User's Manual

Temperature Control and PID Module

Model: F3CU04-0S, F3CU04-1S

IM 34M6H62-02E

YOKOGAWA ◆

Yokogawa Electric Corporation

IM 34M6H62-02E

2nd Edition

Applicable Product

Range Free Controller FA-M3

- Model Code : F3CU04-0S, F3CU04-1S
- Name : Temperature Control and PID Module

The document number and document model code for this manual are given below. Refer to the document number in all communications; also refer to the document number or the document model code when purchasing additional copies of this manual.

- Document No. : IM 34M6H62-02E
- Document Model Code : DOCIM

Media No. IM 34M6H62-02E (CD) 2nd Edition : June 2008 (AR)

Important

■ About This Manual

- This Manual should be passed on to the end user.
- Before using the controller, read this manual thoroughly to have a clear understanding of the controller.
- This manual explains the functions of this product, but there is no guarantee that they will suit the particular purpose of the user.
- Under absolutely no circumstances may the contents of this manual be transcribed or copied, in part or in whole, without permission.
- The contents of this manual are subject to change without prior notice.
- Every effort has been made to ensure accuracy in the preparation of this manual. However, should any errors or omissions come to the attention of the user, please contact the nearest Yokogawa Electric representative or sales office.

■ Safety Precautions when Using/Maintaining the Product

- The following safety symbols are used on the product as well as in this manual.

⚠

Danger. This symbol on the product indicates that the operator must follow the instructions laid out in this instruction manual to avoid the risk of personnel injuries, fatalities, or damage to the instrument. The manual describes what special care the operator must exercise to prevent electrical shock or other dangers that may result in injury or the loss of life.

⏚

Protective Ground Terminal. Before using the instrument, be sure to ground this terminal.

⏚

Function Ground Terminal. Before using the instrument, be sure to ground this terminal.

∼

Alternating current. Indicates alternating current.

⎓

Direct current. Indicates direct current.

The following symbols are used only in the instruction manual.

WARNING

Indicates a “Warning”.

Draws attention to information essential to prevent hardware damage, software damage or system failure.

CAUTION

Indicates a “Caution”

Draws attention to information essential to the understanding of operation and functions.

TIP

Indicates a “TIP”

Gives information that complements the present topic.

SEE ALSO

Indicates a “SEE ALSO” reference.

Identifies a source to which to refer.

- For the protection and safe use of the product and the system controlled by it, be sure to follow the instructions and precautions on safety stated in this manual whenever handling the product. Take special note that if you handle the product in a manner other than prescribed in these instructions, the protection feature of the product may be damaged or impaired. In such cases, Yokogawa cannot guarantee the quality, performance, function and safety of the product.
- When installing protection and/or safety circuits such as lightning protection devices and equipment for the product and control system as well as designing or installing separate protection and/or safety circuits for fool-proof design and fail-safe design of processes and lines using the product and the system controlled by it, the user should implement it using devices and equipment, additional to this product.
- If component parts or consumable are to be replaced, be sure to use parts specified by the company.
- This product is not designed or manufactured to be used in critical applications which directly affect or threaten human lives and safety — such as nuclear power equipment, devices using radioactivity, railway facilities, aviation equipment, air navigation facilities, aviation facilities or medical equipment. If so used, it is the user’s responsibility to include in the system additional equipment and devices that ensure personnel safety.
- Do not attempt to modify the product.

■ Exemption from Responsibility

- Yokogawa Electric Corporation (hereinafter simply referred to as Yokogawa Electric) makes no warranties regarding the product except those stated in the WARRANTY that is provided separately.
- Yokogawa Electric assumes no liability to any party for any loss or damage, direct or indirect, caused by the user or any unpredictable defect of the product.

■ Software Supplied by the Company

- Yokogawa Electric makes no other warranties expressed or implied except as provided in its warranty clause for software supplied by the company.
- Use the software with one computer only. You must purchase another copy of the software for use with each additional computer.
- Copying the software for any purposes other than backup is strictly prohibited.
- Store the original media, such as floppy disks, that contain the software in a safe place.
- Reverse engineering, such as decompiling of the software, is strictly prohibited.
- No portion of the software supplied by Yokogawa Electric may be transferred, exchanged, or sublet or leased for use by any third party without prior permission by Yokogawa Electric.

■ General Requirements for Using the FA-M3

● Avoid installing the FA-M3 in the following locations:

- Where the instrument will be exposed to direct sunlight, or where the operating temperature exceeds the range 0°C to 55°C (32°F to 131°F).
- Where the relative humidity is outside the range 10 to 90%, or where sudden temperature changes may occur and cause condensation.
- Where corrosive or flammable gases are present.
- Where the instrument will be exposed to direct mechanical vibration or shock.
- Where the instrument may be exposed to extreme levels of radioactivity.

● Use the correct types of wire for external wiring:

- Use copper wire with temperature ratings greater than 75°C.

● Securely tighten screws:

- Securely tighten module mounting screws and terminal screws to avoid problems such as faulty operation.
- Tighten terminal block screws with the correct tightening torque as given in this manual.

● Securely lock connecting cables:

- Securely lock the connectors of cables, and check them thoroughly before turning on the power.

● Interlock with emergency-stop circuitry using external relays:

- Equipment incorporating the FA-M3 controller must be furnished with emergency-stop circuitry that uses external relays. This circuitry should be set up to interlock correctly with controller status (stop/run).

● Ground for low impedance:

- For safety reasons, connect the [FG] grounding terminal to a Japanese Industrial Standards (JIS) Class D Ground[*1] (Japanese Industrial Standards (JIS) Class 3 Ground). For compliance to CE Marking, use braided or other wires that can ensure low impedance even at high frequencies for grounding.

[*1] Japanese Industrial Standard (JIS) Class D Ground means grounding resistance of 100 Ω max.

● Configure and route cables with noise control considerations:

- Perform installation and wiring that segregates system parts that may likely become noise sources and system parts that are susceptible to noise. Segregation can be achieved by measures such as segregating by distance, installing a filter or segregating the grounding system.

● Configure for CE Marking Conformance:

- For compliance with CE Marking, perform installation and cable routing according to the description on compliance to CE Marking in the “Hardware Manual” (IM34M6C11-01E).

● Keep spare parts on hand:

- We recommend that you stock up on maintenance parts including spare modules.

● Discharge static electricity before operating the system:

- Because static charge can accumulate in dry conditions, first touch grounded metal to discharge any static electricity before touching the system.

● Never use solvents such as paint thinner for cleaning:

- Gently clean the surfaces of the FA-M3 with a cloth that has been soaked in water or a neutral detergent and wringed.
- Do not use volatile solvents such as benzine or paint thinner or chemicals for cleaning, as they may cause deformity, discoloration, or malfunctioning.

● Avoid storing the FA-M3 controller in places with high temperature or humidity:

- Since the CPU module has a built-in battery, avoid storage in places with high temperature or humidity.
- Since the service life of the battery is drastically reduced by exposure to high temperatures, take special care (storage temperature should be from -20°C to 75°C).
- CPU modules and temperature control modules (F3CT04-□N, F3CR04-□N, F3CV04-1N) have built-in lithium batteries, which serves as backup power supply for programs, device information and configuration information. The service life of this battery is more than 10 years in standby mode at room temperature. Take note that the service life of the battery may be shortened when installed or stored at locations of extreme low or high temperatures. Therefore, we recommend that modules with built-in batteries be stored at room temperature.

● Always turn off the power before installing or removing modules:

- Failing to turn off the power supply when installing or removing modules may result in damage.

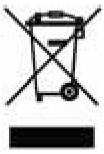
● Do not touch components in the module:

- In some modules you can remove the right side cover and install ROM packs or change switch settings. While doing this, do not touch any components on the printed-circuit board, otherwise components may be damaged and modules may fail to work.

● Do not wire unused terminals:

- Do not wire unused terminals of external connection terminal blocks or unused pins of connectors of the module. Doing so may affect the function of the module.

■ Waste Electrical and Electronic Equipment



Waste Electrical and Electronic Equipment (WEEE), Directive 2002/96/EC

(This directive is only valid in the EU.)

This product complies with the WEEE Directive (2002/96/EC) marking requirement.

The following marking indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category

With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a “Monitoring and Control instrumentation” product.

Do not dispose in domestic household waste.

When disposing products in the EU, contact your local Yokogawa Europe B. V. office.

Introduction

■ Overview of the Manual

This instruction manual describes the specifications, functions and use of the Temperature Control and PID Module. The information is especially useful when you are performing pre-operation engineering.

■ ToolBox for Temperature Control and PID Modules

A dedicated ToolBox software is provided for this module. With this software, you can easily set up various parameters of the module, as well as perform action tests, tuning and monitoring by following screen instructions. For details, see the "ToolBox for Temperature Control and Monitoring Modules User's Manual" (IM34M6Q31-02E).

■ Notation

References to chapters and sections are denoted by the chapter or section number, followed by the chapter or section title enclosed within double-quotation marks.

Relay names and register names are shown with Initial caps.

States or setting values are enclosed within double quotation marks, or displayed with initial caps.

■ Other User's Manuals

● For information on the functions of F3SP66 and F3SP67 sequence CPU modules, refer to:

- Sequence CPU - Functions (for F3SP66, F3SP67) (IM34M6P14-01E)

● For information on the functions of F3SP28, F3SP38, F3SP53, F3SP58 and F3SP59 sequence CPU modules, refer to:

- Sequence CPU - Functions (for F3SP28-3N/3S, F3SP38-6N/6S, F3SP53-4H/4S, F3SP58-6H/6S and F3SP59-7S) (IM34M6P13-01E)

● For information on the functions of F3SP21, F3SP25, F3SP35, F3SP05 and F3SP08 sequence CPU modules, refer to:

- Sequence CPU - Functions (for F3SP21, F3SP25 and F3SP35) (IM34M6P12-02E)

● For information on sequence CPU instructions, refer to:

- Sequence CPU - Instructions (IM34M6P12-03E)

● For information on creating ladder programs, refer to:

- FA-M3 Programming Tool WideField2 (IM34M6Q15-01E)

● For information on the specifications*, configuration*, installation, wiring, trial operation, maintenance and inspection of the FA-M3, as well as information on the system-wide limitation of module installation, refer to:

- Hardware Manual (IM 34M6C11-01E)

*: For information on the specifications of products other than the power supply module, base module, I/O module, cable and terminal block unit, refer to their respective user's manuals.

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FA-M3

Temperature Control and PID Module

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FA-M3

Temperature Control and PID Module
Part A: Function Overview

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Part A provides an overview of the module functions.

A1. Overview

The temperature control and PID module (hereafter called “the module”) is an I/O module to be mounted on the FA-M3 base unit. The module is provided with multiple input and output circuits and performs multiple PID control functions. Figure A1.1 shows a schematic diagram of a system containing the module.

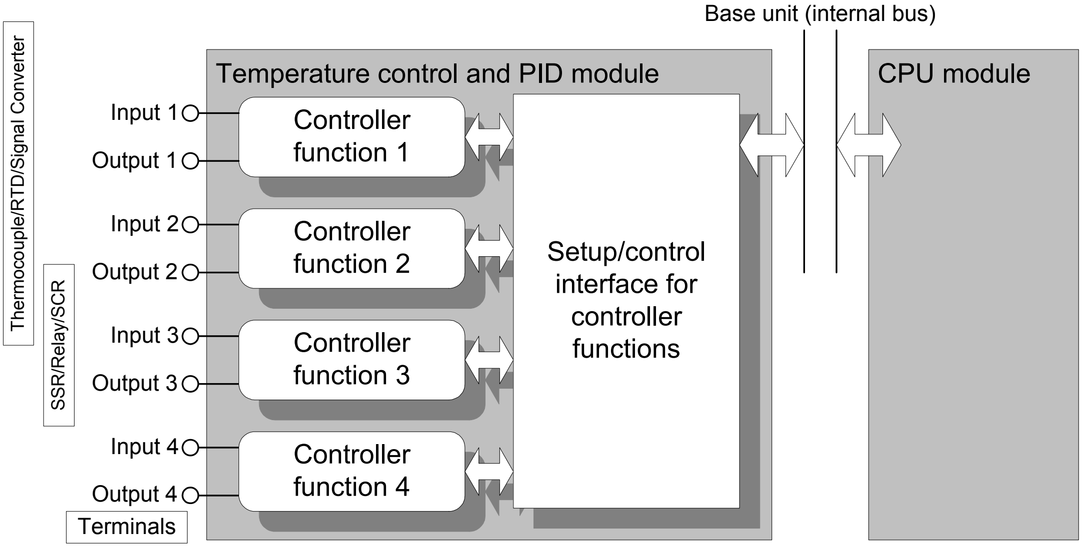
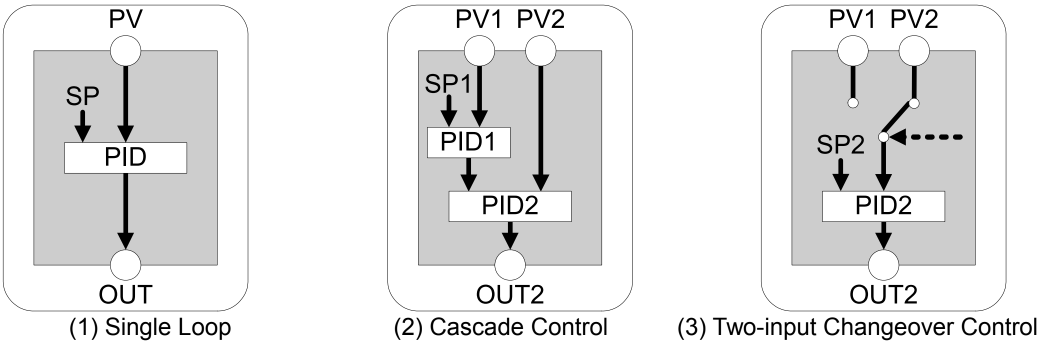


Figure A1.1 Schematic Diagram Showing the Relationship between Sensors, Actuators, Temperature Control and PID Module and CPU Module

The module is provided with four controller functions and one setup and control interface for the controller functions for controlling four loops. The controller functions can be configured to act inter-dependently or independently to support a wide variety of applications.

Three controller modes are available: single loop, cascade control, and two-input changeover control. In the single loop mode (default), individual controller functions operate independently. In the cascade or two-input changeover control mode, two controller functions are combined to act as a single controller function.



(1) Single Loop (2) Cascade Control (3) Two-input Changeover Control

Figure A1.2 Controller Modes

Controller mode, instrument ranges, set points and other parameter values required for module operation can be stored in the module to simplify operation setup at each module startup. A program will then only need to run/stop operation and switch between set points from the CPU module to achieve operation.

■ Features

- **High accuracy, high resolution, high speed**

  The input sampling period for four loops is 200 ms. The sampling period may be set to 100 ms if only two loops are used. The input conversion accuracy is ±0.1% of full scale, and the input resolution is 0.1°C (using 5-digit representation). Low-resolution operation (using 4-digit representation) is also available.

- **Universal input**

  The input type may be set to thermocouple, RTD, or DC voltage for each loop.

- **Dynamic auto-tuning**

  In the dynamic auto-tuning mode, what you have to do before starting operation is to simply set the input type, output type, and set point. The dynamic auto-tuning function automatically determines and tunes the PID parameters during operation. You may disable the function, where appropriate.

■ Main Differences between F3CU04-☐N and F3CU04-☐S

With the F3CU04-☐S module, a specific SP backup procedure needs to be executed to store set points to the EEPROM. Otherwise, set points are not stored to the EEPROM when updated.

With the F3CU04-☐N module, however, set points are always stored automatically when updated. This approach of storing set points unconditionally regardless of whether it is required by an application allows for easier programming and operation, but may damage the EEPROM storage media in an application where set points are constantly updated.

A2. Specifications

A2.1 Model and Suffix Codes

Table A2.1 shows the model name and suffix code of the module.

Table A2.1 **Model and Suffix Codes**

Model	Suffix Code	Style Code	Option Code	Description
F3CU04	-0S	—	—	4 loops Universal input Time-proportional PID output (open collector) Single-slot size
	-1S	—	—	4 loops Universal input Universal output (open collector, 4-20 mA continuous output) Double-slot size

A2.2 Compatibility with CPU Modules

There is no restriction on the type of CPU modules that can be used with this module.

A2.3 General Specifications

Table A2.2 lists the general specifications of the F3CU04-0S and F3CU04-1S temperature control and PID modules.

Table A2.2 General Specifications

Item		Specification	
		F3CU04-0S	F3CU04-1S
Number of loops		4	
Isolation	Between input terminals and internal circuit	Isolated by photocouplers and transformers (tested for 1500 V AC voltage withstanding for 1 minute)	
	Between input terminals		
	Between output terminals and internal circuit		
	Between output terminals	Not isolated.	
Alarm types		12 types of alarm: Upper input limit, lower input limit, upper deviation limit, lower deviation limit, upper/lower deviation limit, and deviation range, all with or without waiting	
Number of alarm outputs (input relays)		4 points per loop (only alarms 1 and 2 have input relays)	
Alarm delay timer		Yes	
Warm-up time		30 minutes min.	
Max. allowable ambient temperature change rate*1		10°C/h max.	
Mounting position		Horizontal or inverted orientation not allowed	
External connection		One 18-point terminal block with M3.5 screws	Two 18-point terminal blocks with M3.5 screws
External dimensions* 2		28.9 (W) x 100 (H) x 106.1 (D) mm	58 (W) x 100 (H) x 106.1 (D) mm
Current consumption		460 mA at 5 V DC	470 mA at 5 V DC
Weight		200 g	350 g

*1: The stated accuracy for the reference junction for thermocouple input deteriorates if the ambient temperature change exceeds this rate.
*2: External dimensions excluding protrusions (for details, see the External Dimensions drawing).

A2.4 Input Specifications

Table A2.3 lists the input specifications of the F3CU04-0S and F3CU04-1S temperature control and PID modules.

Table A2.3 Input Specifications

Item			Specification	
			F3CU04-0S	F3CU04-1S
Input sampling period*1			200ms for 4 loops, or 100ms for 2 loops	
Input types and ranges			See Table A2.4, "Instrument Range and Accuracy". Individual inputs separately configurable by software or collectively by hardware Thermocouple input : 15 ranges RTD input : 9 ranges DC voltage input : 6 ranges	
Burnout detection			Thermocouples or RTDs are checked for burnout. Up-scale, down-scale, or none may be selected.	
	Detection current	Thermocouple	100 nA max.	
		RTD	100 nA max.	
Input insulation resistance			1 MΩ min.	
Allowable signal source resistance		Thermocouple or DC mV input	250 Ω max.	
		DC voltage input	2 kΩ max.	
Allowable wiring resistance		RTD	10 Ω max. per wire (three wires must have the same resistance)	
Measuring current		RTD	Approx. 270 μA	
Reference junction compensation		Thermocouple*2	± 2.0°C (0 to 55°C)	
Allowable input voltage range			-20 to 20 V DC	
Noise reduction*3		Common mode	120 dB (50/60 Hz) min.	
		Normal mode	40 dB (50/60 Hz) min.	
Effect of ambient temperature			± 0.01%/°C or ± 1μV/°C, whichever is greater	

*1: If input sampling period is set to 100 ms for 2 loops, only loops 1 and 2 are available.
*2: This value assumes that all input terminals are correctly wired (that is, solderless termination, wire diameters and connections are correct).
*3: This value assumes that the power supply frequency is correctly selected.

Table A2.4 Instrument Range and Accuracy (for high resolution operation with SW1-1 set to OFF) 1/4

Input Category	Input Type*1	Instrument Range*2	Input Type Selector Switch*3			Software Setting	Accuracy*4	Resolution*2
			SW1-3	SW1-4	SW5			
Software setting (factory setting)			OFF	OFF	0	Instrument ranges may be specified by software using one of the following codes.		
Thermocouple	K*5	-200.0 to 1370.0°C	OFF	OFF	1	1 ($01)	± 0.5°C*5	0.1°C*5
		-200.0 to 1000.0°C			2	2 ($02)		
		-200.0 to 500.0°C			3	3 ($03)	± 0.5°C*6	0.1°C*6
	J	-200.0 to 1200.0°C			4	4 ($04)	± 0.5°C*7	0.1°C*7
		-200.0 to 500.0°C			5	5 ($05)	± 0.5°C*8	0.1°C*8
	T	-270.0 to 400.0°C			6	6 ($06)	± 0.5°C*9	0.1°C*9
	B*10	0.0 to 1600.0°C			7	7 ($07)	± 1.0°C*10	0.1°C*10
	S*11	0.0 to 1600.0°C			8	8 ($08)	± 1.0°C*11	0.1°C*11
	R*11	0.0 to 1600.0°C			9	9 ($09)	± 1.0°C*11	0.1°C*11
	N	-200.0 to 1300.0°C			A	10 ($0A)	± 0.6°C*12	0.1°C*12
	E	-270.0 to 1000.0°C			B	11 ($0B)	± 0.5°C*13	0.1°C*13
	L	-200.0 to 900.0°C			C	12 ($0C)	± 0.6°C	0.1°C
	U	-200.0 to 400.0°C			D	13 ($0D)	± 0.6°C	0.1°C
	W*14	0.0 to 1600.0°C			E	14 ($0E)	± 0.8°C*14	0.1°C*14
	Platinel 2	0.0 to 1390.0°C			F	15 ($0F)	± 0.6°C	0.1°C
RTD	JPt100	-200.0 to 500.0°C	OFF	ON	0	16 ($10)	± 0.4°C	0.1°C
		-200.0 to 200.0°C			1	17 ($11)		
		0.0 to 300.0°C			2	18 ($12)	± 0.3°C	0.1°C
		0.00 to 150.00°C			3	19 ($13)	± 0.20°C	0.03°C
	Pt100	-200.0 to 850.0°C			4	20 ($14)	± 0.4°C	0.1°C
		-200.0 to 500.0°C			5	21 ($15)	± 0.4°C	0.1°C
		-200.0 to 200.0°C			6	22 ($16)		
		0.0 to 300.0°C			7	23 ($17)	± 0.3°C	0.1°C
		0.00 to 150.00°C			8	24 ($18)	± 0.20°C	0.03°C
DC voltage	DC mV input*15	0 to 10.00 mV DC	—*16	ON	9	25 ($19)	± 0.1% of instrument range ± 1 digit*15	
		0 to 100.0 mV DC			A	26 ($1A)		
	DC V input*15	0.000 to 1.000 V DC			B	27 ($1B)		
		0.000 to 5.000 V DC			D	29 ($1D)		
		1.000 to 5.000 V DC			E	30 ($1E)		
		0.00 to 10.00 V DC			F	31 ($1F)		

*1: Applicable standard is JIS/IEC/DIN (ITS-90) for thermocouples and RTD.

*2: For thermocouples K, B, S, R, and W, input ranges may be set wider than their instrument range (see the notes below). However, if the input range width exceeds 1600°C, the resolution becomes twice the indicated value. Furthermore, the actual range for an acceptable input is the input range±5%.

*3: When you turn on the power after changing the hardware switch settings, data stored in the EEPROM is initialized to follow the switch settings.

*4: This accuracy applies if the ambient temperature is 25 ± 5°C and the input value is within the instrument range. If the input type is thermocouple and reference junction compensation is used, you should also take into consideration the accuracy of the reference junction compensation.

*5: For K-type thermocouples, the input range may be set from -270.0 to 1370.0°C beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
-270.0 to -200.0°C: Neither accuracy or resolution is guaranteed.
-200.0 to 0.0°C: ±1.0°C accuracy, 0.2°C resolution

*6: For K-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-200.0 to -180.0°C: ±0.9°C accuracy, 0.2°C resolution
-180.0 to -100.0°C: ±0.6°C accuracy, 0.1°C resolution

*7: For J-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-200.0 to -100.0°C: ±1.0°C accuracy, 0.2°C resolution

*8: For J-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-200.0 to -150.0°C: ±0.6°C accuracy, 0.1°C resolution

*9: For T-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-270.0 to -200.0°C: ±3.5°C accuracy, 0.5°C resolution
-200.0 to -100.0°C: ±1.0°C accuracy, 0.1°C resolution

*10: For B-type thermocouples, the input range may be set from 0.0 to 1800.0°C beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
0.0 to 300.0°C: Neither accuracy nor resolution is guaranteed.
300.0 to 900.0°C: ±2.5°C accuracy, 0.3°C resolution

*11: For S-type and R-type thermocouples, the input range may be set from 0.0 to 1700.0°C beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
0.0 to 200.0°C: ±1.5°C accuracy, 0.2°C resolution

*12: For N-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-200.0 to 0.0°C: ±1.3°C accuracy, 0.3°C resolution

*13: For E-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-270.0 to -200.0°C: ±6.5°C accuracy, 2.0°C resolution
-200.0 to -100.0°C: ±1.0°C accuracy, 0.2°C resolution

*14: For W-type thermocouples, the input range may be set from 0.0 to 2300.0°C beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
0.0 to 100.0°C: ±1.0°C accuracy, 0.2°C resolution

*15: Resolution is determined by the upper and lower limits for the input range, as well as the upper and lower scaling limits. It is represented by one digit.

*16: "–" means that the value is ignored.

Table A2.4 Instrument Range and Accuracy (for low resolution operation with SW1-1 set to OFF) 2/4

Input Category	Input Type[*1]	Instrument Range	Input Type Selector Switch[*3]			Software Setting	Accuracy[*4]	Resolution[*2]
			SW1-3	SW1-4	SW5			
Software setting			ON	OFF	0	Instrument ranges may be specified by software using one of the following codes.		
Thermocouple	K[*5]	-200 to1370°C	ON	OFF	1	33 ($21)	± 2°C[*5]	1°C[*5]
		-200 to1000°C			2	34 ($22)		
		-200 to500°C			3	35 ($23)	± 2°C	1°C
	J	-200 to 1200°C			4	36 ($24)		
		-200 to 500°C			5	37 ($25)		
	T	-270 to 400°C			6	38 ($26)	± 2°C[*6]	1°C
	B[*7]	0 to 1600°C			7	39 ($27)	± 2°C[*7]	1°C[*7]
	S[*8]	0 to 1600°C			8	40 ($28)	± 2°C	1°C
	R[*9]	0 to 1600°C			9	41 ($29)		
	N	-200 to 1300°C			A	42 ($2A)	± 2°C[*9]	1°C
	E	-270 to 1000°C			B	43 ($2B)	± 2°C[*10]	1°C[*10]
	L	-200 to 900°C			C	44 ($2C)	± 2°C	1°C
	U	-200 to 400°C			D	45 ($2D)		
	W[*11]	0 to 1600°C			E	46 ($2E)		
	Platinel 2	0 to 1390°C			F	47 ($2F)		
RTD	JPt100	-200 to 500°C	ON	ON	0	48 ($30)	± 2°C	1°C
		-200 to 200°C			1	49 ($31)		
		0 to 300°C			2	50 ($32)		
		0.0 to 150.0°C			3	51 ($33)	± 0.3°C	0.1°C
	Pt100	-200 to 850°C			4	52 ($34)	± 2°C	1°C
		-200 to 500°C			5	53 ($35)		
		-200 to 200°C			6	54 ($36)		
		0 to 300°C			7	55 ($37)		
		0.0 to 150.0°C			8	56 ($38)	± 0.3°C	0.1°C

*1: Applicable standard is JIS/IEC/DIN (ITS-90) for thermocouples and RTD.

*2: For thermocouples K, B, S, R, and W, input ranges may be set wider than their instrument range (see the notes below). Furthermore, the actual range for an acceptable input is the input range±5%.

*3: When you turn on the power after changing the hardware switch settings, data stored in the EEPROM is initialized to follow the switch settings.

*4: This accuracy applies if the ambient temperature is 25 ± 5°C and the input value is within the instrument range. If the input type is thermocouple and reference junction compensation is used, you should also take into consideration the accuracy of the reference junction compensation.

*5: For K-type thermocouples, the upper and lower input range limits may be set from -270 to 1370°C. The accuracy and resolution depend on measured temperatures as follows:
-270 to -200°C: Neither accuracy nor resolution is guaranteed.

*6: For T-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-270 to -200°C: ±4°C accuracy, 1°C resolution

*7: For B-type thermocouples, the upper and lower input range limits may be set from 0 to 1800°C. The accuracy and resolution depend on measured temperatures as follows:
0 to 300°C: Neither accuracy nor resolution is guaranteed.
300 to 900°C: ±3°C accuracy, 1°C resolution

*8: For S-type and R-type thermocouples, the upper and lower input range limits may be set from 0 to 1700°C.

*9: For N-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-200 to 0°C: ±3°C accuracy, 1°C resolution

*10: For E-type thermocouples, the detailed accuracy and resolution are as follows:
-270 to -200°C: ±8°C accuracy, 2°C resolution
-200 to 1000°C: ±2°C accuracy, 1°C resolution

*11: For W-type thermocouples, the upper and lower input range limits may be set from 0 to 2300°C.

Table A2.4 Instrument Range and Accuracy (for high resolution operation with SW1-1 set to ON) 3/4

Input Category	Input Type[*1]	Instrument Range[*2]	Input Type Selector Switch[*3]			Software Setting	Accuracy[*4]	Resolution[*2]
			SW1-3	SW1-4	SW5			
Software setting (factory setting)			OFF	OFF	0	Instrument ranges may be specified by software using one of the following codes.		
Thermocouple	K[*5]	-328.0 to 2498.0°F	OFF	OFF	1	1 ($01)	± 1.0°F[*5]	0.2°F[*5]
		-328.0 to 1832.0°F			2	2 ($02)	± 1.0°F[*5]	0.2°F[*5]
		-328.0 to 932.0°F			3	3 ($03)	± 1.0°F[*6]	0.2°F[*6]
	J	-328.0 to 2192.0°F			4	4 ($04)	± 1.0°F[*7]	0.2°F[*7]
		-328.0 to 932.0°F			5	5 ($05)	± 1.0°F[*8]	0.2°F
	T	-454.0 to 752.0°F			6	6 ($06)	± 1.0°F[*9]	0.2°F[*9]
	B[*10]	32 to 2912°F			7	7 ($07)	± 2°F[*10]	1°F[*10]
	S[*11]	32 to 2912°F			8	8 ($08)	± 2°F[*11]	1°F
	R[*11]	32 to 2912°F			9	9 ($09)	± 2°F[*11]	1°F
	N	-328.0 to 2372.0°F			A	10 ($0A)	± 1.2°F[*12]	0.2°F[*12]
	E	-454.0 to 1832.0°F			B	11 ($0B)	± 1.0°F[*13]	0.2°F[*13]
	L	-328.0 to 1652.0°F			C	12 ($0C)	± 1.2°F	0.2°F
	U	-328.0 to 752.0°F			D	13 ($0D)	± 1.2°F	0.2°F
	W[*14]	32 to 2912°F			E	14 ($0E)	± 2°F	1°F
	Platinel 2	32.0 to 2534.0°F			F	15 ($0F)	± 1.2°F	0.2°F
RTD	JPt100	-328.0 to 932.0°F	OFF	ON	0	16 ($10)	± 0.8°F	0.2°F
		-328.0 to 392.0°F			1	17 ($11)	± 0.8°F	0.2°F
		32.0 to 572.0°F			2	18 ($12)	± 0.6°F	0.2°F
		32.0 to 302.0°F			3	19 ($13)	± 0.4°F	0.2°F
	Pt100	-328.0 to 1562.0°F			4	20 ($14)	± 0.8°F	0.2°F
		-328.0 to 932.0°F			5	21 ($15)	± 0.8°F	0.2°F
		-328.0 to 392.0°F			6	22 ($16)	± 0.8°F	0.2°F
		32.0 to 572.0°F			7	23 ($17)	± 0.6°F	0.2°F
		32.0 to 302.0°F			8	24 ($18)	± 0.4°F	0.2°F
DC voltage	DC mV input[*15]	0 to 10.00 mV DC	—[*16]	ON	9	25 ($19)	± 0.1% of instrument range ± 1 digit[*15]	
		0 to 100.0 mV DC			A	26 ($1A)		
	DC V input[*15]	0.000 to 1.000 V DC			B	27 ($1B)		
		0.000 to 5.000 V DC			D	29 ($1D)		
		1.000 to 5.000 V DC			E	30 ($1E)		
		0.00 to 10.00 V DC			F	31 ($1F)		

*1: Applicable standard is JIS/IEC/DIN (ITS-90) for thermocouples and RTD.

*2: For thermocouples K, B, S, R, and W, input ranges may be set wider than their instrument range (see the notes below). However, if the input range width exceeds 2880°F, the resolution becomes twice the indicated value. Furthermore, the actual range for an acceptable input is the input range±5%.

*3: When you turn on the power after changing the hardware switch settings, data stored in the EEPROM is initialized to follow the switch settings.

*4: This accuracy applies if the ambient temperature is 77°F±9°F and the input value is within the instrument range. If the input type is thermocouple and reference junction compensation is used, you should also take into consideration the accuracy of the reference junction compensation.

*5: For K-type thermocouples, the input range may be set from -454.0 to 2498.0°F beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
-454.0 to -328.0°F: Neither accuracy or resolution is guaranteed.
-328.0 to 32.0°F: ±2.0°F accuracy, 0.4°F resolution

*6: For K-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-328.0 to -292.0°F: ±2.0°F accuracy, 0.4°F resolution
-292.0 to -148.0°F: ±1.2°F accuracy, 0.2°F resolution

*7: For J-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-328.0 to -148.0°F: ±2.0°F accuracy, 0.4°F resolution

*8: For J-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-328.0 to -238.0°F: ±1.2°F accuracy, 0.2°F resolution

*9: For T-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-454.0 to -328.0°F: ±6.5°F accuracy, 1.0°F resolution
-328.0 to -148.0°F: ±2.0°F accuracy, 0.2°F resolution

*10: For B-type thermocouples, the input range may be set from 32 to 3272°F beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
32 to 572°F: Neither accuracy nor resolution is guaranteed.
572 to 1652°F: ±5°F accuracy, 1°F resolution

*11: For S-type and R-type thermocouples, the input range may be set from 32 to 3092°F beyond its instrument range. The accuracy and resolution depend on measured temperatures as follows:
32 to 392°F: ±3°F accuracy, 1°F resolution

*12: For N-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-328.0 to 32.0°F: ±2.5°F accuracy, 0.6°F resolution

*13: For E-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-454.0 to -328.0°F: ±12.0°F accuracy, 4.0°F resolution
-328.0 to -148.0°F: ±2.0°F accuracy, 0.4°F resolution

*14: For W-type thermocouples, the input range may be set from 32 to 4172°F beyond its instrument range.

*15: Resolution is determined by the upper and lower limits for the input range, as well as the upper and lower scaling limits. It is represented by one digit.

*16: "–" means that the value is ignored.

Table A2.4 Instrument Range and Accuracy (for low resolution operation with SW1-1 set to ON) 4/4

Input Category	Input Type*1	Instrument Range	Input Type Selector Switch*3			Software Setting	Accuracy*4	Resolution*2
			SW1-3	SW1-4	SW5			
Software setting			ON	OFF	0	Instrument ranges may be specified by software using one of the following codes.		
Thermocouple	K*5	-328 to 2498°F	ON	OFF	1	33 ($21)	± 2°F*5	1°F*5
		-328 to 1832°F			2	34 ($22)	± 2°F*5	1°F*5
		-328 to 932°F			3	35 ($23)	± 2°F	1°F
	J	-328 to 2192°F			4	36 ($24)	± 2°F	1°F
		-328 to 932°F			5	37 ($25)	± 2°F	1°F
	T	-454 to 752°F			6	38 ($26)	± 2°F*6	1°F
	B*7	32 to 2912°F			7	39 ($27)	± 2°F*7	1°F*7
	S*8	32 to 2912 °F			8	40 ($28)	± 2°F*8	1°F
	R*8	32 to 2912°F			9	41 ($29)	± 2°F*8	1°F
	N	-328 to 2372°F			A	42 ($2A)	± 2°F*9	1°F
	E	-454 to 1832°F			B	43 ($2B)	± 2°F*10	1°F*10
	L	-328 to 1652°F			C	44 ($2C)	± 2°F	1°F
	U	-328 to 752°F			D	45 ($2D)	± 2°F	1°F
	W*11	32 to 2912°F			E	46 ($2E)	± 2°F	1°F
	Platinel 2	32 to 2534°F			F	47 ($2F)	± 2°F	1°F
RTD	JPt100	-328 to 932°F	ON	ON	0	48 ($30)	± 2°F	1°F
		-328 to 392°F			1	49 ($31)	± 2°F	1°F
		32 to 572°F			2	50 ($32)	± 2°F	1°F
		32 to 302°F			3	51 ($33)	± 2°F	1°F
	Pt100	-328 to 1562°F			4	52 ($34)	± 2°F	1°F
		-328 to 932°F			5	53 ($35)	± 2°F	1°F
		-328 to 392°F			6	54 ($36)	± 2°F	1°F
		32 to 572°F			7	55 ($37)	± 2°F	1°F
		32 to 302°F			8	56 ($38)	± 2°F	1°F

*1: Applicable standard is JIS/IEC/DIN (ITS-90) for thermocouples and RTD.

*2: For thermocouples K, B, S, R, and W, input ranges may be set wider than their instrument range (see the notes below). Furthermore, the actual range for an acceptable input is the input range±5%.

*3: When you turn on the power after changing the hardware switch settings, data stored in the EEPROM is initialized to follow the switch settings.

*4: This accuracy applies if the ambient temperature is 77°F±9°F and the input value is within the instrument range. If the input type is thermocouple and reference junction compensation is used, you should also take into consideration the accuracy of the reference junction compensation.

*5: For K-type thermocouples, the upper and lower input range limits may be set from -454 to 2498°F. The accuracy and resolution depend on measured temperatures as follows:
-454 to 328°F: Neither accuracy nor resolution is guaranteed.

*6: For T-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-454 to -328°F: ±7°F accuracy, 1°F resolution

*7: For B-type thermocouples, the upper and lower input range limits may be set from 32 to 3272°F. The accuracy and resolution depend on measured temperatures as follows:
32 to 572°F: Neither accuracy nor resolution is guaranteed.
572 to 1652°F: ±5°F accuracy, 1°F resolution

*8: For S-type and R-type thermocouples, the upper and lower input range limits may be set from 32 to 3092°F. The accuracy and resolution depend on measured temperatures as follows:
32 to 392°F: ±3°F accuracy, 1°F resolution

*9: For N-type thermocouples, the accuracy and resolution depend on measured temperatures as follows:
-328 to 32°F: ±4°F accuracy, 1°F resolution

*10: For E-type thermocouples, the detailed accuracy and resolution are as follows:
-454 to 328°F: ±12°F accuracy, 4°F resolution
-328 to 148°F: ±3°F accuracy, 1°F resolution

*11: For W-type thermocouples, the upper and lower input range limits may be set from 32 to 4172°F.

A2.5 Output Specifications

Table A2.5 lists the output specifications of the F3CU04-0S and F3CU04-1S temperature control and PID modules.

Table A2.5 Output Specifications

Item		Specification	
		F3CU04-0S	F3CU04-1S
Number of outputs		4	8
External power supply *		24 V DC ±10%, 10 mA	24 V DC ±10%, 250 mA
Time-proportional PID output (open collector output)	Rated load voltage	24 V DC	
	Maximum load current	0.1 A per point	0.1 A per point and 0.4 A for 8 points
	ON residual voltage	0.5 V DC max.	
	OFF leakage current	0.1 mA max.	
	Response time	OFF→ON: 1 ms max., ON→OFF: 1 ms max.	
	Cycle time	0.5 to 240 s	
	Time-proportional resolution	10 ms or 0.05% of F.S., whichever is greater	
Continuous PID output (analog output)	Output range	N.A.	4-20 mA (3.2-20.8 mA)
	Allowable load resistance		600Ω max.
	Output accuracy		±1.0% of F.S.
	Output resolution		0.05% of F.S.

* External power supply is not required if no output terminal is used (that is, if only input terminals are used).

A2.6 Backup Function

The F3CU04-0S or F3CU04-1S temperature control and PID module provides a backup function for storing input type, input range, set points and other parameter values, and hence retaining their values even after power off and on. Parameters designated for backup are stored whenever their corresponding registers are updated, provided the backup function is not disabled. However, you need to execute a specific procedure every time to back up set point values. Otherwise, stored set points will not be updated. Even so, beware that set points will not be updated if the backup function is disabled.

Take note that there is a maximum limit to the number of write operations allowed for the backup function.

Table A2.6 Backup Function

	Description
Stored parameters	Controller parameters, I/O parameters, and operation parameters. For details, refer to the list of registers.
Number of write operations	Up to 100,000 write operations allowed
Disable backup function	This parameter disables the backup function. It may be used, if required, to avoid reaching the maximum limit for write operations.

CAUTION

For details on the I/O data registers that are stored by the backup function and their data position numbers, see Section B2, "Types of Relays and Registers."

CAUTION

In situations where the CPU module frequently overwrites the I/O data registers earmarked to be stored by the backup function, the maximum limit for write operations (100,000 times) may be reached. To prevent this, turn on the Disable Backup Function parameter. Once the write limit is reached, data backup is no longer allowed and the system enters hardware failure mode. Furthermore, parameter data may be reset at system startup to the default values given in Section B2, "Types of Relays and Registers."

A2.7 Function Specifications

Table A2.7 shows the function specifications of the F3CU04-0S and F3CU04-1S temperature control and PID modules.

Table A2.7 Function List (1/2)

Category	Functions		Description
Controller	Input sampling period		Sets the input sampling period (this affects the number of available loops).
	Controller mode selection		Specifies the controller mode for a pair of 2 loops.
	Controller mode	Single loop	Basic controller mode with one control and computation function where two loops operate independently.
		Cascade control	Two control and computation functions perform cascade control (using 2 loops of input and output).
		Two-input changeover	Switches between two measured inputs (using a register or measured value range) and handles them as one measured input (using 2 loops of input).
		Disabled	Loops specified as 'disabled' are not used.
Output processing	Control type selection		Selects from on/off, PID, and heating/cooling control types.
	Control type	ON/OFF	Performs control by turning on (100% output) or turning off the output (0% output). *1
		PID	Controls output according to PID computation results.
		Heating/cooling	Controls both heating and cooling outputs according to PID computation results.
	Output limiter	Output limiter	Sets the upper and lower limits for the control output.
		Rate-of-change limit	Sets the maximum allowable rate-of-change for the control output.
	Output type selection *2		Selects between time-proportional output (open collector) and continuous output (4-20 mA analog output).
	Analog output *2		Specifies a fixed value output for any output terminal not used in a control loop (e.g. when disabled).
Input processing	Input type selection		Sets input type using switches (for all loops) or software (for individual loops).
	Power supply frequency specification		Specifies the power supply frequency. An appropriate setting value will reduce the effect of common mode noise.
	Input range setting		Sets input ranges.
	PV range setting		Sets PV range for two-input changeover mode.
	Burnout selection		Selectable from Up-scale, Down-scale, or OFF (no burnout detection) for thermocouple or RTD input open-circuit detection. *3
	Reference junction compensation		Sets thermocouple reference junction compensation to 'On' or 'Fixed Value'.
	Input computation	Broken-line biasing	Specifies any temperature and its bias value. A compensation value based on the linear interpolation of the specified bias values is automatically added to a measured input. This function is particularly useful for a deteriorated sensor, for which input compensation is desirable.
		Fixed biasing	Specifies a fixed bias value to be automatically added to measured input values. This function is useful when a measured input suffers a fixed deviation due to a known physical problem with a sensor, or when fine adjustment of measured input is desirable for better consistency with values indicated by other equipment, even though data deviation is within tolerance.
		Input filtering	Filtering can be used to remove high frequency noise from measured inputs such as flow rate and pressure. Filtering is a first order delay numerical operation.
		Square root extraction	Performs square root extraction on measured inputs. This function is useful for converting differential pressure signals (of orifice, nozzle, or other types of restriction flowmeter) to flow rate signals.
	Two-input changeover		Sets the two-input changeover mode to perform changeover based on temperature range, preset temperature value, or register value.
	External PV input		External values may be used as control input values. Measured input values that have undergone required processing by a CPU module or other means, may be used as input values.

*1: Numbers within parentheses (100% and 0%) applies when the output is configured as a continuous output (for F3CU04-1S only).

*2: Available for F3CU04-1S only.

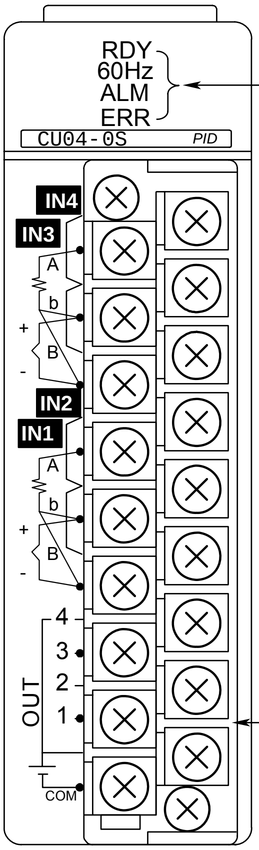
*3: When burnout selection is set to OFF, the measured input value at the time of burnout (open circuit) is unpredictable and may approach either the upper limit or the lower limit. Furthermore, the burnout relay is not set. However +OVER or -OVER detection is performed.

Table A2.7 Function List (2/2)

Category	Functions		Description
Control and computation	Set point	Set points	Four set points can be predefined for each loop. A predefined set point can be selected using the SP number parameter.
		Remote set point	Can be used to continually change the set point value from the CPU module or by other means.
		SP tracking	Retains the set point value when switching from remote to local mode.
		SP limiter	Limits the set point within specified limits in remote or cascade control mode.
		SP gradient setting	Defines acceleration and deceleration independently for varying the control set point at a fixed rate or to prevent an abrupt change in the control set point.
		PV tracking	When a switchover is made from Stop to Run, from Manual to Automatic, or from one SP number to another, the control set point is first set to the current PV value and then gradually changed to the required value at the rate defined by the SP gradient parameters.
	Auto-tuning	Dynamic auto-tuning	Automatically recalculates PID constants to achieve continuous stable control at the beginning of a control operation or when control becomes unstable.
		Auto-tuning	When a start tuning instruction is issued, measures the characteristics of a control object by switching on and then switching off the output, and automatically determines and sets optimal PID constants.
	Control and computation	Forward/reverse operation	Defines the direction of output change (increase or decrease) corresponding to a positive deviation.
		PID control mode	The combination of the CMD parameter (0: standard PID control mode, 1: fixed-point control mode) and the remote/local switch determines the PID control method (PV derivative type PID control or deviation derivative type PID control) with or without bumping.
		Super	Suppresses overshooting using fuzzy logic.
		Anti-reset windup	Prevents excessive integration and hence overshooting by suspending PID computation. The deviation width for resuming PID computation can be set using a parameter.
	PID selection		Selects one of the four PID parameter groups belonging to each loop.
	PID selection method	SP number selection	Switches between four PID parameter groups according to the value of the SP Number Selection parameter.
		Zone PID selection	Automatically switches between PID parameter groups according to PV value. In addition, allows switching to a specific PID parameter group when the deviation is large.
	Operation control		Switches between run/stop, automatic/manual/cascade, remote/local, and other operating modes.
Alarm	Alarm	Alarm setup	Defines four alarms for each loop. Alarms may be defined to trigger with respect to the upper or lower input limit or differential upper or lower limit.
		Waiting	Suppresses alarms during the startup period after power on until the operation stabilizes.
		Delay timer	Reports an alarm only if an alarm condition persists for a minimum duration.
Backup function (Storing of preset values)			Stores parameters to the EEPROM, which is writable up to 100,000 times.

A2.8 Components and Functions

F3CU04-0S



Status Indicators

RDY (green)

Lit when the internal circuit is functioning normally. Turns off when an error occurs in the module.

60 Hz (green)

Indicates the frequency of the commercial power supply,
Off: 50Hz;
On: 60 Hz.

ALM (orange)

Lit when an alarm occurs in any loop.

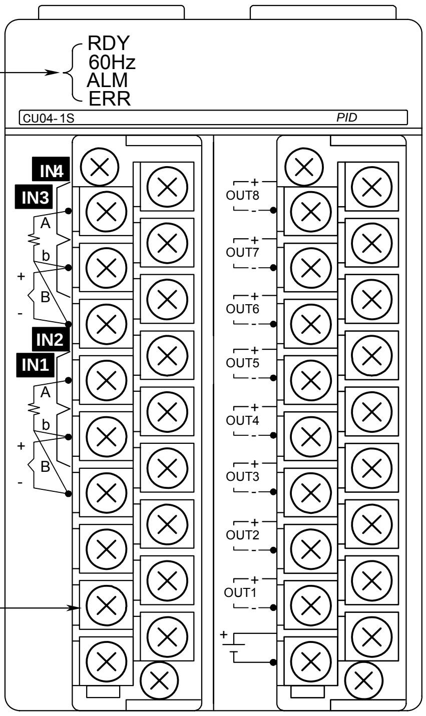
ERR (red)

Lit or flashes when a hardware failure is detected or an error is detected in stored data.
Lit when an error is detected in RAM, ROM, system data, calibration values, ADC, RJC or EEPROM.
Flashes when a parameter error or burnout is detected.

I/O terminal block

18-point detachable terminal block with M3.5 screws.

F3CU04-1S



Status Indicators

RDY (green)

Lit when the internal circuit is functioning normally. Turns off when an error occurs in the module.

60 Hz (green)

Indicates the frequency of the commercial power supply,
Off: 50Hz;
On: 60 Hz.

ALM (orange)

Lit when an alarm occurs in any loop.

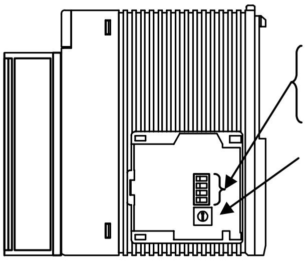
ERR (red)

Lit or flashes when a hardware failure is detected or an error is detected in stored data.
Lit when an error is detected in RAM, ROM, system data, calibration values, ADC, RJC or EEPROM.
Flashes when a parameter error or burnout is detected.

I/O terminal block

18-point detachable terminal block with M3.5 screws.

Figure A2.1 F3CU04-0S, F3CU04-1S Front View



SW1-1: Temperature unit selector switch
SW1-2: Power frequency selector switch
SW1-3: Input type selector switch
SW1-4: Input type selector switch

SW5: Input type selector switch
(Input type is determined by the
combined values of SW1-3, SW1-4, and SW5.)

Note: This is the right side view of the module with its cover removed.

Figure A2.2 Right Side View Showing Input Type and Power Supply Frequency Selector Switches

CAUTION

You may switch the temperature unit between °C and °F using SW1-1. For details, see Section C11, “Selecting Temperature Unit.”

A2.9 External Dimensions

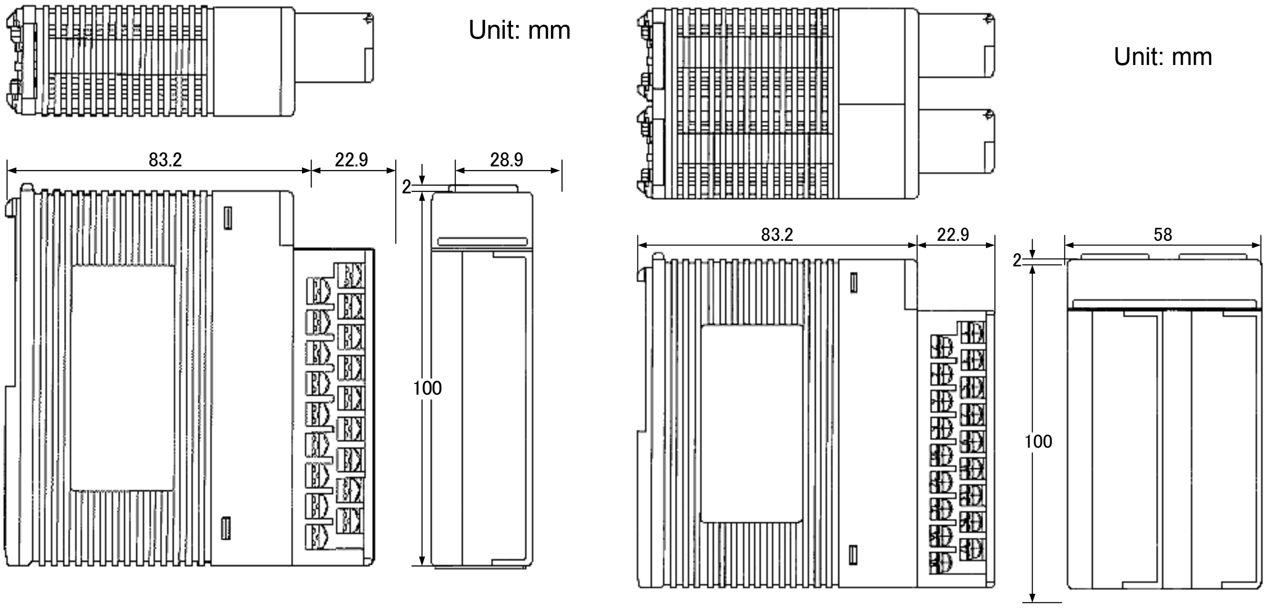


Figure A2.3 External Dimensions

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A3. Startup Procedure

Install the module into your system and perform the following startup procedure.

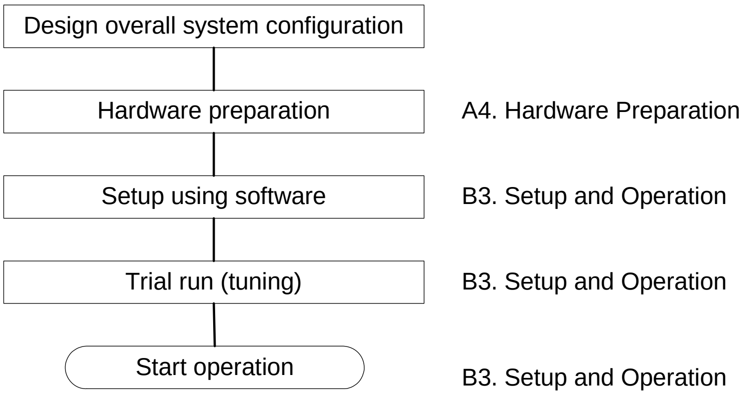


Figure A3.1 Startup Procedure

Before you use the module, you must first design the overall system configuration, set the switches, install the module on the base unit, and perform required wiring and other hardware preparation. Following that, you will set the controller modes and input ranges using software. The software here refers to the FA-M3 Programming Tool WideField2, the BASIC Programming Tool M3 or the ToolBox for Temperature Control and Monitoring modules. The required system components when performing setup are the power supply module, the base module, the CPU module, software and a personal computer for running the software. For details on the required environment for executing the software, including specifications for the personal computer and compatible CPU modules, as well as details on how to operate the software, see the relevant software manuals.

After software setup, perform trial runs to tune parameters for optimal performance. Now, you are ready for actual operation.

Sections A4, "Hardware Preparation" and B3, "Setup and Operation" describe these procedures in detail. For details on how to access the module using software to perform setup and for more information on relays and registers, see Section B1, "Accessing the Module," and B2, "Types of Relays and Registers," respectively.

A4. Hardware Preparation

To use the temperature control and PID module, you must set the operation switches and perform wiring connections. In this chapter, we describe the details of hardware preparation.

Figure A4.1 shows the workflow for hardware preparation. For details on each operation, refer to the sections indicated in the column on the right.

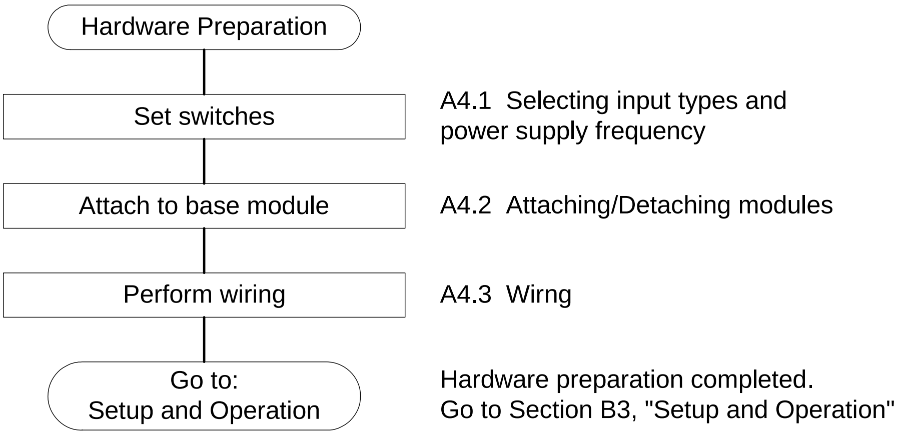
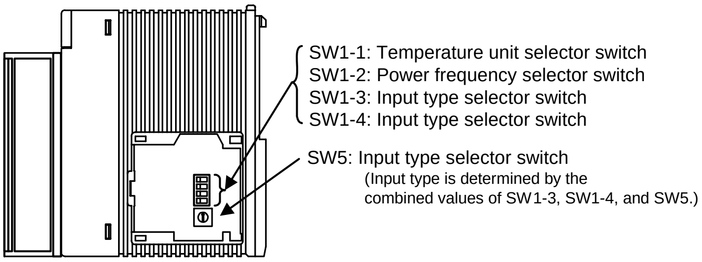


Figure A4.1 Workflow for Hardware Preparation

A4.1 Selecting Input Types and Power Frequency

This section describes how to select appropriate input types for given temperature ranges and how to select a suitable power frequency for a given power supply environment.

Figure A4.2 shows the hardware switches for selecting input types and power frequency.



Note: This is the right side view of the module with its cover removed.

Figure A4.2 Input Types and Power Frequency Selector Switches

Use switches SW1-1, SW1-3, SW1-4 and SW5 to perform input setup. SW1-4 and SW5 together specifies an input type, which apply to all loops, while SW1-3 specifies a resolution and SW1-1 specifies the temperature unit for all loops. For the various switch combinations and their corresponding input type and resolution values, see Table 4.1, “Input Type Selection”.

Use SW1-2 to select a power frequency corresponding to the AC power used in the equipment. For the mapping between SW1-2 and frequency, see Table 4.2, “Power Frequency Settings”. Selecting an appropriate power frequency will reduce interference from common mode noise.

You can also set input types and power frequency using data registers. To do so, set the input type selector switches to “set by software”, that is, “SW5=0; SW1-4=OFF”. This will mean that the power frequency will also have to be set using data registers. The factory switch setting is “set by software.”

For details on input type selection and power frequency selection, see Section C3.1, “Input Type Selection” and Section C3.2, “Power Frequency Selection” respectively.

CAUTION

Always turn off the power before performing switch setup.

CAUTION

You may switch the temperature unit between °C and °F using SW1-1. For details, see Section C11, “Selecting Temperature Unit.”

Table A4.1 Input Type Selection (1/2) (SW1-1 = OFF)

Input Type		Instrument Range	Input Type Selector Switch*2			Software Setting	Input Range*1				
							Default			Allowable Range	
			SW5	SW1-4	SW1-3	IN*3	RL	RH	DEC.P	RL	RH
Software setting *4			0	OFF	X						
Thermocouple	K	-200.0 to 1370.0°C	1	OFF	OFF	1 ($01)	-2000	13700	1	-2700	13700
					ON	33 ($21)	-200	1370	0	-270	1370
		-200.0 to 1000.0°C	2		OFF	2 ($02)	-2000	10000	1	-2700	13700
					ON	34 ($22)	-200	1000	0	-270	1370
		-200.0 to 500.0°C	3		OFF	3 ($03)	-2000	5000	1	-2000	5000
					ON	35 ($23)	-200	500	0	-200	500
	J	-200.0 to 1200.0°C	4		OFF	4 ($04)	-2000	12000	1	-2000	12000
					ON	36 ($24)	-200	1200	0	-200	1200
		-200.0 to 500.0°C	5		OFF	5 ($05)	-2000	5000	1	-2000	5000
					ON	37 ($25)	-200	500	0	-200	500
	T	-270.0 to 400.0°C	6		OFF	6 ($06)	-2700	4000	1	-2700	4000
					ON	38 ($26)	-270	400	0	-270	400
	B	0.0 to 1600.0°C	7		OFF	7 ($07)	0	16000	1	0	18000
					ON	39 ($27)	0	1600	0	0	1800
	S	0.0 to 1600.0°C	8		OFF	8 ($08)	0	16000	1	0	17000
					ON	40 ($28)	0	1600	0	0	1700
	R	0.0 to 1600.0°C	9		OFF	9 ($09)	0	16000	1	0	17000
					ON	41 ($29)	0	1600	0	0	1700
	N	-200.0 to 1300.0°C	A		OFF	10 ($0A)	-2000	13000	1	-2000	13000
					ON	42 ($2A)	-200	1300	0	-200	1300
	E	-270.0 to 1000.0 °C	B		OFF	11 ($0B)	-2700	10000	1	-2700	10000
					ON	43 ($2B)	-270	1000	0	-270	1000
	L	-200.0 to 900.0°C	C		OFF	12 ($0C)	-2000	9000	1	-2000	9000
					ON	44 ($2C)	-200	900	0	-200	900
	U	-200.0 to 400.0°C	D		OFF	13 ($0D)	-2000	4000	1	-2000	4000
					ON	45 ($2D)	-200	400	0	-200	400
	W	0.0 to 1600.0°C	E		OFF	14 ($0E)	0	16000	1	0	23000
					ON	46 ($2E)	0	1600	0	0	2300
	Platinel 2	0.0 to 1390.0°C	F		OFF	15 ($0F)	0	13900	1	0	13900
					ON	47 ($2F)	0	1390	0	0	1390
RTD	JPt100	-200.0 to 500.0°C	0	ON	OFF	16 ($10)	-2000	5000	1	-2000	5000
					ON	48 ($30)	-200	500	0	-200	500
		-200.0 to 200.0°C	1		OFF	17 ($11)	-2000	2000	1	-2000	2000
					ON	49 ($31)	-200	200	0	-200	200
		0.0 to 300.0°C	2		OFF	18 ($12)	0	3000	1	0	3000
					ON	50 ($32)	0	300	0	0	300
		0.00 to 150.00°C	3		OFF	19 ($13)	0	15000	2	0	15000
					ON	51 ($33)	0	1500	1	0	1500
	Pt100	-200.0 to 850.0°C	4		OFF	20 ($14)	-2000	8500	1	-2000	8500
					ON	52 ($34)	-200	850	0	-200	850
		-200.0 to 500.0°C	5		OFF	21 ($15)	-2000	5000	1	-2000	5000
					ON	53 ($35)	-200	500	0	-200	500
		-200.0 to 200.0°C	6		OFF	22 ($16)	-2000	2000	1	-2000	2000
					ON	54 ($36)	-200	200	0	-200	200
		0.0 to 300.0°C	7		OFF	23 ($17)	0	3000	1	0	3000
					ON	55 ($37)	0	300	0	0	300
		0.00 to 150.00°C	8		OFF	24 ($18)	0	15000	2	0	15000
					ON	56 ($38)	0	1500	1	0	1500
DC voltage	0-10mV	0.00 to 10.00 mV	9	ON	X	25 ($19)	0	1000	2	0	1000
	0-100mV	0.0 to 100.0 mV	A			26 ($1A)	0	1000	1	0	1000
	0-1V	0.000 to 1.000 V	B			27 ($1B)	0	1000	3	0	1000
	0-5V	0.000 to 5.000 V	D			29 ($1D)	0	5000	3	0	5000
	1-5V	1.000 to 5.000 V	E			30 ($1E)	1000	5000	3	1000	5000
	0-10V	0.00 to 10.00 V	F			31 ($1F)	0	1000	2	0	1000

*1: For thermocouples K, B, S, R, and W, the upper and lower input range limits may exceed their default values.

*2: When you change the switch settings and then power on the module, all stored data is initialized according to the hardware switch settings. An ‘X’ symbol in the SW1-3 column indicates that the switch setting is ignored.

*3: “Software Setting” refers to values specified for input type selection (IN). Any value not listed here is ignored.

*4: These are factory settings. When ‘set by software’ is selected, the initial value of input type selection (IN) is “1: Thermocouple K”.

Table A4.1 Input Type Selection (2/2) (SW1-1 = ON)

Input Type		Instrument Range	Input Type Selector Switch*2			Software Setting	Input Range*1				
							Default			Allowable Range	
			SW5	SW1-4	SW1-3	IN*3	RL	RH	DEC.P	RL	RH
Software setting *4			0	OFF	X						
Thermocouple	K	-328.0 to 2498.0°F	1	OFF	OFF	1 ($01)	-3280	24980	1	-4540	24980
					ON	33 ($21)	-328	2498	0	-454	2498
		-328.0 to 1832.0°F	2		OFF	2 ($02)	-3280	18320	1	-4540	24980
					ON	34 ($22)	-328	1832	0	-454	2498
		-328.0 to 932.0°F	3		OFF	3 ($03)	-3280	9320	1	-3280	9320
					ON	35 ($23)	-328	932	0	-328	932
	J	-328.0 to 2192.0°F	4		OFF	4 ($04)	-3280	21920	1	-3280	21920
					ON	36 ($24)	-328	2192	0	-328	2192
		-328.0 to 932.0°F	5		OFF	5 ($05)	-3280	9320	1	-3280	9320
					ON	37 ($25)	-328	932	0	-328	932
	T	-454.0 to 752.0°F	6		OFF	6 ($06)	-4540	7520	1	-4540	7520
					ON	38 ($26)	-454	752	0	-454	752
	B	32 to 2912°F	7		OFF	7 ($07)	32	2912	0	32	3272
					ON	39 ($27)	32	2912	0	32	3272
	S	32 to 2912°F	8		OFF	8 ($08)	32	2912	0	32	3092
					ON	40 ($28)	32	2912	0	32	3092
	R	32 to 2912°F	9		OFF	9 ($09)	32	2912	0	32	3092
					ON	41 ($29)	32	2912	0	32	3092
	N	-328.0 to 2372.0°F	A		OFF	10 ($0A)	-3280	23720	1	-3280	23720
					ON	42 ($2A)	-328	2372	0	-328	2372
	E	-454.0 to 1832.0°F	B		OFF	11 ($0B)	-4540	18320	1	-4540	18320
					ON	43 ($2B)	-454	1832	0	-454	1832
	L	-328.0 to 1652.0°F	C		OFF	12 ($0C)	-3280	16520	1	-3280	16520
					ON	44 ($2C)	-328	1652	0	-328	1652
	U	-328.0 to 752.0°F	D		OFF	13 ($0D)	-3280	7520	1	-3280	7520
					ON	45 ($2D)	-328	752	0	-328	752
	W	32 to 2912°F	E		OFF	14 ($0E)	32	2912	0	32	4172
					ON	46 ($2E)	32	2912	0	32	4172
	Platinel 2	32.0 to 2534.0°F	F		OFF	15 ($0F)	320	25340	1	320	25340
					ON	47 ($2F)	32	2534	0	32	2534
RTD	JPt100	-328.0 to 932.0°F	0	ON	OFF	16 ($10)	-3280	9320	1	-3280	9320
					ON	48 ($30)	-328	932	0	-328	932
		-328.0 to 392.0°F	1		OFF	17 ($11)	-3280	3920	1	-3280	3920
					ON	49 ($31)	-328	392	0	-328	392
		32.0 to 572.0°F	2		OFF	18 ($12)	320	5720	1	320	5720
					ON	50 ($32)	32	572	0	32	572
		32.0 to 302.0°F	3		OFF	19 ($13)	320	3020	1	320	3020
					ON	51 ($33)	32	302	0	32	302
	Pt100	-328.0 to 1562.0°F	4		OFF	20 ($14)	-3280	15620	1	-3280	15620
					ON	52 ($34)	-328	1562	0	-328	1562
		-328.0 to 932.0°F	5		OFF	21 ($15)	-3280	9320	1	-3280	9320
					ON	53 ($35)	-328	932	0	-328	932
		-328.0 to 392.0°F	6		OFF	22 ($16)	-3280	3920	1	-3280	3920
					ON	54 ($36)	-328	392	0	-328	392
		32.0 to 572.0°F	7		OFF	23 ($17)	320	5720	1	320	5720
					ON	55 ($37)	32	572	0	32	572
		32.0 to 302.0°F	8		OFF	24 ($18)	320	3020	1	320	3020
					ON	56 ($38)	32	302	0	32	302
DC voltage	0-10mV	0.00 to 10.00 mV	9	ON	X	25 ($19)	0	1000	2	0	1000
	0-100mV	0.0 to 100.0 mV	A			26 ($1A)	0	1000	1	0	1000
	0-1V	0.000 to 1.000 V	B			27 ($1B)	0	1000	3	0	1000
	0-5V	0.000 to 5.000 V	D			29 ($1D)	0	5000	3	0	5000
	1-5V	1.000 to 5.000 V	E			30 ($1E)	1000	5000	3	1000	5000
	0-10V	0.00 to10.00 V	F			31 ($1F)	0	1000	2	0	1000

*1: For thermocouples K, B, S, R, and W, the upper and lower input range limits may exceed their default values.

*2: When you change the switch settings and then power on the module, all stored data is initialized according to the hardware switch settings. An ‘X’ symbol in the SW1-3 column indicates that the switch setting is ignored.

*3: “Software Setting” refers to values specified for input type selection (IN). Any value not listed here is ignored.

*4: These are factory settings. When ‘set by software’ is selected, the initial value of input type selection (IN) is “1: Thermocouple K”.

