和文は裏面をご覧下さい。

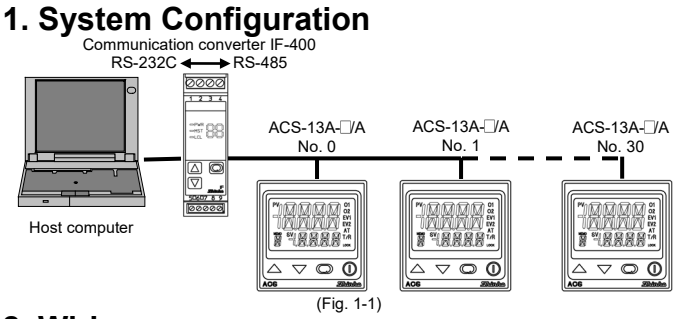
# Communication Instruction Manual ACS-13A-□/A (C5)

**(For Use with the Infrared Temperature Sensor)**

No. ACS11CAJE3 2019.11

This manual explains briefly about communication functions of the digital indicating controller ACS-13A-□/A for exclusive use with the infrared temperature sensor RD-500 series or RD-715-HA.

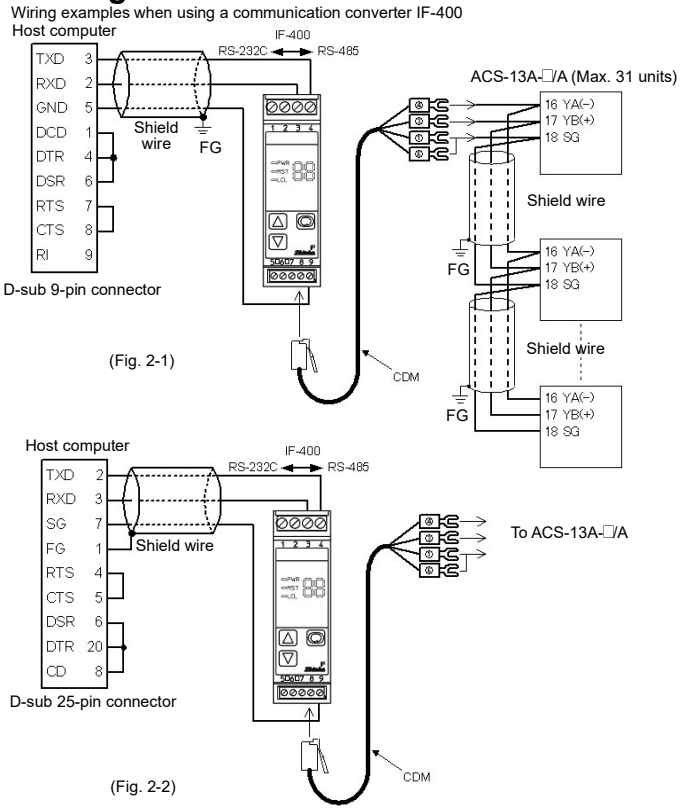
## 1. System Configuration




(Fig. 1-1)

## 2. Wiring

Wiring examples when using a communication converter IF-400




(Fig. 2-1)

(Fig. 2-2)

**Shield Wire**

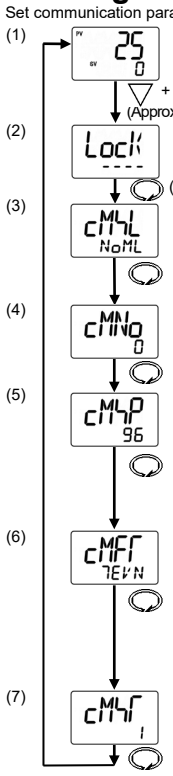
Connect only one end of the shield to the FG to avoid a ground loop. If both ends of the shield wire are connected to the FG, the circuit will be closed, resulting in a ground loop. This may cause noise. Be sure to ground the FG. Recommended cable: OTSC-VB 2PX0.5SQ (made by Onamba Co., Ltd.) or equivalent (Use a twisted pair cable.)

**Terminator (Terminal Resistor)**

The communication converter IF-400 (sold separately) has a built-in terminator.
The terminator is mounted at the end of the wire when connecting multiple peripheral devices to a personal computer. The terminator prevents signal reflection and disturbance.
Do not connect a terminator to the communication line because each ACS-13A-□/A has built-in pull-up and pull-down resistors.

## 3. Setting Communication Parameters

Set communication parameters following the procedure below.




