High Performance Single-phase Thyristor Unit

THV-A1

Communication
Instruction Manual
[Detailed version]

Thank you for purchasing this RKC product. In order to achieve maximum performance and ensure proper operation of the instrument, carefully read all the instructions in this manual. Please place the manual in a convenient location for easy reference.

NOTICE

● This manual assumes that the reader has a fundamental knowledge of the principles of electricity, process control, computer technology and communications.

● The figures, diagrams and numeric values used in this manual are only for explanation purpose.

● RKC is not responsible for any damage or injury that is caused as a result of using this instrument, instrument failure or indirect damage.

● RKC is not responsible for any damage and/or injury resulting from the use of instruments made by imitating this instrument.

● Periodic maintenance is required for safe and proper operation of this instrument. Some components have a limited service life, or characteristics that change over time.

● Every effort has been made to ensure accuracy of all information contained herein. RKC makes no warranty, expressed or implied, with respect to the accuracy of the information. The information in this manual is subject to change without prior notice.

● No portion of this document may be reprinted, modified, copied, transmitted, digitized, stored, processed or retrieved through any mechanical, electronic, optical or other means without prior written approval from RKC.

⚠ **WARNING**

● To prevent injury to persons, damage to the instrument and the equipment, a suitable external protection device shall be required.

● All wiring must be completed before power is turned on to prevent electric shock, fire or damage to the instrument and the equipment.

● This instrument must be used in accordance with the specifications to prevent fire or damage to the instrument and the equipment.

● This instrument is not intended for use in locations subject to flammable or explosive gases.

● Do not touch high-voltage connections such as power supply terminals, etc. to avoid electric shock.

● RKC is not responsible if this instrument is repaired, modified or disassembled by other than factory-approved personnel. Malfunction may occur and warranty is void under these conditions.

CAUTION

- This product is intended for use with industrial machines, test and measuring equipment.
  (It is not designed for use with medical equipment and nuclear energy plant.)
- This is a Environment A instrument (20 to 100 A types). In a domestic environment, this instrument may cause radio interference, in which case the user may be required to take additional measures.
- This instrument (20 to 100 A types) is protected from electric shock by reinforced insulation. Provide reinforced insulation between the wire for the input signal and the wires for instrument power supply, source of power and loads.
- Be sure to provide an appropriate surge control circuit respectively for the following:
  - If input/output or signal lines within the building are longer than 30 meters.
  - If input/output or signal lines leave the building, regardless the length.
- This product is manufactured on the assumption that it is mounted within a control panel. All high-voltage connections such as power supply terminals must be enclosed in the control panel to avoid electric shock to operating personnel.
- All precautions described in this manual should be taken to avoid damage to the instrument or equipment.
- All wiring must be in accordance with local codes and regulations.
- Always use this product at the rated power supply voltage, load current and power frequency.
- All wiring must be completed before power is turned on to prevent electric shock, instrument failure, or incorrect action.
- To prevent instrument damage as a result of failure, protect the power line and the input/output lines from high currents with a suitable overcurrent protection device with adequate breaking capacity such as a fuse, circuit breaker, etc.
- If this product is used for phase control, higher harmonic noise may be generated.
  Therefore in this case, take such measures as separating the power line from the high-voltage line for load drive.
- Prevent metal fragments or lead wire scraps from falling inside instrument case to avoid electric shock, fire or malfunction.
- Tighten each terminal screw to the specified torque found in the manual to avoid electric shock, fire or malfunction.
- For proper operation of this instrument, provide adequate ventilation for heat dissipation.
- Do not connect wires to unused terminals as this will interfere with proper operation of the instrument.
- Turn off the power supply before cleaning the instrument.
- Do not use a volatile solvent such as paint thinner to clean the instrument. Deformation or discoloration may occur. Use a soft, dry cloth to remove stains from the instrument.
- To avoid damage to the instrument display, do not rub with an abrasive material or push the front panel with a hard object.
- Do not connect modular connectors to telephone line.
- A malfunction in this product may occasionally make control operations impossible or prevent alarm outputs, resulting in a possible hazard. Take appropriate measures in the end use to prevent hazards in the event of malfunction.

SYMBOLS

Safety Symbols:

| WARNING | : This mark indicates precautions that must be taken if there is danger of electric shock, fire, etc., which could result in loss of life or injury. |

| CAUTION | : This mark indicates that if these precautions and operating procedures are not taken, damage to the instrument may result. |

⚠ : This mark indicates that all precautions should be taken for safe usage.

📖 : This mark indicates important information on installation, handling and operating procedures.

📖 : This mark indicates supplemental information on installation, handling and operating procedures.

☞ : This mark indicates where additional information may be located.

Character Symbols:

0	1	2	3	4	5	6	7	8	9	Minus	Period
0	1	2	3	4	5	6	7	8	9	-	.

A	B (b)	C	c	D (d)	E	F	G	H	I	J	K
A	b	C	c	d	E	F	G	H	I	J	K

L	M	N (n)	O (o)	P	Q (q)	R (r)	S	T	t	U	u
L	͞n	n	o	P	q	r	S	⌐	t	U	u

V	W	X	Y	Z	Degree	╱	Prime
V	͞u	Y	y	≡	o	-	'

Symbol	Description
8.	Dim lighting
8.	Bright lighting

DOCUMENT CONFIGURATION

As for the document related to this product, there are eight manuals including this manual. According to application of a customer, please read a manual related together. When you do not have a necessary manual, please contact RKC sales office or the agent.

The following manuals can be download from the official RKC website:

http://www.rkcinst.com/english/manual_load.htm.

Manual	Manual Number	Remarks
20 A/30 A/45 A/60 A/80 A/100 A THV-A1 Installation Manual	IMR02D01-E□	A product box contains this manual. This manual explains the mounting and wiring, a name of the front panel, and outline of the operation mode of the product.
150 A/200 A THV-A1 Installation Manual	IMR02D06-E□	
20 A/30 A/45 A/60 A/80 A/100 A THV-A1 Quick Operation Manual	IMR02D02-E□	A product box contains this manual. This manual explains the basic key operation, mode menu, and data setting.
150 A/200 A THV-A1 Quick Operation Manual	IMR02D07-E□	
20 A/30 A/45 A/60 A/80 A/100 A THV-A1 Communication Quick Manual	IMR02D03-E□	A product box contains this manual. (Only THV-A1 provided with the communication function) This manual explains the connection method with host computer, communication parameters, and communication data (except for parameters in Engineering Mode).
150 A/200 A THV-A1 Communication Quick Manual	IMR02D08-E□	
THV-A1 Instruction Manual * [Detailed version]	IMR02D04-E□	This manual explains the method of the mounting and wiring, the operation of various functions, and troubleshooting.
THV-A1 Communication Instruction Manual * **[Detailed version]**	**IMR02D05-E5**	This Manual. This manual explains Modbus, and relating to the communication parameters setting.

* Sold separately

📖 Read this manual carefully before operating the instrument. Please place this manual in a convenient location for easy reference.

CONTENTS

1. OUTLINE

High Performance Single-phase Thyristor unit THV-A1 (hereafter, called THV-A1) interfaces with the host computer via Modbus.

■ Communication port

There are two communication ports: COM. PORT1 and COM. PORT2. The communication ports are used for connection to a host computer or to add on a THV-A1.

■ Communication interface

RS-422A and RS-485 is used for the communication interface.

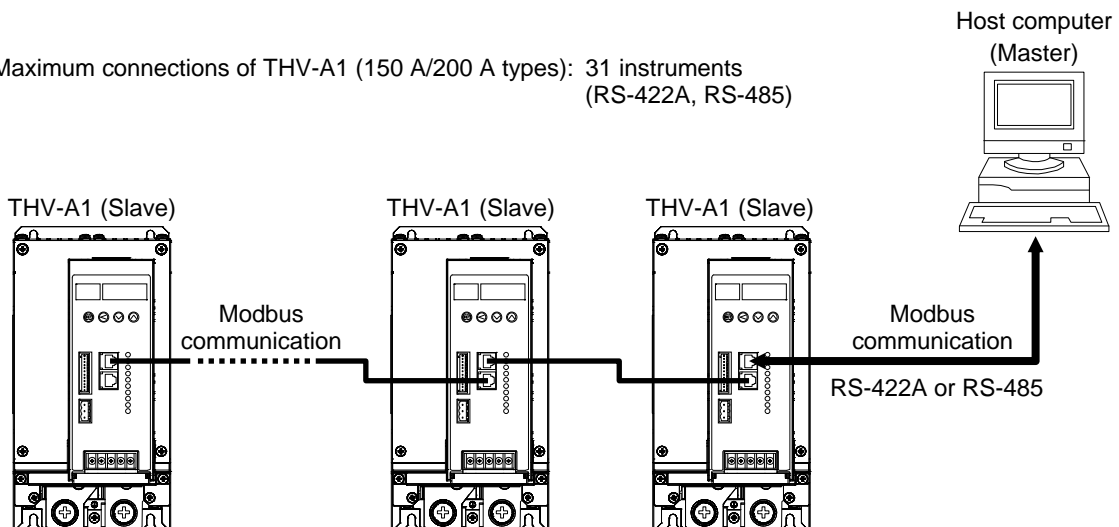For reference purposes, the Modbus protocol identifies the host computer as master, the THV-A1 as slave.

20 A/30 A/45 A/60 A/80 A/100 A types

Maximum connections of THV-A1 (20 A to 100 A types): 31 instruments
(RS-422A, RS-485)

The figure is 20 A/30 A types.
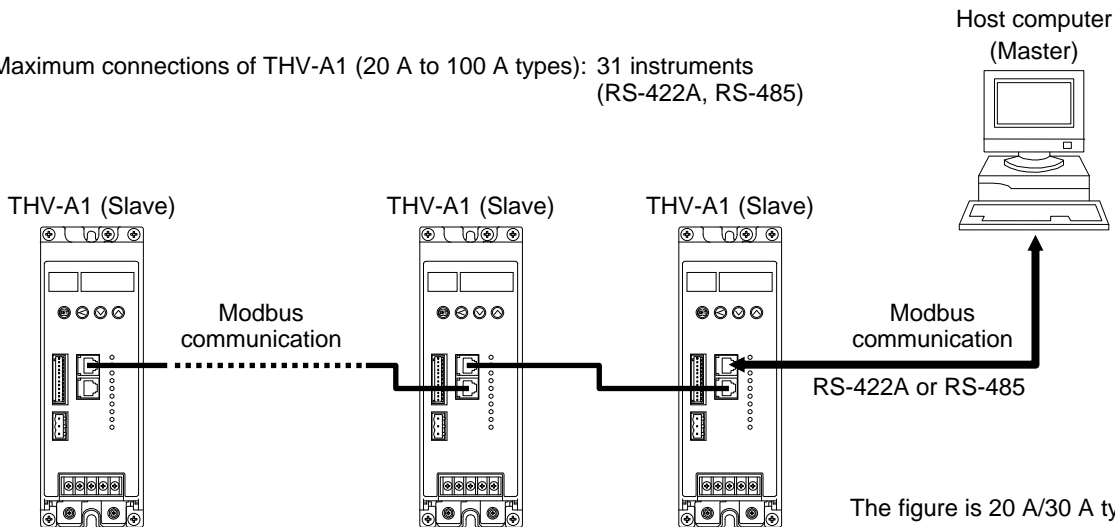
150 A/ 200 A types

Maximum connections of THV-A1 (150 A/200 A types): 31 instruments
(RS-422A, RS-485)

2. SPECIFICATIONS

Interface:
Based on RS-422A, EIA standard
Based on RS-485, EIA standard
Specify either interface when ordering.

