

To prevent accidents arising from the misuse of this controller, please ensure the operator receives this manual. For this product to which communication function has been added, "1" is entered after the heater burnout alarm indication in the model number.


(For the model number and basic operation, refer to the instruction manual for KT7.)

Warning

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

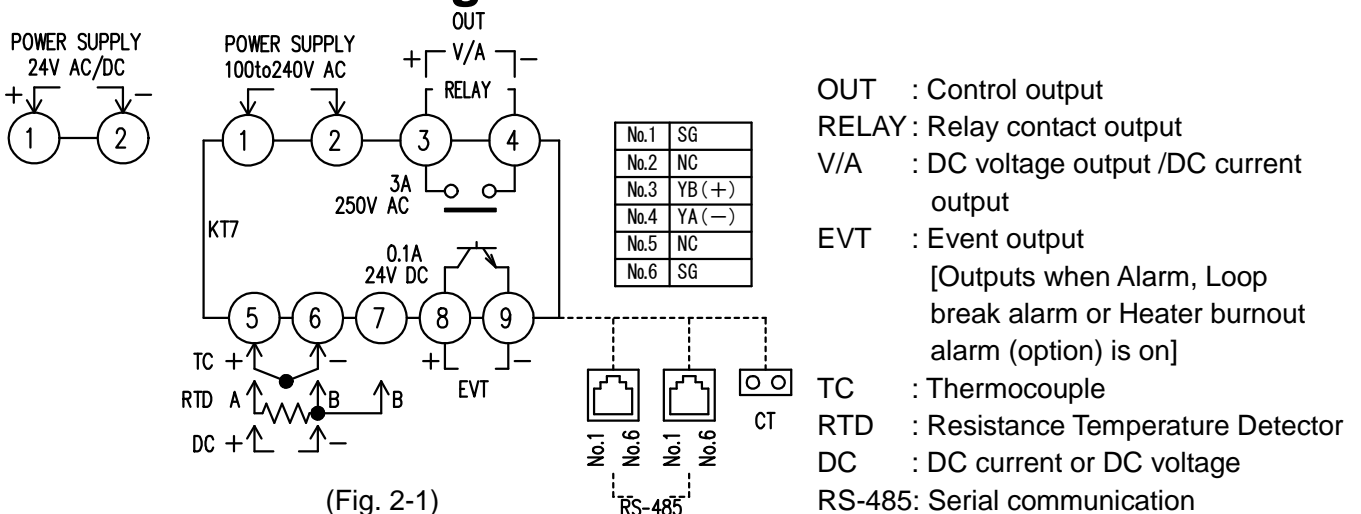
1. Setup of the KT7

Set the items "Communication protocol selection", "Instrument number setting", "Communication speed selection", "Parity selection" and "Stop bit selection" after the "Sensor correction setting" in the Auxiliary function setting mode 1.

To enter Auxiliary function setting mode 1, press the **MODE** key for 3 seconds while holding down the  key.

Character (PV display)	Name, Functions and Setting range	Default (SV display)
$\overline{c\bar{n}4L}$	Communication protocol selection • Selects the Communication protocol. • Modbus ASCII mode: $\overline{n\bar{o}dA}$ Modbus RTU mode: $\overline{n\bar{o}dR}$ $\overline{n\bar{o}nL}$: Not available.	Modbus ASCII
$\overline{c\bar{n}n0}$	Instrument number setting • Sets individual instrument number for each unit when communicating by connecting plural controllers in serial communication. Up to 31 units can be connected, however, the instrument number can be set within the range 0 to 95. • 0 to 95	0
$\overline{c\bar{n}4P}$	Communication speed selection • Selects a communication speed to correspond to that of host computer. • 2400bps: $\overline{24}$, 4800bps: $\overline{48}$, 9600bps: $\overline{96}$, 19200bps: $\overline{192}$	9600bps
$\overline{c\bar{n}Pr}$	Parity selection • Selects the parity. • No parity: $\overline{n\bar{o}nE}$, Even parity: $\overline{E\bar{b}E\bar{n}}$, Odd parity: $\overline{o\bar{d}d}$	Even
$\overline{c\bar{n}4r}$	Stop bit selection • Selects the stop bit. • 1 or 2	1