**Proceed to Auxiliary function setting mode.**
Press and hold the ▽ and ◯ keys (in that order) together for approx.3 seconds in PV/SV display mode.
The unit proceeds to Auxiliary function setting mode.

**Auxiliary function setting mode**
Press the ◯ key twice.
The unit proceeds to Communication protocol.

**Communication protocol**
Select the communication protocol.
NoML : Shinko protocol (Factory default)
ModA : Modbus ASCII mode
ModR : Modbus RTU mode

**Instrument number**
Set the instrument number of the controller one by one when multiple instruments are connected.
Setting range: 0 to 95 (Factory default: 0)

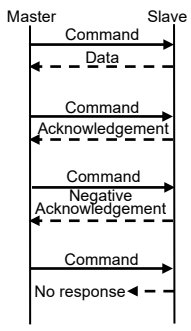
**Communication speed**
Select a communication speed equal to that of the host computer.
24 : 2400 bps
48 : 4800 bps
96 : 9600 bps (Factory default)
192 : 19200 bps

**Data bit/Parity**
Select the data bit and parity.
8NoN : 8 bits/No parity
7NoN : 7 bits/No parity
8EVN : 8 bits/Even
7EVN : 7 bits/Even (Factory default)
8odd : 8 bits/Odd
7odd : 7 bits/Odd

**Stop bit**
Select the stop bit.
1 : 1 bit (Factory default)
2 : 2 bits

## 4. Communication Procedure

Communication starts with command transmission from the host computer (Master) and ends with the response of the ACS-13A-□/A (Slave).




- **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.
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
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 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 is 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 number 0 to 94 and Global address 95.
ASCII (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.)

**Data**: The contents of data (set values) differ depending on the setting command. Composed of 4-digit hexadecimal numbers, using ASCII. (Refer to 7. Communication Command Table.)

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

**Delimiter**: Control code to represent the end of command. ASCII code ETX (03H) fixed.

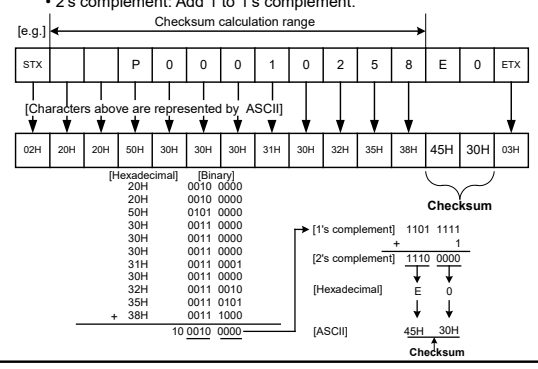
**Error code**: Represents an error type using ASCII.
1 (31H)-----Non-existent command
2 (32H)-----Not used
3 (33H)-----Setting outside the setting range
4 (34H)-----Status unable to be set (e.g. AT is performing)
5 (35H)-----During setting mode by keypad operation

**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 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 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**

SV: 60.0℃ (0258H), 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.




## 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 characters)

**6.2.2 RTU Mode**

3.5 characters transmission time 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, ACS-13A 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 |
|---|---|---|---|---|---|

**(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 0 (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 the following action types.

| 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) 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, when 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 response message, and returned to the master in order to inform it of what kind of error has occurred.

| 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. AT is performing) |
| 18 (12H) | Shinko protocol error code 5, Illegal setting (During setting mode by keypad operation) |

**(3) Data**

Data depends on the function code.
A request message from the master is composed of data item, amount of data and setting data.
A response message from the slave is composed of byte count, data and exception code in negative acknowledgements.
The amount of data to be dealt with in one message is "1". Therefore, the amount of data is fixed as (30H) (30H) (30H) (31H) for ASCII mode. For RTU mode, it is fixed as 0001H. Response byte count is 02H.
Effective range of data is -32768 to 32767 (8000H to 7FFFH).

**(4) Error Check**

**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 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 polynomial series. The remainder is added to the end of the information and transmitted. The generation of 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 last data.
⑨ Set X as CRC-16 to the end of the message in sequence from low order to high order.

## 7. Communication Command Table

● **Data**

**Notes about Setting, Reading Commands**

- The data (set value, decimal) is converted to a hexadecimal number. Negative numbers are represented in 2's complement.
- When connecting multiple slaves, the address (instrument number) must not be duplicated.
- 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 0001H (SV) as an example: Data item in the sending message is 0001H, however, MODBUS protocol Holding Register address is 40002 (1 + 40001).

