MITSUBISHI ELECTRIC

Programmable Controller

MELSEC iQ-R series

MELSEC iQ-R PID Control Function Block Library Reference

SAFETY PRECAUTIONS

(Read these precautions before using Mitsubishi Electric programmable controllers.)

Before using the products described under "Relevant products", please read this manual and the relevant manuals carefully and pay full attention to safety to handle the products correctly.

The precautions given in this manual are concerned with the products only. For the safety precautions of the programmable controller system, refer to the user's manual for the CPU module used and MELSEC iQ-R Module Configuration Manual.

In this manual, the safety precautions are classified into two levels: "⚠ WARNING" and "⚠ CAUTION".

⚠ **WARNING**	Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
⚠ **CAUTION**	Indicates that incorrect handling may cause hazardous conditions, resulting in minor or moderate injury or property damage.

Under some circumstances, failure to observe the precautions given under "⚠ CAUTION" may lead to serious consequences.

Observe the precautions of both levels because they are important for personal and system safety.

Make sure that the end users read this manual and then keep the manual in a safe place for future reference.

CONDITIONS OF USE FOR THE PRODUCT

(1) MELSEC programmable controller ("the PRODUCT") shall be used in conditions;
i) where any problem, fault or failure occurring in the PRODUCT, if any, shall not lead to any major or serious accident; and
ii) where the backup and fail-safe function are systematically or automatically provided outside of the PRODUCT for the case of any problem, fault or failure occurring in the PRODUCT.

(2) The PRODUCT has been designed and manufactured for the purpose of being used in general industries.
MITSUBISHI ELECTRIC SHALL HAVE NO RESPONSIBILITY OR LIABILITY (INCLUDING, BUT NOT LIMITED TO ANY AND ALL RESPONSIBILITY OR LIABILITY BASED ON CONTRACT, WARRANTY, TORT, PRODUCT LIABILITY) FOR ANY INJURY OR DEATH TO PERSONS OR LOSS OR DAMAGE TO PROPERTY CAUSED BY the PRODUCT THAT ARE OPERATED OR USED IN APPLICATION NOT INTENDED OR EXCLUDED BY INSTRUCTIONS, PRECAUTIONS, OR WARNING CONTAINED IN MITSUBISHI ELECTRIC USER'S, INSTRUCTION AND/OR SAFETY MANUALS, TECHNICAL BULLETINS AND GUIDELINES FOR the PRODUCT.
("Prohibited Application")
Prohibited Applications include, but not limited to, the use of the PRODUCT in;
- Nuclear Power Plants and any other power plants operated by Power companies, and/or any other cases in which the public could be affected if any problem or fault occurs in the PRODUCT.
- Railway companies or Public service purposes, and/or any other cases in which establishment of a special quality assurance system is required by the Purchaser or End User.
- Aircraft or Aerospace, Medical applications, Train equipment, transport equipment such as Elevator and Escalator, Incineration and Fuel devices, Vehicles, Manned transportation, Equipment for Recreation and Amusement, and Safety devices, handling of Nuclear or Hazardous Materials or Chemicals, Mining and Drilling, and/or other applications where there is a significant risk of injury to the public or property.

Notwithstanding the above restrictions, Mitsubishi Electric may in its sole discretion, authorize use of the PRODUCT in one or more of the Prohibited Applications, provided that the usage of the PRODUCT is limited only for the specific applications agreed to by Mitsubishi Electric and provided further that no special quality assurance or fail-safe, redundant or other safety features which exceed the general specifications of the PRODUCTs are required. For details, please contact the Mitsubishi Electric representative in your region.

(3) Mitsubishi Electric shall have no responsibility or liability for any problems involving programmable controller trouble and system trouble caused by DoS attacks, unauthorized access, computer viruses, and other cyberattacks.

INTRODUCTION

Thank you for purchasing the Mitsubishi Electric MELSEC iQ-R series programmable controllers.
This manual describes the module function blocks for the PID control function block library listed below.
Before using the products, please read this manual and the relevant manuals carefully and develop familiarity with the functions and performance of the MELSEC iQ-R series programmable controller to handle the products correctly.
When applying the program examples provided in this manual to an actual system, ensure the applicability and confirm that it will not cause system control problems.
Please make sure that the end users read this manual.

CONTENTS

RELEVANT MANUALS

Manual name [manual number]	Description	Available form
MELSEC iQ-R CPU Module User's Manual (Startup) [SH-081263ENG]	Specifications, procedures before operation, and troubleshooting of the CPU module	Print book
		e-Manual PDF
MELSEC iQ-R CPU Module User's Manual (Application) [SH-081264ENG]	Memory, functions, devices, and parameters of the CPU module	Print book
		e-Manual PDF
MELSEC iQ-R Programming Manual (Program Design) [SH-081265ENG]	Program specifications (ladder, ST, FBD/LD, and SFC programs)	e-Manual PDF
MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks) [SH-081266ENG]	Instructions for the CPU module and standard functions/function blocks	e-Manual PDF
MELSEC iQ-R Channel Isolated Thermocouple Input Module/ Channel Isolated RTD Input Module User's Manual (Startup) [SH-081493ENG]	System configuration, specifications, procedures before operation, wiring, and operation examples of the channel isolated thermocouple input module and channel isolated RTD input module	Print book
		e-Manual PDF
MELSEC iQ-R Channel Isolated Thermocouple Input Module/ Channel Isolated RTD Input Module User's Manual (Application) [SH-081495ENG]	Functions, parameter settings, I/O signals, buffer memory, and troubleshooting of the channel isolated thermocouple input module and channel isolated RTD input module	Print book
		e-Manual PDF
MELSEC iQ-R Digital-Analog Converter Module User's Manual (Startup) [SH-081235ENG]	Specifications, procedures before operation, wiring, operation examples, and offset/gain setting of the D/A converter module	Print book
		e-Manual PDF
MELSEC iQ-R Digital-Analog Converter Module User's Manual (Application) [SH-081237ENG]	Functions, parameter settings, troubleshooting, I/O signals, and buffer memory of the D/A converter module	Print book
		e-Manual PDF
MELSEC iQ-R I/O Module User's Manual [SH-081247ENG]	Specifications, procedures before operation, system configuration, wiring, functions, and troubleshooting of the I/O module	Print book
		e-Manual PDF

Point

e-Manual refers to the Mitsubishi Electric FA electronic book manuals that can be browsed using a dedicated tool.

e-Manual has the following features:

- Required information can be cross-searched in multiple manuals.
- Other manuals can be accessed from the links in the manual.
- The hardware specifications of each part can be found from the product figures.
- Pages that users often browse can be bookmarked.
- Sample programs can be copied to an engineering tool.

TERMS

Unless otherwise specified, this manual uses the following terms.

Term	Description
Buffer memory	Memory in an intelligent function module to store data such as setting values and monitor values. For CPU modules, it refers to memory to store data such as setting values and monitor values of the Ethernet function, or data used for data communication of the multiple CPU system function.
Engineering tool	A tool used for setting up programmable controllers, programming, debugging, and maintenance.
Global label	A label that is valid for all the program data when multiple program data are created in the project. There are two types of global label: a module specific label (module label), which is generated automatically by GX Works3, and an optional label, which can be created for any specified device.
Module label	A label that represents one of memory areas (I/O signals and buffer memory areas) specific to each module in a given character string. For the module used, GX Works3 automatically generates this label, which can be used as a global label.

GENERIC TERMS AND ABBREVIATIONS

Unless otherwise specified, this manual uses the following generic terms and abbreviations.

Generic term/abbreviation	Description
Analog-digital converter module FB	A MELSEC iQ-R series analog-digital converter module FB
CPU module	RnCPU, RnENCPU
Digital-analog converter module	A MELSEC iQ-R series digital-analog converter module
Output module	A MELSEC iQ-R series output module
Power supply module	A MELSEC iQ-R series power supply module
RnCPU	R00CPU, R01CPU, R02CPU, R04CPU, R08CPU, R16CPU, R32CPU, R120CPU
RnENCPU	R04ENCPU, R08ENCPU, R16ENCPU, R32ENCPU, R120ENCPU
Temperature input module	A MELSEC iQ-R series temperature input module

1 OVERVIEW

The FB library in this manual performs PID control by combining the analog module or temperature input module with the digital-analog converter module or output module.

1.1 Function Block (FB) List

The following table lists the FBs for the FB library in this manual.
An FB name ends in the FB version information such as "_00A"; however, this reference manual leaves it out.

FB name	FB details
M+PIDCtrl_PIDControl_R	Calculates the PID constants by auto tuning, and executes the velocity two-degree-of-freedom PID operation (inexact differential).
M+PIDCtrl_PIDOperation_R	Calculates the PID constants by auto tuning, and executes the velocity process-value differential PID operation (inexact differential).

Specifications

Item			M+PIDCtrl_PIDControl_R	M+PIDCtrl_PIDOperation_R
PID operation method			Velocity two-degree-of-freedom PID operation (inexact differential)	Velocity process-value differential PID operation (inexact differential)
Control cycle/sampling time			0.5 to 100.0s	1 to 32767ms
Function	Auto tuning		Available	Available
	Warning output		Available	Available (only for input variation warning and output variation warning)
	Manual output		Available	Available
	Limiter	Set value	Upper limit limiter, lower limit limiter, and variation rate limiter	Upper limit limiter and lower limit limiter
		Manipulated value	Upper limit limiter, lower limit limiter, and variation amount limiter	Upper limit limiter and lower limit limiter

1.2 How to Obtain

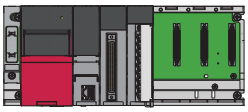
For the FB library, please consult your local Mitsubishi representative.
For how to register the FB library, refer to the 📖 GX Works3 Operating Manual.

1.3 System Configuration

This section describes system configuration examples for using the FB library in this manual.

When using SCR (thyristor)

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



(1) Power supply module
(2) CPU module
(3) Analog-digital converter module or temperature input module
(4) Digital-analog converter module

When using SSR (solid state relay)

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

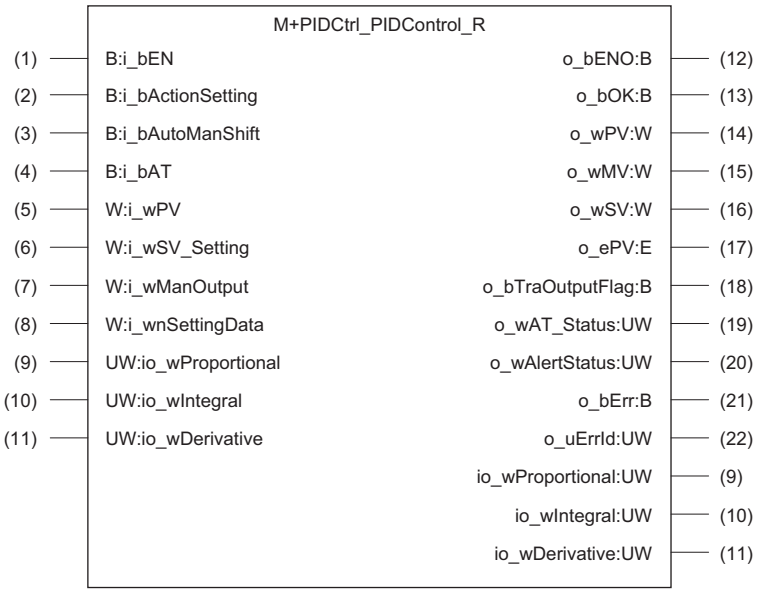
(1) Power supply module
(2) CPU module
(3) Analog-digital converter module or temperature input module
(4) Output module

2 DETAILS

This chapter describes the details of each FB library.

2.1 M+PIDCtrl_PIDControl_R

Overview

Item	Description
Name	M+PIDCtrl_PIDControl_R
Functional overview	Calculates the PID constants by auto tuning, and executes the velocity two-degree-of-freedom PID operation (inexact differential).
Symbol	

Labels to use

Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_bActionSetting	Direct/reverse action setting	Bit	On or off	Sets whether to use the FB with direct actions or reverse actions. • On: Direct action (cooling control) • Off: Reverse action (heating control)
(3)	i_bAutoManShift	AUTO/MAN mode shift	Bit	On or off	Selects AUTO (automatic) mode or MAN (manual) mode. • Off: AUTO mode. The manipulated value (MV) is automatically calculated by PID control. • On: MAN mode. The manipulated value (MV) is manually set by i_wManOutput (MAN output setting).
(4)	i_bAT	Starting/stopping the auto tuning	Bit	On or off	On: Auto tuning starts. Off: Auto tuning stops.
(5)	i_wPV	Process value (PV)	Word [Signed]	-32768 to 32767	Sets the process value (PV) detected by the analog-digital converter module or temperature input module. Example: Set U0\G400 in the following case. • Module used: R60RD8-G • Start I/O number: H00 • Process value used for control: CH1 Temperature process value The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
(6)	i_wSV_Setting	Set value (SV) setting	Word [Signed]	-32768 to 32767	Sets the set value (SV) in the PID control. The setting value should be within the range of the upper limit setting limiter value and the lower limit setting limiter value of i_wnSettingData (setting data).
(7)	i_wManOutput	MAN output setting	Word [Signed]	0 to 1000 (0.0 to 100.0%)	Sets the manipulated value (MV) in the MAN mode. This FB is enabled when i_bAutoManShift (AUTO/MAN mode shift) is set to On: MAN mode.
(8)	i_wnSettingData	Setting data	Word [Signed] (0..23)	☞ Page 9 Setting data	Specifies the start address in which the setting data is stored. The parameters required for PID operation and auto tuning are set in the setting data.

■Setting data

Offset	Name	Data type	Scope	Description
+0	Control output cycle setting	Word [Signed]	5 to 1000 (0.5s to 100.0s)	Sets the pulse cycle (ON/OFF cycle) of the transistor output. • ON time of the control output cycle = Control output cycle × manipulated value (MV) (%) calculated by a PID operation When the manipulated value (MV) is stable, pulses are repeatedly output in the same cycle.
+1	Upper limit value of the input range	Word [Signed]	-32768 to 32767	Sets the upper limit value of the input range of the control target. Example: Set 8500 or less in the following case. • Module used: R60RD8-G • Resistance temperature detector type setting: Pt100 (-200 to 850℃) The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
+2	Lower limit value of the input range	Word [Signed]	-32768 to 32767	Sets the lower limit value of the input range of the control target. Example: Set -2000 or greater in the following case. • Module used: R60RD8-G • Resistance temperature detector type setting: Pt100 (-200 to 850℃) The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
+3	Upper limit output limiter	Word [Signed]	-50 to 1050 (-5.0 to 105.0%)	Sets the upper limit value for actually outputting the manipulated value (MV) calculated by the PID operation to an external device. Set values so that the lower limit output limiter value is smaller than the upper limit output limiter value.
+4	Lower limit output limiter	Word [Signed]	-50 to 1050 (-5.0 to 105.0%)	Sets the lower limit value for actually outputting the manipulated value (MV) calculated by the PID operation to an external device. Set values so that the lower limit output limiter value is smaller than the upper limit output limiter value.

Offset	Name	Data type	Scope	Description
+5	Upper limit setting limiter	Word [Signed]	-32768 to 32767	Sets the upper limit value of the set value (SV) setting. Set values so that the lower limit setting limiter value is smaller than the upper limit setting limiter value. The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
+6	Lower limit setting limiter	Word [Signed]	-32768 to 32767	Sets the lower limit value of the set value (SV) setting. Set values so that the lower limit setting limiter value is smaller than the upper limit setting limiter value. The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
+7	Output variation amount limiter	Word [Signed]	0, 1 to 1000 (0.1% per control output cycle to 100% per control output cycle)	Sets the limit of the output variation amount per control output cycle to regulate a rapid change of the manipulated value (MV). When 0 is set, the output variation amount is not regulated.
+8	Setting variation rate limiter	Word [Signed]	0, 1 to 1000 (0.1% per control output cycle to 100% per control output cycle)	Sets the variation rate of the set value (SV) per control output cycle to regulate a rapid change of the manipulated value (MV). When 0 is set, the setting variation rate is not regulated.
+9	Warning 1 mode setting	Word [Signed]	0 to 11, 25 to 32	Sets the warning mode for Warning 1. 0: No warning 1: Upper limit input warning 2: Lower limit input warning 3: Upper limit deviation warning 4: Lower limit deviation warning 5: Upper/lower limit deviation warning 6: Within-range warning 7: Upper limit input warning with wait 8: Lower limit input warning with wait 9: Upper limit deviation warning with wait 10: Lower limit deviation warning with wait 11: Upper/lower limit deviation warning with wait 25: Input variation (increase side) warning 26: Input variation (decrease side) warning 27: Output variation (increase side) warning 28: Output variation (decrease side) warning 29: Input variation (increase side) warning with wait 30: Input variation (decrease side) warning with wait 31: Output variation (increase side) warning with wait 32: Output variation (decrease side) warning with wait
+10	Warning 2 mode setting	Word [Signed]	0 to 11, 25 to 32	Sets the warning mode for Warning 2. The setting values are the same as for the warning 1 mode setting.
+11	Warning 3 mode setting	Word [Signed]	0 to 11, 25 to 32	Sets the warning mode for Warning 3. The setting values are the same as for the warning 1 mode setting.
+12	Warning 4 mode setting	Word [Signed]	0 to 11, 25 to 32	Sets the warning mode for Warning 4. The setting values are the same as for the warning 1 mode setting.
+13	Warning set value 1	Word [Signed]	Refer to the right column.	Sets the warning set value for Warning 1. In the warning state, b0 in o_wAlertStatus (warning status) turns on. ■Effective range when the warning 1 mode setting is 1 to 4 or 7 to 10 -32768 to 32767 ■Effective range when the warning 1 mode setting is 5, 6, 11, or 25 to 32 0 to 32767
+14	Warning set value 2	Word [Signed]	Refer to the right column.	Sets the warning set value for Warning 2. In the warning state, b1 in o_wAlertStatus (warning status) turns on. ■Effective range when the warning 2 mode setting is 1 to 4 or 7 to 10 -32768 to 32767 ■Effective range when the warning 2 mode setting is 5, 6, 11, or 25 to 32 0 to 32767
+15	Warning set value 3	Word [Signed]	Refer to the right column.	Sets the warning set value for Warning 3. In the warning state, b2 in o_wAlertStatus (warning status) turns on. ■Effective range when the warning 3 mode setting is 1 to 4 or 7 to 10 -32768 to 32767 ■Effective range when the warning 3 mode setting is 5, 6, 11, or 25 to 32 0 to 32767

Offset	Name	Data type	Scope	Description
+16	Warning set value 4	Word [Signed]	Refer to the right column.	Sets the warning set value for Warning 4. In the warning state, b3 in o_wAlertStatus (warning status) turns on. ■Effective range when the warning 4 mode setting is 1 to 4 or 7 to 10 -32768 to 32767 ■Effective range when the warning 4 mode setting is 5, 6, 11, or 25 to 32 0 to 32767
+17	Warning dead band setting	Word [Signed]	0, 1 to 100 (0.1% to 10.0%)	This setting is for the dead band when using a warning. Use this function to activate danger signals of devices or safety devices. When 0 is set, the warning dead band setting is not made.
+18	Timeout time for AT	Word [Signed]	0 to 7200 (0s to 7200s)	Sets the auto tuning timeout time.
+19	Auto tuning control type setting	Word [Signed]	0 to 3	Determines the calculation method of PID control parameters for the auto tuning. 0: Constant-value PI control 1: Constant-value PID control 2: Variable-value PI control 3: Variable-value PID control
+20	Two-degree-of-freedom parameter α	Word [Signed]	0 to 100 (0.00 to 1.00)	Sets the feedforward proportional value for the two-degree-of-freedom PID control. When a larger value is set as α, the effect of the proportion to the set value change reduces.
+21	Two-degree-of-freedom parameter β	Word [Signed]	0 to 100 (0.00 to 1.00)	Sets the feedforward differential value for the two-degree-of-freedom PID control. When a smaller value is set as β, the effect of the differentiation to the set value change increases.
+22	Decimal point position	Word [Signed]	-1, 0, 1	Sets the decimal point position. ■-1: Decimal point position setting is not available. When -1 is set, 0 (fixed value) is stored in o_ePV (process value (℃/℉)). ■0: The process value (PV) is set with no digits beyond the decimal point. When the process value (PV) is 10, o_ePV (process value (℃/℉)) is 10. ■1: The process value (PV) is set to the first decimal place. When the process value (PV) is 10, o_ePV (process value (℃/℉)) is 1.0. Example: Set 1 in the following case. • Module used: R60RD8-G • Resistance temperature detector type setting: Pt100 (-200 to 850℃)
+23	Timer limit setting	Word [Signed]	1 to 10000 (0.01ms to 100.00ms)	Sets the transistor output timer unit. Example: Set 1000 in the following case. • Timer limit setting (high-speed timer/high-speed retentive timer) for "Operation Related Setting" in "CPU Parameter": 10.00ms

Input/output labels

No.	Variable name	Name	Data type	Initial value	Description
(9)	io_wProportional	Proportional band (P)	Word [Signed]	1 to 10000 (0.1% to 1000.0%)	Sets the proportional band (P) for the PID control. When using the PID constants calculated by the auto tuning performed with this FB, specify the same device for input and output.
(10)	io_wIntegral	Integral time (I)	Word [Signed]	0 to 3600 (0s to 3600s)	Sets the integral time (I) for the PID control. When using the PID constants calculated by the auto tuning performed with this FB, specify the same device for input and output.
(11)	io_wDerivative	Derivative time (D)	Word [Signed]	0 to 3600 (0s to 3600s)	Sets the derivative time (D) for the PID control. When using the PID constants calculated by the auto tuning performed with this FB, specify the same device for input and output.

Output labels

No.	Variable name	Name	Data type	Initial value	Description
(12)	o_bENO	Execution status	Bit	Off	On: The execution command is on. Off: The execution command is off.
(13)	o_bOK	Completed successfully	Bit	Off	The on state indicates that PID control is being performed.
(14)	o_wPV	Process value (PV)	Word [Signed]	0	The process value is stored.
(15)	o_wMV	Manipulated value (MV)	Word [Signed]	0	The results (unit: 0.1%) of the PID operation executed on the basis of the process value (PV) are stored. When i_bAutoManShift (AUTO/MAN mode shift) is set to On: MAN mode, the manipulated value (MV) set in i_wManOutput (MAN output setting) is set.
(16)	o_wSV	Set value (SV)	Word [Signed]	0	The set value is stored.
(17)	o_ePV	Process value (℃/℉)	Single-precision real number	0	The process value is stored. The stored value differs depending on the decimal point position set in i_wnSettingData (setting data). Example: When the process value (PV) is 10 • The decimal point position is set to 0: 10 is stored in o_ePV (process value (℃/℉)). • The decimal point position is set to 1: 1.0 is stored in o_ePV (process value (℃/℉)). • The decimal point position is set to -1: 0 (fixed) is stored in o_ePV (process value (℃/℉)).
(18)	o_bTraOutputFlag	Transistor output flag	Bit	Off	The on/off state of the transistor output are stored. Example: Set Y10 in the following case. • Module used: RY41NT2P • Start I/O number: H10 • Signal used for control: B20
(19)	o_wAT_Status	Auto tuning status	Word [Signed]	0	Indicates the auto tuning execution status. 0:Auto tuning not executed 1: Auto tuning executed 2: Auto tuning complete
(20)	o_wAlertStatus	Warning status	Word [Signed]	0	The b corresponding to the warning detected turns on. b0:Warning 1 has occurred. b1:Warning 2 has occurred. b2:Warning 3 has occurred. b3:Warning 4 has occurred. b4:The process value (PV) has exceeded the input range upper limit setting value in i_wnSettingData (setting data). b5: The process value (PV) has fallen below the input range lower limit setting value in i_wnSettingData (setting data). b6: The value set in i_wManOutput (MAN output setting) has exceeded 1000 (100.0%) or the upper limit output limiter value in i_wnSettingData (setting data). b7: The value set in i_wManOutput (MAN output setting) has fallen below 0 (0.0%) or the lower limit output limiter value in i_wnSettingData (setting data). b8: io_wProportional (proportional band (P)) has exceeded 10000 (1000.0%). b9: io_wProportional (proportional band (P)) has fallen below 1 (0.1%). b10: io_wIntegral (integral time (I)) has exceeded 3600 (3600s). b11: io_wIntegral (integral time (I)) has fallen below 0 (0s). b12: io_wDerivative (derivative time (D)) has exceeded 3600 (3600s). b13: io_wDerivative (derivative time (D)) has fallen below 0 (0s). b14: The auto tuning execution time has exceeded the timeout time for AT set in i_wnSettingData (setting data). b15: Though the auto tuning has been executed, the PID constants calculation value became out of the range.
(21)	o_bErr	Completed with an error	Bit	Off	The on state indicates that an error has occurred in the FB.
(22)	o_uErrId	Error code	Word [unsigned]	0	Returns the abnormal code that has occurred in the FB.

FB details

Item	Description
Target device	CPU module: RnCPU, RnENCPU Engineering tool: GX Works3 Version 1.045X or later
Language to use	— (The internal program of this FB is not disclosed.)
Number of steps	4248 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. Options setting of GX Works3: 📖 GX Works3 Operating Manual
Label usage	Label: 272 points [word] Latch label: 0K points [word] The label usage embedded in a program depends on the device specified as an argument and the options setting of GX Works3. Options setting of GX Works3: 📖 GX Works3 Operating Manual
Number of points used for index register	Index register: 0 points Long index register: 0 points
FB compilation method	Macro type
FB dependency	No dependency
FB operation	Arbitrary execution type

Automatic calculation of a manipulated value (MV) by PID control

Execute the PID control as shown below to calculate a manipulated value (MV) automatically.

1. Set the following input labels and turn on i_bEN (execution command).

- i_wPV (process value (PV))
- i_wSV_Setting (set value (SV) setting)
- i_wnSettingData (setting data) (☞ Page 9 Setting data)
- i_bActionSetting (direct/reverse action setting) (☞ Page 14 Switching direct/reverse action)

2. When executing the auto tuning, turn on the following input label. This FB executes the auto tuning and sets the PID constants.

- i_bAT (starting/stopping the auto tuning)

3. The PID operation is executed, and the manipulated value (MV) is output according to the following settings. (☞ Page 21 PID operation).

- Upper limit output limiter value, upper and lower limit output limiter values (☞ Page 19 Upper/lower limit output limiter)
- Upper limit setting limiter value, lower limit setting limiter value (☞ Page 20 Upper/lower limit setting limiter)
- Output variation amount limiter value (☞ Page 20 Output variation amount limiter)
- Setting variation rate limiter value (☞ Page 20 Setting variation rate limiter)
- On/off state of transistor output (☞ Page 21 Transistor output)

4. When the PID control is completed, o_bOK (completed successfully) turns on.

Point

- When i_bEN (execution command) turns on, i_bActionSetting (direct/reverse action setting) and i_wnSettingData (setting data) are read. Therefore, even if the setting is changed while i_bEN (execution command) is on, it will not be enabled.
- When the setting value of i_wnSettingData (setting data) is out of the range, o_bErr (completed with an error) turns on, the FB processing is discontinued, and the error code is stored in o_uErrId (error code) (☞ Page 24 Error code list).

Manual setting of a manipulated value (MV)

Set a manipulated value (MV) manually without using the PID control. (☞ Page 21 Manual output).

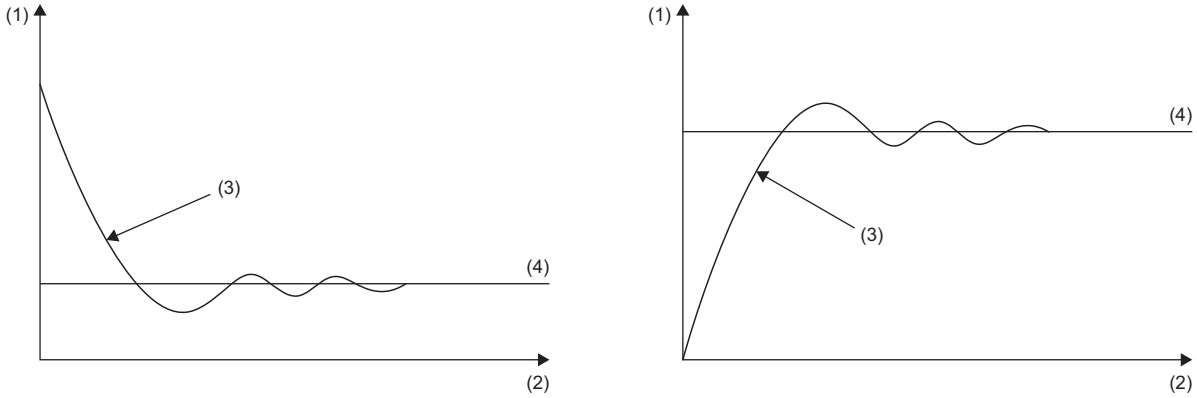
Description of each function

■Switching direct/reverse action

Set whether to use the FB with direct actions or reverse actions in i_bActionSetting (direct/reverse action setting).

- On: The direct action increases the manipulated value (MV) when the process value (PV) becomes greater than the set value (SV). This setting is used for cooling control.
- Off: The reverse action increases the manipulated value (MV) when the process value (PV) becomes smaller than the set value (SV). This setting is used for heating control.

The left figure shows the direct action (cooling control), and the right shows the reverse action (heating control).



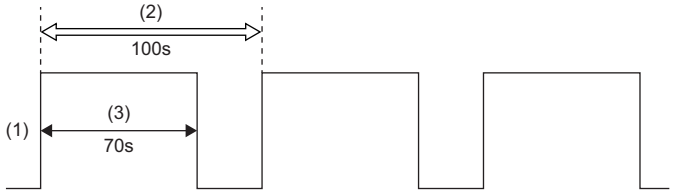
(1) Temperature
(2) Time
(3) Process value (PV)
(4) Set value (SV)

■Control output cycle setting

Set the pulse cycle (ON/OFF cycle) of the transistor output.

Ex.

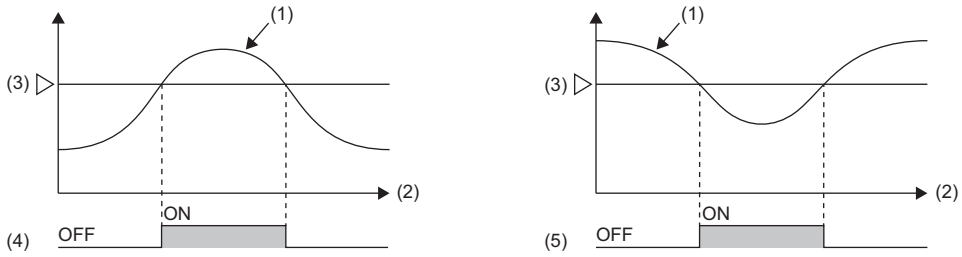
When the control cycle is set to 100s and the manipulated value (MV) is 700 (70.0%), the transistor output turns on for 70s and off for the remaining 30s per 100s. (When the manipulated value is constant, the on/off cycle is the same.)



(1) Transistor output
(2) Control output cycle
(3) Manipulated value (MV) range: 700 (70.0%)

■Upper limit input warning/lower limit input warning

When i_wPV (process value (PV)) becomes equal to or greater than (or equal to or smaller than, for reverse action) the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.
When i_wPV (process value (PV)) becomes smaller than the warning set value, o_wAlertStatus (warning status) automatically turns off.
The left figure shows the direct action (cooling control), and the right shows the reverse action (heating control).