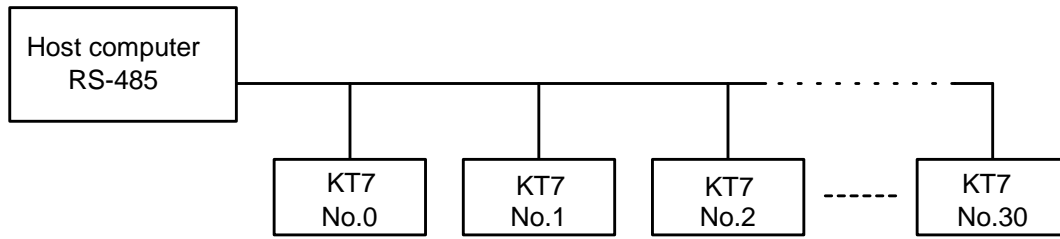
2. Terminal arrangement



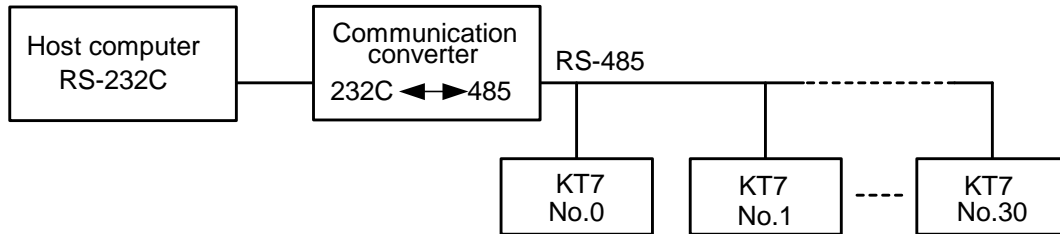
Modular plug applicable to the modular jack of KT7 with communication function is RJ-11 (6-pin type). Recommended model: TM20P-66P (Hirose Electric CO.,LTD.) (Applicable cable diameter: $\varnothing 0.4$ to 0.65mm) For the communication cable, two twisted 2-core cables or one twisted 3-core cable is recommended. When using one twisted 3-core cable, use either pin 1 or pin 6 for SG of the plug.

3. System configuration

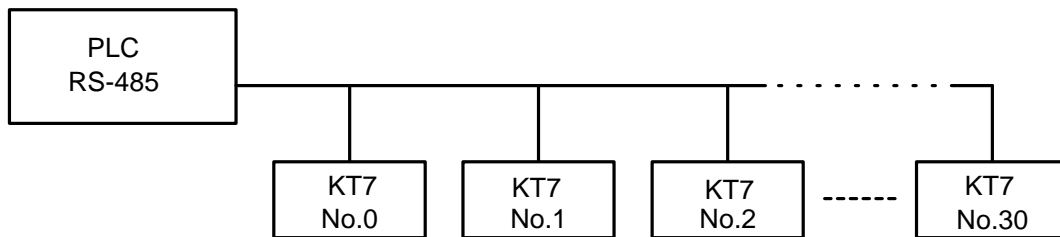
RS-485 multi-drop connection communication



(Fig. 3-1)



(Fig. 3-2)

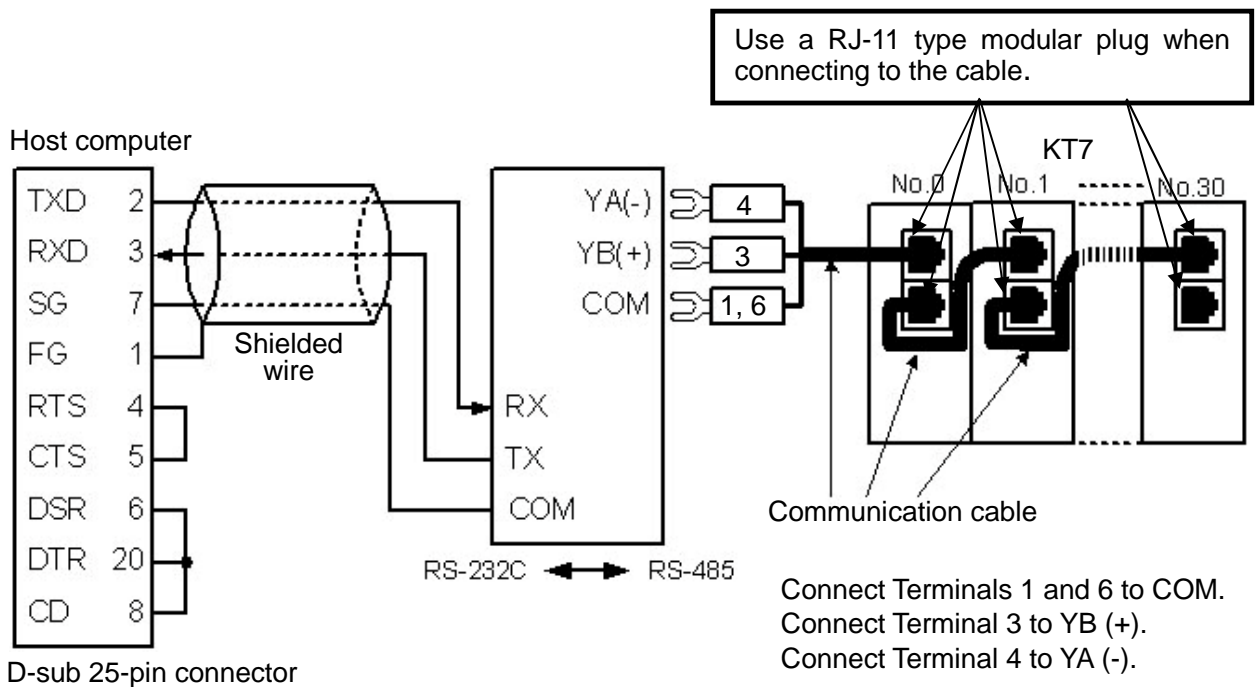


(Fig. 3-3)

