Single-phase Thyristor Unit
(High voltage type)

THV-40

Instruction Manual

RKC INSTRUMENT INC.

IMR02S03-E9

- Company names and product names used in this manual are the trademarks or registered trademarks of the respective companies.

Thank you for purchasing this RKC product. In order to achieve maximum performance and ensure proper operation of your new 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.
- When the withstand voltage test or each test is performed, please contact RKC sales office or the agent. If you make a mistake in the test method, the instrument failure may result.
- 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.

High temperature caution:
Do not touch the heat radiation fin while the power is turned on or just after the power is turned off as it may be at high temperatures.
If touched, burning may result.

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. In a domestic environment, this instrument may cause radio interference, in which case the user may be required to take additional measures.
- 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 instrument 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 or failure, protect the power line and the input/output lines with a protection device such as fuse, 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 dispensation.
- 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.

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	M	n	o	P	q	r	S	T	t	U	u

V	W	X	Y	Z	Degree	Dash
V	W	X	Y	Z	°	-

8.	8.	Dim lighting
8.	8.	Bright lighting

DOCUMENT CONFIGURATION

There are three manuals pertaining to this product. Please be sure to read all manuals specific to your application requirements. If you do not have a necessary manual, please contact RKC sales office, the agent, or download from the official RKC website.

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

https://www.rkcinst.co.jp/english/download-center/

Manual	Manual Number	Remarks
20 A/30 A/45 A/ 60 A/ 80 A/100 A THV-40 Installation Manual	IMR02S01-E□	This manual is enclosed with instrument. This manual explains the mounting and wiring. (The manual is also contained in the supplied CD-ROM. /The manual can also be downloaded from the web.)
150 A/200 A THV-40 Installation Manual	IMR02S02-E□	This manual is enclosed with instrument. This manual explains the mounting and wiring. (The manual is also contained in the supplied CD-ROM. /The manual can also be downloaded from the web.)
THV-40 Instruction Manual	**IMR02S03-E9**	This Manual. This manual explains the method of the mounting and wiring, the operation of various functions, and troubleshooting. (The manual is contained in the supplied CD-ROM. /The manual can also be downloaded from the web.)

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

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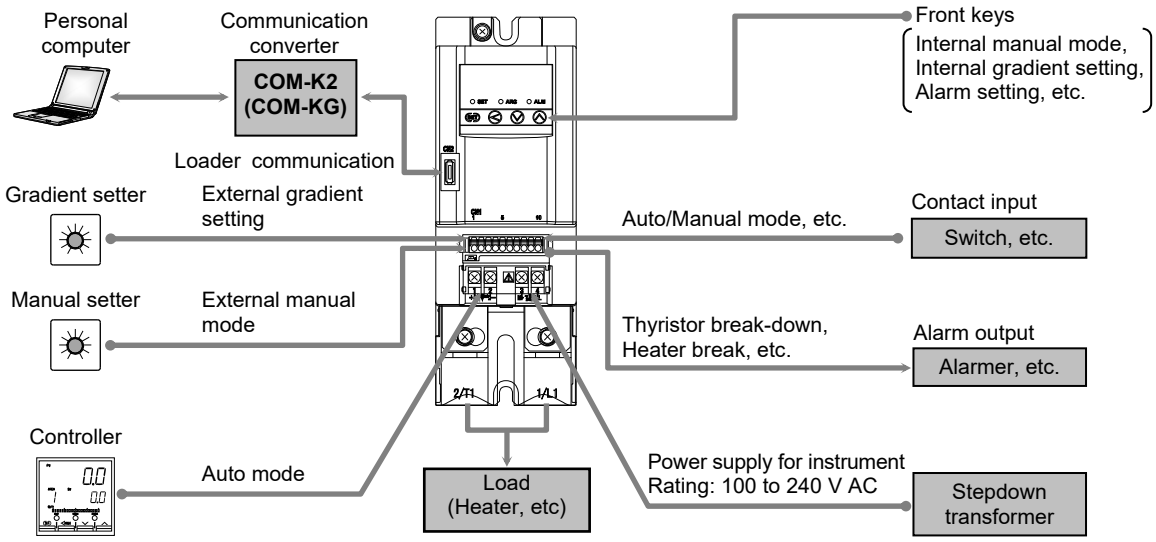
1 OUTLINE

1.1 Features

This instrument is a single-phase thyristor unit for power supply voltage 380 to 480 V AC.
It is possible to adjust power supplied to heaters, etc. by setting the signal from the controller, setter (variable resistor) or front keys.



■ The rated currents of eight types are available.

Power supply voltage	380 to 480 V AC							
Rated current	20 A	30 A	45 A	60 A	80 A	100 A	150 A	200 A

■ The input signal and set value can be checked on the display unit.

The display unit can check the input signal, phase angle, power frequency, current value and set value of each parameter, etc.

■ The front keys can set the gradient setting and manual setting.

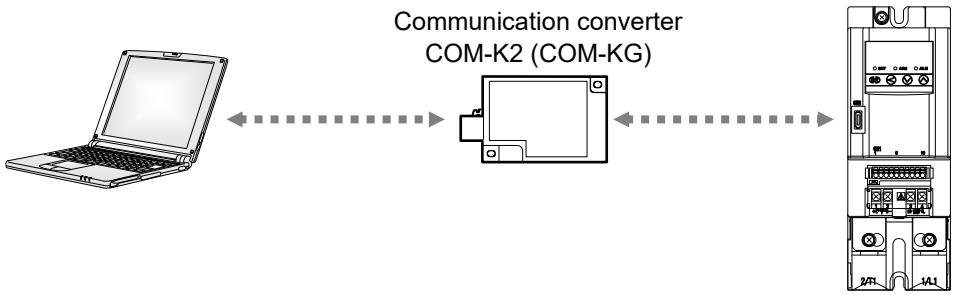
In addition to the setting by an ordinary setter (variable resistor), it is possible to set internal gradient setting and internal manual setting values by the front keys while checking these numeric values shown on the display unit.

■ The control of three types can be selected.

It is possible to select by the front keys and then use any one of Phase control, Zero-cross control (continuous) and Zero-cross control (input synchronous type).

■ Loader communication

This instrument is equipped with a loader communication port as standard. This instrument can be linked to a PC for setup.



Maximum connections: 1 unit

Use with the communication converter, COM-K2 or COM-KG (RKC product).
To perform setup from a PC, a communication tool PROTEM2 is necessary.
Download the PROTEM2 from the official RKC website.

1.2 Checking the Product

Before using this product, check each of the following:

- Model code
- Check that there are no scratch or breakage in external appearance (case, heat radiation fin, front panel, or terminal, etc.).
- Check that all of the items delivered are complete. (Refer to below)

THV – 40 PZ□ – □ * □□ – □ (– □ . . . .)*
(1) (2) (3) (4) (5) (6) (7)

* Code (7) is marked on the label when accessory is specified. The code for accessory will be more than one if the product has more than one accessory.
Combination example of accessories
–1–6: Setter for open loop control [1 set] and
Input/Output connector (plug) and Fuse unit

(1) Power supply for load

40: 380 to 480 V AC

(2) Control method

PZ: Phase control/Zero-cross control (configurable Factory set value: Phase control)

(3) Rated current

020: 20 A AC 060: 60 A AC 150: 150 A AC *
030: 30 A AC 080: 80 A AC 200: 200 A AC *
045: 45 A AC 100: 100 A AC * With Heat sink temperature detection function

(4) Input signal

5: Voltage input 0 to 10 V DC 8: Current input 4 to 20 mA DC
6: Voltage input 1 to 5 V DC V: Voltage pulse input 0/12 V DC

(5) Heater break alarm, Current limit function, Constant current control function and Protection function for control of primary side of a transformer

N: No function
H: Heater break alarm, Current limit function, Constant current control function and Protection function for control of primary side of a transformer
B: Non-linear resistance heater break alarm, Current limit function, Constant current control function and Protection function for control of primary side of a transformer

📖 To control the primary side of the transformer, it is recommended to purchase a THV-40 with a protection function for control of primary side of a transformer.

(6) Alarm output

N: No alarm
A: Alarm output 1 point

(7) Accessories

1: Setter for open loop control (potentiometer, knob and scale plate) [1 set] and Input/Output connector (plug)
2: Setter for open loop control (potentiometer, knob and scale plate) [2 sets] and Input/Output connector (plug)
6: Fuse unit for 20 A, 30 A, 45 A, 60 A, 80 A and 100 A (fast-blow fuse and holder [1 circuit type])
7: Fuse unit (UL approved instrument) for 20 A, 30 A, 45 A, 60 A, 80 A, 100 A, 150 A and 200 A (fast-blow fuse and holder [1 circuit type])
9: Input/Output connector (plug)

■ Accessories (Order Separately)

When you order accessories after this instrument purchase, please specify it with the following code.

Code	Details
THV1P-S01	Setter (potentiometer, knob and scale plate)
THV4P-C01	Input/Output connector (plug)
THV4P-V03	Output voltmeter (600 V span) [For Phase control]
CH1-4H381-006	Stepdown transformer (for instrument power supply)

Code	Details	Fuse rating*
THV4P-F20	Fast-blow fuse for 20 A (Fuse holder: Not UL certified)	25 A
THV4P-F30	Fast-blow fuse for 30 A (Fuse holder: Not UL certified)	40 A
THV4P-F45	Fast-blow fuse for 45 A (Fuse holder: Not UL certified)	63 A
THV4P-F60	Fast-blow fuse for 60 A (Fuse holder: Not UL certified)	80 A
THV4P-F80	Fast-blow fuse for 80 A (Fuse holder: Not UL certified)	100 A
THV4P-FA0	Fast-blow fuse for 100 A (Fuse holder: Not UL certified)	125 A
THV4P-H01	Fuse holder (Not UL certified)	
THV4P-F2B	Fast-blow fuse for 20 A (Fuse holder: UL certified)	20 A
THV4P-F3B	Fast-blow fuse for 30 A (Fuse holder: UL certified)	30 A
THV4P-F4B	Fast-blow fuse for 45 A (Fuse holder: UL certified)	50 A
THV4P-F6B	Fast-blow fuse for 60 A (Fuse holder: UL certified)	63 A
THV4P-F8B	Fast-blow fuse for 80 A (Fuse holder: UL certified)	80 A
THV4P-FAB	Fast-blow fuse for 100 A (Fuse holder: UL certified)	100 A
THV4P-FBB	Fast-blow fuse for 150 A (Fuse holder: UL certified)	200 A
THV4P-FCB	Fast-blow fuse for 200 A (Fuse holder: UL certified)	250 A
THV4P-H04	Fuse holder (UL approved instrument) for 20 A and 30 A	
THV4P-H05	Fuse holder (UL approved instrument) for 45 A, 60 A, 80 A and 100 A	
THV4P-H06	Fuse holder (UL approved instrument) for 150 A	
THV4P-H07	Fuse holder (UL approved instrument) for 200 A	

*Rating of the fuse

■ The accessories attached to product

20 A/30 A/45 A/60 A/80 A/100 A THV-40 Installation Manual (IMR02S01-E☐) or
150 A/200 A THV-40 Installation Manual (IMR02S02-E☐).....1
CD-ROM.....1

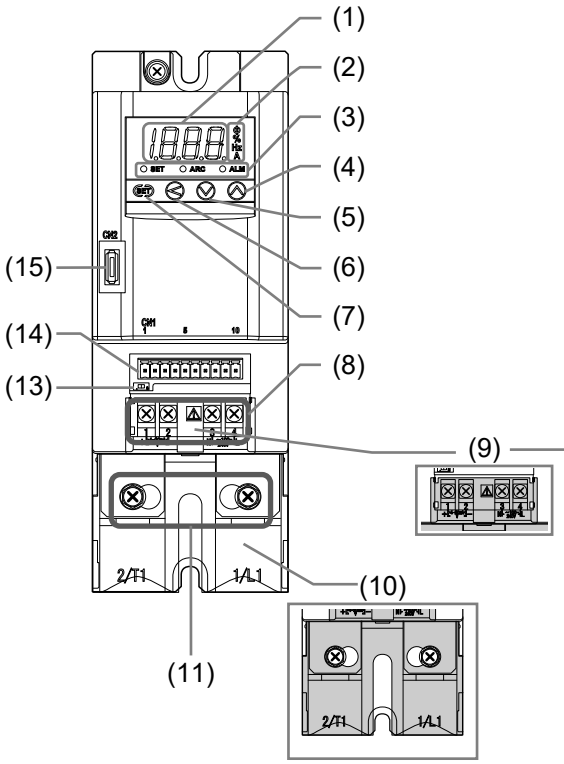
[Contents of CD-ROM]

- ReadMe
- 20 A/30 A/45 A/60 A/80 A/100 A THV-40 Installation Manual (IMR02S01-☐☐) *
- 150 A/200 A THV-40 Installation Manual (IMR02S02-☐☐) *
- THV-40 Instruction Manual (IMR02S03-☐☐) *

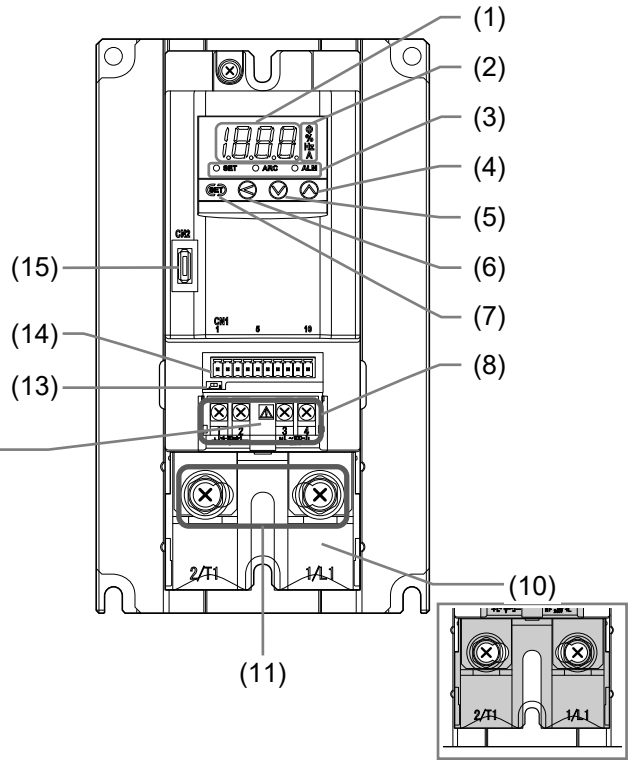
* This manual can be downloaded from the official RKC website.

1.3 Parts Description

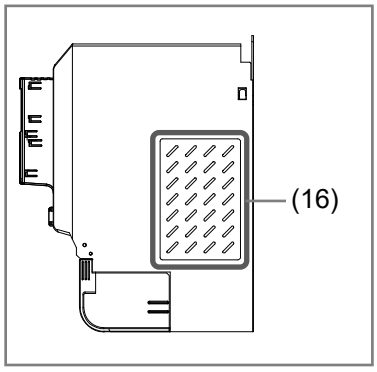
■ **20 A/30 A/45 A types**



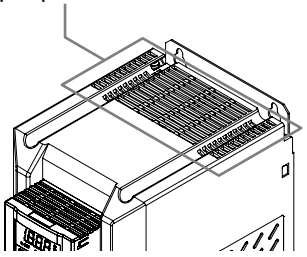
■ **60 A/80 A/100 A types**

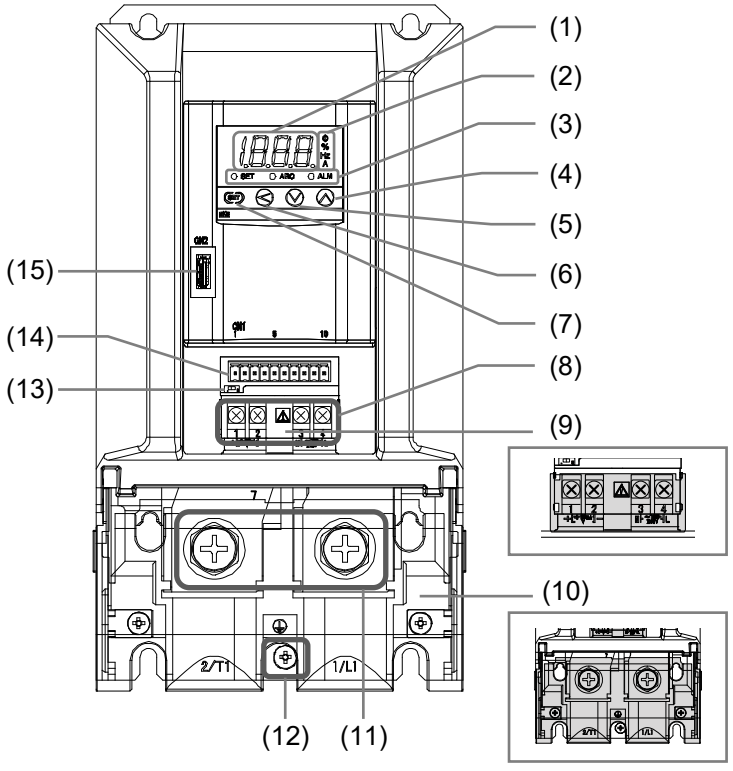


■ **150 A/200 A types**



Cooling fan (2 pieces)
The cooling fan is housed in the upper part of the instrument.





No.	Name	Description
(1)	Display	Shows the parameter symbols, input signal values, and various set values.
(2)	Unit display	Shows unit of input signal values and various set values.
(3)	Indication lamps	• SET: Lights during the setting mode. Flashes while Data setting lock is active. • ARC: Blinks while "knee points" is automatically calculated. (When a Non-linear resistance heater break alarm is used) • ALM: Lights up or blinks when any alarm occurs. The type of the generated alarm can be checked in the Alarm monitor (AL) in the Monitor mode.
(4)	UP key	• Increase numerals. • Used to select the function block (F□) of Engineering mode.
(5)	DOWN key	• Decrease numerals. • Used to select the function block (F□) of Engineering mode.
(6)	Shift key	• Used to select the mode. • Used to show the parameter symbols. • Shift digits when settings are changed.
(7)	SET key	• Used to select the mode. • Used to select the parameters. • Used for set value registration.
(8)	Input terminals (1, 2) Power supply terminals (3, 4)	• Input terminals (No. 1, No. 2) Used to connect input signal wires. • Power supply terminals (No. 3, No. 4) Used to connect power line (for the instrument) from a stepdown transformer.
(9)	Terminal cover (for input/output terminals).	Terminal cover for input and power terminals.
(10)	Terminal cover (for main circuit terminals)	Terminal cover for the main circuit terminal.
(11)	Main circuit terminals (2/T1, 1/L1)	Used to connect main circuit wires.
(12)	Protective earth (PE) terminal	Used to connect the grounding wire. (150 A/200 A types)
(13)	Input signal select switch	Used to select current or voltage input.
(14)	Input/output connector (socket)	Used to connect with a setter (potentiometer), external contact or controller. Also used as an alarm output terminal.
(15)	Loader communication connector	USB connector to connect to the RKC's communication converter COM-K2 or COM-KG.
(16)	Anti-slip finish	The housing has anti-slip finish allowing easy grip of the instrument. (150 A/200 A types)

2 MOUNTING

⚠ WARNING

- In order to prevent electric shock or instrument failure, always mount or remove this instrument after power supplied to the entire system is turned off.
- As the temperature of this instrument becomes high, mount the instrument on a non-inflammable material (metal plate, etc.).
- As this instrument generates a large amount of heat, it is cooled by circulating air by convection. Therefore, if mounted in any direction other than specified, accident or failure may result.
- When carrying this instrument, hold the heat radiation fin. In addition, always carry it with the heat radiation fin cooled. If held by the main body, deformation or damage to the main body may result. (20 to 100 A types)
- To carry the instrument, wait for the radiation fin to cool down. Grip the instrument firmly with your fingers on the anti-slip parts on both sides of the instrument. (150 A/200 A types)

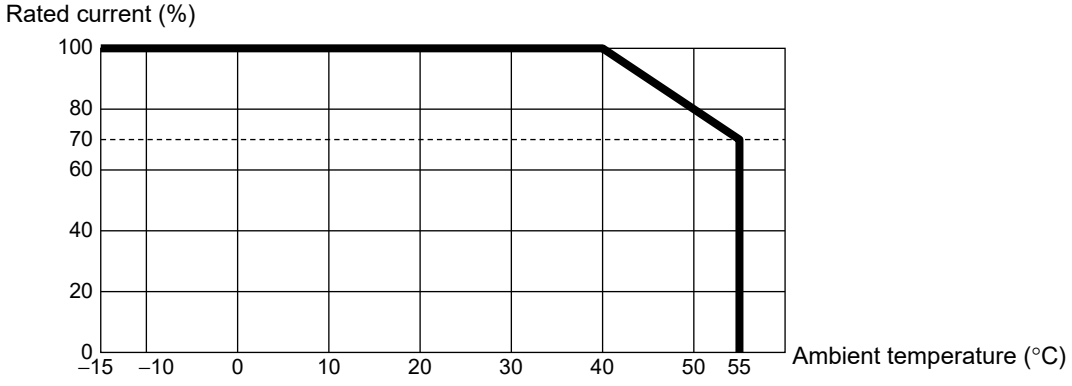
2.1 Mounting Environment

(1) This instrument is intended to be used under the following environmental conditions.

- EN60947-4-3 (Applicable instrument: All types)
  UL508 (Applicable instrument: 20 to 100 A types)
  C22.2 No.14 (Applicable instrument: 20 to 100 A types)
  UL60947-4-1 (Applicable instrument: 150 A/200 A types)
  C22.2 No.60947-4-1 (Applicable instrument: 150 A/200 A types)
  POLLUTION DEGREE 2 (Applicable instrument: All types)

(2) Use this instrument within the following environment conditions:

- Allowable ambient temperature:
  −15 to +55 °C (The rated current drops when the ambient temperature exceeds 40 °C.)



Temperature characteristic (20 to 200 A types)

📖 The environmental condition is the same for close mounting (20 to 100 A types).

- Allowable ambient humidity:
  5 to 95 %RH (Absolute humidity: MAX. W. C 29 g/m^3 dry air at 101.3 kPa)

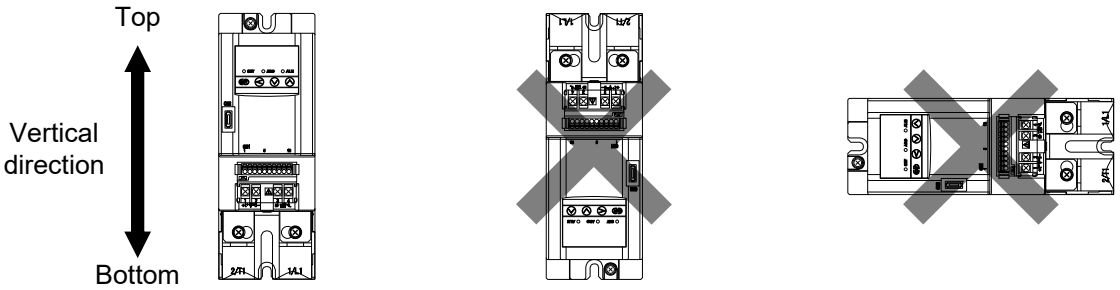
(3) Do not use this instrument in the following environment:
- Sudden change in ambient temperature
- Condensation or icing
- Corrosive or inflammable gases.
- Such a place where there are inflammable materials near this instrument.
- Strong vibration or impact
- Water, oil, chemicals, vapor or steam splashes.
- Excessive dust, salt or iron particles.
- Excessive induction noise, static electricity, magnetic fields or noise.
- Direct air flow from an air conditioner.
- Exposure to direct sunlight.
- Direct radiant heat

2.2 Mounting Cautions

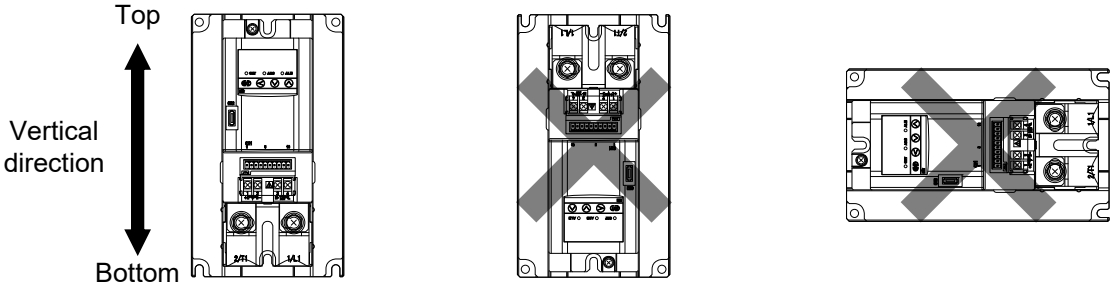
Take the following points into consideration when mounting this instrument.

- The instrument must be mounted in a proper direction. When installing the instrument, observe mounting directions.

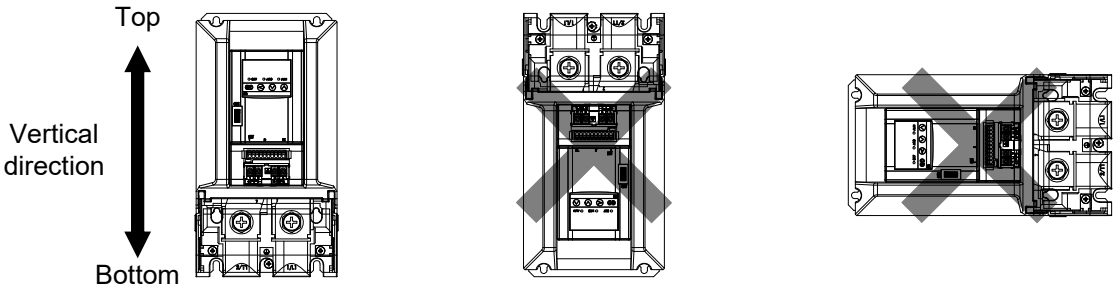
20 A/30 A/45 A types



60 A/80 A/100 A types



150 A/200 A types

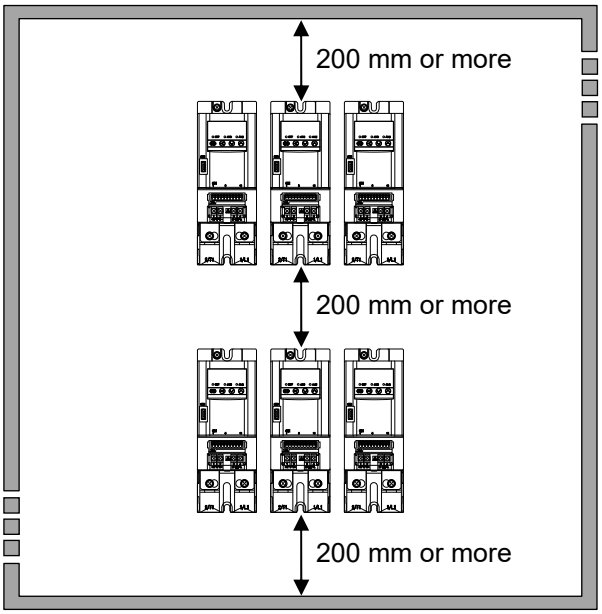


- Provide adequate heat radiation space so that heat does not build up.

- Radiation space

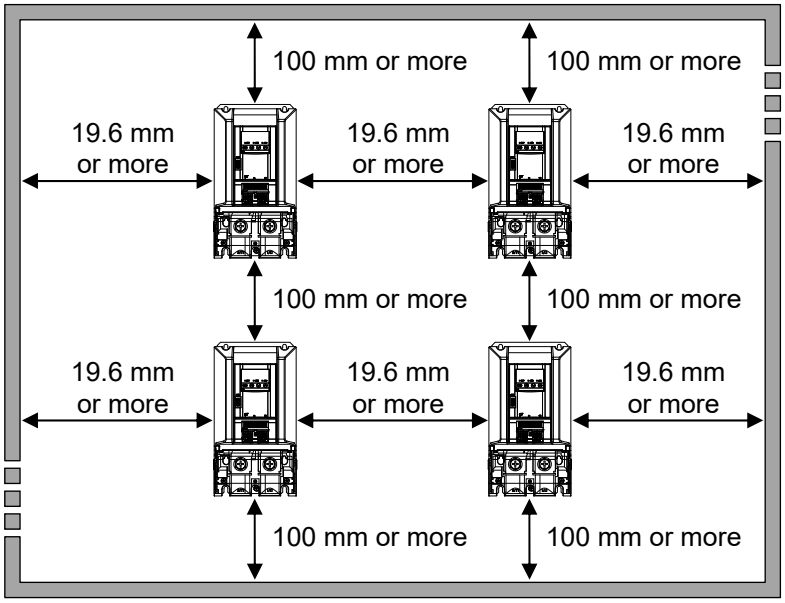
  For 20 to 100A types:

  The instrument requires radiation space above and below it. Allow minimum 200 mm clearance. (The diagram shows the 20 A type. The same space is required for the other types.)

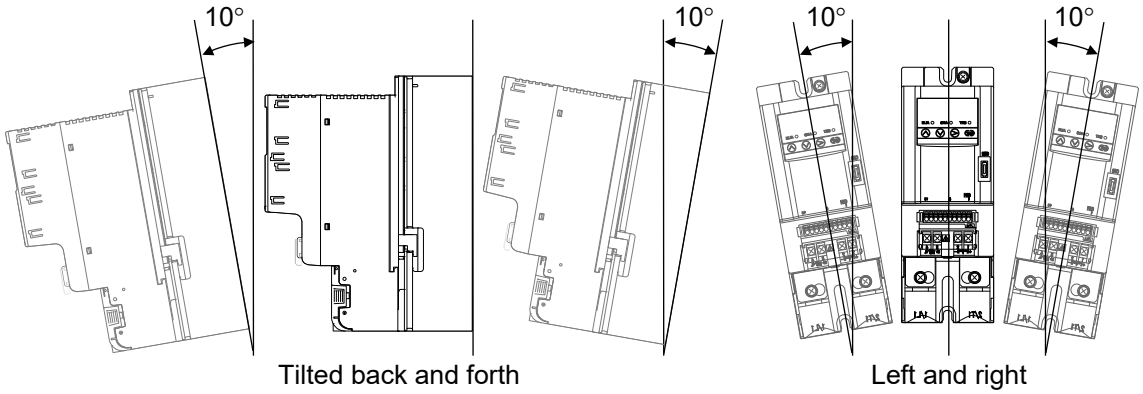


  For 150 and 200A types:

  At least 19.6 mm is necessary on the left and right and at least 100 mm on the top and bottom.



- Mount the instrument tilted within 10 degrees from vertical (back and forth and left and right). (The figure shows a 20 A type, but also observe the same angle for other models.)



- The temperature inside the control panel increases due to heat generation of this instrument itself. Therefore, take into account full ventilation by mounting forced ventilation fans on the panel.

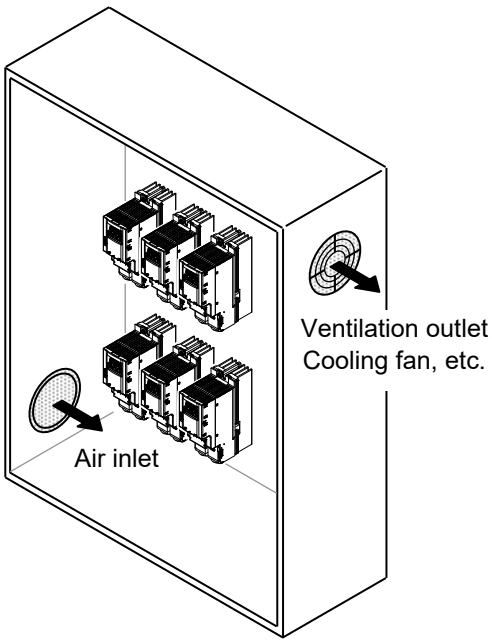


Table of calorific values
(380 to 480 V AC)

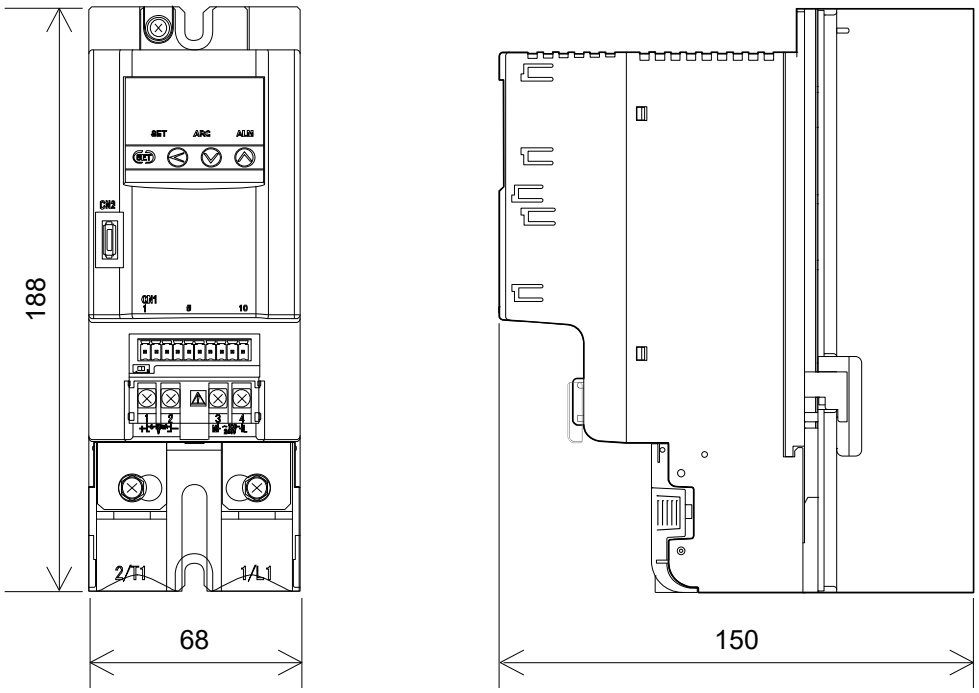
Rating current	Calorific value
20 A	Approx. 30 W
30 A	Approx. 43 W
45 A	Approx. 63 W
60 A	Approx. 84 W
80 A	Approx. 112 W
100 A	Approx. 140 W
150 A	Approx. 200 W
200 A	Approx. 250 W

2.3 Dimensions

■ 20 A/30 A/45 A types

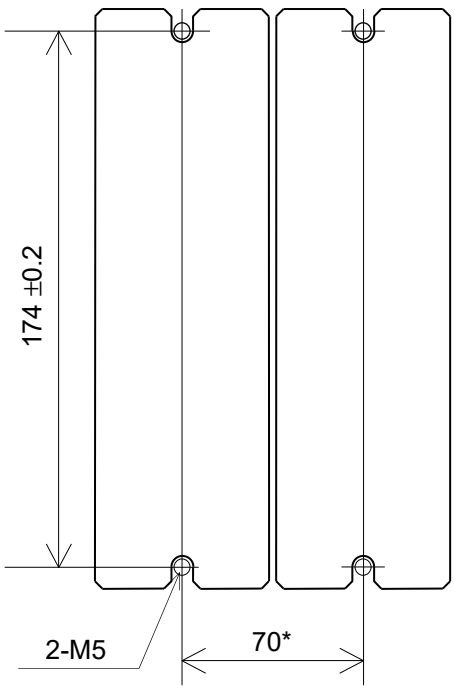
Dimensions

Unit: mm



Mounting dimensions

Unit: mm

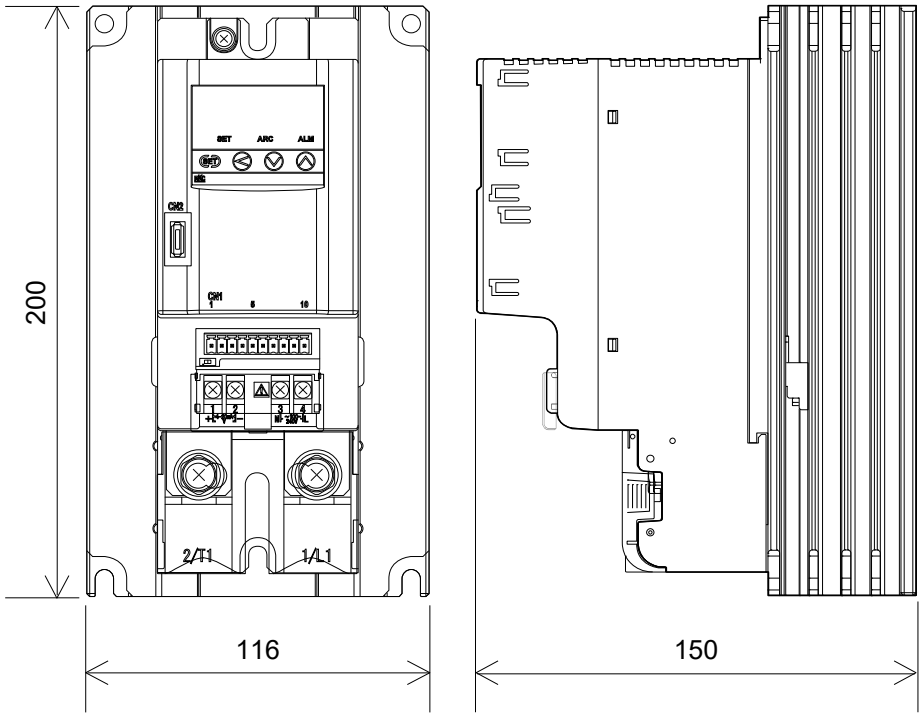


* Minimum space when mounted closely side by side.

■ 60 A/80 A/100 A types

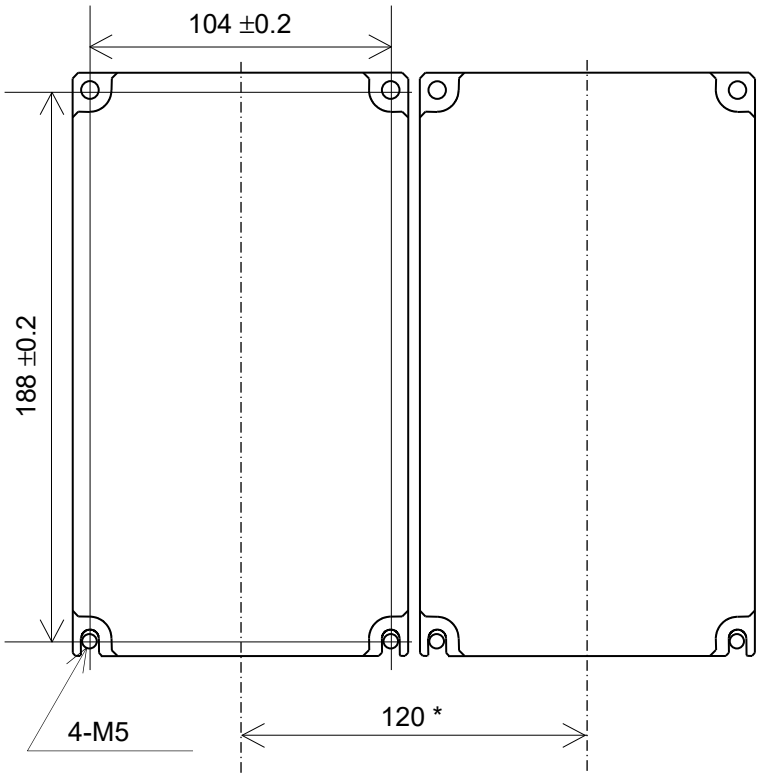
Dimensions

Unit: mm



Mounting dimensions

Unit: mm

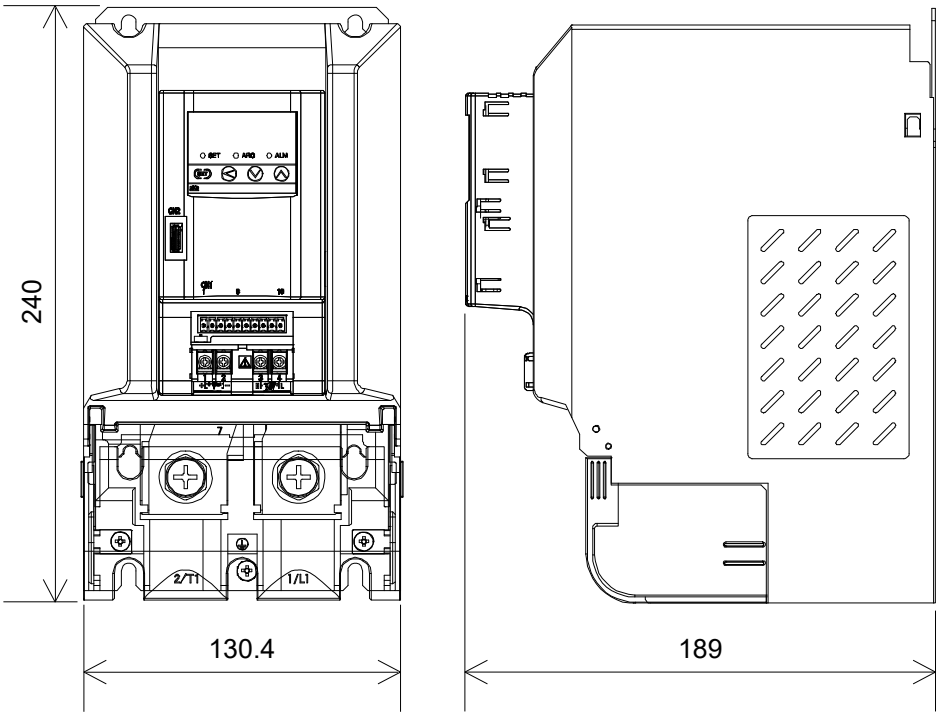


* Minimum space when mounted closely side by side.

■ 150 A/200 A types

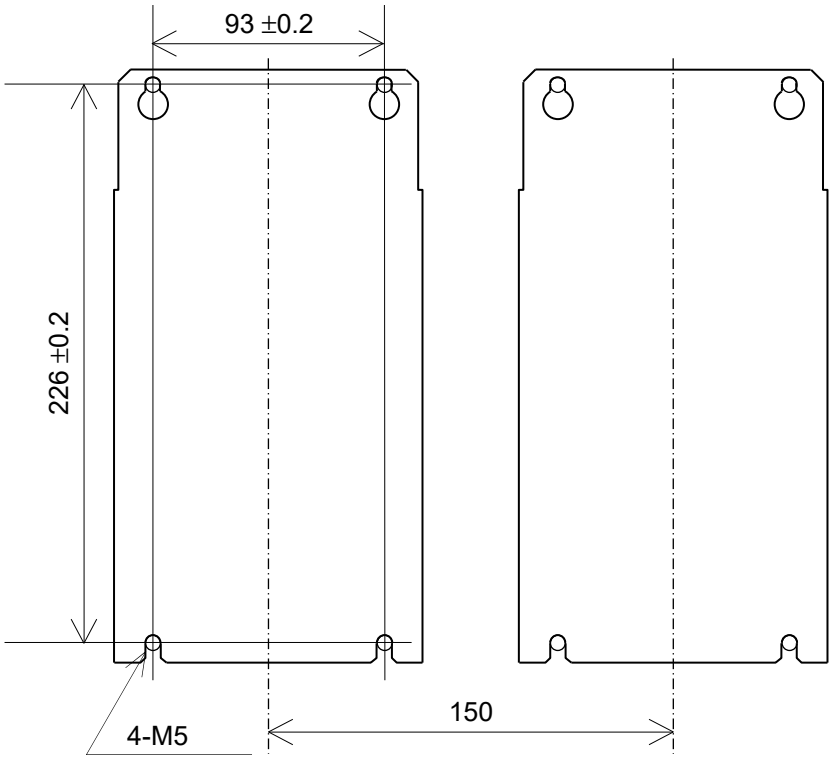
Dimensions

Unit: mm



Mounting dimensions

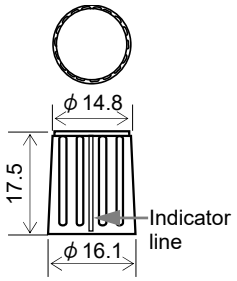
Unit: mm



Both of 150 A and 200A types are not available for being installed close together.

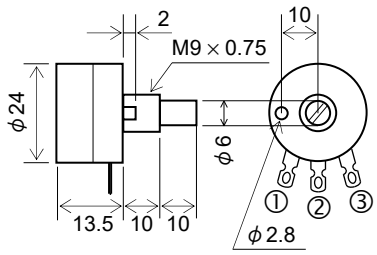
■ Setter [Potentiometer, Knob and Scale plate] (THV1P-S01)

Unit: mm

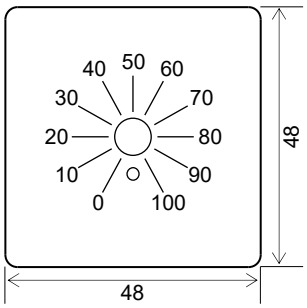


Knob

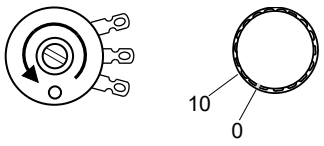
ϕ : Diameter



Potentiometer
(Resistance 5 kΩ, variation characteristic: B)



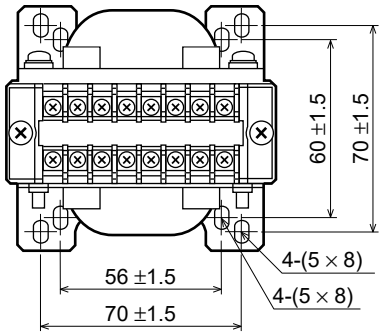
Scale plate

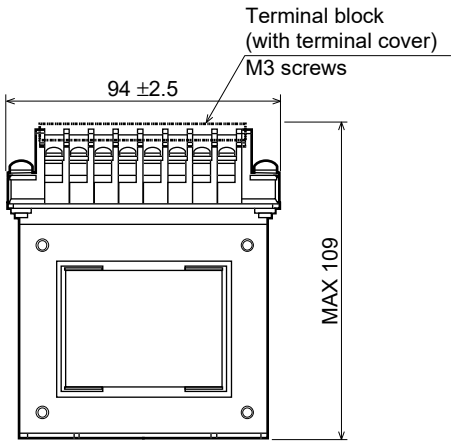


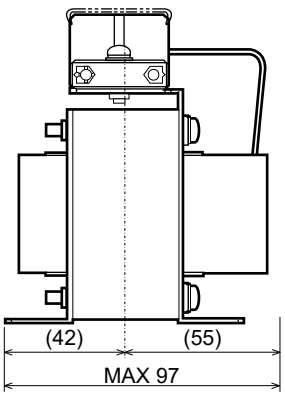
Turn the potentiometer counterclockwise fully before combining it with the scale plate.
When attaching a knob, align the Indicator line on the knob with 0 on the scale plate and then combine it.

■ Stepdown transformer [for instrument power supply] (CH1-4H381-006)

Unit: mm

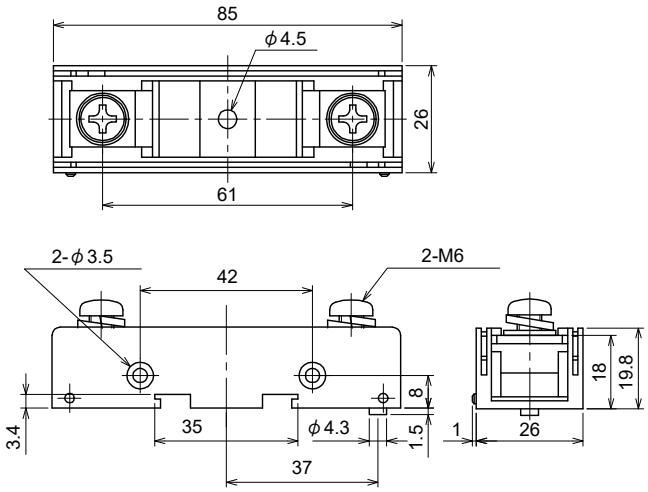






■ Fast-blow fuse for 20 to 100 A [Not UL certified] (THV4P-H01)

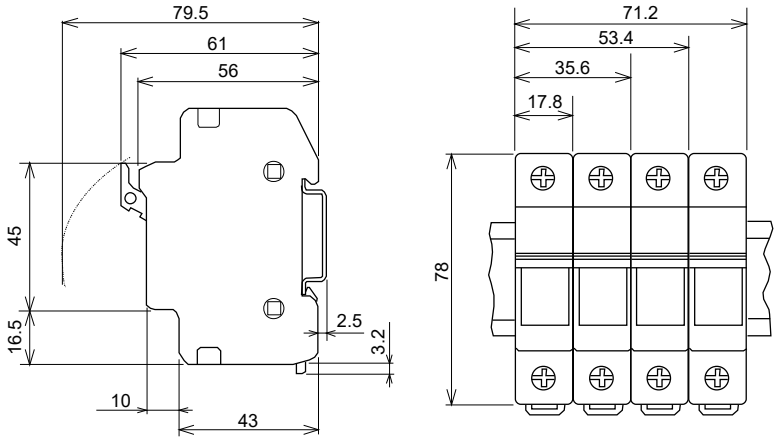
Unit: mm



ϕ: Diameter

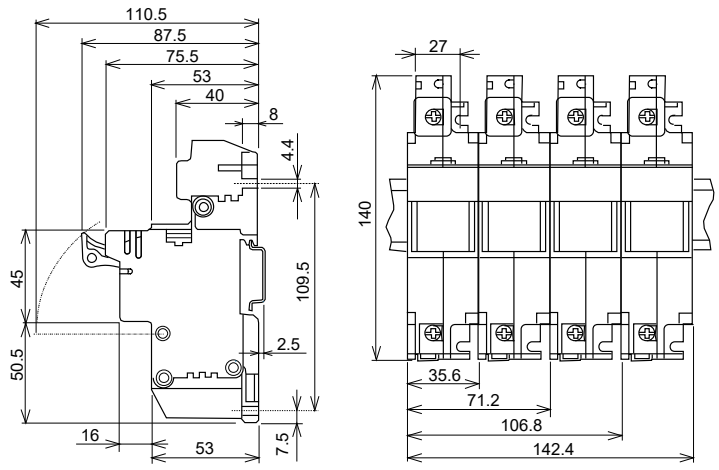
■ Fuse holder (UL approved instrument) for 20 A and 30 A (THVP-H04)

Unit: mm



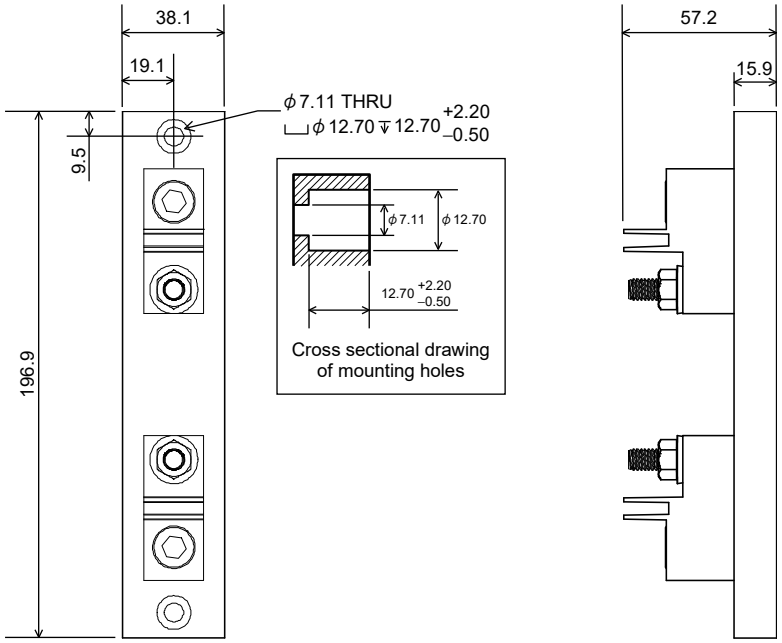
■ Fuse holder (UL approved instrument) for 45 A/60 A/80 A and 100 A (THVP-H05)

Unit: mm



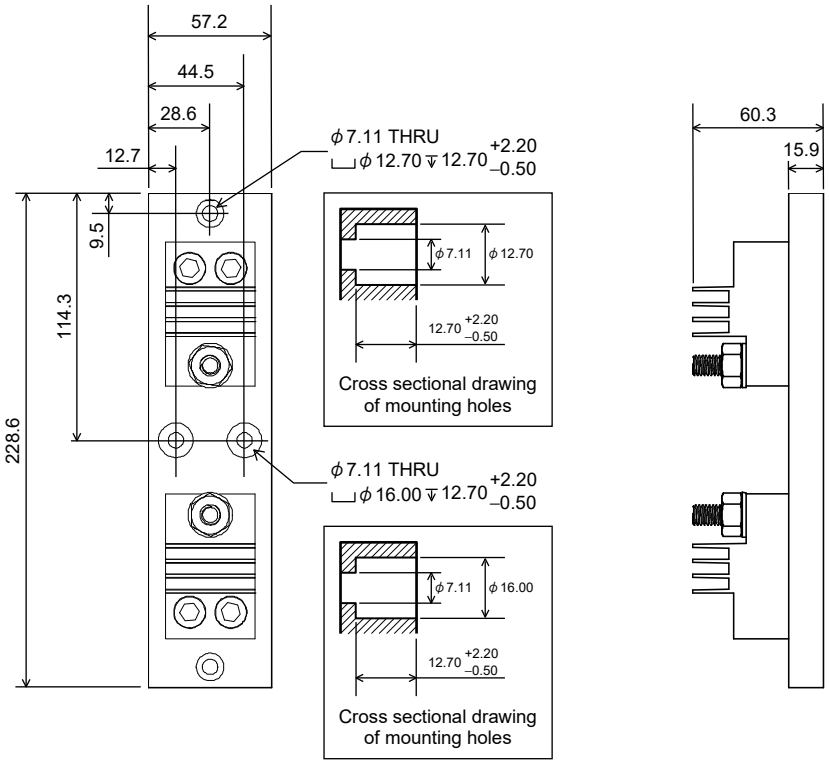
■ Fuse holder (UL approved instrument) for 150 A (THV4P-H06)

Unit: mm



■ Fuse holder (UL approved instrument) for 200 A (THV4P-H07)

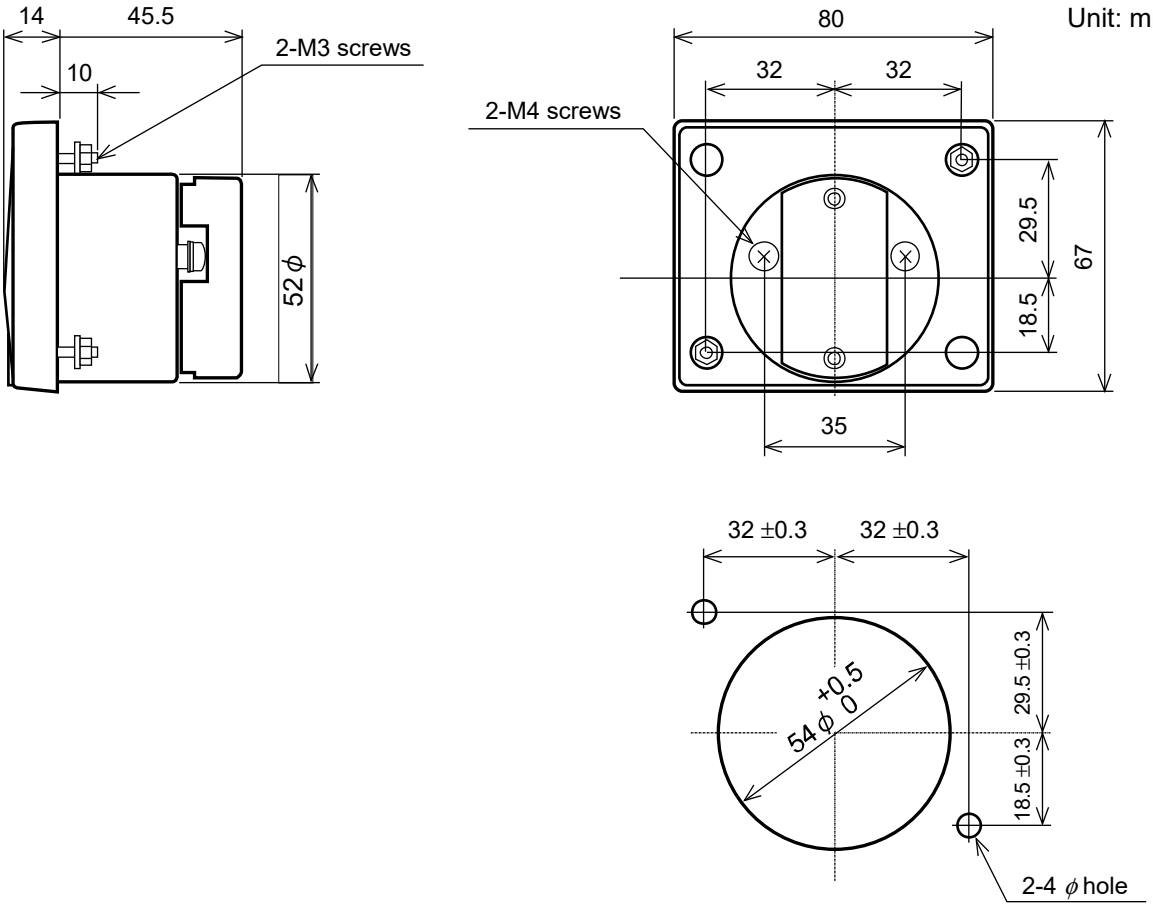
Unit: mm



■ Output voltmeter (600 V span) [For Phase control] (THV4P-V03)

● Output voltmeter

Unit: mm

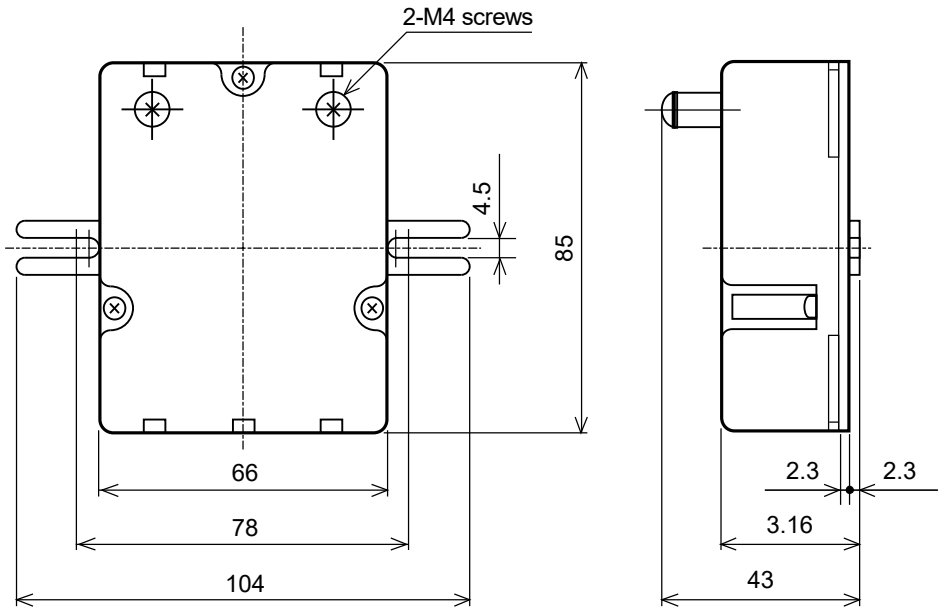


Panel cutout dimensions

ϕ: Diameter

● Series resistor

Unit: mm



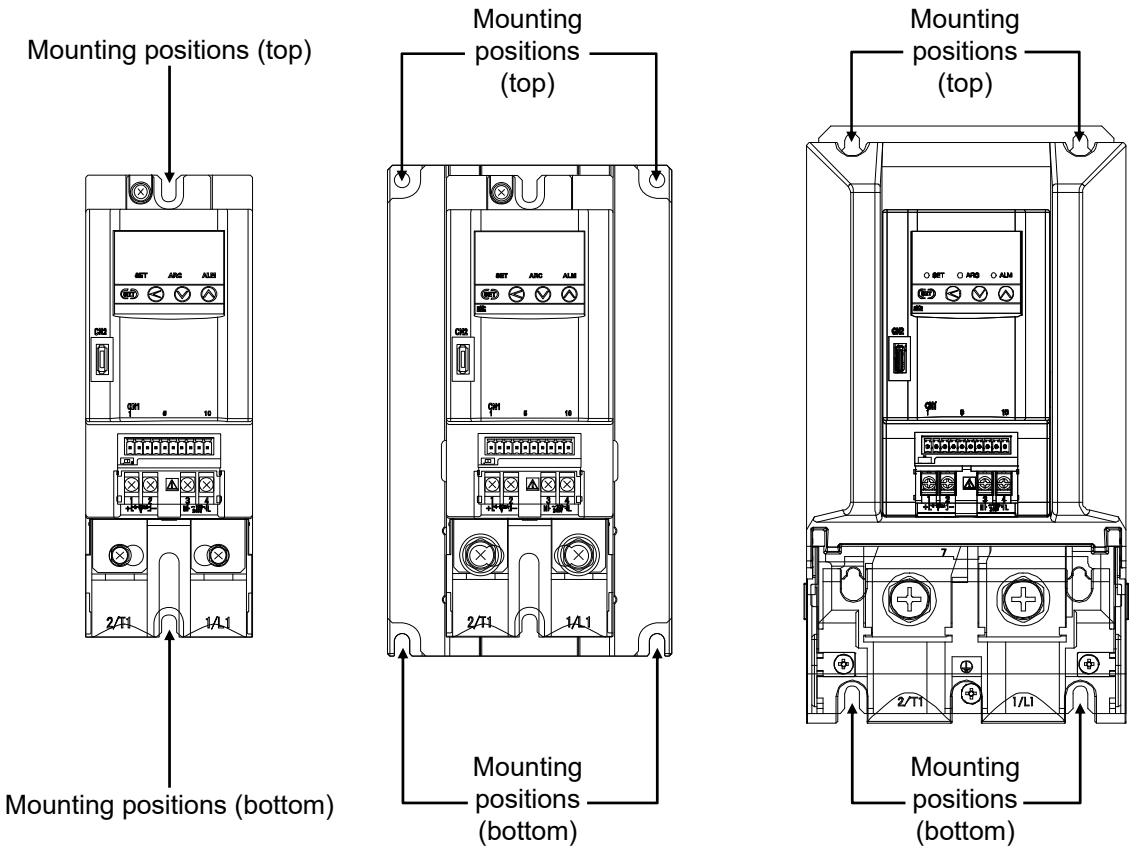
2.4 Mounting Procedures

1. Prepare the holes as specified in **2.3 Dimensions**.

2. Place the instrument in mounting position.

3. Insert the mounting screws into the holes, then tighten them with a screwdriver.

- **Mounting screw**
  Customer must provide the set of screws.
  Screw type: Pan-head screws
  Size: M5, Length: 10 mm
  Recommended tighten torque: 3.6 N·m [36 kgf·cm]



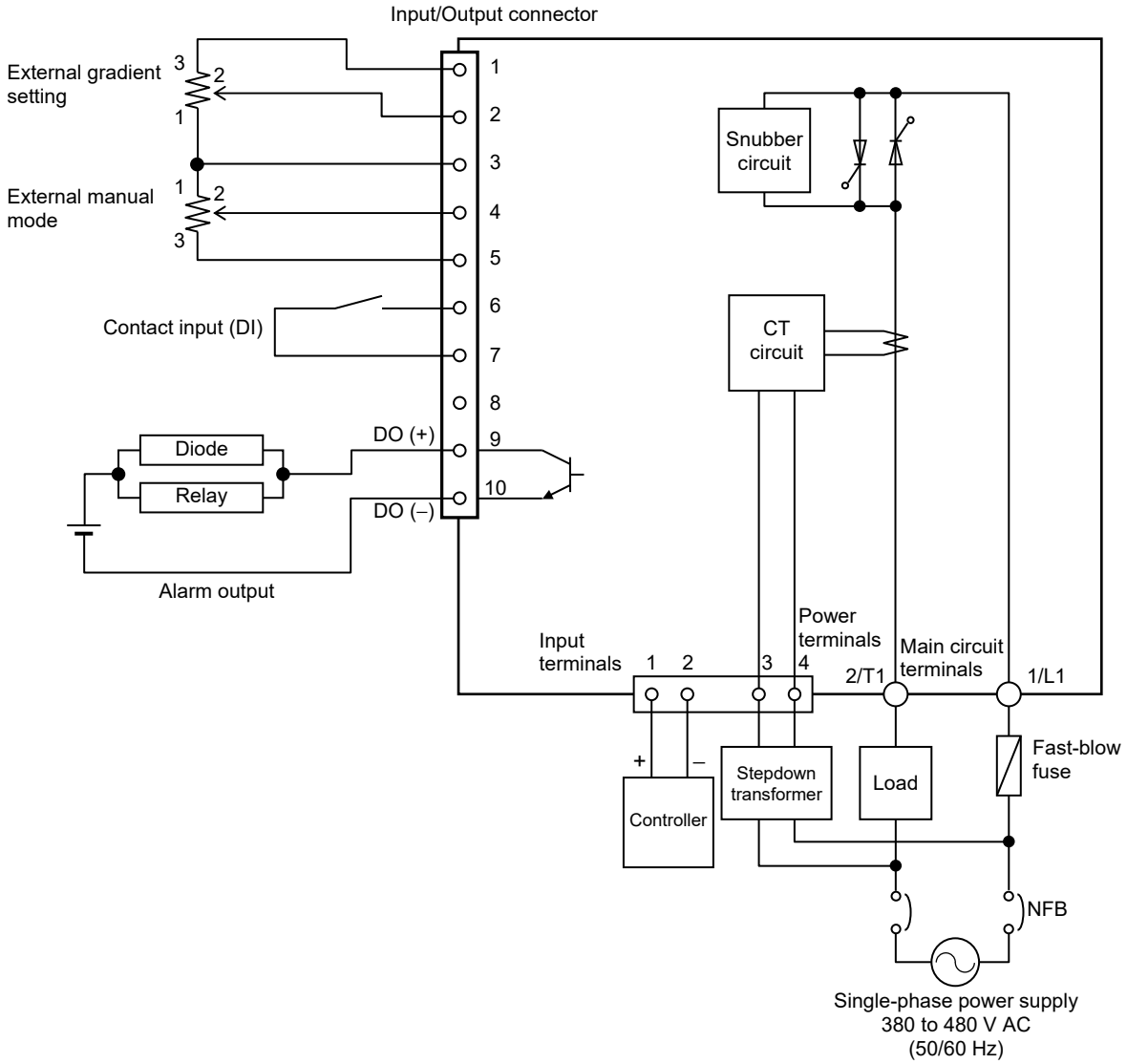
20 A/30 A/45 A types **60 A/80 A/100 A types** **150 A/200 A types**

3 WIRING

⚠ WARNING

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

3.1 Circuit Block Diagram



- The fast-blow fuse, CT circuit and stepdown transformer are optional.
- If the contact input (DI) is used, functions must be assigned to contact input.
- Alarm types must be selected for the alarm outputs.

