MELSEC iQ-R Series
MELSEC PROCESS CONTROL Technical Guide
Sample Programs and Glossaries

-R08PCPU
-R16PCPU
-R32PCPU
-R120PCPU
-R6RFM
-SW1DND-GXW3-E

CONTENTS

CONTENTS

1 SAMPLE PROGRAMS

This document describes examples of sample programs using the process control FB.
The example configurations in this document are not guaranteed to work with your system(s). Make sure to check operation thoroughly before use.

1.1 Control Programs and Loop Tags

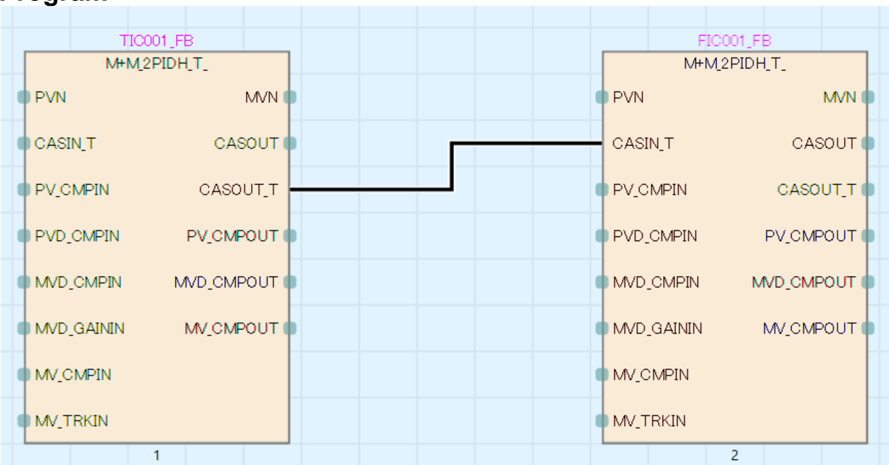
Cascade control

Function

The cascade control consists of a primary loop and a secondary loop. With this control method, early detection of disturbances entering the secondary loop and using the secondary loop to absorb these disturbances eliminates the impact of disturbances on the process, improving the overall control performance.
Typically, the secondary loop response is more than three times faster than that of the primary loop.

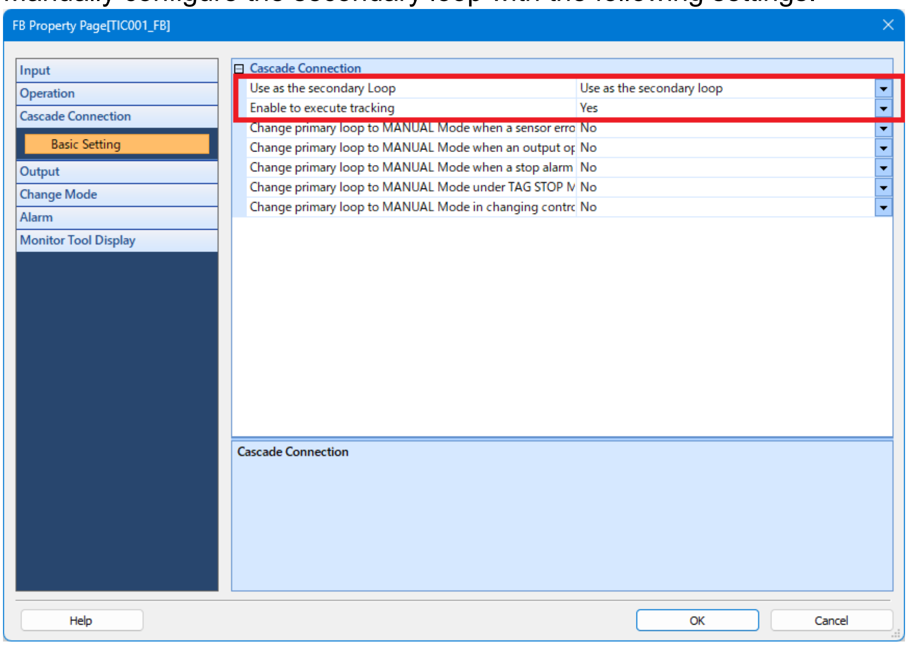
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDIXES 3 Related Functions of Process Various controls

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)

Manually configure the secondary loop with the following settings.



FB property (For M+M_2PIDH_T_)

Variable name	Description	Range	Initial value	Setting used to enable tracking
PID2H_TRK	Tracking flag	0: Disable tracking 1: Enable tracking	0	1
PID2H_SVPTN_B0	Setting value (SV) used	TRUE: Not used FALSE: Used	TRUE	FALSE
PID2H_SVPTN_B1	Setting value (SV) pattern	TRUE: Not primary MV FALSE: Primary MV	TRUE	When the primary loop is a tag FB: FALSE (normally FALSE) When the primary loop is not a tag FB: TRUE

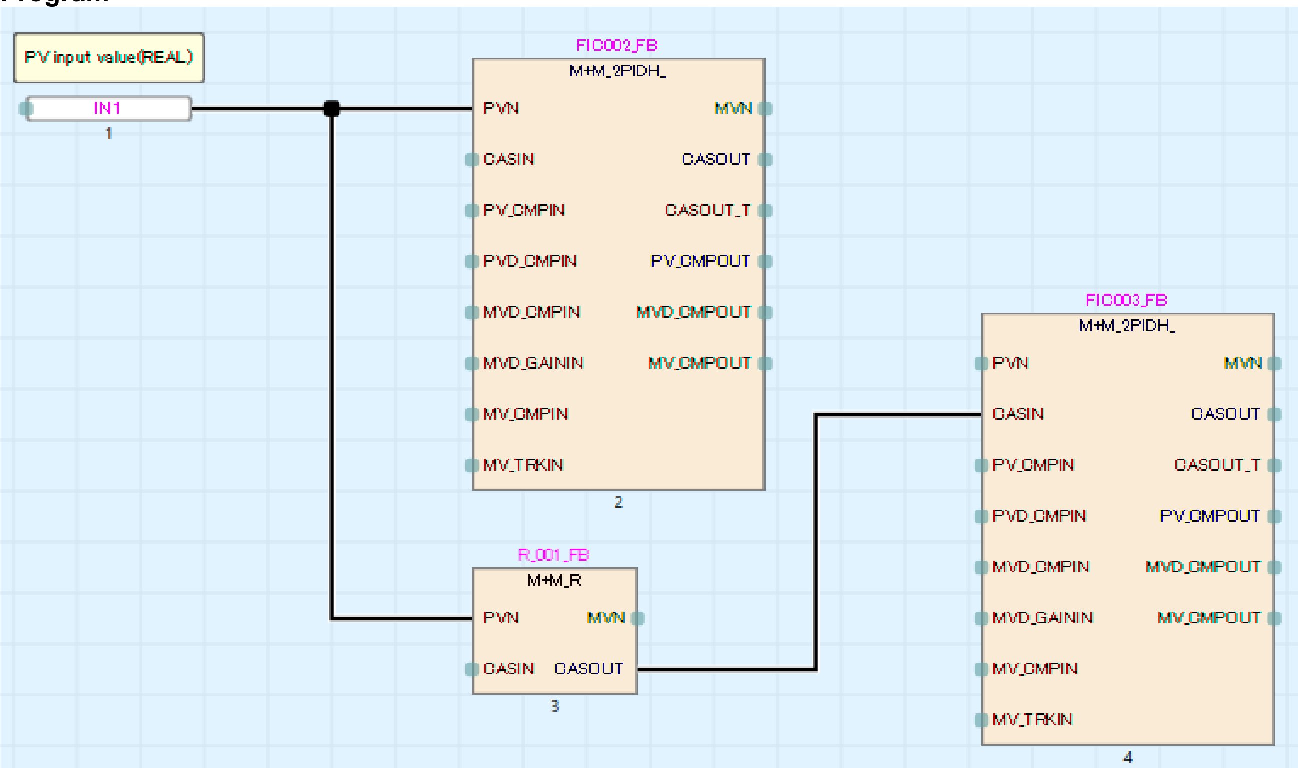
Ratio control

Function

The ratio control is the establishment and use of a proportional relationship between two or more measured amounts. For example, by multiplying the PV value of the tag FB (FIC002_FB) by the ratio of the ratio setter and then inputting this as the SV value of the tag FB (FIC003_FB), the PV value of the tag FB (FIC002_FB) and the PV value of the tag FB (FIC003_FB) can be kept at a constant ratio.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.22 Ratio Control (Disable Tracking for primary loop) (M+M_R)

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)

Program label definition

Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR	PV input value

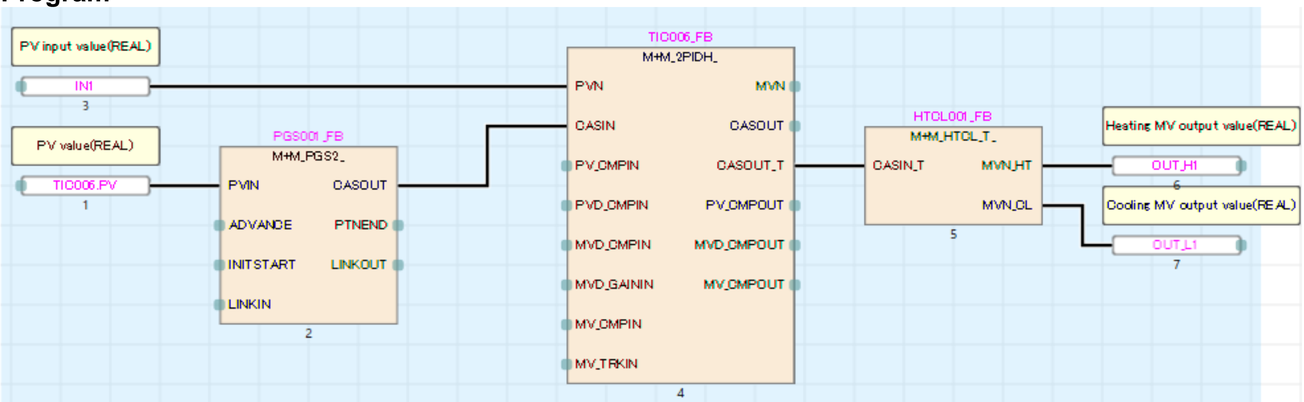
Heating-cooling program control

Function

The heating and cooling output (M+M_HTCL_T_) performs a split conversion on the input value and outputs two manipulated variables. Temperature is controlled by outputting values to both the heating control side and the cooling control side. The multi-point program setter (M+M_PGS2_) allows use of this control in combination with programs of 32 or more steps in duration and set values.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.40 Heating and Cooling Output (M+M_HTCL_T_)

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.37 Multi-Point Program Setter (M+M_PGS2_)

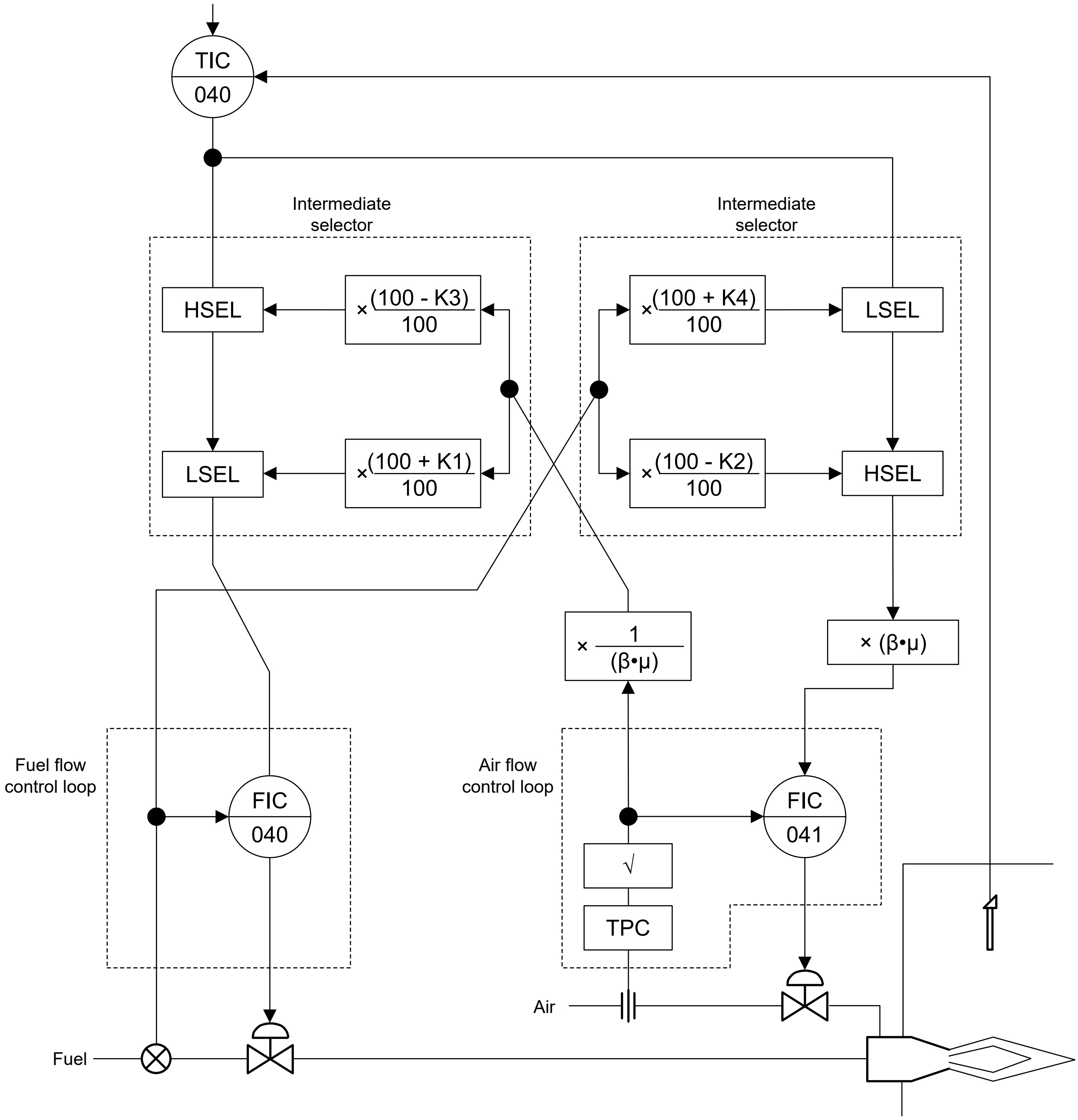
Program label definition

Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR	PV input value
OUT_H1	FLOAT [Single Precision]	VAR	Heating-side MV output value
OUT_L1	FLOAT [Single Precision]	VAR	Cooling-side MV output value

Cross limit control

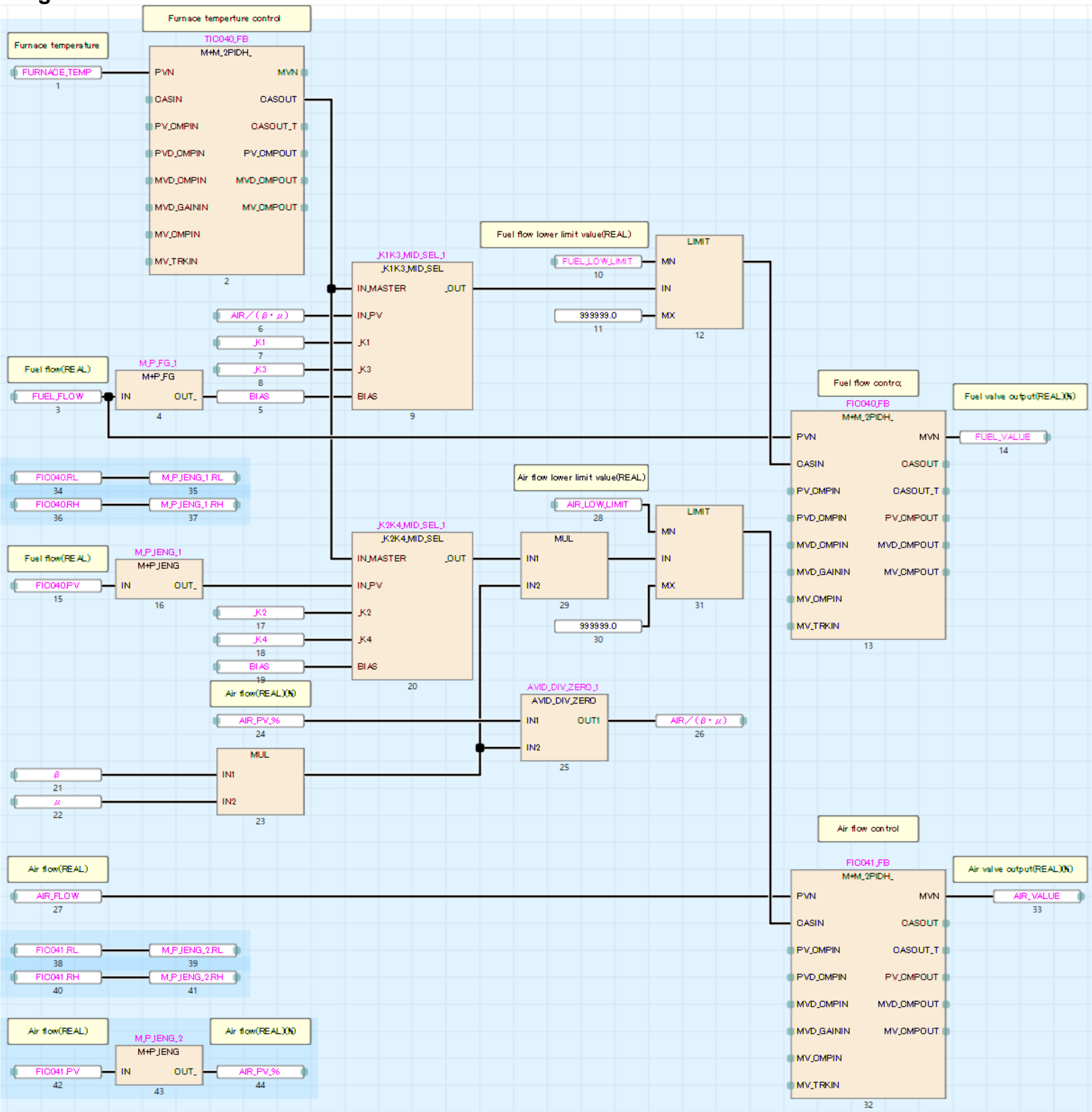
Function

The cross limit control improves combustion efficiency by keeping the air-fuel ratio of a boiler and furnace control within a narrow range.



Remarks
HSEL: HIGH selector
LSEL: LOW selector
TPC: Temperature/pressure correction
μ: Air excess ratio = Actual air/theoretical air
β: Conversion coefficient = (Fuel flow measuring range maximum value × Fuel theoretical air) / Air flow measuring range maximum value
K1: Smoke limit in rising load (%) K2: Smoke limit in reducing load (%)
K3: Air excess limit in reducing load (%) K4: Air excess limit in rising load (%)

Program



Reference: [MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.1 Function Generator (M+P_FG)]

Reference: [MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.5 Engineering Value Inverse Conversion (M+P_IENG)]

Reference: [MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)]

Program label definition

Label name	Data type	Class	Description
_K1K3_MID_SEL_1	_K1K3_MID_SEL	VAR	User-defined FB
_K2K4_MID_SEL_1	_K2K4_MID_SEL	VAR	User-defined FB
AVID_DIV_ZERO_1	AVID_DIV_ZERO	VAR	User-defined FB
M_P_FG_1	M+P_FG	VAR	Function Generator
M_P_IENG_1	M+P_IENG	VAR	Engineering Value Inverse Conversion
M_P_IENG_2	M+P_IENG	VAR	Engineering Value Inverse Conversion
FURNACE_TEMP	FLOAT [Single Precision]	VAR	Furnace temperature
AIR/(β•μ)	FLOAT [Single Precision]	VAR	Air/(Conversion coefficient • Air excess ratio)
_K1	FLOAT [Single Precision]	VAR	Smoke limit in rising load (%)
_K3	FLOAT [Single Precision]	VAR	Air excess limit in reducing load (%)
BIAS	FLOAT [Single Precision]	VAR	Bias
FUEL_LOW_LIMIT	FLOAT [Single Precision]	VAR	Fuel flow lower limit value
FUEL_FLOW	FLOAT [Single Precision]	VAR	Fuel flow
_K2	FLOAT [Single Precision]	VAR	Smoke limit in reducing load (%)
_K4	FLOAT [Single Precision]	VAR	Air excess limit in rising load (%)
β	FLOAT [Single Precision]	VAR	Conversion coefficient
μ	FLOAT [Single Precision]	VAR	Air excess ratio
AIR_PV_%	FLOAT [Single Precision]	VAR	Air flow (%)
AIR_LOW_LIMIT	FLOAT [Single Precision]	VAR	Air flow lower limit value
AIR_FLOW	FLOAT [Single Precision]	VAR	Air flow
FUEL_VALUE	FLOAT [Single Precision]	VAR	Fuel valve output
AIR_VALUE	FLOAT [Single Precision]	VAR	Air valve output

User-defined FB (_K1K3_MID_SEL)

```
_KM3 := IN_PV * (100.0 - _K3)/100.0 - BIAS;
_KM1 := IN_PV * (100.0 + _K1)/100.0 + BIAS;
_OUT := IN_MASTER;
IF _OUT < _KM3 THEN
    _OUT := _KM3;
END_IF;
IF _OUT > _KM1 THEN
    _OUT := _KM1;
END_IF;

```

Label definition of user-defined FB (_K1K3_MID_SEL)

Label name	Data type	Class	Description
IN_MASTER	FLOAT [Single Precision]	VAR_INPUT	Furnace temperature control output value
IN_PV	FLOAT [Single Precision]	VAR_INPUT	Input value
_K1	FLOAT [Single Precision]	VAR_INPUT	Smoke limit in rising load (%)
_K3	FLOAT [Single Precision]	VAR_INPUT	Air excess limit in reducing load (%)
BIAS	FLOAT [Single Precision]	VAR_INPUT	Bias
_OUT	FLOAT [Single Precision]	VAR_OUTPUT	Output value
_KM1	FLOAT [Single Precision]	VAR	K1 operation result
_KM3	FLOAT [Single Precision]	VAR	K3 operation result

User-defined FB (_K2K4_MID_SEL)

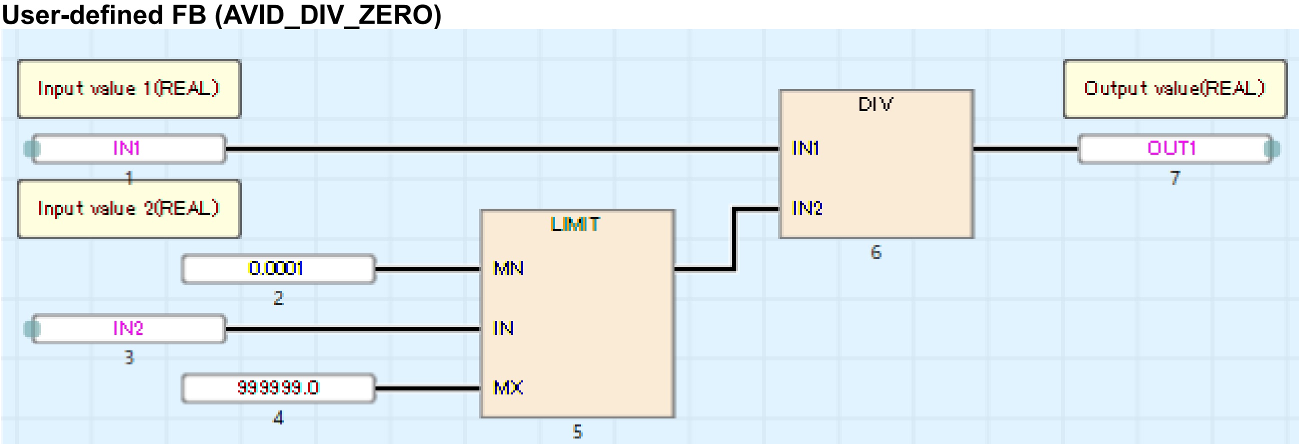
```
_KM4 := IN_PV * (100.0 + _K4)/100.0 + BIAS;
_KM2 := IN_PV * (100.0 - _K2)/100.0 - BIAS;
_OUT := IN_MASTER;
IF _OUT > _KM4 THEN
    _OUT := _KM4;
END_IF;
IF _OUT < _KM2 THEN
    _OUT := _KM2;
END_IF;

```

Label definition of user-defined FB (_K2K4_MID_SEL)

Label name	Data type	Class	Description
IN_MASTER	FLOAT [Single Precision]	VAR_INPUT	Furnace temperature control output value
IN_PV	FLOAT [Single Precision]	VAR_INPUT	Input value
_K2	FLOAT [Single Precision]	VAR_INPUT	Smoke limit in reducing load (%)
_K4	FLOAT [Single Precision]	VAR_INPUT	Air excess limit in rising load (%)
BIAS	FLOAT [Single Precision]	VAR_INPUT	Bias
_OUT	FLOAT [Single Precision]	VAR_OUTPUT	Output value
_KM2	FLOAT [Single Precision]	VAR	K2 operation result
_KM4	FLOAT [Single Precision]	VAR	K4 operation result

User-defined FB (AVID_DIV_ZERO)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.4 Division

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.3 Controlling the Upper/Lower Limit

Label definition of user-defined FB (AVID_DIV_ZERO)

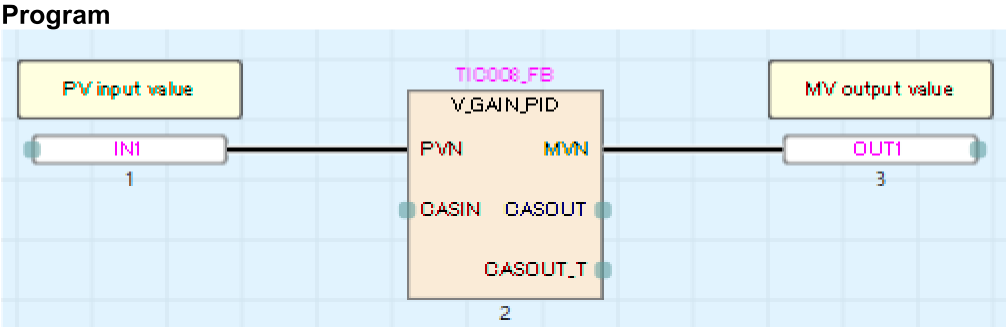
Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR_INPUT	Input value 1
IN2	FLOAT [Single Precision]	VAR_INPUT	Input value 2
OUT1	FLOAT [Single Precision]	VAR_OUTPUT	Output value

Deviated variable gain PID control

Function

This user-defined tag FB is created based on an FB of PID tag type.
The deviated variable gain PID is obtained by multiplying the input value by the broken line correction value that is determined by the deviation value.