4. Wiring

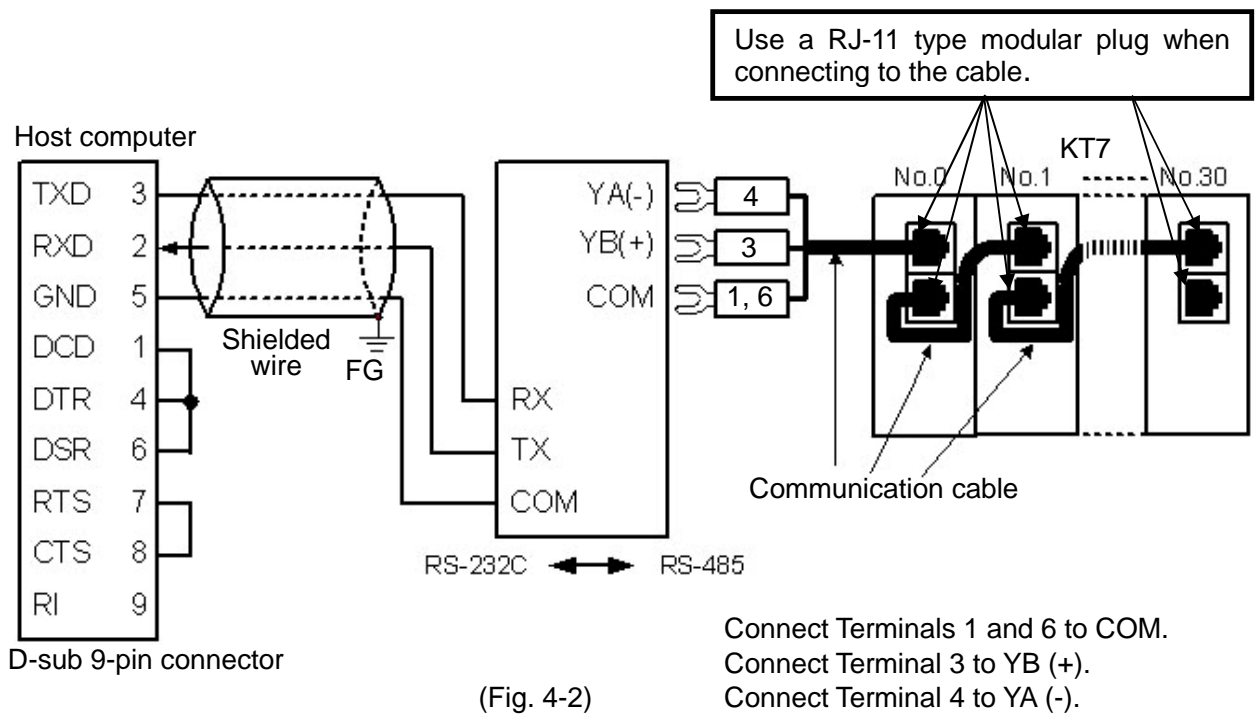
When using communication converter RS-232C

- Connector: D-sub 25-pin
- Connection: RS-232C ↔ RS-485 (Communication speed: 2400, 4800, 9600, 19200bps)