3.2 Wiring of Main Circuit

Conduct wiring by referring to the wiring diagram and the tightening torque table.

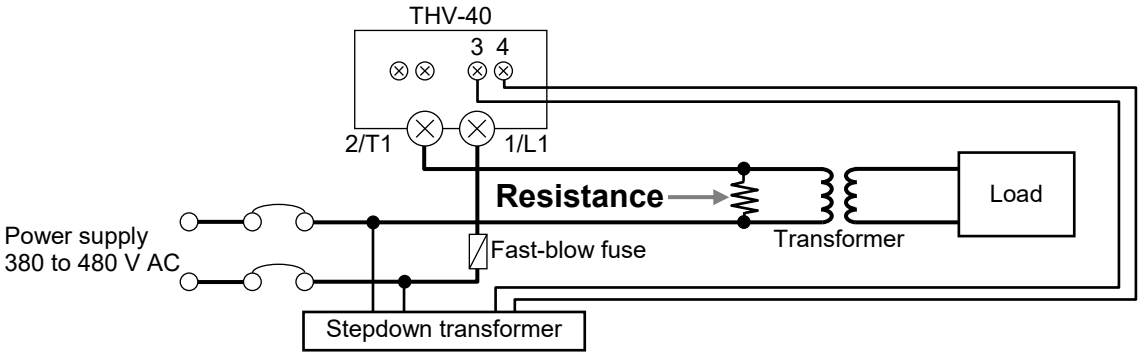
CAUTIONS

- Match the phase between the supply voltage for the instrument and the supply voltage for the load. Without proper matching, the instrument may not work properly.
- Caution for connecting a transformer to the load side of the instrument
  - When a protection function for control of primary side of a transformer is provided:
    To conduct control of primary side of a transformer, make sure protection function for control of primary side of a control is set. Appropriately adjust the soft-start time for in case of secondary side breakdown depending on the operating condition.
  - When a protection function for control of primary side of a transformer is not provided:
    If the action of the device is influenced by excessive current (inrush current, current due to flux saturation of transformer), use a transformer 1.25 T (magnetic flux density) or less. Make sure soft-start time is appropriately set.

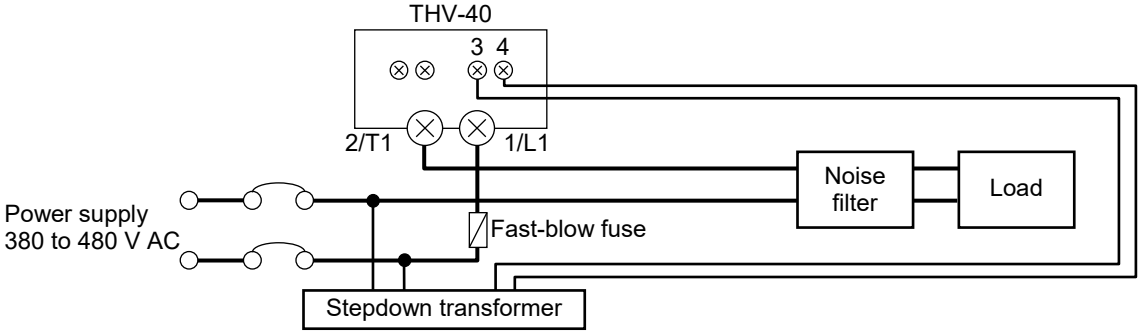
    When connecting a transformer to the load side of this product, make sure that the current value of the primary side of the transformer is equal to or more than the minimum load current of this product. When the current value of the primary side of the transformer is less than the minimum load current value of this product, connect a bleeder resistor in parallel with the primary side of the transformer, and allow the current more than the minimum load current to flow.

    Minimum load current: 0.6 A (20 A type) 1 A (30 A type or more)

    When control is started on this instrument without connecting a load to the transformer, it may result in heat generation or failure of the transformer. Control must be always conducted with the load connected.



- Caution for connecting a noise filter to the load side of the instrument
  When the control of this instrument is started without connecting a load in a configuration where a noise filter is connected to the load side of the instrument, a large surge may occur to the noise filter and a damage of the instrument may result. Control must be always conducted with the load connected.



- There are neither fuses nor power switches in the power circuit of this instrument. Therefore install the fuses and switches near the instrument, if necessary.
- To avoid noise induction, keep input signal wire of controller away from instrument power line, load lines and power lines of other electric equipment. If wiring near high-voltage power is unavoidable, use shielded wires.
- Use wires satisfying the rated current capacity.
- Tighten the hexagon headed bolts on the main circuit terminals using a torque wrench. Always tighten each of them by contacting the diagonal surfaces of the wrench with those of each hexagon head.
- Firmly tighten each terminal hexagon headed bolt with the tightening torque specified below. Otherwise, electric shock, fire or heat generation may result.
- Choose solderless terminals from the following table.

Input terminals (1, 2) and Power supply terminals (3, 4)

	20 A/30 A/45 A/60 A/80 A/100 A/150 A/200 A
Maker	J.S.T Mfg. Co., Ltd.
Parts No.	V1.25-MS3
Applicable wire (twisted wire)	0.5 to 1.25 mm^2
Recommended tightening torque	0.4 N·m (4 kgf·cm)

Main circuit terminals (2/T1, 1/L1)

	20 A/30 A	45 A/60 A	80 A/100 A
Maker	J.S.T Mfg. Co., Ltd.		
Parts No.	V5.5-4 (Circular terminal with isolation)	R14-6 (Circular terminal)	R38-8 (Circular terminal)
Applicable wire (twisted wire)	2.63 to 5.5 mm^2	10.52 to 14 mm^2	26.66 to 38 mm^2
Recommended tightening torque	1.6 N·m (16 kgf·cm)	3.8 N·m (38 kgf·cm)	9.0 N·m (90 kgf·cm)

Main circuit terminals (2/T1, 1/L1)

	150 A	200 A
Maker	J.S.T Mfg. Co., Ltd.	
Parts No.	R60-10 (Circular terminal)	R100-10 (Circular terminal)
Applicable wire (twisted wire)	42.42 to 60.0 mm^2	96.3 to 100.0 mm^2
Recommended tightening torque	18.0 N·m (180 kgf·cm)	

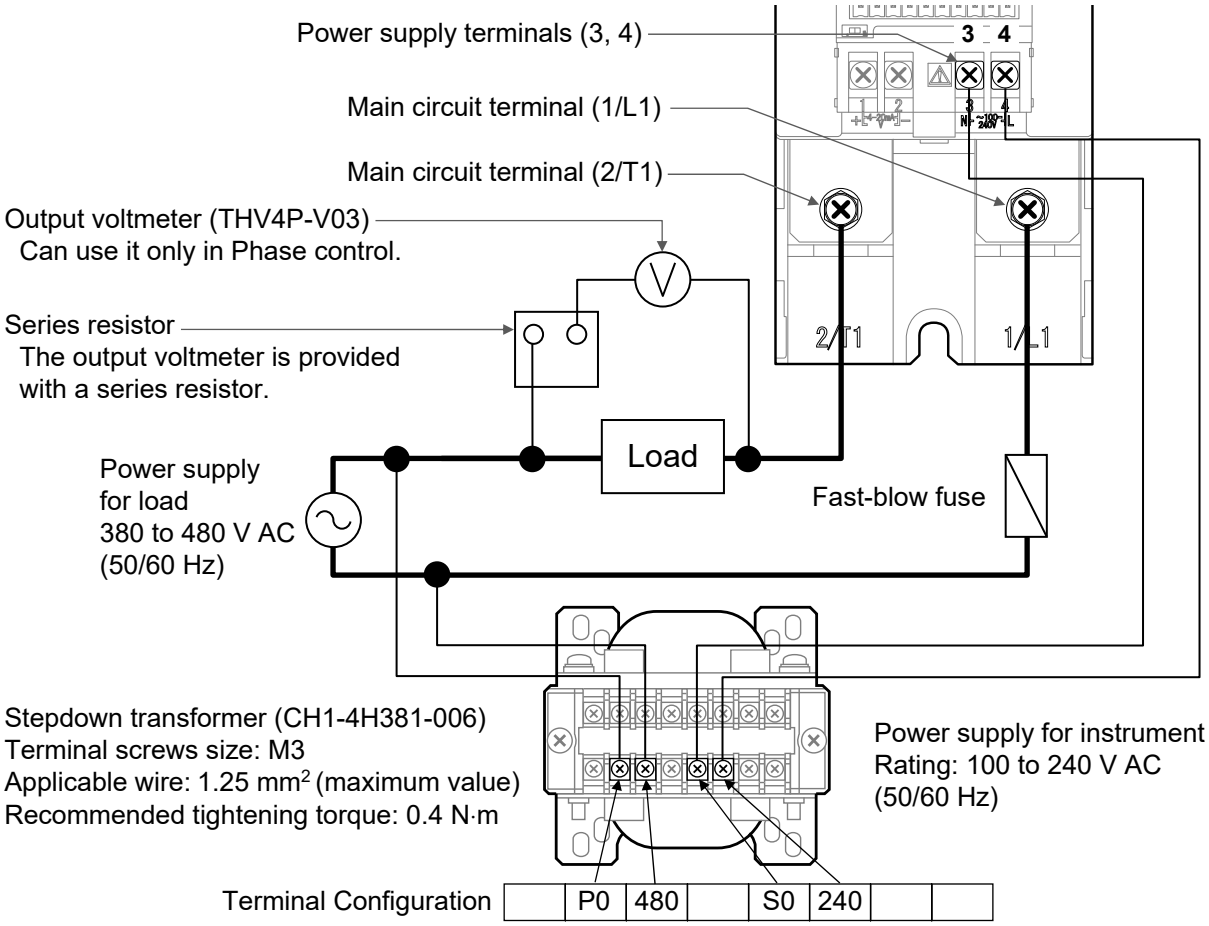
- Make sure that during field wiring parts of conductors cannot come into contact with adjacent conductive parts.
- The 20 to 100 A types of instrument have no PE terminal. There is no need of grounding the 20 to 100 A types of instrument.
- This stepdown transformer (CH1-4H381-006) is specially designed for use with this instrument. DO NOT use this transformer in other applications.
- Up to the following number of THV-40 can be connected to a single stepdown transformer.
  THV-40 (20 to 100 A types): Up to 3 THV-40 (150 A/200 A types): Up to 1
- For the output voltmeter, connect a series resistor.

■ Wiring diagram of main circuit

Match the phase between the supply voltage for the instrument and the supply voltage for the load. Without proper matching, the instrument may not work properly.

☞ Refer to **P. 3-4** for recommended types of solderless terminals for wiring and recommended tightening torque.

☞ Refer to **P. 8-7** for how to remove the terminal cover for the main circuit terminal.



Terminal screws size

	20 A/30 A	45 A/60 A	80 A/100 A	150 A/200 A
Main circuit terminals (2/T1, 1/L1)	M4 × 16	M6 × 16	M8 × 20	M10 × 25
Power supply terminals (3, 4)	M3 × 7 (With 5.8 × 5.8 square washer)			

The fast-blow fuse, output voltmeter and stepdown transformer are optional.

Below is a recommended transformer in case a stepdown transformer is arranged on the customer's side.
Recommended: CHUO ELECTRIC IND.CO.,LTD. Type: CH1-4H381-006

Below is a recommended transformer in case an output voltmeter is arranged on the customer's side.
Recommended: DAIICHI ELECTRONICS CO.,LTD. Type: LSK-8CH (output voltmeter)
DM-41 (series resistor)

The picture shows 20 to 45 A types. Wiring for 60 to 200 A types is the same.
The 150 A/200 A types require protective earth connection.
Refer to **P. 3-7** for the details of the wiring.

■ Wiring diagram of main circuit (Compliance with EMC- and LV directive)

In order to comply with the European EMC- and LV directive the noise filter should be applied. Customer must provide the noise filter.

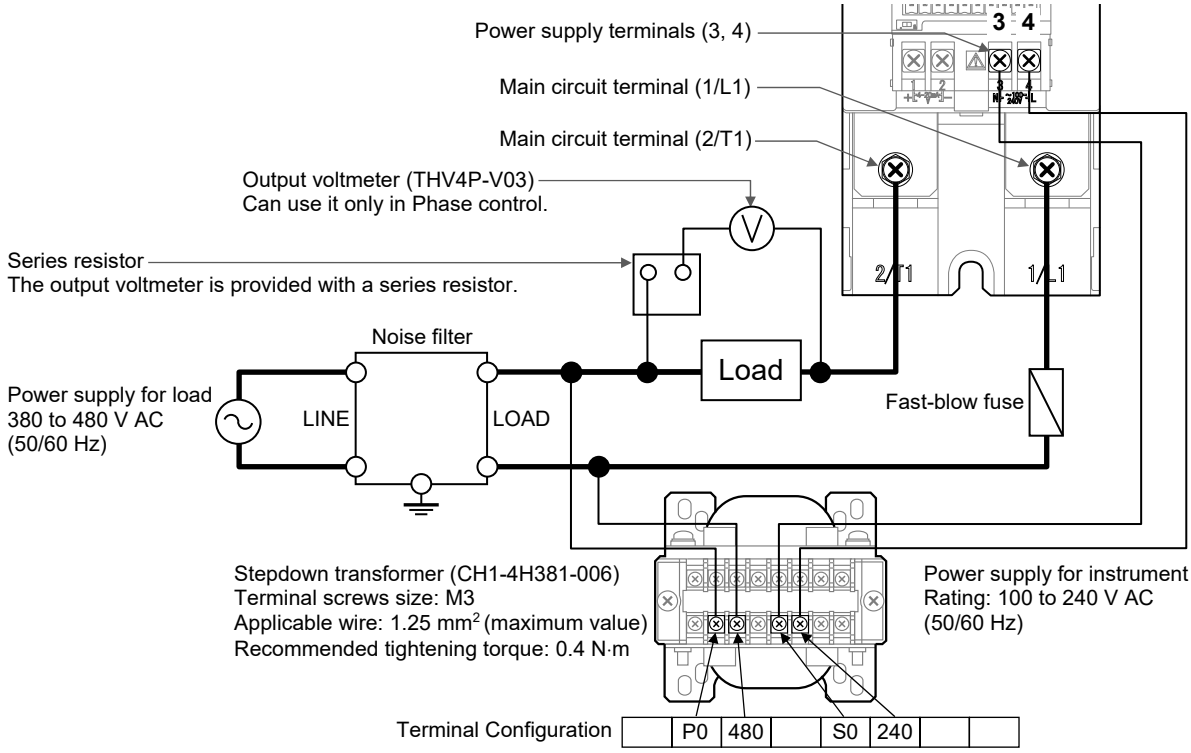
The noise filter specified (SOSHIN ELECTRIC CO., LTD.)

20 A: NF3020C-SVB	60 A: NF3060C-SVB	150 A: HF3150C-SZC
30 A: NF3030C-SVB	80 A: HF3080C-SZC	200 A: NF3200C-VZ
45 A: NF3050C-SVB	100 A: HF3100C-SZC	

Match the phase between the supply voltage for the instrument and the supply voltage for the load. Without proper matching, the instrument may not work properly.

☞ Refer to **P. 3-4** for recommended types of solderless terminals for wiring and recommended tightening torque.

☞ Refer to **P. 8-7** for how to remove the terminal cover for the main circuit terminal.



Terminal screws size

	20 A/30 A	45 A/60 A	80 A/100 A	150 A/200 A
Main circuit terminals (2/T1, 1/L1)	M4 × 16	M6 × 16	M8 × 20	M10 × 25
Power supply terminals (3, 4)	M3 × 7 (With 5.8 × 5.8 square washer)			

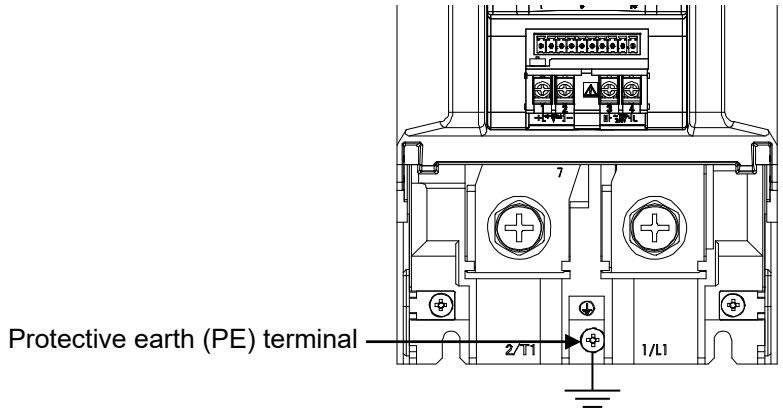
The fast-blow fuse, output voltmeter and stepdown transformer are optional.

Below is a recommended transformer in case a stepdown transformer is arranged on the customer's side.
Recommended: CHUO ELECTRIC IND.CO.,LTD. Type: CH1-4H381-006

Below is a recommended transformer in case an output voltmeter is arranged on the customer's side.
Recommended: DAIICHI ELECTRONICS CO.,LTD. Type: LSK-8CH (output voltmeter)
DM-41 (series resistor)

The picture shows 20 to 45 A types. Wiring for 60 to 200 A types is the same.
The 150 A/200 A types require protective earth connection.
Refer to **P. 3-7** for the details of the wiring.

3.3 Wiring of Protective Earth (PE) Terminal (150 A/200 A types)



- Protective earth no other devices to the location where you earth this device.
- Avoid sharing earth lines with electric motors, motorized equipment, and other equipment that uses large amounts of electrify.
- In the earth system, be careful to earth each point and not to create a earth loop.
- Connect so that the earth resistance is no greater than 100 Ω.
- Use wire of at least 2.0 mm^2 for earth lines.

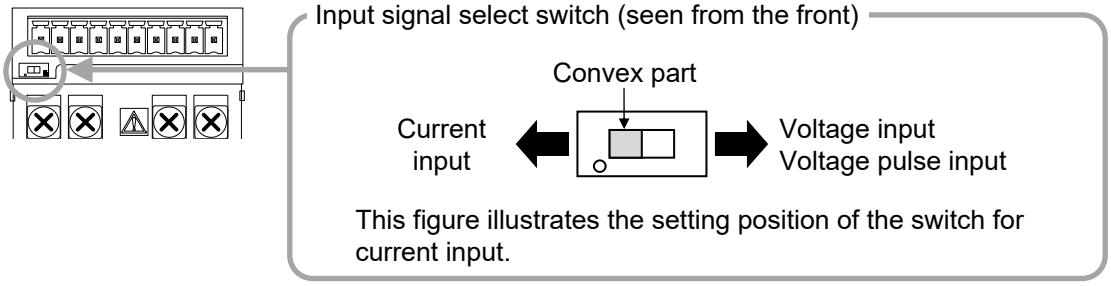
3.4 Wiring of Input Signal

Input signal is factory preset to your specification. In case input signal type needs to be changed on the user's side, attempt wiring after having modified the input signal type.

☞ For details on changing the input signal type, refer to **3.4.2 Input signal type changing method (P. 3-9)**.

3.4.1 Wiring procedure for input signal

1. Make sure that the Input signal select switch is set to the signal specified at the time of ordering. The Input signal select switch is located below the Input/Output connector.



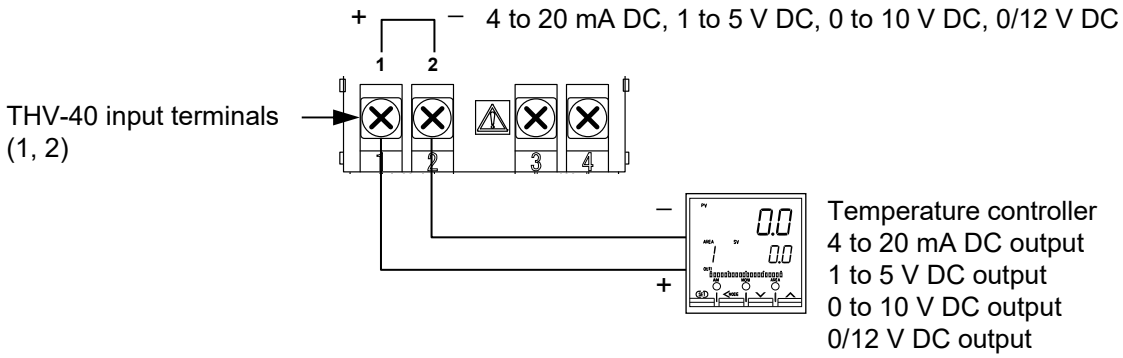
2. Connect output signal from a temperature controller, etc to input terminals 1 (+) and 2 (-) of this instrument.

☞ Refer to **P. 3-4** for recommended types of solderless terminals for wiring and recommended tightening torque.

Input impedance of THV-40 input terminals

Current input: Approx. 50 Ω

Voltage input or Voltage pulse input: Approx. 30 kΩ



Terminal screws size

	20 A/30 A/45 A/60 A/80 A/100 A/150 A/200 A
Input terminals (1, 2)	M3 × 7 (With 5.8 × 5.8 square washer)

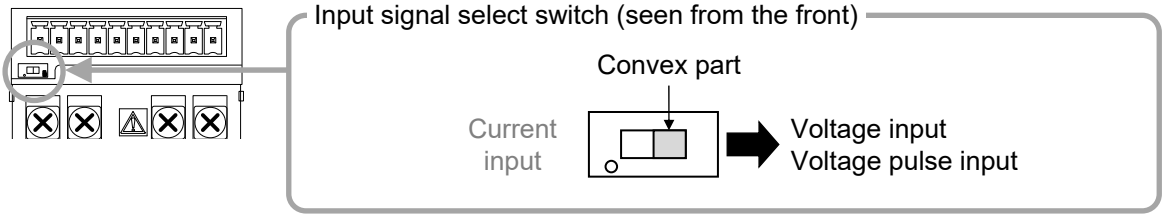
Wiring diagram of input signal

3.4.2 Input signal type changing method

Make sure the input signal type is properly configured before wiring input signals to the instrument. If input signal terminals are already wired, be sure to turn off the output from an external device (such as a temperature controller) before attempting the change of the input signal type.

Example: Example of changing 4 to 20 mA DC current input to 0 to 10 V DC voltage input.

1. Power off the instrument.
2. Set the Input signal select switch to the voltage input from the current input with a small screwdriver. There is an Input signal select switch under a Input/Output connector.



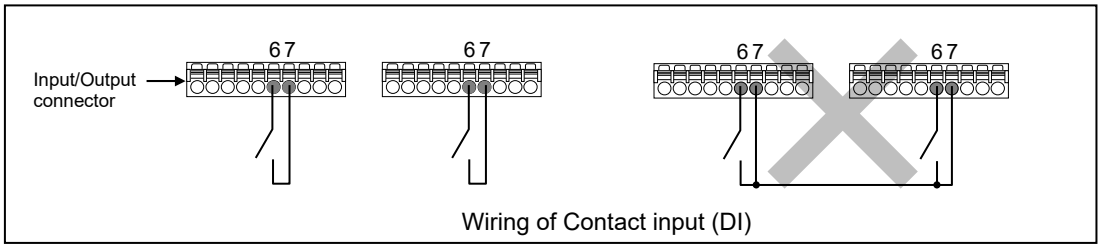
3. Power on the instrument.
4. Enter the "Engineering mode" and set "1: 0 to 10 V DC, 0/12 V DC" with the Input signal type selection (IS).

For the setting method of the Input signal type selection (IS), refer to **5.5 Setting Input Signal at the Time of Auto Mode (P. 5-10)**.

Thus, the changing has been finished.

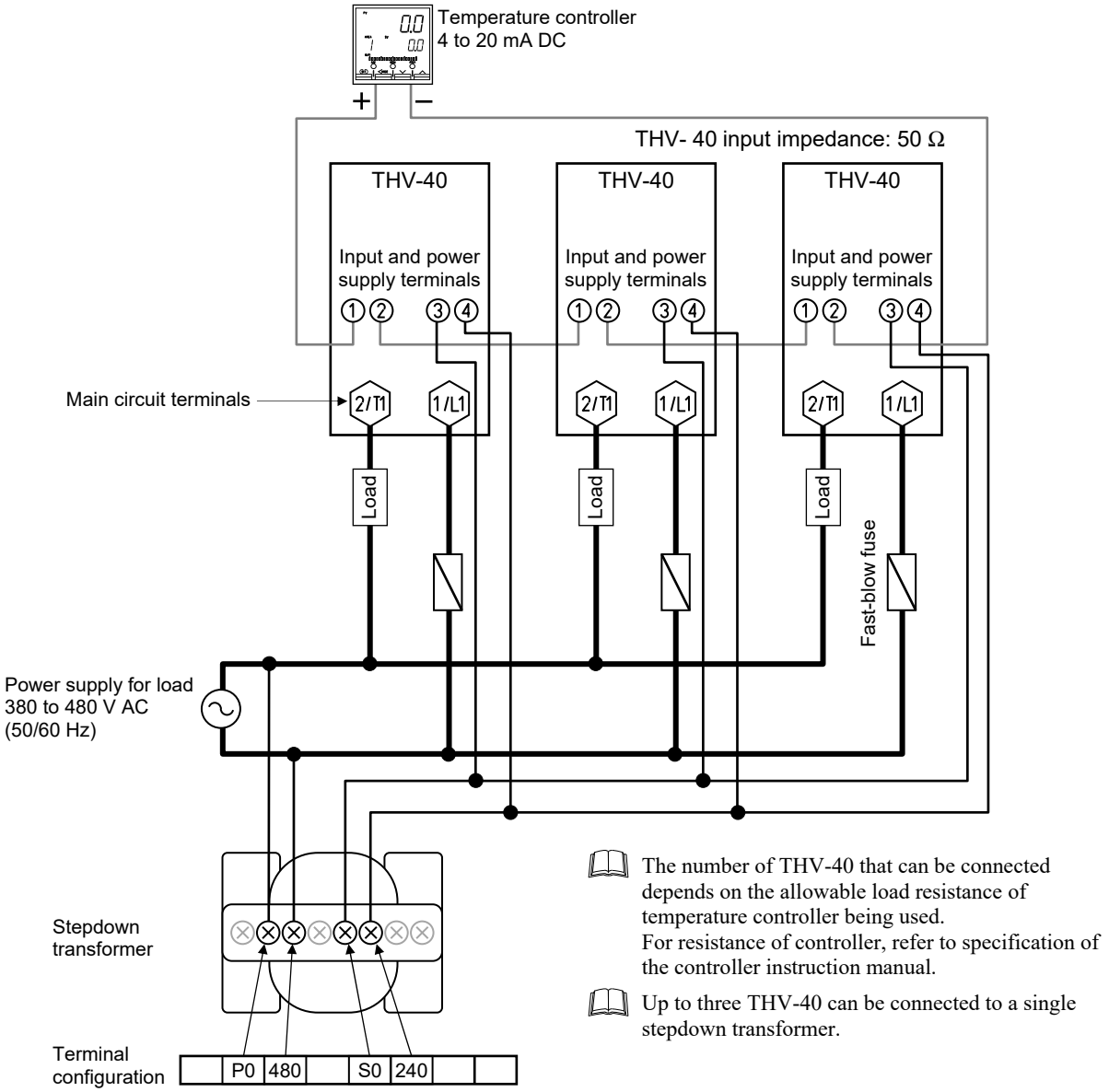
3.4.3 Wiring example of the series connection (For current input)

The Control input, External gradient setting, External manual setting, and Contact inputs (DI) are not insulated. If any connections other than the Control inputs are made between the serially connected devices, the Control input may not be input normally. When connecting Contact inputs (DI), connect each point to 0 V.



Wiring of Contact input (DI)

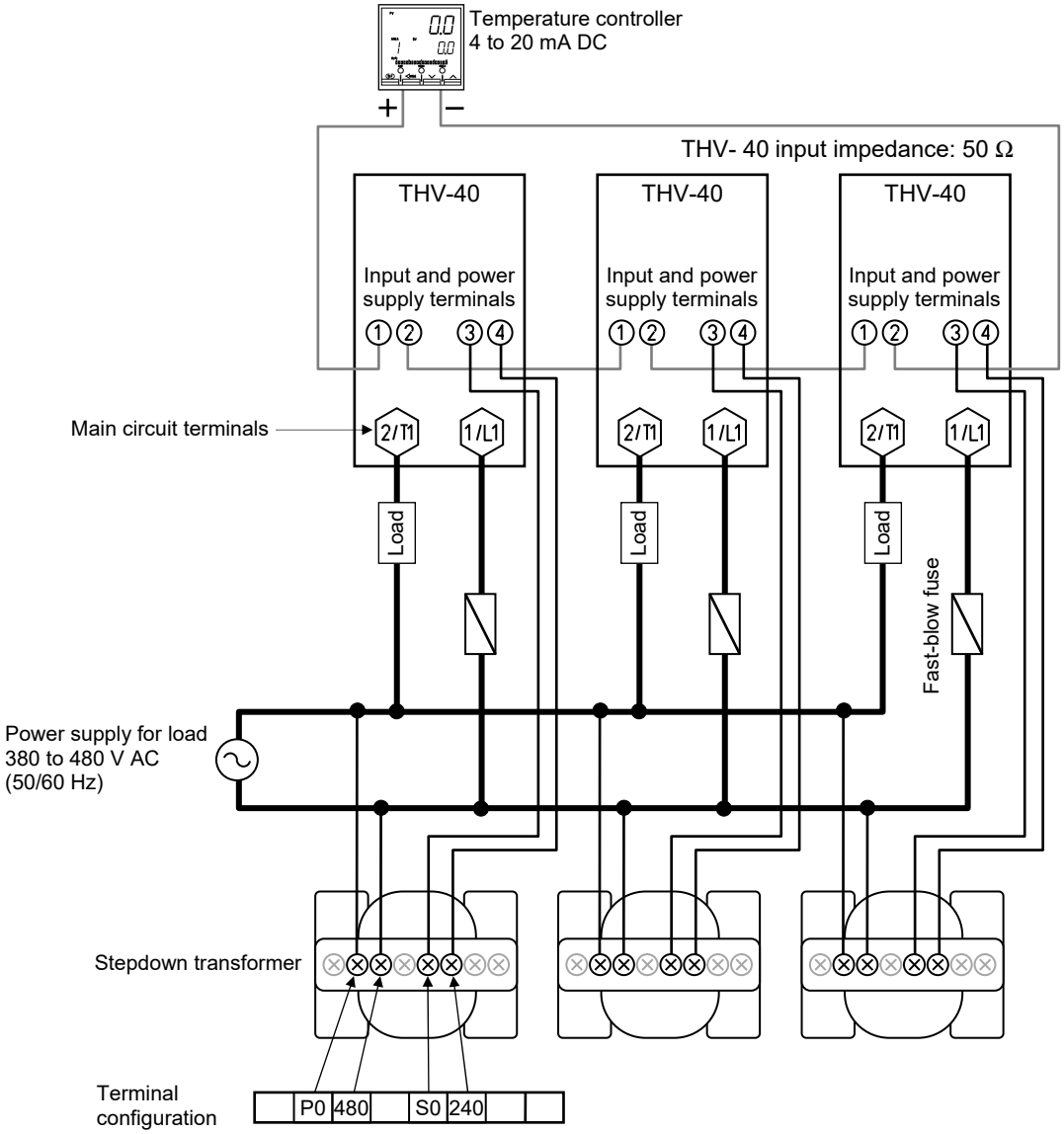
■ Wiring example of the 20 to 100 A types



The number of THV-40 that can be connected depends on the allowable load resistance of temperature controller being used.
For resistance of controller, refer to specification of the controller instruction manual.

Up to three THV-40 can be connected to a single stepdown transformer.

■ Wiring example of the 150 A/200 A types

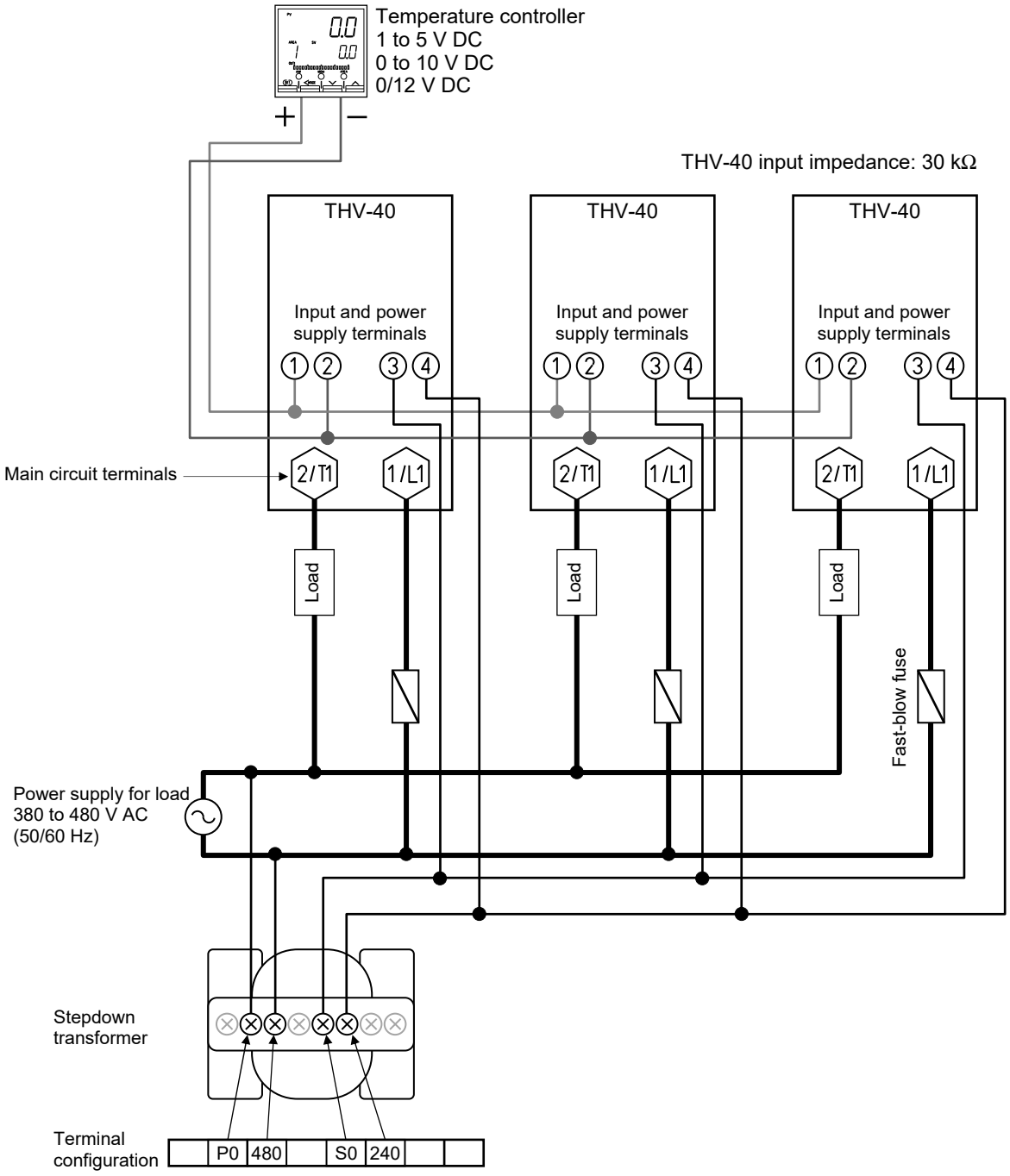


The number of THV-40 that can be connected depends on the allowable load resistance of temperature controller being used. For resistance of controller, refer to specification of the controller instruction manual.

Up to one THV-40 can be connected to a single stepdown transformer.

3.4.4 Wiring example of the parallel connection (For Voltage input or Voltage pulse input)

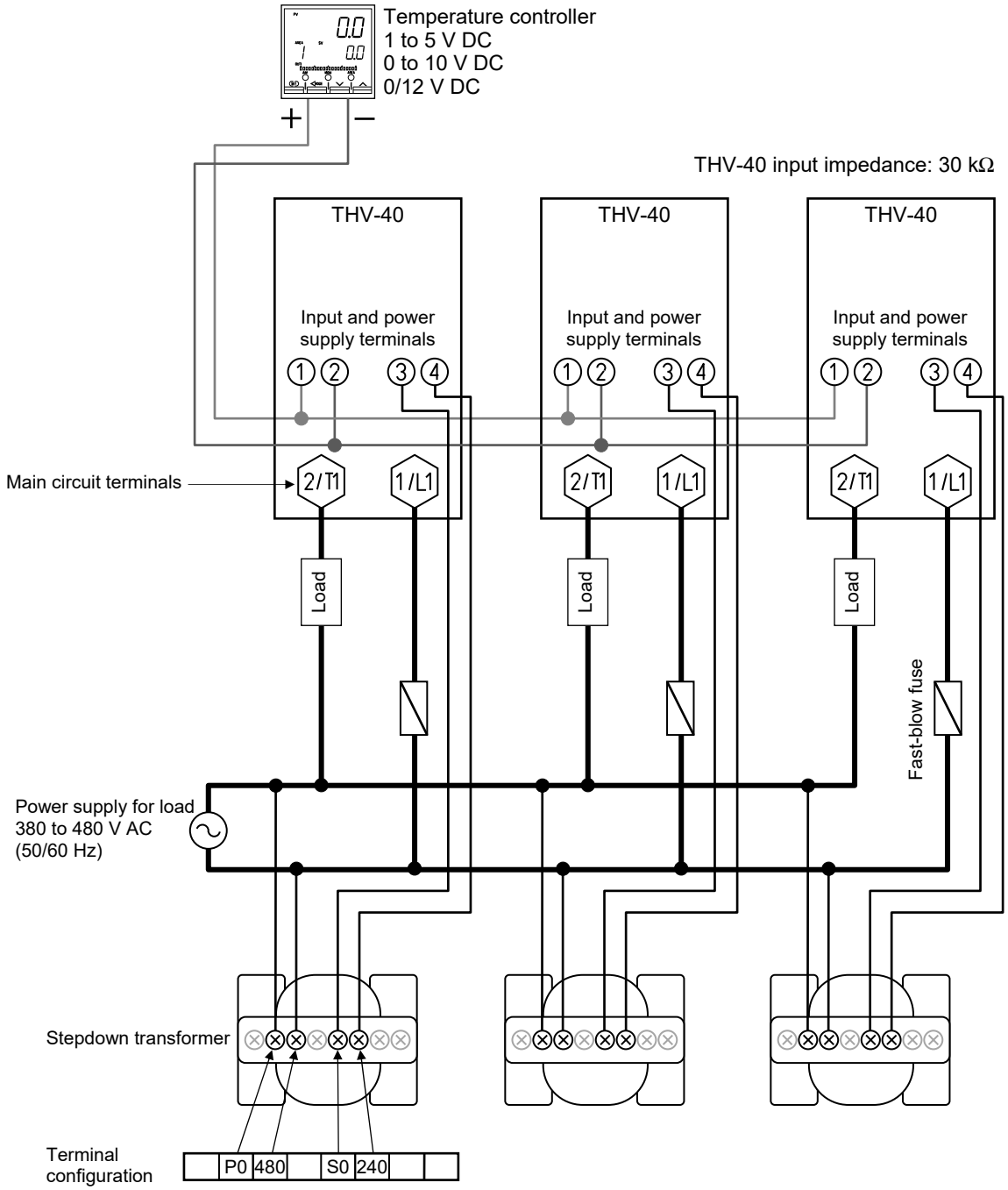
■ Wiring example of the 20 to 100 A types



The number of THV-40 that can be connected depends on the allowable load resistance of temperature controller being used. For resistance of controller, refer to specification of the controller instruction manual.

Up to three THV-40 can be connected to a single stepdown transformer.

■ Wiring example of the 150 A/200 A types



The number of THV-40 that can be connected depends on the allowable load resistance of temperature controller being used. For resistance of controller, refer to specification of the controller instruction manual.

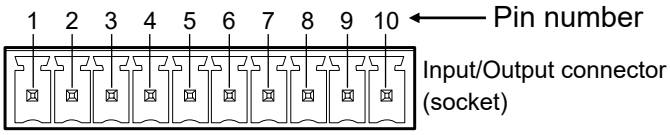
Up to one THV-40 can be connected to a single stepdown transformer.

3.5 Wiring for Input/Output Connector

The input connector is used for the following wiring.

- External gradient setting
- External manual mode
- Contact input (DI)
- Alarm output

3.5.1 Input/Output connector pin number and details



Pin number	Details
1	+2.5 V (Gradient setting input)
2	Gradient setting input (0 to 2.5 V input by gradient setter)
3	0 V (Gradient setting input, Manual mode input)
4	Manual mode input (0 to 2.5 V input by manual setter)
5	+2.5 V (Manual mode input)
6	Contact input: DI (+)
7	0 V (Contact input): DI (−)
8	Unused (Do not connect any device to this terminal.)
9	Open collector output (alarm output): DO (+)
10	Open collector output (alarm output): DO (−)

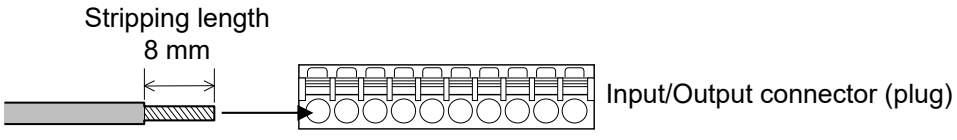
DI: Digital input DO: Digital output

3.5.2 Wire size used for Input/Output connector

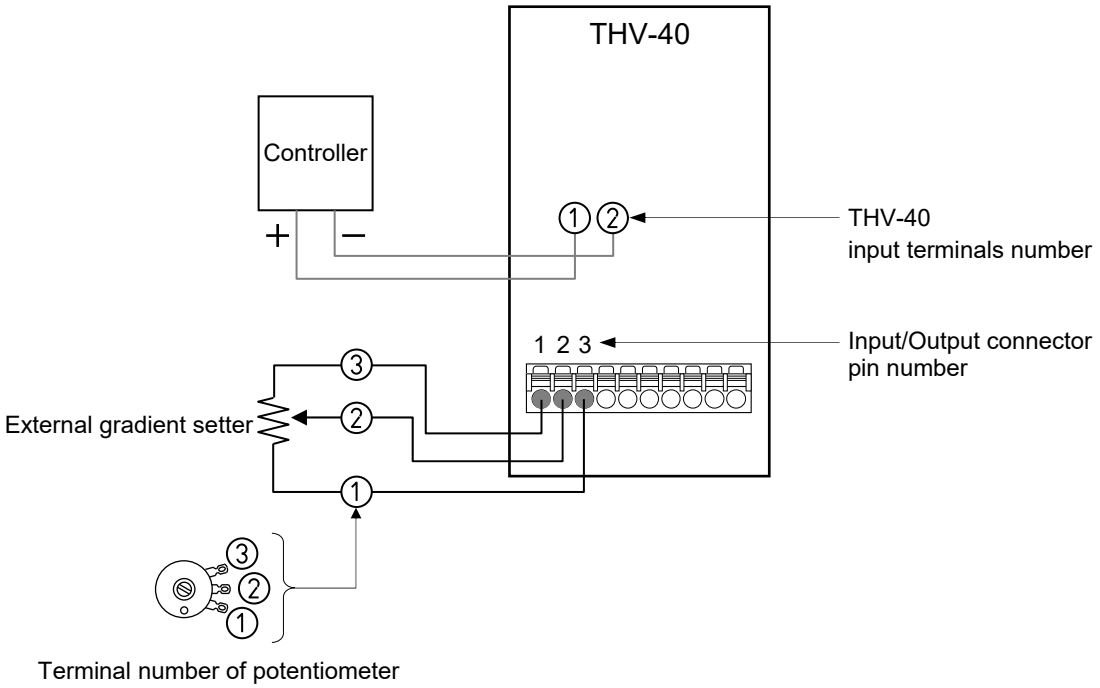
Use the stranded leadwires.

Stranded leadwires: AWG28-20 (cross-section 0.14 to 0.5 mm^2)

Stripping length: 8 mm

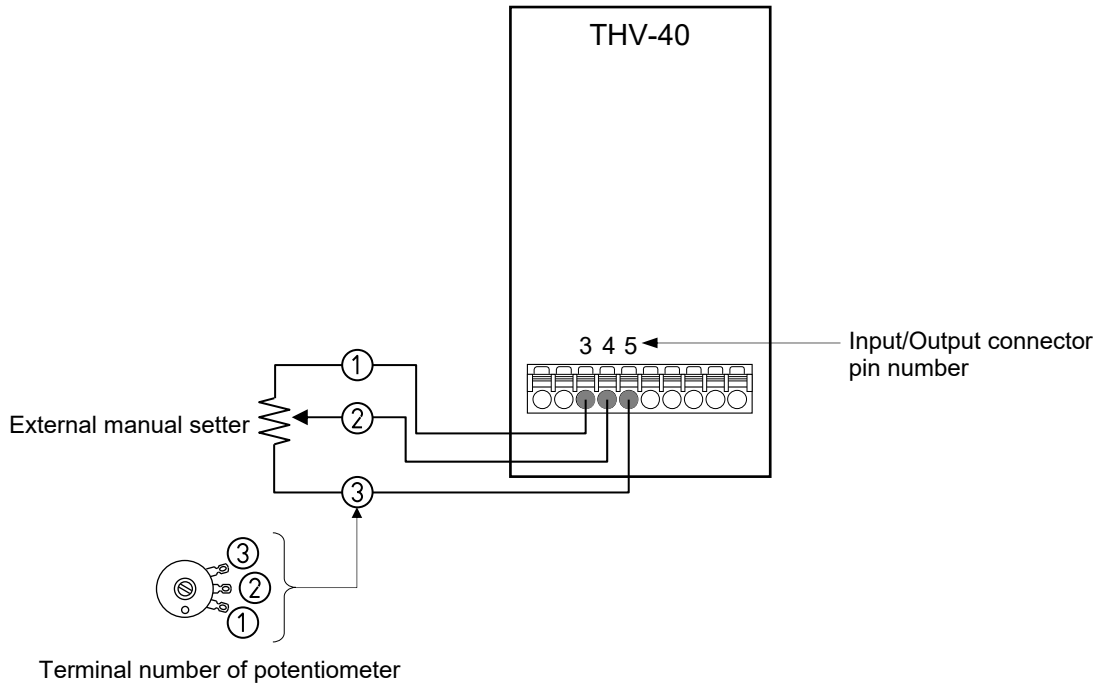


3.5.3 Wiring of external gradient setter

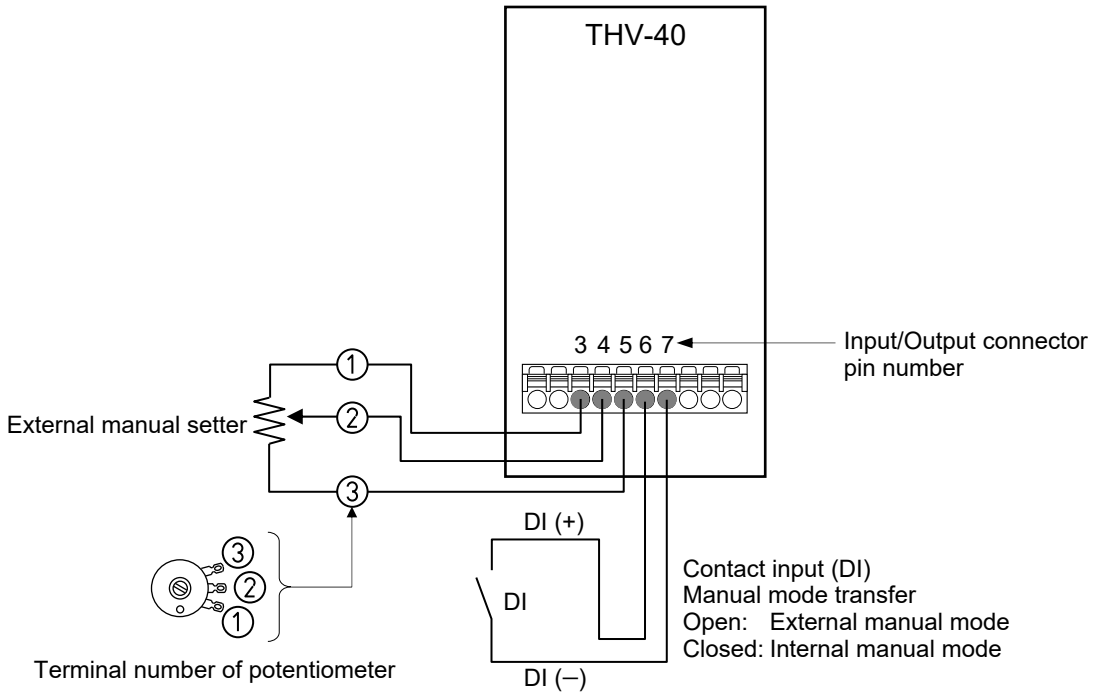


3.5.4 Wiring of external manual setter

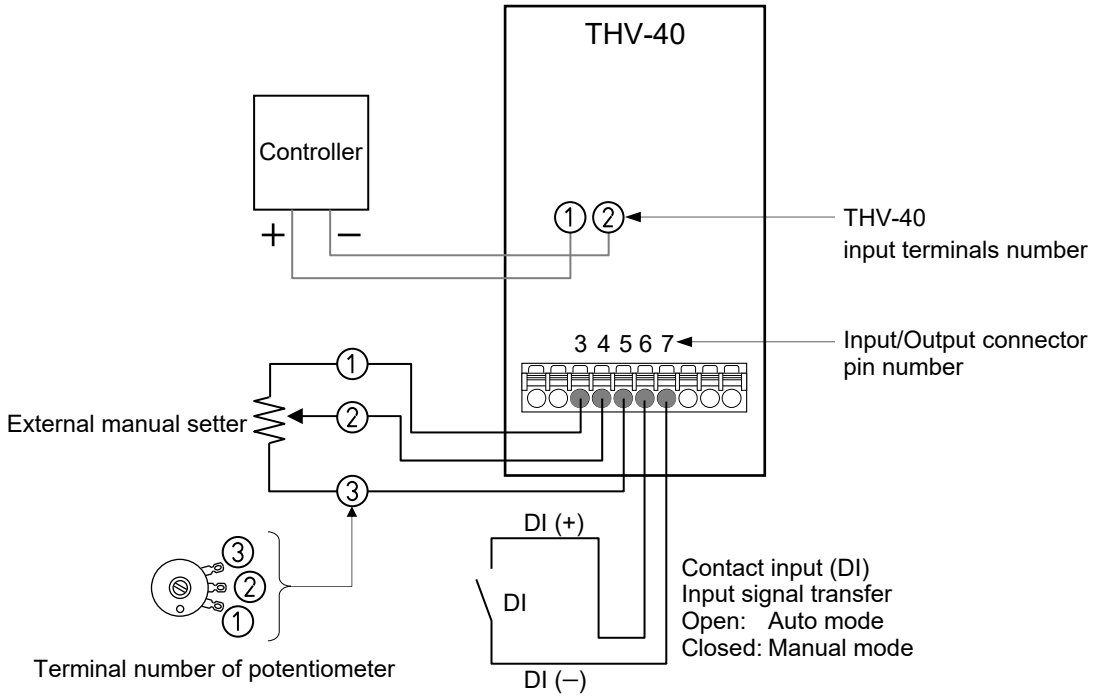
■ Only external manual setter



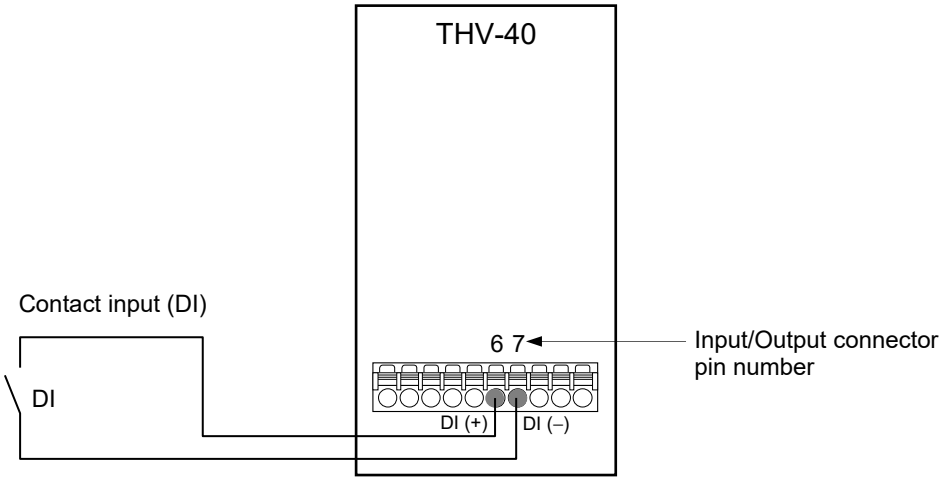
■ External manual setter (With Manual mode transfer)



■ External manual setter (With Input signal transfer)



3.5.5 Wiring of contact input (DI)



To use a Contact input (DI), you need to assign Contact input (DI) function and set the function of each input. Set the following parameters, if necessary.

Function assignment

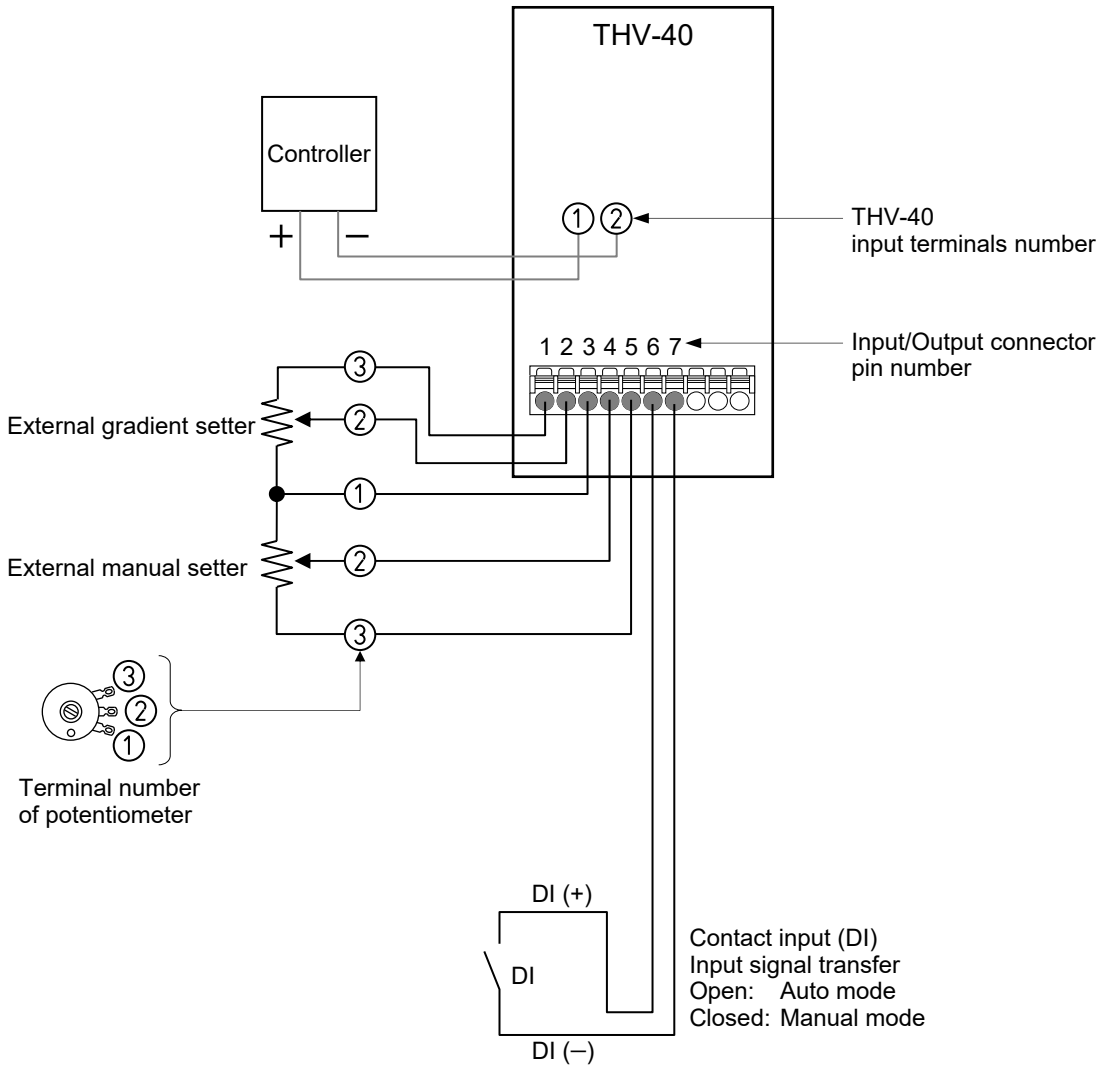
- Contact input (DI) function assignment (C I): P. 5-17

Function of each input

- Control method (Cn): P. 5-9
- Input signal transfer (dA): P. 5-11
- Manual mode transfer (An): P. 5-12
- Soft-start, Soft-down enable/disable (SF): P. 5-16
- Set data lock (LC): P. 5-48

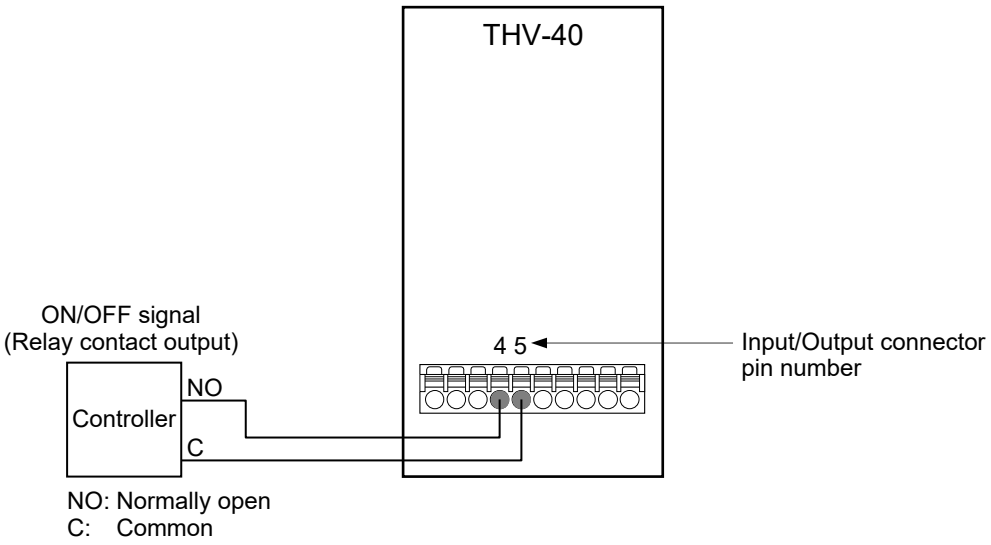
3.5.6 Wiring of Input signal transfer (with external gradient setter)

When both of gradient and manual setters are connected, connect the 0 V wires externally. Just connect a single wire to pin 3.



3.5.7 Wiring of contact input

The ON/OFF signal of the controller turns the thyristor output ON and OFF.



📖 To use the contact input, set the Manual mode transfer (Ahn) of Engineering mode (Function block 2) to "0: External manual mode." (Refer to P. 5-12.)

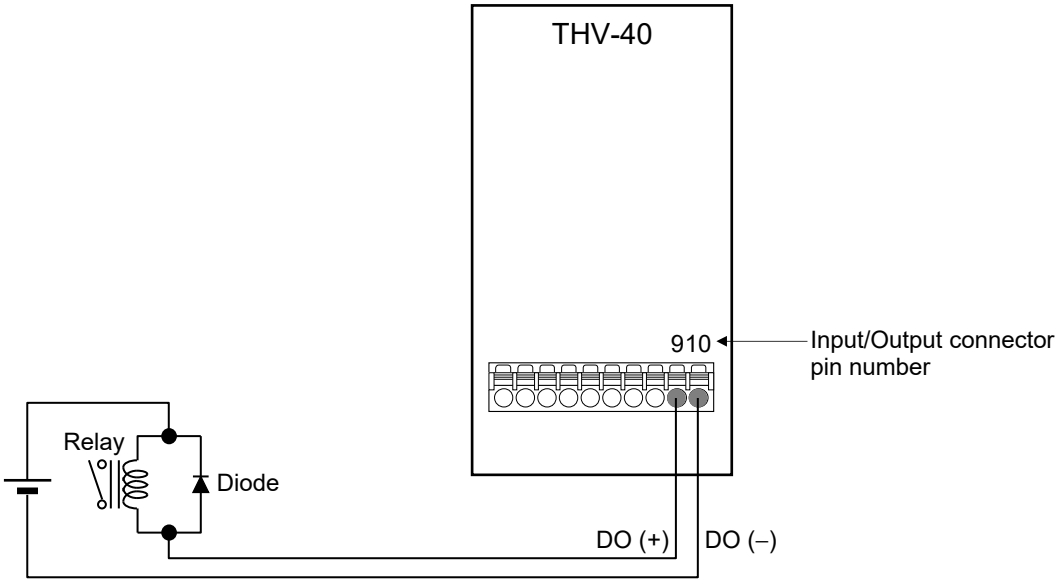
📖 After the Contact input is connected, the Output limiter high and Output limiter low can be set to perform ON/OFF control.

Contact closed: Output limiter high
Contact open: Output limiter low

3.5.8 Wiring of alarm output

A diode should be used and connected as show in the diagram, when using a relay.

When the power is turned on, the Heater break alarm output may be turned on for up to 0.5 ms.
When an interlock circuit or any other related circuit is used, take a necessary measure externally for delaying the activation of the circuit more than 0.5 ms.



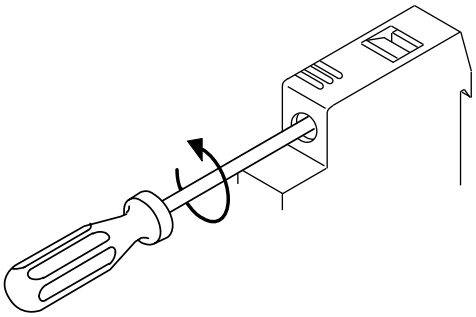
The alarm output needs to be set for the alarm type.
Set "Alarm output logic (L I)" (P. 4-37) in the Engineering mode (function block 4).