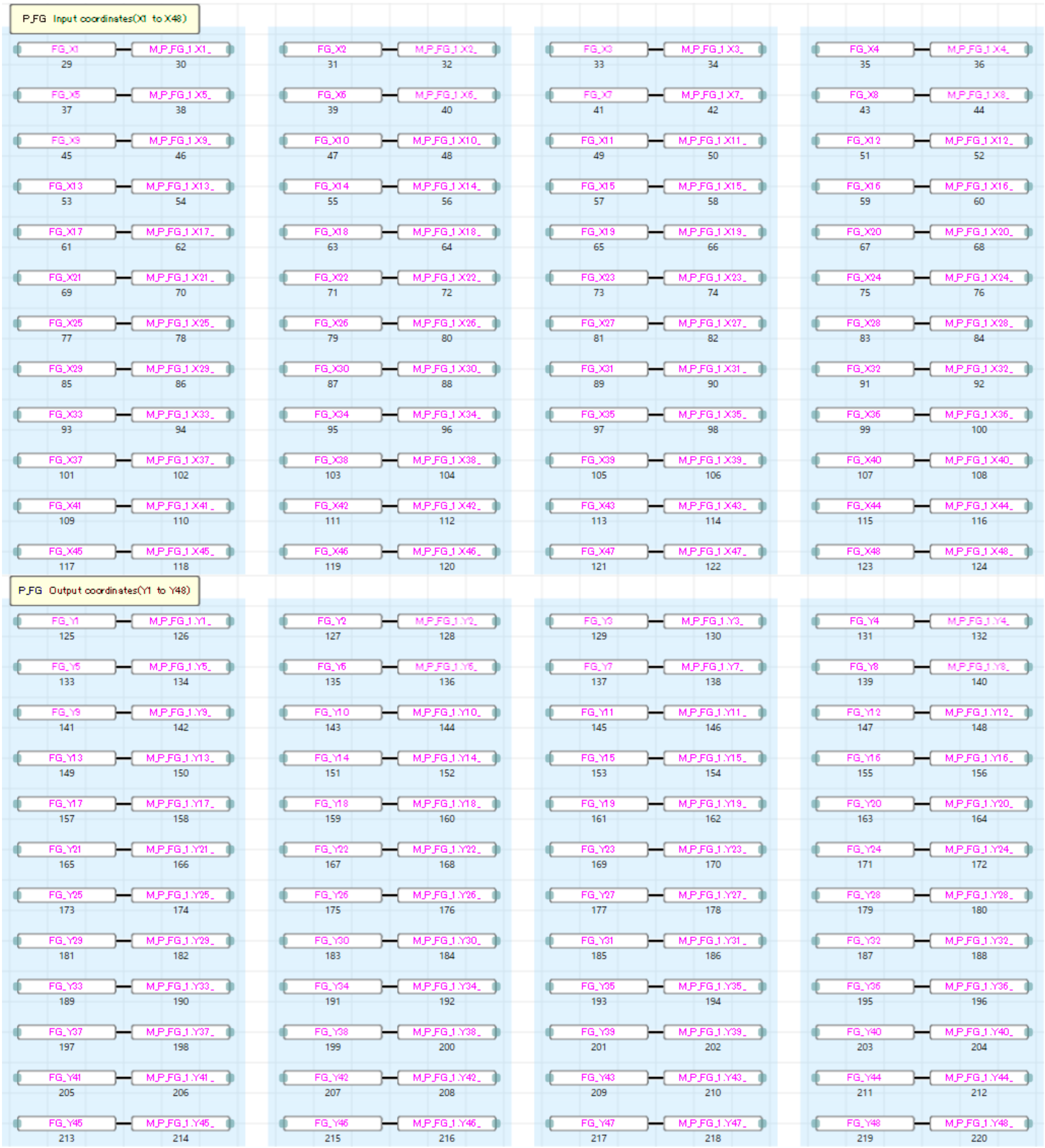
Program



Program label definition

Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR	Input value
OUT1	FLOAT [Single Precision]	VAR	Output value

User-defined FB (V_GAIN_PID)


P_FG Input coordinates(X1 to X48)
FG_X1
M_P_FG_1.X1_
29
30
FG_X2
M_P_FG_1.X2_
31
32
FG_X3
M_P_FG_1.X3_
33
34
FG_X4
M_P_FG_1.X4_
35
36
FG_X5
M_P_FG_1.X5_
37
38
FG_X6
M_P_FG_1.X6_
39
40
FG_X7
M_P_FG_1.X7_
41
42
FG_X8
M_P_FG_1.X8_
43
44
FG_X9
M_P_FG_1.X9_
45
46
FG_X10
M_P_FG_1.X10_
47
48
FG_X11
M_P_FG_1.X11_
49
50
FG_X12
M_P_FG_1.X12_
51
52
FG_X13
M_P_FG_1.X13_
53
54
FG_X14
M_P_FG_1.X14_
55
56
FG_X15
M_P_FG_1.X15_
57
58
FG_X16
M_P_FG_1.X16_
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FG_X17
M_P_FG_1.X17_
61
62
FG_X18
M_P_FG_1.X18_
63
64
FG_X19
M_P_FG_1.X19_
65
66
FG_X20
M_P_FG_1.X20_
67
68
FG_X21
M_P_FG_1.X21_
69
70
FG_X22
M_P_FG_1.X22_
71
72
FG_X23
M_P_FG_1.X23_
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FG_X24
M_P_FG_1.X24_
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FG_X25
M_P_FG_1.X25_
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FG_X26
M_P_FG_1.X26_
79
80
FG_X27
M_P_FG_1.X27_
81
82
FG_X28
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83
84
FG_X29
M_P_FG_1.X29_
85
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FG_X30
M_P_FG_1.X30_
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FG_X31
M_P_FG_1.X31_
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FG_X32
M_P_FG_1.X32_
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FG_X33
M_P_FG_1.X33_
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FG_X34
M_P_FG_1.X34_
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FG_X35
M_P_FG_1.X35_
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FG_X36
M_P_FG_1.X36_
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100
FG_X37
M_P_FG_1.X37_
101
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FG_X38
M_P_FG_1.X38_
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FG_X39
M_P_FG_1.X39_
105
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FG_X40
M_P_FG_1.X40_
107
108
FG_X41
M_P_FG_1.X41_
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FG_X42
M_P_FG_1.X42_
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FG_X43
M_P_FG_1.X43_
113
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FG_X44
M_P_FG_1.X44_
115
116
FG_X45
M_P_FG_1.X45_
117
118
FG_X46
M_P_FG_1.X46_
119
120
FG_X47
M_P_FG_1.X47_
121
122
FG_X48
M_P_FG_1.X48_
123
124
P_FG Output coordinates(Y1 to Y48)
FG_Y1
M_P_FG_1.Y1_
125
126
FG_Y2
M_P_FG_1.Y2_
127
128
FG_Y3
M_P_FG_1.Y3_
129
130
FG_Y4
M_P_FG_1.Y4_
131
132
FG_Y5
M_P_FG_1.Y5_
133
134
FG_Y6
M_P_FG_1.Y6_
135
136
FG_Y7
M_P_FG_1.Y7_
137
138
FG_Y8
M_P_FG_1.Y8_
139
140
FG_Y9
M_P_FG_1.Y9_
141
142
FG_Y10
M_P_FG_1.Y10_
143
144
FG_Y11
M_P_FG_1.Y11_
145
146
FG_Y12
M_P_FG_1.Y12_
147
148
FG_Y13
M_P_FG_1.Y13_
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150
FG_Y14
M_P_FG_1.Y14_
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152
FG_Y15
M_P_FG_1.Y15_
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154
FG_Y16
M_P_FG_1.Y16_
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FG_Y17
M_P_FG_1.Y17_
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158
FG_Y18
M_P_FG_1.Y18_
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160
FG_Y19
M_P_FG_1.Y19_
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162
FG_Y20
M_P_FG_1.Y20_
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FG_Y21
M_P_FG_1.Y21_
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FG_Y22
M_P_FG_1.Y22_
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FG_Y23
M_P_FG_1.Y23_
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FG_Y24
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FG_Y25
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FG_Y26
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FG_Y27
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FG_Y28
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FG_Y29
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FG_Y30
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FG_Y31
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FG_Y32
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FG_Y33
M_P_FG_1.Y33_
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190
FG_Y34
M_P_FG_1.Y34_
191
192
FG_Y35
M_P_FG_1.Y35_
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194
FG_Y36
M_P_FG_1.Y36_
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FG_Y37
M_P_FG_1.Y37_
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FG_Y38
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200
FG_Y39
M_P_FG_1.Y39_
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202
FG_Y40
M_P_FG_1.Y40_
203
204
FG_Y41
M_P_FG_1.Y41_
205
206
FG_Y42
M_P_FG_1.Y42_
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FG_Y43
M_P_FG_1.Y43_
209
210
FG_Y44
M_P_FG_1.Y44_
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FG_Y45
M_P_FG_1.Y45_
213
214
FG_Y46
M_P_FG_1.Y46_
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FG_Y47
M_P_FG_1.Y47_
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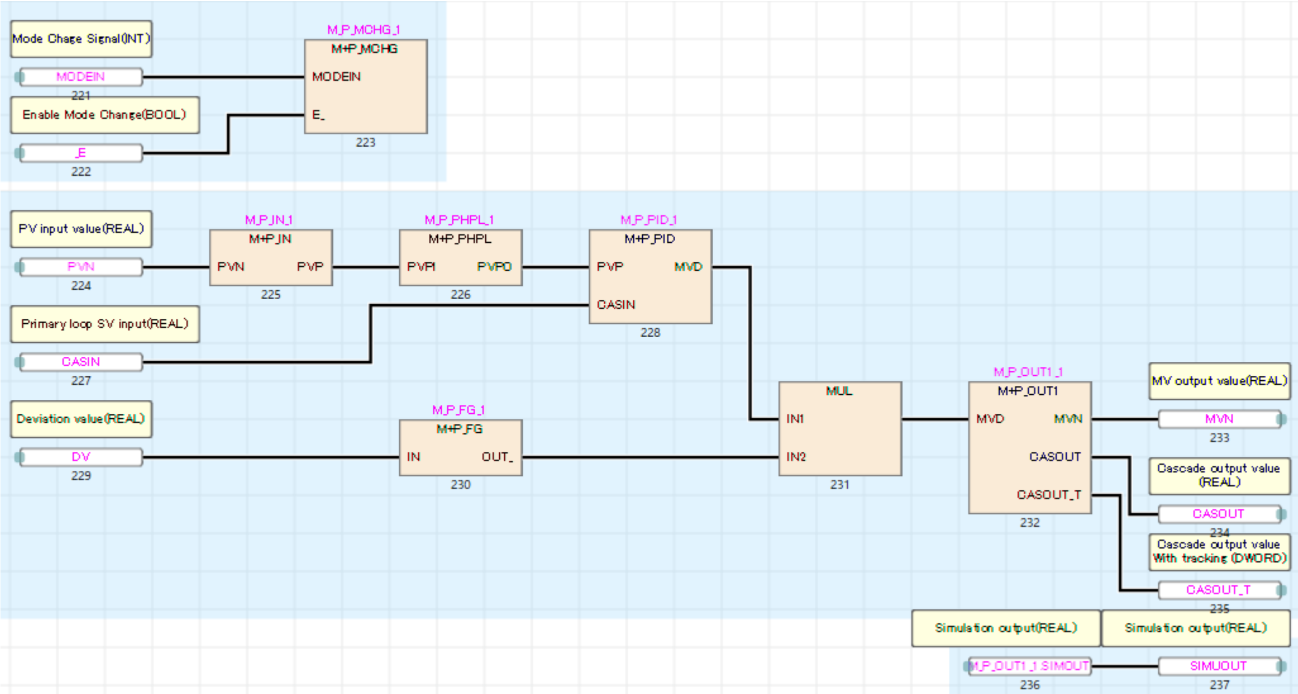
FG_Y48
M_P_FG_1.Y48_
219
220



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 16.1 Change Control Mode (M+P_MCHG)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.1 Analog Input Processing (M+P_IN)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 15.19 High/Low Limit Alarm Check (M+P_PHPL)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 15.4 Velocity Type PID Control (Disable Tracking for primary loop) (M+P_PID)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.1 Function Generator (M+P_FG)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.2 Output Processing-1 with Mode Switching (With Input Addition) (M+P_OUT1)

Label definition of user-defined FB (V_GAIN_PID)

Label name	Data type	Class	Description
M_P_MCHG_1	M+P_MCHG	VAR	Change Control Mode
M_P_IN_1	M+P_IN	VAR	Analog Input Processing
M_P_PHPL_1	M+P_PHPL	VAR	High/Low Limit Alarm Check
M_P_PID_1	M+P_PID	VAR	Velocity Type PID Control
M_P_FG_1	M+P_FG	VAR	Function Generator
M_P_OUT1_1	M+P_OUT1	VAR	Output Processing-1 with Mode Switching
MODEIN	Word [Signed]	VAR_PUBLIC	Mode change signal
_E	Bit	VAR_PUBLIC	Change request
PVN	FLOAT [Single Precision]	VAR_INPUT	PV input value
CASIN	FLOAT [Single Precision]	VAR_INPUT	Cascade input value
DV	FLOAT [Single Precision]	VAR_PUBLIC	Deviation
MVN	FLOAT [Single Precision]	VAR_OUTPUT	MV output value
CASOUT	FLOAT [Single Precision]	VAR_OUTPUT	Cascade output value
CASOUT_T	Double word [Unsigned]/Bit string [32-bit]	VAR_OUTPUT	Cascade output value
SIMOUT	FLOAT [Single Precision]	VAR_PUBLIC	Simulation output value
SIMUOUT	FLOAT [Single Precision]	VAR_PUBLIC	Simulation output value
IN_NMAX	FLOAT [Single Precision]	VAR_PUBLIC	Input upper limit
IN_NMIN	FLOAT [Single Precision]	VAR_PUBLIC	Input lower limit
IN_HH	FLOAT [Single Precision]	VAR_PUBLIC	Upper limit range error
IN_H	FLOAT [Single Precision]	VAR_PUBLIC	Upper limit range error reset
IN_L	FLOAT [Single Precision]	VAR_PUBLIC	Lower limit range error reset
IN_LL	FLOAT [Single Precision]	VAR_PUBLIC	Lower limit range error
PID_MTD	FLOAT [Single Precision]	VAR_PUBLIC	Derivative gain
PID_DVLS	FLOAT [Single Precision]	VAR_PUBLIC	Large deviation alarm hysteresis
PID_PN	Word [Signed]	VAR_PUBLIC	Reverse action/direct action
PID_SVPTN_B0	Bit	VAR_PUBLIC	Use of setting value (SV)
OUT1_NMAX	FLOAT [Single Precision]	VAR_PUBLIC	Output conversion upper limit
OUT1_NMIN	FLOAT [Single Precision]	VAR_PUBLIC	Output conversion lower limit
SIMIN	FLOAT [Single Precision]	VAR_PUBLIC	Simulation input
FG_SN	Word [Signed]	VAR_PUBLIC	Number of points
FG_X1...FG_X48	FLOAT [Single Precision]	VAR_PUBLIC	Input coordinate (X-coordinate)
FG_Y1...FG_Y48	FLOAT [Single Precision]	VAR_PUBLIC	Input coordinate (Y-coordinate)

1.2 Control Programs and Status Tags

Single solenoid valve control

Function

Control is performed by switching between TRUE and FALSE with a single output in response to the ON/OFF operation (M+M_SS2P).

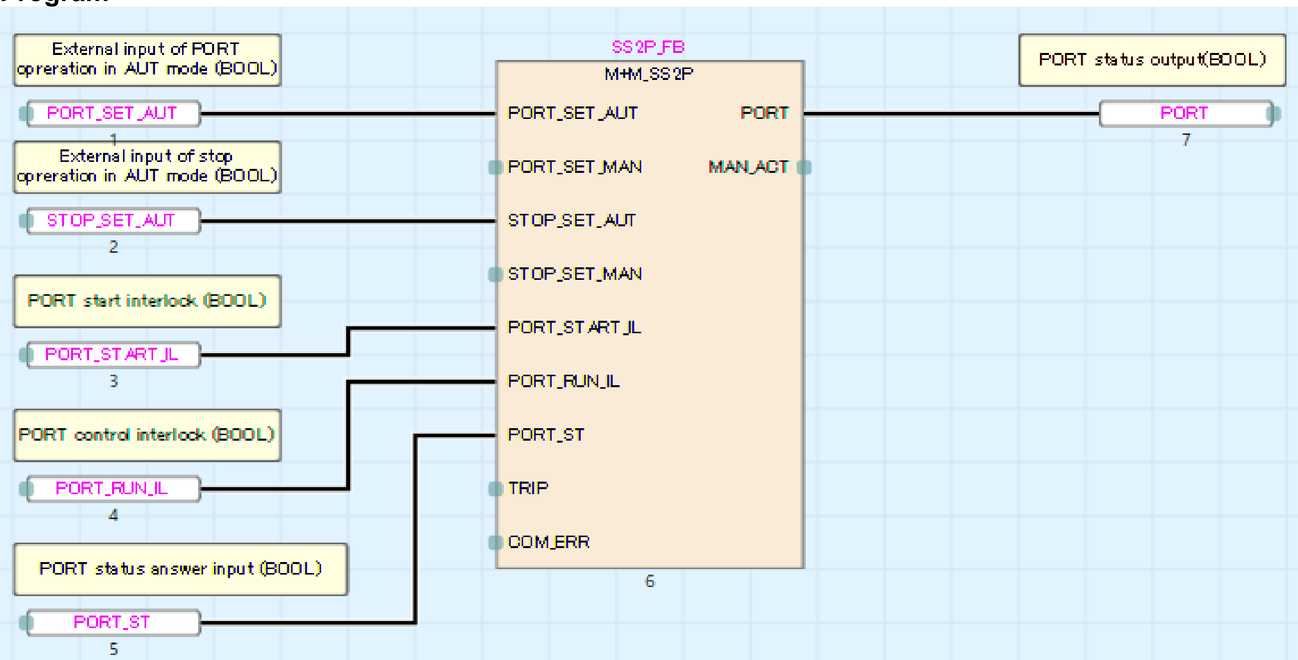
If the PORT control interlock and PORT start interlock become TRUE while the control mode is AUTO, TRUE is continually output to the PORT operation external input while FALSE is continually output to the stop operation external input.

Point

While the FB (M+M_MVAL1) only outputs at the time of valve start (startup pulse), the FB (M+M_SS2P) continually outputs as long as the command signal is input. Refer to the following manuals for specifications of the FB (M+M_MVAL1).

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.3 ON/OFF Operation (2 Input/2 Output) (M+M_MVAL1)

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.12 ON/OFF Operation (2 Input/1 Output(Status)) (M+M_SS2P)

Program label definition

Label name	Data type	Class	Description
PORT_SET_AUT	Bit	VAR	External input of PORT operation in AUT mode
STOP_SET_AUT	Bit	VAR	External input of stop operation in AUT mode
PORT_START_IL	Bit	VAR	PORT start interlock
PORT_RUN_IL	Bit	VAR	PORT control interlock
PORT_ST	Bit	VAR	PORT status answer input
PORT	Bit	VAR	PORT status output

2-position double solenoid valve control

Function

Control is performed by switching the two outputs so that only one of PORT1 or PORT2 is TRUE in response to the ON/OFF operation (M+M_DS2P).

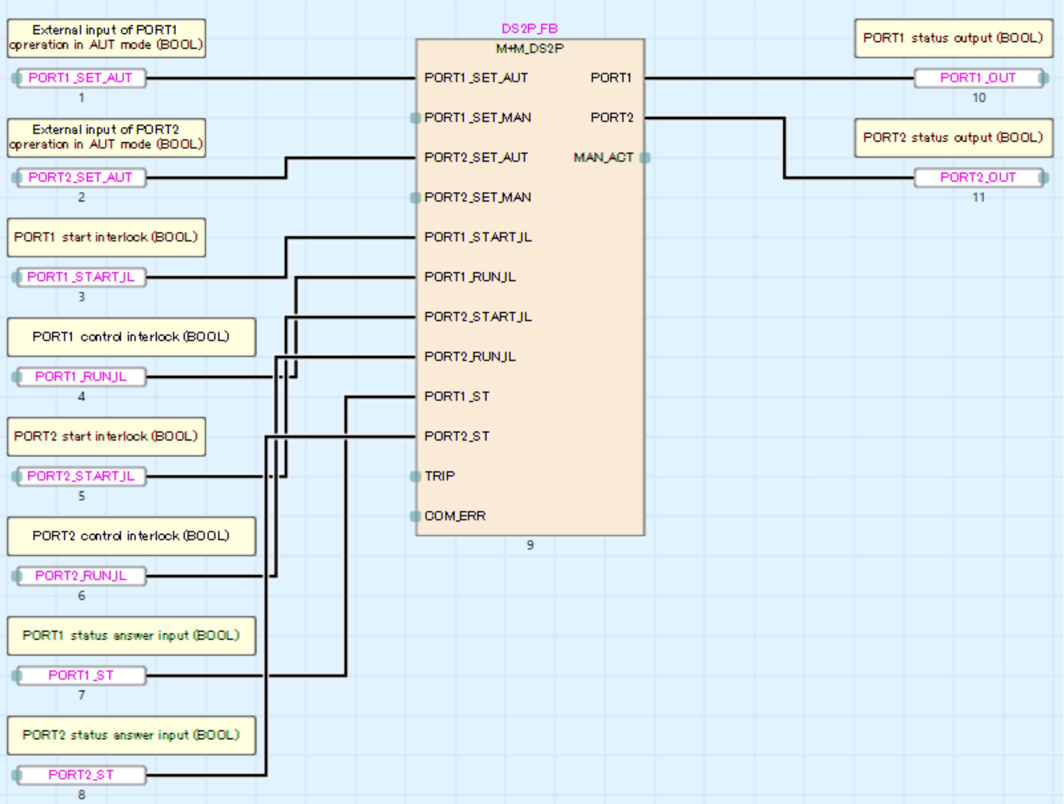
If the control interlock and start interlock for each port (PORT1 and PORT2) become TRUE while the control mode is AUTO, TRUE is continually output to PORT 1 or PORT2 while the corresponding PORT1 or PORT2 operation external input is TRUE.

Point

While the FB (M+M_MVAL1) only outputs at the time of valve start (startup pulse), the FB (M+M_DS2P) continually outputs to PORT1 or PORT2 as long as the command signal is input. Refer to the following manuals for specifications of the FB (M+M_MVAL1).

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.3 ON/OFF Operation (2 Input/2 Output) (M+M_MVAL1)

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.13 ON/OFF Operation (2 Input/2 Output (Status)) (M+M_DS2P)

Program label definition

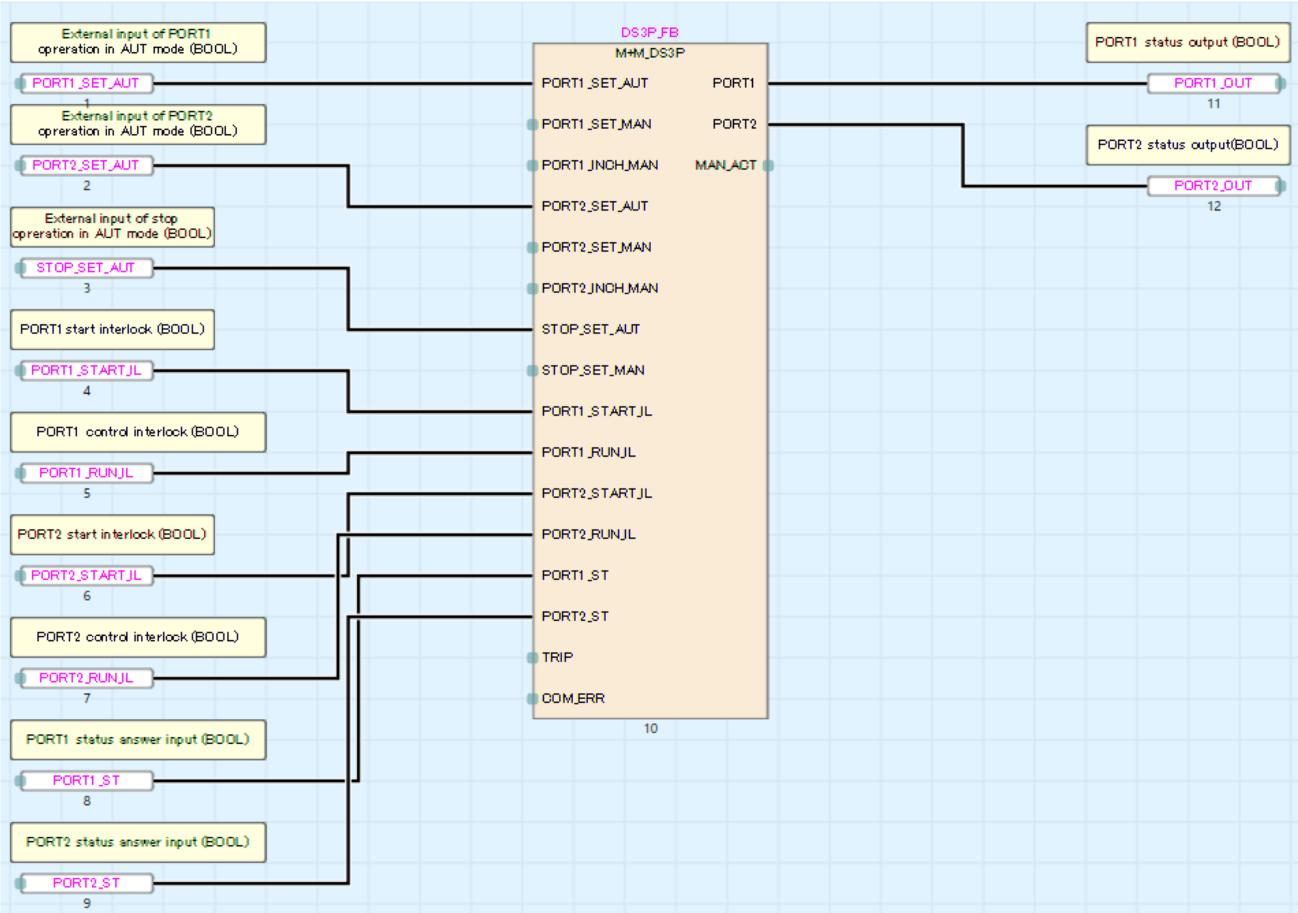
Label name	Data type	Class	Description
PORT1_SET_AUT	Bit	VAR	External input of PORT1 operation in AUT mode
PORT2_SET_AUT	Bit	VAR	External input of PORT2 operation in AUT mode
PORT1_START_IL	Bit	VAR	PORT1 start interlock
PORT1_RUN_IL	Bit	VAR	PORT1 control interlock
PORT2_START_IL	Bit	VAR	PORT2 start interlock
PORT2_RUN_IL	Bit	VAR	PORT2 control interlock
PORT1_ST	Bit	VAR	PORT1 status answer input
PORT2_ST	Bit	VAR	PORT2 status answer input
PORT1_OUT	Bit	VAR	PORT1 status output
PORT2_OUT	Bit	VAR	PORT2 status output

3-position double solenoid valve control

Function

Three patterns of control are performed by switching the two outputs to set only PORT1 or PORT2 to TRUE or set both PORT1 and PORT2 to FALSE in response to the ON/OFF operation (M+M_DS3P).
If the control interlock and start interlock for each port (PORT1 and PORT2) become TRUE while the control mode is AUTO, TRUE is continually output to PORT 1 or PORT2 while the corresponding PORT1 or PORT2 operation external input is TRUE. However, the stop operation external input becoming TRUE has highest priority, which results in both PORT1 and PORT2 outputs becoming FALSE.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.14 ON/OFF Operation (3 Input/2 Output (Status)) (M+M_DS3P)

Program label definition

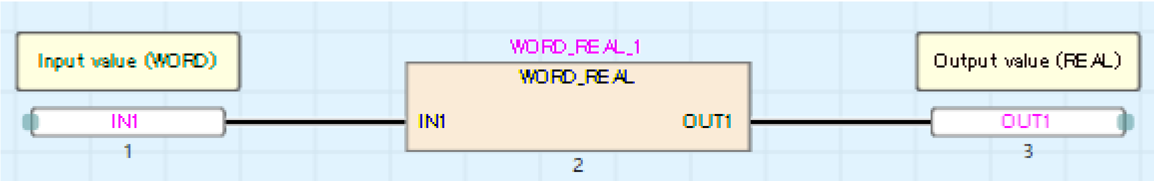
Label name	Data type	Class	Description
PORT1_SET_AUT	Bit	VAR	External input of PORT1 operation in AUT mode
PORT2_SET_AUT	Bit	VAR	External input of PORT2 operation in AUT mode
STOP_SET_AUT	Bit	VAR	External input of stop operation in AUT mode
PORT1_START_IL	Bit	VAR	PORT1 start interlock
PORT1_RUN_IL	Bit	VAR	PORT1 control interlock
PORT2_START_IL	Bit	VAR	PORT2 start interlock
PORT2_RUN_IL	Bit	VAR	PORT2 control interlock
PORT1_ST	Bit	VAR	PORT1 status answer input
PORT2_ST	Bit	VAR	PORT2 status answer input
PORT1_OUT	Bit	VAR	PORT1 status output
PORT2_OUT	Bit	VAR	PORT2 status output

Converting WORD to REAL

Function

Unsigned word data is converted to a single-precision real number.