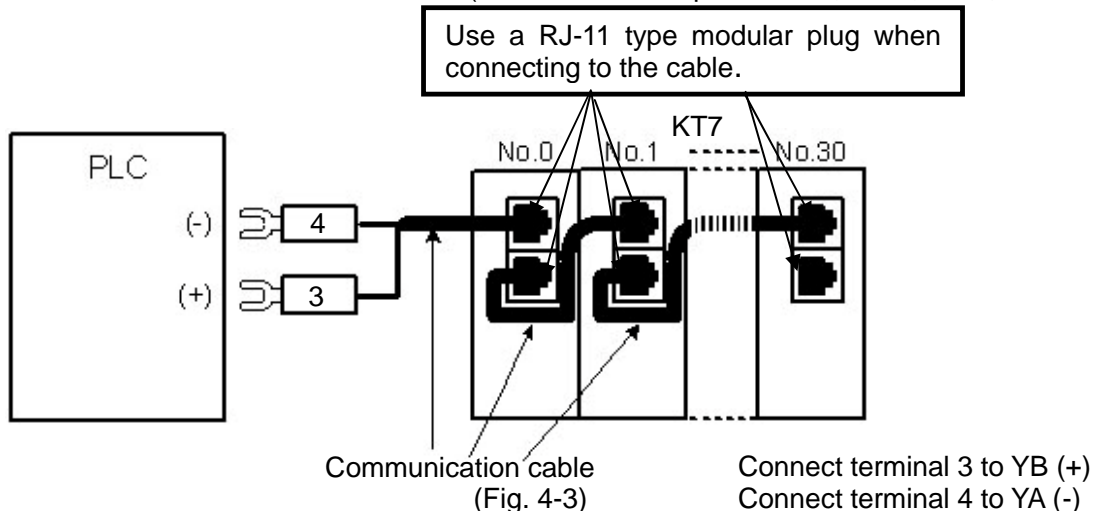


(Fig. 4-1)

- Connector: D-sub 9-pin
Connection: RS-232C ↔ RS-485 (Communication speed: 2400, 4800, 9600, 19200bps)



- **When connecting with PLC (RS-485)**
Connection: RS-485 ↔ RS-485 (Communication speed: 2400, 4800, 9600, 19200bps)



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.

Terminator (Terminal resistor)

Do not connect terminator with the communication line because each KT7 has built-in pull-up and pull-down resistors instead of a terminator.

If there is a large distance between the PLC and the KT7, connect the terminator on the PLC side. (Connect a terminator of 120Ω or more resistance.)

Setup of the KT7

- It is necessary to set the instrument number individually to the KT7 when communicating by connecting plural units in serial communication.
Select a communication speed for the KT7 in accordance with that of the host computer.
- Refer to Chapter 1 "Setup of the KT7" for instrument number setting and communication speed selection.

Memory life of the KT7

The memory can contain up to 1,000,000 (one million) set value entries.

This memory life is sufficient when the set value is changed by keypad operation.

However, when changing the set value frequently via the communication function, be careful not to exceed the 1,000,000 (one million) cycles limit.

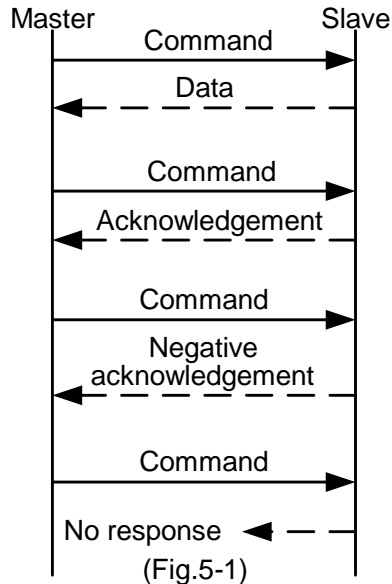
When Lock 1 or Lock 2 is used, every time the set value is changed by the communication function, the changed value is written in the non-volatile memory. If the value changed by the communication function is the same as previous one, it is not written in the non-volatile memory.

When Lock 3 is used and if the set value is changed, the changed value is not written in the non-volatile memory until the power to the controller is turned off. This has no relation to the limit for changes in set value.

Therefore, be sure to use Lock 3 when changing the set value frequently via communication.

5. Communication procedure

Communication starts with command transmission from the host computer (hereafter Master) and ends with the response of the KT7 (hereafter Slave).



- **Response with data**

When the master sends the reading command, the slave responds with the corresponding set value or current action status.

- **Acknowledgement**

When the master sends the setting command, the slave responds by sending an acknowledgement after the processing is terminated.

- **Negative acknowledgement**

When the master sends 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 when broadcast address is set, or when there is a communication error (framing error or parity error), or when LRC or CRC discrepancy is detected.

Communication timing of the RS-485

Slave side

When a slave starts transmission through 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.

Master side (Notice on setting a program)

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.

6. Modbus protocol

6.1 Modbus protocol

Modbus protocol is a communication protocol for the PLC developed by Modicon Inc.

6.2 Transmission mode

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

6.3 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/Odd (Selectable)
	Stop bit	: 1 bit/2 bits (Selectable)
	Error detection:	LRC (Longitudinal Redundancy Check)
	Data interval	: 1 second or less

(1) Message configuration

ASCII mode message is configured to start by [: (colon)(3AH)] and end by [CR (carriage return) (0DH) + LF (Line feed)(0AH)]. (See Fig. 6.3-1)

Header (:)	Slave address	Function code	Data	Error check LRC	Delimiter (CR)	Delimiter (LF)
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(Fig. 6.3-1)

(2) Slave address

Slave address is an individual instrument number on the slave side and is set within the range 00H to 5FH (0 to 95).

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. However slaves do not respond.]

(3) Function code

The function code is the command code for the slave to undertake the following action types (Table 6.3-1). (Table 6.3-1)

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

Function code is used to discern whether the response is normal (acknowledgement) or if any error (negative acknowledgement) is 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, when the master sends request message setting 10H to function code by mistake, slave returns 90H by setting the MSB to 1, because the former is an illegal function.)