- Heater break alarm 1
- Heater break alarm 2
- Power frequency error
- Heat sink temperature abnormality
- Thyristor break-down alarm 1
- Thyristor break-down alarm 2
- Over current alarm
- FAIL alarm (de-energized)

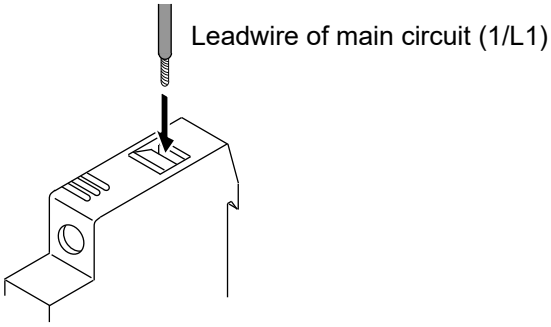
Alarms except FAIL alarm can be configured to Energizing or De-energizing action.

3.6 Wiring Method of Fuse Holder (UL Approved Instrument) for 20 A to 100 A

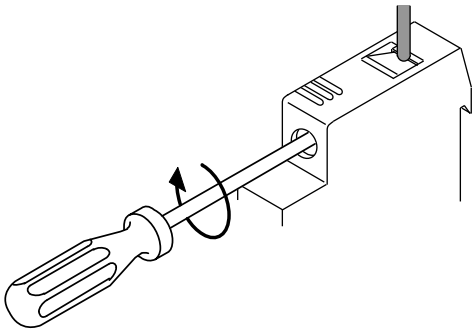
1. Loosen a screw of holder front.



2. Confirm the location and insert a leadwire.



3. Tighten a screw of holder front.
Perform the wiring to the bottom side in the same way as in ***1***, ***2*** and ***3***.



MEMO

DESCRIPTION OF MODE AND PARAMETER

4

4.1 Modes Description of THV-40

The instrument has four different modes, and all settable parameters belong to one of them.

☞ For mode switching, refer to **5.1 Mode Menu (P. 5-2)**.

(1) Monitor Mode

The Input signal, Phase angle ratio, Auto/Manual and other values can be monitored.

☞ Refer to **4.2 Parameter Description of Monitor Mode (P. 4-3)** for parameters in the Monitor mode.

(2) Setting mode 1

The parameters (Soft-start/Soft-down, Internal gradient, Internal manual set value, Set data lock and others) can be set.

☞ Refer to **4.3 Parameter Description of Setting Mode 1 (P. 4-12)** for parameters in the Setting mode 1.

(3) Setting mode 2

Heater break alarm set value, Current limit value, etc. can be set.

🕮 Setting mode 2 appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

☞ Refer to **4.4 Parameter Description of Setting Mode 2 (P. 4-15)** for parameters in the Setting mode 2.

(4) Engineering mode

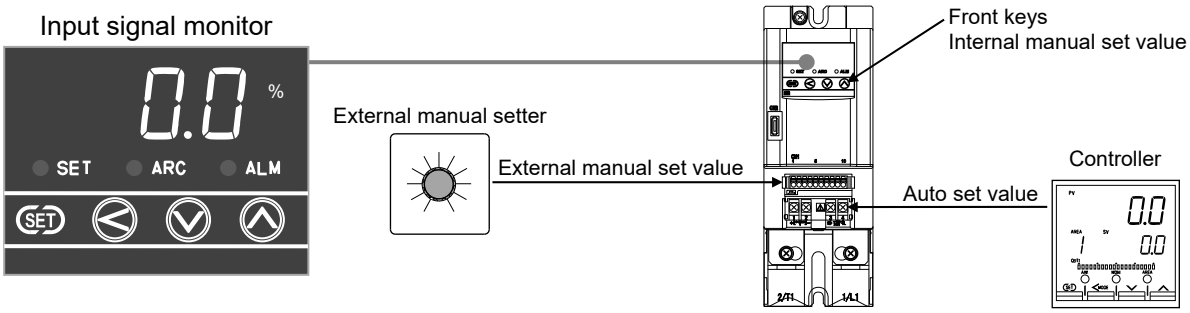
This mode is used to set parameters to meet operating conditions.

☞ Refer to **4.5 Parameter Description of Engineering Mode (P. 4-25)** for parameters in the Engineering mode.

4.2 Parameter Description of Monitor Mode

M1 Input signal monitor 1 (M1)

A set value of the input signal used for the control is displayed among Auto set value, External manual set value, and Internal manual set value. Default setting is Auto set value.



Display range
0.0 to 100.0 %

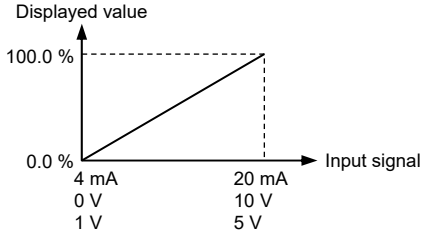
- If the input signal type displayed in Input signal monitor 1 (M1) is changed, control is immediately changed to the set value of the new input signal.
- When the Contact input (DI) is used as "Input signal transfer" or "Manual input transfer," the displayed signal type will be changed every time external contact is switched.
- When the Contact input (DI) is used as "Input signal transfer":
  Selecting the Manual mode by the Contact input (DI) shows either "External manual set value" or "Internal manual set value."
  For manual set value, the value set at Manual mode transfer (AM) in the Engineering mode (function block 2) is displayed.

■ Description of the display value

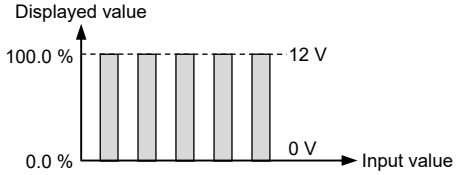
(1) Auto set value (Input signal from controller)

The Input signal from a controller is displayed as a percentage. The input signal from a controller is proportional to the displayed value.

Current input, Voltage input

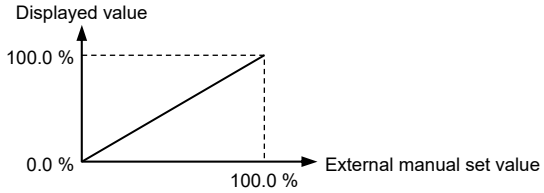


Voltage pulse input



(2) External manual set value (Set value of external manual setter)

A value set by the External manual setter is displayed. The set value of the external manual setter is proportional to the displayed value.

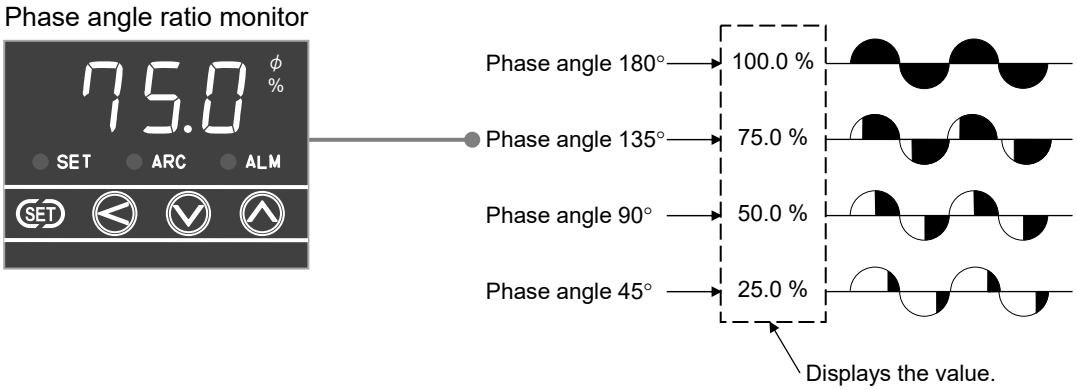


(3) Internal manual set value (Set value set by THV-40 front keys.)

A value set by the Internal manual set value (IM) is displayed.

PA Phase angle ratio monitor (PA)

Displays the phase angle of the trigger point by percentage. Phase angle is obtained by performing computations such as Soft-start/Soft-down time, Gradient setting, Output limiter setting or Base up setting to the input signal.

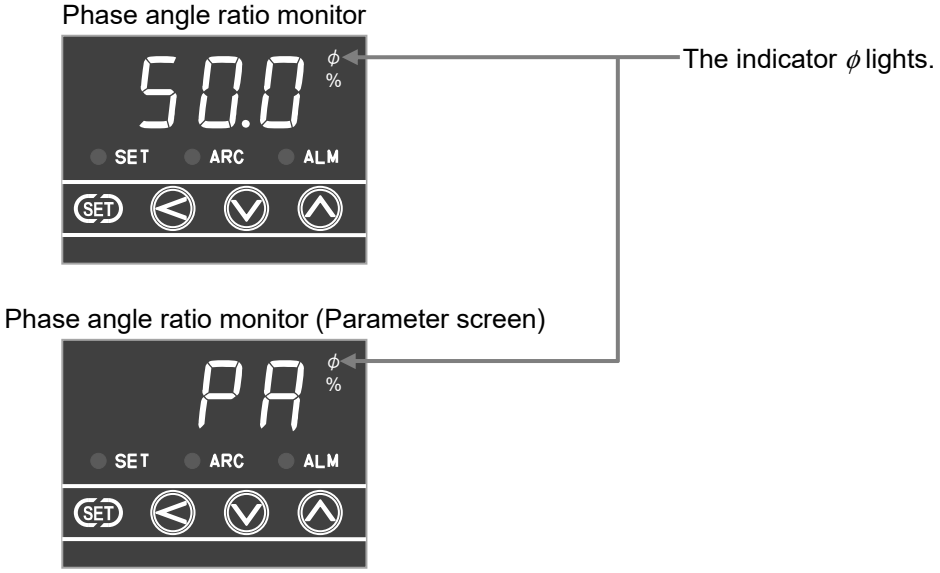


Displays 0.0 % when the phase angle is 0°.
Displays 100.0 % when the phase angle is 180°.

Display range
0.0 to 100.0 %

■ Unit indication

When the Phase angle ratio monitor (PA) is selected, both the LED indicator ϕ and the % unit indicator light to show that the displayed value is the Phase angle ratio.



CT input monitor (CT)

Displays the captured value of current transformer (CT). The displayed current value is the RMS value. Display range varies depending on the instrument specification.

Display range
0.0 to 40.0 A (20 A type)
0.0 to 60.0 A (30 A type)
0.0 to 90.0 A (45 A type)
0 to 120 A (60 A type)
0 to 160 A (80 A type)
0 to 200 A (100 A type)
0 to 300 A (150 A type)
0 to 400 A (200 A type)

CT input monitor (CT) appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

Power frequency monitor (IF)

Displays the power frequency.

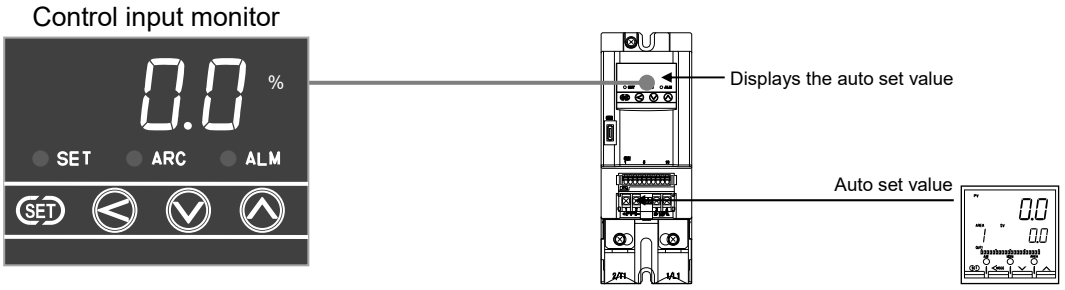
Display range
40 to 70 Hz

If the power frequency goes out of the display range, the display may be as follows:
- If the power frequency goes below 40 Hz, the displayed value is locked to 40.
- If the power frequency goes above 70 Hz, the displayed value is locked to 70.

There is a power frequency monitoring function to this instrument.
For details on function, refer to **6.12 Power Frequency Monitoring Function (P. 6-28)**.

M2 Control input monitor (M2)

The auto set value (input signal from a controller) is displayed in percentage.



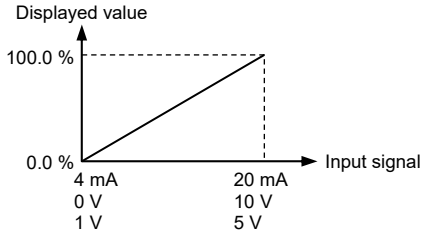
Display range
0.0 to 100.0 %

Displays the “0.0” to the Control input monitor (M2), if the controller is not connected.

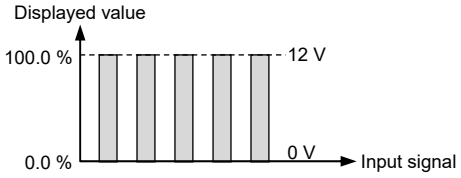
■ Description of the display value

The input signal from a controller is proportional to the displayed value.

Current input, Voltage input



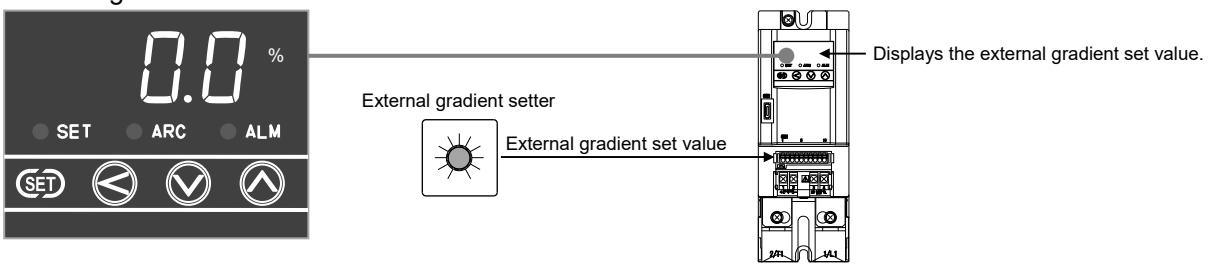
Voltage pulse input



EG External gradient set value monitor (EG)

Displays the external gradient set value (set value of external gradient setter).

External gradient set value monitor

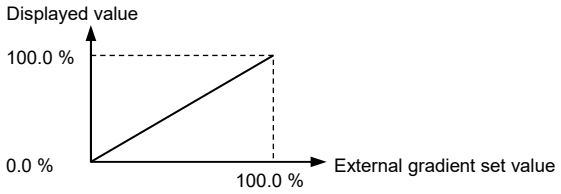


Display range
0.0 to 100.0 %

Displays the "100.0" to the External gradient set value monitor (EG), if the external gradient setter is not connected.

■ Description of the display value

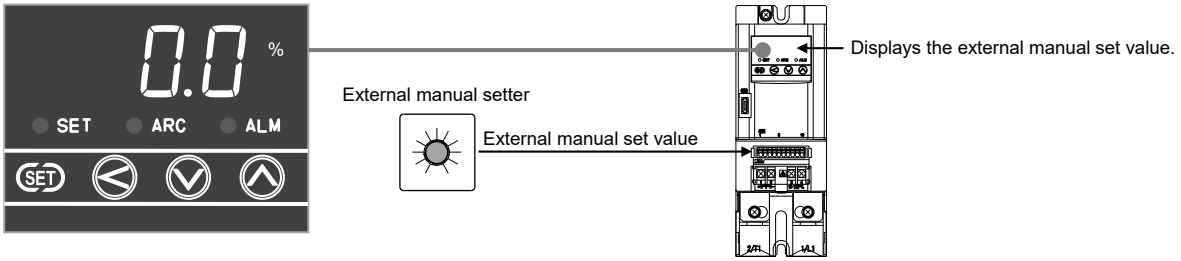
The set value of external gradient setter is proportional to the displayed value.



EM External manual set value monitor (EM)

Displays the external manual set value (set value of external manual setter).

External manual set value monitor

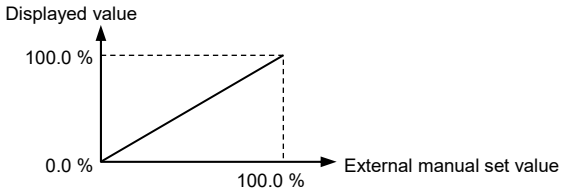


Display range
0.0 to 100.0 %

Displays the "0.0" to the External manual set value monitor (EM), if the external manual setter is not connected.

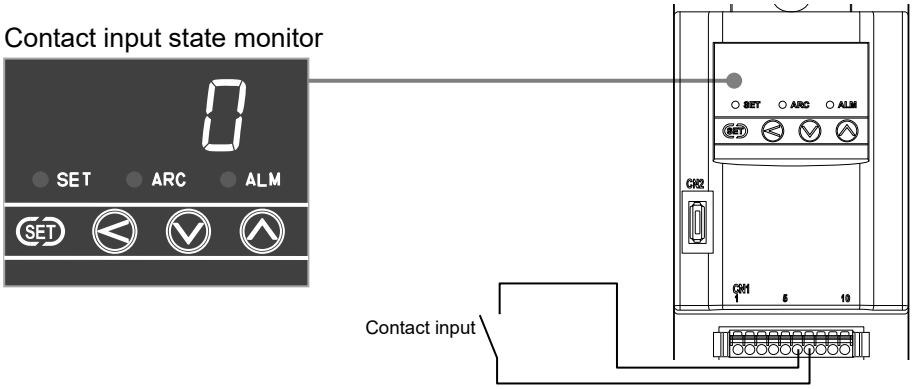
■ Description of the display value

The set value of external manual setter is proportional to the displayed value.



dI Contact input state monitor (dI)

Displays the open or closed state of contact input.



Display range
0: Contact open 1: Contact closed

For users of the THV-1

Please note that the open/close displays of the Contact input state monitor in the THV-1 are opposite of those in the THV-40.

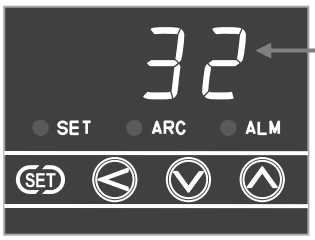
	THV-1	THV-40
Contact open	1	0
Contact closed	0	1

AL Alarm monitor (AL)

In alarm state, error number showing alarm type is displayed.
If two or more alarms happen at the same time, the sum of the error numbers are displayed.

Display example 1: In case of Over current

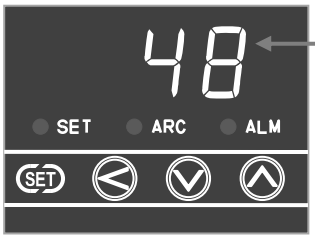
Alarm monitor



The error number “32” is displayed.

Display example 2: In case of Power frequency error and Over current

Alarm monitor



The sum of error numbers is displayed.
“48” (sum of “16” and “32”) is displayed in this case.

Display range
0 to 255 0: No alarm 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL

4.3 Parameter Description of Setting Mode 1

IM Internal manual set value (IM)

Use to set the Internal manual set value.

Setting range	Factory set value
0.0 to 100.0 %	0.0

📖 If the THV-40 power is turned off, Internal manual set value is reset to "0.0."

☞ For the function description, refer to **6.1 Manual mode (P. 6-2)**.

IG Internal gradient set value (IG)

Use to set the Internal gradient set value.

Setting range	Factory set value
0.00 to 2.00 Internal gradient is 0 % when set 0.00. Internal gradient is 100 % when set 1.00. Internal gradient is 200 % when set 2.00.	1.00

📖 When the Control method is Zero-cross control (input synchronous type), Internal gradient set value cannot be used.

☞ For the gradient output characteristic, refer to **6.2 Gradient Setting (P. 6-4)**.

SU Soft-start time (SU)

Use to set the soft-start time.
Set the time for the output to go from 0 % to 100 % within the range 0.0 to 100.0 seconds.

CAUTION

If a load generating a large rush current is used, thyristor break-down may occur if no appropriate Soft-start time is set. In Zero-cross control, no rush current can be suppressed even if the Soft-start time is set.

Setting range	Factory set value
0.0 to 100.0 seconds (0.0: Soft-start function unused)	0.1

- When the Control method is Zero-cross control, Soft-start/Soft-down function is not activated.
- The Soft-start/Soft-down function is not activated at the time of control method switching (Phase control/Zero-cross control).
- Even if the Soft-start function is set to "0.0: Soft-start function unused," the Soft-start function operates when one of the following functions is used:
  When the output is switched to ON from OFF state, the Soft-start function operates for 0.1 second to calculate the maximum phase angle.
  – If the instrument is used for Constant voltage control.
  – If the Current limiter function is used.
- Soft-start/Soft-down function can be enabled/disabled by the parameter or the Contact input.
- ☞ Activation of Soft-start function is selectable (active/inactive at the time of switching the mode from STOP to RUN by the RUN/STOP function of this instrument).
  For details of setting method, refer to **5.10 Settings Soft-Start Function and Soft-Down Function (P. 5-15)**.

■ Caution for using Protection function for control of primary side of a transformer

Action of Soft-start time (SU) 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 the Soft-start time (SU) becomes as follows.

- When Soft-start time (SU) is set to 0.0 seconds, Soft-start function is operated for 0.1 seconds.
- Even if Soft-start, Soft-down enable/disable (SF) is selected to "0: Disable" or "1: Enable (Except switching from STOP to RUN)," the action of Soft-start time (SU) becomes the same as that for "enable."
  When Soft-start time (SU) 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 (SU) becomes the same as that for "enable."
  When Soft-start time (SU) is set to 0.0 seconds, Soft-start function is operated for 0.1 seconds.

Sd Soft-down time (Sd)

Use to set the Soft-down time.
Set the time for the output to go from 100 % to 0 % within the range 0.0 to 100.0 seconds.

Setting range	Factory set value
0.0 to 100.0 seconds (0.0: Soft-down function unused)	0.1

- When the Control method is Zero-cross control, Soft-start/Soft-down function is not activated.
- When the control method is switched between the Phase control and Zero-cross control, Soft-start/Soft-down function is not activated.
- Soft-start/Soft-down function can be enabled/disabled by the parameter or the Contact input.

■ Caution for using Protection function for control of primary side of a transformer

Action of Soft-down time (Sd) 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-down becomes the same as that for Soft-down enable* even if Soft-down function is disabled by the following setting and operation.

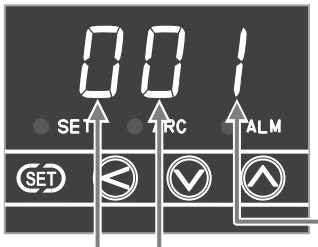
- When Soft-down function is disabled by selecting "0: Disable" or "1: Enable (Except switching from STOP to RUN)" by Soft-start, Soft-down enable/disable (SF).
- When Soft-down function is disabled by the Contact input (DI).

* Soft-down enable: When Soft-down time (Sd) is set to 0.0 seconds, Soft-down function is disabled. Soft-down function is enabled when Soft-down time is set more than 0.0 seconds.

LK Set data lock (LK)

The parameters of Setting mode and Engineering mode can be locked to prevent operation errors.

Set data lock (Setting screen)



Factory set value: 001

Setting range

Setting mode 1, Setting mode 2
0 and 2 to 9: Lock (setting changes not allowed)
1: Unlock (setting changes allowed)

Engineering mode
0 and 2 to 9: Lock (setting changes not allowed)
1: Unlock (setting changes allowed)

Unused

For the function description, refer to **6.4 Set Data Lock Function (P. 6-6)**.

4.4 Parameter Description of Setting Mode 2

nLC Maximum load current set value for alarm (MC)

Use to set the maximum heater current value (maximum load current value) for Heater break alarm. The maximum load current value means a current value which flows through the heater at an output of 100 % (phase angle: 180°).

It is important to set the Maximum load current set value to make a heater break judgment. In addition, if Maximum load current set value is not set properly, malfunction may occur.

If the maximum current value which flows through the heater changes due to heater secular change or deterioration, change the maximum load current set value.

Setting range	Factory set value
0.0 to 22.0 A (20 A type)	20.0
0.0 to 33.0 A (30 A type)	30.0
0.0 to 50.0 A (45 A type)	45.0
0 to 66 A (60 A type)	60
0 to 88 A (80 A type)	80
0 to 110 A (100 A type)	100
0 to 165 A (150 A type)	150
0 to 220 A (200 A type)	200

In the case of Non-linear resistance heater break alarm, the Maximum load current set value is automatically calculated when automatic calculation of the knee point is performed.

Maximum load current set value for alarm screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the details of Maximum load current value calculation method, refer to **5.18 How to Find Maximum Load Current Value (P. 5-24)**.

H1 Heater break alarm 1 setting (H1)

Use to set the Heater break alarm 1 set value.

Setting range	Factory set value
Type 1 (constant resistance type, deviation alarm) and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * (0: Heater break alarm 1 unused) If the Heater break alarm 1 set value is below 2 A, the instrument adjusts the set value to 2 A or more. Type 2 (linearity resistor type, absolute value alarm): 0 to 100 % of Maximum load current set value (0: Heater break alarm 1 unused) * The reference current is the load current value that is assumed for the output phase angle of this instrument.	20

Heater break alarm 1 setting screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the setting procedure, refer to **5.19 Setting Example of Heater Break Alarm (P. 5-29)**.

For the function description, refer to **6.5 Heater Break Alarm/Thyristor Break-Down (optional) (P. 6-8)**.

■ Recommended value of Heater break alarm 1

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

When the Control method is Phase control, RKC recommends:

- Set the Heater break alarm set value to approximately 20 % of the Maximum load current value for Heater break alarm Type 1 (constant resistance type, deviation alarm).
  This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.
- Set the Heater break alarm 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 %.
  This recommended value is a guideline for when there is one connected heater.
- In the case of a Non-linear resistance heater break alarm, 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:

This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

- 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. The set value should be less than the maximum reading of current transformer input.

rb Thyristor break-down detection 1 setting (Tb)

Use to set the Thyristor break-down 1 set value.

Setting range	Factory set value
Type 1 (constant resistance type, deviation alarm) and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * (0: Thyristor break-down 1 unused) If the Thyristor break-down 1 set value is below 2 A, the instrument adjusts the set value to 2 A or more. Type 2 (linearity resistor type, absolute value alarm): 0 to 100 % of Maximum load current set value (0: Thyristor break-down 1 unused) * The reference current is the load current value that is assumed for the output phase angle of this instrument.	20

Thyristor break-down detection 1 setting screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the setting procedure, refer to **5.19 Setting Example of Heater Break Alarm (P. 5-29)**.

For the function description, refer to **6.5 Heater Break Alarm/Thyristor Break-Down (optional) (P. 6-8)**.

■ Recommended value of Thyristor break-down 1 set value

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

When the Control method is Phase control, RKC recommends:

- Set the Thyristor break-down set value to approximately 20 % of the Maximum load current value for Heater break alarm Type 1 (constant resistance type, deviation alarm).
  This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.
- Set the Thyristor break-down 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 Thyristor break-down set value to more than 15 %.
  This recommended value is a guideline for when there is one connected heater.
- In the case of a Non-linear resistance heater break alarm, 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.

This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

H2 Heater break alarm 2 setting (H2)

Use to set the Heater break alarm 2 set value.

Setting range	Factory set value
Type 1 (constant resistance type, deviation alarm) and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * (0: Heater break alarm 2 unused) If the Heater break alarm 2 set value is below 2 A, the instrument adjusts the set value to 2 A or more. Type 2 (linearity resistor type, absolute value alarm): 0 to 100 % of Maximum load current set value (0: Heater break alarm 2 unused) * The reference current is the load current value that is assumed for the output phase angle of this instrument.	15

Heater break alarm 2 setting screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the setting procedure, refer to **5.19 Setting Example of Heater Break Alarm (P. 5-29)**.

For the function description, refer to **6.5 Heater Break Alarm/Thyristor Break-Down (optional) (P. 6-8)**.

■ Recommended value of heater break alarm 2 set value

Although the following values are recommended, the alarm set value varies depending on the load type and the number of connections. 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 set value of Heater break alarm 2 to any value slightly smaller than that of Heater break alarm 1.
  Setting a smaller value for Heater break alarm 2 than that for Heater break alarm 1 enables alarm detection prior to the Heater break alarm 1.
  This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

When the Control method is Phase control and Heater break alarm Type 2 (linearity resistor type, absolute value alarm) is selected:

– Not available for Type 2. Set the “0: Heater break alarm 2 unused.”
  (This may be used instead of the Heater break alarm 1.)

When the Control method is Phase control and Non-linear resistance heater break alarm is selected:

– In the case of a Non-linear resistance heater break alarm, 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 set value of Heater break alarm 2 to any value slightly larger than that of Heater break alarm 1.
Setting a larger value for the Heater break alarm 2 than that for the Heater break alarm 1 enables alarm detection prior to the Heater break alarm 1.
This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

rC Thyristor break-down detection 2 setting (TC)

Use to set the Thyristor break-down 2 set value.

Setting range	Factory set value
Type 1 (constant resistance type, deviation alarm) and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * (0: Thyristor break-down 2 unused) If the Thyristor break-down 2 set value is below 2 A, the instrument adjusts the set value to 2 A or more. Type 2 (linearity resistor type, absolute value alarm): 0 to 100 % of Maximum load current set value (0: Thyristor break-down 2 unused) * The reference current is the load current value that is assumed for the output phase angle of this instrument.	15

Thyristor break-down detection 2 setting screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the setting procedure, refer to **5.19 Setting Example of Heater Break Alarm (P. 5-29)**.

For the function description, refer to **6.5 Heater Break Alarm/Thyristor Break-Down (optional) (P. 6-8)**.

■ Recommended value of Thyristor break-down 2 set value

Although the following values are recommended, the alarm set value varies depending on the load type and the number of connections. 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 set value of Thyristor break-down 2 to any value slightly smaller than that of Thyristor break-down 1.
  Setting a smaller value for Thyristor break-down 2 than that for Thyristor break-down 1 enables alarm detection prior to the Thyristor break-down 1.
  This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

When the Control method is Phase control and Heater break alarm Type 2 (linearity resistor type, absolute value alarm) is selected:

– Not available for Type 2. Set the “0: Thyristor break-down 2 unused.”
  (This may be used instead of the Thyristor break-down 1 set value.)

When the Control method is Phase control and Non-linear resistance heater break alarm is selected:

– In the case of a Non-linear resistance heater break alarm, 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 set value of Thyristor break-down 2 to any value slightly smaller than that of Thyristor break-down 1.

Setting a smaller value for Thyristor break-down 2 than that for Thyristor break-down 1 enables alarm detection prior to the Thyristor break-down 1.

This recommended value is a guideline for when changes in the resistance of the load due to temperature are small.

CL Current limit value setting (CL)

Use to set the Current limit value.

If a load through which a large rush current flows is used, the Current limit function cannot restrict the above current. In this case, use the Current limit function together with the Soft-start function.

Setting range	Factory set value
0.0 to 22.0 A (20 A type)	22.0
0.0 to 33.0 A (30 A type)	33.0
0.0 to 50.0 A (45 A type)	50.0
0 to 66 A (60 A type)	66
0 to 88 A (80 A type)	88
0 to 110 A (100 A type)	110
0 to 165 A (150 A type)	165
0 to 220 A (200 A type)	220

If a Current limit value is set to its maximum value, the Current limit function is deactivated. Factory set value is deactivation state.

If the Current limit value is set to 0.0, the output of THV-40 turns off.

The Current limiter function is not available when Zero-cross control is used.

Current limit value setting screen appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the function description, refer to **6.8 Current Limiter Function (optional) (P. 6-21)**.

4.5 Parameter Description of Engineering Mode

4.5.1 Parameter of function block 1

F.1 Function block 1 (F.1)

This is first parameter symbol of Function block 1 (F.1).

C1 Contact input (DI) function assignment (C1)

Use to assign the Contact input function. The action of assigned function can be switched by opening and closing the contact input.
When the Contact input (DI) is used, priority is given to the setting of the Contact input (DI).
Setting via the front key and/or communication are disabled.

Setting range	Factory set value
0: No function 1: Control method 2: Input signal transfer 3: Manual mode transfer 4: RUN/STOP transfer 5: Soft-start, Soft-down enable/disable 6: Heater break alarm enable/disable 7: Over current alarm enable/disable 8: Set data lock enable/disable	0

☞ For setting examples, refer to **5.11 Assigning Contact Input (DI) Functions (P. 5-17)**.

☞ For function description, refer to **6.9 Contact Input (DI) Function (P. 6-22)**.

■ Settings that become effective based on the Contact input (DI) setting

Function name	Settings that become effective based on the DI setting	
	Open	Closed
Control method	Phase control	Zero-cross control [1]
Input signal transfer	Auto mode	Manual mode [2]
Manual mode transfer	External manual mode	Internal manual mode
RUN/STOP transfer	STOP	RUN
Soft-start, Soft-down enable/disable	Enable [3]	Disable
Heater break alarm enable/disable [4]	Enable	Disable
Over current alarm enable/disable [4]	Enable	Disable
Set data lock enable/disable [5]	Enable (lock)	Disable (unlock)

[1] Zero-cross control may be classified into continuous Zero-cross control or input synchronous type Zero-cross control. When the control mode is switched to Zero-cross by the Contact input (DI), continuous Zero-cross control is selected.
Switching to the input synchronous type Zero-cross control is not available with the Contact input.

[2] The Manual setting may be classified into the External manual mode and the Internal manual mode. When the control mode is switched to the Manual mode, the manual mode set at the Manual mode transfer (AM) in the Engineering mode (Function block 2) is selected.

[3] There are two types of Enable actions.
When "Enable" is selected by the Contact input (DI), the action set at "Soft-start, Soft-down enable/disable (SF)" in the Engineering mode (Function block 2) is selected.

[4] This function is active when Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control and Protection function for control of primary side of a transformer are supplied.

[5] When this lock function is switched to "Enable (lock)" by the Contact input (DI), the mode set at the Set data lock (LK) in the Setting mode 1 is locked.

4.5.2 Parameter of function block 2

F.2 Function block 2 (F.2)

This is first parameter symbol of Function block 2 (F.2).

Cn Control method (CM)

Use to select the Control method.

Setting range	Factory set value
0: Phase control 1: Zero-cross control (continuous) 2: Zero-cross control (input synchronous type)	0

📖 If Control method is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.

☞ For the function description, refer to **6.10 Control Method (P. 6-24)**.

■ Functions that cannot be used with certain Control methods

Some functions cannot be used with certain Control methods (Refer to the table below).

×: Can be used –: Cannot be used

Function	Phase control	Zero-cross control (continuous)	Zero-cross control (input synchronous type)
Internal gradient setting	×	×	–
Soft-start and Soft-down	×	–	–
Current limit	×	–	–
Output mode	×	–	–
Output limiter high	×	×	–
Output limiter low	×	×	–
Output limiter high at operation start	×	–	–
Base-up set value	×	×	–
Heater break alarm (Type 1)	×	–	–
Heater break alarm (Type 2)	×	×	×
Non-linear resistance heater break alarm	×	–	–
Protection function for control of primary side of a transformer	×	–	–

IS Input signal selection (IS)

Use to select the input signal type of Auto mode. Select the same input signal type for both the THV-40 and the controller.

Setting range	Factory set value
0: 4 to 20 mA DC, 1 to 5 V DC 1: 0 to 10 V DC, 0/12 V DC	Based on model code

Selection of current and voltage inputs can be done with the Input signal select switch. (Refer to P. 3-8)

dA Input signal transfer (dA)

Use to select control mode if control is done by Auto mode or Manual mode. Also use to modify the display items of the Input signal monitor (M1).
The value of the action selected in this item can be viewed in the Input signal monitor (M1).

Setting range	Factory set value
0: Auto mode 1: Manual mode	0

If "1: Manual mode" is set, setting is required for Manual mode transfer (AM) in the Engineering mode (function block 2) to operate the instrument with the External manual set value or Internal manual set value.

If Input signal transfer is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.

The auto set value can be viewed constantly in the Control input monitor (M2).

AM Manual mode transfer (AM)

Use to choose the Manual mode whether the control is performed with the External manual mode or the Internal manual mode.

Setting range	Factory set value
0: External manual mode 1: Internal manual mode	0

- If Manual mode transfer is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.
- If the Contact input (DI) function is set to "Input signal transfer," selecting "1 (closed): Manual mode" will switch the mode to the manual setting mode set in this parameter.
- For the function description, refer to **6.1 Manual Mode (P. 6-2)**.

rS RUN/STOP transfer (rS)

Use to transfer the mode between RUN and STOP. In the RUN state, the output of the instrument turns on. In the STOP state, the output of the instrument turns off.

Setting range	Factory set value
0: STOP (Output OFF) 1: RUN (Output ON)	1

If RUN/STOP transfer is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.

■ State of each function in the RUN/STOP

Details	State	
	in STOP	in RUN
THV-40 output	Output OFF	Output ON
Heater break alarm Non-linear resistance heater break alarm	Functions depend on the following settings: • Heater break alarm enable/disable (HF) • Alarm enable/disable during STOP (SA)	
Thyristor break-down alarm*	Function is enabled.	Function is enabled.
Power frequency monitoring	Function is enabled.	Function is enabled.
Over current alarm	Functions depend on the following settings: • Over current alarm enable/disable (oF) • Alarm enable/disable during STOP (SA)	
Heat sink temperature abnormality (150 A/200 A types)	Based on the Alarm enable/disable during STOP (SA).	
FAIL	Function is enabled.	Function is enabled.
Output limiter high *	Function is enabled.	Function is enabled.
Output limiter low *	Function is disabled.	Function is enabled.
Output limiter high at operation start *		This function is activated when the state is switched to RUN.
Base-up setting*	Function is disabled.	Function is enabled.
Display off timer *	Function is enabled.	Function is enabled.
Ramp function (Soft-start/Soft-down function)	The function depends on the setting of Soft-start, Soft-down enable/disable.	

* It is assumed that the function is enabled or set to work.

SF Soft-start, Soft-down enable/disable (SF)

This setting is used to enable or disable the Soft-start function and Soft-down function.
The Soft-start function and Soft-down function can be disabled without changing the Soft-start time or Soft-down time.
It is selectable to enable/disable the Soft-start and the Output limiter high at operation start at the time of switching the instrument from STOP to RUN.

Setting range	Factory set value
0: Disable 1: Enable (Except switching from STOP to RUN) 2: Enable	2

If Soft-start, Soft-down enable/disable is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.

■ Explanation of set values

The actions of Soft-start, Soft-down, and the Output limiter high at operation start occur as follows, depending on the set value.

- **When Protection function for control of primary side of a transformer is not supplied or when it is disabled.**

ON: active, OFF: inactive

Set value	What happened to the instrument?	Soft-start	Soft-down	Output limiter high at operation start
0	Auto set value was changed	OFF	OFF	
	Manual set value was changed	OFF	OFF	
	Switched from STOP to RUN	OFF		OFF *
1	Auto set value was changed	ON	ON	
	Manual set value was changed	ON	ON	
	Switched from STOP to RUN	OFF		OFF *
2	Auto set value was changed	ON	ON	
	Manual set value was changed	ON	ON	
	Switched from STOP to RUN	ON		ON

* The action of the Output limiter high at operation start remains on when the instrument is powered.

- **When Protection function for control of primary side of a transformer is supplied and when it is set enabled.**

ON: active, OFF: inactive

Set value	What happened to the instrument?	Soft-start	Soft-down	Output limiter high at operation start
0	Auto set value was changed	ON	ON or OFF [1]	
	Manual set value was changed	ON	ON or OFF [1]	
	Switched from STOP to RUN	ON		OFF [2]
1	Auto set value was changed	ON	ON	
	Manual set value was changed	ON	ON	
	Switched from STOP to RUN	ON		OFF [2]
2	Auto set value was changed	ON	ON	
	Manual set value was changed	ON	ON	
	Switched from STOP to RUN	ON		ON

[1] The action becomes the same as that for when Soft-down function is enabled.

Soft-down enable: When Soft-down time (Sd) is set to 0.0 seconds, Soft-down function is disabled.
Soft-down function is enabled when Soft-down time is set more than 0.0 seconds.

[2] The action of the Output limiter high at operation start remains on when the instrument is powered.

HF Heater break alarm enable/disable (HF)

This setting is used to enable or disable the Heater break alarm and Thyristor break-down alarm. Disabling this function will not turn on Heater break alarm or the Thyristor break-down alarm.
The Heater break alarm and Thyristor break-down alarm can be disabled without changing the Heater break alarm set value or the Thyristor break-down set value.

Setting range	Factory set value
0: Disable 1: Enable	1

- If Heater break alarm enable/disable is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.
- This setting becomes active if the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

oF Over current alarm enable/disable (oF)

This setting is used to enable or disable the Over current alarm. Disabling this function will not activate the Over current alarm.

Setting range	Factory set value
0: Disable 1: Enable	1

- If Over current alarm enable/disable is set in the Contact input (DI) function assignment (C1), the set value cannot be changed.
- This setting becomes active if the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.
- Disabling the Over current alarm while the Over current alarm is on will not release the alarm.

☞ For the function description, refer to **6.17 Over Current Alarm Function (optional) (P. 6-32)**.

4.5.3 Parameter of function block 3

F.3 Function block 3 (F.3)

This is first parameter symbol of Function block 3 (F.3).

oS Output mode for phase control (oS)

Use to select the Output method for phase control with resistor load.

When Constant current control is selected, no normal operation is performed if the rated current of thyristor differs from that maximum load current flowing through the heater. In such a case, set the gradient so that the Maximum load current value which flows through the heater is obtained at an input signal of 100 %.
[For the setting method, refer to ■ Caution for using constant current control function (P. 6-27).]

Setting range	Factory set value
0: Proportional phase angle to input 1: Proportional voltage to input 2: Proportional square voltage (electric power) to input 3: Constant current control (optional) *	2

* This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

For the output characteristic, refer to **6.11 Output Mode for Phase Control (P. 6-25)**.

LH
LL

Output limiter high (LH)
Output limiter low (LL)

Use to set the high limit value or low limit value of output.

Setting range	Factory set value
0.0 to 100.0 %	Output limiter high: 100.0 Output limiter low: 0.0

- Output limiter high value must be equal or higher than Output limiter low. (Output limiter low ≦ Output limiter high)
- If input synchronous type Zero-cross control is used, the Output limiter high and Output limiter low are not activated.
- When this instrument is set to STOP, the Output limiter low turns off and the low limit output becomes 0 %.

☞ For the function description, refer to **6.14 Output Limiter High and Low (P. 6-29)**.

LS

Output limiter high at operation start (LS)

Use to set the Output limiter high at operation start.

Setting range	Factory set value
0.0 to 100.0 %	50.0

- Output limiter high value at operation start must be lower than Output limiter high.
- Even if Output limiter high value at operation start is set to 0.0, the function is enabled. If Output limiter high value at operation start is set to 0.0 and Output limiter high time at operation start is set to 0.1 seconds or more, the output of the instrument will be OFF for that time only.
- If setting of the Soft-start, Soft-down enable/disable (SF) is set to "2: Enable," the Output limiter high at operation start is activated when this instrument is switched from STOP to RUN.

☞ For the function description, refer to **6.15 Output Limiter High at Operation Start (P. 6-30)**.

LT Output limiter high time at operation start (LT)

Use to set the Output limiter high time at operation start.

Setting range	Factory set value
0 to 600 seconds	0

📖 If Zero-cross control is used, the Output limiter high time at operation start is not activated.

☞ For the function description, refer to **6.15 Output Limiter High at Operation Start (P. 6-30).**

bU Base-up set value (bU)

Use to set the Base-up set value (output bias) of output.

Setting range	Factory set value
–9.9 to +100.0 %	0.0

📖 The Base-up set value will not exceed the Output limiter high.

📖 The Base-up set value is effective only when the Output limiter low is set to 0.0.

📖 If Zero-cross control (input synchronous type) is used, the Base-up function is not activated.

📖 If the instrument is transferred to "STOP," the Base-up function is not activated.

☞ For the function description, refer to **6.16 Base-Up Setting Function (P. 6-31)**.

-no Minimum output phase angle adjustment (Mo)

Use to set the Minimum output phase angle.

Setting range	Factory set value
Output phase angle 5.0 to 15.0 %	5.0

☞ For the function description, refer to **6.20 Minimum Output Phase Angle Adjustment Function (P. 6-35)**.

4.5.4 Parameter of function block 4

F.4 Function block 4 (F.4)

This is first parameter symbol of Function block 4 (F.4).

L1 Alarm output logic (L1)

Set the output alarm type from the alarm terminal on the Input/Output connector.
To have outputs from two or more alarms, set the sum of the setting values as logical *OR*.
For example, to have a logical *OR* output of "1: Heater break alarm" and "2: Thyristor break-down alarm 1," set "3" as a result of "1 + 2."

Setting range	Factory set value
0 to 255 0: No output 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL (fixed at de-energized)	0

If FAIL output is set, all alarm outputs are de-energized.
To have energized type alarm output, do not include the FAIL alarm set value to the Alarm output logic.

The following alarms are optional and must be specified at the time of ordering.
Otherwise, setting is ignored and no output is produced even if the alarm is set.

- Heater break alarm
- Thyristor break-down alarm
- Over current

nA Selection of energized/de-energized alarm output (nA)

Use to set Alarm output action: Energized/De-energized.
Selection of alarm output Energized/De-energized (nA) is enabled if FAIL output is not included to the Alarm output logic (L1).

Setting range	Factory set value
0: Energized 1: De-energized	0

☞ For the function description, refer to **6.6 Energized/De-energized of Alarm Output (P. 6-20)**.

A1 Alarm type selection (A1)

Use to select the type of Heater break alarm in the Phase control.

Setting range	Factory set value
0: Type1 (constant resistance type, deviation alarm) 1: Type2 (linearity resistor type, absolute value alarm) 2: Deviation alarm [ARC-HBA] (Non-linear resistance type)	0

📖 This setting becomes activated in the following cases:

- when the instrument is supplied with Heater break alarm (Non-liner resistance heater break alarm), Current limiter, Constant current control function and Protection function for control of primary side of a transformer.
- Phase control

☞ For the setting example, refer to **5.19.2 Setting example (P. 5-30 to 5-32)**.

☞ For the function description, refer to **6.5 Heater Break Alarm/Thyristor Break-Down Alarm (optional) (P. 6-8)**.

n1 Number of alarm 1 determination (n1)

Use to set the number of determination of Heater break alarm 1 and Thyristor break-down alarm 1. This setting is common to both Heater break alarm 1 and Thyristor break-down alarm 1.

Setting range	Factory set value
1 to 1000 times	30

📖 This setting becomes active only when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

☞ For the function description, refer to **6.7 Number of Alarm Determination (P. 6-20)**.

n2 Number of alarm 2 determination (n2)

Use to set the number of determination of Heater break alarm 2 and Thyristor break-down alarm 2. This setting is common to both Heater break alarm 2 and Thyristor break-down alarm 2.

Setting range	Factory set value
1 to 1000 times	300

📖 This setting becomes active only when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

☞ For the function description, refer to **6.7 Number of Alarm Determination (P. 6-20)**.

SA Alarm enable/disable during STOP (SA)

Use to set the alarm enable/disable during the STOP.

- In case of Heater break alarm:
  Disabling the Alarm enable/disable during STOP (SA) releases the Heater break alarm state by switching the mode to STOP when Heater break alarm occurs in RUN.
- In case of Over current alarm:
  Disabling the Alarm enable/disable during STOP (SA) activates only the Determination of automatic reset of Over current alarm in STOP.
- In case of Heat sink temperature abnormality:
  Disabling the Alarm enable/disable during STOP (SA) allows the instrument to judge an automatic reset at the time of abnormal temperature of the heat sink during STOP state.

Setting range	Factory set value
0: Disable 1: Enable	0

☞ For the setting method, refer to **5.21 Setting Alarm Action in STOP State (P. 5-46)**.

■ Alarm actions when this function is enabled/disabled

Use to set enable/disable of alarm at STOP as well as alarm state of Heater break alarm, Over current alarm and Heat sink temperature abnormality after switching between RUN/STOP.

Heater break alarm *

Alarm enable/disable during STOP (SA) setting	RUN/STOP state	Alarm determination in RUN/STOP
Disable	RUN	Alarm determination active
	STOP	Alarm reset (alarm forced release)
Enable	RUN	Alarm determination active
	STOP	Retain previous alarm state

* The alarm determination of the Thyristor break-down alarm is active regardless of the RUN/STOP state.
  Note: In case of Type 2 (Linearity resistor type, absolute value alarm), the Thyristor break-down alarm determination is active only at 0 % output.

Over current alarm

Alarm enable/disable during STOP (SA) setting	RUN/STOP state	Alarm determination in RUN/STOP
Disable	RUN	Alarm determination active (No determination of automatic reset*)
	STOP	Only determination of automatic reset* is active.
Enable	RUN	Alarm determination active (No determination of automatic reset*)
	STOP	Alarm determination active (No determination of automatic reset*)

* Determination of automatic reset:
  If current transformer input value goes below the Over current alarm determination point six times successively during STOP, alarm state is automatically released.

Heat sink temperature abnormality

Alarm enable/disable during STOP (SA) setting	RUN/STOP state	Alarm determination in RUN/STOP
Disable	RUN	Alarm determination active (No determination of automatic reset*)
	STOP	Alarm determination active (with an automatic reset *)
Enable	RUN	Alarm determination active (No determination of automatic reset*)
	STOP	Alarm determination active (No determination of automatic reset*)

* Determination of automatic reset:
When temperature comes down below approx. 120 °C during STOP state, alarm state is released and automatic reset is performed.

4.5.5 Parameter of function block 5

F.5 Function block 5 (F.5)

This is first parameter symbol of Function block 5 (F.5).

dM Default display selection (dM)

Specify the monitor screen to display when the instrument is powered on or when no action was taken for one minute.

Setting range	Factory set value
0: Input signal monitor 1: CT input monitor 2: Power frequency monitor	0

📖 If the instrument is not supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer, setting "1: CT input monitor" is disregarded and the setting is switched to the Input signal monitor.

dT Display off timer (dT)

Set the time before the display of this instrument goes off.

Setting range	Factory set value
0 to 1000 seconds (0: Constantly lit)	0

☞ For the function description, refer to **6.13 Display Off Function (P. 6-28)**.

ūH Integrated operation time [upper 3 digits] (WH)

Display the Integrated operating time (upper 3 digits).

Display range
0 to 999 (Resolution of display: 1, 000 hours)

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

ūL Integrated operation time [lower 3 digits] (WL)

Displays the Integrated operating time (lower 3 digits).
One hour (one count) is added to the Integrated operation time every time the instrument is powered on and off.
If the total Integrated operating time exceeds 999 hours, these digits move to the Integrated operating time display [upper 3 digits] (WH).

Display range
0 to 999 (Resolution of display: 1 hours)

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

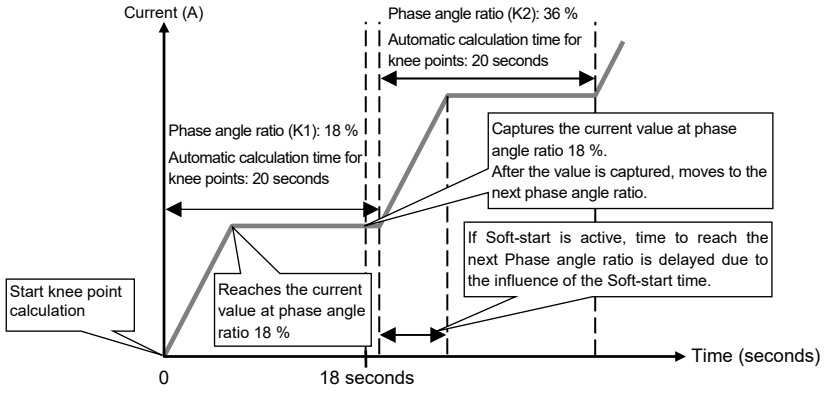
4.5.6 Parameter of function block 6

F.6 Function block 6 (F.6)

This is first parameter symbol of Function block 6 (F.6).

Ht Automatic calculation time for knee points (HT)

Set the time until the heater stabilizes as the output time.
This instrument takes in current values of each phase angle ratio by changing the phase angle ratio in the order K1, K2, K3 and 100 % before knee point is detected. This requires time until heater gets stable at each phase angle ratio. When the phase angle ratio has reached 90 % of the time required for the knee point calculation, the current is taken, and after the time for the knee point calculation has passed, the another phase angle ratio is started.



Setting range	Factory set value
0 to 1000 seconds (0: Automatic detection function of knee points unused)	20

The automatic detection function raises the output of the instrument to 100 %. If you do not want to apply an output of 100 % to the heater, use the Gradient setting, Output limiter, or Current limit to limit the output.

This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

HU Automatic detection of knee points (HU)

Conduct automatic detection of knee points. When this parameter is set to "1: ON," automatic detection of knee points starts. After the automatic detection is completed, the set value returns to "0: OFF" automatically. If automatic detection is aborted, the setting becomes "2: Aborted."

- **It may not be possible to use the non-linear resistance heater break alarm function with some heater types.**
- **Use the Non-linear resistance heater break alarm function in a system with a current capacity of 10 A or more. Current measurement error is ±2 A (for 20 A and 30 A types) or ±5 % of rated current (for 45 A or larger types). If this instrument is used with low current level, the knee point may be calculated within the error range of the current measurement.**

Setting range	Factory set value
0: OFF 1: ON 2: Aborted (Not settable)	0

This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

■ Automatic detection abort condition

Automatic detection of knee points is aborted because of the following reasons:

Factor	Status during abort	Set value
Mode has been switched from RUN to STOP during the automatic detection.	Aborted	Not updated. (The value remains the same as before the automatic detection of knee point was conducted)
Setting of knee points automatic detection has been set to "0: OFF" during the automatic detection.	OFF	
Control mode for phase control has been switched from Phase control to Zero-cross control during the automatic detection.	Aborted	
Current limiter value was changed during the automatic detection.		
Limit value of Output limiter high was changed during the automatic detection.		
Phase angle ratio of knee point was changed during the automatic detection.		
Automatic calculation time for knee points was changed during the automatic detection.		
FAIL alarm occurred during the automatic detection. *		
Over current alarm occurred.		

* If FAIL occurs due to watch dog timer, automatic detection abort condition is not met.

P1 Phase angle ratio at knee point 1 (K1)

The horizontal axis position of knee point 1 is set by the Phase angle ratio (%).

Setting range	Factory set value
0 to 100 %	18

📖 This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

📖 When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

☞ For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

☞ For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

r1 Current value at knee point 1 (r1)

The vertical axis position of knee point 1 is set by the Current value. This is used when the knee point is set manually.

📖 **When setting the current value of the knee point, set a value that is less than the current value of the Maximum load current set value for alarm. If a value greater than the current value of the Maximum load current set value for alarm is set, the alarm function will not operate normally.**

Setting range	Factory set value
0.0 to 22.0 A (20 A type)	3.6
0.0 to 33.0 A (30 A type)	5.4
0.0 to 50.0 A (45 A type)	8.1
0 to 66 A (60 A type)	11
0 to 88 A (80 A type)	14
0 to 110 A (100 A type)	18
0 to 165 A (150 A type)	27
0 to 220 A (200 A type)	36

📖 This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, or Constant current control function and Protection function for control of primary side of a transformer.

📖 When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

☞ For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

☞ For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

U2 Phase angle ratio at knee point 2 (K2)

The horizontal axis position of knee point 2 is set by the Phase angle ratio (%).

Setting range	Factory set value
0 to 100 %	36

This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

r2 Current value at knee point 2 (r2)

The vertical axis position of knee point 2 is set by the Current value.
This is used when the knee point is set manually.

When setting the current value of the knee point, set a value that is less than the current value of the Maximum load current set value for alarm. If a value greater than the current value of the Maximum load current set value for alarm is set, the alarm function will not operate normally.

Setting range	Factory set value
0.0 to 22.0 A (20 A type)	7.2
0.0 to 33.0 A (30 A type)	10.8
0.0 to 50.0 A (45 A type)	16.2
0 to 66 A (60 A type)	22
0 to 88 A (80 A type)	29
0 to 110 A (100 A type)	36
0 to 165 A (150 A type)	54
0 to 220 A (200 A type)	72

This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

U3 Phase angle ratio at knee point 3 (K3)

The horizontal axis position of knee point 3 is set by the Phase angle ratio (%).

Setting range	Factory set value
0 to 100 %	56

📖 This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

📖 When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

☞ For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

☞ For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

r3 Current value at knee point 3 (r3)

The vertical axis position of knee point 3 is set by the Current value.
This is used when the knee point is set manually.

📖 **When setting the current value of the knee point, set a value that is less than the current value of the Maximum load current set value for alarm. If a value greater than the current value of the Maximum load current set value for alarm is set, the alarm function will not operate normally.**

Setting range	Factory set value
0.0 to 22.0 A (20 A type)	11.2
0.0 to 33.0 A (30 A type)	16.8
0.0 to 50.0 A (45 A type)	25.2
0 to 66 A (60 A type)	34
0 to 88 A (80 A type)	45
0 to 110 A (100 A type)	56
0 to 165 A (150 A type)	84
0 to 220 A (200 A type)	112

📖 This setting becomes active when the instrument is supplied with Heater break alarm (or Non-liner resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

📖 When Zero-cross control is used, the Non-linear resistance heater break alarm function cannot be used.

☞ For the setting example, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

☞ For the function description, refer to **(3) Non-linear resistance heater break alarm (P. 6-15)**.

4.5.7 Parameter of function block 7

F.7 Function block 7 (F.7)

This is first parameter symbol of Function block 7 (F.7).

TF Protection function for control of primary side of a transformer (TF)

Use to enable/disable Protection function for control of primary side of a transformer.
This setting must be "1: Protection function for control of primary side of a transformer enable" when Protection function for control of primary side of a transformer is used.

Setting range	Factory set value
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

📖 Protection function for control of primary side of a transformer is optional. (Specify when ordering)

📖 Protection function for control of primary side of a transformer can be used with Heater break alarm or Non-linear resistance heater break alarm.

☞ For the setting example, refer to **5.25 Setting of Protection Function for Control of Primary Side of a Transformer (P. 5-50)**.

☞ For the function description, refer to **6.18 Protection Function for Control of Primary Side of a Transformer (optional) (P. 6-33)**.

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

This is a setting to determine if break (momentary power failure) occurred on the secondary side of the transformer. This parameter is used for Protection function for control of primary side of a transformer. 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," this determination function for break of secondary side of a transformer is enabled.

Setting range	Factory set value
0 to 100 % of reference current value	70

📖 This function is available on the instrument with a Protection function for control of primary side of a transformer.

☞ For the setting example, refer to **5.25 Setting of Protection Function for Control of Primary Side of a Transformer (P. 5-50)**.

☞ For the function description, refer to **6.18 Protection Function for Control of Primary Side of a Transformer (optional) (P. 6-33)**.

rL Output limiter setting in case of a break on the secondary side of the transformer (TL)

Use to set output limiter to suppress control output in case of a break (momentary power failure) on the secondary side of the transformer.
This parameter is used for Protection function for control of primary side of a transformer.
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," this output limiter function for break of secondary side of a transformer is enabled.

Setting range	Factory set value
15.0 to 50.0 % of phase angle	15.0

- When the instrument is automatically recovered from break on the secondary side of a transformer (momentary power failure), the output limiter for a break of secondary side of a transformer will be released.
- This function is available on the instrument with a Protection function for control of primary side of a transformer.
- For the setting example, refer to **5.25 Setting of Protection Function for Control of Primary Side of a Transformer (P. 5-50)**.
- For the function description, refer to **6.18 Protection Function for Control of Primary Side of a Transformer (optional) (P. 6-33)**.

rU Soft-start time in case of break on the secondary side of the transformer (TU)

Use to set the Soft-start time when the instrument is recovered from a break (momentary power failure) on the secondary side of a transformer. This Soft-start function is only activated when the instrument is recovered from a break on the secondary side of a transformer.
This parameter is used for Protection function for control of primary side of a transformer.
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," this Soft-start function for break of secondary side of a transformer is enabled.

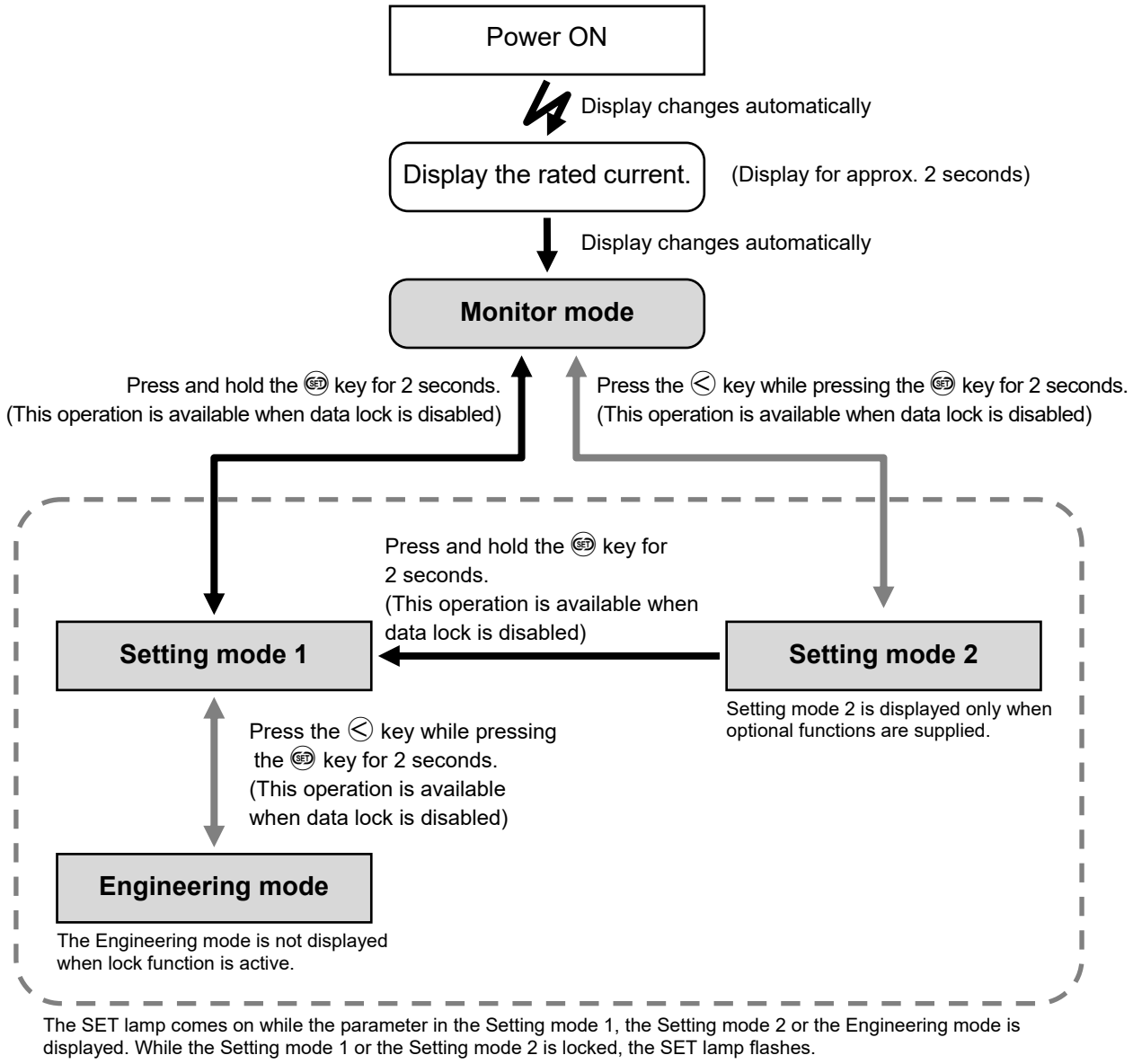
Setting range	Factory set value
0.1 to 100.0 seconds	0.1

- This function is available on the instrument with a Protection function for control of primary side of a transformer.
- For the setting example, refer to **5.25 Setting of Protection Function for Control of Primary Side of a Transformer (P. 5-50)**.
- For the function description, refer to **6.18 Protection Function for Control of Primary Side of a Transformer (optional) (P. 6-33)**.

SETTING 5

5.1 Mode Menu

The instrument has four different modes, and all settable parameters belong to one of them. The following chart shows how to access different mode. Modes can be switched through key operation of SET (SET) and Shift (◁) keys.

