A, FCR-23A)	Corresponds to memory 1 to 7	R/W	Set value Decimal point ignored
0062H to 0068H	Step (1 to 7) time	Corresponds to step 1 to 7	R/W	Set value, Decimal point ignored Converted to minutes, then to hexadecimal figures. (See "Data" on p.14)

0069H	Set value memory number or Step number	R/W	Selection
006AH	AT Perform/Cancel	R/W	0000H: Cancel 0001H: Perform
006BH	OUT1 proportional cycle	R/W	Set value
006CH	OUT2 proportional cycle (For FCD-13A,FCR-13A,FCR-23A)	R/W	Set value
006DH	Manual reset	R/W	Set value Decimal point ignored
006EH	Heater burnout alarm value (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
006FH	Loop break alarm action time	R/W	Set value
0070H	Loop break alarm action span	R/W	Set value Decimal point ignored
0071H	Set value lock (If Lock 3 is selected, the set data will not saved in the memory. By turning the power off, the set values return to the previous one)	R/W	0000H:Unlock 0001H: Lock 1 0002H: Lock 2 0003H: Lock 3
0072H	SV high limit	R/W	Set value Decimal point ignored
0073H	SV low limit	R/W	Set value Decimal point ignored
0074H	Sensor correction value	R/W	Set value Decimal point ignored
0075H	Remote/Local (For FCD-13A, FCR-13A, FCR-23A)	R/W	0000H: Local 0001H: Remote
0076H	Scaling high limit	R/W	Set value Decimal point ignored
0077H	Scaling low limit	R/W	Set value Decimal point ignored
0078H	Decimal point place	R/W	0000H: XXXX 0001H: XXX.X 0002H: XX.XX 0003H: X.XXX
0079H	PV filter time constant	R/W	Set value Decimal point ignored
007AH	OUT1 ON/OFF action hysteresis	R/W	Set value Decimal point ignored
007BH	OUT2 action mode (For FCD-13A, FCR-13A, FCR-23A)	R/W	0000H: Air cooling(Linear) 0001H: Oil cooling (1.5th power of the linear) 0002H: Water cooling(2nd power of the linear)
007CH	OUT2 ON/OFF action hysteresis (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
007DH	A3 type (For FCD-13A)	R/W	0000H: No alarm 0001H: High limit alarm 0002H: High limit alarm with standby 0003H: Low limit alarm 0004H: Low limit alarm with standby 0005H: H/L limits alarm 0006H: H/L limits alarm with standby 0007H: H/L limit range alarm 0008H: H/L limit range alarm with standby 0009H:Process high alarm 000AH: Process high alarm with standby 000BH:Process low alarm 000CH:Process low alarm with standby
007EH	A4 type (For FCD-13A)	R/W	The same as A3 type

007FH	A1 hysteresis	R/W	Set value Decimal point ignored
0080H	A2 hysteresis	R/W	Set value Decimal point ignored
0081H	A3 hysteresis (For FCD-13A)	R/W	Set value Decimal point ignored
0082H	A4 hysteresis (For FCD-13A)	R/W	Set value Decimal point ignored
0083H	A1 action delayed timer	R/W	Set value
0084H	A2 action delayed timer	R/W	Set value
0085H	A3 action delayed timer (For FCD-13A)	R/W	Set value
0086H	A4 action delayed timer (For FCD-13A)	R/W	Set value
0087H	External setting input high limit (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
0088H	External setting input low limit (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
0089H	Transmission output mode (For FCD-13A, FCR-13A, FCR-23A)	R/W	0000H: PV transmission 0001H: SV transmission 0002H: MV transmission
008AH	Transmission output high limit (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
008BH	Transmission output low limit (For FCD-13A, FCR-13A, FCR-23A)	R/W	Set value Decimal point ignored
008CH	Indication selection when control output is OFF	R/W	0000H: OFF indication 0001H: No indication 0002H: PV indication
008DH	SV rise rate	R/W	Set value Decimal point ignored
008EH	SV fall rate	R/W	Set value Decimal point ignored
008FH	Fixed value control/Program control	R/W	0000H: Fixed value control 0001H: Program control
0090H	Control output OFF function	R/W	For fixed value control 0000H: ON 0001H: OFF For program control 0000H: STOP 0001H: RUN
0091H	Auto/Manual control (For FCD-13A, FCR-13A, FCR-23A)	R/W	0000H: Automatic 0001H: Manual
0092H	Manual MV (manipulated variable) (For FCD-13A, FCR-13A, FCR-23A)	R/W	• Settable only in the Manual mode. • The setting range differs depending on OUT1 (OUT2) high and low limit values. • Set value Decimal point ignored
0093H	Infrared emissivity	R/W	Set value Decimal point ignored
0094H	Control output OFF function selection for excess input	R/W	0000H: Prohibited 0001H: Allowed
0095H	A1 action Energized/Deenergized	R/W	0000H: Energized 0001H: Deenergized
0096H	A2 action Energized/Deenergized	R/W	0000H: Energized 0001H: Deenergized
0097H	A3 action Energized/Deenergized (For FCD-13A)	R/W	0000H: Energized 0001H: Deenergized
0098H	A4 action Energized/Deenergized (For FCD-13A)	R/W	0000H: Energized 0001H: Deenergized
0099H	PV	R	PV Decimal point ignored