Connection method:
RS-422A: 4-wire system, half-duplex multi-drop connection
RS-485: 2-wire system, half-duplex multi-drop connection

Synchronous method: Start-stop synchronous type

Communication speed: 9600 bps

Data bit configuration: Start bit: 1
Data bit: 8
Parity bit: Without
Stop bit: 1

Protocol: Modbus

Signal transmission mode:
Remote Terminal Unit (RTU) mode

Function code:
03H (Read holding registers)
06H (Preset single register)
08H (Diagnostics: loopback test)
10H (Preset multiple registers)

Error check method: CRC-16

Error code:
1: Function code error
2: When the mismatched address is specified.
3: When the specified number of data items in the query message exceeds the
   maximum number of data items available
   When the data written exceeds the setting range
4: Self-diagnostic error response

Termination resistor: Connect a separately sold termination resistor (120 Ω   1/2 W) to
the communication port.

Maximum connections of THV-A1:
31 instruments (RS-422A, RS-485)

Signal logic: RS-422A, RS-485

Signal voltage	Logic
V (A) – V (B) ≥ 2 V	0 (SPACE)
V (A) – V (B) ≤ –2 V	1 (MARK)

Voltage between V (A) and V (B) is the voltage of (A) terminal for
the (B) terminal.

IMR02D05-E5

3. WIRING

<div style="border: 1px solid black">

⚠ **WARNING**

To prevent electric shock or instrument failure, turn off the power before connecting or disconnecting the instrument and peripheral equipment.

</div>

📖 The THV-A1 used in the explanation is a 20 A/30 A type. The connection method is the same for other types.

3.1 RS-422A

■ Pin number and signal name

The signals are the same in the communication ports COM.PORT1 and COM.PORT2.

Modular connector pin number

Communication port COM. PORT1

Communication port COM. PORT2

SG   6
T (A)   5
T (B)   4
SG   3
R (B)   2
R (A)   1
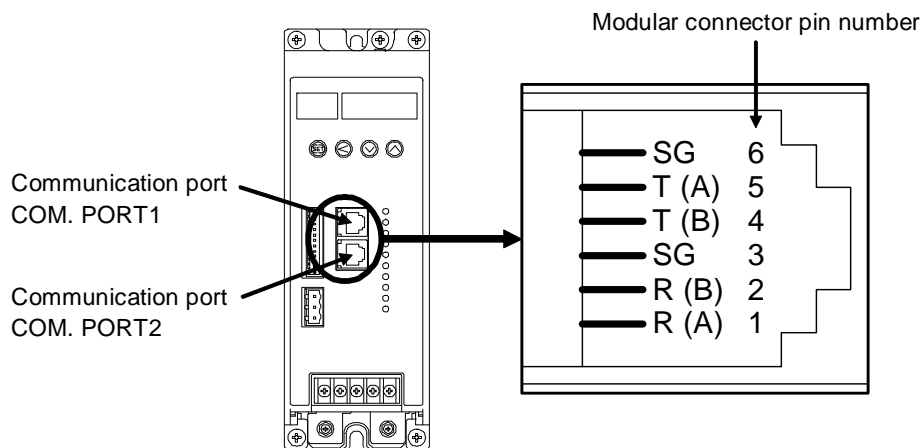
Pin No.	Signal name	Symbol
1	Receive data	R (A)
2	Receive data	R (B)
3	Signal ground	SG
4	Send data	T (B)
5	Send data	T (A)
6	Signal ground	SG

📖 The six-pin type modular connector should be used for the connection to the THV-A1.
　　　Recommended manufacture and model: Hirose Electric, TM4P-66P

■ When the interface of host computer (Master) is RS-422A

The communication cable must be provided by the customer. If communication errors occur frequently, connect termination resistors to the THV-A1.

* COM. PORT1 and COM. PORT2 are internally connected.

■ When the interface of host computer (Master) is RS-232C

When the interface of host computer is RS-232C, connect the RS-232C/RS-422A converter between the host computer and the THV-A1.
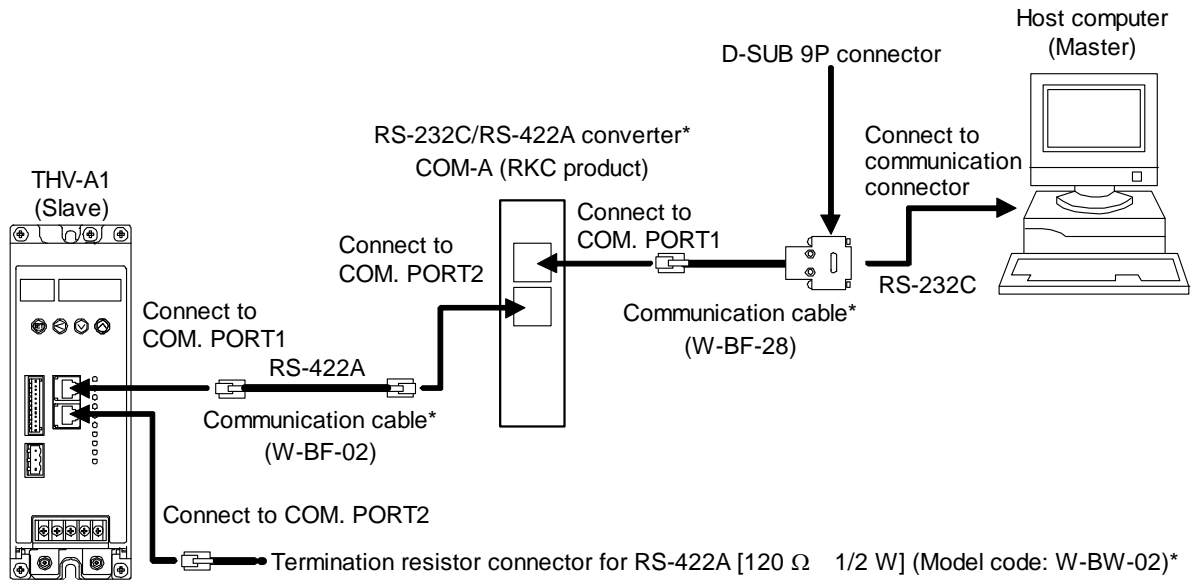
* Communication cable, termination resistor connector or converter (RKC product) is sold separately.

IMR02D05-E5

3.2 RS-485

■ Pin number and signal name

The signals are the same in the communication ports COM.PORT1 and COM.PORT2.
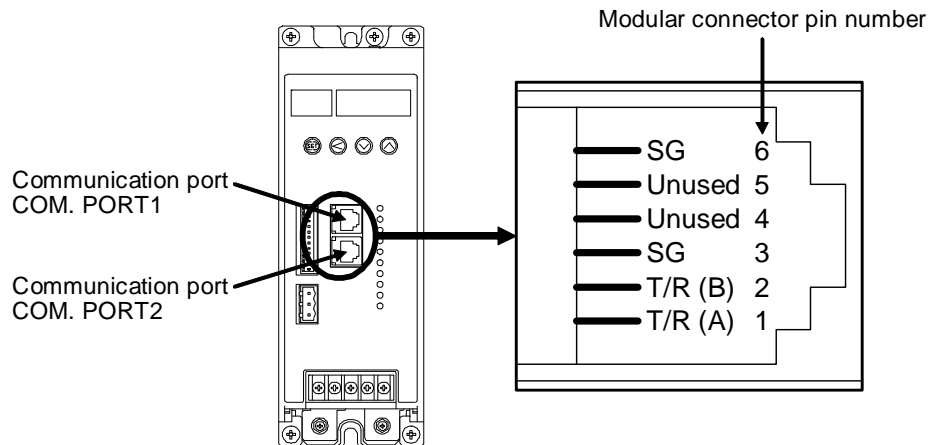
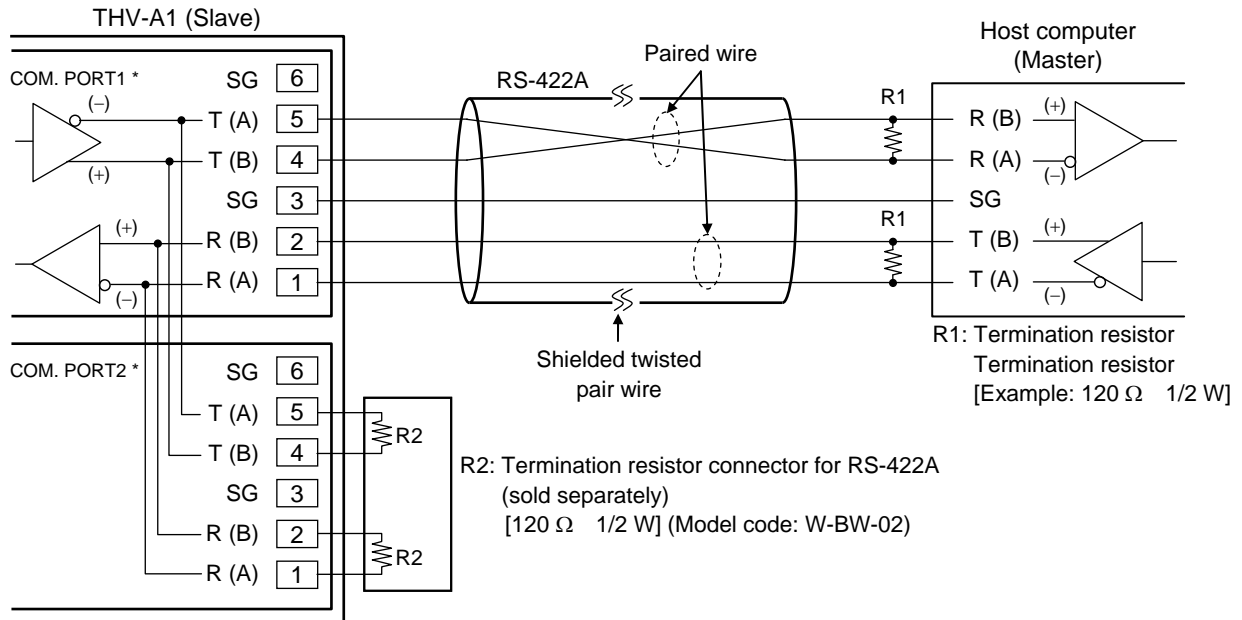| Pin No.	Signal name	Symbol
1	Send/receive data	T/R (A)
2	Send/receive data	T/R (B)
3	Signal ground	SG
4	Unused	—
5	Unused	—
6	Signal ground	SG

The six-pin type modular connector should be used for the connection to the THV-A1.
Recommended manufacture and model: Hirose Electric, TM4P-66P

## ■ When the interface of host computer (Master) is RS-485

The communication cable must be provided by the customer. If communication errors occur frequently, connect termination resistors to the THV-A1.
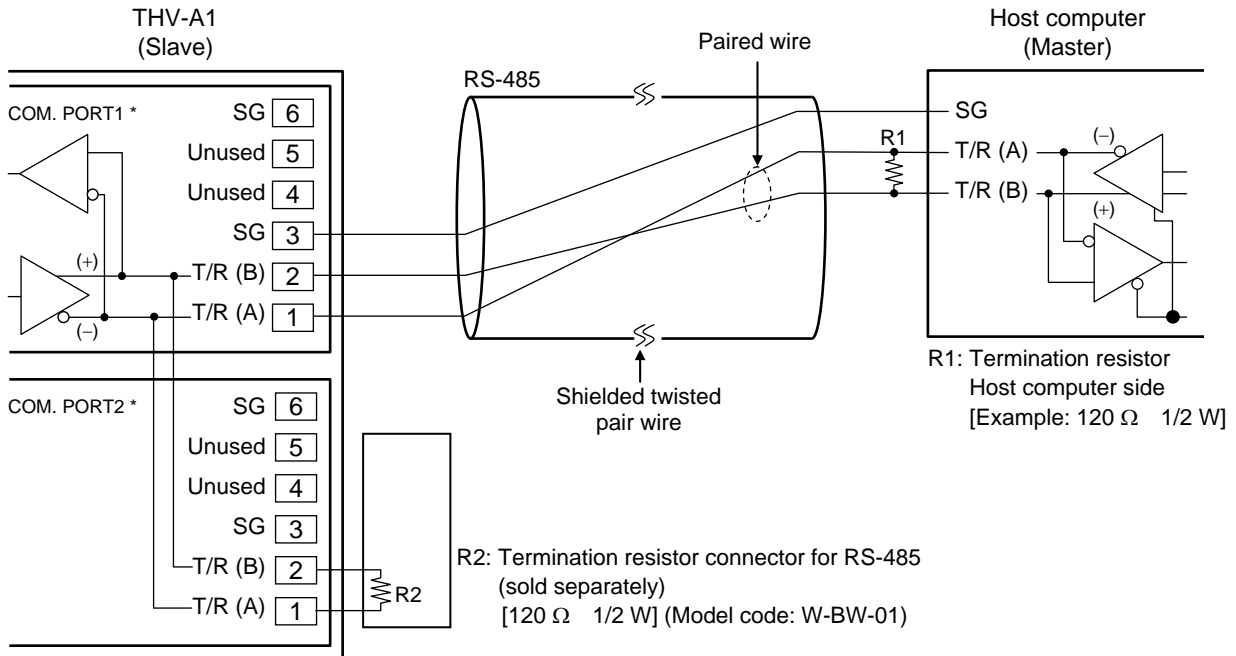
* COM. PORT1 and COM. PORT2 are internally connected.