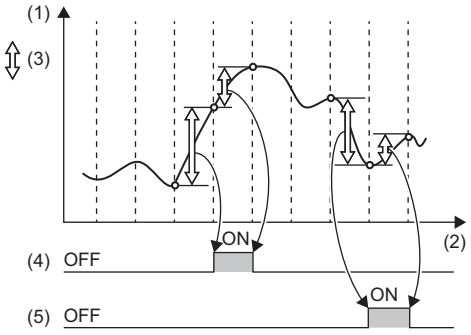


(1) Process value (PV)
(2) Time
(3) Warning set value
(4) Upper limit input warning: When the process value (PV) is equal to or greater than the warning set value, the warning status becomes active.
(5) Lower limit input warning: When the process value (PV) is equal to or smaller than the warning set value, the warning status becomes active.

■Input variation warning/output variation warning

• Input variation warning

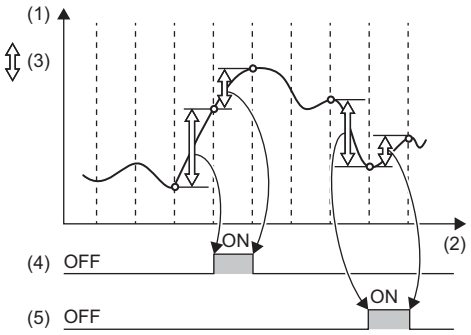
When i_wPV (process value (PV)) exceeds the variation set for the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.



(1) Process value (PV)
(2) Time
(3) Variation
(4) Input variation (increase side) warning
(5) Input variation (decrease side) warning

• Output variation warning

When o_wMV (manipulated value (MV)) exceeds the variation set for the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.

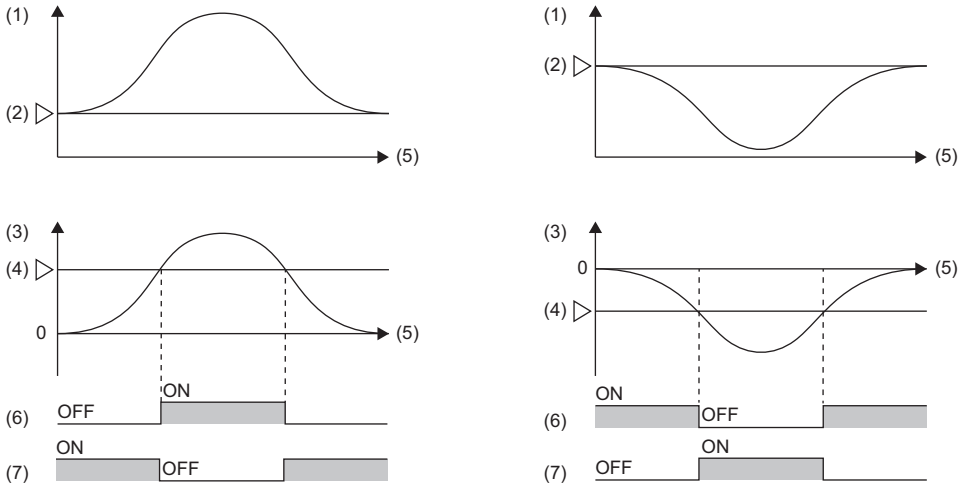


(1) Manipulated value (MV)
(2) Time
(3) Variation
(4) Output variation (increase side) warning
(5) Output variation (decrease side) warning

■Upper limit deviation warning/lower limit deviation warning

When the deviation (E) is equal to or greater than the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.

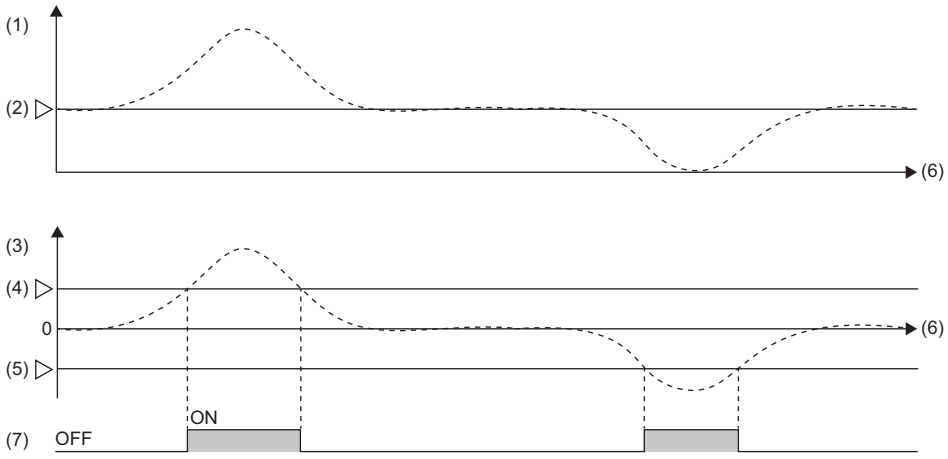
The left figure shows a case when the warning set value is positive, and the right figure shows when the value is negative.



(1) Process value (PV)
(2) Set value (SV)
(3) Deviation (E) = Process value (PV) - Set value (SV)
(4) Warning set value
(5) Time
(6) Upper limit deviation warning
(7) Lower limit deviation warning

■Upper/lower limit deviation warning

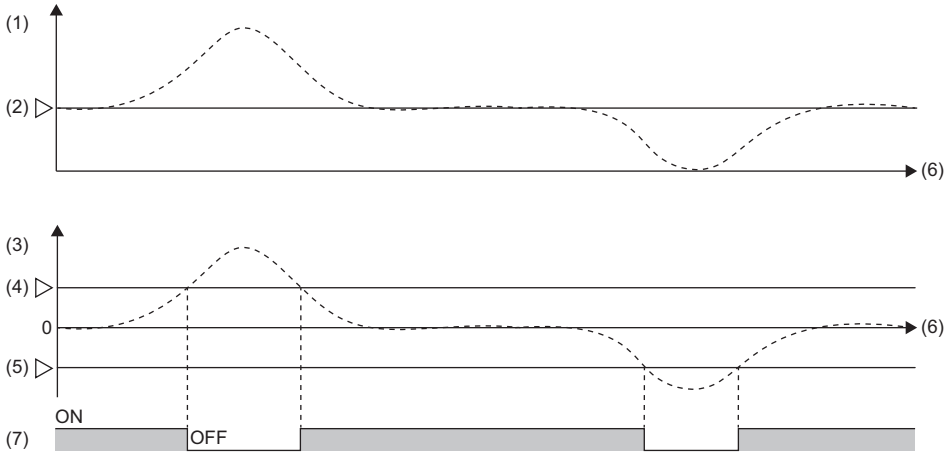
When the deviation (E) is equal to or greater than the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.



(1) Process value (PV)
(2) Set value (SV)
(3) Deviation (E) = Process value (PV) - Set value (SV)
(4) Warning set value
(5) -(Warning set value)
(6) Time
(7) Upper/lower limit deviation warning

■Within-range warning

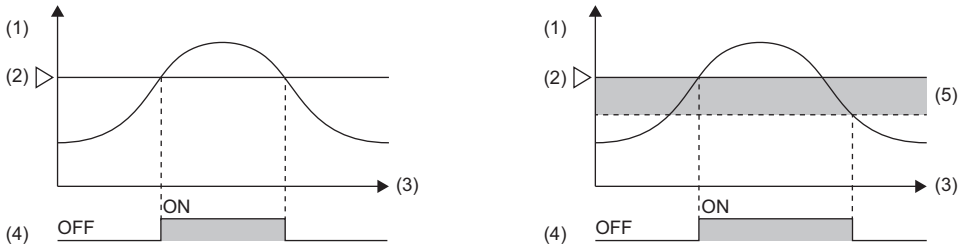
When the deviation (E) is within the warning set value range in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.



(1) Process value (PV)
(2) Set value (SV)
(3) Deviation (E) = Process value (PV) - Set value (SV)
(4) Warning set value
(5) -(Warning set value)
(6) Time
(7) Within-range warning

■Warning dead band

When i_wPV (process value (PV)) or the deviation (E) exceeds the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.
When the value falls below the warning dead band, the corresponding bit of o_wAlertStatus (warning status) turns off.
The left figure shows a case when the warning set value is 0 (0.0%), and the right figure shows when the value is other than 0 (0.0%).



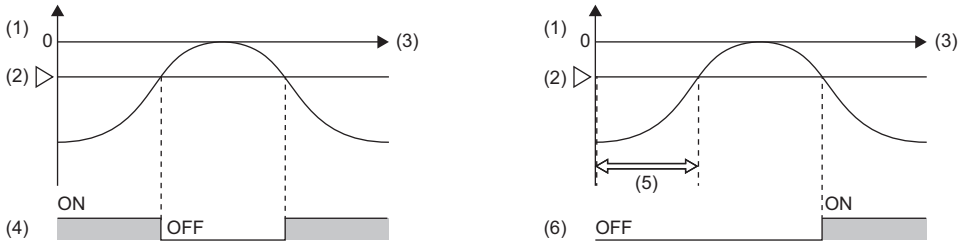
(1) Process value (PV)
(2) Warning set value
(3) Time
(4) Warning status
(5) Warning dead band

■Warning with standby

After i_bEN (execution command) turns on, the function is placed in a standby state, even if the process value (PV) or the deviation (E) is placed in a warning state, and then disables the warning.

Once the process value (PV) or the deviation (E) exits the warning state, the warning becomes enabled.

The left figure shows the lower limit deviation warning, and the right figure the lower limit deviation warning with standby.



(1) Deviation (E) = Process value (PV) - Set value (SV)
(2) Warning set value
(3) Time
(4) Lower limit deviation warning
(5) Standby operation area
(6) Lower limit deviation warning with standby

■Auto tuning

Automatically set the optimal PID constants. Set the calculation method of PID constants in the auto tuning control type setting in i_wnSettingData (setting data). The following table lists the control types.

Setting value	Control type	Description
0	Constant-value PI control	Improves responsiveness to disturbances.
1	Constant-value PID control	
2	Variable-value PI control	Suppresses overshoots at a change of the set value (SV).
3	Variable-value PID control	

- When i_bAT (starting/stopping the auto tuning) is on, auto tuning is performed. In this case, o_wAT_Status (auto tuning status) changes from 0 (auto tuning not executed) to 1 (auto tuning executed). After that, when auto tuning is completed, the value is set to 2 (auto tuning complete), regardless of normal completion or failure.
- When auto tuning is completed, the optimal io_wProportional (proportional band (P)), io_wIntegral (integral time (I)), and io_wDerivative (derivative time (D)) are output.
- During auto tuning, PID control and manual output are not performed.
- If an error is detected during auto tuning, the corresponding bit of o_wAlertStatus (warning status) turns on. (☞ Page 12 Output labels).
- When the auto tuning execution time exceeds the timeout time for AT, b14 of o_wAlertStatus (warning status) turns on. If this status occurs, set a longer timeout time for AT and execute the auto tuning again. Also, check the following, and if the error still cannot be solved, manually set the PID constants. Or, change the heater capacity.

Phenomenon	Action
The process value (PV) does not reach the set value (SV) when the control output turns on.	• Check the heater has been powered on. • Check the upper limit output limiter value. If the value is smaller than 100%, change the value.
The process value (PV) does not reach the set value (SV) when the control output turns off.	• Check the lower limit output limiter value. If the value is greater than 0%, change the value. • The temperatures of the controlled objects may not fall due to effects of the environment. Stop the control of the adjacent controlled objects, and execute the auto tuning on each controlled object.

- After the auto tuning is executed, if the PID constants calculation value becomes out of the range, b15 of o_wAlertStatus (warning status) turns on. If this status occurs, check the following items.

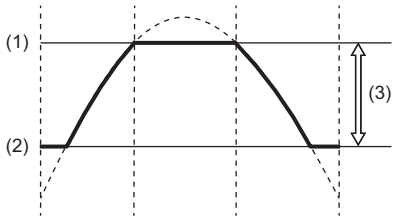
PID constants calculation value	Reason that the warning occurred	Action
Proportional band (P) < 1	The amplitude of the control response during auto tuning is small.	• Check the upper limit output limiter value. If the value is smaller than 100%, change the value. • Check the lower limit output limiter value. If the value is greater than 0%, change the value. • Change the input range lower limit and input range upper limit to narrow the measured temperature range.
Proportional band (P) > 10000	The amplitude of the control response during auto tuning is large.	Change the upper limit output limiter value and the lower limit output limiter value to reduce the amplitude of the control response during auto tuning.
Integral time (I) < 1	The oscillation period of the control response during auto tuning is short.	Set the upper limit output limiter value larger and the lower limit output limiter value smaller.
Integral time (I) > 3600	The oscillation period of the control response during auto tuning is long.	■When the process value (PV) does not decrease after exceeding the set value (SV) • Check the lower limit output limiter value. If the value is greater than 0%, change the value. • The temperatures of the controlled objects may not fall due to effects of the environment. Stop the control of the adjacent controlled objects, and execute the auto tuning on each controlled object. ■When the process value (PV) does not increase after exceeding the set value (SV) • Check the upper limit output limiter value. If the value is smaller than 100%, change the value.
Derivative time (D) > 3600	The oscillation period of the control response during auto tuning is long.	Set the integral time to 3600 or a smaller value.

■Upper/lower limit output limiter

Limit the upper limit and lower limit of o_wMV (manipulated value (MV)).

- When the manipulated value (MV) exceeds the upper limit output limiter, the manipulated value (MV) is corrected to the upper limit output limiter value.
- When the manipulated value (MV) falls below the lower limit output limiter, the manipulated value (MV) is corrected to the lower limit output limiter value.

Ex.



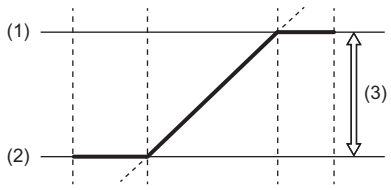
(1) Upper limit output limiter value: 95.0%
(2) Lower limit output limiter value: 10.0%
(3) Manipulated value (MV) range: 100 to 950 (10.0% to 95.0%)

■Upper/lower limit setting limiter

Limit the upper limit and lower limit of i_wSV_Setting (set value (SV) setting).

- When the set value (SV) exceeds the upper limit setting limiter, the set value (SV) is corrected to the upper limit setting limiter value.
- When the set value (SV) falls below the lower limit setting limiter, the set value (SV) is corrected to the lower limit setting limiter value.

Ex.



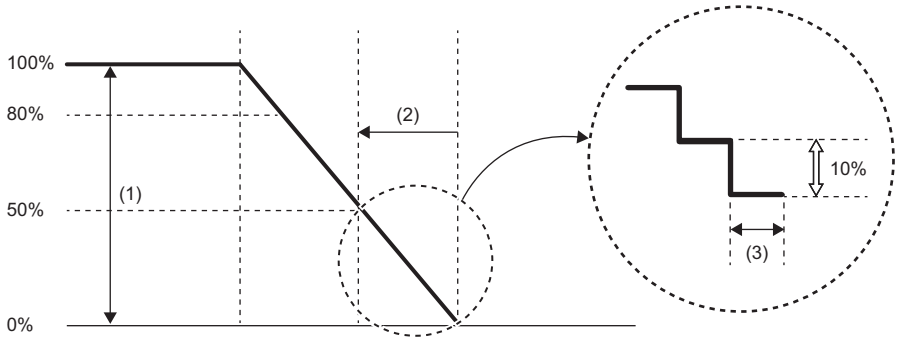
(1) Upper limit setting limiter value: 300.0℃
(2) Lower limit setting limiter value: 100.0℃
(3) Set value (SV) set value: 100.0℃ to 300.0℃

■Output variation amount limiter

Set the limit of the output variation amount per control output cycle to regulate a rapid change of the manipulated value (MV).

Ex.

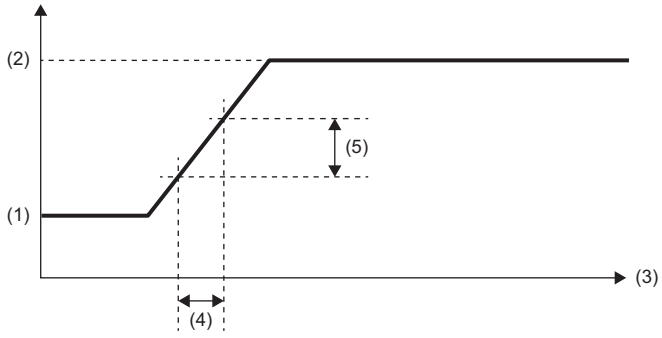
When the output variation limiter is set to 10%, even if the manipulated value (MV) changes suddenly, the variation amount is regulated to 10% per control output cycle.



(1) Manipulated value (MV)
(2) Manipulated value (MV) increased by 50%
(3) Control output cycle

■Setting variation rate limiter

Set the variation rate of the set value (SV) per control output cycle to regulate a rapid change of the set value (SV).



(1) Set value (SV) 1
(2) Set value (SV) 2
(3) Time
(4) Control output cycle
(5) Setting variation rate limiter (0% to 100% of full scale)

■PID operation

The PID operation is performed based on the values of i_wSV_Setting (set value (SV) setting), i_wPV (process value (PV)), io_wProportional (proportional band (P)), io_wIntegral (integral time (I)), and io_wDerivative (derivative time (D)), and o_wMV (manipulated value (MV)) is stored. When io_wProportional (proportional band (P)), io_wIntegral (integral time (I)), and io_wDerivative (derivative time (D)) are out of the range, the corresponding bit of o_wAlertStatus (warning status) turns on. When the value returns to within the range, the warning status automatically turns off.

■Transistor output

Perform transistor output to output o_bTraOutputFlag (transistor output flag) to the output device based on the control output cycle and o_wMV (manipulated value (MV)).

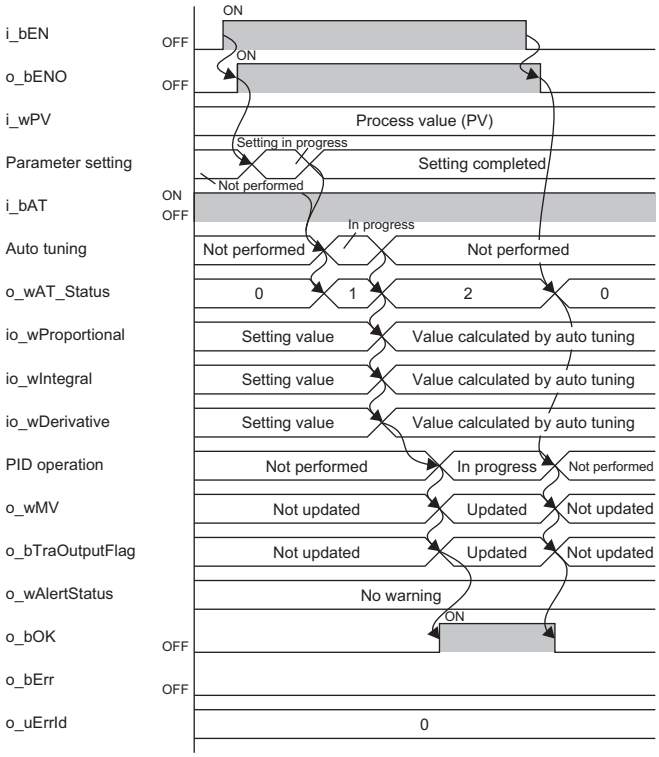
■Manual output

Set a manipulated value (MV) manually without using auto tuning or the PID operation. When i_bAutoManShift (AUTO/MAN mode shift) is set to On: MAN mode, manual output is performed according to i_wManOutput (MAN output setting), and a setting value is entered in o_wMV (manipulated value (MV)). When i_wManOutput (MAN output setting) is out of the range of the upper limit output limiter, lower limit output limiter, or the range of 0 (0.0%) to 1000 (100.0%), the corresponding bit of o_wAlertStatus (warning status) turns on. When the value returns to within the range, the warning status automatically turns off.

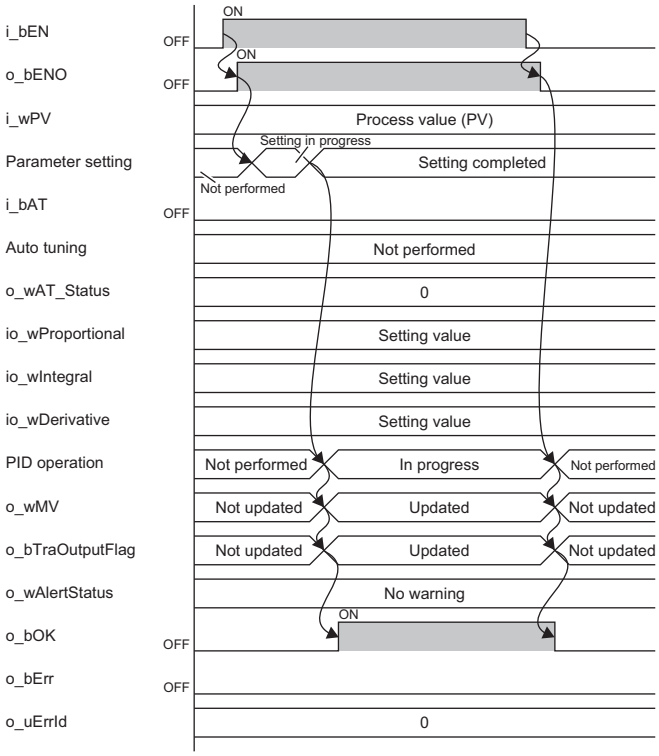
Timing chart of I/O signals

■When the operation is completed successfully

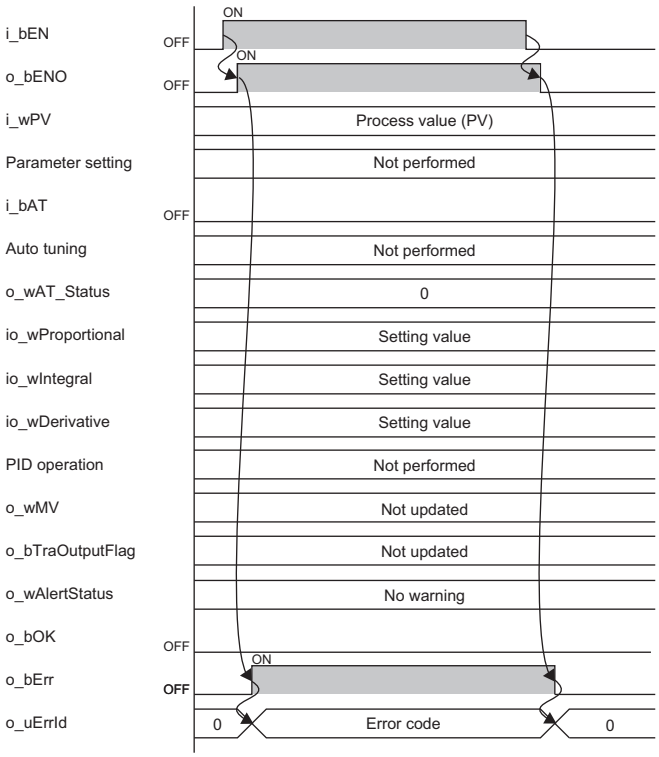
- When auto tuning is used



- When auto tuning is not used



■When the operation is completed with an error



Restrictions and precautions

- This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the system and the requested operation.
- Use this FB in a scan execution type program. When doing so, do not use the FB in the interrupt program that uses the interrupt pointer (I). For details on the execution type of the program, refer to the following.

📖 MELSEC iQ-R CPU Module User's Manual (Application)

- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (execution command).
- When CPU STOP occurs, the Y signal turns off. Write the program for the Y signal operated by o_bTraOutputFlag (transistor output flag) to ensure that the controlled device does not malfunction. Also, for the operation from CPU STOP to RUN, set the operation from the GX Works3 Navigation window ⇨ [Parameter] ⇨ Model of the CPU module ⇨ [CPU Parameter] ⇨ [Output Mode Setting at STOP to RUN] in [Operation Related Setting].
- For setting the output operation when a CPU stop error has occurred, from the GX Works3 Navigation window ⇨ [Parameter] ⇨ [Module Information] ⇨ Module model name ⇨ set [CPU error output mode setting] in [Module Parameter]. Also, for the operation at error occurrence in the CPU module, from the GX Works3 Navigation window ⇨ [Parameter] ⇨ Model of the CPU module ⇨ [CPU Parameter] ⇨ set [CPU Module Operation Setting at Error Detected] in [RAS Setting].
- The FB requires the configuration of the ladder block for every input label.
- Change the memory/device setting of the CPU parameter to the capacity required for using this FB. Failure to do so may cause an error in GX Works3.
- Make the setting that matches the connected device and system from the parameter setting on GX Works3. (📖 GX Works3 Operating Manual)
- The ON time of the transistor output is measured according to the setting value of the timer limit setting (high-speed timer/high-speed retentive timer) in i_wnSettingData (setting data). For the timer limit setting in i_wnSettingData (setting data), set the same value as the timer limit setting (high-speed timer/high-speed retentive timer) set from the GX Works3 Navigation window ⇨ [Parameter] ⇨ Model of the CPU module ⇨ [CPU Parameter] ⇨ [Operating Related Setting].

Error code

Error code list

Error code	Description	Action
0100H	Out of the control output cycle setting range. The control output cycle is set to a value other than 5 to 1000 (0.5s to 100.0s).	Set the control output cycle to a value between 5 and 1000 (0.5s to 100.0s). Review and correct the setting and then execute the FB again.
0101H	Out of the upper limit output limiter setting range. The upper limit output limiter is set to a value other than -50 to 1050 (-5.0% to 105.0%).	Set the upper limit output limiter to a value between -50 and 1050 (-5.0% to 105.0%). Review and correct the setting and then execute the FB again.
0102H	Out of the lower limit output limiter setting range. The lower limit output limiter is set to a value other than -50 to 1050 (-5.0% to 105.0%).	Set the lower limit output limiter to a value between -50 and 1050 (-5.0% to 105.0%). Review and correct the setting and then execute the FB again.
0103H	Out of the output variation limiter setting range. The output variation limiter is set to a value other than 0 to 1000.	Set the output variation limiter to a value between 0 and 1000. Review and correct the setting and then execute the FB again.
0104H	Out of the setting variation rate limiter setting range. The setting variation rate limiter is set to a value other than 0 to 1000.	Set the setting variation rate limiter to a value between 0 and 1000. Review and correct the setting and then execute the FB again.
0105H	Out of the warning 1 mode setting range. The warning 1 mode setting is set to a value other than 0 to 11 or 25 to 32.	Set the warning 1 mode setting to a value between 0 to 11 or 25 to 32. Review and correct the setting and then execute the FB again.
0106H	Out of the warning 2 mode setting range. The warning 2 mode setting is set to a value other than 0 to 11 or 25 to 32.	Set the warning 2 mode setting to a value between 0 to 11 or 25 to 32. Review and correct the setting and then execute the FB again.
0107H	Out of the warning 3 mode setting range. The warning 3 mode setting is set to a value other than 0 to 11 or 25 to 32.	Set the warning 3 mode setting to a value between 0 to 11 or 25 to 32. Review and correct the setting and then execute the FB again.
0108H	Out of the warning 4 mode setting range. The warning 4 mode setting is set to a value other than 0 to 11 or 25 to 32.	Set the warning 4 mode setting to a value between 0 to 11 or 25 to 32. Review and correct the setting and then execute the FB again.
0109H	Out of the warning set value 1 range. When the warning 1 mode setting is 5, 6, 11, or 25 to 32, the warning set value 1 is set to a value other than 0 to 32767.	Set the warning set value 1 to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
010AH	Out of the warning set value 2 range. When the warning 2 mode setting is 5, 6, 11, or 25 to 32, the warning set value 2 is set to a value other than 0 to 32767.	Set the warning set value 2 to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
010BH	Out of the warning set value 3 range. When the warning 3 mode setting is 5, 6, 11, or 25 to 32, the warning set value 3 is set to a value other than 0 to 32767.	Set the warning set value 3 to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
010CH	Out of the warning set value 4 range. When the warning 4 mode setting is 5, 6, 11, or 25 to 32, the warning set value 4 is set to a value other than 0 to 32767.	Set the warning set value 4 to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
010DH	Out of the warning dead band setting range. The warning dead band setting is set to a value other than 0 to 100 (0.0% to 10.0%).	Set the warning dead band setting to a value between 0 and 100 (0.0% to 10.0%). Review and correct the setting and then execute the FB again.
010EH	Out of the timeout time for AT setting range. The timeout time for AT is set to a value other than 0 to 7200 (0s to 7200s).	Set the timeout time for AT to a value between 0 and 7200 (0s to 7200s). Review and correct the setting and then execute the FB again.
010FH	Out of the auto tuning control type setting range. The auto tuning control type setting is set to a value other than 0 to 3.	Set the auto tuning control type setting to a value between 0 and 3. Review and correct the setting and then execute the FB again.
0110H	Out of the two-degree-of-freedom parameter α setting range. The two-degree-of-freedom parameter α is set to a value other than 0 to 100 (0.00 to 1.00).	Set the two-degree-of-freedom parameter α to a value between 0 and 100 (0.00 to 1.00). Review and correct the setting and then execute the FB again.
0111H	Out of the two-degree-of-freedom parameter β setting range. The two-degree-of-freedom parameter β is set to a value other than 0 to 100 (0.00 to 1.00).	Set the two-degree-of-freedom parameter β to a value between 0 and 100 (0.00 to 1.00). Review and correct the setting and then execute the FB again.
0112H	Out of the decimal point position range. The decimal point position is set to a value other than -1, 0, or 1.	Set the decimal point position to -1, 0, or 1. Review and correct the setting and then execute the FB again.
0113H	Out of the timer limit setting range. The timer limit setting is set to a value other than 1 to 10000 (0.01ms to 100.00ms).	Set the timer limit setting to a value between 1 and 10000 (0.01ms to 100.00ms). Review and correct the setting and then execute the FB again.
0200H	The upper limit output limiter value is equal to or smaller than the lower limit output limiter value.	Set the values so that the upper limit output limiter is larger than the lower limit output limiter. Review and correct the setting and then execute the FB again.

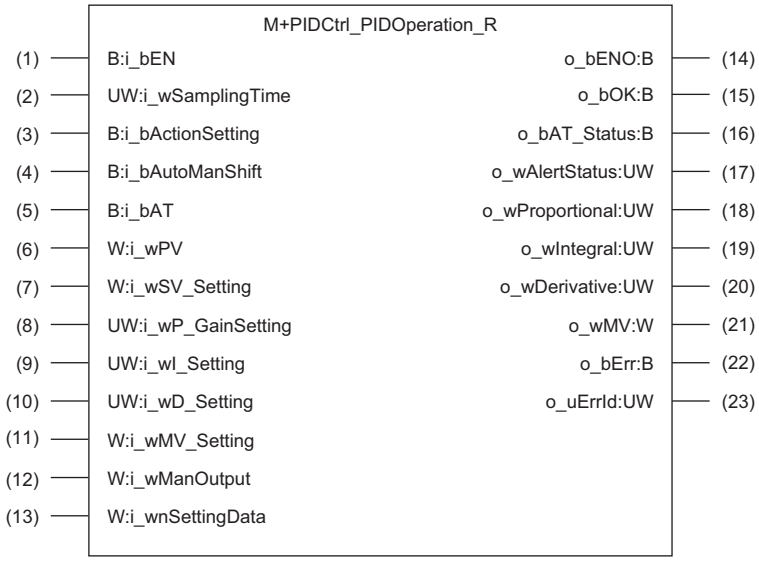
Error code	Description	Action
0201H	The upper limit setting limiter value is equal to or smaller than the lower limit setting limiter value.	Set the values so that the upper limit setting limiter is larger than the lower limit setting limiter. Review and correct the setting and then execute the FB again.
0202H	The input range upper limit value is equal to or smaller than the input range lower limit value.	Set the values so that the input range upper limit is larger than the input range lower limit. Review and correct the setting and then execute the FB again.
0203H	The input range upper limit value is smaller than the set value (SV).	Set the values so that the input range upper limit is equal to or larger than the set value (SV). Review and correct the setting and then execute the FB again.
0204H	The input range lower limit value is larger than the set value (SV).	Set the values so that the input range lower limit is equal to or smaller than the set value (SV). Review and correct the setting and then execute the FB again.