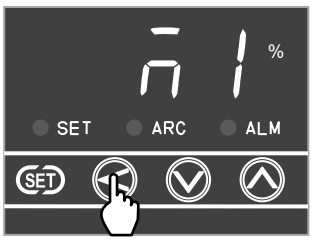


📖 Setting mode 1, Setting mode 2 and Engineering mode return to Monitor mode if key operation is not performed for more than one minute.

☞ To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

5.2 Switching Parameters Within the Same Mode

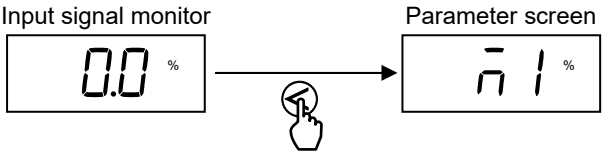
5.2.1 Switching parameters within the mode (Monitor mode)

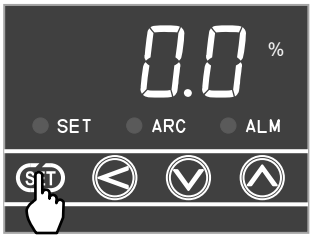


Display parameter symbol

Parameter screen is displayed while the Shift key (◁) is pressed.

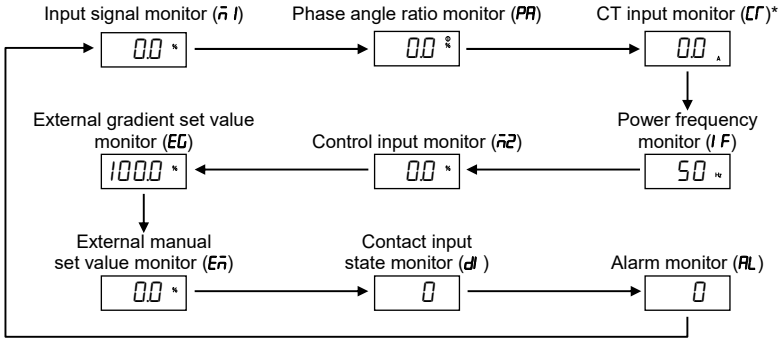
Example: Display the parameter symbol for Input signal monitor.





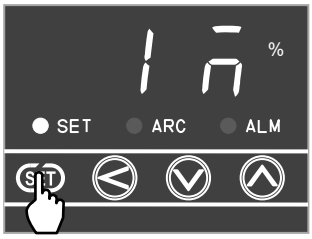
Select Monitor screen

Every time the SET key (SET) is pressed, the screen goes to the next monitor screens.



* CT input monitor appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

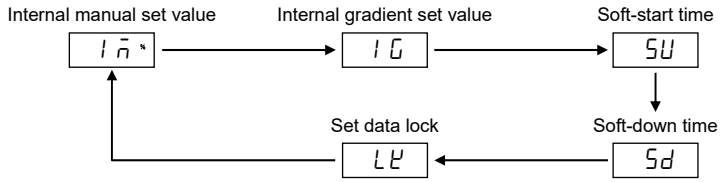
5.2.2 Switching parameters within the mode (Setting mode 1, Setting mode 2)



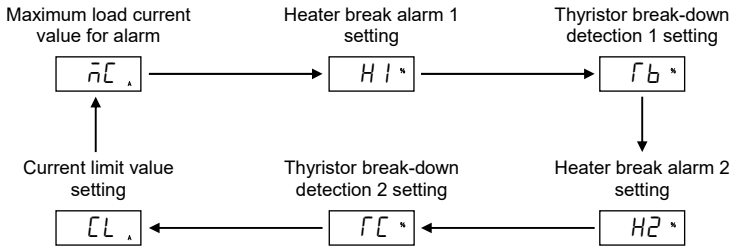
Select Setting item

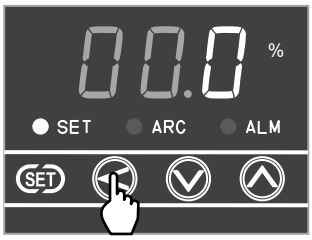
Every time the SET key (SET) is pressed, the screen goes to the next parameter screens. Keep pressing the SET key until the desired setting parameter is displayed.

Parameter screen of Setting mode 1



Parameter screen of Setting mode 2

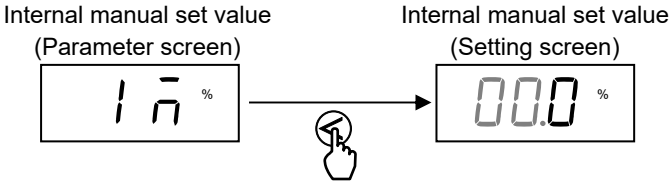




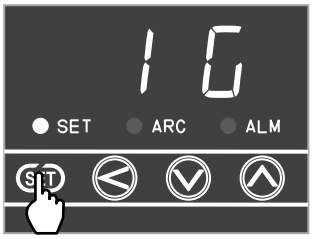
Enter setting screen

Press the Shift key (<) to switch the parameter screen to the setting screen. Then, the parameter becomes adjustable.

Example: Switch the screen to the Internal manual set value.



☞ To change the set value, refer to **5.3 Changing Set Value (P. 5-7)**.

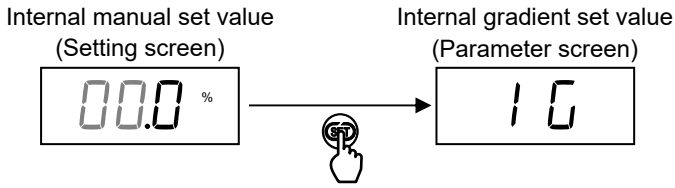


Return to the parameter screen

Press the SET key (SET) to switch the mode to the parameter screen.

After returning from setting, the next parameter is displayed.

Example: Return to the parameter screen from the Internal manual set value screen.



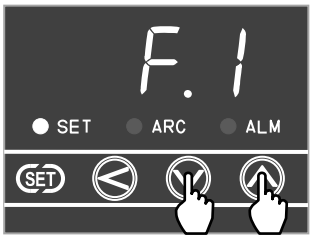
5.2.3 Switching parameters within the mode (Engineering mode)

Parameters in the Engineering mode should be set according to the application before setting any parameter related to operation. Once the parameters in the Engineering mode are set correctly, no further changes need to be made to parameters for the same application under normal conditions.

All parameters of the Engineering mode are displayed regardless of the instrument specification. Parameters of functions that were not specified when you placed the order will also appear. Even if set, these parameters will not be effective.

When changing to the engineering mode, it is necessary to unlock the Engineering mode lock.

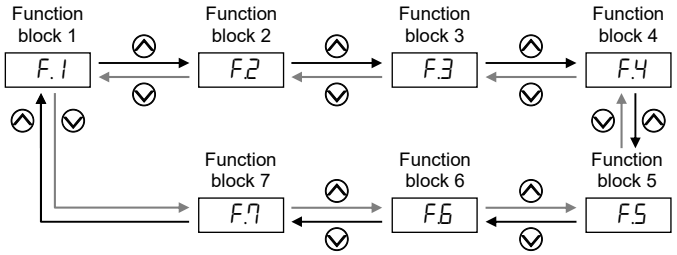
Refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)** for unlocking the Engineering mode.

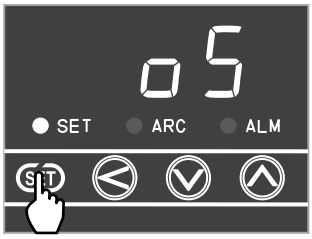


Select Function block (F.☐)

Setting items in the Engineering mode are grouped into Function blocks (F.☐).

Each press of the UP key (⌃) advances one Function block (F.☐) forward. Each press of the DOWN key (⌄) moves one Function block (F.☐) backward.

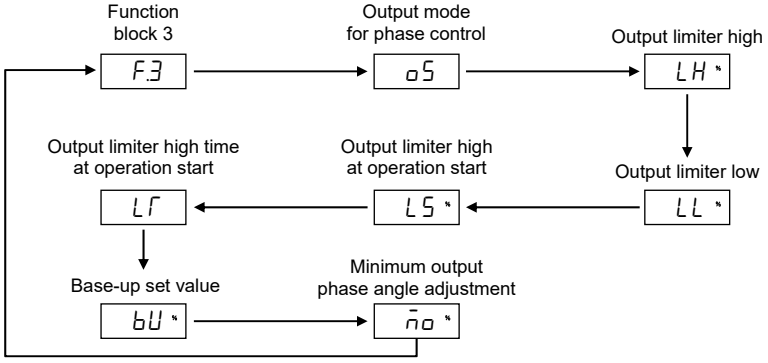


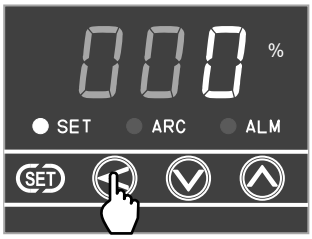


Select setting item

Each press of the SET key (SET) advances the parameter to the next within the same Function block. Continue this procedure until the desired parameter is displayed.

Example: Parameter screens of Function block 3

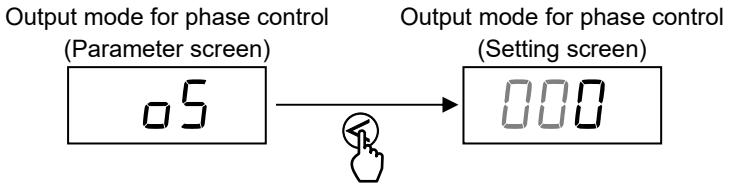




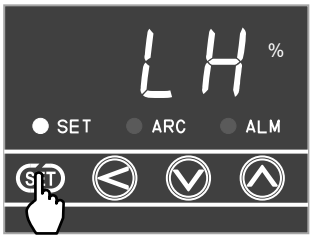
Enter setting screen

Press the Shift key (<) to switch the parameter screen to the setting screen. Then, the parameter becomes adjustable.

Example: Switch the screen to the Output mode for phase control setting.



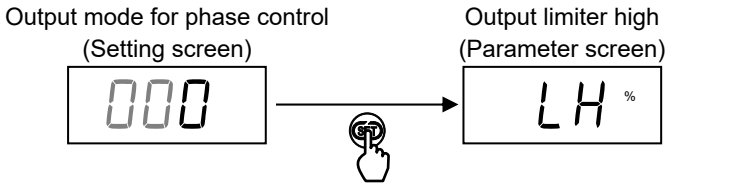
☞ To change the set value, refer to **5.3 Changing Set Value (P. 5-7)**.



Return to the parameter screen

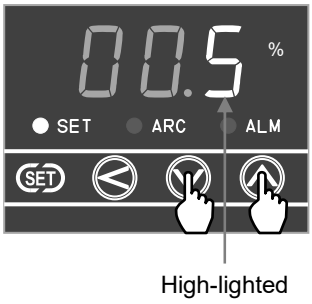
Press the SET key (SET) to switch the mode to the parameter screen.
After returning from setting, the next parameter is displayed.

Example: Switch the screen to the parameter screen from the setting screen of Output mode for phase control setting.



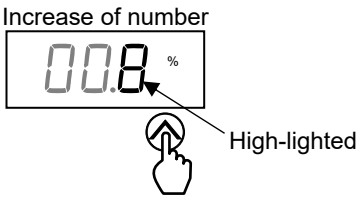
☞ For other setting items in the Engineering mode, refer to the **A.1 List of Parameter Operation (P. A-2)**.

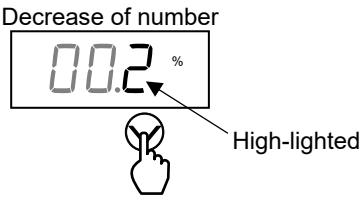
5.3 Changing Set Value



Change set value

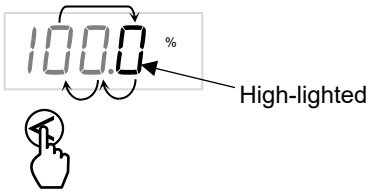
The high-lighted digit indicates which digit can be set. The set value can be adjusted by pressing UP (⌃) and DOWN (⌄) keys.





Shift highlighted digit

Press Shift key (⌃) to go to a different digit.

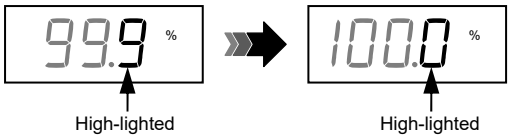


Increase/Decrease numerals

The following is also available when changing the set value.

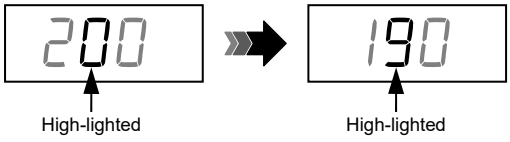
Automatically increase the set value
Increase set value from 99.9 to 100.0:

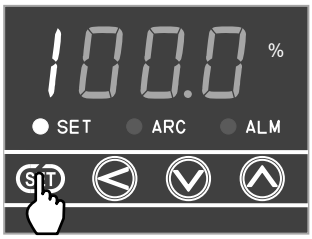
1. Press the Shift key (⌃) to high-lighted the least significant digit (first digit from the right).
2. Press the UP key (⌃) to change to 0. The display changes to 100.0.



Automatically decrease the set value
Decrease set value from 200 to 190:

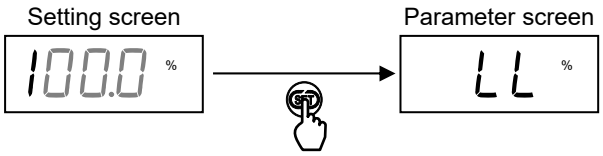
1. Press the Shift key (⌃) to high-lighted the tens place.
2. Press the DOWN key (⌄) to change to 9. The display changes to 190.





Store the set value

To store a new value for the parameter, always press the SET key (SET). The display changes to the next parameter and the new value will be stored.



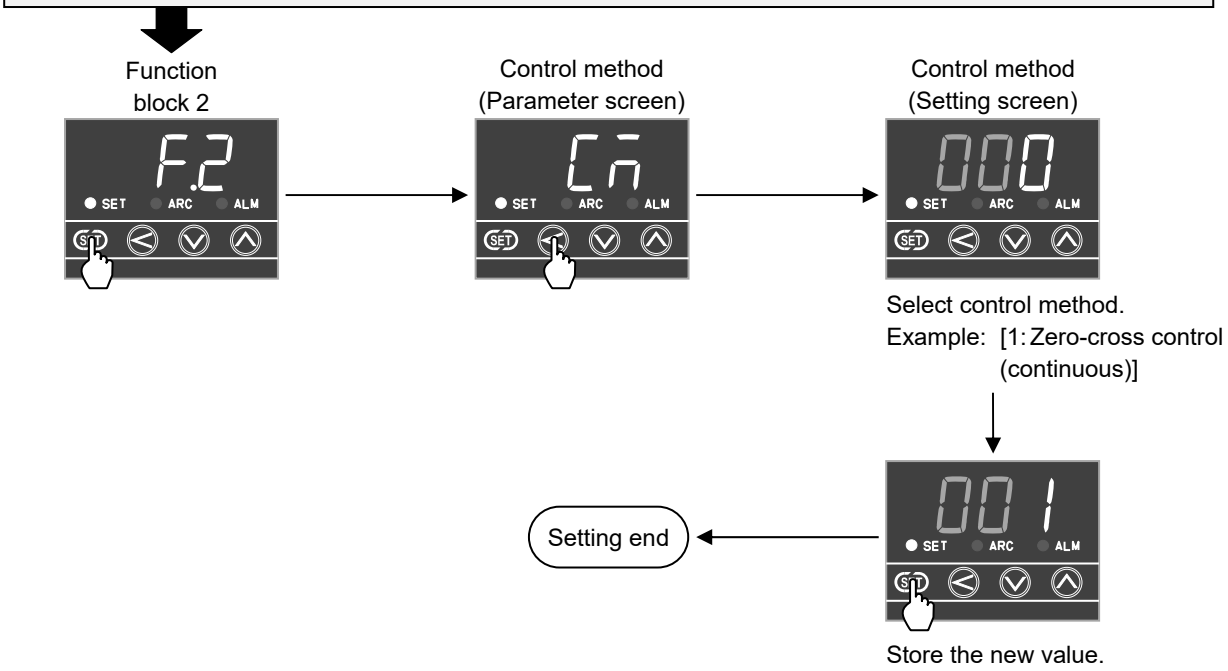
- **Keep the instrument powered on for at least 2 seconds after having stored the changed value. If the instrument is powered off immediately after having stored the changed value, the changed value may not be stored.**
- The modified value is not stored only through key operation of UP (⌃) and DOWN (⌄) keys.
- After a new value has been displayed by using the UP (⌃) and DOWN (⌄) keys, the SET key (SET) must be pressed within 1 minute, or the new value is not stored and the display will return to the Monitor mode.
- After changing to Setting mode 1, Setting mode 2, or Engineering mode, if the key is not pressed for more than 1 minute the display will automatically return to the Monitor mode.

5.4 Setting Phase Control/Zero-Cross Control

Set control method of Phase control or Zero-cross control at Control method (CM).
Control method (CM) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.2 screen displays.



Data range	Factory set value
0: Phase control 1: Zero-cross control (continuous) 2: Zero-cross control (input synchronous type)	0

☞ For description of parameter, refer to **P. 4-27**.

☞ For description of function, refer to **6.10 Control Method (P. 6-24)**.

5.5 Setting Input Signal at the Time of Auto Mode

(1) Select Current or Voltage Input

Select current input or voltage input with the input signal select switch.

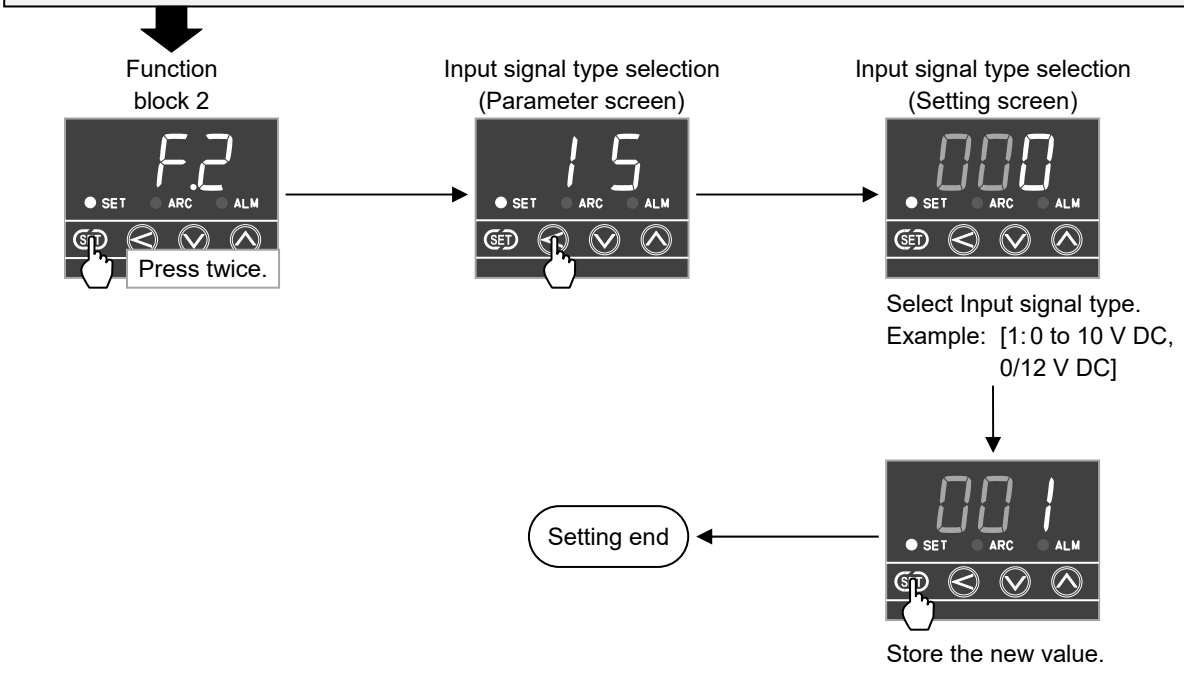
☞ Refer to **3.4.2 Input signal type changing method (P. 3-9)** for details of the input signal select switch.

(2) Set input signal type

Set input signal type (such as 4 to 20 mA DC, 0 to 10V DC, etc) at the Input signal type selection (IS). Input signal type selection (IS) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.2 screen displays.



Data range	Factory set value
0: 4 to 20 mA DC, 1 to 5 V DC 1: 0 to 10 V DC, 0/12 V DC	Based on model code

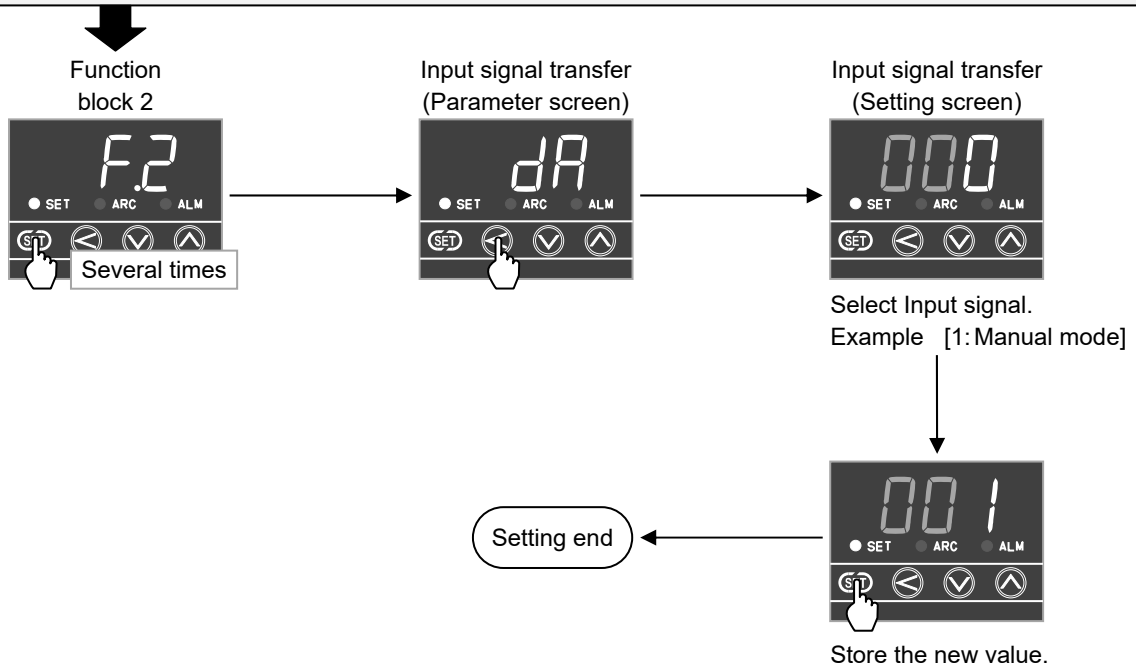
☞ For description of parameter, refer to **P. 4-28**.

5.6 Switching Between Auto Mode/Manual Mode

Select Auto mode or Manual mode at Input signal transfer (dA).
Input signal transfer (dA) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (△) until the F.2 screen displays.



Data range	Factory set value
0: Auto mode 1: Manual mode	0

☞ For description of parameter, refer to **P. 4-28**.

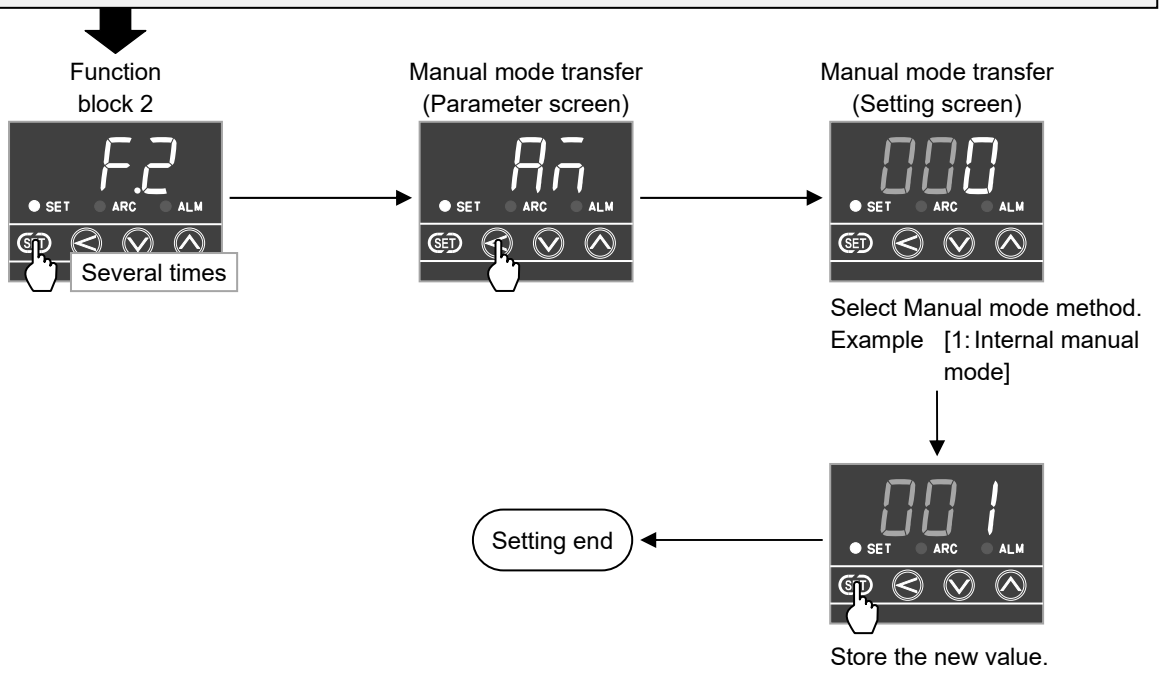
📖 If "Input signal type selection" by Contact input (DI) is used, Auto mode/Manual mode transfer via front key is not available.

5.7 Switching Between External Manual Setting/Internal Manual Setting

Select External manual mode or Internal manual mode at Manual mode transfer (AM).
Manual mode transfer (AM) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (△) until the F.2 screen displays.



Data range	Factory set value
0: External manual mode 1: Internal manual mode	0

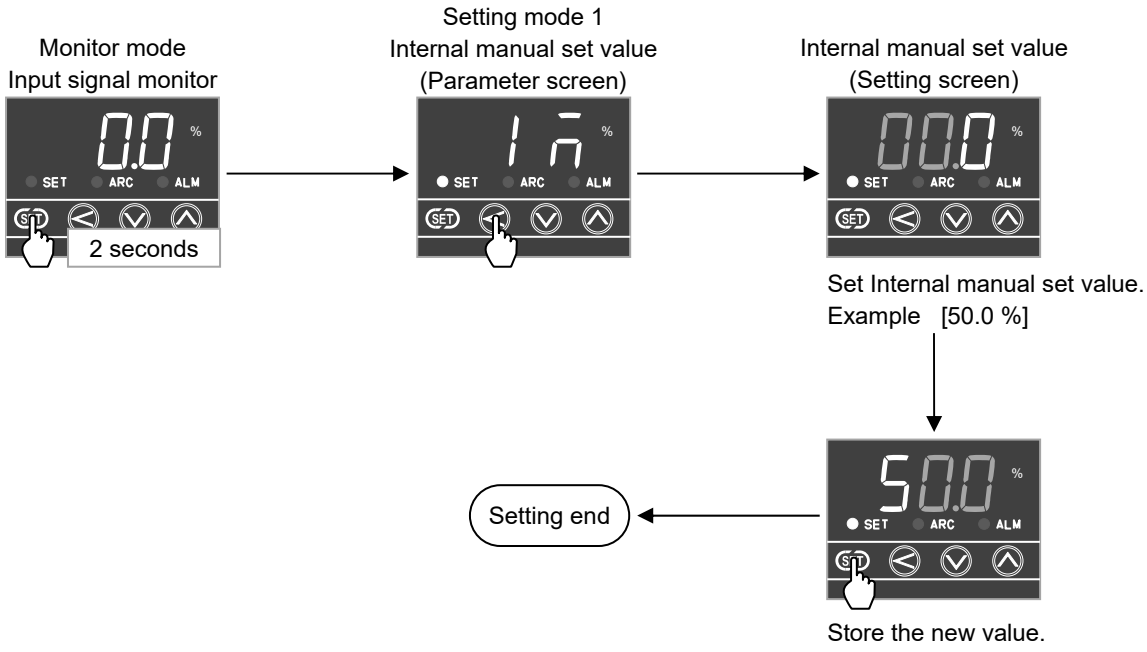
☞ For description of parameter, refer to **P. 4-29**.

If "Manual mode transfer" by Contact input (DI) is used, External manual mode/Internal manual mode transfer via front key is not available.

5.8 Setting Internal Manual Setting

Set Internal manual set value at Internal manual set value (IM).
Internal manual set value (IM) is at Setting mode 1.

☞ The set value in Setting mode 1 cannot be changed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.



Data range	Factory set value
0.0 to 100.0 %	0.0

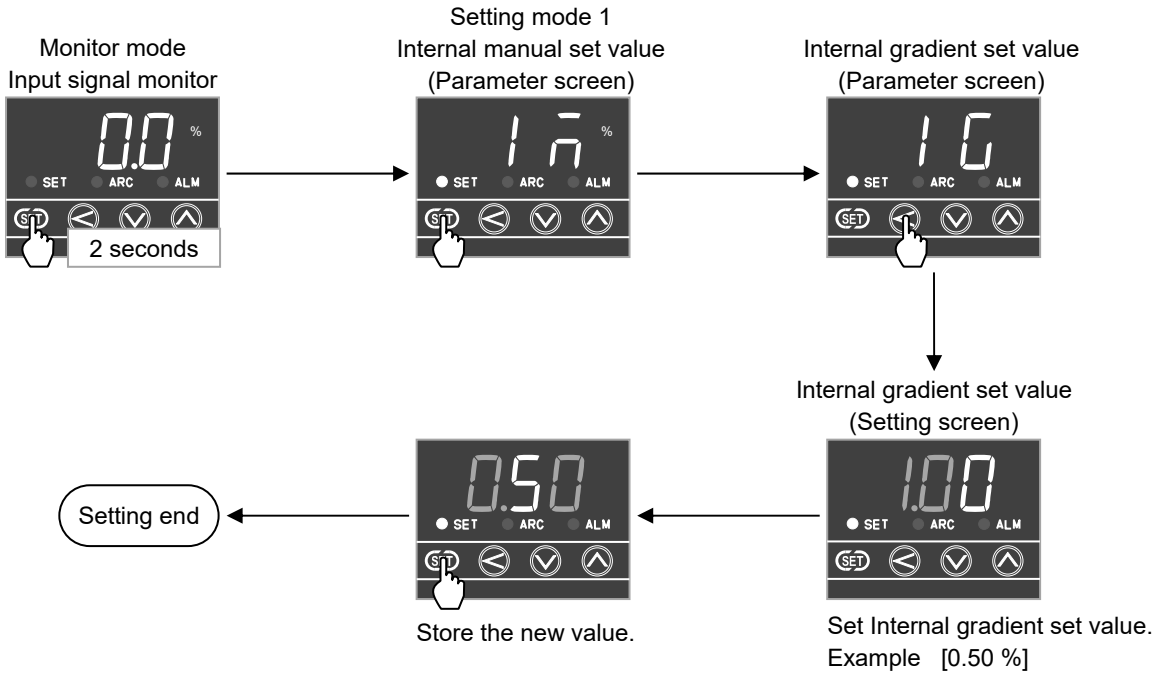
☞ For description of parameter, refer to **P. 4-12**.

☞ For the function description, refer to **6.1 Manual Mode (P. 6-2)**.

5.9 Setting Internal Gradient Setting

Set Internal gradient set value at Internal gradient set value (IG).
Internal gradient set value (IG) is at Setting mode 1.

☞ The set value in Setting mode 1 cannot be changed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.



Data range	Factory set value
0.00 to 2.00	1.00

☞ For description of parameter, refer to **P. 4-12**.

☞ For the function description, refer to **6.2 Gradient Setting Function (P. 6-4)**.

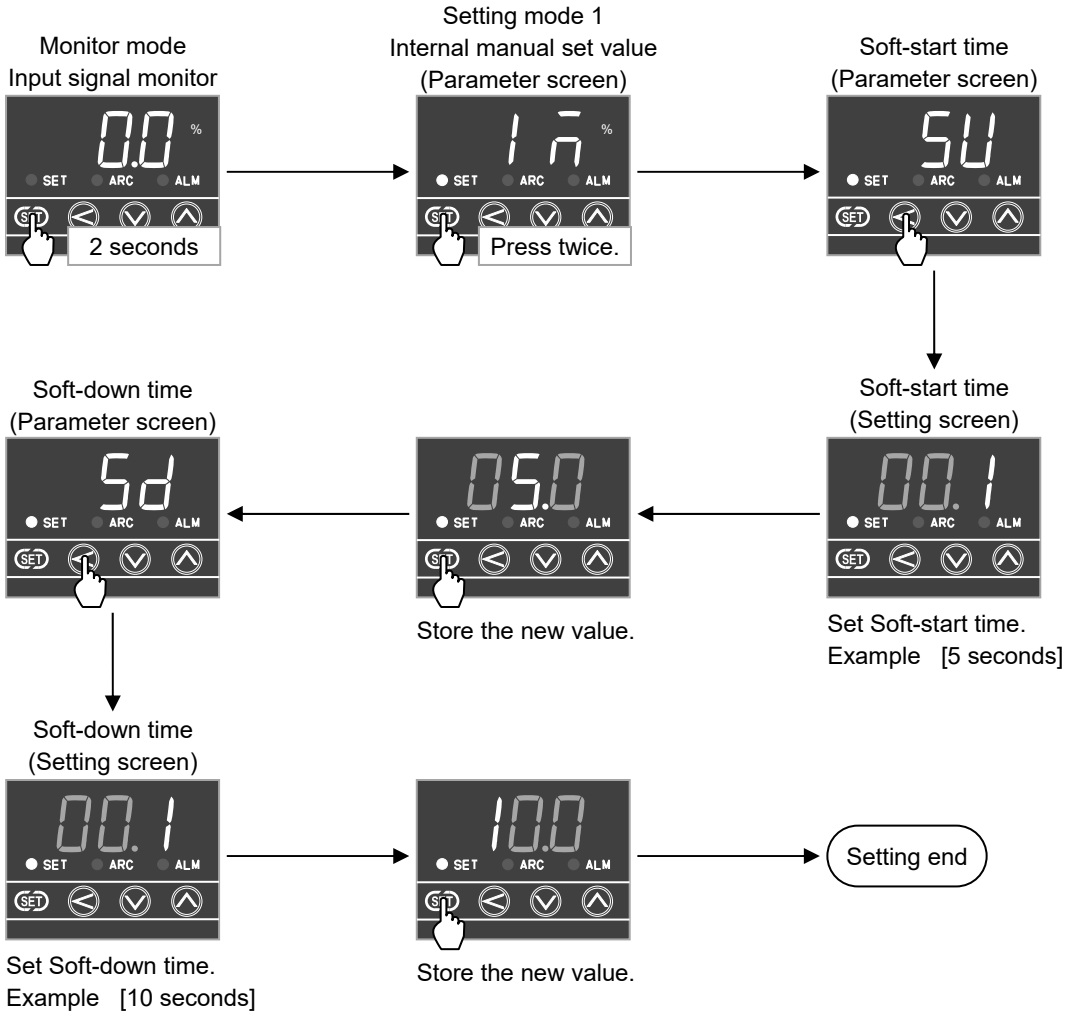
5.10 Setting Soft-Start Function and Soft-Down Function

The Soft-start/Soft-down functions are set at Soft-start time (SU) and Soft-down time (Sd).
Activation of the Soft-start function at the time of switching from STOP to RUN is settable at Soft-start, Soft-down enable/disable (SF).

(1) Set Soft-start and Soft-down time

Soft-start time (SU) and Soft-down time (Sd) are at Setting mode 1.

☞ The set value in Setting mode 1 cannot be changed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.



Data range	Factory set value
0.0 to 100.0 seconds	0.1

☞ For description of parameter, refer to **P. 4-13 and P. 4-14**.

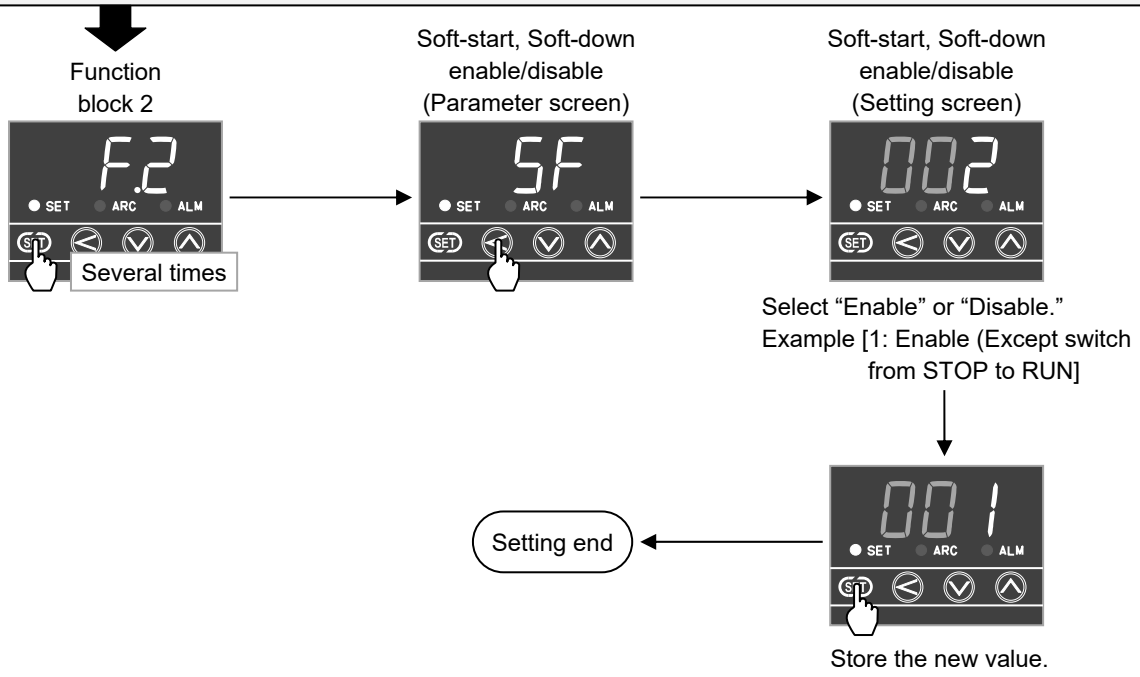
☞ For the function description, refer to **6.3 Ramp Function (Soft-Start/Soft-Down Function) (P. 6-5)**.

(2) Set Soft-start, Soft-down enable/disable function at RUN/STOP

Soft-start, Soft-down enable/disable (SF) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.2 screen displays.



Data range	Factory set value
0: Disable 1: Enable (Except switch from STOP to RUN) 2: Enable	2

☞ For description of parameter, refer to **P. 4-31**.

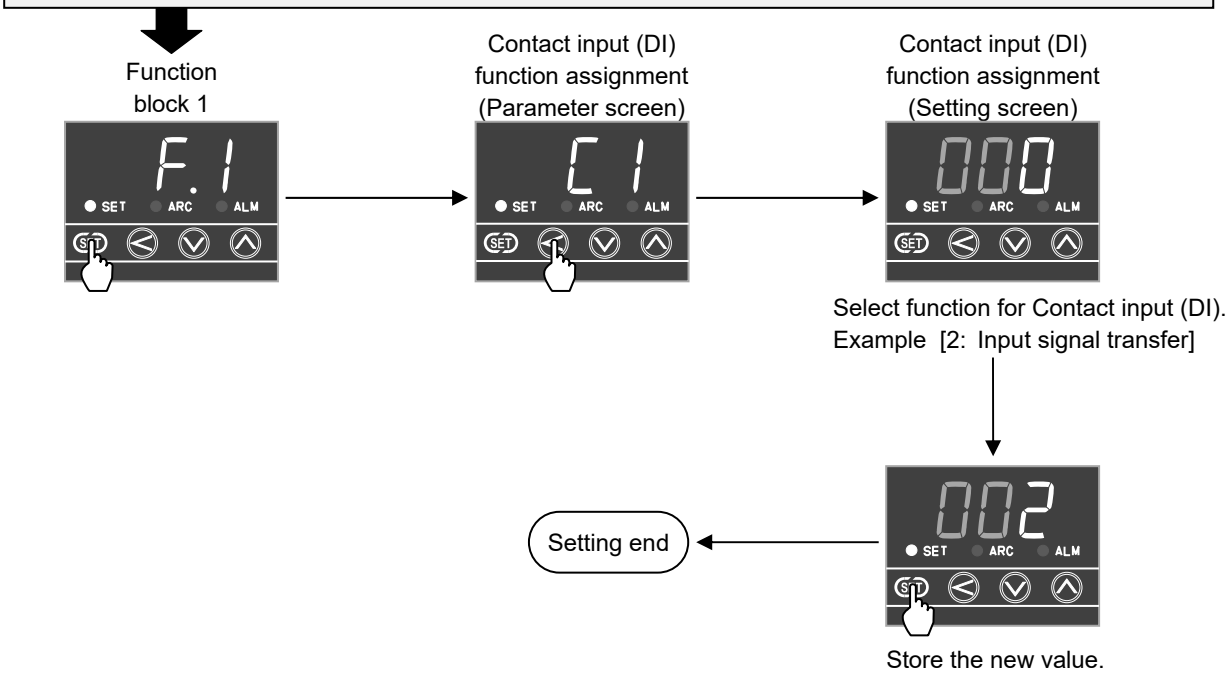
🕮 If Contact input (DI) is used for enabling/disabling the Soft-start/Soft-down function, enabling/disabling the function via front key is not available.

5.11 Assigning Contact Input (DI) Functions

The function of the Contact input (DI) can be configured at Contact input (DI) function assignment (C1).
Contact input (DI) function assignment (C1) is at F.1 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.



Data range	Factory set value
0: No function 1: Control method 2: Input signal transfer 3: Manual mode transfer 4: RUN/STOP transfer 5: Soft-start, Soft-down enable/disable 6: Heater break alarm enable/disable 7: Over current alarm enable/disable 8: Set data lock enable/disable	0

☞ For description of parameter, refer to **P. 4-25**.

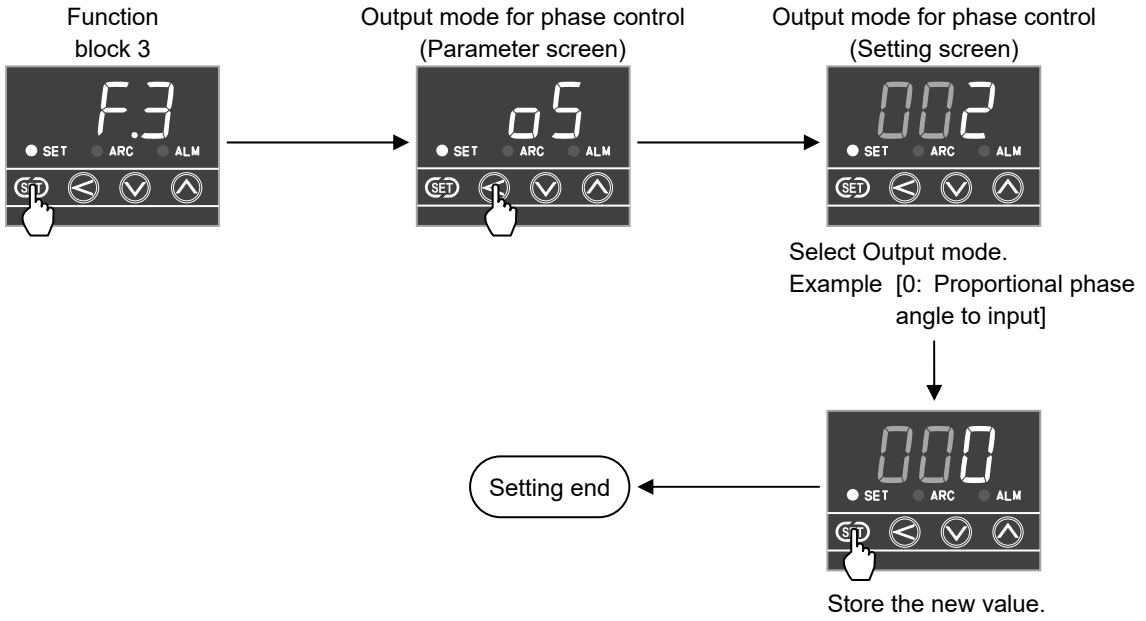
☞ For the function description, refer to **6.9 Contact Input (DI) Function (P. 6-22)**.

5.12 Setting Output Mode for Phase Control

Select Output mode at Output mode for phase control (oS).
Output mode for phase control (oS) is at F.3 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.3 screen displays.



Data range	Factory set value
0: Proportional phase angle to input 1: Proportional voltage to input 2: Proportional square voltage (electric power) to input 3: Constant current control (optional) *	2

* This set value appears when Constant current control function is specified at the time of ordering.

☞ For description of parameter, refer to **P. 4-34**.

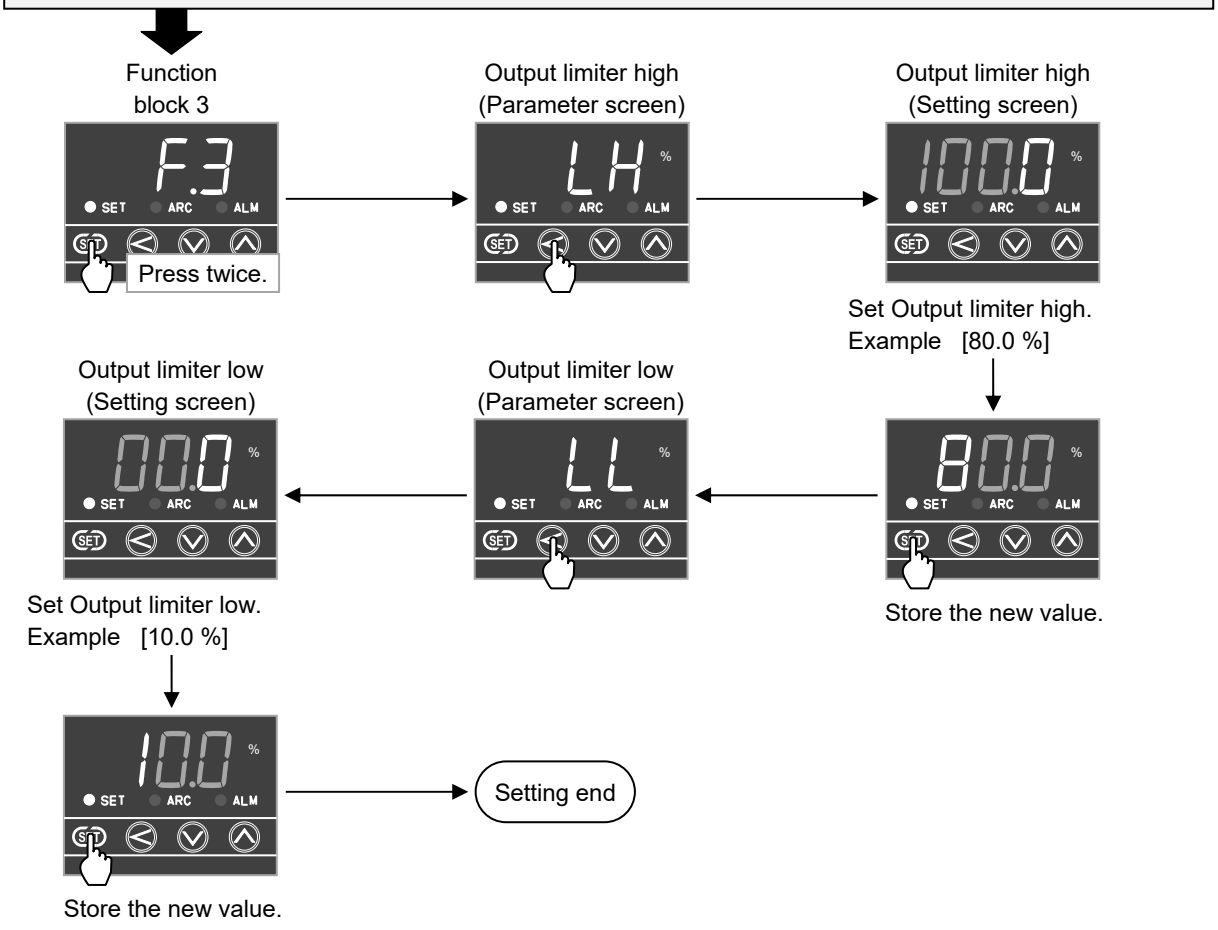
☞ For the function description, refer to **6.11 Output Mode for Phase Control (P. 6-25)**.

5.13 Setting Output Limiter High/Low

Set Output Limiter (high and low) at Output limiter high (LH) or Output limiter low (LL).
Output limiter high (LH) and Output limiter low (LL) are at F.3 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.3 screen displays.



Data range	Factory set value
0.0 to 100.0 % *	Output limiter high: 100.0 Output limiter low: 0.0

* The setting range of the Output limiter high and low is "Output limiter high ≧ Output limiter low."

☞ For description of parameter, refer to **P. 4-35**.

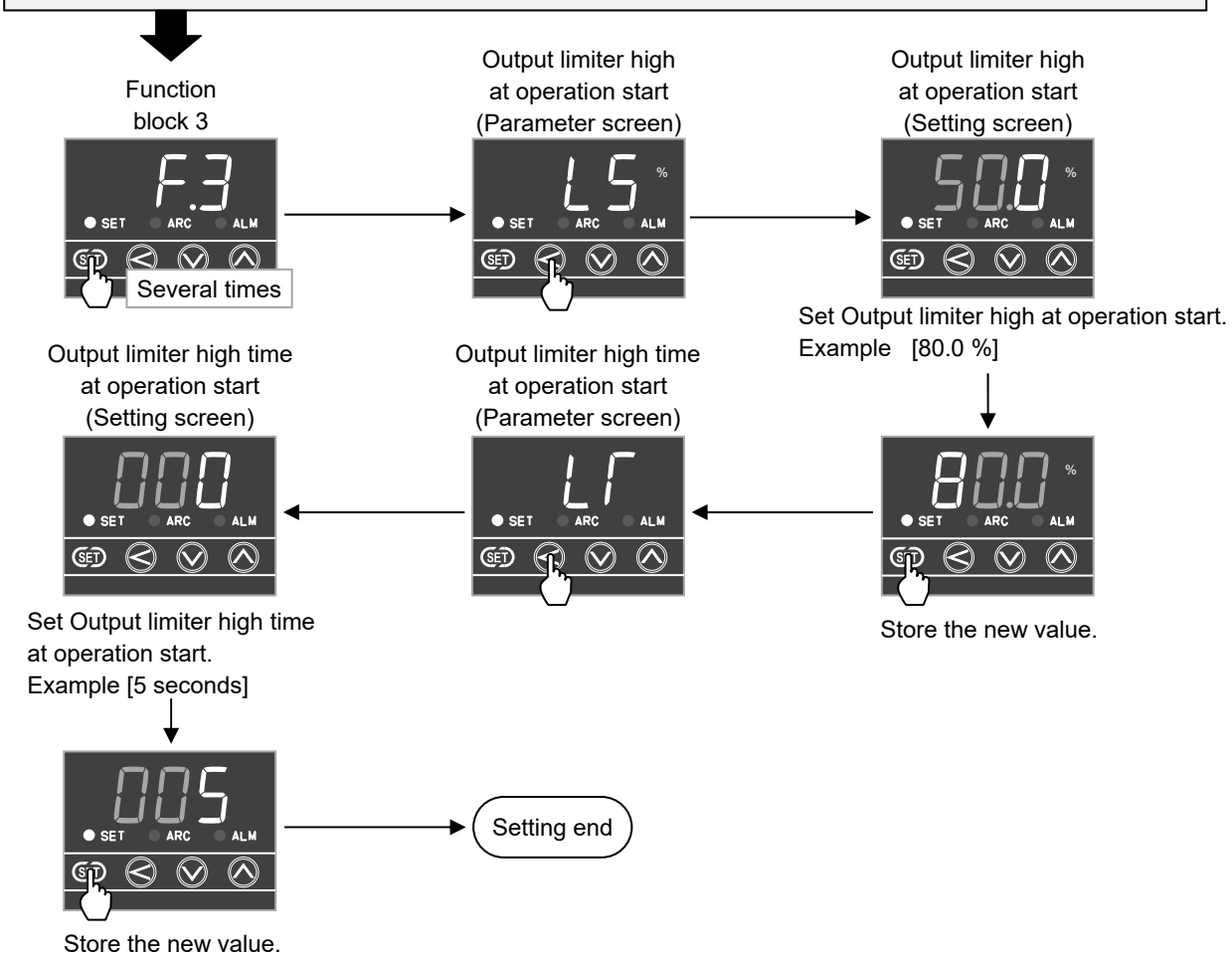
☞ For the function description, refer to **6.14 Output Limiter High and Low (P. 6-29)**.

5.14 Setting Output Limiter High at Operation Start

Output limiter high at operation start is used to set the high limit value of the limiter and its operating time. The high limit value is set at Output limiter high at operation start (LS). The limiter operating time is set at Output limiter high time at operation start (LT).

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.3 screen displays.



Data range	Factory set value
Output limiter high at operation start: 0.0 to 100.0 %	50.0
Output limiter high time at operation start: 0 to 600 seconds	0

☞ For description of parameter, refer to **P. 4-35 and P. 4-36**.

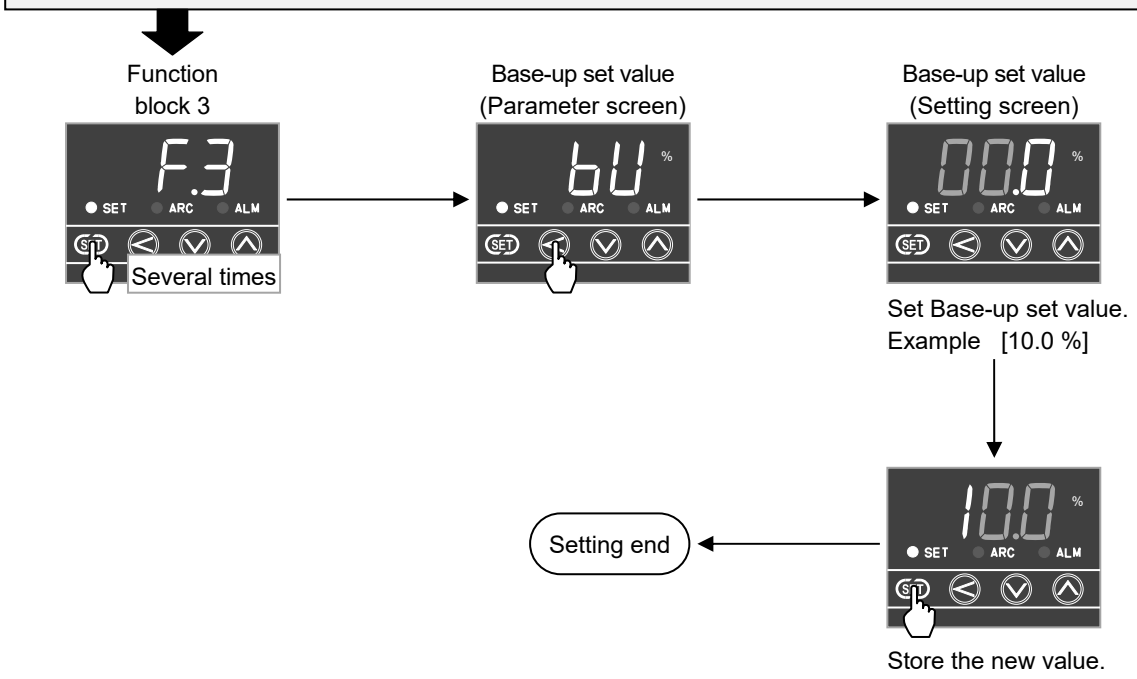
☞ For the function description, refer to **6.15 Output Limiter High at Operation Start (P. 6-30)**.

5.15 Setting Base-Up

Set Base-up set value at Base-up set value (BU).
Base-up set value (BU) is at F.3 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.3 screen displays.



Data range	Factory set value
–9.9 to +100.0 %	0.0

☞ For description of parameter, refer to **P. 4-36**.

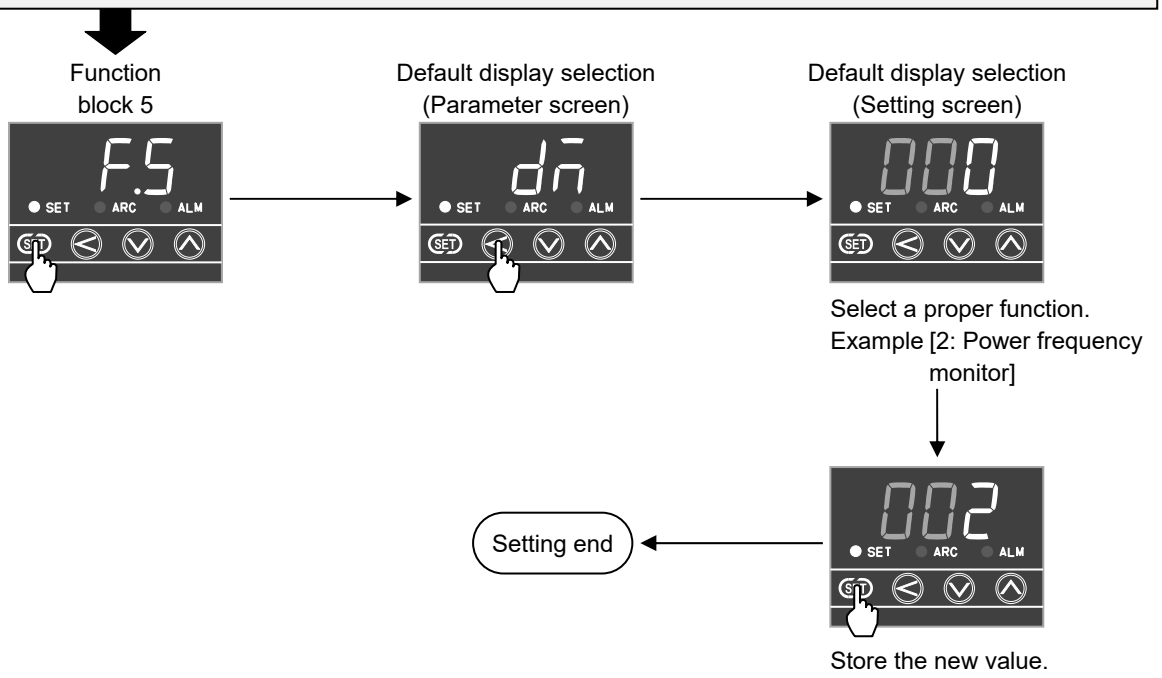
☞ For the function description, refer to **6.16 Base-Up Setting Function (P. 6-31)**.

5.16 Selecting Default Monitor Screen

Select the default monitor screen in Default display selection (dM).
Default display selection (dM) is at F.5 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (△) until the F.5 screen displays.



Data range	Factory set value
0: Input signal monitor 1: CT input monitor * 2: Power frequency monitor	0

* If Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer is not supplied, do not set "1: CT input monitor." Even if "1: CT input monitor" is set, the display is switched to the Input signal monitor.

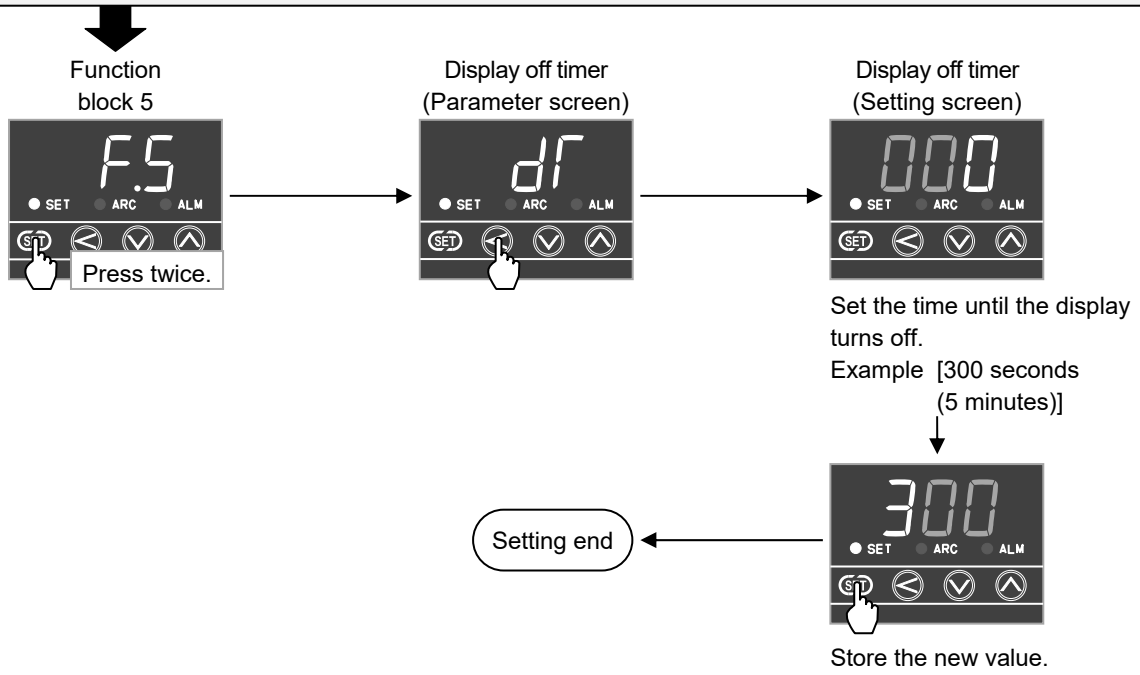
☞ For description of parameter, refer to **P. 4-42**.

5.17 Setting Display Off Function

Set Display off function at Display off timer (dT).
Display off timer (dT) is at F.5 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.5 screen displays.



Data range	Factory set value
0 to 1000 seconds (0: Constantly lit)	0

☞ For description of parameter, refer to **P. 4-42**.

☞ For the function description, refer to **6.13 Display Off Function (P. 6-28)**.

5.18 How to Find Maximum Load Current Value

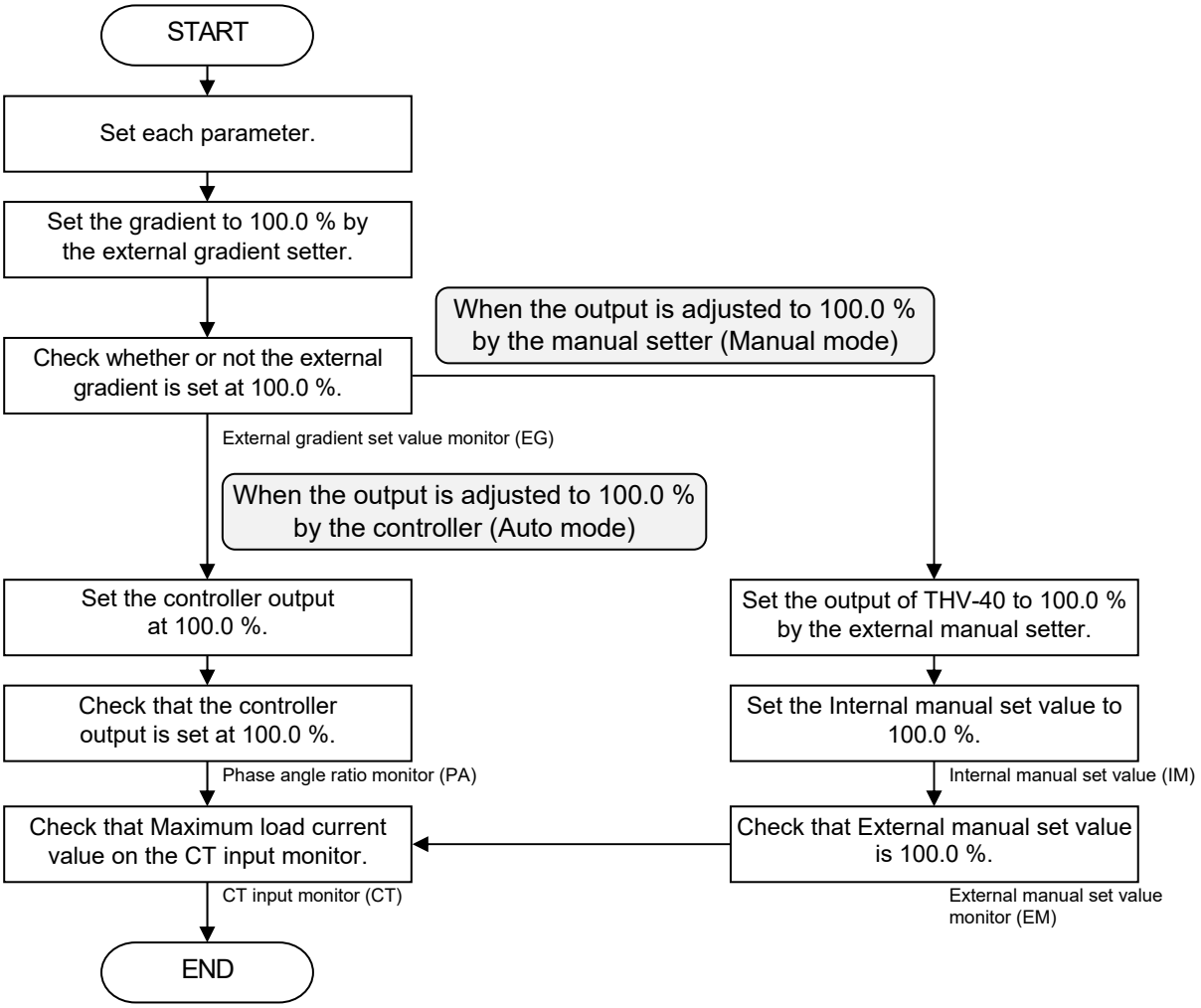
There are three methods to obtain the maximum load current value. In this section two of the three methods (① and ② in the following) are explained.