For negative acknowledgement, exception code (Table 6.3-2) below is set to the data of response message and returned to the master in order to inform it that what kind of error has occurred.

(Table 6.3-2)

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)	Illegal setting (Unsettable status)
18 (12H)	Illegal setting (During setting mode by keypad operation, etc)

(4) Data

Data differs depending on the function code.

A request message from the master is composed of data item, number of data and setting 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).

(5) Error check of 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 LRC is calculated

- 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.

(6) Message example of ASCII mode

① **Reading (Instrument number 1, SV)**

- A request message from the master

Header	Slave address	Function code	Data item	Number of data	Error check LRC	Delimiter	
(3AH)	(30H 31H)	(30H 33H)	(30H 30H 30H 31H)	(30H 30H 30H 31H)	(46H 41H)	(0DH 0AH)	Number of characters
1	2	2	4	4	2	2	←

(Fig. 6.3-2)

The number of data means the data item to be read, and it is fixed as (30H 30H 30H 31H).

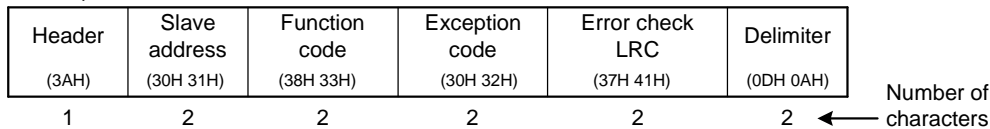
- Response message from the slave in normal status (When SV=100°C)

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

(Fig.6.3-3)

The number of response bytes means the number of bytes of the data which has been read, and it is fixed as (30H 32H).

- Response message from the slave in exception (error) status (When non-existent data item is sent)

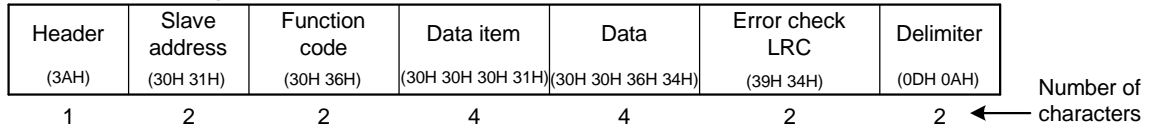


(Fig. 6.3-4)

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

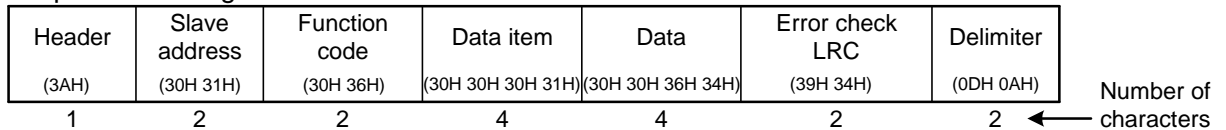
② **Setting (Instrument number 1, SV=100°C)**

- A request message from the master



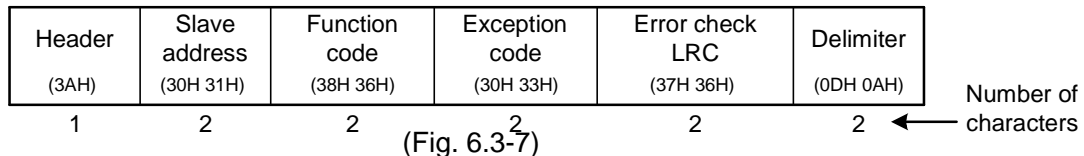
(Fig. 6.3-5)

- Response message from the slave in normal status



(Fig. 6.3-6)

- Response message from the slave in exception (error) status (When a value out of the setting range is set.)



(Fig. 6.3-7)

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

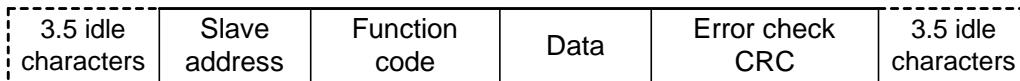
6.4 RTU mode

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

Data format Start bit : 1 bit
 Data bit : 8 bits
 Parity : Even/No/Odd (Selectable)
 Stop bit : 1 bit/2 bits (Selectable)
 Error detection : CRC-16 (Cyclic Redundancy Check)
 Data interval : 3.5 characters transmission time or less

(1) Message configuration

RTU mode is configured to start after idle time is processed for more than 3.5 character transmission and end after idle time is processed for more than 3.5 character transmission. (See Fig. 6.4-1)



(Fig. 6.4-1)

(2) Slave address

Slave address is an individual instrument number on the slave side and is set within the range 00H to 5FH (0 to 95).

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. However slaves do not respond.]