Table A4.2 Power Frequency Selection

Power Frequency Selection	Power Frequency Selector Switch (SW1-2)	Software Setting[*1]	Remarks
		FREQ	
50 Hz	OFF	0	Factory setting
60 Hz	ON	1	

*1: “Software Setting” refers to values specified for FREQ. Any value not listed here is ignored. To enable software setting, set the input type selector switches to “set by software”, that is, “SW5=0; SW1-4=OFF”. If software setting is enabled, the initial power frequency setting follows SW1-2. This may be subsequently overridden using the “software setting”.

A4.2 Attaching/Detaching Modules

After setting hardware switches, attach the module to the base unit. This section describes the procedure for attaching/detaching the module and the necessary precautions.

■ Attaching Modules

Figure A4.3 shows how to attach this module to the base module. First hook the anchor slot at the bottom of the module to be attached onto the anchor pin on the bottom of the base module. Push the top of this module towards the base module until the anchor/release button clicks into place.

CAUTION

Always switch off the power before attaching or detaching a module.

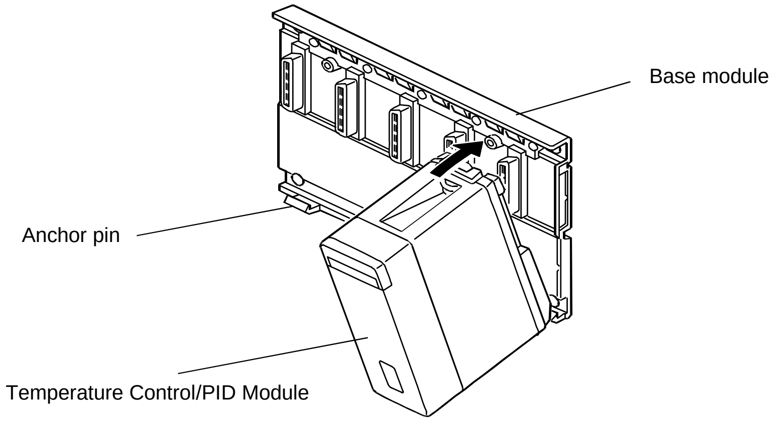


Figure A4.3 Attaching Modules

CAUTION

DO NOT bend the connector on the rear of the module by force during the above operation. If the module is pushed with improper force, the connector may bend causing an error.

■ Detaching Modules

To remove this module from the base module, reverse the above operation. Press the anchor/release button on the top of this module to unlock it and tilt the module away from the base module. Then lift the module off the anchor pin at the base.

■ Attaching Modules in Intense Vibration Environments

If the module is used in intense vibration environments, fasten the module with a screw. Use screws of type listed in the table below. Insert these screws into the screw holes on top of the module and tighten them with a Phillips screwdriver.

Screw Required
M4-size Binder screw 12 to 15 mm long (or 14 to 15 mm if fitted with a washer)

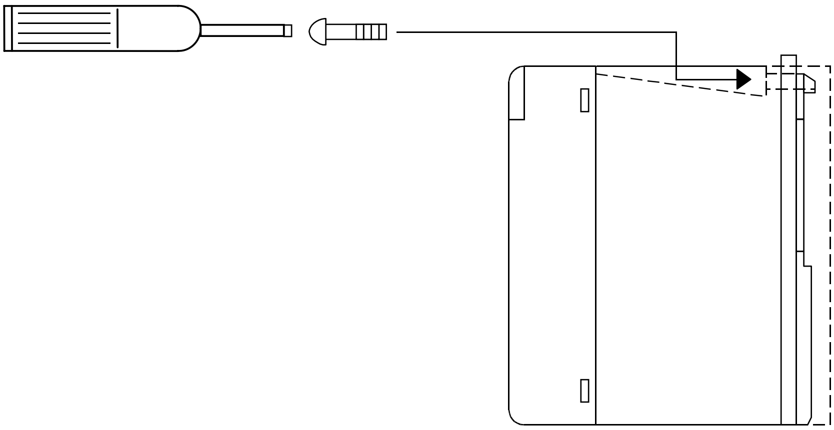


Figure A4.4 Tightening the Module

A4.3 Wiring

After attaching the module to the base module, connect the input and output signal wires to the module. This section describes wiring precautions. Actual wiring can be performed before or after program creation, at your convenience.

A4.3.1 Wiring Precautions

To wire the module, see Section A4.3.2, “Terminal Wiring Diagram” and observe the following precautions.

(1) For thermocouples with a terminal box, use the specified compensating wire.

(2) For resistance temperature detector (RTD) input, use a lead wire with low resistance (10 Ω/wire max.) with the three wires having identical resistance.

(3) To protect the input circuitry against noise, observe the following precautions.

- (a) The wiring for the input circuit must be kept as far away as possible from the power supply or grounding circuitry.
- (b) Twisting the input wire at short equal intervals may be effective against interference from electromagnetic-induced noise.
- (c) Using a shielded wire may effectively protect against static-induced noise. Strip off the outer shield to expose the wire, and ground it with an FG clamp. (two-point grounding should be avoided.)
- (d) Attach a ferrite core to the wire near the exit of the panel enclosure to reduce the effect of noise if the input wiring leads outside the panel enclosure.

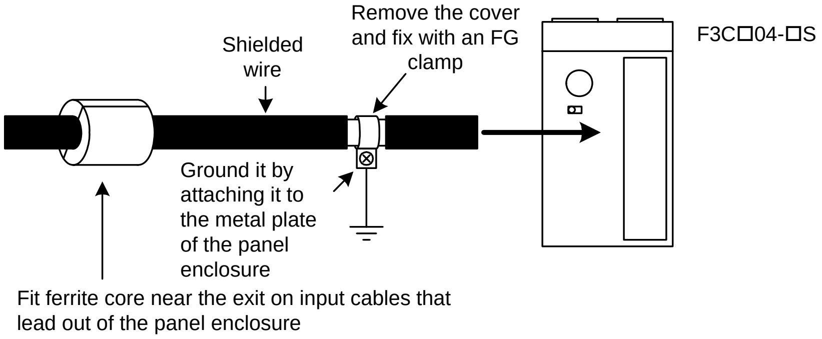


Figure A4.5 Wiring Precautions

Table A4.3 FG Clamps and Ferrite Core Recommended by Yokogawa

FG clamp	Kitagawa Kogyo Industries Co., Ltd.	FGC Series
Ferrite core	Kitagawa Kogyo Industries Co., Ltd.	RFC Series
	TDK Corporation	ZCAT Series
	Tokin Corporation	ESD-SR Series

(4) We recommend using crimp contact (for 3.5mm screw) with insulating sleeve to connect a signal wire to a terminal.

Table A4.4 Connection Method and Recommended Terminal Block Type

Wire Type	Shielded twist-pair wire
Wire's Rated Temperature	75°C min.
Wire Connection Method	Using solderless terminal

	Manufacturer	Model	Compatible Wire Size
Solderless terminals and compatible wire size	Japan Solderless Terminal Mfg Co., Ltd.	V1.25-M3	AWG22 to 18 (0.33 to 0.82 mm^2) (Copper wire)
	Nippon Tanshi Co., Ltd.	RAV1.25-3.5	
	Japan Solderless Terminal Mfg Co., Ltd.	V1.25-M4	
	Japan Solderless Terminal Mfg Co., Ltd.	V2-M4	AWG16 to 14 (1.3 to 2.1 mm^2) (Copper wire)
Crimping Torque	0.8 N·m (7.1 lbf·in)		

(5) If you have an open collector driving an auxiliary relay or other inductive load, install a diode close to and parallel to the load to eliminate sparks, as shown in Figure A4.6.

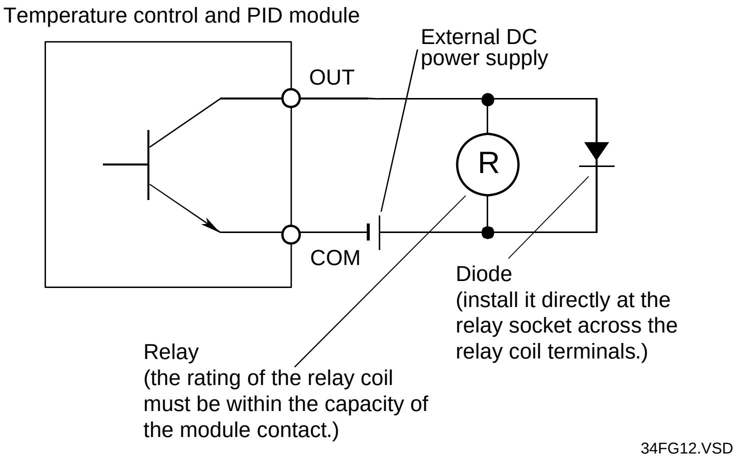


Figure A4.6 Surge Suppressor

CAUTION

If you configure an output terminal as an open collector and have it drive an auxiliary relay or other inductive load, install a surge suppressor as described above. If the output terminal is subjected to a surge voltage exceeding the maximum allowable rating of the output circuit, the circuit may be damaged permanently.

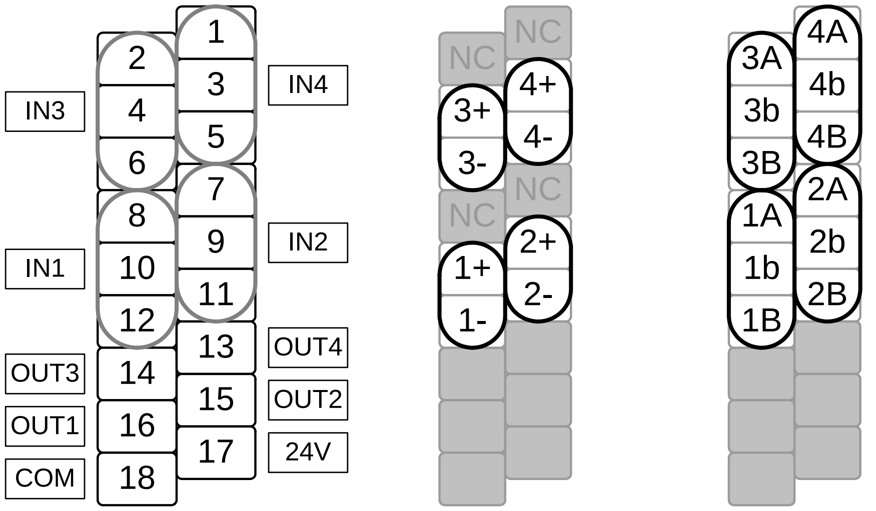
(6) If you have an open collector driving a solid state relay (SSR), install a bleeder resistor across the SSR terminals. The resistance should be determined, taking into consideration the off leakage current of the output terminal and the SSR's recovery voltage. For instance, if the SSR's recovery voltage is 1 V or more, the resistance of the bleeder resistor should be 10 kΩ (= 1 V/0.1 mA) or less.

CAUTION

If you configure an output terminal as an open collector and have it drive an SSR, install a bleeder resistor as described above. Note that the SSR may fail to turn off depending on the OFF-leakage current, the resistance of the bleeder resistor and the SSR's recovery voltage. For details, see the user's manual for the SSR.

A4.3.2 Terminal Wiring Diagram

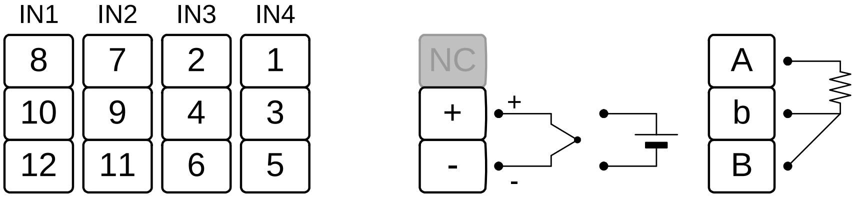
■ Terminal Diagram and Wiring Example for F3CU04-0S



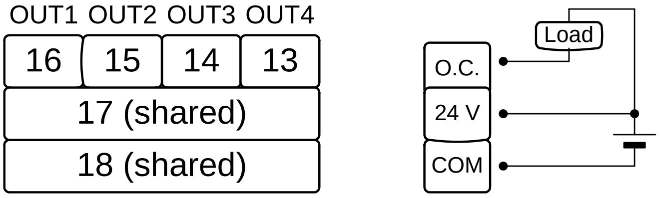
a) Terminal Assignment Diagram

For thermocouple and DC voltage input

For RTD input



b) Input Terminal Wiring Diagram



c) Output Terminal Wiring Diagram

Figure A4.7 Terminal Wiring Diagram

WARNING

No wire must be connected to the terminals marked "NC" in the terminal assignment diagram or terminal wiring diagram. Otherwise, the module will not function normally. All output terminals must be wired following instructions given in Section A4.3.1, "Wiring Precautions."

■ Output Terminal Wiring Example for F3CU04-0S

The output terminals of F3CU04-0S are open collector only.

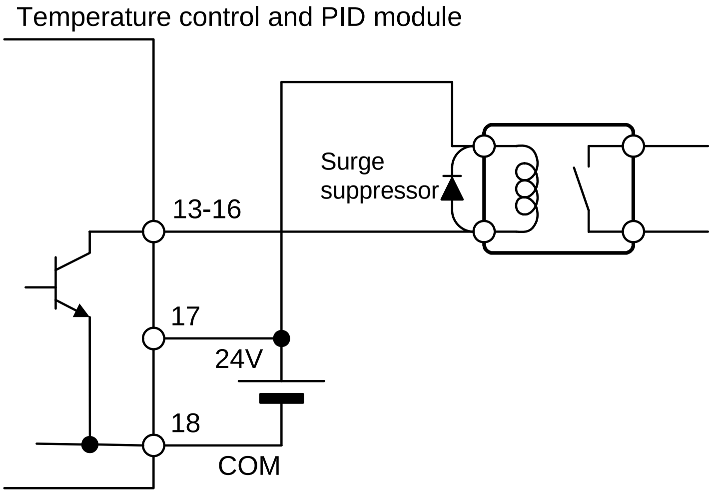


Figure A4.8 Wiring Example for Connecting a Relay

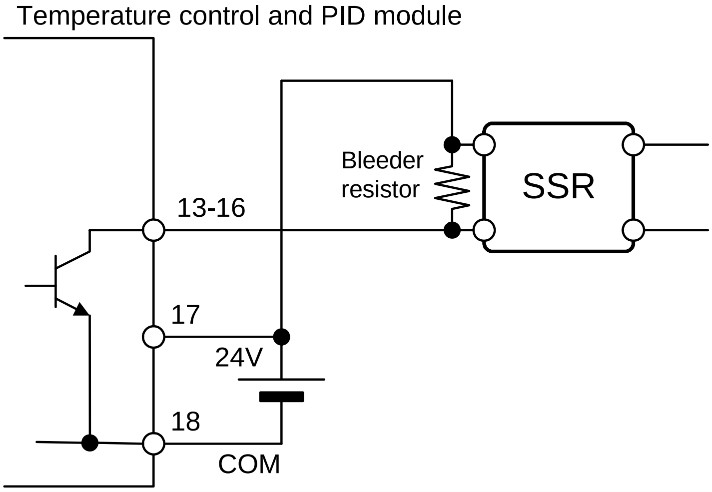
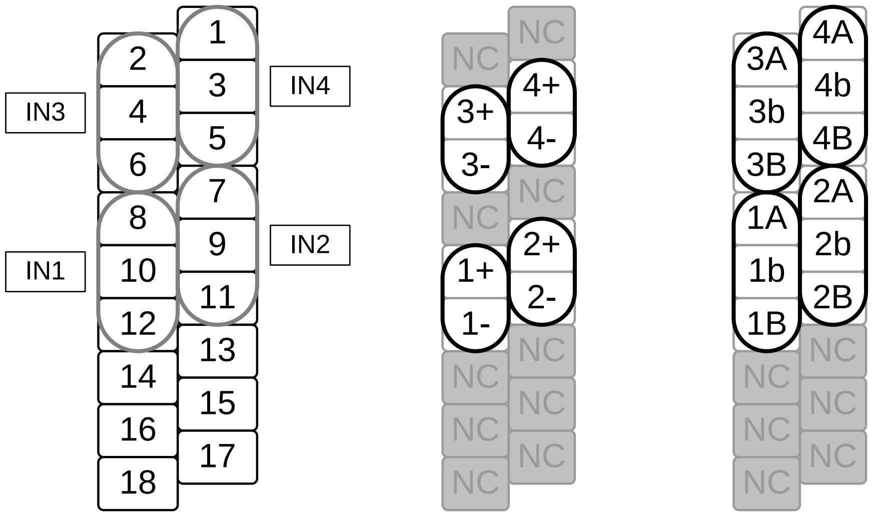


Figure A4.9 Wiring Example for Connecting an SSR

CAUTION

Read Section A4.3.1, "Wiring Precautions" before performing wiring.

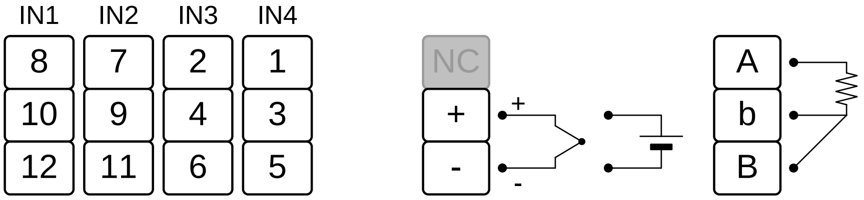
■ Terminal Diagram and Wiring Example for F3CU04-1S



a) Terminal Assignment Diagram for F3CU04-1S

For thermocouple and DC voltage input

For RTD input



b) Input Terminal Wiring Diagram for F3CU04-1S

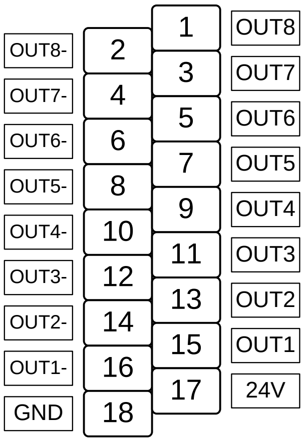
Figure A4.10 Terminal Wiring Diagram

WARNING

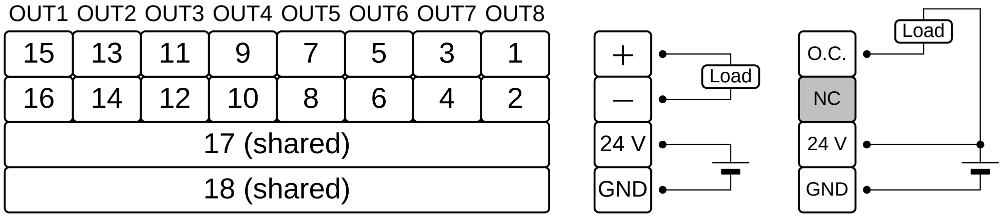
No wire must be connected to the terminals marked "NC" in the terminal assignment or terminal wiring diagram. Otherwise, the module will not function normally.

WARNING

All output terminals of F3CU04-1S are located on the right terminal block. Terminals 13-18 are not output terminals on F3CU04-1S, but are output terminals on F3CU04-0S. No wire must be connected to these terminals on F3CU04-1S. Otherwise, the module will not function normally.



a) Output Terminal Assignment for F3CU04-1S



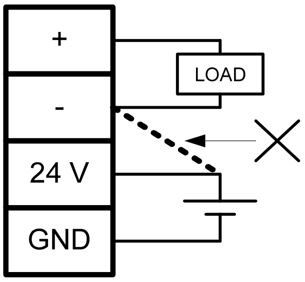
b) Output Terminal Wiring Diagram for F3CU04-1S (Analog Output) (Open Collector Output)

Note: The output type may be selected for each loop of F3CU04-1S. For details on output type selection, see Section B3.1.4, "Setting Output Terminals." Wiring depends on and thus must be done according to the output type selected.

Figure A4.11 Output Terminal Wiring Diagram for F3CU04-1S

WARNING

If F3CU04-1S is used for current output to drive an external load with the OUTPUT parameter set to "Analog," ensure that the wires from the 24 V power supply are connected correctly as shown in the above figure before supplying the power to the module. The module will be damaged if the positive wire of the 24 V power supply is wrongly connected to a negative load terminal (terminal number 2, 4, 6, 8, 10, 12, 14, or 16).



WARNING

If the output terminals of F3CU04-1S are configured as open collector output, share the 24 V DC power supply of the module as shown in the above figure. No wire must be connected to the terminals of F3CU04-1S marked "NC" in the output terminal wiring diagram for open collector output if the Output Type Selection (OUTPUT) parameter is set to “Open Collector”.

■ Output Terminal Wiring Example for F3CU04-1S

The output terminals of F3CU04-1S may be configured either for open collector or analog output (4-20 mA) for each loop by software.

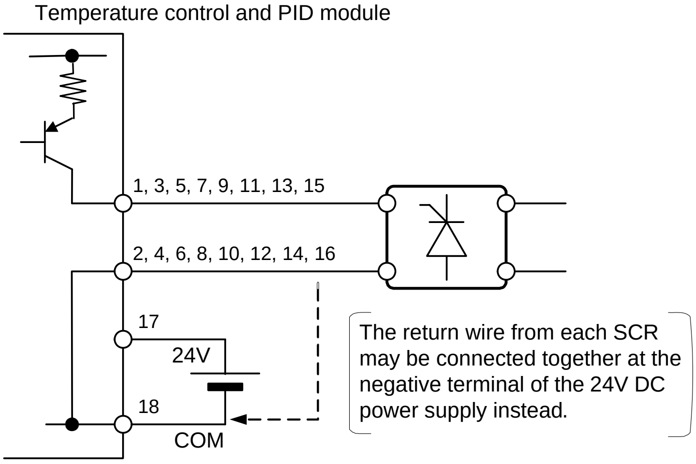


Figure A4.12 Wiring Example for Connecting an SCR (analog output)

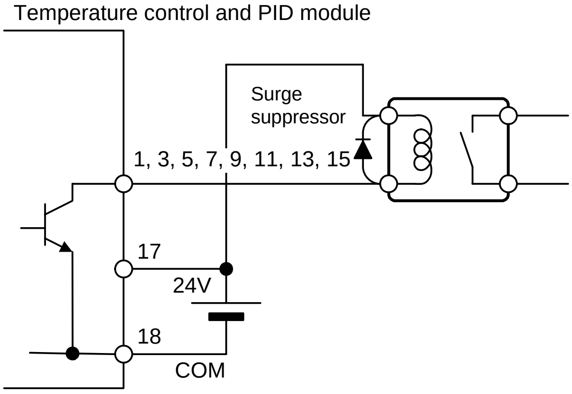


Figure A4.13 Wiring Example for Connecting a Relay (open collector output)

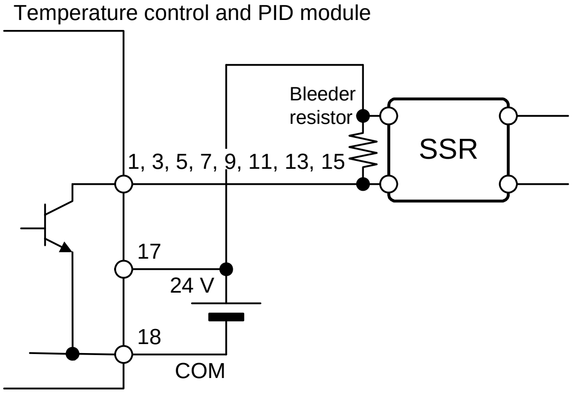


Figure A4.14 Wiring Example for Connecting an SSR (open collector output)

WARNING

In each wiring example, no wire must be connected to any terminal whose terminal number is not shown in the diagram. Always read Section A4.3.1, "Wiring Precautions" before performing wiring.

FA-M3

Temperature Control and PID Module
Part B: Parameter Description

IM 34M6H62-02E 2nd Edition

Part B describes the parameters of the module.

B1. Accessing the Module

The relays and registers of this module can be accessed from a sequence CPU or BASIC CPU. This chapter explains the precautions when reading from or writing to the module from a CPU. For details on the relays and registers provided with this module, see Chapter B2, "Types of Relays and Registers".

Content	See
Accessing from a CPU	B1.1 Accessing Using Sequence Instructions
Accessing from a BASIC CPU	B1.2 Accessing Using BASIC
Precautions when reading from and writing to the module	B1.3 Writing and Reading after Powering On

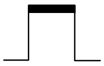
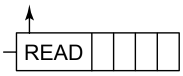
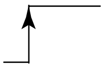
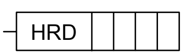
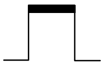
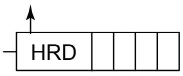
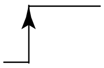
B1.1 Accessing Using Sequence Instructions

Accesses to this module from a sequence CPU can be classified into three types, namely, reading from data registers, writing to data registers and reading from input relays.

■ Reading Registers (READ / HRD)

Use the Read instruction or High Speed Read instruction for reading registers. Reading is performed in 16-bit units.

Table B1.1 Reading Registers

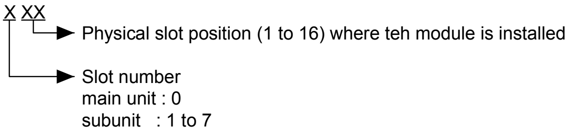
Function No.	Instruction	Mnemonic	Symbol	Is Input condition Required?		Execution Condition	Step count	Processing unit	Carry
				Yes	No				
81	Read	READ		✓	—		5	16 bits	—
81P		↑READ					6		
83	High speed read	HRD		✓	—		5	16 bits	—
83P		↑HRD					6		

● Description of Symbols

READ	SL	n1	D	k
HRD	SL	n1	D	k

SL : Slot Number
n1 : First Data Position Number for Reading
D : First Device Number for Writing Read Data
k : Transfer Data Count

Slot Number: a 3-digit integer (leading '0's may be omitted)



Physical slot position (1 to 16) where teh module is installed

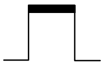
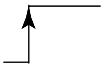
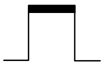
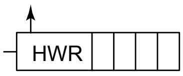
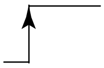
Slot number
main unit : 0
subunit : 1 to 7

First Data Position Number for Reading : Data position number from which to start reading
First Device Number for Writing Read Data : For available devices, (see "Sequence CPU Modules - Instructions" manual.)
Transfer Data Count : Number of data to read

Writing to Registers (WRITE / HWR)

Use the Write instruction or High Speed Write instruction for writing to registers. These instructions write the value stored in the specified data device number into the specified area. Writing is performed in 16-bit units.

Table B1.2 Writing to Registers

Function No.	Instruction	Mnemonic	Symbol	Is Input condition Required?		Execution Condition	Step count	Processing unit	Carry
				Yes	No				
82	Write	WRITE		✓	—		5	16 bits	—
82P		↑ WRITE					6		
84	High speed write	HWR		✓	—		5	16 bits	—
84P		↑ HWR					6		

Description of Symbols

WRITE	S	SL	n2	k

HWR	S	SL	n2	k

S : First Device Number for Write Data
SL : Slot Number
n2 : First Data Position Number for Writing
k : Transfer Data Count

First Device Number for Write Data: First device number containing write data. For available devices, see "Sequence CPU Instruction Manual - Instructions".

Slot Number: a 3-digit integer (leading '0's may be omitted)

X XX
XX → Physical slot position (1 to 16) where the module is installed
X → Slot number
main unit : 0
subunit : 1 to 7

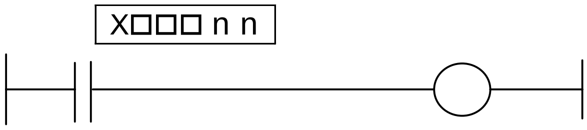
First Data Position Number for Writing : Data position number from which to start writing
Transfer Data Count : Number of write data

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, “Reading and Writing after Powering On”.

■ Reading Input Relays

Use the LD and other basic instructions to read from a relay in bit units.



☐☐☐ denotes the slot number where the module is installed.

Figure B1.1 Reading Relays

For details on sequence instructions and programming, see:

- IM 34M6P14-01E Sequence CPU — Functions (for F3SP66-4S, F3SP67-6S)
- IM 34M6P13-01E Sequence CPU — Functions (for F3SP28-3N/3S, F3SP38-6N/6S, F3SP53-4H/4S, F3SP58-6H/6S, F3SP59-7S)
- IM 34M6P12-03E Sequence CPU — Instructions
- IM 34M6Q15-01E FA-M3 Programming Tool WideField2 User's Manual

TIP

This module is provided with an interrupt function for use with BASIC CPUs and other non-sequence CPUs. As the interrupt function is not designed for use with sequence CPUs, it may not work as expected when used with sequence CPUs. Hence, do not use the interrupt function with a sequence CPU.

B1.2 Accessing Using BASIC

Table B1.3 lists the BASIC statements that can be used to access this module from a BASIC CPU.

Table B1.3 Available BASIC Statements

Function	Syntax	Description
Declare use of module	Example: ASSIGN CX04=SL SL : Slot number	Defines the mapping between module and slot number. Always execute this statement before accessing this module. Execute this statement in the main program.
Read data from registers	Example: ENTER SL, n NOFORMAT; I or ENTER SL NOFORMAT; I(*) SL : Slot number n : Data position number I : Name of input variable for storing read data	Reads data position number n of the module installed in slot SL and stores it in input variable I. If the data position number is omitted, reads data sequentially starting from register 1 into input array variable I(*).
Write data to registers	Example: OUTPUT SL, n NOFORMAT;I or OUTPUT SL NOFORMAT;I(*) SL : Slot number n : Data position number I : Output variable name storing data to be written	Writes output variable I to data position number n of the module installed in slot SL. If the data position number is omitted, writes output array variable I(*) sequentially to registers, starting at data position number 1.
Read input relays	Example: STATUS SL,101; P SL : Slot number P : Name of variable for storing read data	Reads input relays X□□□01 to X□□□16 of the module installed in slot number SL and stores the data in variable P.
Interrupt detection	Example: ON INT SL,n GOTO {Label, etc.} ON INT SL,n GOSUB {Label, etc.} ON INT SL,n CALL {Subprogram} SL : Slot number n : Terminal number	The module generates an interrupt when it detects an OFF→ON transition of input relay for terminal number n of the module installed in slot number SL. Refer to the list of relays to find out which relays support interrupts.

CAUTION

Using a BASIC statement not listed in Table B1.3 may produce unexpected results.

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, “Reading and Writing after Powering On”.

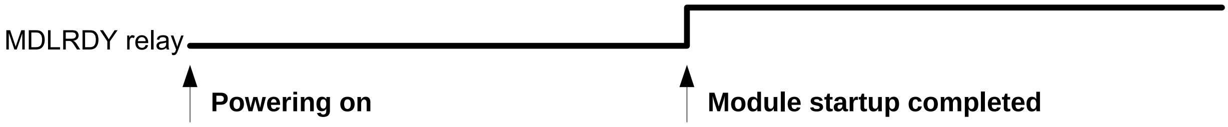
B1.3 Writing and Reading after Powering On

Do not read from and write to I/O data registers before module startup completes. This can be ensured by checking that the MDLRDY relay is set.

Table B1.4 Relays Related to Writing after Powering On

Input Relay Number X□□□nn*1	Symbol	Description	Data Values
X16	MDLRDY	Module startup has completed	0: During startup, 1: Startup completed

*1: □□□ denotes the slot number where the module is installed.



Data written before startup is completed may be ignored. Similarly, values for any data read may be invalid.

All data read or written after startup has completed are valid.

Figure B1.2 Checking for Module Startup Completion after Powering On

After power on, it takes up to approximately 2 seconds for the module startup to complete (startup initialization). Any data written during this period may be ignored. For instance, if a write instruction to the special relay M35, “On for 1 Scan after Program Start” is used in a sequence program to start a program after power on, the written data may be ignored.

CAUTION

If data is written before the MDLRDY relay turns on, such data may be overwritten during module initialization. If data is written for a stored parameter, the data may be overwritten by stored data; if data is written for a non-stored parameter, the data may be overwritten by its default parameter value.

Similarly, if data is read before the MDLRDY relay is set, the data read may be invalid.

B2. Types of Relays and Registers

This module provides input relays and input/output data registers for accessing the module from a CPU module. This chapter describes these relays and registers.

B2.1 Types of Relays

This module has 7 input relays for each loop and 4 system-wide input relays, but no output relay. Table B2.1 (1/2) lists the loop-specific input relays. Table B2.1 (2/2) lists the system-wide input relays. For details on each relay, refer to the text section indicated in the “See Also” column.

Table B2.1 List of Input Relays (1/2)

Input Relay Number X□□□nn*1				Symbol	Description	Data Range	Interrupt	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
X01	X09	X17	X25	ALM1.R	Alarm 1	0: Normal, 1: Alarm 1	✓	C8.
X02	X10	X18	X26	ALM2.R	Alarm 2	0: Normal, 1: Alarm 2	✓	
X03	X11	X19	X27	A/M	Auto/manual *2	0: Auto, 1: Manual	—	B3.4
X04	X12	X20	X28	AT.RDY	Auto-tuning completed	0: AT in progress 1: AT completed	✓	C5.2
X05	X13	X21	X29	HOUT.R	Heating control output	0: OFF, 1: ON	—	C2.4
X06	X14	X22	X30	COUT.R	Cooling control output	0: OFF, 1: ON	—	
X07	X15	X23	X31	FUNC.ERR	Burnout or error detected *3	0: Normal 1: Error detected	✓	C3.5 C10.

*1: □□□ denotes the slot number where the module is installed.

*2: For details on how to check the operation status in the cascade control mode, see the description for the cascade control mode.

*3: Denotes that self-diagnostics has detected a burnout, AD converter error or other errors, which prohibits normal operation.

Table B2.1 List of Input Relays (2/2)

Input Relay Number X□□□nn*1	Symbol	Description	Data Range	Interrupt	See Also
X08	CMDRDY	Command processing completed	0: Processing in progress; 1: Processing completed	✓	B2.3
X16	MDLRDY	Module startup completed	0: Startup in progress; 1: Startup completed	✓	B1.3
X24	SETUP.R	Setup mode	0: Normal operation mode 1: Setup mode	✓	B2.3
X32	SPWR.R	Write SP to EEPROM completed	0: Write in progress or not started 1: Write completed	✓	B2.4

*1: □□□ denotes the slot number where the module is installed.

TIP

A “✓” mark in the “Interrupt” column denotes that the module allows an interrupt to be sent to the CPU module when the input relay changes from 0 to 1. This allows a program on the CPU module to easily detect, say, an alarm. For details on interrupt handling, read the instruction manual for the software used.

TIP

Input relays are refreshed at intervals defined by the input sampling period (100 or 200 ms) of the module, except that the HOUT.R and COUT.R relays are refreshed at refreshing intervals for output terminals (1/1000 of cycle time or 10 ms, whichever is longer).

CAUTION

An interrupt that is sent to the CPU module immediately after module startup may be ignored if the CPU module is not ready to receive interrupts. Therefore, always check the status of the module immediately after startup by reading the state of individual relays.

B2.2 Types of Registers

This module is provided with input/output data registers for configuring module operation and reading operation status. Registers for configuration include basic setup elements, as well as supplementary setup elements for supporting various modes of operation. Set these registers appropriately to suit the intended usage. In addition to registers for reading the status of individual loops, other registers are provided to store process data for all loops, arranged sequentially within a data area. Table B2.2 lists the categories of I/O data registers provided, along with a short description for each category. Table B2.3 and subsequent tables list the I/O data registers by category.

Table B2.2 Structural Overview of I/O Data Registers

Category			Description	See Also
Common	Common process data		These are basic process-related data for all loops, comprising constantly-monitored process-related data including PV, control set point and control output.	B2.2.1
	Analog output settings		These parameters are only available for F3CU04-1S. They can be used to specify analog output of a specific value (4-20 mA) for any output terminal not used for control output.	B2.2.2
	Setup control parameters		Use these parameters to enable various settings, required when controller parameters or I/O parameters are updated. For details on the procedure, see Section B2.3, “How to Enable Settings.”	B2.2.3 B2.3
	Function control parameters		Use these parameters to configure the operation of module functions on a module-wide basis.	B2.2.4
	Controller parameters		Use these parameters to set up the basic operation of the module, such as input sampling period and controller mode, on a module-wide basis.	B2.2.5 B3.1
Loops 1 to 4	Process data		These are process-related data for each loop. They include PV, control set point, control output, error status, etc., which can be used for monitoring the operation of the module.	B2.2.8
	Operation control parameters		Use these parameters to control the operation of individual loops. They control run/stop, automatic/manual/cascade, auto-tuning and other operation control modes, as well as manual output and other operation control parameters.	B2.2.9
	I/O parameters	I/O type settings	Use these parameters to select input and output types for individual loops. These are the most basic loop-specific parameters.	B2.2.10 B3.2
		Input range settings	Use these parameters to change input ranges and other input-related settings or select burnout operations for individual loops.	
		PV range settings	These parameters are only valid in the two-input changeover mode, and are used for defining the PV range in two-input changeover control. By default, the PV range follows the input range of the even-numbered loop.	
	Operation parameters	Two-input changeover function settings	Use these parameters to perform setup when using the two-input changeover mode. They can be used for setting the changeover method and temperature.	B3.3
		SP-related function settings	Use these parameters to define set points for individual loops, as required. They can be used for setting upper and lower input limits, rate-of-change, and tracking.	
		PV-related function settings	Use these parameters to perform PV-related setup for individual loops, as required. They can be used for configuring PV correction, square root extraction and input filtering.	
		Operation-related function settings	Use these parameters to configure control operation for individual loops, as required. They can be used to set up dynamic auto-tuning, the “super” function, control mode, and other control-related functions.	
		Output-related function settings	Use these parameters to configure control output for individual loops, as required. They can be used for setting control output cycle time and rate-of-change limits.	
		Alarm-related function settings	Use these parameters to set up the operation of the alarm functions for individual loops as required. They can be used to set the alarm type, hysteresis, and ON delay timer.	
		PID parameters 1	Use these parameters to configure PID control-related functions for individual loops. They can be used for specifying set points, alarm preset values, proportional band, integral time, and derivative time. Up to four parameter groups can be defined for each loop.	
		PID parameters 2		
		PID parameters 3		
		PID parameters 4		

CAUTION

Controller parameters and I/O parameters must be enabled before any written content can take effect. For details on how to enable such parameters, see Section B2.3, “How to Enable Settings.”

■ Common Precautions for Registers

CAUTION

Only registers listed in Table B2.3 and subsequent tables are valid data registers provided with this module. Any number missing from the “Data Position Number” column in these tables is omitted intentionally. When a value written to a valid data register exceeds the valid data range, as indicated in the “Data Range” column in these tables, the written value is ignored and the original value is restored. An out-of-range value written to a controller parameter or I/O parameter, however, remains and is returned as read data until an instruction is executed to enable the parameter, at which time, the out-of-range value will be restored to the original value. At the same time, an error status is returned.

Any data written to a read-only (R/O) data register is ignored and does not affect module operation. However, if the register is read immediately after the write operation (for example, within the same scan of the sequence program), the written value may be returned.

Any data written to an undefined register or a register that is considered invalid for a module type or controller mode is ignored and does not affect module operation. If the register is read after the write operation, however, the written value or a register-specific value may be returned. The register-specific value may or may not be a constant value.

CAUTION

The “Attribute” column in a table indicates whether a register can be read and written. “RO” indicates a read-only register, whilst “RW” indicates a register that can be read, as well as written.

A “✓” mark in the “Stored” column indicates that the content of the register is stored, and need not be re-written to the module after power off and on. When changing the value of a stored register, beware, however, that there is a maximum limit to the number of write operations allowed on the EEPROM. By default, writing to a stored register automatically updates the data stored in the EEPROM. To suspend this updating of the EEPROM, you should disable the backup function.

CAUTION

You need to execute a specific procedure every time to back up set point values. Otherwise, stored set points will not be updated.

CAUTION

Up to 100,000 write operations to the EEPROM are allowed. Beware that this write limit may be exceeded if registers with a “✓” mark in the “Stored” column are frequently updated. In such situations, you should disable the backup function by setting “NBKUP=1”. Note, however, that the NBKUP register value itself is not stored, and is always reset to 0 at power up.

B2.2.1 Common Process Data

These are basic process-related data common to all loops, including PV, control set point, control output, and other constantly monitored process-related data.

Table B2.3 Common Process Data

	Data Position Number	Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
PV	1	PV.1	Process value	Industrial unit	-5.0 to 105.0% of (PRL to PRH)	—	RO	—	C3.
	2	PV.2				—	RO	—	
	3	PV.3				—	RO	—	
	4	PV.4				—	RO	—	
Control set point	11	CSP.1	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4.
	12	CSP.2				—	RO	—	
	13	CSP.3				—	RO	—	
	14	CSP.4				—	RO	—	
Control output	21	HOUT.1	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—	C2. C7.1
	22	HOUT.2				—	RO	—	
	23	HOUT.3				—	RO	—	
	24	HOUT.4				—	RO	—	
Cooling Control output	31	COUT.1	Cooling Control output	%	0 to OL: for heating/cooling output	—	RO	—	C7.1
	32	COUT.2				—	RO	—	
	33	COUT.3				—	RO	—	
	34	COUT.4				—	RO	—	
Operating Status	41	RUN.STUS.1	Operating Status	None	Each bit is on or off depending on the status. For details, see text section under “See Also.”	—	RO	—	C10.
	42	RUN.STUS.2				—	RO	—	
	43	RUN.STUS.3				—	RO	—	
	44	RUN.STUS.4				—	RO	—	
Error Status	51	ERR.STUS.1	Error Status	None	Each bit is on or off depending on the status. For details, see text section under “See Also.”	—	RO	—	C10.
	52	ERR.STUS.2				—	RO	—	
	53	ERR.STUS.3				—	RO	—	
	54	ERR.STUS.4				—	RO	—	

B2.2.2 Analog Output Settings

These are parameters available only for F3CU04-1S. They can be used to specify an analog continuous output of a specific value (4-20 mA) for any output terminal not used for controlled output.

Table B2.4 Analog Output Setting Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
61				AOUT1	Output preset value	%	-500 to 10500 (-5.00 to 105.00%)	0	RW	—	C2.5
62				AOUT2				0	RW	—	
63				AOUT3				0	RW	—	
64				AOUT4				0	RW	—	
65				AOUT5				0	RW	—	
66				AOUT6				0	RW	—	
67				AOUT7				0	RW	—	
68				AOUT8				0	RW	—	

CAUTION

This function is available only for F3CU04-1S. An Output Terminal Selection (OUTSEL1-8) parameter must be setup to output an output preset value specified here (see Section B2.2.7, "Controller Parameters").

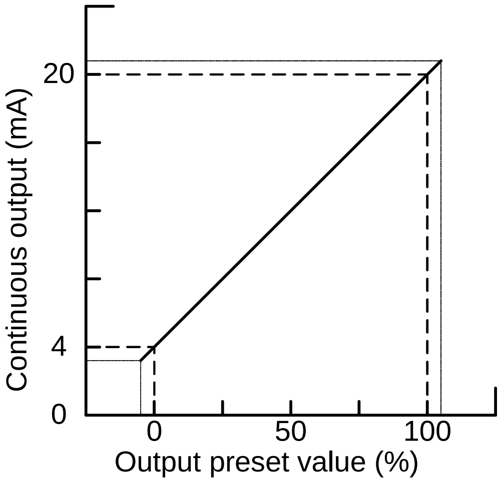


Figure B2.1 Relationship between Output Preset Value and Control Output

B2.2.3 Setup Control Parameters

Use these parameters to enable various settings, required when controller parameters and I/O parameters are updated. For details on the procedure, see Section B2.3, “How to Enable Settings”.

Table B2.5 Setup Control Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
71				SETUP	Setup	None	0: Disable setup instruction operand; 1: Enable setup instruction operand	0	RW	—	B2.3
72				OPE	Setup instruction operand	None	1, 2, 4, 8 or 16. For details, see Table B2.6.	0	RW	—	
73				STUS	Setup instruction response	None	0: No error; data position number of error register; or -32767: Invalid operation (SETUP = 0)	0	RO	—	

Table B2.6 Setup Instruction Operand Values (data position number: 72)

Preset Value	Description	Explanation
1	Initialize all parameters	Reverts all parameters to their factory settings. [*1]
2	Enable controller parameters	Enables the controller parameters, which are the most basic setup elements. The module also initializes I/O parameters and operation parameters based on the controller parameter values.
4	Enable I/O type settings	Enables the Input Type Selection parameter. The module also initializes input range settings, PV range settings and operation parameters based on the input type selection parameter value.
8	Enable input range settings	Enables the input range settings for measured input as required. The module initializes PV range settings and operation parameters based on these settings.
16	Enable PV range settings	Enables the PV range settings, which are required only in Two-input Changeover mode. The module initializes operation parameters based on these settings.

[*1] Input type and power frequency selection defined by the hardware switches have precedence over software settings.

CAUTION

Writing to the Setup Instruction Operand (OPE) register a value that is not listed in Table B2.6, “Setup Instruction Operand Values (data position number: 72),” has no effect on module operation. When the setup operation completes, the Setup Instruction Operand (OPE) register resets to 0.

CAUTION

For details on the procedures for enabling settings, see Section B2.3, “How to Enable Settings”.

B2.2.4 SP Backup Parameters

Use these parameters to back up SP values to the EEPROM.

Table B2.7 SP Value Backup Operation Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
74				SPWR	Write set point to EEPROM	None	0: Write not started or completed “WR”: Write to EEPROM	0	RW	—	B2.4

B2.2.5 Function Control Parameters

Use these parameters to define the operation of module functions on a module-wide basis.

Table B2.8 Function Control Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
75				NBKUP	Disable backup function	None	0: Enable backup to EEPROM 1: Disable backup to EEPROM	0	RW	—	C9

B2.2.6 EEPROM Write Counter

The EEPROM Write Counter counts the number of write-to-EEPROM executions. Once the value of the EEPROM write counter reaches its maximum limit, subsequent write-to-EEPROM executions are no longer counted, although they can still be executed until the EPPROM actually fails.

Table B2.9 SP Value Backup Operation Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
77 and 78 (long word)）				EEP.CNTR	EEPROM Write Counter	Times	1 to 100,000	—	RO	—	—

WARNING

You should disable the backup function if you expect parameters that are designated to be automatically stored to be frequently updated. By default, the module automatically stores the values of such parameters to the EEPROM each time they are updated. If parameter values are frequently updated and the number of write executions exceeds the maximum limit of 100,000, EEPROM may fail and subsequent storing is not guaranteed. Therefore, in situations where stored parameters are frequently updated, you should always disable the backup function using the NBKUP parameter.

CAUTION

The EEPROM write counter counts the number of write-to-EEPROM executions, but not the number of write executions to individual data position numbers.

B2.2.7 Controller Parameters

Use these parameters to set up the basic operation of the module, such as input sampling period and controller mode, on a module-wide basis.

Table B2.10 Controller Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
81				FREQ	Power frequency selection *1	None	0: 50Hz 1: 60Hz	—	RW	✓	C3.2
82				SMP	Input sampling period *2	None	0: 100 ms 1: 200 ms	1	RW	✓	B3.1.2
83				MD12	Controller mode	None	0: Two single loops 1: Two-input changeover control 2: Cascade control 3: Single loop (odd-numbered disabled) 4: Both loops disabled	0	RW	✓	C1.
84				MD34				0	RW	✓	
87				OUTPUT	Output type selection *3	None	Each terminal may be configured for either open collector or analog output.	0	RW	✓	C2.2
90				REV	Firmware revision	None	—	—	—	—	—
91				OUTSEL1	Output terminal selection *4	None	1-4: Heating outputs 1-4 11-14: Cooling outputs 1-4 21-28: Output preset values 1-8 *3	1	RW	✓	C2.3
92				OUTSEL2				2	RW	✓	
93				OUTSEL3				3	RW	✓	
94				OUTSEL4				4	RW	✓	
95				OUTSEL5				11	RW	✓	
96				OUTSEL6				12	RW	✓	
97				OUTSEL7				13	RW	✓	
98				OUTSEL8				14	RW	✓	

*1 The power frequency is set by default to the value set with the power frequency selector switch SW1-2. It can also be selected with SW1-2. For details on how to do so, see Section A4.1, “Selecting Input Types and Power Frequency”. If the power frequency is set using a hardware switch, the setting cannot be changed by software.

*2 This preset value imposes some restrictions on the number of loops that can be used. A value of 100ms allows up to 2 loops to be used, whilst a value of 200ms allows up to 4 loops to be used.

*3 This parameter is available only with F3CU04-1S. After selecting “Output preset value n” using the Output Terminal Selection parameter, you must also specify a corresponding Output Preset Value (AOUTn) parameter value. (see also Section B2.2.2, "Analog Output Settings").

*4 The F3CU04-0S module has only four output terminals. Thus, registers OUTSEL 5-8 are disabled and data range 21-28 is ignored.

CAUTION

The controller parameters must be enabled before any written content can take effect. For details on how to enable these parameters, see Section B2.3, “How to Enable Settings.”

CAUTION

Changing a controller parameter initializes other related parameters. Always set controller parameters before setting I/O parameters and operation parameters.

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, “Writing and Reading after Powering On.”

Table B2.11 Output Type Selection

Data Position Number	Symbol	Description		Relationship between Bit and Terminal									Data Range
			Terminal	15-8	7	6	5	4	3	2	1	0	
87	OUTPUT	Output type selection	1	—	—	—	—	—	—	—	—	✓	0: Open collector output (default) 1: Analog output
			2	—	—	—	—	—	—	—	✓	—	
			3	—	—	—	—	—	—	✓	—	—	
			4	—	—	—	—	—	✓	—	—	—	
			5	—	—	—	—	✓	—	—	—	—	
			6	—	—	—	✓	—	—	—	—	—	
			7	—	—	✓	—	—	—	—	—	—	
			8	—	✓	—	—	—	—	—	—	—	

Note: Setting a bit to 1 or 0 sets the corresponding terminal to analog output and open collector output respectively.

CAUTION

Output type selection is available only with model F3CU04-1S, provided with continuous output function.

B2.2.8 Process Data

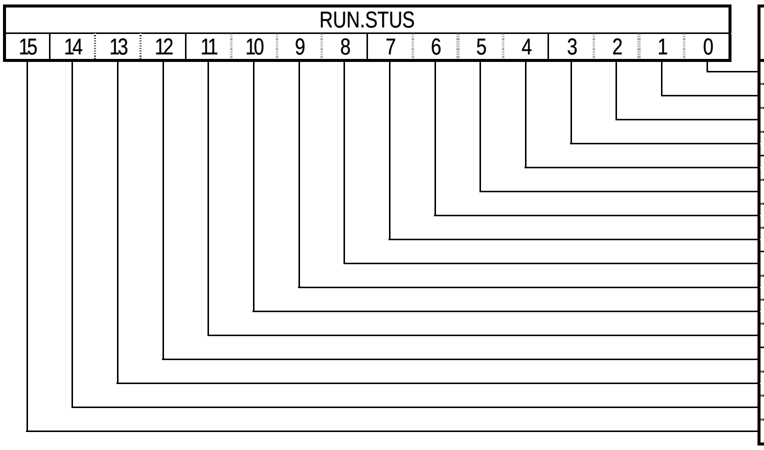
These are process-related data for each loop. They include PV, control set point, control output, error status, etc., which can be used for monitoring the operation of the module.

Table B2.12 Process Data

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
101	301	501	701	PVIN	Input process value	Industrial unit	-5% to 105% of (SL to SH)	—	RO	—	C3.
102	302	502	702	PV	Process value	Industrial unit	-5% to 105% of (PRL to PRH)	—	RO	—	
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4.
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/ cooling output	—	RO	—	C2. C7.1
105	305	505	705	COUT	Cooling control output	%	0 to OL: for heating/cooling output	—	RO	—	
106	306	506	706	PIDNO	Current PID number	None	1 to 4	—	RO	—	C6.9
107	307	507	707	CSPNO	Current SP number	None	1 to 4	—	RO	—	C4.1
108	308	508	708	RUN.STUS	Operating status	None	See Table B2.13.	—	RO	—	C10.
109	309	509	709	ALM.STUS	Alarm status	None	See Table B2.14.	—	RO	—	C8.
110	310	510	710	ERR.STUS	Error status	None	See Table B2.15.	—	RO	—	C10.
111	311	511	711	AT.STUS	Auto-tuning status	None	0: AT normal exit 1: AT executing 2: AT manually stopped 3: AT error exit	—	RO	—	C5.2

Operating Status

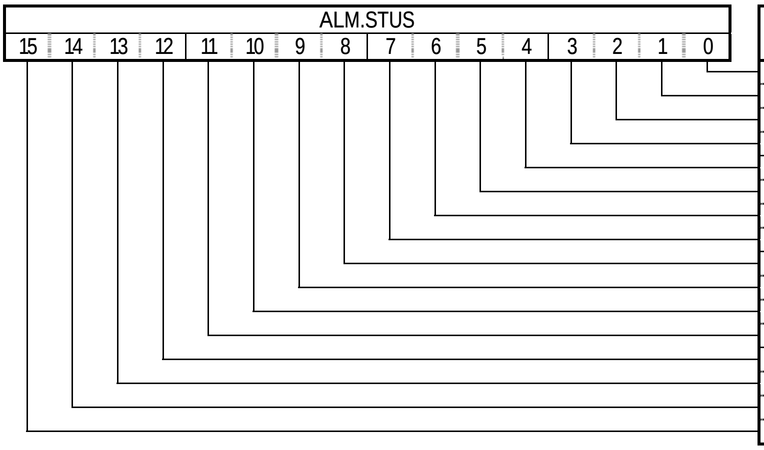
Table B2.13 Operating Status



Bit pos.	Symbol	Description
0	RUN/STP	0: Stop, 1: Run
1	AUT/MAN	0: Automatic, 1: Manual
2	CAS	1:Cascade
3	RMT/LOC	0: Remote, 1: Local
4	EXPV/PV	0: Normal, 1: External input
5	EXOUT/OUT	0: Normal, 1: External output
6	—	
7	—	
8	B.OUT	1: PVIN burnout
9	+OVER	1: PVIN +OVER
10	–OVER	1: PVIN –OVER
11	B.OUT	1: PV burnout
12	+OVER	1: PV +OVER
13	–OVER	1: PV –OVER
14	—	
15	FUNC.ERR	1: Error detected

Alarm Status

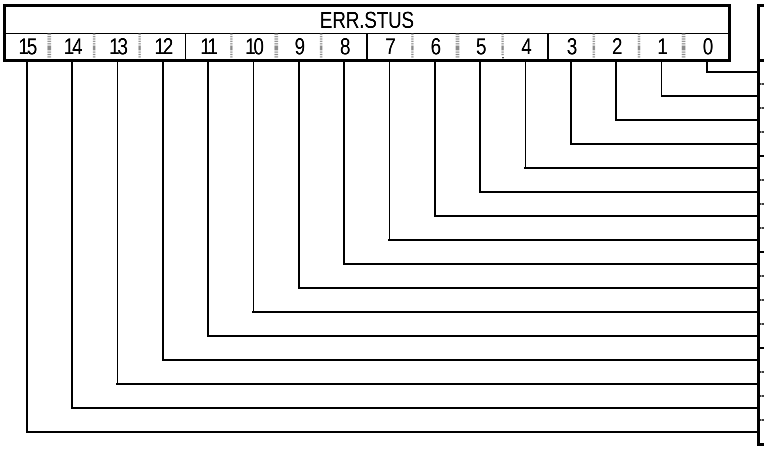
Table B2.14 Alarm Status



Bit pos.	Symbol	Description
0	ALM1	Alarm 1 generated
1	ALM2	Alarm 2 generated
2	ALM3	Alarm 3 generated
3	ALM4	Alarm 4 generated
4	ALMW1	Alarm 1 waiting
5	ALMW2	Alarm 2 waiting
6	ALMW3	Alarm 3 waiting
7	ALMW4	Alarm 4 waiting
8	—	
9	—	
10	—	
11	—	
12	—	
13	—	
14	—	
15	—	

Error Status

Table B2.15 Error Status



Bit pos.	Description
0	—
1	System data error
2	Calibration value error
3	Controller or I/O parameter error
4	Operation parameter error
5	AD converter error
6	RJC error
7	EEPROM error
8	—
9	—
10	—
11	—
12	—
13	—
14	—
15	—

B2.2.9 Operation Control Parameters

Use these parameters to control the operation of individual loops. They control the switching of operation-related modes, including run/stop, automatic/manual/cascade and auto-tuning, and set the Manual Output and other operation parameters.

Table B2.16 Operation Control Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
121	321	521	721	RUN/STP	Run/stop selection	None	0: Stop, 1: Run	0	RW	—	C7.1
122	322	522	722	A/M/C	Automatic/manual/ cascade selection	None	0: Auto, 1: Manual 2: Cascade [*1]	0	RW	—	C7.2 C7.4
	323		723	INSEL	Input selection	None	0: Input 1, 1: Input 2	0	RW	—	C3.11
124	324	524	724	RMT/LOC	Remote/local selection	None	0: Local, 1: Remote	0	RW	—	C7.3
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input	0	RW	—	C3.12
126	326	526	726	EXOUT/ OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—	C2.6
127	327	527	727	AT	Start Auto-tuning	None	0: AT stop 1-5: AT start (reverts to 0 when AT stops)	0	RW	—	C5.2
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
131	331	531	731	EXPV	External input	Industrial unit	-5.0 to 105.0% of (SL to SH)	SL	RW	—	C3.12
132	332	532	732	EXRJC	Reference junction temperature	Industrial unit	-100 to 700 (-10.0 to 70.0°C)	0	RW	—	C3.6
133	333	533	733	RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—	C4.2
134	334	534	734	MOUT	Manual output	%	OL to OH: One output 0 to OH: Heating/cooling output	0	RW	—	C7.2 C7.4
135	335	535	735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—	
136	336	536	736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—	C2.6

*1: The controller mode must be set to Cascade Control before cascade selection can take effect. Set the operation control parameters of the even-numbered loop in Cascade mode.

CAUTION

All operation parameters revert to their default values after power on. Hence, always set their values again after power on.

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, "Writing and Reading after Powering On."

B2.2.10 I/O Parameters

The I/O parameters are classified into two categories: required and optional. The required setup parameters must always be checked and set, and the optional setup parameters may be set as required. All I/O parameters apply to individual loops.

The required setup parameters are input type selection and control type selection parameters. They are the most basic loop setup elements.

The optional setup parameters include PV-related parameters for changing the input range and selecting a burnout operation, as well as parameters that are used only in two-input changeover mode.

■ I/O Type Settings

These parameters are used to select input types (ranges) and output control types for individual loops. These parameters are the most basic loop setup elements.

Table B2.17 I/O Parameters (1/3)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
141	341	541	741	OT	Control type selection	None	0: PID control 1: ON/OFF control 2: Heating/cooling PID control 3: Heating/cooling ON/OFF control	0	RW	✓	C2.1
142	342	542	742	IN	Input type selection[*1]	None	1-31, 33-56 For details, see Table A4.1, "Input Type Selection."		RW	✓	C3.1

[*1] To select input type by software, you must set the input type selector switches to “set by software”, that is, “SW5=0 and SW1-4=OFF” (also see Section A4.1, "Selecting Input Types and Power Frequency").

■ Input Range Settings

Use these parameters to set up the input of individual loops, as required, such as changing the input range or selecting an appropriate burnout operation.

Table B2.17 I/O Parameters (2/3)

Data Position Number				Symbol	Description	Unit	Data Range		Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4									
143	343	543	743	RH	Input range upper limit	Industrial unit	See Table A4.1, “Input Type Selection”.			RW	✓	C3.3
144	344	544	744	RL	Input range lower limit							
145	345	545	745	DEC.P	Decimal point position	None				RO	✓	
146	346	546	746	SH	Scaling upper limit	None	-30000 to 30000; 0 < SH - SL ≤ 30000. Changeable only for DC voltage input with a maximum resolution of 14 bits (16384).	Thermocouple input, RTD input	RH	RW	✓	
								DC voltage input	1000			
147	347	547	747	SL	Scaling lower limit			Thermocouple input, RTD input	RL	RW	✓	
								DC voltage input	0			
148	348	548	748	SDP	Scaling decimal point position	None	0 to 4 Changeable only for DC voltage input	Thermocouple input, RTD input	DEC.P	RW	✓	
								DC voltage input	1			
149	349	549	749	RJC	Reference junction compensation	None	0: Fixed value 1: ON		1	RW	✓	C3.6
150	350	550	750	BSL	Burnout selection	None	0: OFF 1: Up Scale 2: Down Scale (Valid for Thermocouple input and RTD input)		1	RW	✓	C3.5

■ PV Range Settings

These parameters are only valid in Two-input Changeover mode, and are used for defining the input range in Two-input Changeover mode. By default, the PV range follows the input range of the even-numbered loop.

Table B2.17 I/O Parameters (3/3)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
—	351	—	751	PRH	PV range upper limit	Industrial unit	- 30000 to 30000; 0 < (PRH - PRL) ≤ 30000. Changeable only for even-numbered loops in two-input changeover mode with a maximum resolution of 14 bits (16384).	SH	RW	✓	C3.4
—	352	—	752	PRL	PV range lower limit			SL	RW	✓	
—	353	—	753	PDP	PV range decimal point position	None	0 to 4 Changeable only for even-numbered loops in two-input changeover mode	SDP	RW	✓	

CAUTION

I/O parameters must be enabled before any written content can take effect. For details on how to enable such parameters, see Section B2.3, “How to Enable Settings.”

CAUTION

Changing an I/O parameter initializes operation parameters. Therefore, always set I/O parameters before setting operation parameters.

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, “Writing and Reading after Powering On.”

B2.2.11 Operation Parameters

There are two types of operation parameters: PID parameters and function settings. The PID parameters include set point, proportional band, integral time, derivative time, and alarm preset value parameters. The function settings include the two-input changeover-related, SP-related, PV-related, operation-related, and alarm-related function settings.

Unlike controller parameters and I/O parameters, operation parameters need not be enabled before taking effect. The module checks the contents of the I/O data registers for any change at input sampling intervals, and automatically enables any changes if the new values are within valid data range. If new values are out of range, the module discards them and restores the registers to their original values.

WARNING

You should disable the backup function if you expect parameters that are designated to be automatically stored to be frequently updated. By default, the module automatically stores the values of such parameters to the EEPROM each time they are updated. If parameter values are frequently updated and the number of write executions exceeds the maximum limit of 100,000, EEPROM may fail and subsequent storing is not guaranteed. Therefore, in situations where stored parameters are frequently updated, you should always disable the backup function using the NBKUP parameter.

CAUTION

Changing a controller parameter or I/O parameter initializes operation parameters. Therefore, always set controller parameters and I/O parameters before operation parameters.

CAUTION

You must observe some precautions when writing to the module. For details, see Section B1.3, “Writing and Reading after Powering On.”

■ Two-input Changeover Function Settings

Use these parameters to perform setup as required when using Two-input Changeover mode. They can be used for setting the changeover mode and changeover temperature.

Table B2.18 Two-input Changeover Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
	361		761	SELMD	Two-input changeover mode	None	0: Automatic changeover using temperature range 1: Automatic changeover using two-input changeover upper limit 2: Manual changeover using input selection	0	RW	✓	C3.11
	362		762	SELH	Two-input changeover upper limit	Industrial unit	PRL to PRH if SELL < SELH. If SELL ≥ SELH, changeover occurs with respect to SELH.	PRL+1	RW	✓	
	363		763	SELL	Two-input changeover lower limit			PRL	RW	✓	

■ SP-related Function Settings

Use these parameters to define set points for individual loops, as required. They can be used for setting upper and lower input limits, rate-of-change, and tracking.

Table B2.19 SP-related Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
164	364	564	764	SPH	Upper SP limit	Industrial	PRL to PRH if SPL < SPH CSP is fixed at SPL if SPL ≥ SPH	PRH	RW	✓	C4.3
165	365	565	765	SPL	Lower SP limit			PRL	RW	✓	
166	366	566	766	SPR.UP	SP up gradient	Industrial	0 to (PRH-PRL) 0: SP gradient disabled	0	RW	✓	C4.4
167	367	567	767	SPR.DN	SP down gradient			0	RW	✓	
168	368	568	768	SPR.TM	Gradient time unit	None	0: Hour, 1: Minute	0	RW	✓	
169	369	569	769	SP.TR	SP tracking mode	None	0: Tracking enabled 1: Tracking disabled	1	RW	✓	C4.6

■ PV-related Function Settings

Use these parameters to perform PV-related setup for individual loops, as required. They can be used for configuring PV correction, square root extraction and input filtering.

Table B2.20 PV-related Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
171	371	571	771	BS	Fixed bias	Industrial	-(SH-SL) to (SH-SL)	0	RW	✓	C3.8
172	372	572	772	FL	Input filter	Seconds	0: OFF, 1 to 120 seconds	0	RW	✓	C3.10
173	373	573	773	X1	Broken-line input 1	Industrial	-5.0% to 105.0% of (SL to SH)	SL	RW	✓	C3.7
174	374	574	774	Y1	Broken-line bias 1	Industrial	-(SH-SL) to (SH-SL)	0	RW	✓	
175	375	575	775	X2	Broken-line input 2	Industrial	-5.0% to 105.0% of (SL to SH)	SL	RW	✓	
176	376	576	776	Y2	Broken-line bias 2	Industrial	-(SH-SL) to (SH-SL)	0	RW	✓	
177	377	577	777	X3	Broken-line input 3	Industrial	-5.0% to 105.0% of (SL to SH)	SL	RW	✓	
178	378	578	778	Y3	Broken-line bias 3	Industrial	-(SH-SL) to (SH-SL)	0	RW	✓	
179	379	579	779	SR	Square root extraction	None	0: OFF; 1: ON	0	RW	✓	C3.9
180	380	580	780	LC	Low cut	Industrial	0.0 to 5.0% of (SH-SL))	1.0% of (SH -SL)	RW	✓	

■ Operation-related Function Settings

Use these parameters to configure control operation for individual loops, as required. They can be used to set up dynamic auto-tuning, the “super” function, control mode, and other control operation-related functions.

Table B2.21 Operation-related Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
181	381	581	781	SELF	Dynamic auto-tuning enable	None	0: Disabled, 1: Enabled	0	RW	✓	C5.1
182	382	582	782	SC	"Super" enable code	None	0: Disabled, 1: Enabled	0	RW	✓	C6.7
183	383	583	783	ARW	ARW setting	%	0: Automatic, 500 to 2000: (50.0 to 200.0%)	0	RW	✓	C6.8
184	384	584	784	CMD	Control mode	None	0: Standard PID control 1: Fixed-point control	0	RW	✓	C6.6
185	385	585	785	ZONE	Zone PID selection	None	0: Disabled, 1: Enabled	0	RW	✓	C6.9
186	386	586	786	1RP	Reference point 1	Industrial	PRL to PRH	PRL	RW	✓	C6.9.2
187	387	587	787	2RP	Reference point 2	Industrial	PRL to PRH	PRL	RW	✓	
188	388	588	788	RHY	Zone switching hysteresis	Industrial	0 to (PRH-PRL)	(PRH - PRL) x 0.5%	RW	✓	
189	389	589	789	RDV	Reference deviation	Industrial	0 to (PRH-PRL) 0: Reference deviation disabled	0	RW	✓	

■ Output-related Function Settings

Use these parameters to configure control output for individual loops, as required. They can be used for setting control output cycle time and rate-of-change limits.

Table B2.22 Output-related Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
191	391	591	791	CT	Cycle time	s	5 to 1200 (0.5 to 120.0 s)	300	RW	✓	C2.4.2
192	392	592	792	CTc	Cooling cycle time	s		300	RW	✓	
193	393	593	793	MVR	Rate-of-change limit	% per second	0: Disabled 1 to 1000 (0.1 to 100.0%/s)	0	RW	✓	C2.4.2

■ Alarm-related Function Settings

Use these parameters to set up the operation of the alarm functions for individual loops as required. They can be used to set up the alarm type, hysteresis, and ON delay timer.

Table B2.23 Alarm-related Function Settings

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
281	481	681	881	AL1	Alarm 1 type	None	0: OFF 1: Upper limit 2: Lower limit 3: Upper deviation limit 4: Lower deviation limit 7: Upper/lower deviation limit 8: Deviation range 11: Upper limit with waiting 12: Lower limit with waiting 13: Upper deviation limit with waiting 14: Lower deviation limit with waiting 17: Upper/lower deviation limit with waiting 18: Deviation range with waiting	1	RW	✓	C8.1 C8.2
282	482	682	882	AL2	Alarm 2 type			2	RW	✓	
283	483	683	883	AL3	Alarm 3 type			1	RW	✓	
284	484	684	884	AL4	Alarm 4 type			2	RW	✓	
285	485	685	885	HY1	Alarm 1 hysteresis	Industrial unit	0 to (PRH-PRL)	(PRH - PRL) x 0.5%	RW	✓	C8.1
286	486	686	886	HY2	Alarm 2 hysteresis				RW	✓	
287	487	687	887	HY3	Alarm 3 hysteresis				RW	✓	
288	488	688	888	HY4	Alarm 4 hysteresis				RW	✓	
289	489	689	889	DLY1	Alarm 1 ON delay	Second	0 to 999 (0 to 999 s)	0	RW	✓	C8.3
290	490	690	890	DLY2	Alarm 2 ON delay				RW	✓	
291	491	691	891	DLY3	Alarm 3 ON delay				RW	✓	
292	492	692	892	DLY4	Alarm 4 ON delay				RW	✓	

■ PID Parameters

Use these parameters to configure PID control-related functions for individual loops. They can be used for specifying set points, alarm preset values, proportional band, integral time, and derivative time. Up to four parameter groups can be defined for each loop.

CAUTION

You need to execute a specific procedure every time to update stored set point values. Otherwise, stored set points will not be updated so the parameters revert to their last stored values whenever the module is turned off and then on again. For details, see Section B2.4, "How to Back up SP Values to EEPROM."