Version update history of the FB

Version	Date	Description
00	April 2021	Newly created
01	April 2024	The following problem was solved: when a warning set value of the input labels is a negative value, some of the errors are not checked.

2.2 M+PIDCtrl_PIDOperation_R

Overview

Item	Description
Name	M+PIDCtrl_PIDOperation_R
Functional overview	Calculates the PID constants by auto tuning, and executes the velocity process-value differential PID operation (inexact differential).
Symbol	

Labels to use

Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_wSamplingTime	Sampling time (TS)	Word [Signed]	1 to 32767 (1 to 32767ms)	Sets the cycle (ms) for the PID operation. It cannot be executed with a value shorter than the operation cycle of the CPU module.
(3)	i_bActionSetting	Direct/reverse action setting	Bit	On or off	Selects whether to use the FB with direct actions or reverse actions. • On: Direct action (cooling control) • Off: Reverse action (heating control)
(4)	i_bAutoManShift	AUTO/MAN mode shift	Bit	On or off	Selects AUTO (automatic) mode or MAN (manual) mode. • Off: AUTO mode. Calculate the manipulated value (MV) by the PID operation. • On: MAN mode. Set the manipulated value (MV) by i_wManOutput (MAN output setting).
(5)	i_bAT	Starting/stopping the auto tuning	Bit	On or off	On: Auto tuning starts. Off: Auto tuning stops.
(6)	i_wPV	Process value (PV)	Word [Signed]	-32768 to 32767	Sets the process value (PV) detected by the analog-digital converter module or temperature input module. Example: Set U0\G400 in the following case. • Module used: R60RD8-G • Start I/O number: H00 • Process value used for control: CH1 Temperature process value The measurement range differs depending on the parameter setting of the module used. (📖 User's manual for the module used)
(7)	i_wSV_Setting	Set value (SV) setting	Word [Signed]	-32768 to 32767	Sets the set value for the PID operation. However, when using the limit cycle method, if the set value for auto tuning differs from the set value for PID control, a value with an added bias value must be set, and the actual set value from when o_bAT_Status (auto tuning status) turns off must be stored.
(8)	i_wP_GainSetting	Proportional gain (P) setting	Word [Signed]	1 to 32767 (1 to 32767%)	Sets the proportional gain (P) for the PID operation.
(9)	i_wI_Setting	Integral time (I) setting	Word [Signed]	0 to 32767 (0 to 32767×100ms)	Sets the integral time (I) for the PID operation. When 0 is specified, it is treated as ∞. (No integration)
(10)	i_wD_Setting	Derivative time (D) setting	Word [Signed]	0 to 32767 (0 to 32767% × 10ms)	Sets the derivative time (D) for the PID operation. When 0 is specified, no deviation is used.
(11)	i_wMV_Setting	Manipulated value (MV) setting	Word [Signed]	-32768 to 32767	Sets the initial manipulated value for the PID operation. For normal processing, set the initial manipulated value. When using the step response method, set the step manipulated value.
(12)	i_wManOutput	MAN output setting	Word [Signed]	-32768 to 32767	Sets the manipulated value (MV) in the MAN mode. This FB is enabled when i_bAutoManShift (AUTO/MAN mode shift) is set to On: MAN mode.
(13)	i_wnSettingData	Setting data	Word [Signed] (0..12)	☞ Page 28 Setting data	Sets the parameters required for PID operation and auto tuning, and specifies the start address of that setting data.

■Setting data

Offset	Name	Data type	Scope	Description
+0	Action setting (ACT)	b0	On or off	Sets the input variation warning operation. Off: Disable On: Enable
		b1	On or off	Sets the output variation warning operation. Off: Disable On: Enable Do not turn on b1 and b2 simultaneously.
		b2	On or off	Sets the operation of the upper limit output limiter and lower limit output limiter. Off: Disable On: Enable Do not turn on b1 and b2 simultaneously.
		b3	On or off	Sets the operation of the upper limit setting limiter and lower limit setting limiter. Off: Disable On: Enable
		b4	On or off	Selects an auto tuning mode. Off: Step response method On: Limit cycle method
		b5 to b15		System area
+1	Input filter constant (α)	Word [Signed]	0 to 99 (0 to 99%)	Sets the input filter constant. When 0 is specified, no input filter is used.
+2	Derivative gain (KD)	Word [Signed]	0 to 100 (0 to 100%)	Sets the derivative gain (KD) for the PID control. When 0 is specified, no derivative gain is used.
+3	Input variation (increase side) warning set value	Word [Signed]	0 to 32767	Sets the input variation (increase side) warning set value. The FB is enabled when b0 for the action setting (ACT) is on.
+4	Input variation (decrease side) warning set value	Word [Signed]	0 to 32767	Sets the input variation (decrease side) warning set value. The FB is enabled when b0 for the action setting (ACT) is on.
+5	Output variation (increase side) warning set value	Word [Signed]	0 to 32767	Sets the output variation (increase side) warning set value. The FB is enabled when b1 for the action setting (ACT) is on and b2 is off.
	Upper limit output limiter		-32768 to 32767	Sets the upper limit output limiter value for the manipulated value (MV). The FB is enabled when b1 for the action setting (ACT) is off and b2 is on.
+6	Output variation (decrease side) warning set value	Word [Signed]	0 to 32767	Sets the output variation (decrease side) warning set value. The FB is enabled when b1 for the action setting (ACT) is on and b2 is off.
	Lower limit output limiter		-32768 to 32767	Sets the lower limit output limiter value for the manipulated value (MV). The FB is enabled when b1 for the action setting (ACT) is off and b2 is on.
+7	Upper limit setting limiter	Word [Signed]	-32768 to 32767	Sets the upper limit setting limiter value of the set value (SV) setting. The FB is enabled when b3 for the action setting (ACT) is on. Set values so that the lower limit setting limiter value is smaller than the upper limit setting limiter value. The measurement range differs depending on the parameter setting of the module used. For details, refer to the user's manual of the corresponding module.
+8	Lower limit setting limiter	Word [Signed]	-32768 to 32767	Sets the upper limit setting limiter value of the set value (SV) setting. The FB is enabled when b3 for the action setting (ACT) is on. Set values so that the lower limit setting limiter value is smaller than the upper limit setting limiter value. The measurement range differs depending on the parameter setting of the module used. For details, refer to the user's manual of the corresponding module.
+9	Threshold (hysteresis)	Word [Signed]	0 to 32767	Set the threshold (hysteresis) to prevent chattering of the process value (PV) during the auto tuning (limit cycle method).
+10	AT upper limit output limiter (ULV)	Word [Signed]	-32768 to 32767	Sets the upper limit value for the manipulated value (MV) during the auto tuning (limit cycle method).
+11	AT lower limit output limiter (LLV)	Word [Signed]	-32768 to 32767	Sets the lower limit value for the manipulated value (MV) during the auto tuning (limit cycle method).
+12	Wait setting parameter (KW)	Word [Signed]	-50 to 32717 (-50 to 32717%)	Sets the wait setting parameter from when the auto tuning (limit cycle method) is completed until the PID operation starts. During the wait, the AT lower limit output limiter (LLV) value is stored in the manipulated value (MV).

Output labels

No.	Variable name	Name	Data type	Initial value	Description
(14)	o_bENO	Execution status	Bit	Off	On: The execution command is on. Off: The execution command is off.
(15)	o_bOK	Completed successfully	Bit	Off	The on state indicates that PID control is being performed.
(16)	o_bAT_Status	Auto tuning status	Bit	Off	Indicates the auto tuning execution status. Off: Auto tuning has not been executed or is complete On: Auto tuning executed
(17)	o_wAlertStatus	Warning status	Word [Signed]	0	The bit corresponding to the warning detected turns on. b0: Input variation (increase side) warning b1: Input variation (decrease side) warning b2: Output variation (increase side) warning b3: Output variation (decrease side) warning b4 to b15 are system areas.
(18)	o_wProportional	Proportional gain (P)	Word [Signed]	0	Returns the proportional gain (P) for the PID operation.
(19)	o_wIntegral	Integral time (I)	Word [Signed]	0	Returns the integral time (I) for the PID operation.
(20)	o_wDerivative	Derivative time (D)	Word [Signed]	0	Returns the derivative time (D) for the PID operation.
(21)	o_wMV	Manipulated value (MV)	Word [Signed]	0	Stores the results of the PID operation executed on the basis of the process value (PV). ■When using the limit cycle method During the auto tuning, the AT upper limit output limiter (ULV) value or the AT lower limit output limiter (LLV) value is automatically output. The specified manipulated value is set after the auto tuning is completed. ■When using the step response method The manipulated value during the auto tuning is not changed by the FB. ■When in manual mode The manipulated value (MV) set in i_wManOutput (MAN output setting) is stored.
(22)	o_bErr	Completed with an error	Bit	Off	The on state indicates that an error has occurred in the FB.
(23)	o_uErrId	Error code	Word [unsigned]	0	Returns the abnormal code that has occurred in the FB.

FB details

Item	Description
Target device	CPU module: RnCPU and RnENCPU with firmware version 17 or later (For R00CPU, R01CPU, and R02CPU, all versions can be used.) Engineering tool: GX Works3 Version 1.045X or later
Language to use	Ladder diagram
Number of steps	422 steps (for the MELSEC iQ-R series) The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. Options setting of GX Works3: 📖 GX Works3 Operating Manual
Label usage	Label: 76 points [word] Latch label: 0K points [word] The label usage embedded in a program depends on the device specified as an argument and the options setting of GX Works3. Options setting of GX Works3: 📖 GX Works3 Operating Manual
Number of points used for index register	Index register: 0 points Long index register: 0 points
FB compilation method	Macro type
FB dependency	No dependency
FB operation	Arbitrary execution type

Automatic calculation of a manipulated value (MV) by PID control

Execute the PID control as shown below to calculate a manipulated value (MV) automatically.

In the PID operation of this FB, the PID operation instruction (PID) of the CPU module is used. For details, refer to the following.

📖 MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)

1. Set the following input labels and turn on i_bEN (execution command).

- i_wPV (process value (PV))
- i_wSV_Setting (set value (SV) setting)
- i_wnSettingData (setting data) (☞ Page 28 Setting data)
- i_bActionSetting (direct/reverse action setting) (☞ Page 31 Switching direct/reverse action)

2. When executing the auto tuning, turn on the following input label. This FB executes the auto tuning and sets the PID constants.

- i_bAT (starting/stopping the auto tuning)

3. The PID operation is executed, and the manipulated value (MV) is output according to the following settings. (☞ Page 40 PID operation).

- Upper limit output limiter value, lower limit output limiter value (☞ Page 34 Upper/lower limit output limiter)
- Upper limit setting limiter value, lower limit setting limiter value (☞ Page 34 Upper/lower limit setting limiter)

4. When the PID control is completed, o_bOK (completed successfully) turns on.

Point

- When i_bEN (execution command) turns on, i_wMV_Setting (manipulated value (MV) setting), i_bActionSetting (direct/reverse action setting) and i_wnSettingData (setting data) are read. Therefore, even if the setting is changed while i_bEN (execution command) is on, it will not be enabled.
- If the set value is out of the range, the error code is stored in o_uErrId (error code). (☞ Page 24 Error code list).
- If an error occurs in the PID operation instruction (PID), an error occurs in the CPU module. Check the error code of the CPU module.

Manual setting of a manipulated value (MV)

Set a manipulated value (MV) manually without using the PID control. (☞ Page 40 Manual output).

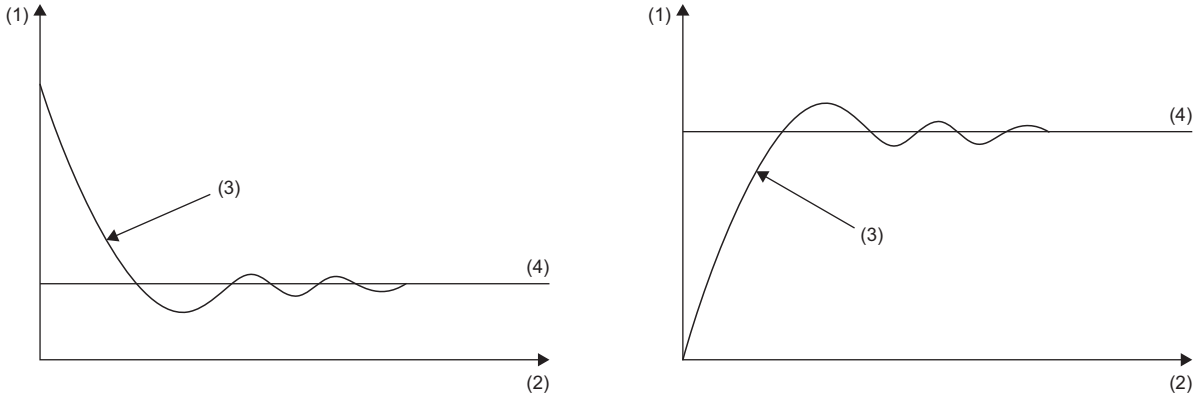
Description of each function

■Switching direct/reverse action

Set whether to use the FB with direct actions or reverse actions in i_bActionSetting (direct/reverse action setting).

- On: The direct action increases the manipulated value (MV) when the process value (PV) becomes greater than the set value (SV). This setting is used for cooling control.
- Off: The reverse action increases the manipulated value (MV) when the process value (PV) becomes smaller than the set value (SV). This setting is used for heating control.

The left figure shows the direct action (cooling control), and the right shows the reverse action (heating control).



(1) Temperature
(2) Time
(3) Process value (PV)
(4) Set value (SV)

Point

- When the auto tuning (limit cycle method) is used, the desired direction of the PID operation (direct action or reverse action) needs to be set.
- When the auto tuning (step response method) is used, no matter whether the auto tuning is performed in direct action or reverse action, direct action or reverse action is automatically set upon completion.

■Sampling time (TS)

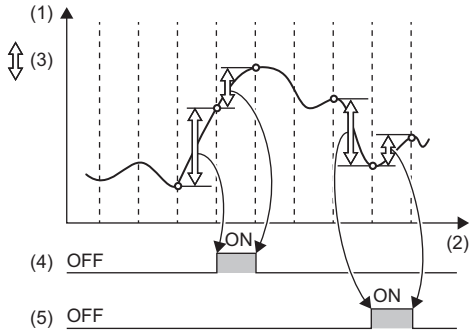
Set the cycle (ms) for the PID operation.

- When executing the PID control or auto tuning (limit cycle method), set values so that the operation cycle of the CPU module is shorter than the sampling time. If the sampling time is shorter than one operation cycle of the CPU module, an error occurs in the CPU module.
- When executing the auto tuning (step response method), set the value to 1000ms (1 second) or more.

■Input variation warning/output variation warning

• Input variation warning

When i_wPV (process value (PV)) exceeds the variation set for the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.



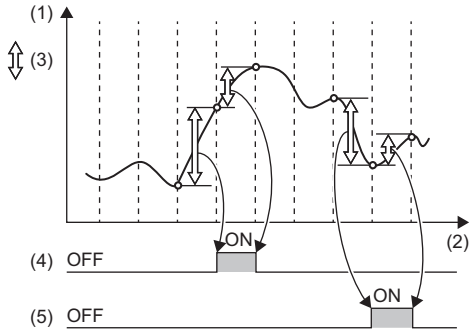
(1) Process value (PV)
(2) Time
(3) Variation
(4) Input variation (increase side) warning
(5) Input variation (decrease side) warning

When using the input variation warning, the action setting (ACT) and input variation warning set value need to be set. The variation is the previous process value (PV) minus the current process value (PV).

Item	Item	Description
Action setting (ACT)	i_wnSettingData [0] (setting data) b0	On: Input variation warning enabled
Input variation (increase side) warning set value	i_wnSettingData [3] (setting data)	0 to 32767
Input variation (decrease side) warning set value	i_wnSettingData [4] (setting data)	0 to 32767

• Output variation warning

When o_wMV (manipulated value (MV)) exceeds the variation set for the warning set value in i_wnSettingData (setting data), the corresponding bit of o_wAlertStatus (warning status) turns on.



(1) Manipulated value (MV)
(2) Time
(3) Variation
(4) Output variation (increase side) warning
(5) Output variation (decrease side) warning

• Output variation warning setting

When using the output variation warning, the action setting (ACT) and output variation warning set value need to be set. The variation is the previous manipulated value (MV) minus the current manipulated value (MV).

Item	Item	Description
Action setting (ACT)	i_wnSettingData [0] (setting data) b1	On: Output variation warning enabled
	i_wnSettingData [0] (setting data) b2	Off
Output variation (increase side) warning set value	i_wnSettingData [5] (setting data)	0 to 32767
Output variation (decrease side) warning set value	i_wnSettingData [6] (setting data)	0 to 32767

■Auto tuning

Automatically set the optimal PID constants.

When using the auto tuning, set the following value for the calculation method of PID constants.

Setting item		Description
Action setting (ACT)	i_wnSettingData [0] (setting data) b4	On: Limit cycle method Off: Step response method

- When i_bAT (starting/stopping the auto tuning) is on, auto tuning is performed. In this case, o_bAT_Status (auto tuning status) is on.
- When the auto tuning is completed, o_bAT_Status (auto tuning status) turns off, and the optimal o_wProportional (proportional gain (P)), o_wIntegral (integral time (I)), and o_wDerivative (derivative time (D)) are output.
- During auto tuning, PID control and manual output are not performed.

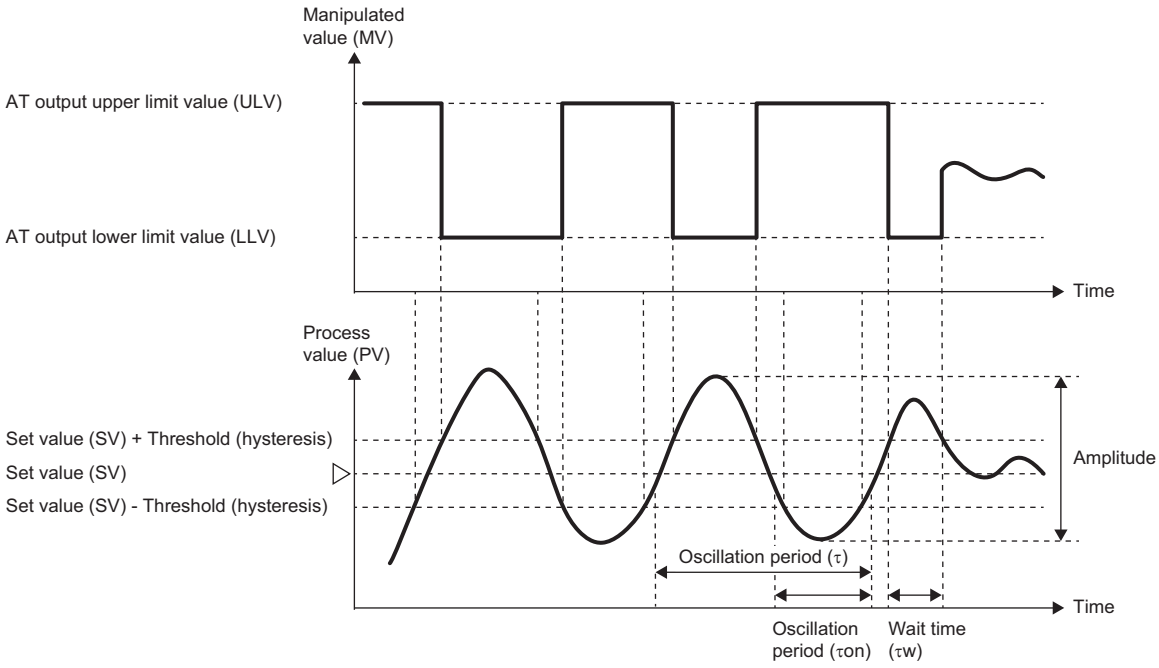
Point

When using the limit cycle method, set the following values.

- The threshold (hysteresis) according to the fluctuation of the process value (PV)
- The AT upper limit output limiter (ULV) and AT lower limit output limiter (LLV) that are output to the manipulated value (MV) during the auto tuning
- The wait setting parameter (KW) from when the auto tuning is completed to when the PID operation starts

The following formula and graphs show the relationships among the threshold (hysteresis), the AT upper limit output limiter (ULV) value, the AT lower limit output limiter (LLV) value, and the wait setting parameter (KW) when the auto tuning (limit cycle method) is used.

- The wait time (τw) = (50 + wait setting parameter (KW)) / 100 × (oscillation period (τ - τon))



Precautions

When using the step response method, note the following precautions.

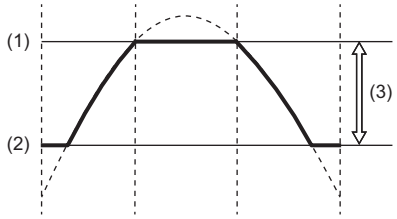
- When the variation from the process value (PV) to the set value (SV) at the start of auto tuning changes by 1/3 or more, the auto tuning is completed, and the auto tuning status turns off.
- Set the step manipulated value (manipulated value (MV)) to a value that represents the maximum possible output value for the output equipment × 0.5 to 1.
- If the difference between the process value (PV) and the set value (SV) at the start of auto tuning is less than 150, the auto tuning cannot be performed correctly. If the difference is less than 150, set the set value (SV) for the auto tuning.

■Upper/lower limit output limiter

Limit the upper limit and lower limit of o_wMV (manipulated value (MV)).

- When the manipulated value (MV) exceeds the upper limit output limiter, the manipulated value (MV) is corrected to the upper limit output limiter value.
- When the manipulated value (MV) falls below the lower limit output limiter, the manipulated value (MV) is corrected to the lower limit output limiter value.

Ex.



(1) Upper limit output limiter value
(2) Lower limit output limiter value
(3) Manipulated value (MV) range

When using the upper/lower limit output limiter, set the following values.

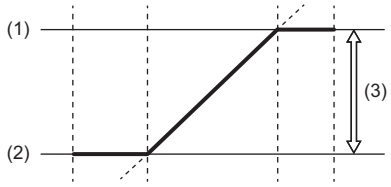
Setting item		Description
Action setting (ACT)	i_wnSettingData [0] (setting data) b1	Off
	i_wnSettingData [0] (setting data) b2	On: Upper/lower limit output limiter enabled
Upper limit output limiter	i_wnSettingData [5] (setting data)	-32768 to 32767
Lower limit output limiter	i_wnSettingData [6] (setting data)	-32768 to 32767

■Upper/lower limit setting limiter

Limit the upper limit and lower limit of i_wSV_Setting (set value (SV) setting).

- When the set value (SV) exceeds the upper limit setting limiter, the set value (SV) is corrected to the upper limit setting limiter value.
- When the set value (SV) falls below the lower limit setting limiter, the set value (SV) is corrected to the lower limit setting limiter value.

Ex.



(1) Upper limit setting limiter value: 300.0℃
(2) Lower limit setting limiter value: 100.0℃
(3) Set value (SV) set value: 100.0℃ to 300.0℃

When using the upper/lower limit setting limiter, set the following values.

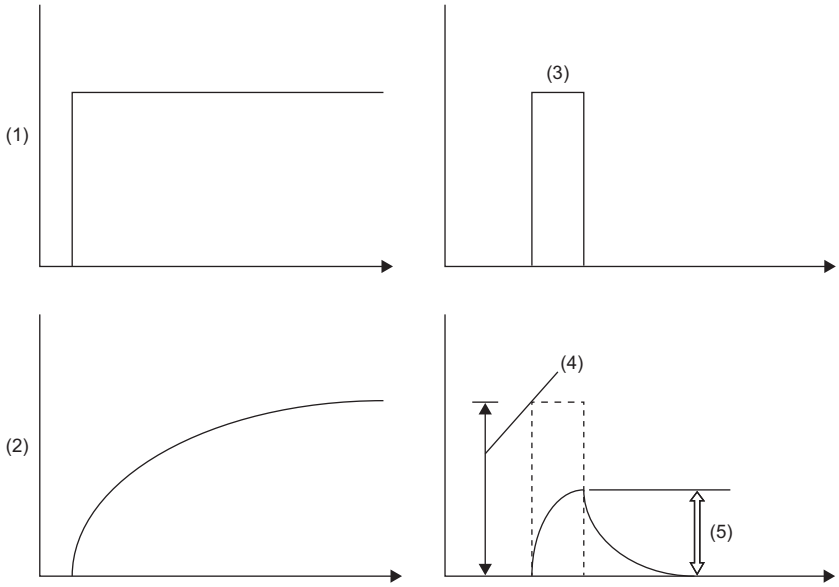
Setting item		Description
Action setting (ACT)	i_wnSettingData [0] (setting data) b3	On: Upper/lower limit setting limiter enabled
Upper limit setting limiter	i_wnSettingData [7] (setting data)	-32768 to 32767
Lower limit setting limiter	i_wnSettingData [8] (setting data)	-32768 to 32767

■Input filter constant (α)

The input filter constant (α) is a software filter that reduces the noise fluctuation of the process value (PV). By setting the time constant of this filter in accordance with the characteristics of the control target and its noise level, the noise influence is suppressed.

- If the input filter constant (α) is too small, the effect as a filter is reduced.
- If the input filter constant (α) is too large, the input response deteriorates.

Because the input filter constant (α) affects the set value (SV), it affects the proportional action, integral action, and derivative action.



(1) Actual process value (PV)
(2) Process value (PV) through the input filter
(3) Pulse input by noise
(4) Input amplitude
(5) Input amplitude through the input filter

■Proportional gain (P) setting

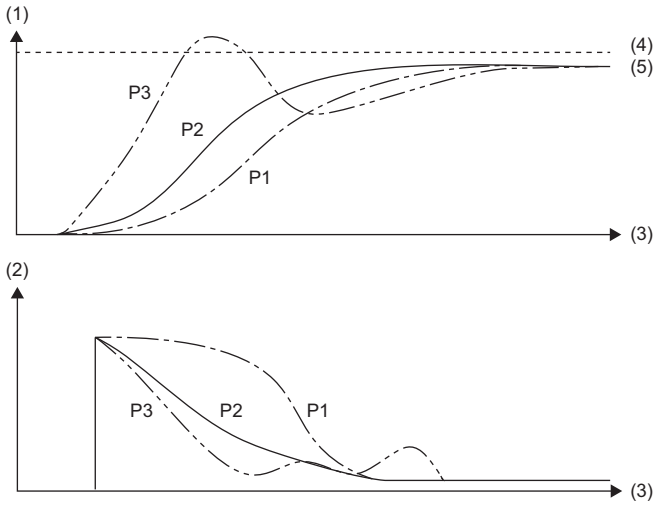
A proportional action produces a manipulated value (MV) that is proportional to the deviation (E) (difference between the set value (SV) and process value (PV)). This proportion is called the proportional gain (P).

• Manipulated value (MV) = Proportional gain (P) × Deviation (E)

Setting the proportional gain (P) to a large value strengthens the operation such that the process value (PV) becomes closer to the set value (SV).

Ex.

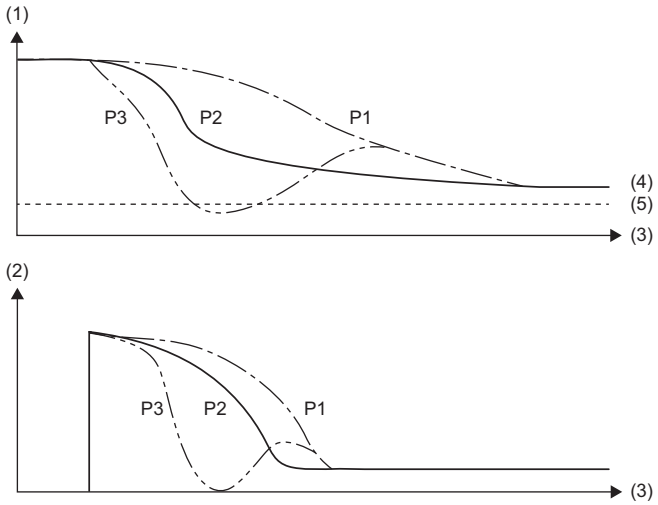
When the proportional gain (P) is set to P3>P2>P1 in the proportional action (P action) for reverse action (heating control)



(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Set value (SV)
(5) Process value (PV)

Ex.

When the proportional gain (P) is set to P3>P2>P1 in the proportional action (P action) for direct action (cooling control)



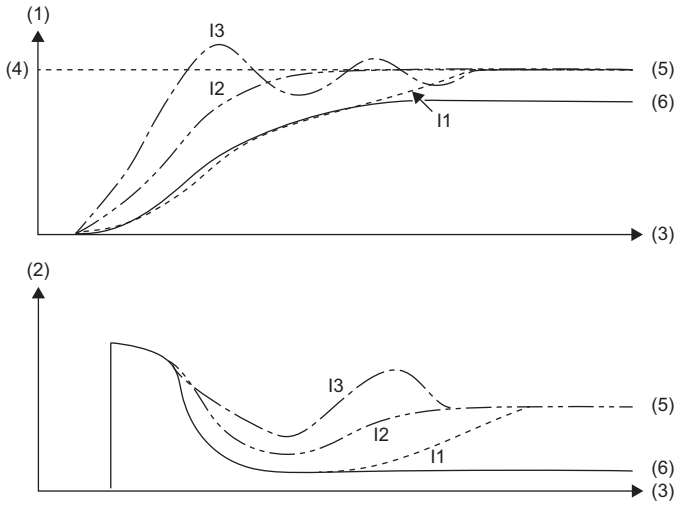
(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Process value (PV)
(5) Set value (SV)

■Integral time (I) setting

The integral time is the time from when deviation occurs in the integral action to when the output of the integral action becomes the output of the proportional action. The smaller the integral time, the stronger the integral action.

Ex.

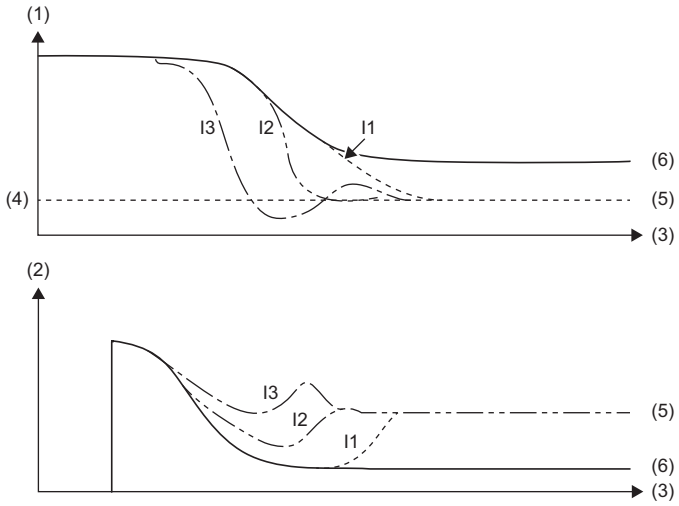
When the integral time (I) is set to 0<I3<I2<I1 in the PI operation for reverse action (heating control)



(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Set value (SV)
(5) Process value in PI operation
(6) Process value in proportional action

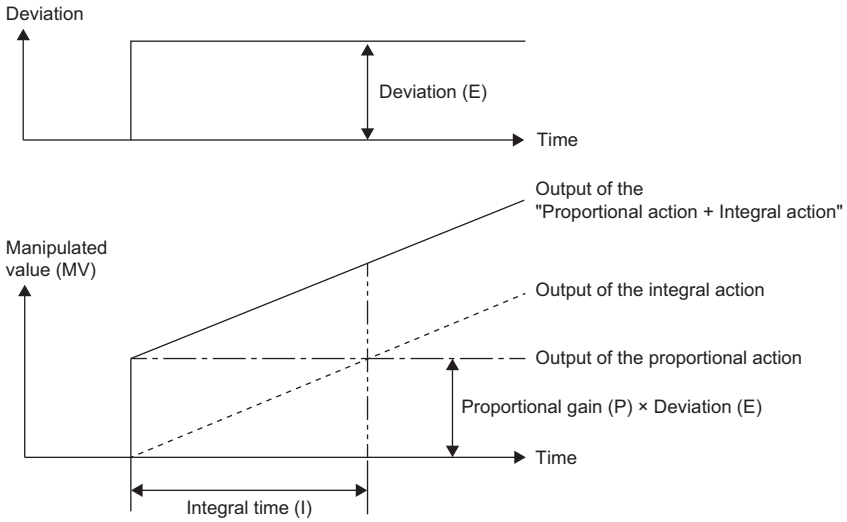
Ex.