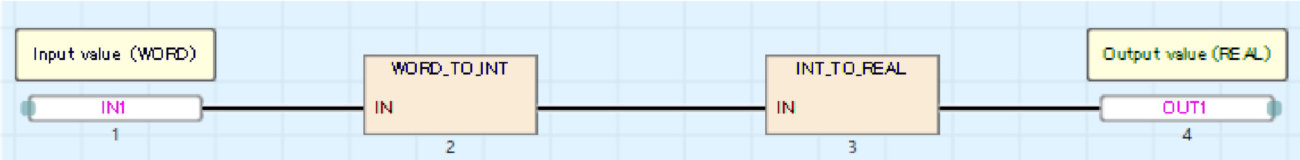
Program



Program label definition

Label name	Data type	Class	Description
WORD_REAL_1	WORD_REAL	VAR	User-defined FB
IN1	Word [Unsigned]/Bit string [16 bits]	VAR	Input value
OUT1	FLOAT [Single Precision]	VAR	Output value

User-defined FB (WORD_REAL)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.9 Converting WORD to INT
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.20 Converting INT to WORD

Label definition of user-defined FB (WORD_REAL)

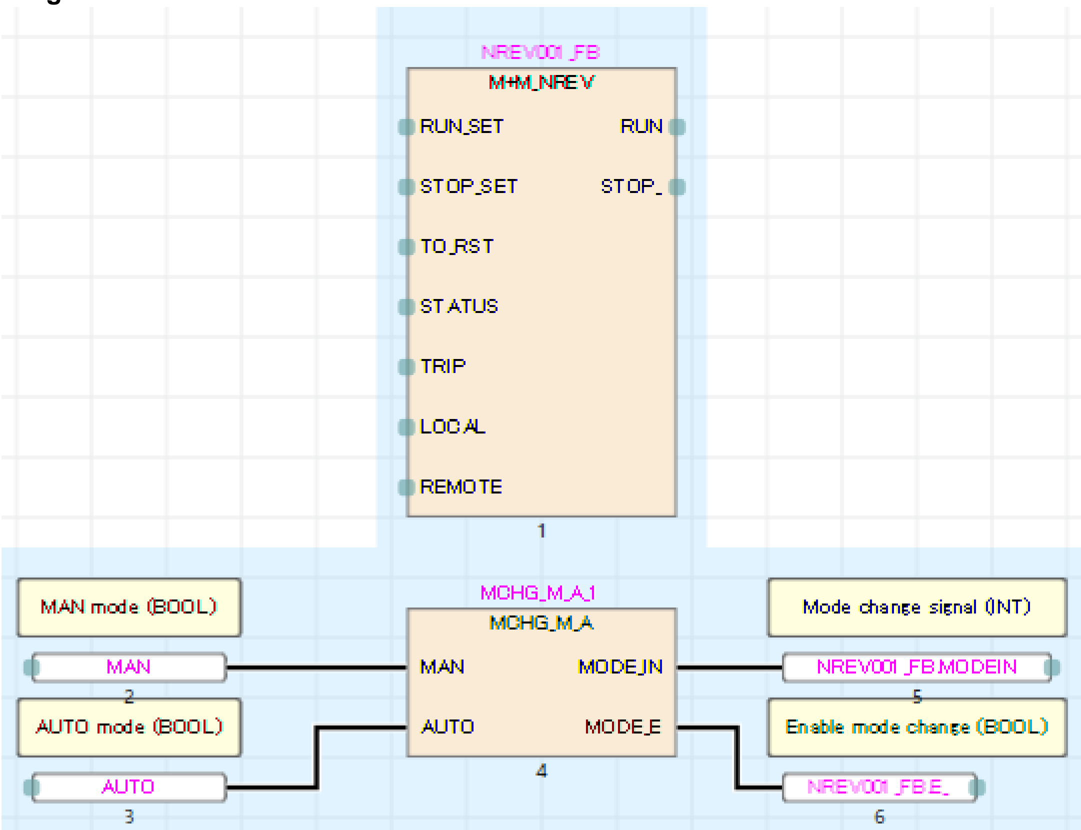
Label name	Data type	Class	Description
IN1	Word [Unsigned]/Bit string [16 bits]	VAR_INPUT	Input value
OUT1	FLOAT [Single Precision]	VAR_OUTPUT	Output value

Control mode change (MAN_AUTO)

Function

- When the MAN input changes from FALSE to TRUE, the mode switch signal changes to the MAN mode (1), and the switch request changes from FALSE to TRUE.
- When the AUTO input changes from FALSE to TRUE, the mode switch signal changes to the AUTO mode (2), and the switch request changes from FALSE to TRUE.
- The motor irreversible (M + M_NREV) mode switches between the MAN mode and AUTO mode.

Program

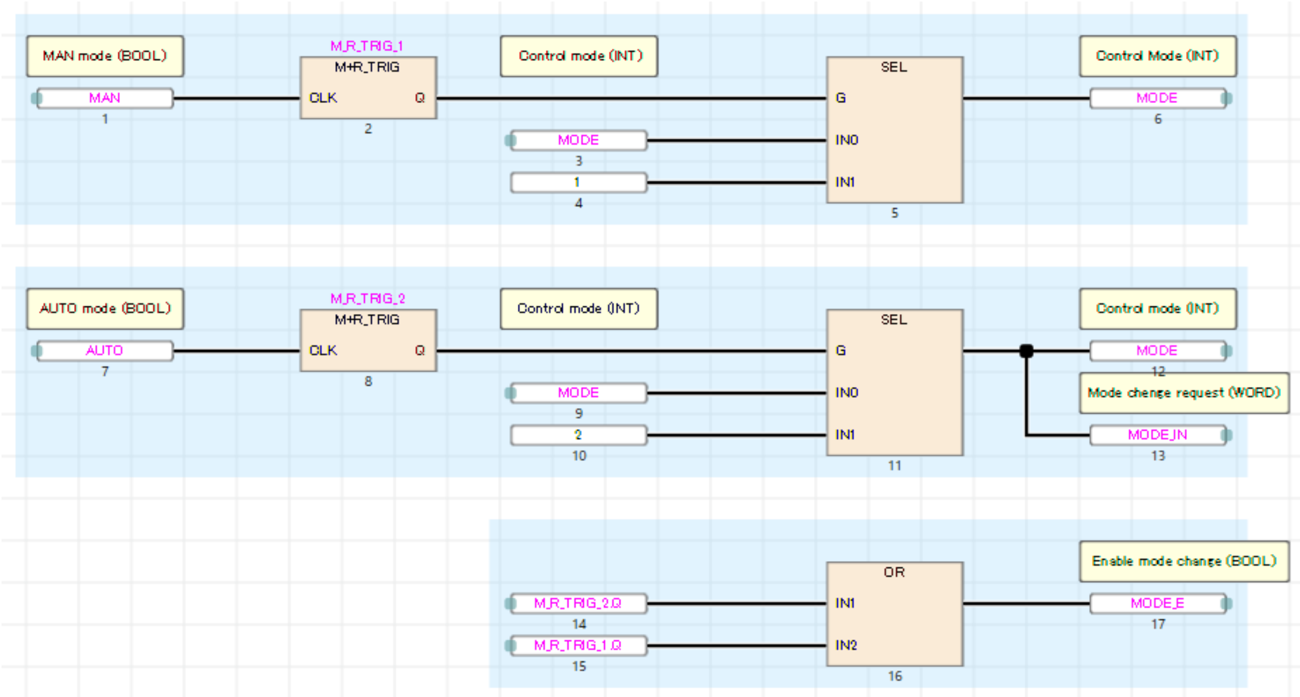


Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18.1 Motor Irreversible (2 Input/2 Output) (M+M_NERV)

Program label definition

Label name	Data type	Class	Description
MCHG_M_A_1	MCHG_M_A	VAR	User-defined FB
MAN	Bit	VAR	MAN mode
AUTO	Bit	VAR	AUTO mode

User-defined FB (MCHG_M_A)



Reference: [MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 11.1 Rising Edge Detection (M+R_TRIG)]

Reference: [MELSEC iQ-R Programming Manual (CPU Module Instructions) 5.1 Contact Instructions]

Reference: [MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value]

Label definition of user-defined FB (MCHG_M_A)

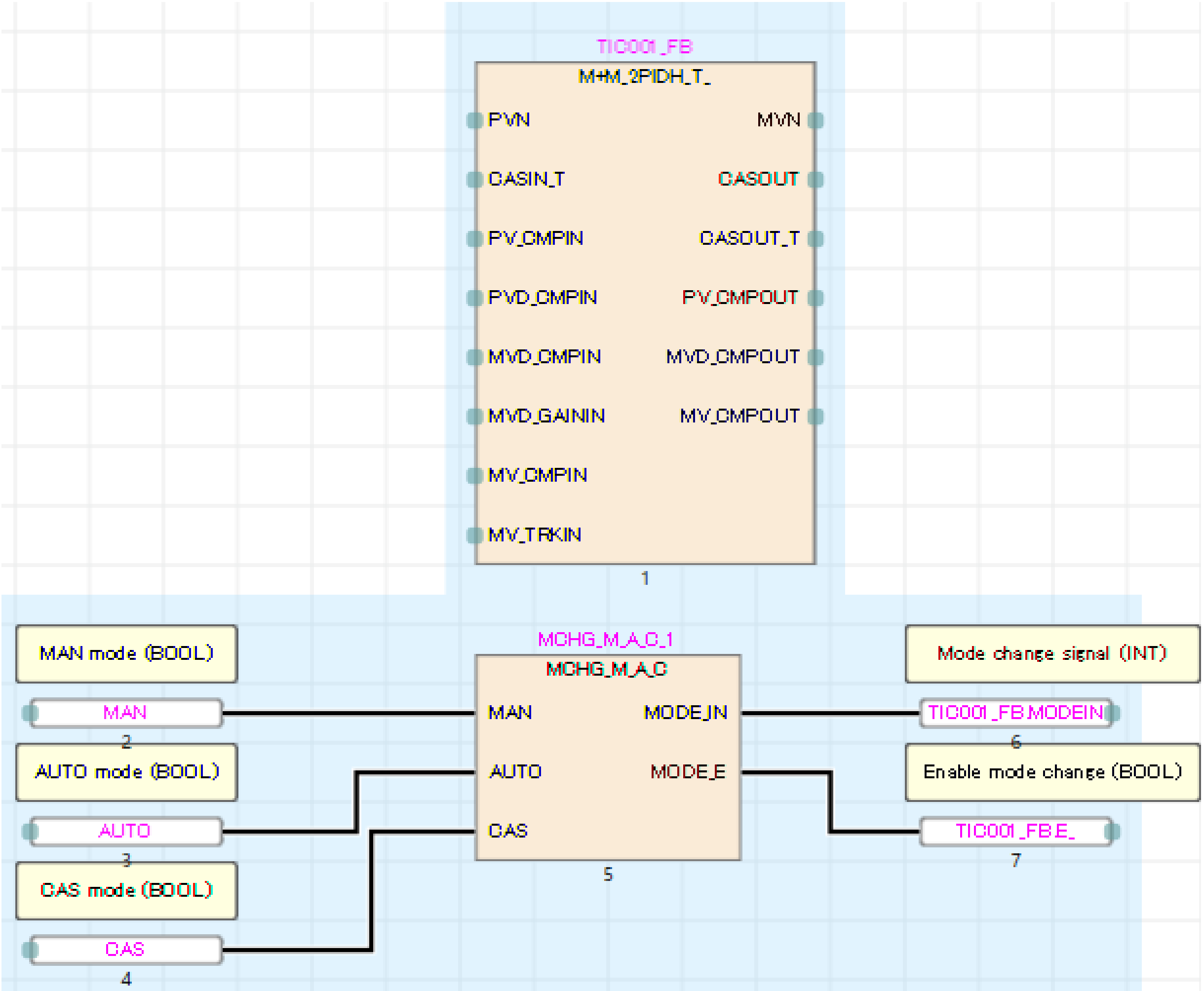
Label name	Data type	Class	Description
M_R_TRIG_1	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_2	M+R_TRIG	VAR	Rising edge detection
MAN	Bit	VAR_INPUT	MAN mode
AUTO	Bit	VAR_INPUT	AUTO mode
MODE_IN	Word [Signed]	VAR_OUTPUT	Mode change signal
MODE_E	Bit	VAR_OUTPUT	Change request
MODE	Word [Signed]	VAR	Mode

Control mode change (MAN_AUTO_CAS)

Function

- When the MAN input changes from FALSE to TRUE, the mode switch signal changes to the MAN mode (1), and the switch request changes from FALSE to TRUE.
- When the AUTO input changes from FALSE to TRUE, the mode switch signal changes to the AUTO mode (2), and the switch request changes from FALSE to TRUE.
- When the CAS input changes from FALSE to TRUE, the mode switch signal changes to the CASCADE mode (3), and the switch request changes from FALSE to TRUE.
- The mode of the 2-degree-of-freedom advanced PID control (M+M_2PIDH_T_) switches between the MAN mode, AUTO mode, and CASCADE mode.

Program

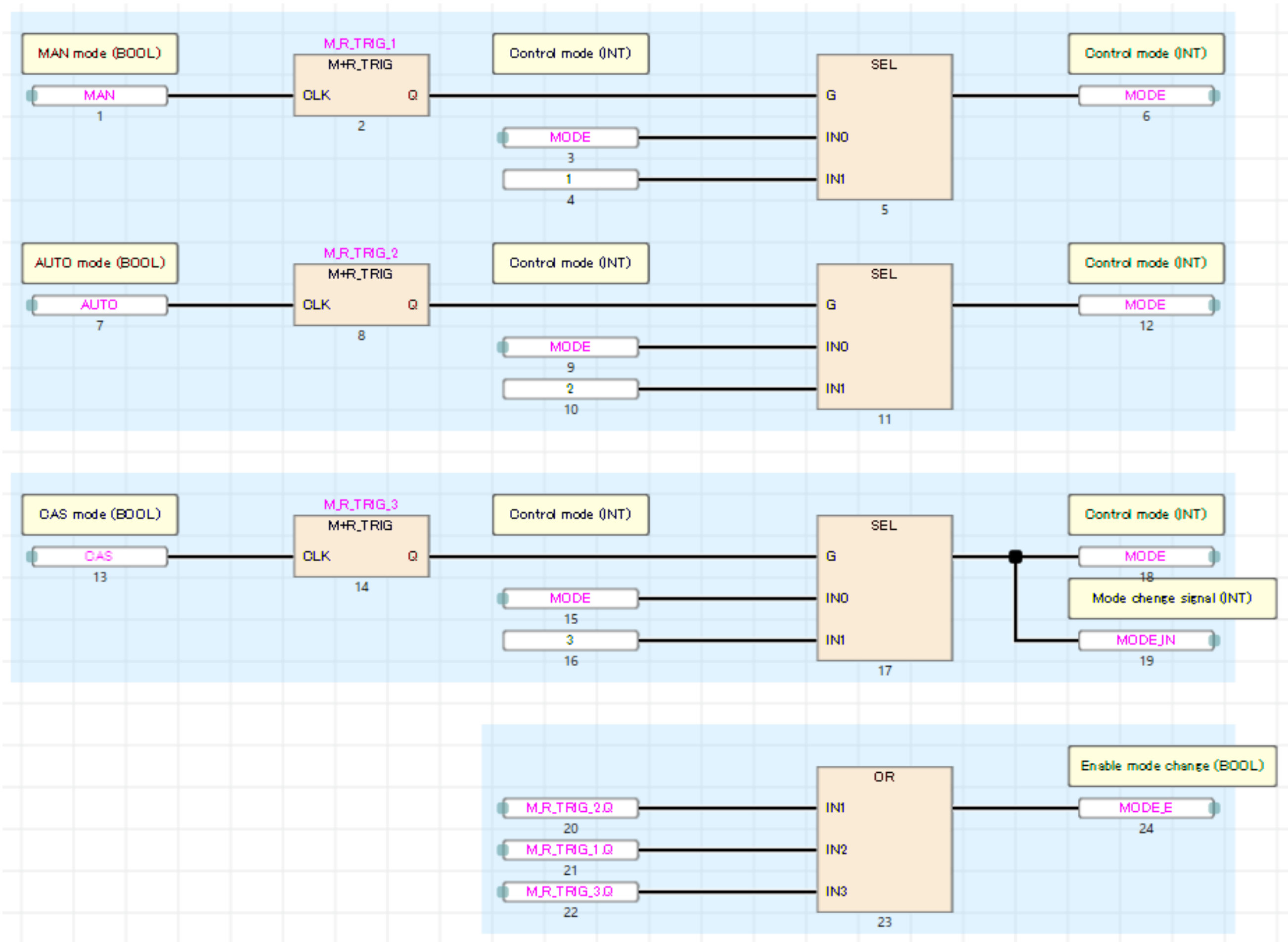


Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)

Program label definition

Label name	Data type	Class	Description
MCHG_M_A_C_1	MCHG_M_A_C	VAR	User-defined FB
MAN	Bit	VAR	MAN mode
AUTO	Bit	VAR	AUTO mode
CAS	Bit	VAR	CAS mode

User-defined FB



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 11.1 Rising Edge Detection (M+R_TRIG)
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 5.1 Contact Instructions
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value

Label definition of user-defined FB

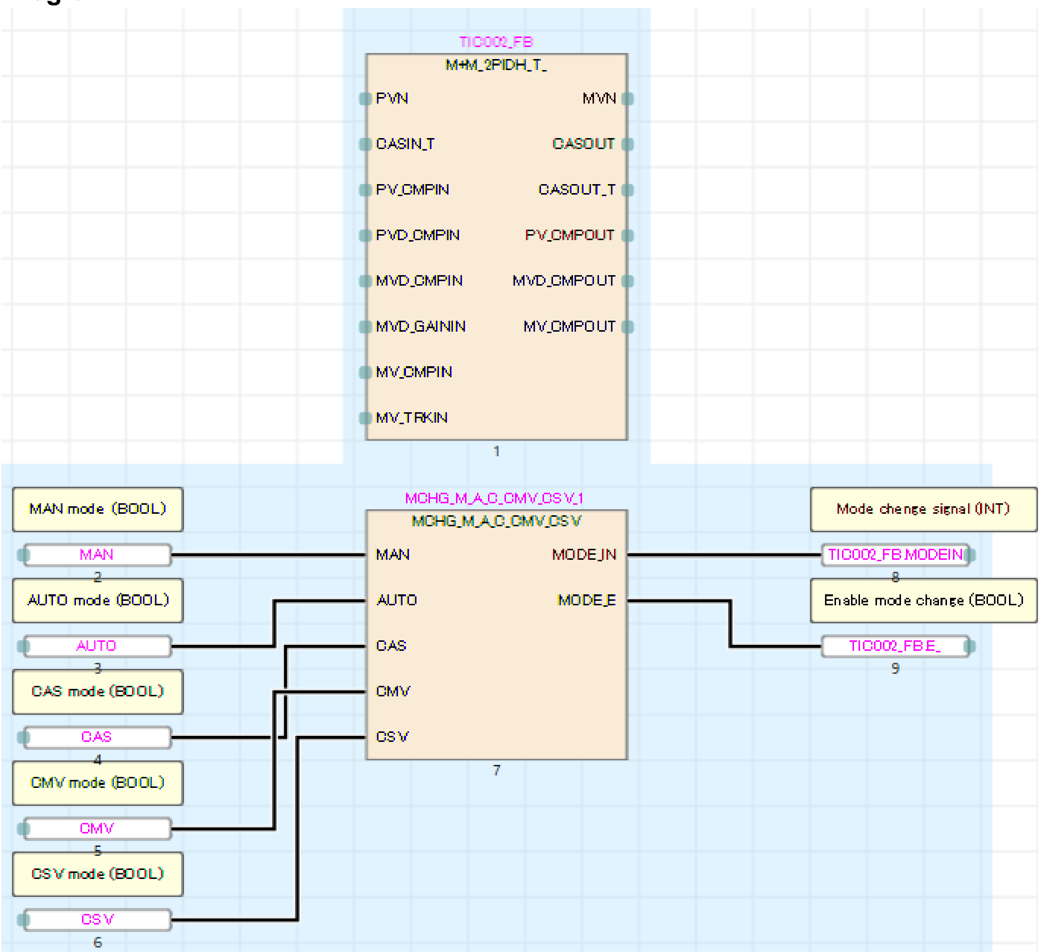
Label name	Data type	Class	Description
M_R_TRIG_1	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_2	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_3	M+R_TRIG	VAR	Rising edge detection
MAN	Bit	VAR_INPUT	MAN mode
AUTO	Bit	VAR_INPUT	AUTO mode
CAS	Bit	VAR_INPUT	CAS mode
MODE_IN	Word [Signed]	VAR_OUTPUT	Mode change signal
MODE_E	Bit	VAR_OUTPUT	Change request
MODE	Word [Signed]	VAR	Mode

Control mode change (MAN_AUTO_CAS_CMV_CSV)

Function

- When the MAN input changes from FALSE to TRUE, the mode switch signal changes to the MAN mode (1), and the switch request changes from FALSE to TRUE.
- When the AUTO input changes from FALSE to TRUE, the mode switch signal changes to the AUTO mode (2), and the switch request changes from FALSE to TRUE.
- When the CAS input changes from FALSE to TRUE, the mode switch signal changes to the CASCADE mode (3), and the switch request changes from FALSE to TRUE.
- When the CMV input changes from FALSE to TRUE, the mode switch signal changes to the CMV mode (4), and the switch request changes from FALSE to TRUE.
- When the CSV input changes from FALSE to TRUE, the mode switch signal changes to the CASCADE mode (5), and the switch request changes from FALSE to TRUE.
- The mode of the 2-degree-of-freedom advanced PID control (M+M_2PIDH_T_) switches between the MAN mode, AUTO mode, CASCADE mode, CMV mode, and CSV mode.