Table B2.24 PID Parameters (1/4)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
201	401	601	801	1.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular	B2.4 C4.1
202	402	602	802	1.A1	Alarm 1 preset value	Industrial	-30000 to 30000	PRH	RW	✓	C8
203	403	603	803	1.A2	Alarm 2 preset value			PRL	RW	✓	
204	404	604	804	1.A3	Alarm 3 preset value			PRH	RW	✓	
205	405	605	805	1.A4	Alarm 4 preset value			PRL	RW	✓	
206	406	606	806	1.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓	C6.2
207	407	607	807	1.TI	Integral time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓	C6.3
208	408	608	808	1.TD	Derivative time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓	C6.4
209	409	609	809	1.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH Fixed at OL if OL ≥ OH	1000	RW	✓	C2.4.2
210	410	610	810	1.OL	Lower output limit			0 (1000 in heating/ cooling control)	RW	✓	
211	411	611	811	1.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓	C6.3
212	412	612	812	1.HYS	ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
213	413	613	813	1.DR	Forward/ reverse switch	None	0: Reverse 1: Forward (always 0 in heating/cooling control)	0	RW	✓	C6.1
214	414	614	814	1.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
215	415	615	815	1.HYS.C	Cooling ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
216	416	616	816	1.DB	Dead band	Industrial	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
217	417	617	817	1.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
218	418	618	818	1.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Irregular: You need to execute a specific procedure every time to update stored set point values.

Table B2.24 PID Parameters (2/4)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
221	421	621	821	2.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular	B2.4 C4.1
222	422	622	822	2.A1	Alarm 1 preset value	Industrial	-30000 to 30000	PRH	RW	✓	C8
223	423	623	823	2.A2	Alarm 2 preset value			PRL	RW	✓	
224	424	624	824	2.A3	Alarm 3 preset value			PRH	RW	✓	
225	425	625	825	2.A4	Alarm 4 preset value			PRL	RW	✓	
226	426	626	826	2.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓	C6.2
227	427	627	827	2.TI	Integral time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓	C6.3
228	428	628	828	2.TD	Derivative time	second	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓	C6.4
229	429	629	829	2.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH Fixed at OL if OL ≥ OH	1000	RW	✓	C2.4.2
230	430	630	830	2.OL	Lower output limit			0 (1000 in heating/ cooling control)	RW	✓	
231	431	631	831	2.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓	C6.3
232	432	632	832	2.HYS	ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
233	433	633	833	2.DR	Forward/ reverse switch	None	0: Reverse 1: Forward (Always 0 in heating/cooling control)	0	RW	✓	C6.1
234	434	634	834	2.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
235	435	635	835	2.HYS.C	Cooling ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
236	436	636	836	2.DB	Dead band	Industrial	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
237	437	637	837	2.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
238	438	638	838	2.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Irregular: You need to execute a specific procedure every time to update stored set point values.

Table B2.24 PID Parameters (3/4)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
241	441	641	841	3.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular	B2.4 C4.1
242	442	642	842	3.A1	Alarm 1 preset value	Industrial	-30000 to 30000	PRH	RW	✓	C8
243	443	643	843	3.A2	Alarm 2 preset value			PRL	RW	✓	
244	444	644	844	3.A3	Alarm 3 preset value			PRH	RW	✓	
245	445	645	845	3.A4	Alarm 4 preset value			PRL	RW	✓	
246	446	646	846	3.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓	C6.2
247	447	647	847	3.TI	Integral time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓	C6.3
248	448	648	848	3.TD	Derivative time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓	C6.4
249	449	649	849	3.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH Fixed at OL if OL ≥ OH	1000	RW	✓	C2.4.2
250	450	650	850	3.OL	Lower output limit			0 (1000 in heating/ cooling control)	RW	✓	
251	451	651	851	3.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓	C6.3
252	452	652	852	3.HYS	ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
253	453	653	853	3.DR	Forward/ reverse switch	None	0: Reverse, 1: Forward (Fixed at 0 in heating/cooling control)	0	RW	✓	C6.1
254	454	654	854	3.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
255	455	655	855	3.HYS.C	Cooling ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
256	456	656	856	3.DB	Dead band	Industrial	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
257	457	657	857	3.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
258	458	658	858	3.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Irregular: You need to execute a specific procedure every time to update stored set point values.

Table B2.24 PID Parameters (4/4)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
261	461	661	861	4.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular	B2.4 C4.1
262	462	662	862	4.A1	Alarm 1 preset value	Industrial	-30000 to 30000	PRH	RW	✓	C8
263	463	663	863	4.A2	Alarm 2 preset value			PRL	RW	✓	
264	464	664	864	4.A3	Alarm 3 preset value			PRH	RW	✓	
265	465	665	865	4.A4	Alarm 4 preset value			PRL	RW	✓	
266	466	666	866	4.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓	C6.2
267	467	667	867	4.TI	Integral time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓	C6.3
268	468	668	868	4.TD	Derivative time	Second	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓	C6.4
269	469	669	869	4.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH Fixed at OL if OL ≥ OH	1000	RW	✓	C2.4.2
270	470	670	870	4.OL	Lower output limit			0 (1000 in heating/ cooling control)	RW	✓	
271	471	671	871	4.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓	C6.3
272	472	672	872	4.HYS	ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
273	473	673	873	4.DR	Forward/ reverse switch	None	0: Reverse, 1: Forward (Always 0 in heating/cooling control)	0	RW	✓	C6.1
274	474	674	874	4.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
275	475	675	875	4.HYS.C	Cooling ON/OFF control hysteresis	Industrial	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
276	476	676	876	4.DB	Dead band	Industrial	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
277	477	677	877	4.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
278	478	678	878	4.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Irregular: You need to execute a specific procedure every time to update stored set point values.

TIP

How switching of a PID parameter group is carried out depends on the PID selection method. Normally, it is controlled by the SP Number Selection (SPNO) operation control parameter. In Zone PID mode, the proportional band, integral time and other PID control-related parameters are switched according to the zone PID setting. For details on the Zone PID mode, see Section C6.9, "PID Selection Method (SP Number Selection, Zone PID Selection)."

B2.3 How to Enable Settings

Parameters described in Section B2.2.7, “controller Parameters,” and Section B2.2.10, “I/O Parameters,” must be enabled before their settings can take effect. This section describes how to enable various settings and check for successful completion.

Table B2.25 lists the input relays and Table B2.26 lists the I/O data registers that are used for enabling controller parameters and I/O parameters.

Write '1: Enable setup instruction operand' to SETUP. Next, write the required parameter values and then enable them by writing the appropriate setup instruction operand value to OPE. If the parameters fail to be enabled, a non-zero value is returned in STUS, indicating an error. Correct the error and retry. After confirming that there is no error, end the procedure by setting SETUP to '0: Disable setup instruction operand'.

Table B2.25 Relays for Enabling Settings

Input Relay Number X□□□nn [*1]	Symbol	Description	Data Range	Interrupt
X08	CMDRDY	Command processing completed	0: Processing, 1: Processing completed	✓
X16	MDLRDY	Module startup completed	0: Processing, 1: Processing completed	✓
X24	SETUP.R	Setup mode	0: Normal state, 1: Setup mode	✓

*1 □□□ denotes the slot number where the module is installed.

Table B2.26 Data Registers for Enabling Settings

Data Position Number				Symbol	Description	Data Range	Default Value	Attribute	**Stored**	**See Also**
Loop 1	Loop 2	Loop 3	Loop 4							
71				SETUP	Setup	0: Disable setup instruction operand 1: Enable setup instruction operand	0	RW	—	—
72				OPE	Setup Instruction Operand	1, 2, 4, 8, 16: See Table B2.27 for details.	0	RW	—	—
73				STUS	Setup Instruction Response	0: No error; Data position number of error register -32767: Invalid operation (SETUP = 0)	0	RO	—	—

Table B2.27 Setup Instruction Operand (OPE) Values

Preset Value	Description	Explanation
1	Initialize all parameters	Reverts all parameters to their factory settings. [*1]
2	Enable controller parameters	Enables the controller parameters, which are the most basic setup elements. The module initializes I/O parameters and operation parameters based on the controller parameter values.
4	Enable I/O type settings	Enables the I/O Type Selection parameter, which defines the input type and control output type. The module initializes input range settings, PV range settings and Operation parameters based on the input type selection parameter value.
8	Enable input range settings	Enables the input range settings, which sets up the PV as required. The module initializes PV range settings and operation parameters based on these settings.
16	Enable PV range settings	Enables the PV range settings, which are required only in Two-input Changeover mode. The module initializes operation parameters based on these settings.

*1 Input type and power frequency selection defined by the hardware switches have precedence over software settings.

CAUTION

Writing to the Setup Instruction Operand (OPE) register a value, which is not listed in Table B2.27, “Setup Instruction Operand (OPE) Values,” has no effect on module operation. When the setup operation completes, the Setup Instruction Operand (OPE) register resets to 0.

CAUTION

The OPE register functions only when the module is in Setup mode. Accessing the OPE register before transiting to Setup mode generates an error, and returns an error value of –32767 in the STUS register.

CAUTION

Always finishing enabling all required settings, always set SETUP to '0: Disable setup instruction operand'. With SETUP set to '1: Enable setup instruction operand', no I/O refreshing or control computation can be executed.

■ State Transition

The operating states of the module can be classified into 3 types. For details on how to transit to a new state and check for successful transition, as well as details on the content of registers and relays in each state, see Table B.2.28, "Content of Registers and Relays in Each Operating State".

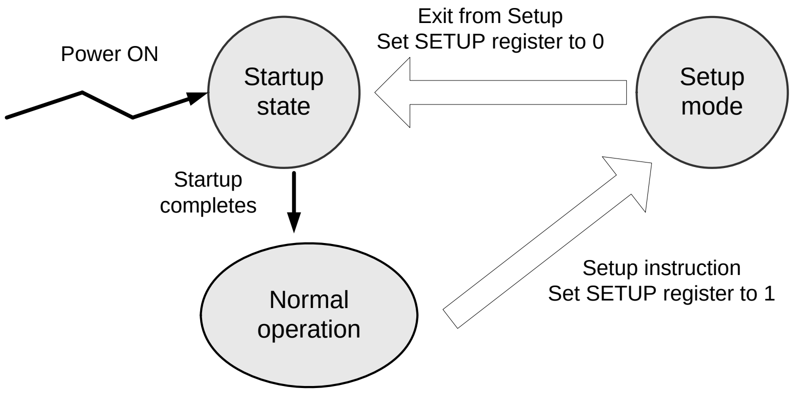


Figure B2.2 Operating State Transition Diagram

● Power on

When power is turned on, the module enters startup state.

● Startup completes (Transition from Startup state to normal operation)

When startup completes, the module enters Normal Operation state. The MDLRDY relay automatically turns on, to indicate that the module has entered Normal Operation state. Normal Operation State begins in Stop mode and Automatic mode.

● Setup instruction (Transition from normal operation to Setup mode)

Writing a value of 1 to the Setup register initiates a transition to Setup mode. When the transition completes, the SETUP.R relay turns on to indicate that the module has entered Setup mode.

● Exit from Setup (Transition from Setup mode to Startup state)

Writing a value of 0 to the Setup register initiates an exit from Setup mode. When the exit completes, the Setup.R relay resets, and the module transits to Startup state. The MDLRDY relay resets to indicate that the module is in Startup state.

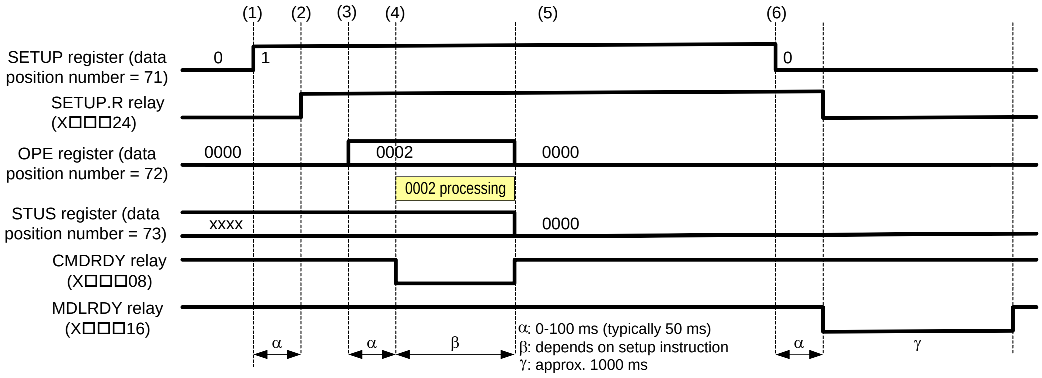
Table B2.28 Content of Registers and Relays in Each Operating State

	MDLRDY Relay	SETUP.R Relay	Read Operation	Write Operation	Process Data	Operation Control Parameters
Startup State	0	0	×	×	Undefined	Undefined
Normal Operation	1	0	✓	✓	Normal vales	Normal values
Setup Mode	1	1	✓	✓	Default values	Default values

× : Data is invalid in this state.
✓: Data is valid in this state.

■ Procedure for Enabling Controller and I/O Parameter Values

Figure B2.3 illustrates the procedure for enabling controller parameter and I/O parameter values. Two I/O data registers, namely, SETUP and OPE, are used to enable settings, whilst three relays (SETUP.R, CMDRDY, MDLRDY) and one input data register (STUS) are used to check for successful execution.



α: 0-100 ms (typically 50 ms)
β: depends on setup instruction
γ: approx. 1000 ms

↑: If SETUP is set to 1 during an operation parameter change, SETUP.R may take a longer time to turn on.

Figure B2.3 Procedure for Enabling Controller Parameters and I/O Parameters

(1) Write a value of 1 to the SETUP register to transit to Setup mode and enable the OPE register. To confirm that the module is now in Setup mode, check that the SETUP.R relay has turned on. In Setup mode, the module suspends refreshing of data registers and the control output value is “0%”.

(2) Write the new parameter value.

(3) Write to the OPE register an appropriate OPE value to initiate the process for enabling the new parameter value.

(4) The module resets the CMDRDY relay as the setup process begins. It then resets the OPE register to 0, initializes the related parameters, writes the exit status to the STUS register, and finally turns on the CMDRDY relay upon setup completion. Therefore, to confirm setup completion, check that CMDRDY has turned on.

(5) Read the STUS register to determine if setup is successful. During setup, the module performs range checks on all registers within the range to be enabled, in ascending order of their data position numbers. If it finds an out-of-range register value, it restores the original register value and returns the data position number of the register in the STUS register. Note that only the first error register number is returned, although range check is performed over all registers within the range to be enabled. You may repeat steps 2 to 5 to enable other settings as required.

(6) Finally, write a value of 0 to the SETUP register to exit from Setup mode. The module initializes the operation parameters according to the new settings. The same precautions about module startup apply to this initialization. For details, see Section B1.3, “Writing and Reading after Powering On”.

CAUTION

The STUS register is a read-only register, which is updated after execution of each setup instruction. When executing a sequence of setup instructions, check the STUS register after each execution to determine if setup is successful.

CAUTION

If a sequence program has a long execution cycle, a rising edge in the CMDRDY relay may fail to be detected. In such situations, confirm completion of setup by checking that the OPE register is reset to 0.

CAUTION

Always confirm that transition to Setup mode has been completed before writing to the OPE register. If data is written to the OPE register before transition has completed, the setup process will not start.

CAUTION

Always write new parameter values before executing the corresponding setup instruction to enable the parameter values. Otherwise, the written values will be ignored.

■ Sample Program for Setting Controller and I/O parameters

The sample program shown below writes a list of controller and I/O parameters sequentially on the rising edge of /I00001. It disables the backup function as it sets up the parameters each time the sequence program runs. The controller and I/O parameters set up by the sample program include power frequency selection, input type, input range, and scale parameters. You may modify the sample program to set up other controller and I/O parameters to suit your application.

After returning from Setup mode, the sample program sets up operation parameters. You may modify the program to set up other operation parameters as required. As operation parameters are automatically initialized whenever input range and other I/O parameters or controller parameters are modified, you must set them again if I/O or controller parameters are modified. No special procedure is required to enable operation parameter values, which take effect once written.

This sample program writes the following parameter values sequentially, and then enables these values.

- Controller parameters:
  Power frequency selection = 60 Hz
- I/O parameters:
  input type selection for loop1 = Type K -200 to 1000°C (I/O type settings)
  input type selection for loop2 = Type K -200 to 500°C (I/O type settings)
  input type selection for loop3 = DC voltage 1-5 V (I/O type settings)
  input type selection for loop4 = DC voltage 0-5 V (I/O type settings)
  RL and RH for loop1 = 0°C for RL, 1000°C for RH (input range settings)
  RL and RH for loop2 = 0°C for RL, 500°C for RH (input range settings)
  RL and RH for loop4 = 0 V for RL, 2 V for RH (input range settings)
  SL and SH for loop3 = 0 for SL, 20000 for SH (input range settings)
  SL and SH for loop4 = 0 for SL, 10000 for SH (input range settings)
- Operation parameters:
  PID parameter for loops 1-4 = file register values

For the I/O parameters, the sample program first sets up the I/O types and then the input ranges.

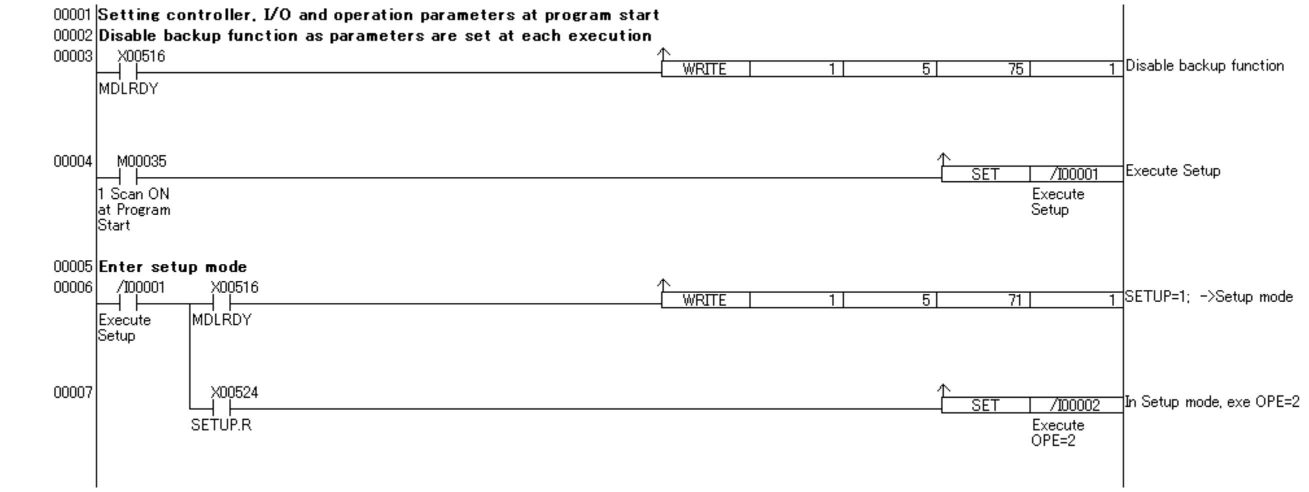


Figure B2.4 Sample Program for Setting Controller and I/O Parameters (1/6)

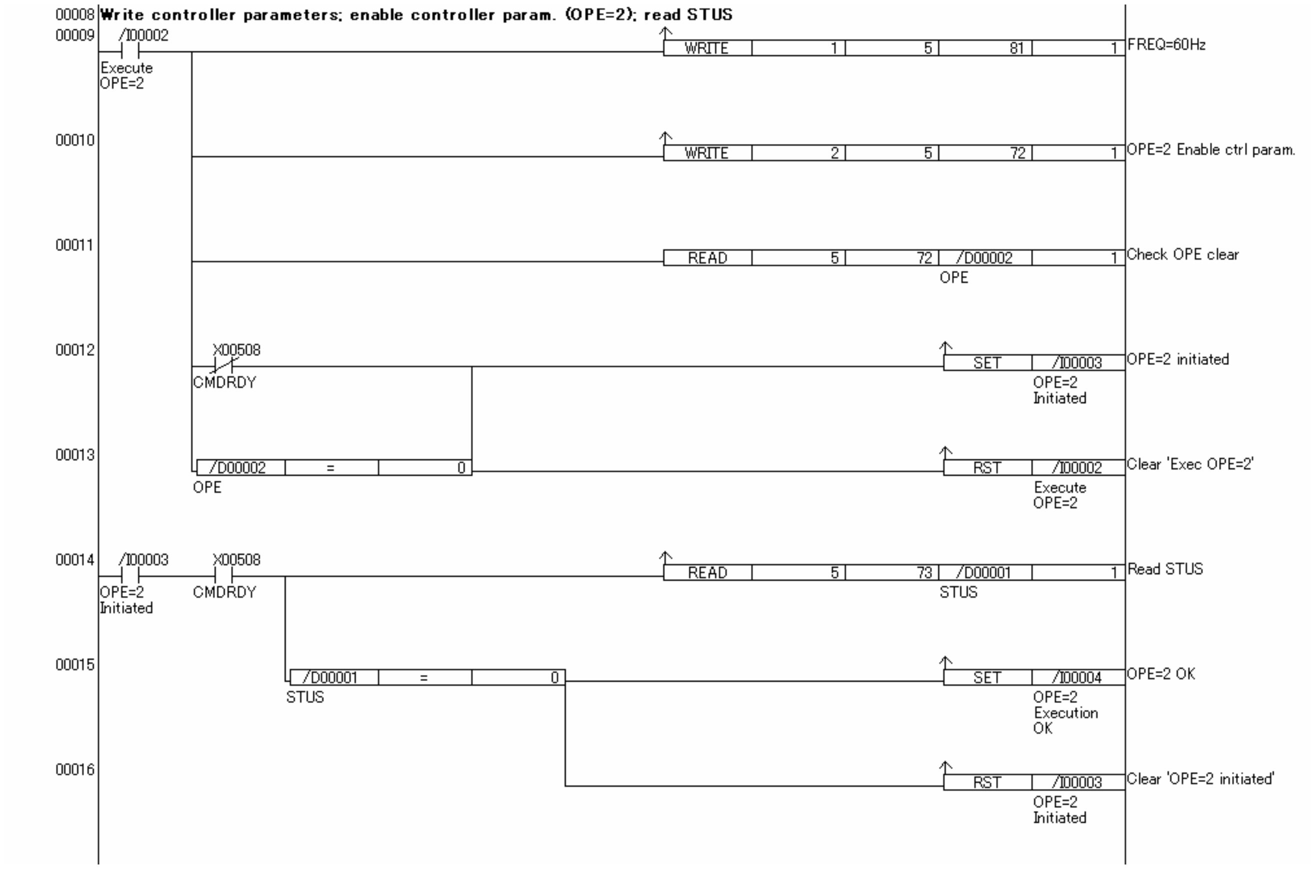


Figure B2.4   Sample Program for Setting Controller and I/O Parameters (2/6)

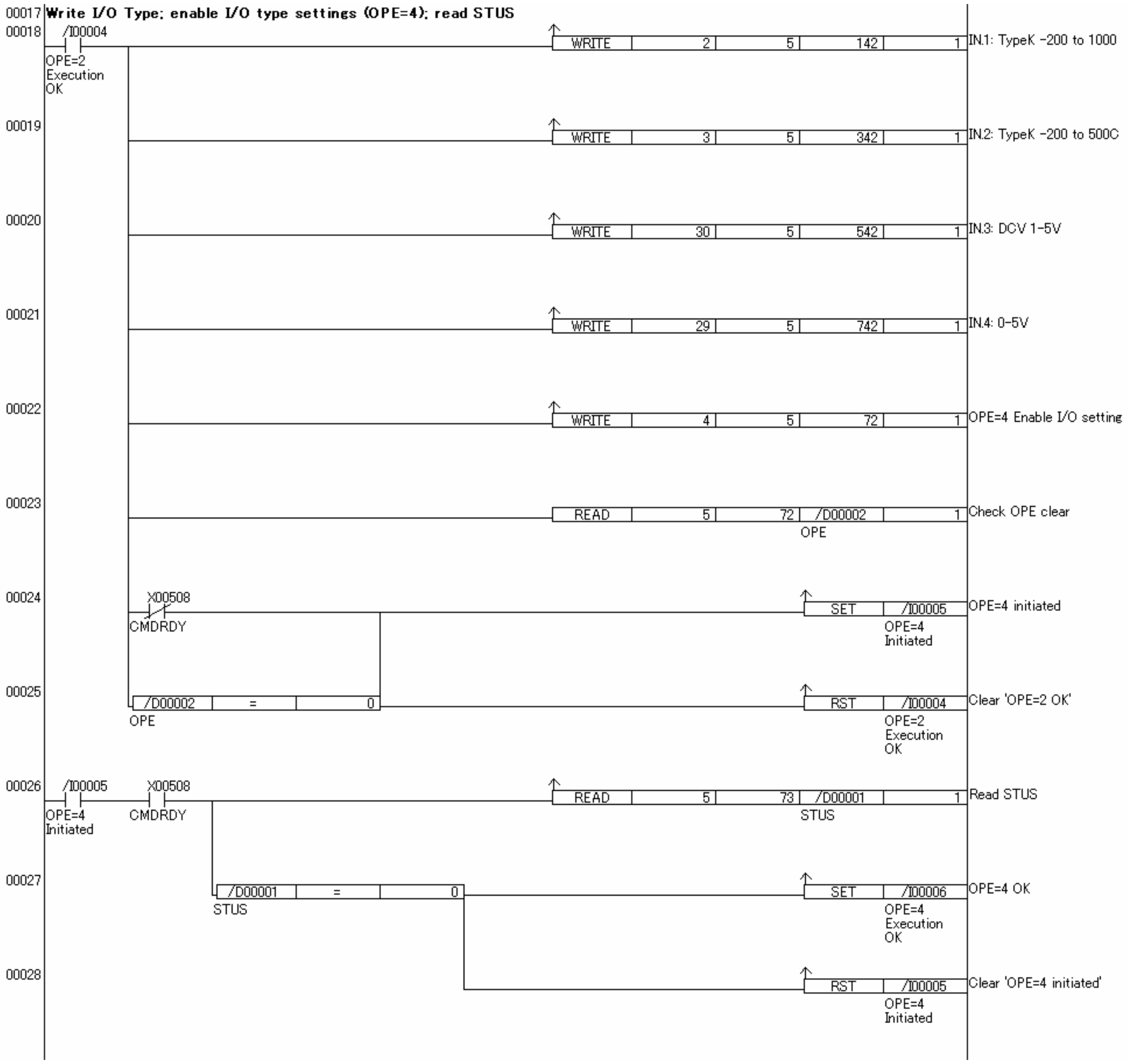
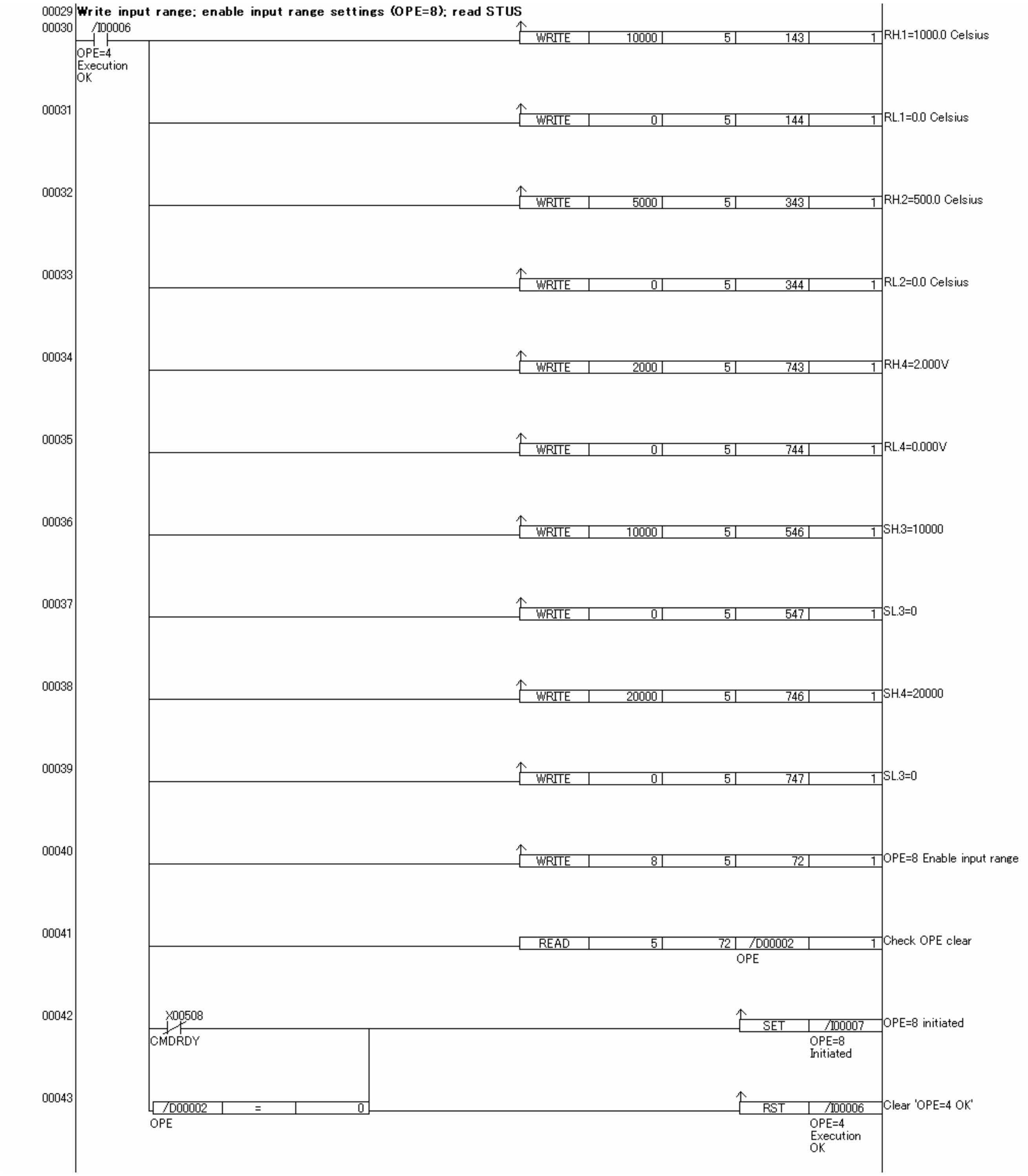


Figure B2.4   Sample Program for Setting Controller and I/O Parameters (3/6)



```
00029 Write input range; enable input range settings (OPE=8); read STUS
00030  /I00006                        ↑ WRITE  10000    5   143         1  RH.1=1000.0 Celsius
       OPE=4
       Execution
       OK
00031                                 ↑ WRITE      0    5   144         1  RL.1=0.0 Celsius
00032                                 ↑ WRITE   5000    5   343         1  RH.2=500.0 Celsius
00033                                 ↑ WRITE      0    5   344         1  RL.2=0.0 Celsius
00034                                 ↑ WRITE   2000    5   743         1  RH.4=2.000V
00035                                 ↑ WRITE      0    5   744         1  RL.4=0.000V
00036                                 ↑ WRITE  10000    5   546         1  SH.3=10000
00037                                 ↑ WRITE      0    5   547         1  SL.3=0
00038                                 ↑ WRITE  20000    5   746         1  SH.4=20000
00039                                 ↑ WRITE      0    5   747         1  SL.3=0
00040                                 ↑ WRITE      8    5    72         1  OPE=8 Enable input range
00041                                   READ       5   72  /D00002      1  Check OPE clear
                                                           OPE
00042       X00508                               ↑ SET   /I00007         OPE=8 initiated
            CMDRDY                                       OPE=8
                                                         Initiated
00043       /D00002  =  0                        ↑ RST   /I00006         Clear 'OPE=4 OK'
            OPE                                          OPE=4
                                                         Execution
                                                         OK
```

Figure B2.4   Sample Program for Setting Controller and I/O Parameters (4/6)

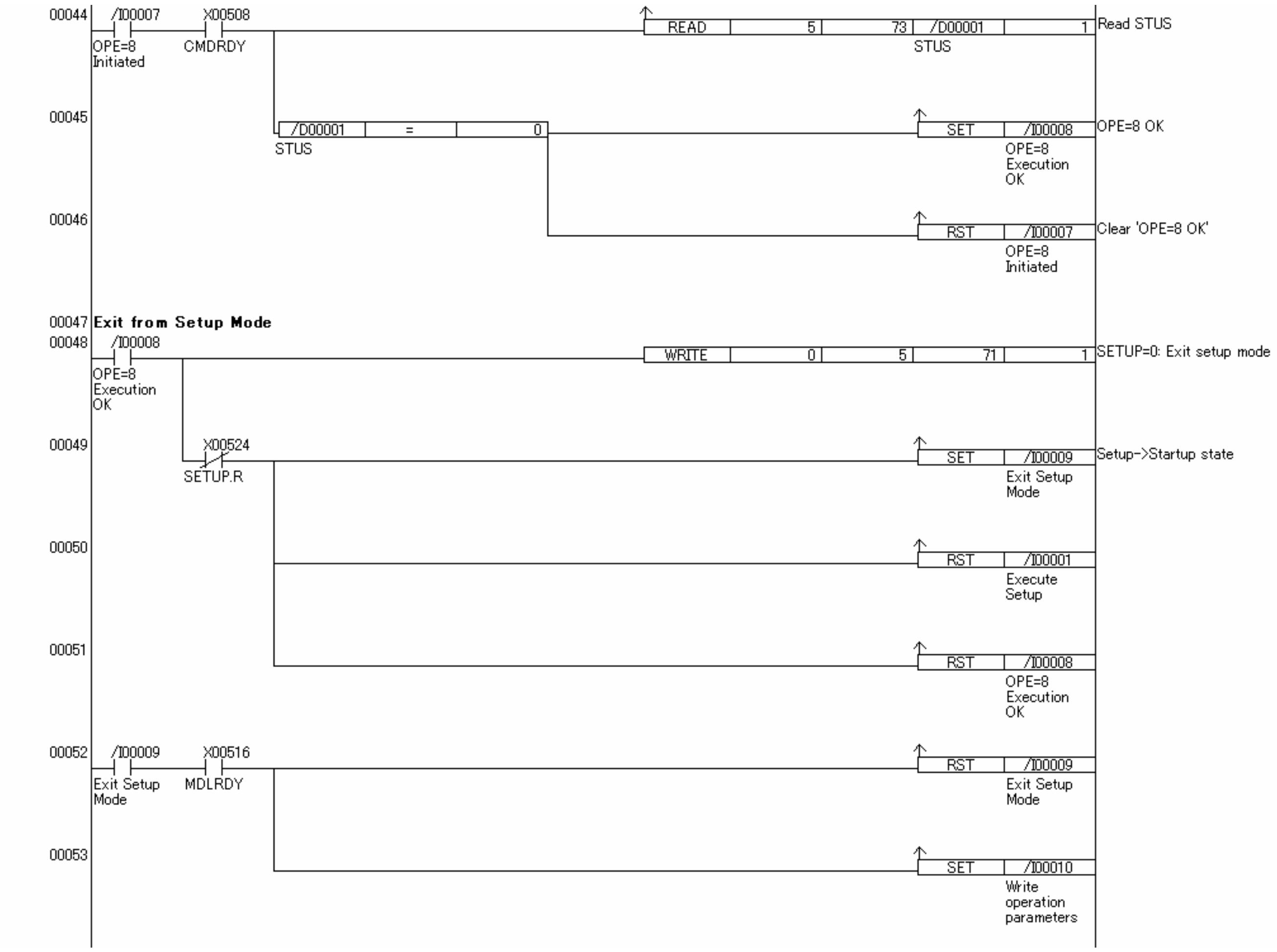


Figure B2.4 Sample Program for Setting Controller and I/O Parameters (5/6)

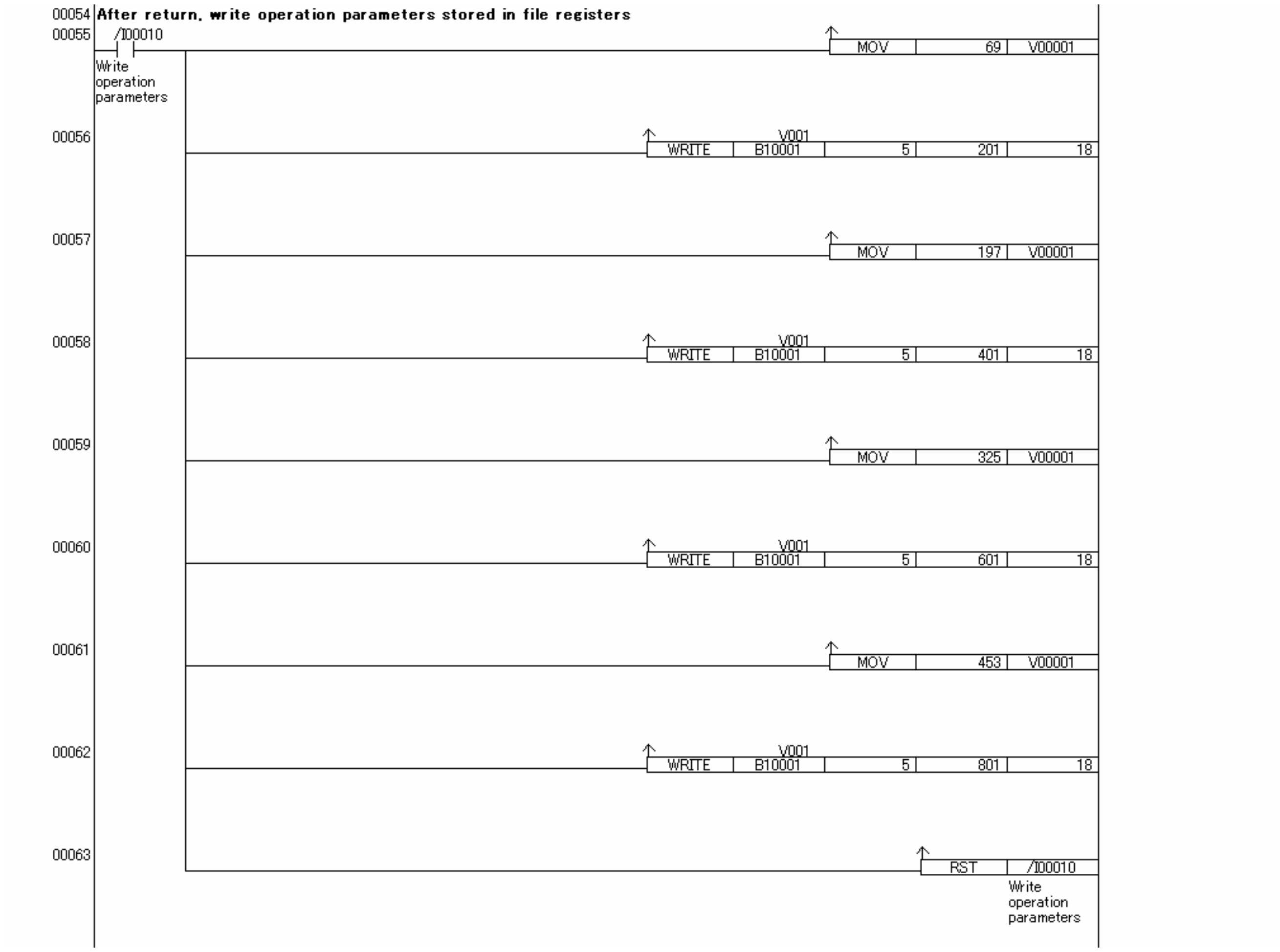


Figure B2.4   Sample Program for Setting Controller and I/O Parameters (6/6)

B2.4 How to Back up SP Values to EEPROM

The SP backup function is provided for writing SP values to the EEPROM so that these parameter values are retained even after power off and on. In situations where you want to predefine SP values so that they are valid right after power on, back up the values to the EEPROM using the procedure given below. The SP backup function, when executed, writes all SP values of all loops (1.SP.1 to 4.SP.4) to the EEPROM. Unless you perform this procedure, SP values are not stored, and revert to their last stored values after power off and on. However, beware that SP backup will not be executed if the parameter backup function is disabled using the NBKUP parameter.

TIP

Updated SP values take effect immediately regardless of whether they are backed up to EEPROM. There is no need to execute the SP backup function if SP values need not be retained.

Table B2.29 I/O Parameters Related to SP Backup

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
74				SPWR	Write set point to EEPROM	None	0: No write “WR”: Write	0	RW	—
75				NBKUP	Disable backup function	None	0: Backup 1: No backup	0	RW	—
77 and 78 (long word)				EEP.CNTR	EEPROM write counter	Times	1 to 100,000	—	RO	—
201	401	601	801	1.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular
221	421	621	821	2.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular
241	441	641	841	3.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular
261	461	661	861	4.SP	Set point	Industrial	PRL to PRH	PRL	RW	Irregular

Table B2.30 Input Relays Related to SP Backup

Input Relay Number X☐☐☐nn*1				Symbol	Description	Data Range	Interrupt
Loop 1	Loop 2	Loop 3	Loop 4				
32				SPWR.R	Write SP to EEPROM Completed	0: Write in progress or not started; 1: Write completed	✓

*1: ☐☐☐ denotes the slot number where the module is installed.

CAUTION

The SP backup function cannot be executed as long as the module is put into Setup mode for the purpose of enabling controller and I/O parameter settings. After ensuring that controller and I/O parameter settings are enabled, set up the required SP parameters and then perform SP backup.

CAUTION

The SP backup function is available only with the F3CU04-1S and F3CU04-0S modules of firmware revision 6 or higher. It is not available with F3CU04-1N or F3CU04-0N. You can determine the revision of a module’s firmware from the REV value indicated on the nameplate located on the side of the module, or from the value of the REV register (data position number 90). As an example, “REV 06:05” on the nameplate denotes firmware revision 6 and hardware revision 5.

■ Procedure for Writing SP Values to EEPROM

After writing the required SP values, write “WR” or hexadecimal string “$5752” to the SPWR register to initiate backup of the SP values to the EEPROM. You can write the SP values and perform SP backup even within the same scan. After backup is completed, the module turns on the SPWR.R relay. Writing “WR” or hexadecimal string “$5752” to the SPWR register executes SP backup only once. To repeat SP backup, you need to first write a value of 0 to the SPWR register, and after confirming that the SPWR.R relay is reset, again write “WR” or hexadecimal string “$5752” to the SPWR register.

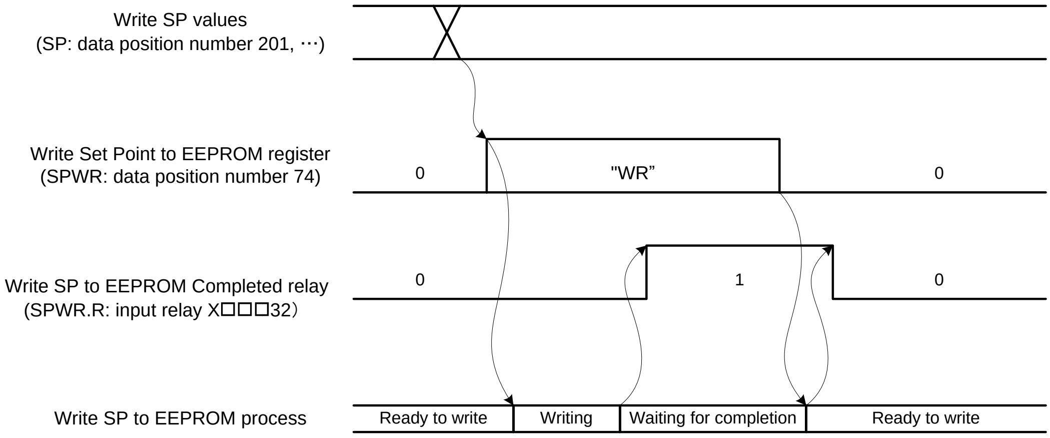


Figure B2.5 Procedure for Writing SP Values to EEPROM

CAUTION

The SP backup function is available only with the F3CU04-1S and F3CU04-0S modules of firmware revision 6 or higher. It is not available with F3CU04-1N and F3CU04-0N. You can determine the revision of a module’s firmware from the REV value indicated on the nameplate located on the side of the module, or from the value of the REV register (data position number 90). As an example, “REV 06:05” on the nameplate denotes firmware revision 6 and hardware revision 5.

CAUTION

If you write a “WR” value to the SPWR register on a module such as F3CU04-1N or F3CU04-0N, which does not support the SP backup function, the module does nothing and the SPWR.R (X☐☐☐32) relay remain as 0. This will not, however, adversely affect module operation.

■ SP Backup Sample Program

This sample program writes an SP value (stored in D00101) when relay I00101 turns on, and when relay I00102 turns on, it rewrites the SP value and, at the same time, backs up all SP values to the EEPROM.

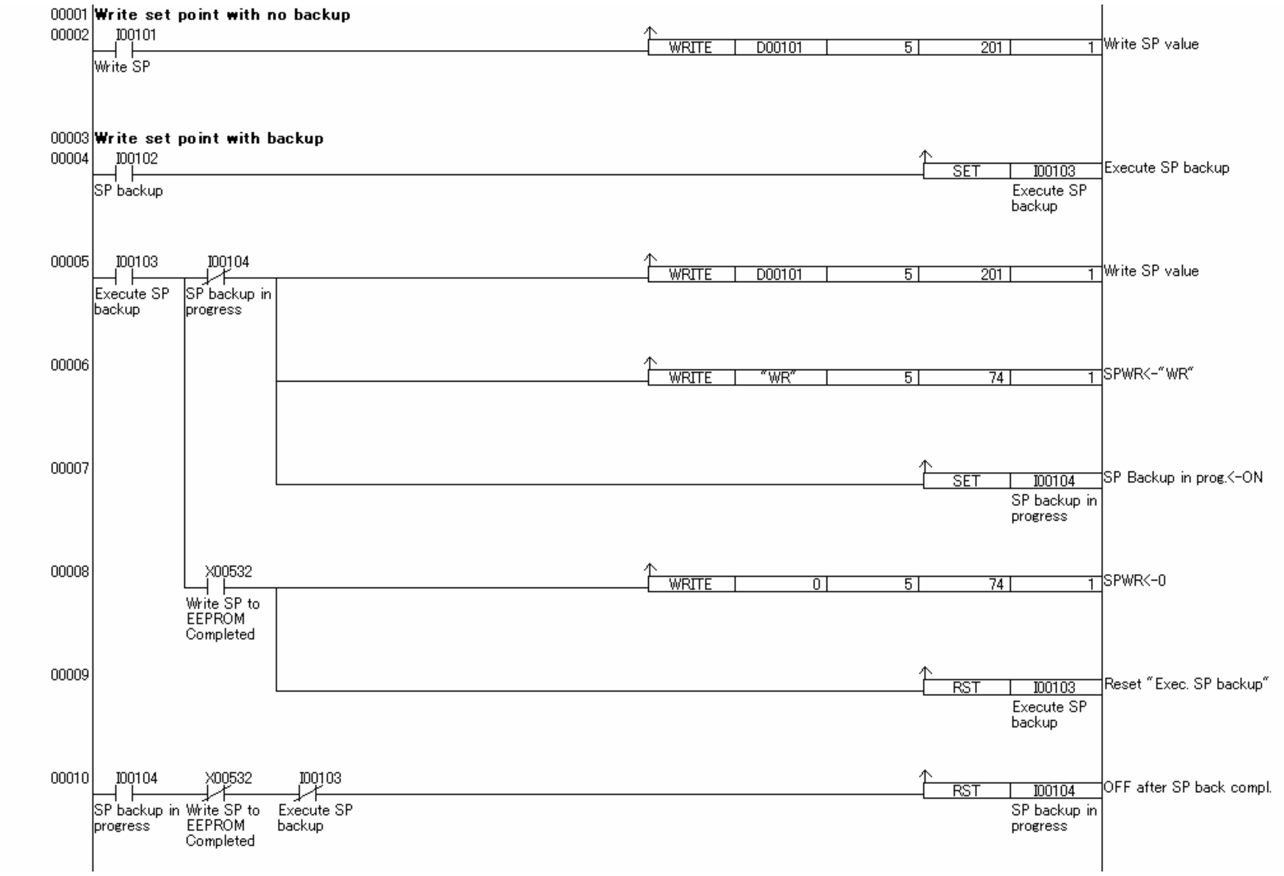


Figure B2.6 Sample Program for Writing SP Values to EEPROM

B2.5 Initializing All Settings

To initialize all settings, use the procedure described in B2.3, “How to Enable Settings,” with the Setup Instruction Operand (OPE) register set to Initialize All Settings.

B3. Setup and Operation

The module is provided with multiple built-in controller functions to support various forms of operations. Before you can use the module, you must select and configure the controller functions. This chapter describes the basic workflow from setup to operation.

For details on individual functions, see Part C, “Function Description”.
For details on module access, use Chapter B1, “Accessing the Module.”

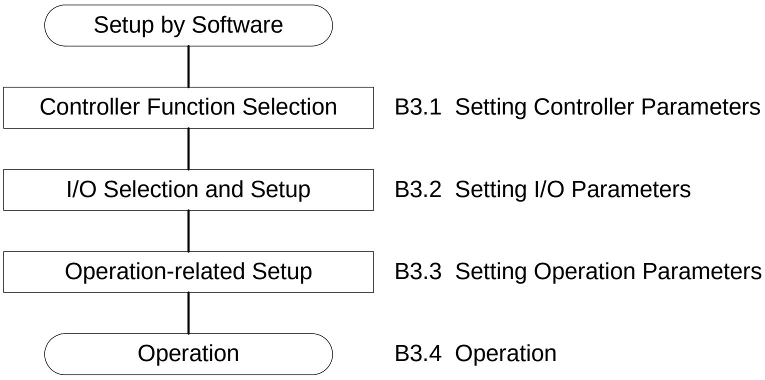


Figure B3.1 Procedure from Setup to Operation

Figure B3.1 shows the procedure flow from setup to operation. Updating a parameter may inadvertently affect (initialize) other parameters, and thus it is important that you perform setup in the sequence described above.

Section B3.1, “Setting Controller Parameters” describes how to combine loops to match a specific usage and perform other module-wide setup. Section B3.2, “Setting I/O Parameters” describes how to set up basic I/O-related elements, such as input type selection and input range for individual loops. Section B3.3, “Setting Operation Parameters” describes the operation-related parameters, as well as how to start the auto-tuning function (when dynamic auto-tuning is not selected). Lastly, Section B3.4, “Operation” describes operation-related procedures.

B3.1 Setting Controller Parameters

Controller parameters are used for performing module-wide setup to suit the operating environment and mode of use. They define the most basic operations of the module.

The setup elements are described in Sections B3.1.1, “Power Frequency Selection”, B3.1.2, “Input Sampling Period,” B3.1.3, “Controller Mode” and B3.1.4, “Setting Output Terminals.” You should set these parameters to match the operating and usage environment. The controller parameters must be enabled before any written content can take effect. For details on how to enable parameter settings, see Section B2.3, “How to Enable Settings.”

CAUTION

Changing a controller parameter initializes the parameters of the module. Always set controller parameters before other parameters.

B3.1.1 Power Frequency Selection

Use this parameter to select a power frequency that matches the power supply environment.

Table B3.1 Power Frequency Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
81				FREQ	Power frequency selection [*1]	None	0: 50Hz, 1: 60Hz	0	RW[*1]	✓	C3.2

*1 The power frequency can also be selected using a hardware switch. For details on how to do so, see Section A4.1, “Selecting Input Types and Power Frequency”. If the power frequency is set using the hardware switch, the setting cannot be changed by software.

Selecting an appropriate power frequency reduces interference of common mode noise from the power supply on input signals.

B3.1.2 Input Sampling Period

This parameter sets the input sampling period. Beware that a short sampling period restricts the number of available loops.

Table B3.2 Input Sampling Period

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
82				SMP	Input Sampling period [*1]	None	0: 100 ms, 1: 200 ms	1	RW	✓	—

*1 This setting restricts the number of available loops. A value of 100ms allows up to 2 loops to be used, whilst a value of 200ms allows up to 4 loops to be used. Table B3.3 lists the usable loops for different preset values.

Table B3.3 Mapping between Input Sampling Period and Usable Loops

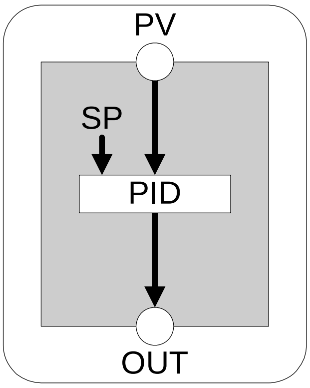
Input Sampling Period	Preset Value	Usable Loops [*1]				Remarks
		1	2	3	4	
100 ms	0	✓	✓	—	—	The output function of each loop is always available, even for loops 3 and 4.
200 ms	1	✓	✓	✓	✓	Default Value

*1 ‘✓’ : usable; ‘— ‘: not usable.

B3.1.3 Controller Mode

The controller mode parameters configure how loops are combined. The module supports the single loop, two-input changeover, and cascade control modes. In the two-input changeover or cascade control mode, two loops are combined and used as one.

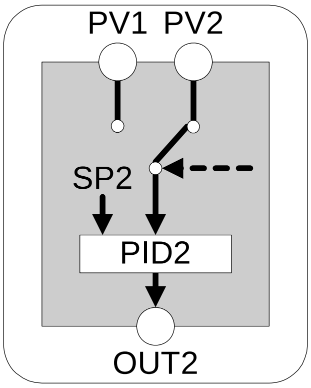
■ Single Loop Mode



This is the standard mode of use.

In this mode, each loop operates independently, and is configured separately. The description from Section B3.2, “Setting I/O Parameters,” to Section B3.4, “Operation,” assumes the use of the single loop mode.

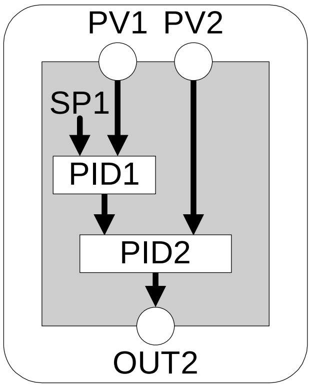
■ Two-input Changeover Mode



This mode uses two loops and switches between the two inputs.

In this mode, setup and operation act on a pair of loops (loops 1 and 2, or loops 3 and 4). Only the parameters of loop 2 and 4 are used in control operation. The description from Section B3.2, “Setting I/O Parameters,” to Section B3.4, “Operation,” assumes the use of the single loop mode. For details on setup and operation unique to the two-input changeover mode, see Section C1.3, “Two-input Changeover Control."

■ Cascade Control Mode



This mode uses two loops connected in series, with one serving as the primary loop and the other as the secondary loop.

In this mode, setup and operation act on a pair of loops (loops 1 and 2, or loops 3 and 4). Only the parameters of loop 2 or 4 are used in control operation. The description from Section B3.2, “Setting I/O Parameters,” to Section B3.4, “Operation,” assumes the use of the single loop mode. For details on setup and operation unique to the cascade control mode, see Section C1.2, “Cascade Control."

The controller mode is configured for a pair of loops. Register MD12 corresponds to loops 1 and 2, whilst MD34 corresponds to loops 3 and 4. Table B3.5 shows the mapping between controller mode preset values and loops.

Table B3.4 Controller Mode

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
83				MD12	Controller mode	None	0 to 4: See Table B3.5 for details.	0	RW	✓	C1
		84		MD34				0	RW	✓	

Table B3.5 Controller Mode and Loops

Symbol	Description	Relationship between Controller Mode Preset Value and Loop		
			Odd-numbered Loop (Loop 1 or 3)	Even-numbered Loop (Loop 2 or 4)
MD12 MD34	Controller mode	0: Two single loops	Single loop	Single loop
		1: Two-input changeover control	Low temperature input [*1]	High temperature input
		2: Cascade control	Primary loop	Secondary loop
		3: Single loop (Odd-numbered loop is disabled)	Not used	Single loop
		4: Both loops disabled	Not used	Not used

*1: Only the input function of the loop is used.

CAUTION

Controller Mode is a controller parameter. Changing a controller parameter reverts all parameters of the module to their default values.

However, switching between the Disabled and Single Loop modes, that is, between controller modes 0, 3 and 4 will not initialize the parameters.

B3.1.4 Setting Output Terminals

Output terminal setup defines the control output from each output terminal. Use the Output Type Selection (OUTPUT) parameter to select continuous analog output or open collector output for each terminal. Use the Output Terminal Selection (OUTSEL 1-8) parameters to map individual output terminals to control output preset values.

These parameter settings must be enabled before they can take effect. For details on how to enable parameter settings, see Section B2.3, "How to Enable Settings."

Table B3.6 Relationship between Output Terminal Setting and Loop

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
87				OUTPUT	Output type selection [*1]	None	Selects open collector or analog output for each output terminal.	0	RW	✓	C2.2
91				OUTSEL1	Output terminal selection [*2]	None	1 to 4: Heating outputs 1-4 11 to 14: Cooling outputs 1-4 [*3] 21 to 28: Output preset values 1-8 [*4]	1	RW	✓	C2.3
92				OUTSEL2				2			
93				OUTSEL3				3			
94				OUTSEL4				4			
95				OUTSEL5				11			
96				OUTSEL6				12			
97				OUTSEL7				13			
98				OUTSEL8				14			

*1: Output type selection is available only with F3CU04-1S, which supports continuous output. It specifies output type for each output terminal. See also Table B3.7

*2: For F3CU04-0S, which has only four output terminals, neither registers OUTSET 5-8 nor values 21-28 are available.

*3: The Control Type Selection (OT) parameter (see Section B3.2.2, "Control Type Selection") must be set to heating/cooling control before an output terminal can be configured for cooling output.

*4: For details on how to configure an output terminal for analog output by selecting an output preset value, see Section B2.2.2, "Analog Output Settings." Analog output is available only with F3CU04-1S.

Table B3.7 Output Type Selection

Data Position Number	Symbol	Description		Relationship between Bits and Terminals									Data Range
			Terminal	15-8	7	6	5	4	3	2	1	0	
87	OUTPUT	Output type selection	1	—	—	—	—	—	—	—	—	✓	0: Open collector output (default) 1: Analog output
			2	—	—	—	—	—	—	—	✓	—	
			3	—	—	—	—	—	—	✓	—	—	
			4	—	—	—	—	—	✓	—	—	—	
			5	—	—	—	—	✓	—	—	—	—	
			6	—	—	—	✓	—	—	—	—	—	
			7	—	—	✓	—	—	—	—	—	—	
			8	—	✓	—	—	—	—	—	—	—	

Note: Setting a bit to 1 and 0 configures the corresponding terminal indicated by a tick for analog output and open collector output respectively.

CAUTION

Output type selection is available only with F3CU04-1S, which supports continuous output.

CAUTION

The Output Type Selection (OUTPUT) parameter and the Output Terminal Selection (OUTSEL1-8) parameters are controller parameters. Changing a controller parameter reverts all parameters of the module to their default values.

B3.1.5 Sample Program for Setting Controller Parameters

This section shows a sample program for setting controller parameters. The program sets the power supply to 60Hz, and disables loops 3 and 4.

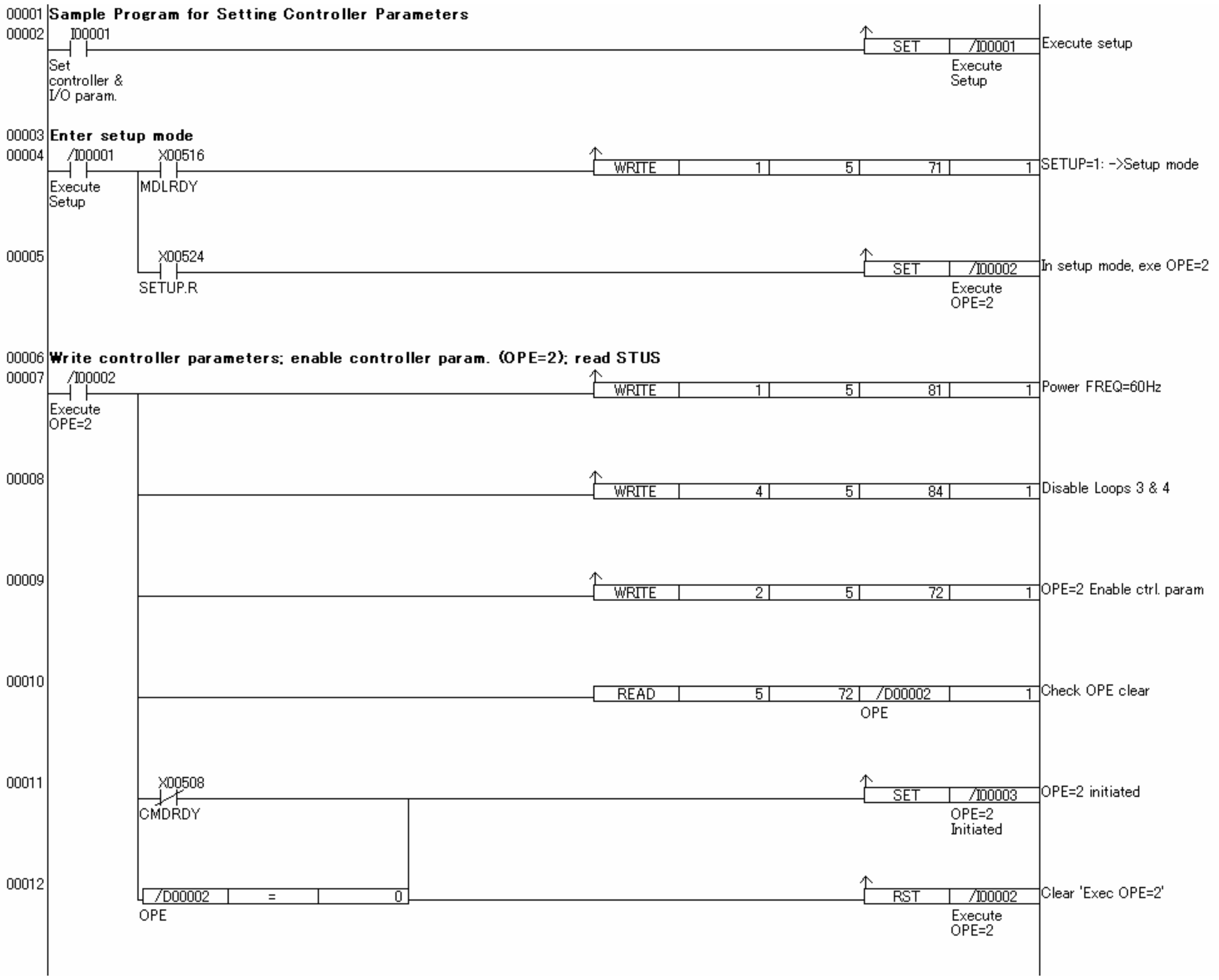


Figure B3.2 Sample Program for Setting Controller Parameters (1/2)

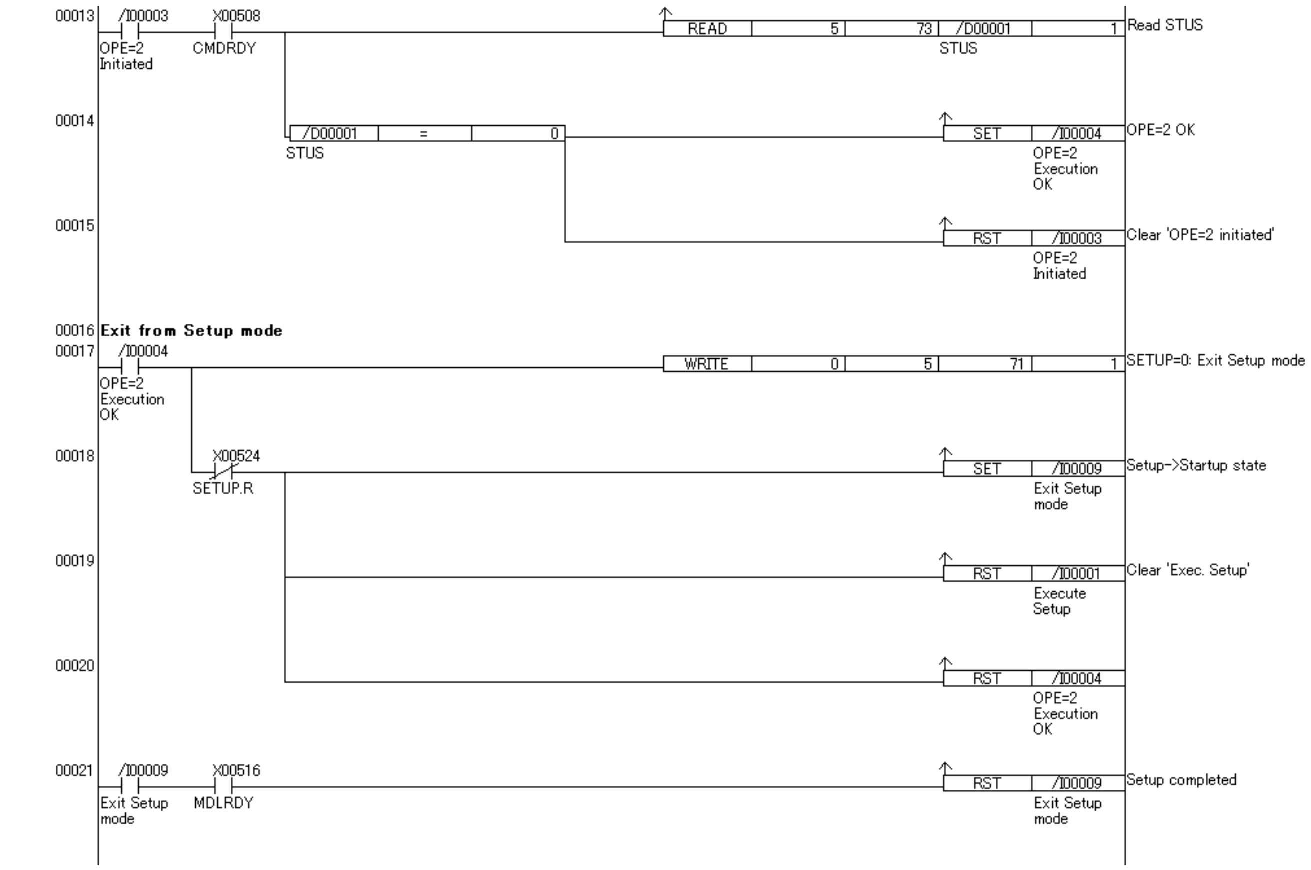


Figure B3.2 Sample Program for Setting Controller Parameters (2/2)

B3.2 Setting I/O Parameters

I/O parameters are classified into two categories: required I/O parameters that must be checked and set, and optional I/O parameters that can be set as required. All I/O parameters apply to individual loops.

The required parameters are described in Sections B3.2.1, “Input Type Selection,” and B3.2.2, "Control Type Selection."

Optional I/O parameters are used for changing the input range, for selecting burnout detection, as well as for setting the upper and lower limits of the PV range when using Two-input Changeover control.

For details on functions selectable with optional I/O parameters, see Chapter C3, “PV-related Functions”.

I/O parameters must be enabled before any written content can take effect. For details on how to enable parameter settings, see Section B2.3, “How to Enable Settings.”

CAUTION

Changing an I/O parameter initializes operation parameters and other related I/O parameters. Therefore, always set I/O parameters before setting operation parameters.

B3.2.1 Input Type Selection

These parameters specify the input type of individual loops. Select a preset value that matches the temperature range and voltage range of the sensor to be used.

Table B3.8 Input Type Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop 2	Loop 3	Loop 4								
142	342	542	742	IN	Input type selection *1	None	1 to 31, 33 to 56 For details, see Table A4.1, "Input Type Selection."		RW *1	✓	C3.1

*1 You can also select input types using hardware switches as described in Section A4.1, "Selecting Input Types and Power Frequency." If a selection is made using a hardware switch, the setting cannot be changed by software.

B3.2.2 Control Type Selection

This parameter specifies the control type for each loop.

Table B3.9 Control Type Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
141	341	541	741	OT	Control type selection	None	0: PID control 1: ON/OFF control 2: Heating/cooling PID control 3: Heating/cooling ON/OFF control	0	RW	✓	C2.1

For details on how to assign a specific output type to a specific output terminal, see Section B3.1.4, "Setting Output Terminals." See also Section C2, "Output-related Functions."

B3.2.3 Sample Program for Setting I/O Parameters

This section shows a sample program for setting I/O parameters. The program sets the input types, followed by the input ranges for loops 1 and 2.