■ When the interface of host computer (Master) is RS-232C

Use a RS-232C/RS-485 converter with an automatic send/receive transfer function. The communication cable must be provided by the customer. If communication errors occur frequently, connect termination resistors to the THV-A1.
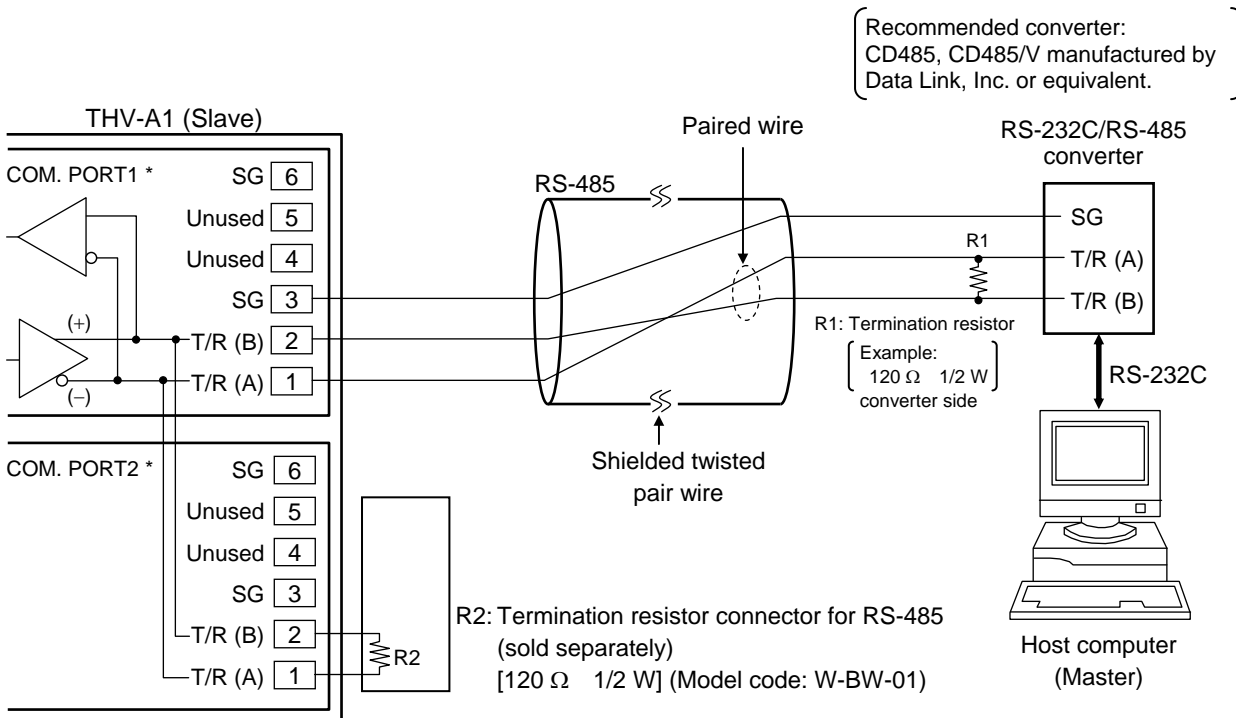
* COM. PORT1 and COM. PORT2 are internally connected.

3.3 Multiple THV-A1 Connections

Connections can be added using our communication cable (sold separately: W-BF-02).
W-BF-02 cable can be used for both RS-422A and RS-485.
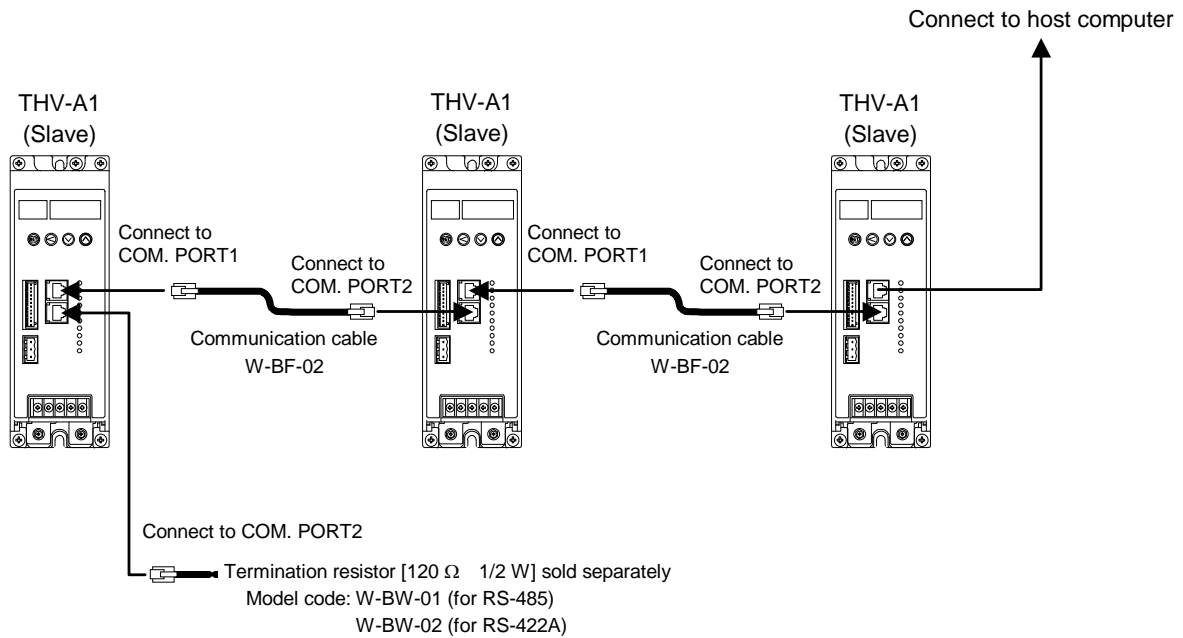
4. SETTING

To establish communication parameters between host computer and THV-A1, it is necessary to set the device address (THV-A1 device address) and interval time on each THV-A1 in the setting mode 1.
The communication speed and data bit configuration of the THV-A1 are fixed at the values indicated below. Set the communication speed and data bit configuration of the host computer to the same values as the THV-A1.

> • Communication speed: 9600 bps
> • Data bit configuration: Data 8-bit, Without parity, Stop 1-bit

4.1 Display Flowcharts
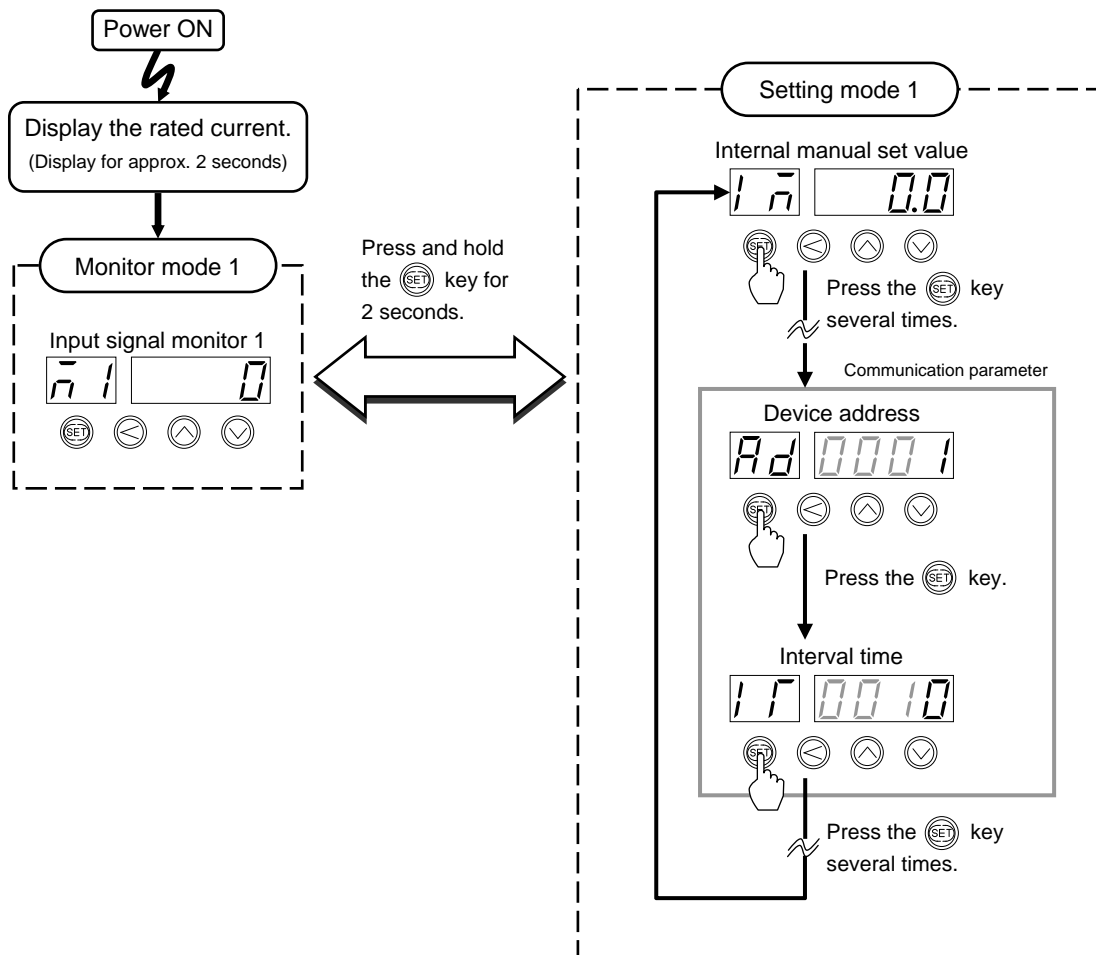
After completing all communication parameter settings, turn on the power again, and register the new value which changed.

Setting mode 1 automatically returns to the monitor mode 1 if no key operation is performed for more than 1 minute.

4.2 Description of Each Parameter

📖 After completing all communication parameter settings, turn on the power again, and register the new value which changed.