When the integral time (I) is set to 0<I3<I2<I1 in the PI operation for direct action (cooling control)



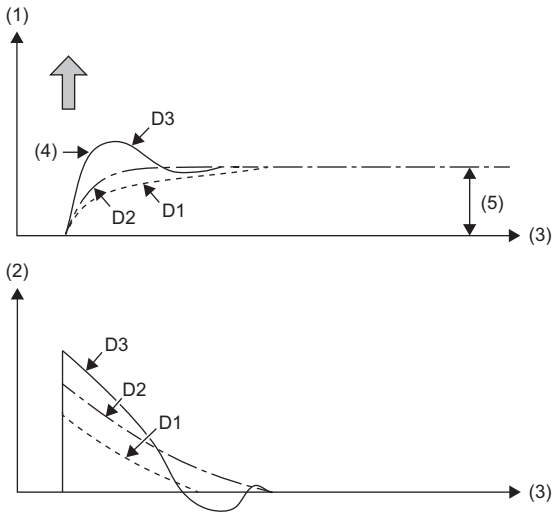
(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Set value (SV)
(5) Process value in PI operation
(6) Process value in proportional action

The integral action is an operation that changes the output to eliminate continuously occurring deviation. It eliminates residual deviation caused by proportional action.



■Derivative time (D) setting

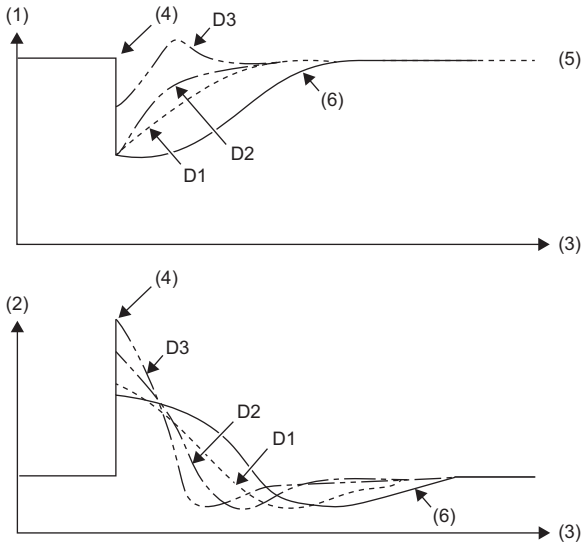
Respond sensitively to fluctuations due to disturbances in the process value (PV) and minimize the fluctuations.
Setting the derivative time (D) to a large value strengthens the operation such that the control target is prevented from significantly changing due to disturbance.
The derivative time (D) does not need to be used.



(1) Deviation
(2) Manipulated value (MV)
(3) Time
(4) Disturbance
(5) Deviation (E)

Ex.

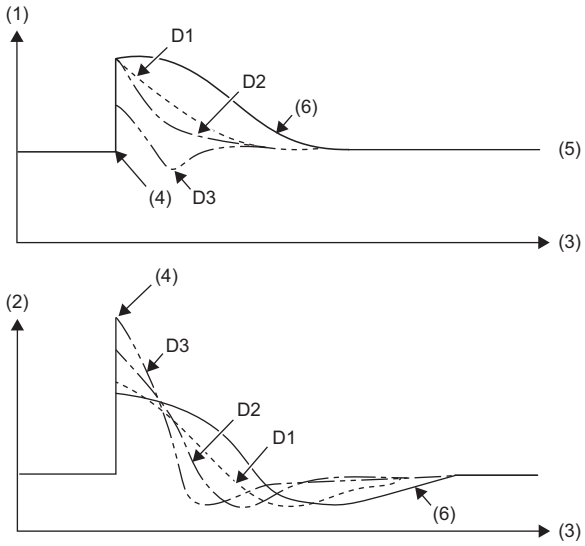
When the derivative time (D) is set to D3>D2>D1 in the PID action for reverse action (heating control)



(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Output variation due to disturbance
(5) Set value (SV)
(6) PI operation (no derivative action)

Ex.

When the derivative time (D) is set to D3>D2>D1 in the PID action for direct action (cooling control)



(1) Temperature
(2) Manipulated value (MV)
(3) Time
(4) Output variation due to disturbance
(5) Set value (SV)
(6) PI operation (no derivative action)

■Derivative gain (KD)

Filter the output of the derivative action. The derivative gain (KD) affects only the derivative action.

- When the derivative gain (KD) is set to a small value, changes in the process value (PV) caused by disturbances are instantly responded to.
- When the derivative gain (KD) is set to a large value, changes in the process value (PV) caused by disturbances are responded to over a long period of time.

First, set the derivative gain (KD) to 0 and adjust it with the input filter (α). If the response to disturbances in the output changes is too sensitive, increase the value.

■PID operation

The PID operation is performed based on the values of i_wSV_Setting (set value (SV) setting), i_wPV (process value (PV)), i_wP_GainSetting (proportional gain (P) setting), i_wI_Setting (integral time (I) setting), i_wD_Setting (derivative time (D) setting), and o_wMV (manipulated value (MV)) is stored.

■Manual output

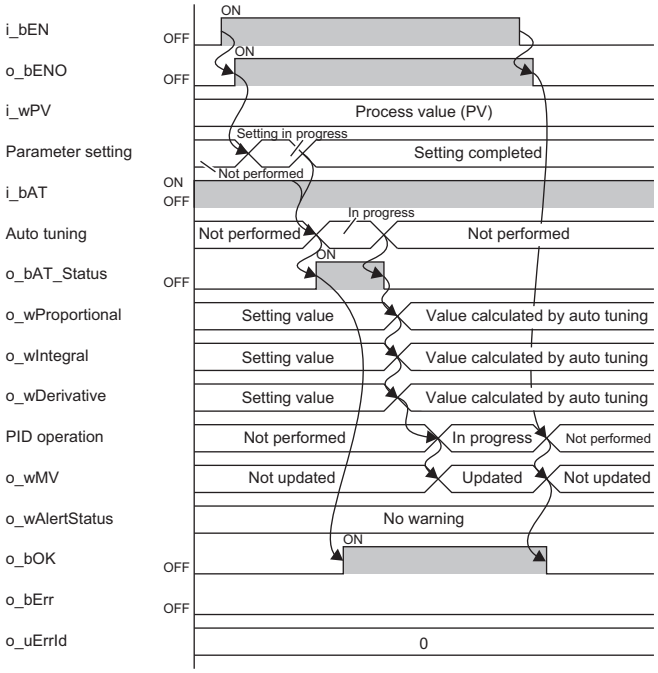
Set a manipulated value (MV) manually without using auto tuning or the PID operation.

When i_bAutoManShift (AUTO/MAN mode shift) is set to On: MAN mode, manual output is performed according to i_wManOutput (MAN output setting), and a setting value is entered in o_wMV (manipulated value (MV)).

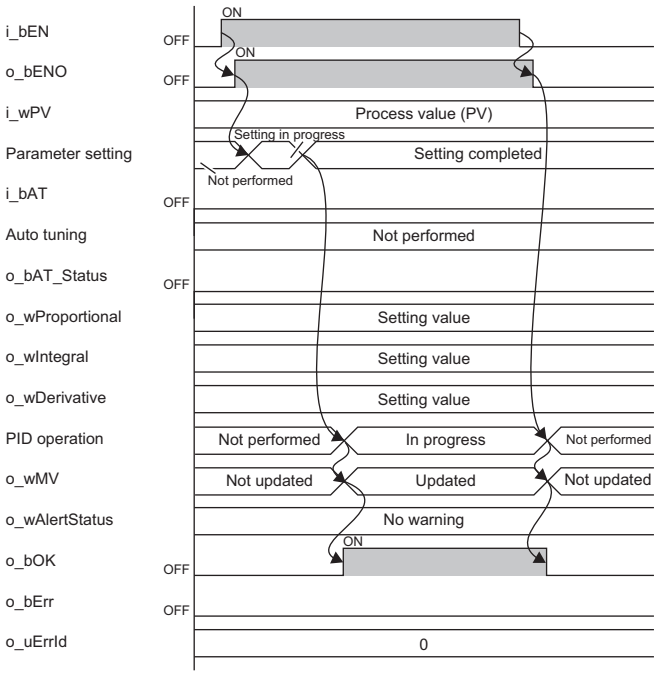
Timing chart of I/O signals

■When the operation is completed successfully

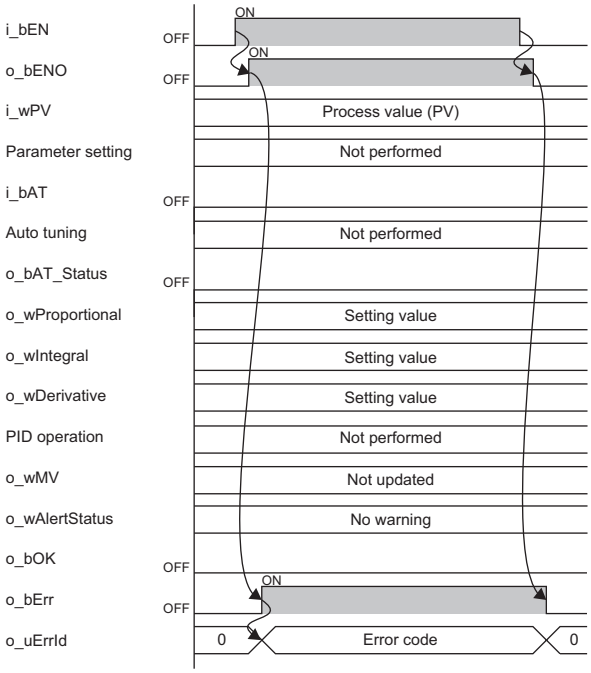
- When auto tuning is used



- When auto tuning is not used



■When the operation is completed with an error



Restrictions and precautions

- This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the system and the requested operation.
- Use this FB in a scan execution type program. When doing so, do not use the FB in the interrupt program that uses the interrupt pointer (I). For details on the execution type of the program, refer to the following.

📖 MELSEC iQ-R CPU Module User's Manual (Application)

- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (execution command).
- To use more than one of this FB, care must be taken to avoid duplication of the device numbers used for operation.
- The FB requires the configuration of the ladder block for every input label.
- Change the memory/device setting of the CPU parameter to the capacity required for using this FB. Failure to do so may cause an error in GX Works3.
- Make the setting that matches the connected device and system from the parameter setting on GX Works3. (📖 GX Works3 Operating Manual)
- This FB uses the PID operation instruction (PID). For errors that occur with the PID operation instruction (PID), check the error code of the CPU module.

Error code

Error code list

Error code	Description	Action
0114H	Out of the sampling time range. The sampling time is set to a value other than 1 to 32767.	Set the sampling time to a value between 1 and 32767. Review and correct the setting and then execute the FB again.
0115H	Out of the proportional gain (P) setting range. The proportional gain (P) is set to a value other than 1 to 32767 (1 to 32767%).	Set the proportional gain (P) to a value between 1 and 32767 (1 to 32767%). Review and correct the setting and then execute the FB again.
0116H	Out of the integral time (I) setting range. The integral time (I) is set to a value other than 0 to 32767 (0 to 32767 × 100ms).	Set the integral time (I) to a value between 0 and 32767 (0 to 32767 × 100ms). Review and correct the setting and then execute the FB again.
0117H	Out of the derivative time (D) setting range. The derivative time (D) is set to a value other than 0 to 32767 (0 to 32767% × 10ms).	Set the derivative time (D) to a value between 0 and 32767 (0 to 32767 × 10ms). Review and correct the setting and then execute the FB again.
0118H	Out of the input filter constant range. The input filter constant (α) is set to a value other than 0 to 99 (0 to 99%).	Set the input filter constant (α) to a value between 0 and 99 (0 to 99%). Review and correct the setting and then execute the FB again.
0119H	Out of the derivative gain (KD) range. The derivative gain (KD) is set to a value other than 0 to 100 (0 to 100%).	Set the derivative gain (KD) to a value between 0 and 100 (0 to 100%). Review and correct the setting and then execute the FB again.
011AH	Out of the input variation warning set value range. The input variation (increase side) warning set value or input variation (decrease side) warning set value is set to a value other than 0 to 32767.	Set the input variation (increase side) warning set value or input variation (decrease side) warning set value to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
011BH	Out of the output variation warning set value range. The output variation (increase side) warning set value or output variation (decrease side) warning set value is set to a value other than 0 to 32767.	Set the output variation (increase side) warning set value or output variation (decrease side) warning set value to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
011CH	Out of the threshold (hysteresis) range. The threshold (hysteresis) is set to a value other than 0 to 32767.	Set the threshold (hysteresis) to a value between 0 and 32767. Review and correct the setting and then execute the FB again.
011DH	Out of the wait setting parameter (KW) range. The wait setting parameter (KW) is set to a value other than -50 to 32717.	Set the wait setting parameter (KW) to a value between -50 and 32717. Review and correct the setting and then execute the FB again.
0200H	The upper limit output limiter value is equal to or smaller than the lower limit output limiter value.	Set the values so that the upper limit output limiter is larger than the lower limit output limiter. Review and correct the setting and then execute the FB again.
0201H	The upper limit setting limiter value is equal to or smaller than the lower limit setting limiter value.	Set the values so that the upper limit setting limiter is larger than the lower limit setting limiter. Review and correct the setting and then execute the FB again.
0205H	The output variation warning and the upper/lower limit output limiter are both set.	Enable either the output variation warning or the upper/lower limit output limiter. Review and correct the setting and then execute the FB again.
0206H	The AT upper limit output limiter (ULV) is equal to or smaller than the AT lower limit output limiter (LLV).	Set the values so that the AT upper limit output limiter (ULV) is larger than the AT lower limit output limiter (LLV). Review and correct the setting and then execute the FB again.

Version update history of the FB

Version	Date	Description
00	April 2021	Newly created

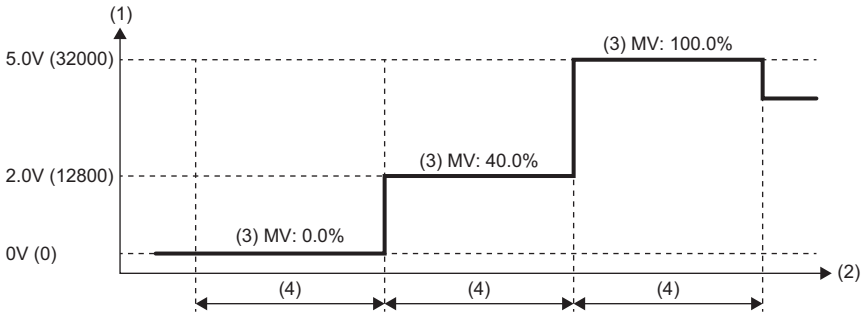
3 APPLICATION EXAMPLES

This chapter describes application examples of each FB library.

3.1 M+PIDCtrl_PIDControl_R

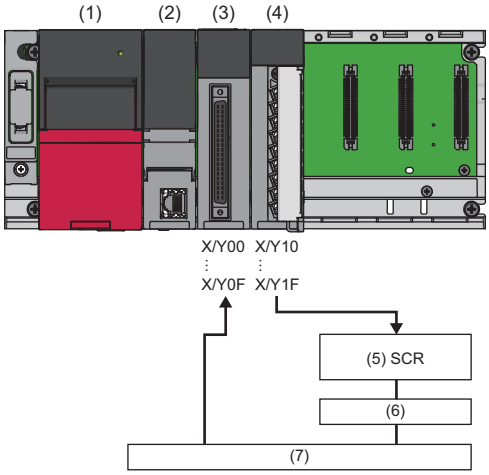
When using SCR (thyristor)

This PID control program reads the temperature measured by the resistance temperature detector (Pt100, -200℃ to 850.0℃) connected to CH1 of R60RD8-G, and outputs the DC voltage (0 to 5V) from CH1 of R60DA4.
The following image shows the relationship between the manipulated value (MV) and the output voltage of the R60DA4 when 0 to 5V is output for a manipulated value (MV) of 0 to 1000 (0.0% to 100.0%).



(1) Output voltage, ( ): Digital value
(2) Time
(3) Manipulated value
(4) Control output cycle setting

System configuration

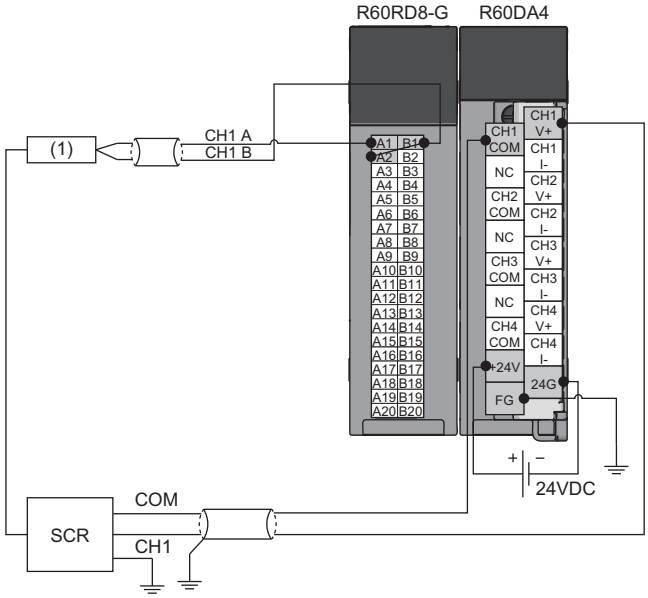


No.	Product	Model name
(1)	Power supply module	R61P
(2)	CPU module	R04CPU
(3)	Channel isolated RTD input module	R60RD8-G
(4)	Digital-analog converter module	R60DA4
(5)	Thyristor module	Input voltage (0 to 5V)
(6)	Heater	—
(7)	Control target	Uses resistance temperature detector (Pt100, -200℃ to 850.0℃)

Precautions

Ladder blocks must be configured for all input labels. If a circuit is not set, the value is considered an undefined value.

Wiring example



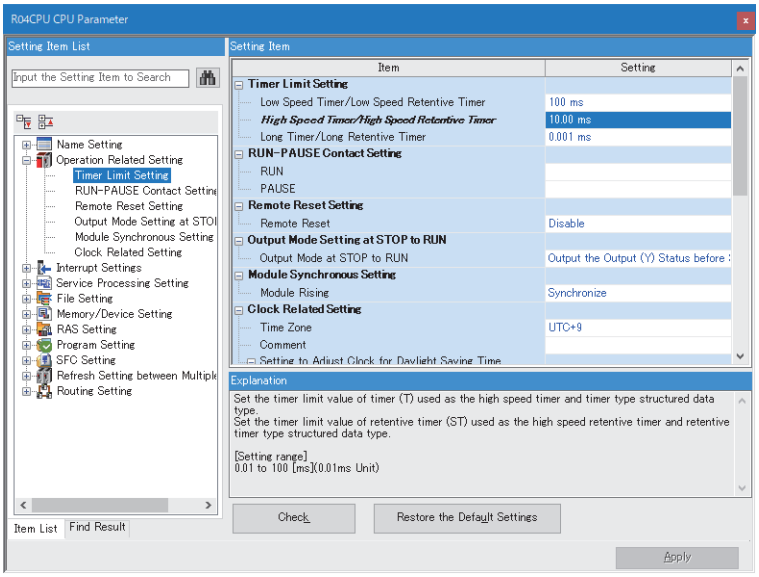
(1) Control target

Parameter setting

■CPU parameter

In the CPU parameters of R04CPU, set the following "High Speed Timer/High Speed Retentive Timer" to "10.00ms" and specify the timer limit setting. Leave all other CPU parameters as their defaults.

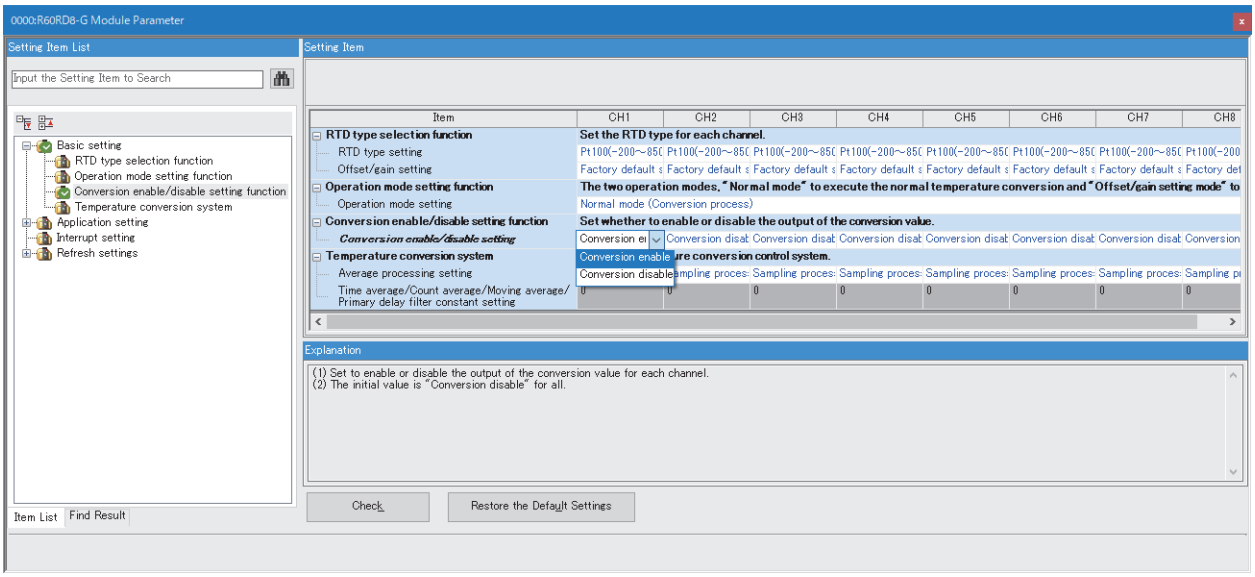
[Navigation window] ⇨ [Parameter] ⇨ [R04CPU] ⇨ [CPU Parameter] ⇨ [Operation Related Setting]



■Module parameters for the temperature input module

In the R60RD8-G module parameters, set the following "Conversion enable/disable setting" to "Conversion enable". Leave all other module parameters as their defaults.

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60RD8-G] ⇨ [Basic Setting]

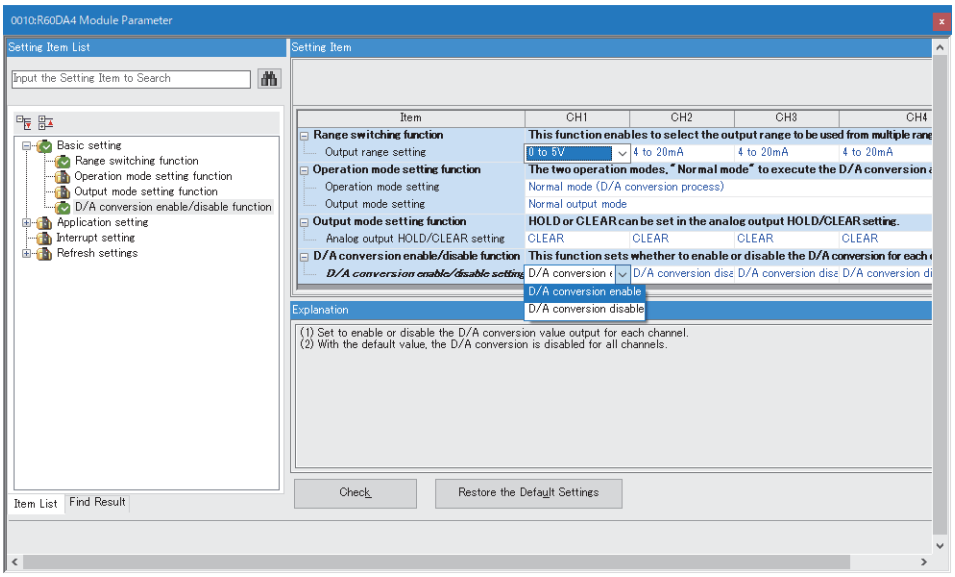


■Module parameters for the digital-analog converter module

In the R60DA4 module parameters, set the following values. Leave all other module parameters as their defaults.

- "Output range setting": "0 to 5V"
- "D/A conversion enable/disable setting": "D/A conversion enabled"

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60DA4] ⇨ [Basic Setting]



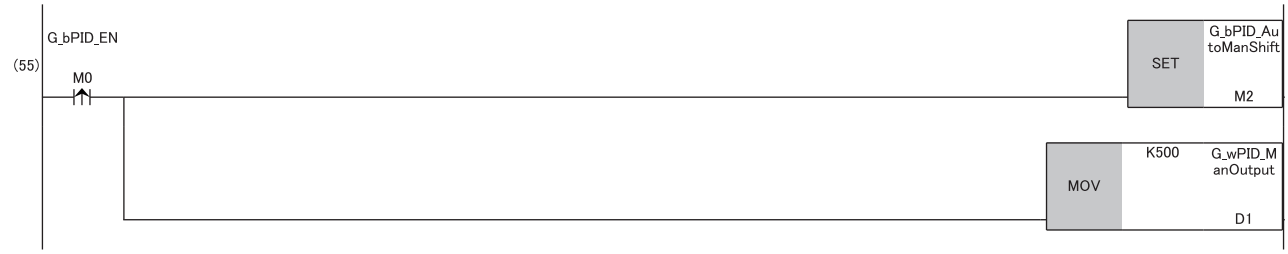
For the "Output range setting", check the input voltage specifications of the SCR (thyristor) and select from the following. Check the digital value and resolution of the output range, and set the upper/lower limit output limiter value of the manipulated value (MV).

Output range	Digital value	Resolution
0 to 5V	0 to 32000	156.3μV
1 to 5V		125.0μV
-10 to 10V	-32000 to 32000	312.5μV
User range setting		

Program example

A program that executes the PID control to calculate a manipulated value (MV) automatically. This program also executes the auto tuning. (☞ Page 13 Automatic calculation of a manipulated value (MV) by PID control).

For setting a manipulated value (MV) manually without using the PID control, change (55) in the program as follows. (☞ Page 21 Manual output).



Program examples

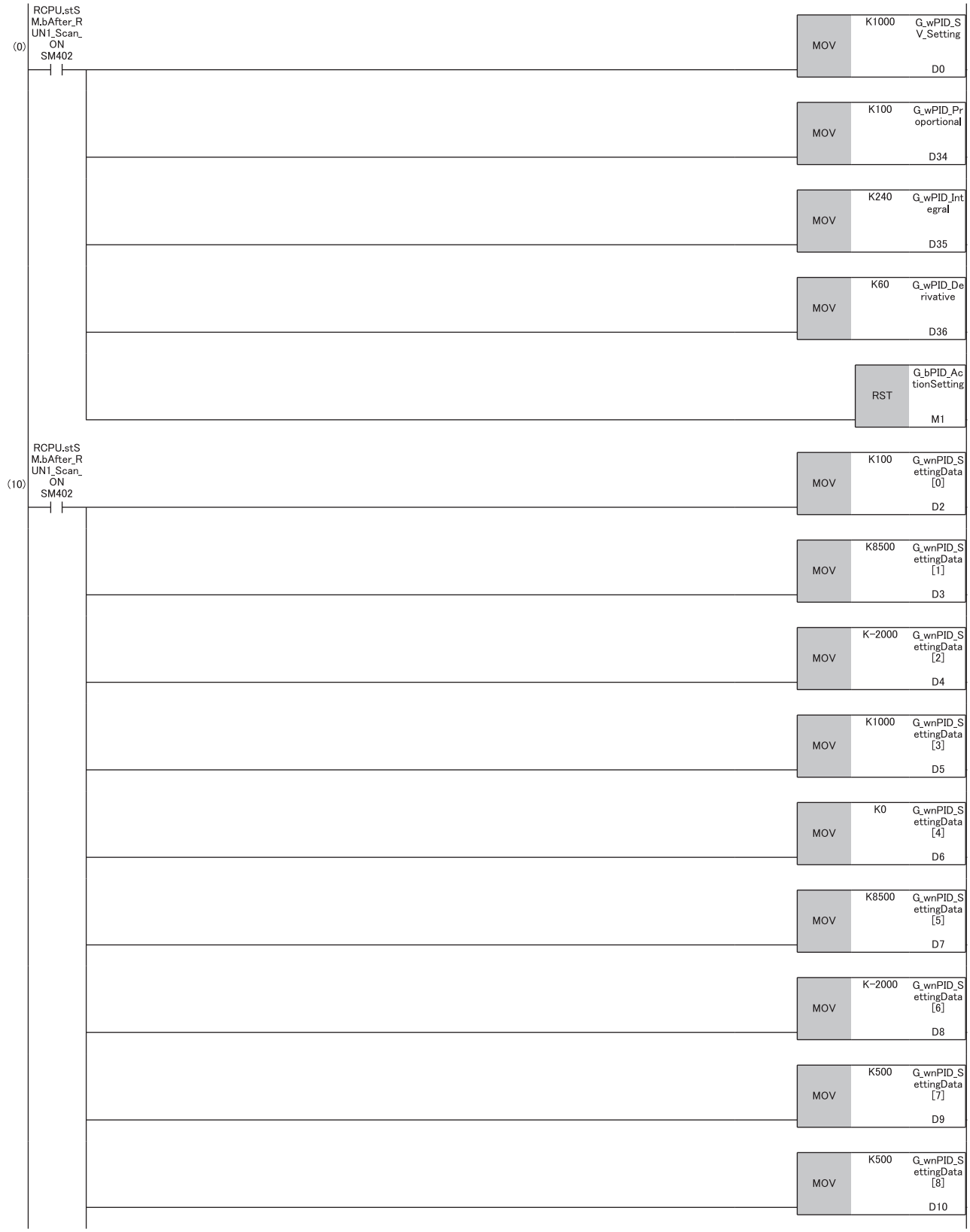
■Label setting

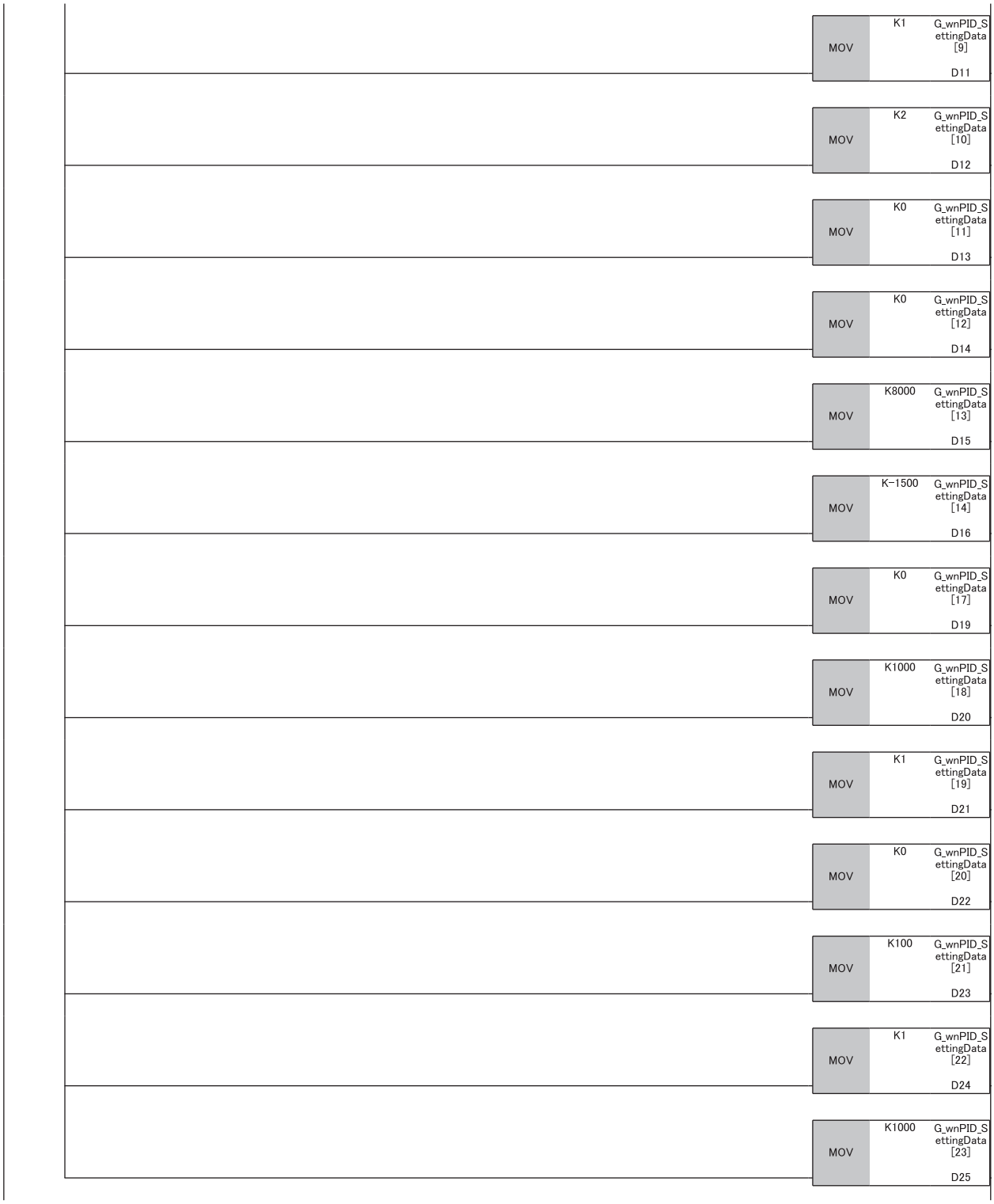
Classification	Label name	Description	Device
Module label	RCPU.stSM.bAfter_RUN1_Scan_ON	Turns on one scan after RUN	SM402
	R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue	CH1 Temperature process value	—
	R60DA_1.bCH1OutputEnableDisableFlag	CH1 Output enable/disable flag	Y11
	R60DA_1.stnControl[0].wDigitalValue	CH1 Digital value	—
Labels to be defined	Define global labels as follows.		