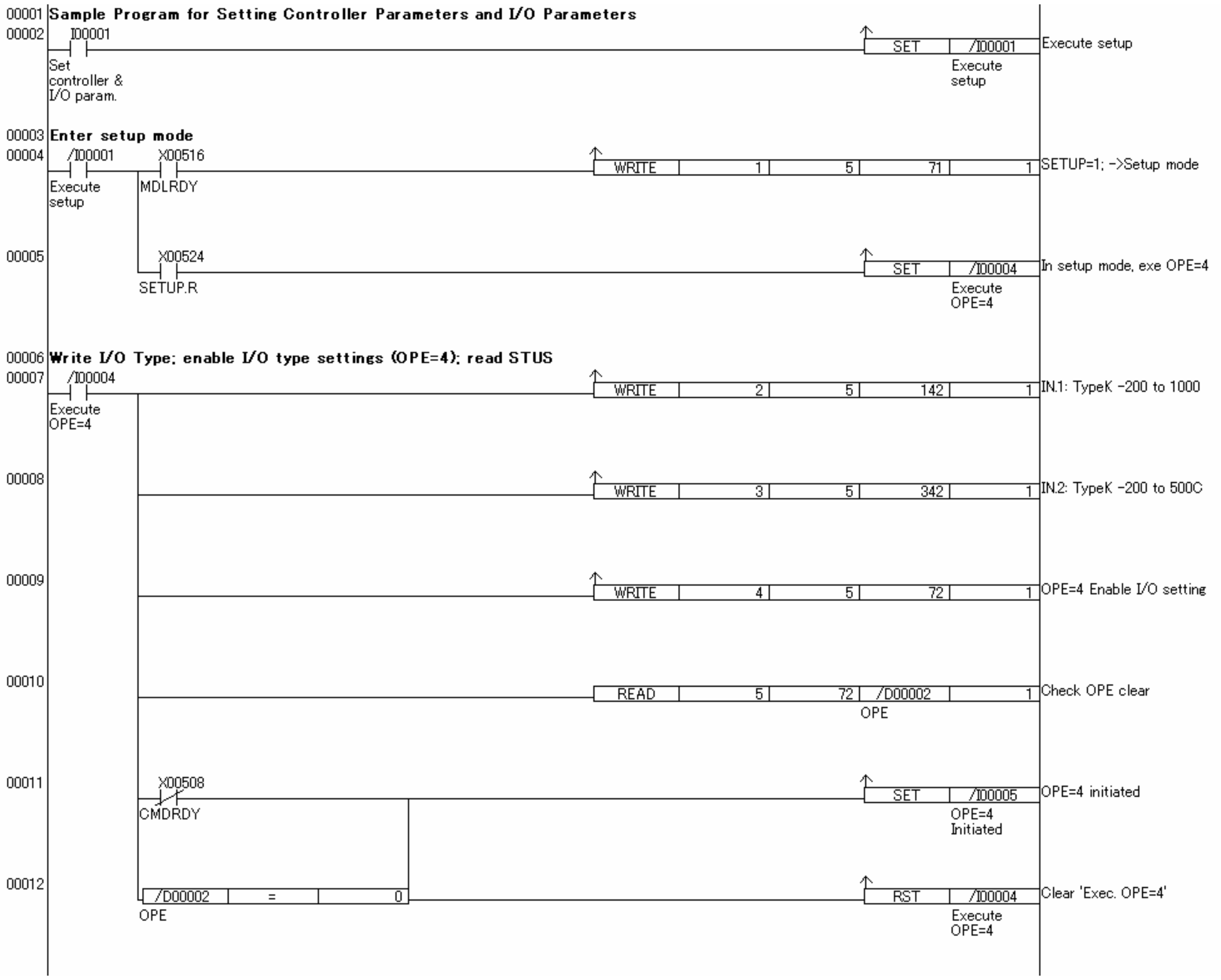


Figure B3.3 Sample Program for Setting I/O Parameters (1/3)

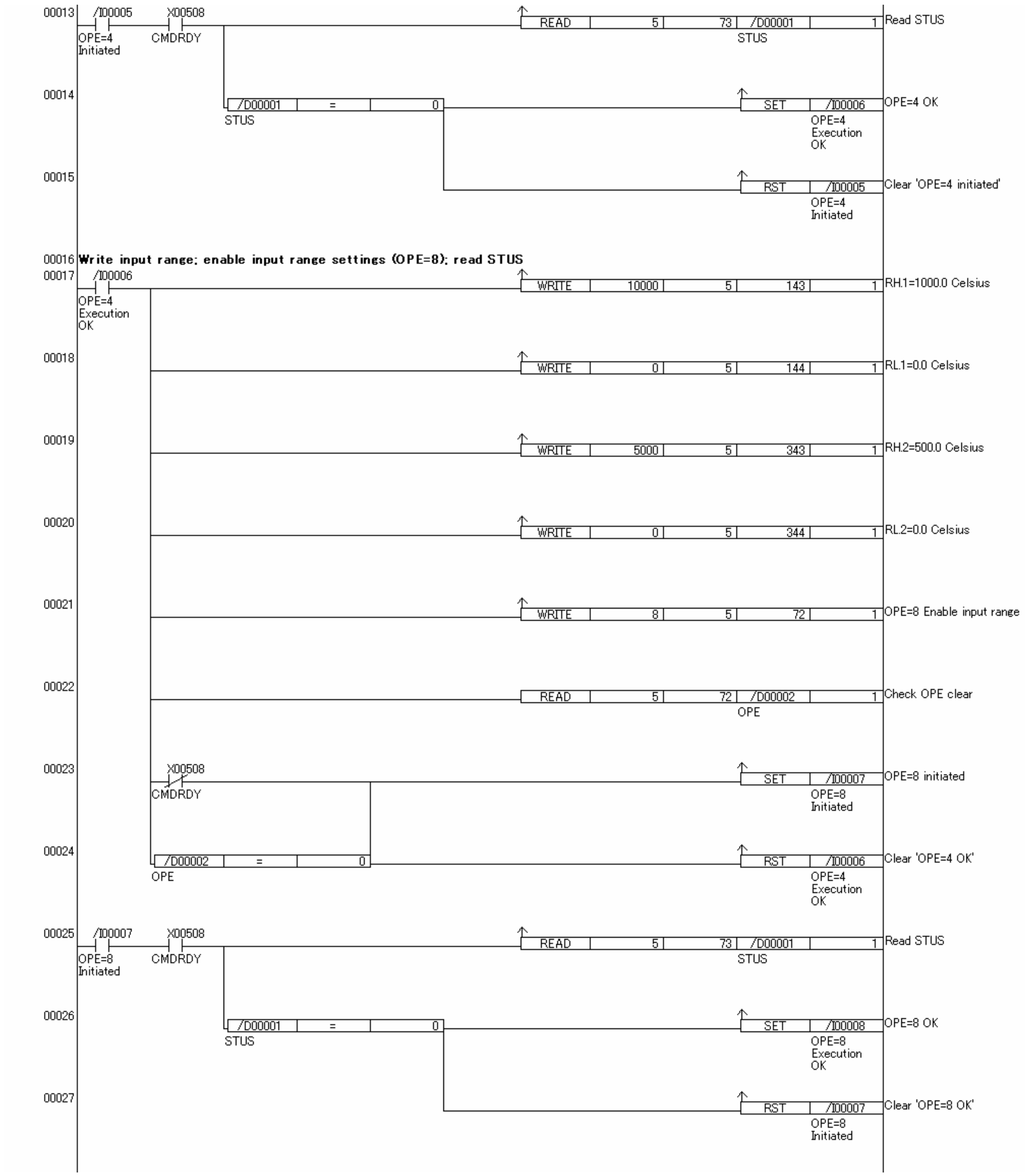


Figure B3.3 Sample Program for Setting I/O Parameters (2/3)

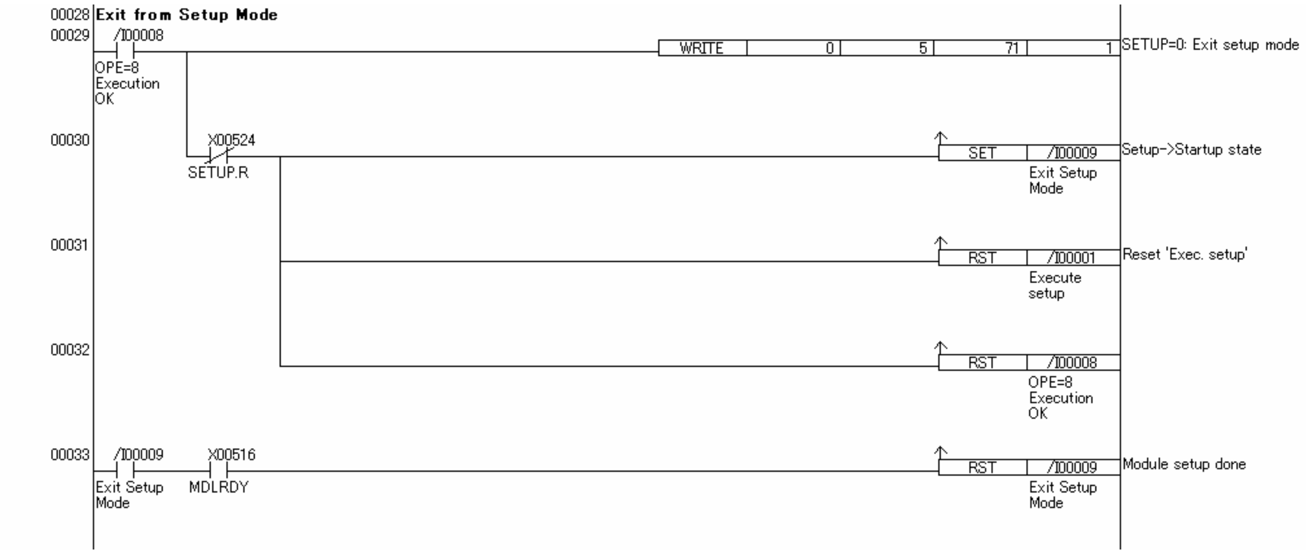


Figure B3.3 Sample Program for Setting I/O Parameters (3/3)

B3.3 Setting Operation Parameters

Operation parameters define module operation. They are classified into PID parameters and function settings.

This section describes the operation parameters that must be set before you can start module operation as described in Section B3.4, "Operation." The function settings, which are optional, include output-, PV-, SP-, and alarm-related function settings. For details, see Sections C2, "Output-related Functions," C3, "PV-related Functions," C4, "SP-related Functions," and C8, "Alarm Function."

The operation parameters that must be set before module operation depend on whether you intend to use dynamic auto-tuning. Go to Section B3.3.1, "Preparing for Dynamic Auto-tuning," if you intend to use dynamic auto-tuning. You may skip to Section B3.3.2, "Preparing for PID Control," otherwise.

CAUTION

Changing a controller parameter or I/O parameter initializes all operation parameters. Therefore, always set the controller parameters and I/O parameters before setting the operation parameters.

B3.3.1 Preparing for Dynamic Auto-tuning

In dynamic auto-tuning mode, the PID control parameters (proportional band, integral time, and derivative time) are automatically determined and set. To enter dynamic auto-tuning mode, set the Dynamic Auto-tuning Enable (SELF) parameter to 1 (enabled) as shown in Table B3.10. When SELF is set to 1, it is automatically enabled (no additional procedure is required to enable the setting). Now you are ready to start module operation.

Table B3.10 Dynamic Auto-tuning Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
181	381	581	781	SELF	Dynamic auto-tuning enable	None	0: Disabled 1: Enabled	0	RW	✓	C5.1

CAUTION

There are some pre-conditions for using dynamic auto-tuning: the controller mode must be set to either Single Loop or Two-input Changeover Control, and the control type must be set to PID Control. For details on dynamic auto-tuning, see Section C5.1, "Dynamic Auto-tuning."

When not using dynamic auto-tuning, set the PID control parameters manually as described in Section B3.3.2, "Preparing for PID Control."

Table B3.11 Operation Parameters That Must be Set when Using Dynamic Auto-tuning[*1]

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
201	401	601	801	1.SP	Set point	Industrial unit	PRL to PRH	PRL	RW	✓	C4.

*1: To switch between PID parameter groups, see Section C4, "SP-related Functions."

CAUTION

You need to execute a specific procedure every time to update stored set point values. Otherwise, stored set points will not be updated so the parameters revert to their last stored values whenever the module is turned off and then on again. For details, see Section B2.4, "How to Back up SP Values to EEPROM."

B3.3.2 Preparing for PID Control

To perform PID control without dynamic auto-tuning, you must manually set the PID control parameters, namely, the Proportional Band (PB), Integral Time (TI) and Derivative Time (TD) parameters according to the characteristics of the controlled object. If you specify inappropriate PID parameter values, you will not be able to achieve the desired control. You may directly change the PB, TI, and TD registers, or use the auto-tuning function to let the module adjust the parameter values automatically.

CAUTION

Before directly changing the PB, TI or TD register, you must set the Dynamic Auto-tuning Enable (SELF) parameter to “0: disabled.” Otherwise, the dynamic auto-tuning function will overwrite the modified value.

Table B3.12 Operation Parameters That Must be Set for PID Control [*1]

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
201	401	601	801	1.SP	Set point	Industrial unit	PRL to PRH	PRL	RW	✓	C4.1
206	406	606	806	1.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓	C6.2
207	407	607	807	1.TI	Integral time	Second	0: OFF 1 to 6000 (1 to 6000 s)	240	RW	✓	C6.3
208	408	608	808	1.TD	Derivative time	Second		60	RW	✓	C6.4

*1 To switch between PID parameter groups, see Section C4, "SP-related Functions."

CAUTION

You need to execute a specific procedure every time to update stored set point values. Otherwise, stored set points will not be updated so the parameters revert to their last stored values whenever the module is turned off and then on again. For details, see Section B2.4, "How to Back up SP Values to EEPROM."

Set the PID control parameters PB, TI, and TD in Table B3.12 to appropriate values. To set these parameters automatically with the auto-tuning function, first define the set point, and then start the auto-tuning function as described below. Let us assume that the set point to be used is 1.SP.

Table B3.13 I/O Registers Used in Auto-tuning

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
111	311	511	711	AT.STUS	Auto-tuning status	None	0: AT normal exit 1: AT executing 2: AT manually stopped 3: AT error exit	—	RO	—	C5.2
121	321	521	721	RUN/STP	Run/stop selection	None	0: Stop 1: Run	0	RW	—	C7.1
122	322	522	722	A/M/C	Automatic/manual /cascade selection	None	0: Automatic 1: Manual 2: Cascade *1	0	RW	—	C7.2 C7.4
127	327	527	727	AT	Start auto-tuning	None	0: Stop AT 1 to 5: Start AT *2 (reverts to 0 when AT is completed)	0	RW	—	C5.2

*1 For details on cascade control, see Section C1, "Controller Mode."
*2 For details on auto-tuning, see Section C5.2, "Auto-tuning."

Table B3.14 Input Relays Used in Auto-tuning

Input Relay Number X□□□nn *1				Symbol	Description	Data Range	Interrupt	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
X04	X12	X20	X28	AT.RDY	Auto-tuning completed	0: AT in progress, 1: AT completed	✓	C5.2

*1 □□□ denotes the slot number where the module is installed.

Set the set point to be used in control operation to Set Point register 1.SP (see Table B3.12). Then set the AT register to 1 to start the auto-tuning function. When auto-tuning begins, the AT.RDY relay is set to 0 and the AT.STUS register is set to 1. When auto-tuning completes, the AT register automatically returns to 0 and the AT.RDY relay is set to 1. To abort an ongoing auto-tuning, set the AT register to 0. In this case, the PID parameters retain their values before auto-tuning is started.

For details on how auto-tuning operates, how to start zone PID, or how to confirm the completion of auto-tuning, see Section C5.2, "Auto-tuning."

CAUTION

Before starting auto-tuning for a particular loop, you must first set the RUN/STP register of the loop to ‘1: Run’ and the A/M/C register of the loop to ‘0: Automatic’. Then, set the AT register to 1.

If not all required conditions are satisfied, auto-tuning will be aborted.

B3.3.3 Sample Program for Setting Operation Parameters

This section shows a sample program for setting operation parameters. Always set controller parameters and I/O parameters before operation parameters.

■ Setting Operation Parameters for Dynamic Auto-tuning

The following is a sample program for setting operation parameters for dynamic auto-tuning. The program enables dynamic auto-tuning, specifies a set point, and sets up Run/Stop and other operation control parameters essential for module operation.

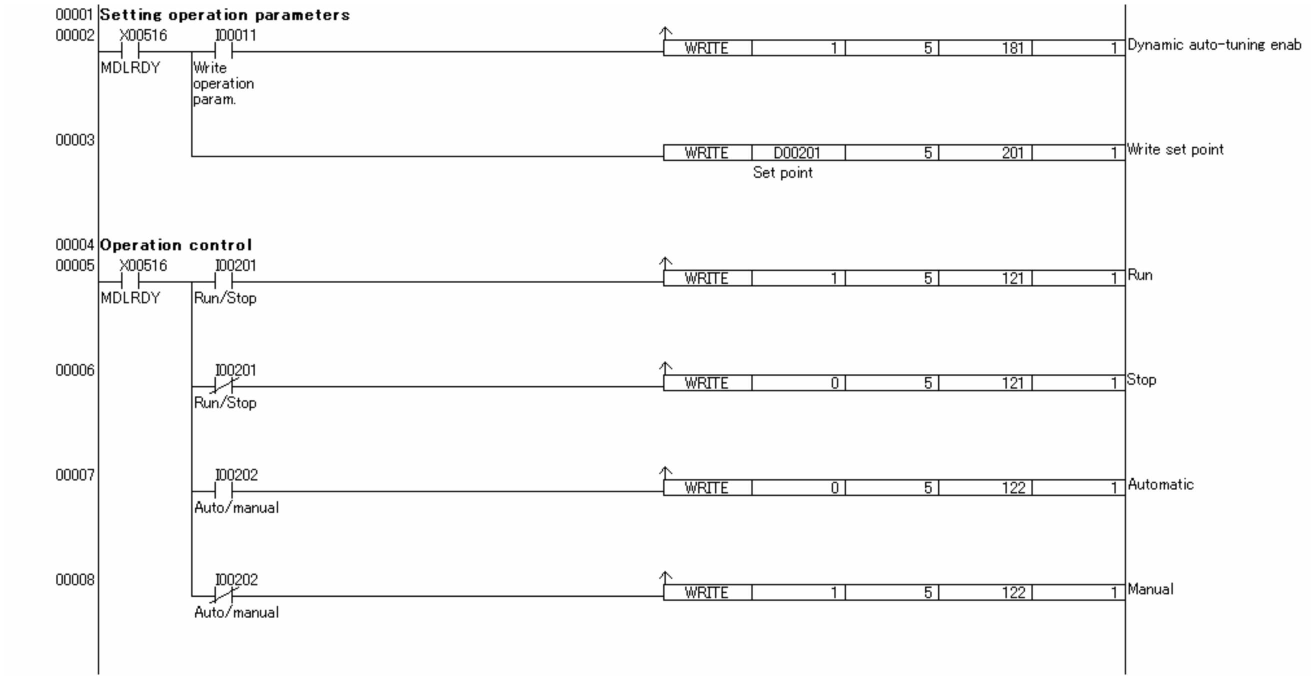


Figure B3.4 Sample Program for Setting Operation Parameters for Dynamic Auto-tuning

■ Setting Operation Parameters for PID Control

The following is a sample program for setting operation parameters for PID control. It specifies a set point and sets Run/Stop, Auto-tuning Enable, and other operation control parameters essential for module operation.

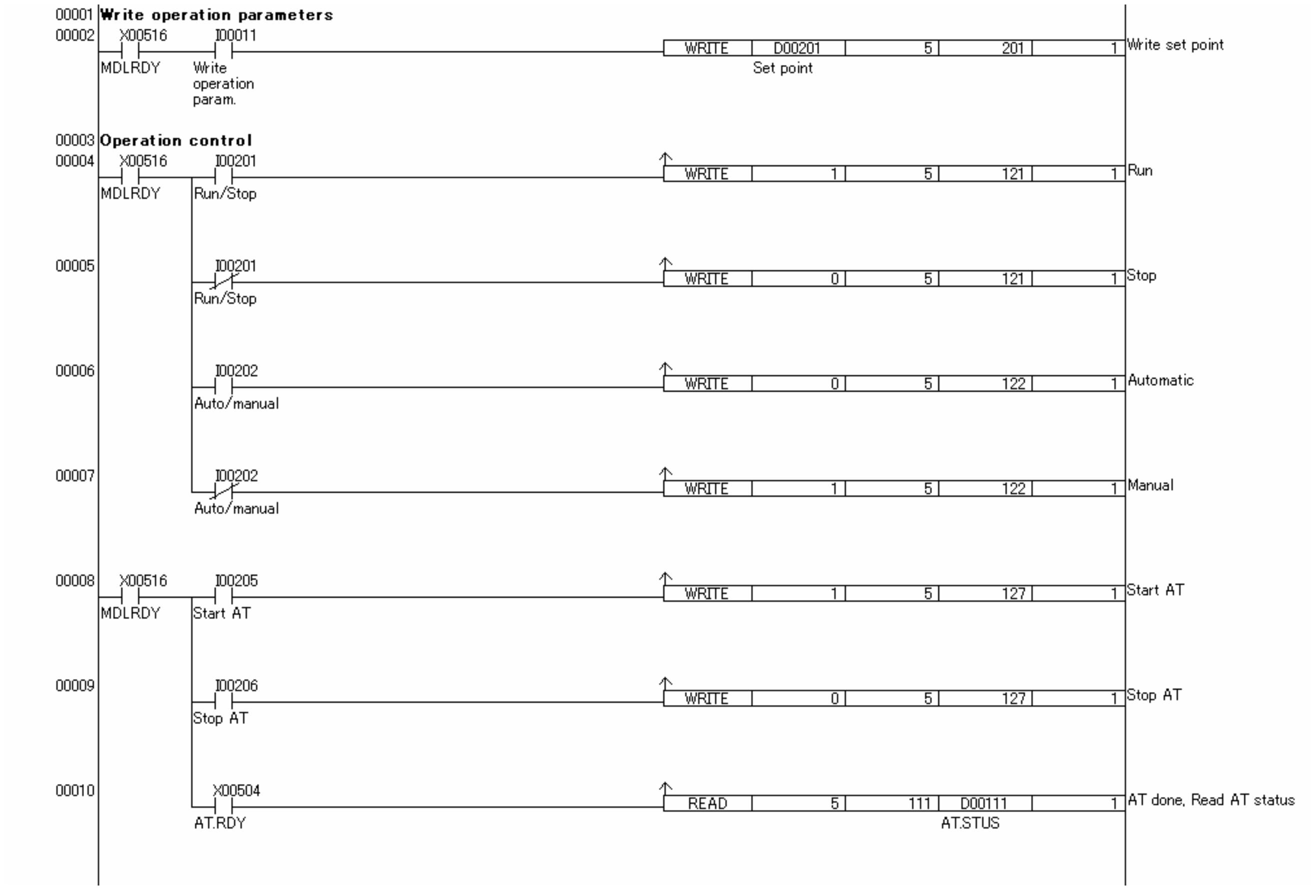


Figure B3.5 Sample Program for Setting Operation Parameters for PID Control

B3.4 Operation

Once you have completed the setup described in Sections B3.1, “Setting Controller Parameters,” B3.2, "Setting I/O Parameters," and B3.3, “Setting Operation Parameters”, the module is ready for operation. Start module operation in manual or automatic mode by writing to the RUN/STP and A/M/C registers. To operate in Manual mode, specify an output level using the Manual Output (MOUT) register.

For information on SP number selection, remote set point, and other operation control functions, see Section C7, "Operation Control."

Table B3.15 Operation Control Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
121	321	521	721	RUN/STP	Run/stop selection	None	0: Stop 1: Run	0	RW	—	C7.1
122	322	522	722	A/M/C	Automatic/manual /cascade selection *!	None	0: Automatic 1: Manual 2: Cascade (only valid for the even-numbered loop in cascade control mode)	0	RW	—	C7.2 C7.4
124	324	524	724	RMT/LOC	Remote/local selection	None	0: Local, 1: Remote	0	RW	—	C7.3
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
133	333	533	733	RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—	C4.2
134	334	534	734	MOUT	Manual output (for single output or heating output in heating/cooling control)	%	OL to OH: for single output; 0 to OH: for heating/cooling control	0	RW	—	C7.2 C7.4

*1: The controller mode must be set to Cascade Control before the ‘Cascade’ option can be selected. Set the operation control parameters of the even-numbered loop (loop 2 or 4) in cascade mode.

Table B3.16 Relationship between Operating Status, Operation Control, and Output Values

Operating Status	Operation Control		Output	Remarks
	RUN/STP	A/M/C		
Stop	0	0	POUT (and POUTC)	This is the status immediately after power up. In Stop mode, the stored value of the Preset Output parameter is output.
		1		
Automatic	1	0	HOUT (and COUT)	
Manual		1	MOUT (and MOUTC)	

B4. Sample Program

This chapter describes a sample program that uses the module for controlling temperatures. It sets the power supply frequency, input type, input range, set point and other parameters, as well as runs the module and starts the auto-tuning function. If it detects an error, it reads the error status. The program assumes that the module is installed in slot 5 of the main unit.

Table B4.1 lists the internal relays used in this sample program, along with their intended usage.

Table B4.1 Internal Relays Used in the Sample Program

Relay Number	Name and Usage	Remarks
I00001	Execute setup	All parameters set by this program are stored internally in the module and thus do not need to be setup after each power up. These relays therefore need to be operated only when the module is replaced or when parameter values are modified. Run/stop and automatic/manual, however, need to be selected at the beginning of each operation, as these settings are not stored in the module.
I00011	Write operation parameters	
I00102	Backup SP values	
I00201	Run/Stop	
I00202	Auto/Manual	
I00205	Start AT	
I00206	Stop AT	

CAUTION

You need to execute a specific procedure every time to update stored set point values. Otherwise, stored set points will not be updated so the parameters revert to their last stored values whenever the module is turned off and then on again. For details, see Section B2.4, "How to Back up SP Values to EEPROM."

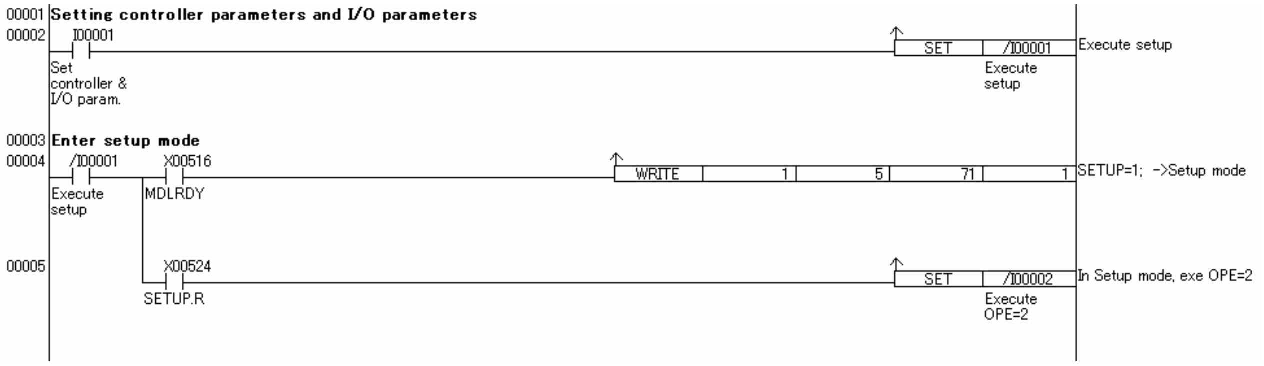


Figure B4.1 Sample Program (Component for Setting Setup Parameters) (1/5)

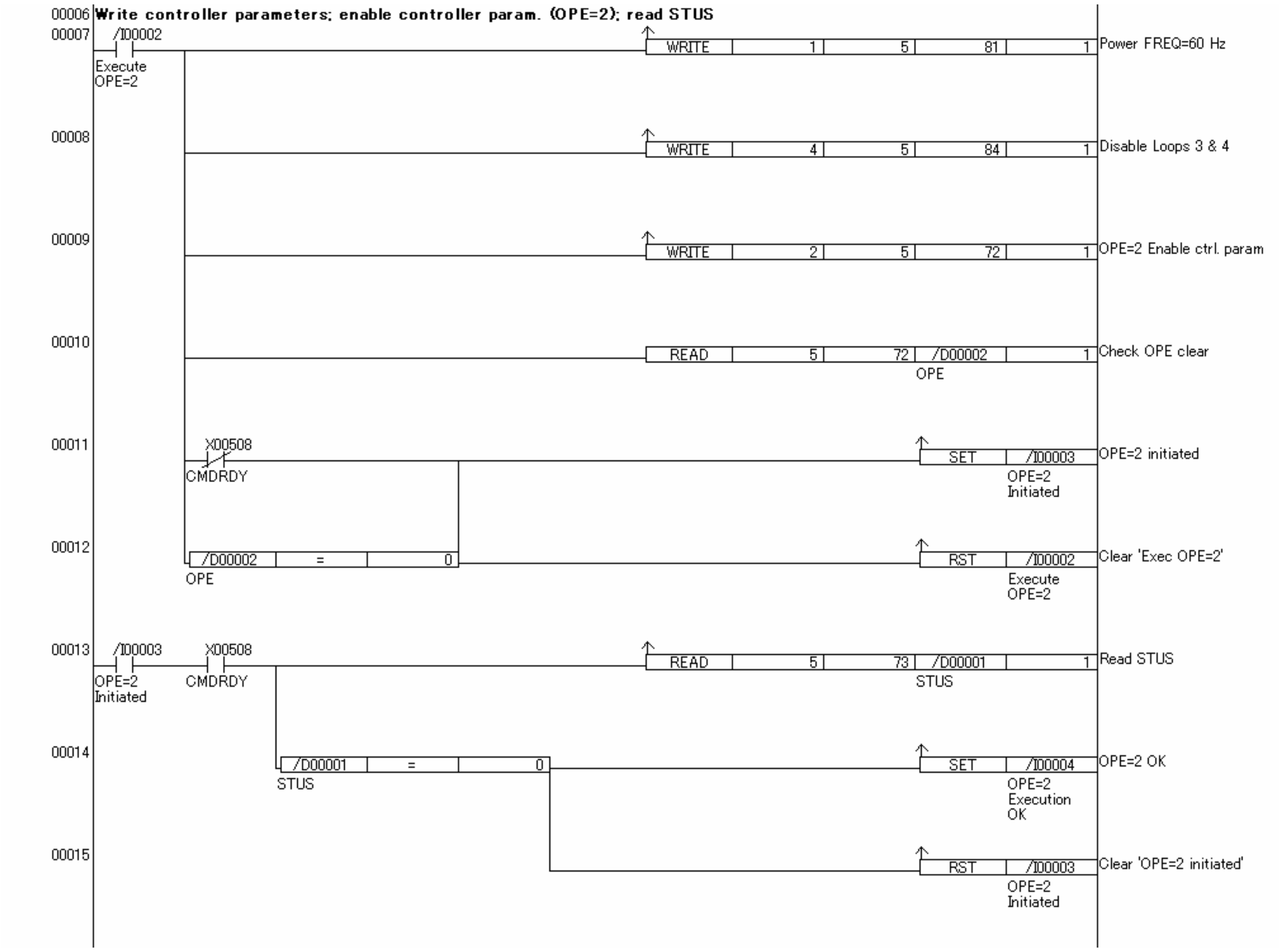


Figure B4.1 Sample Program (Component for Setting Setup Parameters) (2/5)

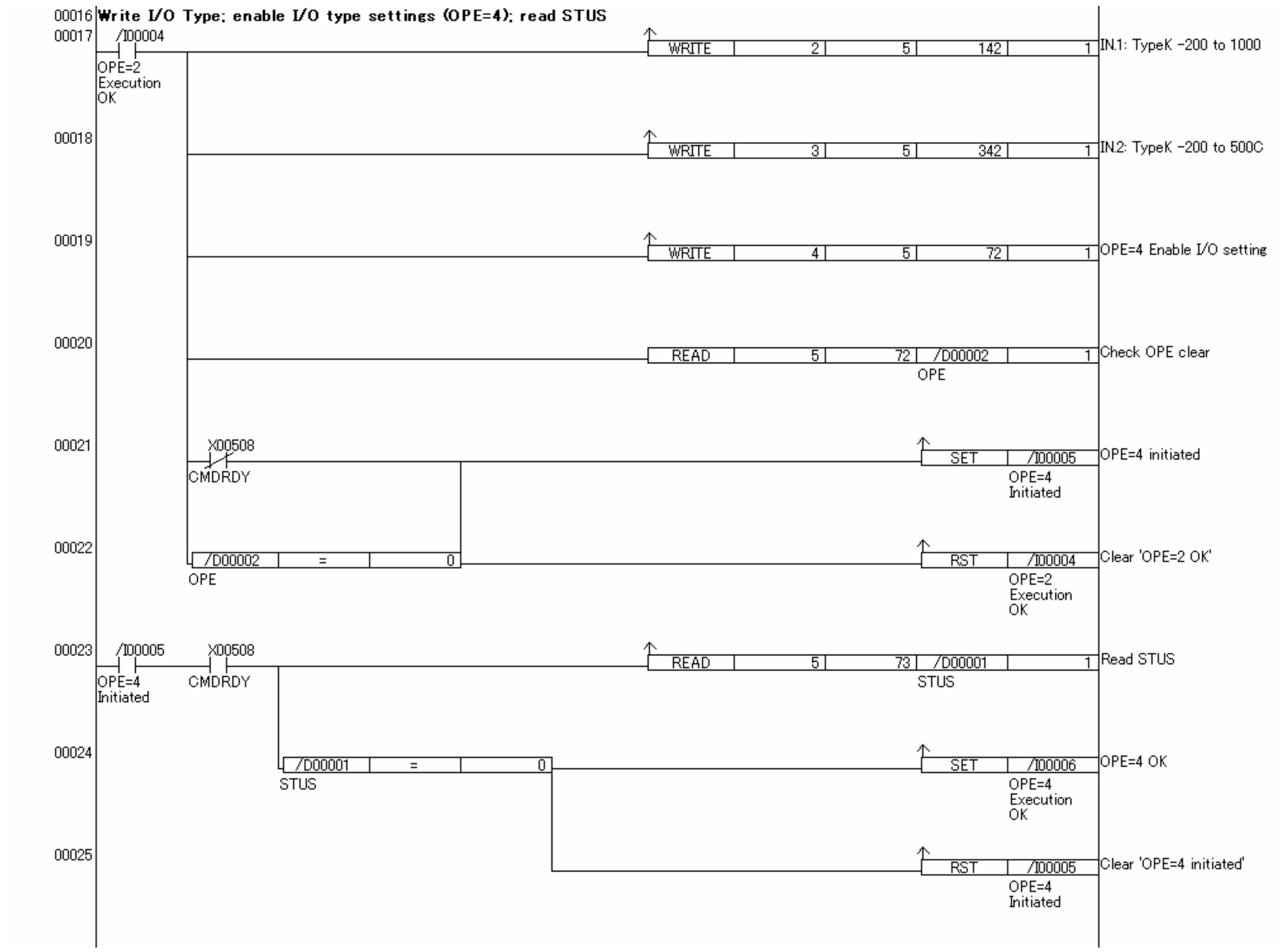


Figure B4.1 Sample Program (Component for Setting Setup Parameters) (3/5)

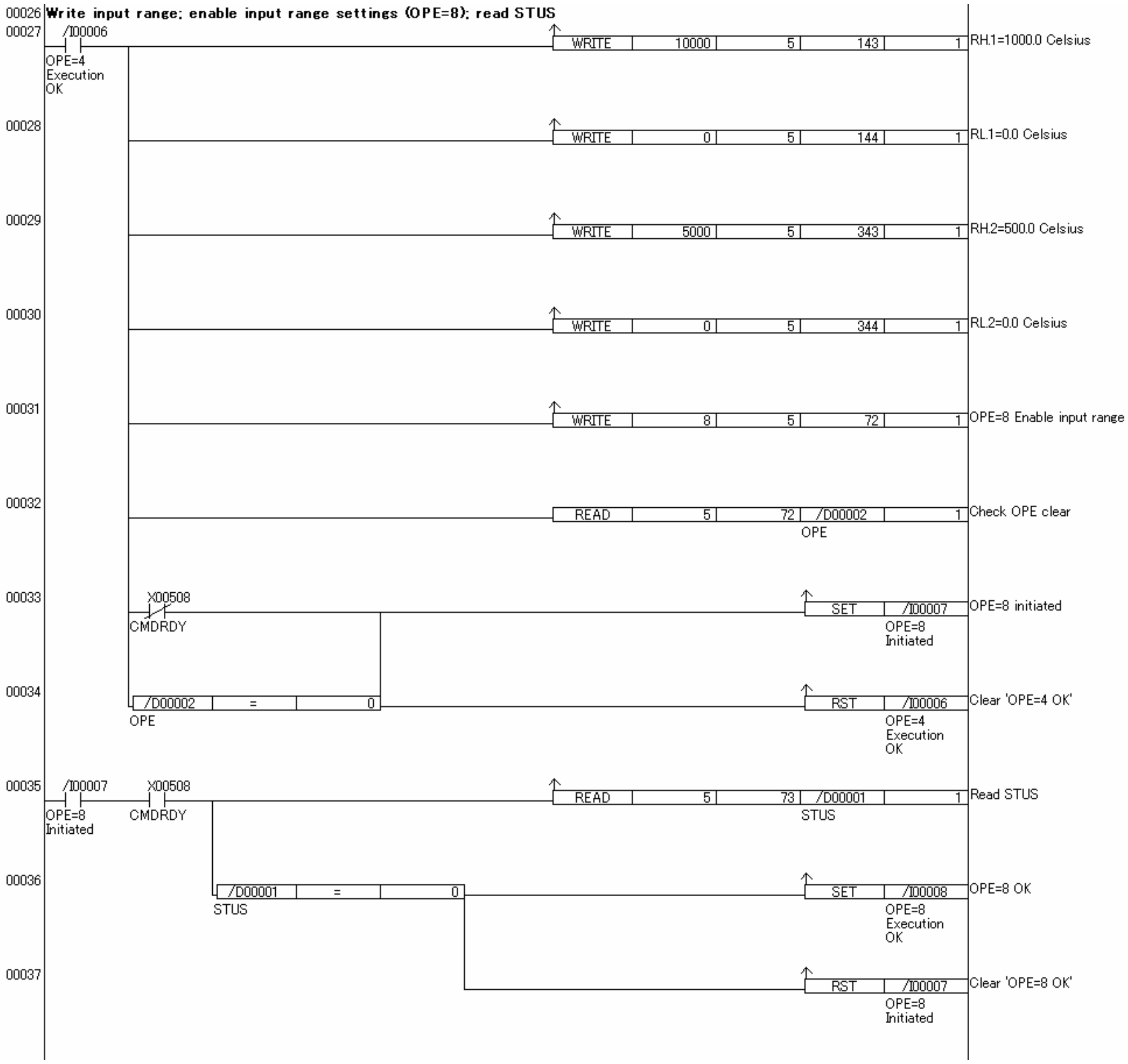


Figure B4.1 Sample Program (Component for Setting Setup Parameters) (4/5)

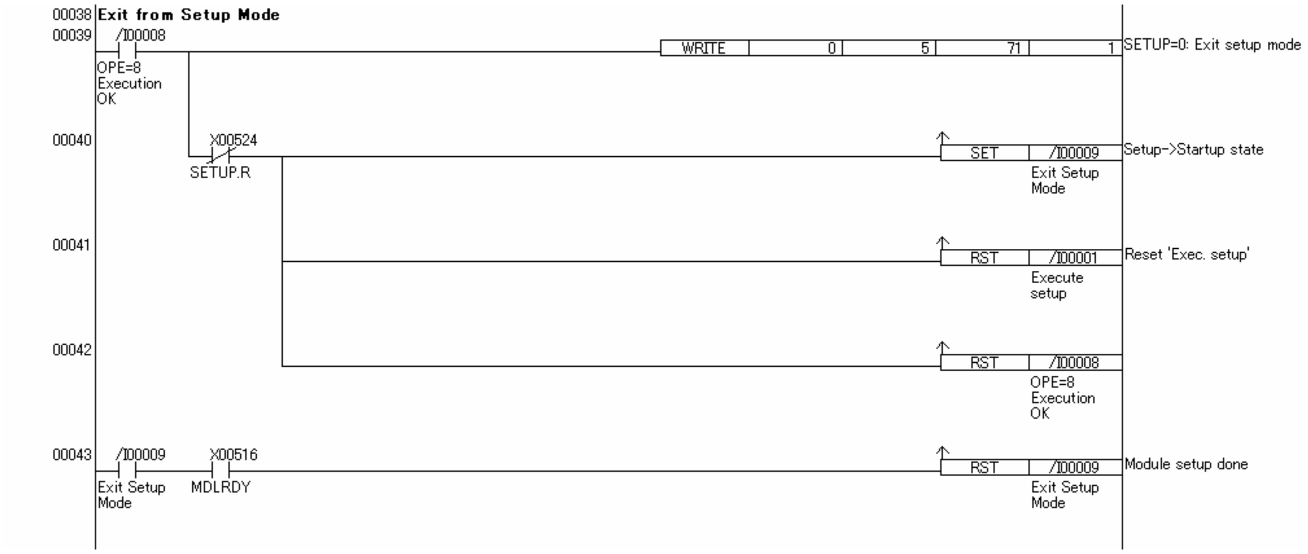


Figure B4.1 Sample Program (Component for Setting Setup Parameters) (5/5)

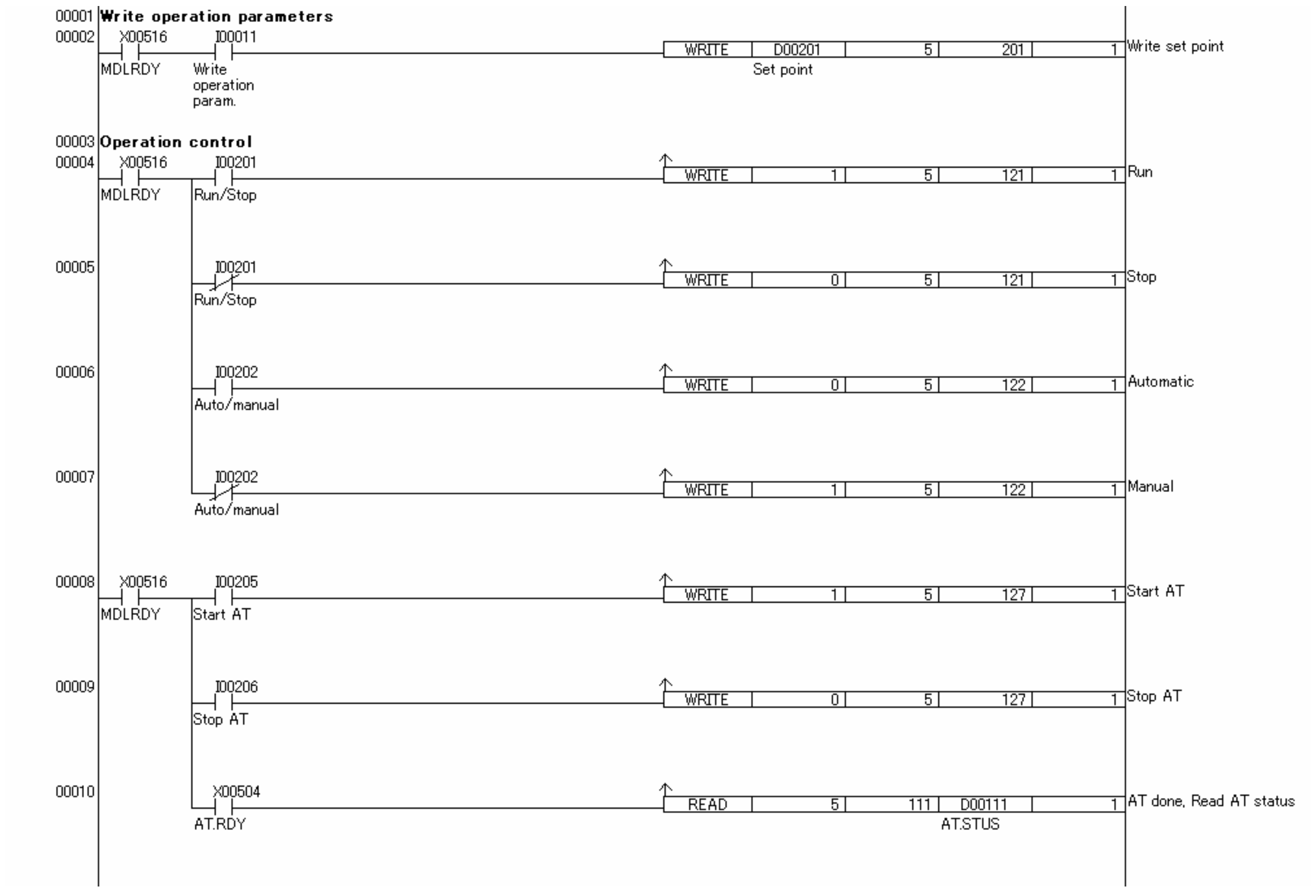


Figure B4.2 Sample Program (Component for Operation Parameter Setup and Operation Control) (1/3)

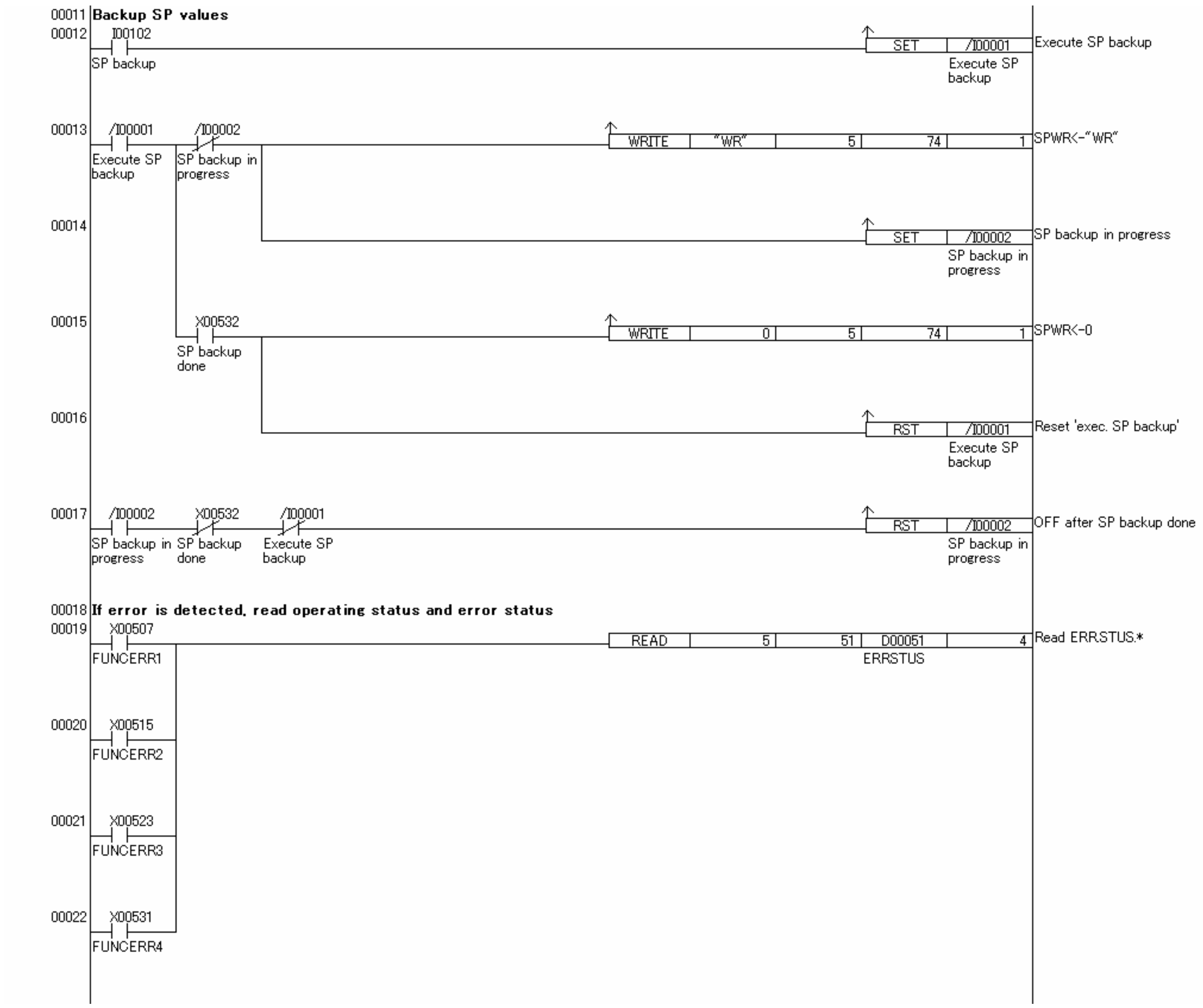


Figure B4.2 **Sample Program**
(Component for Operation Parameter Setup and Operation Control) (2/3)

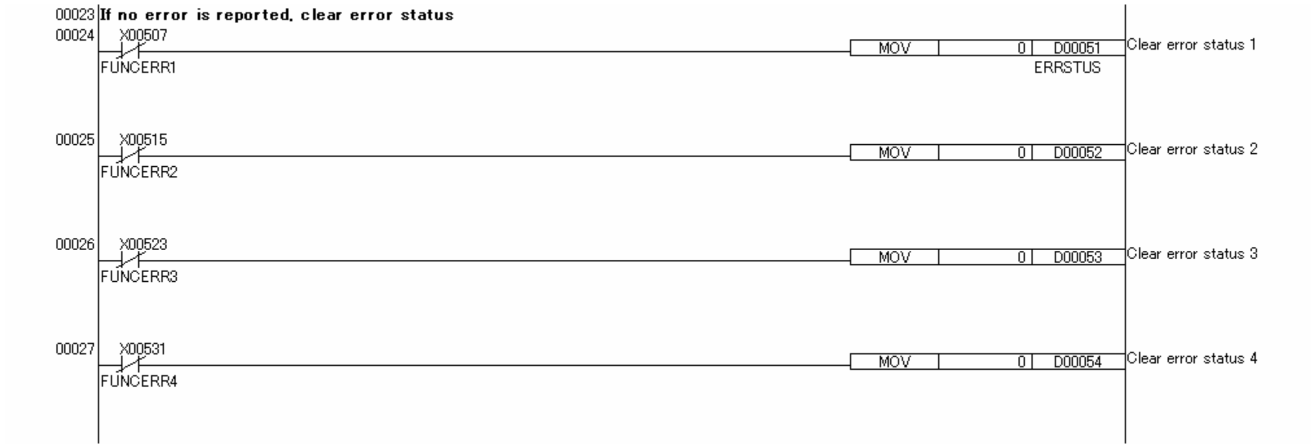


Figure B4.2 Sample Program (Component for Operation Parameter Setup and Operation Control) (3/3)

FA-M3

Temperature Control and PID Module
Part C: Function Description

IM 34M6H62-02E 2nd Edition

Part C describes the functions of the module.

This module has four controller loops, which can be configured to operate in pairs or individually to serve different purposes. This part first describes the controller mode that defines the way these controller loops are used, followed by the individual functions of the module.

C1.	Controller Mode	Describes the interdependency of the controller loops.
C2.	Output-related Functions	Describes output type selection and other output-related functions.
C3.	PV-related Functions	Describes PV input type selection and other input-related functions.
C4.	SP-related Functions	Describes set point (SP), limiter, and other SP-related functions.
C5.	Auto-tuning Function	Describes the Dynamic Auto-tuning and the normal Auto-tuning function.
C6.	Control and Computation Function	Describes the control and computation function settings.
C7.	Operation Control	Describes the Run/Stop and other operation control modes.
C8.	Alarm Function	Describes the alarm-related functions.
C9.	Disable Backup Function	Describes how to disable backup of parameters.
C10.	Self-diagnosis Function	Describes the self-diagnosis function for monitoring operation status and hardware failure.
C11.	Selecting Temperature Unit	Describes how to set the temperature unit (°C or °F) to be used with the module.

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C1. Controller Mode

The controller mode defines the interdependency of the four controller loops of the module. When the controller mode is set to single loop, each controller operates independently. When the controller mode is set to cascade control or two-input changeover control, a pair of controller loops 1 and 2, or a pair of controller loops 3 and 4, cooperate to function like a single controller. For an overview on control modes, see Section B3.1.3, "Controller Mode."

The controller mode selection uses the MD12 or MD34 register for a pair of controller loops 1 and 2 or a pair of controller loops 3 and 4 respectively.

Table C1.1 Parameters Related to Controller Mode

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
83				MD12	Controller mode	None	0: Two single loops 1: Two-input changeover control 2: Cascade control 3: One single loop (odd-numbered loops are disabled) 4: Both loops are disabled	0	RW	✓
		84		MD34		None				

Table C1.2 How Controller Loops are Used according to the Controller Mode Setting

Symbol	Description	How Loops are Used		
			Odd-numbered Loop (1 or 3)	Even-numbered Loop (2 or 4)
MD12 MD34	Controller Mode	0: Two single loops	Single loop	Single loop
		1: Two-input changeover control	Cooling input *1	Heating input
		2: Cascade control	Primary loop of cascade	Secondary loop of cascade
		3: One single loop (odd-numbered loops are disabled)	Disabled	Single loop
		4: Both loops are disabled.	Disabled	Disabled

*1 Only the input side of the loop is used.

For details on Single Loop, Cascade Control, and Two-input Changeover control modes, see Sections C1.1, "Single Loop," C1.2, "Cascade Control," and C1.3, "Two-input Changeover Control" respectively. For details on how to disable the controller functions, see Section C1.4, "Disabled Mode."

CAUTION

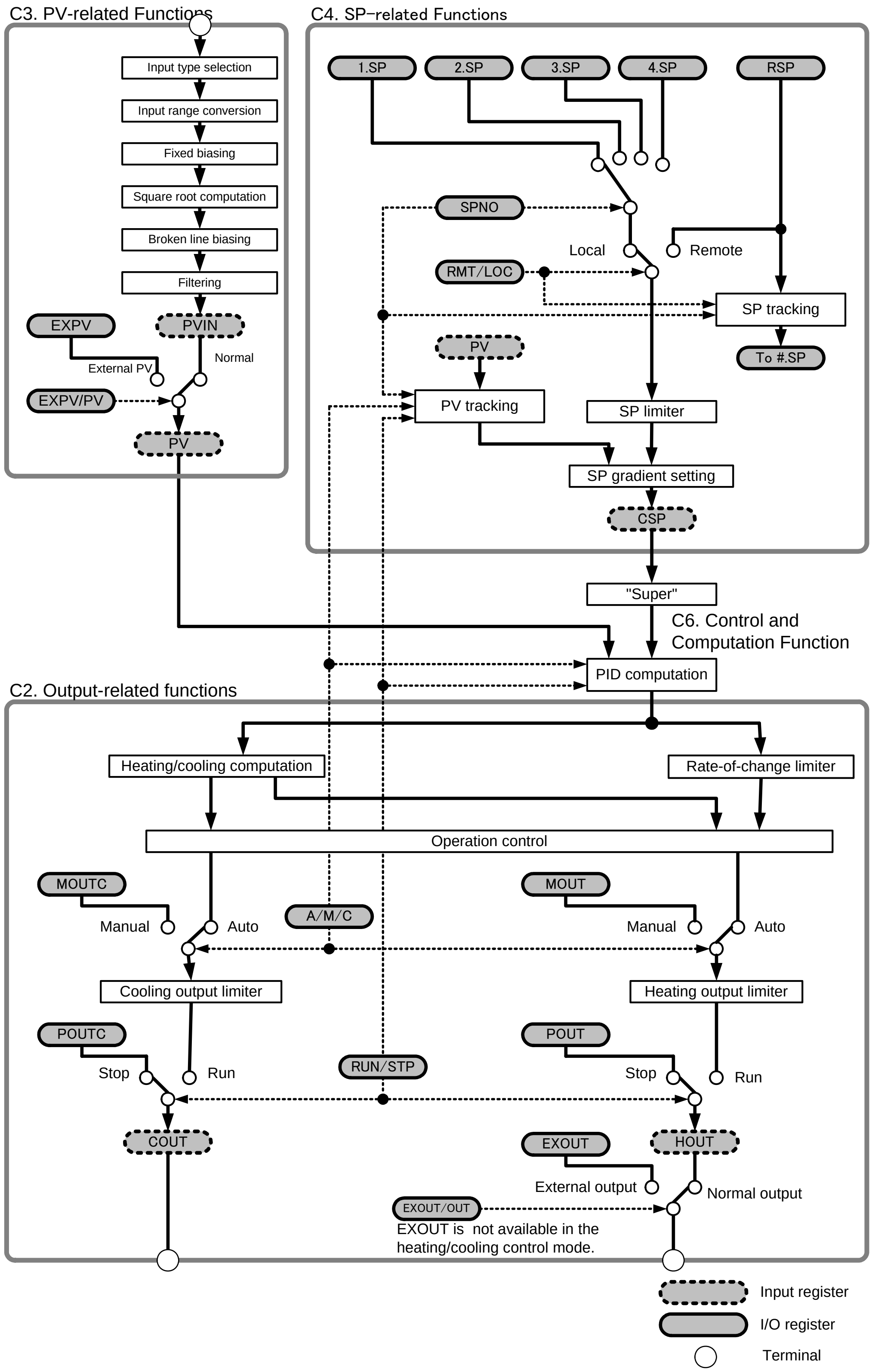
The MD12 and MD34 (Controller Mode) registers are controller parameters. Changing a controller parameter normally reverts all parameters of the module to their default values. However, switching between the values 0, 3 and 4 (between the disabled-mode and single-loop settings) of MD12 or MD34 does not initialize the parameters.

CAUTION

The Controller Mode settings must be enabled to take effect. For details on how to enable settings, see Section B2.3, "How to Enable Settings."

C1.1 Single Loop

When the controller mode is set to Single Loop, you get the most basic control operation where each controller operates independently. You will set up each loop separately, and perform run/stop and other operations for each loop separately.



This flowchart illustrates the module functions as functional blocks. Some details are omitted intentionally to facilitate reading. For details on each functional block, see the relevant section indicated.

Figure C1.1 Overview of Single Loop Mode

Table C1.3 Parameters Related to Single Loop

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
101	301	501	701	PVIN	Input process value	Industrial unit	-5 to 105% of (SL to SH)	—	RO	—	C3
102	302	502	702	PV	Process value	Industrial unit	-5 to 105% of (PRL to PRH)	—	RO	—	
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—	C2 C7.1
105	305	505	705	COUT	Cooling control output	%	0 to OL: For heating/cooling output	—	RO	—	
121	321	521	721	RUN/STP	Run/stop selection	None	0: Stop; 1: Run	0	RW	—	C7.1
122	322	522	722	A/M/C	Automatic/manual/ cascade selection	None	0: Automatic, 1: Manual 2: Cascade [*1]	0	RW	—	C7.2 C7.4
124	324	524	724	RMT/LOC	Remote/local selection	None	0: Local 1: Remote	0	RW	—	C7.3
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input	0	RW	—	C3.12
126	326	526	726	EXOUT/ OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—	C2.6
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
131	331	531	731	EXPV	External input	Industrial unit	-5 to 105% of (SL to SH)	SL	RW	—	C3.12
133	333	533	733	RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—	C4.2
134	334	534	734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—	C7.2 C7.4
135	335	535	735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—	
136	336	536	736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—	C2.6

*1 The controller mode must be set to Cascade Control before Automatic/Manual/Cascade Selection (A/M/C) can be set to 2 (Cascade). In cascade control mode, operation proceeds according to the setup for the even-numbered loop (2 or 4).

The single-loop mode is the most basic controller mode, where the module performs computation using the control and computation function and outputs the control output (HOUT and COUT) as defined by the output-control functions so that the process value (PV) as processed by the Input PV-related functions approaches the control set point (CSP) as defined by the SP-related functions.

The PV-related functions process the output from a thermocouple, RTD or other temperature sensors according to the characteristics of individual sensors. In particular, the filter function reduces noise and other disturbances, and the biasing functions correct for deviations between devices. For details, see Section C3, "PV-related Functions."

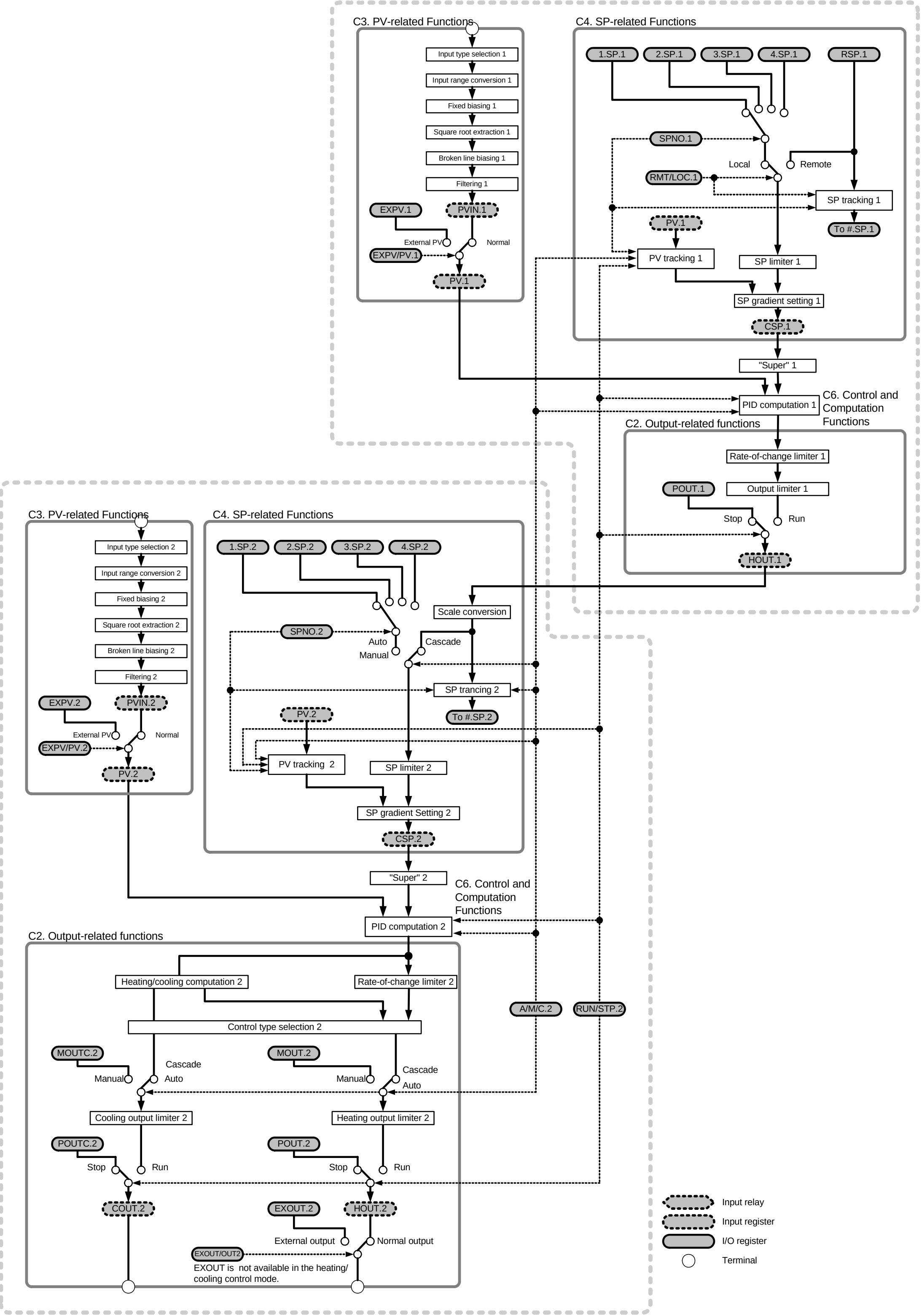
The SP-related functions set up and select set points (SP), and perform processing to prevent abrupt changes. In addition, the remote set point (RSP) can be used to receive successive external set points. For details, see Section C4, "SP-related Functions."

The control and computation function computes control output values so that the PV approaches the set point. The control method may be set to ON/OFF, PID, or heating/cooling PID control to suit an application. For details, see Section C6, "Control and Computation Function."

The output control functions process the output so that the upper limit, lower limit, or the rate-of-change limit will not be exceeded. They also perform processing to prevent sudden changes in the output level due to, say, switching between Automatic and Manual mode. For details, see Section C2, "Output-related Functions."

C1.2 Cascade Control

When the controller mode is set to Cascade Control, a pair of controller loops 1 and 2 or a pair of controller loops 3 and 4 form a cascaded loop. In cascade control mode, parameters of the even-numbered controller loop (2 or 4) are used for run/stop and other operations.



This flowchart illustrates the module functions as functional blocks. Some details are omitted intentionally to facilitate reading. For details on each functional block, see the relevant section indicated.

Figure C1.2 Overview of Cascade Control

Table C1.4 Parameters Related to Cascade Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
101	301	501	701	PVIN	Input process value	Industrial unit	-5 to 105% of (SL to SH)	—	RO	—	C3
102	302	502	702	PV	Process value	Industrial unit	-5 to 105% of (PRL to PRH)	—	RO	—	
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—	C2 C7.1
	305		705	COUT	Cooling control output	%	0 to OL: For heating/cooling output	—	RO	—	
	321		721	RUN/STP	Run/stop selection	None	0: Stop; 1: Run	0	RW	—	C7.1
	322		722	A/M/C	Automatic/manual/ cascade selection	None	0: Automatic, 1: Manual 2: Cascade [*1]	0	RW	—	C7.2 C7.4
124		524		RMT/LOC	Remote/local selection	None	0: Local 1: Remote	0	RW	—	C7.3
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input	0	RW	—	C3.12
	326		726	EXOUT/OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—	C2.6
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
131	331	531	731	EXPV	External input	Industrial unit	-5 to 105% of (SL to SH)	SL	RW	—	C3.12
133		533		RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—	C4.2
	334		734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—	C7.2 C7.4
	335		735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—	
	336		736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—	C2.6

*1 The controller mode must be set to Cascade Control before Automatic/Manual/Cascade Selection (A/M/C) can be set to 2 (Cascade). In cascade control mode, operation proceeds according to the setup for the even-numbered loop (2 or 4).

In cascade control mode, controller loops 1 and 2 or loops 3 and 4 form a pair, where the odd-numbered loop (1 or 3) is the primary loop and the even-numbered loop (2 or 4) is the secondary loop, and the output from the primary loop is used as the control set point for the secondary loop.

The control and computation function of the primary loop controls its output so that the control set point for the secondary loop will not change suddenly when a transition is made from manual or automatic mode to cascade mode. This is called the tracking function. The control method is always PID control.

In cascade control mode, the SP-related functions of the secondary loop use the output from the primary loop as its control set point, and thus remote setting function is not available.

For details on cascade control operation, see Section C1.2.1, "Cascade Control Operation." For details on each functional block, see Sections C3, "PV-related Functions," C4, "SP-related Functions," C6, "Control and Computation Function," and C2, "Output-related Functions."

TIP

Cascade control is a kind of feedback control system where controllers are connected serially so that the output from one controller changes the set point of the next controller. It is useful in situations where it is desirable to minimize impact from external disturbances.

C1.2.1 Cascade Control Operation

■ Operating Status and Cascade Control

In cascade control mode, run/stop selection (RUN/STP) or automatic/manual/cascade selection (A/M/C) is specified using parameters of the secondary loop (loop 2 or 4).

With “Stop” specified, the secondary loop outputs the preset output (n.POUT) and the preset cooling output (n.POUT.C) (for heating/cooling control), and the control output (HOUT) from the primary loop is set to its preset output (n.POUT).

With “Run” and “Cascade” specified, the control output (HOUT) from the primary loop is converted to the PV range and used as the control set point (CSP) for the secondary loop.

With “Run” and “Automatic” specified, one of the set points (n.SP) of the secondary loop is selected by the SP-related functions and used as the control set point (CSP) for the secondary loop. In this mode, the control output (HOUT) of the primary loop is the converted value of the control set point (CSP) of the secondary loop, which is scaled to the output range.

With “Run” and “Manual” specified, the secondary loop outputs Manual Output (MOUT) and Manual Cooling Output (MOUTC) (for heating/cooling control). In this mode, the control output (HOUT) of the primary loop is the converted value of the control set point (CSP) of the secondary loop, which is scaled to the output range.

Note: “n.” in the parameter symbol denotes a PID number, which is an integer ranging from 1 to 4.

Table C1.5 Control Set Point and Control Output in Various Operating Status

Operating Status		Primary Loop	Secondary Loop		
RUN/STP	A/M/C	Control Output	Control Set Point	Control Output	Cooling Control Output
Stop	Automatic	Preset output of the primary loop	Control set point of secondary loop	Preset output of the secondary loop	Preset cooling output of the secondary loop
	Manual				
	Cascade		Range-converted value of the control output of the primary loop		
Run	Automatic	Range-converted value of the control set point of the secondary loop	Control set point as defined for the secondary loop	Value computed for the control set point	Value computed for the control set point
	Manual			Manual output of the secondary loop	Manual cooling output of the secondary loop
	Cascade	Value computed for the control set point of the primary loop	Range-converted value of the control output from the primary loop	Value computed for the control set point	Value computed for the control set point

TIP

In cascade control mode, the SP-related functions of the secondary loop converts the control output from the primary loop expressed as a percentage into the control set point, scaled to the input range (PRL to PRH) for the secondary loop.

- The primary loop output within the range 0.0%-100.0% is converted to the input range (PRL to PRH) for the secondary loop.

  Example: If the input range of the secondary loop is 0.0-1200.0°C, a control output of 55.0% from the primary loop converts to a control set point of 660.0°C for the secondary loop.

CAUTION

If a burnout is detected in the primary loop in cascade control mode, the module automatically switches to Automatic mode.

■ Performing PID Adjustment in Cascade Control

Use the following procedure to perform auto-tuning or manual PID adjustment:

(1) Perform auto-tuning or manual PID adjustment in automatic mode to determine optimal PID values for the secondary loop.

(2) Switch to cascade control mode, and perform auto-tuning or manual PID adjustment for the primary loop to determine optimal PID values.