① Method of finding the maximum load current value by the THV-40 output
② Calculate the heater current rating.
(When it is not possible to flow the maximum current through each heater)
③ Automatically set the maximum load current value with the Automatic detection function of knee points.

☞ For the Non-linear resistance heater break alarm, refer to **5.20.3 Set Automatic detection of knee points (P. 5-39)**.

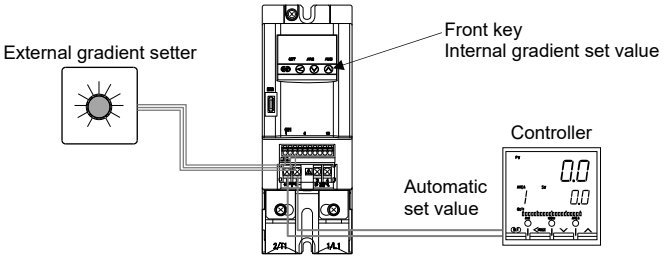
5.18.1 Method of finding the maximum load current value by the THV-40 output

Check the current value by the CT input monitor with the THV-40 output set at 100 %. The value checked at this time corresponds to the maximum load current value.
Set the output at 100 % by the controller (Auto mode) or manual setter (Manual mode).



■ Example of finding the maximum load current value with the THV-40 output set at 100.0 %

This is how to check the maximum load current value when used together with the controller.
After having set necessary parameters and the gradient, check the maximum load current value with the output from the controller set at 100.0 %.



(1) Set parameters to produce 100 % output

If the following parameters are used to limit the output, the output will never reach 100 % even with the input 100 %. To obtain 100 % output, set each parameter as follows.

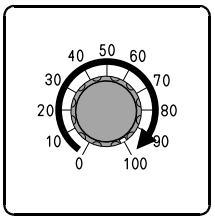
Mode	Symbol		Name	Settings
Setting mode 1	IG	(IG)	Internal gradient set value	Set the Internal gradient set value to 1.00. (Factory set value: 1.00)
Setting mode 2	CL	(CL)	Current limit value setting	Set the Current limit value setting to factory set value. Factory set values depend on the current rating of the instrument. Factory set value of each type 20 A type: 22.0 A 30 A type: 33.0 A 45 A type: 50.0 A 60 A type: 66 A 80 A type: 88 A 100 A type: 110 A 150 A type: 165 A 200 A type: 220 A
Engineering mode Function block 3	oS	(oS)	Output mode for phase control	Select any one of the following modes. 0: Proportional phase angle to input 1: Proportional voltage to input 2: Proportional square voltage (electric power) to input (factory set value)
	LH	(LH)	Output limiter high	Set the Output limiter high to 100.0 % (factory set value).
	bU	(bU)	Base-up set value	Set the Base-up set value to 0.0 % or more. (Factory set value: 0.0 %)

If Soft-start time or Output limiter high at operation start is set, the output becomes 100 % after the set time has passed.

(2) Set the external gradient to 100.0 %.

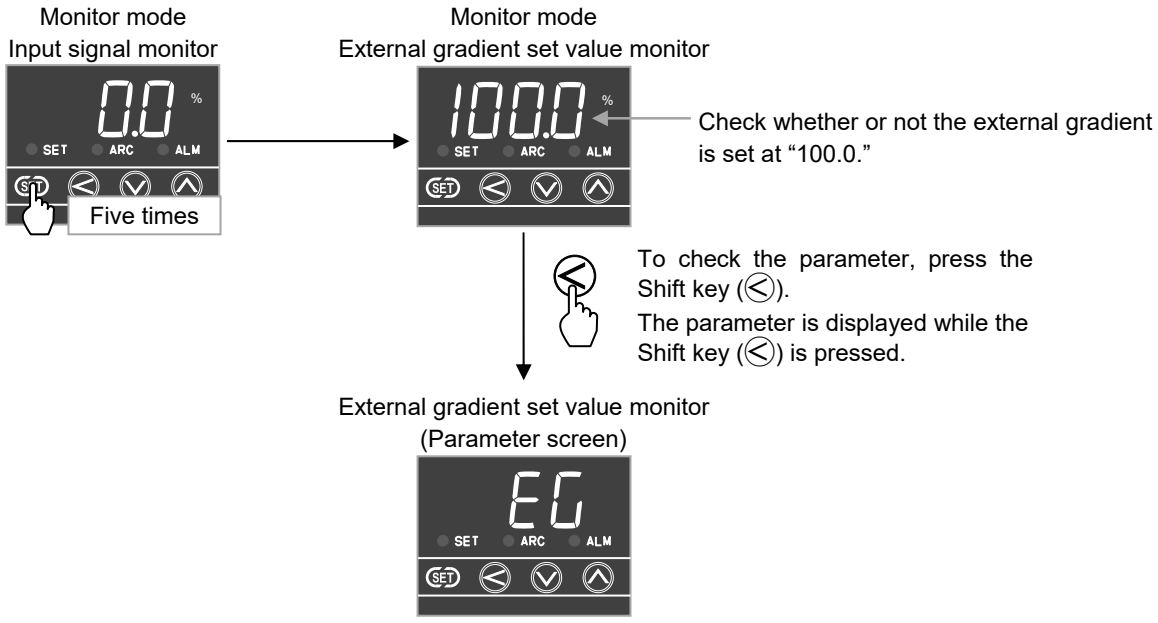
Align the arrow on the knob with “100” on the scale plate.

External gradient setter



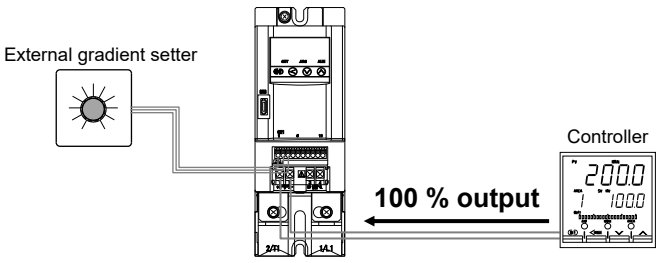
☞ When an external gradient setter is not used, go to procedure (4).

(3) Check whether or not the external gradient is set at 100.0 %.



(4) Set the controller output at 100.0 %.

Make adjustment so that the controller output becomes 100.0 %.

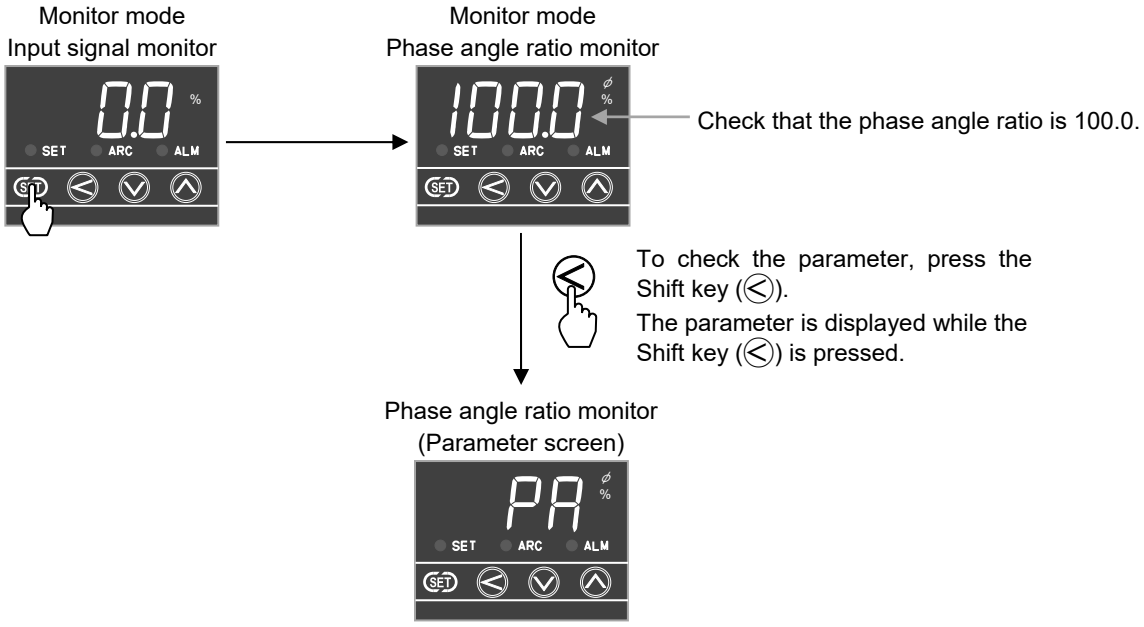


📖 When the output is manually set at 100 %

- When set by the external manual setter, set the output at 100.0 % with the knob placed in the position of “100.” (External manual mode must be enabled.)
- When set by the front keys, set the Internal manual set value (IM) to “100.0” and the output to “100.0 %.” (Internal manual mode must be enabled.)

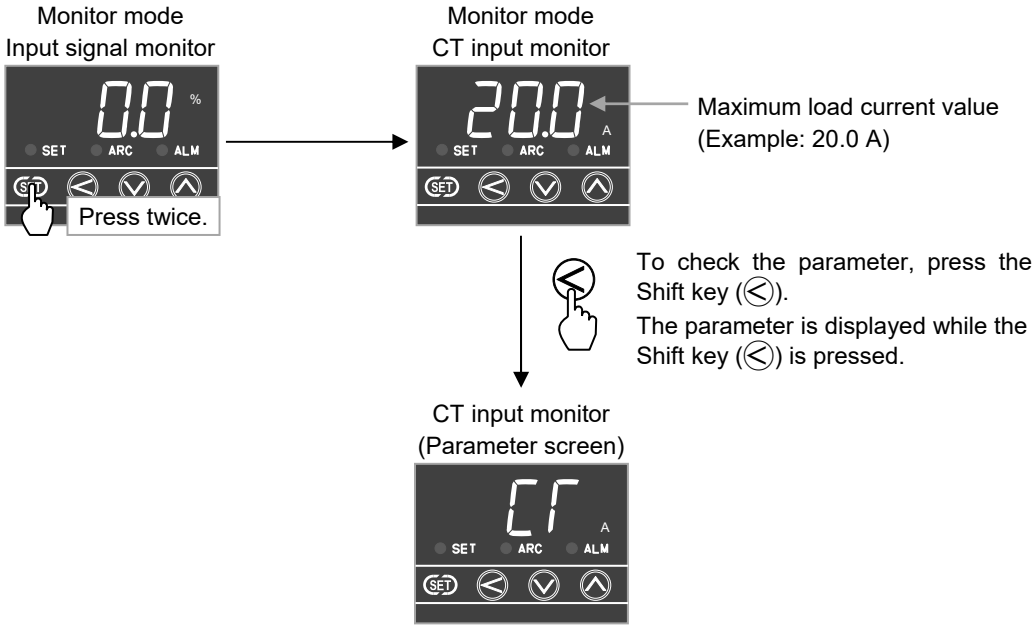
(5) Check that the controller output is set at 100.0 %.

Select the Phase angle ratio monitor (PA) and check that the phase angle ratio is 100.0 %.
If the phase angle ratio is 100.0 %, the output from this instrument is also 100.0 %.



(6) Check for the current value (maximum load current value) at a controller output of 100.0 %.

Check for the current value at a controller output of 100.0 %. Select the CT input monitor (CT) and check the displayed current value which is the maximum load current.



5.18.2 Calculate the heater current rating (When it is not possible to flow the maximum current through each heater)

This is a method of finding the maximum load current value when each heater may be damaged if letting the maximum current flow through the heater. The maximum load current value is found by the equation for calculation.

1. Check for heater power supply voltage and capacity.
Refer to the catalog or instruction manual for the heater used to check for the heater power supply voltage and capacity.

2. Calculate the maximum load current value.
Find the maximum load current value by the equation for calculation.

Equation of calculating:
Heater capacity / Power supply voltage = Maximum load current value

Example: For heaters with a capacity of 8 kW and a power supply voltage of 400 V AC (Power factor is assumed to be 1.)

8000 (heater capacity) / 400 (power supply voltage) = 20 (maximum load current value)
Maximum load current value 20 A

5.19 Setting Example of Heater Break Alarm

The procedure for setting the Heater break alarm is the same as that for any of Phase control and Zero-cross control.

5.19.1 Setting procedure

STEP 1
To find the maximum load current value.

☞ Refer to **5.18 How to Find Maximum Load Current Value (P. 5-24)**.

STEP 2
Set parameters of alarm.

Unlock the Engineering mode.
• Set data lock (LK)

Set parameters of Engineering mode.
• Alarm output logic (L1)
• Selection of energized/de-energized alarm output (nA)
• Alarm type selection (A1) *
• Number of alarm 1 determination (n1)
• Number of alarm 2 determination (n2)
• Alarm enable/disable during STOP (SA)

* Set alarm type only for Phase control.
Setting is ignored for Zero-cross control.

☞ Refer to **5.19.2 Setting Example (P. 5-30 to 5-34)**.

STEP 3
Set maximum load current value.

Set Maximum load current value for alarm (MC) of Setting mode 2.

☞ Refer to **5.19.2 Setting Example (P. 5-30 to 5-34)**.

STEP 4
Set each alarm set value.

Set parameters of Setting mode 2.
• Heater break alarm 1 setting (H1)
• Thyristor break-down detection 1 setting (Tb)
• Heater break alarm 2 setting (H2) *
• Thyristor break-down detection 2 setting (TC) *

* If the alarm type is Type 2 (linear resistance type, absolute value alarm), these two functions marked with * are not used and should be disabled.

☞ Refer to **5.19.2 Setting Example (P. 5-30 to 5-34)**.

5.19.2 Setting example

The procedure for setting the following conditions is explained as an example.

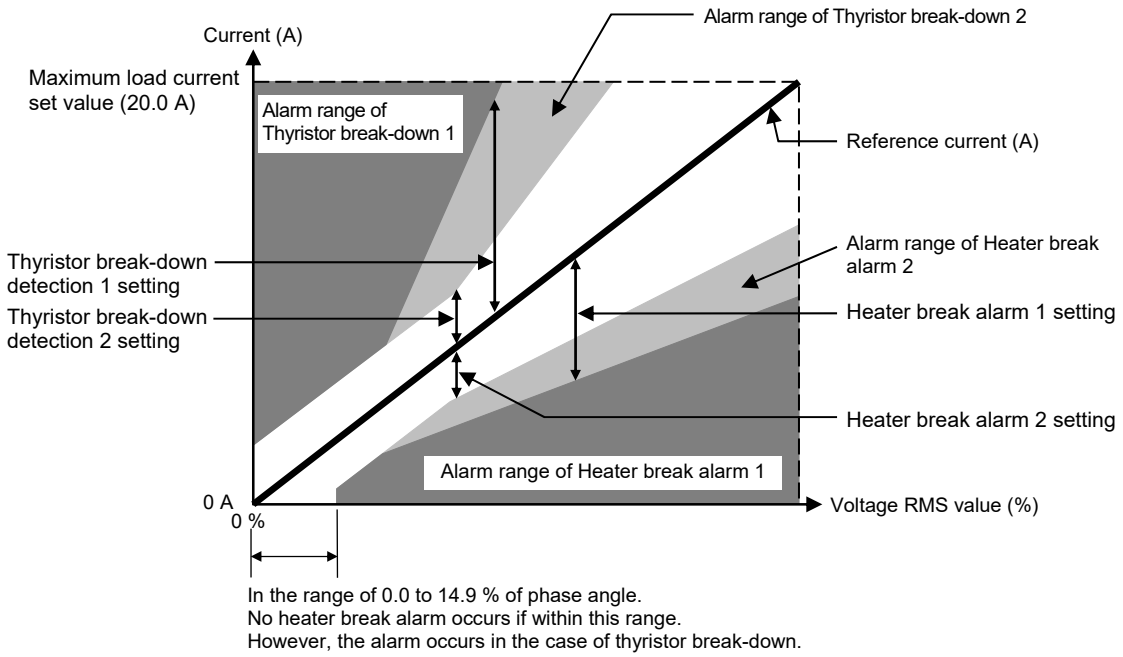
< Operating condition >

THV-40:	20 A type
Control method:	Phase control
Output adjustment:	Auto mode
Power supply voltage:	400 V AC
Heater capacity:	8 kW
Maximum load current set value:	20.0 A
Heater break alarm 1 setting:	Use to detect a heater break. [Set value: 20 %]
Thyristor break-down detection 1 setting:	Use to detect a thyristor short circuit [Set value: 20 %]
Heater break alarm 2 setting:	This parameter is used to provide alarm output before Heater break alarm 1 takes place. [Set value: 15 %]
Thyristor break-down detection 2 setting:	This parameter is used to provide alarm output before Thyristor break-down alarm 1 takes place. [Set value: 15 %]
Heater break alarm type:	Type 1 (constant resistance type, deviation alarm) [Set value: 0]
Alarm output:	Logical *OR* of the following alarms. [Set value: 15]

- Heater break alarm 1
- Thyristor break-down alarm 1
- Heater break alarm 2
- Thyristor break-down alarm 2

Energized/De-energized of alarm: Energized [Set value: 0]

Operation chart



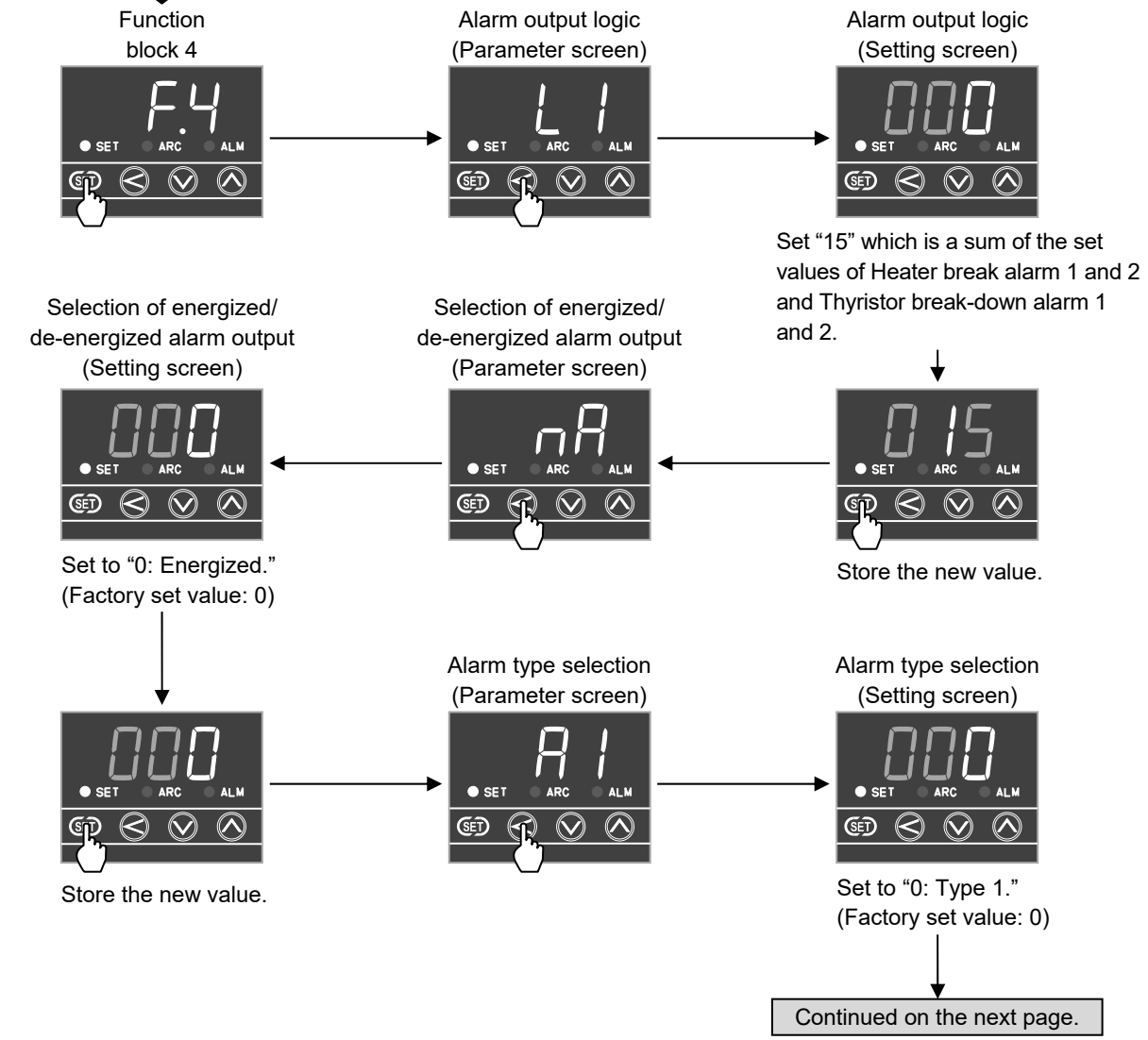
(1) Unlock the setting data

Unlock the Engineering mode.

☞ Refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

(2) Set the Engineering mode

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.4 screen displays.



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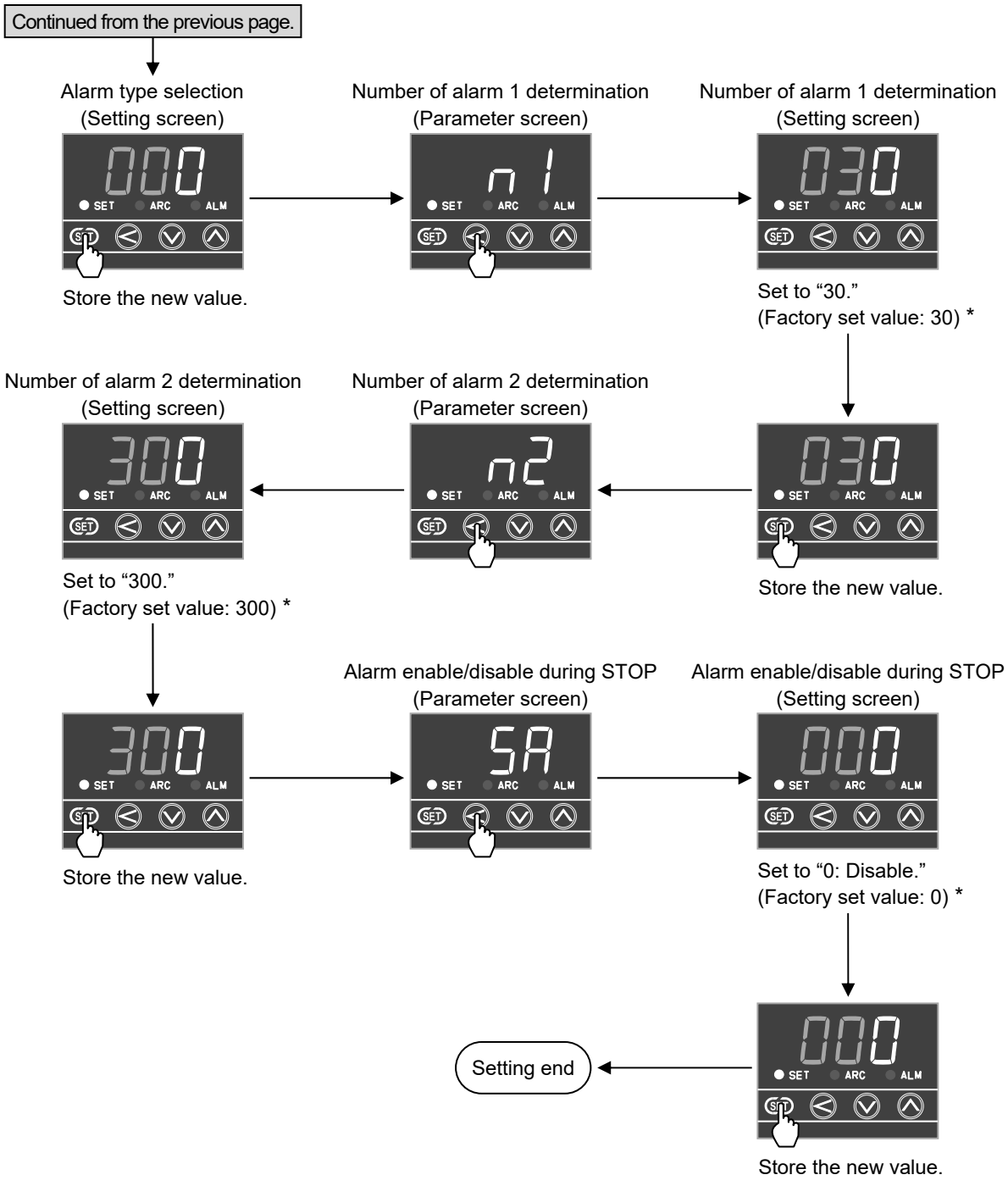
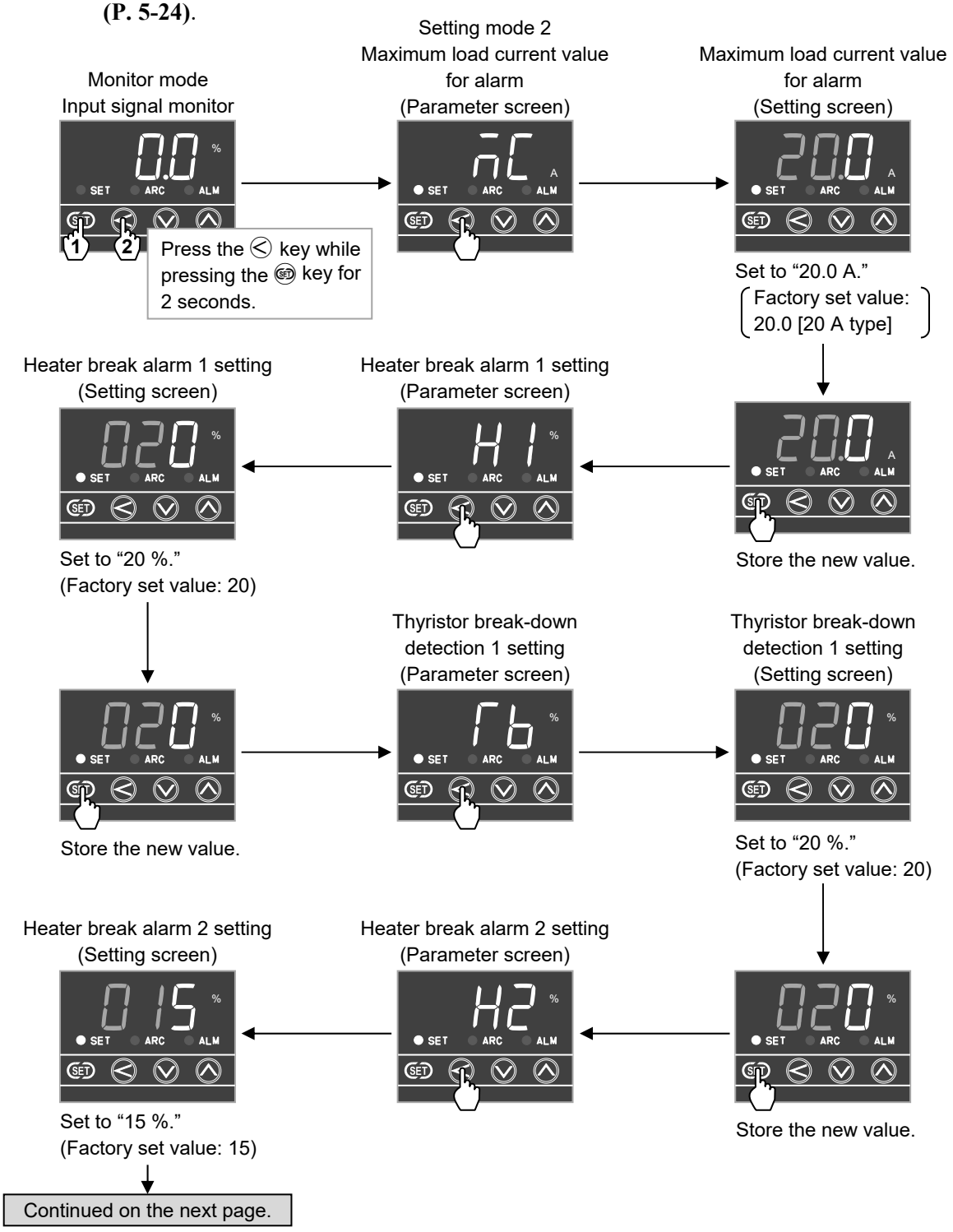


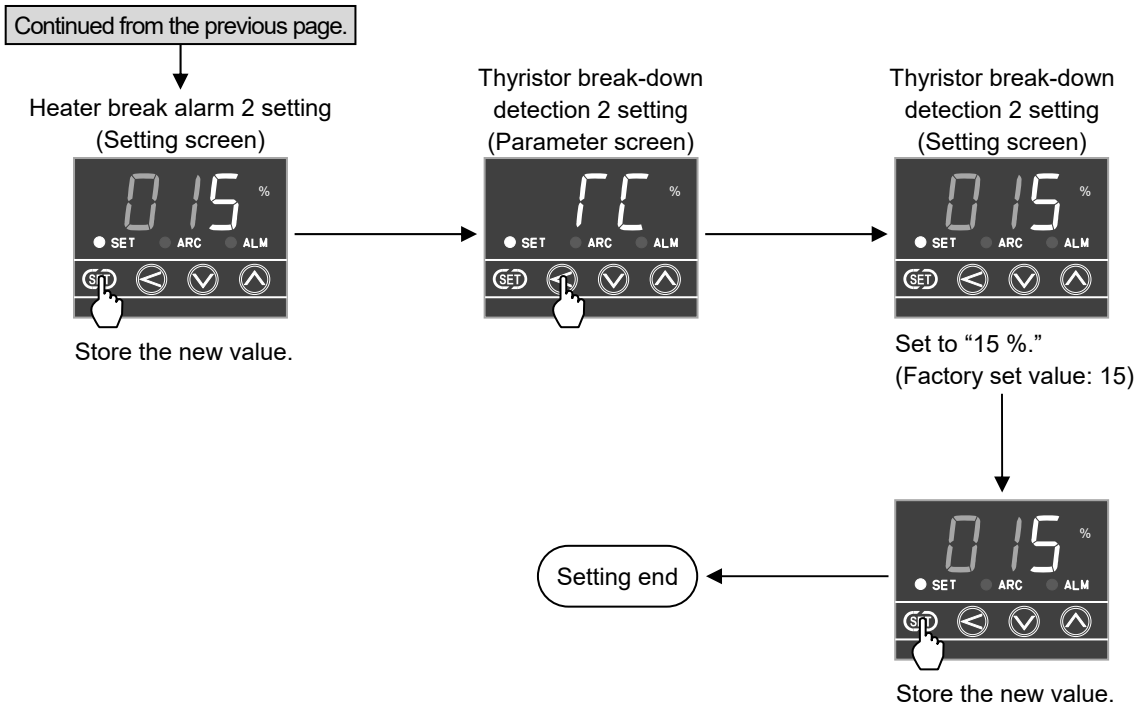
* Here, factory set value is set. However, set any value meeting the customer's system.

(3) Set each alarm set value

Before setting the set values of the alarms, check the maximum load current value. If the maximum load current value is not set, a heater break judgment cannot be made, and thus it is important to verify that this has been set. In addition, if the correct maximum load current set value is not set, wrong operation may result.

For the maximum load current, refer to **5.18 How to Find Maximum Load Current Value (P. 5-24)**.



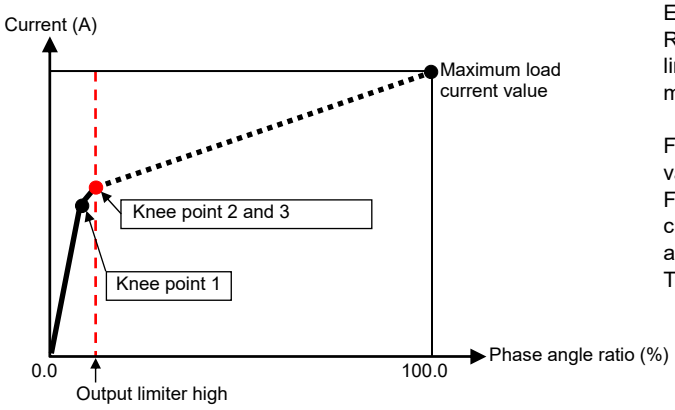

Continued from the previous page.
Heater break alarm 2 setting
(Setting screen)
015
%
SET
ARC
ALM
Store the new value.
Thyristor break-down
detection 2 setting
(Parameter screen)
rC
%
SET
ARC
ALM
Thyristor break-down
detection 2 setting
(Setting screen)
015
%
SET
ARC
ALM
Set to “15 %.”
(Factory set value: 15)
015
%
SET
ARC
ALM
Store the new value.
Setting end

5.20 Setting Example of Non-linear Resistance Heater Break Alarm

5.20.1 Precautions for using the Non-linear resistance heater break alarm

- It may not be possible to use the Non-linear resistance heater break alarm function with some heater types.
- During the Automatic detection of knee points, the Output mode may be temporarily Proportional phase angle to input even if the output mode is set to other than Proportional phase angle to input.
- The Knee point automatic calculation function raises the output of the THV-40 to 100 %.
  If you do not want to apply an output of 100 % to the heater, use the gradient setting, Output limiter, or Current limiter to limit the output. However, when the output is limited by the Output limiter high, the Output mode may be temporarily Proportional phase angle to input. If the instrument is used in Proportional voltage to input or Proportional square voltage (electric power) to input, it is required to calculate the Output limiter high in the Proportional phase angle to input. In case of the Constant voltage control, this calculation is not possible. Limit the output using the Current limiter.
- When the Automatic detection of knee point is executed with the output limited by Output limiter high or Current limiter, the calculation result may be as follows if the knee point or the maximum load current value is above the limiter point.
  - Output limiter high

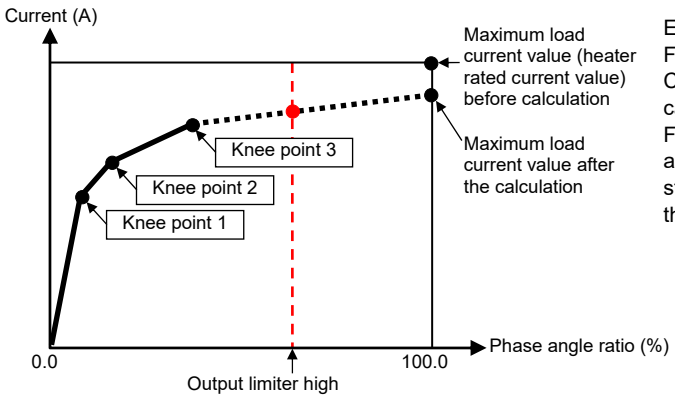
  In case Output limiter high is set at any point below the knee point 3.



Explanation of the left figure
Reference current value is obtained by drawing a line between the output limiter high value and the maximum load current value.

For the knee point 1, Phase angle ratio and Current value at knee point 1 are automatically calculated.
For knee points 2 and 3, Phase angle ratio and the current value around the Output limiter high are automatically calculated.
The maximum load current value is not updated.

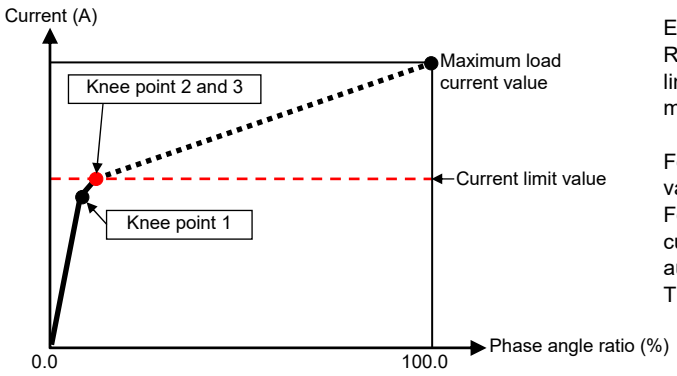
In case the Output limiter high value is set anywhere between the knee point 3 and the maximum load current.



Explanation of the left figure
For the knee points 1 to 3, Phase angle ratio and Current value of knee points are automatically calculated.
For the maximum load current, the current value is automatically calculated from the gradient of the straight line drawn between the Knee point 3 and the Output limiter high value.

● Current limiter

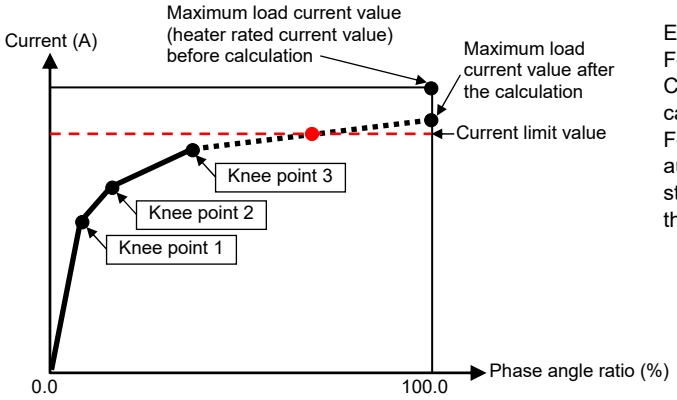
In case Current limiter value is set at any point below the knee point 3.



Explanation of the left figure
Reference current value is obtained by drawing a line between the Current limiter value and the maximum load current value.

For the knee point 1, Phase angle ratio and Current value at knee point 1 are automatically calculated.
For knee points 2 and 3, Phase angle ratio and the current value around the Current limiter value are automatically calculated.
The maximum load current value is not updated.

In case the Current limiter value is set anywhere between the knee point 3 and the maximum load current.



Explanation of the left figure
For the knee points 1 to 3, Phase angle ratio and Current value of knee points are automatically calculated.
For the maximum load current, the current value is automatically calculated from the gradient of the straight line drawn between the Knee point 3 and the Current limiter value.

■ When manually setting Knee points, set the “Phase angle ratio at knee point” and “Current value at knee point” for each Knee point in order from the Knee point with the smallest phase angle ratio.

– Set the knee point with the smallest phase angle ratio by setting “Phase angle ratio at knee point 1 (K1)” and “Current value at knee point 1 (r1).”
– Set the knee point with the intermediate phase angle ratio by setting “Phase angle ratio at knee point 2 (K2)” and “Current value at knee point 2 (r2).”
– Set the knee point with the largest phase angle ratio by setting “Phase angle ratio at knee point 3 (K3)” and “Current value at knee point 3 (r3).”

■ Modifying any of the following items during the Automatic detection of knee points, the automatic detection is aborted. If the automatic detection is aborted, the Phase angle ratio and the Current value of the knee point are not updated.

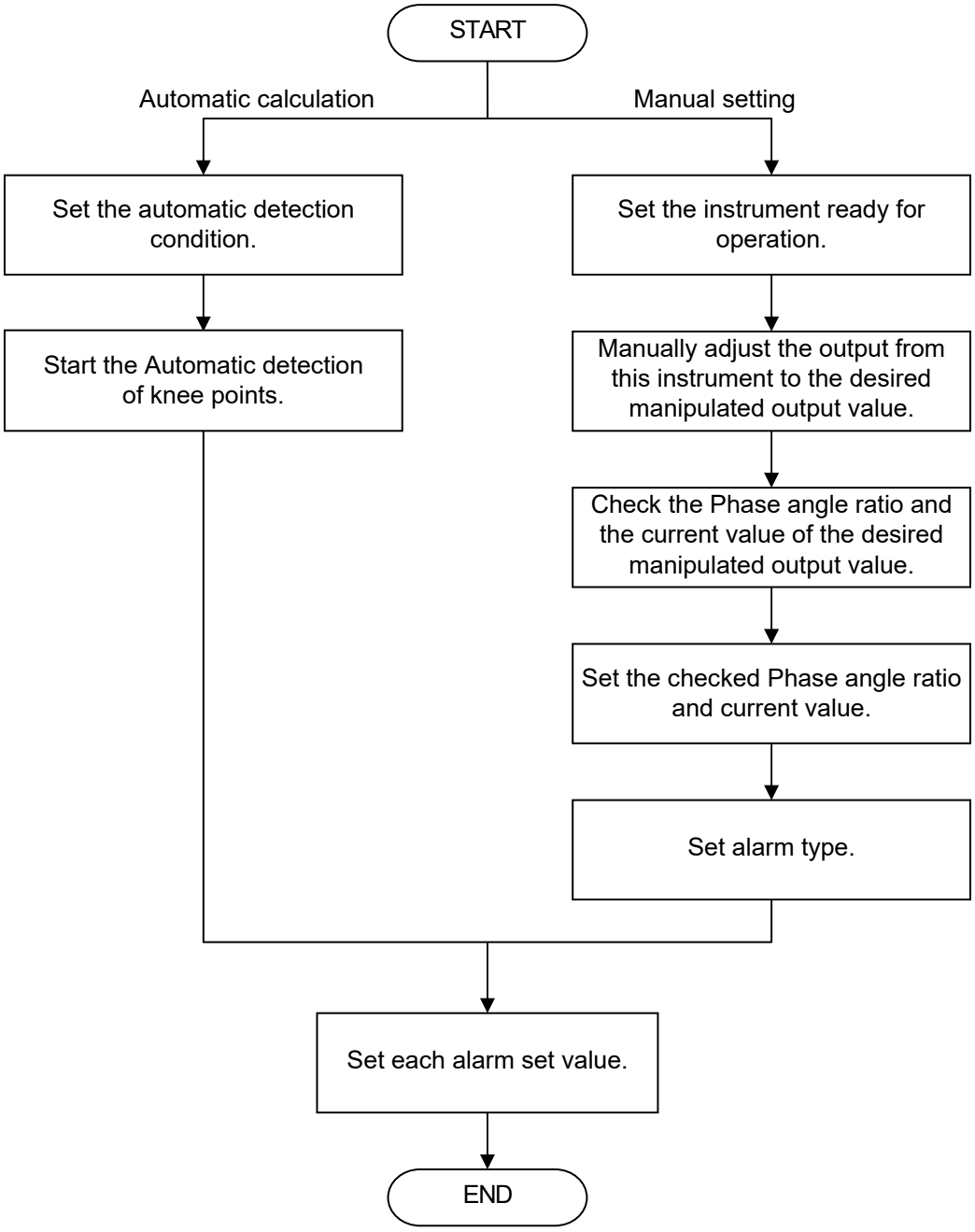
– Current limit value setting (CL)
– Control method (CM)
– RUN/STOP transfer (RS)
– Output limiter high (LH)
– Automatic calculation time for knee points (HT)
– Automatic detection of knee points (HU)
– Phase angle ratio at knee point 1 to 3 (K1 to K3)

- The following input signals are disregarded during automatic calculation of the Knee point.
  - Automatic set value (Input signal from controller)
  - External manual set value (Input signal from external manual setter)
  - Internal manual set value (Set by the THV-40 front keys)
- If one or both of the following alarms are generated during the Automatic detection of the knee points, the Automatic detection is aborted, and the Phase angle ratio and the Current value of the knee point are not updated.
  - when FAIL alarm takes place.
  - when Over current alarm takes place.
  - when Heat sink temperature abnormality takes place.
- Setting the Automatic detection of knee points (HU) to “1: ON” while the instrument is set to STOP will not start the automatic detection. To start the automatic detection, set the instrument to RUN.

  However, change of the following parameters before switching the instrument to RUN will return the Automatic detection of knee points (HU) setting to “0: OFF.”
  - Current limit value setting (CL)
  - Control method (CM)
  - Output limiter high (LH)

5.20.2 Setting procedure

Non-linear resistance heater break alarm can be set in two ways: One is the Automatic detection of the phase angle ratio and the Current value of the knee point. The other is Manual setting.
If Heater break and Thyristor break-down cannot be properly detected with the Phase angle ratio and the Current value of the knee points automatically detected, set the knee points manually.



5.20.3 Set Automatic detection of knee points

(1) Preparation prior to the Automatic detection of the knee points

Set the following parameters before calculating the knee point.

Mode	Symbol		Name	Description
Setting mode1	SU	(SU)	Soft-start time	Set the actual values that are used.
	Sd	(Sd)	Soft-down time	Set the actual values that are used.
Setting mode 2	MC	(MC)	Maximum load current set value for alarm	Set rated current of heater.
	CL	(CL)	Current limit value setting	Set the actual values that are used.
Engineering mode F.2	CM	(CM)	Control method	Set to "0: Phase control."
	rS	(rS)	RUN/STOP transfer	Set to "1: RUN (Output ON)."
Engineering mode F.3	LH	(LH)	Output limiter high	When the Output mode for phase control is used for Proportional phase angle to input: Set the Output limiter high value which is to be used. When the Output mode for phase control is used for Proportional voltage to input or Proportional square voltage (electric power) to input: Set the Output limiter high value obtained from the conversion table. (Refer to **A.3 Conversion table (P. A-15)** for details.) During the automatic detection of knee points, regardless of the Output mode for phase control (OS), the instrument is operated with the Phase angle ratio to input to detect the knee points. It is necessary to convert the Output limiter high value now used by the user to the Output limiter high value for the Proportional phase angle to input. When the Output mode for phase control is used for Constant current control: Conversion is not available in case of Constant current control.
Engineering mode F.4	A1	(A1)	Alarm type selection	Set to "2: Deviation alarm [ARC-HBA] (Non-linear resistance type)." (This item may be set after completion of the Automatic detection of the knee points.)
Engineering mode F.6	HT	(HT)	Automatic calculation time for knee points	Set the actual values that are used. In case heater temperature characteristics are not stable, extend the output time longer.

Continued on the next page.

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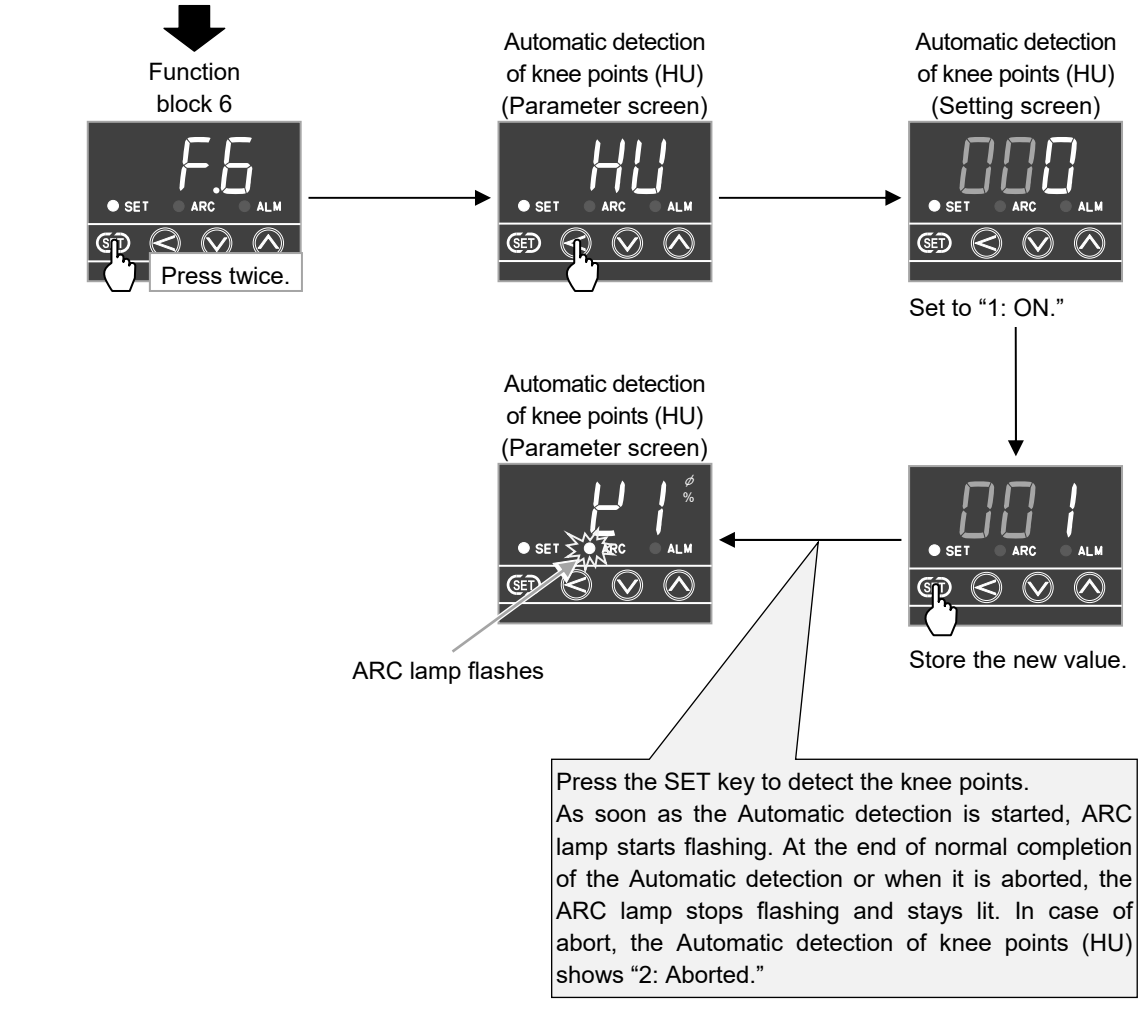
Mode	Symbol		Name	Description
Engineering mode F.6	U1	(K1)	Phase angle ratio at knee point 1	Set the actual values that are used. This item is not required to be chanted in case of the calculation with the default value, which is set to the Phase angle ratio of knee points appropriate for common lamp heaters. This value is the Phase angle ratio of knee points in case of using the lamp heater used at the rated current. If the lamp heater is not used around the current rating, set the Phase angle ratio of knee points suitable for the user's application.
	U2	(K2)	Phase angle ratio at knee point 2	
	U3	(K3)	Phase angle ratio at knee point 3	

(2) Starting Automatic detection of knee points

Execute the "Automatic detection of knee points (HU)" at F.6 in the Engineering mode to automatically detect the knee points.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.6 screen displays.



(3) Set alarms

Set each alarm referring to "**(3) Set each alarm set value**" (**P. 5-33, 5-34**).

5.20.4 Set to manually check the knee points

To manually check the Phase angle ratio and Current value of knee points, enter control signal via either Auto mode or Manual mode, to output the desired value. In this example, Internal manual mode is used for explanation. Determine three Internal manual set values.

(1) Preparation before check

Set the External gradient and the following parameters before checking the Phase angle ratio and Current value of knee points. Determine the Internal manual set values for setting the desired knee point.

• External gradient setting

If an External gradient setter is used, set the External gradient set value to the actually used value.

• Parameter settings

Mode	Symbol		Name	Description
Setting mode 1	IG	(IG)	Internal gradient set value	Set the actual values that are used.
	SU	(SU)	Soft-start time	Set the actual values that are used.
	Sd	(Sd)	Soft-down time	Set the actual values that are used.
Setting mode 2	MC	(MC)	Maximum load current set value for alarm	Check the maximum load current value and set it here. (Refer to **P. 5-24**)
	CL	(CL)	Current limit value setting	Set the actual values that are used.
Engineering mode F.2	CM	(CM)	Control method	Set to "0: Phase control."
	rS	(rS)	RUN/STOP transfer	Set to "1: RUN (Output ON)."
	SF	(SF)	Soft-start, Soft-down enable/disable	Set the actual values that are used.
Engineering mode F.3	oS	(oS)	Output mode for phase control	Set the actual values that are used.
	LH	(LH)	Output limiter high	Set the actual values that are used.
	LL	(LL)	Output limiter low	Set the actual values that are used.
	bU	(bU)	Base-up set value	Set the actual values that are used.

• Internal manual set value

Determine three Internal manual set values where you wish to set knee points.

In this example, we assume that the Internal manual set values are 22.1 %, 55.4 % and 83.3 %.

(2) Set knee points manually

☞ For selecting mode, refer to **5.1 Mode Menu (P. 5-2)**.

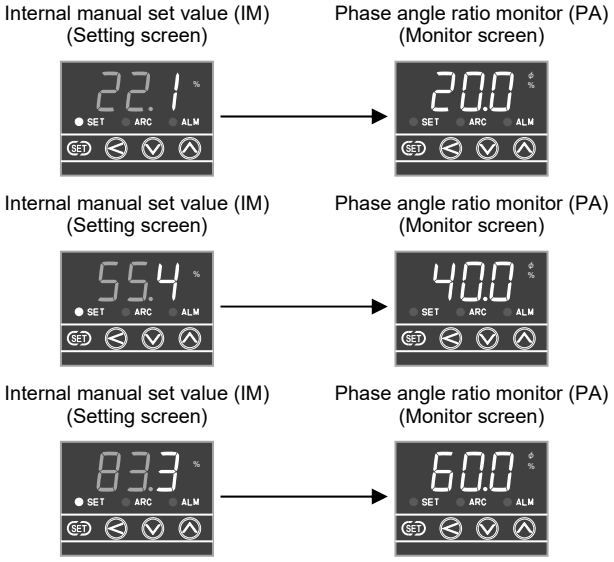
☞ Refer to **P. 5-3** to **5-6** for switching between monitor screen and parameters.

☞ For details on changing the numeric value, **5.3 Changing Set Value (P. 5-7)**.

1. Before setting the Knee points, make sure necessary conditions are set, referring to the preparation before check (**P. 5-42**).

2. Check and write down the Phase angle ratio and Current values.
Set the Internal manual set values previously determined to the Internal manual set value (IM) in Setting mode 1, and write down the Phase angle ratio and the Current value. The Phase angle ratio can be checked on the "Phase angle ratio monitor (PA)" and the current value on the "CT input monitor (CT)." (In this example, we set 22.1 %, 55.4 % and 83.3 % in turns).

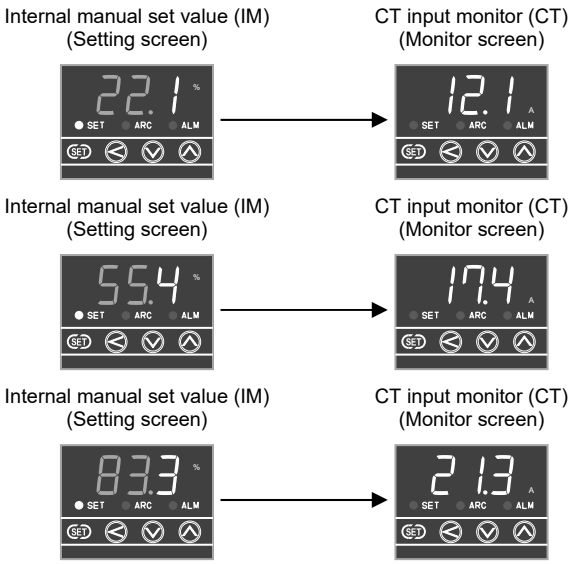
Display example of Phase angle ratio



Record the Phase angle ratio.

Internal manual set value	Phase angle ratio *
22.1 %	20.0 %
55.4 %	40.0 %
83.3 %	60.0 %

Display example of Current value



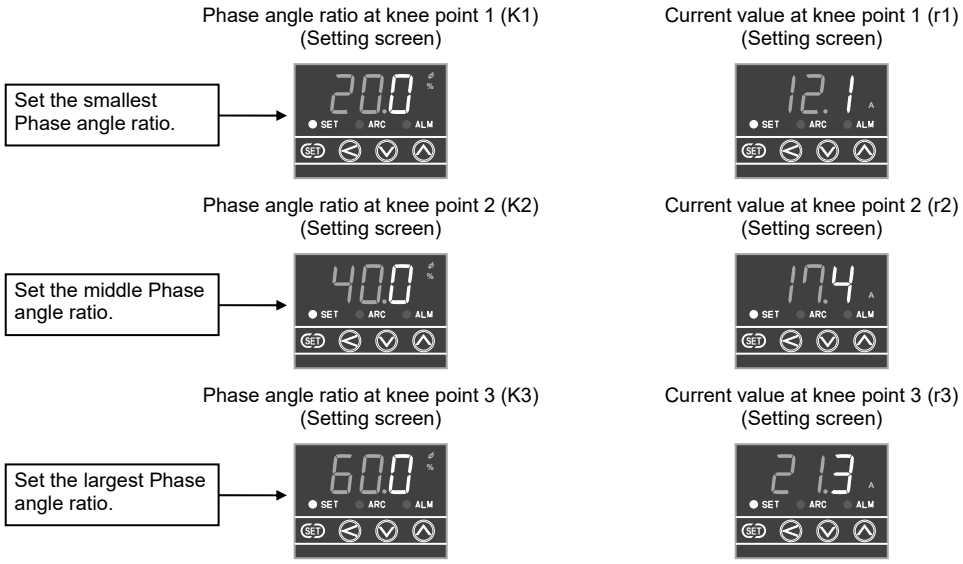
Record the Current value.

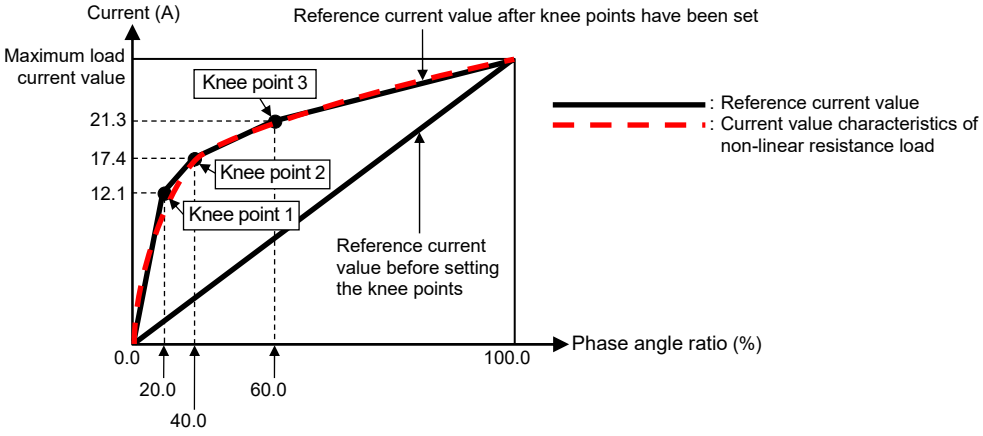
Internal manual set value	Current value*
22.1 %	12.1 A
55.4 %	17.4 A
83.3 %	21.3 A

* Phase angle ratio and Current value in the table are examples. Actual heater values will be different.

3. Set the written down Phase angle ratio and current value. Set the "Phase angle ratio of knee point" and the "Current value of knee point" from the knee point with the smallest phase angle.

Engineering mode F.6





Reference current value after knee points have been set

4. Set alarm type to Non-linear resistance heater break alarm.
Call Alarm type selection (A1) at F.4 in the Engineering mode, and set "2: Deviation alarm [ARC-HBA] (Non-linear resistance type)."
Setting "2" enables Non-linear resistance heater break alarm.

This completes the manual setting of knee points.

(3) Set alarms

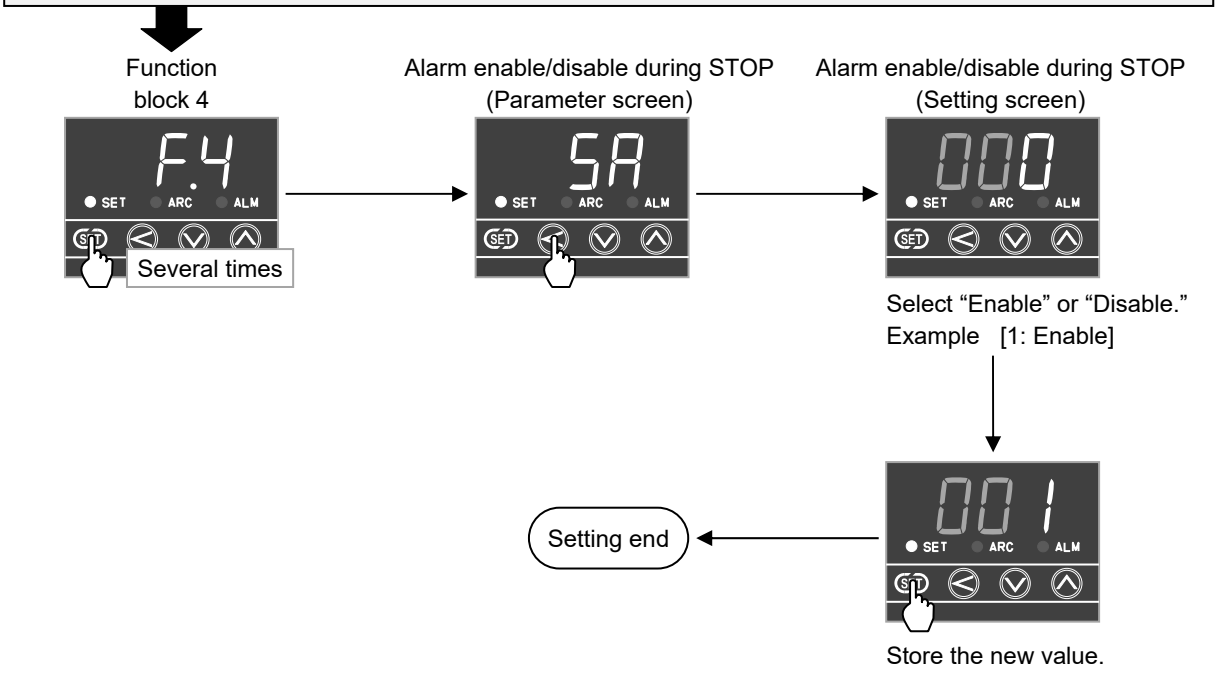
Set each alarm referring to "**(3) Set each alarm set value**" (**P. 5-33, 5-34**).

5.21 Setting Alarm Action in STOP State

The alarm action during the STOP state can be set by "Alarm enable/disable during STOP (SA)." Alarm enable/disable during STOP (SA) is at F.4 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (△) until the F.4 screen displays.