	Label Name	Data Type		Class	Assign (Device/Label)
1	G_bPID_EN	Bit	...	VAR_GLOBAL	M0
2	G_bPID_ActionSetting	Bit	...	VAR_GLOBAL	M1
3	G_bPID_AutoManShift	Bit	...	VAR_GLOBAL	M2
4	G_bPID_AT	Bit	...	VAR_GLOBAL	M3
5	G_bPID_ENO	Bit	...	VAR_GLOBAL	M5
6	G_bPID_OK	Bit	...	VAR_GLOBAL	M6
7	G_bPID_TraOutputFlag	Bit	...	VAR_GLOBAL	M7
8	G_bPID_Err	Bit	...	VAR_GLOBAL	F0
9	G_wPID_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D0
10	G_wPID_ManOutput	Word [Signed]	...	VAR_GLOBAL	D1
11	G_wnPID_SettingData	Word [Signed](0..23)	...	VAR_GLOBAL	D2
12	G_wPID_PV	Word [Signed]	...	VAR_GLOBAL	D26
13	G_wPID_MV	Word [Signed]	...	VAR_GLOBAL	D27
14	G_wPID_SV	Word [Signed]	...	VAR_GLOBAL	D28
15	G_ePID_PV	FLOAT [Single Precision]	...	VAR_GLOBAL	D29
16	G_wPID_AT_Status	Word [Signed]	...	VAR_GLOBAL	D31
17	G_wPID_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D32
18	G_uPID_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D33
19	G_wPID_Proportional	Word [Signed]	...	VAR_GLOBAL	D34
20	G_wPID_Integral	Word [Signed]	...	VAR_GLOBAL	D35
21	G_wPID_Derivative	Word [Signed]	...	VAR_GLOBAL	D36
22	G_w2PID_DigitalValue	Word [Signed](0.1)	...	VAR_GLOBAL	D37

■Initial setting

Set the initial value for the FB after CPU RUN.

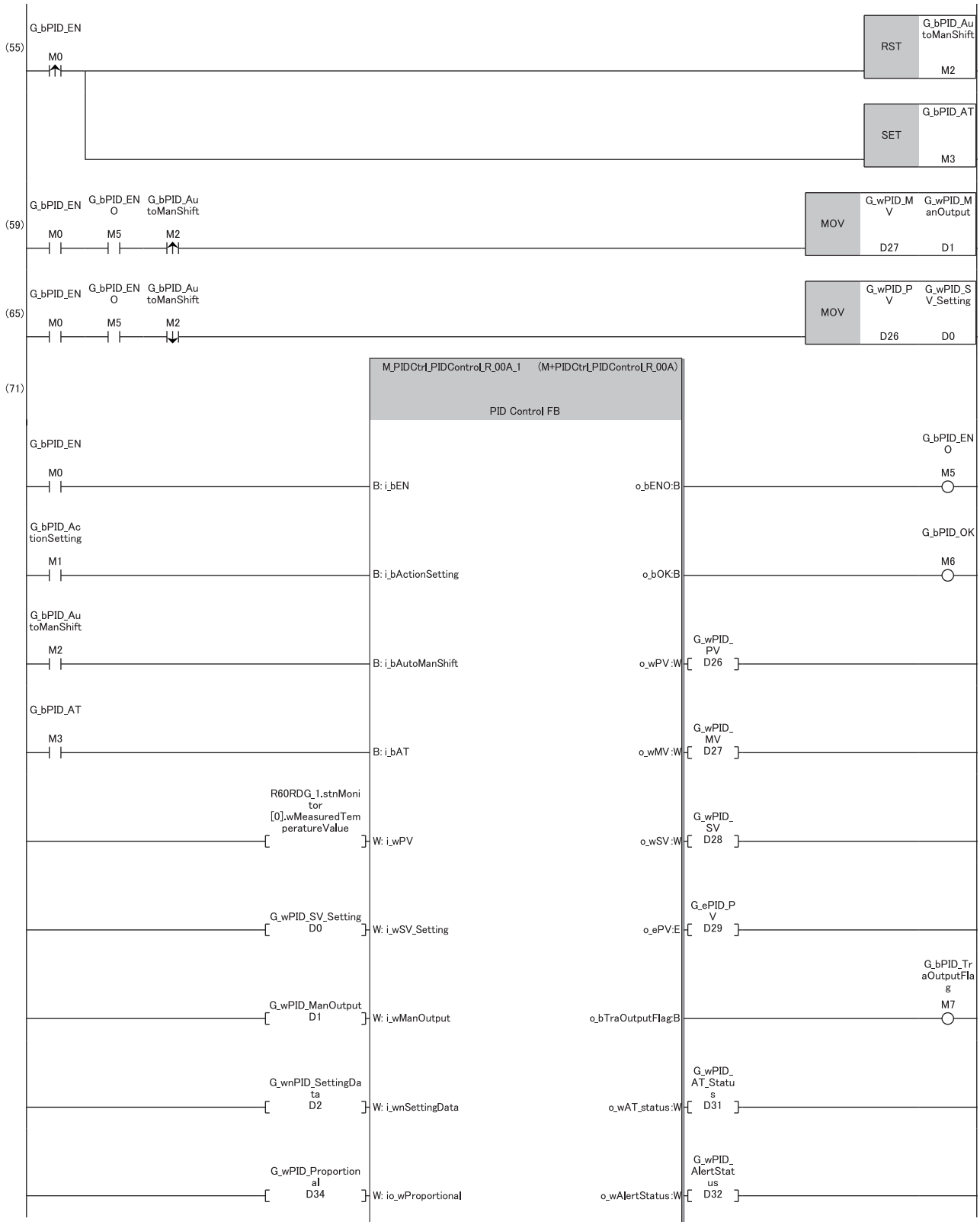


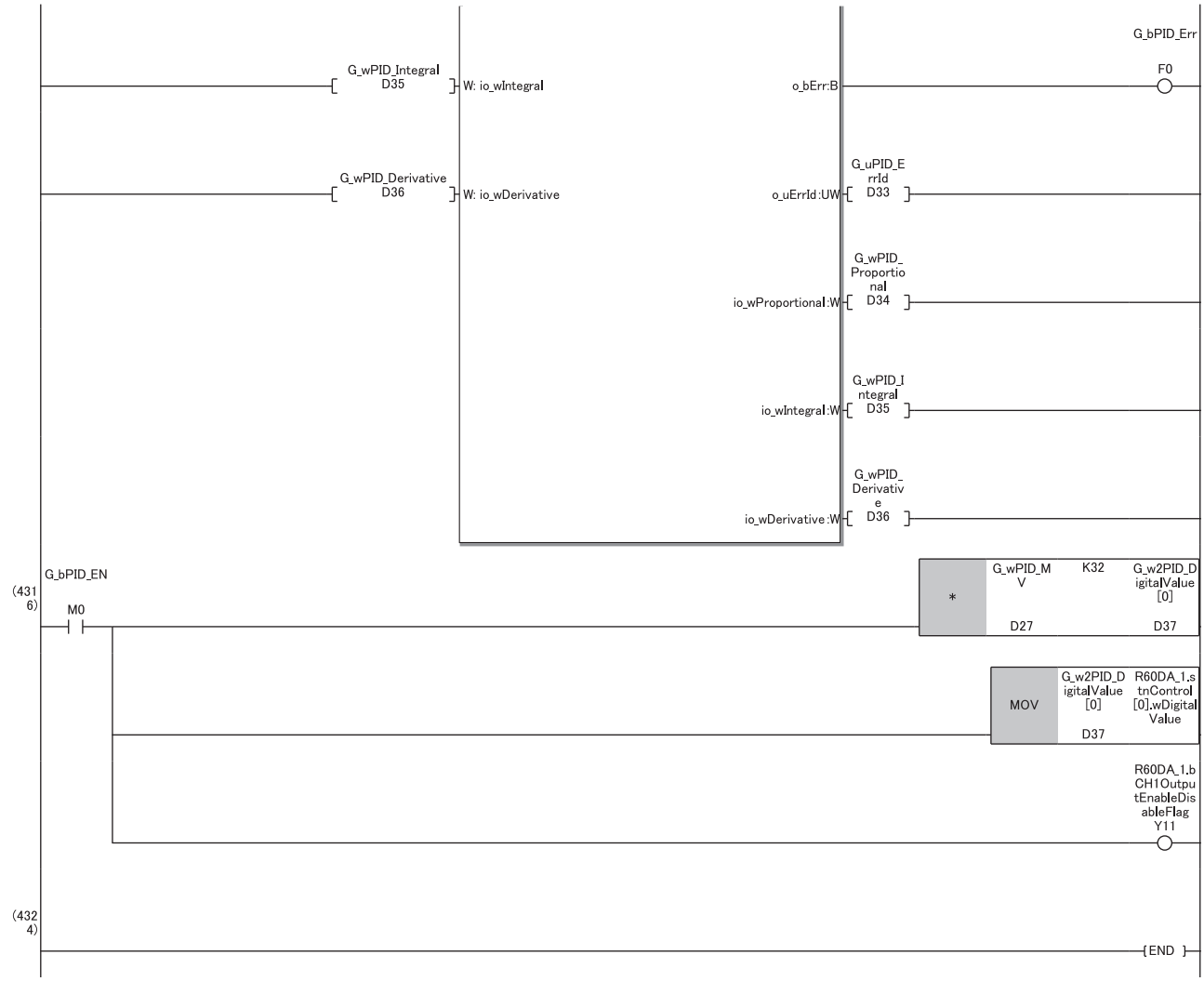

MOV
K1
G_wnPID_SettingData[9]
D11
MOV
K2
G_wnPID_SettingData[10]
D12
MOV
K0
G_wnPID_SettingData[11]
D13
MOV
K0
G_wnPID_SettingData[12]
D14
MOV
K8000
G_wnPID_SettingData[13]
D15
MOV
K-1500
G_wnPID_SettingData[14]
D16
MOV
K0
G_wnPID_SettingData[17]
D19
MOV
K1000
G_wnPID_SettingData[18]
D20
MOV
K1
G_wnPID_SettingData[19]
D21
MOV
K0
G_wnPID_SettingData[20]
D22
MOV
K100
G_wnPID_SettingData[21]
D23
MOV
K1
G_wnPID_SettingData[22]
D24
MOV
K1000
G_wnPID_SettingData[23]
D25

■PID control

When G_bPID_EN (PID control execution command) turns on, the PID constants are calculated, and PID control is executed for the process value obtained via CH1.

By turning G_bPID_AutoManShift (AUTO/MAN mode shift) on or off, automatic calculation and manual setting of the manipulated value (MV) switch.





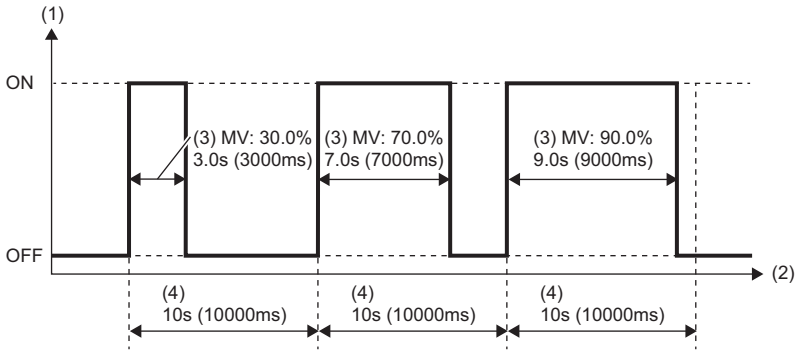
(55)Set this item when automatically calculating the manipulated value (MV) (☞ Page 13 Automatic calculation of a manipulated value (MV) by PID control). When calculation of the PID constants by auto tuning is not required, turn off G_bPID_AT (auto tuning start/stop).

(59)To avoid sudden changes in the manipulated value (MV) when the mode is switched from AUTO to MAN, store the manipulated value (MV) from immediately before in the MAN output setting.

(65)To avoid sudden changes in the manipulated value (MV) when the mode is switched from MAN to AUTO, store the process value (PV) from immediately before in the set value (SV) setting.

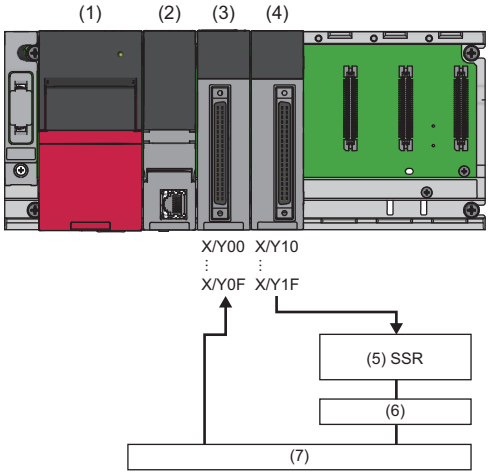
When using SSR (solid state relay)

This PID control program reads the temperature measured by the resistance temperature detector (Pt100, -200℃ to 850.0℃) connected to CH1 of R60RD8-G. The following image shows the relationship between a manipulated value (MV) of 0 to 1000 (0.0% to 100.0%) and the RY41NT2P output.



(1) Output
(2) Time
(3) Manipulated value
(4) Control output cycle setting

System configuration

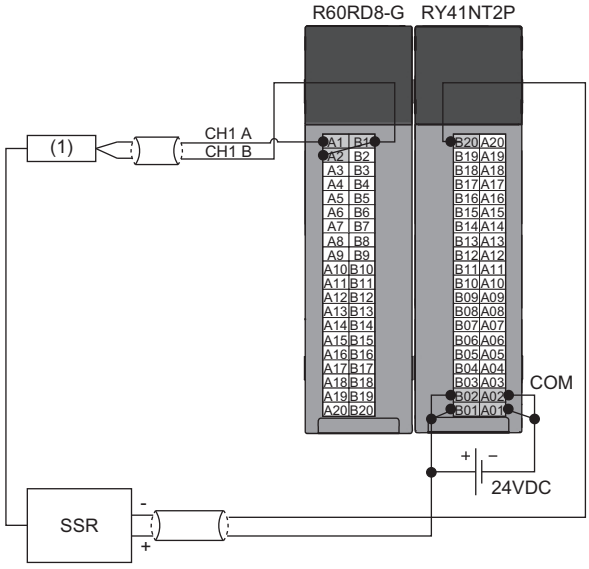


No.	Product	Model name
(1)	Power supply module	R61P
(2)	CPU module	R04CPU
(3)	Channel isolated RTD input module	R60RD8-G
(4)	Transistor output module	RY41NT2P
(5)	Solid state relay	—
(6)	Heater	—
(7)	Control target	Uses resistance temperature detector (Pt100, -200℃ to 850.0℃)

Precautions

Ladder blocks must be configured for all input labels. If a circuit is not set, the value is considered an undefined value.

Wiring example



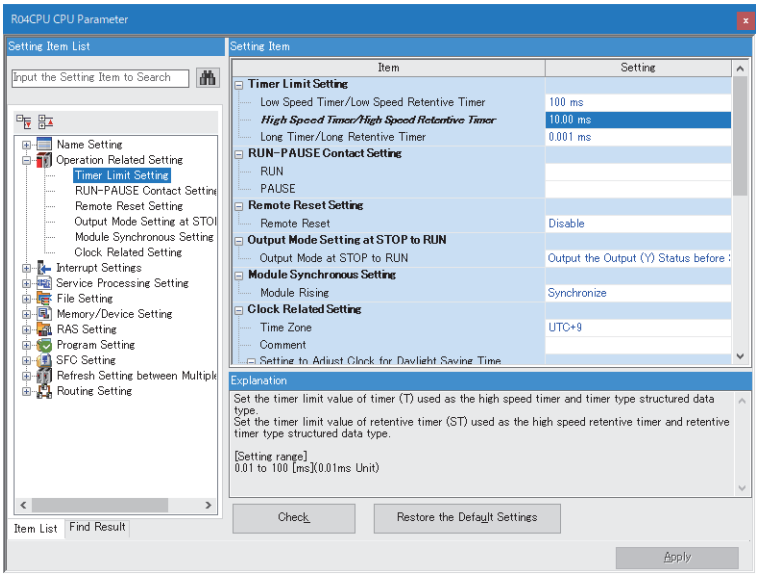
(1) Control target

Parameter setting

■CPU parameter

In the CPU parameters of R04CPU, set the following "High Speed Timer/High Speed Retentive Timer" to "10.00ms" and specify the timer limit setting. Leave all other CPU parameters as their defaults.

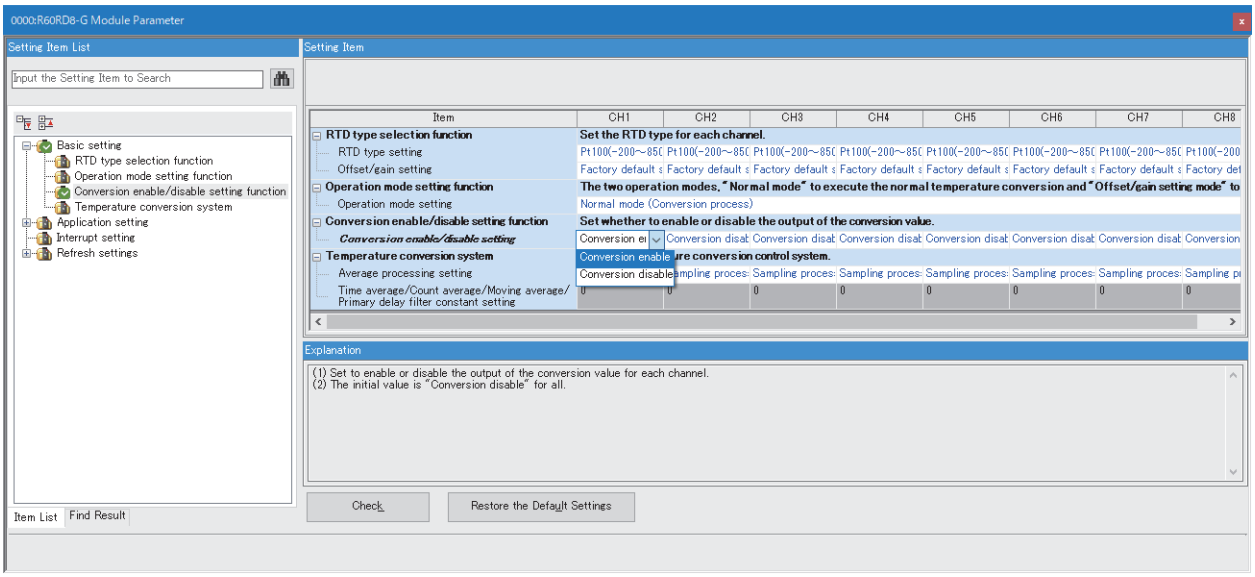
[Navigation window] ⇨ [Parameter] ⇨ [R04CPU] ⇨ [CPU Parameter] ⇨ [Operation Related Setting]



■Module parameters for the temperature input module

In the R60RD8-G module parameters, set the following "Conversion enable/disable setting" to "Conversion enable". Leave all other module parameters as their defaults.

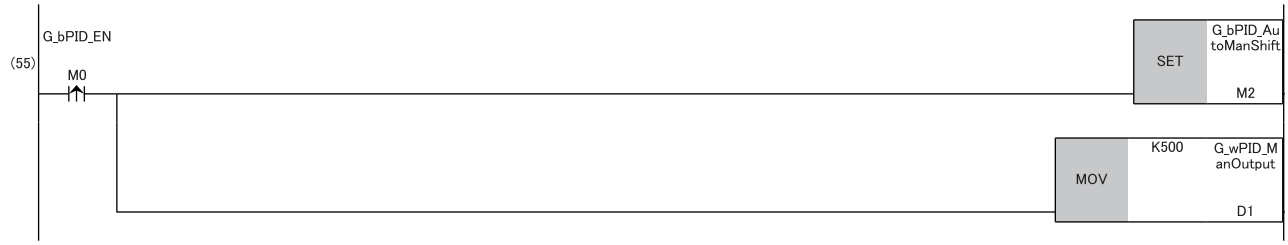
[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60RD8-G] ⇨ [Basic Setting]



Program example

A program that executes the PID control to calculate a manipulated value (MV) automatically. This program also executes the auto tuning. (☞ Page 13 Automatic calculation of a manipulated value (MV) by PID control).

For setting a manipulated value (MV) manually without using the PID control, change (55) in the program as follows. (☞ Page 21 Manual output).



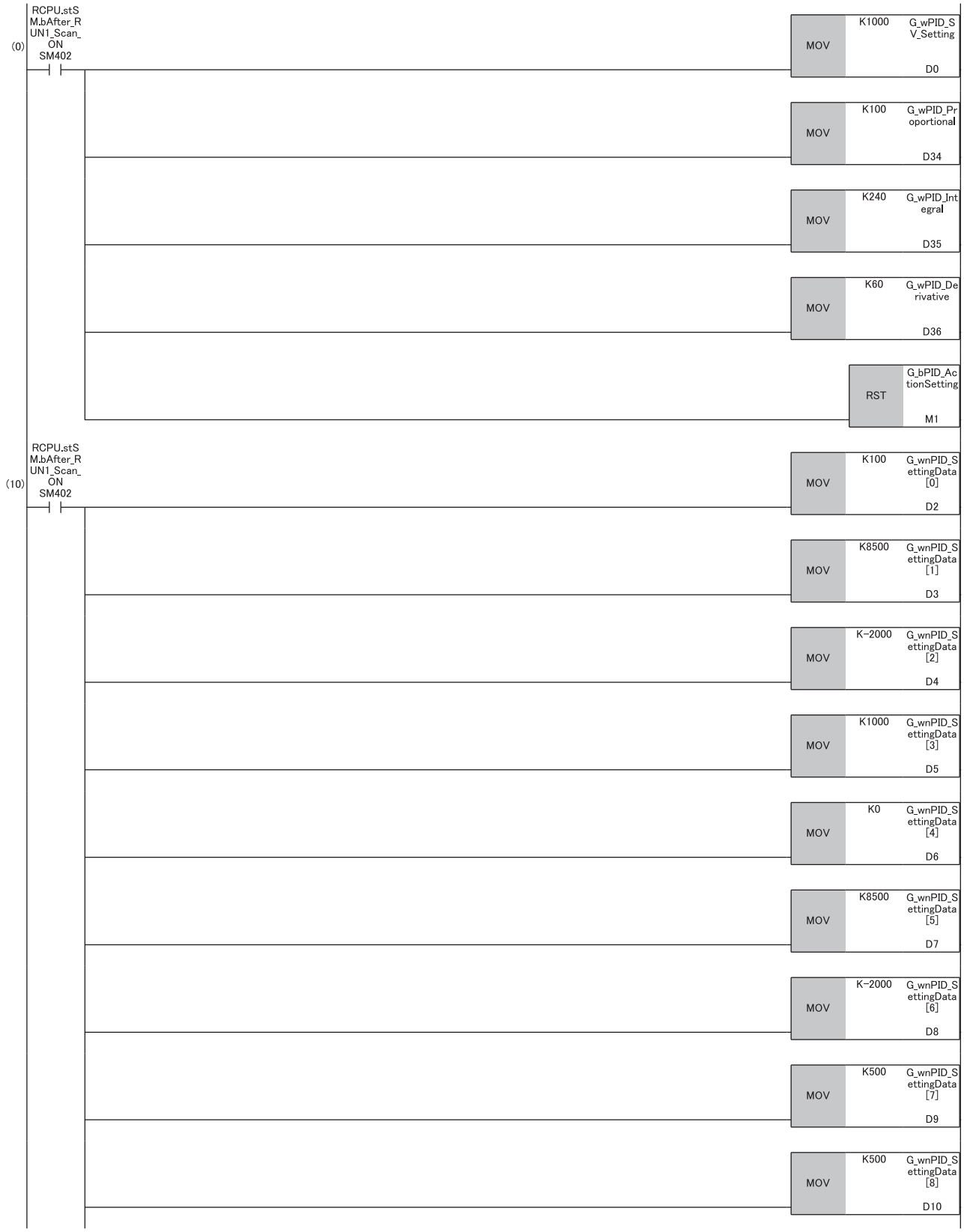
■Label setting

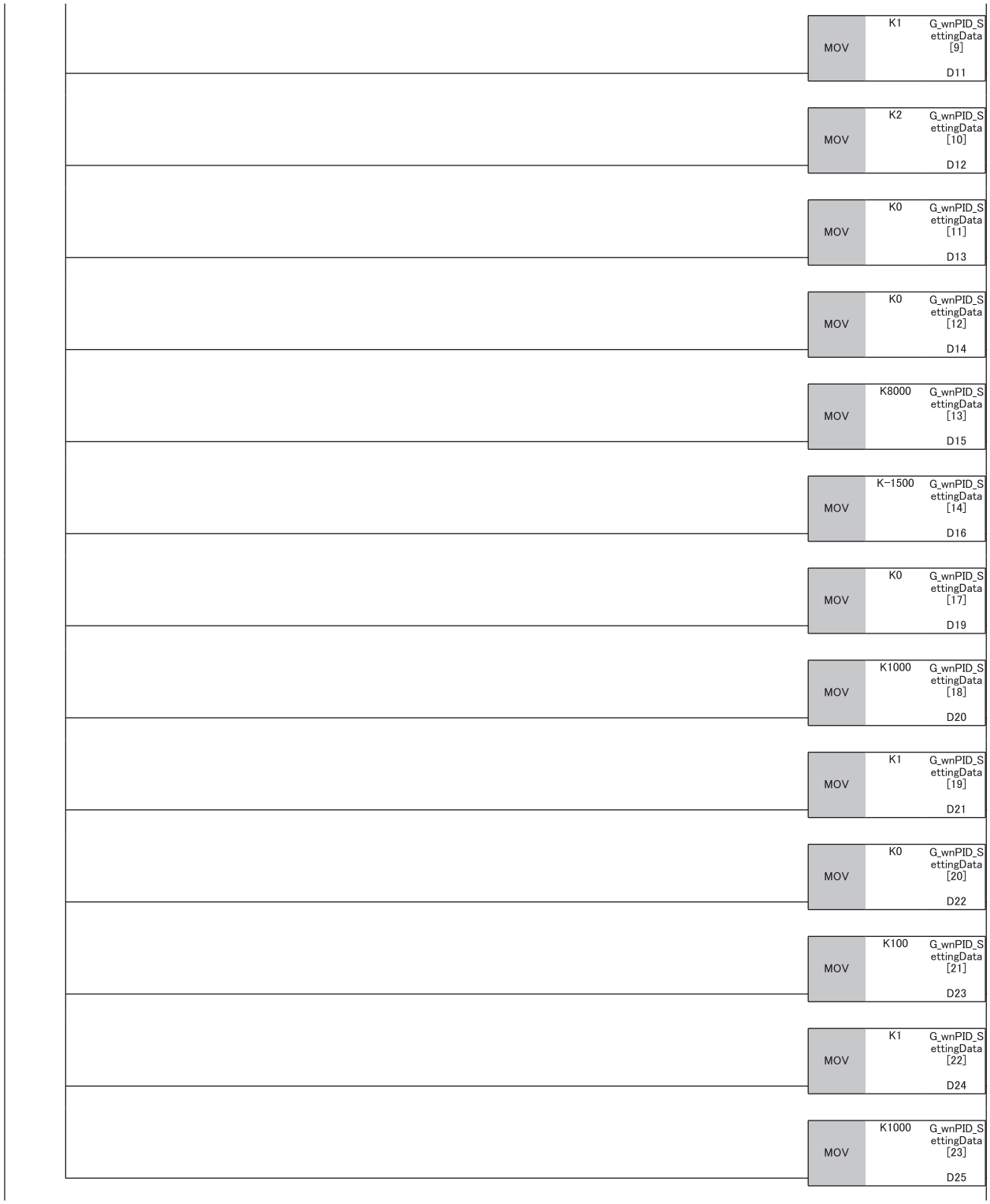
Classification	Label name	Description	Device
Module label	RCPU.stSM.bAfter_RUN1_Scan_ON	Turns on one scan after RUN	SM402
	R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue	CH1 Temperature process value	—
Labels to be defined	Define global labels as follows.		