009AH	OUT1 MV (manipulated variable)	R	OUT1 MV Decimal point ignored
009BH	OUT2 MV (manipulated variable) (For FCD-13A, FCR-13A, FCR-23A)	R	OUT2 MV Decimal point ignored
009CH	Current SV during program control	R	Current SV Decimal point ignored
009DH	Remaining time during program control	R	Remaining time Decimal point ignored Converted to minutes, then to hexadecimal figures. (See "Data" on p.14)
009EH	Status flag	R	0000 0000 0000 0000 2^{15} to 2^{0} 2^{0} digit: OUT1 (Control output 1) 0: OFF, 1: ON 2^{1} digit: OUT2 (Control output 2) 0: OFF, 1: ON 2^{2} digit: A1 output 0: OFF, 1: ON 2^{3} digit: A2 output 0: OFF, 1: ON 2^{4} digit: A3 output 0: OFF, 1: ON 2^{5} digit: A4 output 0: OFF, 1: ON 2^{6} digit: Heater burnout alarm output 0: OFF, 1: ON 2^{7} digit: Loop break alarm output 0: OFF, 1: ON 2^{8} digit: Overscale 0: OFF, 1: ON 2^{9} digit: Underscale 0: OFF, 1: ON 2^{10} to 2^{15} digit: Not used. Always 0
009FH	Selected Set value memory number (running step)	R	Selected number

● **Data**

Note on setting, reading command

- The data (set value, decimal) is converted to hexadecimal figures. A negative number is represented by 2's complement.
- When connecting plural slaves, the address (instrument number) must not be duplicated.
- For Step (1 to 7) time (0036H, 0062H to 0068H for Modbus), and Remaining time during program control (0084H, 009DH for Modbus), time is converted to minutes, then to hexadecimal figures, and ASCII is used.
  (e.g.) 1 hour 30 minutes ⟶ 90minutes ⟶ 005AH (hexadecimal)
  99 hours 59 minutes ⟶ 5999minutes ⟶ 176FH (hexadecimal)

Setting command

- 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 the alarm type is changed during Alarm 3 type selection (0023H, 007DH for Modbus) and Alarm 4 type selection (0024H, 007EH for Modbus), the alarm value will revert to "0". Also alarm output status will be initialized.
- It is possible to set the set value with the setting command of the communication function even when the set value is locked.
- Although the options are not applied, setting the items for the options is possible using the setting command. However, they will not function.
- Instrument numbers, communication speed and protocol of the slave cannot be set by communication function.
- When sending a command by Global address (Shinko protocol) or Broadcast address (Modbus protocol), the same command is sent to all the slaves connected. However, the response is not returned.
- The memory can store up to 1,000,000 (one million) entries.
  If the number of settings exceeds the limit, the data will not be saved. So frequent transmission via communication is not recommended.

Reading command

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

● **Negative acknowledgement**

The slave will return Error code 1 (31H) (Shinko protocol) or Exception code 1 (01H) (Modbus protocol) in the following cases.

- When AT Perform/Cancel (0003H, 006AH for Modbus protocol) is selected during PI action or ON/OFF action.

The slave will return Error code 4 (34H) (Shinko protocol) or Exception code 17 (11H) (Modbus protocol) in the following cases.

- If "Cancel (0000H)" of AT Perform/Cancel (0003H, 006AH for Modbus protocol) is selected while Auto-tuning is being cancelled.
- When "Perform (0001H)" of AT Perform/Cancel (0003H, 006AH for Modbus protocol) is selected while Auto-tuning is performing

● **Notes on programming monitoring software**

How to speed up the scan time

When monitoring plural units of FC series, set the program so that requisite minimum pieces of data such as PV (0080H, 0099H for Modbus protocol), OUT1 MV (0081H, 009AH for Modbus), Status flag (0085H, 009EH for Modbus), etc. can be read, and for other data, set the program so that they can be read only when their set value has changed. This will speed up the scan time.

Note when sending all set values at one time

- If alarm type is changed during Alarm 3 type selection (0023H, 007DH for Modbus) or Alarm 4 type selection (0024H, 007EH for Modbus), the alarm value will revert to "0". First, send the selected alarm type, then send the alarm value.