CAUTION

- Changing the Automatic/Manual/Cascade Selection (A/M/C) of the secondary loop from Automatic to Cascade or Manual during auto-tuning stops auto-tuning.
- Changing the Automatic/Manual/Cascade Selecton (A/M/C) of the primary loop from Cascade to Automatic or Manual during auto-tuning stops auto-tuning.

■ Functional Limitations in Cascade Control

Table C1.6 Functional Limitations in Cascade Control

	Set Point Function	Output-related Functions
Primary Loop	The PV tracking operation interlocks with the Run/Stop Selection and the Automatic/Manual/Cascade Selection specified for the secondary loop.	Control Type Selection is disabled (PID Control is always used). In automatic or manual mode, the control output of the primary loop follows the control set point of the secondary loop (tracking function).
Secondary Loop	In cascade control mode, the control output from the primary loop is used as the control set point for the secondary loop. The Remote/Local Selection is disabled (Local is always selected).	No limitations
See Also	C4, “SP-related Functions”	C2, “Output-related Functions”

CAUTION

To stabilize the control output from the secondary loop in situations where the output from the primary loop changes drastically, set the control mode (CMD) of the secondary loop to “Fixed-point Control”. For details on the PID control mode, see Section C6.6, “PID Control Mode.”

CAUTION

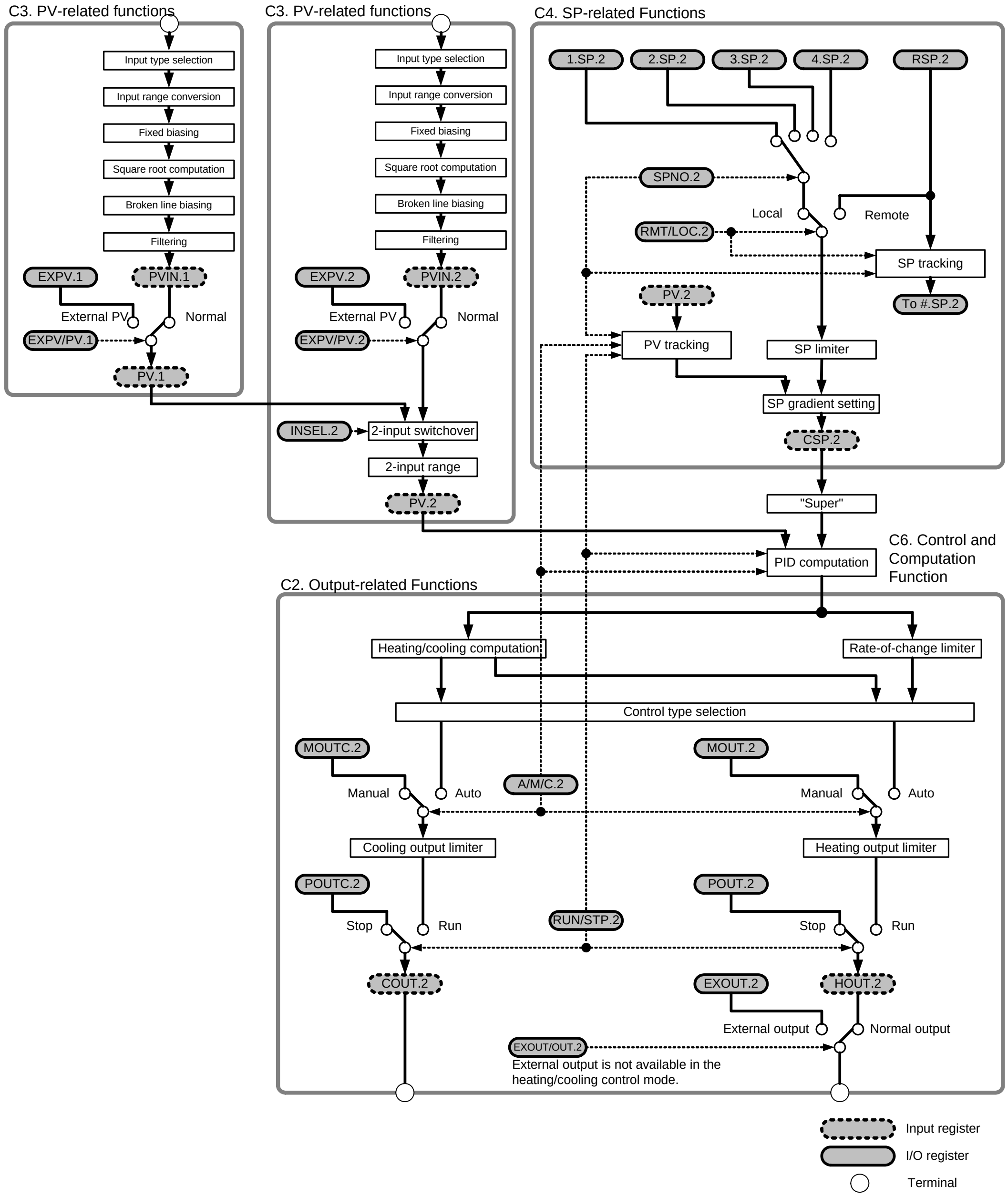
In cascade control mode, the control set point for the secondary loop is constrained by the upper and lower output limits (n.OH and n.OL) of the primary loop, as well as the upper and lower SP limits (n.SPH and n.SPL) of the secondary loop.

The specified upper and lower SP limits (n.SPH and n.SPL) of the secondary loop must be appropriate for the upper and lower output limits (n. OH and n. OL) of the primary loop respectively. If the two values do not fit, the output of the secondary loop may overshoot significantly. For details, see the CAUTION in Section C4.3, “Limiting the Set Point.”

Note: “n.” in the parameter symbol denotes a PID number, which is an integer ranging from 1 to 4.

C1.3 Two-input Changeover Control

When the controller mode is set to Two-input Changeover Control, a pair of controller loops 1 and 2 or a pair of controller loops 3 and 4 is used to control a single target through changeover between the two PVs.



This flowchart illustrates the module functions as functional blocks. Some details are omitted intentionally to facilitate reading. For details on each functional block, see the relevant section indicated.

Figure C1.3 Overview of Two-input Changeover Control

Table C1.7 Parameters Related to Two-input Changeover Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
101	301	501	701	PVIN	Input process value	Industrial unit	-5 to 105% of (SL to SH)	—	RO	—	C3
102	302	502	702	PV	Process value	Industrial unit	-5 to 105% of (PRL to PRH)	—	RO	—	
	303		703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4
	304		704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—	C2 C7.1
	305		705	COUT	Cooling control output	%	0 to OL: for heating/cooling output	—	RO	—	
	321		721	RUN/STP	Run/stop selection	None	0: Stop; 1: Run	0	RW	—	C7.1
	322		722	A/M/C	Automatic/manual/ cascade selection	None	0: Automatic, 1: Manual	0	RW	—	C7.2 C7.4
	323		723	INSEL	Input selection	None	0: Input 1, 1: Input 2	0	RW	—	C3.11
	324		724	RMT/LOC	Remote/local selection	None	0: Local 1: Remote	0	RW	—	C7.3
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input	0	RW	—	C3.12
	326		726	EXOUT/ OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—	C2.6
	328		728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
131	331	531	731	EXPV	External input	Industrial unit	-5 to 105% of (SL to SH)	SL	RW	—	C3.12
	333		733	RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—	C4.2
	334		734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—	C7.2 C7.4
	335		735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—	
	336		736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—	C2.6
	361		761	SELMD	Two-input changeover mode	None	0: Automatic changeover using temperature range 1: Automatic changeover using upper limit 2: Manual changeover using input selection	0	RW	✓	C3.11
	362		762	SELH	Two-input changeover upper limit	Industrial unit	PRL to PRH if SELL < SELH. If SELL ≥ SELH, changeover occurs with respect to SELH.	PRL+ 1	RW	✓	
	363		763	SELL	Two-input changeover lower limit			PRL	RW	✓	

In two-input changeover control mode, loops 1 and 2, or loops 3 and 4 form a pair; the even-numbered loop (loop 2 or 4) takes control and the input process value switches between the input process values of the odd-numbered loop and the even-numbered loop.

For the odd-numbered loop, only the PV-related functions are used.

For the even-numbered loop, the PV-related functions switch between the input process value of the odd-numbered loop and the even-numbered loop. Changeover is performed manually (using operation control parameters) or automatically (by specifying higher/lower temperature ranges). When changeover is based on temperature ranges, the odd-numbered loop covers the lower temperature range while the even-numbered loop covers the higher temperature range.

For details on individual functional blocks, see Sections C3, "PV-related Functions," C4, "SP-related Functions," C6, "Control and Computation Function," and C2, "Output-related Functions."

TIP

The two-input changeover control mode uses two sets of PV processing functions, and is useful especially for switching between two control targets according to the operating status, or switching between two types of sensors according to the monitored temperature.

Two-input Changeover Control Operation

The odd-numbered loop uses only its PV-related functions. The even-numbered loop uses all its functions: SP-related functions, control and computation function, and output-related functions. Therefore, run/stop selection, automatic/manual selection, and other operations are done with the even-numbered loop.

Functional Limitations in Two-input Changeover Control

Table C1.8 Functional Limitations in Two-input Changeover Control

	PV-related Functions	SP-related Functions	Output-related Functions
Odd-numbered loop	No limitations	Not available	Not available
Even-numbered loop	No limitations	No limitations	No limitations
See Also	C3, "PV-related Functions"	C4, “SP-related Functions”	C2, “Output-related Functions”

PV Range Setting

Setting the PV range for two-input changeover control requires special attention.

First, set up the PV range for each loop using the input range parameters RH and RL (or the scaling parameters, SH and SL for DC voltage input). To combine two PV ranges into one, set up the PV range parameters, PRH and PRL. This causes two inputs to be combined and handled as one PV.

For details, see Sections C3, "PV-related Functions" and C4, "SP-related Functions." For details on the two-input changeover control operation, see Section C3.11, "Two-input Changeover."

CAUTION

The PV range upper and lower limits, PRH and PRL, are set by default to the input range upper and lower limits, RH and RL, (or the scaling upper and lower limits, SH and SL, for DC voltage input) of the even-numbered loop. Redefine PRH and PRL as required.

C1.4 Disabled Mode

The Disabled mode suspends one or both controller functions for a pair of two loops. The 'Single Loop (odd-numbered loop disabled)' controller mode disables the odd-numbered loop. The Both Loops Disabled mode disables both loops of the pair. All controller functions are deactivated for a disabled loop.

Even if a loop is disabled, functions for accessing, setting and controlling the loop are still available. If an out-of-range value is written to a disabled loop, an error occurs. If a stored parameter of a disabled loop is changed, the new parameter value is stored.

For a disabled loop, no input computation, PID computation or output computation is performed; no input or output values are updated; and the alarm relays are forced to OFF.

A disabled loop does not function even if its parameters are set.

CAUTION

If the controller mode is set to 'Single Loop (odd-numbered loop disabled)', the even-numbered loop acts as a Single Loop.

CAUTION

The MD12 and MD34 (Controller Mode) registers are controller parameters. Changing a controller parameter normally reverts all parameters of the module to their default values. However, switching between the values 0, 3 and 4 (between the disabled-mode and single-loop settings) of MD12 or MD34 does not initialize the parameters.

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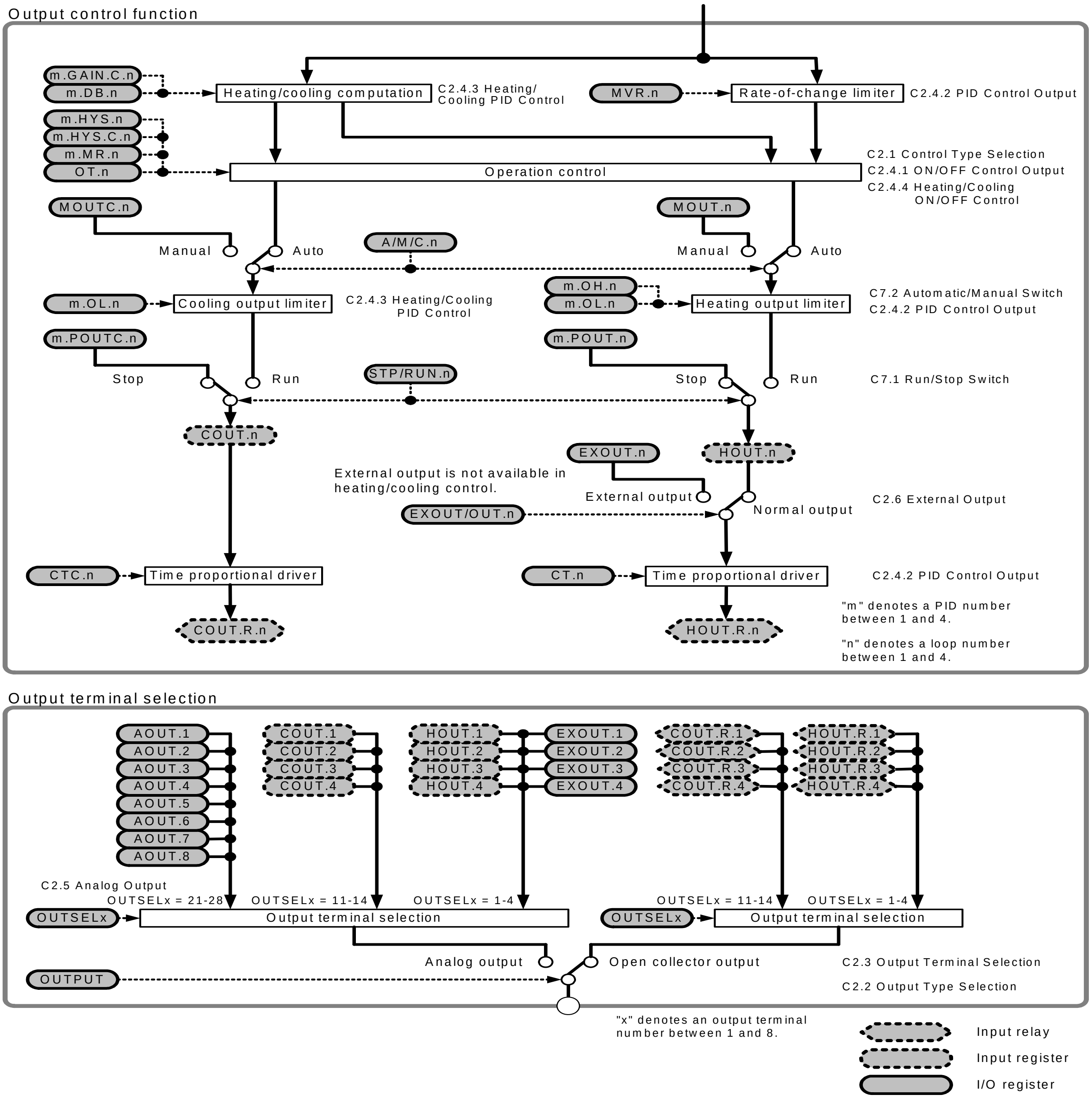
C2. Output-related Functions

The output-related functions are used to set up output-related parameters and perform output operation. The functions are broadly classified into two groups: output control and output terminal selection.

- **Output control functions set up parameters that affect the control and computation results and perform output operations.**

- **Output terminal selection defines how individual output terminals are used.**



Output control function

Output terminal selection

Figure C2.1 Overview of Output-related Functions

Table C2.1 Output-related Parameters (1/3)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
61				AOUT1	Output preset value	%	-500 to 10500 (-5.00 to 105.00%)	0	RW	—	C2.5
62				AOUT2				0	RW	—	
63				AOUT3				0	RW	—	
64				AOUT4				0	RW	—	
65				AOUT5				0	RW	—	
66				AOUT6				0	RW	—	
67				AOUT7				0	RW	—	
68				AOUT8				0	RW	—	
87				OUTPUT	Output type selection	None	Either open collector or analog output may be selected for each terminal.	0	RW	✓	C2.2
91				OUTSEL1	Output terminal selection	None	1-4: Heating outputs 1-4 11-14: Cooling outputs 1-4 21-28: Output preset values 1-8	1	RW	✓	C2.3
92				OUTSEL2				2	RW	✓	
93				OUTSEL3				3	RW	✓	
94				OUTSEL4				4	RW	✓	
95				OUTSEL5				11	RW	✓	
96				OUTSEL6				12	RW	✓	
97				OUTSEL7				13	RW	✓	
98				OUTSEL8				14	RW	✓	

Table C2.1 Output-related Parameters (2/3)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—	C2 C7.1
105	305	505	705	COUT	Cooling control output	%	0 to OL: for heating/cooling output	—	RO	—	
121	321	521	721	RUN/STP	Run/stop selection	None	0: Stop, 1: Run	0	RW	—	C7.1
122	322	522	722	A/M/C	Automatic/manual/cascade selection	None	0: Automatic, 1: Manual 2: Cascade	0	RW	—	C7.2 C7.4
126	326	526	726	EXOUT/OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—	C2.6
134	334	534	734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—	C7.2 C7.4
135	335	535	735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—	
136	336	536	736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—	C2.6
141	341	541	741	OT	Control type selection	None	0: PID control 1: ON/OFF control 2: Heating/cooling PID control 3: Heating/cooling ON/OFF control	0	RW	✓	C2.1
191	391	591	791	CT	Cycle time	Second	5 to 1200 (0.5 to 120.0 s)	300	RW	✓	C2.4.2
192	392	592	792	CTc	Cooling cycle time	Second		300	RW	✓	—
193	393	593	793	MVR	Rate-of-change limit	%/s	0: OFF, 1 to 100 (0.1 to 100.0% per second)	0	RW	✓	C2.4.2

Table C2.1 Output-related Parameters (3/3)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
209	409	609	809	1.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓	C2.4.2
210	410	610	810	1.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓	
212	412	612	812	1.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
214	414	614	814	1.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
215	415	615	815	1.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
216	416	616	816	1.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
217	417	617	817	1.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
218	418	618	818	1.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	
229	429	629	829	2.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓	C2.4.2
230	430	630	830	2.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓	
232	432	632	832	2.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
234	434	634	834	2.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
235	435	635	835	2.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
236	436	636	836	2.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
237	437	637	837	2POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
238	438	638	838	2.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4								
249	449	649	849	3.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓	C2.4.2
250	450	650	850	3.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓	
252	452	652	852	3.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
254	454	654	854	3.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
255	455	655	855	3.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
256	456	656	856	3.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
257	457	657	857	3.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
258	458	658	858	3.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
269	469	669	869	4.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓	C2.4.2 C6.3
270	470	670	870	4.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓	
272	472	672	872	4.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.1
274	474	674	874	4.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓	C2.4.3
275	475	675	875	4.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C2.4.4
276	476	676	876	4.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓	C2.4.3 C2.4.4
277	477	677	877	4.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	C7.1
278	478	678	878	4.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓	

Changing the Output Type Selection (OUTPUT) parameter, the Output Terminal Selection (OUTSEL 1-8) parameters, or the Control Type Selection (OT) parameter automatically initializes related parameters. Therefore, always set up these parameters before other parameters.

CAUTION

The OUTPUT, OUTSEL 1-8, or OT setting must be enabled to take effect. For details on how to enable settings, see Section B2.3, "How to Enable Settings."

C2.1 Control Type Selection

The Control Type Selection function selects the type of control and computation for a controller.

You can use the Control Type Selection (OT) parameter to select one out of four types of control and computation function. For details on each type of control and computation function, see Sections C2.4.1, "ON/OFF Control Output" and C2.4.2, "PID Control Output."

Table C2.2 Control Type Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
141	341	541	741	OT	Control type selection	None	0: PID control 1: ON/OFF control 2: Heating/cooling PID control 3: Heating/cooling ON/OFF control	0	RW	✓

CAUTION

The OT setting must be enabled to take effect. For details on how to enable settings, see Section B2.3, "How to Enable Settings."

C2.2 Output Type Selection

The Output Type Selection (OUTPUT) parameter, available only with F3CU04-1S, defines what type of output appears at the output terminals.

Set or reset bits of the OUTPUT parameter corresponding to individual terminals to select either analog (4-20 mA current output) or open collector output for each terminal.

Table C2.3 Output Type Selection

Data Position Number	Symbol	Description		Relationship between Bit and Terminal									Data Range
			Terminal	15-8	7	6	5	4	3	2	1	0	
87	OUTPUT	Output type selection	1	—	—	—	—	—	—	—	—	✓	0: Open collector output (default) 1: Analog output
			2	—	—	—	—	—	—	—	✓	—	
			3	—	—	—	—	—	—	✓	—	—	
			4	—	—	—	—	—	✓	—	—	—	
			5	—	—	—	—	✓	—	—	—	—	
			6	—	—	—	✓	—	—	—	—	—	
			7	—	—	✓	—	—	—	—	—	—	
			8	—	✓	—	—	—	—	—	—	—	

Note: Setting a bit marked by '✓' to 1 or 0 sets up analog output or open collector output for the corresponding terminal.

CAUTION

The OUTPUT setting must be enabled to take effect. For details on how to enable settings, see Section B2.3, "How to Enable Settings."

C2.3 Output Terminal Selection

The output terminal selection (OUTSELn) parameters define whether each output terminal outputs control output (HOUTn or COUTn) or analog output (AOUTn). Analog output allows manual analog output, which simply outputs a specified analog value, and is available only with F3CU04-1S. Use the OUTSELn parameters (n is 1-4 for F3CU04-0S, and 1-8 for F3CU04-1S) to configure individual terminals.

Table C2.4 Output Terminal Selection Parameters (for F3CU04-0S)

Data Position Number	Symbol	Description	Default Value	Relationship between Setting and Output
91	OUTSEL1	Output terminal 1	1	1 : HOUT.1 2 : HOUT.2 3 : HOUT.3 4 : HOUT.4 11 : COUT.1 12 : COUT.2 13 : COUT.3 14 : COUT.4
92	OUTSEL2	Output terminal 2	2	
93	OUTSEL3	Output terminal 3	3	
94	OUTSEL4	Output terminal 4	4	

Table C2.5 Output Terminal Selection Parameters (for F3CU04-1S)

Data Position Number	Symbol	Description	Default Value	Relationship between Setting and Output
91	OUTSEL1	Output terminal 1	1	1 : HOUT.1 2 : HOUT.2 3 : HOUT.3 4 : HOUT.4 11 : COUT.1 12 : COUT.2 13 : COUT.3 14 : COUT.4 21 : AOUT1 22 : AOUT2 23 : AOUT3 24 : AOUT4 25 : AOUT5 26 : AOUT6 27 : AOUT7 28 : AOUT8
92	OUTSEL2	Output terminal 2	2	
93	OUTSEL3	Output terminal 3	3	
94	OUTSEL4	Output terminal 4	4	
95	OUTSEL5	Output terminal 5	11	
96	OUTSEL6	Output terminal 6	12	
97	OUTSEL7	Output terminal 7	13	
98	OUTSEL8	Output terminal 8	14	

CAUTION

The OUTSEL 1-8 settings must be enabled to take effect. For details on how to enable settings, see Section B2.3, "How to Enable Settings."

CAUTION

For F3CU04-1S, an output terminal must be set to Analog Output (4-20 mA current output) using the Output Type Selection (OUTPUT) parameter before it can be set to output AOUTn using the Output Terminal Selection (OUTSELn) parameter. If an output terminal is set to Open Collector using the Output Type Selection (OUTPUT) parameter, and it is then set to output AOUTn, the open collector of that terminal is always 0 (off).

C2.4 Control Types and their Operations

Two control types are available: ON/OFF control output and PID control output.

C2.4.1 ON/OFF Control Output

In ON/OFF control, the module turns on or off an output according to the deviation between the control set point (CSP) and the PV. To set the control type to ON/OFF Control, set the Control Type Selection (OT) parameter to 1. For details, see Section C2.1, “Control Type Selection."

Table C2.6 I/O Registers related to ON/OFF Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
212	412	612	812	1.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
232	432	632	832	2.HYS					RW	✓
252	452	652	852	3.HYS					RW	✓
272	472	672	872	4.HYS					RW	✓

Table C2.7 Input Relays related to ON/OFF Control

Input Relay Number X☐☐☐nn *1				Symbol	Description	Data Range
Loop1	Loop2	Loop3	Loop4			
X05	X13	X21	X29	HOUT.R	Heating control output	0: OFF 1: ON

*1 ☐☐☐ denotes the slot number where the module is mounted.

The hysteresis parameters specify the minimum deviation of the PV from the control set point, or the hysteresis that will trigger an ON-to-OFF or OFF-to-ON output transition. The hysteresis is set for each controller loop in industrial unit. The following description of hysteresis assumes that the Forward/Reverse Switch parameter is set to Reverse Control. For details on forward control and reverse control, see Section C6.1, “Forward Operation and Reverse Operation"

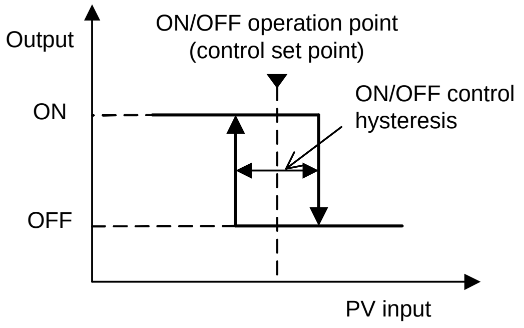


Figure C2.2 Schematic Diagram of ON/OFF Control (for reverse operation)

In ON/OFF control mode, the output turns off only when the PV exceeds the CSP by a certain amount, and turns on again when PV is less than the CSP by a certain amount, as shown by the arrows in the figure. The difference between the PV at which the output turns off and the PV at which the output turns on is called hysteresis. If the hysteresis is too small, chattering (output turning on and off too frequently) may occur. Increase the hysteresis to prevent chattering as necessary.

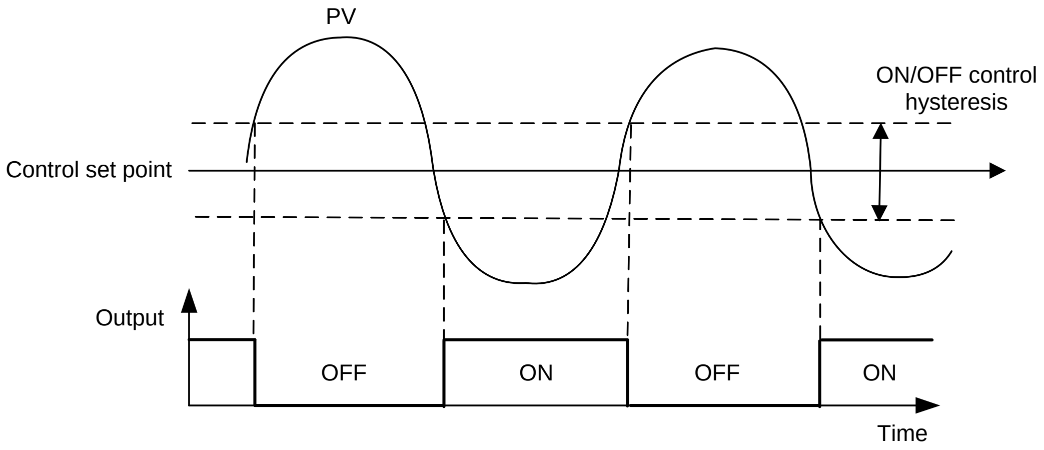


Figure C2.3 ON/OFF Control Operation Example (for reverse operation)

■ Manual Operation

In Manual mode, you can control the ON/OFF output manually by writing 100.0 or 0.0% to the Manual Output (MOUT) parameter.

TIP

If you set MOUT to a value smaller than 0.0%, the value is treated as 0.0%. If the preset value is 0.1% or larger, it is treated as 100.0%.

CAUTION

- The output limiter is disabled.
- The rate-of-change limit is disabled.

C2.4.2 PID Control Output

In PID control output, the module continuously adjusts its output according to the deviation between the control set point (CSP) and the PV. To select PID control output, set the Control Type Selection (OT) parameter to 0. For details, see Section C2.1, “Control Type Selection."

There are two types of PID control output, namely, time-proportional PID control output and continuous PID control output, which can be specified for each terminal. To configure a terminal for time-proportional PID control, set the Output Type Selection (OUTPUT) parameter to Open Collector. To configure a terminal for continuous PID control, set the Output Type Selection (OUTPUT) parameter to Analog Output. For details on the control and computation function and various PID parameters, see Section C6, "Control and Computation Function."

■ Time-proportional PID Control Output

In time-proportional PID control mode, the PID computation result, HOUT, is output after it is converted to ON/OFF duty cycle as defined by the Cycle Time (CT) parameter. 100% duty cycle means “always on”, 0% duty cycle means “always off”, and 25% duty cycle means “on for 25% and off for 75% of the cycle time”. In heating/cooling control operation, the PID computation result, COUT, is output after it is converted to ON/OFF duty cycle as defined by the Cooling Cycle Time (CTc) parameter.

Table C2.8 I/O Registers Related to Time-proportional PID Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—
191	391	591	791	CT	Cycle time	s	5 to 1200 (0.5 to 120.0 s)	300	RW	✓
192	392	592	792	CTc	Cooling cycle time	s		300	RW	✓

Table C2.9 Input Registers Related to Time-proportional PID Control

Input Relay Number X☐☐☐nn *1				Symbol	Description	Data Range
Loop 1	Loop 2	Loop 3	Loop 4			
X05	X13	X21	X29	HOUT.R	Heating control output	0: OFF 1: ON
X06	X14	X221	X30	COUT.R	Cooling control output	0: OFF 1: ON

*1 ☐☐☐ denotes the slot number where the module is installed.

A smaller Cycle Time (CT) parameter value means finer control. However, too short a cycle time means frequent ON/OFF operations, which may shorten the life of a relay, which is used as an output element. We recommend setting CT to around 10-30 s when using mechanical relay output.

The resolution of the CT setting is 0.5 s. If you specify an intermediate value, the value will be truncated appropriately. For example, if you specify 20.6 s for CT, the value is treated as 20.5 s.

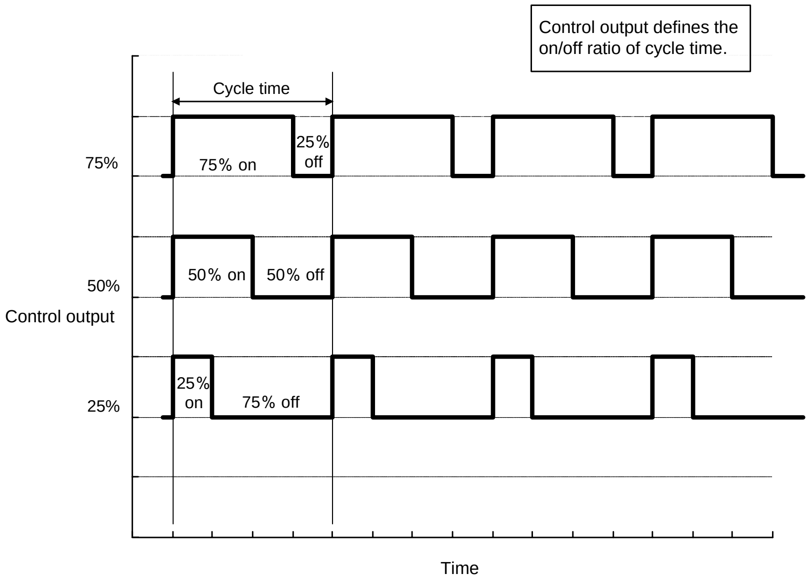


Figure C2.4 Time-proportional PID Control Output

■ Continuous PID Control Output

In continuous PID control, the PID computation result, HOUT, is output as a continuous analog signal in the form of a 4-20 mA current.

Table C2.10 I/O Registers Related to Continuous PID Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
104	304	504	704	HOUT	Control output	%	OL to OH: for single output 0 to OH: for heating/cooling output	—	RO	—

CAUTION

Continuous PID control is available only with F3CU04-1S.

TIP

Time-proportional PID control output and continuous PID control output differ only in the output type. To configure a terminal for time-proportional PID control, set the Output Type Selection (OUTPUT) parameter to Open Collector. To configure a terminal for continuous PID control, set the Output Type Selection (OUTPUT) parameter to Analog Output (4-20 mA current output).

TIP

The output of an output terminal also depends on the Output Terminal Selection parameter. For details on output terminal selection, see Section C2.3, "Output Terminal Selection."

■ Output Limiter

The output limiter defines the range for the output control value by specifying the upper and lower output limits, which may be defined for each loop or each PID parameter group.

Table C2.11 Output Limiter Registers

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
209	409	609	809	1.OH	Upper output limit	%	-5.0 to 105.0% if OL ＜ OH. OL is always output if OL ≥ OH.	1000	RW	✓
210	410	610	810	1.OL	Lower output limit			0	RW	✓
229	429	629	829	2.OH	Upper output limit	%	-5.0 to 105.0% if OL ＜ OH. OL is always output if OL ≥ OH.	1000	RW	✓
230	430	630	830	2.OL	Lower output limit			0	RW	✓
249	449	649	849	3.OH	Upper output limit	%	-5.0 to 105.0% if OL ＜ OH. OL is always output if OL ≥ OH.	1000	RW	✓
250	450	650	850	3.OL	Lower output limit			0	RW	✓
269	469	669	869	4.OH	Upper output limit	%	-5.0 to 105.0% if OL ＜ OH. OL is always output if OL ≥ OH.	1000	RW	✓
270	470	670	870	4.OL	Lower output limit			0	RW	✓

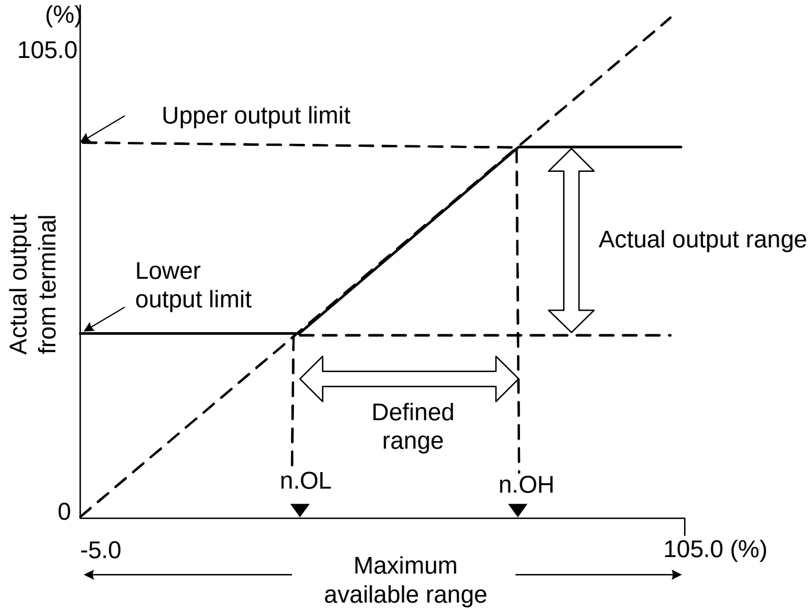


Figure C2.5 Output Limiter

CAUTION

In stop mode, the output limiter is disabled. The module outputs the preset value, POUT.

■ Rate-of-change Limit

The rate-of-change limit prevents drastic changes in the output by defining the maximum rate of change allowed in the control output. This function is useful for protecting a controlled load or machine.

For example, supposing that the rate-of-change is set to 2% per second, even if the PID computation result changes instantly from 0 to 100%, the actual output changes linearly from 0 to 100% over a duration of 50 s.

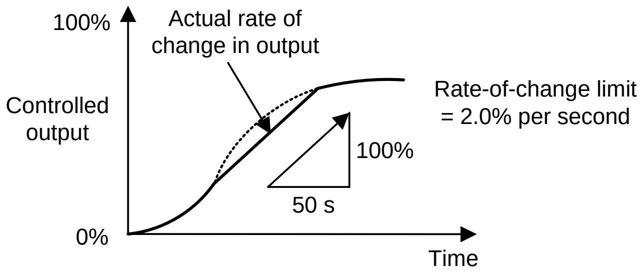


Figure C2.6 Rate-of-change Limit

Table C2.12 Rate-of-change Limit Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
193	393	593	793	MVR	Rate-of-change limit	%/s	0: OFF 1 to 1000 (0.1 to 100.0% per second)	0	RW	✓

CAUTION

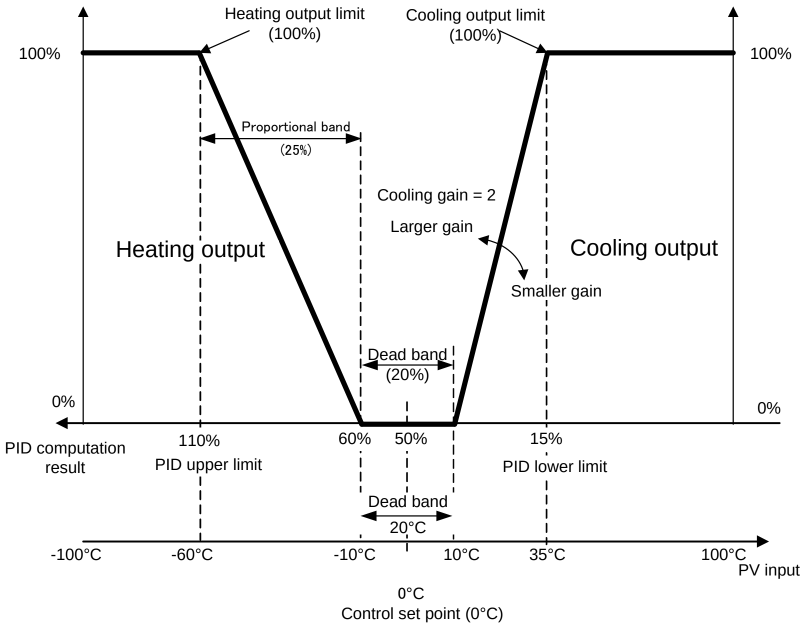
The rate-of-change limit is disabled in the following situations:

- When the Run/Stop Selection is set to Stop
- When the Automatic/manual/cascade Selection is set to Manual
- If burnout or AD converter error is detected when the Automatic/manual/cascade Selection is set to Automatic (see Section C10, "Self-diagnosis Function")
- When heating/cooling PID control is selected.

C2.4.3 Heating/Cooling PID Control

In Heating/Cooling PID Control, the module computes its output according to the deviation between the control set point (CSP) and the PV, and outputs the PID computation result as heating and cooling outputs. To select Heating/Cooling PID Control, set the Control Type Selection (OT) parameter to 2. For details, see Section C2.1, “Control Type Selection."

A large PID computation result is output as a heating output, whilst a small PID computation result is output as a cooling output. A dead band, with no heating and cooling outputs, can be defined using the Dead Band (DB) parameter. If DB is set to a negative value, both heating and cooling outputs are generated in the dead band. If the heating and cooling capacities of a process differ, you can define a cooling gain to balance the heating and cooling control loop gains.



PRL to PRH = -100 to 100°C, integral time = OFF, derivative time = OFF, manual reset = 0%

Figure C2.7 Heating/Cooling Operation in P Control

TIP

Heating and cooling output values are calculated as follows:

- Heating output = (PID computation result - dead band [%]/2 - 50%) x 2
- Cooling output = (50% - PID computation result - dead band [%]/2) x 2 x cooling gain

where dead band [%] is converted from industrial unit to percentage as follows:

Dead band [%] = ((dead band in industrial unit)/(PRH - PRL) x 100%) x 100%/(proportional band x 2)

TIP

In P control, the PID computation result is obtained as follows:

PID computation result = 100/proportional band x (CSP - PV) + manual reset value/2 + 50%

where 50% is added so that both the heating and cooling output values will be 0 when the deviation (CSP - PV) is 0. This 50% is not added in PID control.

Table C2.13 Parameters Related to Heating/Cooling PID Control (1/2)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
134	334	534	734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—
135	335	535	735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—
206	406	606	806	1.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
207	407	607	807	1.TI	Integral time	s	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓
208	408	608	808	1.TD	Derivative time	s	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
209	409	609	809	1.OH	Upper output limit for PID parameter 1	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓
210	410	610	810	1.OL	Lower output limit for PID parameter 1			0 (or 1000 for heating/cooling control)	RW	✓
211	411	611	811	1.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
214	414	614	814	1.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓
216	416	616	816	1.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
217	417	617	817	1.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
218	418	618	818	1.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
226	426	626	826	2.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
227	427	627	827	2.TI	Integral time	s	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓
228	428	628	828	2.TD	Derivative time	s	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
229	429	629	829	2.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓
230	430	630	830	2.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓
231	431	631	831	2.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
234	434	634	834	2.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓
236	436	636	836	2.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
237	437	637	837	2POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
238	438	638	838	2.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
246	446	646	846	3.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
247	447	647	847	3.TI	Integral time	s	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓
248	448	648	848	3.TD	Derivative time	s	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
249	449	649	849	3.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓
250	450	650	850	3.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓
251	451	651	851	3.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
254	454	654	854	3.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓
256	456	656	856	3.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
257	457	657	857	3.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
258	458	658	858	3.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
266	466	666	866	4.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
267	467	667	867	4.TI	Integral time	s	0: OFF, 1 to 6000 (1 to 6000 s)	240	RW	✓
268	468	668	868	4.TD	Derivative time	s	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
269	469	669	869	4.OH	Upper output limit	%	-5.0 to 105.0% if OL < OH. OL is always output if OL ≥ OH.	1000	RW	✓
270	470	670	870	4.OL	Lower output limit			0 (or 1000 for heating/cooling control)	RW	✓
271	471	671	871	4.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
274	474	674	874	4.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓
276	476	676	876	4.DB	Dead band	Industrial unit	PID control: -10.0 to 10.0% of (PRH - PRL) ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓

Table C2.13 Parameters Related to Heating/Cooling PID Control (2/2)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
277	477	677	877	4.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
278	478	678	878	4.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓

CAUTION

The rate-of-change limit is disabled in heating/cooling PID control.

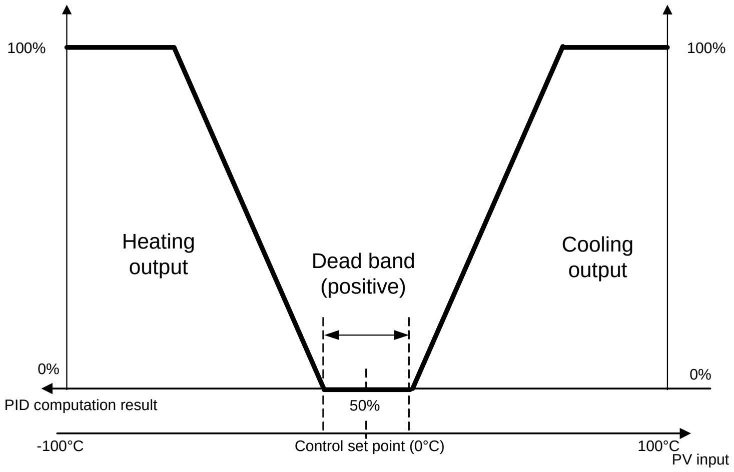
Table C2.14 Input Relays Related to Heating/Cooling PID Control

Input Relay Number X□□□nn [*1]				Symbol	Description	Data Range
Loop1	Loop2	Loop3	Loop4			
X05	X13	X20	X29	HOUT.R	Heating control output	0: OFF 1: ON
X06	X14	X21	X30	COUT.R	Cooling control output	0: OFF 1: ON

*1 □□□ denotes the slot number where the module is installed.

■ Dead Band

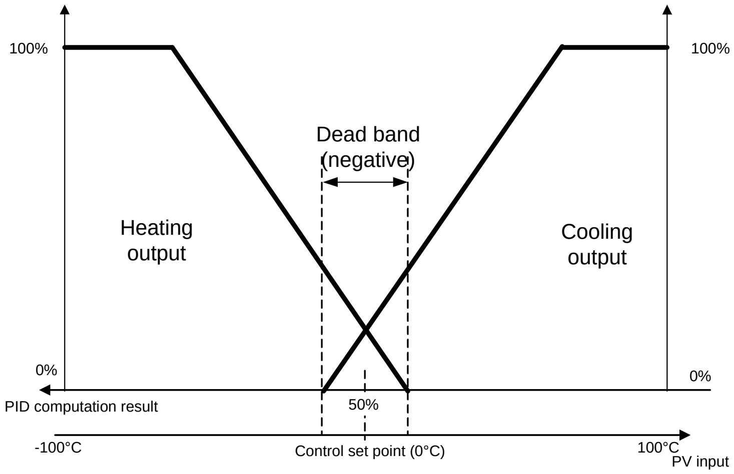
When a positive dead band value is specified, no heating and cooling output is generated within the dead band.



PRL to PRH = -100°C to 100°C, integral time = OFF, derivative time = OFF, manual reset = 0%

Figure C2.8 Positive Dead Band (for P control)

When a negative dead band value is specified, both heating and cooling outputs are generated and overlap within the dead band.



PRL to PRH = -100°C to 100°C, integral time = OFF, derivative time = OFF, manual reset = 0%

Figure C2.9 Negative Dead Band (for P control)

Table C2.15 Dead Band in Heating/Cooling PID Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
216	416	616	816	1.DB	Dead band	Industrial unit	For PID control: -10.0 to 10.0% of (PRH - PRL) For ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
236	436	636	836	2.DB				0	RW	✓
256	456	656	856	3.DB				0	RW	✓
276	476	676	876	4.DB				0	RW	✓

CAUTION

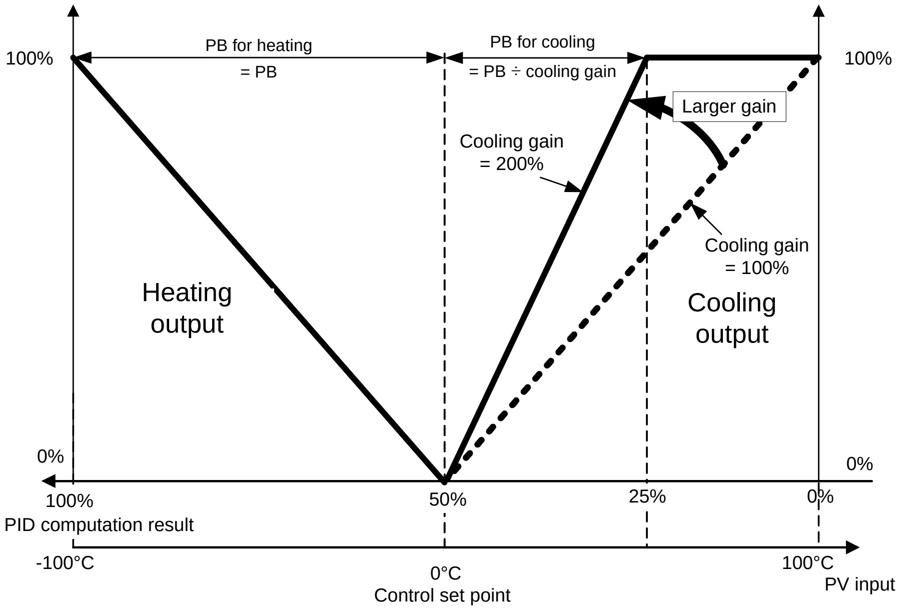
Although the setting range of the dead band (DB) is ±10.0% of (PRH - PRL), if a specified value is beyond ±(proportional band) (±PB), it is further limited to within ±(PB) in PID computation.

■ Setting the Cooling Gain

In heating/cooling PID control, control output is calculated based on heating parameters. Parameters other than proportional band, namely, integral time and derivative time, are common to both heating and cooling output calculations. The proportional band for cooling output is adjusted using the cooling gain as follows:

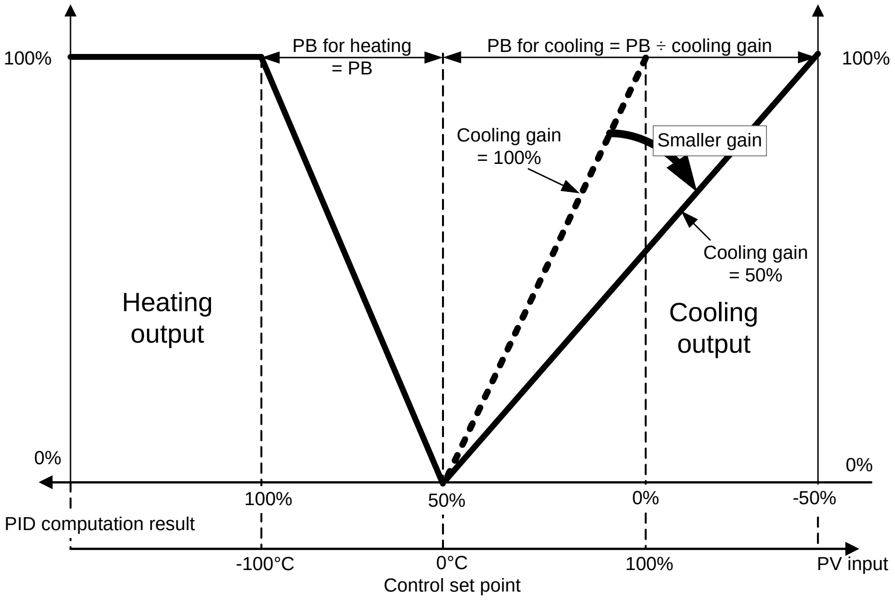
- Proportional band for heating output = Proportional band
- Proportional band for cooling output = Proportional band ÷ cooling gain

For example, with the cooling gain set to 200% in P control with manual reset = 0%, if a deviation produces 10% heating output, the same deviation in the reverse direction will produce 20% cooling output.



PRL to PRH = -100°C to 100°C, integral time = OFF, derivative time = OFF, manual reset = 0%, dead band = 0

Figure C2.10 When Cooling Gain is Larger Than 100%



PRL to PRH = -100°C to 100°C, integral time = OFF, derivative time = OFF, manual reset = 0%, dead band = 0
Note: This is only a conceptual diagram. In real operation, the PV input cannot assume a value of 150°C when the input range upper limit is set to 100°C.

Figure C2.11 When Cooling Gain is Smaller Than 100%

Table C2.16 Cooling Gain in Heating/Cooling PID Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
214	414	614	814	1.GAIN.C	Cooling gain	%	1 to 999 (1 to 999%)	100	RW	✓
234	434	634	834	2.GAIN.C				100	RW	✓
254	454	654	854	3.GAIN.C				100	RW	✓
274	474	674	874	4.GAIN.C				100	RW	✓

■ Manual Operation

In Manual mode, the output from the module is determined by the Manual Output (MOUT) parameter or the Manual Cooling Output (MOUTC) parameter, either of which can be set manually. The heating output range is between 0% and the Upper Output Limit (OH), and the cooling output range is between 0% and the Lower Output Limit (OL).

Changing heating output automatically changes cooling output, and vice versa, according to the values of the dead band and the cooling gain. If the dead band is positive, changing heating output causes cooling output to become 0%, and vice versa. If the dead band is negative, changing heating output within the dead band causes cooling output to be changed according to the cooling gain, and vice versa.

When Manual mode is switched to Automatic mode, “bump-less” control, without sudden change in output, begins. However, if the cooling output is less than the Lower Output Limit (OL) because of a small cooling gain setting, the cooling output would be at OL, that is, the cooling output will “bump” to OL when switching from Manual mode to Automatic mode.

Table C2.17 Manual Heating/Cooling PID Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
134	334	534	734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—
135	335	535	735	MOUTC	Manual cooling output	%	0 to OL	0	RW	—

CAUTION

To set the heating and cooling outputs separately, you can switch to Stop mode and change the preset output. However, do not update these preset output parameters continuously (as ramp waveform data) because they are stored parameters and are thus automatically written to the EEPROM whenever updated, but the EEPROM has a maximum limit on the number of write operations.

■ Heating/Cooling Control Output Limits

The upper limit of the heating output is defined with the Upper Output Limit (n.OH) parameter (where n: 1-4), and the upper limit of the cooling output is defined with the Lower Output Limit (n.OL) parameter (where n: 1-4). The lower limit of the heating or cooling output is fixed at 0%.

Table C2.18 Heating/Cooling Control Output Limits

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
209	409	609	809	1.OH	Upper output limit	%	0 to 1050 (0.0 to 105.0%)	1000	RW	✓
210	410	610	810	1.OL	Lower output limit			1000	RW	✓
229	429	629	829	2.OH	Upper output limit	%	0 to 1050 (0.0 to 105.0%)	1000	RW	✓
230	430	630	830	2.OL	Lower output limit			1000	RW	✓
249	449	649	849	3.OH	Upper output limit	%	0 to 1050 (0.0 to 105.0%)	1000	RW	✓
250	450	650	850	3.OL	Lower output limit			1000	RW	✓
269	469	669	869	4.OH	Upper output limit	%	0 to 1050 (0.0 to 105.0%)	1000	RW	✓
270	470	670	870	4.OL	Lower output limit			1000	RW	✓

CAUTION

In Automatic mode, depending on the dead band and cooling gain preset values, sometimes the cooling output will never reach the Lower Output Limit (n.OL) (n: 1-4).

TIP

In Automatic mode of heating/cooling PID control, the output range is defined by restricting the PID computation result within upper and lower limits that are calculated from the specified upper and lower output limits as follows:

- Upper limit for PID computation result =
  upper output limit (n.OH) (n: 1-4)/2 + dead band [%]/2 + 50%
- Lower limit for PID computation result =
  50% - lower output limit (n.OL) (n: 1-4)/(2 x cooling gain) - dead band [%]/2

where the dead band is converted from industrial unit to percentage as follows:

Dead band [%] = ((dead band in industrial unit)/(PRH - PRL) x 100%) x 100%/(proportional band x 2).

The PID computation result is further restricted within ±200%. Therefore, even if the computed lower limit for PID computation result is less than -200%, the PID computation result is still limited by -200% and so is the cooling output.

C2.4.4 Heating/Cooling ON/OFF Control

In Heating/Cooling ON/OFF Control, the module turns on or turns off the heating or cooling output depending on the deviation between the control set point (CSP) and the PV. To select Heating/Cooling ON/OFF Control, set the Control Type Selection (OT) parameter to 3. For details, see Section C2.1, "Control Type Selection."

The value of the heating or cooling output is either 0% or 100%.

You can specify a dead band around the CSP for turning on the heating and cooling outputs.
You can also specify a hysteresis for on/off or off/on transitions in the heating or cooling output.

Conditions for turning on and turning off heating control output

On condition: (CSP - PV) $\geq$ DB/2 + HYS/2

Off condition: (CSP - PV) < DB/2 - HYS/2

Conditions for turning on and turning off cooling control output

On condition: (CSP - PV) $\leq$ -(DB/2 + HYS.C/2)

Off condition: (CSP - PV) > -(DB/2 - HYS.C/2)

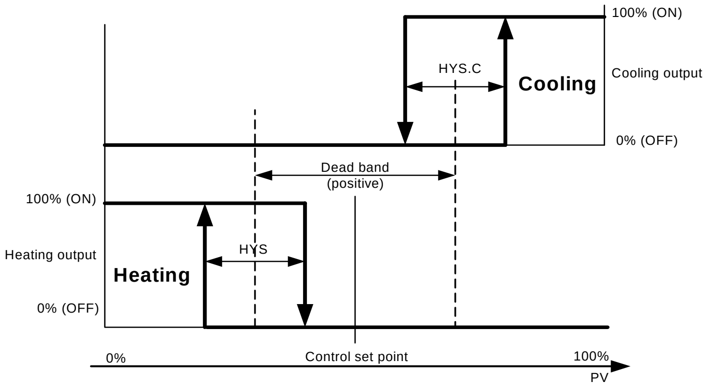


Figure C2.12 Heating/Cooling ON/OFF Control (with positive dead band)

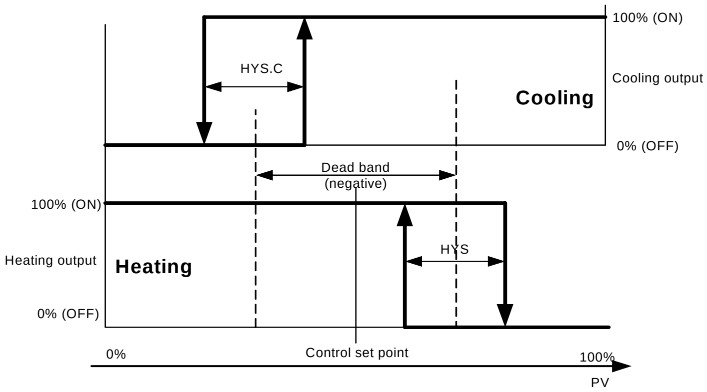


Figure C2.13 Heating/Cooling ON/OFF Control (with negative dead band)

■ Manual Operation

In Manual mode, the output from the module is determined by the Manual Output (MOUT) parameter or the Manual Cooling Output (MOUTC) parameter, which you can set manually. You may set MOUT and MOUTC independently. The value of MOUT or MOUTC must be either 0.0% or 100.0%.

Table C2.19 Parameters Related to Heating/Cooling ON/OFF Control

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
212	412	612	812	1.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
215	415	615	815	1.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
216	416	616	816	1.DB	Dead band	Industrial unit	ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
232	432	632	832	2.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
235	435	635	835	2.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
236	436	636	836	2.DB	Dead band	Industrial unit	ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
252	452	652	852	3.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
255	455	655	855	3.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
256	456	656	856	3.DB	Dead band	Industrial unit	ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓
272	472	672	872	4.HYS	ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
275	475	675	875	4.HYS.C	Cooling ON/OFF control hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓
276	476	676	876	4.DB	Dead band	Industrial unit	ON/OFF control: -50.0 to 50.0% of (PRH - PRL)	0	RW	✓

TIP

If you set the Manual Output (MOUT) parameter or the Manual Cooling Output (MOUTC) parameter to a value smaller than 0.0%, that value is treated as 0.0%. If the preset value is 0.1% or larger, it is treated as 100.0%.

CAUTION

The output limiter and rate-of-change limit is disabled in heating/cooling ON/OFF control.

Table C2.20 Input Relays Related to Heating/Cooling ON/OFF Control

Input Relay Number X□□□nn *1				Symbol	Description	Data Range
Loop 1	Loop 2	Loop 3	Loop 4			
X05	X13	X21	X29	HOUT.R	Control output (time-proportional or ON/OFF control)	0: OFF 1: ON
X06	X14	X221	X30	COUT.R	Cooling control output (time-proportional or ON/OFF control)	0: OFF 1: ON

*1 □□□ denotes the slot number where the module is installed.

C2.5 Analog Output

The analog output function is available only with F3CU04-1S.

If an output terminal is not used as a control output, it may be configured for an analog output (4-20 mA).

To configure an output terminal for analog output, set its corresponding bit in the Output Type Selection (OUTPUT) parameter to 1 (Analog Output), and set the corresponding Output Terminal Selection (OUTSELn) parameter (n = 1-8) to an integer ranging from 21 to 28 corresponding to AOUT1-8. To output a desired analog output level (4-20 mA), set the corresponding Output Preset Value (AOUTn) parameter (n = 1-8) to the desired value.

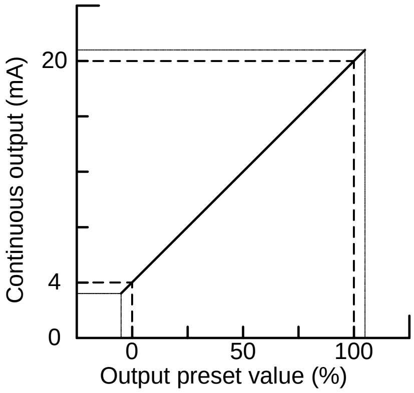


Figure C2.14 Relationship between Output Preset Value and Continuous Current Output

Table C2.21 Parameters Related to Analog Output (1/2)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
61				AOUT1	Output preset value	%	-500 to 10500 (-5.00 to 105.00%)	0	RW	—
62				AOUT2				0	RW	—
63				AOUT3				0	RW	—
64				AOUT4				0	RW	—
65				AOUT5				0	RW	—
66				AOUT6				0	RW	—
67				AOUT7				0	RW	—
68				AOUT8				0	RW	—

Table C2.21 Parameters Related to Analog Output (2/2)

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
87				OUTPUT	Output type selection	None	Either open collector or analog output may be selected for each terminal.	0	RW	✓
91				OUTSEL1	Output terminal selection	None	1 to 4: Heating output 1-4 11 to 14: Cooling output 1-4 21 to 28: Output preset value 1-8	1	RW	✓
92				OUTSEL2				2	RW	✓
93				OUTSEL3				3	RW	✓
94				OUTSEL4				4	RW	✓
95				OUTSEL5				11	RW	✓
96				OUTSEL6				12	RW	✓
97				OUTSEL7				13	RW	✓
98				OUTSEL8				14	RW	✓

CAUTION

The analog output function is available only with F3CU04-1S.

C2.6 External Output

You may switch the output between Control Output (HOUT) and External Output (EXOUT) using the EXOUT/OUT parameter.

When EXOUT/OUT is set to 0 (Normal output), the PID computation result or some other control and computation result is output.

When EXOUT/OUT is set to 1 (External output), the output value specified by the External Output (EXOUT) parameter is output. EXOUT is not constrained by the upper or lower output limit.

As an example, a sequence CPU may read the value of HOUT, correct or otherwise process the value, and then write the processed value to EXOUT.

Table C2.22 Parameters Related to External Output

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
126	326	526	726	EXOUT/OUT	External/normal output selection	None	0: Normal output 1: External output	0	RW	—
136	336	536	736	EXOUT	External output	%	-5.0 to 105.0%	0	RW	—

CAUTION

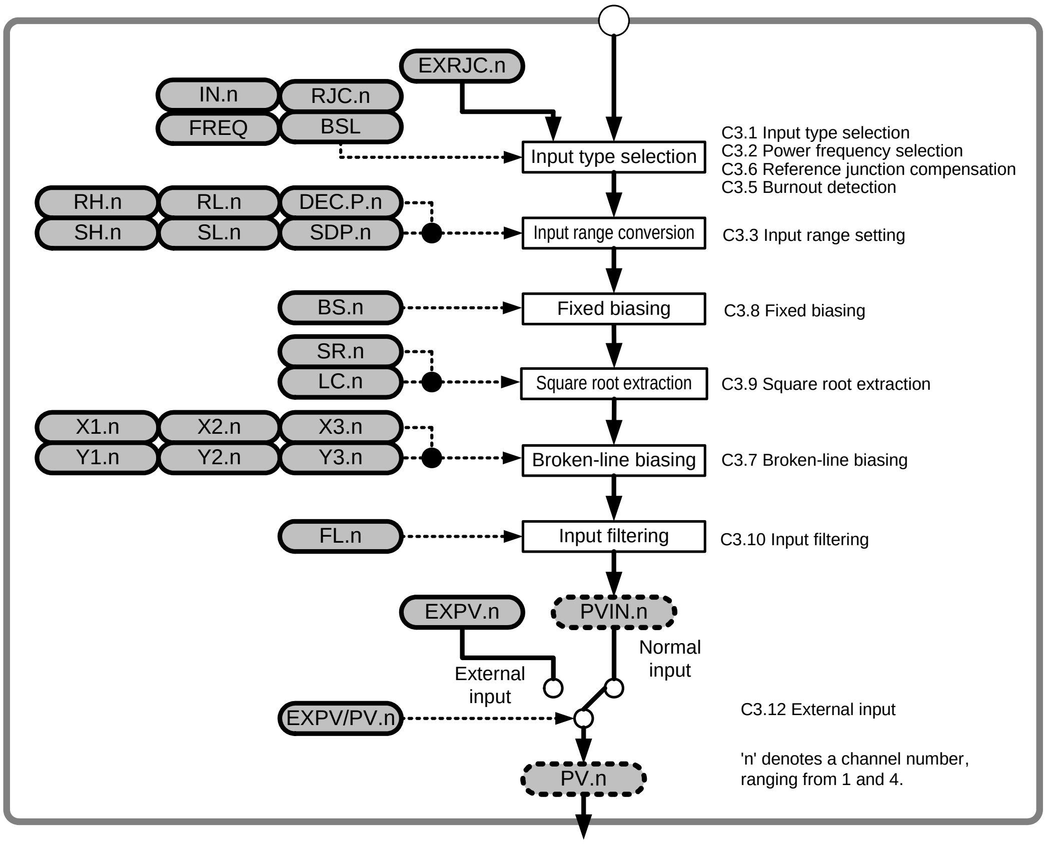
Do not use the following functions when external output is selected.

- Auto-tuning
- ON/OFF control

C3. PV-related Functions

PV-related functions are used to set up and control inputs.

PV-related functions perform input-related processing. They also perform processing for two-input changeover control, which uses two types of input to achieve wide-range measurements.



Two-input changeover

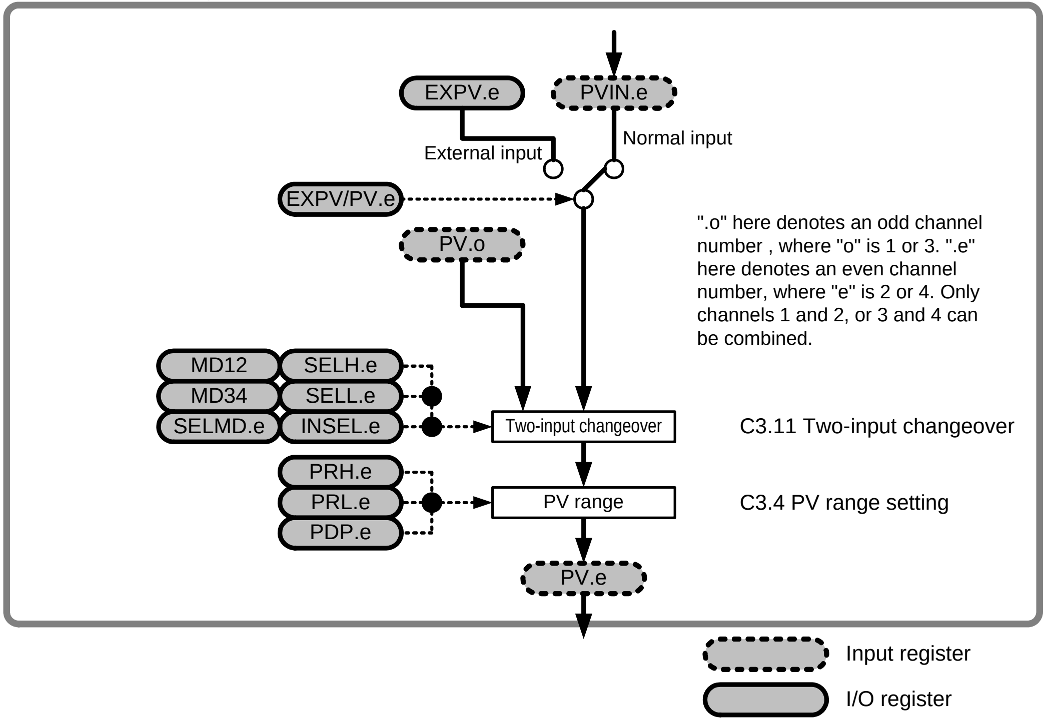


Figure C3.1 Block Diagram of PV-related Functions

Parameters related to the preceding block diagram are described below.

Table C3.1 PV-related Parameters

Data Position Number				Symbol	Description	Unit	Data Range		Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4									
101	301	501	701	PVIN	Input process value	Industrial unit	-5.0% to 105.0% of (SL to SH)		—	RO	—	C3
102	302	502	702	PV	Process value	Industrial unit	-5.0% to 105.0% of (PRL to PRH)		—	RO	—	
	323		723	INSEL	Input selection (only valid for two-input changeover control)	None	0: Input 1 1: Input 2		0	RW	—	C3.11
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input		0	RW	—	C3.12
131	331	531	731	EXPV	External input	Industrial unit	From -5.0% to 105.0% of (SL to SH)		SL	RW	—	
132	332	532	732	EXRJC	Reference junction temperature	Industrial unit	-100 to 700 (-10.0°C to 70.0°C)		0	RW	—	C3.6
142	342	542	742	IN	Input type selection [*1]	None	1-31 and 33-56 For details, see Table A4.1, "Input Type Selection."		Depends on switch setting	RW	✓	C3.1
143	343	543	743	RH	Input range upper limit	Industrial unit	See Table A4.1, "Input Type Selection."			RW	✓	C3.3
144	344	544	744	RL	Input range lower limit							
145	345	545	745	DEC.P	Decimal point position	None				RO	✓	
146	346	546	746	SH	Scaling upper limit	Industrial unit	-30000 to 30000; 0 < SH - SL ≤ 30000. Changeable only for DC voltage input with a maximum resolution of 14 bits (16384).	Thermocouple, RTD DC voltage input	RH 1000	RW	✓	
147	347	547	747	SL	Scaling lower limit			Thermocouple, RTD DC voltage input	RL 0	RW	✓	
148	348	548	748	SDP	Scaling decimal point position	None	0 to 4 Changeable only for DC voltage input	Thermocouple, RTD DC voltage input	DEC.P 1	RW	✓	
149	349	549	749	RJC	Reference junction compensation	None	0: Fixed value 1: ON		1	RW	✓	C3.6
150	350	550	750	BSL	Burnout selection (for thermocouple or RTD input)	None	0: OFF 1: Up Scale 2: Down Scale		1	RW	✓	C3.5
	351		751	PRH	PV range upper limit	Industrial unit	-30000 to 30000; 0 < PRH - PRL ≤ 30000. Changeable only for even-numbered loops in two-input changeover control with a maximum resolution of 14 bits (16384).		SH	RW	✓	C3.4
	352		752	PRL	PV range lower limit	Industrial unit			SL	RW	✓	
	353		753	PDP	PV range decimal point position	None	0 to 4 Changeable only for even-numbered loops in two-input changeover mode.		SDP	RW	✓	
	361		761	SELMD	Two-input changeover mode	None	0: Automatic changeover using temperature range 1: Automatic changeover using two-input changeover upper limit 2: Manual changeover using input selection		0	RW	✓	C3.11
	362		762	SELH	Two-input changeover upper limit	None	PRL to PRH; (SELL < SELH. If SELL ≥ SELH, changeover will be with respect to SELH.		PRL+1	RW	✓	
	363		763	SELL	Two-input changeover lower limit	None			PRL	RW	✓	
171	371	571	771	BS	Fixed bias	Industrial unit	-(SH - SL) to (SH – SL)		0	RW	✓	C3.8
172	372	572	772	FL	Input filter	Seconds	0: OFF 1 to 120 seconds		0	RW	✓	C3.10
173	373	573	773	X1	Broken-line input 1	Industrial unit	-5.0% to 105.0% of (SL to SH)		SL	RW	✓	C3.7
174	374	574	774	Y1	Broken-line bias 1	Industrial unit	-(SH-SL) to (SH-SL)		0	RW	✓	
175	375	575	775	X2	Broken-line input 2	Industrial unit	-5.0% to 105.0% of (SL to SH)		SL	RW	✓	
176	376	576	776	Y2	Broken-line bias 2	Industrial unit	-(SH-SL) to (SH-SL)		0	RW	✓	
177	377	577	777	X3	Broken-line input 3	Industrial unit	-5.0% to 105.0% of (SL to SH)		SL	RW	✓	
178	378	578	778	Y3	Broken-line bias 3	Industrial unit	-(SH-SL) to (SH-SL)		0	RW	✓	
179	379	579	779	SR	Square root extraction	None	0: OFF (no square root extraction) 1: ON (square root extraction)		0	RW	✓	C3.9
180	380	580	780	LC	Low cut	Industrial unit	0.0%-5.0% of (SH-SL)		1.0% x (SH-SL)	RW	✓	

*1 Input type selector switches must be set with values SW5 = 0 and SW1-4 = OFF, as described in Section A4.1, "Selecting Input Types and Power Frequency," input type selection can be made using software.