Program

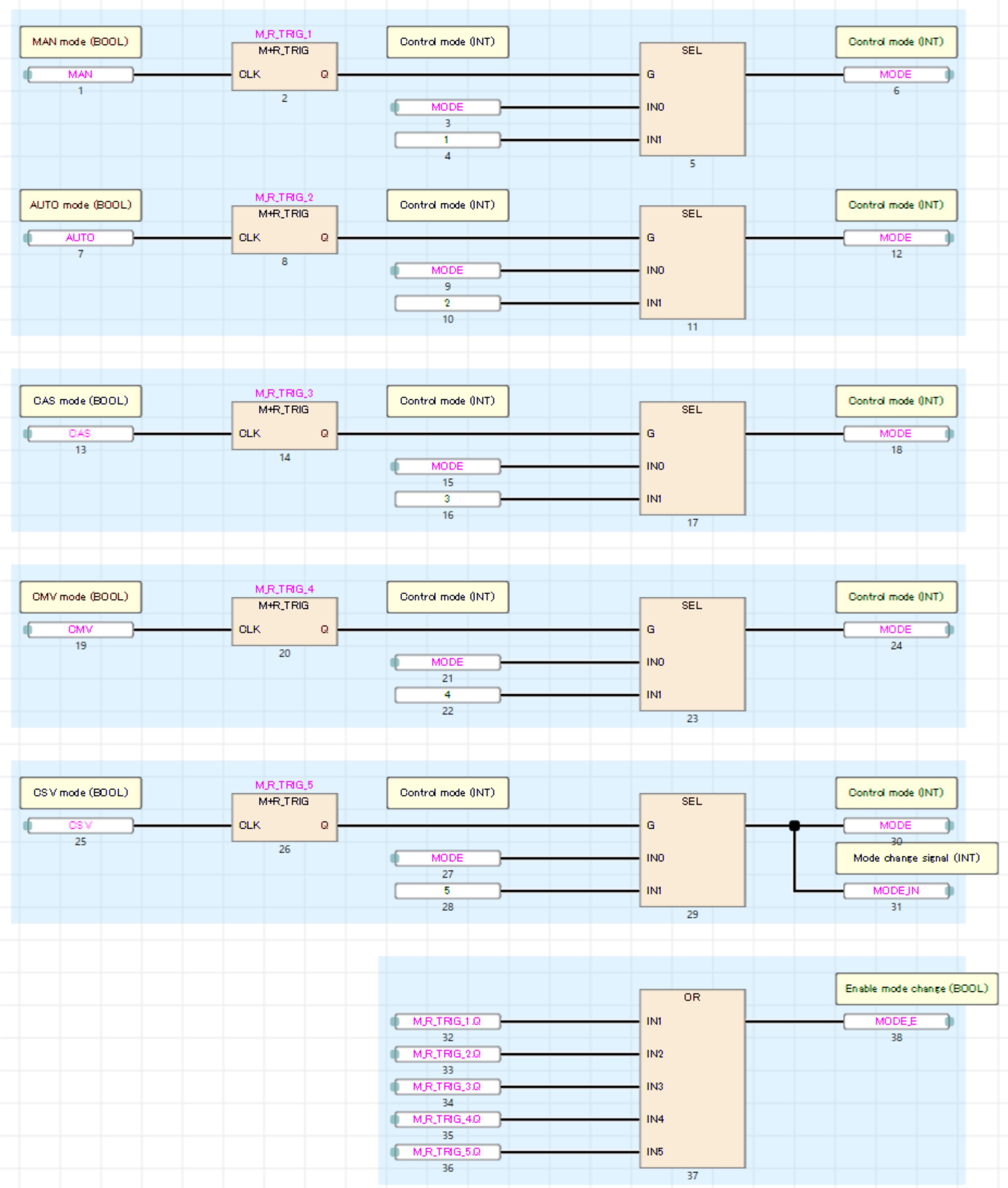


Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)

Program label definition

Label name	Data type	Class	Description
MCHG_M_A_C_CMV_CSV_1	MCHG_M_A_C_CMV_CSV	VAR	User-defined FB
MAN	Bit	VAR	MAN mode
AUTO	Bit	VAR	AUTO mode
CAS	Bit	VAR	CAS mode
CMV	Bit	VAR	CMV mode
CSV	Bit	VAR	CSV mode

User-defined FB (MCHG_M_A_C_CMV_CSV)



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 11.1 Rising Edge Detection (M+R_TRIG)

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 5.1 Contact Instructions

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value

Label definition of user-defined FB (MCHG_M_A_C_CMV_CSV)

Label name	Data type	Class	Description
M_R_TRIG_1	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_2	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_3	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_4	M+R_TRIG	VAR	Rising edge detection
M_R_TRIG_5	M+R_TRIG	VAR	Rising edge detection
MAN	Bit	VAR_INPUT	MAN mode
AUTO	Bit	VAR_INPUT	AUTO mode
CAS	Bit	VAR_INPUT	CAS mode
CMV	Bit	VAR_INPUT	CMV mode
CSV	Bit	VAR_INPUT	CSV mode
MODE_IN	Word [Signed]	VAR_OUTPUT	Mode change signal
MODE_E	Bit	VAR_OUTPUT	Change request
MODE	Word [Signed]	VAR	Mode

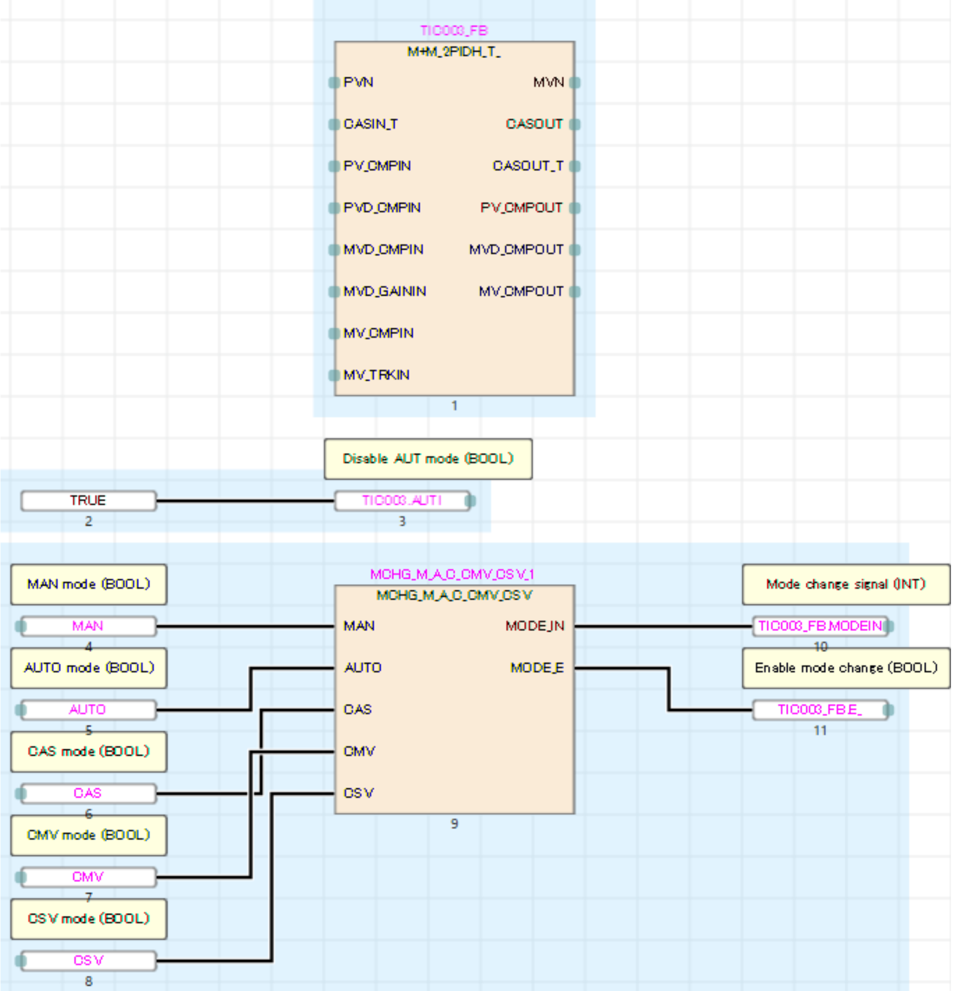
Control mode prohibition

Function

- Specific control modes (MAN, AUTO, CASCADE, CMV, CSV) of 2-degree-of-freedom advanced PID control (M+M_2PIDH_T_) are prohibited.
- To prohibit a specific control mode, set the mode prohibition setting in the corresponding loop tag memory to TRUE.

MANI: Setting to prohibit the MAN mode
AUTI: Setting to prohibit the AUTO mode
CASI: Setting to prohibit the CAS mode
CMVI: Setting to prohibit the COMPUTER MV mode (mode to set the MV with an upper layer computer)
CSVI: Setting to prohibit the COMPUTER SV mode (mode to set the SV with an upper layer computer)

Program (program that prohibits the AUTO mode)



Reference: [MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)]

Program label definition

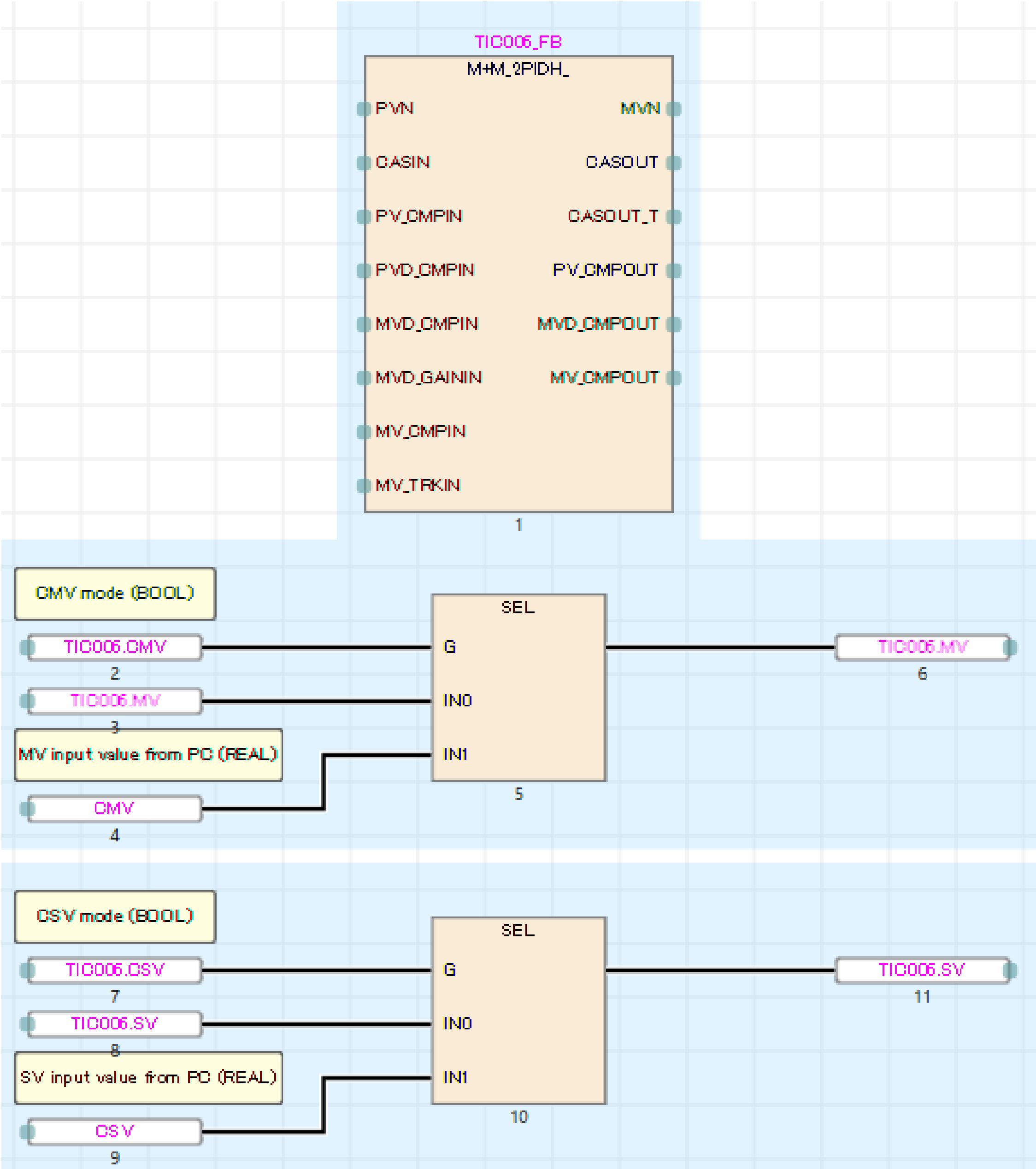
Label name	Data type	Class	Description
Control mode change_M_A_C_CMV_CSV_1	Control mode change_M_A_C_CMV_CSV	VAR	User-defined FB
MAN	Bit	VAR	MAN mode
AUTO	Bit	VAR	AUTO mode
CAS	Bit	VAR	CAS mode
CMV	Bit	VAR	CMV mode
CSV	Bit	VAR	CSV mode

Writing the MV and SV from an upper layer computer or other external devices (HMIs)

Function

The MV or SV can be set from an upper layer computer or other external devices (HMIs) while the tag FB control mode is the CMV mode or CSV mode.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value

Program label definition

Label name	Data type	Class	Description
CMV	FLOAT [Single Precision]	VAR	MV input value from PC
CSV	FLOAT [Single Precision]	VAR	SV input value from PC

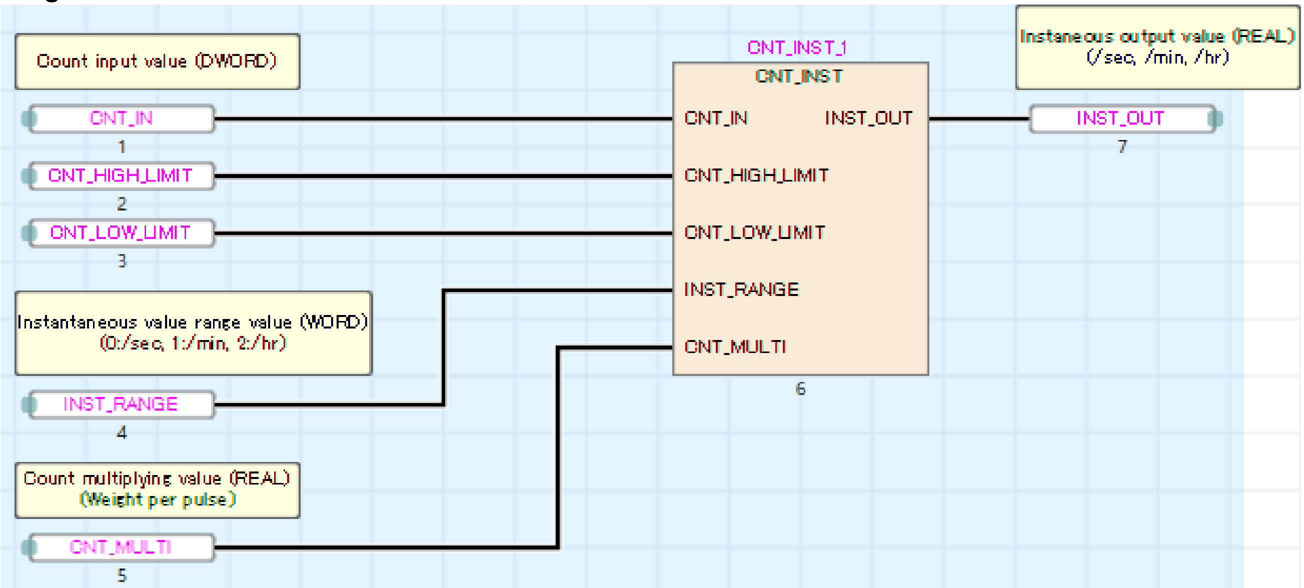
1.4 Input Programs and Sensors

Converting a sensor count input value to an instantaneous output value

Function

The sensor count output is converted into an instantaneous output value by converting the count input value for one second from the analog input module. (The execution cycle of programs using this user-defined FB should be set to 1000 ms in the program execution setting.)

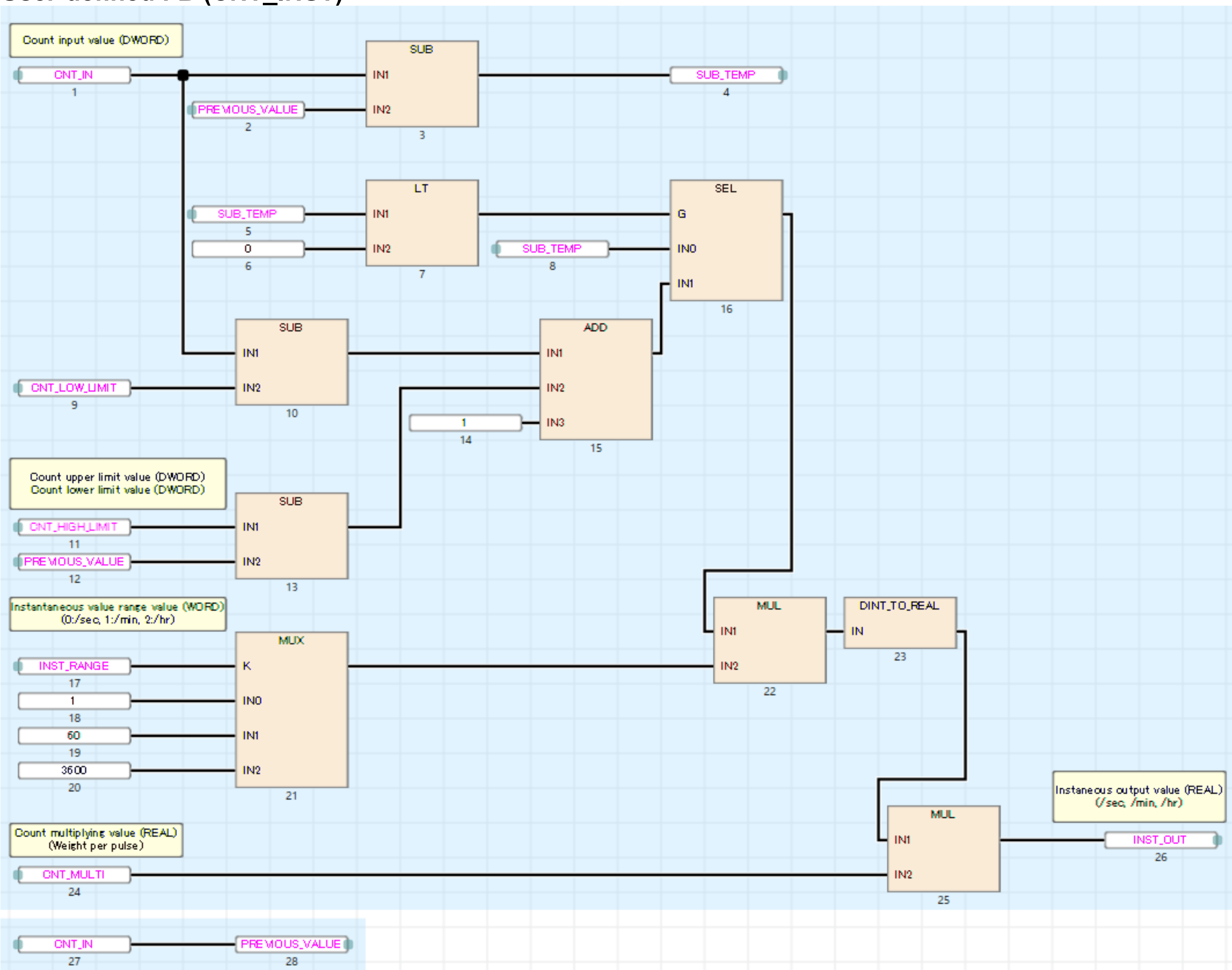
Program



Program label definition

Label name	Data type	Class	Description
CNT_INST_1	CNT_INST	VAR	User-defined FB
CNT_IN	Double word [Signed]	VAR	Count input value
CNT_HIGH_LIMIT	Double word [Signed]	VAR	Count upper limit value
CNT_LOW_LIMIT	Double word [Signed]	VAR	Count lower limit value
INST_RANGE	Word [Signed]	VAR	Instantaneous value range value
CNT_MULTI	FLOAT [Single Precision]	VAR	Count multiplying value
INST_OUT	FLOAT [Single Precision]	VAR	Instantaneous output value

User-defined FB (CNT_INST)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.1 Addition

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.2 Multiplication

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.3 Subtraction

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.4 Multiplexer

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 38.1 Comparing Data

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.33 Converting DINT to REAL

Label definition of user-defined FB (CNT_INST)

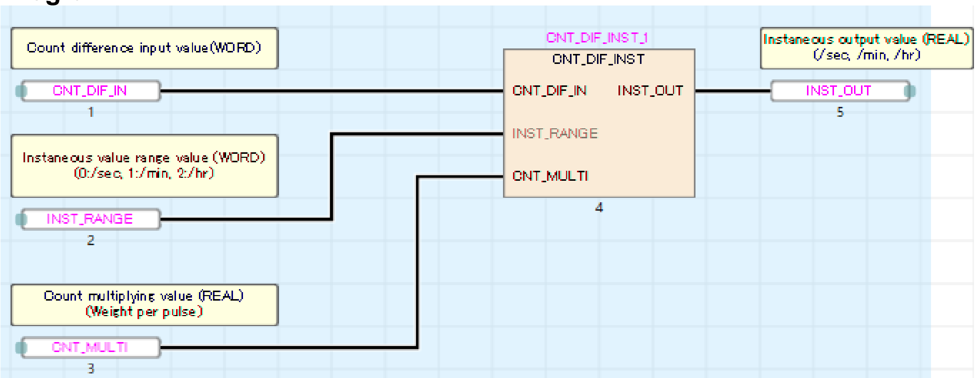
Label name	Data type	Class	Description
CNT_IN	Double word [Signed]	VAR_INPUT	Count input value
CNT_HIGH_LIMIT	Double word [Signed]	VAR_INPUT	Count upper limit value
CNT_LOW_LIMIT	Double word [Signed]	VAR_INPUT	Count lower limit value
INST_RANGE	Word [Signed]	VAR_INPUT	Instantaneous value range value
CNT_MULTI	FLOAT [Single Precision]	VAR_INPUT	Count multiplying value
INST_OUT	FLOAT [Single Precision]	VAR_OUTPUT	Instantaneous output value
PREVIOUS_VALUE	Double word [Signed]	VAR	Count previous value
SUB_TEMP	Double word [Signed]	VAR	Count difference value

Converting the sensor count difference input value to an instantaneous output value

Function

The sensor pulse output is converted into an instantaneous output value by converting the count difference pulse input value per second from the pulse input module (when the count cycle setting is set to one second). The range of instantaneous value units includes /sec, /min, and /hr.

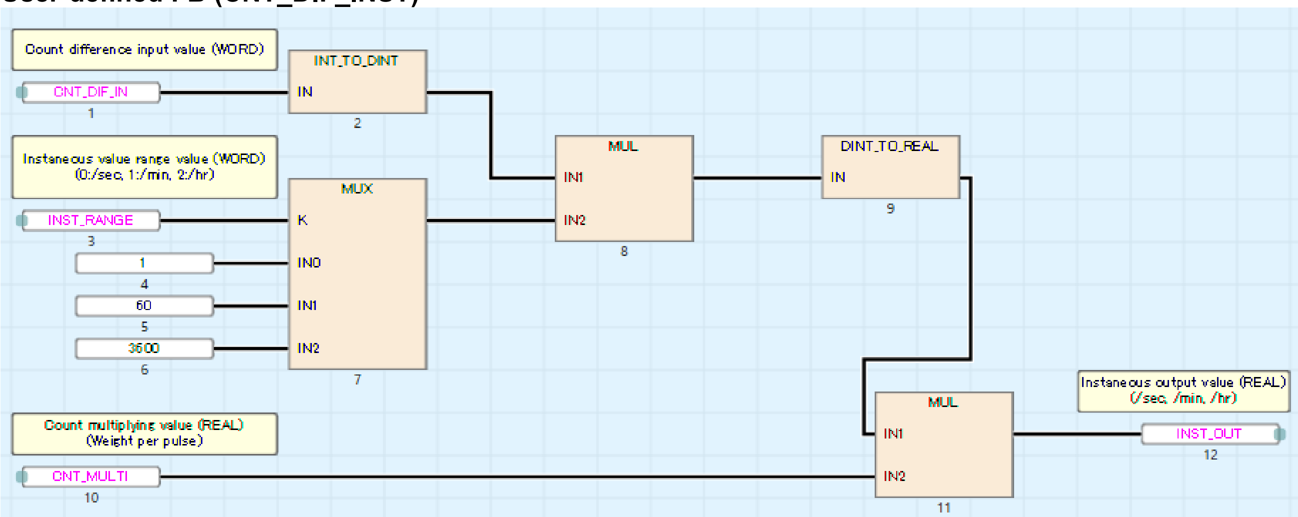
Program



Program label definition

Label name	Data type	Class	Description
CNT_DIF_INST_1	CNT_DIF_INST	VAR	User-defined FB
CNT_DIF_IN	Word [Signed]	VAR	Count difference input value
INST_RANGE	Word [Signed]	VAR	Instantaneous value range value
CNT_MULTI	FLOAT [Single Precision]	VAR	Count multiplying value
INST_OUT	FLOAT [Single Precision]	VAR	Instantaneous output value

User-defined FB (CNT_DIF_INST)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.22 Converting INT to DINT
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.2 Multiplication
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.4 Multiplexer
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.33 Converting DINT to REAL

Label definition of user-defined FB (CNT_DIF_INST)

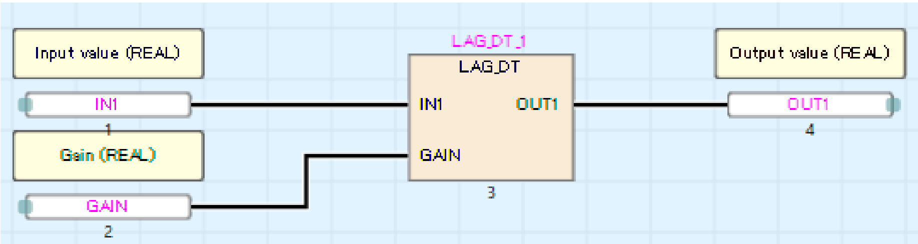
Label name	Data type	Class	Description
CNT_DIF_IN	Word [Signed]	VAR	Count difference input value
INST_RANGE	Word [Signed]	VAR	Instantaneous value range value
CNT_MULTI	FLOAT [Single Precision]	VAR	Count multiplying value
INST_OUT	FLOAT [Single Precision]	VAR	Instantaneous output value

First order lag and dead time

Function

The first order lag and dead time correction are added to an input value and are then output.