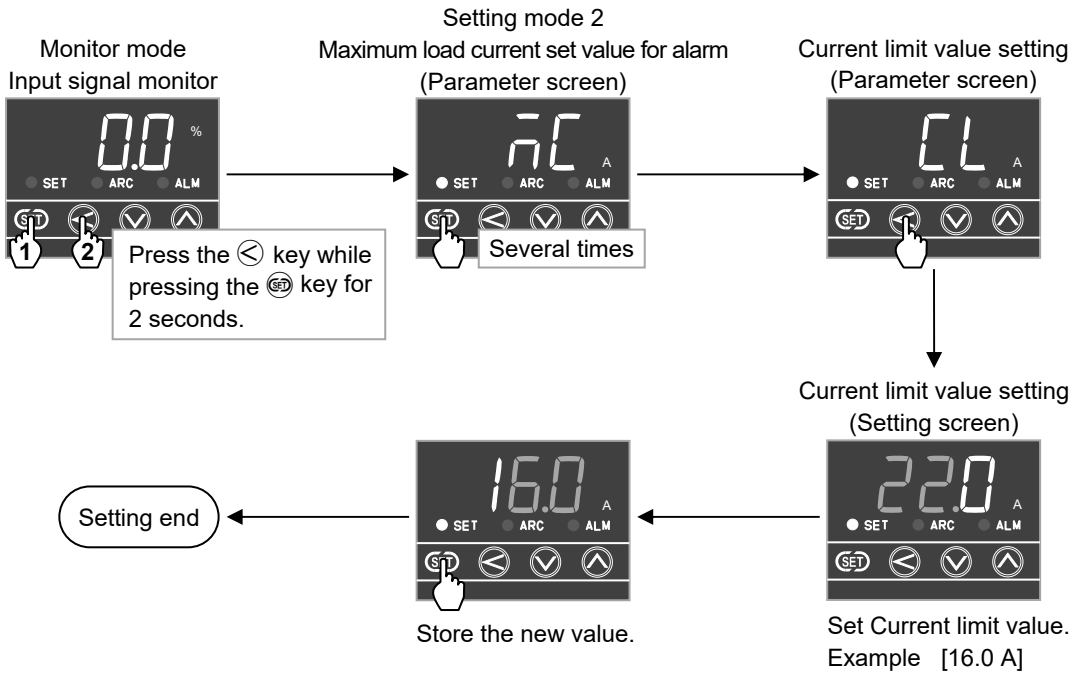
Data range	Factory set value
0: Disable 1: Enable	0

☞ For description of parameter, refer to **P. 4-40**.

5.22 Setting Current Limiter

Set Current limit function at Current limit value setting (CL).
Current limit value setting (CL) is at Setting mode 2.

☞ Setting mode 2 cannot be adjusted while the set data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.



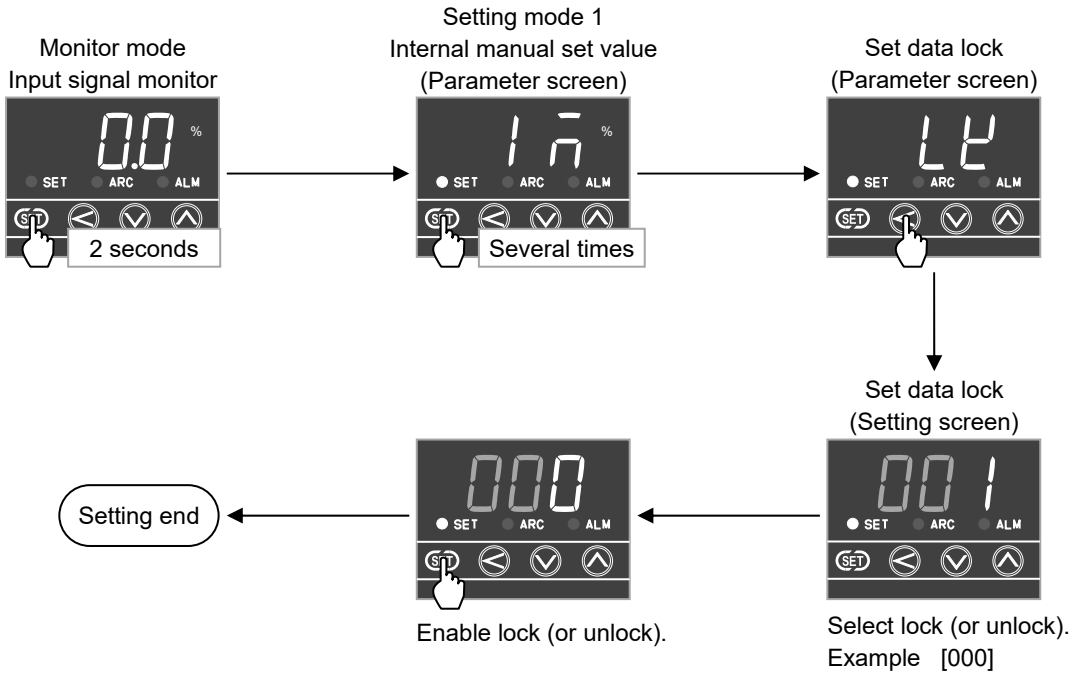
Data range	Factory set value
0.0 to 22.0 A (20 A type)	22.0
0.0 to 33.0 A (30 A type)	33.0
0.0 to 50.0 A (45 A type)	50.0
0 to 66 A (60 A type)	66
0 to 88 A (80 A type)	88
0 to 110 A (100 A type)	110
0 to 165 A (150 A type)	165
0 to 220 A (200 A type)	220

☞ For description of parameter, refer to **P. 4-24**.

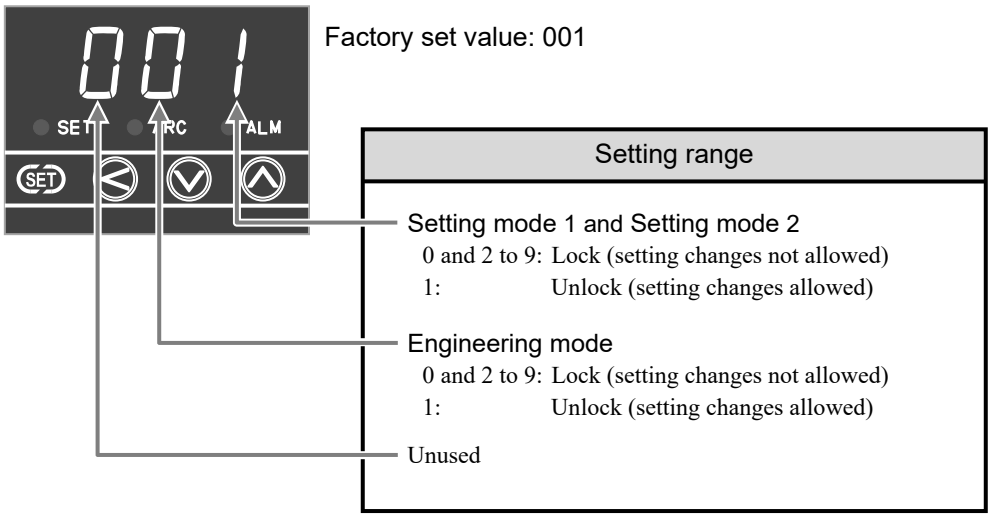
☞ For the function description, refer to **6.8 Current Limiter Function (optional) (P. 6-21)**.

5.23 Locking/Unlocking Setting Data

Lock/Unlock of the set data can be done at Set data Lock (LK).
Set data lock (LK) is at Setting mode 1.



Set data lock (Setting screen)



☞ For description of parameter, refer to **P. 4-14**.

☞ For the function description, refer to **6.4 Set Data Lock Function (P. 6-6)**.

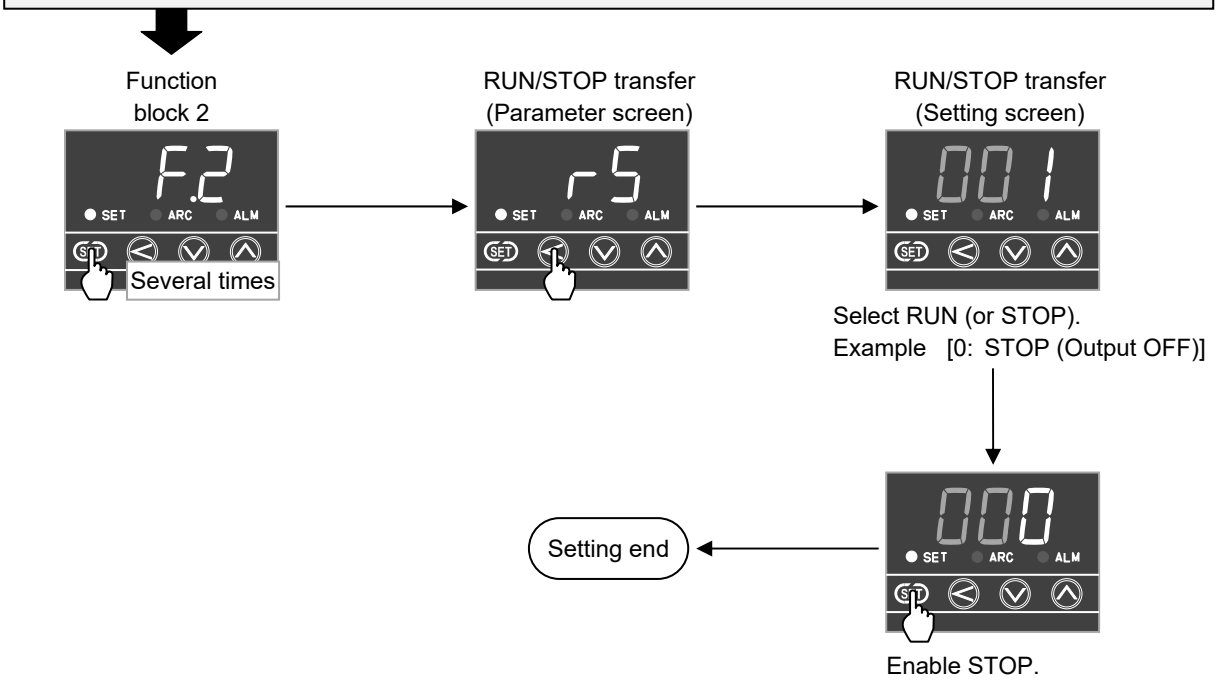
📖 While Contact input (DI) configured to "Set data lock enable/disable" is active, changing of setting via front key is not possible.

5.24 Switching between RUN/STOP of the Instrument

Run/Stop transfer of this instrument can be set at RUN/STOP transfer (rS).
RUN/STOP transfer (rS) is at F.2 in the Engineering mode.

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (◁) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (△) until the F.2 screen displays.



Data range	Factory set value
0: STOP (Output OFF) 1: RUN (Output ON)	1

☞ For description of parameter, refer to **P. 4-30**.

🕮 If "RUN/STOP transfer" by Contact input (DI) is used, RUN/STOP transfer via front key is not available.

5.25 Setting of Protection Function for Control of Primary Side of a Transformer

Setting of Protection function of control of primary side of a transformer is made by parameters in F.7 in the Engineering mode. The following parameters need to be adjusted to suit your system.
(If the factory set values satisfy the requirements, they can be used as they are)
After having the following parameters properly adjusted, enable the protection function for primary side of a transformer.

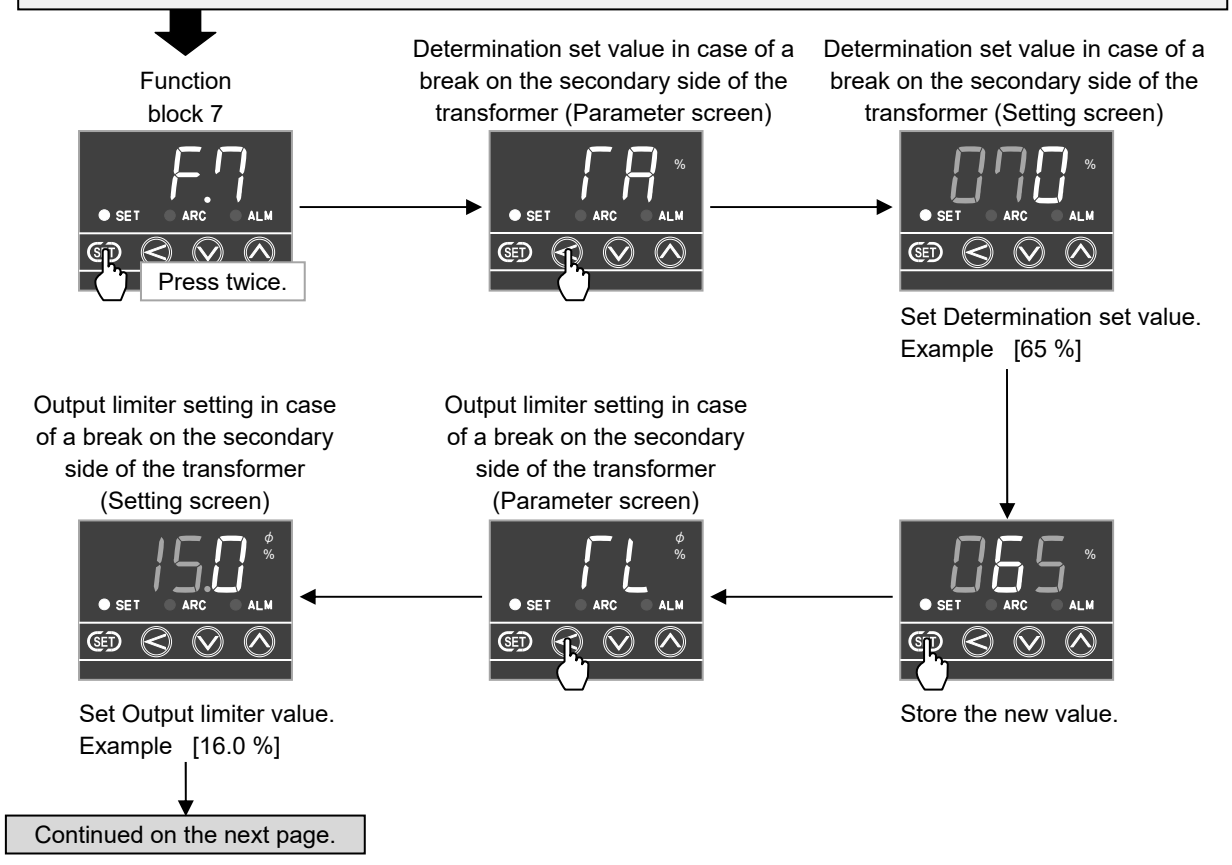
Parameters:

- Determination set value in case of a break on the secondary side of the transformer (TA)
  [Factory set value: 70 % of reference current value]
- Output limiter setting in case of a break on the secondary side of the transformer (TL)
  [Factory set value: 15.0 % of phase angle]
- Soft-start time in case of break on the secondary side of the transformer (TU)
  [Factory set value: 0.1 seconds]

■ Setting procedure

☞ The Engineering mode is not displayed while Data lock is active.
To unlock setting, refer to **5.23 Locking/Unlocking Setting Data (P. 5-48)**.

1. Press and hold the SET key (SET) for 2 seconds at Monitor mode until Setting mode 1 is displayed.
2. Press the Shift key (<) while pressing the SET key (SET) for 2 seconds at Setting mode 1 until Engineering mode is displayed.
3. Keep pressing the UP key (^) until the F.7 screen displays.



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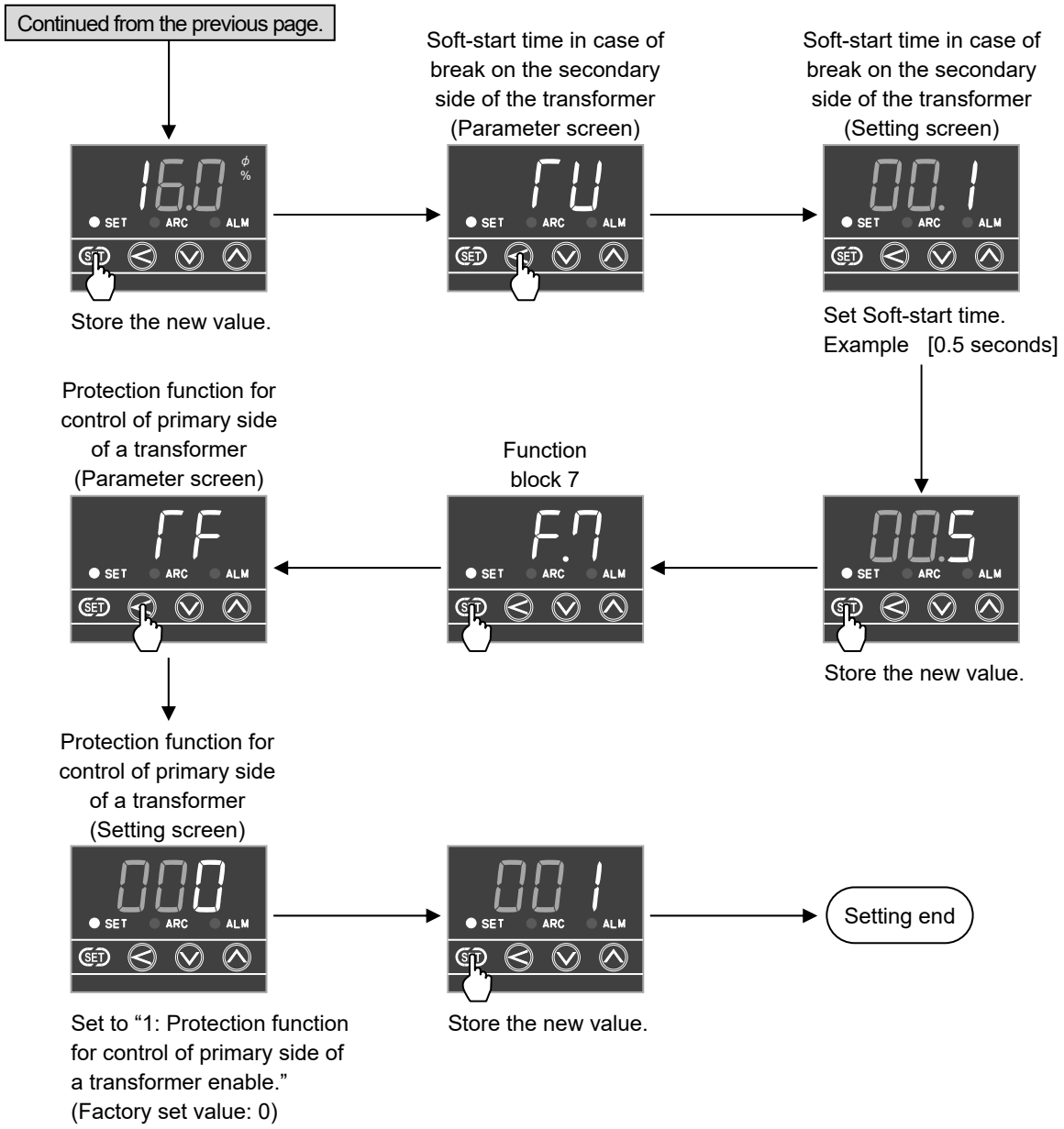


Data range	Factory set value
Protection function for control of primary side of a transformer: 0: Protection function for control of primary side of a transformer disable 1: Protection function for control of primary side of a transformer enable	0
Determination set value in case of a break on the secondary side of the transformer: 0 to 100 % of reference current value	70
Output limiter setting in case of a break on the secondary side of the transformer: 15.0 to 50.0 % of phase angle	15.0
Soft-start time in case of break on the secondary side of the transformer: 0.1 to 100.0 seconds	0.1

☞ For description of parameter, refer to **P. 4-49 and 4-50**.

☞ For the function description, refer to **6.18 Protection Function for Control of Primary Side of a Transformer (optional) (P. 6-33)**.

MEMO

6 FUNCTIONS

6.1 Manual Mode

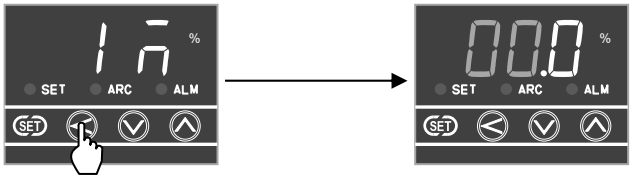
The manipulated output value of this instrument can be manually set. There are two manual setting methods:

- Set by front keys of this instrument. (internal manual mode)
- Set by external manual setter.

■ Set by front keys (Internal manual mode)

The output value can be set manually using the front keys of the instrument. This is done in “Internal manual set value (IM)” of Setting mode 1.

Setting mode 1　Internal manual setting (IM)



The Internal manual set value reverts to 0.0 when the power of the instrument is turned off.

The Internal manual set value is valid in either of the following states:

When Contact input (DI) is not used.

- The Input signal transfer (dA) is set to “1: Manual mode.”
- The Manual mode transfer (AM) is set to “1: Internal manual mode.”

When Contact input (DI) is used as “Input signal transfer.”

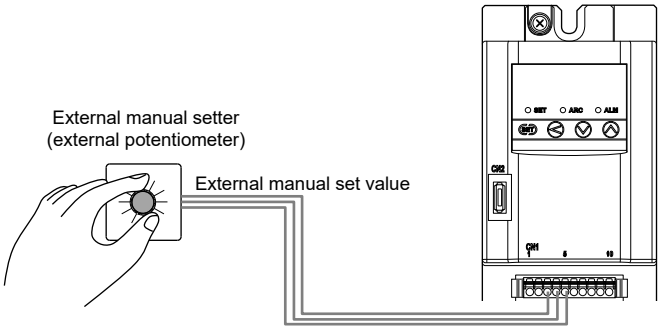
- When the contact is closed (Manual mode).
- The Manual mode transfer (AM) is set to “1: Internal manual mode.”

When Contact input (DI) is used as “Manual mode transfer.”

- When the contact is closed (Internal manual mode).
- The Input signal transfer (dA) is set to “1: Manual mode.”

■ Set by external manual setter (external potentiometer)

The output value of the instrument can be set using the external manual setter.



The External manual set value is valid in either of the following states:

When Contact input (DI) is not used.

- The Input signal transfer (dA) is set to “1: Manual mode.”
- The Manual mode transfer (AM) is set to “0: External manual mode.”

When Contact input (DI) is used as “Input signal transfer.”

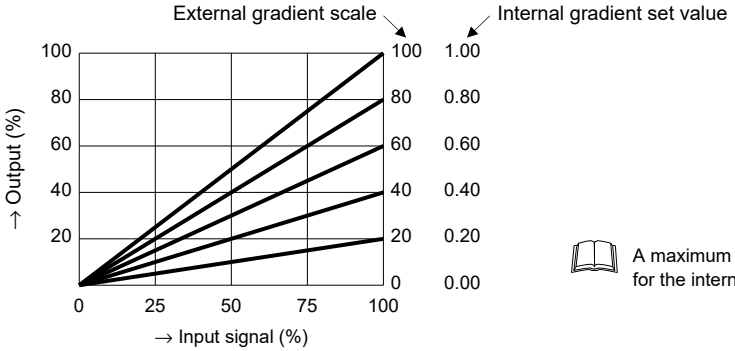
- When the contact is closed (Manual mode).
- The Manual mode transfer (AM) is set to “0: External manual mode.”

When Contact input (DI) is used as “Manual mode transfer.”

- When Contact input (DI) is used as “External manual mode.”
- The Input signal transfer (dA) is set to “1: Manual mode.”

6.2 Gradient Setting Function

Gradient setting is a multiplier to be applied to output voltage to the load to adjust the output value depending on an application.



Gradient output characteristics

A maximum of 2.00 can be set for the internal gradient set value.

The output value is adjusted by Gradient setting function as follows.

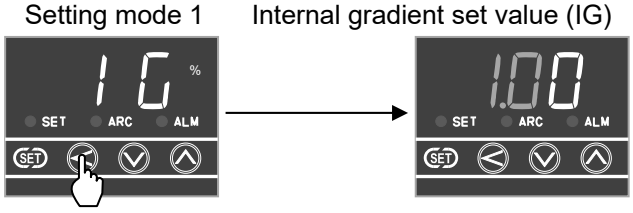
- (Output voltage calculated by Auto mode) × (Internal gradient set value) × (External gradient set value)
- (Output voltage calculated by Auto mode) × (Internal gradient set value)
- (Output by Manual set value) × (Internal gradient set value) × (External gradient set value)

If it is necessary to make only the External gradient set value valid, set the Internal gradient set value to 1.00.

The following two types of Gradient setting are available.

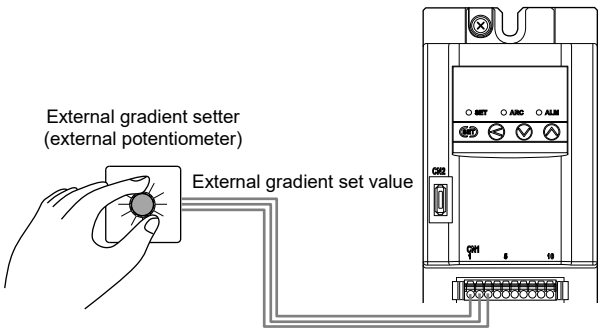
■ Internal gradient setting set by the instrument front keys

The Gradient set value can be set manually using the front keys of the instrument.
This is done in “Internal gradient set value (IG)” of Setting mode 1.



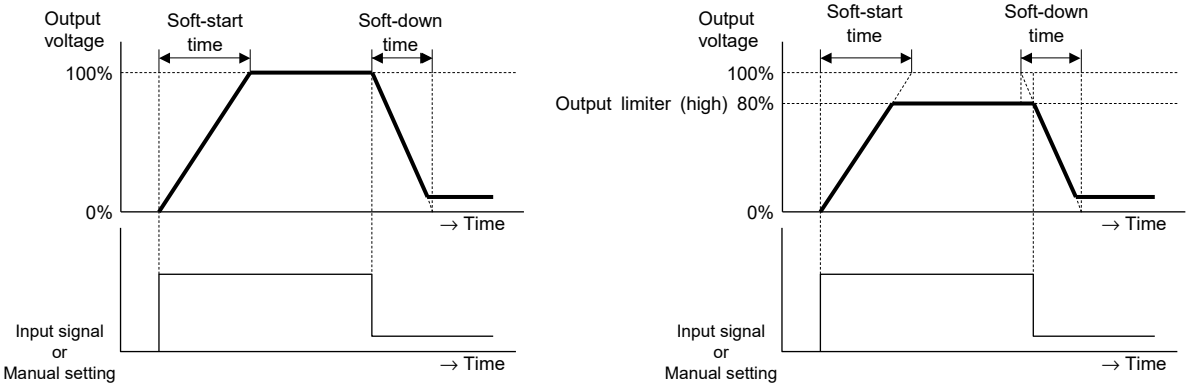
■ External gradient setting set by the external gradient setter (external potentiometer)

Set the Gradient set value by the external gradient setter (external potentiometer)



6.3 Ramp Function (Soft-Start/Soft-Down Function)

Soft-start/Soft-down function gradually ramps up/down the output voltage to the demand level over the set time to prevent a sudden change in load or voltage.
The Soft-start/Soft-down time sets a period of time from 0 % to 100 % or 100 % to 0 %.



Soft-start/Soft-down action diagram

If a load generating large rush current is used, thyristor break-down may occur when no Soft-start time is appropriately set.
(When the Heater break alarm or Non-linear resistance heater break alarm is used)

In Zero-cross control, no rush current can be suppressed even if the Soft-start time is set.

In case of Power frequency error, Over current alarm or Heat sink temperature abnormality (150 A/200 A types), the output of this instrument may be turned off, but the Soft-down function will not be activated.
When the Power frequency error or Over current alarm is cleared and the instrument is automatically reset, the Soft-start function will not be activated even if the output of the instrument is turned on.

6.4 Set Data Lock Function

This function is used to restrict mode changes and parameter setting changes by key operation. This function prevents the operator from making errors during operation. Settings are configured using the front keys or Contact inputs (DI).

■ Mode which can be locked

– Setting mode 1, Setting mode 2

When locked, set values cannot be changed. [Except set data lock (LK)]
However, the Setting mode can be switched to allow set values to be checked.

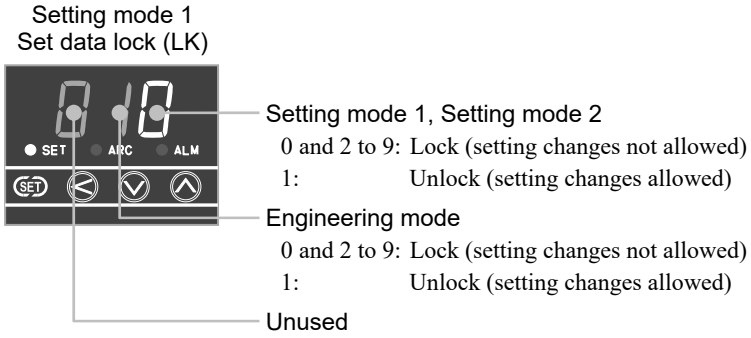
– Engineering mode

When locked, the mode cannot be changed to Engineering mode. Set values cannot be changed or checked.

Display during Set data lock
When the locked Setting mode is selected, the SET lamp flashes to indicate the lock mode.
All numeric values on the setting screen become brightly lit.

■ When the data is locked by front keys

The set data lock can be set in Set data lock (LK) of Setting mode 1.



Set value and lock state

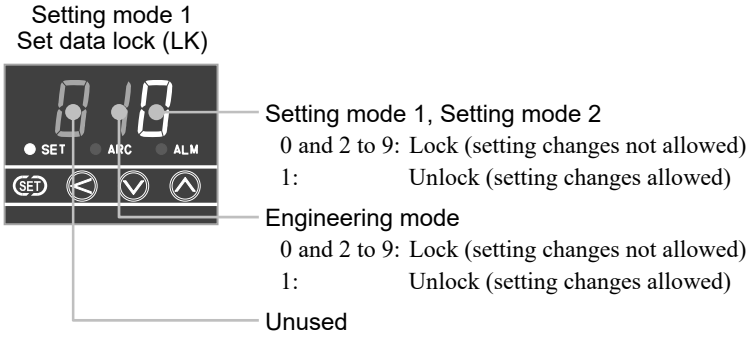
Set value of Set data lock (LK) *	Engineering mode	Setting mode 1 Setting mode 2
000	Lock	Lock
001	Lock	Unlock
010	Unlock	Lock
011	Unlock	Unlock

* To lock the setting, a value between 2 and 9 can be used instead of "0."

■ When the data is locked by Contact input (DI)

Before locking the setting data, set the following parameter.
Set data lock and unlock becomes available by switching the contacts open and close.

1. Adjust the Set data lock (LK) for Setting mode 1 (0 and 2 to 9: Lock) to lock with the Contact input (DI).



The following table shows the lock state by the front key and the Contact input (DI).

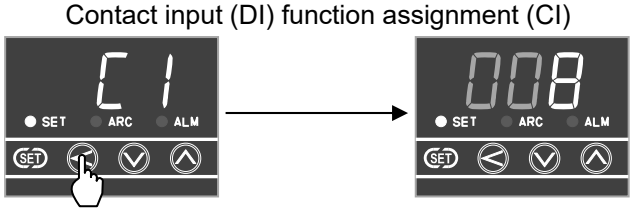
Set value of Set data lock (LK) [1]	Contact input (DI) state [2]	Actual lock state	
		Engineering mode	Setting mode 1 Setting mode 2
000	Open	Lock	Lock
	Closed	Unlock	Unlock
001	Open	Lock	Unlock
	Closed	Unlock	Unlock
010	Open	Unlock	Lock
	Closed	Unlock	Unlock
011	Open	Unlock	Unlock
	Closed	Unlock	Unlock

[1] To lock the setting, a value between 2 and 9 can be used instead of "0"

[2] Open: Lock (setting changes not allowed) Closed: Unlock (setting changes allowed)

If the external contact is switched to open (lock) in Engineering mode, it is possible to switch from Engineering mode to another mode. Once you have switched to another mode, it will not be possible to switch back to Engineering mode unless the external contact is closed (unlock).

2. Set the Contact input (DI) function assignment in the Engineering mode to "8: Set data lock enable/disable."

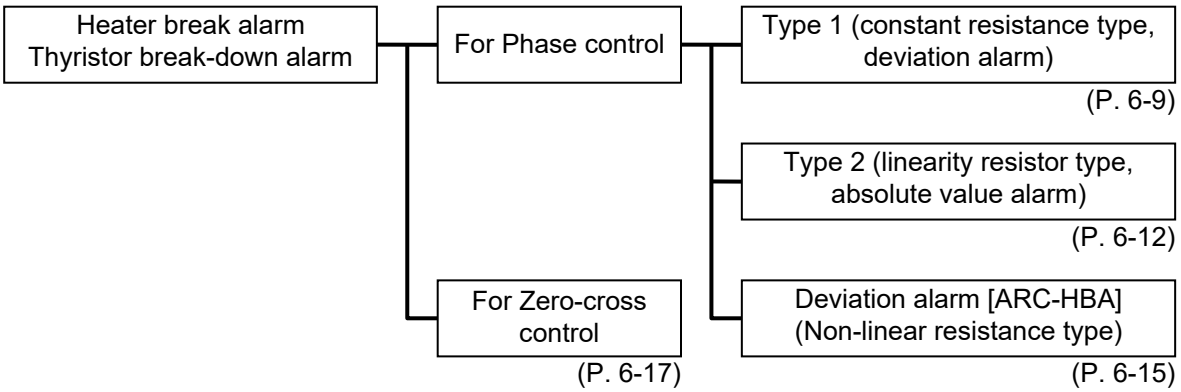


6.5 Heater Break Alarm/Thyristor Break-Down Alarm (optional)

Use the heater break alarm and Thyristor break-down alarm in a system with a current capacity of 10 A or more.
Because the error of the current measurement is ±2 A (for 20 A and 30 A types) or ±5 % of the current rating (for 45 A or larger types), the Heater break alarm may not properly function if it is used with a small load current value.

6.5.1 Outline

Heater break alarm/Thyristor break-down alarm measure the current flowing to the load with the current transformer (CT) and compare the measured value with the alarm set value. If the measured value is larger or smaller than the alarm set value, the instrument generates alarm.
The Heater break alarm/Thyristor break-down alarm are available for the alarm for Phase control and Zero-cross control. In case of Phase control, there are three types to choose a proper type according to the application. Each of Heater break alarm and Thyristor break-down alarm has two alarm setpoints.



6.5.2 Alarm differential gap

If the measured value from the current transformer (CT) is around the alarm set value, due to the fluctuation of the input, Heater break alarm or Thyristor break-down alarm may be generated repeatedly.
To avoid such frequent alarm state, an alarm differential gap where alarm state is not checked is supplied on the OFF side against the alarm set value.

Alarm differential gap

The Alarm differential gap is as follows regardless of the alarm type.

- 20 A/30 A/45 A type: 0.3 A
- 60 A/80 A/100 A/150 A/200 A type: 1 A

6.5.3 Heater break alarm/Thyristor break-down alarm for phase control

(1) Type 1 (constant resistance type, deviation alarm)

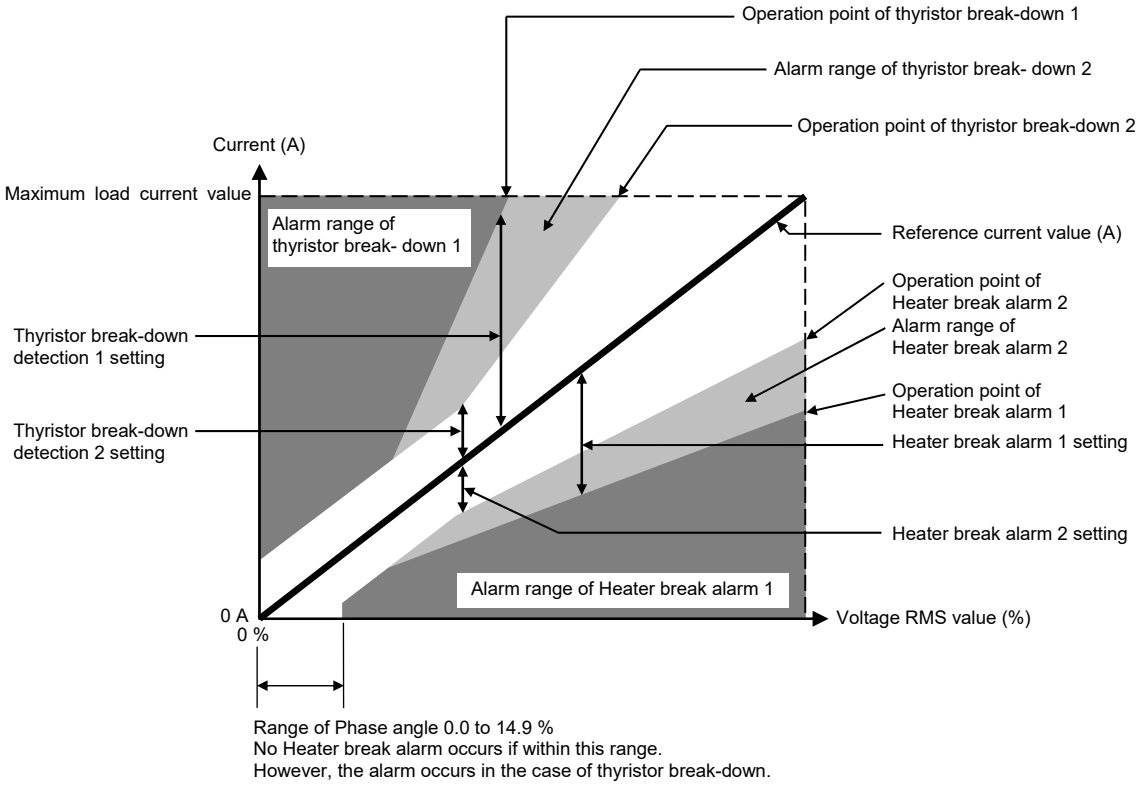
■ Outline of Type 1

The Heater break alarm/Thyristor break-down alarm of Type 1 instrument performs the following calculation to determine the alarm state.

1. Calculates reference current * for each RMS (%) suitable for the phase angle.
2. Calculates the operation point from the deviation between the reference current value and the alarm set value.
3. Determines the alarm condition when the current value detected by the current transformer (CT) has exceeded the operation point and entered the alarm range.

The deviation between the reference current value and the alarm operation point is 0 to 100 % of the reference current or 2 A, whichever is larger.
If the condition may attempt to change the set value below 2 A, this instrument makes adjustment to keep the set value 2 A or more.

* The reference current is the load current value that is assumed for the output phase angle of this instrument.



- If alarm is generated above the reference current value, it is a Thyristor break-down alarm.
- If alarm is generated below the reference current value, it is a Heater break alarm.

Operation chart of Type 1

■ Heater useable for Type 1

The heater break alarm of Type 1 can be used for general heating elements making small resistance changes (approx. 10 %) with temperature variations.
(General heating elements: Nichrome, ferrochromium, graphite, kanthal A, etc.)

Cannot be used for noble metal or silicon carbide heating elements.

Type 1 cannot be used for any power supply waveforms other than a sine waveform.

■ Determination of Heater break alarm and alarm reset

To avoid malfunction of the alarm, the Heater break alarm will not function if the phase angle is less than 15 % (below 15 % of the maximum load current value).

• Determination of heater break

While the phase angle is 15 % or more, if the current input value from the CT stays within the Heater break alarm ON area continuously for "Number of alarm determination by 10 times (5 samplings)*," alarm is generated.

Current transformer (CT) input value ≦ {(Maximum load current value × Voltage RMS value [%]) × (100 % – Heater break alarm set value [%])}

• Determination of alarm release

In case of phase angle 15 % or more, if the input value of the current transformer (CT) is outside of the Heater break alarm range for 10 times (5 samplings)* repeatedly, the alarm is released.

Current transformer (CT) input value ≦ {(Maximum load current value × Voltage RMS value [%]) × (100 % – Heater break alarm set value [%])}

* 5 consecutive cycles: Five cycles of power supply frequency

■ Determination of Thyristor break-down alarm and alarm release

• Determination of Thyristor break-down alarm

If the current input value from the CT stays within the Thyristor break-down alarm ON area continuously for "Number of alarm determination by 10 times (5 samplings)*," alarm is generated.

Current transformer (CT) input value ≧ {(Maximum load current value × Voltage RMS value [%]) × (100 % + Thyristor break-down detection setting [%])}

• Determination of release of Thyristor break-down alarm

When the input value of the current transformer (CT) is outside of the Thyristor break-down alarm range for 10 times (5 samplings)* repeatedly, the alarm is released.

Current transformer (CT) input value < {(Maximum load current value × Voltage RMS value [%]) × (100 % + Thyristor break-down detection setting [%])} – Differential gap

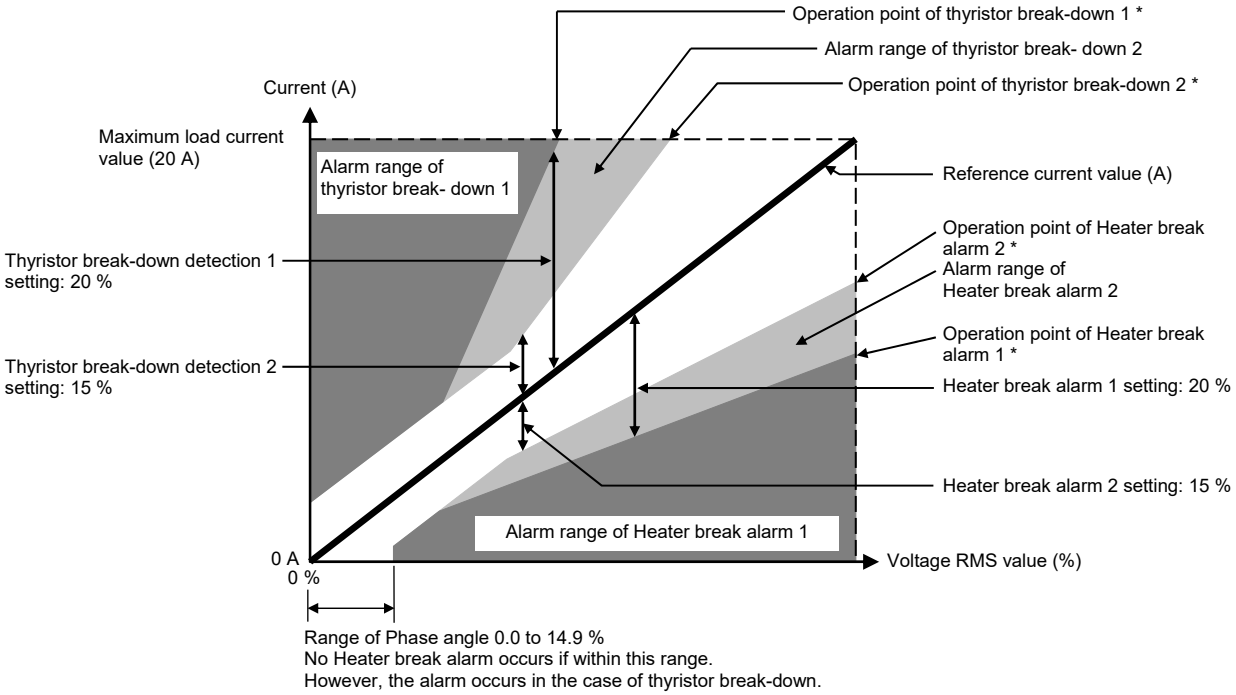
* 5 consecutive cycles: Five cycles of power supply frequency

■ Application of Type 1

When the parameters are set to the values below, operation takes place as shown in the graph.
(This setting example is for a 20 A type. All parameters except "Alarm output logic (L1)" are default settings.)

Mode	Parameter	Set value
Setting mode2	Maximum load current value for alarm (MC)	20.0 A
	Heater break alarm 1 setting (H1)	20 % [1] [The set value is a percentage (%) against the reference current value.]
	Thyristor break-down detection 1 setting (Tb)	20 % [2] [The set value is a percentage (%) against the reference current value.]
	Heater break alarm 2 setting (H2)	15 % [3] [The set value is a percentage (%) against the reference current value.]
	Thyristor break-down detection 2 setting (TC)	15 % [4] [The set value is a percentage (%) against the reference current value.]
Engineering mode	Control method (CM)	0 (Phase control)
	Heater break alarm enable/disable (HF)	1 (Enable)
	Alarm output logic (L1)	15 (Logical *OR* of Heater break alarm1, Thyristor break-down alarm 1, Heater break alarm 2 and Thyristor break-down alarm 2)
	Selection of energized/de-energized alarm output (nA)	0 (Energized)
	Alarm type selection (A1)	0 (Type 1: constant resistance type)
	Number of alarm 1 determination (n1)	30 times
	Number of alarm 2 determination (n2)	300 times
	Alarm enable/disable during STOP (SA)	0 (Disable)

[1] Equation for conversion to a current value (A): Current value = Reference current value × Heater break alarm 1 setting (%)
[2] Equation for conversion to a current value (A): Current value = Reference current value × Thyristor break-down detection 1 setting (%)
[3] Equation for conversion to a current value (A): Current value = Reference current value × Heater break alarm 2 setting (%)
[4] Equation for conversion to a current value (A): Current value = Reference current value × Thyristor break-down detection 2 setting (%)



* The alarm operation point is calculated from the deviation between the reference current value and the alarm set value. Below is an example of the calculation.

In case reference current value is 15 A:
Alarm operation point of Heater break alarm 1/Thyristor break-down 1 set values (20 %) is 3 A.
(Alarm is turned on when the current transformer (CT) input value deviates from the reference current value by 3 A)
Alarm operation point of Heater break alarm 2/Thyristor break-down 2 set values (15 %) is 2.25 A.
(Alarm is turned on when the current transformer (CT) input value deviates from the reference current value by 2.25 A)

In case reference current value is 12 A:
Alarm operation point of Heater break alarm 1/Thyristor break-down 1 set values (20 %) is 2.4 A.
(Alarm is turned on when the current transformer (CT) input value deviates from the reference current value by 2.4 A)
The calculated alarm operation point of Heater break alarm 2/Thyristor break-down 2 set values (15 %) is 1.8 A, but as it is 2 A or lower, the alarm operation point should be 2 A.
(Alarm is turned on when the current transformer (CT) input value deviates from the reference current value by 2 A)

(2) Type 2 (linearity resistor type, absolute value alarm)

■ Outline of Type 2

Heater break alarm/Thyristor break-down alarm of Type 2 is used to detect a break of a single heater.
For the Type 2, alarm set value is calculated based on the maximum load current value.
Alarm state is determined if the input value from the current transformer (CT) is below the Heater break alarm set value or if it is above the Thyristor break-down set value.

📖 **Set the Heater break alarm set value or Thyristor break-down set value to approximately 10 % of the maximum load current value. Do not set the heater break alarm set value to more than 15 %.**

📖 No Type 2 can be used when two or more heaters are used in parallel connection.

■ Heater useable for Type 2

The heater break alarm of Type 2 can be used for heating elements such as noble metals making large resistance changes with temperature variations. (Heating elements such as noble metals: Platinum, molybdenum, tungsten, superkanthal, tantalum, etc.)

■ Determination of Heater break alarm and alarm reset

📖 **To avoid malfunction of the alarm, the Heater break alarm will not function if the phase angle is less than 15% (below 15% of the maximum load current value).**

• Determination of heater break

While the phase angle is 15 % or more, if the current input value from the CT stays within the Heater break alarm ON area continuously for "Number of alarm determination by 10 times (5 samplings)*," alarm is generated.

Current transformer (CT) input value ≦ Maximum load current value × Heater break alarm set value [%]

• Determination of alarm release

In case of phase angle 15 % or more, if the input value of the current transformer (CT) is outside of the Heater break alarm range for 10 times (5 samplings)* repeatedly, the alarm is released.

Current transformer (CT) input value ＞ (Maximum load current value × Heater break alarm set value [%]) + Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

■ Determination of Thyristor break-down alarm and alarm release

In case of the phase angle other than 0 %, determination of Thyristor break-down alarm is not made.

- Determination of Thyristor break-down alarm

While the phase angle is at 0 %, if the input from the current transformer (CT) is within the Thyristor break-down "ON" area for "the Number of alarm determination by 10 times (5 samplings) *" continuously, then alarm is generated.

Current transformer (CT) input value ≧ Maximum load current value × Thyristor break-down detection setting [%]

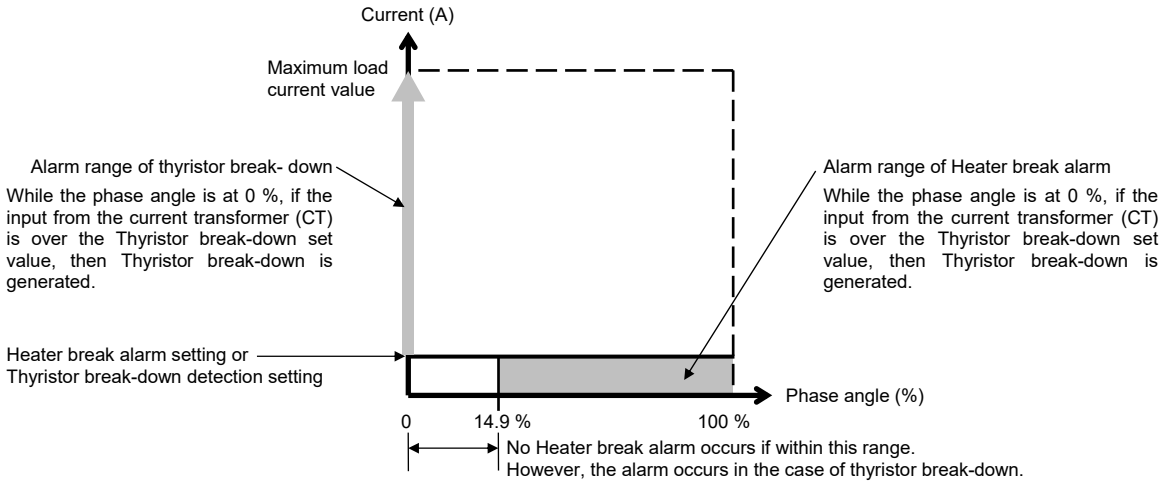
- Determination of release of Thyristor break-down alarm

While the phase angle is at 0 %, if the input from the current transformer (CT) is outside the Thyristor break-down "ON" area for "the Number of alarm determination by 10 times (5 samplings) *" continuously, then alarm is released.

Current transformer (CT) input value < (Maximum load current value × Thyristor break-down detection setting [%]) − Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

■ Operation chart of Type 2

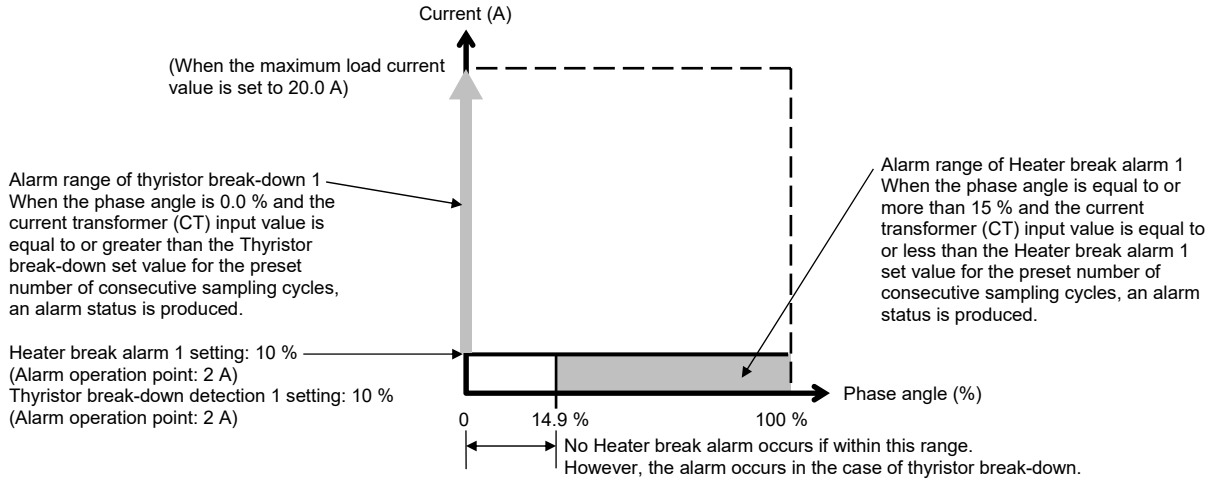


■ Application of Type 2

When the parameters are set to the values below, operation takes place as shown in the graph.

Mode	Parameter	Set value
Setting mode2	Maximum load current value for alarm (MC)	20.0 A
	Heater break alarm 1 setting (H1)	10 % [1] [The set value is a percentage (%) against the Maximum load current value.]
	Thyristor break-down detection 1 setting (Tb)	10 % [2] The set value is a percentage (%) against the Maximum load current value.]
	Heater break alarm 2 setting (H2)	0 % (Heater break alarm 2 unused) The set value is a percentage (%) against the Maximum load current value.]
	Thyristor break-down detection 2 setting (TC)	0 % (Thyristor break-down alarm 2 unused) The set value is a percentage (%) against the Maximum load current value.]
Engineering mode	Control method (CM)	0 (Phase control)
	Heater break alarm enable/disable (HF)	1 (Enable)
	Alarm output logic (L1)	3 (Logical *OR* of Heater break alarm1, Thyristor break-down alarm 1)
	Selection of energized/de-energized alarm output (nA)	0 (Energized)
	Alarm type selection (A1)	1 (Type 2: linearity resistor type, absolute value alarm)
	Number of alarm 1 determination (n1)	1 times
	Alarm enable/disable during STOP (SA)	0 (Disable)

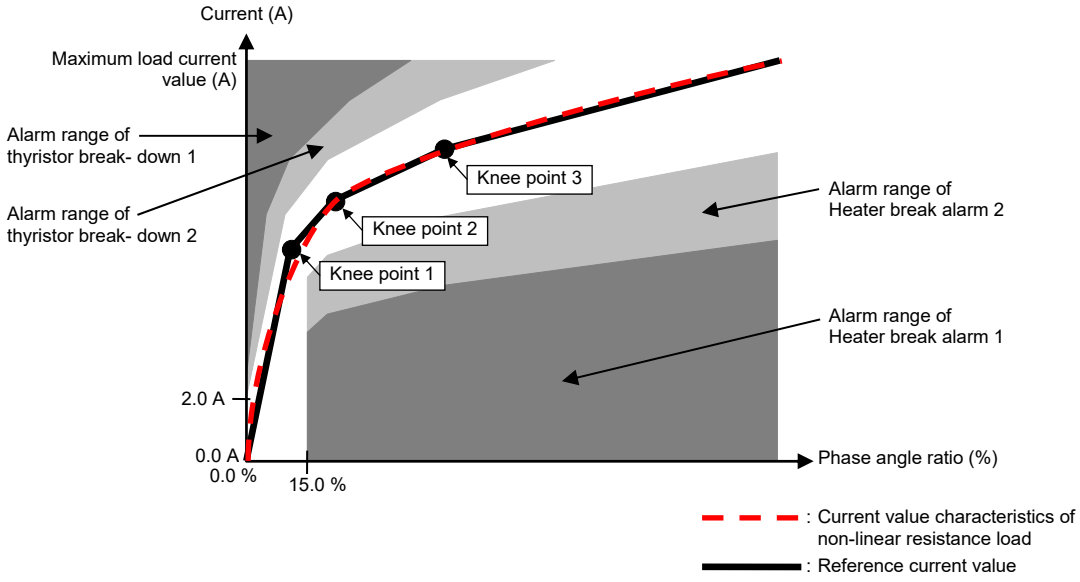
[1] Equation for conversion to a current value (A): Current value = Maximum load current value × Heater break alarm 1 setting (%)
[2] Equation for conversion to a current value (A): Current value = Maximum load current value × Thyristor break-down detection 1 setting (%)



(3) Non-linear resistance heater break alarm

It may not be possible to use the Non-linear resistance heater break alarm function with some heater types.

The Non-linear resistance heater break alarm is used to detect breaks in loads with large changes in resistance due to temperature (lamp heaters, etc.). Adjustment is made for the properties of non-linear resistance loads by adding 3 knee points to the computed reference current of the instrument.



■ Automatic detection function of knee points

Automatic detection function of knee points is a function to automatically set the following parameters.

- Current value (r1 to r3) at knee point 1 to 3
- Maximum load current value for alarm (MC)
- Phase angle ratio (K1 to K3) at knee point 1 to 3

This function adjusts the output of this instrument from 0 % till 100 %, measures the phase angle ratio at knee points 1, 2, and 3 and the current value at the phase angle ratio of 100 %, and automatically rewrites the current values and the maximum load current values of knee points.
When automatic detection is executed with the Current limiter value, Output limiter high, or Soft-start time set, if phase angle ratio different from that before the execution of the automatic detection is measured, phase angle values at knee points 1 through 3 (K1 to K3) are also automatically re-written.

■ Determination of Heater break alarm and alarm reset

To avoid malfunction of the alarm, the Heater break alarm will not function if the phase angle is less than 15% (below 15% of the maximum load current value).

• Determination of heater break

While the phase angle is 15% or more, if the current input value from the CT stays within the Heater break alarm ON area continuously for "Number of alarm determination by 10 times (5 samplings)*," alarm is generated.

Current transformer (CT) input value ≦ {(Reference current value is against the phase angle [A]) × (100 % – Heater break alarm setting [%])}

• Determination of alarm release

In case of phase angle 15 % or more, if the input value of the current transformer (CT) is outside of the Heater break alarm range for 10 times (5 samplings)* repeatedly, the alarm is released.

Current transformer (CT) input value ＞ {(Reference current value is against the phase angle [A]) × (100 % – Heater break alarm setting [%])} + Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

■ Determination of Thyristor break-down alarm and alarm release

• Determination of Thyristor break-down alarm

If the current input value from the CT stays within the Thyristor break-down alarm ON area continuously for "Number of alarm determination by 10 times (5 samplings)*," alarm is generated.

Current transformer (CT) input value ≧ {(Reference current value is against the phase angle [A]) × (100 % + Thyristor break-down detection setting [%])}

• Determination of release of Thyristor break-down alarm

When the input value of the current transformer (CT) is outside of the Thyristor break-down alarm range for 10 times (5 samplings)* repeatedly, the alarm is released.

Current transformer (CT) input value ＜ {(Reference current value is against the phase angle [A]) × (100 % + Thyristor break-down detection setting [%])} – Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

For the setting of knee points, refer to **5.20 Setting Example of Non-linear Resistance Heater Break Alarm (P. 5-35)**.

6.5.4 Heater break alarm/Thyristor break-down alarm for Zero-cross control

The alarm state is judged based on whether the current transformer (CT) input value is below the Heater break alarm set value or above the Thyristor break-down set value.

■ Determination of Heater break alarm and alarm reset

While the output of this instrument is off, alarm determination is not done.

• Determination of heater break

While the output of this instrument is on, if the input value from the current transformer (CT) stays inside the Heater break alarm ON range for 10 times in a row ("Number of alarm determination by 10 times (5 samplings) *"), then alarm is generated.

Current transformer (CT) input value ≦ Maximum load current value × Differential gap [%]

• Determination of alarm release

While the output of this instrument is on, if the input value from the current transformer (CT) stays outside the Heater break alarm ON range for 10 times (5 samplings)* repeatedly, then alarm is released.

Current transformer (CT) input value ＞ (Maximum load current value × Heater break alarm setting [%]) + Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

■ Determination of Thyristor break-down alarm and alarm release

When the output from this instrument is on, determination of Thyristor break-down is not done.

• Determination of Thyristor break-down alarm

While the output of this instrument is off, if the input value from the current transformer (CT) stays inside the Thyristor break-down alarm ON range for 10 times in a row ("Number of alarm determination by 10 times (5 samplings) *"), then alarm is generated.

Current transformer (CT) input value ≧ Maximum load current value × Thyristor break-down detection setting [%]

• Determination of release of Thyristor break-down alarm

While the output of this instrument is off, if the input value from the current transformer (CT) stays outside the Thyristor break-down alarm ON range for 10 times (5 samplings)* repeatedly, then alarm is released.

Current transformer (CT) input value ＜ (Maximum load current value × Thyristor break-down detection setting [%]) – Differential gap

* 5 consecutive cycles: Five cycles of power supply frequency

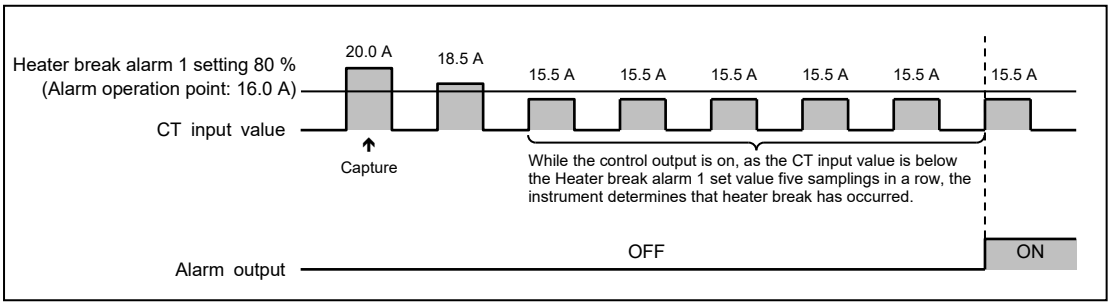
■ Application

● Setting example of heater break alarm

When the parameters are set to the values below, operation takes place as shown in the graph.

Mode	Parameter	Set value
Setting mode2	Maximum load current value for alarm (MC)	20.0 A
	Heater break alarm 1 setting (H1)	80 % * [The set value is a percentage (%) against the Maximum load current value.]
Engineering mode	Control method (CM)	1 (Zero-cross control [continuous])
	Heater break alarm enable/disable (HF)	1 (Enable)
	Alarm output logic (L1)	1 (Heater break alarm1)
	Selection of energized/de-energized alarm output (nA)	0 (Energized)
	Alarm type selection (A1)	1 (Type 2: linearity resistor type, absolute value alarm)
	Number of alarm 1 determination (n1)	1 times
	Alarm enable/disable during STOP (SA)	0 (Disable)

* Equation for conversion to a current value (A): Current value = Maximum load current value × Heater break alarm 1 setting (%)



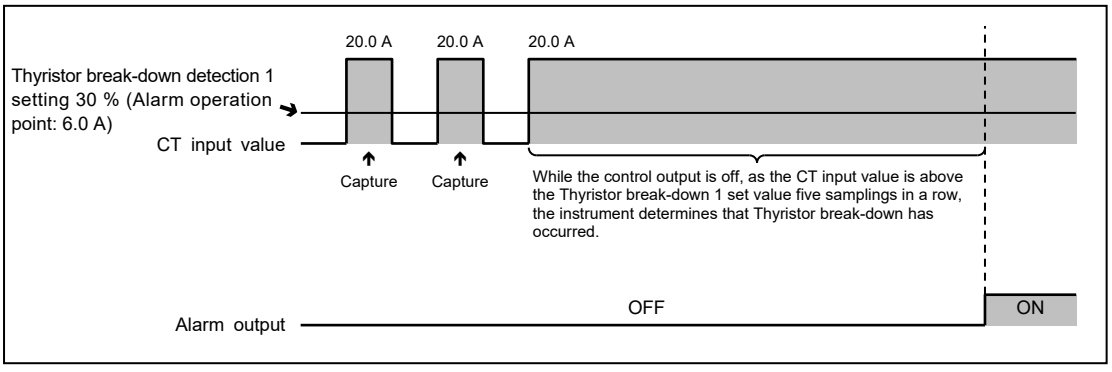
This chart shows the case when Control output is 50 %.

● Setting example of Thyristor break-down alarm

When the parameters are set to the values below, operation takes place as shown in the graph.

Mode	Parameter	Set value
Setting mode2	Maximum load current value for alarm (MC)	20.0 A
	Thyristor break-down detection 1 setting (Tb)	30 % * [The set value is a percentage (%) against the Maximum load current value.]
Engineering mode	Control method (CM)	1 (Zero-cross control [continuous])
	Heater break alarm enable/disable (HF)	1 (Enable)
	Alarm output logic (L1)	8 (Thyristor break-down alarm 2)
	Selection of energized/de-energized alarm output (nA)	0 (Energized)
	Alarm type selection (A1)	1 (Type 2: linearity resistor type, absolute value alarm)
	Number of alarm 1 determination (n1)	1 times
	Alarm enable/disable during STOP (SA)	0 (Disable)

* Equation for conversion to a current value (A): Current value = Maximum load current value × Thyristor break-down detection 1 setting (%)



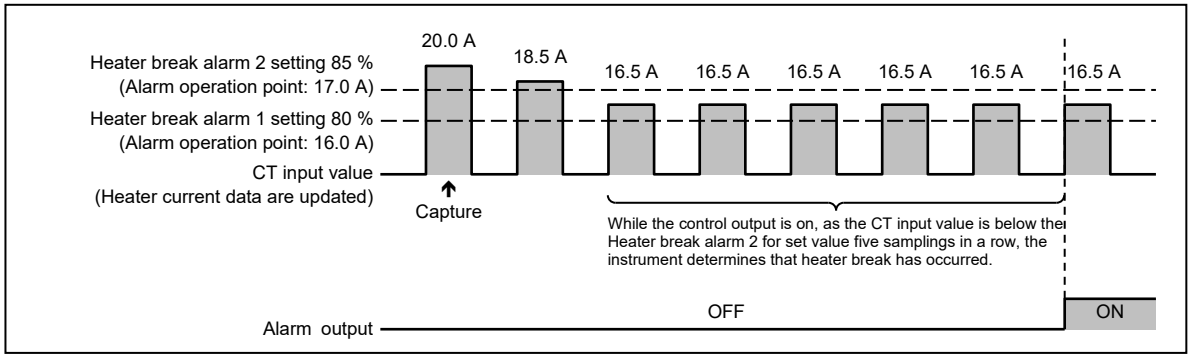
● When two Heater break alarms are used

When the parameters are set to the values below, operation takes place as shown in the graph.