	Label Name	Data Type		Class	Assign (Device/Label)
1	G_bPID_OutputSignal	Bit	...	VAR_GLOBAL	Y10
2	G_bPID_EN	Bit	...	VAR_GLOBAL	M0
3	G_bPID_ActionSetting	Bit	...	VAR_GLOBAL	M1
4	G_bPID_AutoManShift	Bit	...	VAR_GLOBAL	M2
5	G_bPID_AT	Bit	...	VAR_GLOBAL	M3
6	G_bPID_ENO	Bit	...	VAR_GLOBAL	M5
7	G_bPID_OK	Bit	...	VAR_GLOBAL	M6
8	G_bPID_TraOutputFlag	Bit	...	VAR_GLOBAL	M7
9	G_bPID_Err	Bit	...	VAR_GLOBAL	F0
10	G_wPID_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D0
11	G_wPID_ManOutput	Word [Signed]	...	VAR_GLOBAL	D1
12	G_wnPID_SettingData	Word [Signed](0..23)	...	VAR_GLOBAL	D2
13	G_wPID_PV	Word [Signed]	...	VAR_GLOBAL	D26
14	G_wPID_MV	Word [Signed]	...	VAR_GLOBAL	D27
15	G_wPID_SV	Word [Signed]	...	VAR_GLOBAL	D28
16	G_ePID_PV	FLOAT [Single Precision]	...	VAR_GLOBAL	D29
17	G_wPID_AT_Status	Word [Signed]	...	VAR_GLOBAL	D31
18	G_wPID_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D32
19	G_uPID_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D33
20	G_wPID_Proportional	Word [Signed]	...	VAR_GLOBAL	D34
21	G_wPID_Integral	Word [Signed]	...	VAR_GLOBAL	D35
22	G_wPID_Derivative	Word [Signed]	...	VAR_GLOBAL	D36

■Initial setting

Set the initial value for the FB after CPU RUN.

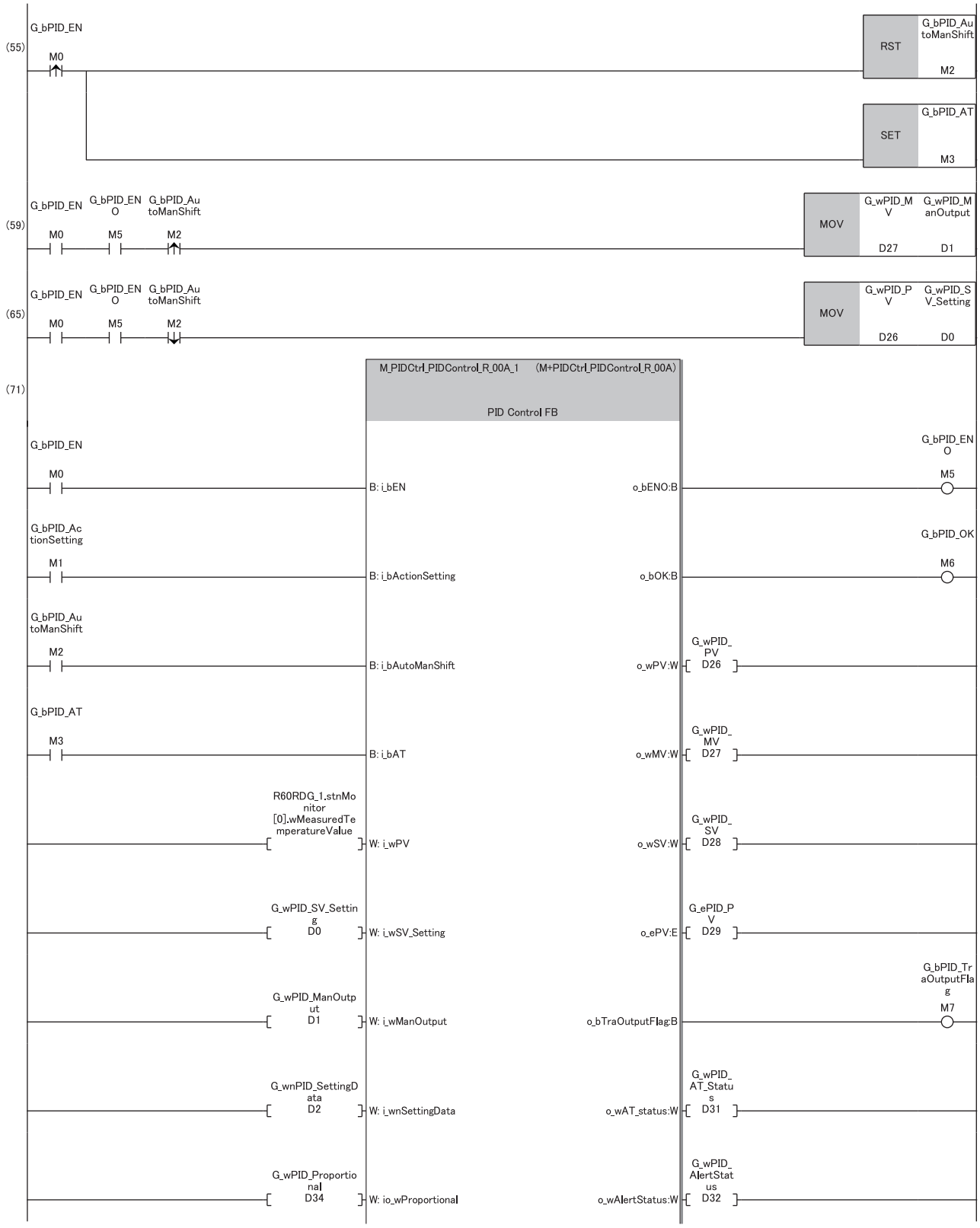


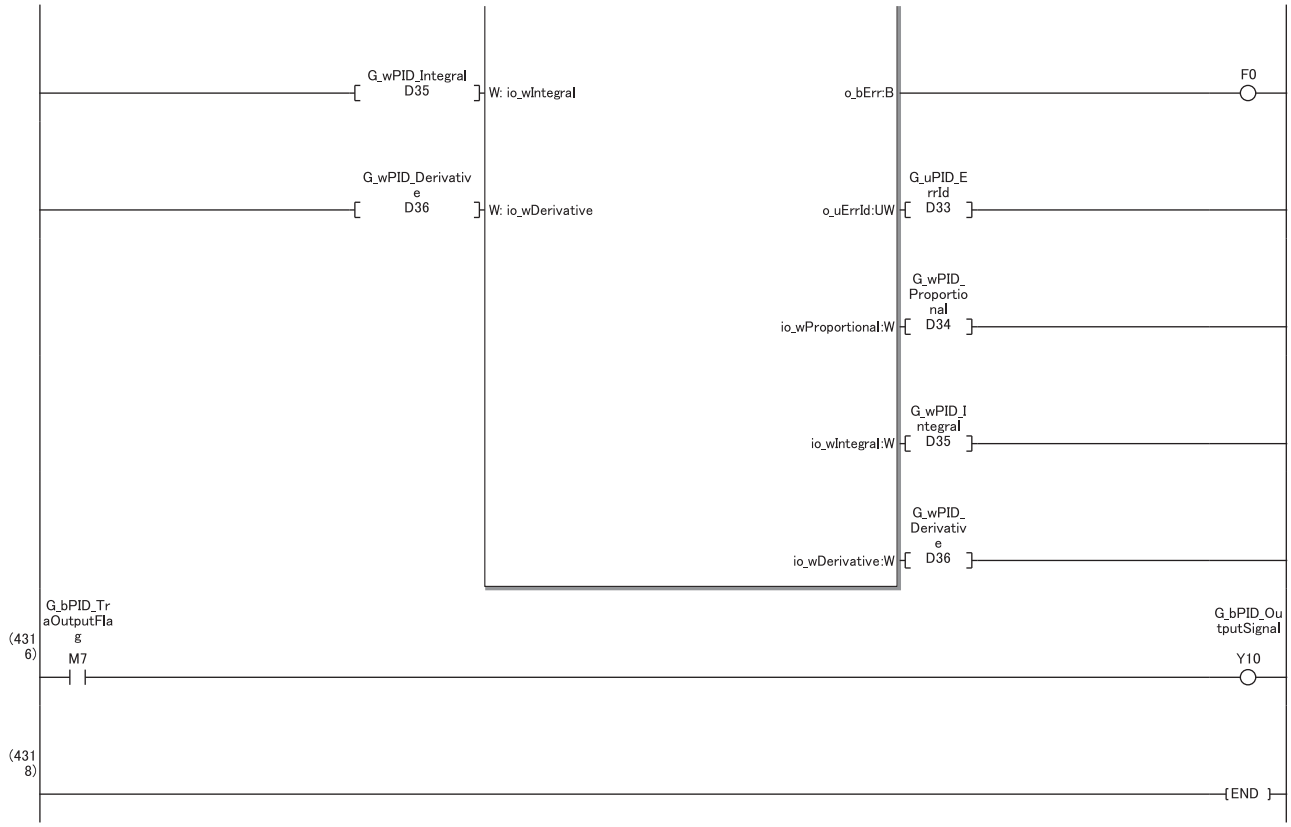

MOV
K1
G_wnPID_SettingData[9]
D11
MOV
K2
G_wnPID_SettingData[10]
D12
MOV
K0
G_wnPID_SettingData[11]
D13
MOV
K0
G_wnPID_SettingData[12]
D14
MOV
K8000
G_wnPID_SettingData[13]
D15
MOV
K-1500
G_wnPID_SettingData[14]
D16
MOV
K0
G_wnPID_SettingData[17]
D19
MOV
K1000
G_wnPID_SettingData[18]
D20
MOV
K1
G_wnPID_SettingData[19]
D21
MOV
K0
G_wnPID_SettingData[20]
D22
MOV
K100
G_wnPID_SettingData[21]
D23
MOV
K1
G_wnPID_SettingData[22]
D24
MOV
K1000
G_wnPID_SettingData[23]
D25

■PID control

When G_bPID_EN (PID control execution command) turns on, the PID constants are calculated, and PID control is executed for the process value obtained via CH1.

By turning G_bPID_AutoManShift (AUTO/MAN mode shift) on or off, automatic calculation and manual setting of the manipulated value (MV) switch.





(55)Set this item when automatically calculating the manipulated value (MV) (☞ Page 13 Automatic calculation of a manipulated value (MV) by PID control). When calculation of the PID constants by auto tuning is not required, turn off G_bPID_AT (auto tuning start/stop).

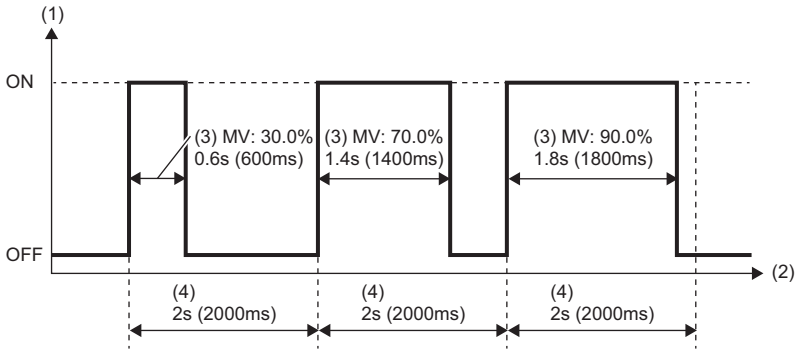
(59)To avoid sudden changes in the manipulated value (MV) when the mode is switched from AUTO to MAN, store the manipulated value (MV) from immediately before in the MAN output setting.

(65)To avoid sudden changes in the manipulated value (MV) when the mode is switched from MAN to AUTO, store the process value (PV) from immediately before in the set value (SV) setting.

When performing the cascade control

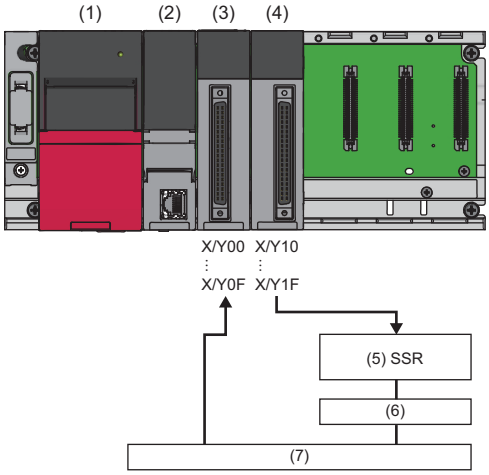
This section describes an application example of cascade control by using more than one of this FB.

This PID control program reads the temperature measured by the resistance temperature detector (Pt100, -200℃ to 850.0℃) connected to CH1 of R60RD8-G. The following image shows the relationship between a manipulated value (MV) of 0 to 1000 (0.0% to 100.0%) and the RY41NT2P output.



(1) Output
(2) Time
(3) Manipulated value
(4) Control output cycle setting

System configuration

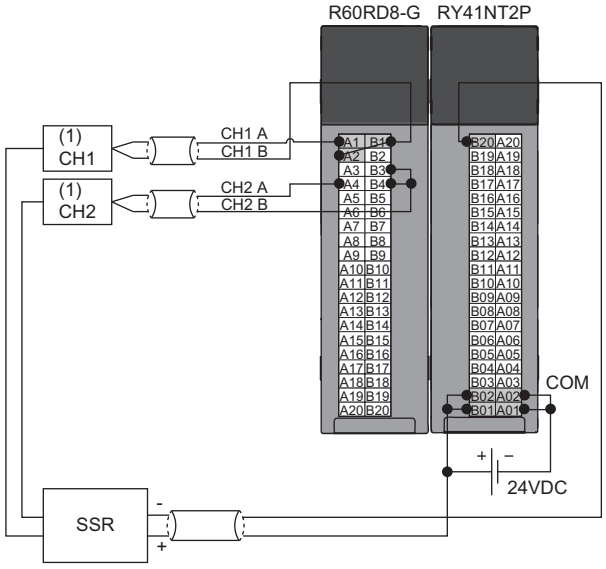


No.	Product	Model name
(1)	Power supply module	R61P
(2)	CPU module	R04CPU
(3)	Channel isolated RTD input module	R60RD8-G
(4)	Transistor output module	RY41NT2P
(5)	Solid state relay	—
(6)	Heater	—
(7)	Control target	Uses resistance temperature detector (Pt100, -200℃ to 850.0℃)

Precautions

Ladder blocks must be configured for all input labels. If a circuit is not set, the value is considered an undefined value.

Wiring example



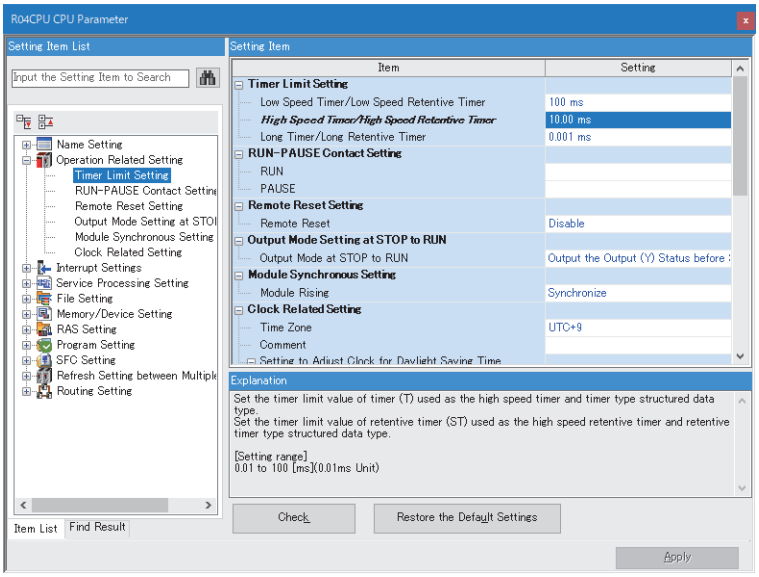
(1) Control target

Parameter setting

■CPU parameter

In the CPU parameters of R04CPU, set the following "High Speed Timer/High Speed Retentive Timer" to "10.00ms" and specify the timer limit setting. Leave all other CPU parameters as their defaults.

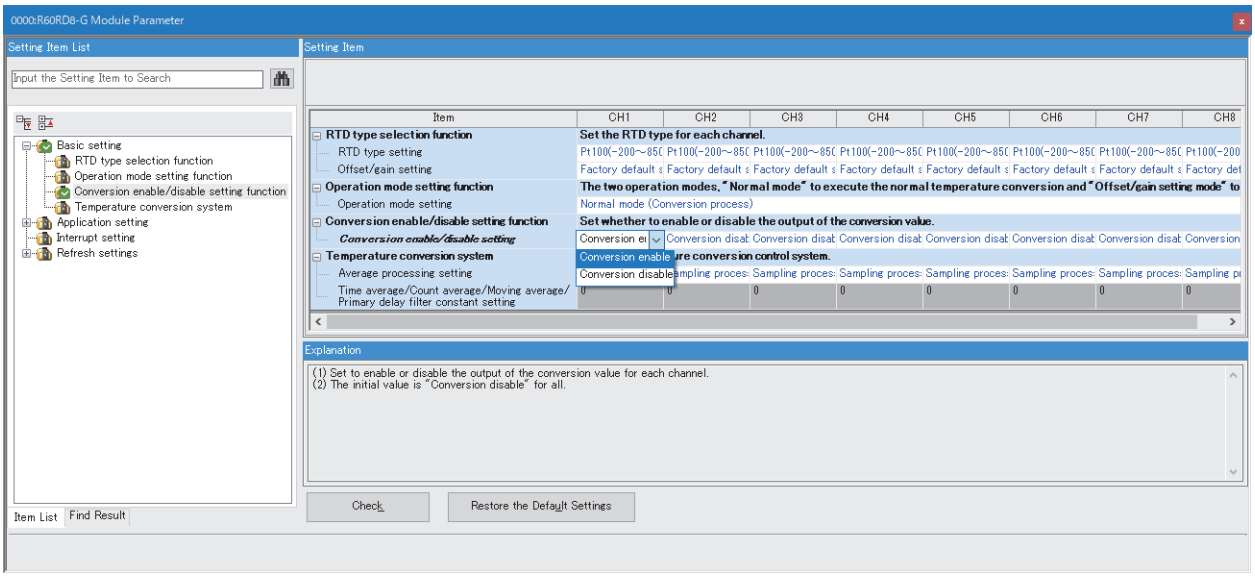
[Navigation window] ⇨ [Parameter] ⇨ [R04CPU] ⇨ [CPU Parameter] ⇨ [Operation Related Setting]



■Module parameters for the temperature input module

In the R60RD8-G module parameters, set the following "Conversion enable/disable setting" to "Conversion enable". Leave all other module parameters as their defaults.

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60RD8-G] ⇨ [Basic Setting]



Program example

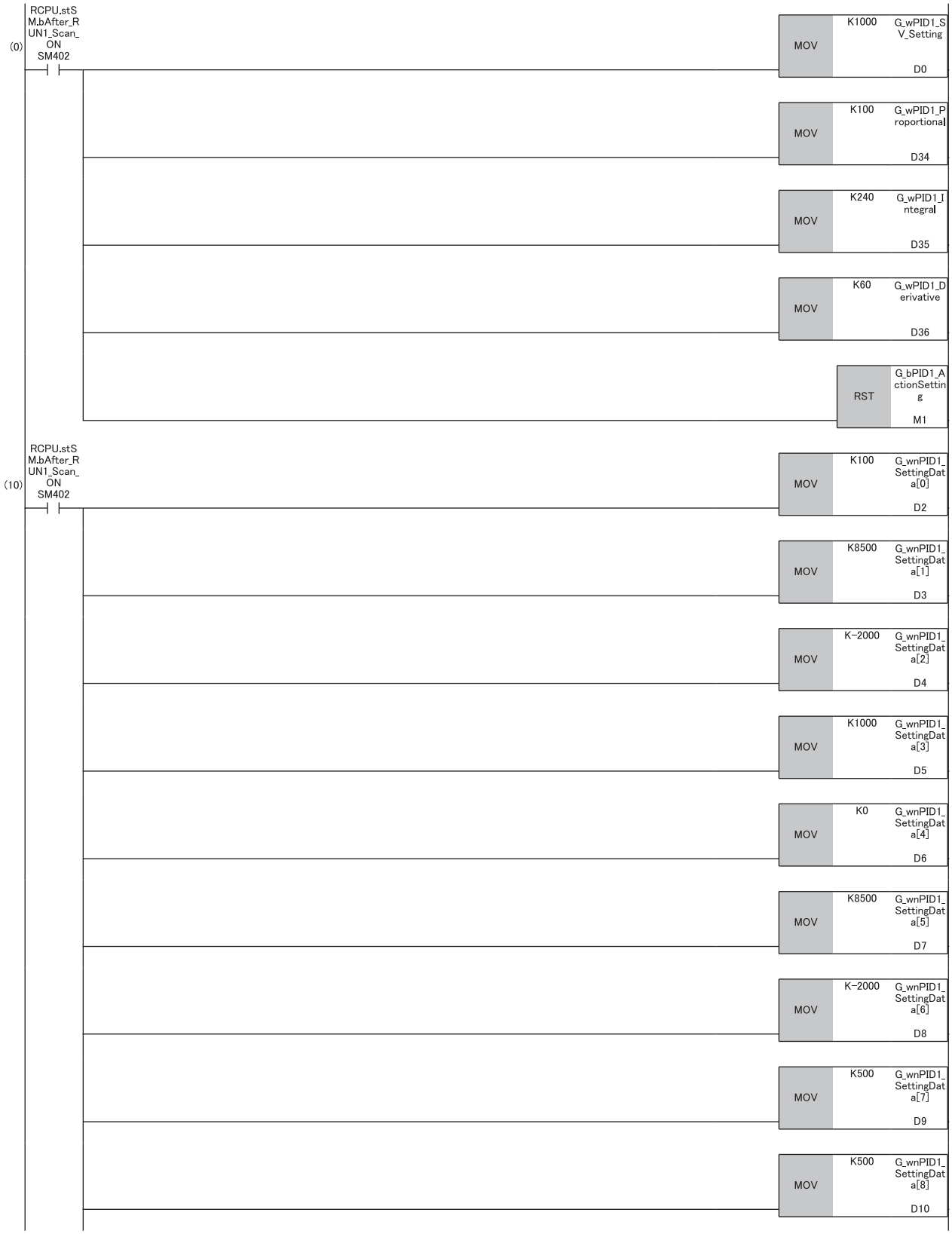
■Label setting

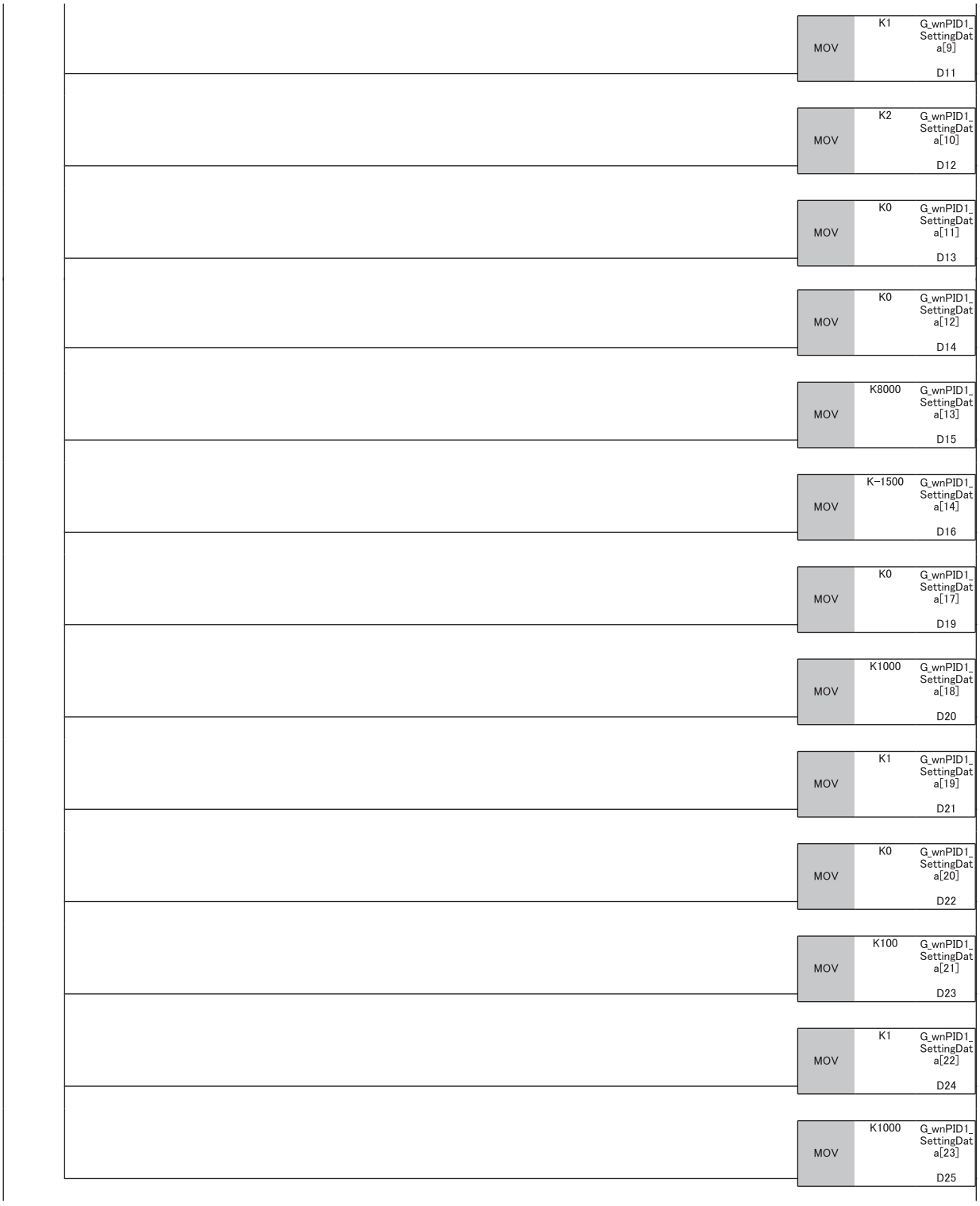
Classification	Label name	Description	Device
Module label	RCPU.stSM.bAlways_ON	Always ON	SM400
	RCPU.stSM.bAfter_RUN1_Scan_ON	Turns on one scan after RUN	SM402
	R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue	CH1 Temperature process value	—
	R60RDG_1.stnMonitor[1].wMeasuredTemperatureValue	CH2 Temperature process value	—
Labels to be defined	Define global labels as follows.		

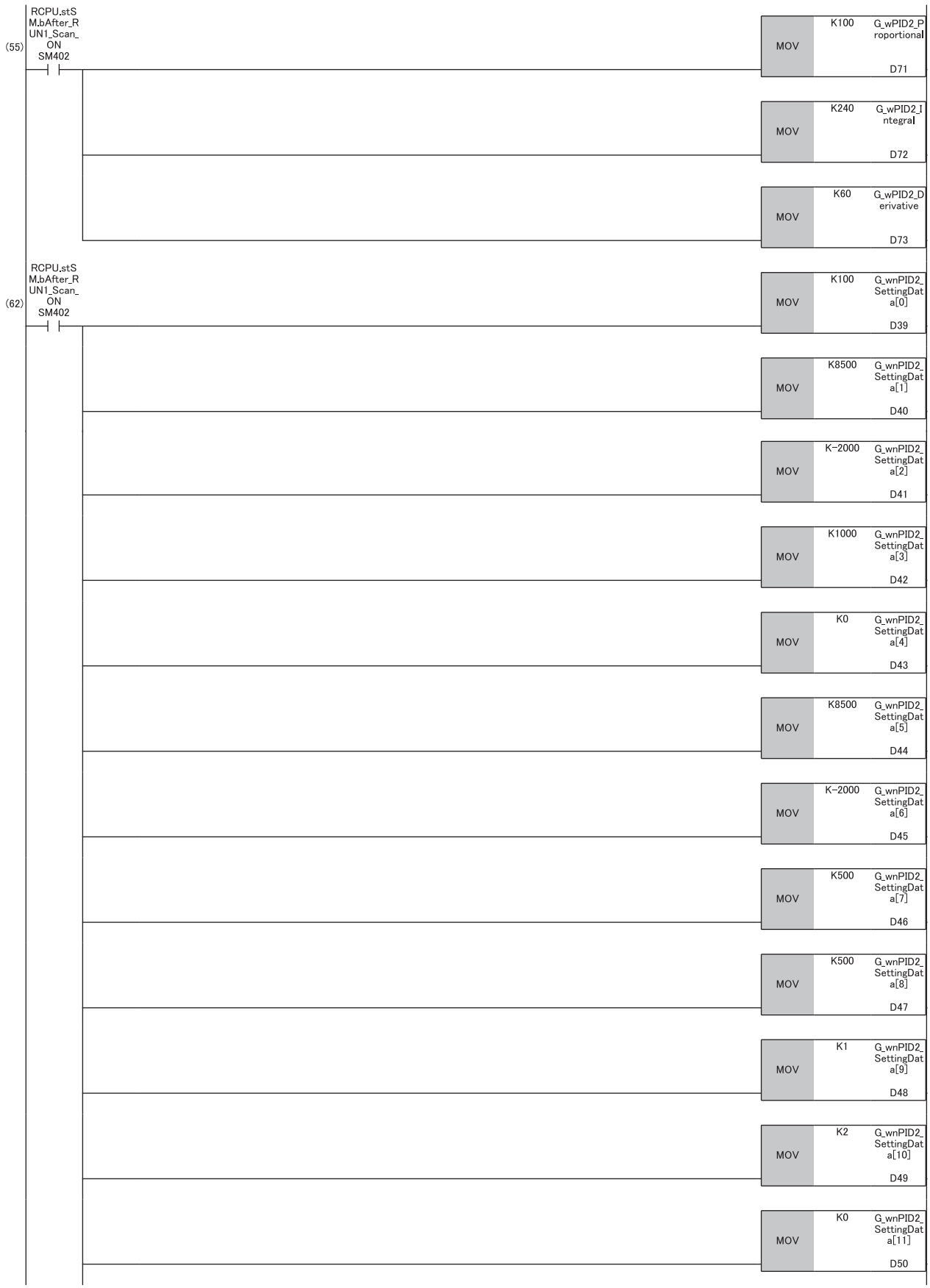
	Label Name	Data Type		Class	Assign (Device/Label)
1	G_bPID2_OutputSignal	Bit	...	VAR_GLOBAL	Y10
2	G_bPID1_EN	Bit	...	VAR_GLOBAL	M0
3	G_bPID1_ActionSetting	Bit	...	VAR_GLOBAL	M1
4	G_bPID1_AutoManShift	Bit	...	VAR_GLOBAL	M2
5	G_bPID1_AT	Bit	...	VAR_GLOBAL	M3
6	G_bPID2_AT	Bit	...	VAR_GLOBAL	M4
7	G_bPID1_ENO	Bit	...	VAR_GLOBAL	M5
8	G_bPID1_OK	Bit	...	VAR_GLOBAL	M6
9	G_bPID1_TraOutputFlag	Bit	...	VAR_GLOBAL	M7
10	G_bPID2_ENO	Bit	...	VAR_GLOBAL	M8
11	G_bPID2_OK	Bit	...	VAR_GLOBAL	M9
12	G_bPID2_TraOutputFlag	Bit	...	VAR_GLOBAL	M10
13	G_bPID1_Err	Bit	...	VAR_GLOBAL	F0
14	G_bPID2_Err	Bit	...	VAR_GLOBAL	F1
15	G_wPID1_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D0
16	G_wPID1_ManOutput	Word [Signed]	...	VAR_GLOBAL	D1
17	G_wnPID1_SettingData	Word [Signed](0..23)	...	VAR_GLOBAL	D2
18	G_wPID1_PV	Word [Signed]	...	VAR_GLOBAL	D26
19	G_wPID1_MV	Word [Signed]	...	VAR_GLOBAL	D27
20	G_wPID1_SV	Word [Signed]	...	VAR_GLOBAL	D28
21	G_ePID1_PV	FLOAT [Single Precision]	...	VAR_GLOBAL	D29
22	G_wPID1_AT_Status	Word [Signed]	...	VAR_GLOBAL	D31
23	G_wPID1_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D32
24	G_uPID1_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D33
25	G_wPID1_Proportional	Word [Signed]	...	VAR_GLOBAL	D34
26	G_wPID1_Integral	Word [Signed]	...	VAR_GLOBAL	D35
27	G_wPID1_Derivative	Word [Signed]	...	VAR_GLOBAL	D36
28	G_wPID2_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D37
29	G_wPID2_ManOutput	Word [Signed]	...	VAR_GLOBAL	D38
30	G_wnPID2_SettingData	Word [Signed](0..23)	...	VAR_GLOBAL	D39
31	G_wPID2_PV	Word [Signed]	...	VAR_GLOBAL	D63
32	G_wPID2_MV	Word [Signed]	...	VAR_GLOBAL	D64
33	G_wPID2_SV	Word [Signed]	...	VAR_GLOBAL	D65
34	G_ePID2_PV	FLOAT [Single Precision]	...	VAR_GLOBAL	D66
35	G_wPID2_AT_Status	Word [Signed]	...	VAR_GLOBAL	D68
36	G_wPID2_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D69
37	G_uPID2_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D70
38	G_wPID2_Proportional	Word [Signed]	...	VAR_GLOBAL	D71
39	G_wPID2_Integral	Word [Signed]	...	VAR_GLOBAL	D72
40	G_wPID2_Derivative	Word [Signed]	...	VAR_GLOBAL	D73
41	G_wPID2_RangeWidth	Word [Signed]	...	VAR_GLOBAL	D74
42	G_wPID2_CalcValue	Word [Signed]	...	VAR_GLOBAL	D75
43	G_d2PID2_CalcValue	Double Word [Signed](0..1)	...	VAR_GLOBAL	D76