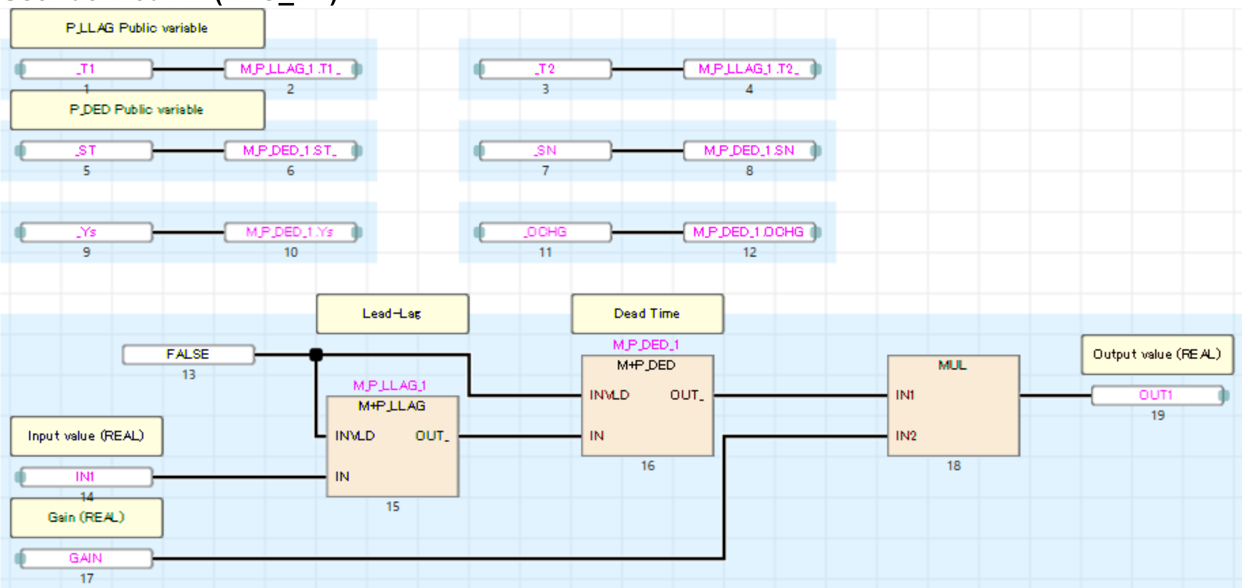
Program



Program label definition

Label name	Data type	Class	Description
LAG_DT_1	LAG_DT	VAR	User-defined FB
IN1	FLOAT [Single Precision]	VAR	Input value
GAIN	FLOAT [Single Precision]	VAR	Gain
OUT1	FLOAT [Single Precision]	VAR	Output value

User-defined FB (LAG_DT)



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 9.1 Lead-Lag (M+P_LLAG)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 9.4 Dead Time (M+P_DED)

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.2 Multiplication

Label definition of user-defined FB (LAG_DT)

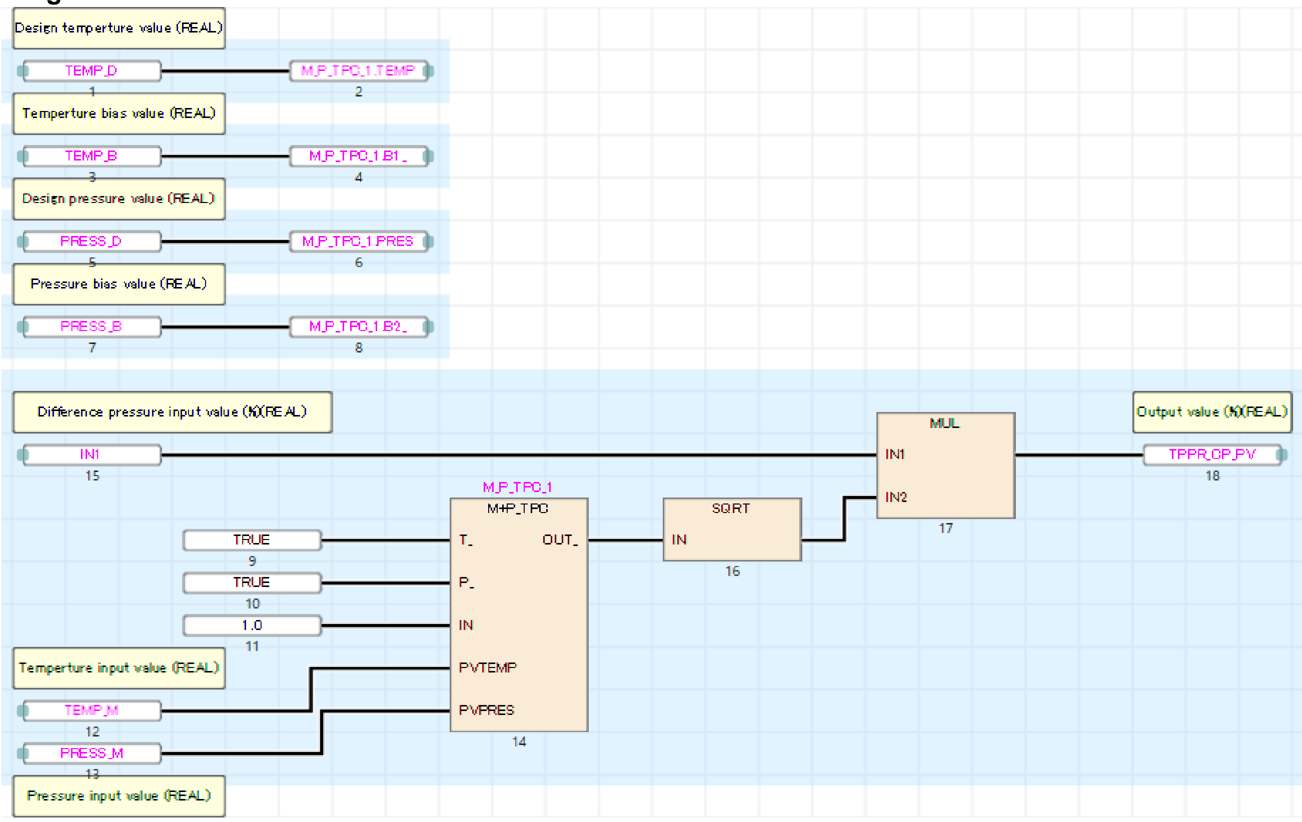
Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR_INPUT	Input value
GAIN	FLOAT [Single Precision]	VAR_INPUT	Gain
OUT1	FLOAT [Single Precision]	VAR_OUTPUT	Output value
_T1	FLOAT [Single Precision]	VAR_PUBLIC	LAG constant 1
_T2	FLOAT [Single Precision]	VAR_PUBLIC	LAG constant 2
_ST	FLOAT [Single Precision]	VAR_PUBLIC	DED constant 1
_SN	Word [Signed]	VAR_PUBLIC	DED constant 2
_Ys	FLOAT [Single Precision]	VAR_PUBLIC	DED constant 3
_OCHG	Word [Signed]	VAR_PUBLIC	DED constant 4
M_P_LLAG_1	M+P_LLAG	VAR	Lead-Lag
M_P_DED_1	M+P_DED	VAR	Dead Time

Temperature/pressure correction (with square root)

Function

The temperature/pressure correction (with square root) is added to a difference pressure input value and is output.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.6 Temperature/Pressure Correction (M+P_TPC)

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 33.2 Calculating the Square Root

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.2 Multiplication

Program label definition

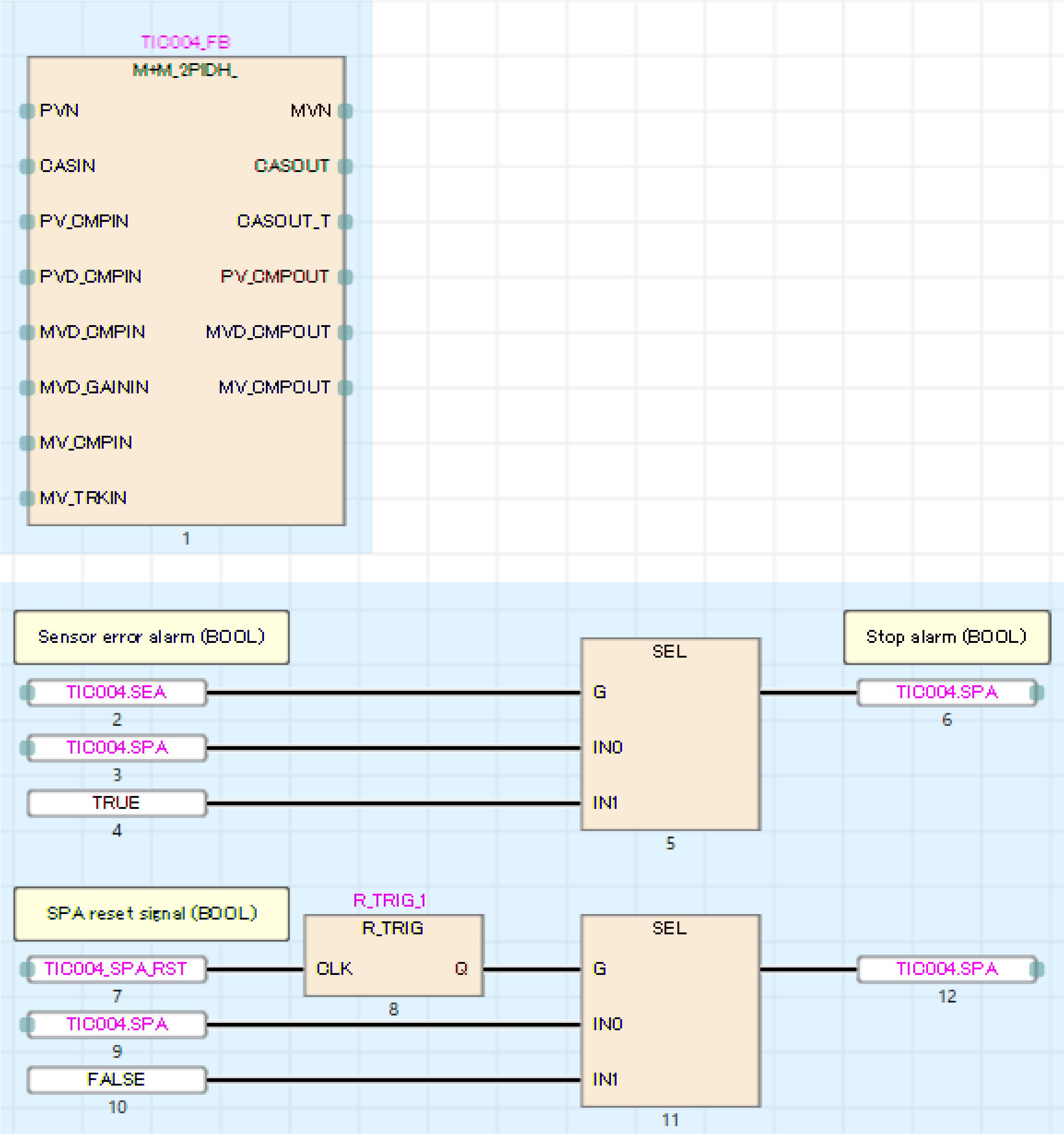
Label name	Data type	Class	Description
M_P_TPC_1	M+P_TPC	VAR	Temperature/Pressure Correction
TEMP_D	FLOAT [Single Precision]	VAR	Design temperature value
TEMP_B	FLOAT [Single Precision]	VAR	Temperature bias value
TEMP_M	FLOAT [Single Precision]	VAR	Temperature input value
PRESS_D	FLOAT [Single Precision]	VAR	Design pressure value
PRESS_B	FLOAT [Single Precision]	VAR	Pressure bias value
PRESS_M	FLOAT [Single Precision]	VAR	Pressure input value
IN1	FLOAT [Single Precision]	VAR	Difference pressure input value (%)
TPPR_CP_PV	FLOAT [Single Precision]	VAR	Output value (%)

Loop stop processing due to sensor error

Function

- The sensor error (SEA) becomes TRUE due to an error in a sensor that provides input to a loop tag FB. The loop stop processing is executed and control is stopped by using the program to set the stop alarm (SPA) to TRUE when a sensor error (SEA) occurs. The control mode can be switched to MAN. The sensor error (SEA) is set to FALSE.
- The stop alarm (SPA) is cleared when the program sets it to FALSE.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 11.1 Rising Edge Detection (M+R_TRIG)
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value

Program label definition

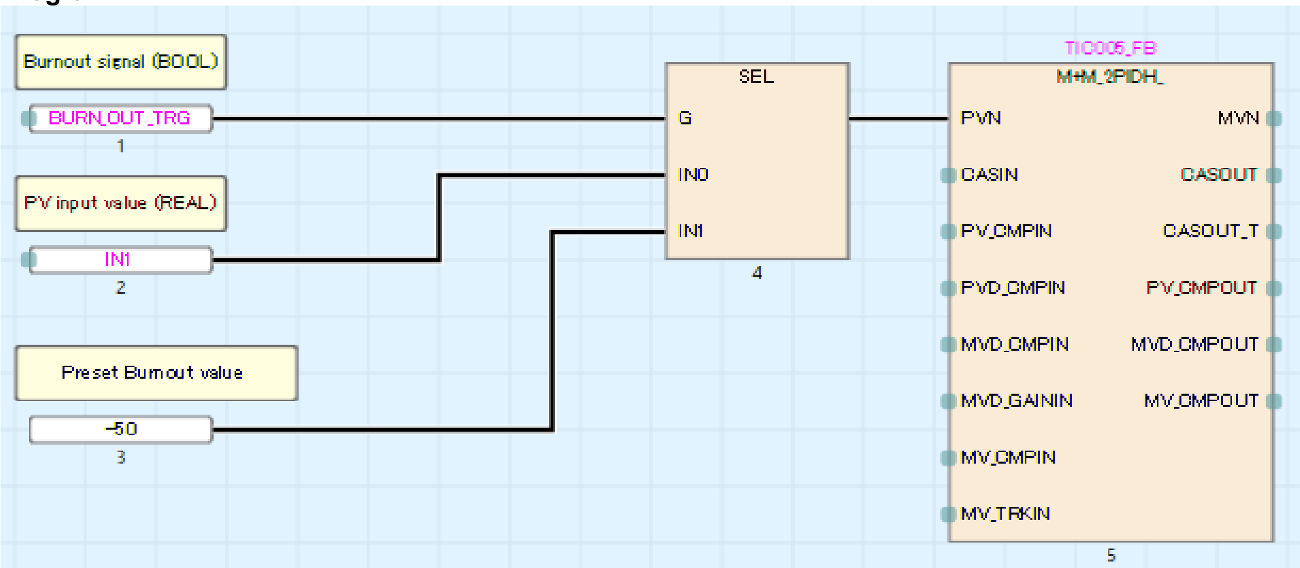
Label name	Data type	Class	Description
TIC004_SPA_RST	Bit	VAR	SPA reset signal
R_TRIG_1	R_TRIG	VAR	Pulse

Sensor burnout preset

Function

The input value is switched to a preset value when a sensor burnout occurs. A temporary value is input to stop the control when a sensor fails.

Program



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)

Program label definition

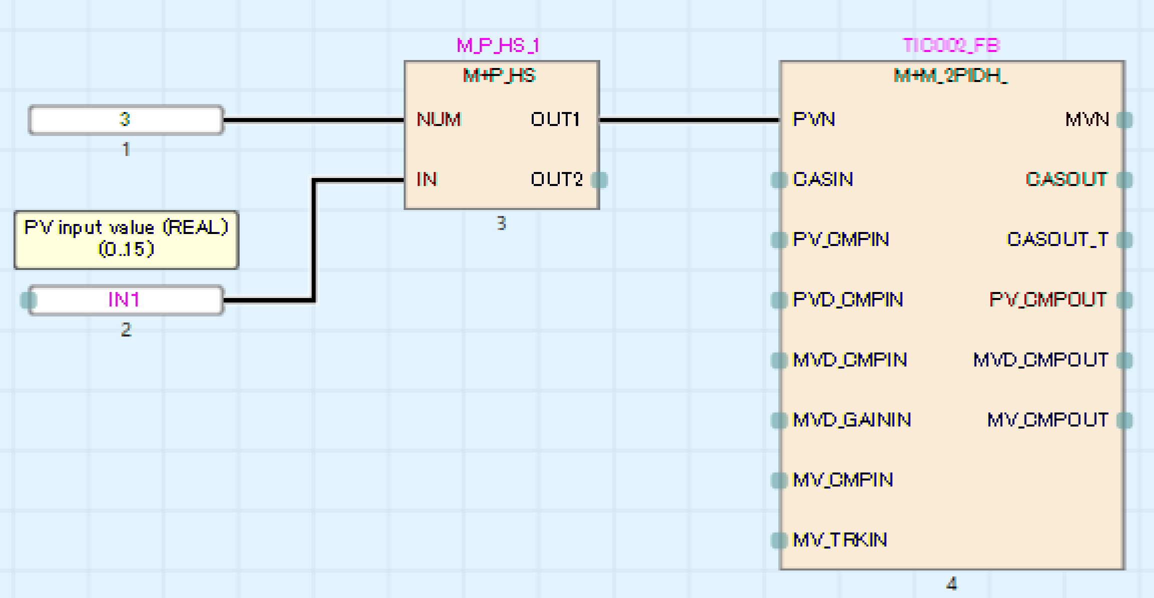
Label name	Data type	Class	Description
BURN_OUT_TRG	Bit	VAR	Burnout signal
IN1	FLOAT [Single Precision]	VAR	PV input value

Selection control (input high selector)

Function

The maximum value of multiple input values is used as input. Inputting the maximum value enables safer control.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.1 High Selector (M+P_HS(_E))
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)

Program label definition

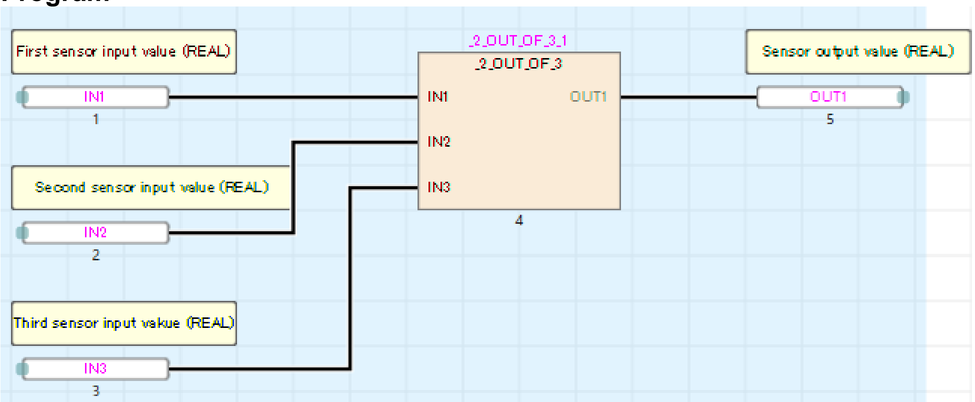
Label name	Data type	Class	Description
M_P_HS_1	M+P_HS	VAR	High Selector
IN1	FLOAT [Single Precision] (0..15)	VAR	PV input value

2 OUT OF 3

Function

When one sensor out of three total sensors fails, the correct sensor input value is read from the other two sensors. This assumes that abnormal upper limit value will be generated by a failed sensor.

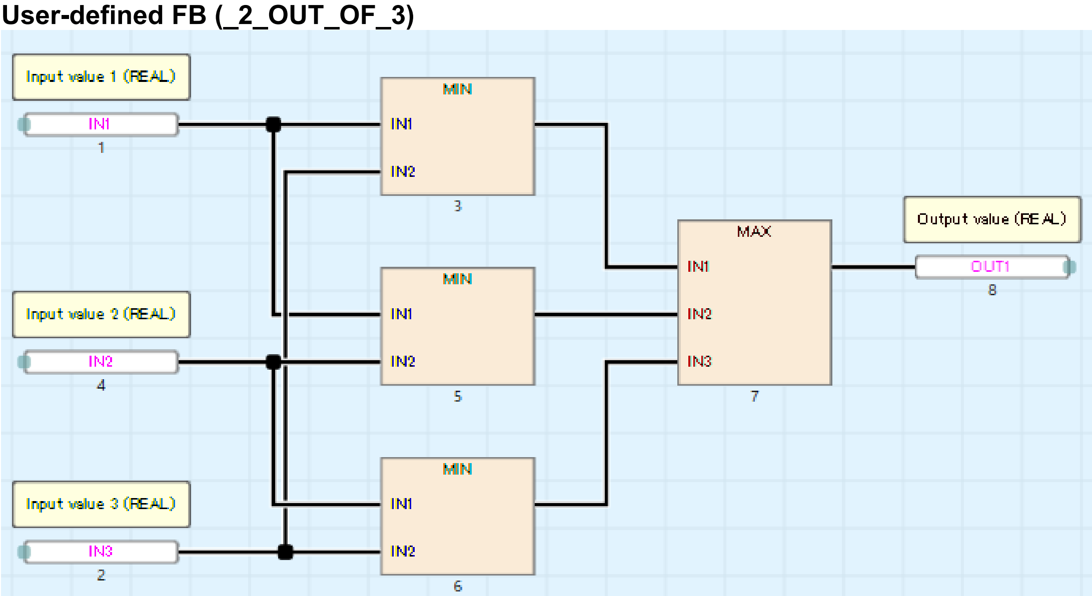
Program



Program label definition

Label name	Data type	Class	Description
_2_OUT_OF_3_1	_2_OUT_OF_3	VAR	User-defined FB
IN1	FLOAT [Single Precision]	VAR	First sensor input value
IN2	FLOAT [Single Precision]	VAR	Second sensor input value
IN3	FLOAT [Single Precision]	VAR	Third sensor input value
OUT1	FLOAT [Single Precision]	VAR	Sensor output value

User-defined FB (_2_OUT_OF_3)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.2 Selecting the Maximum/Minimum Value

Label definition of user-defined FB (_2_OUT_OF_3)

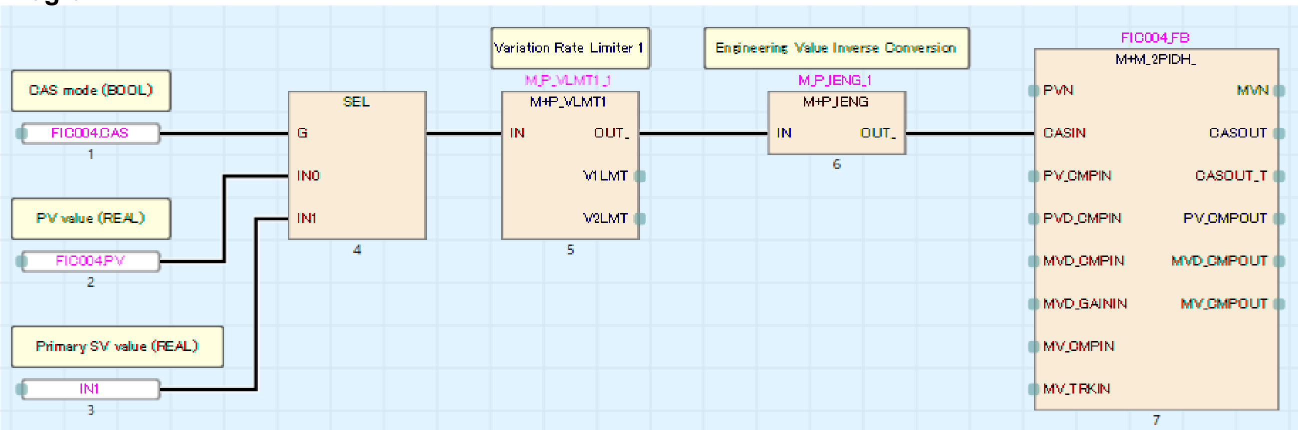
Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR_INPUT	Input 1 value
IN2	FLOAT [Single Precision]	VAR_INPUT	Input 2 value
IN3	FLOAT [Single Precision]	VAR_INPUT	Input 3 value
OUT1	FLOAT [Single Precision]	VAR_OUTPUT	Output value

Process variable tracking (when the input to CASIN is not the CASOUT output of the loop tag FB)

Function

- When the control mode is CASCADE, the primary SV value is input to CASIN.
- When the control mode is not CASCADE, the PV value is tracked in CASIN, and by matching the SV value and PV value, sudden changes to the MV value are suppressed and the mode is switched bumplessly.

Program



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 9.6 Variation Rate Limiter 1 (M+P_VLMT1)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.5 Engineering Value Inverse Conversion (M+P_IENG)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)

Program label definition

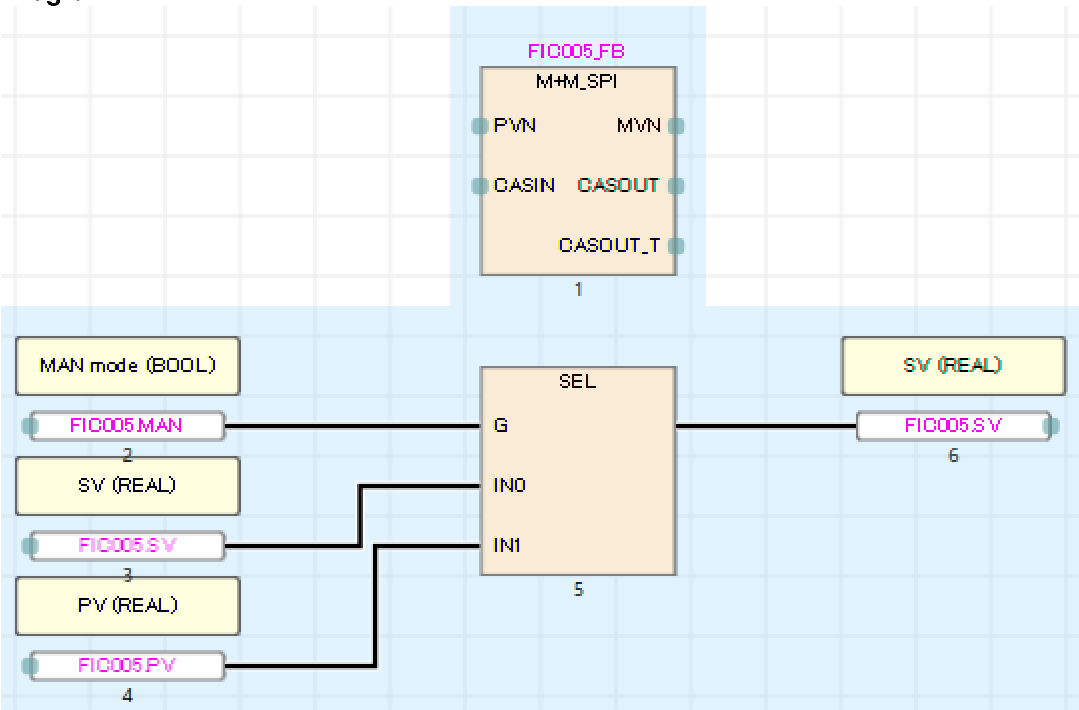
Label name	Data type	Class	Description
M_P_VLMT1_1	M+P_VLMT1	VAR	Variation Rate Limiter 1
M_P_IENG_1	M+P_IENG	VAR	Engineering Value Inverse Conversion
IN1	FLOAT [Single Precision]	VAR	Primary SV value

Process variable tracking (when switching to the MAN mode)

Function

- When the control mode is MAN, the PV value is tracked, and by matching the SV value and PV value, sudden changes to the MV value are suppressed and the mode is switched bumplessly.
- When the control mode is AUT, the SV value is changed. (This function is already included in the 2-degree-of-freedom advanced PID control (M_2PIDH_ and M_2PIDH_T_), and thus this program does not need to be created.)

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.16 Sample PI Control (Disable Tracking for primary loop) (M+M_SPI)
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.1 Selecting a Value

Program label definition

None

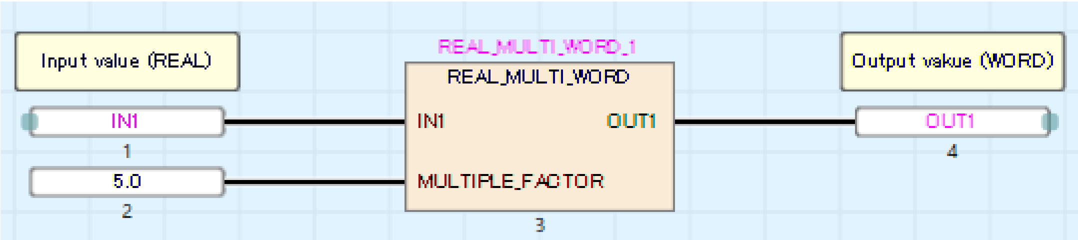
1.6 Output Programs and External Devices (HMI)

Converting single-precision real number data x N times to integer type

Function

Single-precision real number data is multiplied by N and converted into the integer type (signed word).