Symbol	Name	Data range	Description	Factory set value
𝐴𝑑 (Ad)	Device address	0 to 99	Do not use the same device address for more than one THV-A1 (Slave) in multi-drop connection. Communication is not possible when the address is 0.	1
𝐼𝑇 (IT)	Interval time	0 to 250 ms	The interval time for the THV-A1 (Slave) should be set to provide a time for host computer (Master) to finish sending all data including stop bit and to switch the line to receive status for the host.	10

📖 About interval time
The interval time for the THV-A1 (Slave) should be set to provide a time for host computer (Master) to finish sending all data including stop bit and to switch the line to receive status for host.
If the interval time between the two is too short, the THV-A1 (Slave) may send data before the host computer (Master) is ready to receive it.
In this case, communication transmission cannot be conducted correctly.

📖 The communication speed and data bit configuration of the THV-A1 (Slave) are fixed at the values indicated below.

- Communication speed: 9600 bps
- Data bit configuration: Data bit: 8
  Parity bit: Without
  Stop bit: 1

4.3 Setting Procedure Example

📖   After completing all communication parameter settings, turn on the power again, and register the new value which changed.

📖   If the data is locked, values cannot be changed. Release the lock before changing values.

☞   For the set data lock, refer to the **THV-A1 Instruction Manual [Detailed version] (IMR02D04-E□).**

1. Press and hold the SET key for two seconds to go to the setting mode 1 from the monitor mode 1.

Monitor mode 1   Setting mode 1
Input signal monitor 1   Internal manual set value (IM)
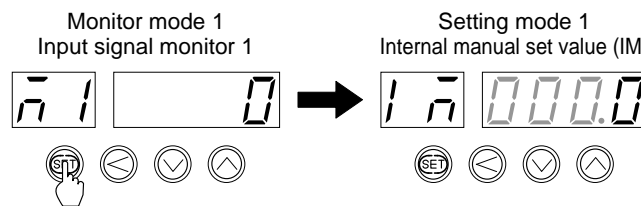
2. Press the SET key several times to go to the device address from the setting mode 1.

Setting mode 1
Internal manual set value (IM)   Device address (Ad)
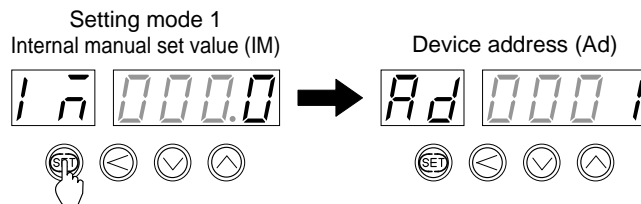
3. Set the device address (slave address). Press the UP key to change the number to "2." (Here, the device address is set at "2" as an example.)

Device address (Ad)   Device address (Ad)
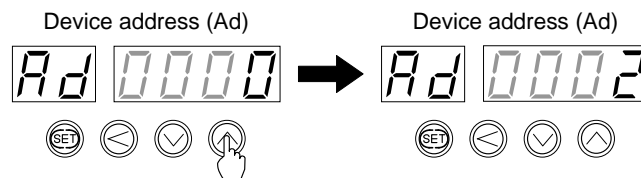
4. Press the SET key to store the new value. The display goes to the interval time (IT).

Device address (Ad)   Interval time (IT)
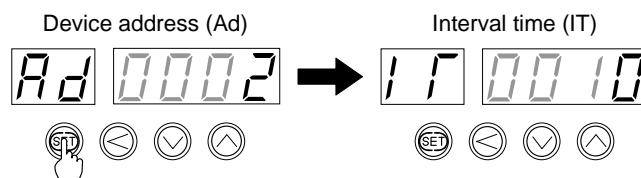
📖   When the value is changed, it will be automatically stored after two seconds without any key operation.

5. Set the interval time. The factory set value will be used, so press the SET key. The display goes to the next parameter. (Here, the interval time is set at "10 (factory set value)" as an example.)

Interval time (IT)   Set data lock (LK)

$$I\ r\quad 00\ 10\quad \rightarrow\quad L\ h\quad 0001$$
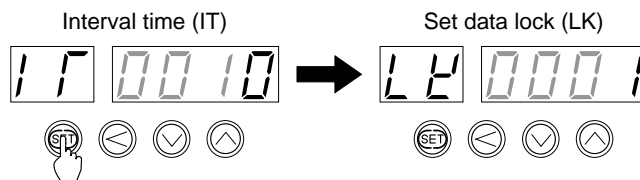
📖   If constant current control or constant power control is specified in the options, memory area setting (MS) will appear after interval time (IT).

6. To save the new values, turn the power off and then on. This completes the communication settings.

4.4 Communication Requirements

■ Processing times during data send/receive

THV-A1 (Slave) requires the following processing times during data send/receive. Have the host computer (Master) switch from reception to transmission after the times below elapse.

📖 Response send time is time at having set interval time in 0 ms.

Procedure details	Time
Read holding registers [03H] Response send time after the slave receives the query message (When 80 registers are collectively read)	10 ms max.
Preset single register [06H] Response send time after the slave receives the query message	5 ms max.
Diagnostics (loopback test) [08H] Response send time after the slave receives the query message	5 ms max.
Preset multiple registers [10H] Response send time after the slave receives the query message (When 68 registers are collectively write)	10 ms max.

■ RS-422A/RS-485 Fail-safe

A transmission error may occur with the transmission line disconnected, shorted or set to the high-impedance state.

In order to prevent the above error, it is recommended that the fail-safe function be provided on the receiver side of the host computer (Master).

The fail-safe function can prevent a framing error from its occurrence by making the receiver output stable to the MARK (1) when the transmission line is in the high-impedance state.

■ Data backup

The nonvolatile memory (EEPROM) for data backup has limitations on the number of memory rewrite times (Approx. One million times).

5. PROTOCOL

The master controls communication between master and slave. A typical message consists of a request (query message) sent from the master followed by an answer (response message) from the slave. When master begins data transmission, a set of data is sent to the slave in a fixed sequence. When it is received, the slave decodes it, takes the necessary action, and returns data to the master.

📖 Data send/receive state for MODBUS can be monitored by using PROTEM2 (communication tool).
The PROTEM2 can be downloaded from the RKC official website:
http://www.rkcinst.com/.

5.1 Message Format

The message consists of four parts: slave address, function code, data, and error check code which are always transmitted in the same sequence.

Slave address
Function code
Data
Error check CRC-16
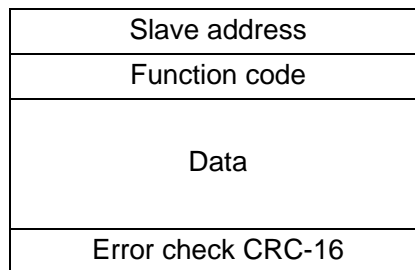
Message format

■ Slave address

The slave address is a number from 1 to 99 manually set at the front key of THV-A1.

☞ For details, refer to **4. SETTING (P. 8)**.

Although all connected slave units receive the query message sent from the master, only the slave with the slave address coinciding with the query message will accept the message.

■ Function code

The function codes are the instructions set at the master and sent to the slave describing the action to be executed. The function codes are included when the slave responds to the master.

☞ For details, refer to **5.2 Function Code (P. 14)**.

■ Data

The data to execute the function specified by the function code is sent to the slave and corresponding data returned to the master from the slave.

☞ For details, refer to **5.6 Message Format (P. 19)**, **5.7 Data Configuration (P. 23)** and **6. COMMUNICATION DATA LIST (P. 28)**.

■ Error check

An error checking code (CRC-16: Cyclic Redundancy Check) is used to detect an error in the signal transmission.

☞ For details, refer to **5.5 Calculating CRC-16 (P. 16)**.

5.2 Function Code

Function code contents

Function code (Hexadecimal)	Function	Contents
03H	Read holding registers	Input signal monitor 1, Phase angle ratio monitor, Voltage value monitor, etc.
06H	Preset single register	Internal manual set value, Internal gradient set value, Soft-start time, Maximum load current value, Heater break alarm set value, etc. (For each word)
08H	Diagnostics (loopback test)	Loopback test
10H	Preset multiple registers	Internal manual set value, Internal gradient set value, Soft-start time, Maximum load current value, Heater break alarm set value, etc.

Message length of each function (Unit: byte)

Function code (Hexadecimal)	Function	Query message		Response message	
		Min	Max	Min	Max
03H	Read holding registers	8	8	7	255
06H	Preset single register	8	8	8	8
08H	Diagnostics (loopback test)	8	8	8	8
10H	Preset multiple registers	11	133	8	8

5.3 Communication Mode

Signal transmission between the master and slaves is conducted in Remote Terminal Unit (RTU) mode.

Items	Contents
Data bit length	8-bit (Binary)
Start mark of message	Unused
End mark of message	Unused
Message length	Refer to **5.2 Function code**
Data time interval	Less than 24-bit time *
Error check	CRC-16 (Cyclic Redundancy Check)

* When sending a command message from the master, set intervals of data configuring one message to time shorter than the 24-bit time. If time intervals become time longer than the 24-bit time the relevant slave assumes that message sending from the master is terminated to deform the message format. As a result, the slave does not make a response.

5.4 Slave Responses

(1) Normal response

- In the response message of the Read Holding Registers, the slave returns the read out data and the number of data items with the same slave address and function code as the query message.
- In the response message of the Preset Single Register, the slave returns the same message as the query message.
- In the response message of the Diagnostics (Loopback test), the slave returns the same message as the query message.
- In the response message of the Preset Multiple Registers, the slave returns the slave address, the function code, starting number, and number of holding registers in the multi-query message.

(2) Defective message response

- If the query message from the master is defective, except for transmission error, the slave returns the error response message without any action.

Slave address
Function code
Error code
Error check CRC-16

Error response message

- If the self-diagnostic function of the slave detects an error, the slave will return an error response message to all query messages.
- The function code of each error response message is obtained by adding 80H to the function code of the query message.

Error code	Contents
1	Function code error (An unsupported function code was specified)
2	When the mismatched address is specified.
3	When the specified number of data items in the query message exceeds the maximum number of data items available When the data written exceeds the setting range
4	Self-diagnostic error response

(3) **No response**

The slave ignores the query message and does not respond when:
- The slave address in the query message does not coincide with any slave address settings.
- The CRC code of the master does not coincide with that of the slave.
- Transmission error such as overrun, framing, parity and etc., is found in the query message.
- Data time interval in the query message from the master exceeds 24 bit's time.

5.5 Calculating CRC-16

The Cyclic Redundancy Check (CRC) is a 2 byte (16-bit) error check code. After constructing the data message, not including start, stop, or parity bit, the master calculates a CRC code and appends this to the end of the message. The slave will calculate a CRC code from the received message, and compare it with the CRC code from the master. If they do not coincide, a communication error has occurred and the slave does not respond.

The CRC code is formed in the following sequence:

1. Load FFFFH to a 16-bit CRC register.

2. *Exclusive OR* ($\oplus$) the first byte (8 bits) of the message with the CRC register. Return the result to the CRC register.

3. Shift the CRC register 1 bit to the right.

4. If the carry flag is 1, *exclusive OR* the CRC register with A001 hexadecimal and return the result to the CRC register. If the carry flag is 0, repeat step *3*.

5. Repeat step *3* and *4* until there have been 8 shifts.

6. *Exclusive OR* the next byte (8 bits) of the message with the CRC register.

7. Repeat step *3* through *6* for all bytes of the message (except the CRC).

8. The CRC register contains the 2 byte CRC error code. When they are appended to the message, the low-order byte is appended first, followed by the high-order byte.