C3.1 Input Type Selection

Input types may be selected either using hardware switches (for all loops collectively) or using software (for individual loops).

Input type selection using software is available only when switches SW1-4 = OFF and SW5 = 0. Input type selection by software uses the I/O data register for the Input Type Selection (IN) parameter. For details on input type selection using switches, see Section A4.1, "Selecting Input Type and Power Frequency."

Table C3.2 Input Type Selection Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
142	342	542	742	IN	Input type selection [*1]	None	1 to 31, 33 to 56 For details, see Table A4.1, "Input Type Selection."		RW[*1]	✓

*1: You can also select the input types using hardware switches as described in Section A4.1, "Selecting Input Types and Power Frequency." If a selection is made using hardware switch, the setting cannot be changed by software.

CAUTION

The I/O parameters, including the input type selection (IN) parameter, must be enabled before their settings can take effect. For details, see Section B2.3, "How to Enable Settings."

Table C3.3 Input Type Selection (1/2) (SW1-1 = OFF)

Input Type		Instrument Range	Input Type Selector Switch[*2]			Software Setting	Input Range[*1]				
							Default			Allowable Range	
			SW5	SW1-4	SW1-3	IN[*3]	RL	RH	DEC.P	RL	RH
Software setting[*4]			0	OFF	X						
Thermocouple	K	-200.0 to 1370.0°C	1	OFF	OFF	1 ($01)	-2000	13700	1	-2700	13700
					ON	33 ($21)	-200	1370	0	-270	1370
		-200.0 to 1000.0°C	2		OFF	2 ($02)	-2000	10000	1	-2700	13700
					ON	34 ($22)	-200	1000	0	-270	1370
		-200.0 to 500.0°C	3		OFF	3 ($03)	-2000	5000	1	-2000	5000
					ON	35 ($23)	-200	500	0	-200	500
	J	-200.0 to 1200.0°C	4		OFF	4 ($04)	-2000	12000	1	-2000	12000
					ON	36 ($24)	-200	1200	0	-200	1200
		-200.0 to 500.0°C	5		OFF	5 ($05)	-2000	5000	1	-2000	5000
					ON	37 ($25)	-200	500	0	-200	500
	T	-270.0 to 400.0°C	6		OFF	6 ($06)	-2700	4000	1	-2700	4000
					ON	38 ($26)	-270	400	0	-270	400
	B	0.0 to 1600.0°C	7		OFF	7 ($07)	0	16000	1	0	18000
					ON	39 ($27)	0	1600	0	0	1800
	S	0.0 to 1600.0°C	8		OFF	8 ($08)	0	16000	1	0	17000
					ON	40 ($28)	0	1600	0	0	1700
	R	0.0 to 1600.0°C	9		OFF	9 ($09)	0	16000	1	0	17000
					ON	41 ($29)	0	1600	0	0	1700
	N	-200.0 to 1300.0°C	A		OFF	10 ($0A)	-2000	13000	1	-2000	13000
					ON	42 ($2A)	-200	1300	0	-200	1300
	E	-270.0 to 1000.0 °C	B		OFF	11 ($0B)	-2700	10000	1	-2700	10000
					ON	43 ($2B)	-270	1000	0	-270	1000
	L	-200.0 to 900.0°C	C		OFF	12 ($0C)	-2000	9000	1	-2000	9000
					ON	44 ($2C)	-200	900	0	-200	900
	U	-200.0 to 400.0°C	D		OFF	13 ($0D)	-2000	4000	1	-2000	4000
					ON	45 ($2D)	-200	400	0	-200	400
	W	0.0 to 1600.0°C	E		OFF	14 ($0E)	0	16000	1	0	23000
					ON	46 ($2E)	0	1600	0	0	2300
	Platinel 2	0.0 to 1390.0°C	F		OFF	15 ($0F)	0	13900	1	0	13900
					ON	47 ($2F)	0	1390	0	0	1390
RTD	JPt100	-200.0 to 500.0°C	0	ON	OFF	16 ($10)	-2000	5000	1	-2000	5000
					ON	48 ($30)	-200	500	0	-200	500
		-200.0 to 200.0°C	1		OFF	17 ($11)	-2000	2000	1	-2000	2000
					ON	49 ($31)	-200	200	0	-200	200
		0.0 to 300.0°C	2		OFF	18 ($12)	0	3000	1	0	3000
					ON	50 ($32)	0	300	0	0	300
		0.00 to 150.00°C	3		OFF	19 ($13)	0	15000	2	0	15000
					ON	51 ($33)	0	1500	1	0	1500
	Pt100	-200.0 to 850.0°C	4		OFF	20 ($14)	-2000	8500	1	-2000	8500
					ON	52 ($34)	-200	850	0	-200	850
		-200.0 to 500.0°C	5		OFF	21 ($15)	-2000	5000	1	-2000	5000
					ON	53 ($35)	-200	500	0	-200	500
		-200.0 to 200.0°C	6		OFF	22 ($16)	-2000	2000	1	-2000	2000
					ON	54 ($36)	-200	200	0	-200	200
		0.0 to 300.0°C	7		OFF	23 ($17)	0	3000	1	0	3000
					ON	55 ($37)	0	300	0	0	300
		0.00 to 150.00°C	8		OFF	24 ($18)	0	15000	2	0	15000
					ON	56 ($38)	0	1500	1	0	1500
DC voltage	0-10mV	0.00 to 10.00 mV	9	ON	X	25 ($19)	0	1000	2	0	1000
	0-100mV	0.0 to 100.0 mV	A			26 ($1A)	0	1000	1	0	1000
	0-1V	0.000 to 1.000 V	B			27 ($1B)	0	1000	3	0	1000
	0-5V	0.000 to 5.000 V	D			29 ($1D)	0	5000	3	0	5000
	1-5V	1.000 to 5.000 V	E			30 ($1E)	1000	5000	3	1000	5000
	0-10V	0.00 to 10.00 V	F			31 ($1F)	0	1000	2	0	1000

*1: For thermocouples K, B, S, R, and W, the upper and lower input range limits may exceed their default values.

*2: Data stored in the internal memory is initialized to the hardware switch values when power is turned on. An 'X' symbol in the SW1-3 column indicates that the switch setting is ignored.

*3: "Software Setting" refers to values stored in data register IN. Any value not listed here is ignored.

*4: This is the factory setting. When 'set by software' is selected, the initial value of data register IN is 'I: Thermocouple K'.

Table C3.3 Input Type Selection (2/2) (SW1-1 = ON)

Input Type		Instrument Range	Input Type Selector Switch[*2]			Software Setting	Input Range[*1]				
							Default			Allowable Range	
			SW5	SW1-4	SW1-3	IN[*3]	RL	RH	DEC.P	RL	RH
Software setting [*4]			0	OFF	X						
Thermocouple	K	-328.0 to 2498.0°F	1	OFF	OFF	1 ($01)	-3280	24980	1	-4540	24980
					ON	33 ($21)	-328	2498	0	-454	2498
		-328.0 to 1832.0°F	2		OFF	2 ($02)	-3280	18320	1	-4540	24980
					ON	34 ($22)	-328	1832	0	-454	2498
		-328.0 to 932.0°F	3		OFF	3 ($03)	-3280	9320	1	-3280	9320
					ON	35 ($23)	-328	932	0	-328	932
	J	-328.0 to 2192.0°F	4		OFF	4 ($04)	-3280	21920	1	-3280	21920
					ON	36 ($24)	-328	2192	0	-328	2192
		-328.0 to 932.0°F	5		OFF	5 ($05)	-3280	9320	1	-3280	9320
					ON	37 ($25)	-328	932	0	-328	932
	T	-454.0 to 752.0°F	6		OFF	6 ($06)	-4540	7520	1	-4540	7520
					ON	38 ($26)	-454	752	0	-454	752
	B	32 to 2912°F	7		OFF	7 ($07)	32	2912	0	32	3272
					ON	39 ($27)	32	2912	0	32	3272
	S	32 to 2912°F	8		OFF	8 ($08)	32	2912	0	32	3092
					ON	40 ($28)	32	2912	0	32	3092
	R	32 to 2912°F	9		OFF	9 ($09)	32	2912	0	32	3092
					ON	41 ($29)	32	2912	0	32	3092
	N	-328.0 to 2372.0°F	A		OFF	10 ($0A)	-3280	23720	1	-3280	23720
					ON	42 ($2A)	-328	2372	0	-328	2372
	E	-454.0 to 1832.0°F	B		OFF	11 ($0B)	-4540	18320	1	-4540	18320
					ON	43 ($2B)	-454	1832	0	-454	1832
	L	-328.0 to 1652.0°F	C		OFF	12 ($0C)	-3280	16520	1	-3280	16520
					ON	44 ($2C)	-328	1652	0	-328	1652
	U	-328.0 to 752.0°F	D		OFF	13 ($0D)	-3280	7520	1	-3280	7520
					ON	45 ($2D)	-328	752	0	-328	752
	W	32 to 2912°F	E		OFF	14 ($0E)	32	2912	0	32	4172
					ON	46 ($2E)	32	2912	0	32	4172
	Platinel 2	32.0 to 2534.0°F	F		OFF	15 ($0F)	320	25340	1	320	25340
					ON	47 ($2F)	32	2534	0	32	2534
RTD	JPt100	-328.0 to 932.0°F	0	ON	OFF	16 ($10)	-3280	9320	1	-3280	9320
					ON	48 ($30)	-328	932	0	-328	932
		-328.0 to 392.0°F	1		OFF	17 ($11)	-3280	3920	1	-3280	3920
					ON	49 ($31)	-328	392	0	-328	392
		32.0 to 572.0°F	2		OFF	18 ($12)	320	5720	1	320	5720
					ON	50 ($32)	32	572	0	32	572
		32.0 to 302.0°F	3		OFF	19 ($13)	320	3020	1	320	3020
					ON	51 ($33)	32	302	0	32	302
	Pt100	-328.0 to 1562.0°F	4		OFF	20 ($14)	-3280	15620	1	-3280	15620
					ON	52 ($34)	-328	1562	0	-328	1562
		-328.0 to 932.0°F	5		OFF	21 ($15)	-3280	9320	1	-3280	9320
					ON	53 ($35)	-328	932	0	-328	932
		-328.0 to 392.0°F	6		OFF	22 ($16)	-3280	3920	1	-3280	3920
					ON	54 ($36)	-328	392	0	-328	392
		32.0 to 572.0°F	7		OFF	23 ($17)	320	5720	1	320	5720
					ON	55 ($37)	32	572	0	32	572
		32.0 to 302.0°F	8		OFF	24 ($18)	320	3020	1	320	3020
					ON	56 ($38)	32	302	0	32	302
DC voltage	0-10mV	0.00 to 10.00 mV	9	ON	X	25 ($19)	0	1000	2	0	1000
	0-100mV	0.0 to 100.0 mV	A			26 ($1A)	0	1000	1	0	1000
	0-1V	0.000 to 1.000 V	B			27 ($1B)	0	1000	3	0	1000
	0-5V	0.000 to 5.000 V	D			29 ($1D)	0	5000	3	0	5000
	1-5V	1.000 to 5.000 V	E			30 ($1E)	1000	5000	3	1000	5000
	0-10V	0.00 to10.00 V	F			31 ($1F)	0	1000	2	0	1000

*1: For thermocouples K, B, S, R, and W, the upper and lower input range limits may exceed their default values.

*2: Data stored in the internal memory is initialized to the hardware switch values when power is turned on. An 'X' symbol in the SW1-3 column indicates that the switch setting is ignored.

*3: "Software Setting" refers to values stored in data register IN. Any value not listed here is ignored.

*4: This is the factory setting. When 'set by software' is selected, the initial value of data register IN is 'I: Thermocouple K'.

C3.2 Power Frequency Selection

Power frequency may be set either by switches or software. Power frequency selection by software is available only when switches SW1-4 = OFF and SW5=0. The default value is determined by SW1-2.

An appropriate power frequency setting reduces the interference of common-mode noise from the power supply on input signals.

The parameter used is as follows:

Table C3.4 Power Frequency Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
81				FREQ	Power frequency selection [*1]	None	0: 50 Hz, 1: 60 Hz	0	RW [*1]	✓

*1 The default value is either 0 or 1 depending on the setting of SW1-2. Power frequency may also be set with SW1-2. For details, see Section A4.1, "Selecting Input Type and Power Frequency." Switch setting takes precedence over parameter setting.

CAUTION

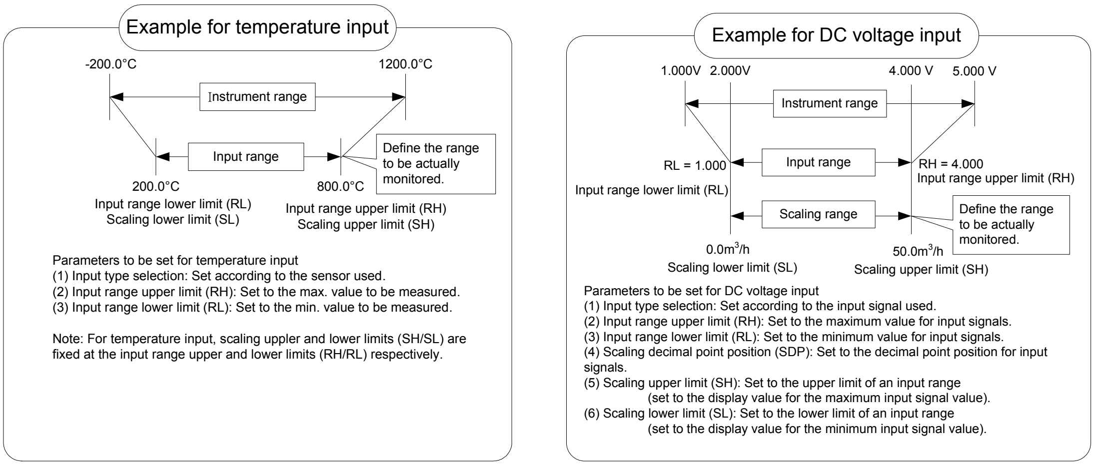
The I/O parameters, including the input type selection (IN) parameter, must be enabled before their settings can take effect. For details, see Section B2.3, "How to Enable Settings."

C3.3 Input Range Setting

For each instrument range selected using Input Type Selection, you may define an input range, which is the actual temperature range to be monitored, by specifying upper (RH) and lower (RL) limits within the instrument range. Some input types such as thermocouple W, however, allow an input range that is wider than the instrument range. For details, see Table C3.3, "Input Type Selection."

For example, to define an input range of 200.0-800.0°C for an instrument range of -200.0 to 1200.0°C for a thermocouple J input, set RH = 8000 and RL = 2000 (SH and SL are equal to RH and RL for temperature input).

Likewise, to define an input range of 2-4 V for an instrument range of 1.000-5.000 V for DC voltage input with a display range of 0.0-50.0, set RH = 4000, RL = 2000, SDP = 1, SH = 500, and SL = 0.



Parameters to be set for temperature input
(1) Input type selection: Set according to the sensor used.
(2) Input range upper limit (RH): Set to the max. value to be measured.
(3) Input range lower limit (RL): Set to the min. value to be measured.

Note: For temperature input, scaling uppler and lower limits (SH/SL) are fixed at the input range upper and lower limits (RH/RL) respectively.

Parameters to be set for DC voltage input
(1) Input type selection: Set according to the input signal used.
(2) Input range upper limit (RH): Set to the maximum value for input signals.
(3) Input range lower limit (RL): Set to the minimum value for input signals.
(4) Scaling decimal point position (SDP): Set to the decimal point position for input signals.
(5) Scaling upper limit (SH): Set to the upper limit of an input range (set to the display value for the maximum input signal value).
(6) Scaling lower limit (SL): Set to the lower limit of an input range (set to the display value for the minimum input signal value).

Figure C3.2 Examples of Input Range Setting

As shown in Figure C3.1, "Block Diagram of PV-related Functions," input values within a defined input range undergo computation before it is provided as an input process value, PVIN, to the system. For details on the computations performed, see Sections C3.9, "Square Root Extraction," C3.7, "Broken-line Biasing," C3.8, "Fixed Biasing," and C3.10, "Input Filtering."

Table C3.5 Parameters of Input-related Functions

Data Position Number				Symbol	Description	Unit	Data Range		Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4								
101	301	501	701	PVIN	Input process value	Industrial unit	-5.0% to 105.0% of (SL to SH)		—	RO	—
143	343	543	743	RH	Input range upper limit	Industrial unit	See Table A4.1 or C3.3, "Input Type Selection."			RW	✓
144	344	544	744	RL	Input range lower limit						
145	345	545	745	DEC.P	Decimal point position	None				RO	✓
146	346	546	746	SH	Scaling upper limit	None	-30000 to 30000; 0 < SH - SL ≤ 30000. Changeable only for DC voltage input with a maximum resolution of 14 bits (16384).	Thermocouple, RTD	RH	RW	✓
								DC voltage input	1000		
147	347	547	747	SL	Scaling lower limit			Thermocouple, RTD	RL	RW	✓
								DC voltage input	0		
148	348	548	748	SDP	Scaling decimal point position	None	0 to 4 Changeable only for DC voltage input	Thermocouple, RTD	DEC.P	RW	✓
								DC voltage input	1		

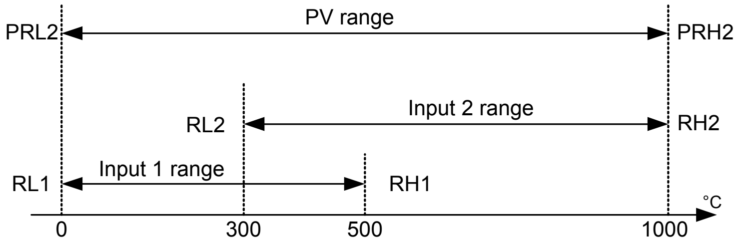
CAUTION

Changing an input range does not improve accuracy or resolution.

C3.4 PV Range Setting (for use in two-input changeover mode only)

The PV range setting defines the range of the output process value in Two-input Changeover mode, in cases where the two input signals have different input ranges. The PV range setting can only be changed in the two-input changeover mode and no other mode.

For example, if input 1 (loop 1) has input range of 0-500°C (RL=0°C; RH=500°C) and input 2 (loop 2) has input range of 300-1000°C (RL=300°C; RH=1000°C), you may set the PV range of loop 2 to 0-1000°C (PRL=0°C; PRH=1000°C).



In the figure, a number after a parameter symbol denotes a loop number. For example, RL2 means the input range lower limit (RL) for loop 2.

Figure C3.3 Examples of PV Range Setting

Table C3.6 PV Range Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
101	301	501	701	PVIN	Input process value	Industrial unit	-5.0% to 105.0% of (SL to SH)	—	RO	—
102	302	502	702	PV	Process value	Industrial unit	-5.0% to 105.0% of (PRL to PRH)	—	RO	—
	351		751	PRH	PV range upper limit	Industrial unit	-30000 to 30000; 0 < PRH - PRL ≤ 30000. Changeable only for even loops in Two-input Changeover control with a maximum resolution of 14 bits (16384).	SH	RW	✓
	352		752	PRL	PV range lower limit	Industrial unit		SL	RW	✓
	353		753	PDP	PV range decimal point position	None	0 to 4 Changeable only for even loops in Two-input Changeover control. Always the same as SDP.	SDP	RW	✓

For details on how to switch between two inputs, see Section C3.11, "Two-input Changeover."

CAUTION

PRH and PRL (PV range) are set by default to RH and RL (input range) of the even loop (2 or 4) for temperature input, or SH and SL (scaling range) of the even loop for DC voltage input. Redefine the PRH and PRL values as necessary.

C3.5 Burnout Detection

Burnout detection checks for an open circuit on an input.

For thermocouple or RTD input, you may define a burnout condition by specifying the direction of change in the input value and the final input value. For DC voltage input, burnout detection is not available.

When an open-circuit occurs with the Burnout Selection (BSL) parameter set to ‘Up-Scale’, the input value rises to a final value of 105% of the input range (or the PV range in Two-input Changeover mode).

When an open-circuit occurs with Burnout Selection (BSL) set to ‘Down-Scale’, the input value drops to a final value of -5.0% of the input range (or the PV range in Two-input Changeover mode).

If Burnout Selection (BSL) is set to ‘OFF’, the input value is undefined when an open circuit occurs, and may reach the upper or lower limit, but even if this happens, the FUNC.ERR relay and the corresponding bit of the RUN.STUS register are not set.

If an open circuit is detected in Run and Automatic operating status, the preset output value is output as the control output, and the operation of the alarm depends on the input value at that moment.

If an open circuit is detected in Run and Manual operating status, the manual output value is output as if no open circuit has occurred.

Table C3.7 Burnout-related Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
41 108	42 308	43 508	44 708	RUN.STUS	Operating status	None	On/off for individual bits.	—	RO	—
150	350	550	750	BSL	Burnout selection	None	0: OFF 1: Up-scale 2: Down-scale (valid only for thermocouple and RTD input)	1	RW	✓

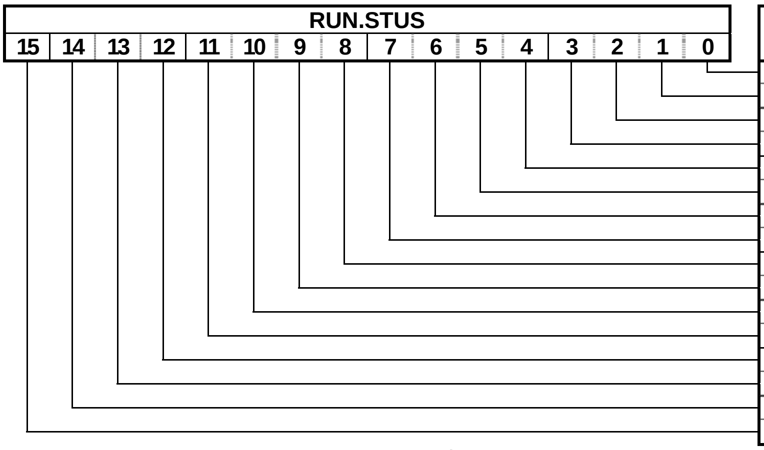
Table C3.8 Burnout Detection Relay

Input Relay Number X□□□nn[*1]				Symbol	Description	Data Range
Loop 1	Loop 2	Loop 3	Loop 4			
07	15	23	31	FUNC.ERR	Burnout or other error detected[*2]	0: Normal, 1: Error

*1: □□□ denotes the slot number where the module is installed.

*2: Notifies that a burnout has been detected, or that self-diagnosis has detected an AD converter error or some other error that affects normal module operation.

Table C3.9 Operating Status



Bit Pos.	Symbol	Description
0	RUN/STP	0: Stop, 1: Run
1	AUT/MAN	0: Automatic, 1: Manual
2	CAS	1: Cascade mode
3	RMT/LOC	0: Local, 1: Remote
4	EXPV/PV	0: Normal, 1: External input
5	EXOUT/OUT	0: Normal, 1: External output
6	—	
7	—	
8	B.OUT	1: PVIN burnout
9	+OVER	1: PVIN +OVER
10	-OVER	1: PVIN -OVER
11	B.OUT	1: PV burnout
12	+OVER	1: PV +OVER
13	-OVER	1: PV -OVER
14	—	
15	FUNC.ERR	1: Error detected

A PVIN burnout always reflects the input condition of the corresponding loop.
A PV burnout in Single Loop control is equivalent to a PVIN burnout.
A PV burnout detected on an even loop in two-input changeover control may mean an actual burnout on either the even loop or the odd loop of the pair of loops.

CAUTION

Burnout detection is not performed when EXPV/PV is set to “1: external input”.

CAUTION

If the Burnout Selection (BSL) parameter is set to ‘Down-scale’ for a thermocouple range, a burnout may not be detected in high temperature environments exceeding 40°C.

In this situation, set the alarm type to ‘Lower Limit’, set an appropriate alarm preset value, and use the alarm for burnout detection instead.

C3.6 Reference Junction Compensation

When Reference Junction Compensation (RJC) is set to ‘1: ON’, the temperature of the terminal block of the module is automatically measured and used for reference junction compensation in the thermocouple temperature measurement.

If an external reference point device is used to provide even better reference junction compensation, set RJC to ‘0: Fixed Value’, and set EXRJC to the reference junction temperature.

Table C3.10 Reference Junction Compensation Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
149	349	549	749	RJC	Reference junction compensation	None	0: Fixed value 1: ON	1	RW	✓
132	332	532	732	EXRJC	Reference junction temperature	Industrial unit	-100 to 700 (-10.0°C to 70.0°C)	0	RW	—

C3.7 Broken-line Biasing

The broken-line biasing function adds different bias values to input values depending on their magnitude.

This function is useful for correcting offset or gain error (due to sensor characteristics, degradation or other reasons) over parts of an input range.

As shown in the figure below, by specifying the input values (X) and corresponding bias values (Y) for any three points, bias correction is performed throughout the input range.

Use parameters X1 to X3 to specify three input values, and parameters Y1 to Y3 to specify their corresponding bias values.

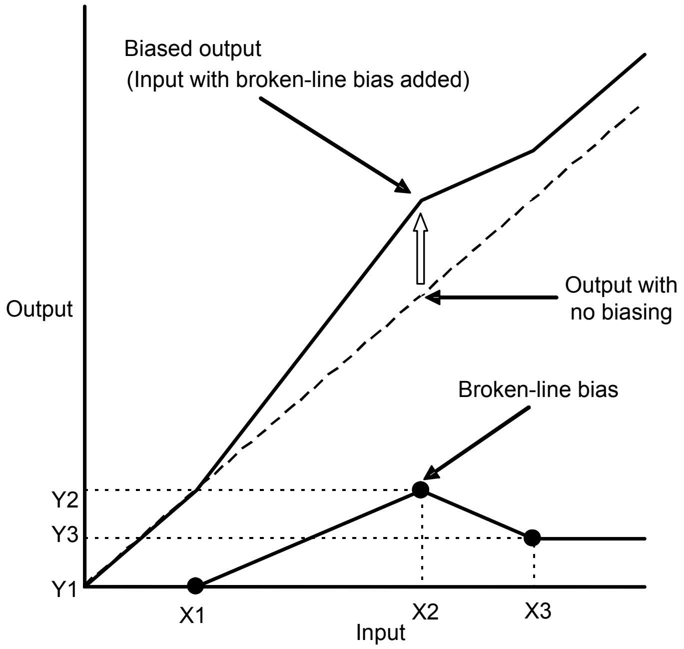


Figure C3.4 Broken-line Biasing Example

Table C3.11 Broken-line Biasing Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
173	373	573	773	X1	Broken-line input 1	Industrial unit	-5.0%to105.0% of (SL to SH)	SL	RW	✓
174	374	574	774	Y1	Broken-line bias 1	Industrial unit	-(SH-SL) to (SH-SL)	0	RW	✓
175	375	575	775	X2	Broken-line input 2	Industrial unit	-5.0%to105.0% of (SL to SH)	SL	RW	✓
176	376	576	776	Y2	Broken-line bias 2	Industrial unit	-(SH-SL) to (SH-SL)	0	RW	✓
177	377	577	777	X3	Broken-line input 3	Industrial unit	-5.0%to105.0% of (SL to SH)	SL	RW	✓
178	378	578	778	Y3	Broken-line bias 3	Industrial unit	-(SH-SL) to (SH-SL)	0	RW	✓

CAUTION

When using the broken-line biasing function, you must specify all broken-line bias related parameters (X1 to X3, and Y1 to Y3). Furthermore, the specified input values (X1 to X3) must be such that X1 ≤ X2 ≤ X3.

C3.8 Fixed Biasing

The fixed biasing function adds a constant bias to input values throughout the input range.

This function is especially useful when a sensor output is always lower than true values by a fixed amount due to the physical condition of the sensor. For example, it may be used when the temperature of a material in a furnace is indirectly determined by measuring the ambient temperature in the furnace, where a fixed bias is added to the ambient temperature to represent the temperature of the material. The function is also useful for rectifying deviations among outputs from different sensors, which are within precision tolerance, or for correcting the output from a degraded sensor.

Table C3.12 Fixed Biasing Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
171	371	571	771	BS	Fixed bias	Industrial unit	-(SH-SL) to (SH-SL)	0	RW	✓

C3.9 Square Root Extraction

The square root extraction function is especially useful for converting differential pressures measured with a restriction flowmeter using an orifice or nozzle into flow rates.

You can also specify a low-cut point below which no square root extraction is done.

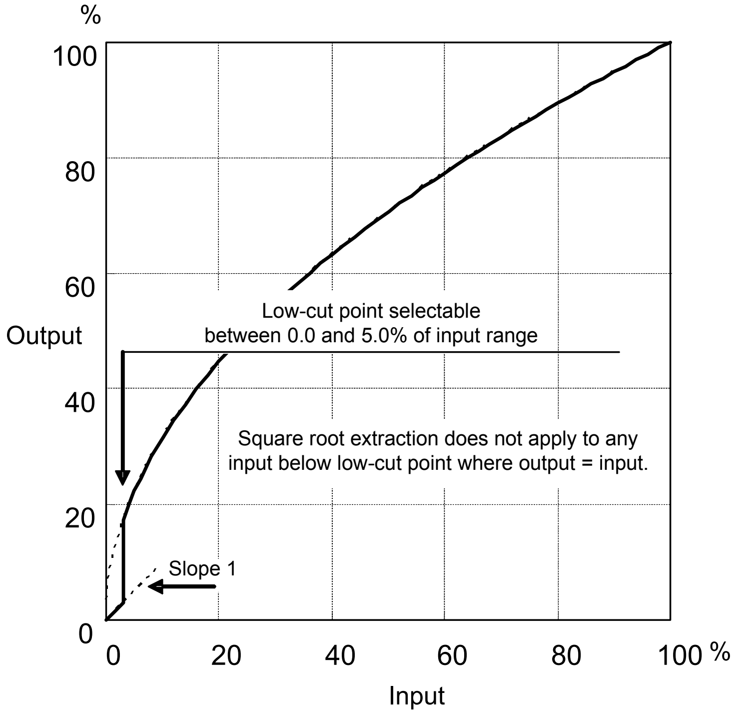


Figure C3.5 Square Root Extraction Example

Table C3.13 Square Root Extraction Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
179	379	579	779	SR	Square root extraction	None	0: OFF (no square root extraction) 1: ON (square root extraction)	0	RW	✓
180	380	580	780	LC	Low-cut	Industrial unit	0 to (0.0-5.0%) of (SH - SL)	1.0% x (SH - SL)	RW	✓

CAUTION

This function is available only in the DC voltage input mode. It is ignored if specified in thermocouple or RTD input mode.

C3.10 Input Filtering

The input filtering function removes noise from input signals.

It is especially useful for removing high frequency noise from flow rate or pressure input signals.

When a larger time-constant is specified for this function, more noise is removed and the input signal becomes cleaner and more stable. On the other hand, a larger time-constant provides more input filtering, making the module less responsive to changes in the input signal. Thus the Input Filter parameter should be set to the minimum required value. (see Figure C3.6)

The input filter performs 1st order delay calculation for filtering.

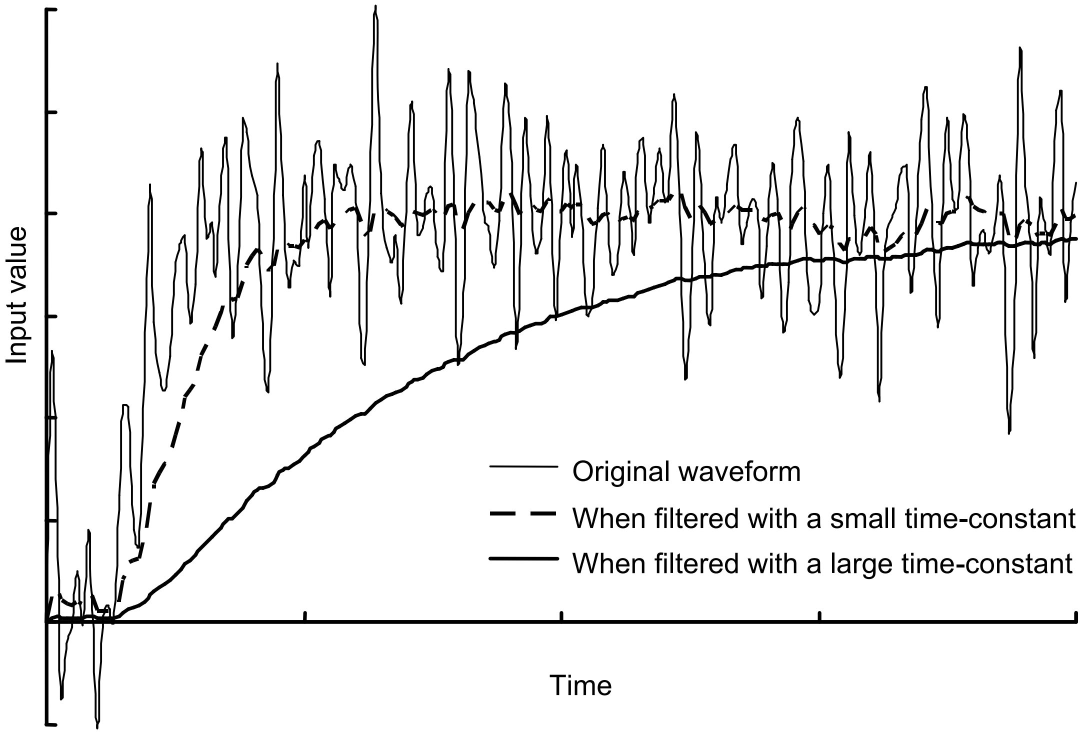


Figure C3.6 How Input Filtering Affects Input Signal

Table C3.14 Input Filter Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
172	372	572	772	FL	Input filter	Second	0: OFF, 1 to 120 s	0	RW	✓

C3.11 Two-input Changeover (for use in two-input changeover mode only)

The two-input changeover function has three modes, which are selected by the Two-Input Changeover Mode (SELMD) parameter.

Table C3.15 Two-input Changeover Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
	361		761	SELMD	Two-input changeover mode	None	0: Automatic changeover using temperature range 1: Automatic changeover using upper limit 2: Manual changeover using input selection	0	RW	✓
	362		762	SELH	Two-input changeover upper limit	Industrial unit	PRL to PRH if SELL < SELH. If SELL ≥ SELH, changeover occurs with respect to SELH.	PRL+1	RW	✓
	363		763	SELL	Two-input changeover lower limit			PRL	RW	✓
	323		723	INSEL	Input selection	None	0: Input 1 1: Input 2	0	RW	–

■ Automatic Changeover Using Temperature Range (SELMD: 0)

In this mode, Input 1 is used when it is below the two-input changeover lower limit (SELL), Input 2 is used when it is above the two-input changeover upper limit (SELH), and the average (PV) of Input 1 and Input 2, given by the equation below, is used between SELL and SELH (overlapping range).

$$\text{PV} = \left(1 - \frac{input\ 1 - SELL}{SELH - SELL}\right) \times input\ 1 + \left(\frac{input\ 1 - SELL}{SELH - SELL}\right) \times input\ 2$$

Figure C3.7 illustrates how the PV is selected from Input 1, Input 2 and the average of Input 1 and Input 2.

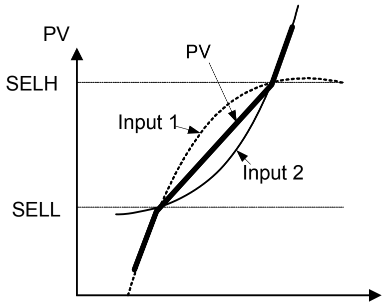


Figure C3.7 PV Value in Changeover Mode

CAUTION

- Input 1 must be used for the lower temperature range.
- Input 1 and Input 2 must be defined with overlapping ranges.

■ Automatic Changeover Using Upper Limit (SELMD: 1)

In this mode, Input 1 is used when it is not higher than SELH, and Input 2 is used when Input 1 is higher than SELH, as follows:

Input 1 ≤ SELH: Input 1 is selected.

Input 1 > SELH: Input 2 is selected.

■ Manual Changeover Using Input Selection (SELMD: 2)

Switches between input 1 and input 2 according to the Input Selection (INSEL) parameter, as follows:

INSEL = 0: Input 1 is selected.

INSEL = 1: Input 2 is selected.

The PV may change abruptly when changeover is made between Input 1 and Input 2, as illustrated below.

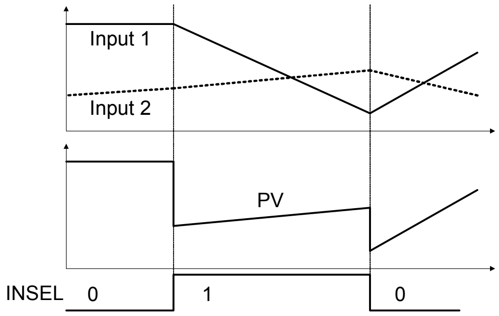


Figure C3.8 Changeover Using Input Selection (INSEL) Parameter

TIP

If two inputs have different values, switching between the two inputs would result in an abrupt change in controlled output. To prevent this, this mode uses the average of the two inputs as the PV value within the overlapping range. For this to work in Automatic Changeover Using Temperature Range mode (SELMD = 0), you must define input 1 and input 2 with overlapping ranges.

C3.12 External Input

The input value used for monitoring and controlling may be switched to an external input, which may be, say, processed data from a CPU module.

An external input must fall within the range of -5.0% to 105.0% of (SL to SH).

Use the EXPV/PV parameter to switch between external input and normal input.

An external input may also be used for testing without a thermocouple or sensor connected.

Table C3.16 External Input Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
131	331	531	731	EXPV	External input	Industrial unit	-5.0% to 105.0% of (SL to SH)	SL	RW	—
125	325	525	725	EXPV/PV	External/normal input selection	None	0: Normal input 1: External input	0	RW	—

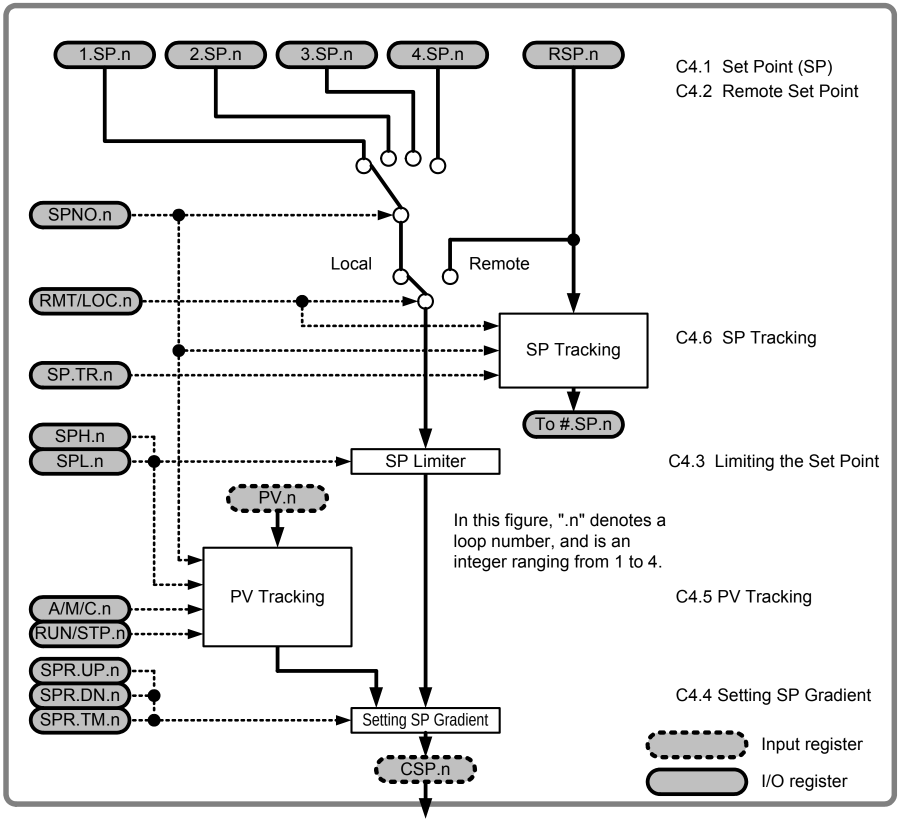
CAUTION

Burnout detection is not performed if the EXPV/PV parameter is set to “1: External Input”.

C4. SP-Related Functions

This chapter describes the selection of the set points used in control and computation functions, as well as changes in set point value accompanied by a change in operation control modes.

SP Functions



SP Functions (secondary loop in cascade operation)

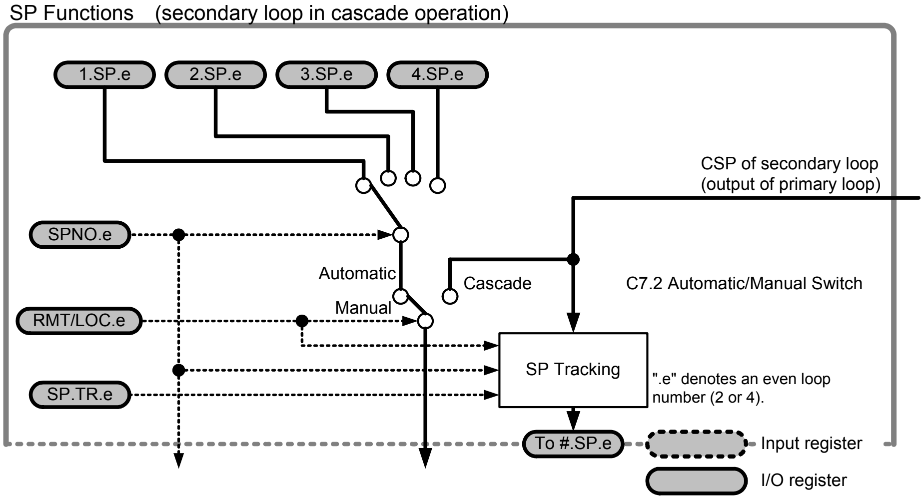


Figure C4.1 Overview of SP-related Functions

C4.1 Set Point (SP)

Any one of the pre-defined set points (1.SP to 4.SP) or a remote set point (RSP) can be selected as the control set point (CSP). The set points (1.SP to 4.SP) can be stored in EEPROM for data retention purposes at power off.

This feature is useful, say, for switching between set point values when switching production between different product types.

- Set the Set Point (1.SP to 4.SP) parameters to different set point values.
- For a loop in Single-Loop or Two-input Changeover mode, or the primary loop in Cascade control mode, set the Remote/Local Selection (RMT/LOC) parameter to 0 (Local).
- For the secondary loop in Cascade Control mode, set the Automatic/Manual/Cascade Selection (A/M/C) parameter to Automatic.
- To change the set point, select the desired Set Point parameter using the SP Number Selection (SPNO) parameter.
- To see which SP number is currently selected, read the CSPNO parameter.

Changing the SPNO parameter in local mode operation selects the following parameters (where n denotes the value of SPNO and is an integer ranging from 1 to 4).

n.SP	Set Point
n.A1	Alarm 1 Preset Value
n.A2	Alarm 2 Preset Value
n.A3	Alarm 3 Preset Value
n.A4	Alarm 4 Preset Value

TIP

If the Zone PID Selection (ZONE) parameter is set to ‘0: Disabled’, changing the SP Number Selection (SPNO) also changes the PID constants, including PB, TI and TD. For details on the parameters that are changed, see Section C6.9, “PID Selection Method”.

Table C4.1 SP-related Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
103	303	503	703	CSP	Control set point	Industrial Unit	PRL to PRH	—	RO	—
107	307	507	707	CSPNO	Current SP number	None	1 to 4	—	RO	—
122	322	522	722	A/M/C	Automatic/manual/ cascade selection	None	0: Automatic 1: Manual 2: Cascade[*1]	0	RW	—
124	324	524	724	RMT/LOC	Remote/local selection	None	0: Local 1: Remote	0	RW	—
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—
201	401	601	801	1.SP	Set point	Industrial Unit	PRL to PRH	PRL	RW	Irregular
221	421	621	821	2.SP	Set point	Industrial Unit	PRL to PRH	PRL	RW	Irregular
241	441	641	841	3.SP	Set point	Industrial Unit	PRL to PRH	PRL	RW	Irregular
261	461	661	861	4.SP	Set point	Industrial Unit	PRL to PRH	PRL	RW	Irregular

[*1] The controller mode must be set to Cascade Control before Automatic/Manual/Cascade Selection (A/M/C) can be set to 2 (Cascade). In cascade control mode, operation proceeds according to the setup for the even-numbered loop (2 or 4).

CAUTION

- You need to execute a specific procedure every time to update stored set point values. Otherwise, stored set points will not be updated so the parameters revert to their last stored values whenever the module is turned off and then on again. For details, see Section B2.4, "How to Back up SP Values to EEPROM."
- For F3CU04-☐N, set points (1.SP to 4.SP) are always automatically stored to EEPROM when updated. Updating set points frequently may damage the EEPROM stoarge media. Therefore, if the set point is to be changed continually (as a ramp signal, for example), you should make use of the remote set point (RSP) instead.

C4.2 Remote Set Point

Any one of the pre-defined set points (1.SP to 4.SP) or a remote set point (RSP) can be selected as the control set point (CSP). The RSP signal is intended to be updated continually (for example, as a ramp signal from the CPU module) and hence, is not stored to the EEPROM when updated.

- For a loop in Single-Loop mode or Two-input Changeover mode, or the primary loop of Cascade control mode, set the Remote/Local Selection (RMT/LOC) parameter to 1 (Remote).
- Set the Remote Set Point (RSP) to a desired set point value.

Changing the SP Number Selection (SPNO) parameter during remote operation selects the following parameters (where n denotes the value of SPNO, and is an integer ranging from 1 to 4).

- n.A1 Alarm 1 Preset Value
- n.A2 Alarm 2 Preset Value
- n.A3 Alarm 3 Preset Value
- n.A4 Alarm 4 Preset Value

TIP

If the Zone PID Selection (ZONE) parameter is set to ‘0: Disabled’, changing the SP Number Selection (SPNO) also changes the PID constants, including PB, TI and TD. For details on the parameters that are changed, see Section C6.9, “PID Selection Method”.

Table C4.2 Parameters Related to Remote Set Point

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—
122	322	522	722	A/M/C	Automatic/manual/cascade selection	None	0: Automatic 1: Manual 2: Cascade *1	0	RW	—
124	324	524	724	RMT/LOC	Remote/local selection	None	0: Local 1: Remote	0	RW	—
133	333	533	733	RSP	Remote set point	Industrial unit	PRL to PRH	PRL	RW	—

*1 The controller mode must be set to Cascade Control before Automatic/Manual/Cascade Selection (A/M/C) can be set to 2 (Cascade). In cascade control mode, operation proceeds according to the setup for the even-numbered loop (2 or 4).

CAUTION

The remote set point function is not available for the secondary loop in cascade control mode.

C4.3 Limiting the Set Point

You can set upper limit and lower limit for the control set point (CSP).

This feature is useful in situations where it is desirable to limit the control set point within a certain temperature range, depending on the characteristics of equipment and materials involved.

- Set the SP Upper Limit (SPH) parameter to the desired upper limit and the SP Lower Limit (SPL) parameter to the desired lower limit.

The SP limit function is always enabled, regardless of the remote/local selection.

It is always enabled for the secondary loop in cascade control, regardless of the Automatic/manual/cascade selection.

Table C4.3 Parameters Related to the Set Point Limit Function

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—
164	364	564	764	SPH	Upper SP limit	Industrial unit	PRL to PRH If SPL<SPH. If SPL ≥ SPH, CSP is always equal to SPL.	PRH	RW	✓
165	365	565	765	SPL	Lower SP limit			PRL	RW	✓

CAUTION

Set the SP limits such that SPL < SPH.

If SPL ≥ SPH, then the control set point (CSP) will always be equal to SPL.

CAUTION

If SPH and SPL are used in the secondary loop in cascade control, align the Upper Output Limit (OH) and Lower Output Limit (OL) of the primary loop with SPH and SPL of the secondary loop respectively. Otherwise, the control set point of the secondary loop may be constrained by SPH or SPL of the secondary loop, resulting in a large PV overshoot in the primary loop. For instance, if the SPH of the secondary loop is 50% of the PV range between PRH and PRL, it is recommended that OH of the primary loop be set to 50%.

C4.4 Setting SP Gradient

To prevent drastic changes in the Control Set Point (CSP), or to vary the CSP at a fixed rate, you can set the SP Up Gradient (SPR.UP) or SP Down Gradient (SPR.DN) parameters.

- Use the SP Up Gradient (SPR.UP) parameter to specify the rate of change in the increasing direction.
- Use the SP Down Gradient (SPR.DN) parameter to specify the rate of change in the decreasing direction.
- Use the SP Gradient Time Unit (SPR.TM) parameter to specify the unit of time for the rate of change.

The SP gradient function acts in the following situations:

- When the Set Point parameter selected by an SP Number Selection is changed.
- When the Remote Set Point parameter is changed in remote mode.
- When the SP Number Selection (SPNO) parameter is changed.

In the following situations, the SP gradient function acts so that the process value (PV) approaches the control set point at the specified gradient. This function is called PV tracking. It is disabled when burnout is detected. For details, see Section C4.5, "PV Tracking."

- When the SP Number Selection (SPNO) parameter is changed.
- When parameter setup is changed from “Manual” to “Run” and “Automatic” or to “Run” and “Cascade”.
- When parameter setup is changed from “Stop” to “Run” and “Automatic” or to “Run” and “Cascade”.

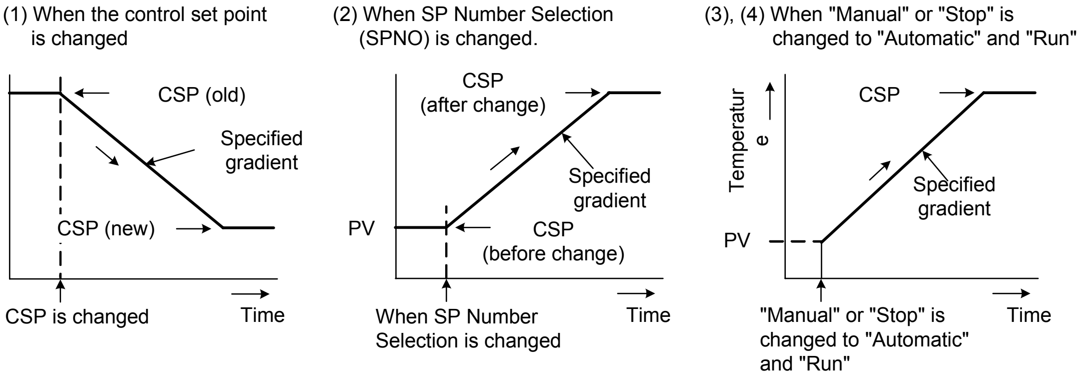


Figure C4.2 Setting SP Gradient

Table C4.4 Parameters Related to SP Gradient

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
102	302	502	702	PV	Process value	Industrial unit	-5.0% to 105.0% of (PRL to PRH)	—	RO	—
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—
166	366	566	766	SPR.UP	SP up gradient	Industrial unit	0 to (PRH-PRL). Function is disabled if value is 0.	0	RW	✓
167	367	567	767	SPR.DN	SP down gradient			0	RW	✓
168	368	568	768	SPR.TM	SP gradient time unit	None	0: hour; 1: minute	0	RW	✓

Example specifying SP Up Gradient (SPR.UP)

This example illustrates the use of the SP Up Gradient (SPR.UP) parameter (see Figure C4.3).

The system is operating with 1.SP and then switched to 2.SP. The CSP rises at a fixed rate. In the following example, the temperature difference between 2.SP and 1.SP is 140ºC, and it is desired to achieve this temperature change in 2 minutes. Hence, SPR.UP is set to 70 (ºC/minute).

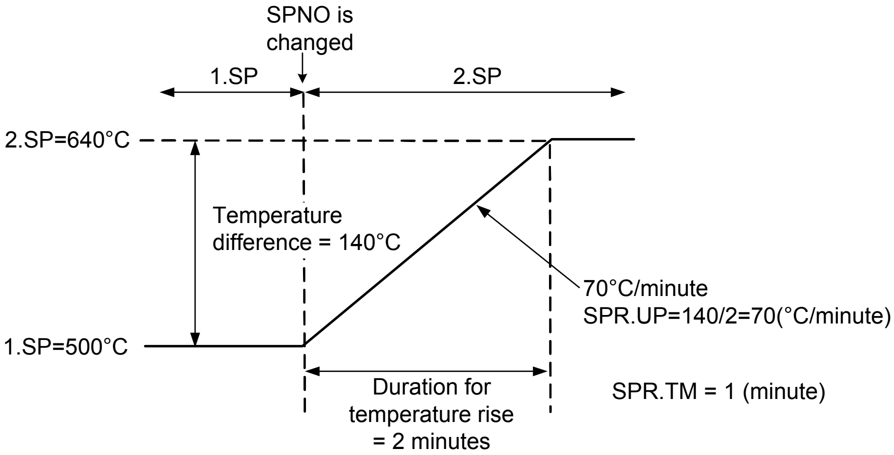


Figure C4.3 Example Specifying SP Up Gradient

$$\text{SPR.UP} = \frac{\text{Temp. diff. } (^\circ\text{C})}{\text{Time (minute)*}} = \frac{140^\circ\text{C}}{2 \text{ minutes}} = 70\ (^\circ\text{C/minute})$$

*: The time unit can be hour or minute, and is specified using the SP Gradient Time Unit (SPR.TM) parameter.

C4.5 PV Tracking

The PV tracking function first makes the CSP temporarily the same as the current PV value, and then changes the CSP gradually to the true CSP value according to the SP gradient setting. This function is enabled when the SP up gradient (SPR.UP) or SP down gradient (SPR.DN) parameter is set to a non-zero value.

PV tracking acts in the following situations:

- When the SP Number Selection (SPNO) parameter is changed.
- When the operating mode is changed from “Manual” to “Run” and “Automatic” or from “Manual” to “Run” and “Cascade”.
- When the operating mode is changed from “Stop” to “Run” and “Automatic” or from “Stop” to “Run” and “Cascade”.

The PV tracking function is disabled when a burnout or AD converter error is detected. When the SP number is changed, the PV tracking function changes the CSP gradually according to the SP gradient setting from the value designated by the old SP number to the value designated by the new SP number.

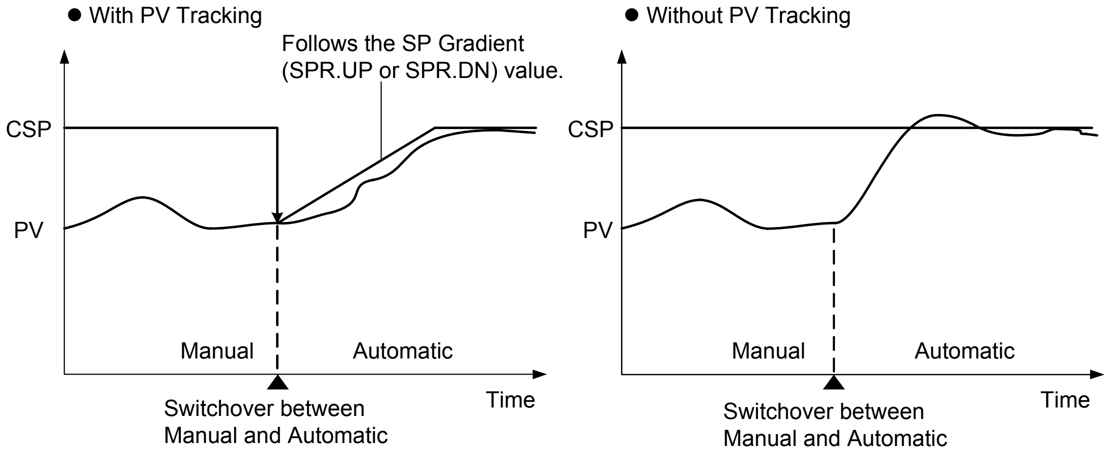


Figure C4.4 PV Tracking Operation

Table C4.5 Parameters Related to PV Tracking

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
102	302	502	702	PV	Process value	Industrial unit	-5.0 to 105.0% of PRL to PRH	—	RO	—
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—
166	366	566	766	SPR.UP	SP up gradient	Industrial unit	0 to (PRH-PRL) PV tracking function is disabled when value is 0.	0	RW	✓
167	367	567	767	SPR.DN	SP down gradient			0	RW	✓
168	368	568	768	SPR.TM	SP gradient time unit	None	0: hour; 1: minute	0	RW	✓

CAUTION

The PV tracking function is disabled if the SP Up Gradient and the SP Down Gradient are set to 0 (OFF).

- If PV < CSP, the function acts if the SP Up Gradient (SPR.UP) parameter is non-zero.
- If PV ≥ CSP, the function acts if SP Down Gradient (SPR.DN) parameter is non-zero.

C4.6 SP Tracking

When a loop is switched from remote to local mode, the SP tracking function automatically sets the selected Set Point (n.SP) in local mode to the value of the Remote Set Point (RSP) immediately preceding the switchover.

SP tracking can be used to prevent a drastic change in the CSP when switching from remote to local mode.

To enable SP tracking, set the SP Tracking Mode (SP.TR) parameter to “0: Tracking on”.

SP tracking acts in the following situations.

- When the Remote/Local Selection (RMT/LOC) parameter is changed from “Remote” to “Local”.
- When the Automatic/Manual/Cascade Selection (A/M/C) parameter of a secondary loop in cascade control is changed from “Cascade” to “Automatic” or “Manual”.

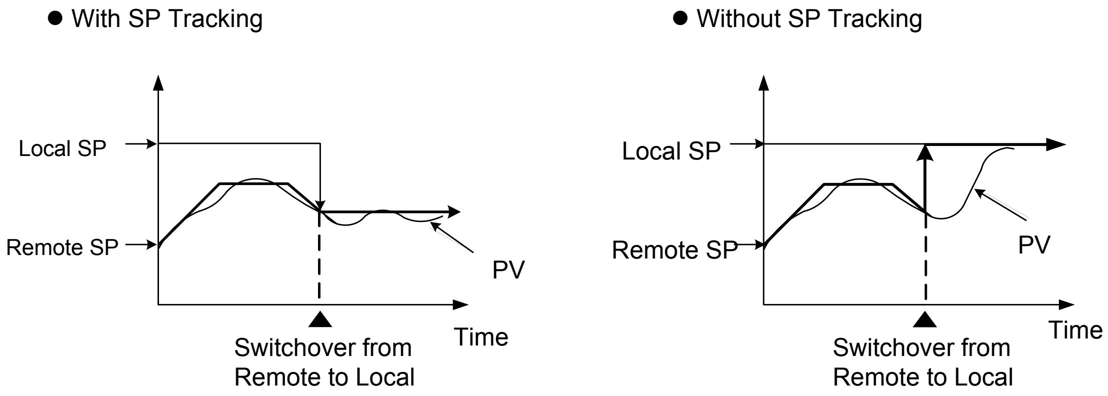


Figure C4.5 SP Tracking Operation

Table C4.6 Parameters Related to SP Tracking

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
169	369	569	769	SP.TR	SP Tracking Mode	None	0: Tracking on 1: Tracking off	1	RW	✓

CAUTION

If you want to store the SP value as the result of SP tracking to EEPROM, you have to initiate an SP backup procedure. Otherwise, no SP values are stored and, whenever the module is turned off and then on again, the SP parameters will revert to their last stored values. For details, see Section B2.4, "How to Back up SP Values to EEPROM."

C5. Auto-Tuning Function

There are two types of auto-tuning, namely, dynamic auto-tuning, where the module performs tuning automatically, and (normal) auto-tuning, where the module performs tuning when instructed by parameters.

C5.1 Dynamic Auto-tuning

Dynamic auto-tuning is a control function where the module observes the movements of the measured values and output values, and automatically determines the optimal PID values when it begins operation or when hunting occurs in measured values.

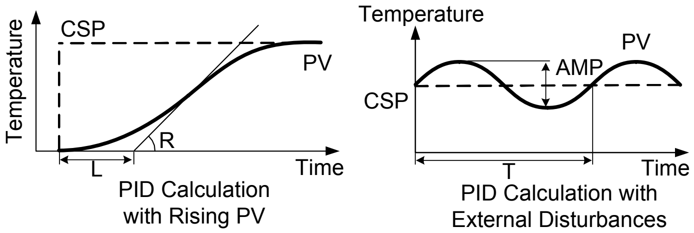
It is especially useful when the characteristics of the controlled object are such that normal auto-tuning is not feasible, as well as in situations where control is unstable when the set point is changed.

Dynamic auto-tuning is a type of self-tuning. Dynamic auto-tuning begins calculating PID values when the conditions for PID calculation (to be described later) become true. When the conditions become no longer true, it ends the calculation and updates the PID values. Sometimes, it may fail to obtain proper PID values due to external disturbances or other factors. If it cannot obtain proper PID values using the measured results, it does not update the PID values.

- To use dynamic auto-tuning, set the Dynamic auto-tuning Enable (SELF) parameter to “1: Enabled”.
- The following PID values are updated by dynamic auto-tuning: Proportional Band (PB), Integral Time (TI) and Derivative Time (TD). The PID parameter group to be updated is determined by the Current PID Number (PIDNO) parameter.

Dynamic auto-tuning operates when any of the following conditions for PID calculation is true.

- The output scales out to OH after control begins (changing from “Stop” to “Run” in automatic or cascade mode).
- After changing a set point, the output scales out to OH.
- PV input oscillates more than 2°C for temperature input or 0.5% of PV input range for DC voltage input due to external disturbances, etc.



PID Calculation with Rising PV

PID Calculation with External Disturbances

Figure C5.1 PID Calculation Method

TIP

- Even during dynamic auto-tuning, control computation is carried out using current PID values that are defined. In situations where the control output does not scale out to OH, current PID values may not be changed automatically.
- In situations where stable control is achieved with PID values calculated using dynamic auto-tuning, disabling dynamic auto-tuning can avoid inadvertent changes to the PID values due to external disturbances or other factors.
- Executing auto-tuning during dynamic auto-tuning terminates the calculation of PID values in dynamic auto-tuning. If the condition for PID calculation is again true after auto-tuning ends, dynamic auto-tuning restarts PID calculation.

Dynamic auto-tuning does not operate when any of the following conditions is true.

- When Dynamic auto-tuning Enable (SELF) is set to “0: Disabled”
- When Control Type Selection (OT) is not set to “0: PID Control”
- When Zone PID Selection (ZONE) is set to “1: Enabled”
- When Run/Stop Selection (RUN/STP) is set to “0: Stop”
- When Automatic/Manual/Cascade Selection (A/M/C) is set to “1: Manual”.
- When Remote/Local Selection (RMT/LOC) is set to “1: Remote”.
- For the secondary loop in cascade control
- When the Rate-of-Change Limit (MVR) is not “0: Off”
- When the SP Up Gradient (SPR.UP) or SP Down Gradient (SPR.DN) is not “0: Off”.
- When a burnout or AD converter error is detected

Table C5.1 Parameters Related to Dynamic auto-tuning

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
181	381	581	781	SELF	Dynamic auto-tuning enable	None	0: disabled; 1: enabled	0	RW	✓

CAUTION

Dynamic auto-tuning updates the PID parameters automatically when PID values are calculated. In situations where this is undesirable, set the Dynamic auto-tuning Enable (SELF) parameter to “0: Disabled”.

CAUTION

Dynamic auto-tuning should not be used with the following processes:

- Equipment with interference and equipment subjected to regular external disturbances
- Fast response processes such as flow control or pressure control systems

CAUTION

When performing dynamic auto-tuning, always turn on the controlled load (e.g. heater) before starting dynamic auto-tuning. In addition, always perform control in a closed loop.

If you fail to observe these precautions, or if there are interference or external disturbances during measurement, the calculated PID values may be inappropriate. If control remains unstable even after you continue with dynamic auto-tuning, adopt the following measures and recalculate the PID values.

- Set the PID group in use to the following values: PB=5.0%; TI=1 second; TD=Off.
- Enter Stop mode, and again change to Run mode.

If you still cannot achieve stable control after adopting these measures, disable dynamic auto-tuning, and perform normal auto-tuning, or calculate the PID values manually.

C5.2 Auto-tuning

The auto-tuning function automatically measures the process characteristics, and then calculates and sets the optimal PID constants.

When auto-tuning is activated after SP is set, the control output value temporarily assumes the form of on/off steps such that PV oscillates around SP, and the module automatically calculates the optimal PID constants from the response data. This method is known as the “Limit Cycle” method.

To activate auto-tuning, set the Start Auto-tuning (AT) parameter to any integer from 1 to 5. After auto-tuning begins, the output is made to turn off or turn on whenever the PV passes through the set point (see Section C5.2.1, “Tuning Points and Stored PID Number”). When the PV reaches the third peak, as shown in Figure C5.2, the PID constants are calculated, stored and auto-tuning ends.

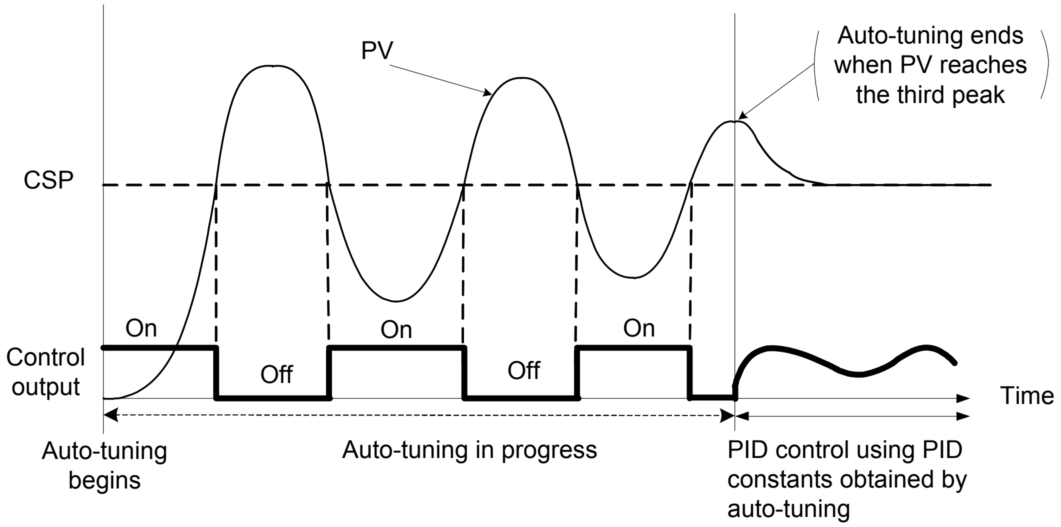


Figure C5.2 Auto-tuning Function

If the Output Type Selection (OUTPUT) is set to “Continuous Output (Analog output)”, the on/off operation during auto-tuning will run with the values specified by the Upper Output Limit (OH) and Lower Output Limit (OL) parameters. If the Output Type Selection (OUTPUT) is set to “Time Proportional Output (Open collector output)”, auto-tuning runs with 100% (always on) and 0% (always off), unrestricted by the upper and lower output limits.

CAUTION

Auto-tuning should not be used with the following processes:

- Fast response processes such as flow control or pressure control systems
- Any process whose output must never be on/off, even temporarily
- Any process where large stress on the controlled load must be avoided
- Any process where product quality may be affected if the measured value exceeds the tolerance range.

Auto-tuning does not run if any of the following conditions is true.