(3) Function code

The function code is the command code for the slave to undertake the following action types (Table 6.4-1).

(Table 6.4-1)

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Function code is used to discern whether the response is normal (acknowledgement) or if any error (negative acknowledgement) is 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, when the master sends request message setting 10H to function code by mistake, slave returns 90H by setting the MSB to 1, because the former is an illegal function.)

For negative acknowledgement, exception code (Table 6.4-2) below is set to the data of response message and returned to the master in order to inform it that what kind of error has occurred.

(Table 6.4-2)

Exception code	Contents
1 (01H)	Illegal function (Non-existent function)
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3 (03H)	Illegal data value (Value out of the setting range)
17 (11H)	Illegal setting (Unsettable status)
18 (12H)	Illegal setting (During setting mode by keypad operation, etc)

(4) Data

Data differs depending on the function code.

A request message from the master side is composed of data item, number of data and setting data.

A response message from the slave side is composed of number of bytes, data and exception code in negative acknowledgement. Effective range of data is -32768 to 32767 (8000H to 7FFFH).

(5) Error check of RTU mode

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

How CRC is calculated

In the CRC system, the information is divided by the polynomial series. The remainder is added to the end of the information and transmitted. The generation of the polynomial series is as follows.

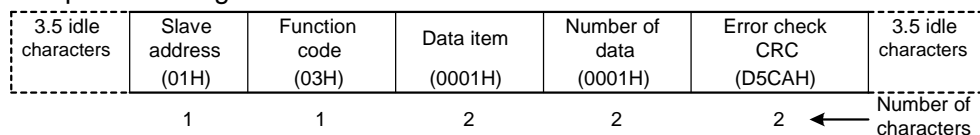
(Generation of the polynomial series: $X^{16} + X^{15} + X^2 + 1$)

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

(6) Message example of RTU mode

① Reading (Instrument number 1, SV)

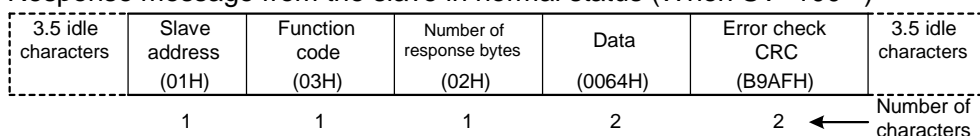
- A request message from the master



(Fig. 6.4-2)

The number of data means the data item to be read, and it is fixed as 0001H.

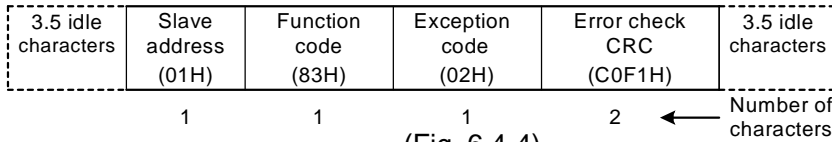
- Response message from the slave in normal status (When SV=100°C)



(Fig. 6.4-3)

The number of response bytes means the number of bytes of the data which has been read, and it is fixed as 02H.

- Response message from the slave in exception (error) status (When non-existent data item is sent)

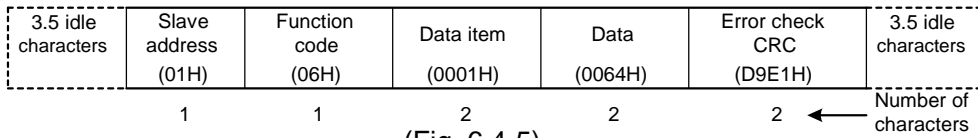


(Fig. 6.4-4)

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

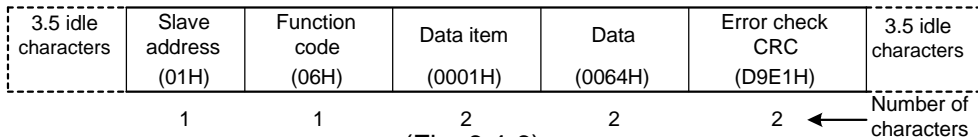
② Setting (Instrument number 1, SV=100°C)

- A request message from the master



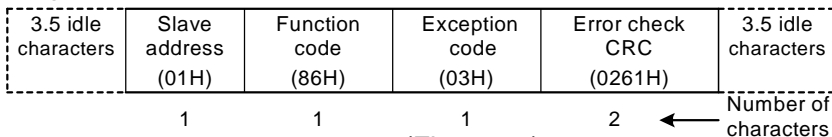
(Fig. 6.4-5)

- Response message from the slave in normal status



(Fig. 6.4-6)

- Response message from the slave in exception (error) status (When a value out of the setting range is set)



(Fig. 6.4-7)

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

7. Communication command table

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.