● **When communicating with a PLC**

Command example (Shinko protocol) when communicating with a Mitsubishi PLC (FX series, etc.)

• Reading (Top D register: D100)

Address 1, PV reading

Sending Data	(STX)(!)( )( )(0)(0)(8)(0)(D)(7)(ETX)		
Command		Register	Code
Header (STX)	02H	D100(LSB)	02H
Address	1	D100(MSB)	21H
Sub address	20H	D101(LSB)	20H
Command type	20H	D101(MSB)	20H
Data item	&H80	D102(LSB)	30H
		D102(MSB)	30H
		D103(LSB)	38H
		D103(MSB)	30H
Checksum		D104(LSB)	44H
		D104(MSB)	37H
Delimiter (ETX)	03H	D105(LSB)	03H

Communication setting [MOVP H0C86 D8120]
Reading + Setting [RS D100 K11 D108 K26]
Reading only [RS D100 K11 D106 K26]

1 [MOV H2102 D100]
2 [MOV H2020 D101]
3 [MOV H3030 D102]
4 [MOV H3038 D103]
5 [MOV H3744 D104]
6 [MOV H03 D105]

• Setting (Top D register: D120)

Address 1, Memory No. 1, SV setting [When setting SV to 600℃ (0258H)]

Sending Data	(STX)(!)(!)(P)(0)(0)(0)(1)(0)(2)(5)(8)(D)(E)(ETX)		
Command		Register	Code
Header (STX)	02H	D120(LSB)	02H
Address	1	D120(MSB)	21H
Sub address	1	D121(LSB)	21H
Command type	P	D121(MSB)	50H
Data item	&H1	D122(LSB)	30H
		D122(MSB)	30H
		D123(LSB)	30H
		D123(MSB)	31H
Data item	600	D124(LSB)	30H
		D124(MSB)	32H
		D125(LSB)	35H
		D125(MSB)	38H
Checksum		D126(LSB)	44H
		D126(MSB)	45H
Delimiter (ETX)	03H	D127(LSB)	03H

Reading + Setting [RS D120 K15 D128 K26]
Reading only [RS D120 K15 D128 K22]

1 [MOV H2102 D120]
2 [MOV H5021 D121]
3 [MOV H3030 D122]
4 [MOV H3130 D123]
5 [MOV H3230 D124]
6 [MOV H3835 D125]
7 [MOV H4544 D126]
8 [MOV H03 D127]

7. Specifications

Cable length : RS-232C: 10m (Max), RS-485: 1km (Max)
Communication method: Half-duplex communication
Communication speed : 9600bps (2400, 4800, 9600, 19200bps) Selectable by keypad
Synchronization : Start-stop synchronization
Code form : ASCII
Error correction : Command request repeat system
Error detection : Parity check, Checksum (Shinko protocol), LRC (Modbus protocol)
Communication protocol : Shinko protocol/Modbus ASCII (Selectable by keypad)
Data format : Start bit: 1, Data bit: 7, Parity: Even, Stop bit: 1

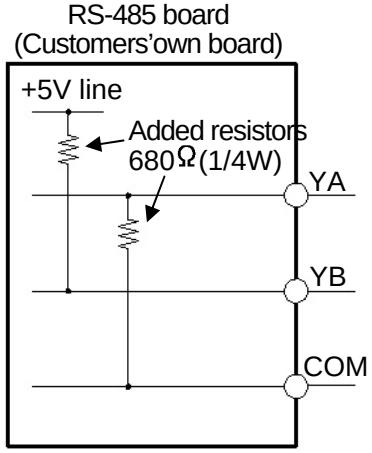
8. Troubleshooting

If any malfunctions occur, refer to the following items after checking the power supply of the host computer and the FC series.

● Problem: Communication failure

Check the following
The connection or wiring of communication is not secure.
A burnout or imperfect contact on the communication cable and the connector
Communication speed of the FC series does not coincide with that of the host computer.
The data bit, parity and stop bit of the host computer do not accord with those of the FC series.
The instrument number (address) of the FC series does not coincide with that of the command.
The instrument numbers (addresses) are duplicated in multiple FC series.
When communicating by RS-485 (C5 option), make sure that the program is appropriate for the transmission timing.

For the C5 option, when communicating with the host computer using RS-485 board (or customers'own board) instead of Shinko IF-400, communications sometimes cannot be carried out successfully. In this case, connect 2 resistors of 680Ω (1/4W) as shown on the right.



(Fig. 8-1)

● Problem: Although communication is occurring, the response is 'NAK'.

Check the following
Check whether or not a non-existent command code has been sent.
The setting command data exceeds the setting range of the FC series.
The controller cannot be set when functions such as AT are performing.
The operation mode is under the front keypad operation setting mode.

For further inquiries, please consult our agency or the shop where you purchased the unit.

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