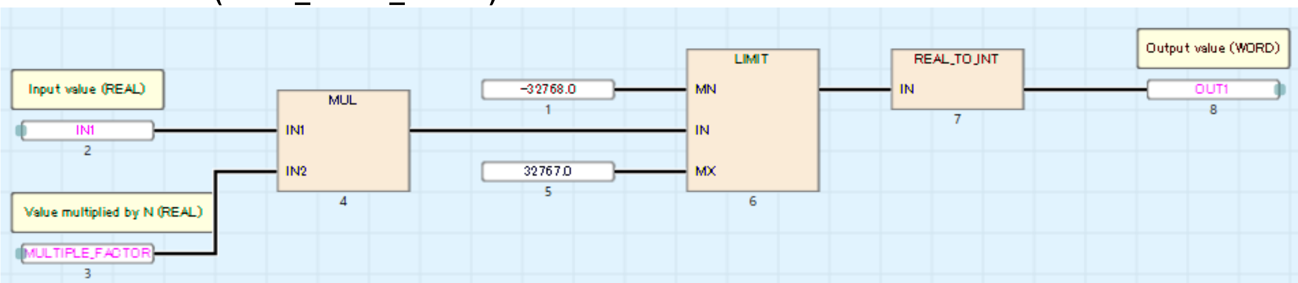
Program



Program label definition

Label name	Data type	Class	Description
REAL_MULTI_WORD_1	REAL_MULTI_WORD	VAR	User-defined FB
IN1	FLOAT [Single Precision]	VAR	Input value
OUT1	Word [Signed]	VAR	Output value

User-defined FB (REAL_MULTI_WORD)



Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 34.2 Multiplication

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 37.3 Controlling the Upper/Lower Limit

Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.40 Converting REAL to INT

Label definition of user-defined FB (REAL_MULTI_WORD)

Label name	Data type	Class	Description
IN1	FLOAT [Single Precision]	VAR	Input value
MULTI_FACTOR	FLOAT [Single Precision]	VAR	Value multiplied by N
OUT1	Word [Signed]	VAR	Output value

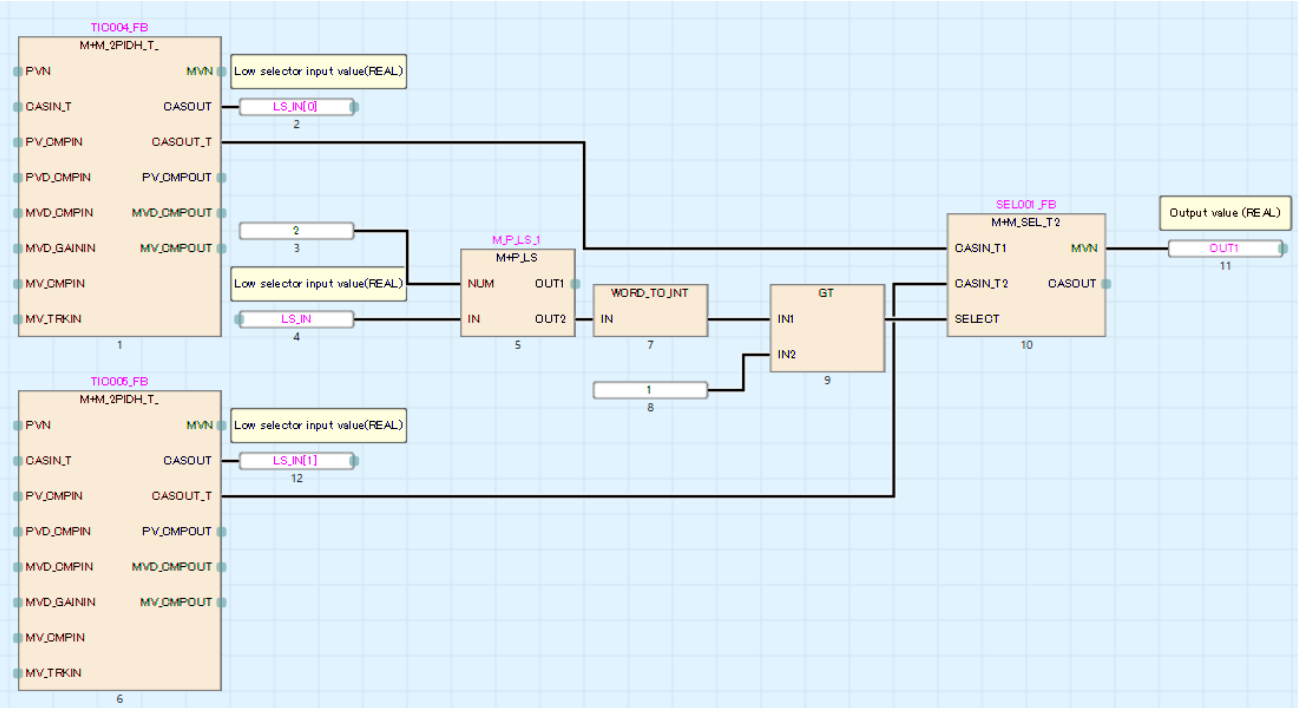
1.7 Output Programs and Loop Processing

Output override (low selector)

Function

MVs from two PID loop tag FBs are compared and the smaller one is output from M+M_SEL_T2.
When M+M_SEL_T2 is in the MAN mode, the MV values of the two PID loops are tracked.

Program



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.2 Low Selector (M+P_LS(_E))
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 32.9 Converting WORD to INT
Reference: MELSEC iQ-R Programming Manual (CPU Module Instructions) 38.1 Comparing Data
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.33 Loop Selector (Enable Tracking for primary loop by CASIN_T1/_T2) (M+M_SEL_T2)

Program label definition

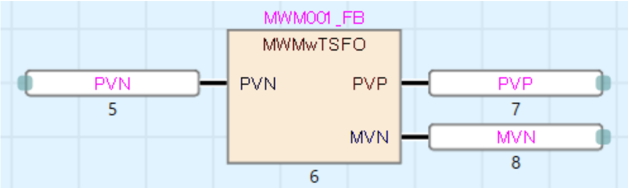
Label name	Data type	Class	Description
M_P_LS_1	M+P_LS	VAR	Low Selector
LS_IN	FLOAT [Single Precision] (0..15)	VAR	Low selector input value
OUT1	FLOAT [Single Precision]	VAR	Output value

Tight shut/full open (tag type MWM)

Function

Processing is performed using the tight shut/full open function according to the output value.
When MVN is 0% or less, the processing result is reduced to the tight shut output value (Tshut), and when MVN is 100% or more, it is increased to the full open output value (FOpen).

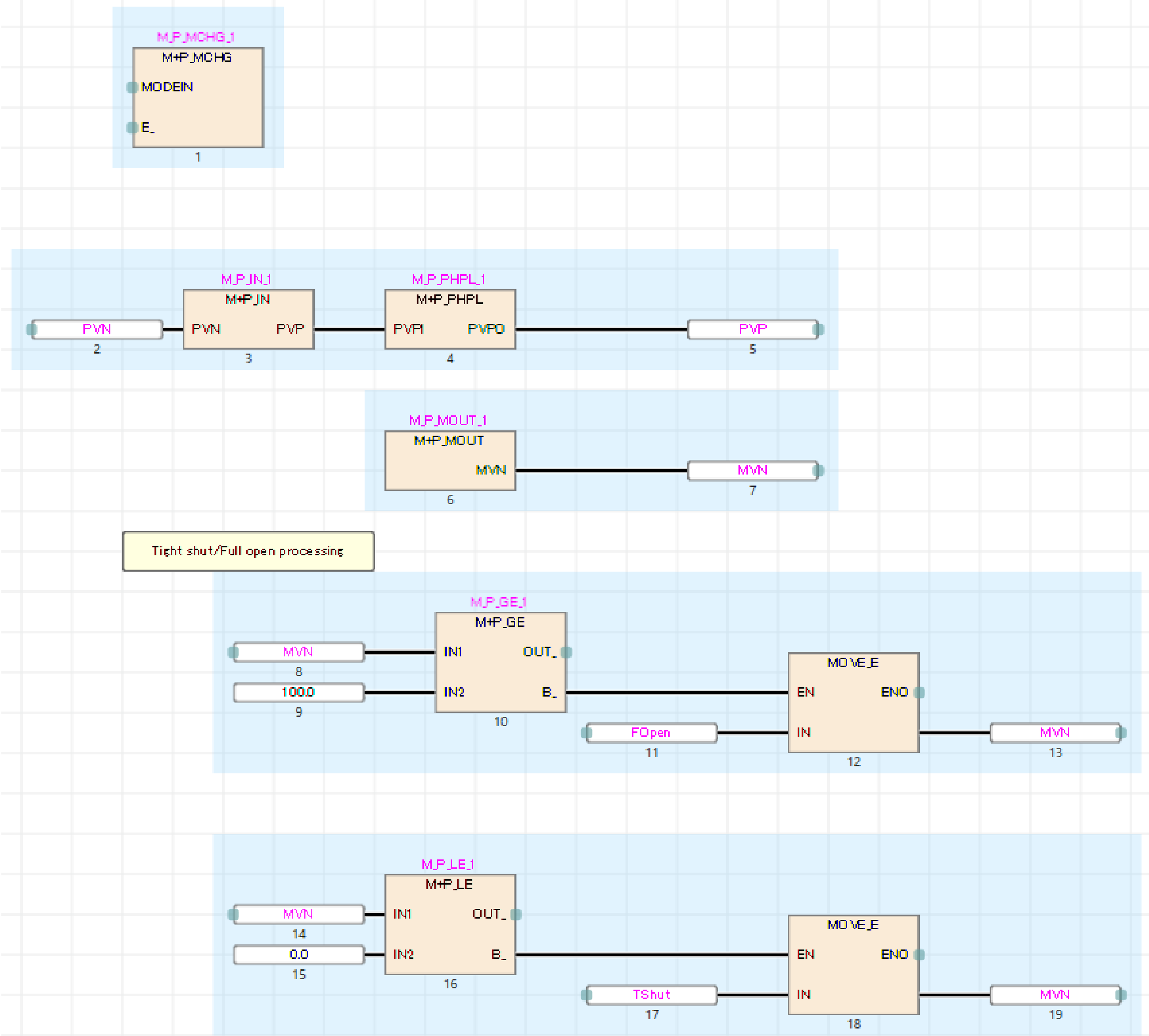
Program



Program label definition

Label name	Data type	Class	Description
PVN	FLOAT [Single Precision]	VAR	PV input
PVP	FLOAT [Single Precision]	VAR	PV value
MVN	FLOAT [Single Precision]	VAR	MV value

User-defined FB (MWMwTSFO)



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 14.1 Analog Input Processing (M+P_IN)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 14.5 Manual Output (M+P_MOUT)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 16.1 Change Control Mode (M+P_MCHG)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 15.19 High/Low Limit Alarm Check (M+P_PHPL)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 8.4 Comparison (>=) with setting value (M+P_GE)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 8.5 Comparison (<=) with setting value (M+P_LE)

Label definition of user-defined FB (MWMwTSFO)

Label name	Data type	Class	Description
M_P_IN_1	M+P_IN	VAR	Analog Input Processing
M_P_MOUT_1	M+P_MOUT	VAR	Manual output
M_P_MCHG_1	M+P_MCHG	VAR	Change Control Mode
M_P_PHPL_1	M+P_PHPL	VAR	High/Low Limit Alarm Check
PVP	FLOAT [Single Precision]	VAR_OUTPUT	Output value (PV)
PVN	FLOAT [Single Precision]	VAR_INPUT	Input value
MVN	FLOAT [Single Precision]	VAR_OUTPUT	Output value (MV)
FOpen	FLOAT [Single Precision]	VAR_PUBLIC	Full open output value
TShut	FLOAT [Single Precision]	VAR_PUBLIC	Tight shut output value
M_P_GE_1	M+P_GE	VAR	Comparison (>=) with setting value
M_P_LE_1	M+P_LE	VAR	Comparison (<=) with setting value

Point

It is recommended that the tight shut/full open function be used in combination with an isolated analog output module that supports a range setting (extended mode) allowing a wider output range than the standard 4 to 20 mA or 1 to 5 V settings.

For modules that do not have an extended mode in the range setting, the tight shut/full open function can be achieved by setting the range to 0 to 20 mA or 0 to 5 V and reconfiguring the upper and lower output conversion limits of this FB.

Reference: Tight shut/full open function in MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) Appendix 3 Related Functions of Process

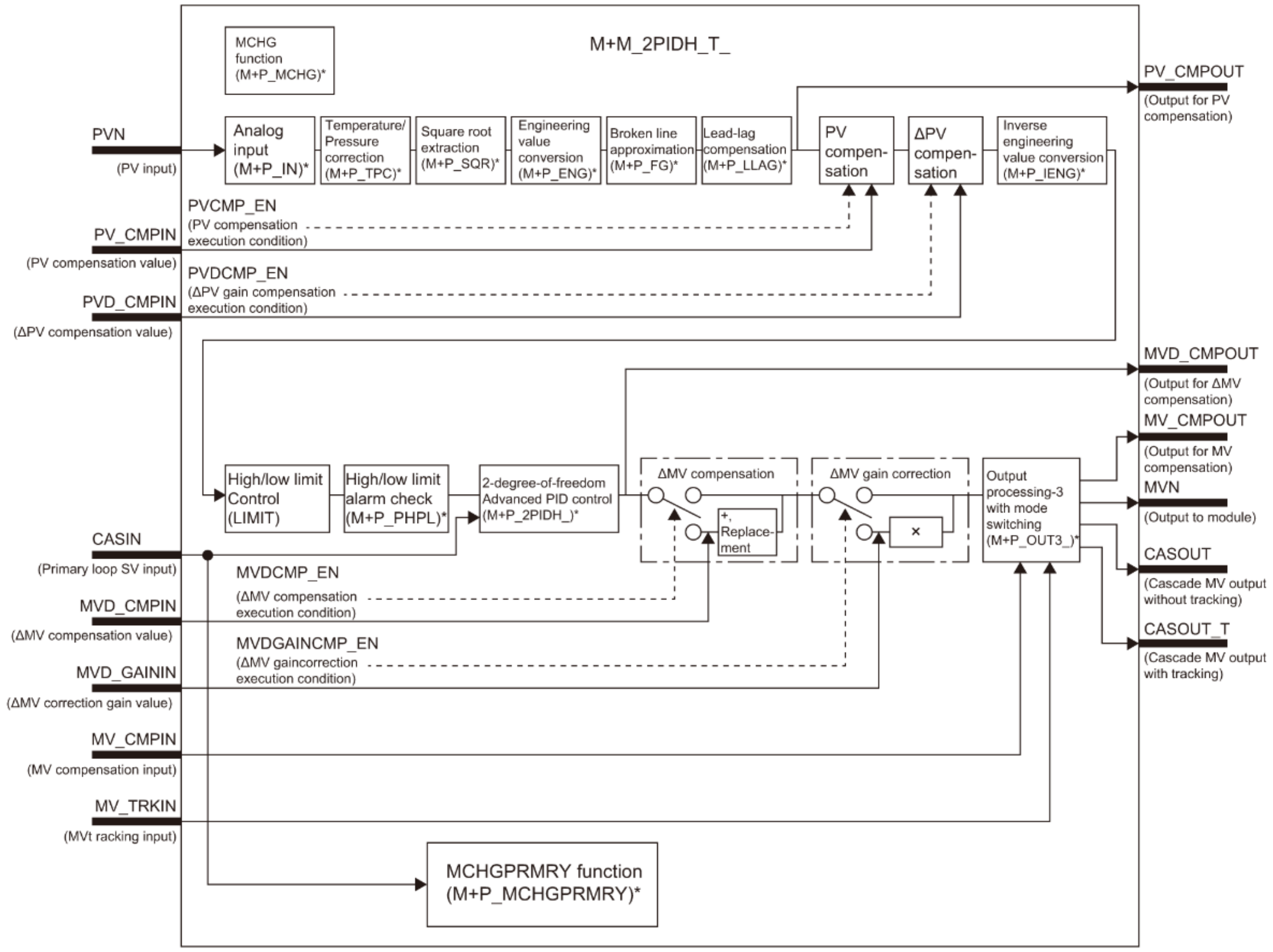
2 FUNCTION DETAILS OF 2-DEGREE-OF-FREEDOM ADVANCED PID CONTROL TAG FB

2.1 Overview

The 2-degree-of-freedom advanced PID control tag FB is an advanced tag FB made by adding functions, such as the MV compensation, PV compensation, temperature/pressure correction, tag stop, PV tracking, preset MV, MV rate-of-change limiter, and cascade direct, to the 2-degree-of-freedom PID control tag FB. From simple controls to advanced controls such as the variable gain PID control, compensation operation, correction operation, and feedforward control, this tag FB can be used in a wide range of controls.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_)

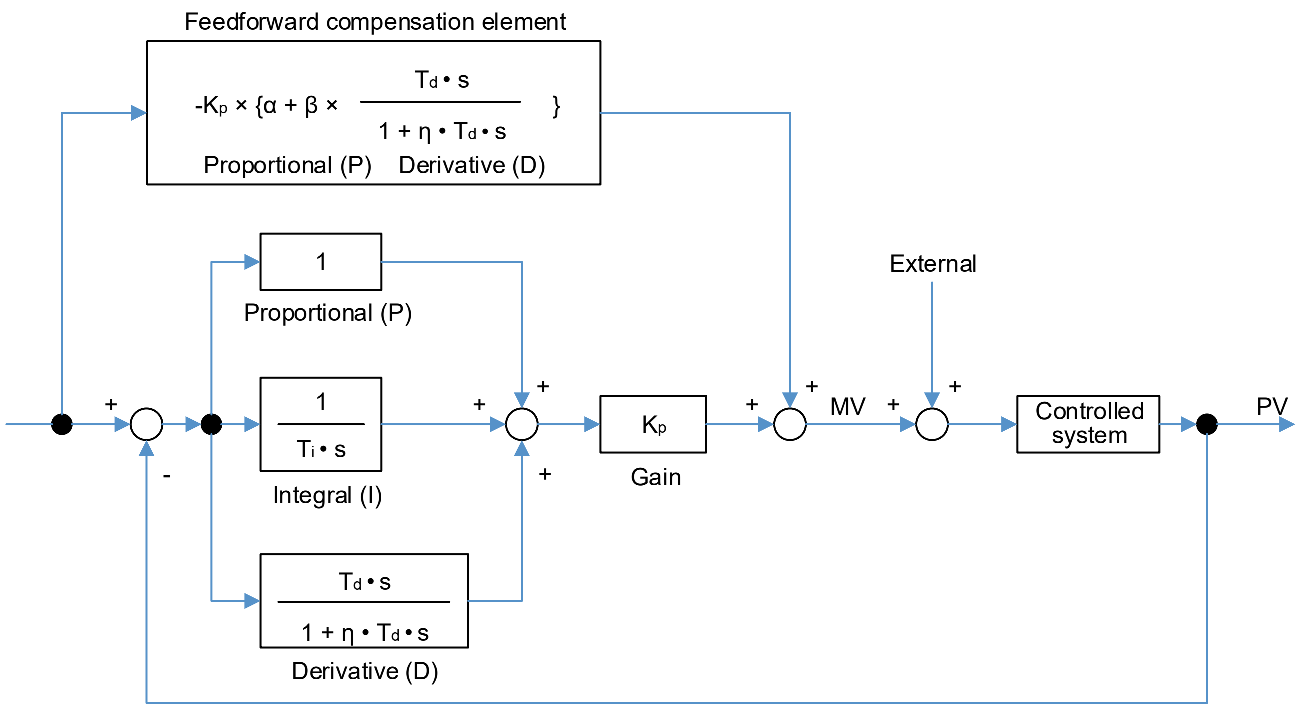
Block diagram



*(M+P_□) indicates the main structure member tag access FB which is the main component of each function.

2.2 2-degree-of-freedom PID Control

A control system basically requires two functions. One is the disturbance response function. This function minimizes the impact of external disturbances whenever they occur. The other is the target tracking function. Controlled amount tracks changes in setting values. With the conventional PID control, parameters optimized for the disturbance response are not optimum for the target tracking. Similarly, parameters optimized for the target tracking are not optimal for the disturbance response. With the 2-degree-of-freedom PID control, parameters are adjusted independently for the disturbance response and target tracking to implement both the functions. The 2-degree-of-freedom parameters α and β are used in this control.



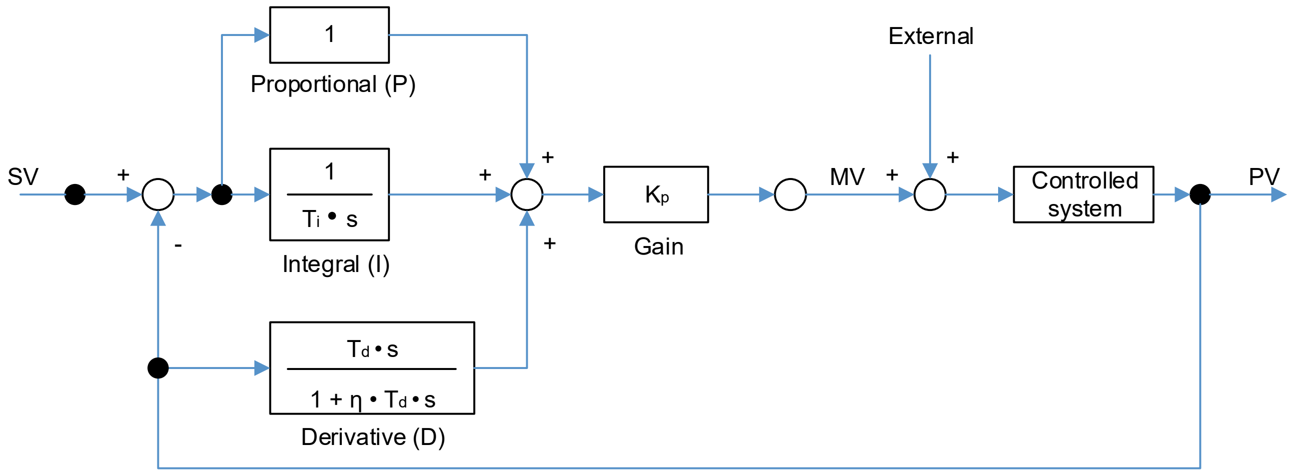
When α is 0 and β is 0

This is the same as the normal PID control as the feedforward compensation element will be 0.

When α is 0 and β is 1

The feedforward compensation element will be $SV \times -Kp \times \frac{Td \cdot s}{1 + \eta \cdot Td \cdot s}$.

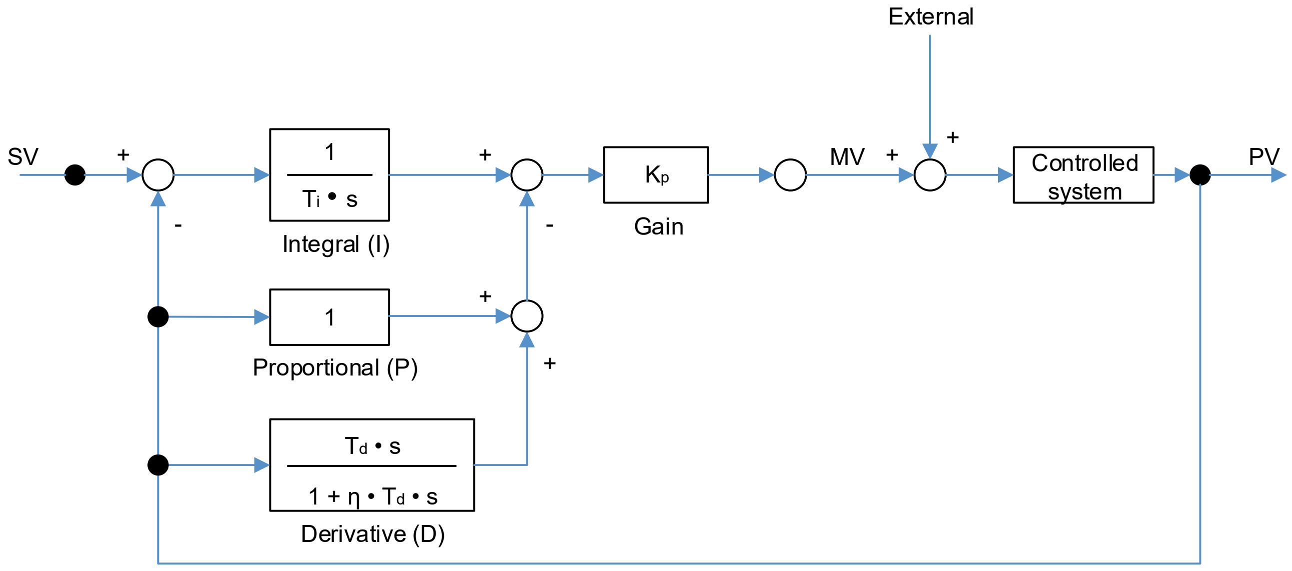
As the derivative term of the feedforward compensation element is $(SV - PV) \times Kp \times \frac{Td \cdot s}{1 + \eta \cdot Td \cdot s}$, the derivative term is $-PV \times Kp \times \frac{Td \cdot s}{1 + \eta \cdot Td \cdot s}$, and the control will be the PV-derivative type PID control (PI-D control).



When the SV is changed in a step shape with the normal PID control, the derivative operation causes drastic changes (kicks) to the MV. With the PI-D control, the normal PID operation is performed on changes to the PV, but the PI operation is performed on changes to the SV, which reduces the impact of step-shaped changes to the SV.

When α is 1 and β is 1

The derivative term is the same as that for when α is 0 and β is 1.
The proportional term of the feedforward compensation element is SV × -Kp.
As the proportional term of the feedforward compensation element is (SV - PV) × -Kp, the proportional term is -PV × Kp.
As a result, the control will be the PV-proportional and -derivative type PID control (I-PD control).