■ The flow chart of CRC-16

```
                    START
                      │
          FFFFH → CRC Register
                      │
   CRC Register ⊕ next byte of the message → CRC Register
                      │
                   0 → n
                      │
          Shift CRC Register right 1 bit
                      │
              Carry flag is 1 ──No──┐
                      │             │
                    Yes            │
                      │             │
   CRC Register ⊕ A001H → CRC Register
                      │             │
                   n + 1 → n ◄──────┘
                      │
         No── n > 7
                      │
                    Yes
                      │
         No── Is message complete ?
                      │
                    Yes
                      │
   Reverse with high-order byte and low-order byte of CRC register
                      │
                    END
```
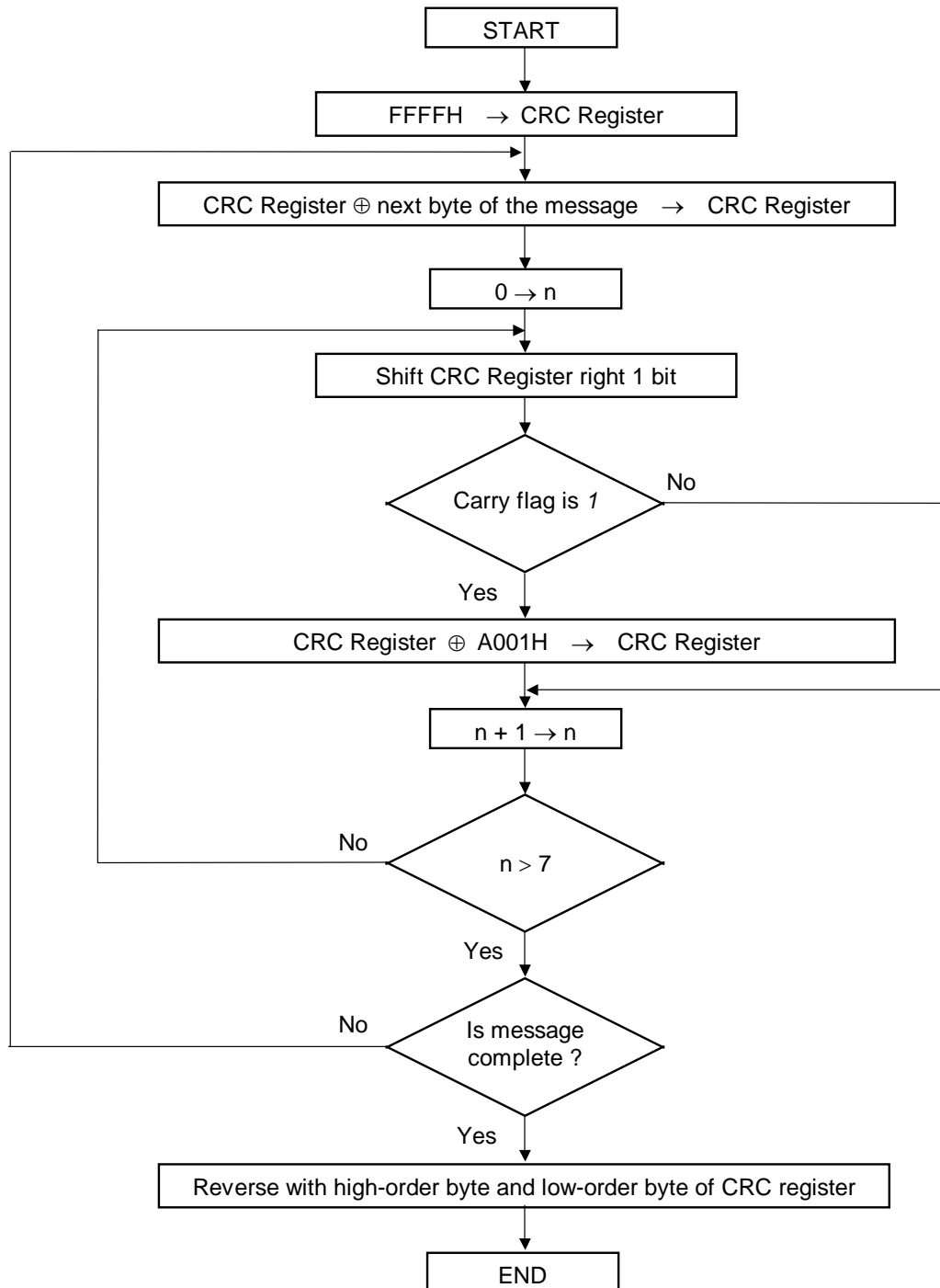
The ⊕ symbol indicates an *exclusive OR* operation. The symbol for the number of data bits is *n*.

■ Example of a CRC calculation in the 'C' language

This routine assumes that the data types 'uint16' and 'uint8' exists. Theses are unsigned 16-bit integer (usually an 'unsigned short int' for most compiler types) and unsigned 8-bit integer (unsigned char). 'z_p' is a pointer to a Modbus message, and 'z_messaage_length' is its length, excluding the CRC. Note that the Modbus message will probably contain NULL characters and so normal C string handling techniques will not work.

uint16 calculate_crc（byte *z_p, unit16 z_message_length）

```
/* CRC runs cyclic Redundancy Check Algorithm on input z_p      */
/* Returns value of 16 bit CRC after completion and             */
/* always adds 2 crc bytes to message                           */
/* returns 0 if incoming message has correct CRC                */

{
    uint16 CRC= 0xffff;
    uint16 next;
    uint16 carry;
    uint16 n;
    uint8 crch, crcl;

    while (z_messaage_length--) {
        next = (uint16) *z_p;
        CRC ^= next;
        for (n = 0; n < 8; n++) {
            carry = CRC & 1;
            CRC >>= 1;
            if (carry) {
                CRC ^= 0xA001;
            }
        }
        z_p++;
    }
    crch = CRC / 256;
    crcl = CRC % 256
    z_p [z_messaage_length++] = crcl;
    z_p [z_messaage_length] = crch;
    return CRC;
}
```

5.6 Message Format

5.6.1 Read holding registers [03H]

The query message specifies the starting register address and quantity of registers to be read.
The contents of the holding registers are entered in the response message as data, divided into two parts: the high-order 8-bit and the low-order 8-bit, arranged in the order of the register numbers.

Example: The contents of the four holding registers from 0000H [Input signal monitor 1] to 0003H [CT input monitor] are the read out from slave address 2.

Query message

Slave address		02H	
Function code		03H	
Starting No.	High	00H	First holding register address
	Low	00H	
Quantity	High	00H	The setting must be between 1 (0001H) and 80 (0050H).
	Low	04H	
CRC-16	High	44H	
	Low	3AH	

Normal response message

Slave address		02H	
Function code		03H	
Number of data		08H	→ Number of holding registers × 2
First holding register contents	High	00H	
	Low	0AH	
Next holding register contents	High	00H	
	Low	0AH	
Next holding register contents	High	00H	
	Low	4FH	
Next holding register contents	High	00H	
	Low	08H	
CRC-16	High	98H	
	Low	83H	

Error response message

Slave address		02H
80H + Function code		83H
Error code		03H
CRC-16	High	F1H
	Low	31H

5.6.2 Preset single register [06H]

The query message specifies data to be written into the designated holding register. The write data is arranged in the query message with high-order 8-bit first and low-order 8-bit next. Only R/W holding registers can be specified.

Example: Data is written into the holding register 000CH [Internal manual set value] of slave address 1.

Query message

Slave address		01H
Function code		06H
Holding register number	High	00H
	Low	0CH
Write data	High	00H
	Low	32H
CRC-16	High	C8H
	Low	1CH

Any data within the range

Normal response message

Slave address		01H
Function code		06H
Holding register number	High	00H
	Low	0CH
Write data	High	00H
	Low	32H
CRC-16	High	C8H
	Low	1CH

Contents will be the same as query message data.

Error response message

Slave address		01H
80H + Function code		86H
Error code		02H
CRC-16	High	C3H
	Low	A1H

5.6.3 Diagnostics (Loopback test) [08H]

The master's query message will be returned as the response message from the slave.
This function checks the communication system between the master and slave (the controller).

Example: Loopback test for slave address 1

Query message

Slave address		01H
Function code		08H
Test code	High	00H
	Low	00H
Data	High	1FH
	Low	34H
CRC-16	High	E9H
	Low	ECH

Test code must be set to 00.

Any pertinent data

Normal response message

Slave address		01H
Function code		08H
Test code	High	00H
	Low	00H
Data	High	1FH
	Low	34H
CRC-16	High	E9H
	Low	ECH

Contents will be the same as query message data.

Error response message

Slave address		01H
80H + Function code		88H
Error code		03H
CRC-16	High	06H
	Low	01H

5.6.4 Preset multiple registers [10H]

The query message specifies the starting register address and quantity of registers to be written.
The write data is arranged in the query message with high-order 8-bit first and low-order 8-bit next. Only R/W holding registers can be specified.

Example: Data is written into the two holding registers from 000CH [Internal manual set value], 000DH [Internal gradient set value] of slave address 1.

Query message

Slave address		01H	
Function code		10H	
Starting number	High	00H	First holding register address
	Low	0CH	
Quantity	High	00H	The setting must be between 1 (0001H) and 80 (0050H).
	Low	02H	
Number of data		04H	→ Number of holding registers × 2
Data to first register	High	00H	
	Low	32H	
Data to next register	High	00H	Any pertinent data
	Low	64H	
CRC-16	High	53H	
	Low	DEH	

Normal response message

Slave address		01H
Function code		10H
Starting number	High	00H
	Low	0CH
Quantity	High	00H
	Low	02H
CRC-16	High	81H
	Low	CBH

Error response message

Slave address		01H
80H + Function code		90H
Error code		02H
CRC-16	High	CDH
	Low	C1H

5.7 Data Configuration

5.7.1 Data range

The numeric range of data used in Modbus protocol is 0000H to FFFFH. Only the set value within the setting range is effective.

📖 FFFFH represents −1.

■ Data processing with decimal points

The Modbus protocol does not recognize data with decimal points during communication.

● Data with one decimal place

CT input monitor	Manipulated output value setting of inflection point 1
Internal manual set value	Current value setting of inflection point 1
Soft-start time	Manipulated output value setting of inflection point 2
Soft-down time	Current value setting of inflection point 2
Maximum load current set value for alarm	Manipulated output value setting of inflection point 3
Current limit value setting	Current value setting of inflection point 3
Output limiter (high)	Output limiter setting in case of a break on the secondary side of the transformer
Output limiter (low)	
Output limiter (high) at operation start	Soft-start time in case of break on the secondary side of the transformer
Output limiter (high) time at operation start	
Base-up set value	
Output time setting for automatic calculation of inflection point	

Example: When Internal manual set value is 5.0 %, 5.0 is processed as 50,
50 = 0032H

Internal manual set value	High	00H
	Low	32H

● Data with two decimal places

Power value monitor

Internal gradient set value

Example: When Internal gradient set value is 0.55 second, 0.55 is processed as 55,
55 = 0037H

Internal gradient set value	High	00H
	Low	37H

● **Data with no decimal place**

Input signal monitor 1

Phase angle ratio monitor

Voltage value monitor

Power frequency monitor

Power supply voltage monitor

Input signal monitor 2

External gradient set value monitor

External manual set value monitor

Contact input state monitor

Memory area monitor

Interval time

Memory area setting

Set data lock

Memory area selection

Heater break alarm 1 set value setting

Thyristor break-down set value setting

Heater break alarm 2 set value setting

Contact input 1 (DI1) function assignment

Contact input 2 (DI2) function assignment

Contact input 3 (DI3) function assignment

Control method

Input signal selection

Contact input action

RUN/STOP transfer

Alarm interlock

Soft-start, soft-down enable/disable

Heater break alarm enable/disable

Over current alarm enable/disable

Output mode for phase control

Alarm 1 output logic

Alarm 2 output logic

Number of heater break alarm 1 delay times

Heater break alarm 1 type

Number of heater break alarm 2 delay times

Heater break alarm 2 type

ROM version

Integrated operation time [upper 2 digits]

Integrated operation time [lower 4 digits]

Action selection of heater break alarm

Protection function for control of primary side of a transformer

Determination set value in case of a break on the secondary side of the transformer

Example: When Phase angle ratio monitor is 70 %,
72 = 0046H

Phase angle ratio monitor	High	00H
	Low	46H

5.7.2 Caution for handling communication data

- If data (holding register) exceeding the accessible address range is accessed, an error response message is returned.