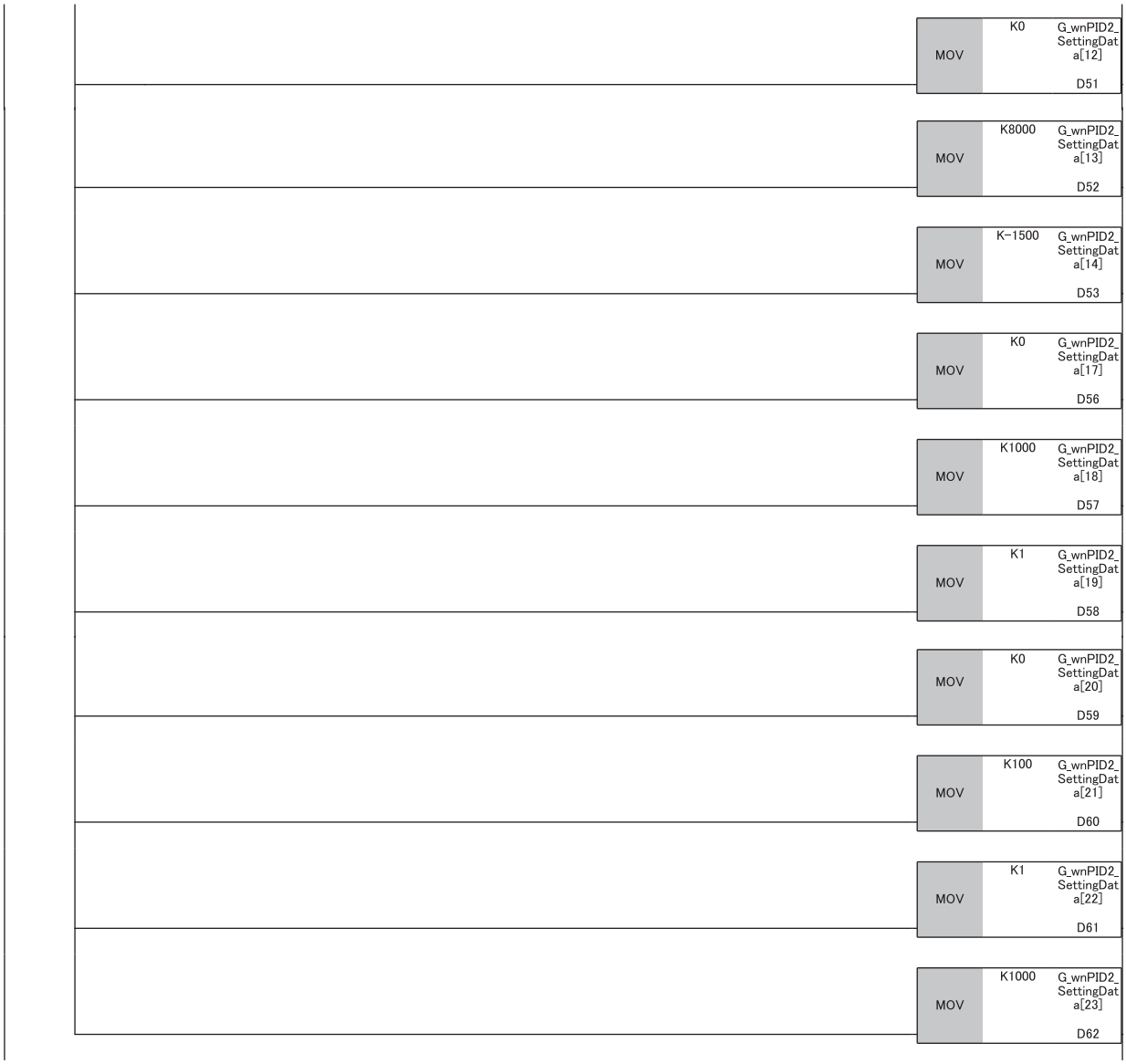
■PID control

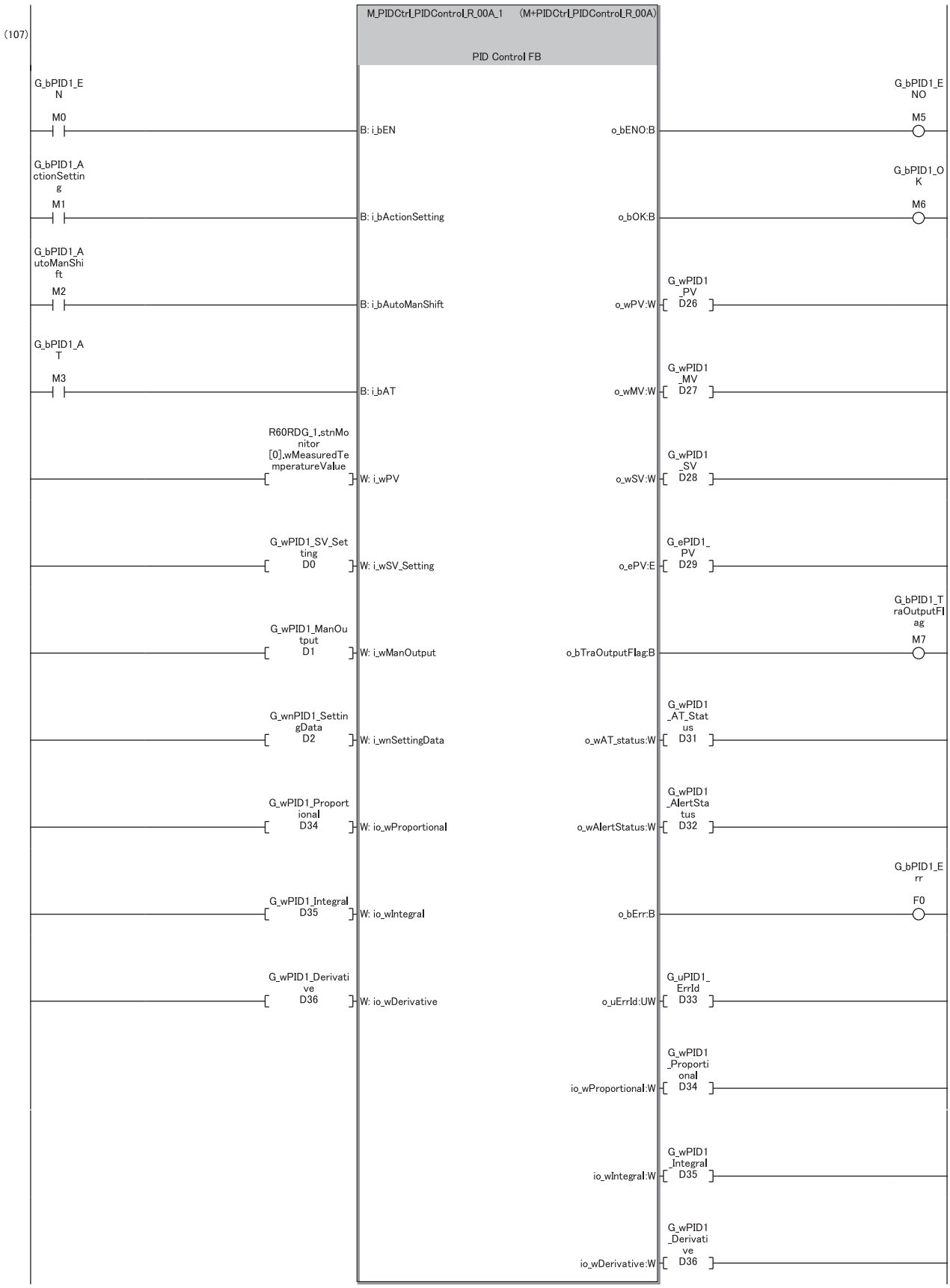
When G_bPID_EN (PID control execution command) turns on, the cascade control is performed.

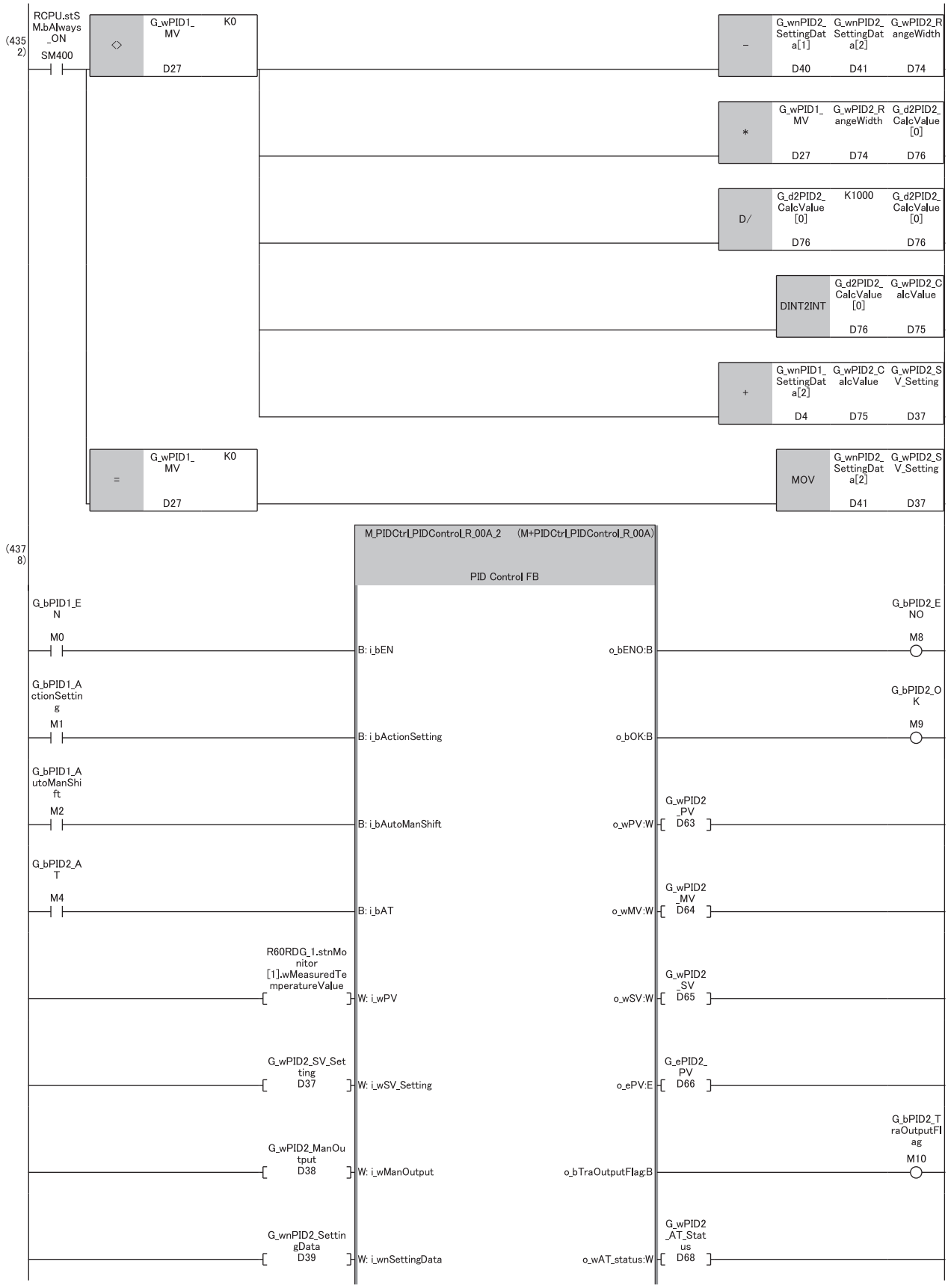


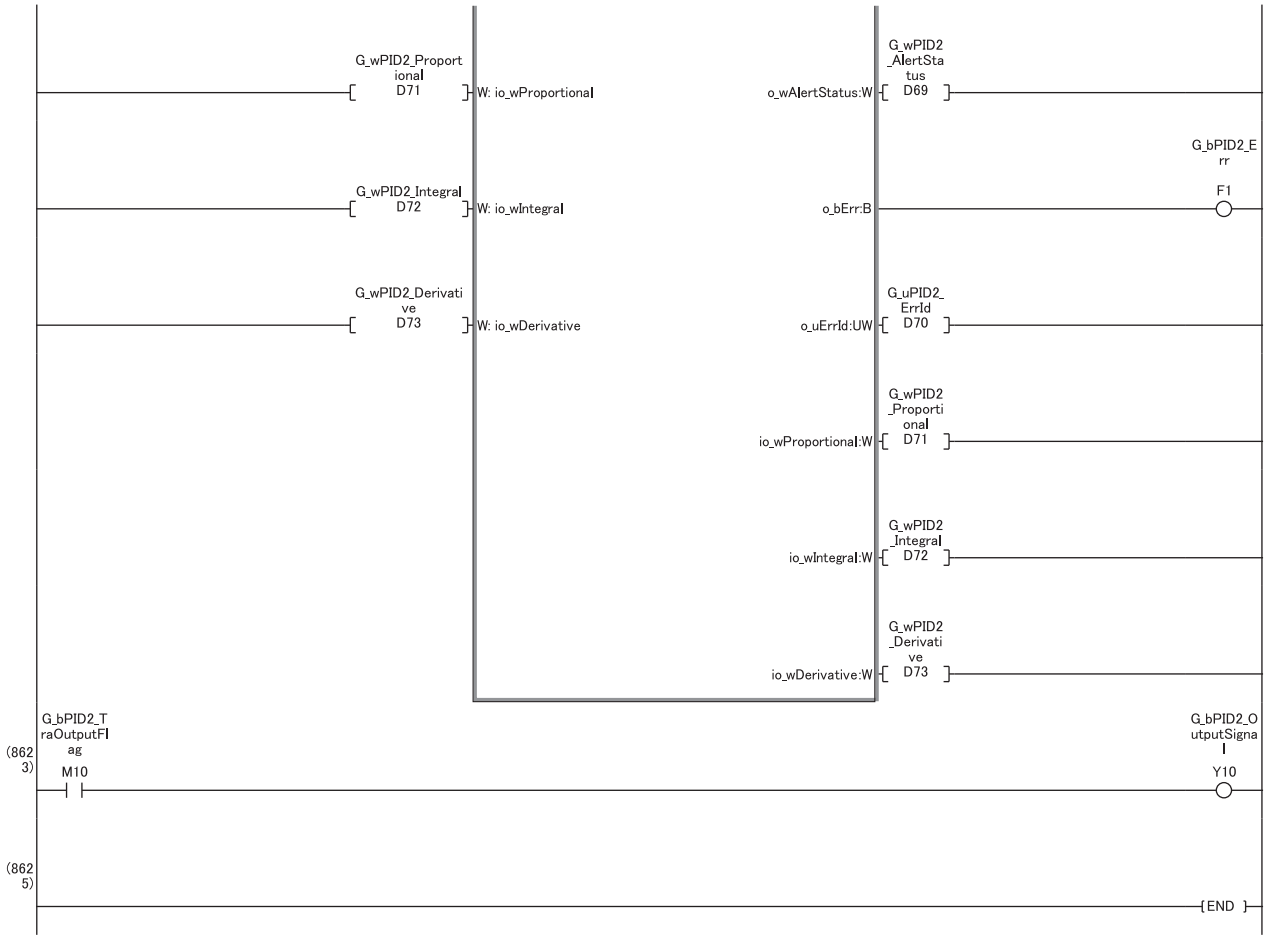

MOV
K1
G_wnPID1_SettingData[9]
D11
MOV
K2
G_wnPID1_SettingData[10]
D12
MOV
K0
G_wnPID1_SettingData[11]
D13
MOV
K0
G_wnPID1_SettingData[12]
D14
MOV
K8000
G_wnPID1_SettingData[13]
D15
MOV
K-1500
G_wnPID1_SettingData[14]
D16
MOV
K0
G_wnPID1_SettingData[17]
D19
MOV
K1000
G_wnPID1_SettingData[18]
D20
MOV
K1
G_wnPID1_SettingData[19]
D21
MOV
K0
G_wnPID1_SettingData[20]
D22
MOV
K100
G_wnPID1_SettingData[21]
D23
MOV
K1
G_wnPID1_SettingData[22]
D24
MOV
K1000
G_wnPID1_SettingData[23]
D25


(55)
RCPU.stSM.bAfter_RUN1_Scan_ONSM402
MOV K100 G_wPID2_Proportional D71
MOV K240 G_wPID2_Integral D72
MOV K60 G_wPID2_Derivative D73
(62)
RCPU.stSM.bAfter_RUN1_Scan_ONSM402
MOV K100 G_wnPID2_SettingData[0] D39
MOV K8500 G_wnPID2_SettingData[1] D40
MOV K-2000 G_wnPID2_SettingData[2] D41
MOV K1000 G_wnPID2_SettingData[3] D42
MOV K0 G_wnPID2_SettingData[4] D43
MOV K8500 G_wnPID2_SettingData[5] D44
MOV K-2000 G_wnPID2_SettingData[6] D45
MOV K500 G_wnPID2_SettingData[7] D46
MOV K500 G_wnPID2_SettingData[8] D47
MOV K1 G_wnPID2_SettingData[9] D48
MOV K2 G_wnPID2_SettingData[10] D49
MOV K0 G_wnPID2_SettingData[11] D50


MOV
K0
G_wnPID2_SettingData[12]
D51
MOV
K8000
G_wnPID2_SettingData[13]
D52
MOV
K-1500
G_wnPID2_SettingData[14]
D53
MOV
K0
G_wnPID2_SettingData[17]
D56
MOV
K1000
G_wnPID2_SettingData[18]
D57
MOV
K1
G_wnPID2_SettingData[19]
D58
MOV
K0
G_wnPID2_SettingData[20]
D59
MOV
K100
G_wnPID2_SettingData[21]
D60
MOV
K1
G_wnPID2_SettingData[22]
D61
MOV
K1000
G_wnPID2_SettingData[23]
D62


(107)
M_PIDCtrl_PIDControl_R_00A_1 (M+PIDCtrl_PIDControl_R_00A)
PID Control FB
G_bPID1_EN
M0
B: i_bEN
o_bENO:B
G_bPID1_ENO
M5
G_bPID1_ActionSetting
M1
B: i_bActionSetting
o_bOK:B
G_bPID1_OK
M6
G_bPID1_AutoManShift
M2
B: i_bAutoManShift
o_wPV:W
G_wPID1_PV
D26
G_bPID1_AT
M3
B: i_bAT
o_wMV:W
G_wPID1_MV
D27
R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue
W: i_wPV
o_wSV:W
G_wPID1_SV
D28
G_wPID1_SV_Setting
D0
W: i_wSV_Setting
o_ePV:E
G_ePID1_PV
D29
G_wPID1_ManOutput
D1
W: i_wManOutput
o_bTraOutputFlag:B
G_bPID1_TraOutputFlag
M7
G_wnPID1_SettingData
D2
W: i_wnSettingData
o_wAT_status:W
G_wPID1_AT_Status
D31
G_wPID1_Proportional
D34
W: io_wProportional
o_wAlertStatus:W
G_wPID1_AlertStatus
D32
G_bPID1_Err
F0
G_wPID1_Integral
D35
W: io_wIntegral
o_bErr:B
G_wPID1_Derivative
D36
W: io_wDerivative
o_uErrId:UW
G_uPID1_ErrId
D33
io_wProportional:W
G_wPID1_Proportional
D34
io_wIntegral:W
G_wPID1_Integral
D35
io_wDerivative:W
G_wPID1_Derivative
D36

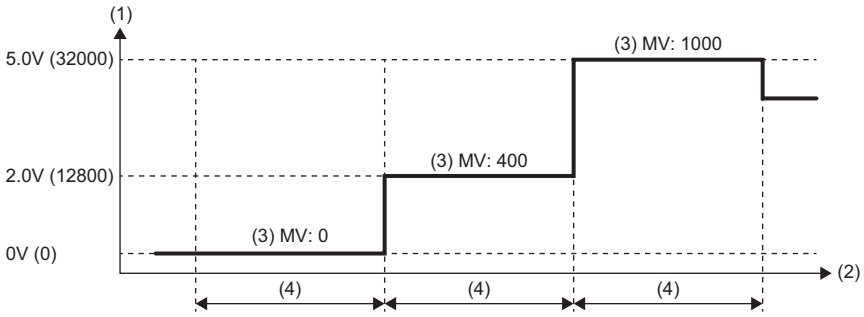

(4352)
RCPU.stSM.bAlways_ON
SM400
◇
G_wPID1_MV
K0
D27
−
G_wnPID2_SettingData[1]
G_wnPID2_SettingData[2]
G_wPID2_RangeWidth
D40
D41
D74
*
G_wPID1_MV
G_wPID2_RangeWidth
G_d2PID2_CalcValue[0]
D27
D74
D76
D/
G_d2PID2_CalcValue[0]
K1000
G_d2PID2_CalcValue[0]
D76
D76
DINT2INT
G_d2PID2_CalcValue[0]
G_wPID2_CalcValue
D76
D75
+
G_wnPID1_SettingData[2]
G_wPID2_CalcValue
G_wPID2_SV_Setting
D4
D75
D37
=
G_wPID1_MV
K0
D27
MOV
G_wnPID2_SettingData[2]
G_wPID2_SV_Setting
D41
D37
(4378)
M_PIDCtrl_PIDControl_R_00A_2 (M+PIDCtrl_PIDControl_R_00A)
PID Control FB
G_bPID1_EN
M0
B: i_bEN
o_bENO:B
G_bPID2_ENO
M8
G_bPID1_ActionSetting
M1
B: i_bActionSetting
o_bOK:B
G_bPID2_OK
M9
G_bPID1_AutoManShift
M2
B: i_bAutoManShift
o_wPV:W
G_wPID2_PV
D63
G_bPID2_AT
M4
B: i_bAT
o_wMV:W
G_wPID2_MV
D64
R60RDG_1.stnMonitor[1].wMeasuredTemperatureValue
W: i_wPV
o_wSV:W
G_wPID2_SV
D65
G_wPID2_SV_Setting
D37
W: i_wSV_Setting
o_ePV:E
G_ePID2_PV
D66
G_wPID2_ManOutput
D38
W: i_wManOutput
o_bTraOutputFlag:B
G_bPID2_TraOutputFlag
M10
G_wnPID2_SettingData
D39
W: i_wnSettingData
o_wAT_status:W
G_wPID2_AT_Status
D68


G_wPID2_Proportional
D71
W: io_wProportional
G_wPID2_Integral
D72
W: io_wIntegral
G_wPID2_Derivative
D73
W: io_wDerivative
o_wAlertStatus:W
G_wPID2_AlertStatus
D69
o_bErr:B
G_bPID2_Err
F1
o_uErrId:UW
G_uPID2_ErrId
D70
io_wProportional:W
G_wPID2_Proportional
D71
io_wIntegral:W
G_wPID2_Integral
D72
io_wDerivative:W
G_wPID2_Derivative
D73
(8623)
G_bPID2_TraOutputFlag
M10
G_bPID2_OutputSignal
Y10
(8625)
END

3.2 M+PIDCtrl_PIDOperation_R

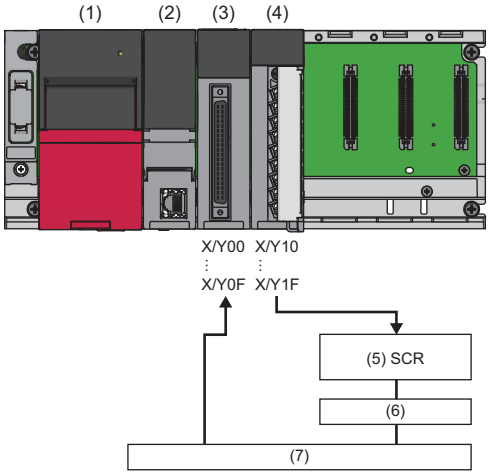
When using SCR (thyristor)

This PID control program reads the temperature measured by the resistance temperature detector (Pt100, -200℃ to 850.0℃) connected to CH1 of R60RD8-G, and outputs the DC voltage (0 to 5V) from CH1 of R60DA4. The following image shows the relationship between the manipulated value (MV) and the output voltage of the R60DA4 when 0 to 5V is output for a manipulated value (MV) of 0 to 1000.
In this case, the manipulated value (MV) settings are upper limit output limiter: 1000, lower limit output limiter: 0, AT upper limit output limiter (ULV): 1000, and AT lower limit output limiter (LLV): 0.



(1) Output voltage, ( ): Digital value
(2) Time
(3) Manipulated value
(4) Sampling time

System configuration

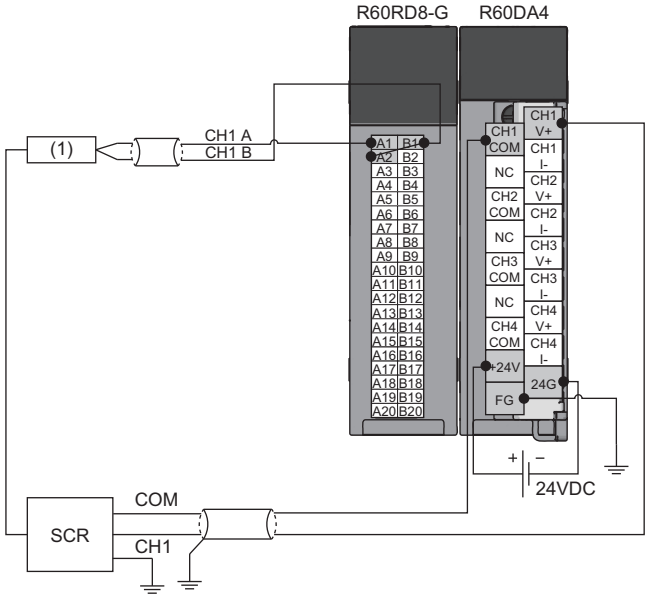


No.	Product	Model name
(1)	Power supply module	R61P
(2)	CPU module	R04CPU
(3)	Channel isolated RTD input module	R60RD8-G
(4)	Digital-analog converter module	R60DA4
(5)	Thyristor module	Input voltage (0 to 5V)
(6)	Heater	—
(7)	Control target	Uses resistance temperature detector (Pt100, -200℃ to 850.0℃)

Precautions

Ladder blocks must be configured for all input labels. If a circuit is not set, the value is considered an undefined value.

Wiring example



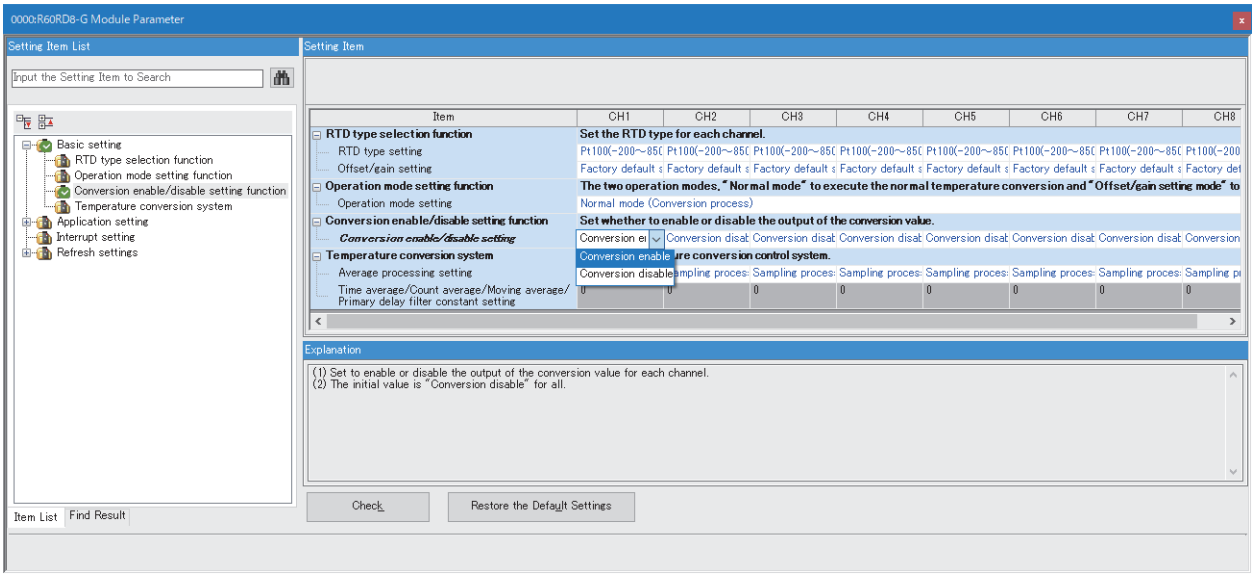
(1) Control target

Parameter setting

■Module parameters for the temperature input module

In the R60RD8-G module parameters, set the following "Conversion enable/disable setting" to "Conversion enable". Leave all other module parameters as their defaults.

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60RD8-G] ⇨ [Basic Setting]

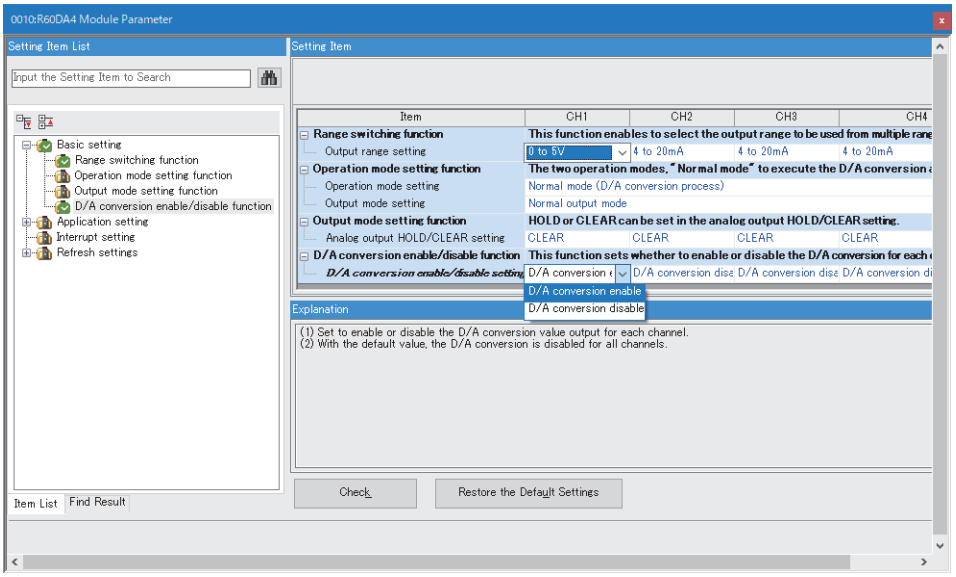


■Module parameters for the digital-analog converter module

In the R60DA4 module parameters, set the following values. Leave all other module parameters as their defaults.