Modbus function code	Data item	Data
03H/06H	0001H: SV	Set value
03H/06H	0002H: Not used	
03H/06H	0003H: AT/Auto-reset	0000H: Cancel 0001H: Perform
03H/06H	0004H: OUT proportional band	Set value
03H/06H	0005H: Not used	
03H/06H	0006H: Integral time	Set value
03H/06H	0007H: Derivative time	Set value
03H/06H	0008H: OUT proportional cycle	Set value
03H/06H	0009H: Not used	
03H/06H	000AH: Manual reset	Set value
03H/06H	000BH: Alarm value	Set value
03H/06H	000CH: Not used	
03H/06H	000DH: Not used	
03H/06H	000EH: Not used	
03H/06H	000FH: HB (Heater burnout alarm) value	Set value
03H/06H	0010H: LA (Loop break alarm) time	Set value
03H/06H	0011H: LA (Loop break alarm) span	Set value
03H/06H	0012H: Set value lock (*1)	0000H: Unlock 0002H: Lock 2 0001H: Lock 1 0003H: Lock 3
03H/06H	0013H: Not used	
03H/06H	0014H: Not used	
03H/06H	0015H: Sensor correction value	Set value
03H/06H	0016H: Not used	
03H/06H	0017H: Not used	

03H/06H	0018H: Scaling high limit	Set value
03H/06H	0019H: Scaling low limit	Set value
03H/06H	001AH: Decimal point place	0000H: XXXX (No decimal point) 0001H: XXX.X (1 digit after decimal point) 0002H: XX.XX (2 digits after decimal point) 0003H: X.XXX (3 digits after decimal point)
03H/06H	001BH: PV filter time constant	Set value
03H/06H	001CH: OUT high limit	Set value
03H/06H	001DH: OUT low limit	Set value
03H/06H	001EH: OUT ON/OFF action hysteresis	Set value
03H/06H	001FH: Not used	
03H/06H	0022H: Not used	
03H/06H	0023H: Alarm type (*2)	0000H: No alarm action 0001H: High limit alarm 0002H: Low limit alarm 0003H: High/Low limits alarm 0004H: High/Low limit range alarm 0005H: Process high alarm 0006H: Process low alarm 0007H: High limit alarm with standby 0008H: Low limit alarm with standby 0009H: High/Low limits alarm with standby
03H/06H	0024H: Not used	
03H/06H	0025H: Alarm hysteresis	Set value
03H/06H	0026H: Not used	
03H/06H	0027H: Not used	
03H/06H	0028H: Not used	
03H/06H	0029H: Alarm action delayed timer	Set value
03H/06H	002AH: Not used	
03H/06H	003FH: Not used	
03H/06H	0040H: Alarm action Energized/ Deenergized	0000H: Energized 0001H: Deenergized
03H/06H	0041H: Not used	
03H/06H	0042H: Alarm HOLD function	0000H: Alarm Not Holding 0001H: Alarm Holding
03H/06H	0043H: Not used	
03H/06H	0044H: Input type	0000H: K [-200 to 1370°C] 0001H: K [-199.9 to 400.0°C] 0002H: J [-200 to 1000°C] 0003H: R [0 to 1760°C] 0004H: S [0 to 1760°C] 0005H: B [0 to 1820°C] 0006H: E [-200 to 800°C] 0007H: T [-199.9 to 400.0°C] 0008H: N [-200 to 1300°C] 0009H: PL-II [0 to 1390°C] 000AH: C (W/Re5-26) [0 to 2315°C] 000BH: Pt100 [-199.9 to 850.0°C] 000CH: JPt100 [-199.9 to 500.0°C] 000DH: Pt100 [-200 to 850°C] 000EH: JPt100 [-200 to 500°C] 000FH: K [-320 to 2500°F] 0010H: K [-199.9 to 750.0°F] 0011H: J [-320 to 1800°F] 0012H: R [0 to 3200°F] 0013H: S [0 to 3200°F] 0014H: B [0 to 3300°F] 0015H: E [-320 to 1500°F]