- Writing data to an item not in the specifications will not cause an error. The data will be written, however, it will be invalid.

- If a power outage occurs while data is being written, the data may not be written even though a response message is returned normally.

- If data range or address error occurs during data writing, it is not processed as an error. Except the data that error occurred, normal data is written in data register. Therefore, it is necessary to confirm data after the end of setting data.

- Communication data includes data that becomes RO (read only) depending on the specification. No error occurs even if data is written when set to RO. However in this case, no data is written.

  ☞   For details, refer to **6. COMMUNICATION DATA LIST (P. 28)**.

- Send the next command message at time intervals of 30 bits after the master receives the response message.

5.7.3 How to use memory area data

Memory area function can store up to 4 individual sets of heater break alarms and parameters.
One of the 4 areas stored in memory can be called up as necessary and used for alarm monitoring.
The memory area used for alarm monitoring is called the "control area."

Types of communication data that can be stored in the memory area:
・Maximum load current set value ・Heater break alarm 2 set value
・Heater break alarm 1 set value ・Current limit value
・Thyristor break-down set value

To specify a memory area, use memory area selection (Address: 0014H) and memory area setting (Address: 0012H) communication data.

Memory area selection (Address: 0014H)
Used to store memory area data. This lets you select the memory area number where data will be stored.

Memory area setting (Address: 0012H)
Used to specify a memory area number for alarm monitor.
During operation, alarm monitor is performed using the memory area data set with memory area setting (Address: 0012H).

📖 The memory area function can be used when standard heater break alarm is used.

■ Read and write of memory area data

If any memory area number to perform data read and write is specified by the memory area selection (0014H), data corresponding to the specified memory area number is called up to the register addresses from 0015H to 0019H. By using these register addresses from 0015H to 0019H, it becomes possible to read and write data in any memory area.

Communication data	Register address
Memory area selection	0014H
Maximum load current set value for alarm	0015H
Heater break alarm 1 set value setting	0016H
Thyristor break-down set value setting	0017H
Heater break alarm 2 set value setting	0018H
Current limit value setting	0019H

← Register address to specify memory area

} Register address of memory area data

[Example 1] When data on the heater break alarm 1 set value in memory area 2 is read

1. The memory area number, "2" is written to the memory area selection (0014H).
Data in Memory area 2 is called up to the register addresses 0014H to 0019H.

Register address		
Memory area selection	0014H	2	← Memory area number "2"
Maximum load current set value for alarm	0015H	20
Heater break alarm 1 set value setting	0016H	20
Thyristor break-down set value setting	0017H	20	The data of memory area 2 is loaded into these register addresses.
Heater break alarm 2set value setting	0018H	15
Current limit value setting	0019H	220

2. Data "20" on heater break alarm 1 set value setting (0016H) is read.

[Example 2] When the thyristor break-down set value in memory area 2 is changed to 80

1. The memory area number, "2" is written to the memory area selection (0014H).
Data in Memory area 2 is called up to the register addresses 0014H to 0019H.

Register address ────────────┐
                              ▼
Memory area selection	0014H	2	← Memory area number "2"
Maximum load current set value for alarm	0015H	20	⎫
Heater break alarm 1 set value setting	0016H	20	
Thyristor break-down set value setting	0017H	20	⎬ The data of memory area 2 is loaded into these register addresses.
Heater break alarm 2 set value setting	0018H	15	
Current limit value setting	0019H	220	⎭
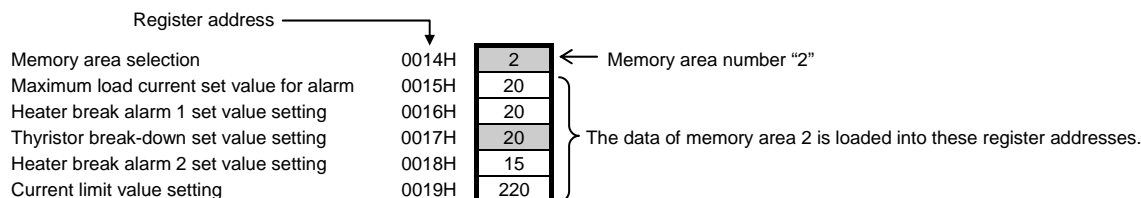
2. "80" is written to the thyristor break-down set value setting (0017H).

■ Memory area transfer

Any memory area used for alarm monitor is specified by the memory area setting (0012H).

📖   The memory area number can be changed at either RUN or STOP.

Communication data	Register address
Memory area setting	0012H	← Register address to specify memory area

[Example]   When performing alarm monitor by calling up data in Memory area 3

1. The memory area number, "3" is written to the memory area setting (0012H).
When the number of memory area setting (0012H) is changed, memory area selection (0014H) also changes to the same memory area number. In addition, the data of the new memory area is loaded into register addresses 0014H to 0019H.
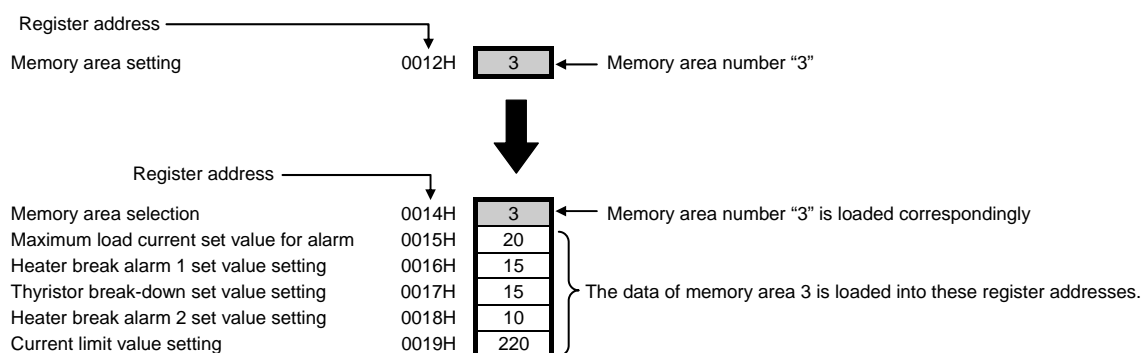
Register address ────────────┐
                              ▼
Memory area setting	0012H	3	← Memory area number "3"

▼

Register address ────────────┐
                              ▼
Memory area selection	0014H	3	← Memory area number "3" is loaded correspondingly
Maximum load current set value for alarm	0015H	20	⎫
Heater break alarm 1 set value setting	0016H	15	
Thyristor break-down set value setting	0017H	15	⎬ The data of memory area 3 is loaded into these register addresses.
Heater break alarm 2 set value setting	0018H	10	
Current limit value setting	0019H	220	⎭

📖   When the number of memory area setting (0012H) is changed, memory area selection (0014H) changes to the same memory area number; however, when memory area selection (0014H) is changed, the memory number of memory area setting (0012H) does not change.

2. Alarm monitor is performed by using data in the memory area 3.

6. COMMUNICATION DATA LIST

6.1 Reference to Communication Data List

(1) (2) (3) (4) (5)

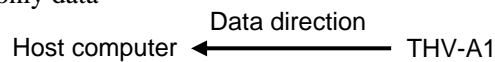| No.	Name	Modbus register address HEX	DEC	Attri-bute	Data range	Factory set value
1	Input signal monitor 1	0000	0	RO	0 to 100 %	—
2	Phase angle ratio monitor	0001	1	RO	0 to 100 %	—
3	CT input monitor [1]	0002	2	RO	0.0 to 27.0 A (20 A type) 0.0 to 40.5 A (30 A type) 0.0 to 60.8 A (45 A type) 0.0 to 81.0 A (60 A type) 0.0 to 108.0 A (80 A type) 0.0 to 135.0 A (100 A type) 0.0 to 202.5 A (150 A type) 0.0 to 270.0 A (200 A type)	—
4	Voltage value monitor	0003	3	RO	0 to 280 A	—

(1) Name: Communication data name

(2) Modbus register address:
Modbus communication data register addresses
HEX: Hexadecimal
DEC: Decimal

(3) Attribute: A method of how communication data items are read or written when viewed from the host computer is described.

RO: Read only data

Data direction
Host computer ◄─────────── THV-A1

R/W: Read and Write data

Data direction
Host computer ◄─────────► THV-A1
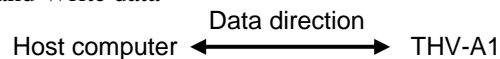
(4) Data range: Read or write range of communication data

Bit data

16-bit data

Bit 15 ·· Bit 0
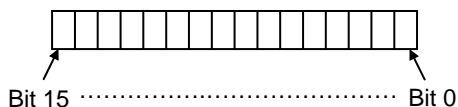
(5) Factory set value: Factory set value of communication data

☞ For details on the data, refer to **THV-A1 Instruction Manual [Detailed version] (IMR02D04-E□)**.

6.2 Communication Data

📖 If the interval time (address: 0011H) of No. 18 is changed, turn on the power again, and register the new value which changed.

No. 27 to 64 are engineering mode data. Engineering mode data are locked prior to shipping. Release the engineering mode lock using the set data lock (address: 0013H).

No.	Name	Modbus register address HEX	DEC	Attri-bute	Data range	Factory set value
1	Input signal monitor 1	0000	0	RO	0 to 100 %	—
2	Phase angle ratio monitor	0001	1	RO	0 to 100 %	—
3	CT input monitor [1]	0002	2	RO	0.0 to 27.0 A (20 A type) 0.0 to 40.5 A (30 A type) 0.0 to 60.8 A (45 A type) 0.0 to 81.0 A (60 A type) 0.0 to 108.0 A (80 A type) 0.0 to 135.0 A (100 A type) 0.0 to 202.5 A (150 A type) 0.0 to 270.0 A (200 A type)	—
4	Voltage value monitor	0003	3	RO	0 to 280 V ⎛ 90 to 264 V AC [Power supply voltage range] Rating 100 to 240 V AC ⎞	—
5	Power value monitor [2]	0004	4	RO	0.00 to 7.56 kW (20 A type) 0.00 to 11.34 kW (30 A type) 0.00 to 17.01 kW (45 A type) 0.00 to 22.68 kW (60 A type) 0.00 to 30.24 kW (80 A type) 0.00 to 37.80 kW (100 A type) 0.00 to 56.70 kW (150 A type) 0.00 to 75.60 kW (200 A type)	—
6	Power frequency monitor	0005	5	RO	40 to 70 Hz	—
7	Power supply voltage monitor	0006	6	RO	0 to 280 V ⎛ 90 to 264 V AC [Power supply voltage range] Rating 100 to 240 V AC ⎞	—
8	Input signal monitor 2	0007	7	RO	0 to 100 %	—
9	External gradient set value monitor	0008	8	RO	0 to 100 %	—
10	External manual set value monitor	0009	9	RO	0 to 100 %	—
11	Contact input state monitor	000A	10	RO	Bit data Bit 0: Contact input 1 (DI1) Bit 1: Contact input 2 (DI2) Bit 2: Contact input 3 (DI3) Bit 3 to Bit 15: Unused Data 0: Contact open 1: Contact closed [Decimal number: 0 to 7]	—
12	Memory area monitor [1]	000B	11	RO	1 to 4	—

[1] This data becomes valid on the instrument with a constant current control or constant power control.

[2] This data becomes valid on the instrument with a constant power control.