- "Output range setting": "0 to 5V"
- "D/A conversion enable/disable setting": "D/A conversion enabled"

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60DA4] ⇨ [Basic Setting]



For the "Output range setting", check the input voltage specifications of the SCR (thyristor) and select from the following. Check the digital value and resolution of the output range, and set the upper/lower limit output limiter value of the manipulated value (MV).

Output range	Digital value	Resolution
0 to 5V	0 to 32000	156.3μV
1 to 5V		125.0μV
-10 to 10V	-32000 to 32000	312.5μV
User range setting		

Program example

■Label setting

Classification	Label name	Description	Device
Module label	RCPU.stSM.bAfter_RUN1_Scan_ON	Turns on one scan after RUN	SM402
	R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue	CH1 Temperature process value	—
	R60DA_1.bCH1OutputEnableDisableFlag	CH1 Output enable/disable flag	Y11
	R60DA_1.stnControl[0].wDigitalValue	CH1 Digital value	—
Labels to be defined	Define global labels as follows.		

	Label Name	Data Type		Class	Assign (Device/Label)
1	G_bPID_EN	Bit	...	VAR_GLOBAL	M0
2	G_bPID_ActionSetting	Bit	...	VAR_GLOBAL	M1
3	G_bPID_AutoManShift	Bit	...	VAR_GLOBAL	M2
4	G_bPID_AT	Bit	...	VAR_GLOBAL	M3
5	G_bPID_ENO	Bit	...	VAR_GLOBAL	M4
6	G_bPID_OK	Bit	...	VAR_GLOBAL	M5
7	G_bPID_AT_Status	Bit	...	VAR_GLOBAL	M6
8	G_bPID_Err	Bit	...	VAR_GLOBAL	F0
9	G_wPID_SamplingTime	Word [Signed]	...	VAR_GLOBAL	D0
10	G_wPID_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D1
11	G_wPID_P_GainSetting	Word [Signed]	...	VAR_GLOBAL	D2
12	G_wPID_I_Setting	Word [Signed]	...	VAR_GLOBAL	D3
13	G_wPID_D_Setting	Word [Signed]	...	VAR_GLOBAL	D4
14	G_wPID_MV_Setting	Word [Signed]	...	VAR_GLOBAL	D5
15	G_wPID_ManOutput	Word [Signed]	...	VAR_GLOBAL	D6
16	G_wnPID_SettingData	Word [Signed](0.1 2)	...	VAR_GLOBAL	D7
17	G_wPID_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D20
18	G_wPID_Proportional	Word [Signed]	...	VAR_GLOBAL	D21
19	G_wPID_Integral	Word [Signed]	...	VAR_GLOBAL	D22
20	G_wPID_Derivative	Word [Signed]	...	VAR_GLOBAL	D23
21	G_wPID_MV	Word [Signed]	...	VAR_GLOBAL	D24
22	G_uPID_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D25
23	G_uPID_PrePV	Word [Signed]	...	VAR_GLOBAL	D26
24	G_w2PIDControl_DigitalValue	Word [Signed](0.1)	...	VAR_GLOBAL	D27
25	G_bPID_CPU_Error	Bit	...	VAR_GLOBAL	M1 00

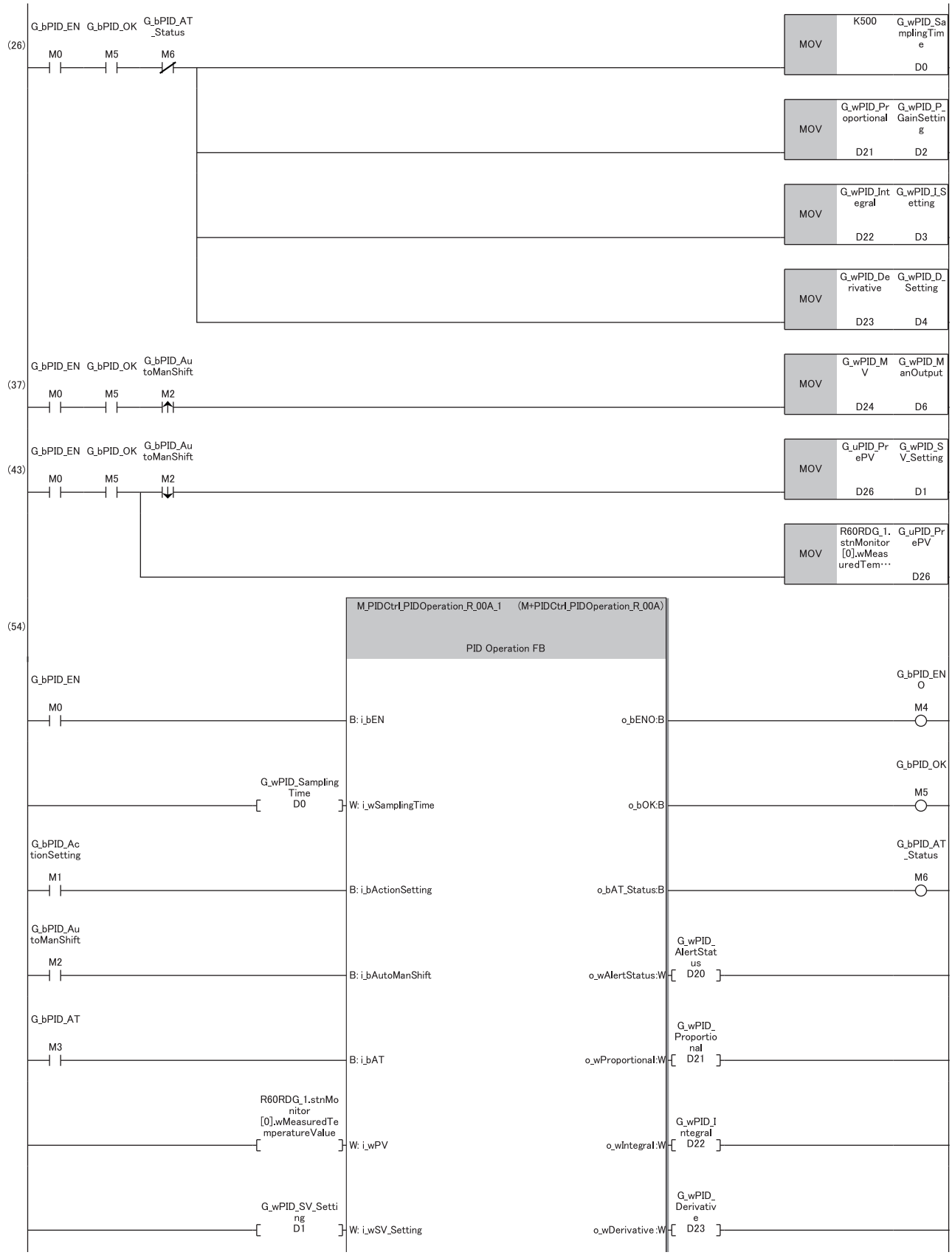
■Initial setting

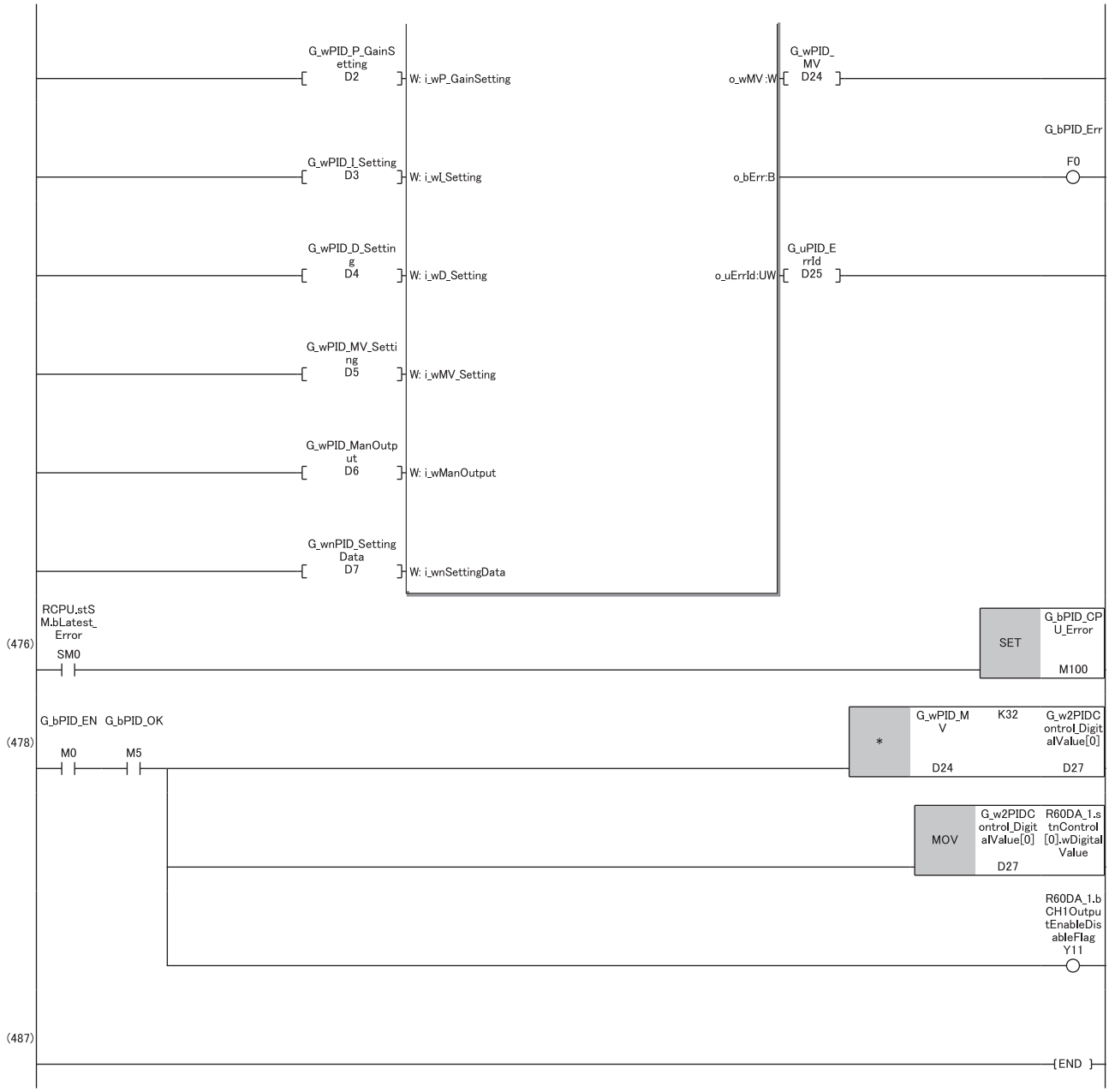
Set the initial value for the FB after CPU RUN.

■PID control

When G_bPID_EN (PID control execution command) turns on, the PID constants are calculated, and PID control is executed for the process value obtained via CH1.

By turning G_bPID_AutoManShift (AUTO/MAN mode shift) on or off, automatic calculation and manual setting of the manipulated value (MV) switch.





(26)Re-set the parameters after the completion of auto tuning (☞ Page 30 Automatic calculation of a manipulated value (MV) by PID control).
When calculation of the PID constants by auto tuning is not required, turn off G_bPID_AT (auto tuning start/stop).

(37)To avoid sudden changes in the manipulated value (MV) when the mode is switched from AUTO to MAN, store the manipulated value (MV) from immediately before in the MAN output setting.

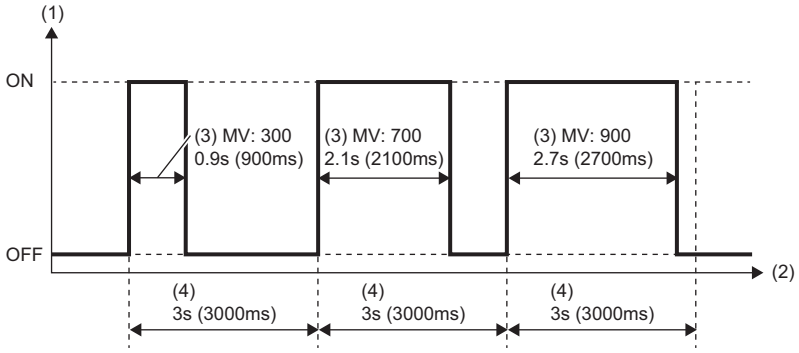
(43)To avoid sudden changes in the manipulated value (MV) when the mode is switched from MAN to AUTO, store the process value (PV) from immediately before in the set value (SV) setting.

(476)Since this FB uses the PID operation instruction (PID), an error in the CPU module may occur.
Prepare the error recovery processing in the CPU module separately to suit the system and the requested operation.

When using SSR (solid state relay)

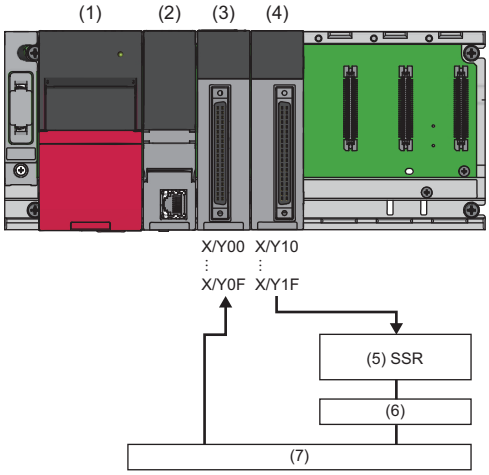
This PID control program reads the temperature measured by the resistance temperature detector (Pt100, -200℃ to 850.0℃) connected to CH1 of R60RD8-G. The following image shows the relationship between a manipulated value (MV) of 0.0 to 100.0% and the RY41NT2P output.

In this case, the manipulated value (MV) settings are upper limit output limiter: 1000, lower limit output limiter: 0, AT upper limit output limiter (ULV): 1000, and AT lower limit output limiter (LLV): 0.



(1) Output
(2) Time
(3) Manipulated value
(4) Sampling time

System configuration

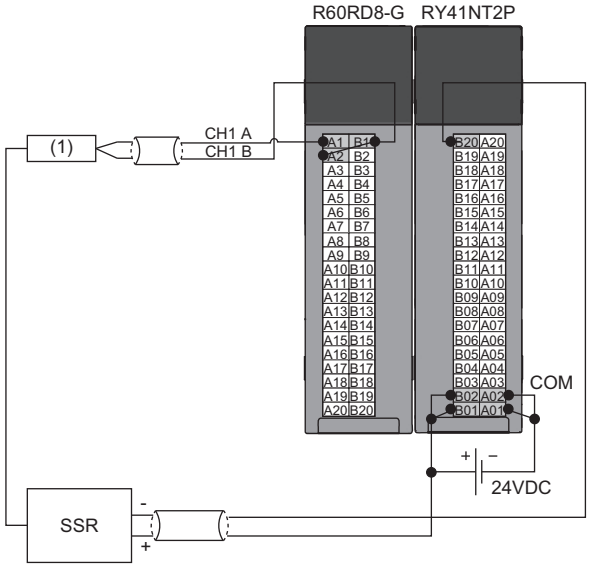


No.	Product	Model name
(1)	Power supply module	R61P
(2)	CPU module	R04CPU
(3)	Channel isolated RTD input module	R60RD8-G
(4)	Transistor output module	RY41NT2P
(5)	Solid state relay	—
(6)	Heater	—
(7)	Control target	Uses resistance temperature detector (Pt100, -200℃ to 850.0℃)

Precautions

Ladder blocks must be configured for all input labels. If a circuit is not set, the value is considered an undefined value.

Wiring example



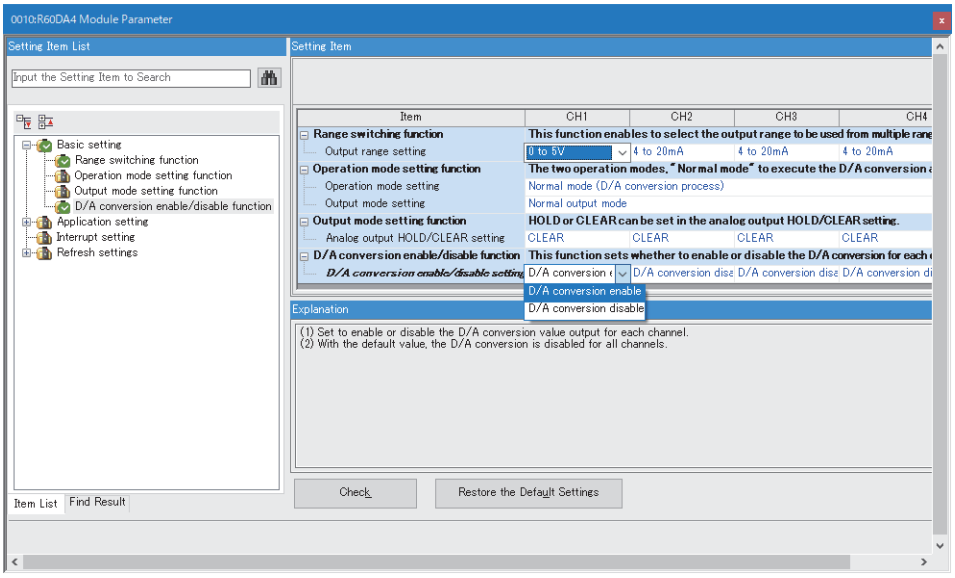
(1) Control target

Parameter setting

■CPU parameter

In the CPU parameters of R04CPU, set the following "High Speed Timer/High Speed Retentive Timer" to "10.00ms" and specify the timer limit setting. Leave all other CPU parameters as their defaults.

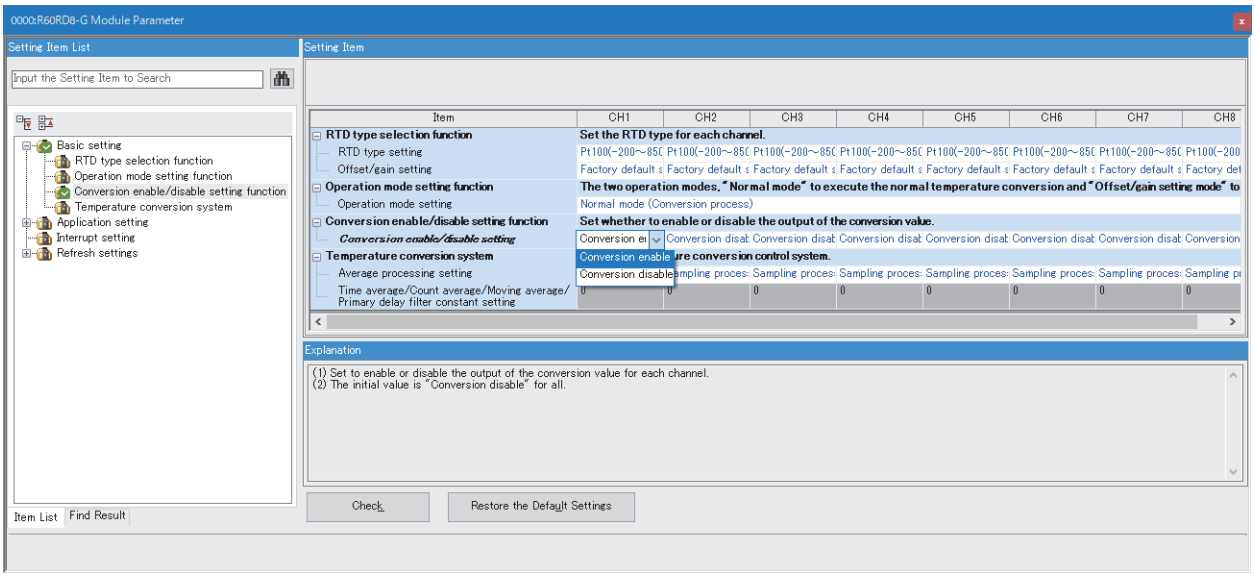
[Navigation window] ⇨ [Parameter] ⇨ [R04CPU] ⇨ [CPU Parameter] ⇨ [Operation Related Setting]



■Module parameters for the temperature input module

In the R60RD8-G module parameters, set the following "Conversion enable/disable setting" to "Conversion enable". Leave all other module parameters as their defaults.

[Navigation window] ⇨ [Parameter] ⇨ [Module Information] ⇨ [R60RD8-G] ⇨ [Basic Setting]



Program example

■Label setting

Classification	Label name	Description	Device
Module label	RCPU.stSM.bAfter_RUN1_Scan_ON	Turns on one scan after RUN	SM402
	R60RDG_1.stnMonitor[0].wMeasuredTemperatureValue	CH1 Temperature process value	—
	RCPU.stSM.bLatest_Error	Latest error	SM0
Labels to be defined	Define global labels as follows.		

	Label Name	Data Type		Class	Assign (Device/Label)
1	G_bPID_HeaterSignal	Bit	...	VAR_GLOBAL	Y10
2	G_bPID_EN	Bit	...	VAR_GLOBAL	M0
3	G_bPID_ActionSetting	Bit	...	VAR_GLOBAL	M1
4	G_bPID_AutoManShift	Bit	...	VAR_GLOBAL	M2
5	G_bPID_AT	Bit	...	VAR_GLOBAL	M3
6	G_bPID_ENO	Bit	...	VAR_GLOBAL	M4
7	G_bPID_OK	Bit	...	VAR_GLOBAL	M5
8	G_bPID_AT_Status	Bit	...	VAR_GLOBAL	M6
9	G_bPID_OutSigSettingFlag1	Bit	...	VAR_GLOBAL	M7
10	G_bPID_Err	Bit	...	VAR_GLOBAL	F0
11	G_wPID_SamplingTime	Word [Signed]	...	VAR_GLOBAL	D0
12	G_wPID_SV_Setting	Word [Signed]	...	VAR_GLOBAL	D1
13	G_wPID_P_GainSetting	Word [Signed]	...	VAR_GLOBAL	D2
14	G_wPID_I_Setting	Word [Signed]	...	VAR_GLOBAL	D3
15	G_wPID_D_Setting	Word [Signed]	...	VAR_GLOBAL	D4
16	G_wPID_MV_Setting	Word [Signed]	...	VAR_GLOBAL	D5
17	G_wPID_ManOutput	Word [Signed]	...	VAR_GLOBAL	D6
18	G_wnPID_SettingData	Word [Signed](0..12)	...	VAR_GLOBAL	D7
19	G_wPID_AlertStatus	Word [Signed]	...	VAR_GLOBAL	D20
20	G_wPID_Proportional	Word [Signed]	...	VAR_GLOBAL	D21
21	G_wPID_Integral	Word [Signed]	...	VAR_GLOBAL	D22
22	G_wPID_Derivative	Word [Signed]	...	VAR_GLOBAL	D23
23	G_wPID_MV	Word [Signed]	...	VAR_GLOBAL	D24
24	G_uPID_ErrId	Word [Unsigned]/Bit String [16-bit]	...	VAR_GLOBAL	D25
25	G_uPID_PrePV	Word [Signed]	...	VAR_GLOBAL	D26
26	G_w2PID_HeaterTimerCycle	Word [Signed](0.1)	...	VAR_GLOBAL	D28
27	G_w2PID_HeaterTimerOnTime	Word [Signed](0.1)	...	VAR_GLOBAL	D30
28	G_tdPID_HeaterTimer	Timer	...	VAR_GLOBAL	T0
29	G_bPID_CPU_Error	Bit	...	VAR_GLOBAL	M100

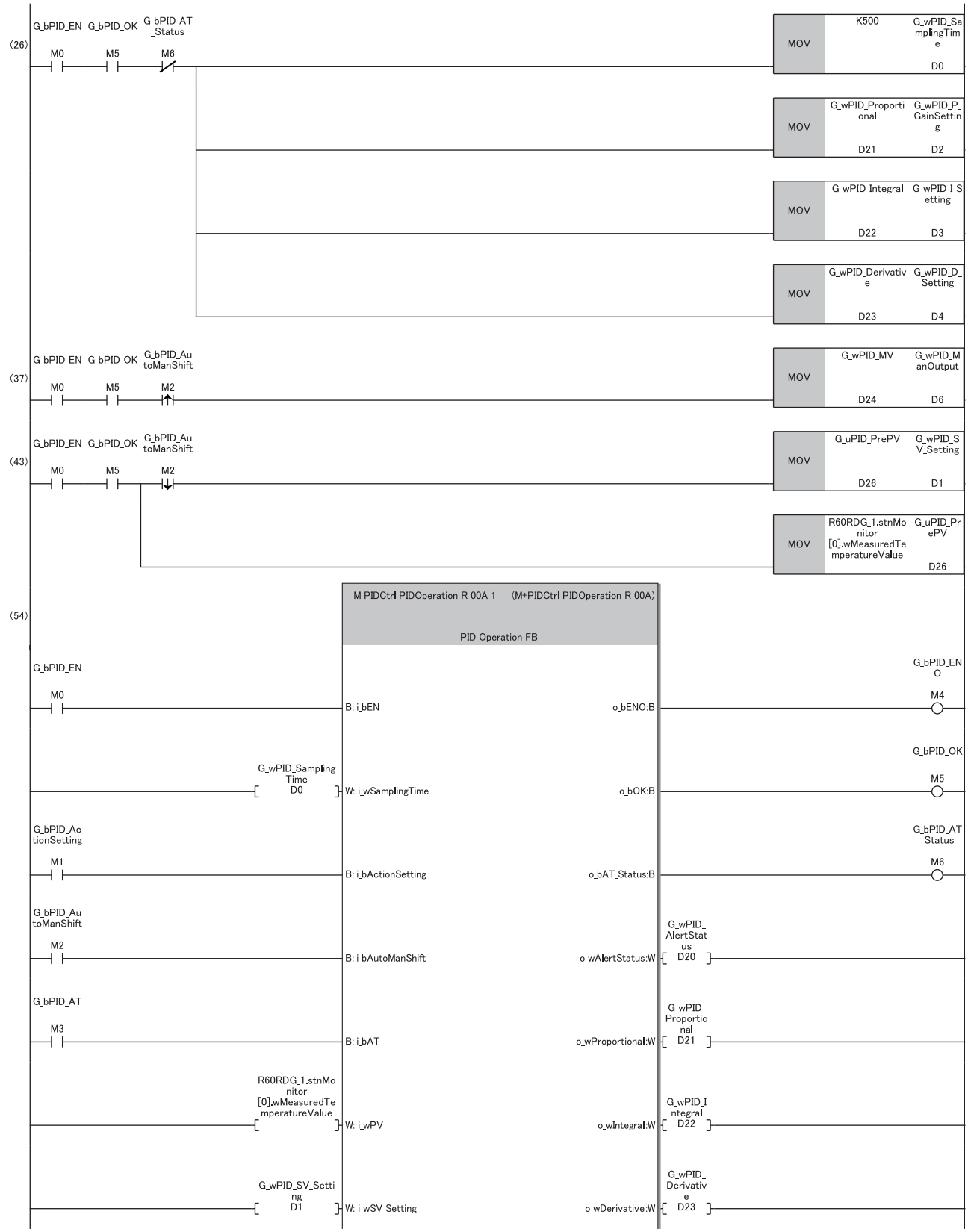
■Initial setting

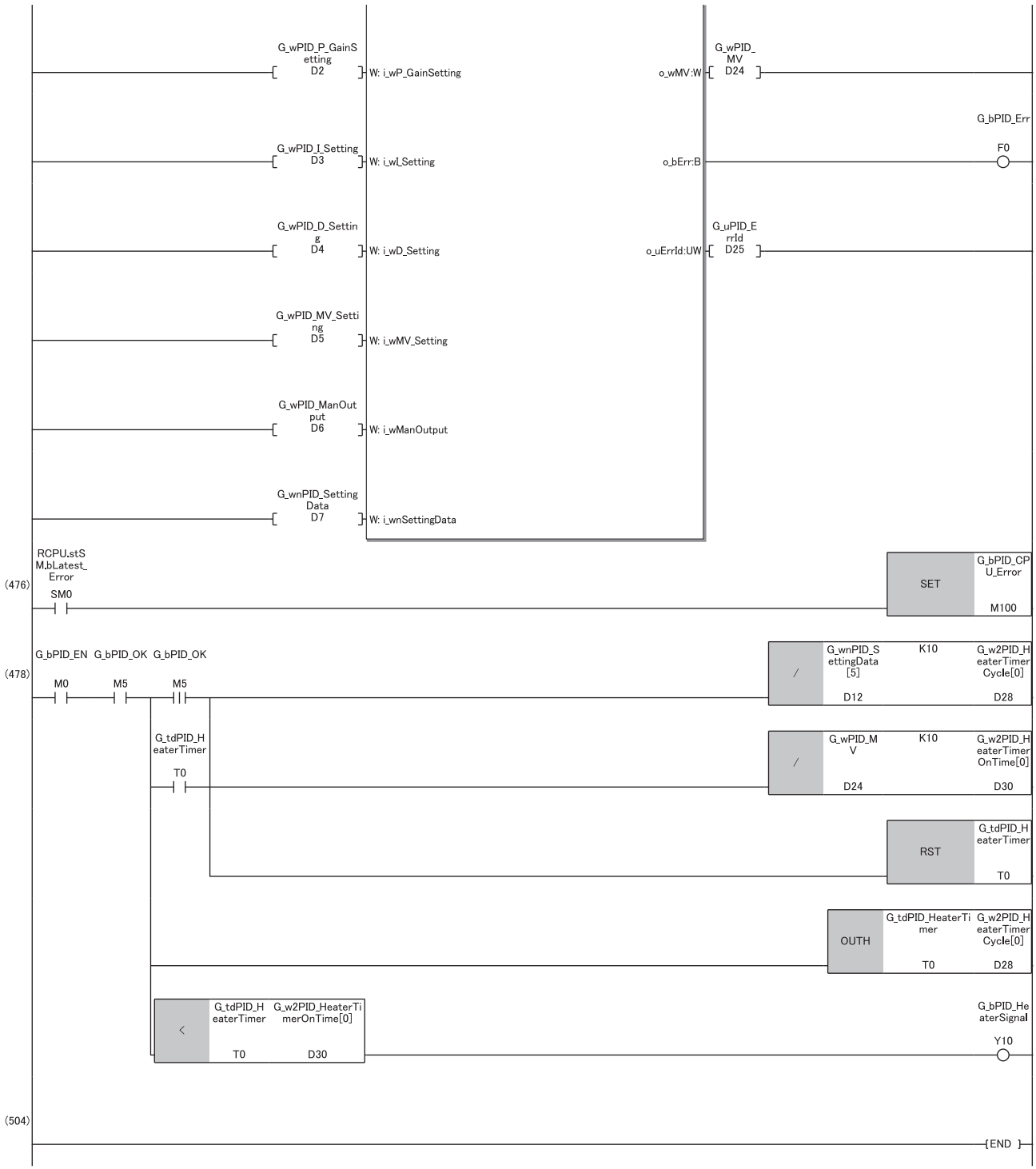
Set the initial value for the FB after CPU RUN.

■PID control

When G_bPID_EN (PID control execution command) turns on, the PID constants are calculated, and PID control is executed for the process value obtained via CH1.

By turning G_bPID_AutoManShift (AUTO/MAN mode shift) on or off, automatic calculation and manual setting of the manipulated value (MV) switch.





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MEMO

INSTRUCTION INDEX

M

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MEMO

REVISIONS

*The manual number is given on the bottom left of the back cover.

Revision date	*Manual number	Description
April 2021	BCN-P5999-1397-A	First edition
April 2024	BCN-P5999-1397-B	■Added or modified parts Section 2.1, 2.2

Japanese manual number: BCN-P5999-1396-B

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BCN-P5999-1397-B(2404)MEE

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
NAGOYA WORKS: 1-14, YADA-MINAMI 5-CHOME, HIGASHI-KU, NAGOYA 461-8670, JAPAN