- When Control Type Selection (OT) is set to “1: On/off control” or “3: Heating/cooling on/off control”.
- When Run/Stop Selection (RUN/STP) is set to “0: Stop”.
- When Automatic/Manual/Cascade Selection (A/M/C) is set to “1: Manual” when not in cascade controller mode.
- When Automatic/Manual/Cascade Selection (A/M/C) of the primary loop in cascade control is not set to “2: Cascade.”
- When Automatic/Manual/Cascade Selection (A/M/C) of the secondary loop in cascade control is not set to “0: Automatic.”

Any of the following events will abort an auto-tuning session.

- When any of the conditions mentioned in the previous paragraph becomes true.
- When the module is powered off.
- When entering the Setup mode.
- When a burnout or AD converter error is detected.
- When auto-tuning fails to end even after running for approximately 24 hours.
- When the Start Auto-tuning (AT) parameter is set to “0: Off”.

You can check the status of auto-tuning using the Auto-tuning Completed (AT.RDY) input relay and the Auto-tuning Status (AT.STUS) I/O register.

The AT.RDY input relay is 1 when the Start Auto-Tuning (AT) relay is 0, and it is 0 when the AT relay is set to an integer from 1 to 5.

Table C5.2 Auto-tuning Completed (AT.RDY) Relay

Input Relay Number X☐☐☐nn[*1]				Symbol	Description	Data Range	Interrupt
Loop1	Loop2	Loop3	Loop4				
X04	X12	X20	X28	AT.RDY	Auto-tuning Completed	0: Auto-tuning in progress; 1: Auto-tuning completed	✓

*1 ☐☐☐ denotes the slot number where the module is installed.

Table C5.3 Auto-tuning Status (AT.STUS)

AT.STUS	Description	Remarks
0	Normal exit	Normal exit; At power on; or In Setup mode.
1	Executing	Auto-tuning is in progress
2	Manually stopped	AT is set to “0: Off” during auto-tuning execution.
3	Error exit	One of the following conditions was true during auto-tuning execution. - A burnout or AD converter error is detected. - Auto-tuning fails to terminate even after running for approximately 24 hours. - RUN/STP is set to “0: Stop”. - A/M/C is set to “1: Manual” when not in cascade controller mode. - A/M/C of the primary loop in cascade control is set to any value other than “2: Cascade”. - A/M/C of the secondary loop in cascade control is set to any value other than “0: Automatic”.

C5.2.1 Tuning Points and Stored PID Number

Setting the Start Auto-tuning (AT) parameter to an integer value ranging from 1 to 5 starts auto-tuning. Setting AT to 1, 2, 3 or 4 performs tuning for 1.PID to 4.PID respectively. Setting AT to 5 performs auto-tuning for 1.PID to 4.PID sequentially.

The auto-tuning operation turns on or turns off the output when the PV passes through a tuning point. If the Zone PID Selection (ZONE) is set to 1 (Enabled), setting AT to 5 calculates the PID values using the mean values of successive reference points (1RP, 2RP) as tuning points.

Auto-tuning updates the following PID values: Proportional Band (PB), Integral Time (TI), Derivative Time (TD) and Cooling Gain (GAIN.C). The following table shows which PID parameter group is updated.

Table C5.4 Tuning Point and Stored PID Number (1/2)
(when Zone PID Selection (ZONE) = 0 (Disabled))

AT	Tuning Point *1, *2	PID Parameter Group for Storing AT Results
1	Set Point (1.SP)	1.PID
2	Set Point (2.SP)	2.PID
3	Set Point (3.SP)	3.PID
4	Set Point (4.SP)	4.PID
5*3	(1) Set Point (1.SP)	1.PID
	(2) Set Point (2.SP)	2.PID
	(3) Set Point (3.SP)	3.PID
	(4) Set Point (4.SP)	4.PID

*1 Tuning points are limited within 3% to 97% of the input range. The upper and lower range limits are RH and RL for thermocouple and RTD input; SH and SL for direct voltage input and PRH and PRL for two-input changeover control.

*2 If the Remote/Local Selection (RMT/LOC) is set to “Remote”, the Remote Set Point (RSP) is used as the tuning point.

*3 If AT=5, auto-tuning is performed successively for set points (1), (2), (3) and (4).

Table C5.4 Tuning Point and Stored PID Number (2/2)
(when Zone PID Selection (ZONE) = 1(Enabled))

AT	Tuning Point *1	PID Parameter Group for Storing AT Results
1	Control set point (CSP)	1.PID
2	Control set point (CSP)	2.PID
3	Control set point (CSP)	3.PID
4	Control set point (CSP)	4.PID
5*2	(1) (1RP – Lower range limit) / 2	1.PID
	(2) (2RP – 1RP) / 2	2.PID
	(3) (Upper range limit – 2RP) / 2	3.PID
	(4) (Upper range limit – lower range limit) / 2	4.PID

*1 Tuning points are limited to within 3% to 97% of the input range. The upper and lower range limits are RH and RL for thermocouple and RTD input; SH and SL for direct voltage input and PRH and PRL in two-input changeover control mode.

*2 If AT=5, auto-tuning is performed successively for set points (1), (2), (3) and (4).

CAUTION

If auto-tuning is executed during an increase or decrease of the CSP due to the SP gradient function, the current set point (1.SP to 4.SP) or the Remote Set Point (RSP) is used as the tuning point. CSP also changes to the current set point value.

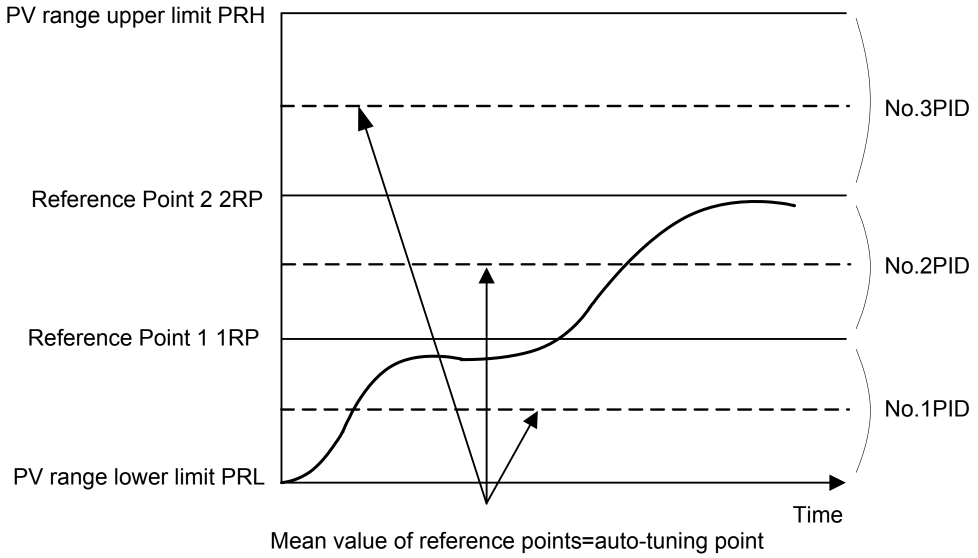


Figure C5.3 Auto-tuning with Zone PID

CAUTION

When Zone PID Selection (ZONE) is 1 (Enabled), the tuning point is automatically calculated and auto-tuning is performed. To avoid exceeding the temperature limits of the controlled object, you can set upper and lower range limits. The upper and lower range limits are RH and RL for thermocouple/RTD input, SH and SL for direct voltage input, and PRH and PRL for two-input changeover control.

Table C5.5 Parameters Related to Auto-tuning

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
127	327	527	727	AT	Start auto-tuning	None	0: Stop AT 1-5: Start AT (reverts to zero when auto-tuning completes)	0	RW	—
111	311	511	711	AT.STUS	Auto-tuning status	None	0: Normal exit 1: Executing 2: Manually stopped 3: Error exit	—	RO	—
185	385	585	785	ZONE	Zone PID selection	None	0: Disabled 1: Enabled	0	RW	✓
186	386	586	786	1RP	Reference point 1	Industrial unit	PRL to PRH	PRL	RW	✓
187	387	587	787	2RP	Reference point 2	Industrial unit	PRL to PRH	PRL	RW	✓
188	388	588	788	RHY	Zone switching hysteresis	Industrial unit	0 to (PRH-PRL)	(PRH – PRL) × 0.5%	RW	✓
189	389	589	789	RDV	Reference deviation	Industrial unit	0 to (PRH-PRL); Function is disabled when value is 0.	0	RW	✓

C6. Control and Computation Function

C6.1 Forward Operation and Reverse Operation

Forward operation or reverse operation defines the direction of change (increase or decrease) of the control output value corresponding to a positive difference between the CSP and PV. (Switching between forward operation and reverse operation is, however, not available in Heating/Cooling Control mode.)

You can switch between forward operation and reverse operation even in Run mode.

In reverse operation (default factory setting), the control output value is decreased if PV is larger than CSP, and is increased if PV is smaller than CSP (see Figure C6.1 below).

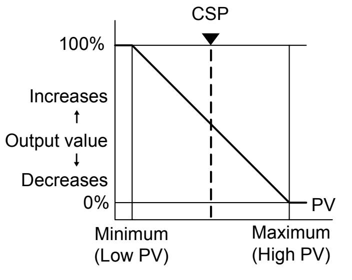
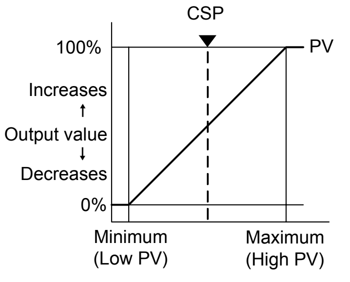
	Reverse Operation		Forward Operation	
Relation between PV and CSP	PV > CSP	PV < CSP	PV > CSP	PV < CSP
On/Off Output	OFF	ON	ON	OFF
Continuous Output	Current decreases	Current increases	Current increases	Current decreases
Time Proportional Output	On-time decreases	On-time increases	On-time increases	On-time reduces
Direction of Output Change	Reverse Operation  Control output value=(PV-CSP)+50%		Forward Operation  Control output value=(CSP-PV)+50%	

Figure C6.1 Output Directions in Forward Operation and Reverse Operation

Table C6.1 Parameters Related to Forward Operation and Reverse Operation

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
213	413	613	813	1.DR	Forward/reverse switch	None	0: Reverse operation; 1: Forward operation (Always 0 in heating/cooling control)	0	RW	✓
233	433	633	833	2.DR	Forward/reverse switch	None	0: Reverse operation; 1: Forward operation (Always 0 in heating/cooling control)	0	RW	✓
253	453	653	853	3.DR	Forward/reverse switch	None	0: Reverse operation; 1: Forward operation (Always 0 in heating/cooling control)	0	RW	✓
273	473	673	873	4.DR	Forward/reverse switch	None	0: Reverse operation; 1: Forward operation (Always 0 in heating/cooling control)	0	RW	✓

C6.2 Proportional Band

■ Difference Between On/Off Operation and Proportional Operation

In on/off operation, the control output alternates between “ON” and “OFF” depending on whether the deviation is positive or negative.

In proportional operation, the control output varies in direct proportion to the deviation, scaled by the value of the Proportional Band (PB) parameter.

The PB parameter controls the sensitivity of the proportional operation.

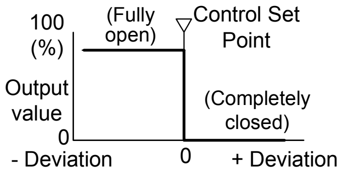
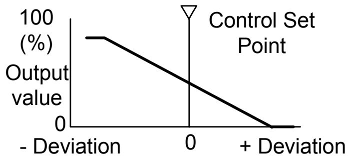
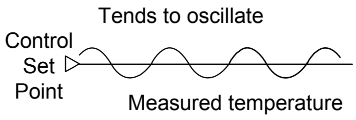
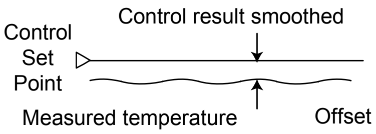
	On/Off Operation	Proportional Operation
Control Output (for reverse operation)	No intermediate states  	Output continuously changes in proportion to deviation. 
Control result	 	
Offset (steady-state deviation)	No deviation	In principle, a steady state deviation (offset) will occur between the control set point and the measured temperature.

Figure C6.2 On/Off Operation Versus Proportional Operation

■ More about Proportional Band

The proportional band defines the percentage change in input (or deviation) that will produce a 100% change in the control output, where the percentage change in input is deemed to be 100% if the PV value changes from PRL to PRH.

Defining a smaller proportional band produces a larger output change for a given deviation, and reduces the offset. However, it may cause the control output to oscillate. Therefore the proportional band needs to be tuned within an appropriate range to the smallest value without causing oscillation. Setting the proportional band to its minimum value of 0% produces an on/off control.

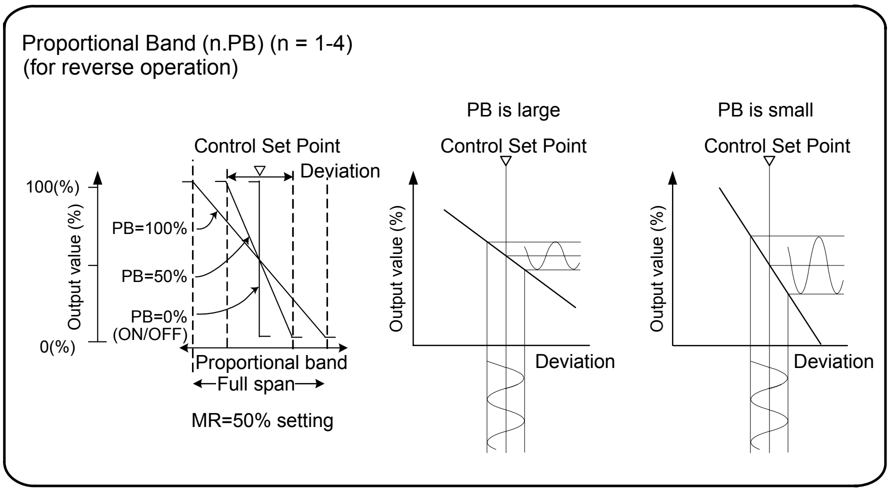
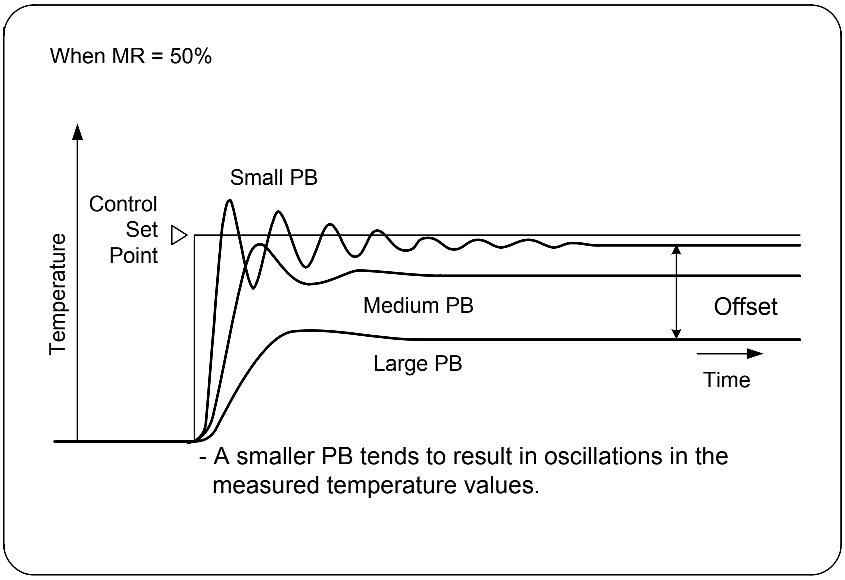


Figure C6.3 Proportional Band

■ Adjusting the Proportional Band

When fine-tuning a proportional band obtained from auto-tuning, or when adjusting the proportional band manually, note the following points.

- Always adjust downwards from a larger value to a smaller value.
- If oscillations appear, it means that the PB setting is too small.
- Adjusting the proportional band will not eliminate the offset. (Adjusting the Integral Time (TI) and Manual Reset (MR) parameters may however eliminate the offset.)



- A smaller PB tends to result in oscillations in the measured temperature values.

Figure C6.4 Adjusting the Proportional Band

Table C6.2 Proportional Band Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
206	406	606	806	1.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
226	426	626	826	2.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
246	446	646	846	3.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓
266	466	666	866	4.PB	Proportional band	%	1 to 9999 (0.1 to 999.9%)	50	RW	✓

C6.3 Integral Time and Manual Reset Value

■ About Integral Time

A function that automatically reduces the offset (steady state deviation) that would theoretically be unavoidable in a proportional operation is called an integral action (I action), with the integral time (TI) parameter defining the sensitivity of the integral action. The integral action increases or decreases its output continuously in proportion to the integral of the deviation (the product of deviation and its duration).

The integral action is used in conjunction with the normal proportional action to yield the proportional integral action (PI action).

Integral Time (TI) is defined as the length of time required for an integral action alone to produce the same amount of change that a proportional action alone would produce, given a stepped deviation. The longer the integral time, the slower will be the output change. Conversely, the shorter the integral time, the faster will be the output changes.

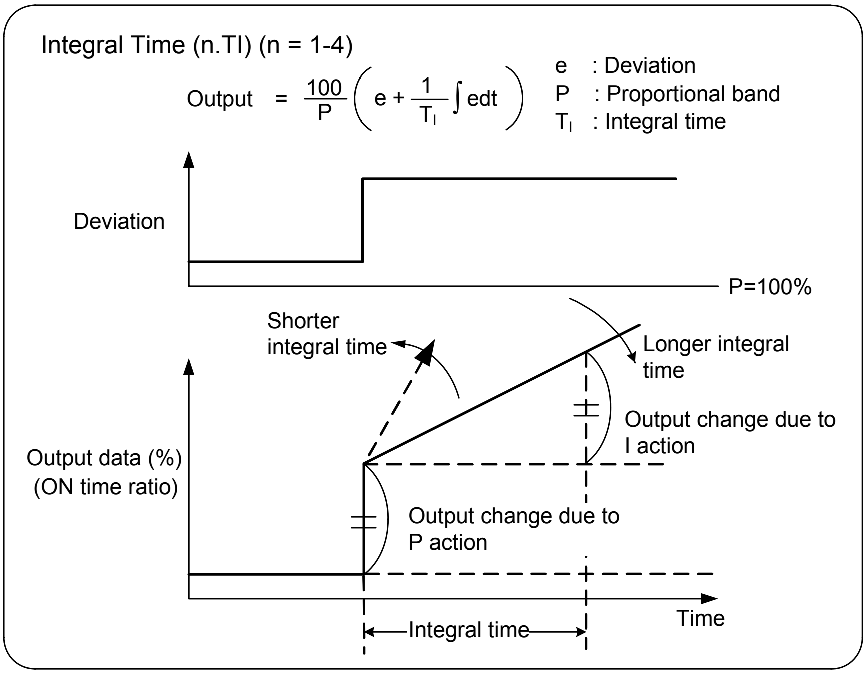


Figure C6.5 Integral Time

- To turn off the integral action, set the Integral Time (TI) parameter to “0: OFF”.
- To eliminate the offset when TI=OFF, use the Manual Reset (MR) parameter.

■ Manual Reset Value

The Manual Reset (MR) function is used to manually reduce the offset (steady-state deviation) in proportional action (P control) or proportional derivative action (PD control) where Integral Time (TI) is set to OFF. The function allows you to shift the control output by a certain value so as to reduce the offset.

■ Adjusting the Integral Time

When adjusting the integral time manually, note the following points:

- The adjustment is primarily for reducing the offset.
- Always adjust downwards from a longer time to a shorter time.
- When reducing the proportional band, appearance of long periodic oscillations indicates that the proportional band is too short. Setting too short an integral time produces similar oscillations in the measured value. However, oscillations caused by the integral action are characterized by longer periods than those caused by the proportional band.

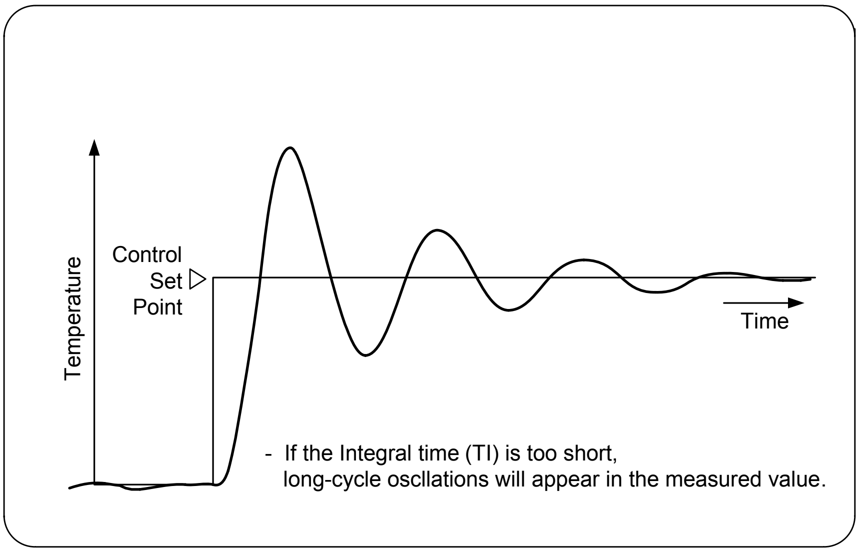


Figure C6.6 Adjusting the Integral Time

■ Adjusting the Manual Reset Value

When adjusting the manual reset value (MR), note the following points:

- Adjust MR so as to reduce the offset.
- Adjust MR so that it does not produce an offset in the opposite direction.

A manual reset value that is too large will produce an offset in the opposite direction.

Table C6.3 Integral Time and Manual Reset Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
207	407	607	807	1.TI	Integral time	Second	0:OFF, 1to 6000 (1-6000 s)	240	RW	✓
227	427	627	827	2.TI	Integral time	Second	0:OFF, 1to 6000 (1-6000 s)	240	RW	✓
247	447	647	847	3.TI	Integral time	Second	0:OFF, 1to 6000 (1-6000 s)	240	RW	✓
267	467	667	867	4.TI	Integral- time	Second	0:OFF, 1to 6000 (1-6000 s)	240	RW	✓
211	411	611	811	1.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
231	431	631	831	2.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
251	451	651	851	3.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓
271	471	671	871	4.MR	Manual reset value	%	-5.0 to 105.0%	500	RW	✓

C6.4 Derivative Time

■ About Derivative Time

If the time constant or lag time of the controlled object is too long, proportional action or proportional integral action alone may not provide a fast enough corrective operation, often resulting in overshooting. One way to improve controllability is to take into account the tendency of the deviation (whether increasing or decreasing) and trigger appropriate corrective action earlier. The derivative action (D action) changes the output proportionally to the gradient (rate of change) of the deviation, with the Derivative Time (TD) parameter defining the sensitivity of the derivative action.

In proportional derivative (PD) action, derivative Time (TD) is defined as the length of time required for a proportional action alone to produce the same amount of output change that a derivative action alone would produce given a deviation with a specific gradient.

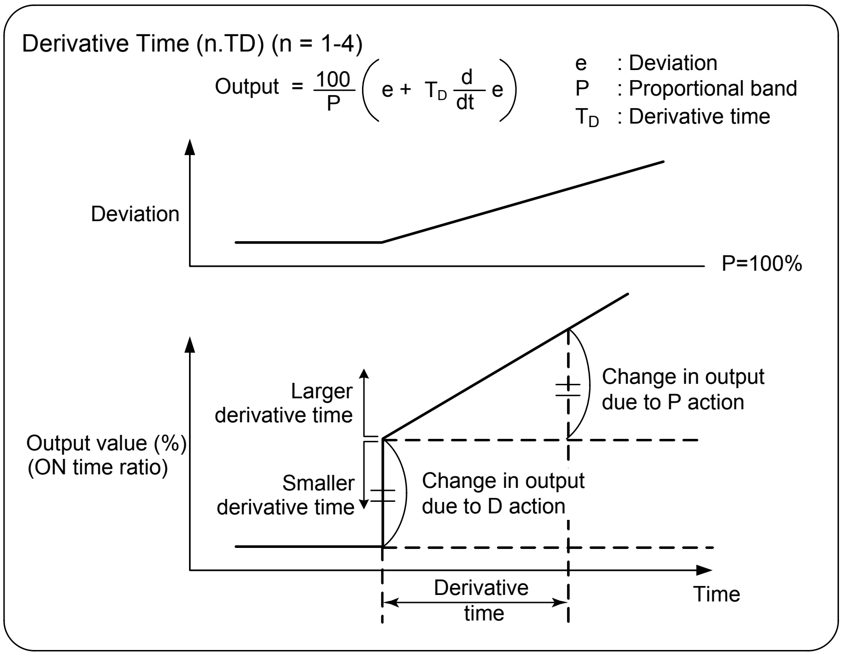


Figure C6.7 Derivative Time

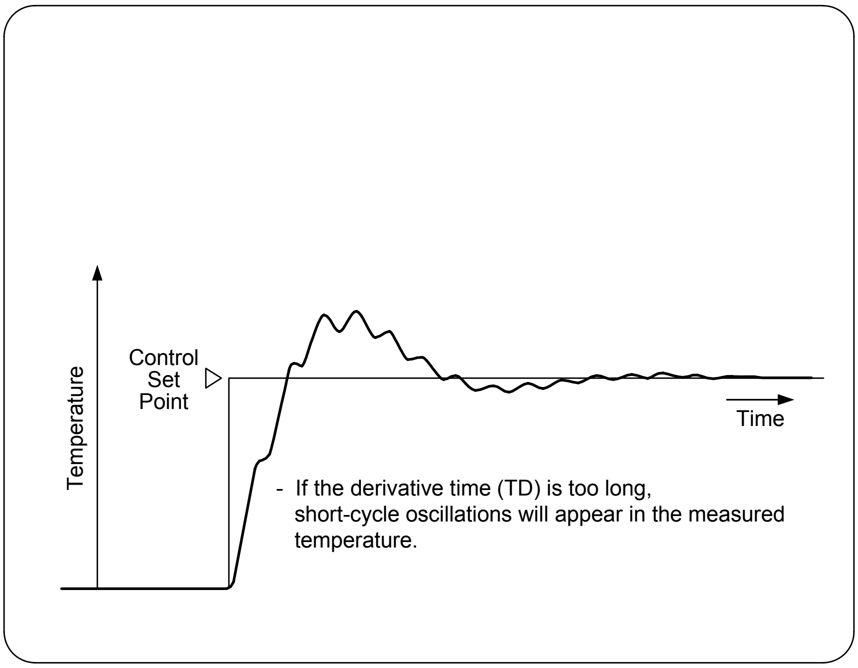
■ Adjusting the Derivative Time

When adjusting the derivative time manually, note the following points:

- Adjust upwards from a shorter duration to a longer duration.
- Appearance of short periodic oscillations indicates that the derivative time is too long.

A longer derivative time strengthens the corrective action and causes oscillations in the output. Oscillations due to the derivative action are characterized by short periods.

Setting the Derivative Time (TD) parameter to 0 disables the derivative action. Always set TD to 0 for fast response inputs such as pressure or flow rate, or inputs that are inherently oscillating such as an optical sensor.



- If the derivative time (TD) is too long, short-cycle oscillations will appear in the measured temperature.

Figure C6.8 Adjusting Derivative Time

Table C6.4 Derivative Time Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
208	408	608	808	1.TD	Derivative time	Seconds	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
228	428	628	828	2.TD	Derivative time	Seconds	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
248	448	648	848	3.TD	Derivative time	Seconds	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓
268	468	668	868	4.TD	Derivative time	Seconds	0: OFF, 1 to 6000 (1 to 6000 s)	60	RW	✓

C6.5 Manual Adjustment of PID Constants

The following formula shows the relationship between the output and the PID constants. Bear this formula in mind when adjusting PID constants manually.

To perform manual adjustment of PID constants, follow steps (2) to (5) given below.

- Procedure for adjusting PID constants manually

$$\text{Output} = \frac{100}{PB}\left(e + \frac{1}{TI}\int edt + TD\frac{d}{dt}e \right)$$

e: Deviation PB: Proportional band TI: Integral time
TD: Derivative time

(1) (If possible, use auto-tuning. Otherwise do the following:)

(2) Adjust PB, TI and TD, in this order. Change the values gradually whilst checking and writing down the result.

(3) Start with a large PB and decrease it gradually. If oscillations appear in the PV, stop and increase PB by a few seconds.

(4) Start with a large TI and decrease it gradually. If long oscillations appear in the PV, stop and increase TI by a few seconds.

(5) Start with a small TD and increase it gradually. If short oscillations appear in the PV, stop and decrease TI by a few seconds.

- Typical values for manual tuning of temperature, pressure and flow rate

		Setting Range (typical)	Initial value for tuning (typical)	Remarks
Pressure	PB	100 to 300%	200%	
	TI	5 to 30 s	15 s	
	TD	OFF	OFF	
Flow Rate	PB	100 to 240%	150%	
	TI	8 to 30 s	20 s	
	TD	OFF	OFF	
Inlet temperature	PB	5 to 30%	10%	Inlet temperature control (TD = OFF for air-con)
	TI	180 to 600 s	300 s	
	TD	3 to 30 s	5 s	
Outlet temperature	PB	5 to 30%	20%	Heat exchanger temperature control
	TI	30 to 60 s	40 s	
	TD	0 to 5 s	2 s	

Figure C6.9 Procedure for Manual Adjustment of PID Constants

C6.6 PID Control Mode

This module provides 2 PID control modes, namely, Standard PID Control mode and Fixed-point Control mode, which are selectable using the Control Mode (CMD) parameter.

In either control mode, either PV Derivative Type PID Control Method or Deviation Derivative Type PID Control Method is adopted depending on the operating mode. Furthermore, the control mode also determines whether the control output value bumps when the Set Point (1.SP to 4.SP) selected using the SP Number Selection parameter is changed.

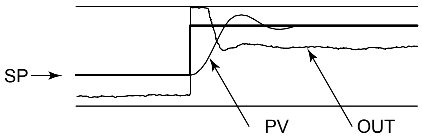
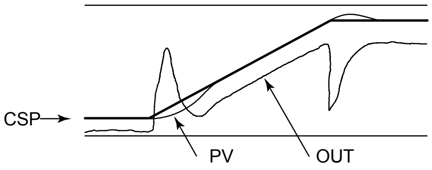
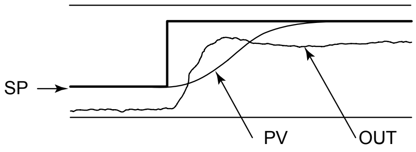
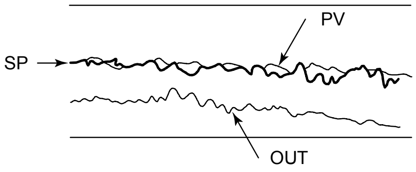
PID Control Mode Type	Control Method	Description of Control Operation	Operating Status
Standard PID control mode (factory setting)	PV derivative type PID Bump in control output when CSP is changed	Adopt PV derivative type PID in order to quickly bring the PV to an updated CSP. The PV derivative type PID control method immediately generates a fraction of the output defined by the ratio of the deviation generated by a change in CSP to the proportional band (PB) parameter to quickly bring the PV to an updated CSP. 	Local
	Deviation derivative type PID	The deviation derivative type PID control method tracks a programmed pattern closely by activating derivative action (TD) for deviation arising from minute changes in a CSP that varies successively, following a programmed pattern. 	Remote or Cascade
Fixed-point control mode	PV derivative type PID Bumpless control output when CSP is changed	Use this function to avoid disorder in the PV due to over-reaction in the control output value (OUT) in response to a change in the CSP in continuous fixed-point control. In PV derivative type PID control with bumpless control output, when CSP is changed, only integral action (TI) is employed to gradually remove the resultant deviation, without a sudden change in the output value (OUT). 	Local
	PV derivative type PID Bump in control output when CSP is changed	Use this function when the secondary loop in cascade control is used. It produces stable control output, which does not over-react to output from the primary loop. 	Remote or Cascade

Figure C6.10 PID Control Mode

Table C6.5 Parameters Related to PID Control Mode

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
184	384	584	784	CMD	Control mode	None	0: Standard PID control 1: Fixed-point control	0	RW	✓

■ PV Derivative Type PID Control Method

In this PID control method, the derivative action acts only on the PV. This method is effective to reduce output bumps due to SP change in Local mode.

■ Deviation Derivative Type PID Control Method

In this PID control method, the derivative action acts on deviation. As the derivative action acts on a change in SP, this method is useful in situations where it is important that the output tracks the SP closely.

C6.7 “Super” Overshooting Suppression Function

The “Super” overshooting suppression function uses fuzzy logic to suppress overshooting. It is particularly effective in the following situations when used together with the auto-tuning function.

- For suppressing overshooting
- For reducing start-up time
- For handling large load fluctuations
- For handling frequent changes in SP values

The “Super” function is enabled by setting the Super Enable Code (SC) parameter to “1: Enabled”. When enabled, it monitors the deviation and once it detects the risk of overshooting, it automatically changes to a somewhat lower virtual control set point (Supplementary Set Point (SSP)). When the deviation again enters a range where there is no risk of overshooting, the function reverts little by little to the original set point.

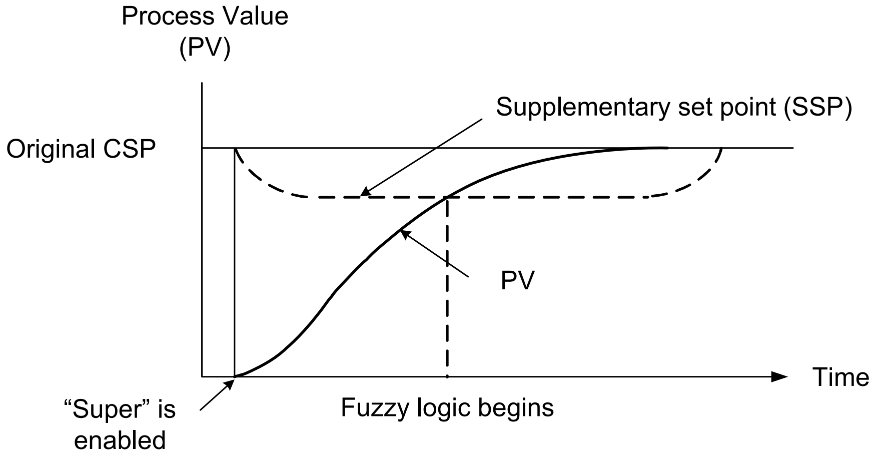


Figure C6.11 “Super” Function

Table C6.6 Parameters Related to the “Super” Function

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
182	382	582	782	SC	“Super” enable code	None	0: Disabled; 1: Enabled	0	RW	✓

CAUTION

- The “Super” function applies only to PID operation. If the Integral Time and Derivative Time parameters are set to “0: Off”, then the “Super” function will not act even if the Super Enable Code (SC) parameter is set to “1: Enabled”.
- As the “Super” function requires the PB, TI and TD parameters to be set correctly, you should set proper PID values using auto-tuning or other means before setting the Super Enable Code (SC) parameter to “1: Enabled”.

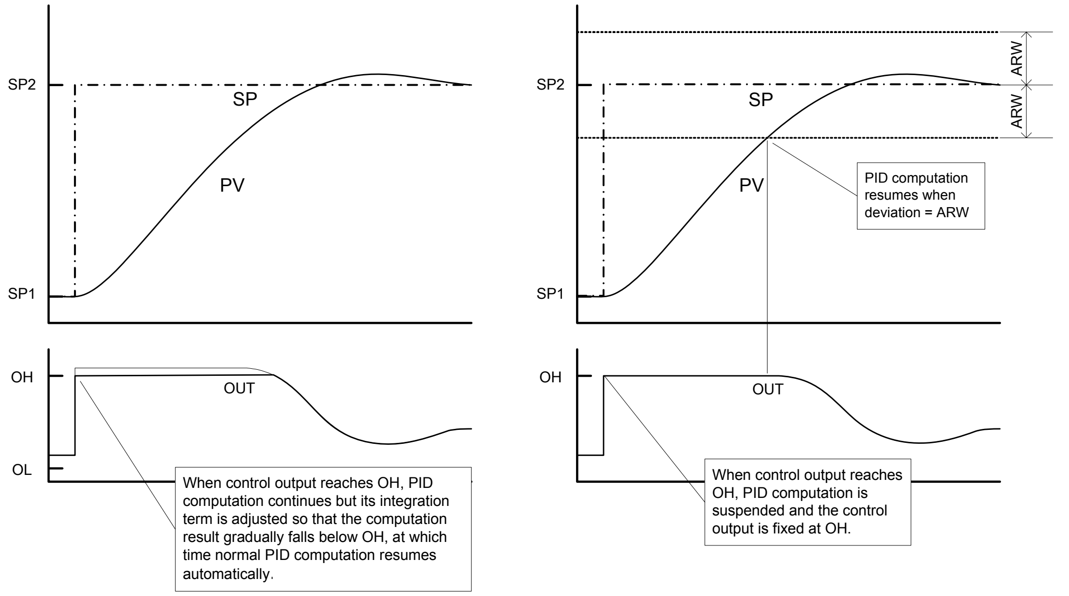
C6.8 Anti-reset Windup

The anti-reset windup function suppresses overshoot, which tends to develop right after PID control operation begins. The function is triggered when the control output reaches its upper (OH) or lower (OL) limit. It runs in two modes, namely Automatic and Manual, which can be selected using the ARW parameter. The two modes differ in when normal PID control is resumed. This timing is automatically determined in automatic mode, but predefined in manual mode.

The default value of ARW is 0 (automatic mode). In the automatic mode, PID computation continues even if the control output reaches its upper or lower limit while the integral term is adjusted so that the new computation result brings the control output back within the control output range. Once the control output returns within the output range, normal PID computation resumes.

If ARW is set to a non-zero value, the anti-reset windup function runs in manual mode, where PID computation is suspended when the control output reaches its upper or lower limit, and resumed when the deviation falls within the range specified with ARW. Here the value of ARW is a percentage of the proportional band (PB). Thus, if ARW is set to 100%, PID computation resumes when the deviation falls within a range equal to PB.

Example: If ARW = 100% and PB = 20%, the integral computation resumes when the deviation is 20% or less, as the inequality expression 'deviation x 100/20 < 100' must be satisfied.



When control output reaches OH, PID computation continues but its integration term is adjusted so that the computation result gradually falls below OH, at which time normal PID computation resumes automatically.

PID computation resumes when deviation = ARW

When control output reaches OH, PID computation is suspended and the control output is fixed at OH.

Automatic mode (with ARW set to 0)

Manual mode (with ARW set to a non-zero value)

Figure C6.12 Anti-reset Windup Function

Table C6.7 Parameters Related to Anti-reset Windup

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
183	383	583	783	ARW	ARW Setting	%	0: Automatic 500 to 2000 (50.0 to 200.0%)	0	RW	✓

CAUTION

The ARW parameter is not meant for enabling and disabling the Anti-Reset Windup function.

C6.9 PID Selection Method (SP Number Selection, Zone PID Selection)

Either SP Number Selection or Zone PID Selection can be selected as the PID selection method using the Zone PID Selection (ZONE) parameter.

Setting Zone PID Selection (ZONE) to “0: Disabled” selects the SP Number Selection method.

Setting Zone PID Selection (ZONE) to “1: Enabled” selects the Zone PID Selection method.

Table C6.8 Parameters Related to PID Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
106	306	506	706	PIDNO	Current PID number	None	1 to 4	—	RO	—
185	385	585	785	ZONE	Zone PID selection	None	0: Disabled 1: Enabled	0	RW	✓

You can read the Current PID Number (PIDNO) parameter to confirm the PID number currently selected.

The PIDNO selects a PID parameter group, which consists of the following elements (where n denotes the PIDNO parameter value, and is an integer ranging from 1 to 4):

- n.PB	Proportional Band
- n.TI	Integral Time
- n.TD	Derivative Time
- n.OH	Upper Output Limit
- n.OL	Lower Output Limit
- n.MR	Manual Reset Value
- n.HYS	On/Off Control Hysteresis
- n.DR	Forward/Reverse Switch
- n.GAIN.C	Cooling Gain
- n.HYS.C	Cooling On/Off Control Hysteresis
- n.DB	Dead Band
- n.POUT	Preset Output
- n.POUT.C	Cooling Preset Output

TIP

The current Set Point (1.SP to 4.SP) and Alarm Preset Value (1.An to 4.An where n=1 to 4) are selected by the SP Number Selection (SPNO) parameter.

C6.9.1 SP Number Selection

Setting the Zone PID Selection (ZONE) parameter to “0: Disabled” selects SP Number Selection as the PID selection method.

The SP Number Selection method switches the set point (1.SP to 4.SP) and the PID parameter group concurrently. It is used in batch control where the set point and PID values are to be changed at the same time.

Use the SP Number Selection (SPNO) parameter to switch the set point and PID parameter group.

The number specified by the SPNO parameter becomes the Current SP Number (CSPNO) parameter and the Current PID Number (PIDNO). Changing the SPNO also activates the PV tracking function (see Section C4.5, “PV Tracking”).

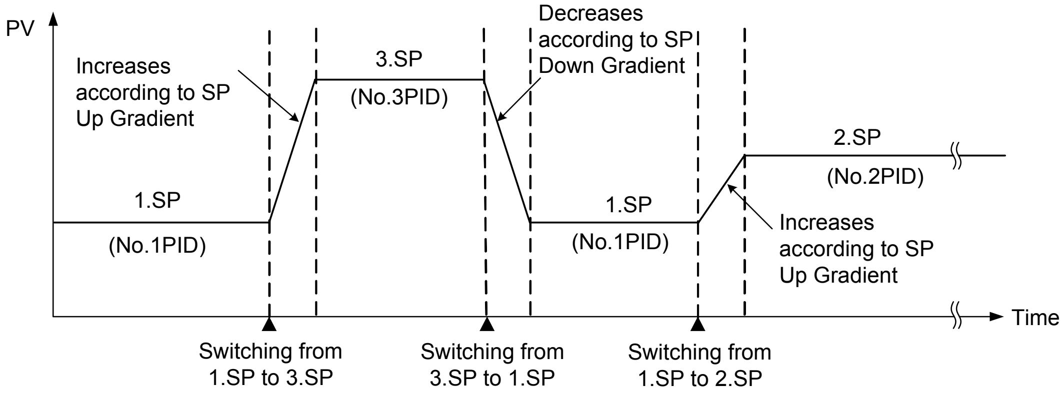


Figure C6.13 Switching of Set Point Accompanied by Change in PID Constant Group (when switching to PV=nSP)

TIP

If the Remote/Local Selection (RMT/LOC) parameter is set to “1: Remote”, control and computation proceeds with the value of the Remote Set Point (RSP) parameter and the PID values of the PID parameter group specified by the SP Number Selection (SPNO) parameter.

C6.9.2 Zone PID Selection

Setting the Zone PID Selection (ZONE) parameter to “1: Enabled” selects Zone PID Selection as the PID selection method.

The Zone PID Selection method switches between PID parameter groups automatically depending on the PV value. It can be used in chemical reaction apparatus where the chemical reaction gain changes with temperature.

As shown in the figure below, the input range defined by the upper and lower limits can be divided into three zones using the Reference Point 1 (1RP) and Reference Point 2 (2RP) parameters. You can assign optimal PID values for each of these zones. As the PV value moves from the current zone to a different zone, the module automatically switches to the PID values assigned to that new zone.

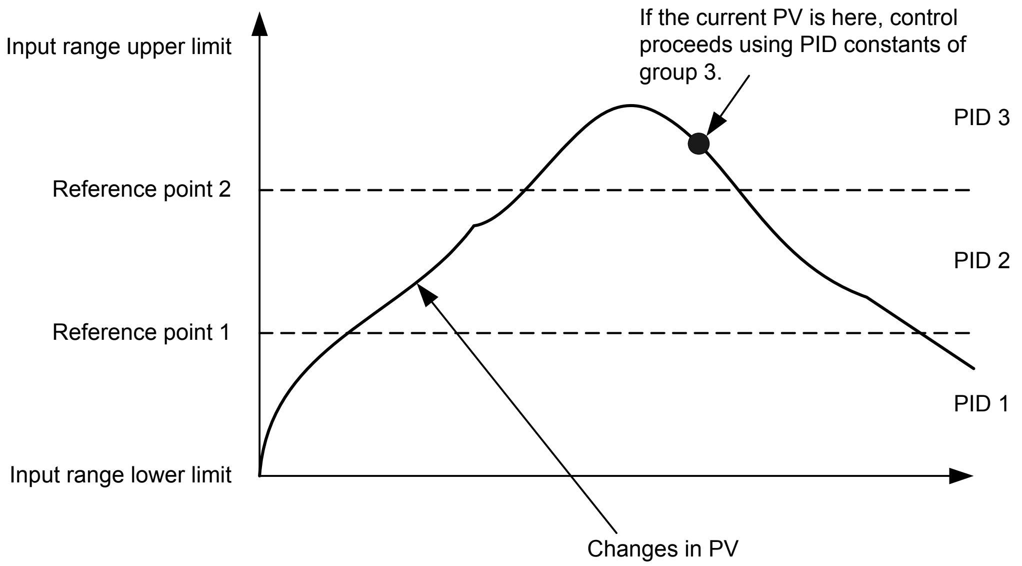


Figure C6.14 Zone PID Selection

Table C6.9 Parameters Related to Zone PID Selection

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
186	386	586	786	1RP	Reference Point 1	Industrial unit	PRL to PRH	PRH	RW	✓
187	387	587	787	2RP	Reference Point 2	Industrial unit	PRL to PRH	PRH	RW	✓

Note: If 1RP ≥ 2RP, the 2RP parameter is handled as though its value is equal to 1RP.

■ Zone Switching Hysteresis

The Zone Switching Hysteresis (RHY) parameter can be used to define a hysteresis when switching between zones.

Zone switching hysteresis comes into play when the Current PID Number (PIDNO) parameter is reduced, say, from 3 to 2, or from 2 to 1. It also applies when operation is switched from PID parameter group 1, 2 or 3 to group 4, according to the Reference Deviation (RDV) parameter.

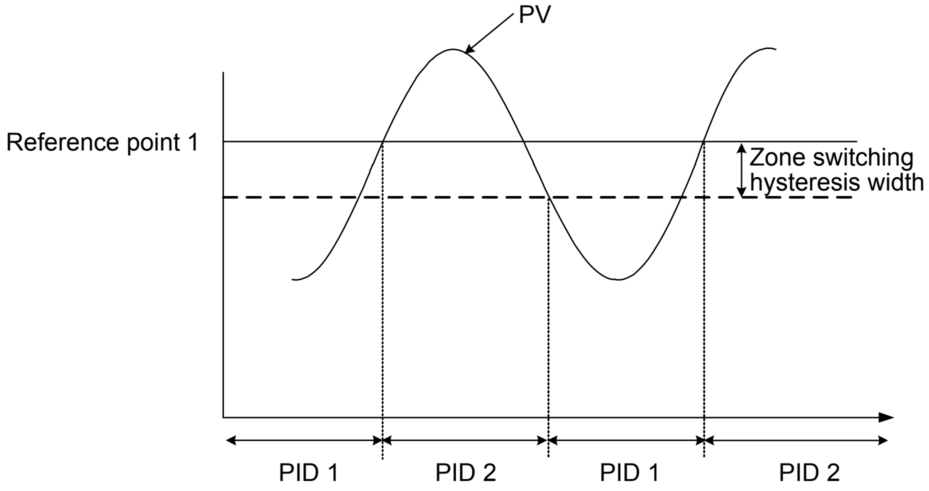


Figure C6.15 Hysteresis Width

Table C6.10 Parameters Related to Hysteresis

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
188	388	588	788	RHY	Zone Switching Hysteresis	Industrial unit	0 to (PRH-PRL)	(PRH – PRL) × 0.5%	RW	✓

■ Reference Deviation

The Reference Deviation (RDV) parameter allows you to switch between PID parameter groups according to the magnitude of the deviation.

When the difference between the PV and CSP is larger than the value of the Reference Deviation (RDV) parameter, the PID parameter group intended for large deviations is selected (PIDNO = 4).

For instance, when the deviation is large, proportional band can be reduced to bring the PV to the CSP more quickly.

PID parameter group switching by the Reference Deviation (RDV) parameter has priority over switching by the Reference Point (1RP, 2RP) parameters. In addition, when the deviation falls below the Reference Deviation (RDV), operation reverts to using the Zone PID parameter group corresponding to the PV at that point.

The Zone Switching Hysteresis (RHY) parameter applies when a switchover from PID parameter group 1, 2 or 3 to PID parameter group 4 is made due to reference deviation.

Table C6.11 Parameters Related to Reference Deviation

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
189	389	589	789	RDV	Reference deviation	Industrial unit	0 to (PRH-PRL) Setting to 0 disables the reference deviation function.	0	RW	✓

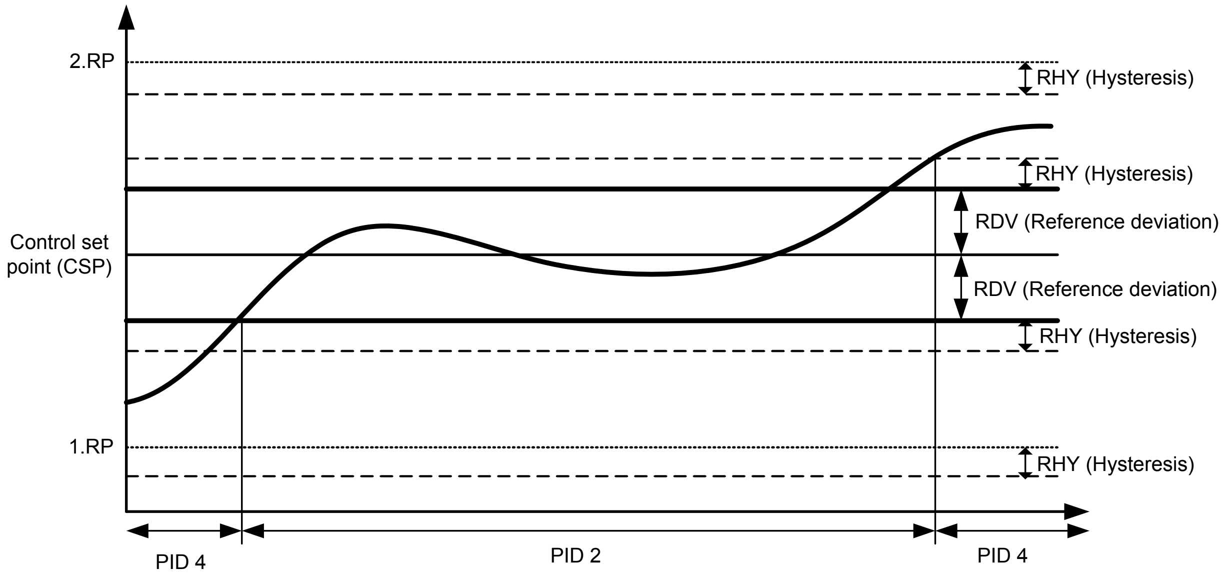


Figure C6.16 Reference Deviation Selection

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C7. Operation Control

C7.1 Run/Stop Switch

Setting the Run/Stop Selection (RUN/STP) parameter to “0: Stop” stops PID computation, and outputs the preset output. The preset output is output as is, unconstrained by the upper and lower output limits. The output rate-of-change limit is also disabled in Stop mode.

The output value in Stop mode depends on the Control Type Selection (OT) as shown in the table below.

Table C7.1 Control Output in Stop Mode

OT	Control Output (HOUT)	Cooling Control Output (COUT)
0	Preset output (POUT)	0%
1	0% if preset output (POUT) ≤ 0.0%; 100.0% if POUT ≥ 0.1%	0%
2	Preset output (POUT)	Cooling preset output (POUT.C)
3	0% if preset output (POUT) ≤ 0.0%; 100.0% if POUT ≥ 0.1%	0% if cooling preset output (POUT.C) ≤ 0.0%; 100.0% if POUT.C ≥ 0.1%

Switching from “Run” to “Stop” bumps the output value to the preset output.

For details on the operation after switching from “Stop” to “Run,” see Section C7.1.1, “Operation after Switching from Stop Mode to Run Mode”

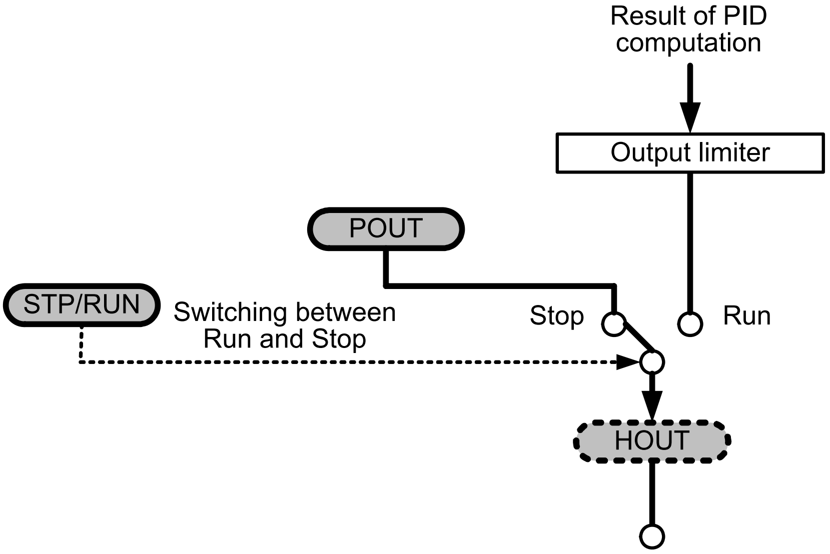


Figure C7.1 Block Diagram for RUN/STP Parameter

C7.1.1 Operation after Switching from Stop Mode to Run Mode

When OT = "0: PID Control":

In general, the switch is "bump-less" on the control output value. However, if the preset output is beyond the upper and lower output limits (OH, OL), the output value bumps to a value limited by OH and OL.

In Automatic mode, control and computation begins with the control output value immediately after the switch as the origin (if Integral Time is off, the control output value bumps to the new value).

In Manual mode, the control output (POUT) value is copied to the Manual Output (MOUT) register when switching from Stop Mode to Run Mode.

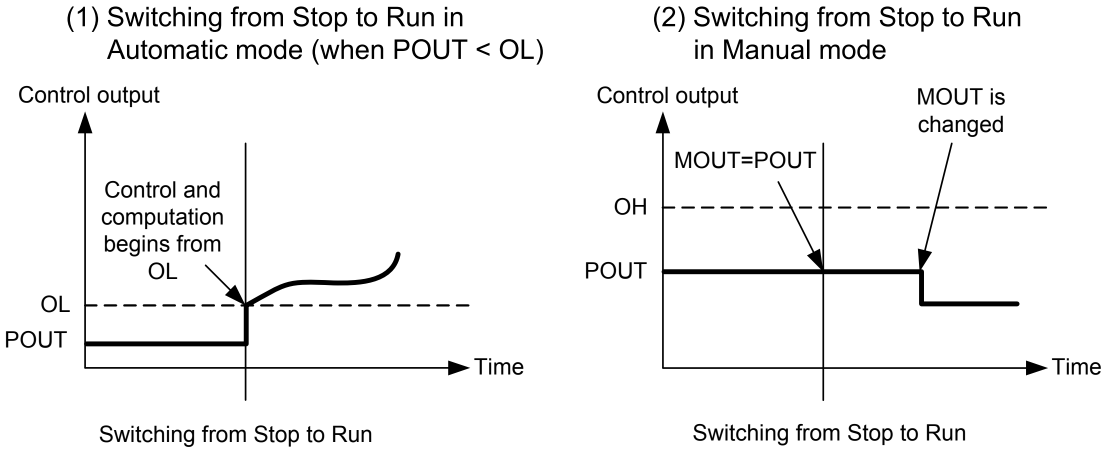


Figure C7.2 Switching to Run Mode in PID Control

When OT = "1: On/Off Control":

In Automatic mode, the control output value is determined by the PV and CSP values, independent of the control output value in Stop mode.

In Manual mode, the control output (POUT) value is copied to the Manual Output (MOUT) register when switching from Stop mode to Run mode.

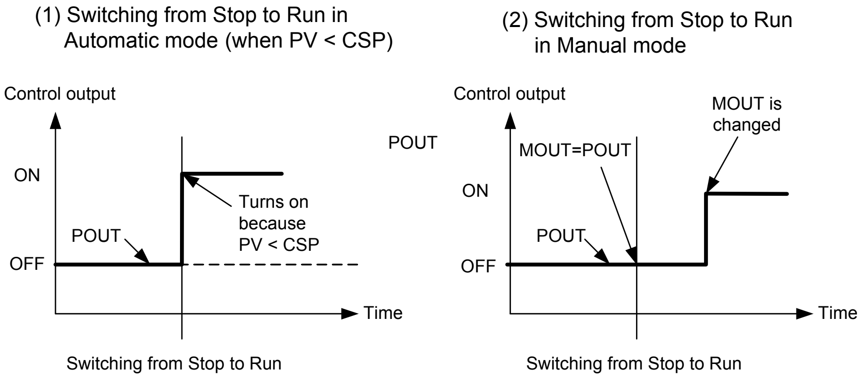


Figure C7.3 Switching to Run Mode in On/Off Control

When OT = “2: Heating/Cooling PID Control”:

The control output value and the cooling control output value bump to 0.0%. However, if the Dead Band (DB) is negative, the control output value may bump to a value other than 0.0% (defined by the setting).

In Automatic mode, control and computation begins with the control output value immediately after the switch as the origin (if the Integral Time (TI) is set to ‘0: OFF’, the control output bumps to the new value).

In Manual mode, the computed control output (HOUT, COUT) values are copied to the manual output (MOUT, MOUTC) registers when switching from Stop mode to Run mode.

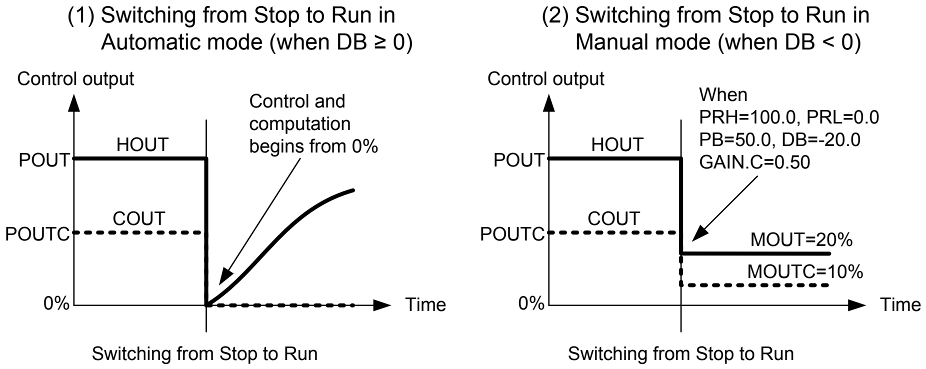


Figure C7.4 Switching to Run Mode in Heating/Cooling PID Control

When OT = “3: Heating/Cooling On/Off Control”:

In Automatic mode, the output values are determined by the PV and CSP, independent of the output values in Stop Mode.

In Manual mode, the computed control output (HOUT, COUT) values are copied to the manual output (MOUT, MOUTC) registers when switching from Stop mode to Run mode.

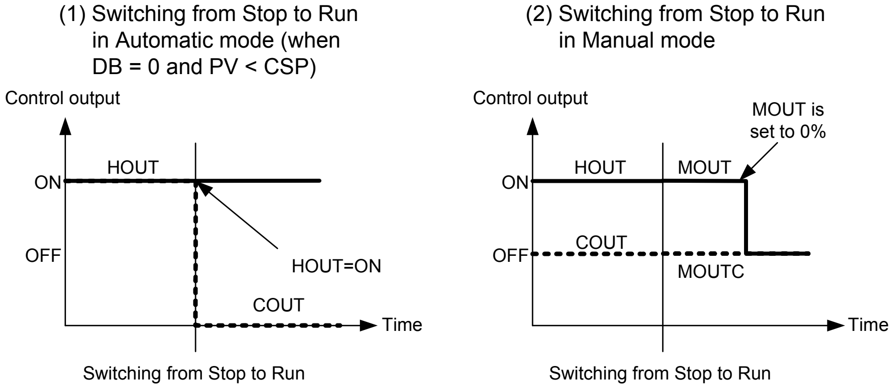


Figure C7.5 Switching to Run Mode in Heating/Cooling On/Off Control

For all control output states, the operation of the secondary loop in Cascade mode is the same as that in Automatic mode.

Table C7.2 Parameters Related to Run/Stop Switching

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
217	417	617	817	1.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
237	437	637	837	2POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
257	457	657	857	3.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
277	477	677	877	4.POUT	Preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
218	418	618	818	1.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
238	438	638	838	2.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
258	458	658	858	3.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
278	478	678	878	4.POUT.C	Cooling preset output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
121	321	521	721	RUN/STP	Run/Stop Selection	None	0: Stop 1: Run	0	RW	—

C7.2 Automatic/Manual Switch

Setting the Automatic/Manual/Cascade Selection (A/M/C) parameter to “1: Manual” allows you to output any arbitrary value manually. Manual output operates only when the Run/Stop Selection (RUN/STP) parameter is set to “Run”. If “Stop” is specified, the preset output is output instead. (See Section C7.1, “Run/Stop Switch”)

When changing the Automatic/Manual/Cascade Selection (A/M/C) parameter from “Automatic” to “Manual” in Run mode, the control output value remains the same before and after the change. That is, the switch is “bump-less”.

In Manual mode, the PID computation function stops and the output value can be changed manually using the Manual Output (MOUT) parameter and the Cooling Manual Output (MOUTC) parameter. Specifying a manual output value beyond the range defined by the Upper Output Limit (OH) and Lower Output Limit (OL) parameters will result in a control output limited by OH and OL. The output rate-of-change limit is, however, disabled in Manual mode.

In On/Off Control mode, only output values of 100% or 0% are allowed. (For details, see paragraph “■ Manual Operation” in Section C2.4.1, “On/Off Control Output”).

In Heating/Cooling PID Control mode, manual output is carried out on the heating output or the cooling output. (For details, see “■ Manual Operation” in Section C2.4.3, “Heating/Cooling PID Control.”)

In Heating/Cooling On/Off Control mode, manual output can be carried out separately for the heating output and the cooling output. Only output values of 100% or 0% are allowed. (For details, see “■ Manual Operation” in Section C2.4.4, “Heating/Cooling On/Off Control.”)

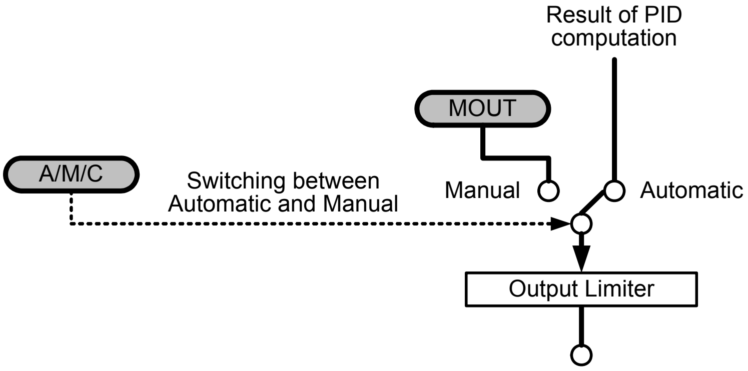


Figure C7.6 Manual Operation Block Diagram

To check whether a loop is in Automatic or Manual mode, use the Auto/Manual (A/M) input relay.

Table C7.3 Parameters Related to Automatic/Manual Switching

Input Relay Number X☐☐☐nn[*1]				Symbol	Description	Data Range	Interrupt
Loop1	Loop2	Loop3	Loop4				
X03	X11	X19	X27	A/M	Auto/Manual[*2]	0: Automatic; 1: Manual	—

*1 ☐☐☐ denotes the slot number where the module is installed.
*2 For details on how to check the operating status in Cascade Control mode, refer to descriptions on cascade control.

C7.2.1 Operation after Switching from Manual Mode to Automatic Mode

When OT = “0: PID Control” or OT = “2: Heating/Cooling PID Control”:

The switch is “bump-less” on the control output value. Control and computation begins with the output value immediately after the switch as the origin (if Integral Time (TI) is set to “0: OFF”, the control output bumps to the new value).

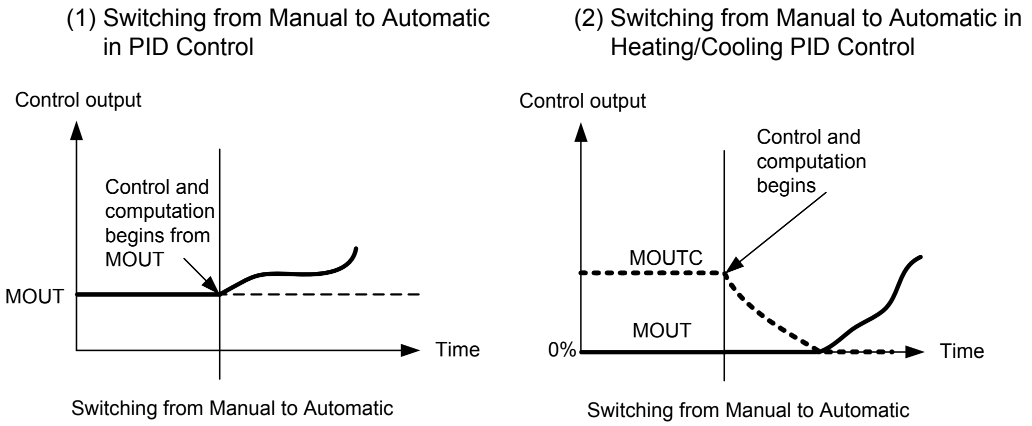


Figure C7.7 Switching to Automatic Mode in PID Control or Heating/Cooling PID Control

When OT = “1: On/Off Control” or OT = “3: Heating/Cooling On/Off Control”:

The control output value is determined by the PV and CSP values, independent of the control output value in Manual mode.

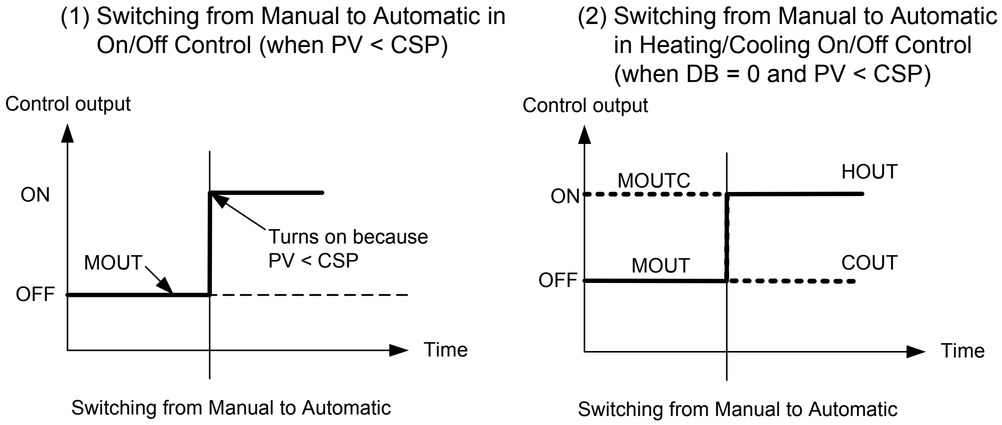


Figure C7.8 Switching to Automatic Mode in PID Control or Heating/Cooling PID Control

Table C7.4 Parameters Related to Automatic/Manual Switching

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
134	334	534	734	MOUT	Manual output	%	OL to OH: for single output 0 to OH: for heating/cooling output	0	RW	—
135	335	535	735	MOUTC	Manual Cooling output	%	0 to OL	0	RW	—
122	322	522	722	A/M/C	Automatic/Manual/ Cascade Selection	None	0: Automatic 1: Manual 2: Cascade [*1]	0	RW	—

*1 The controller mode must be set to Cascade Control before Automatic/Manual/Cascade Selection (A/M/C) can be set to 2 (Cascade). In cascade control, operation proceeds according to the setup for the even-numbered loop (loop 2 or 4).

C7.3 Remote/Local Switch

You can use the Remote/Local Selection (RMT/LOC) parameter to switch between Local mode and Remote mode.

In Local mode, one of the preset Set Point parameters (1.SP to 4.SP) is used as the set point. For details, see Section C4.1, “Set Point (SP).”

In Remote mode, an external value that is obtained and written to the Remote Set Point (RSP) parameter is used as the set point. For details, see Section 4.2, “Remote Set Point.”

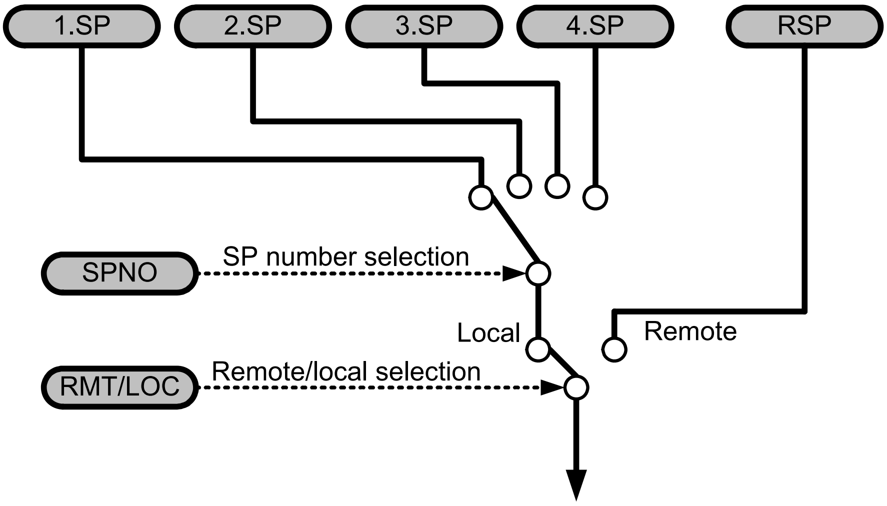


Figure C7.9 Block Diagram for Remote/Local Switching

Table C7.5 Parameters Related to Remote/Local Switching

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
133	333	533	733	RSP	Remote Set Point	Industrial unit	PRL to PRH	PRL	RW	—
124	324	524	724	RMT/LOC	Remote/Local Selection	None	0: Local 1: Remote	0	RW	—

C7.4 Automatic/Manual/Cascade Switch

Automatic/Manual/Cascade switching is enabled only in cascade control. Setting is performed using the Automatic/Manual/Cascade Selection (A/M/C) parameter of the even-numbered loop.