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
13	Internal manual set value [1]	000C	12	R/W	0.0 to 100.0 %	0.0
14	Internal gradient set value [2]	000D	13	R/W	0.00 to 2.00 ⌈ 0.00: Internal gradient 0 % ⌉ ⌊ 2.00: Internal gradient 200 % ⌋	1.00
15	Soft-start time [3, 4]	000E	14	R/W	0.0 to 100.0 seconds (0.0: Soft-start function unused)	0.1
16	Soft-down time [3]	000F	15	R/W	0.0 to 100.0 seconds (0.0: Soft-down function unused)	0.1

[1] If the power supply is turned off, the internal manual set value is automatically reset to "0.0."

[2] This data becomes valid when the control method is the phase control or zero-cross control (continuous).

[3] This data becomes valid when the control method is the phase control.

[4] Caution for using protection function for control of primary side of a transformer

Action of soft-start time (000EH) and soft-down time (000FH) depends on the setting (enable/disable) of protection function for control of primary side of a transformer.

When protection function for control of primary side of a transformer is enabled, the action of soft-start time (000EH) and soft-down time (000FH) becomes as follows.

- When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

- Even if soft-start, soft-down enable/disable (0022H) is selected to "disable," the action of soft-start time (000EH) and soft-down time (000FH) becomes the same as that for "enable." When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

- Even if soft-start and soft-down functions are selected to "disable" by the contact input (DI), the action of the soft-start time (000EH) and soft-down time (000FH) becomes the same as that for "enable." When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

- When the mode is switched from STOP to RUN by RUN/STOP transfer (0020H)
  Soft-start function starts working for a period of soft-start time (000EH).
  When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

- When the mode is switched from STOP to RUN by the contact input (DI)
  Soft-start function starts working for a period of soft-start time (000EH).
  When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
17	Unused	0010	16	—	—	—
18	Interval time	0011	17	R/W	0 to 250 ms	10
19	Memory area setting [1, 2]	0012	18	R/W	1 to 4	1
20	Set data lock	0013	19	R/W	0000 to 9999 The ones place: Setting mode 1, Setting mode 2 The tens place: Engineering mode The hundreds place: Unused The thousands place: Unused Data　　　0: Lock 　　　　　1: Unlock Do not set any values other than 0 and 1.	0001
21	Memory area selection [1]	0014	20	R/W	1 to 4	1
22	Maximum load current set value for alarm [1] ★	0015	21	R/W	0.0 to 22.0 A　(20 A type) 0.0 to 33.0 A　(30 A type) 0.0 to 50.0 A　(45 A type) 0.0 to 66.0 A　(60 A type) 0.0 to 88.0 A　(80 A type) 0.0 to 110.0 A (100 A type) 0.0 to 165.0 A (150 A type) 0.0 to 220.0 A (200 A type)	20.0 30.0 45.0 60.0 80.0 100.0 150.0 200.0

★ Parameters which can be registered in the memory area.

[1] This data becomes valid on the instrument with a constant current control or constant power control.

[2] When the memory area setting (0012H) is changed, the memory area selection (0014H) changes to the same memory area number. However, if memory area selection (0014H) changes, memory area setting (0012H) does not change.
When a contact input (DI) is used, the contact input (DI) setting has priority.

| No. | Name | Modbus register address | | Attri-bute | Data range | Factory set value |
		HEX	DEC			
23	Heater break alarm 1 set value setting [1,2] ★	0016	22	R/W	0 to 100 % of maximum load current set value (0: Heater break alarm 1 unused)	20
24	Thyristor break-down set value setting [1,3] ★	0017	23	R/W	0 to 100 % of maximum load current set value (0: Thyristor break-down alarm unused)	20

★ Parameters which can be registered in the memory area.

[1] This data becomes valid on the instrument with a constant current control or constant power control.

[2] Although the following values are recommended, the alarm set value varies depending on the load type and the number of connection. Set the value suited to your system.

■ When the control method is Phase Control, RKC recommends:
- Set the heater break set value to approximately 20 % of the maximum load current value for heater break alarm Type 1 (constant resistance type, deviation alarm).
- Set the heater break set value to approximately 10 % of the maximum load current value for heater break alarm Type 2 (linearity resistor type, absolute value alarm). Do not set the heater break alarm set value to more than 15 %.
- In the case of a heater break alarm that supports non-linear resistance, there is no recommended value because the load characteristics vary depending on the non-linear load type.

■ When the control method is zero-cross Control, RKC recommends:
- Set the heater break alarm set value to approximately 80 % of the reading of current transformer input.
- Set the heater break alarm set value to a slightly smaller value to prevent a false alarm when power supply variation is large.
- Set the heater break alarm set value to a slightly larger value to detect a failure of one heater when more than one heaters are connected in parallel. But the set value should be less than the maximum reading of current transformer input.

[3] Although the following values are recommended, the alarm set value varies depending on the load type and the number of connection. Set the value suited to your system.

■ When the control method is Phase Control, RKC recommends:
- Set the heater break set value to approximately 20 % of the maximum load current value for heater break alarm Type 1 (constant resistance type, deviation alarm).
- Set the heater break set value to approximately 10 % of the maximum load current value for heater break alarm Type 2 (linearity resistor type, absolute value alarm).
- In the case of a heater break alarm that supports non-linear resistance, there is no recommended value because the load characteristics vary depending on the non-linear load type.

■ When the control method is zero-cross Control, RKC recommends:
Set the thyristor break-down set value to approximately 80 % of the maximum load current value.

| No. | Name | Modbus register address | | Attri-bute | Data range | Factory set value |
		HEX	DEC			
25	Heater break alarm 2 set value setting [1, 2] ★	0018	24	R/W	0 to 100 % of maximum load current set value (0: Heater break alarm 2 unused)	15
26	Current limit value setting [1, 3] ★	0019	25	R/W	0.0 to 22.0 A (20 A type) 0.0 to 33.0 A (30 A type) 0.0 to 50.0 A (45 A type) 0.0 to 66.0 A (60 A type) 0.0 to 88.0 A (80 A type) 0.0 to 110.0 A (100 A type) 0.0 to 165.0 A (150 A type) 0.0 to 220.0 A (200 A type)	22.0 33.0 50.0 66.0 88.0 110.0 165.0 220.0

★ Parameters which can be registered in the memory area.

[1] This data becomes valid on the instrument with a constant current control or constant power control.

[2] Although the following values are recommended, the alarm set value varies depending on the load type and the number of connection. Set the value suited to your system.

■ When the control method is Phase Control and heater break alarm Type 1 (constant resistance type, deviation alarm) is selected, RKC recommends:
  - Set the value must be equal or less than the heater break alarm 1 set value.

■ When the control method is Phase Control and heater break alarm Type 2 (linearity resistor type, absolute value alarm) is selected:
  - For the type 2, this item is not available. Set the "0: Heater break alarm 2 unused."

  📖 The heater break alarm 2 set value cannot be used as the heater break alarm that supports non-linear resistance. The heater break alarm 2 set value is activated as the standard heater break alarm.

■ When the control method is zero-cross Control, RKC recommends:
  - If the alarm needs to be output before a heater break occurs, set the set value of heater break alarm 2 to any value slightly larger than that of heater break alarm 1.
  - If the alarm needs to be output before thyristor break-down occurs, set the set value of heater break alarm 2 to any value slightly smaller than that of heater break alarm 1.

[3] If a current limit value is set to its maximum value, the current limit function is deactivated.
When set to 0.0, the output of the THV-A1 turns off.
In addition, when the zero-cross control is used, this data becomes invalid.

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
27	Contact input 1 (DI1) function assignment	001A	26	R/W	0: No function 1: Auto mode/Manual mode transfer [1, 2] 2: RUN/STOP transfer [2] 3: Alarm interlock release [2]	0
28	Contact input 2 (DI2) function assignment	001B	27	R/W	4: Heater break alarm enable/disable [2, 3] 5: Soft-start, soft-down enable/disable [2, 4] 6: Set data lock/unlock [2, 5] 7: Over current alarm enable/disable [2, 3]	0
29	Contact input 3 (DI3) function assignment	001C	28	R/W	8: Memory area transfer [3, 6, 7, 8] Take care that assignments of functions 1 to 7 are not duplicated.	0

[1] Select the setting mode by contact input action (address: 001FH).

[2] Contact input (DI) state

When a contact input (DI) is used, the contact input (DI) setting has priority (Excluding the set data lock/unlock).

Name	Items selected depending on DI state	
	Open	Closed
Auto mode/Manual mode transfer	Auto mode	Manual mode
RUN/STOP transfer	STOP	RUN
Alarm interlock release		Alarm interlock release
Heater break alarm enable/disable	Enable	Disable
Soft-start, soft-down enable/disable	Enable	Disable
Set data lock/unlock	Lock	Unlock
Over current alarm enable/disable	Enable	Disable

[3] This data becomes valid on the instrument with a constant current control or constant power control.

[4] This data becomes valid when the control method is the phase control.

[5] The mode locked by the contact input (DI) accords with the set data lock (address: 0013H) setting.

[6] When the heater break alarm supports non-linear resistance is used, this data becomes invalid.

[7] When a contact input (DI) is used, the contact input (DI) setting has priority.

[8] Memory area transfer uses two contact input (DI) points.

Assign memory area transfer to contact input 1 (DI1). When assigned to contact input 1 (DI1), memory area transfer is also automatically assigned to contact input 2 (DI2).

Memory area transfer cannot be assigned to contact input 2 (DI2) and contact input 3 (DI3).

DI No.	Memory areas selected depending on DI state			
	Memory area 1	Memory area 2	Memory area 3	Memory area 4
DI1	Open	Closed	Open	Closed
DI2	Open	Open	Closed	Closed

No.	Name	Modbus register address HEX	Modbus register address DEC	Attri-bute	Data range	Factory set value
30	Control method	001D	29	R/W	0: Phase control 1: Zero-cross control (continuous) [1] 2: Zero-cross control (input synchronous type) [1]	0
31	Input signal selection	001E	30	R/W	0: 0 to 20 mA DC, 0 to 5 V DC, 0 to 10 V DC [2], 0/12 V DC, 0/24 V DC 1: 4 to 20 mA DC, 1 to 5 V DC, 0/12 V DC, 0/24 V DC	Factory set value varies depending on the instrument specification.
32	Contact input action	001F	31	R/W	0: External manual mode ↔ Auto mode [3, 4] 1: Internal manual mode ↔ Auto mode [3, 4] 2: Internal manual mode (fixed) [3] 3: External manual mode (fixed) [3]	0
33	RUN/STOP transfer [5, 6]	0020	32	R/W	0: STOP (THV-A1 output OFF) 1: RUN (THV-A1 output ON)	1
34	Alarm interlock [7]	0021	33	R/W	0: Unused 1: Use	0

[1] When the zero-cross control is selected, the data of output mode (address: 0025H) becomes invalid.

[2] If 0 to 10 V DC is specified at the time of ordering, this cannot be changed to an input signal other than voltage pulse input (0/12 V DC, 0/24 V DC).

[3] Settings that become effective based on the contact input (DI) setting:

Contact input action (dA) setting	Settings that become effective based on the DI setting	
	Closed	Open
0: External manual mode ↔ Auto mode	External manual mode	Auto mode
1: Internal manual mode ↔ Auto mode	Internal manual mode	Auto mode
2: Internal manual mode (fixed)	Internal manual mode	
3: External manual mode (fixed)	External manual mode	

[4] When the contact input action is set to "0: External manual mode ↔ Auto mode" or "1: Internal manual mode ↔ Auto mode," the contact input (DI) setting has priority.

[5] When a contact input (DI) is used, the contact input (DI) setting has priority.