		0016H: T [-199.9 to 750.0°F] 0017H: N [-320 to 2300°F] 0018H: PL-II [0 to 2500°F] 0019H: C (W/Re5-26) [0 to 4200°F] 001AH: Pt100 [-199.9 to 999.9°F] 001BH: JPt100 [-199.9 to 900.0°F] 001CH: Pt100 [-300 to 1500°F] 001DH: JPt100 [-300 to 900°F] 001EH: 4 to 20mA DC [-1999 to 9999] 001FH: 0 to 20mA DC [-1999 to 9999] 0020H: 0 to 1V DC [-1999 to 9999] 0021H: 0 to 5V DC [-1999 to 9999] 0022H: 1 to 5V DC [-1999 to 9999] 0023H: 0 to 10V DC [-1999 to 9999]
03H/06H	0045H: Direct/Reverse action	0000H: Heating (Reverse action) 0001H: Cooling (Direct action)
03H/06H	0046H: Not used	
03H/06H	0047H: AT bias	Set value
03H/06H	0048H: ARW (anti-reset windup)	Set value
03H/06H	006FH: Key Lock	0000H: Key enabled 0001H: Key Lock
06H	0070H: Key operation change flag clearing	0000H: No action 0001H: All clearing
03H	0080H: PV reading	Present PV (input value)
03H	0081H: MV reading	Present MV (manipulated variable)
03H	0082H: Not used	
03H	0083H: Not used	
03H	0084H: Not used	
03H	0085H: OUT status reading	0000 0000 0000 0000 2^{15} to 2^0 2^0 digit: OUT 0: OFF 1: ON 2^1 digit: Not used (Always 0) 2^2 digit: Alarm output 0: OFF 1: ON 2^3 digit: Not used (Always 0) 2^4 digit: Not used (Always 0) 2^5 digit: Not used (Always 0) 2^6 digit: HB (Heater burnout alarm) output 0: OFF 1: ON (When sensor burnout, 0: OFF) 2^7 digit: LA (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} digit: Not used (Always 0) 2^{11} digit: AT/Auto-reset 0: OFF 1: ON 2^{12} digit: Not used (Always 0) 2^{13} digit: Converter function 0: Controller 1: Converter 2^{14} digit: Not used (Always 0) 2^{15} digit: Key operation change 0: No 1: Yes
03H	0086H: Not used	
03H	0087H: Not used	
03H	00A0H: Not used	

03H	00A1H: Instrument information reading	0000 0000 0000 0000 2^{15} to 2^0 2^0 digit: Not used (Always 0) 2^1 digit: Not used (Always 0) 2^2 digit: Alarm function 0: Not applied 1: Applied 2^3 digit: Not used (Always 0) 2^4 digit: Not used (Always 0) 2^5 digit: Not used (Always 0) 2^6 digit: HB (Heater burnout alarm) 0: Not applied 1: Applied 2^7 digit: LA (Loop break alarm) 0: Not applied 1: Applied 2^8 to 2^{15} digit: Not used (Always 0)
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(*1) When Lock 3 is designated, the set data is not saved in the memory.

This is why the set value reverts to the one before Lock 3 when power is turned OFF.

(*2) When alarm type is changed, the alarm set value reverts to the default value and alarm output status is also initialized.

Notice

When data setting is changed by front keypad operation, the data that is related to the changed item is also changed automatically as shown in Example 1 below.

However, when the data setting is changed by communication function, the related data does not change as shown in Example 2 below. (Only the changed data is altered.)

(Example 1) SV high limit: 1370°C

SV : 1000°C

When SV high limit is changed to 800°C by the front keypad operation, both SV high limit and SV are changed to 800°C.

(Example 2) SV high limit: 1370°C

SV : 1000°C

When SV high limit is changed to 800°C by communication function, SV high limit is changed to 800°C, however, SV is maintained at the same temperature 1000°C.

8. Specifications

Communication	: Half-duplex Cable length: Maximum communication distance 1000m Cable resistance: Within 50 Ω (Terminator is not necessary or 120 Ω or more on the PLC side.)
Communication line	: EIA RS-485
Connectable number of units	: Maximum 31 units to 1 host computer
Communication speed	: 2400, 4800, 9600, 19200bps (Selectable by keypad operation)
Synchronous system	: Start-stop synchronous
Code form	: ASCII, binary Error detection: Parity check, Checksum (LRC, CRC)
Error correction	: Command request repeat system
Data format	: Start bit : 1 Data bit : 7, 8 Parity : Even, Odd, No parity Stop bit : 1

9. Troubleshooting

If any malfunctions occur, refer to the following items after checking the power supply to the master and the slave.

- **Problem: Communication failure**

Check the following
The connection or wiring of communication is not secure.
Burnout or imperfect contact on the communication cable and the connector.
Communication speed of the slave does not coincide with that of the master.
The data bit, parity and stop bit of the master do not accord with those of the slave.
The instrument number of the slave does not coincide with that of the command.
The instrument numbers are duplicated in multiple slaves.
When communicating without using communication converter, make sure that the program is appropriate for the transmission timing.

- **Problem: Although communication is occurring, the response is 'exception code'.**

Check the following
Check that a non-existent command code has not been sent.
The setting command data exceeds the setting range of the slave.
The controller cannot be set when functions such as AT is 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.

Panasonic Industrial Devices SUNX Co., Ltd.

<http://panasonic.net/id/pidsx/global>

Overseas Sales Division (Head Office)

2431-1 Ushiyama-cho, Kasugai-shi, Aichi, 486-0901, Japan

Phone: +81-568-33-7861 FAX: +81-568-33-8591

About our sale network, please visit our website.

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Panasonic Electric Works Europe AG

Rudolf-Diesel-Ring 2 83607 Holzkirchen, Germany

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