Figure C7.10 shows the mode transition diagram.

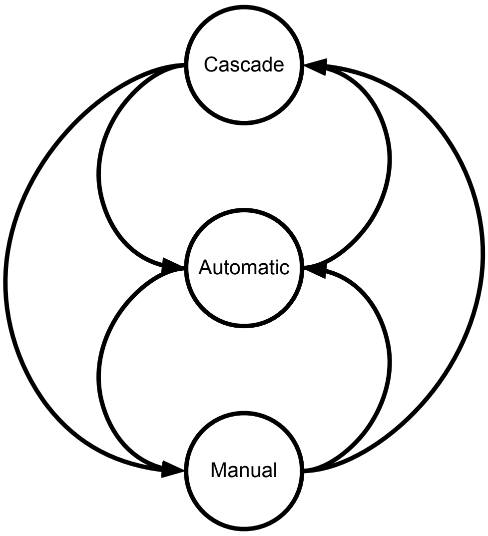


Figure C7.10 Switching Modes

Table C7.6 Operating Status and Input Relays in Cascade Control

A/M/C (even-numbered loop)	Odd-numbered Loop				Even-numbered Loop			
	RUN.STUS Input Register			A/M Input Relay *1	RUN.STUS Input Register			A/M Input Relay *1
	CAS	AUT/MAN	RMT/LOC		CAS	AUT/MAN	RMT/LOC	
0: Automatic	0	0	Same as RMT/LOC I/O register of the odd-numbered loop	0	0	0	0	0
1: Manual	0	1		0	0	1	0	1
2: Cascade	1	0		1	1	0	1	0

*1 By reading the A/M input relay for both the odd-numbered and even-numbered loops, you can determine whether a loop is in automatic, manual or cascade mode.

Table C7.7 Parameters Related to Cascade Mode Switching

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
108	308	508	708	RUN.STUS	Operating Status	None	See Table B2.13	—	RO	—
	322		722	A/M/C	Automatic/Manual/Cascade Selection	None	0: Automatic 1: Manual 2: Cascade	0	RW	—

Table C7.8 Input Relays Related to Cascade Mode Switching

Input Relay Number X□□□nn*1				Symbol	Description	Data Range	Interrupt
Loop1	Loop2	Loop3	Loop4				
X03	X11	X19	X27	A/M	Automatic/Manual	0: Automatic; 1: Manual	—

*1 □□□ denotes the slot number where the module is installed.

C7.4.1 Cascade Mode

In cascade mode control, the output value of the primary loop is used as the set point of the secondary loop.

The primary loop uses the control set point (CSP1) of the odd-numbered loop and the process value (PV1) of the odd-numbered loop to perform control and computation (PID1) of the odd-numbered loop.

The secondary loop uses the control output value (OUTPUT1) of the odd-numbered loop as the control set point (CSP2), uses the process value (PV2) of the even-numbered loop to perform control and computation (PID2) of the even-numbered loop, and outputs the control output value (OUTPUT2).

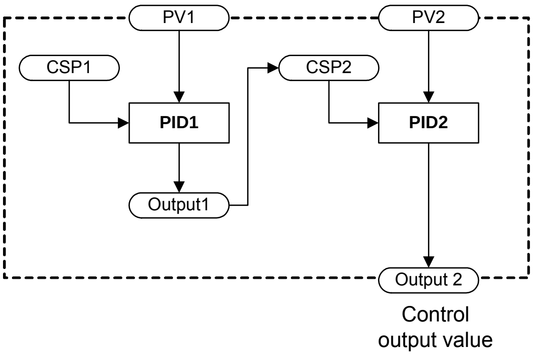


Figure C7.11 Schematic Diagram for Cascade Control

When switching from Automatic or Manual mode to Cascade mode, as the PID1 output from the primary loop is set equal to CSP2 of the secondary loop beforehand, the PID control output from the secondary loop will change smoothly in cascade mode starting with the current output value.

C7.4.2 Automatic Mode

In Automatic mode, only the secondary loop is operating.

The secondary loop uses the control set point of the even-numbered loop (CSP2) and the process value of the even-numbered loop (PV2) to perform control and computation in the even-numbered loop (PID2) and output the control output value (OUTPUT2).

The primary loop has no effect on control but its measured value can still be read.

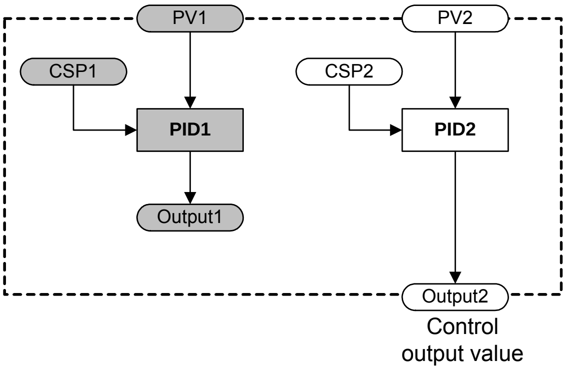


Figure C7.12 Schematic Diagram in Automatic Mode

When Cascade mode is switched to Automatic mode, the value of CSP2 is determined by the SP value of the secondary loop (even-numbered loop). Therefore, it is recommended that you temporarily set the SP value equal to the CSP2 value immediately before transiting from Cascade to Automatic mode. To inherit the set point in Cascade mode, set SP Tracking Mode (SP.TR) of the secondary loop to "0: ON".

C7.4.3 Manual Mode

In Manual mode, you can output any arbitrary value.

The secondary loop outputs as control output values (OUTPUT2) the values of the manual output (MOUT and MOUTC) parameters of the even-numbered loop.

The PV2 and CSP2 values of the secondary loop, as well as the primary loop have no effect on control. However, the PV1 and PV2 values can still be read.

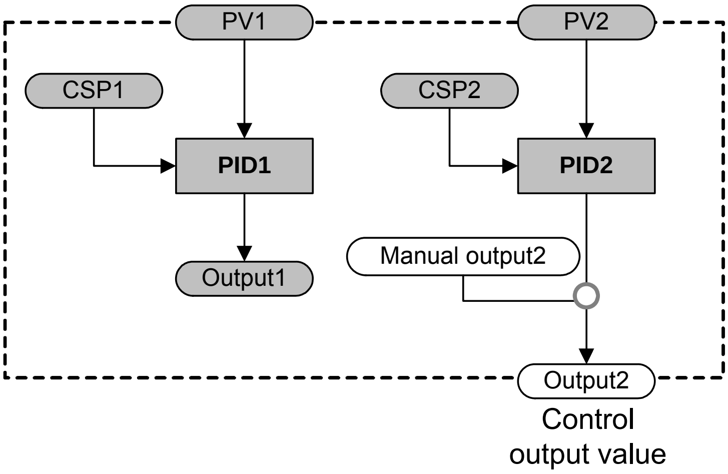


Figure C7.13 Schematic Diagram in Manual Mode

C7.5 Preset Output Function

When the Run/Stop Selection (RUN/STP) is set to “Stop”, the values of the Preset Output (POUT, POUTC) parameters are output as the control output values.

These values are also output when a burnout or AD converter error is detected provided the Automatic/Manual/Cascade Selection (A/M/C) parameter is set to “Automatic” or “Cascade”.

The preset output (POUTC, POUTC) values are unrestricted by the values of the Upper Output Limit and Lower Output Limit (OH and OL) parameters.

Table C7.9 Parameters Related to Preset Output

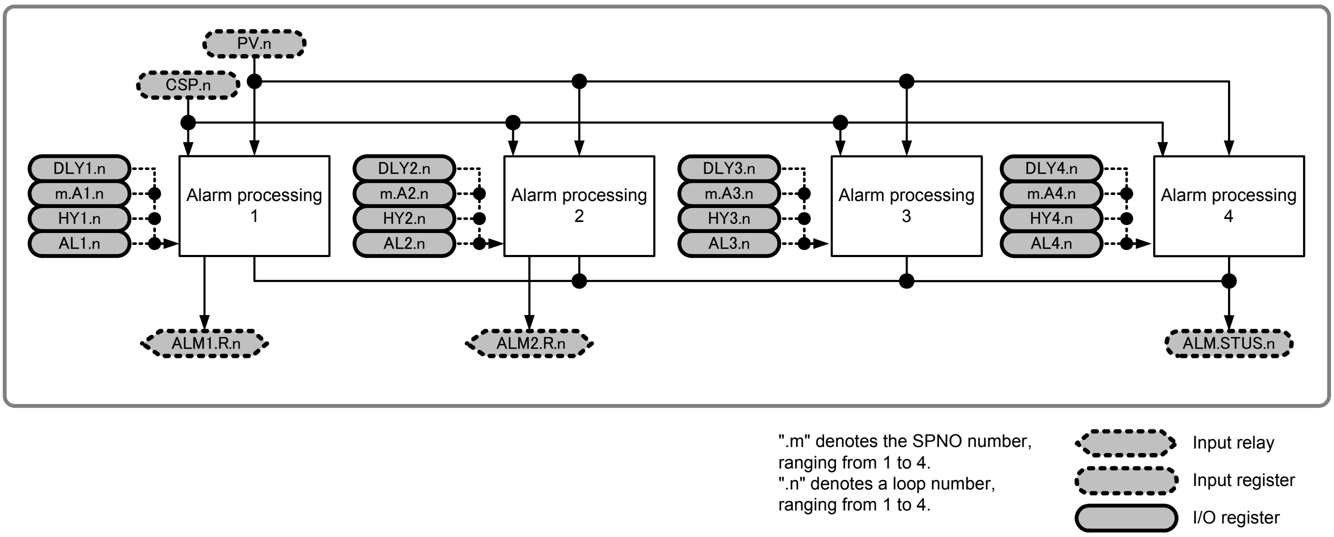
Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop1	Loop2	Loop3	Loop4							
217	417	617	817	1.POUT	Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
237	437	637	837	2POUT	Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
257	457	657	857	3.POUT	Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
277	477	677	877	4.POUT	Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
218	418	618	818	1.POUT.C	Cooling Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
238	438	638	838	2.POUT.C	Cooling Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
258	458	658	858	3.POUT.C	Cooling Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
278	478	678	878	4.POUT.C	Cooling Preset Output	%	-50 to 1050 (-5.0 to 105.0%)	0	RW	✓
121	321	521	721	RUN/STP	Run/Stop Selection	None	0: Stop 1: Run	0	RW	—

C8. Alarm Function

This chapter describes the alarm function of the module.

The module provides four alarms for each loop. Each alarm can be disabled or its alarm type can be selected from a list of available alarm types.

In addition, four sets of alarm preset values can be defined for each loop. Each set of alarm preset values consists of four preset values for the four alarms of a loop. You can specify which set of alarm preset values is to be used during operation using the SP Number Selection (SPNO) parameter. You can also modify the alarm preset value of an alarm during operation.



".m" denotes the SPNO number, ranging from 1 to 4.
".n" denotes a loop number, ranging from 1 to 4.

Figure C8.1 Block Diagram of Alarm Functions

CAUTION

Alarms 3 and 4 have no associated input relay. Their statuses are indicated by corresponding bits of ALM.STUS.

Table C8.1 Alarm Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4								
102	302	502	702	PV	Process value	Industrial unit	-5.0 to 105.0% of (PRL to PRH)	—	RO	—	C3
103	303	503	703	CSP	Control set point	Industrial unit	PRL to PRH	—	RO	—	C4
107	307	507	707	CSPNO	Current SP number	None	1 to 4	—	RO	—	C4
109	309	509	709	ALM.STUS	Alarm status	None	Each bit represents an alarm condition, which is either on or off.	—	RO	—	C8.1
128	328	528	728	SPNO	SP number selection	None	1 to 4	1	RW	—	C4.1
202	402	602	802	1.A1	Alarm 1 preset value	Industrial unit	-30000 to 30000	PRH	RW	✓	C8.4
203	403	603	803	1.A2	Alarm 2 preset value			PRL	RW	✓	C8.4
204	404	604	804	1.A3	Alarm 3 preset value			PRH	RW	✓	C8.4
205	405	605	805	1.A4	Alarm 4 preset value			PRL	RW	✓	C8.4
222	422	622	822	2.A1	Alarm 1 preset value	Industrial unit	-30000 to 30000	PRH	RW	✓	C8.4
223	423	623	823	2.A2	Alarm 2 preset value			PRL	RW	✓	C8.4
224	424	624	824	2.A3	Alarm 3 preset value			PRH	RW	✓	C8.4
225	425	625	825	2.A4	Alarm 4 preset value			PRL	RW	✓	C8.4
242	442	642	842	3.A1	Alarm 1 preset value	Industrial unit	-30000 to 30000	PRH	RW	✓	C8.4
243	443	643	843	3.A2	Alarm 2 preset value			PRL	RW	✓	C8.4
244	444	644	844	3.A3	Alarm 3 preset value			PRH	RW	✓	C8.4
245	445	645	845	3.A4	Alarm 4 preset value			PRL	RW	✓	C8.4
262	462	662	862	4.A1	Alarm 1 preset value	Industrial unit	-30000 to 30000	PRH	RW	✓	C8.4
263	463	663	863	4.A2	Alarm 2 preset value			PRL	RW	✓	C8.4
264	464	664	864	4.A3	Alarm 3 preset value			PRH	RW	✓	C8.4
265	465	665	865	4.A4	Alarm 4 preset value			PRL	RW	✓	C8.4
281	481	681	881	AL1	Alarm 1 type	None	0: OFF 1: Upper limit 2: Lower limit 3: Upper deviation limit 4: Lower deviation limit 7: Upper/lower deviation limit 8: Deviation range 11: Upper limit with waiting 12: Lower limit with waiting 13: Upper deviation limit with waiting 14: Lower deviation limit with waiting 17: Upper/lower deviation limit with waiting 18: Deviation range with waiting	1	RW	✓	C8.1
282	482	682	882	AL2	Alarm 2 type			2	RW	✓	C8.1
283	483	683	883	AL3	Alarm 3 type			1	RW	✓	C8.1
284	484	684	884	AL4	Alarm 4 type			2	RW	✓	C8.1
285	485	685	885	HY1	Alarm 1 hysteresis	Industrial unit	0 to (PRH - PRL)	(PRH - PRL) x 0.5%	RW	✓	C8.1
286	486	686	886	HY2	Alarm 2 hysteresis				RW	✓	C8.1
287	487	687	887	HY3	Alarm 3 hysteresis				RW	✓	C8.1
288	488	688	888	HY4	Alarm 4 hysteresis				RW	✓	C8.1
289	489	689	889	DLY1	Alarm 1 ON delay	second	0 to 999	0	RW	✓	C8.3
290	490	690	890	DLY2	Alarm 2 ON delay				RW	✓	C8.3
291	491	691	891	DLY3	Alarm 3 ON delay				RW	✓	C8.3
292	492	692	892	DLY4	Alarm 4 ON delay				RW	✓	C8.3

Table C8.2 Alarm Input Relays

Input relay Number X☐☐☐nn *				Symbol	Description	Data Range	Interrupt
Loop 1	Loop 2	Loop 3	Loop 4				
01	09	17	25	ALM1.R	Alarm 1	0: Normal, 1: Alarm 1	✓
02	10	18	26	ALM2.R	Alarm 2	0: Normal, 1: Alarm 2	✓

* ☐☐☐ denotes the slot number where the module is installed.

CAUTION

Alarms 3 and 4 have no associated input relay. Their status is indicated by the corresponding bit of ALM.STUS.

C8.1 Alarm Types

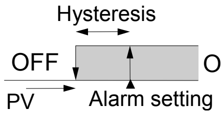
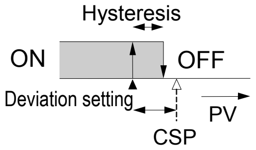
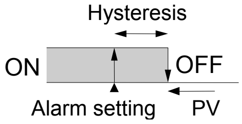
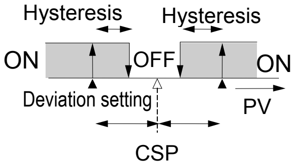
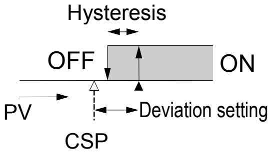
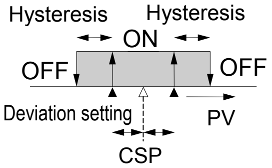
Table C8.3 lists the alarm types. For details on their operations, see Table C8.4.

Table C8.3 List of Alarm Types

Alarm Types	Description	Alarm Types	Description
0	No alarm		
1	Upper limit without waiting	11	Upper limit with waiting
2	Lower limit without waiting	12	Lower limit with waiting
3	Upper deviation limit without waiting	13	Upper deviation limit with waiting
4	Lower deviation limit without waiting	14	Lower deviation limit with waiting
7	Upper/lower deviation limit without waiting	17	Upper/lower deviation limit with waiting
8	Deviation range without waiting	18	Deviation range with waiting

Table C8.4 describes the alarm functions. Alarm types 1-8 are without waiting, and alarm types 11-18 are with waiting. For details on the wait function, see Section C8.2, "Wait Function."

Table C8.4 Alarm Functions

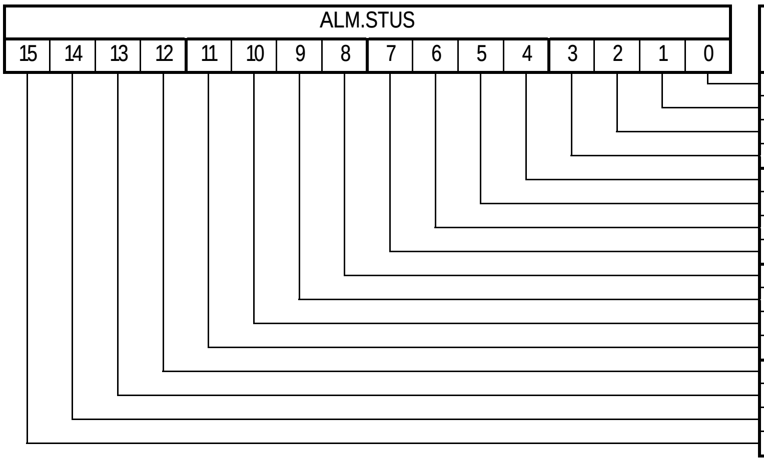
Alarm Function	Operation	Alarm Type	Alarm Function	Operation	Alarm Type
	‘ON’, ‘OFF’ denote alarm conditions			‘ON’, ‘OFF’ denote alarm conditions	
No alarm		OFF			
Upper limit		1 11	Lower deviation limit		4 14
Lower limit		2 12	Upper/lower deviation limit		7 17
Upper deviation limit		3 13	Deviation range		8 18

CAUTION

The ALM LED on the front panel of the module lights up if any alarm (1-4) is generated in any loop (1-4).

■ Alarm Status

Table C8.5 Alarm Status



Bit pos.	Symbol	Description
0	ALM1	Alarm 1 occurred
1	ALM2	Alarm 2 occurred
2	ALM3	Alarm 3 occurred
3	ALM4	Alarm 4 occurred
4	ALMW1	Alarm 1 waiting
5	ALMW2	Alarm 2 waiting
6	ALMW3	Alarm 3 waiting
7	ALMW4	Alarm 4 waiting
8	—	
9	—	
10	—	
11	—	
12	—	
13	—	
14	—	
15	—	

The data position number of ALM.STUS is 109 for loop1, 309 for loop2, 509 for loop3, or 709 for loop4.

C8.2 Wait Function

When the wait function is specified, the alarm function is temporarily disabled (enters wait state) for a specified period after the following events:

- Power up
- Change in SP number (SPNO)

Figure C8.2 below shows an example of the alarm function when the alarm type is set to Lower Limit with Waiting.

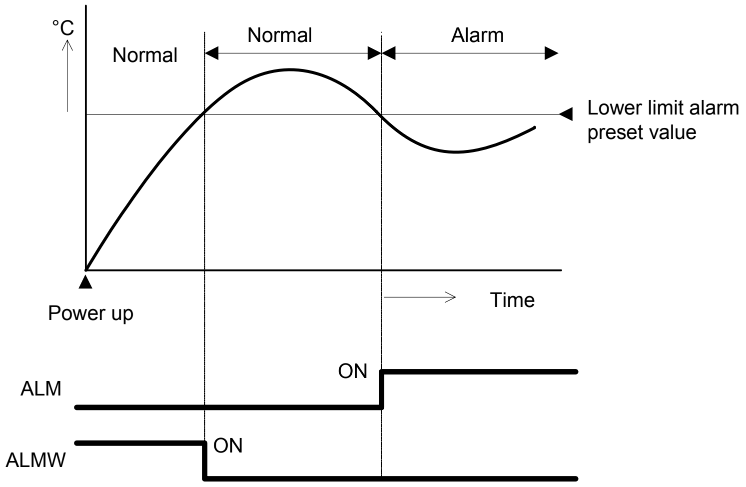


Figure C8.2 Operation of the Wait Function

TIP

After an alarm condition is detected, the module again enters wait state if any of the following events occur:

- Power up
- Change in Set Point (1.SP to 4.SP) parameter (when selected by the SPNO parameter in local mode)
- Change in the SP Number Selection (SPNO) parameter
- Change in alarm type

C8.3 Alarm Delay Timer

The alarm delay timer function delays the generation of an alarm. The alarm turns on only if the alarm condition persists until a delay timer times out.

If an alarm condition disappears before a delay timer times out, the timer resets. Changing the alarm type or powering down also resets the delay timer.

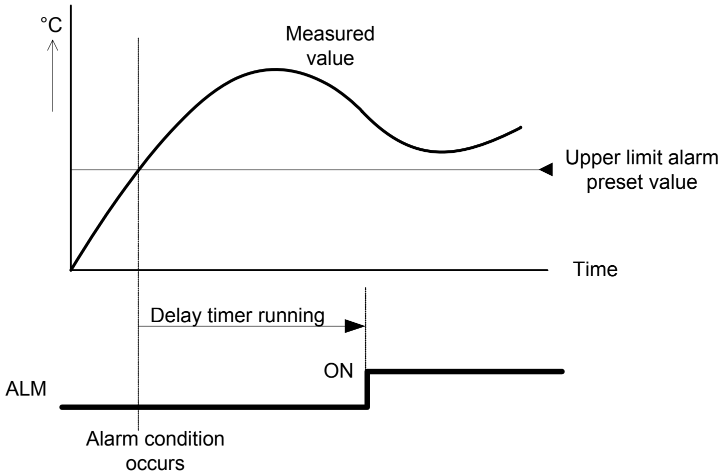


Figure C8.3 Alarm Delay Timer

C8.4 Selecting Alarm Preset Values

There is a set of four alarm preset values A1 to A4, which can be selected by setting the SP Number (SPNO) parameter. Changing the SP Number changes all the alarm preset values at the same time. For details on SP number selection, see Section C6.9.1, "SP Number Selection."

Table C8.6 Selection of Alarm Preset Values

SP number (SPNO)	Available Alarm Preset Values
1	1.A1, 1.A2, 1.A3, 1.A4
2	2.A1, 2.A2, 2.A3, 2.A4
3	3.A1, 3.A2, 3.A3, 3.A4
4	4.A1, 4.A2, 4.A3, 4.A4

TIP

- Changing the SPNO parameter does not affect alarm type, alarm hysteresis, or alarm delay timer.
- Alarm preset values are always switched as a set of 4. Switching to an individual alarm preset value, not in a set, is not allowed.

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C9. Disable Backup Function

The Disable Backup Function (NBKUP) can be used to suspend the automatic storing of parameters to the EEPROM. Use this function to protect the EEPROM if parameters are updated frequently.

The module has two types of parameters: stored and non-stored. Stored parameters preserve their data in EEPROM even when the module is powered down provided NBKUP is set to 0 (backup). Beware that there is a limit to the number of times stored parameters can be updated.

For details on whether a parameter is stored or non-stored, see the individual parameter table or the list of registers.

The default value of the Disable Backup Function (NBKUP) parameter is 0 (backup). With NBKUP=0, when a stored parameter is updated, its data is written to the EEPROM and thus preserved even if power supply is turned off.

As there is a maximum limit to the number of write operations (approx. 100,000 times) allowed for the EEPROM, be careful not to exceed the limit. Once the limit is reached, a hardware failure may occur and subsequent storage is not guaranteed.

If stored parameters are updated frequently, set NBKUP to 1 (no backup) to protect the EEPROM. In this case, stored parameters will not be written to the EEPROM when updated. Thus, when the module is turned off and turned on again, the parameters revert to their last stored values and must be updated again if required.

CAUTION

Do not attempt to change the value of the Disable Backup Function (NBKUP) parameter from 1 (no backup) to 0 (backup) by writing to the parameter.

To enable the backup function, simply switch off and then switch on the module. Since the NBKUP parameter is not a stored parameter, its value will reset to 0 (backup) after power up.

TIP

If you update some parameters after changing the NBKUP parameter to 0 (backup), and then switch off and switch on the module, you may find that not all parameter values are what you expect. This is because the module stores parameters only when they are changed.

Table C9.1 Disable Backup Function Parameter

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
75				NBKUP	Disable Backup Function	None	0: Enable backup to EEPROM 1: Disable backup to EEPROM	0	RW	—

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C.10 Self-diagnosis Function

This chapter describes how to identify and rectify problems that may occur at power up or during normal operation.

C10.1 How to Check for Errors

When an error occurs, the ERR LED lights up, and the Operating Status (RUN.STUS) and Error Status (ERR.STUS) registers indicate details of the error. For details on how to identify and handle errors, see Part D, “Troubleshooting”.

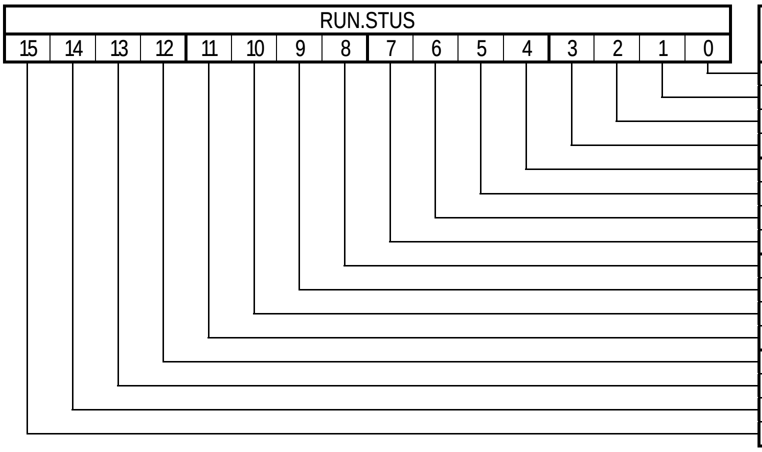
C10.2 List of Error Statuses

When an error occurs, the Operating Status (RUN.STUS) and Error Status (ERR.STUS) registers provide error information by turning on relevant bits.

Table C10.1 Error-related Parameters

Data Position Number				Symbol	Description	Unit	Data Range	Default Value	Attribute	Stored
Loop 1	Loop 2	Loop 3	Loop 4							
41	42	43	44	RUN.STUS	Operating status	None	On/off for individual bits. For details, see Table C10.2.	— —	RO RO	— —
108	308	508	708					— —	RO RO	— —
51	52	53	54	ERR.STUS	Error status	None	On/off for individual bits. For details, see Table C10.3.	— —	RO RO	— —
110	310	510	710					— —	RO RO	— —

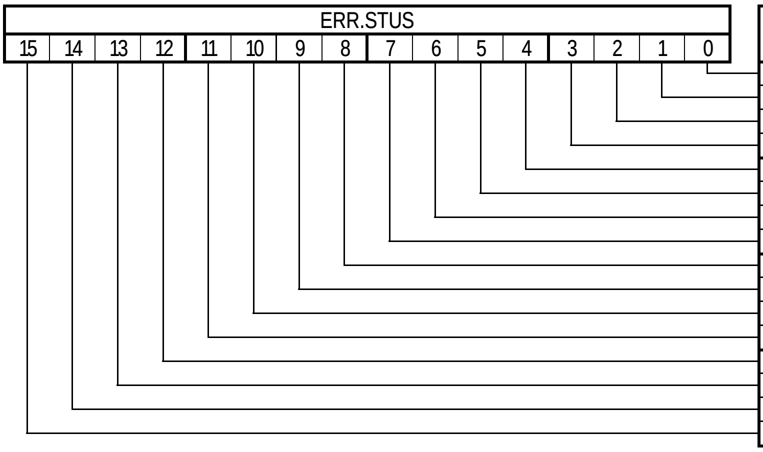
Table C10.2 Operating Status



Bit pos.	Symbol	Description
0	RUN/STP	0: Stop 1: Run
1	AUT/MAN	0: Automatic 1: Manual
2	CAS	1: Cascade
3	RMT/LOC	0: Local 1: Remote
4	EXPV/PV	0: Normal input 1: External Input
5	EXOUT/OUT	0: Normal output 1: External Output
6	–	
7	–	
8	B.OUT	1: PVIN burnout
9	+OVER	1: PVIN +OVER
10	- OVER	1: PVIN -OVER
11	B.OUT	1: PV burnout
12	+OVER	1: PV +OVER
13	- OVER	1: PV -OVER
14	–	
15	FUNC.ERR	1: Error detected

PVIN+OVER occurs when input exceeds 105% of the input range, and PVIN-OVER occurs when input is below -5% of the input range. PV+OVER and PV-OVER are equivalent to PVIN+OVER and PVIN-OVER in Single-input mode. In Two-input Changeover mode, PV+OVER occurs when input exceeds 105% of the PV input range of the even loop, and PV-OVER occurs when input is below -5% of the PV input range of the even loop. For details on PVIN burnout and PV burnout, see Section C3.5, "Burnout Detection." When the FUNC.ERR bit of the RUN.STUS parameter is set, detailed error information is provided in the ERR.STUS parameter.

Table C10.3 Error Status



Bit pos.	Usage
0	–
1	System data error
2	Calibration value error
3	Controller or I/O parameter error
4	Operation parameter error
5	AD converter error
6	RJC error
7	EEPROM error
8	–
9	–
10	–
11	–
12	–
13	–
14	–
15	–

■ Troubleshooting Errors at Power Up

The following table lists the errors that may be returned by the self-diagnosis procedure at power up. Check the relevant registers shown in Table C10.1 for the error status.

Table C10.4 Startup Errors

ERR.STUS (bit pos.)	LED Indicator		Error Condition	Controller Operation	Measurement	Control Output	Troubleshooting	Status
	RDY	ERR						
Unknown	Off	Off	RAM error	Stops operating.	Unreliable	≤ 0% or OFF	Have the module repaired.	Hardware failure
Unknown			ROM error					
1	Lit	Lit	System data error					
2			Calibration value error	Initializes calibration value and resumes normal operation.	Normal operation (accuracy is not guaranteed)	0% or OFF		
3		Flashing	Controller or I/O parameter value error	Automatically initializes controller or I/O parameter and resumes normal operation.	Normal operation	Normal operation (accuracy is not guaranteed)	Parameters have been initialized. Check and set the parameters again, as required.	
4			Operation parameter value error	Automatically initializes operation parameter and resumes normal operation.		Normal operation		

■ Troubleshooting Operation Errors

The tables below list the errors that may be detected during operation. Check the relevant registers shown in Table C10.1 for the error status.

Table C10.5 Operation Errors (1/2)

ERR.STUS (bit pos.)	LED Indicator		Error Condition	Controller Operation	Measurement	Control Output	Troubleshooting	Status
	RDY	ERR						
5	Lit	lit	AD converter error	Normal operation	105%	Automatic: Preset output Manual: Normal operation [*1]	Input type setting	Incorrect wiring
6			RJC error in loop	Operation continues with reference junction compensation disabled.	Reference junction is assumed to be at 0°C.	Normal operation	Have the module repaired.	Hardware failure
7			EEPROM error	Normal operation continues but parameter backup to EEPROM is not done.	Normal operation			

*1 In Cascade Control mode, the control output originates from the secondary loop (even-numbered loop). This error, however, results in the specified Preset Output. If this error occurs in the primary loop (odd-numbered loop), the secondary loop is automatically switched to Automatic mode and operation continues.

Table C10.5 Operation Errors (2/2)

ERR.STUS (bit pos.)	LED Indicator		Error Condition	Controller Operation	Measurement	Control Output	Troubleshooting	Status
	RDY	ERR						
11	Lit	Flashing	PV burnout in loop	Depends on burnout selection (BSL).	Depends on BSL burnout selection.	Automatic: Preset output Manual: Normal operation [*1]	Check the sensor and sensor circuit.	Process error
12/13		Off	PV ± OVER in loop	Continues operation with PV = 105% or -5%	Limit values	Normal operation	Check the process.	
Unknown	Unknown	Unknown	Out of control (due to abnormal power supply or noise)	CPU resets.	Unknown	≤ 0% or OFF	If switching off and on does not restore normal operation, have the module repaired.	Hardware failure

*1 In Cascade Control mode, the control output originates from the secondary loop (even-numbered loop). This error, however, results in the specified Preset Output. If this error occurs in the primary loop (odd-numbered loop), the secondary loop is automatically switched to Automatic mode and operation continues.

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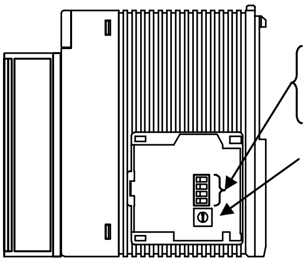
C11. Selecting Temperature Unit

This section describes how to set the temperature unit used with this module.

You may switch the temperature unit between °C (Celsius) and °F (Fahrenheit) using switch SW1-1 located on the side of the module.



SW1-1: Temperature unit selector switch
SW1-2: Power frequency selector switch
SW1-3: Input type selector switch
SW1-4: Input type selector switch

SW5: Input type selector switch
(Input type is determined by the combined values of SW1-3, SW1-4, and SW5.)

Note: This is the right side view of the module with its cover removed.

Figure C11.1 Input Type, Power Frequency, and Temperature Unit Selector Switches on the Side of the Module

TableC11.1 Temperature Unit Selection

Temperature Unit	Temperature Unit Selector Switch	Remarks
°C	OFF	Factory setting
°F	ON	

CAUTION

Always turn off the power before performing switch setup.

CAUTION

A change in the setting of the temperature unit selector switch is processed as a change in input type, and thus causes the input/output parameters and the operation parameters to be reset to default values. Perform parameter setup again, if required.

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Temperature Control and PID Module
Part D: Troubleshooting

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Part D describes how to troubleshoot problems related to the module.

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D1. Before Performing Checks

This module acts on SP (set point) and PV (process value) input and performs control and computation to output a computation result, forming a closed loop. Therefore, any improper control parameter or input/output setup may result in control problems, such as unstable input or no output. If you encounter these problems, follow the troubleshooting steps given below for a specific problem and correct any inappropriate connection or setup. For details on the errors that are detected by the self-diagnosis function and how to recover from a detected error, see Section C10, "Self-diagnosis Function." For details on register and relay positions, see Part E, "Relays and Registers."

The module stores many preset values internally. Sometimes, temporary preset values are written for testing purposes, such as during trial runs and program debugging, and are left uncorrected. They are stored in the module, even after power off. Such unintentional preset values may result in unexpected operations subsequently. If replacing a module solves a problem, it is highly likely that the replaced module has some invalid stored preset values. In this case, we recommend that you check all preset values. Alternatively, initialize all preset values to their default (factory setting) and then change individual preset values as required, and check for correct operation. For details on how to initialize all preset values, see Section B2.5, “Initializing All Settings."

TIP

For efficient setup and monitoring of the module, we recommend that you use the Toolbox for Temperature Control and Monitoring Modules and the Advanced Function Module Register Monitor of WideField2.

D2. Troubleshooting a Specific Problem

This chapter describes troubleshooting for some common error phenomena, which may be observed during module operation. If you observe any of the following error phenomena, follow the troubleshooting instructions described in the corresponding text sections given on the following pages:

(1) Input does not change, or fluctuates excessively.

(2) Any LED indicator other than RDY and 60 Hz is lit or flashing.

(3) The loop is out of control (with an oscillating response)

(4) Output does not respond to or follow a changed set point value.

(5) Excessive overshooting

(6) Settings are not enabled.

(1) Input does not change, or fluctuates excessively

If input does not change, or fluctuates excessively, there may be a problem with sensor connection, module usage, or register preset values. Follow the steps below to locate the cause. Also see (3), "The loop is out of control (with an oscillating response)" if the module is used as a controller.

- Confirm that the sensor is securely and correctly connected.
- Confirm that the registers are correctly set. See the table below.

Data Position Number				Symbol	Content	Check Items	See Also
Loop 1	Loop 2	Loop 3	Loop 4				
71				SETUP	Setup	Is SETUP set to 1? It must be set to 0.	B2.3
81				FREQ	Power frequency selection	Is FREQ correctly set to match the frequency of the power supply used? It must be correctly set.	B3.1.1
82				SMP	Input sampling period	Is the loop whose input does not change available for use? To use loops 3 and 4, Input sampling period should be set to 200 ms.	B3.1.2
83				MD12	Controller mode	Is the loop whose input does not change available for use? If the loop is disabled, enable it.	B3.1.3
		84		MD34			
142	342	542	742	IN	Input type selection	Is the input type appropriate for the sensor type used? Set the input type to match the sensor used.	B3.2.1
172	372	572	772	FL	Input filter	Is excessive noise interfering with the input? Set FL to an appropriate value.	C3.10

(2) Any LED indicator other than RDY and 60 Hz is lit or flashing

If any LED indicator other than the RDY and 60 Hz LED indicators (e.g. ALM or ERR LED indicator) is lit or flashing, an alarm or error has been detected. An input circuit may be incorrectly connected, or the self-diagnosis function may have detected an internal error. Follow the steps below to locate the cause.

- All loops with no sensor connected should be disabled using the controller mode registers.
- For a loop configured for thermocouple or DC voltage input, no signal connection must be made to its NC terminals, as shown in Section A4.3.2, "Terminal Wiring Diagram.″ Otherwise an AD converter error may be detected.
- Check that register preset values are appropriate. See the table below.

Data Position Number				Symbol	Content	Check Items	See Also
Loop 1	Loop 2	Loop 3	Loop 4				
83				MD12	Controller mode	All loops with no sensor connected must be disabled.	C1
		84		MD34			
102	302	502	702	PV	Process value	Are values proper? Check the values against PRL and PRH.	C3
108	308	508	708	RUN.STUS	Operating status	Is bit 15 set? If so, check ERR.STUS.	C10.2
109	309	509	709	ALM.STUS	Alarm status	Are any of bits 0-3 set? If so, check the corresponding alarm type, alarm setting, and alarm hysteresis.	C8.1
110	310	510	710	ERR.STUS	Error status	Is any bit set? If so, check the indicated cause.	C10.2
202	402	602	802	1.A1	Alarm 1 preset value	If an alarm is detected, check its alarm conditions.	C8.1
203	403	603	803	1.A2	Alarm 2 preset value		
204	404	604	804	1.A3	Alarm 3 preset value		
205	405	605	805	1.A4	Alarm 4 preset value		
222	422	622	822	2.A1	Alarm 1 preset value		
223	423	623	823	2.A2	Alarm 2 preset value		
224	424	624	824	2.A3	Alarm 3 preset value		
225	425	625	825	2.A4	Alarm 4 preset value		
242	442	642	842	3.A1	Alarm 1 preset value		
243	443	643	843	3.A2	Alarm 2 preset value		
244	444	644	844	3.A3	Alarm 3 preset value		
245	445	645	845	3.A4	Alarm 4 preset value		
262	462	662	862	4.A1	Alarm 1 preset value		
263	463	663	863	4.A2	Alarm 2 preset value		
264	464	664	864	4.A3	Alarm 3 preset value		
265	465	665	865	4.A4	Alarm 4 preset value		
281	481	681	861	AL1	Alarm 1 type		
282	482	682	862	AL2	Alarm 2 type		
283	483	683	863	AL3	Alarm 3 type		
284	484	684	884	AL4	Alarm 4 type		
285	485	685	885	HY1	Alarm 1 hysteresis		
286	486	686	886	HY2	Alarm 2 hysteresis		
287	487	687	887	HY3	Alarm 3 hysteresis		
288	488	688	888	HY4	Alarm 4 hysteresis		

(3) The loop is out of control (with an oscillating response)

If the loop is out of control (with an oscillating response), it may be due to an improper value in an operation control, input, control or output parameter. Follow the steps below to locate the cause.

Data Position Number				Symbol	Description	Check Items	See Also
Loop 1	Loop 2	Loop 3	Loop 4				
121	321	521	721	RUN/STP	Run/stop selection	Is RUN/STP set to “1: Run”?	C.7.1
122	322	522	722	A/M/C	Automatic/manual/ cascade selection	Is A/M/C set to either Automatic or Cascade?	C.7.4
141	341	541	741	OT	Control type selection	Is ON/OFF Control selected? ON/OFF control tends to result in an oscillating output.	C.2.1
181	381	581	781	SELF	Dynamic auto-tuning enable		C.5.1
182	382	582	782	SC	"Super" enable code		C6.7
191	391	591	791	CT	Cycle time		C2.4
192	392	592	792	CTc	Cooling cycle time		C2.4

- If time proportional output is selected, check that the cycle time (CT) is compatible with the system response. In this mode, the input sampling period is actually determined by CT. If the actuator allows, you can reduce CT to improve the system characteristics.
- Are the PID parameters automatically set with auto-tuning? If so, check that the PID parameter values are proper. For details on how to start auto-tuning, see Section C5.2, "Auto-tuning." For details on how to adjust the PID parameters manually, see Section C6.5, "Manual Adjustment of PID Constants."
- Are the PID parameters automatically set with dynamic auto-tuning? If so, check that the PID parameter values are proper. If not, disable dynamic auto-tuning, and either use (normal) auto-tuning or manually set the PID parameters. For details on how to start auto-tuning, see Section C5.2, "Auto-tuning." For details on how to manually tune the PID parameters, see Section C6.5, "Manual Adjustment of PID Constants."
- Is the control output fluctuating excessively? If so, you can adjust the PID parameters, input filter or relative positions between sensors and actuators to suppress fluctuations.
- If multiple loops are used, are they interfering with each other? If sensors or actuators of different loops are located too near to each other, the output from one loop may significantly affect the PV value of another loop.
- If the above measures still fail to solve the problem, replace the loop and repeat the same troubleshooting steps. If you have a spare module, replace the module and repeat the same troubleshooting steps. If the problem persists, check for and correct any faulty sensors or wiring. If the problem disappears, check the operation as described in Section D1, "Before Performing Checks."

(4) Output does not respond to or follow a changed set point value

- Does the control set point (CSP) change with the set point (SP)? If not, check whether the SP Up Gradient (SPR.UP), SP Down Gradient (SPR.DN) and SP Gradient Time Unit (SPR.TM) parameters have been specified inadvertently. Setting the SP gradient parameters will slow down the response of the CSP.
- Is the output type of the loop correctly selected? Is the wiring to a controlled load correct? Is an external 24 V DC power supply connected to the module? Remember that an output from the module requires an external power supply to drive the load.
- Does the output change with SP? If not, check the value of the control output parameter (HOUT or COUT). Also check the values of the Output Type Selection (OUTPUT), Output Terminal Selection (OUTSEL 1-4), and Forward/Reverse Switch (DR) parameters. Remember that output is either 0 or 100% in ON/OFF control mode.
- If the above measures still fail to solve the problem, see (1), "Input does not change, or fluctuates excessively" given in this chapter.

(5) Excessive overshooting

- Is the overshooting suppression function "Super" enabled? If not, enable it and check if the problem disappears.
- If "Super" is enabled, disable it by setting SC to 0 to see if the problem disappears. Sometimes, "Super" may increase instead of reduce overshooting when PID parameter values are inappropriate.
- Try to suppress overshooting by adjusting the PID parameters as described in Section C6.5, "Manual Adjustment of PID Constants."
- If the above measures still fail to solve the problem, replace the loop and repeat the troubleshooting steps. If you have a spare module, replace the module and repeat the troubleshooting steps.

(6) Settings are not enabled

- Controller parameters and I/O parameters (input and output types, input range, and PV range) must be enabled before their setting can take effect. For details on how to enable parameter settings, see Section B2.3, "How to Enable Settings."

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Part E: Relays and Registers

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Part E lists all the relays and registers used by the module, which can be accessed from a sequence CPU or BASIC CPU as described in Sections B1.1 to B1.3 (see the table below). For details on precautions when accessing the module from a CPU, see also Chapter B2, “Types of Relays and Registers”.

For Information on:	See Also:
Accessing from the sequence CPU	B1.1, "Accessing Using Sequence Instructions"
Accessing from the BASIC CPU	B1.2, "Accessing Using BASIC"
Precautions when writing to the module	B1.3, "Writing and Reading after Powering On"

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E1. List of Registers

Table E1.1 Common Process Data

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop1	Loop2	Loop3	Loop4					
1				PV.1	Process value	RO	—	C3
	2			PV.2		RO	—	
		3		PV.3		RO	—	
			4	PV.4		RO	—	
5					Not used			
6								
7								
8								
9								
10								
11				CSP.1	Control set point	RO	—	C4
	12			CSP.2		RO	—	
		13		CSP.3		RO	—	
			14	CSP.4		RO	—	
15					Not used			
16								
17								
18								
19								
20								
21				HOUT.1	Control output	RO	—	C2 C7.1
	22			HOUT.2		RO	—	
		23		HOUT.3		RO	—	
			24	HOUT.4		RO	—	
25					Not used			
26								
27								
28								
29								
30								
31				COUT.1	Cooling control output	RO	—	C7.1
	32			COUT.2		RO	—	
		33		COUT.3		RO	—	
			34	COUT.4		RO	—	
35					Not used			
36								
37								
38								
39								
40								
41				RUN.STUS.1	Operating status	RO	—	C10
	42			RUN.STUS.2		RO	—	
		43		RUN.STUS.3		RO	—	
			44	RUN.STUS.4		RO	—	
45					Not used			
46								
47								
48								
49								
50								
51				ERR.STUS.1	Error status	RO	—	C10
	52			ERR.STUS.2		RO	—	
		53		ERR.STUS.3		RO	—	
			54	ERR.STUS.4		RO	—	
55					Not used			
56								
57								
58								
59								
60								

Table E1.2 Analog Output Settings

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
61				AOUT1	Output preset value	RW	—	C2.5
62				AOUT2		RW	—	
63				AOUT3		RW	—	
64				AOUT4		RW	—	
65				AOUT5		RW	—	
66				AOUT6		RW	—	
67				AOUT7		RW	—	
68				AOUT8		RW	—	
69					Not used			
70								

Table E1.3 Setup Control Parameters

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
71				SETUP	Setup	RW	—	B2.3
72				OPE	Setup instruction operand	RW	—	
73				STUS	Setup instruction response	RO	—	
74				SPWR	Write Set Point to EEPROM	RW	—	B2.4

Table E1.4 Function Control Parameters

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
75				NBKUP	Disable backup function	RW	—	C9.
76					Not used			
77				EEP.CNTR	EEPROM write counter	RO	—	B2.2.6
78								
79					Not used			
80								

Table E1.5 Controller Parameters

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
81				FREQ	Power frequency selection	RW	✓	C3.2
82				SMP	Input sampling period	RW	✓	B3.1.2
83				MD12	Controller mode	RW	✓	C1.
84				MD34		RW	✓	
85					Not used			
86								
87				OUTPUT	Output type selection	RW	✓	C2.2
88					Not used			
89								
90				REV	Firmware revision	RO	—	—
91				OUTSEL1	Output terminal selection	RW	✓	C2.3
92				OUTSEL2		RW	✓	
93				OUTSEL3		RW	✓	
94				OUTSEL4		RW	✓	
95				OUTSEL5		RW	✓	
96				OUTSEL6		RW	✓	
97				OUTSEL7		RW	✓	
98				OUTSEL8		RW	✓	
99					Not used			
100								

Table E1.6 Process Data

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
101	301	501	701	PVIN	Input process value	RO	—	C3.
102	302	502	702	PV	Process value	RO	—	
103	303	503	703	CSP	Control set point	RO	—	C4.
104	304	504	704	HOUT	Control output	RO	—	C2. C7.1
105	305	505	705	COUT	Cooling control output	RO	—	
106	306	506	706	PIDNO	Current PID number	RO	—	C6.9
107	307	507	707	CSPNO	Current SP number	RO	—	C4.1
108	308	508	708	RUN.STUS	Operating status	RO	—	C10.
109	309	509	709	ALM.STUS	Alarm status	RO	—	C8.
110	310	510	710	ERR.STUS	Error status	RO	—	C10.
111	311	511	711	AT.STUS	Auto-tuning status	RO	—	C5.2
112	312	512	712		Not used			
113	313	513	713					
114	314	514	714					
115	315	515	715					
116	316	516	716					
117	317	517	717					
118	318	518	718					
119	319	519	719					
120	320	520	720					

Table E1.7 Operation Control Parameters

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
121	321	521	721	RUN/STP	Run/stop selection	RW	—	C7.1
122	322	522	722	A/M/C	Auto/manual/cascade selection	RW	—	C7.2 C7.4
123	323	523	723	INSEL	Input selection	RW	—	C3.11
124	324	524	724	RMT/LOC	Remote/local selection	RW	—	C7.3
125	325	525	725	EXPV/PV	External/normal input selection	RW	—	C3.12
126	326	526	726	EXOUT/OUT	External/normal output selection	RW	—	C2.6
127	327	527	727	AT	Start auto-tuning	RW	—	C5.2
128	328	528	728	SPNO	SP number selection	RW	—	C4.1
129	329	529	729		Not used			
130	330	530	730					
131	331	531	731	EXPV	External input	RW	—	C3.12
132	332	532	732	EXRJC	Reference junction temperature	RW	—	C3.6
133	333	533	733	RSP	Remote set point	RW	—	C4.2
134	334	534	734	MOUT	Manual output	RW	—	C7.2 C7.4
135	335	535	735	MOUTC	Manual cooling output	RW	—	
136	336	536	736	EXOUT	External output	RW	—	C2.6
137	337	537	737		Not used			
138	338	538	738					
139	339	539	739					
140	340	540	740					

Table E1.8 I/O Parameters

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
141	341	541	741	OT	Control type selection	RW	✓	C2.1
142	342	542	742	IN	Input type selection	RW	✓	C3.1
143	343	543	743	RH	Input range upper limit	RW	✓	C3.3
144	344	544	744	RL	Input range lower limit			
145	345	545	745	DEC.P	Decimal point position	RO	✓	
146	346	546	746	SH	Scaling upper limit	RW	✓	
147	347	547	747	SL	Scaling lower limit	RW	✓	
148	348	548	748	SDP	Scaling decimal point position	RW	✓	
149	349	549	749	RJC	Reference junction compensation	RW	✓	C3.6
150	350	550	750	BSL	Burnout selection	RW	✓	C3.5
151	351	551	751	PRH	PV range upper limit	RW	✓	C3.4
152	352	552	752	PRL	PV range lower limit	RW	✓	
153	353	553	753	PDP	PV range decimal point position	RW	✓	
154	354	554	754		Not used			
155	355	555	755					
156	356	556	756					
157	357	557	757					
158	358	558	758					
159	359	559	759					
160	360	560	760					

Table E1.9 Operation Parameters (1/3)

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
161	361	561	761	SELMD	Two-input changeover mode	RW	✓	C3.11
162	362	562	762	SELH	Two-input changeover upper limit	RW	✓	
163	363	563	763	SELL	Two-input changeover lower limit	RW	✓	
164	364	564	764	SPH	Upper SP limit	RW	✓	C4.3
165	365	565	765	SPL	Lower SP limit	RW	✓	
166	366	566	766	SPR.UP	SP up gradient	RW	✓	C4.4
167	367	567	767	SPR.DN	SP down gradient	RW	✓	
168	368	568	768	SPR.TM	SP gradient time unit	RW	✓	
169	369	569	769	SP.TR	SP tracking mode	RW	✓	C4.6
170	370	570	770		Not used			
171	371	571	771	BS	Fixed bias	RW	✓	C3.8
172	372	572	772	FL	Input filter	RW	✓	C3.10
173	373	573	773	X1	Broken-line input 1	RW	✓	C3.7
174	374	574	774	Y1	Broken-line bias 1	RW	✓	
175	375	575	775	X2	Broken-line input 2	RW	✓	
176	376	576	776	Y2	Broken-line bias 2	RW	✓	
177	377	577	777	X3	Broken-line input 3	RW	✓	
178	378	578	778	Y3	Broken-line bias 3	RW	✓	
179	379	579	779	SR	Square root extraction	RW	✓	C3.9
180	380	580	780	LC	Low-cut	RW	✓	
181	381	581	781	SELF	Dynamic auto-tuning enable	RW	✓	C5.1
182	382	582	782	SC	“Super” enable code	RW	✓	C6.7
183	383	583	783	ARW	ARW setting	RW	✓	C6.8
184	384	584	784	CMD	Control mode	RW	✓	C6.6
185	385	585	785	ZONE	Zone PID selection	RW	✓	C6.9
186	386	586	786	1RP	Reference point 1	RW	✓	C6.9.2
187	387	587	787	2RP	Reference point 2	RW	✓	C6.9.2
188	388	588	788	RHY	Zone switching hysteresis	RW	✓	
189	389	589	789	RDV	Reference deviation	RW	✓	
190	390	590	790		Not used			
191	391	591	791	CT	Cycle time	RW	✓	C2.4.2
192	392	592	792	CTc	Cooling cycle time	RW	✓	—
193	393	593	793	MVR	Rate-of-change limit	RW	✓	C2.4.2
194	394	594	794		Not used			
195	395	595	795					
196	396	596	796					
197	397	597	797					
198	398	598	798					
199	399	599	799					
200	400	600	800					

Table E1.9 Operation Parameters (2/3)

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
201	401	601	801	1.SP	Set point	RW	Irregular	B2.4 C4.1
202	402	602	802	1.A1	Alarm 1 preset value	RW	✓	C8.1
203	403	603	803	1.A2	Alarm 2 preset value	RW	✓	
204	404	604	804	1.A3	Alarm 3 preset value	RW	✓	
205	405	605	805	1.A4	Alarm 4 preset value	RW	✓	
206	406	606	806	1.PB	Proportional band	RW	✓	C6.2
207	407	607	807	1.TI	Integral time	RW	✓	C6.3
208	408	608	808	1.TD	Derivative time	RW	✓	C6.4
209	409	609	809	1.OH	Upper output limit	RW	✓	C2.4.2
210	410	610	810	1.OL	Lower output limit	RW	✓	
211	411	611	811	1.MR	Manual reset value	RW	✓	C6.3
212	412	612	812	1.HYS	ON/OFF control hysteresis	RW	✓	C2.4.1
213	413	613	813	1.DR	Forward/reverse switch	RW	✓	C6.1
214	414	614	814	1.GAIN.C	Cooling gain	RW	✓	C2.4.3
215	415	615	815	1.HYS.C	Cooling ON/OFF control hysteresis	RW	✓	C2.4.4
216	416	616	816	1.DB	Dead band	RW	✓	C2.4.3 C2.4.4
217	417	617	817	1.POUT	Preset output	RW	✓	C7.1
218	418	618	818	1.POUT.C	Cooling preset output	RW	✓	
219	419	619	819		Not used			
220	420	620	820					
221	421	621	821	2.SP	Set point	RW	Irregular	B2.4 C4.1
222	422	622	822	2.A1	Alarm 1 preset value	RW	✓	C8.1
223	423	623	823	2.A2	Alarm 2 preset value	RW	✓	
224	424	624	824	2.A3	Alarm 3 preset value	RW	✓	
225	425	625	825	2.A4	Alarm 4 preset value	RW	✓	
226	426	626	826	2.PB	Proportional band	RW	✓	C6.2
227	427	627	827	2.TI	Integral time	RW	✓	C6.3
228	428	628	828	2.TD	Derivative time	RW	✓	C6.4
229	429	629	829	2.OH	Upper output limit	RW	✓	C2.4.2
230	430	630	830	2.OL	Lower output limit	RW	✓	
231	431	631	831	2.MR	Manual reset value	RW	✓	C6.3
232	432	632	832	2.HYS	ON/OFF control hysteresis	RW	✓	C2.4.1
233	433	633	833	2.DR	Forward/reverse switch	RW	✓	C6.1
234	434	634	834	2.GAIN.C	Cooling gain	RW	✓	C2.4.3
235	435	635	835	2.HYS.C	Cooling ON/OFF control hysteresis	RW	✓	C2.4.4
236	436	636	836	2.DB	Dead band	RW	✓	C2.4.3 C2.4.4
237	437	637	837	2.POUT	Preset output	RW	✓	C7.1
238	438	638	838	2.POUT.C	Cooling preset output	RW	✓	
239	439	639	839		Not used			
240	440	640	840					

Irregular: You need to execute a specific procedure every time to update stored set point values.

Table E1.9 Operation Parameters (3/3)

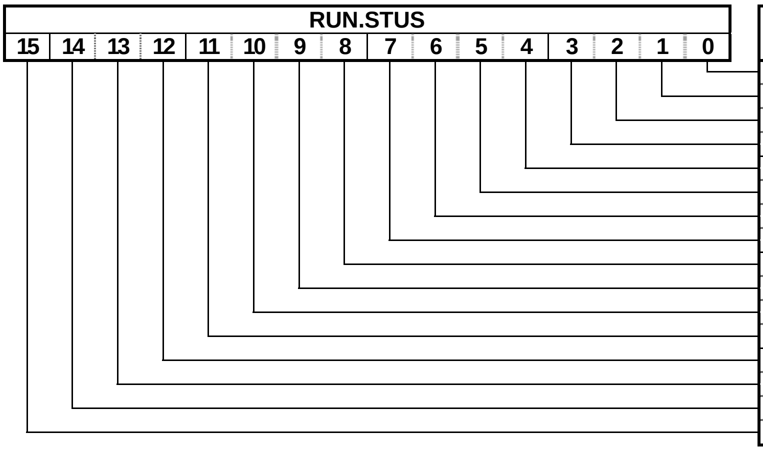
Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
241	441	641	841	3.SP	Set point	RW	Irregular	B2.4 C4.1
242	442	642	842	3.A1	Alarm 1 preset value	RW	✓	C8.1
243	443	643	843	3.A2	Alarm 2 preset value	RW	✓	
244	444	644	844	3.A3	Alarm 3 preset value	RW	✓	
245	445	645	845	3.A4	Alarm 4 preset value	RW	✓	
246	446	646	846	3.PB	Proportional band	RW	✓	C6.2
247	447	647	847	3.TI	Integral time	RW	✓	C6.3
248	448	648	848	3.TD	Derivative time	RW	✓	C6.4
249	449	649	849	3.OH	Upper output limit	RW	✓	C2.4.2
250	450	650	850	3.OL	Lower output limit	RW	✓	
251	451	651	851	3.MR	Manual reset value	RW	✓	C6.3
252	452	652	852	3.HYS	ON/OFF control hysteresis	RW	✓	C2.4.1
253	453	653	853	3.DR	Forward/reverse switch	RW	✓	C6.1
254	454	654	854	3.GAIN.C	Cooling gain	RW	✓	C2.4.3
255	455	655	855	3.HYS.C	Cooling ON/OFF control hysteresis	RW	✓	C2.4.4
256	456	656	856	3.DB	Dead band	RW	✓	C2.4.3 C2.4.4
257	457	657	857	3.POUT	Preset output	RW	✓	C7.1
258	458	658	858	3.POUT.C	Cooling preset output	RW	✓	
259	459	659	859		Not used			
260	460	660	860					
261	461	661	861	4.SP	Set point	RW	Irregular	B2.4 C4.1
262	462	662	862	4.A1	Alarm 1 preset value	RW	✓	C8.1
263	463	663	863	4.A2	Alarm 2 preset value	RW	✓	
264	464	664	864	4.A3	Alarm 3 preset value	RW	✓	
265	465	665	865	4.A4	Alarm 4 preset value	RW	✓	
266	466	666	866	4.PB	Proportional band	RW	✓	C6.2
267	467	667	867	4.TI	Integral time	RW	✓	C6.3
268	468	668	868	4.TD	Derivative time	RW	✓	C6.4
269	469	669	869	4.OH	Upper output limit	RW	✓	C2.4.2
270	470	670	870	4.OL	Lower output limit	RW	✓	
271	471	671	871	4.MR	Manual reset value	RW	✓	C6.3
272	472	672	872	4.HYS	ON/OFF control hysteresis	RW	✓	C2.4.1
273	473	673	873	4.DR	Forward/reverse switch	RW	✓	C6.1
274	474	674	874	4.GAIN.C	Cooling gain	RW	✓	C2.4.3
275	475	675	875	4.HYS.C	Cooling ON/OFF control hysteresis	RW	✓	C2.4.4
276	476	676	876	4.DB	Dead band	RW	✓	C2.4.3 C2.4.4
277	477	677	877	4.POUT	Preset output	RW	✓	C7.1
278	478	678	878	4.POUT.C	Cooling preset output	RW	✓	
279	479	679	879		Not used			
280	480	680	880					

Irregular: You need to execute a specific procedure every time to update stored set point values.

Table E1.10 Alarm-related Settings

Data Position Number				Symbol	Description	Attribute	Stored	See Also
Loop 1	Loop 2	Loop 3	Loop 4					
281	481	681	881	AL1	Alarm 1 type	RW	✓	C8.1
282	482	682	882	AL2	Alarm 2 type	RW	✓	
283	483	683	883	AL3	Alarm 3 type	RW	✓	
284	484	684	884	AL4	Alarm 4 type	RW	✓	
285	485	685	885	HY1	Alarm 1 hysteresis	RW	✓	C8.1
286	486	686	886	HY2	Alarm 2 hysteresis	RW	✓	
287	487	687	887	HY3	Alarm 3 hysteresis	RW	✓	
288	488	688	888	HY4	Alarm 4 hysteresis	RW	✓	
289	489	689	889	DLY1	Alarm 1 ON delay	RW	✓	C8.3
290	490	690	890	DLY2	Alarm 2 ON delay	RW	✓	
291	491	691	891	DLY3	Alarm 3 ON delay	RW	✓	
292	492	692	892	DLY4	Alarm 4 ON delay	RW	✓	
293	493	693	893		Not used			
294	494	694	894					
295	495	695	895					

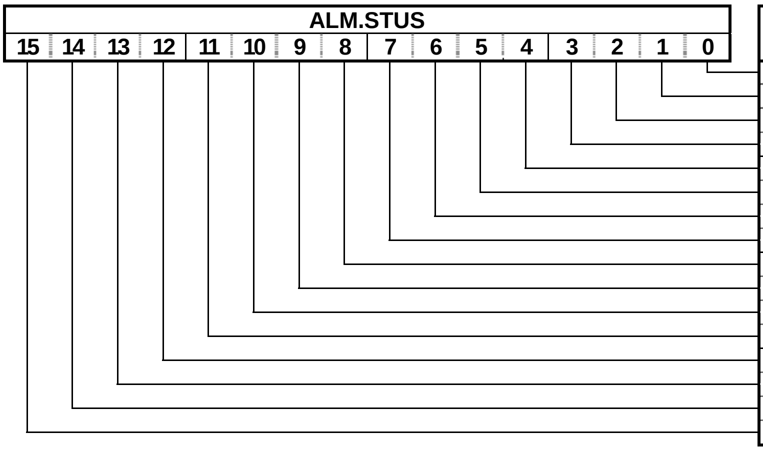
Table E1.11 Operating Status



Bit pos.	Symbol	Description
0	RUN/STP	0: Stop, 1: Run
1	AUT/MAN	0: Automatic, 1: Manual
2	CAS	1: Cascade
3	RMT/LOC	0: Remote, 1: Local
4	EXPV/PV	0: Normal, 1: External input
5	EXOUT/OUT	0: Normal, 1: External output
6	—	
7	—	
8	B.OUT	1: PVIN burnout
9	+OVER	1: PVIN +OVER
10	-OVER	1: PVIN –OVER
11	B.OUT	1: PV-burnout
12	+OVER	1: PV +OVER
13	–OVER	1: PV –OVER
14	—	
15	FUNC.ERR	1: Error detected

The data position number of RUN.STUS is 41 or 108 for loop1, 42 or 308 for loop2, 43 or 508 for loop3, and 44 or 708 for loop4.

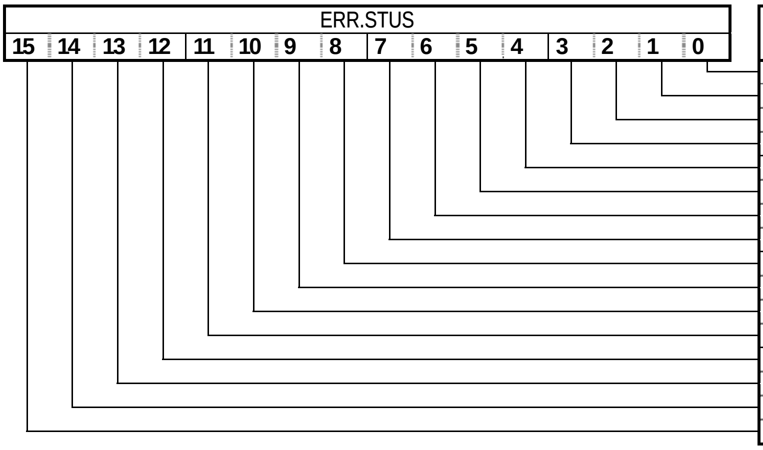
Table E1.12 Alarm Status



Bit pos.	Symbol	Description
0	ALM1	Alarm 1 generated
1	ALM2	Alarm 2 generated
2	ALM3	Alarm 3 generated
3	ALM4	Alarm 4 generated
4	ALMW1	Alarm 1 waiting
5	ALMW2	Alarm 2 waiting
6	ALMW3	Alarm 3 waiting
7	ALMW4	Alarm 4 waiting
8	—	
9	—	
10	—	
11	—	
12	—	
13	—	
14	—	
15	—	

The data position number of ALM.STUS is 109 for loop1, 309 for loop2, 509 for loop3, or 709 for loop4.

Table E1.13 Error Status



Bit pos.	Description
0	—
1	System data error
2	Calibration value error
3	Controller or I/O parameter error
4	Operation parameter error
5	AD converter error
6	RJC error
7	EEPROM error
8	—
9	—
10	—
11	—
12	—
13	—
14	—
15	—

The data position number of ERR.STUS is 51 or 110 for loop1, 52 or 310 for loop2, 53 or 510 for loop3, and 54 or 710 for loop4.

■ Common Precautions for Registers

CAUTION

In Tables E1.1 to E1.10, only data registers specified with symbol and description are valid data registers provided with this module. Data registers displayed with gray background or labeled as "not used" in the "Description" column are invalid.

Any data written to an invalid register is ignored, causing no adverse effect on module operation. If you read from such invalid registers, the written value or a register-specific value is returned. The register-specific value may or may not be a fixed value.

CAUTION

The “Attribute” column in a table indicates whether a register can be read and written. “RO” indicates a read-only register, whilst “RW” indicates a register that can be read, as well as written.

A “✓” mark in the “Stored” column indicates that the content of the register is stored, and need not be re-written to the module after power off and on. When changing the value of a stored register, beware, however, that there is a maximum limit to the number of write operations allowed on the EEPROM. By default, writing to a stored register updates the data stored in the EEPROM. To suspend this updating of the EEPROM, you should disable the backup function.

CAUTION

Up to 100,000 write operations to the EEPROM are allowed. Beware that this write limit may be exceeded if registers with a “✓” mark in the “Stored” column are frequently updated. In such situations, you should disable the backup function by setting “NBKUP=1”. Note, however, that the NBKUP register value itself is not stored, and is always reset to 0 at power up.

E2. List of Relays

Table E2.1 List of Relays

Input Relay Number X□□□nn				Symbol	Description	Interrupt	See Also
Loop 1	Loop 2	Loop 3	Loop 4				
X01	X09	X17	X25	ALM1.R	Alarm 1	✓	C8.
X02	X10	X18	X26	ALM2.R	Alarm 2	✓	
X03	X11	X19	X27	A/M	Auto/manual	—	B3.4
X04	X12	X20	X28	AT.RDY	Auto-tuning completed	✓	C5.2
X05	X13	X21	X29	HOUT.R	Heating control output	—	C2.4
X06	X14	X22	X30	COUT.R	Cooling control output	—	
X07	X15	X23	X31	FUNC.ERR	Burnout or error detected	✓	C3.5 C10.
X08				CMDRDY	Command processing completed	✓	B2.3
X16				MDLRDY	Module startup completed	✓	B1.3
X24				SETUP.R	Setup mode	✓	B2.3
X32				SPWR.R	Write SP to EEPROM completed	✓	B2.4

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FA-M3

Temperature Control and PID Module

IM 34M6H62-02E 2nd Edition

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