[6] When protection function for control of primary side of a transformer is set enabled, switching from STOP to RUN will activate the soft-start function for a period set with the soft-start time (000EH). When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

[7] To use the alarm interlock release function in a contact input (DI), set to "1: Use." When in the alarm interlock release (contact closed) state, the alarm interlock function will not operate. The contact input (DI) setting has priority.

No.	Name	Modbus register address HEX	Modbus register address DEC	Attri-bute	Data range	Factory set value
35	Soft-start, soft-down enable/disable [1, 2, 3]	0022	34	R/W	0: Soft-start, soft-down disable 1: Soft-start, soft-down enable	1
36	Heater break alarm enable/disable [1, 4]	0023	35	R/W	0: Heater break alarm disable 1: Heater break alarm enable	1
37	Over current alarm enable/disable [1, 4]	0024	36	R/W	0: Over current alarm disable 1: Over current alarm enable	1
38	Output mode for phase control [2]	0025	37	R/W	0: Proportional phase angle to input 1: Proportional voltage to input 2: Proportional square voltage (electric power) to input 3: Constant current control [4] 4: Constant voltage control 5: Constant power control [5] 6: Square voltage feedback	Factory set value varies depending on the instrument specification.
39	Output limiter (high) [6]	0026	38	R/W	0.0 to 100.0 % [Output limiter (low) $\leq$ Output limiter (high)]	100.0
40	Output limiter (low) [6]	0027	39	R/W	0.0 to 100.0 % [Output limiter (low) $\leq$ Output limiter (high)]	0.0
41	Output limiter (high) at operation start [2]	0028	40	R/W	0.0 to 100.0 % [7] [Output limiter (high) at operation start $\leq$ Output limiter (high)]	50.0
42	Output limiter (high) time at operation start [2]	0029	41	R/W	0.0 to 600.0 seconds (0.0: Output limiter function at operation start disable)	0.0
43	Base-up set value [6]	002A	42	R/W	−10.0 to +100.0 % [8] [Base-up set value $\leq$ Output limiter (high)]	0.0

[1] When a contact input (DI) is used, the contact input (DI) setting has priority.

[2] This data becomes valid when the control method is the phase control.

[3] When protection function for control of primary side of a transformer is enabled, the action of soft-start and soft-down becomes the same as that for enable even if soft-start, soft-down enable/disable (0022H) is set to disabled.
When soft-start time (000EH) is set to 0.0 seconds, soft-start function is operated for 0.1 seconds.

[4] This data becomes valid on the instrument with a constant current control or constant power control.

[5] This data becomes valid on the instrument with a constant power control.

[6] This data becomes valid when the control method is the phase control or zero-cross control (continuous).

[7] Output limiter (high) value at operation start must be lower than output limiter (high).

[8] The base-up set value is effective only when the output limiter (low) is set to 0.0.

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
44	Alarm 1 output logic [1]	002B	43	R/W	0: No output 1: Power frequency error (energized) 2: Board error (energized) 4: Power supply voltage error (energized) 8: Heater break alarm 1 (energized) [2] 16: Heater break alarm 2 (energized) [2] 32: Thyristor break-down alarm (energized) [2] 64: Over current (energized) [2] 128: Fuse break (energized) 256: Heat sink temperature abnormality (energized) [3] 512: FAIL (de-energized) • To set the alarm output to "de-energized," set the thousands digit to "1." (However, excluding FAIL) For example, to set the alarm output of "2: Board error (energized)" as "de-energized," set "1002." • To output the alarm output by logical *OR*, set the sum of the set values. For example, to generate the alarm output of "board error (energized)" and "over current error (energized)" by logical *OR*, set to "66." To set it as "de-energized," set to "1066." • Mixed output of energized and de-energized is not possible. In addition, logical add output of FAIL (de-energized) is not possible, and thus this must be set independently.	0
45	Alarm 2 output logic [1]	002C	44	R/W		0
46	Number of heater break alarm 1 delay times [2]	002D	45	R/W	1 to 100 times	30
47	Heater break alarm 1 type [2, 4]	002E	46	R/W	0: Type 1 (constant resistance type, deviation alarm) 1: Type 2 (linearity resistor type, absolute value alarm)	0

[1] Alarm output is outputted on the instrument with an alarm output 2 points.

[2] This data becomes valid on the instrument with a constant current control or constant power control.

[3] The data becomes valid on the instrument with a heat sink temperature detection function.

[4] This data becomes valid when the control method is the phase control.

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
48	Number of heater break alarm 2 delay times [1]	002F	47	R/W	1 to 1000 times	300
49	Heater break alarm 2 type [1, 2]	0030	48	R/W	0: Type 1 (constant resistance type, deviation alarm) 1: Type 2 (linearity resistor type, absolute value alarm)	0
50	ROM version	0031	49	RO	Display the version of loading software.	—
51	Integrated operation time [upper 2 digits]	0032	50	RO	0 to 99 (Resolution of display: 10, 000 hours) [3]	—
52	Integrated operation time [lower 4 digits]	0033	51	RO	0 to 9999 (Resolution of display: 1 hours) [4]	—
53	Output time setting for automatic calculation of inflection point [5]	0034	52	R/W	0.0 to 100.0 seconds (0.0: Inflection point calculation function unused)	20.0
54	Action selection of heater break alarm [5]	0035	53	R/W	0: Standard heater break alarm 1: Heater break alarm supports non-linear resistance 2: Start inflection point calculation [6]	0
55	Manipulated output value setting of inflection point 1 [5]	0036	54	R/W	0.0 to 100.0 %	0.0
56	Current value setting of inflection point 1 [5]	0037	55	R/W	0.0 to 22.0 A (20 A type) 0.0 to 33.0 A (30 A type) 0.0 to 50.0 A (45 A type) 0.0 to 66.0 A (60 A type) 0.0 to 88.0 A (80 A type) 0.0 to 110.0 A (100 A type) 0.0 to 165.0 A (150 A type) 0.0 to 220.0 A (200 A type)	0.0
57	Manipulated output value setting of inflection point 2 [5]	0038	56	R/W	0.0 to 100.0 %	0.0

- **When the heater break alarm supports non-linear resistance is not provided, this data becomes invalid. In addition, when the zero-cross control is used, the non-linear resistance heater break alarm function cannot be used.**

- **Use this function in a system with a current capacity of 10 A or more. As the measuring accuracy of the current transformer (CT) is within ±2 % of the THV-A1 rated current, no heater break alarm may normally operate if used at a smaller load current value.**

[1] This data becomes valid on the instrument with a constant current control or constant power control.

[2] This data becomes valid when the control method is the phase control.

[3] Up to 999,999 from 0 including the upper and lower digits can be displayed.

[4] If the total integrated operating time exceeds 9,999 hours, these digits move to the integrated operating time display [upper 2 digits].

[5] This data becomes valid on the instrument with a non-linear resistance heater break alarm. In addition, when the zero-cross control is used, the non-linear resistance heater break alarm function cannot be used.

[6] Set value returns to "1" when the calculation of the inflection point ends.
If calculation of the inflection point ends abnormally, the display will revert to the values below and the inflection point data will not be updated.
- If action selection of heater break alarm was changed from 0 to 2, it will revert to 0.
- If action selection of heater break alarm was changed from 1 to 2, it will revert to 1.

No.	Name	Modbus register address HEX	Modbus register address DEC	Attri-bute	Data range	Factory set value
58	Current value setting of inflection point 2 [1]	0039	57	R/W	0.0 to 22.0 A (20 A type) 0.0 to 33.0 A (30 A type) 0.0 to 50.0 A (45 A type) 0.0 to 66.0 A (60 A type) 0.0 to 88.0 A (80 A type) 0.0 to 110.0 A (100 A type) 0.0 to 165.0 A (150 A type) 0.0 to 220.0 A (200 A type)	0.0
59	Manipulated output value setting of inflection point 3 [1]	003A	58	R/W	0.0 to 100.0 %	0.0
60	Current value setting of inflection point 3 [1]	003B	59	R/W	0.0 to 22.0 A (20 A type) 0.0 to 33.0 A (30 A type) 0.0 to 50.0 A (45 A type) 0.0 to 66.0 A (60 A type) 0.0 to 88.0 A (80 A type) 0.0 to 110.0 A (100 A type) 0.0 to 165.0 A (150 A type) 0.0 to 220.0 A (200 A type)	0.0
61	Protection function for control of primary side of a transformer [2]	004C	76	R/W	0: Protection function for control of primary side of a transformer disable 1: Protection function for control of primary side of a transformer enable	0
62	Determination set value in case of a break on the secondary side of the transformer [2,3]	004D	77	R/W	0 to 100 % of computed standard heater current value	70
63	Output limiter setting in case of a break on the secondary side of the transformer [2,3]	004E	78	R/W	15.0 to 50.0 % of phase angle	15.0
64	Soft-start time in case of break on the secondary side of the transformer [2,3]	004F	79	R/W	0.1 to 100.0 seconds	0.1

[1] This data becomes valid on the instrument with a non-linear resistance heater break alarm. In addition, when the zero-cross control is used, the non-linear resistance heater break alarm function cannot be used.

[2] This data becomes valid on the instrument with a constant current control or constant power control.

[3] This data becomes valid when protection function for control of primary side of a transformer is set to "1: Protection function for control of primary side of a transformer enable."

No.	Name	Modbus register address		Attri-bute	Data range	Factory set value
		HEX	DEC			
65	Error number	003C	60	RO	1: Calibration data error 2: Back-up error 4: A/D conversion error 32: Power frequency error 64: Power supply voltage error 128: Watchdog timer error	—
66	Alarm code	003D	61	RO	0: No output 1: Power frequency error 2: Board error 4: Power supply voltage error 8: Heater break alarm 1 16: Heater break alarm 2 32: Thyristor break-down alarm 64: Over current 128: Fuse break 256: Heat sink temperature abnormality If two or more error occurs simultaneously, the sum of all alarm codes is displayed.	—

7. TROUBLESHOOTING

⚠️ **WARNING**

- To prevent electric shock or instrument failure, always turn off the system power before replacing the instrument.

- To prevent electric shock or instrument failure, always turn off the power before mounting or removing the instrument.

- To prevent electric shock or instrument failure, do not turn on the power until all the wiring is completed. Make sure that the wiring has been properly made before applying power to the instrument.

- To prevent electric shock or instrument failure, do not touch the inside of the instrument.

- All wiring must be performed by authorized personnel with electrical experience in this type of work.

CAUTION

All wiring must be completed before power is turned on to prevent electric shock, instrument failure, or incorrect action.
The power must be turned off before repairing work for input break and output failure including replacement of sensor, contactor or SSR, and all wiring must be completed before power is turned on again.

This section lists some of the main causes and solutions for communication problems.
If you cannot solve a problem, please contact RKC sales office or the agent, on confirming the type name and specifications of the product.

Problem	Probable cause	Solution
No response	Wrong connection, no connection or disconnection of the communication cable	Confirm the connection method or condition and connect correctly
	Breakage, wrong wiring, or imperfect contact of the communication cable	Confirm the wiring or connector and repair or replace the wrong one
	Mismatch of the setting data of communication speed and data bit configuration with those of the host computer	Confirm the settings and set them correctly
	Wrong address setting	
	A transmission error (overrun error, framing error, parity error or CRC-16 error) is found in the query message	Re-transmit after time-out occurs or verify communication program
	The time interval between adjacent data in the query message is too long, exceeding 24-bit time	
Error code 1	Function cod error (Specifying nonexistent function code)	Confirm the function code
Error code 2	When any address other than 0000H to 003DH are specified	Confirm the address of holding register
Error code 3	When the specified number of data items in the query message exceeds the maximum number of data items available	Confirm the setting data
	When the data written exceeds the setting range	
Error code 4	Self-diagnostic error	Turn off the power to the instrument. If the same error occurs when the power is turned back on, please contact RKC sales office or the agent.

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