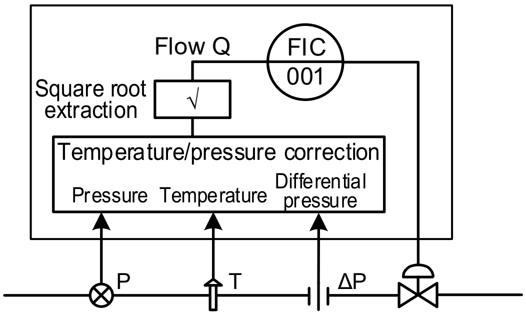
Changes to the MV following the stepped changes of the SV from proportional operations are not as significant as those from derivative operations, but still occur. With the I-PD control, the I operation is performed on changes to the SV, and this further reduces the impact of step-shaped changes to the SV. However, this means that the operation to quickly follow the target value has been removed, resulting in a slower response.

2.3 Square Root Extraction Function and Temperature/Pressure Correction Function

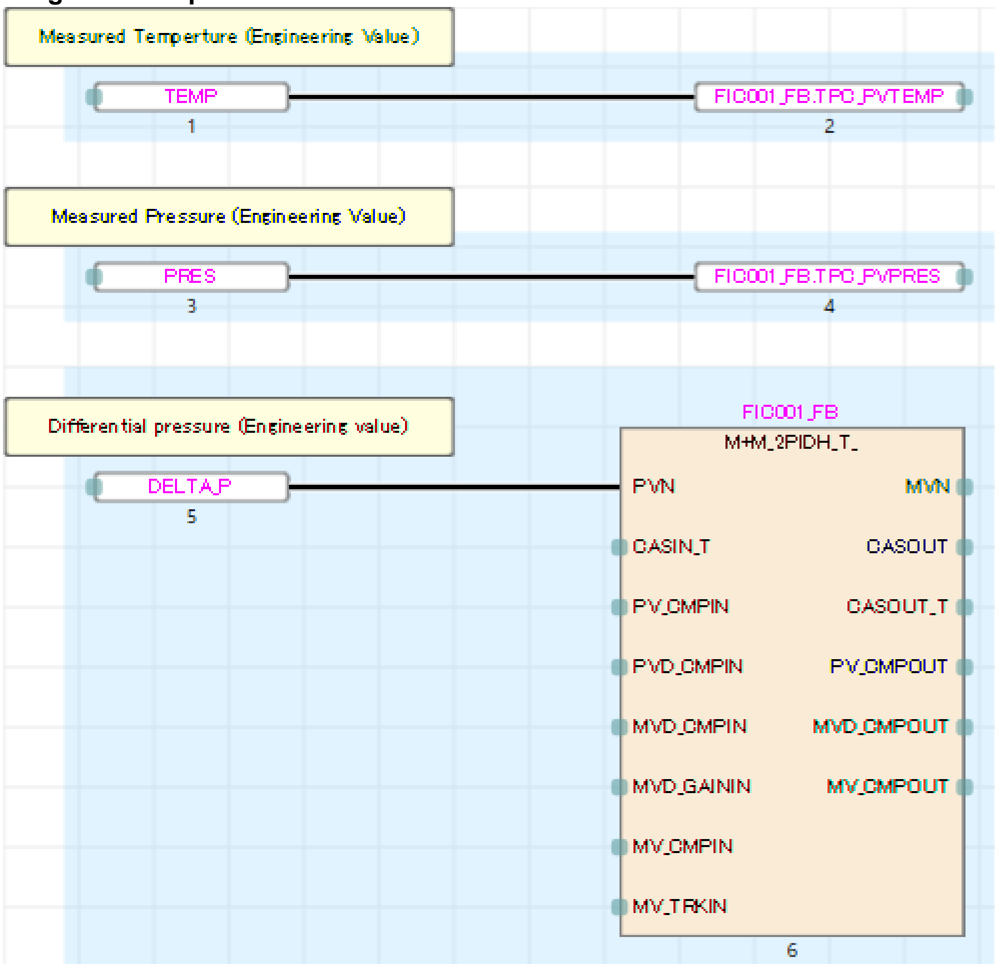
Execute the square root extraction to convert signals of square characteristics from the sensor into proportional characteristic when measuring flow through differential pressure of an orifice or venturi tube. Add the temperature/pressure correction if conditions of the measured fluid (temperature and pressure) are different from design specifications. The 2-degree-of-freedom advanced PID control enables those functions with setting parameters.

→ 1.4 Input Programs and Sensors Temperature/pressure correction (with square root)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.6 Temperature/Pressure Correction (M+P_TPC)



Program example



Parameter (default of FB property) settings

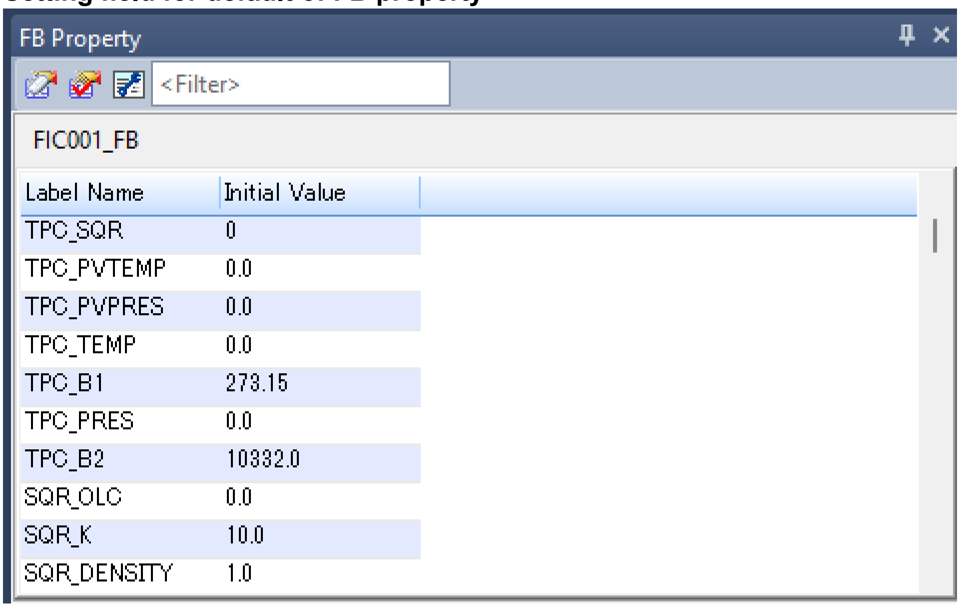
Square root extraction

Variable name	Item	Initial value	Description
SQR_OLC	Output low cut-off value	0.0	Output is cut off when the value becomes unstable due to small input value. Set it to 10.0 when the input value is 1% (coefficient 10.0).
SQR_K	Coefficient	10.0	The process FB performs the internal operations in percentages. Set it to 10.0.
SQR_DENSITY	Density correction value	1.0	To perform density correction, the density correction value must be substituted with the program. Set it to 1.0 when not performing density correction.

Temperature/pressure correction

Variable name	Item	Initial value	Description
TPC_SQR	Temperature/pressure correction pattern	0	Set the correction pattern when performing correction. 0: No correction 1: Square root extraction 2: Temperature correction + Square root extraction 3: Pressure correction + Square root extraction 4: Temperature/pressure correction + Square root extraction
TPC_TEMP	Design temperature	0.0	Set the temperature in the design specifications. Set the same unit as that for the measured temperature.
TPC_B1	Bias temperature	273.15	Set the bias temperature to perform the correction calculation with absolute temperature. Set it to 273.15 when Celsius (°C) is set as the unit.
TPC_PRES	Design pressure	0.0	Set the pressure in the design specifications. Set the same unit as that for the measured pressure.
TPC_B2	Bias pressure	10332.0	Set the bias pressure to perform the correction calculation with absolute pressure. Set it to 10332.0 when mmH2O is set as the unit. Set it to 101.3 when kPa is set as the unit.

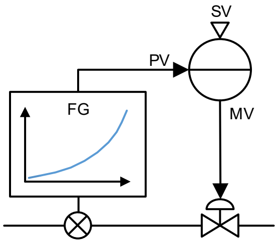
Setting field for default of FB property



2.4 Broken Line

Broken line is used when the value from the measurement target is not in proportion to the measurement input value from the sensor, and the curve of relationship between them is approximated by a broken line.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.1 Function Generator (M+P_FG)



Variable name	Item	Initial value	Description
FG_SN	Number of points	0.0	Set the number of points used for approximation through the broken line correction processing. No correction is performed when it is set to 0.
FG_X1 to FG_X48	Input coordinate (X-coordinate)	0.0	Set the input coordinates of points used for the broken line correction processing. Set them using engineering variables.
FG_Y1 to FG_Y48	Output coordinate (Y-coordinate)	0.0	Set the output coordinates of points used for the broken line correction processing. Set them using engineering variables.

2.5 Filter

(1) First order lag filter

The noise of input value is eliminated with a first order lag low-pass filter represented as $\frac{1}{1 + sT}$. Refer to the following discrete system expression.

$$PVf = \frac{T \times PVf_{n-1}T +}{\Delta T} + \frac{\Delta T \times PV}{T + \Delta T}$$

T: Time constant, ΔT: Execution cycle, PV: Present input value, PVf_{n-1}: Previous filter value, PVf: Present filter value

Variable name	Item	Initial value	Description
LLAG_EN	First order lag execution condition	FALSE	Set it to TRUE to use the first order lag filter.
LLAG_T1	Lag time	1.0	Set the lag time (second) of the first order lag filter.

Performing the inverse Fourier transform on the first order lag of $Y(s) = \frac{1}{1 + sT} \times X(s)$ results in

$$y(t) + T \times \frac{dy(t)}{dx} = x(t) \ .$$

This becomes $y(t) \rightarrow y(n), \frac{dy(t)}{dx} \rightarrow \frac{y(n) - y(n-1)}{\Delta T}, x(t) \rightarrow x(n)$ in the discrete system of the sampling period ΔT, which is substituted into the continuous system expression as

$$y(n) + T \times \frac{y(n) - y(n-1)}{\Delta T} = x(n) \ .$$

y(n) is factored as $y(n) = \frac{T \times y(n-1)}{T + \Delta T} + \frac{\Delta T \times x(n)}{T + \Delta T}$.

(2) Digital filter

The digital filter processing is performed for the input value.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.1 Analog Input Processing (M+P_IN)

Digital filter processing value = T2 + α (Previous digital filter processing value - T2)

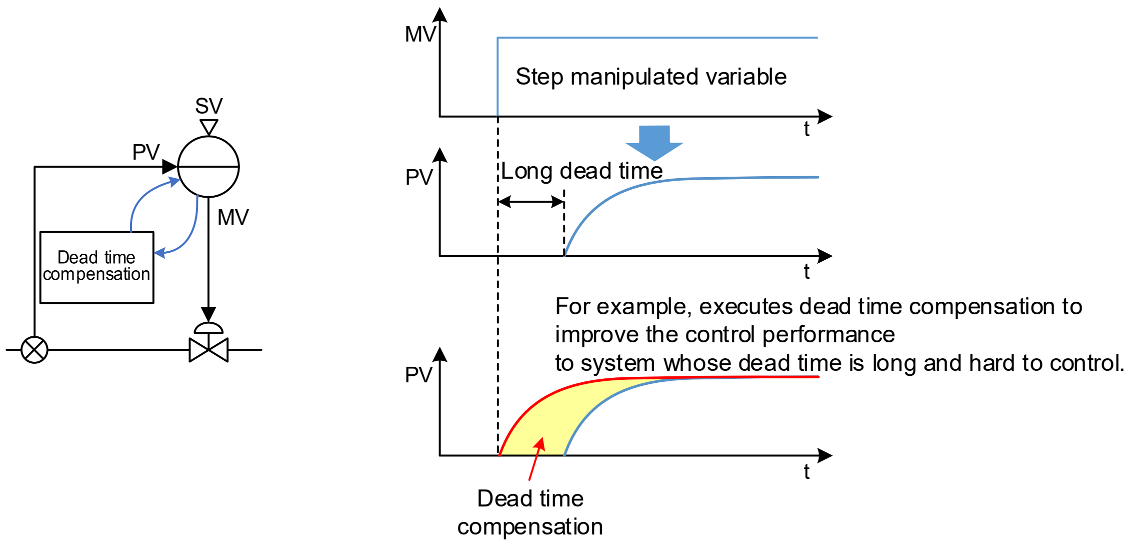
α: Filter coefficient, T2: Inverse engineering value conversion processing value

Variable name	Item	Initial value	Description
ALPHA	PV filter coefficient	0.2	Set the filter coefficient of the digital filter processing performed for input values. The digital filter processing is simpler processing than the first order lag processing.

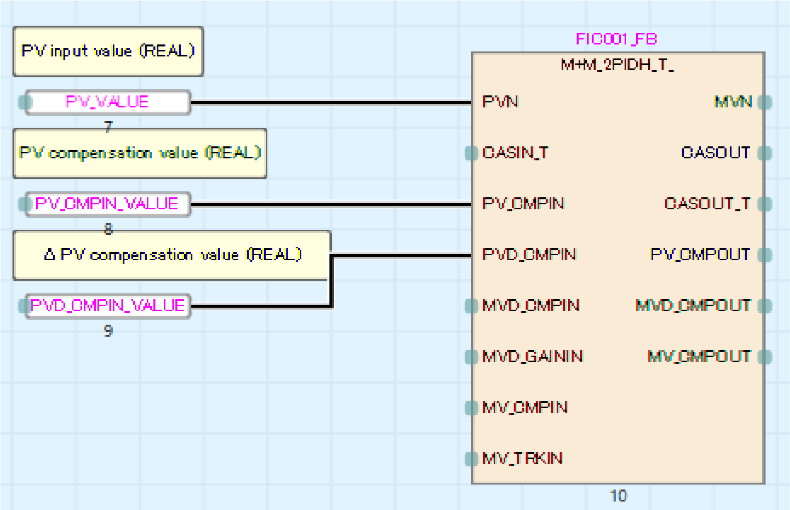
2.6 PV Compensation and ΔPV Compensation

To control processes with a long dead time, execute addition or replacement of the compensation value from the external to PV input.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T_) PV compensation



Program example



Set the following public variables to enable the PV compensation or ΔPV compensation.

Variable name	Item	Initial value	Description
PVCMP_EN	PV compensation execution condition	FALSE	Set it to TRUE (execute) to add or replace the compensation value from the external and apply it to the PV value.
PVCMP_MODE	PV compensation mode	0	Select whether to add or replace the compensation value. • 0: Add • 1: Replace
PVDCMP_EN	ΔPV compensation execution condition	FALSE	Set it to TRUE (execute) to add the ΔPV compensation value (PVD_CMPIN) to the internal additive value ΣPVD_CMPIN.

The following table describes processing results in accordance with the configured settings.

Condition		Processing result
PVCMP_EN = TRUE	PVCMP_MODE = 0 (Add)	IN + PV_CMPIN
	PVCMP_MODE = 1 (Replace)	PV_CMPIN
PVCMP_EN = FALSE	-	IN

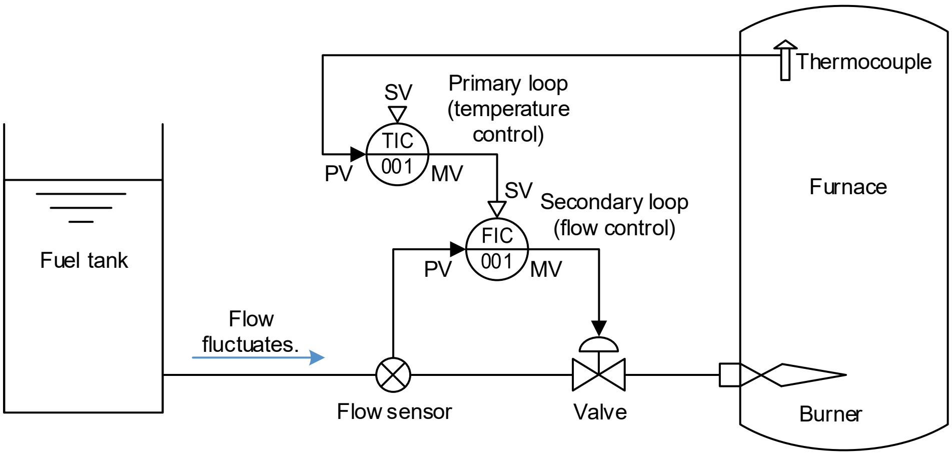
IN: Input value (PV value), PV_CMPIN: Compensation value

2.7 Cascade Control

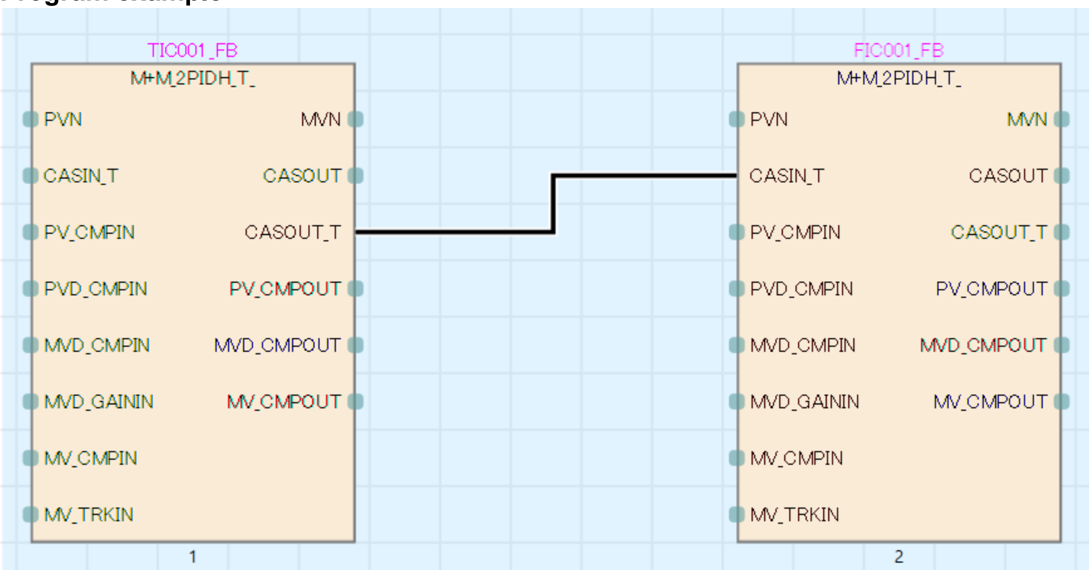
The cascade control combines two controls to function as one. It consists of a primary loop and a secondary loop. As shown in the example in the following figure, the overall response of the furnace temperature control is improved by using the secondary loop to absorb the effect of fluctuations in fuel supply.

→ 1.1 Control Programs and Loop Tags   Cascade control

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction)   APPENDICES 3 Related Functions of Process   Cascade control



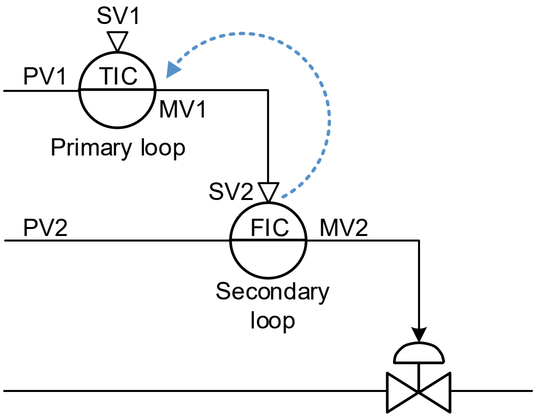
Program example



To track the primary loop, set the following operation constants for the secondary loop in addition to connecting the CASOUT_T pin of the primary loop to the CASIN_T pin of the secondary loop.

Variable name	Item	Initial value	Description
PID2H_TRK	Tracking flag	0	Set it to 1 to enable tracking. • 0: Disable tracking • 1: Enable tracking
PID2H_SVPIN_B0	Setting value (SV) used	TRUE	Set it to FALSE (use) when tracking is enabled. TRUE: Not used FALSE: Used
PID2H_SVPIN_B1	Setting value (SV) pattern	TRUE	Set it to FALSE when tracking is enabled and the primary loop is a tag FB. (Set to FALSE normally.) TRUE: Not primary MV, FALSE: Primary MV

During cascade control, the SV of the secondary loop is transferred to the MV of the primary loop to prevent sudden changes of the SV when the control mode of the secondary loop is changed (SV2 is transferred to MV1 in the following example).

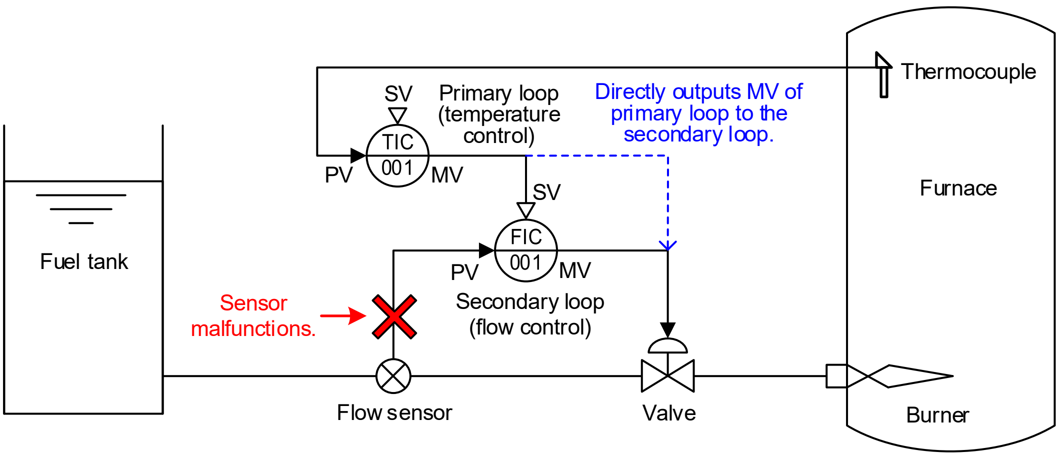


2.8 Cascade Direct

The CASCADE DIRECT mode can be selected as the control mode for the 2PIDH tag. The cascade direct control can respond to failures of the secondary loop sensor by directly outputting the primary loop output as the secondary loop output during cascade connection.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.4 Output Proccessing-3 with Mode Switching (With Input Addition and Compensation) Cascade direct

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Related Functions of Process Cascade direct (M+M_2PIDH_T_)

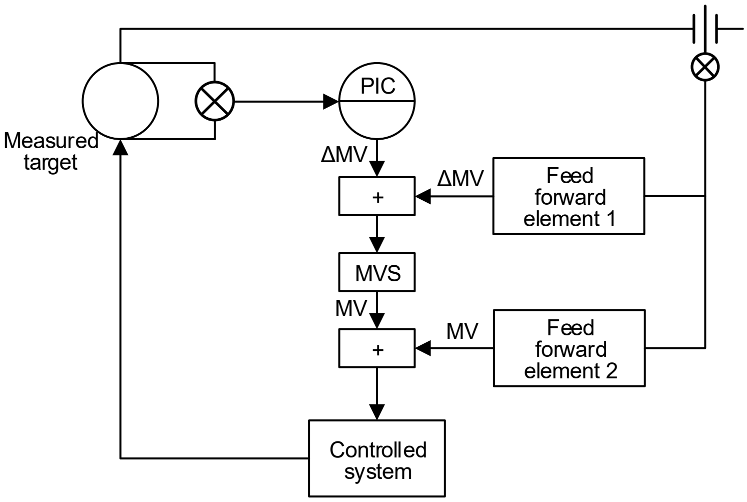


2.9 MV Compensation and ΔMV Compensation

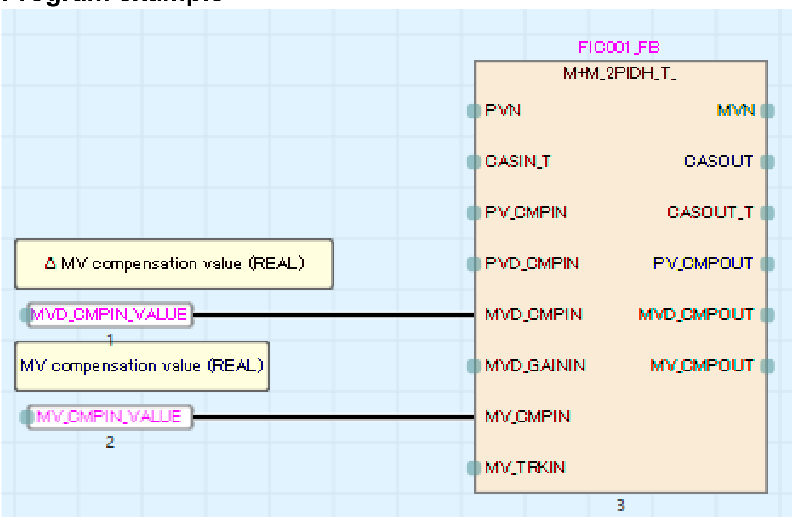
Because the feedback control generally causes a lag in response, use the feedforward control together if the amount of change in the operation is known in advance. The output amount of the feedforward control is added as the ΔMV compensation or MV compensation value.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.4 Output Processing-3 with Mode Switching MV compensation

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) ΔMV compensation



Program example



Set the following public variables to enable the MV compensation or ΔMV compensation.

Variable name	Item	Initial value	Description
MVDCMP_EN	ΔMV compensation execution condition	FALSE	Set it to TRUE (execute) to add or replace the compensation value from the external and apply it to the ΔMV value.
MVDCMP_MODE	ΔMV compensation mode	0	Select whether to add or replace the compensation value. 0: Add 1: Replace
OUT3_MVCMP_EN	MV compensation execution condition	FALSE	Set it to TRUE (execute) to add or replace the compensation value from the external and apply it to the provisional MV value.
OUT3_MVCMP_MODE	MV compensation mode	0	Select whether to add or replace the compensation value. 0: Add 1: Replace

The following table describes processing results in accordance with the configured settings.