Mode	Parameter	Set value
Setting mode2	Maximum load current value for alarm (MC)	20.0 A
	Heater break alarm 1 setting (H1)	80 % [1] [The set value is a percentage (%) against the Maximum load current value.]
	Heater break alarm 2 setting (H2)	85 % [2] [The set value is a percentage (%) against the Maximum load current value.]
Engineering mode	Control method (CM)	1 (Zero-cross control [continuous])
	Heater break alarm enable/disable (HF)	1 (Enable)
	Alarm output logic (L1)	5 (Logical *OR* of Heater break alarm 1, Heater break alarm 2)
	Selection of energized/de-energized alarm output (nA)	0 (Energized)
	Alarm type selection (A1)	1 (Type 2: linearity resistor type, absolute value alarm)
	Number of alarm 1 determination (n1)	1 times
	Number of alarm 2 determination (n2)	1 times
	Alarm enable/disable during STOP (SA)	0 (Disable)

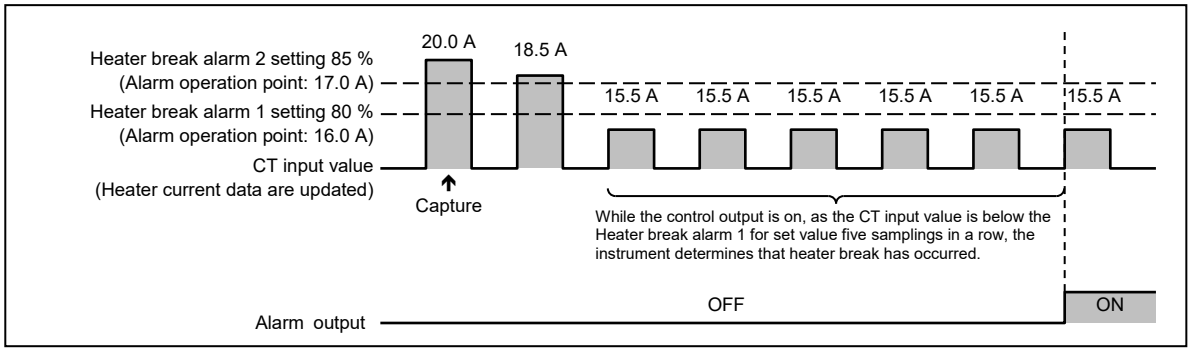
[1] Equation for conversion to a current value (A): Current value = Maximum load current value × Heater break alarm 1 setting (%)
[2] Equation for conversion to a current value (A): Current value = Maximum load current value × Heater break alarm 2 setting (%)

Operation chart of Heater break alarm 2 setting



This chart shows the case when Control output is 50 %.

Operation chart of Heater break alarm 1 setting



This chart shows the case when Control output is 50 %.

6.6 Energized/De-energized of Alarm Output

This instrument allows selection of Energized/De-energized alarm output. Below is the alarm output on/off state when the alarm output is set to energized or de-energized.

Table for explaining operation (At power-ON)

Setting of Energized/De-energized	State of alarm output	
	Non-alarm status	Alarm status
Energized	Alarm output OFF	Alarm output ON
De-energized	Alarm output ON	Alarm output OFF

Selection of alarm output Energized/De-energized is enabled if FAIL output is not included to the Alarm output logic (L1).

6.7 Number of Alarm Determination

The Number of alarm determination is that which delays the occurrence of alarm in order to prevent alarm malfunctioning. When an alarm condition becomes ON status, the output is suppressed until the preset number of sampling times elapses. After the preset number of sampling times elapses, if the alarm output is still ON status, the output will be produced. In addition, if the alarm state is released while the number of alarm determination is being activated, the alarm output is not turned on.

Number of alarm determination for Heater break alarm 1 and Thyristor break-down alarm 1

Number of alarm 1 determination (1 to 1000 times) × 10 times (5 samplings*)

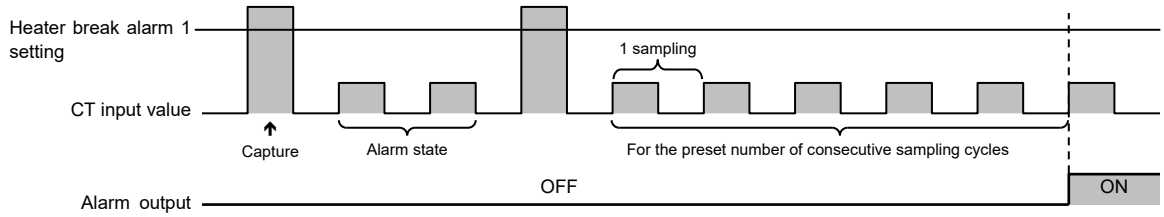
Number of alarm determination for Heater break alarm 2 and Thyristor break-down alarm 2

Number of alarm 2 determination (1 to 1000 times) × 10 times (5 samplings*)

* 5 consecutive cycles: Five cycles of power supply frequency

Example: Zero-cross control

When Number of alarm 1 determination (n1) is set to 1, alarm output will be activated after alarm state has been checked 10 times (5 samplings) in succession.



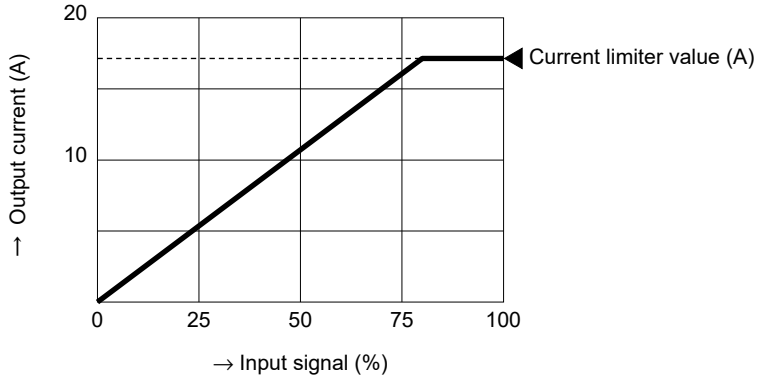
This chart shows the case when Control output is 50 %.

6.8 Current Limiter Function (optional)

This is the function of limiting an output current to a value not exceeding the preset current limit value. A current value is measured for each constant cycle and then the maximum phase angle not exceeding the current limit value is calculated from the above current value thus measured.
If the phase angle at that current output is larger than the maximum phase angle calculated, the current is output at the maximum phase angle to restrict that current.
The maximum phase angle is calculated during a time period of 0.1 seconds after the power is turned on. The Current limit function is activated after the maximum phase angle is calculated.

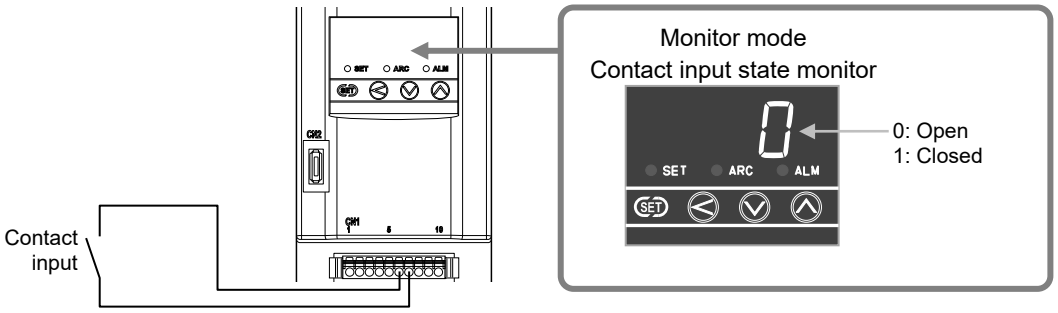
- **If a load through which large rush current flows is used, the Current limit function cannot restrict the above current. In this case, use the Current limit function together with the Soft-start function.**
- Even if the Soft-start time is set to 0.0 second or if the Soft-start function is disabled, the Soft-start function may work for 0.1 second after power has been applied in order to calculate the maximum phase angle.
- If a current limit value is set to its maximum value, the Current limit function is deactivated.
- The Current limiter function cannot be used when Zero-cross control is selected.

Example: 20 A type



6.9 Contact Input (DI) Function

Functions can be selected by external contact signals. There are eight functions that can be selected by the Contact input (DI). The function of the Contact input (DI) can be allocated.
The state of an external contact can be checked on the Contact input state monitor (dI).
When the Contact input (DI) is used, setting by the Contact input (DI) has a priority to the others.
Setting via front key or loader communication becomes unavailable.



For users of the THV-1
Please note that the open/close displays of the contact input state monitor in the THV-1 are opposite those in the THV-40.

	THV-1	THV-40
Open	1	0
Closed	0	1

■ Contact input (DI) function types

(1) Control method

A contact signal can be used to switch between Phase control and Zero-cross control (continuous).

Open: Phase control
Closed: Zero-cross control (continuous)

(2) Input signal transfer

A contact signal can be used to switch between Auto mode and Manual mode.
There are two types of manual setting: External manual mode and Internal manual mode.
When the Manual mode is selected, the Manual mode set at the Manual mode transfer (AM) in the Engineering mode (function block 2) is selected.

Open: Auto mode
Closed: Manual mode

(3) Manual mode transfer

A contact signal can be used to switch between External manual mode and Internal manual mode.

Open: External manual mode
Closed: Internal manual mode

(4) RUN/STOP transfer

A contact signal can be used to switch between RUN and STOP.
When switched to RUN (closed), the output of the instrument turns ON.
When switched to STOP (open), the output of the instrument turns OFF.

Open: STOP
Closed: RUN

(5) Soft-start, Soft-down enable/disable

A contact signal can be used to enable or disable the Soft-start/Soft-down function.
This makes it possible to disable the Soft-start and Soft-down functions without setting the Soft-start time and Soft-down time to "0."
There are two types of Enable actions. When "Enable" is selected by the Contact input (DI), the action set at "Soft-start, Soft-down enable/disable (SF)" in the Engineering mode (Function block 2) is selected.

Open: Enable
Closed: Disable

(6) Heater break alarm enable/disable *

A contact signal can be used to enable or disable the Heater break alarm and Thyristor break-down alarm. This makes it possible to disable the Heater break alarm and Thyristor break-down alarm without setting the Heater break alarm set value and Thyristor break-down alarm set value to "0."

Open: Enable
Closed: Disable

(7) Over current alarm enable/disable *

A contact signal can be used to enable or disable the Over current alarm function.

Open: Enable
Closed: Disable

(8) Set data lock enable/disable

Data set Enable (lock)/Disable (unlock) is selectable with the Contact input.
When this lock function is switched to "Enable (lock)" by the Contact input (DI), the mode set at the Set data lock (LK) in the Setting mode 1 is locked.

Open: Enable
Closed: Disable

☞ Refer to the following pages for the procedures to assign the "Set data lock" function to the Contact input (DI).

- **When the data is locked by Contact input (DI) (P. 6-7)**
- **5.11 Assigning Contact Input (DI) Functions (P. 5-17)**

* These functions are available when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

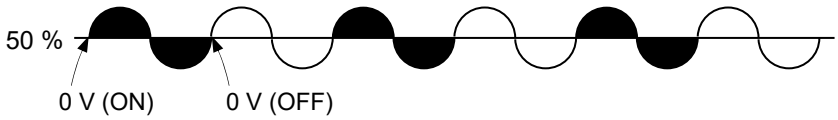
6.10 Control Method

■ Phase control

Phase control is to continuously control electric power supplied to a load by changing phase angle θ of AC voltage applied to the load. Each half-cycle has ON and OFF time.

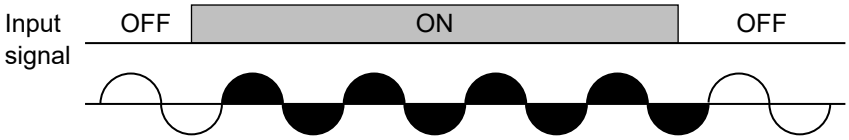
■ Zero-cross control (Continuous)

Continuous zero-cross control is to control electric power supplied to a load by turning the power supply voltage ON and OFF at the point of 0 V AC so that the high frequency noise can be suppressed compared with phase control. This on and off time is typically measured in milliseconds.



■ Zero-cross control (Input synchronous type)

Input synchronous type zero-cross control is to turn the power supply ON and OFF synchronously with the pulse signal from a controller.

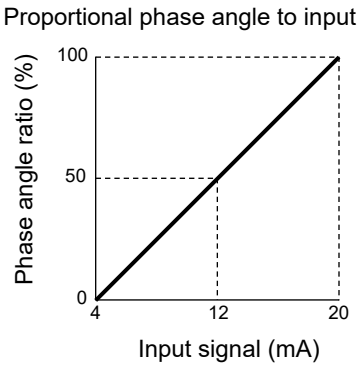


6.11 Output Mode for Phase Control

When phase control is selected for a resistance load, one of the following four output types can be selected. (The Output mode setting is invalid when the control method is zero-cross control.)

(1) Proportional phase angle to input

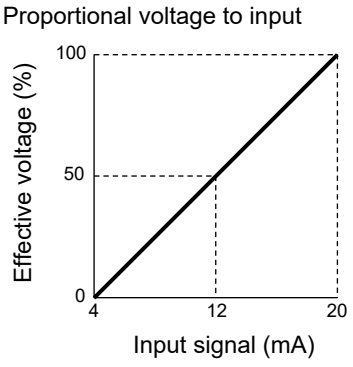
This is the output mode to manipulate the trigger point (phase angle) of the AC voltage to be applied to the load in proportion to the change of the input signal.
For example, the trigger point (phase angle) when the input signal is 4 to 20 mA DC becomes as follows.



- Input signal 4 mA DC: Phase angle 0° (phase angle ratio: 0 %)
- Input signal 12 mA DC: Phase angle 90° (phase angle ratio: 50 %)
- Input signal 20 mA DC: Phase angle 180° (phase angle ratio: 100 %)

(2) Proportional voltage to input

This is the output mode to manipulate the trigger point (phase angle) in proportion to the change of the input signal and the AC voltage to be applied to the load. This mode is effective to produce voltage output linear to the input from the temperature controller.



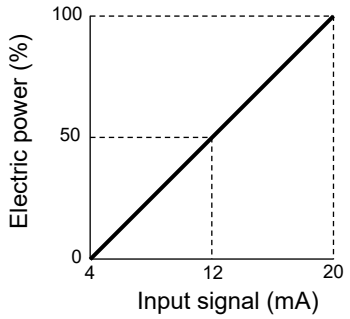
Action of Proportional voltage to input

For example, if the AC voltage to be applied to the load is 400 V AC, this instrument provides output voltage of 200 V AC (50 % of 400 V AC) when the input signal of 50 % is received.
However, if the AC voltage applied to the load becomes 380 V AC, the output voltage from this instrument for the receipt of 50 % input signal becomes 190 V AC (50 % of 380 V AC).
In case of the Proportional voltage to input, change of the AC voltage applied to the load also changes the output voltage from this instrument.

(3) Proportional square voltage (electric power) to input

Manipulation of the trigger point (phase angle) so that the change of the input signal and the change of the AC voltage to be applied to the load are changed in proportion to each other will not cause the change of the proportion of the power. The proportional square voltage (electric power) to input is the output mode to manipulate the trigger point (phase angle) in proportion to the electric power.

Proportional square voltage (electric power) to input

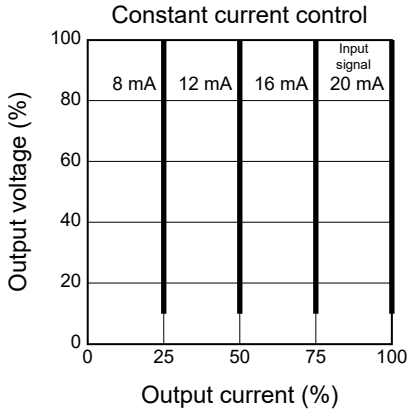


The Proportional square voltage (electric power) to input is not a mode to keep the electric power constant against the change of the load like the Constant power control.

(4) Constant current control

This is the function used to keep the output current constant in proportion to the input signal.
This function is effective when a heater with large resistance changes caused by temperature variations is used (such as tantalum, superkanthal, tungsten, platinum, or molybdenum).
The maximum output current when the Constant current control function is used coincides with the rated current in the instrument specification.

Constant current control



Operating condition	Stability
Power supply voltage variation: Within ±10 % of supply voltage for load	± 10 % of maximum current rating
Load variation: Within 2 times	

Constant current control is optional.

■ Caution for using constant current control function

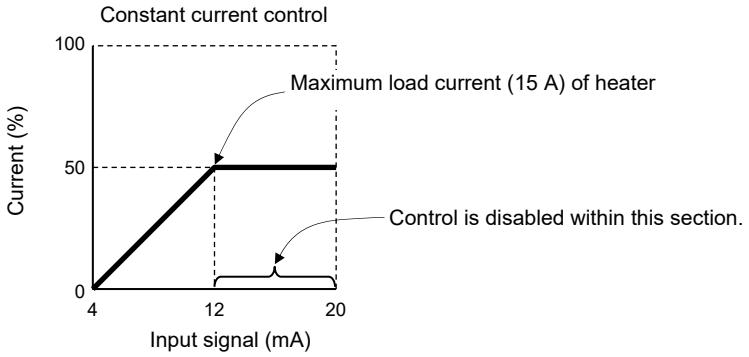
The Constant current control sets the reference so that the output current becomes the current rating of the instrument in case of the 100 % input signal. If the rated current of instrument differs from that maximum load current flowing through the heater, compensate for the difference by setting the gradient. If there is the difference, a section where control is disabled may come into existence. A compensation example when there is a difference between the currents flowing through the instrument and the heater is shown in the following.

Example: When used in the following condition

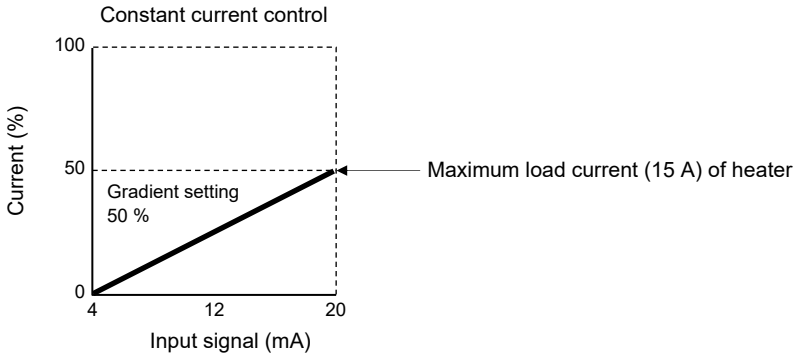
- Rated current of THV-40: 30 A
- Maximum load current of heater: 15 A
- Input signal from controller: 4 to 20 mA DC
- Soft-start time setting: 0.0 second

When Constant current control is used, the Soft-start function operates for 4 cycles after the power is turned on, even if the Soft-start time is set to 0.0 second.

When used without setting the gradient, the maximum heater load current becomes 15 A at an input signal of 12 mA. In this case, control is disabled if the input signal exceeds 12 mA.



In this case, set the gradient to 50 % so that the maximum heater load current will become 15 A at an input signal of 20 mA. The gradient is valid even if internally set or set by the external gradient setter.



6.12 Power Frequency Monitoring Function

When the instrument is powered on, the power supply frequency is checked for 50 Hz or 60 Hz and if the power supply frequency deviates from the detection range, an error is generated.
In case the power supply frequency cannot be checked, an error is also generated.

Detection range: 45.0 to 54.9 Hz (50 Hz)
55.0 to 64.9 Hz (60 Hz)

Action on occurrence of error: AT lamp flashes (If Alarm output logic is set)
THV-40 output is turned off.
(The output can be turned ON when the error is canceled.)

For users of the THV-A1
The detection range of the instrument differs from the detection ranges of the THV-A1.

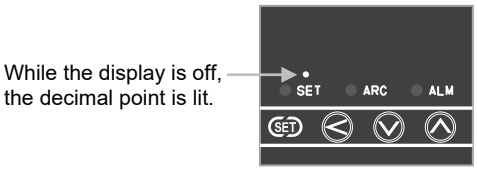
Power supply frequency	Detection range	
	THV-A1	THV-40
50 Hz	45.0 to 64.9 Hz	45.0 to 54.9 Hz
60 Hz		55.0 to 64.9 Hz

6.13 Display Off Function

This is a function to turn off the display unit (7 segment LED) if any key is not operated for a certain length of time. To turn on the display again, touch any key on the front panel.
The time till the display goes off can be set with the Display off timer (dT) in the Engineering mode (Function block 5).

Data range: 0 to 1000 seconds (0: Constantly lit)

While the display is off, only the leftmost decimal point is lit.



Even while the display is off, indication lamps are not turned off.

Even while the display is off, if error is detected by the self-diagnosis, all lamps and displays are turned on.

For the setting method, refer to **5.17 Setting Display Off Function (P. 5-23)**.

6.14 Output Limiter High and Low

This function limits the output range. Output limiter function is related to other functions.

- Output limiter high and low have priority to the output value [1] calculated with gradient setting function. The maximum output from the instrument will not exceed the Output limiter high and the minimum output will not go below the Output limiter low.
- Output limiter high has priority to the output value [2] calculated with gradient setting and Base-up setting function. The maximum output from the instrument will not exceed the Output limiter high.
- When Output limiter low is not set to zero (0.0), the Base-up setting function is invalid.

[1] Proportional phase angle to input, Proportional voltage to input or Proportional square voltage (electric power) to input:

Output value = (Input signal) × (Internal gradient setting) × (External gradient setting)

Constant current control:

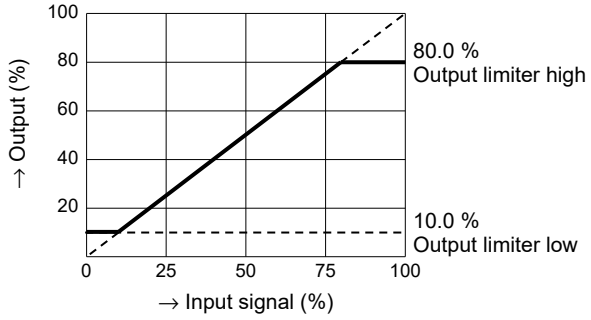
Output value = Input signal

[2] Proportional phase angle to input, Proportional voltage to input or Proportional square voltage (electric power) to input:

Output value = (Input signal) × (Internal gradient setting) × (External gradient setting) + (Base-up set value)

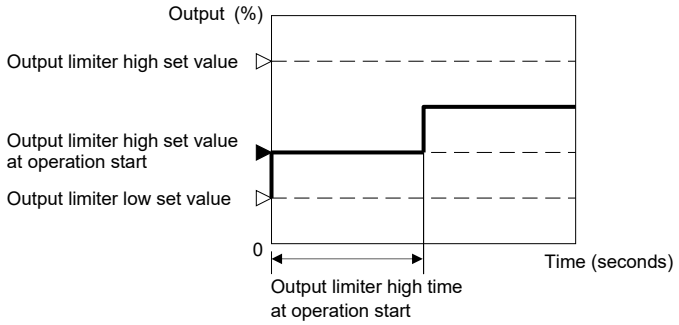
Constant current control:

Output value = (Input signal) + (Base-up set value)



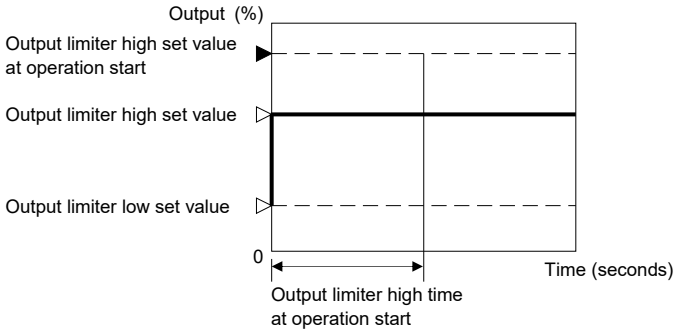
6.15 Output Limiter High at Operation Start

This is a function to limit the output for the set time period (Output limiter high time at operation start) when the instrument is powered up or when the mode is changed from STOP to RUN.
It is possible to lessen rush current by using this function. The use of this function is effective for any heater (halogen lamp, platinum, tungsten, molybdenum, etc.) through which rush current flows.

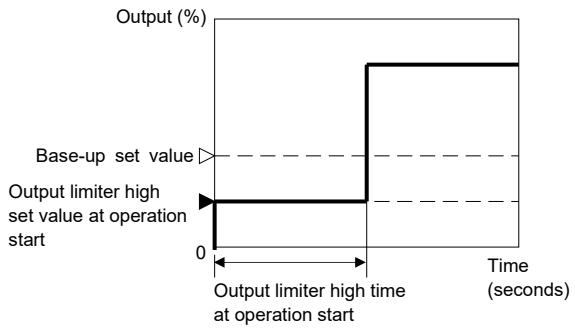


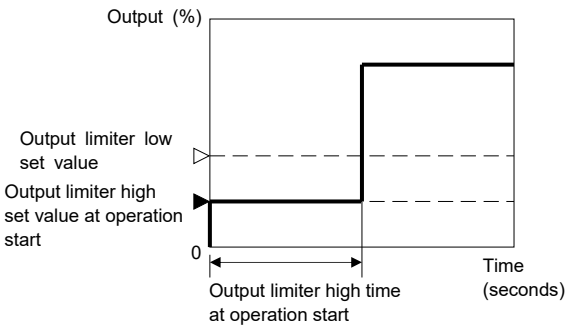
■ Priority order of Output limiter

In case the Output limiter high at operation start is set at a larger value than the Output limiter high value, priority is given to the Output limiter high.

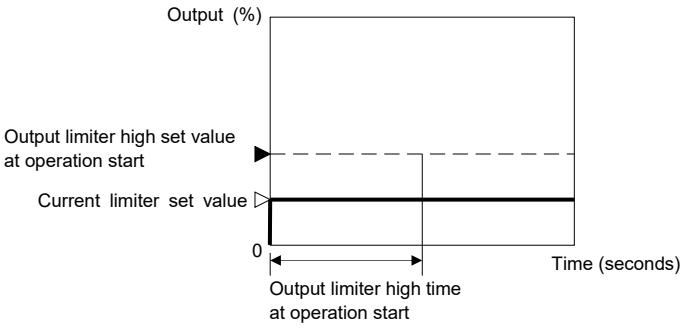


In case the Output limiter high at operation start is set at a smaller value than the Base-up set value and the Output limiter low value, priority is given to the Output limiter high at operation start.





In case the Output limiter high at operation start is set at a larger value than the Current limiter value, priority is given to the Current limiter value.

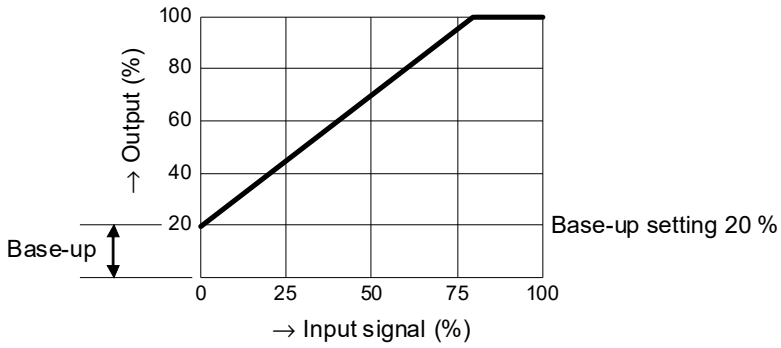


6.16 Base-Up Setting Function

Base-up setting function adds positive bias to the output value calculated with Gradient setting function.

- Base-up setting is valid only when Output limiter low is set to zero (0.0).
- Output limiter high has priority to the output value * calculated with gradient setting and Base-up setting function. The maximum output from the instrument will not exceed the Output limiter high.

  * Output value = (Input signal) × (Gradient set value) + (Base-up set value)



The Base-up set value is effective only when the Output limiter low is set to 0.0.

6.17 Over Current Alarm Function (optional)

This is a function to protect the thyristor element by detecting the overcurrent. In case current 1.2 times larger than the current rating flows into the instrument, the overcurrent alarm is generated.

Current value 1.2 times larger than the current rating.

20 A type: 24 A
30 A type: 36 A
45 A type: 54 A
60 A type: 72 A
80 A type: 96 A
100 A type: 120 A
150 A type: 180 A
200 A type: 240 A

■ Conditions for generating the Over current alarm

If all of the following conditions are satisfied, Over current alarm is turned on.

- Over current alarm enable/disable (oF) is set to enable.
- Current 1.2 times larger than the current rating of this instrument is detected six times in a row.

■ Conditions for releasing the Over current alarm

If all of the following conditions are satisfied, Over current alarm is turned off.

- The instrument is powered off and powered on again.
- The detected current value is smaller than the over current detection value by six times in a row in the STOP state when the Alarm enable/disable during STOP (SA) is set to “Disable.”

■ Actions when Over current alarm is generated

- Alarm monitor (AL) shows 32 (Over current alarm).
- When Over current alarm is specified in the Alarm output logic selection (L1), the alarm output turns on.
- The output from this instrument is turned off.

■ Actions when Over current alarm is released

- The Alarm monitor (AL) shows zero again.
- When Over current alarm is specified in the Alarm output logic selection (L1), the alarm output turns off.
- The output from this instrument is turned on.

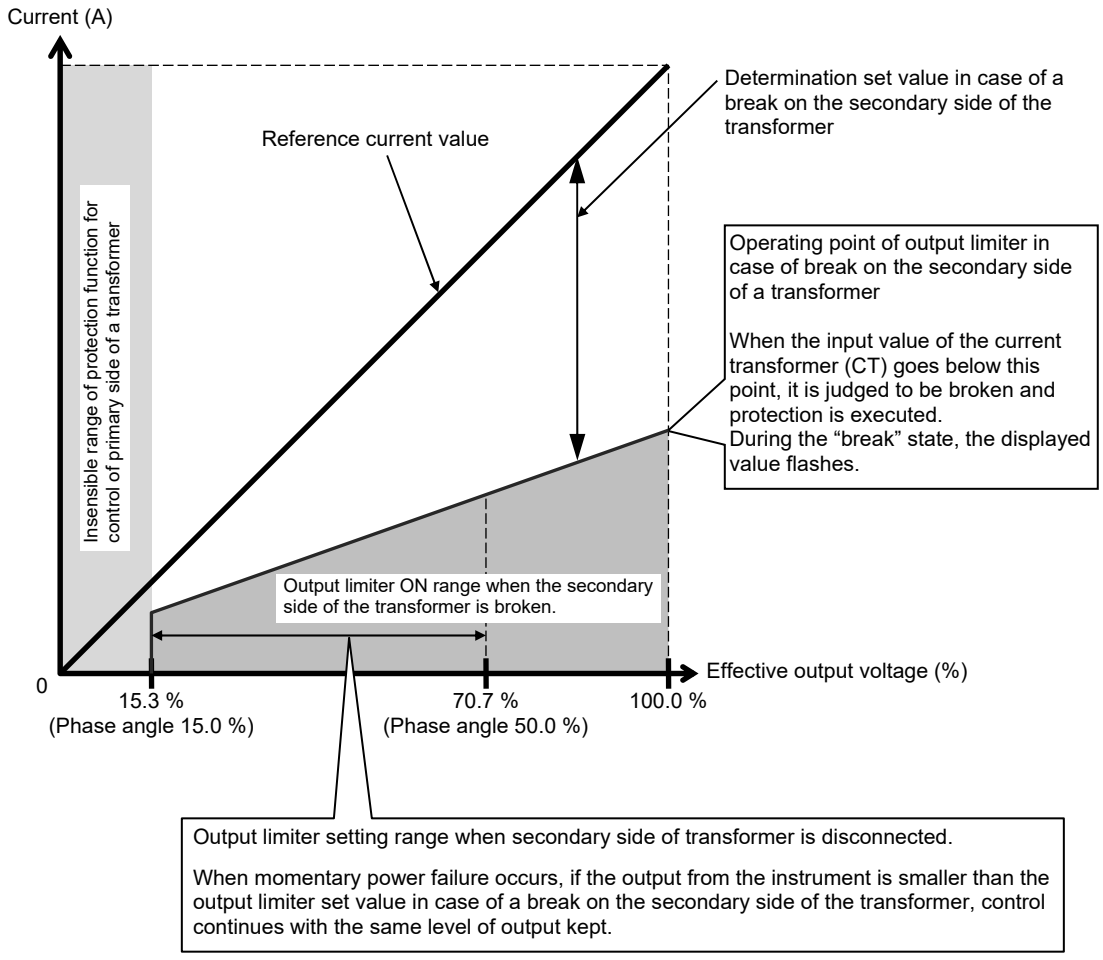
6.18 Protection Function for Control of Primary Side of a Transformer (optional)

If momentary power failure occurs during execution of the control of primary side of a transformer, inrush current is generated. Protection function for control of primary side of a transformer is to protect the thyristor from the inrush current. With this protection function enabled, when momentary power failure occurs, the instrument determines that the secondary side of a transformer was disconnected and suppresses the output. When the instrument is automatically reset from the breakdown (momentary power failure), the soft-start function suppresses the inrush current.
To use this protection, the following parameters need to be set.

- Protection function for control of primary side of a transformer (ꞱF)
- Determination set value in case of a break on the secondary side of the transformer (ꞱA)
- Output limiter setting in case of a break on the secondary side of the transformer (ꞱL)
- Soft-start time in case of break on the secondary side of the transformer (ꞱU)

☞ For the setting procedure, refer to page P. 5-50 and 5-51.

■ Operation chart



■ Determination of break and release of secondary side of transformer

• Determination of break

While control of primary side of a transformer is executed, if the current transformer (CT) value goes below the determination set value in case of a break on the secondary side of the transformer, it is judged to be a break (momentary power failure). Below is a formula to convert the Determination set value in case of a break on the secondary side of the transformer (TA) into the current value (A).

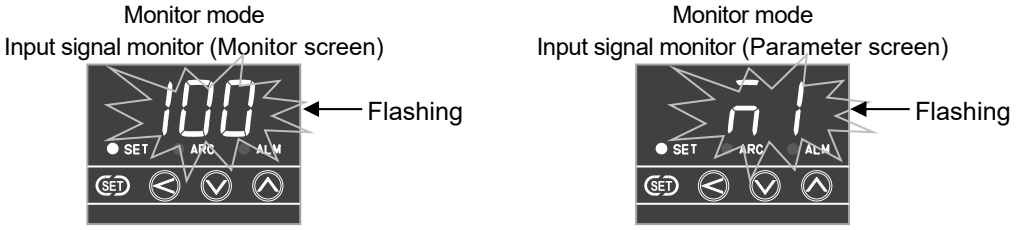
Current value [A] = Maximum load current set value [A] × Effective output voltage [%] × (100 % – Determination set value in case of a break on the secondary side of the transformer [%])

• Determination of release

While the phase angle is 15 % or more, when the current goes over the Determination set value in case of a break on the secondary side of the transformer by 0.3 A (instrument of 60 A or more: 1 A), it is judged to be a release from a break (momentary power failure).

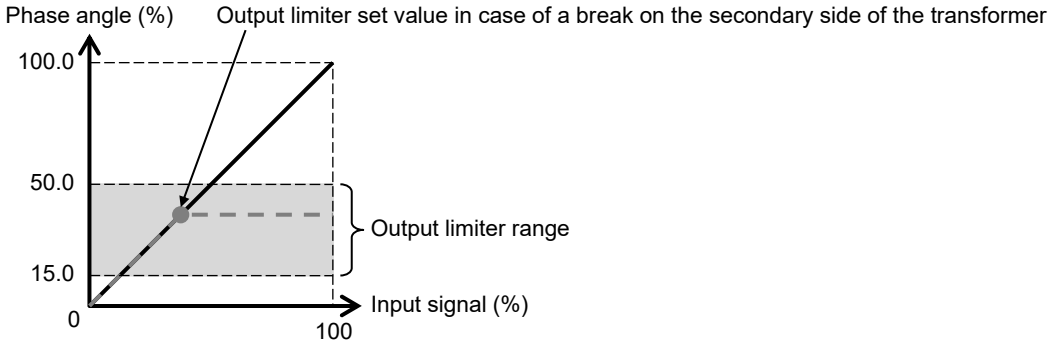
■ Display in case of break of secondary side of a transformer

When the signal level goes below the Determination set value in case of a break on the secondary side of the transformer, the parameter symbols and displayed value flashes. (Parameter symbols and displayed value of Monitor mode flash) When the instrument is automatically released from the break (momentary power failure), the display stops flashing and remains lit.



■ Output limiter setting in case of a break on the secondary side of the transformer

This is a function to limit the phase angle between 15.0 % and 50.0 % when the signal goes below the Ddetermination set value in case of a break on the secondary side of the transformer.



■ Soft-start function in case of break on the secondary side of the transformer

This is a soft-start function which is activated when the instrument is automatically released from the break (momentary power failure) of the secondary side of the transformer. This function suppresses the inrush current at the time of automatic release from the break (momentary power failure).

While the soft-start function of the Soft-start time (SU) is working, if break (momentary power failure) of secondary side of a transformer occurs, Protection function for control of primary side of a transformer starts working to suppress the output. When released from the break (momentary power failure), the instrument changes the output according to the Soft-start time in case of break on the secondary side of the transformer (TU). After elapse of the Soft-start time in case of break on the secondary side of the transformer (TU), the Soft-start time (SU) takes over, and output is changed in the remaining time of the Soft-start time (SU).

6.19 Heat Sink Temperature Detection Function (150 A/200 A types)

This is an alarm function to detect a rapid temperature rise of the heat sink (radiation fin) to protect the thyristor element.

■ Conditions for generating the Heat sink temperature abnormality

When the heat sink temperature exceeds approx. 120 ºC, the Heat sink temperature abnormality turns on.

■ Conditions for releasing the Heat sink temperature abnormality

- Power off the instrument and wait till the temperature comes down below approx. 120 °C. Then, power on the instrument again.
- While Alarm enable/disable during STOP (SA) is disabled, if the heat sink temperature is below approx. 120 ºC during STOP state.

■ Actions when Heat sink temperature abnormality is generated

- Alarm monitor (AL) shows 64 (Heat sink temperature abnormality).
- When Heat sink temperature abnormality is specified in the Alarm output logic selection (L1), the alarm output turns on.
- The output from this instrument is turned off.

■ Actions when Heat sink temperature abnormality is released

- The Alarm monitor (AL) shows zero again.
- When Heat sink temperature abnormality is specified in the Alarm output logic selection (L1), the alarm output turns off.
- The output from this instrument is turned on.

6.20 Minimum Output Phase Angle Adjustment Function

This function (Minimum output phase angle adjustment function) is used to adjust the minimum output phase angle to prevent misfiring when firing is done only on one side of the output due to the distortion of the power supply waveform.
The Minimum output phase angle can be set in the Engineering mode at F.3 Minimum output phase angle adjustment (Mo).

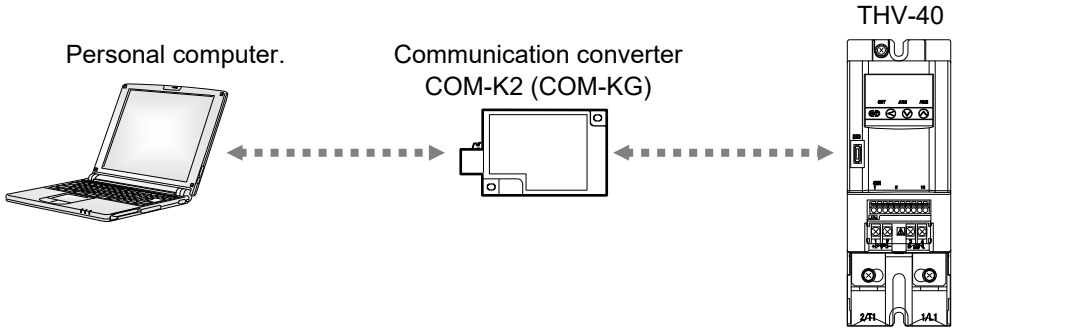
MEMO

LOADER COMMUNICATION

7

7.1 Outline of Loader Communication

Loader communication allows instrument data to be set from a personal computer.
With the Communication Tool PROTEM2, the setting data once stored in the PC can be transferred to other instruments. This speeds up the setup process compared to the manual setup via front key.
RKC communication converter COM-K2 or COM-KG (sold separately) is required for the loader communication. The power supply of the COM-K2 or COM-KG is a bus power type. The instrument can be set up powered from the PC without applying power to the instrument.



Maximum connections: 1 unit

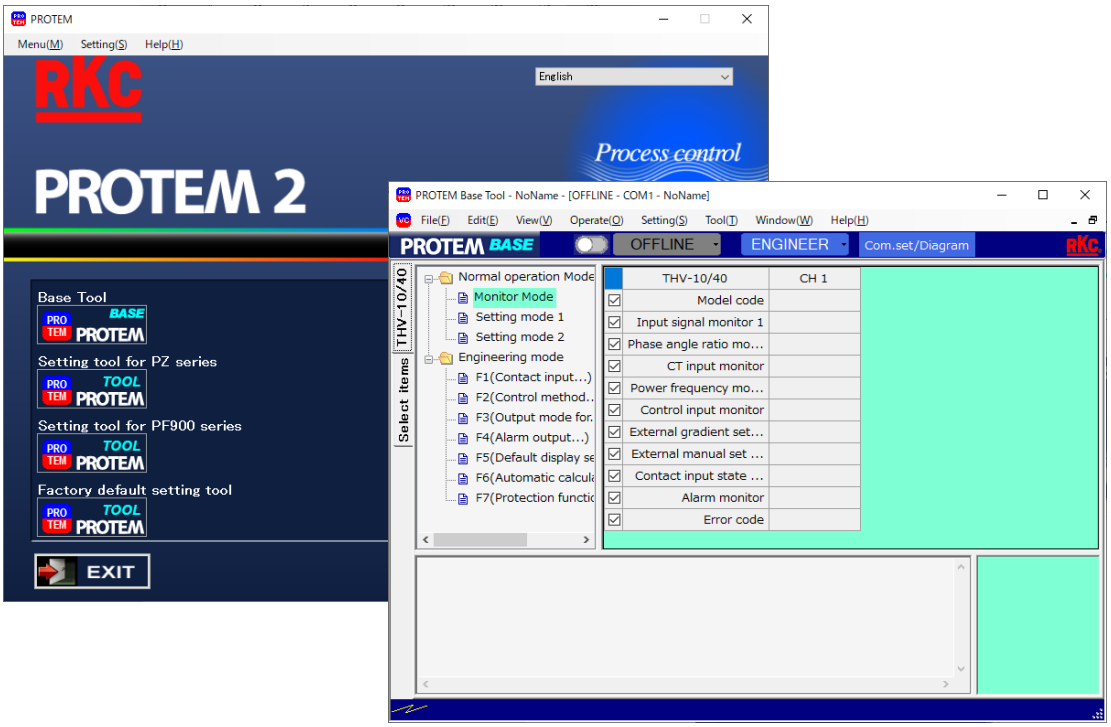
The Loader port is only for parameter setup.

■ Communication Tool PROTEM2

The Communication Tool PROTEM2 is integrated software for managing the setting parameters and measured values of our instruments and includes the following tools.

- Base tool:
  Enables checking and setting of parameters of our instruments.
- Recipe tool
  Enables global management of parameters of our instruments (e.g. save to PC, send to instruments).
- Logging tool:
  Provides visualization of the data and recording in CSV format.

PROTEM2 scre en example



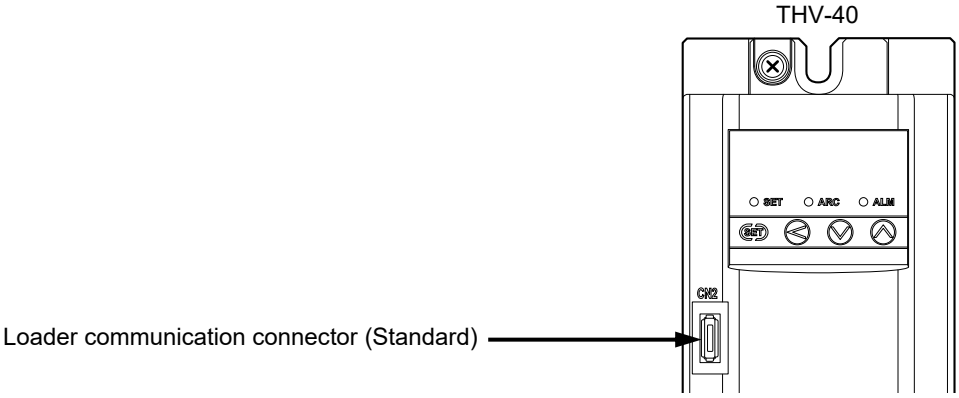
Download the PROTEM2 from the official RKC website.

7.2 Connections for Loader Communication

RKC Communication converter COM-K2 or COM-KG, loader communication cable and USB cable are required for connecting this instrument to the personal computer.

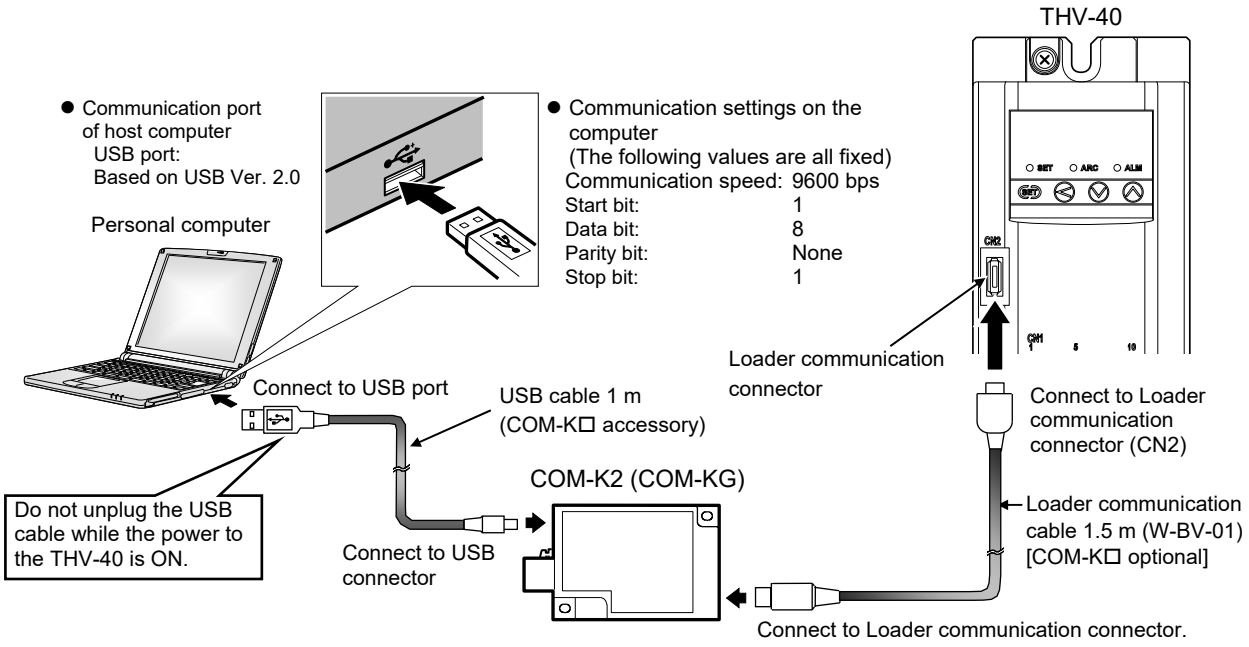
☞ For the COM-K2, refer to the **COM-K2 Instruction Manual**.
For the COM-KG, refer to the **COM-KG Instruction Manual**.

■ Position of loader communication connector



■ Wiring method

Connect the instrument, COM-K2 or COM-KG, and personal computer using a USB cable and a loader communication cable. Make sure the connectors are oriented correctly when connecting.



When using the COM-K2, USB driver must be installed on the personal computer. The USB driver can be downloaded the official RKC website. Installation of the USB driver is not necessary when the COM-KG is used on Windows 10.

The power supply of the COM-K2 or COM-KG is a bus power type. The instrument can be set up powered from the PC without applying power to the instrument.

7.3 Communication Data List

■ Reference to communication data list

(1) (2) (3) (4) (5) (6)

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
1	Model code	**ID**	32	RO	Model code (character)	—
2	Input signal monitor	**M1**	7	RO	0.0 to 100.0 %	—
3	Phase angle ratio monitor	**PA**	7	RO	0.0 to 100.0 %	—
4	CT input monitor *	**CT**	7	RO	0.0 to 40.0 A(20 A type) 0.0 to 60.0 A(30 A type) 0.0 to 90.0 A(45 A type) 0 to 120 A (60 A type) 0 to 160 A (80 A type) 0 to 200 A (100 A type) 0 to 300 A (150 A type) 0 to 400 A (200 A type)	—

(1) Name: Communication data name

(2) RKC identifier: Communication identifier of RKC communication

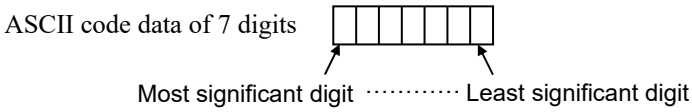
(3) No. of digits: Number of maximum digits

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

RO: Read only data

R/W: Read or write range of communication data

(5) Data range: Read or write range of communication data



(6) Factory set value: Factory set value of communication data

■ Communication data

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
1	Model code	**ID**	16	RO	Model code (character)	—
2	Input signal monitor	**M1**	7	RO	0.0 to 100.0 %	—
3	Phase angle ratio monitor	**PA**	7	RO	0.0 to 100.0 %	—
4	CT input monitor *	**CT**	7	RO	0.0 to 40.0 A (20 A type) 0.0 to 60.0 A (30 A type) 0.0 to 90.0 A (45 A type) 0 to 120 A (60 A type) 0 to 160 A (80 A type) 0 to 200 A (100 A type) 0 to 300 A (150 A type) 0 to 400 A (200 A type)	—
5	Power frequency monitor	**IF**	7	RO	40 to 70 Hz	—
6	Control input monitor	**M2**	7	RO	0.0 to 100.0 %	—
7	External gradient set value monitor	**EG**	7	RO	0.0 to 100.0 %	—
8	External manual set value monitor	**EM**	7	RO	0.0 to 100.0 %	—
9	Contact input state monitor	**DI**	7	RO	0: Contact open 1: Contact closed	—
10	Alarm monitor	**AL**	7	RO	0 to 255 0: No alarm 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL	—
11	Error code	**ER**	7	RO	1: Adjusted data error 2: Back-up error 4: A/D conversion error When two or more errors occur at the same time, those error codes are summed up.	—
12	Internal manual set value	**IM**	7	R/W	0.0 to 100.0 % If the THV-40 power is turned off, Internal manual set value is reset to "0.0."	0.0

* This communication data returns "0 (0.0)" as a read value if Heater break alarm (or Heater break alarm for non-linear resistance), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer is not supplied.

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
13	Internal gradient set value	**IG**	7	R/W	0.00 to 2.00	1.00
14	Soft-start time	**SU**	7	R/W	0.0 to 100.0 seconds (0.0: Soft-start function unused)	0.1
15	Soft-down time	**SD**	7	R/W	0.0 to 100.0 seconds (0.0: Soft-down function unused)	0.1
16	Set data lock [1]	**LK**	7	R/W	Least significant digit: Setting mode 1, Setting mode 2 2nd digit: Engineering mode 3rd digit to Most significant digit: Unused Data 0 and 2 to 9: Lock 1: Unlock	001
17	Maximum load current value for alarm [2]	**MC**	7	R/W	0.0 to 22.0 A (20 A type)	20.0
					0.0 to 33.0 A (30 A type)	30.0
					0.0 to 50.0 A (45 A type)	45.0
					0 to 66 A (60 A type)	60
					0 to 88 A (80 A type)	80
					0 to 110 A (100 A type)	100
					0 to 165 A (150 A type)	150
					0 to 220 A (200 A type)	200
18	Heater break alarm 1 setting [2]	**H1**	7	R/W	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current [3] Type 2: 0 to 100 % of Maximum load current value 0: Heater break alarm 1 unused	20
19	Thyristor break-down detection 1 setting [2]	**TB**	7	R/W	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current [3] Type 2: 0 to 100 % of Maximum load current value 0: Thyristor break-down alarm 1 unused	20
20	Heater break alarm 2 setting [2]	**H2**	7	R/W	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current [3] Type 2: 0 to 100 % of Maximum load current value 0: Heater break alarm 2 unused	15

[1] While the set data is locked, communication data of Setting mode 1, Setting mode 2 and the Engineering mode are read only (RO) except Set data lock (LK).

[2] This communication data is read/write (R/W) when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer. The data is read only (RO) if these functions are not supplied.

[3] The reference current is the load current value that is assumed for the output phase angle of this instrument.
If the condition may attempt to change the set value below 2 A, this instrument makes adjustment to keep the set value 2 A or more.

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
21	Thyristor break-down detection 2 setting [1]	**TC**	7	R/W	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current [2] Type 2: 0 to 100 % of Maximum load current value 0: Thyristor break-down alarm 2 unused	15
22	Current limit value setting [3]	**CL**	7	R/W	0.0 to 22.0 A (20 A type)	22.0
					0.0 to 33.0 A (30 A type)	33.0
					0.0 to 50.0 A (45 A type)	50.0
					0 to 66 A (60 A type)	66
					0 to 88 A (80 A type)	88
					0 to 110 A (100 A type)	110
					0 to 165 A (150 A type)	165
					0 to 220 A (200 A type)	220
23	Contact input (DI) function assignment	**C1**	7	R/W	0: No function 1: Control method Open: Phase control Closed: Zero-cross control 2: Input signal transfer Open: Auto mode Closed: Manual mode 3: Manual mode transfer Open: External manual mode Closed: Internal manual mode 4: RUN/STOP transfer Open: STOP Closed: RUN 5: Soft-start, Soft-down enable/disable Open: Enable Closed: Disable 6: Heater break alarm enable/disable Open: Enable Closed: Disable 7: Over current alarm enable/disable Open: Enable Closed: Disable 8: Set data lock enable/disable Open: Enable Closed: Disable	0

[1] This communication data is read/write (R/W) when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer. The data is read only (RO) if these functions are not supplied.

[2] The reference current is the load current value that is assumed for the output phase angle of this instrument.
If the condition may attempt to change the set value below 2 A, this instrument makes adjustment to keep the set value 2 A or more.

[3] The Current limiter function can be used for Phase control.
If a Current limit value is set to its maximum value, the Current limit function is deactivated.
If the Current limit value is set to 0 (0.0), the output of instrument turns off.

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
24	Control method [1]	**CM**	7	R/W	0: Phase control 1: Zero-cross control (continuous) 2: Zero-cross control (input synchronous type)	0
25	Input signal type selection	**IS**	7	R/W	0: 4 to 20 mA DC, 1 to 5 V DC 1: 0 to 10 V DC, 0/12 V DC	Based on model code
26	Input signal transfer [1]	**DA**	7	R/W	0: Auto mode 1: Manual mode	0
27	Manual mode transfer [1]	**AM**	7	R/W	0: External manual mode 1: Internal manual mode	0
28	RUN/STOP transfer [1]	**RS**	7	R/W	0: STOP (Output OFF) 1: RUN (Output ON)	1
29	Soft-start, Soft-down enable/disable [1]	**SF**	7	R/W	0: Disable 1: Enable (Except switching from STOP to RUN) 2: Enable For description of set value, refer to **P. 4-31**.	2
30	Heater break alarm enable/disable [1]	**HF**	7	R/W	0: Disable 1: Enable	1
31	Over current alarm enable/disable [1]	**OF**	7	R/W	0: Disable 1: Enable	1
32	Output mode for phase control	**OS**	7	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 (optional)[2]	2
33	Output limiter high [3]	**LH**	7	R/W	0.0 to 100.0 %	100.0
34	Output limiter low [3]	**LL**	7	R/W	0.0 to 100.0 %	0.0
35	Output limiter high at operation start	**LS**	7	R/W	0.0 to 100.0 %	50.0
36	Output limiter high time at operation start	**LT**	7	R/W	0 to 600 seconds	0
37	Base-up set value	**BU**	7	R/W	–9.9 to +100.0 %	0.0

[1] Priority is given to the Contact input (DI) and setting via communication is not available while the Contact input (DI) function is used.

[2] This communication data is writable when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

[3] The setting range of the Output limiter high and low is "Output limiter high ≧ Output limiter low."

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
38	Alarm output logic	**L1**	7	R/W	0 to 255 0: No output 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL (fixed at de-energized)[1]	0
39	Selection of energized/de-energized alarm output [2]	**NA**	7	R/W	0: Energized 1: De-energized	0
40	Alarm type selection [3]	**A1**	7	R/W	0: Type 1 (constant resistance type, deviation alarm) 1: Type 2 (linearity resistor type, absolute value alarm) 2: Deviation alarm [ARC-HBA] (Non-linear resistance type)	0
41	Number of alarm 1 determination [3]	**N1**	7	R/W	1 to 1000 times	30
42	Number of alarm 2 determination [3]	**N2**	7	R/W	1 to 1000 times	300
43	Alarm enable/disable during STOP	**SA**	7	R/W	0: Disable 1: Enable	0
44	Default display selection	**DM**	7	R/W	0: Input signal monitor 1: CT input monitor [4] 2: Power frequency monitor	0
45	Display off timer	**DT**	7	R/W	0 to 1000 seconds (0: Constantly lit)	0
46	Integrated operation time [upper 3 digits]	**WH**	7	R/W	0 to 999	0
47	Integrated operation time [lower 3 digits]	**WL**	7	R/W	0 to 999	0
48	Automatic calculation time for knee points [3]	**HT**	7	R/W	0 to 1000 seconds (0: Automatic detection function of knee points unused)	20

[1] If FAIL output is specified, all outputs including FAIL output become de-energizing type. If energizing type output is required, do not include the FAIL output to the alarm output logic.

[2] Selection of alarm output Energized/De-energized is enabled if FAIL output is not included to the Alarm output logic (L1).

[3] This communication data is valid when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

[4] If the instrument is not supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, or Constant current control function, setting "1: CT input monitor" is disregarded and the setting is switched to the Input signal monitor.

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
49	Automatic detection of knee points [1]	**HU**	7	R/W	0: OFF 1: ON 2: Aborted [2]	0
50	Phase angle ratio at knee point 1 [1]	**K1**	7	R/W	0 to 100 %	18
51	Current value at knee point 1 [1]	**R1**	7	R/W	0.0 to 22.0 A (20 A type)	3.6
					0.0 to 33.0 A (30 A type)	5.4
					0.0 to 50.0 A (45 A type)	8.1
					0 to 66 A (60 A type)	11
					0 to 88 A (80 A type)	14
					0 to 110 A (100 A type)	18
					0 to 165 A (150 A type)	27
					0 to 220 A (200 A type)	36
52	Phase angle ratio at knee point 2 [1]	**K2**	7	R/W	0 to 100 %	36
53	Current value at knee point 2 [1]	**R2**	7	R/W	0.0 to 22.0 A (20 A type)	7.2
					0.0 to 33.0 A (30 A type)	10.8
					0.0 to 50.0 A (45 A type)	16.2
					0 to 66 A (60 A type)	22
					0 to 88 A (80 A type)	29
					0 to 110 A (100 A type)	36
					0 to 165 A (150 A type)	54
					0 to 220 A (200 A type)	72
54	Phase angle ratio at knee point 3 [1]	**K3**	7	R/W	0 to 100 %	56
55	Current value at knee point 3 [1]	**R3**	7	R/W	0.0 to 22.0 A (20 A type)	11.2
					0.0 to 33.0 A (30 A type)	16.8
					0.0 to 50.0 A (45 A type)	25.2
					0 to 66 A (60 A type)	34
					0 to 88 A (80 A type)	45
					0 to 110 A (100 A type)	56
					0 to 165 A (150 A type)	84
					0 to 220 A (200 A type)	112

[1] This communication data is valid when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

[2] This data is read only (RO).

No.	Name	RKC Identifier	No. of digits	Attribute	Data range	Factory set value
56	Protection function for control of primary side of a transformer *	TF	7	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
57	Determination set value in case of a break on the secondary side of the transformer *	TA	7	R/W	0 to 100 % of reference current value	70
58	Output limiter setting in case of a break on the secondary side of the transformer *	TL	7	R/W	15.0 to 50.0 % of phase angle	15.0
59	Soft-start time in case of break on the secondary side of the transformer *	TU	7	R/W	0.1 to 100.0 seconds	0.1
60	Minimum output phase angle adjustment	**Mo**	7	R/W	Output phase angle 5.0 to 15.0 %	5.0

* This communication data is valid when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

8 MAINTENANCE

⚠ WARNING

- In order to prevent electric shock or instrument failure, always conduct necessary work after power supplied to the entire system is turned off.
- Conduct work after this instrument is cooled. As the temperature of this instrument is very high just after the power is turned off, never touch the instrument while hot.

8.1 Daily Inspection

Inspect the instrument periodically in order to prevent accidents or instrument failure.

Check item	Details
Inspecting main circuit terminal tightening torque	As the large current flows through each hexagon headed bolt used for the main circuit terminal, the loosened bolt may generate heat to cause ignition. Inspect the tightening torque of the bolt periodically. If loosened, tighten it with adequate torque. Recommended tightening torque: 1.6 N·m [16 kgf·cm] (20 A/30 A types) 3.8 N·m [38 kgf·cm] (45 A/60 A types) 9.0 N·m [90 kgf·cm] (80 A/100 A types) 18.0 N·m [180 kgf·cm] (150 A/200 A types)
Cleaning of thyristor	The attachment of dust to the heat radiation fins may reduce the cooling effect. Therefore, remove the dust attached using a vacuum cleaner.

8.2 Error Displays

If an error occurs, the following display processing is made according to the cause of the abnormality.

- Adjusted data error, Back-up error and A/D conversion error

  If an error occurs, an error number and a monitor mode screen are alternatively displayed. If two or more alarms have occurred, the sum of the error numbers is displayed.

- Watchdog timer

  Only ALM lamp lights, and all others turn off.

- Power supply voltage error

  All indications are turned off.

Error number	Description	Display	Action	Solution
1	Adjusted data error	Error number 1 and Monitor mode screen alternatively.	THV-40 output OFF Alarm terminal open.	Turn off the power at once. If an error occurs after the power is turned on again, please contact RKC sales office or the agent.
2	Back-up error	Error number 2 and Monitor mode screen alternatively.		
4	A/D conversion error	Error number 4 and Monitor mode screen alternatively.		
—	Watchdog timer	ALM lamp lights All others turn off		Turn off the power at once. If error repeats even after the instrument is powered up, the instrument may need to be repaired or replaced. Contact our sales distributors or RKC.
—	Power supply voltage error	All lamp turns off		

8.3 Troubleshooting

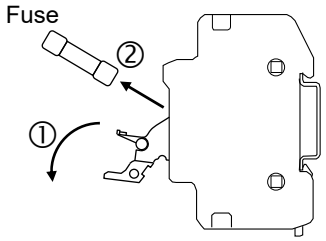
General causes to be assumed and measures to be taken when an error occurs in this instrument are described in the following. For any inquiries, please contact RKC sales office or the agent, to confirm the specifications of the product.

Problem	Possible cause	Solution
No output	The power supply voltage is not being supplied	Supply the power.
	No gradient is set	Set the external gradient or internal gradient.
	There is no automatic setting input	Check the output signal setting of the instrument and the type of thyristor input signal. Check if the temperature controller is properly functioning.
		If the Contact input (DI) is used for switching between Auto and Manual modes, set the contact input to OPEN (Auto mode).
		Set "0: Auto mode" at Input signal transfer (dA).
	The fast-blow fuse is broken.	Replace the fast-blow fuse.
	This instrument is not set to RUN	If switching between RUN and STOP is performed by Contact input (DI), close the contact (RUN).
		Set the "1: RUN" by RUN/STOP transfer (rS) of Engineering mode.
	The Current limit value is set to 0.0.	Set the set value of the Current limit value setting (CL) to a proper value.
No output is turned off.	The automatic set value is set to the maximum value.	Check the output signal of temperature controller.
	A thyristor element is shorted.	Please contact RKC sales office or the agent.
The ALM lamp lights up or blinks	Error of this instrument	Please contact RKC sales office or the agent.
	A heater is broken.	Turn off the power, and check or replace the heater, etc.
	A thyristor element is shorted.	Turn off the power, and check or replace the heater, etc.
	A current of more than 1.2 times the rating of this instrument flowed.	Turn off the power, and check or replace the heater, etc.
	Power frequency is out of the allowable range (detection range) when power is turned on or during operation.	Check the value of power supply frequency, and turn off the power at once. If a lamp lights after the power is turned on again, please contact RKC sales office or the agent.