**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.)
- Setting range of each item is the same as that of keypad operation.
- When the data has a decimal point, a whole number (hexadecimal) without a decimal point is used.
- If an alarm type is changed in [Alarm 1 type (0023H)] or [Alarm 2 type (0024H)], Alarm 1 value (000BH) or Alarm 2 value (000CH) will revert to 0 (zero). Alarm output status will also be initialized.
- Settings via software communication are possible even when the set value is locked.
- Even if options are not ordered, settings via software communication will be possible. However, their command contents will not function.

**Reading Command**

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

| Shinko Command Type | Modbus Function Code | Data Item | | Data |
|---|---|---|---|---|
| 20H/50H | 03H/06H | 0001H | SV | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0003H | Auto-tuning/Auto-reset | 0000H: Cancel, 0001H: Perform |
| 20H/50H | 03H/06H | 0004H | OUT1 proportional band | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0005H | OUT2 proportional band | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0006H | Integral time | Set value |
| 20H/50H | 03H/06H | 0007H | Derivative time | Set value |
| 20H/50H | 03H/06H | 0008H | OUT1 proportional cycle | Set value |
| 20H/50H | 03H/06H | 0009H | OUT2 proportional cycle | Set value |
| 20H/50H | 03H/06H | 000BH | Alarm 1 value | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 000CH | Alarm 2 value | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 000FH | Heater burnout alarm value | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0012H | Set value lock | 0000H: Unlock 0002H: Lock 2<br>0001H: Lock 1 0003H: Lock 3 |
| 20H/50H | 03H/06H | 0015H | Sensor correction | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0016H | Overlap/Dead band | Set value |
| 20H/50H | 03H/06H | 001BH | PV filter time constant | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 001CH | OUT1 high limit | Set value |
| 20H/50H | 03H/06H | 001DH | OUT1 low limit | Set value |
| 20H/50H | 03H/06H | 001EH | OUT1 ON/OFF hysteresis | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 001FH | OUT2 cooling method | 0000H: Air cooling<br>0001H: Oil cooling<br>0002H: Water cooling |
| 20H/50H | 03H/06H | 0020H | OUT2 high limit | Set value |
| 20H/50H | 03H/06H | 0021H | OUT2 low limit | Set value |
| 20H/50H | 03H/06H | 0022H | OUT2 ON/OFF hysteresis | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0023H | Alarm 1 type | |
| | | | 0000H: No alarm action<br>0001H: High limit alarm<br>0002H: Low limit alarm<br>0003H: H/L limits alarm<br>0004H: H/L limit range | 0005H: Process high alarm<br>0006H: Process low alarm<br>0007H: High limit with standby<br>0008H: Low limit with standby<br>0009H: H/L limits with standby |
| 20H/50H | 03H/06H | 0024H | Alarm 2 type | Same as Alarm 1 type |
| 20H/50H | 03H/06H | 0025H | Alarm 1 hysteresis | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0026H | Alarm 2 hysteresis | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0029H | Alarm 1 delay time | Set value |
| 20H/50H | 03H/06H | 002AH | Alarm 2 delay time | Set value |
| 20H/50H | 03H/06H | 0032H | Indication when output OFF | 0000H: OFF indication<br>0001H: No indication<br>0002H: PV indication<br>0003H: PV+ Alarm action |
| 20H/50H | 03H/06H | 0033H | SV rise rate | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0034H | SV fall rate | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0037H | Control output OUT/OFF | 0000H: Control output ON<br>0001H: Control output OFF |
| 20H/50H | 03H/06H | 0038H | Auto/Manual control | 0000H: Automatic control<br>0001H: Manual control |
| 20H/50H | 03H/06H | 0039H | Manual control MV | Set value |
| 20H/50H | 03H/06H | 0040H | Alarm 1 Energized/De-energized | 0000H: Energized<br>0001H: De-energized |
| 20H/50H | 03H/06H | 0041H | Alarm 2 Energized/De-energized | 0000H: Energized<br>0001H: De-energized |
| 20H/50H | 03H/06H | 0044H | Temperature range | 0000H: 0.0 to 250.0℃<br>0001H: 0.0 to 500.0℃*<br>0002H: 32.0 to 482.0℉<br>0003H: 32.0 to 932.0℉* |
| 20H/50H | 03H/06H | 0045H | Direct/Reverse action | 0000H: Reverse action<br>0001H: Direct action |
| 20H/50H | 03H/06H | 0048H | ARW | Set value |
| 20H/50H | 03H/06H | 0049H | Heater burnout alarm 2 value | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 004AH | OUT1 rate-of-change | Set value |
| 20H/50H | 03H/06H | 0050H | Backlight selection | |
| | | | 0000H: All backlit 0004H: PV+SV Displays backlit<br>0001H: PV Display backlit 0005H: PV+Action indicators backlit<br>0002H: SV Display backlit 0006H: SV+Action indicators backlit<br>0003H: Action indicators backlit | |
| 20H/50H | 03H/06H | 0051H | PV color | |
| | | | 0000H: Green 0001H: Red 0002H: Orange<br>0003H: When Alarm ON: Green→Red<br>0004H: When Alarm ON: Orange→Red<br>0005H: PV continuous change<br>0006H: PV continuous change + Alarm ON, Red | |
| 20H/50H | 03H/06H | 0052H | PV color range | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0053H | Backlight time | Set value |
| 20H/50H | 03H/06H | 0054H | Infrared emissivity | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0055H | Infrared emissivity 2 | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0056H | Infrared emissivity 3 | Set value (Decimal point ignored) |
| 20H/50H | 03H/06H | 0057H | Infrared emissivity 4 | Set value (Decimal point ignored) |
| 50H | 06H | 0070H | Key operation change flag clearing | 0000H: No action<br>0001H: Clear all |
| 20H | 03H | 0080H | PV (Process variable) | PV (Process variable)<br>Decimal point ignored |
| 20H | 03H | 0081H | OUT1 MV | OUT1 MV (Decimal point ignored) |
| 20H | 03H | 0082H | OUT2 MV | OUT2 MV (Decimal point ignored) |
| 20H | 03H | 0083H | SV (When SV rises or falls) | SV (Decimal point ignored) |
| 20H | 03H | 0085H | Status flag | |
| | | | $2^0$: OUT1 | 0: OFF, 1: ON<br>(Direct current output: Not fixed) |
| | | | $2^1$: OUT2 | 0: OFF, 1: ON |
| | | | $2^2$: Alarm 1 output | 0: OFF, 1: ON |
| | | | $2^3$: Alarm 2 output | 0: OFF, 1: ON |
| | | | $2^6$: Heater burnout alarm output | 0: OFF, 1: ON<br>(When sensor burnout, 0: OFF) |
| | | | $2^8$: Overscale | 0: OFF, 1: ON |
| | | | $2^9$: Underscale | 0: OFF, 1: ON |
| | | | $2^{10}$: Control output OUT/OFF | 0: ON, 1: OFF |
| | | | $2^{11}$: During AT/Auto-reset | 0: OFF, 1: During AT/Auto-reset |
| | | | $2^{12}$: OUT/OFF key function | 0: Control output OFF<br>1: Auto/Manual control |
| | | | $2^{14}$: Auto/Manual control | 0: Auto, 1: Manual |
| | | | $2^{15}$: Change in key operation | 0: No, 1: Yes |
| | | | $2^4$, $2^5$, $2^7$, $2^{13}$: | Not used, Always 0 |
| 20H | 03H | 0086H | CT1 current value | CT1 current value<br>(Decimal point ignored) |
| 20H | 03H | 0087H | CT2 current value | CT2 current value<br>(Decimal point ignored) |

* For the RD-715-HA, ranges 0.0 to 500.0℃ and 32.0 to 932.0℉ are available.

## 8. Specifications

| | |
|---|---|
| Cable length: | 1.2 km (Max.), Cable resistance: Within 50 Ω (Terminators are not necessary, but if used, use 120 Ω minimum on both sides.) |
| Communication line: | EIA RS-485 |
| Communication method: | Half-duplex communication |
| Communication speed: | 9600 bps (2400, 4800, 19200 bps) Selectable by keypad |
| Synchronization method: | Start-stop synchronization |
| Code: | ASCII, Binary |
| Error detection: | Parity check, checksum (Shinko protocol), LRC (MODBUS ASCII), CRC-16 (MODBUS RTU) |
| Error correction: | Command request repeat system |

Shinko Technos. Co., Ltd. URL: http://www.shinko-technos.co.jp/e/
2-5-1, Senbahigashi, Minoo, Osaka, Japan TEL: +81-72-727-6100 FAX: +81-72-727-7006