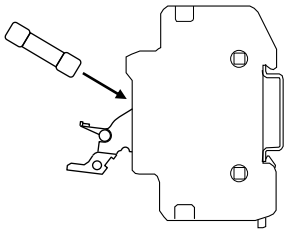
Problem	Possible cause	Solution
The ALM lamp lights up or blinks	The temperature of the thyristor element (SCR) exceeded 120 °C.	Power off the instrument and wait until the heat sink (radiation fin) temperature comes down. If the ALM lamp lights again after the instrument has been powered on, please contact RKC sales office or the agent.
		If Alarm enable/disable during STOP (SA) is disabled, stop the instrument and cool down the heat sink (radiation fin). When the heat sink (radiation fin) temperature comes down to approx. 120 °C, alarm will go off.
	No soft-start time is appropriately set.	If a load generating large rush current is used, thyristor break-down may occur when no soft-start time is appropriately set. In such a case, make the soft-start time longer.
The cooling fan has stopped	Dust, oil, or other substance has collected.	Turn off the power and contact an RKC sales office or the agent.
	The cooling fan has failed.	
	The cooling fan has reached the end of its service life.	

8.4 Replacement of UL Certified Fuse (For 20 to 100 A)

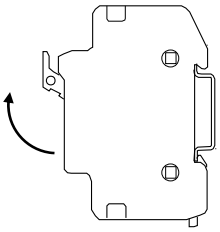
1. Open front lid. Take the fuse out of the holder.



2. Insert the new fuse.



3. Close front lid to finish the work.



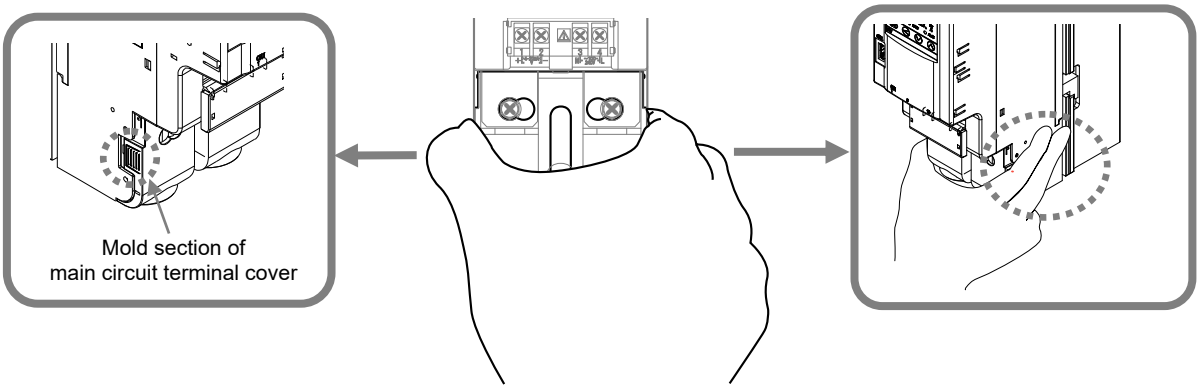
The Figure shows the type of 20 A and 30 A. However, the procedure for replacement is the same as for the type of 45 A to 100 A.

8.5 Removal of Terminal Cover (For Main Circuit Terminals)

The terminal cover (for main circuit terminals) of this instrument can be flipped open and removed. When attempting wiring, removal of the cover may make the job easier.
Proceed as follows to remove the cover from the instrument.

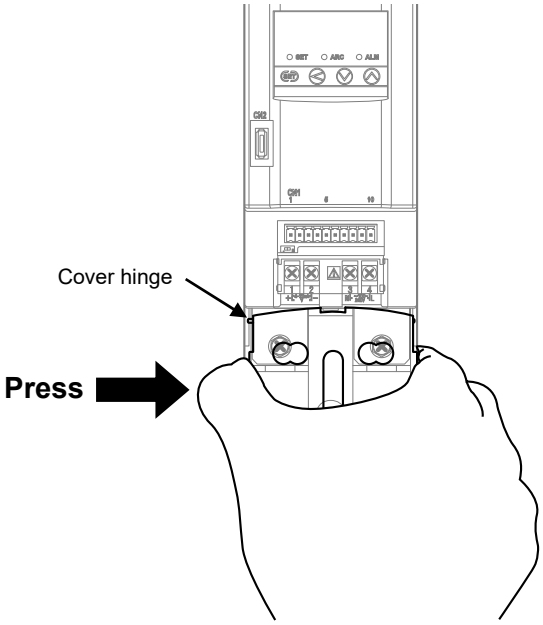
■ 20 to 100 A types

1. Hold the side of the instrument with the index and the middle fingers and hold the mold section of the terminal cover (for main circuit terminals) with the thumb.

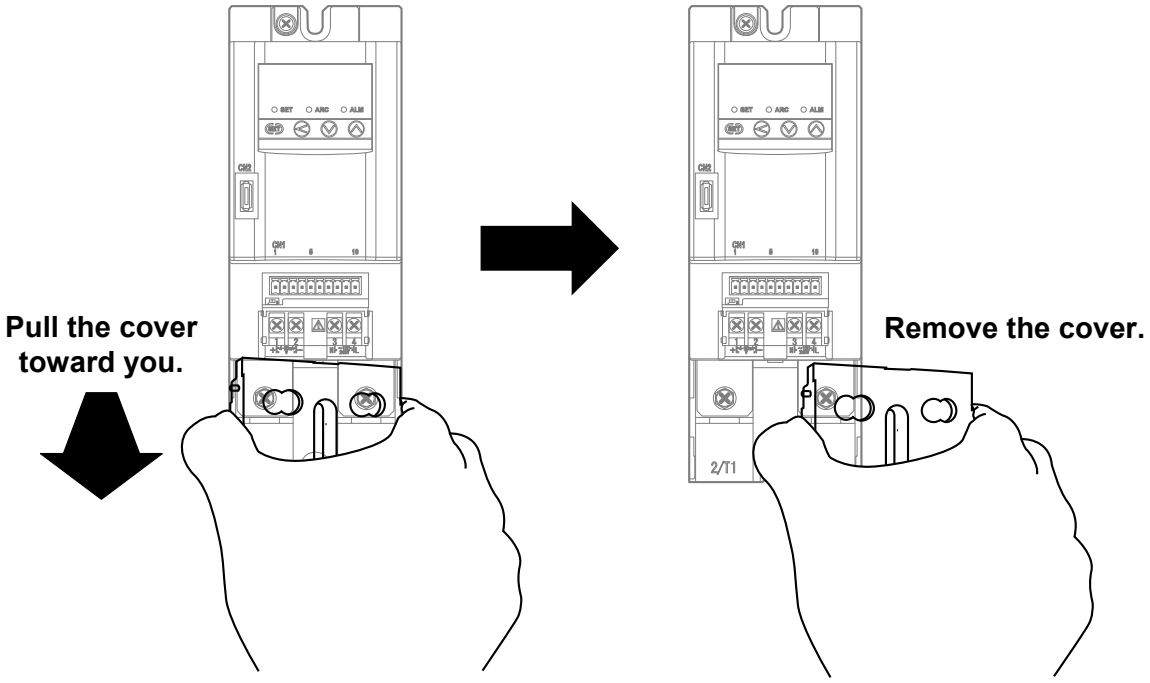


2. Squeeze the side mold section of the terminal cover (for main circuit terminals) with the thumb to remove the cover hinge out of the hole on the instrument.

Do not press the mold section of the cover with too much force. The cover may be broken.



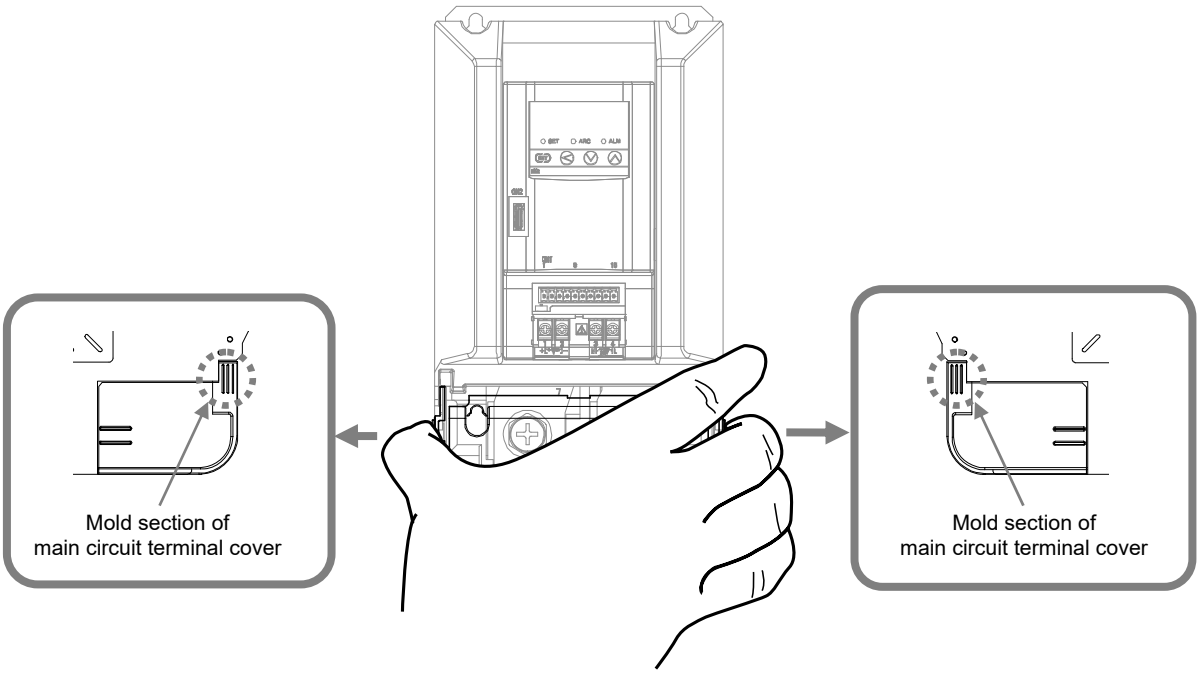
3. Once the cover hinge is out of the hole, pull the cover toward you to remove.



After having completed the wiring of the mains circuit, install the terminal cover for the mains circuit for safety.

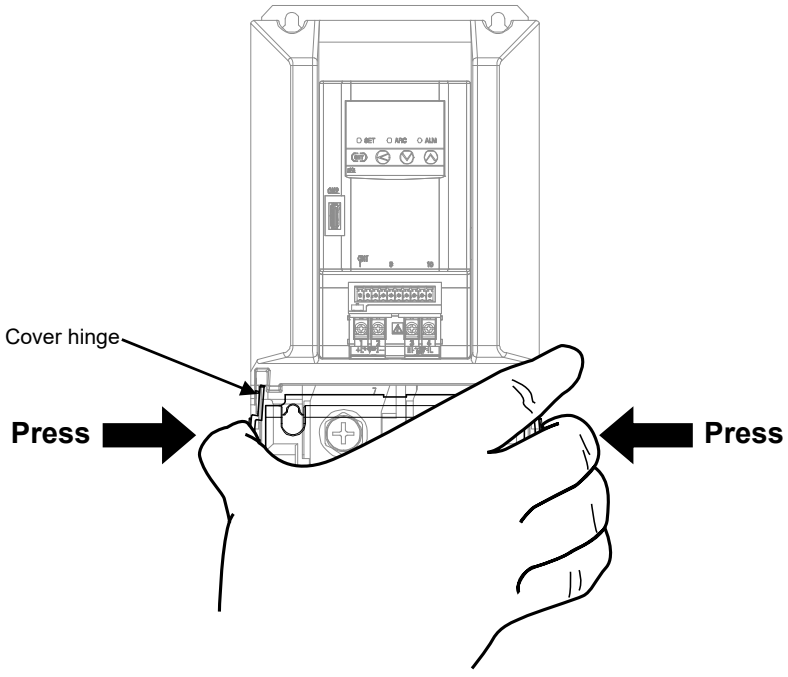
■ 150 A/200 A types

1. Hold the mold section of the terminal cover (for main circuit terminals) with the thumb and the middle finger.

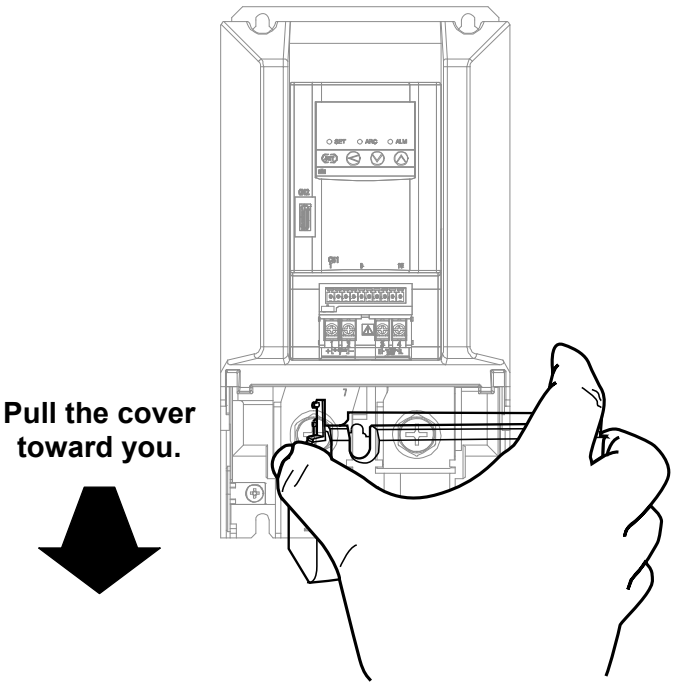


2. Squeeze the side mold section of the terminal cover (for main circuit terminals) with the thumb and the middle finger to remove the cover hinge out of the hole on the instrument.

Do not press the mold section of the cover with too much force. The cover may be broken.



3. Pull the terminal cover toward you to remove it.



After having completed the wiring of the mains circuit, install the terminal cover for the mains circuit for safety.

SPECIFICATIONS

9

■ SCR output

Number of phase: Single-phase

Maximum rated current: 20 A AC, 30 A AC, 45 A AC, 60 A AC, 80 A AC, 100 A AC, 150 A AC and 200 A AC (Specify when ordering)
The rated current drops when the ambient temperature exceeds 40 °C.

Minimum load current: 20 A rating: 0.6 A (When output is 98 %)
Rating 30 A or more: 1 A (When output is 98 %)

Supply voltage for load: 323 to 528 V AC [Including power supply voltage variation]
(Rating: 380 to 480 V AC)

Power frequency: 50/60 Hz (Automatic discriminating)

Allowable power frequency variations:
50 Hz ±1 Hz, 60 Hz ±1 Hz (Performance guarantee)

Output voltage range: 0 to 98 % of supply voltage for load
(excluding voltage drops due to fuse effects)

Control method:

- Phase control
  Output mode: Proportional phase angle to input
  Proportional voltage to input
  Proportional square voltage (electric power) to input
  Constant current control (optional)
- Zero-cross control (continuous)
  Minimum on/off time: 20 ms (at 50 Hz)
  16.67 ms (at 60 Hz)
- Zero-cross control (input synchronous type)
  Minimum on/off time: 20 ms (at 50 Hz)
  16.67 ms (at 60 Hz)

Applicable load:

- Phase control
  Resistor load (Corresponding utilization category: AC-51)
  Control of primary side of a transformer
  The magnetic flux density must be 1.25 T [12,500 Gauss] or less when the protection function for control of primary side of a transformer is not provided.
  Such loads that cause rush current (lamp heaters, transformers, etc) need Soft-start time setting to suppress the current within 1.35 times of the current rating.
- Zero-cross control (Continuous or Input synchronous type)
  Resistor load (Corresponding utilization category: AC-51)

Rated conditional short-circuit current:
700 A (20 A, 30 A), 1000 A (45 A, 60 A), 1400 A (80 A, 100 A),
4200 A (150 A, 200 A)

Short-circuit protective device (fuse):

Breaking capacity: 100 kA (fast-blow fuse for 20 A to 100 A), Not UL certified
200 kA (fast-blow fuse for 20 A to 200 A), UL certified

Output setting range:

Auto set value (control input): 0.0 to 100.0 %
Internal manual set value: 0.0 to 100.0 % Set by the THV-40 front keys
External manual set value: 0.0 to 100.0 % Set by the setter (optional)

Output correction:

Internal gradient set value: 0.00 to 2.00 Set by the THV-40 front keys
External gradient set value: 0.0 to 100.0 % Set by the setter (optional)
Output limiter high set value: 0.0 to 100.0 % Set by the THV-40 front keys
Output limiter low set value: 0.0 to 100.0 % Set by the THV-40 front keys
Base-up set value: –9.9 to +100.0 %
Set by the THV-40 front keys
Output limiter high at operation start:
High limit setting:
0.0 to 100.0 %
Set by the THV-40 front keys
Time setting: 0 to 600 seconds
Set by the THV-40 front keys
Soft-start/Soft-down function: 0.0 to 100.0 % Set by the THV-40 front keys
Current limiter function (optional):
The Current limit function is activated only during phase control.
Setting range: 20 A type: 0.0 to 22.0 A
30 A type: 0.0 to 33.0 A
45 A type: 0.0 to 50.0 A
60 A type: 0 to 66 A
80 A type: 0 to 88 A
100 A type: 0 to 110 A
150 A type: 0 to 165 A
200 A type: 0 to 220 A

If a Current limit value is set to its maximum value, the Current limit function is deactivated. If a Current limit value is set to 0.0 (0), the output is turned off.
Output limiter setting in case of a break on the secondary side of the transformer:
Output limiter function for break of secondary side of a transformer operates when determination has been made that the secondary side is disconnected at the time of phase control.
Output limiter setting in case of a break on the secondary side of the transformer range:
15.0 to 50.0 % of phase angle
Minimum output phase angle adjustment function:
Output phase angle 5.0 to 15.0 %
Set by the THV-40 front keys

Power off leakage current:

Approx. 30 mA AC (load voltage 480 V rms, 60 Hz, Ta = 25 °C)

■ Alarm output (optional)

Number of outputs: 1 point
Output type: Open collector output
Output method: Sink type
Allowable load current: 100 mA
Load voltage: 30 V DC or less
Voltage drop at ON: 2 V or less (at maximum load current)
Leakage current at OFF: 0.1 mA or less

■ Output accuracy, stability

Output mode:
Proportional phase angle: ±10 % of power supply voltage for load
Proportional voltage: ±10 % of power supply voltage for load
Proportional square voltage (electric power):
±10 % of power supply voltage for load
Constant current control: ±10 % of maximum current rating
Power supply voltage variation:
Within ±10 % of power supply voltage for load
Load variation:
Within 2 times

Control input accuracy: ±5 % + 1 digit of span

Current measurement accuracy:
±5 % of maximum current rating or ±2 A (whichever is larger)

External manual setting accuracy:
±5 % of span
±15 % of span (against the scale of external manual setter)

External gradient setting accuracy:
±5 % of span
±15 % of span (against the scale of external gradient setter)

Measurement accuracy of frequency:
±1 Hz (However, the measurement range of frequency is 40 to 70 Hz)

■ Input

Control input:

Number of input point:	1 point
Input signal:	Current input 4 to 20 m A DC (Input impedance: Approx. 50 Ω) Voltage input 1 to 5 V DC (Input impedance: Approx. 30 kΩ) Voltage input 0 to 10 V DC (Input impedance: Approx. 30 kΩ) Voltage pulse input 0/12 V DC (Input impedance: Approx. 30 kΩ)
Sampling cycle:	At 50 Hz: 10 ms At 60 Hz: 8.33 ms
Action at input break:	Indicates value near 0 %.
Allowable input range:	Current: −6 to +35 mA Voltage: −1.5 to +19 V

External manual mode:

Number of inputs:	1 point
Allowable resistance range:	4 to 6 kΩ
Input range:	0.0 to 100.0 %
Sampling cycle:	At 50 Hz: 10 ms At 60 Hz: 8.33 ms
Action at input break:	+2.5 V output: Near the 0 % Common: Near the 100 % Setting input: Near the 0 %

External gradient setting:

Number of inputs:	1 point
Allowable resistance range:	4 to 6 kΩ
Input range:	0.0 to 100.0 %
Sampling cycle:	At 50 Hz: 10 ms At 60 Hz: 8.33 ms
Action at input break:	+2.5 V output: 20 % or less Common: Near the 100 % Setting input: Near the 100 %

Contact input:

Number of inputs:	1 point
Input type:	Dry contact input
OFF state (open):	50 kΩ or more
ON state (closed):	1 kΩ or less
Contact current:	5 mA or less
Voltage when opened:	Approx. 4 V DC
Capture judgment time:	At 50 Hz: 100 ms At 60 Hz: 83.33 ms

Current transformer (CT) input (optional):

Input:	Current transformer (CT): Incorporated in unit	
Input range:	20 A:	0.0 to 40.0 A
	30 A:	0.0 to 60.0 A
	45 A:	0.0 to 90.0 A
	60 A:	0 to 120 A
	80 A:	0 to 160 A
	100 A:	0 to 200 A
	150 A:	0 to 300 A
	200 A:	0 to 400 A
Sampling cycle:	At 50 Hz: 10 ms	
	At 60 Hz: 8.33 ms	

■ Indication lamp

Parameter/Data display: 3 digits + 1/2 7-segments LED (orange)
The Monitor mode parameter and numeric data flash at the interval of 1 second when break (momentary power failure) has been detected on the secondary side of a transformer while a Protection function of control of primary side of a transformer is enabled.

SET lamp: LED (orange)
Lights during the Setting mode

ARC lamp: LED (orange)
Indication: ARC lamp flashes during the automatic detection of the knee points.

ALM lamp: LED (red)
Indication: Lights when Heater break alarm occurs
Lights when Thyristor break-down alarm occurs
Flashes when Power frequency error occurs.
Flashes when Over current alarm occurs.
Flashes when Heat sink temperature abnormality occurs.
Flashes when FAIL alarm occurs.

Unit display: ϕ: LED (orange)
Indication: Lights while the Unit display shows the data of the Output phase angle.
%: LED (orange)
Indication: Lights while the Unit display shows the data of [%].
Hz: LED (orange)
Indication: Lights while the Unit display shows the data of [Hz].
A: LED (orange)
Indication: Lights while the Unit display shows the data of [A].

■ Alarm function

Heater break alarm/Thyristor break-down alarm:

Alarm action types: Deviation alarm (constant resistance type)
Absolute value alarm
Deviation alarm [ACR-HBA] (Non-linear resistance type)

Alarm setting rage: Deviation alarm (constant resistance type)
Settable from 0 to 100 % of the reference current or 2 A, whichever is larger.
Absolute value alarm
0 to 100 % of Maximum load current value
Deviation alarm [ACR-HBA] (Non-linear resistance type)
Settable from 0 to 100 % of the reference current or 2 A, whichever is larger.

Number of settings of knee points:
3 points

Setting range of knee point:
Phase angle ratio: 0 to 100 % of 180°
Load current value: 0 to Maximum load current value

Maximum load current value setting:

20 A type:	0.0 to 22.0 A
30 A type:	0.0 to 33.0 A
45 A type:	0.0 to 50.0 A
60 A type:	0 to 66 A
80 A type:	0 to 88 A
100 A type:	0 to 110 A
150 A type:	0 to 165 A
200 A type:	0 to 220 A

Alarm determination cycle:

At 50 Hz:	100 ms
At 60 Hz:	83.33 ms

Number of Alarm 1 determination:
1 to 1000

Number of Alarm 2 determination:
1 to 1000

Automatic detection of knee points function:
Detection method: Output is adjusted between 0 to 100 %, and load current value is measured during the fixed setpoint control at 4 points of phase angle ratio, and Knee point of the reference current is set.
Fixed setpoint control point:
18, 36, 56 and 100 % of 180°
Automatic calculation time for knee points:
0 to 1000 seconds
Update of data: At the completion of automatic calculation

Power frequency error: Alarm determination area:
Outside of 45 to 54.9 Hz and 55 to 64.9 Hz
Output at Alarm state:
THV-40 output OFF

Over current alarm: Alarm determination area:
When the load current exceeds the permissible limit (1.2 times of the maximum current rating) during the operation.
Output at Alarm state:
THV-40 output OFF

Heat sink temperature abnormality:
Alarm determination area:
Alarm is generated when the heat sink temperature exceeds approx. 120 °C.
Output at Alarm state:
THV-40 output OFF

FAIL: Alarm condition: When error is detected by self-diagnosis function.

Additional function: Alarm output logic:
Two or more types of alarm outputs can be specified by Logical *OR* function.
Selection of energized/de-energized alarm output:
Selectable
(If FAIL alarm is selected, output type is de-energized only)
Alarm enable/disable during STOP:
Heater break alarm is reset and initialized by disabling the alarm and switching to STOP. Output status other than Heater break alarm is not initialized.
Heater break alarm enable/disable:
Selectable
(Alarm is not generated when the alarm is disabled.)
Over current alarm enable/disable:
Selectable
(Alarm is not generated when the alarm is disabled.)

Protection function for control of primary side of a transformer:

Applicable control method:
Phase control

Setting range: Protection function for control of primary side of a transformer:
0 (disable)/1 (enable)

Determination set value in case of a break on the secondary side of the transformer:
0 to 100 % of reference current value
(Deviation setting against the reference current value.)

Output limiter setting in case of a break on the secondary side of the transformer:
15.0 to 50.0 % of phase angle

Soft-start time in case of break on the secondary side of the transformer:
0.1 to 100.0 seconds

Abnormity judgment conditions:
Phase angle 15 % or more

Sampling cycle: 0.5 of power cycle

Action at the time of automatic release from the break (momentary power failure) of secondary side of the transformer:
Output by soft-start function at the time of the break (momentary power failure) of secondary side of transformer.

■ Loader communication

Loader communication: For RKC communication protocol only

Synchronous method: Start-stop synchronous type

Communication speed: 9600 bps

Data bit configuration: Start bit: 1
Data bit: 8
Parity bit: None
Stop bit: 1

Protocol: ANSI X3.28-1976 subcategories 2.5 and A4

Maximum number of connection points:
1 point (Address: 0 fixed)

Connection method: COM-K□ special cable (equivalent to W-BV-01-1500)

Interval time: 10 ms

Other: Power can be supplied from the COM-K2 or COM-KG.
In this case, the display shows "---."

■ Self-diagnostic function

Self-diagnostic item	Error display	Communication at error	Output at error	Error recovery
Adjustment data error	Error code 1 screen and Monitor mode screen are alternately displayed.	Error code 1	THV-40 output OFF Alarm output open	Alarm is reset by removing the cause of the alarm and applying power to the instrument.
Back-up error	Error code 2 screen and Monitor mode screen are alternately displayed.	Error code 2		
A/D conversion error	Error code 4 screen and Monitor mode screen are alternately displayed.	Error code 4		
Watchdog timer	ALM lamp lights All the other display is OFF	Communication stop		
Power supply voltage error	All lamp turns off	Communication stop		

■ General specifications

Supply voltage for instrument:

85 to 264 V AC [Including power supply voltage variation]
(Rating 100 to 240 V AC) 50/60 Hz
Frequency variation: At 50 Hz: 48 to 52 Hz At 60 Hz: 58 to 62 Hz

Match the phase of the instrument power supply with that for the load power supply.

Power consumption:

20 to 100 A types:
5 VA MAX. (100 V AC) rush current 5.6 A or less
8 VA MAX. (240 V AC) rush current 13.3 A or less
150 A/200 A types:
12.5 VA MAX. (100 V AC) rush current 21 A or less
22.0 VA MAX. (240 V AC) rush current 55 A or less

Insulation resistance:

	Radiator fins (PE terminal) [1]	Main circuit terminals	Power terminals for instrument	Input terminals [2]	Alarm terminals
Radiator fins (PE terminal) [1]					
Main circuit terminals	500 V DC 20 MΩ or more				
Power terminals for instrument	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more			
Input terminals [2]	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more		
Alarm terminals	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more	500 V DC 20 MΩ or more	

[1] 150 A/200 A types

[2] Input terminals: Control input, External gradient setting, External manual setting, Contact input, Loader communication

Withstand voltage:

50/60 Hz, 1 minute

Time: 1 minute	Radiator fins (PE terminal) [1]	Main circuit terminals	Power terminals for instrument	Input terminals [2]	Alarm terminals
Radiator fins (PE terminal) [1]					
Main circuit terminals	2500 V				
Power terminals for instrument	20 to 100 A: 2500 V 150 A/200 A: 2000 V	2500 V			
Input terminals [2]	2500 V	2500 V	2300 V		
Alarm terminals	2500 V	2500 V	2300 V	2000 V	

[1] 150 A/200 A types

[2] Input terminals: Control input, External gradient setting, External manual setting, Contact input, Loader communication

Power failure:

Power failure: A power failure of approx. 50 ms or less will not affect the control circuit.
Memory backup: Backed up by non-volatile memory
Number of writing: Approx. 1,000,000 times
Data storage period: Approx. 10 years
Recovery operation when power fails:
Same action as when power is turned on

Calorific values:

20 A type: Approx. 30 W		80 A type:	Approx. 112 W
30 A type: Approx. 43 W		100 A type:	Approx. 140 W
45 A type: Approx. 63 W		150 A type:	Approx. 200 W
60 A type: Approx. 84 W		200 A type:	Approx. 250 W

■ Environment conditions

Transportation and Storage environment conditions:

Vibration

Number of vibration	Level		Attenuation slope
HZ	$(m/s^2)^2/Hz$	$[g^2/Hz]$ *	dB/oct
3	0.048	(0.005)	—
3 to 6	—	—	+13.75
6 to 18	1.15	(0.012)	—
18 to 40	—	—	–9.34
40	0.096	(0.001)	—
40 to 200	—	—	–1.29
200	0.048	(0.0005)	—

The effective value of the acceleration is 5.8 m/s^2 [0.59 g*] within the number of vibration.

* g = 9.806658 m/s^2

Shock: Height 60 cm or less

Temperature: −40 to +70 °C

Humidity: Less than 5 to 95 %RH (Non condensing)

Absolute humidity: MAX.W.C 35 g/m^3 dry air at 101.3 kPa

Working environment condition(s):

Ambient temperature:

−15 to +55 °C (Operation guarantee range)

Ambient humidity:

5 to 95 %RH

(Absolute humidity: MAX.W.C 29 g/m^3 dry air at 101.3 kPa)

Ambient atmosphere:

A location without:

- Rapid changes in ambient temperature which may cause condensation.
- Corrosive or inflammable gases.
- Water, oil, chemicals, vapor or steam splashes.
- Direct air flow from an air conditioner.
- Exposure to direct sunlight.
- Excessive heat accumulation.
- Dust and vibration

■ Mounting and Structure

Mounting method: Panel mounting

Mounting orientation: Datum plane ±10°

Case color: Bluish white

Case material: PPE-GF20 (Flame retardancy: UL94 V-1)

Panel sheet material: Polyester

Weight:
20 A/30 A/45 A types: Approx. 1.3 kg
60 A/80 A/100 A types: Approx. 1.8 kg
150 A/200 A types: Approx. 3.7 kg

Dimensions:
20 A/30 A/45 A types: 68 × 188 × 150 mm (W × H × D)
60 A/80 A/100 A types: 116 × 200 × 150 mm (W × H × D)
150 A/200 A types: 130.4 × 240 × 189 mm (W × H × D)

■ Standard

Safety standards:

20 to 100 A types
UL: UL508 (file No. E177758), POLLUTION DEGREE 2
cUL: C22.2 No. 14 (file No. E177758), POLLUTION DEGREE 2
150 A/200 A types
UL: UL60947-4-1 (file No. E177758), POLLUTION DEGREE 2
cUL: C22.2 No. 60947-4-1 (file No. E177758), POLLUTION DEGREE 2

CE marking:

In order to comply with the European EMC- and LV directive the noise filter should be applied.
The noise filter specified (SOSHIN ELECTRIC CO., LTD.):
20 A type: NF3020C-SVB
30 A type: NF3030C-SVB
45 A type: NF3050C-SVB
60 A type: NF3060C-SVB
80 A type: HF3080C-SZC
100 A type: HF3100C-SZC
150 A type: HF3150C-SZC
200 A type: NF3200C-VZ
LVD: EN60947-4-3 (Form 4), POLLUTION DEGREE 2
Rated insulation voltage: 690 V
EMC: EN60947-4-3 (Form 4)
RoHS: EN IEC 63000

EMC test standards:

Emissions
The EMC emissions test standards required by the standard EN 60947-4-3 'Contactors and motor-starters - AC semiconductor motor controllers and contactors for non-motor loads' are presented in table 1.

Table 1: EMC emissions standards compliance

20 to 100 A types

Emission type	Test standard
Conducted disturbance	CISPR 11 Environment A Group 2
Radiated EM field	CISPR 11 Environment A

150 A/200 A types

Emission type	Test standard
Conducted disturbance	CISPR 11 Environment A Group 1
Radiated EM field	CISPR 11 Environment A

Immunity
The EMC immunity test standards required by the standard EN 60947-4-3 ‘Contactors and motor-starters - AC semiconductor motor controllers and contactors for non-motor loads’ are presented in table 2.

Table 2: EMC immunity standards compliance

20 to 200 A types

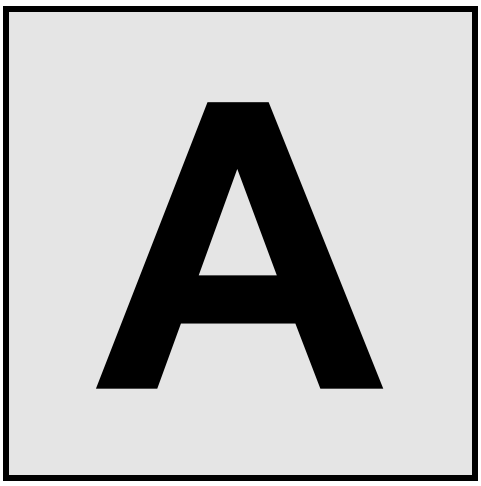
Test type	Test standard	Test level
Electrostatic discharge	EN 61000-4-2	Contact: 4 kV Air: 8 kV
Radiated, radio frequency electromagnetic field	EN 61000-4-3	Enclosure port: 80–1000 MHz: 10 V/m 1.4 GHz−2 GHz: 10 V/m
Electrical fast transient/burst	EN 61000-4-4	AC Power port: 2 kV Signal port: 1 kV
Surge	EN 61000-4-5	AC Power port: 2 kV (line to earth) 1 kV (line to line)
Conducted disturbances induced by radio frequency fields	EN 61000-4-6	AC Power port Signal port: 0.15–80 MHz: 10 V
Voltage dips	EN 61000-4-11	AC Power port: 0 % during 0.5 cycle * 0 % during 1 cycle * 40 % during 10/12 cycles * 70 % during 25/30 cycles * 80 % during 250/300 cycles * * Rated operational voltage
Voltage interruptions	EN 61000-4-11	AC Power port: 0 % during 250/300 cycles (Rated operational voltage)

Overload current profile and duty cycle:

$1.1 \times I_e$–60s: 100–12

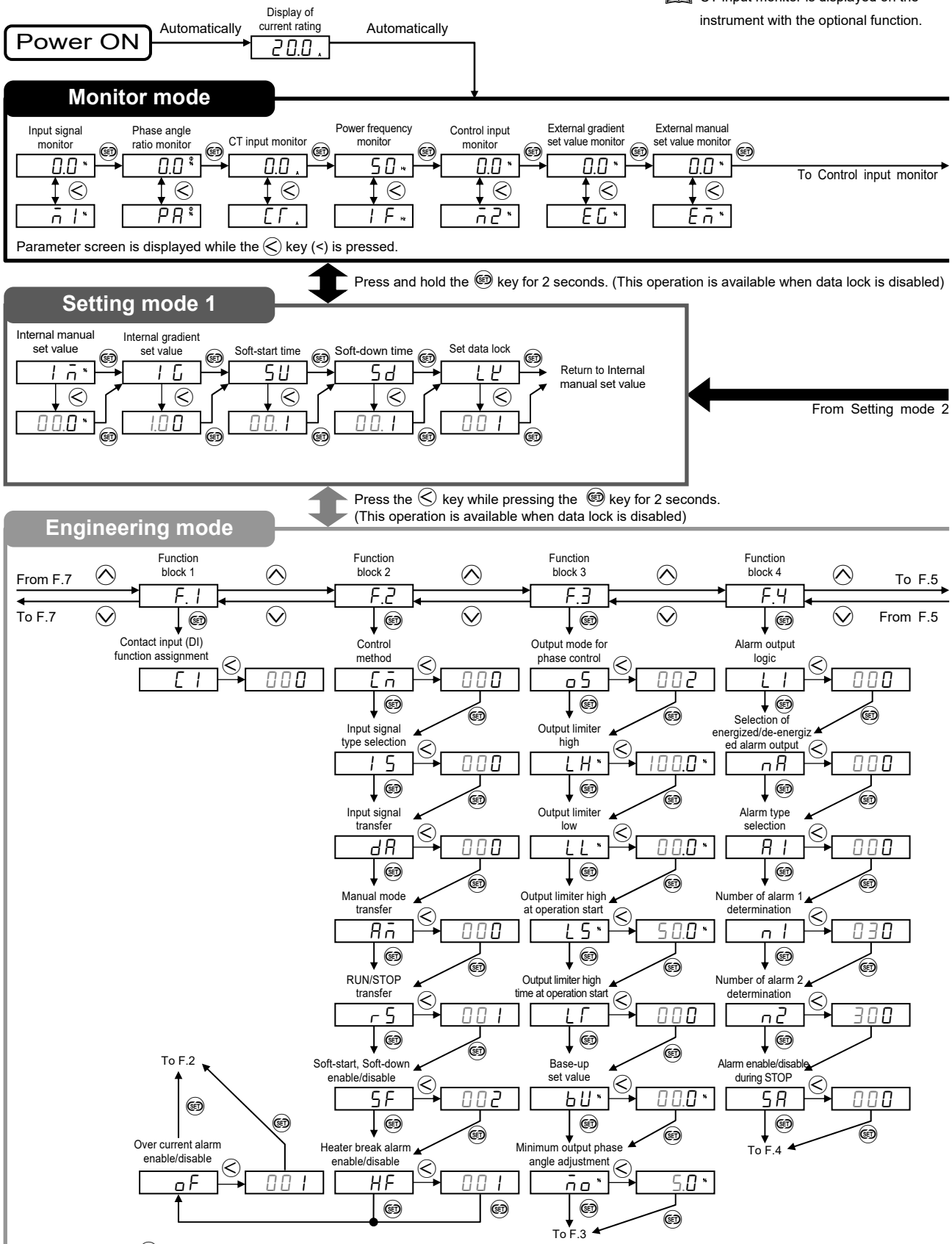
MEMO

APPENDIX



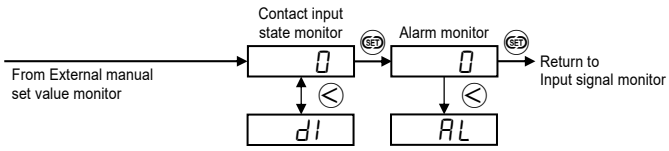
A.1 List of Parameter Operation

CT input monitor is displayed on the instrument with the optional function.



Setting mode 2 is displayed on the instrument with the optional function.

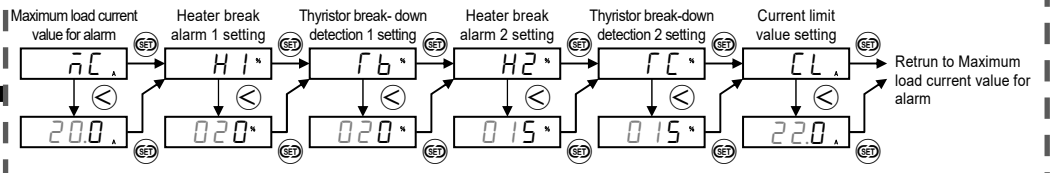
Monitor mode



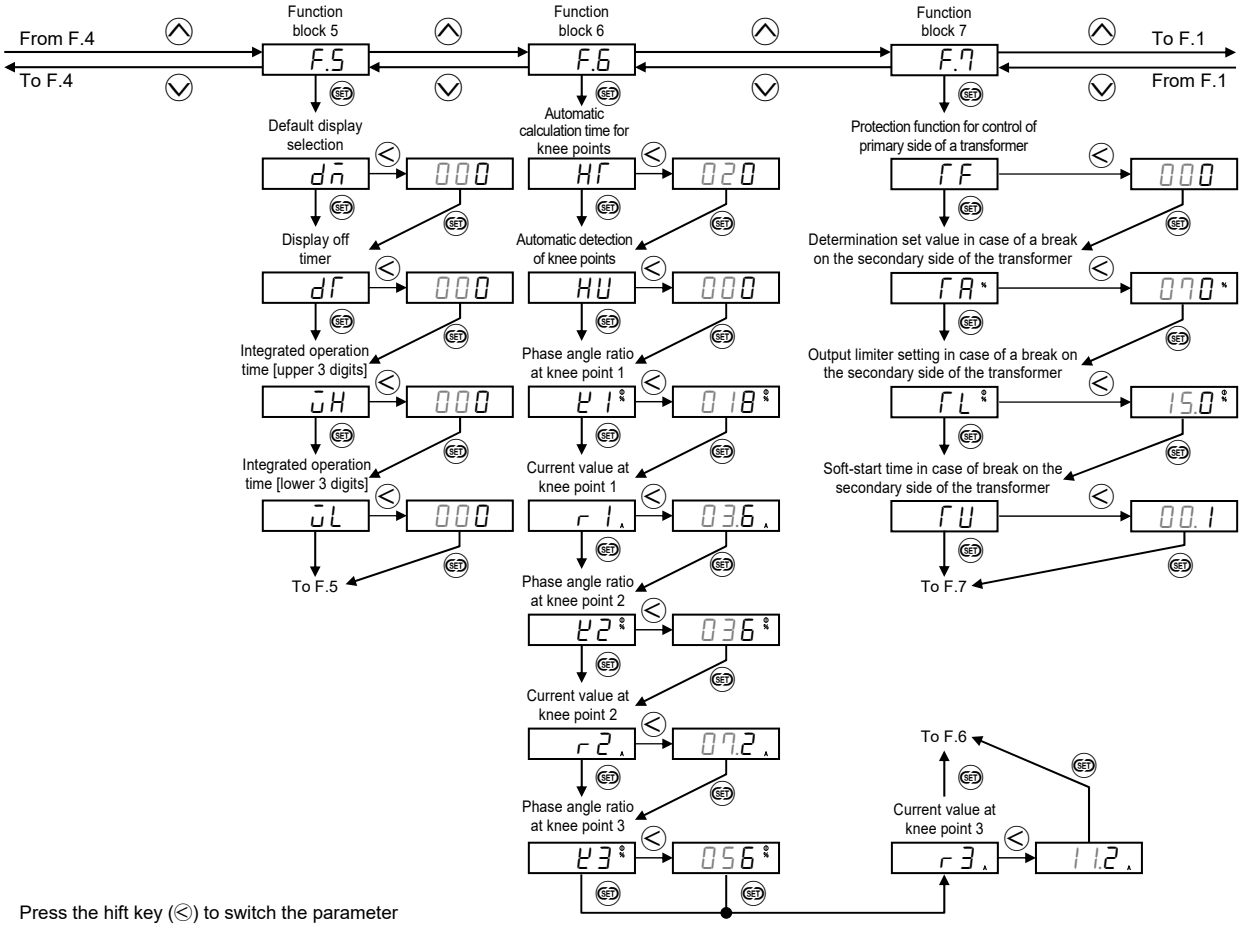
Press the key while pressing the key for 2 seconds.
(This operation is available when data lock is disabled)

Press and hold the key for 2 seconds.
(This operation is available when data lock is disabled)

Setting mode 2



Engineering mode



Press the hift key ( ) to switch the parameter screen to the setting screen.

A.2 Parameter List

User set value column may be used as a memo of the user set values.

■ Monitor mode

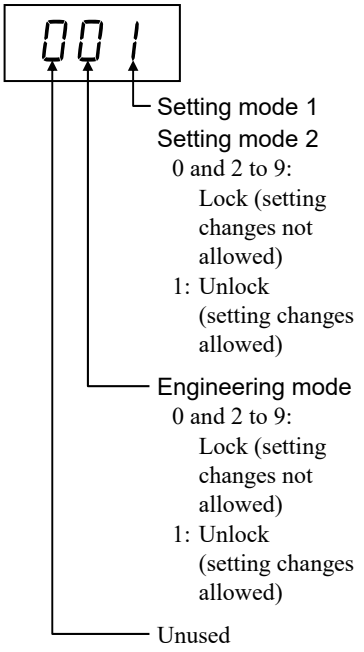
No.	Symbol	Name	Display range	Factory set value	User set value	Page
1	M1 (M1)	Input signal monitor	0.0 to 100.0 %	—	—	P. 4-3
2	PA (PA)	Phase angle ratio monitor	0.0 to 100.0 %	—	—	P. 4-5
3	CT (CT)	CT input monitor *	0.0 to 40.0 A (20 A type) 0.0 to 60.0 A (30 A type) 0.0 to 90.0 A (45 A type) 0 to 120 A (60 A type) 0 to 160 A (80 A type) 0 to 200 A (100 A type) 0 to 300 A (150 A type) 0 to 400 A (200 A type)	—	—	P. 4-6
4	IF (IF)	Power frequency monitor	40 to 70 Hz	—	—	P. 4-6
5	M2 (M2)	Control input monitor	0.0 to 100.0 %	—	—	P. 4-7
6	EG (EG)	External gradient set value monitor	0.0 to 100.0 %	—	—	P. 4-8
7	EM (EM)	External manual set value monitor	0.0 to 100.0 %	—	—	P. 4-9
8	dI (dI)	Contact input state monitor	0: Contact open 1: Contact closed	—	—	P. 4-10
9	AL (AL)	Alarm monitor	0 to 255 0: No alarm 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL	—	—	P. 4-11

* This monitor screen is displayed only when the Heater break alarm (or Non-linear resistance heater break alarm), Current limiter, Constant current control function and Protection function for control of primary side of a transformer is supplied.

■ Setting mode 1

If the Setting mode 1 is locked, unlock the Setting mode 1 first before attempting the change of the set values. (Factory set value: Unlock)

The parameters of this instrument can be set whether this instrument is either in the RUN state or in the STOP state.

No.	Symbol	Name	Display range	Factory set value	User set value	Page
1	IM	Internal manual set value	0.0 to 100.0 % If the THV-40 power is turned off, internal manual set value is reset to "0.0."	0.0		P. 4-12
2	IG	Internal gradient set value	0.00 to 2.00	1.00		P. 4-12
3	SU	Soft-start time	0.0 to 100.0 seconds (0.0: Soft-start function unused)	0.1		P. 4-13
4	Sd	Soft-down time	0.0 to 100.0 seconds (0.0: Soft-down function unused)	0.1		P. 4-14
5	LK	Set data lock *		001		P. 4-14

* State when locking is active.

- When the Setting mode 1 and Setting mode 2 are locked, set values in the setting mode cannot be changed. [except the Set data lock (LK)]
  However, the setting mode can be accessed to allow set values to be checked.
- Access to the Engineering mode is not available.

■ Setting mode 2

If the Setting mode 2 is locked, unlock the Setting mode 2 first before attempting the change of the set values. (Factory set value: Unlock)

📖 Setting mode 2 appears when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

📖 The parameters of this instrument can be set whether this instrument is either in the RUN state or in the STOP state.

No.	Symbol	Name	Display range	Factory set value	User set value	Page
1	nC (MC)	Maximum load current value	0.0 to 22.0 A (20 A type)	20.0		P. 4-15
			0.0 to 33.0 A (30 A type)	30.0		
			0.0 to 50.0 A (45 A type)	45.0		
			0 to 66 A (60 A type)	60		
			0 to 88 A (80 A type)	80		
			0 to 110 A (100 A type)	100		
			0 to 165 A (150 A type)	150		
			0 to 220 A (200 A type)	200		
2	HI (HI)	Heater break alarm 1 setting	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * Type 2: 0 to 100 % of Maximum load current value 0: Heater break alarm 1 unused	20		P. 4-16
3	Tb (Tb)	Thyristor break-down detection 1 setting	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * Type 2: 0 to 100 % of Maximum load current value 0: Thyristor break-down alarm 1unused	20		P. 4-18
4	H2 (H2)	Heater break alarm 2 setting	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current * Type 2: 0 to 100 % of Maximum load current value 0: Heater break alarm 2 unused	15		P. 4-20

* The reference current is the load current value that is assumed for the output phase angle of this instrument.
If the condition may attempt to change the set value below 2 A, this instrument makes adjustment to keep the set value 2 A or more.

Setting mode 2

No.	Symbol	Name	Display range	Factory set value	User set value	Page
5	rC (TC)	Thyristor break-down detection 2 setting	Type 1 and Non-linear resistance heater break alarm: 0 to 100 % of the reference current [1] Type 2: 0 to 100 % of Maximum load current value 0: Thyristor break-down alarm 2 unused	15		P. 4-22
6	CL (CL)	Current limit value setting [2]	0.0 to 22.0 A (20 A type)	22.0		P. 4-24
			0.0 to 33.0 A (30 A type)	33.0		
			0.0 to 50.0 A (45 A type)	50.0		
			0 to 66 A (60 A type)	66		
			0 to 88 A (80 A type)	88		
			0 to 110 A (100 A type)	110		
			0 to 165 A (150 A type)	165		
			0 to 220 A (200 A type)	220		

[1] The reference current is the load current value that is assumed for the output phase angle of this instrument.
If the condition may attempt to change the set value below 2 A, this instrument makes adjustment to keep the set value 2 A or more.

[2] The Current limiter function can be used for Phase control.
If a Current limit value is set to its maximum value, the Current limit function is deactivated.
If the Current limit value is set to 0 (0.0), the output of instrument turns off.

■ Engineering mode

If the Engineering mode is locked, unlock the Engineering mode first before attempting the change of the set values. (Factory set value: Lock)

The parameters of this instrument can be set whether this instrument is either in the RUN state or in the STOP state.

No.	Symbol	Name	Display range	Factory set value	User set value	Page
1	F. 1 (F.1)	**Function block 1**	—	—	—	P. 4-25
2	C 1 (C1)	Contact input (DI) function assignment	0: No function 1: Control method Open: Phase control Closed: Zero-cross control 2: Input signal transfer Open: Auto mode Closed: Manual mode 3: Manual mode transfer Open: External manual mode Closed: Internal manual mode 4: RUN/STOP transfer Open: STOP Closed: RUN 5: Soft-start, Soft-down enable/disable Open: Enable Closed: Disable 6: Heater break alarm enable/disable Open: Enable Closed: Disable 7: Over current alarm enable/disable Open: Enable Closed: Disable 8: Set data lock enable/disable Open: Enable Closed: Disable	0		P. 4-25

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
3	F.2 (F.2)	**Function block 2**	—	—	—	P. 4-27
4	CM (CM)	Control method [1]	0: Phase control 1: Zero-cross control (continuous) 2: Zero-cross control (input synchronous type)	0		P. 4-27
5	IS (IS)	Input signal type selection	0: 4 to 20 mA DC, 1 to 5 V DC 1: 0 to 10 V DC, 0/12 V DC	Based on model code.		P. 4-28
6	dA (dA)	Input signal transfer	0: Auto mode 1: Manual mode	0		P. 4-28
7	AM (AM)	Manual mode transfer	0: External manual mode 1: Internal manual mode	0		P. 4-29
8	rS (rS)	RUN/STOP transfer *	0: STOP (Output OFF) 1: RUN (Output ON)	1		P. 4-30
9	SF (SF)	Soft-start, Soft-down enable/disable	0: Disable 1: Enable (Except switching from STOP to RUN) 2: Enable	2		P. 4-31
10	HF (HF)	Heater break alarm enable/disable	0: Disable 1: Enable	1		P. 4-33
11	oF (oF)	Over current alarm enable/disable	0: Disable 1: Enable	1		P. 4-33

* If the Contact input (DI) function is used, priority is given to the Contact input (DI) and setting via the front key is not available.

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
12	F.3 (F.3)	**Function block 3**	—	—	—	P. 4-34
13	oS (oS)	Output mode for phase control	0: Proportional phase angle to input 1: Proportional voltage to input 2: Proportional square voltage (electric power) to input 3: Constant current control (optional) [1]	2		P. 4-34
14	LH (LH)	Output limiter high [2]	0.0 to 100.0 %	100.0		P. 4-35
15	LL (LL)	Output limiter low [2]	0.0 to 100.0 %	0.0		P. 4-35
16	LS (LS)	Output limiter high at operation start	0.0 to 100.0 %	50.0		P. 4-35
17	LT (LT)	Output limiter high time at operation start	0 to 600 seconds	0		P. 4-36
18	bU (bU)	Base-up set value	–9.9 to +100.0 %	0.0		P. 4-36
19	Mo (Mo)	Minimum output phase angle adjustment	Output phase angle 5.0 to 15.0 %	5.0		P. 4-36

[1] This is displayed when the Constant current function is specified at the time of ordering.
[2] The setting range of the Output limiter high and low is “Output limiter high ≧ Output limiter low.”

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
20	F.4 (F.4)	**Function block 4**	—	—	—	P. 4-37
21	L1 (L1)	Alarm output logic	0 to 255 0: No output 1: Heater break alarm 1 2: Thyristor break-down alarm 1 4: Heater break alarm 2 8: Thyristor break-down alarm 2 16: Power frequency error 32: Over current alarm 64: Heat sink temperature abnormality (150 A/200 A types) 128: FAIL (fixed at de-energized) [1]	0		P. 4-37
22	nA (nA)	Selection of energized/de-energized alarm output [2]	0: Energized 1: De-energized	0		P. 4-38
23	A1 (A1)	Alarm type selection	0: Type1 (constant resistance type, deviation alarm) 1: Type2 (linearity resistor type, absolute value alarm) 2: Deviation alarm [ARC-HBA] (Non-linear resistance type)	0		P. 4-38
24	n1 (n1)	Number of alarm 1 determination	1 to 1000 times	30		P. 4-39
25	n2 (n2)	Number of alarm 2 determination	1 to 1000 times	300		P. 4-39
26	SA (SA)	Alarm enable/disable during STOP	0: Disable 1: Enable	0		P. 4-40

[1] If FAIL output is specified, all outputs including FAIL output become de-energizing type. If energizing type output is required, do not include the FAIL output to the alarm output logic.

[2] Selection of alarm output Energized/De-energized is enabled if FAIL output is not included to the Alarm output logic (L1).

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
27	F.5 (F.5)	**Function block 5**	—	—	—	P. 4-42
28	dM (dM)	Default display selection	0: Input signal monitor* 1: CT input monitor 2: Power frequency monitor	0		P. 4-42
29	dT (dT)	Display off timer	0 to 1000 seconds (0: Constantly lit)	0		P. 4-42
30	WH (WH)	Integrated operation time [upper 3 digits]	0 to 999	0		P. 4-43
31	WL (WL)	Integrated operation time [lower 3 digits]	0 to 999	0		P. 4-43

* If the instrument is not supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer, setting "1: CT input monitor" is disregarded and the setting is switched to the Input signal monitor.

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
32	F.6 (F.6)	**Function block 6**	—	—	—	P. 4-44
33	HT (HT)	Automatic calculation time for knee points	0.0 to 1000 seconds (0: Automatic detection function of knee points unused)	20		P. 4-44
34	HU (HU)	Automatic detection of knee points	0: OFF 1: ON 2: Aborted	0		P. 4-45
35	K1 (KI)	Phase angle ratio at knee point 1	0 to 100 %	18		P. 4-46
36	r1 (r1)	Current value at knee point 1	0.0 to 22.0 A (20 Atype)	3.6		P. 4-46
			0.0 to 33.0 A (30 Atype)	5.4		
			0.0 to 50.0 A (45 Atype)	8.1		
			0 to 66 A (60 Atype)	11		
			0 to 88 A (80 Atype)	14		
			0 to 110 A (100 A type)	18		
			0 to 165 A (150 A type)	27		
			0 to 220 A (200 A type)	36		
37	K2 (K2)	Phase angle ratio at knee point 2	0 to 100 %	36		P. 4-47
38	r2 (r2)	Current value at knee point 2	0.0 to 22.0 A (20 A type)	7.2		P. 4-47
			0.0 to 33.0 A (30 A type)	10.8		
			0.0 to 50.0 A (45 A type)	16.2		
			0 to 66 A (60 A type)	22		
			0 to 88 A (80 A type)	29		
			0 to 110 A (100 A type)	36		
			0 to 165 A (150 A type)	54		
			0 to 220 A (200 A type)	72		
39	K3 (K3)	Phase angle ratio at knee point 3	0 to 100 %	56		P. 4-48
40	r3 (r3)	Current value at knee point 3	0.0 to 22.0 A (20 A type)	11.2		P. 4-48
			0.0 to 33.0 A (30 A type)	16.8		
			0.0 to 50.0 A (45 A type)	25.2		
			0 to 66 A (60 A type)	34		
			0 to 88 A (80 A type)	45		
			0 to 110 A (100 A type)	56		
			0 to 165 A (150 A type)	84		
			0 to 220 A (200 A type)	112		

The parameter in Function block 6 are valid when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

Engineering mode

No.	Symbol	Name	Display range	Factory set value	User set value	Page
41	F.7 (F.7)	**Function block 7**	—	—	—	P. 4-49
42	TF (TF)	Protection function for control of primary side of a transformer	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		P. 4-49
43	TA (TA)	Determination set value in case of a break on the secondary side of the transformer	0 to 100 % of reference current value	70		P. 4-49
44	TL (TL)	Output limiter setting in case of a break on the secondary side of the transformer	15.0 to 50.0 % of phase angle	15.0		P. 4-50
45	TU (TU)	Soft-start time in case of break on the secondary side of the transformer	0.1 to 100.0 seconds	0.1		P. 4-50

The parameter in Function block 7 are valid when the instrument is supplied with Heater break alarm (or Non-linear resistance heater break alarm), Current limiter function, Constant current control function and Protection function for control of primary side of a transformer.

A.3 Conversion Table

If the instrument is used under such conditions as described below, you need to convert the Output limiter high value to the output limiter high value for the Proportional phase angle mode before executing the automatic detection of knee points. Use the conversion table to determine the output limiter high value for the Proportional phase angle mode.

Conditions

- Output mode for phase control is set to the Proportional voltage to input and the Output limiter high value is used.
- Output mode for phase control is set to the Proportional square voltage (electric power) to input and the Output limiter high value is used.

After the knee points have been successfully calculated, set the Output limiter high value back to the original value used in the Proportional voltage to input or the Proportional square voltage (electric power) to input.

■ Setting example of Output limiter high value

Example: When the instrument is used with the Proportional voltage to input and when the Output limiter high value is set to “40.0 %”

1. Look for a value close to 40.0 % in the conversion table from the column of the Proportional voltage to input. In this example, “40.25 %” would be the nearest value (Refer to P. A-16).
2. Look for a value that is converted to the value for the Proportional phase angle.
   In the conversion table, refer to the value in the same row as the Proportional voltage to input.
   In this case the nearest value for the Proportional phase angle is “31.00 %.”
3. Set “31.0” to the Output limiter high value before executing the automatic detection of knee points.

■ Conversion table

Output mode for phase control		
Proportional voltage to input	Proportional square voltage (electric power) to input	Proportional phase angle to input
0.00 %	0.00 %	0.00 %
0.26 %	0.00 %	1.00 %
0.73 %	0.01 %	2.00 %
1.33 %	0.02 %	3.00 %
2.05 %	0.04 %	4.00 %
2.86 %	0.08 %	5.00 %
3.76 %	0.14 %	6.00 %
4.73 %	0.22 %	7.00 %
5.77 %	0.33 %	8.00 %
6.87 %	0.47 %	9.00 %
8.03 %	0.65 %	10.00 %
9.25 %	0.86 %	11.00 %
10.51 %	1.11 %	12.00 %
11.82 %	1.40 %	13.00 %
13.18 %	1.74 %	14.00 %
14.57 %	2.12 %	15.00 %
16.01 %	2.56 %	16.00 %

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Conversion table

Output mode for phase control		
Proportional voltage to input	Proportional square voltage (electric power) to input	Proportional phase angle to input
17.47 %	3.05 %	17.00 %
18.97 %	3.60 %	18.00 %
20.50 %	4.20 %	19.00 %
22.05 %	4.86 %	20.00 %
23.63 %	5.58 %	21.00 %
25.23 %	6.37 %	22.00 %
26.85 %	7.21 %	23.00 %
28.49 %	8.12 %	24.00 %
30.14 %	9.08 %	25.00 %
31.81 %	10.12 %	26.00 %
33.48 %	11.21 %	27.00 %
35.17 %	12.37 %	28.00 %
36.86 %	13.58 %	29.00 %
38.55 %	14.86 %	30.00 %
40.25 %	16.20 %	31.00 %
41.95 %	17.60 %	32.00 %
43.65 %	19.05 %	33.00 %
45.35 %	20.56 %	34.00 %
47.04 %	22.12 %	35.00 %
48.72 %	23.74 %	36.00 %
50.40 %	25.40 %	37.00 %
52.06 %	27.11 %	38.00 %
53.72 %	28.86 %	39.00 %
55.36 %	30.65 %	40.00 %
56.98 %	32.47 %	41.00 %
58.59 %	34.33 %	42.00 %
60.19 %	36.22 %	43.00 %
61.76 %	38.14 %	44.00 %
63.31 %	40.08 %	45.00 %
64.84 %	42.04 %	46.00 %
66.35 %	44.02 %	47.00 %
67.83 %	46.01 %	48.00 %
69.28 %	48.00 %	49.00 %
70.71 %	50.00 %	50.00 %
72.11 %	52.00 %	51.00 %
73.48 %	53.99 %	52.00 %
74.82 %	55.98 %	53.00 %
76.13 %	57.96 %	54.00 %
77.41 %	59.92 %	55.00 %
78.65 %	61.86 %	56.00 %
79.86 %	63.78 %	57.00 %
81.04 %	65.67 %	58.00 %
82.18 %	67.53 %	59.00 %
83.28 %	69.35 %	60.00 %

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Conversion table

Output mode for phase control		
Proportional voltage to input	Proportional square voltage (electric power) to input	Proportional phase angle to input
84.35 %	71.14 %	61.00 %
85.38 %	72.89 %	62.00 %
86.37 %	74.60 %	63.00 %
87.33 %	76.26 %	64.00 %
88.25 %	77.88 %	65.00 %
89.13 %	79.44 %	66.00 %
89.97 %	80.95 %	67.00 %
90.77 %	82.40 %	68.00 %
91.54 %	83.80 %	69.00 %
92.27 %	85.14 %	70.00 %
92.96 %	86.42 %	71.00 %
93.61 %	87.63 %	72.00 %
94.23 %	88.79 %	73.00 %
94.81 %	89.88 %	74.00 %
95.35 %	90.92 %	75.00 %
95.86 %	91.88 %	76.00 %
96.33 %	92.79 %	77.00 %
96.76 %	93.63 %	78.00 %
97.17 %	94.42 %	79.00 %
97.54 %	95.14 %	80.00 %
97.88 %	95.80 %	81.00 %
98.18 %	96.40 %	82.00 %
98.46 %	96.95 %	83.00 %
98.71 %	97.44 %	84.00 %
98.93 %	97.88 %	85.00 %
99.13 %	98.26 %	86.00 %
99.30 %	98.60 %	87.00 %
99.45 %	98.89 %	88.00 %
99.57 %	99.14 %	89.00 %
99.68 %	99.35 %	90.00 %
99.76 %	99.53 %	91.00 %
99.83 %	99.67 %	92.00 %
99.89 %	99.78 %	93.00 %
99.93 %	99.86 %	94.00 %
99.96 %	99.92 %	95.00 %
99.98 %	99.96 %	96.00 %
99.99 %	99.98 %	97.00 %
100.00 %	99.99 %	98.00 %
100.00 %	100.00 %	99.00 %
100.00 %	100.00 %	100.00 %

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