Condition		Processing result
OUT3_MVCMP_EN = TRUE	OUT3_MVCMP_MODE = 0 (Add)	T + MV_CMPIN
	OUT3_MVCMP_MODE = 1 (Replace)	MV_CMPIN
OUT3_MVCMP_EN = FALSE	-	T

T: Provisional MV value, MV_CMPIN: MV compensation value

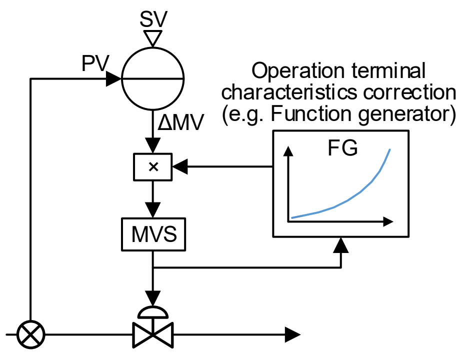
Condition		Processing result
MVDCMP_EN = TRUE	MVDCMP_MODE = 0 (Add)	IN + MVD_CMPIN
	MVDCMP_MODE = 1 (Replace)	MVD_CMPIN
MVDCMP_EN = FALSE	-	IN

IN: Input value (ΔMV value), MVD_CMPIN: MV compensation value

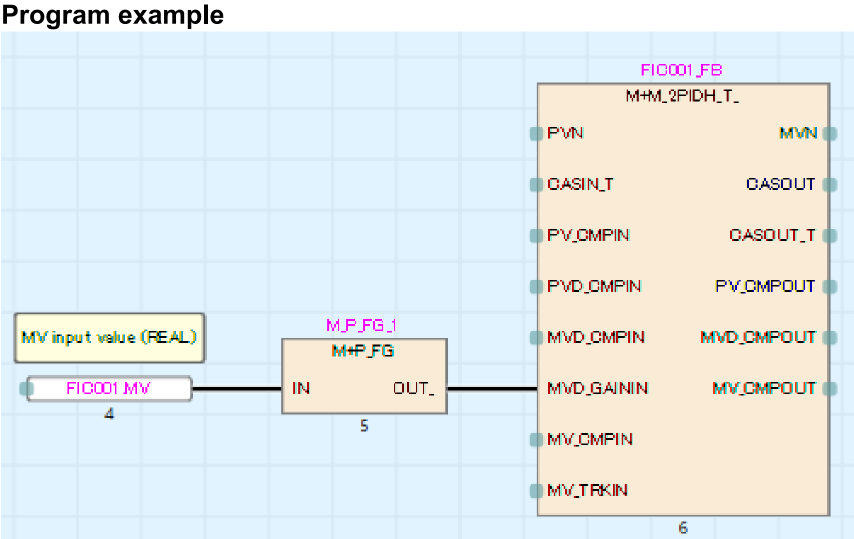
2.10 ΔMV Gain Correction Function

Gain correction using the broken line correction or other means is performed on the ΔMV to stabilize control in response to changes in the load or target value. The correction is made in accordance with the operation terminal characteristics.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control ΔMV gain correction



Program example



Set the following public variables to enable the ΔMV gain correction.

Variable name	Item	Initial value	Description
MVDGAINCMP_EN	ΔMV gain correction execution condition	FALSE	Set it to TRUE (execute) to multiply the ΔMV by the gain correction value.

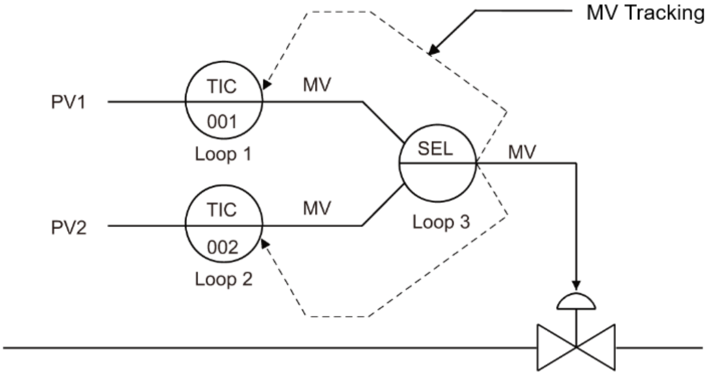
The following table describes processing results in accordance with the configured settings.

Condition	Processing result
MVDGAINCMP_EN = TRUE	IN × MVD_GAININ
MVDGAINCMP_EN = FALSE	IN

IN: Input value (ΔMV value), MVD_GAININ: Gain correction value

2.11 MV Tracking

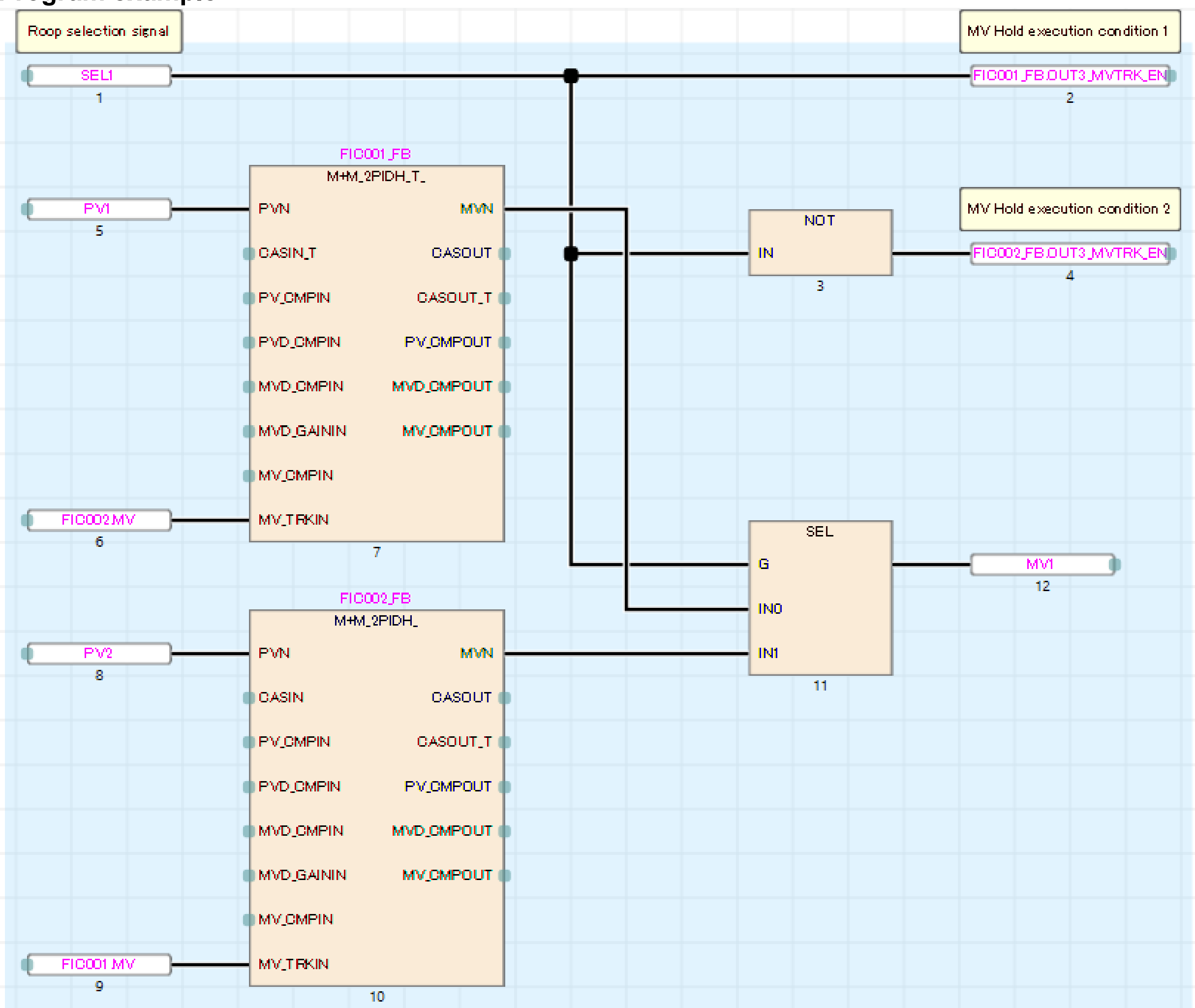
The MV value is switched to the tracking input so that the loop is switched bumplessly.



If the MV output from two loops is selected by a selector, the MV of the selected loop is tracked the MV of the unselected loop so that the loop is switched bumplessly.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.4 Output Processing-3 with Mode Switching MV tracking

Program example



Set the following public variables to switch the MV value to the tracking input.

Variable name	Item	Initial value	Description
OUT3_MVTRK_EN	MV tracking execution condition	FALSE	Set it to TRUE (execute) to switch the MV value to the tracking input.

The following table describes processing results in accordance with the configured settings.

Condition	Processing result
OUT3_MVTRK_EN = TRUE	MV_TRKIN
OUT3_MVTRK_EN = FALSE	T

T: Provisional MV value, MV_TRKIN: Tracking input value

2.12 MV Output Selection

Output can be selected (MV value hold, preset MV output) for the event of an error or tag stop. Set the following public variables to use this function.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.4 Output Processing-3 with Mode Switching (With Input Addition and Compensation) (M+P_OUT3_)

Variable name	Item	Initial value	Description
OUT3_PREMV_EN	Preset MV execution condition	FALSE	Set it to TRUE (execute) to output a preset MV.
OUT3_PREMV_V	Preset MV value	0.0	When preset MV is selected, set an MV value to be output as the preset MV value when an error occurs.
OUT3_STP_OTYPE	Output selection in loop stop or tag stop	0	Set the method for MV output in loop stop ([1]) or tag stop ([2]). Select the hold or preset value. 0: Hold 1: Preset value
OUT3_SEA_OTYPE	MV output selection when a sensor alarm occurs	0	Set the method for MV output in the occurrence of sensor alarm ([3]). 0: Hold 1: Preset MV output 2: Do not perform hold or preset MV output
OUT3_MVREV_EN	MV reverse execution condition	FALSE	Enable/disable the MV reverse output. When the MV reverse output is enabled, output is converted by the MV inverse processing (100-MV).

The following table describes processing results in accordance with the configured settings.

Preset MV

Condition	Processing result
PREMV_EN = TRUE	PREMV_V
PREMV_EN = FALSE	T

T: Provisional MV value, PREMV_V: Preset MV value

Loop stop processing

Condition	Processing result
OUT3_STP_OTYPE = 0	MV value hold
OUT3_STP_OTYPE = 1	Preset MV output

Output processing when a sensor alarm occurs

Condition	Processing result
OUT3_SEA_OTYPE = 0	MV value hold
OUT3_SEA_OTYPE = 1	Preset MV output
OUT3_SEA_OTYPE = 2	The result of PID operation + Output addition processing is output.

[1] When a loop tag data alarm is triggered (such as sensor error (SEA)), the control mode can be forced to the MANUAL mode by changing the stop alarm (SPA) from FALSE to TRUE. Create a user program to implement the operation to change the stop alarm (SPA) from FALSE to TRUE.

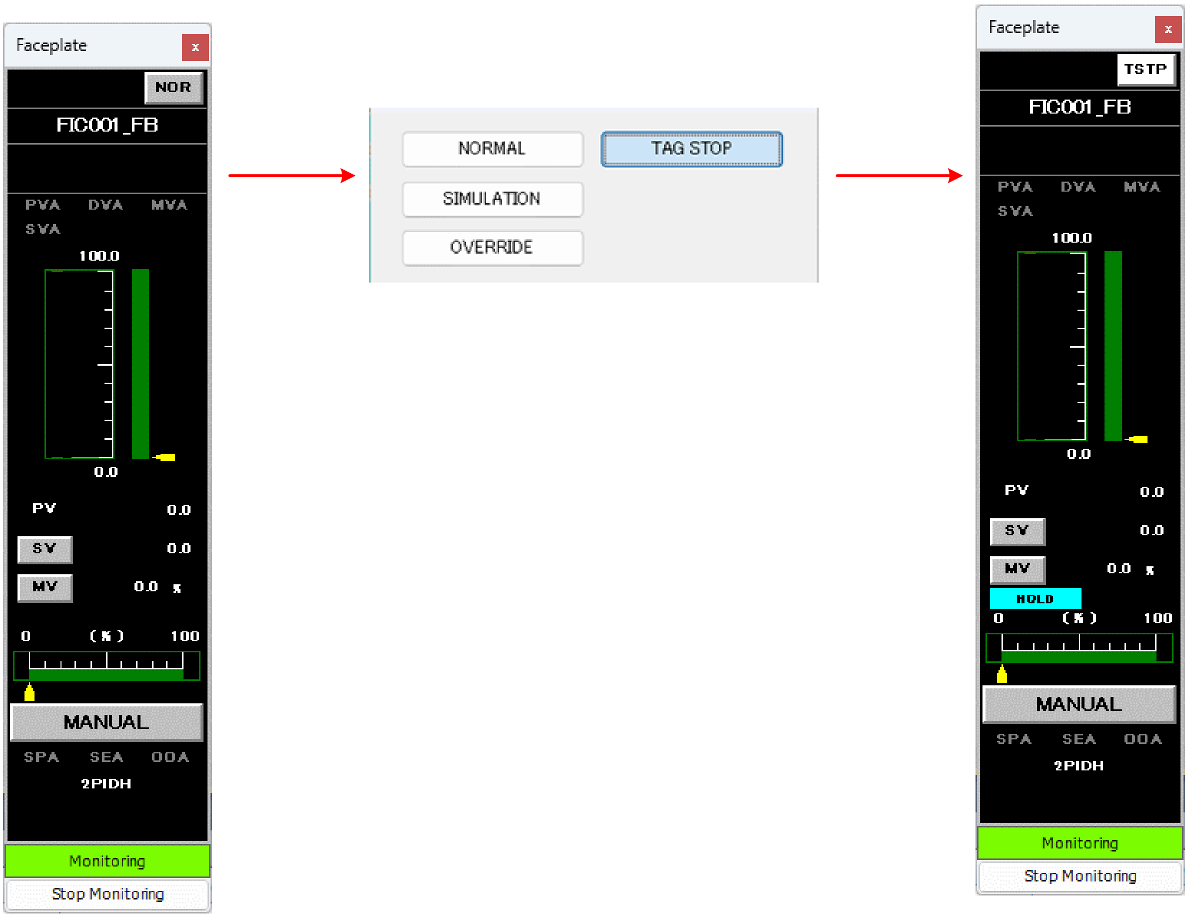
[2] The tag stop function stops the input processing and loop control operation. This will be used with tags reserved for future use. This is set by changing the I/O mode of the faceplate.

[3] A sensor alarm (SEA) is triggered when an upper limit range error or lower limit range error occurs.

2.13 Tag Stop Function

The tag stop function stops the input processing and loop control operation. Setting the tag stop (TAG STOP) automatically changes the control mode to MANUAL. "MV value hold" or "Preset MV output" can be selected for MV in changing to MANUAL mode. The tag stop function can be set with the Change I/O mode dialog box of faceplate.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Tag stop function (TAG STOP mode)



3 GLOSSARY

This glossary mainly lists process control related terms which are required for process control engineering.
Terms are listed in order of alphabetical order and numerical order. Related terms are indicated with "→", and antonyms are indicated with "↔".

<A>

Absolute pressure

The amount of pressure measured based on the full (absolute) vacuum state. To indicate that the pressure is absolute pressure, add abs after the engineering unit. (Example: 5 kg/cm^2abs)

↔ Gauge pressure

Alarm status

Alarm status indicates the alarm occurrence status of tag alarm such as upper upper limit alarm (HH), upper limit alarm (H), lower limit alarm (L), lower lower limit alarm (LL).

Alarm level

Alarm level is the level of importance for alarm item of tag alarm. The levels are major alarm and minor alarm.

Analog input module

An analog input module imports analog standardized signal of 4 to 20 mA, 0 to 5 V DC from a sensor to PLC CPU. Types of analog input module channels include channel non-isolated type which shares a common line, channel isolated type which has different common lines, distributor with 2-wire transmitter type, and direct connectable type with thermocouple and temperature-measuring resistor.

Analog output module

An analog output module outputs analog standardized signal of 4 to 20 mA, 0 to 5 V DC from PLC CPU to the operation terminal. Types of analog output module channels include channel non-isolated type which shares a common line and channel isolated type which has different common lines.

AUT/AUTO

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

→ AUTO mode

Auto tuning

Method that detects dynamic characteristics of control targets and automatically obtains proportional gain (Kp), integral time (Ti), and derivative time (Td) of PID.
Auto tuning can be performed with step response method and limit cycle method in the 2-degree-of-freedom advanced PID tag FB.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Related Functions of Process Auto tuning

→ Optimum value adjustment method

AUTO mode

The mode performs control using setting value (SV) set on the HMI screen.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

<B>

Batch process control

A type of control which produces various products with the same equipment or devices. It has processes such as polymerization and mixture. Complex control such as switching recipes for each kind of products, selecting processes, and CIP is required. Recently, types of batch process control have been increasing. In batch production processes, the production operations (batch recipe registration, batch reservation, execution recipe expansion, batch progress management, batch sequence execution management, device monitoring, and performance collection) are called batch management. One of the standards for batch management is the ISA SP88 model. A type of control which produces the same type of products with the same equipment or devices is called continuous process control.

Blend PI control

The blend PI control reduces the sum of deviations over a certain period of time to zero, focusing on maintaining a constant control amount over a long period of time without being concerned about fluctuations in the control amount over short period of times.

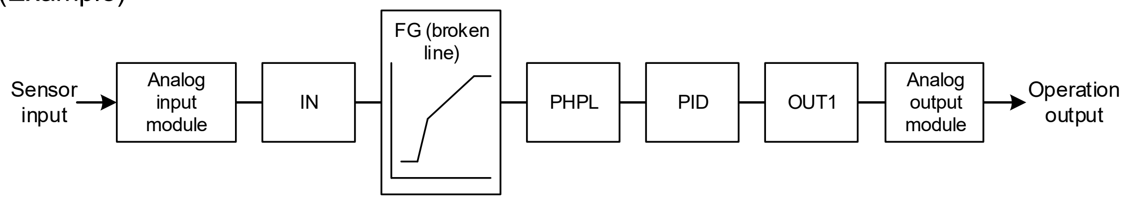
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.17 I-PD Control (Enable Tracking for primary loop) (M+M_IPD_T) **to** MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.20 Blend PI Control (Disable Tracking for primary loop) (M+M_BPI)

Broken line correction

It is used when the value from the measurement target is not in proportion to the process variable from the sensor. Input value is approximated and corrected by a broken line. The process FB P_FG is equivalent to the broken line correction.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.1 Function Generator (M+P_FG)

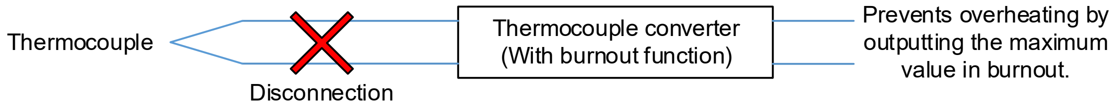
(Example)



Burnout

When the converter input is in the no-input state due to sensor disconnection or other causes, the converter output signal can be set to the upper limit or lower limit. This is called burnout.

Example: For a thermocouple, the thermocouple converter output is set to the maximum value during burnout to prevent overheating.



Bumpless

At the time of mode switching between AUTO and MANUAL, this function prevents step-shaped changes caused by a sudden change of the MV output, and ensures the MV to be converted smoothly without bump.

<C>

CAS/CASCADE

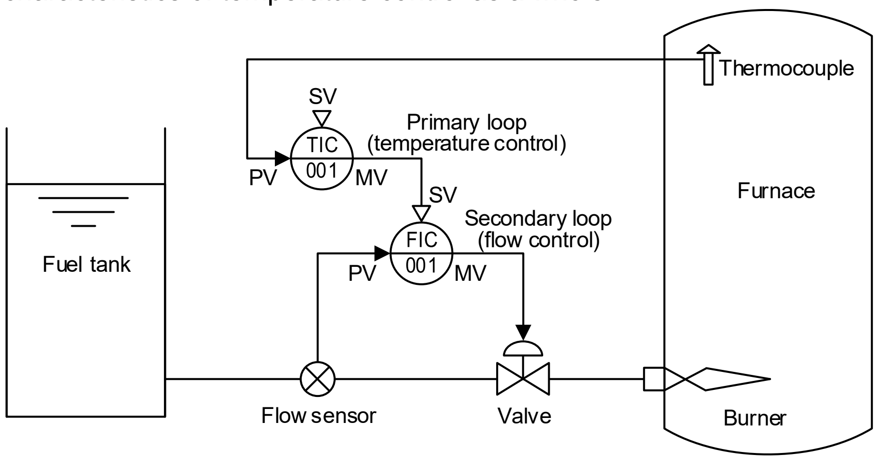
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

→ CASCADE mode

Cascade control

Cascade control consists of two loops: a primary loop and secondary loop. With this control method, early detection of disturbances entering the secondary loop and using the secondary loop to absorb these disturbances eliminates the impact of disturbances on the process, improving the overall control performance. Generally, it is preferable to set the response of the secondary loop to three times or more faster than that of the primary loop.

The following diagram is an example of controlling the furnace temperature in a certain value. It absorbs fluctuations in fuel supply by flow control of the secondary control loop and improves response characteristics of temperature control as a whole.



Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Cascade control

→ Tracking (Cascade with tracking)

CASCADE mode

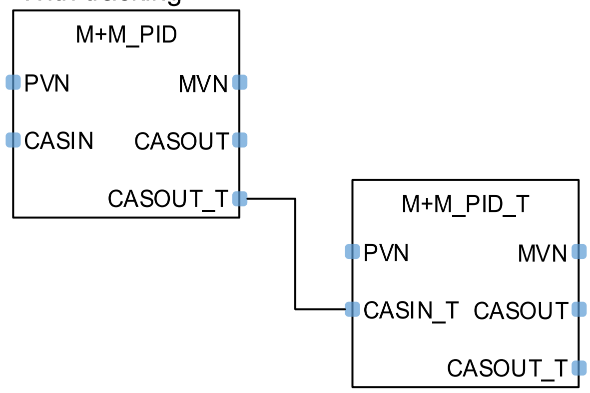
This is the mode for cascade control which controls the manipulated variable (MV) of the primary loop as the setting value (SV) of the secondary loop. This mode is also used when regarding setting value (SV) as the primary indicated value such as interlock operation with other loops and the case of combination with a program setter.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

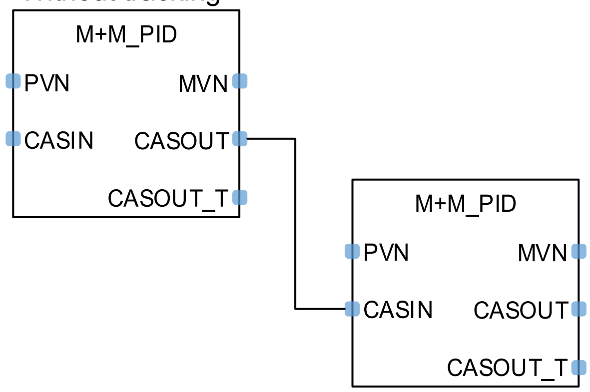
CASIN pin/CASOUT pin

CASIN pin: Input pins on the tag FB for SV value input of the cascade control secondary loop and setting value input from a PLC program. "_T" is added to the names of the pins which have the tracking function.
CASOUT pin: Output pins from the cascade control primary loop to the secondary loop. "_T" is added to the names of the pins which have the tracking function.

• With tracking



• Without tracking



CMV

Abbreviation for COMPUTER MV. It is a control mode in which the MV value can be changed from an upper layer computer.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

Cold junction compensation

A compensation function to reduce measurement errors caused by temperature changes around the reference side terminal in thermocouple inputs. For temperature measurement using a thermocouple module, it is necessary to maintain the reference side terminal at 0°C. However, in practice, it is difficult to keep the reference side terminal at 0°C. Therefore, this function minimizes the error by adding the thermal electromotive force corresponding to the ambient temperature to the internal amplifier for 0°C compensation.

Cold start

A system which outputs values from the reset value not the previous value at the time of a restart after a power failure of the control system. On the other hand, a system which outputs values from the previous value is called hot start.

↔ Hot start

Control cycle

A cycle of control operation implemented by the PID operation, etc. In a continuous control function block, operations such as input processing starts every execution cycle, however, the PID control operation starts every control cycle. (The control cycle should be set to an integral multiple of the execution cycle.) Instructions for which control cycles can be set are M+P_PID, M+P_BPI, M+P_IPD, M+P_ONF2, M+P_ONF3, M+P_R, M+P_2PID, etc.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.5 Program Execution Control Setting the control cycle (CT)

(Reference) Selection example of control cycle (CT)

In the PID control, when the integral time is long, lengthening the control cycle (CT) improves the control performance.

Selection example of control cycle

Integral time (Ti)	Control cycle (CT) (guideline)
1 to 40 seconds	1 second
1 to 80 seconds	2 seconds
81 to 160 seconds	4 seconds

→ Execution cycle

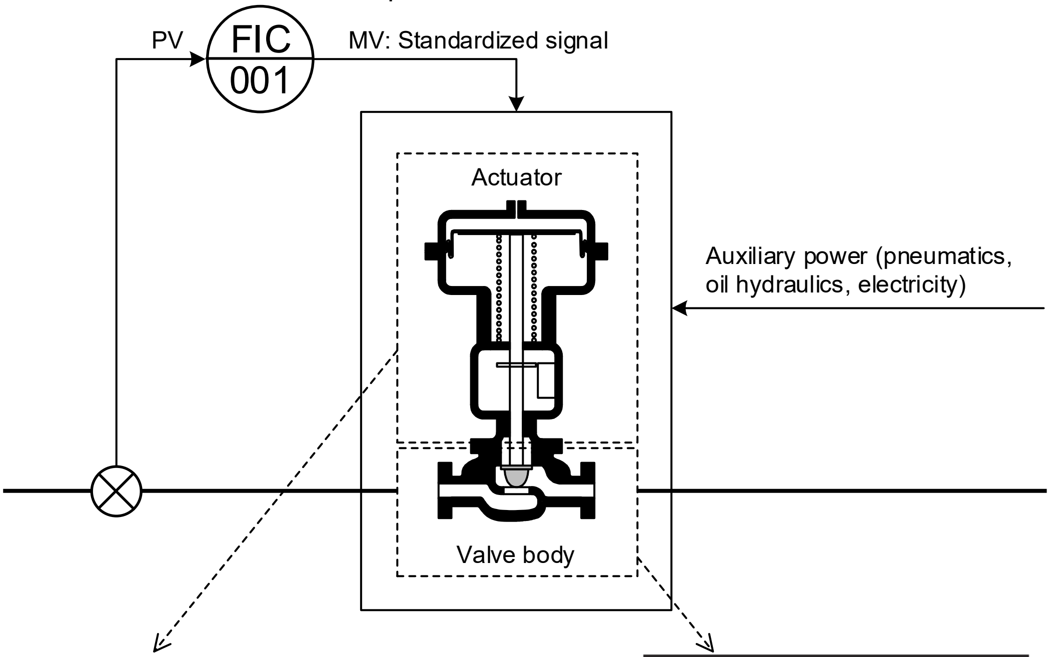
Control mode

The control mode is switched between MANUAL (MANUAL, MAN, M), AUTO (AUTO, AUT, A), CASCADE (CASCADE, CAS, C), etc. to switch the control operation status of the tag FB. There is called the operation mode as well.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

Control valve

When an operation signal is received from the controlling unit of the automatic control, a valve is operated with auxiliary power such as pneumatic pressure, hydraulic pressure, and electricity, and the variables are controlled to the specified ones. It consists of an actuator and valve.



Actuator	
	Diaphragm type
	Bellow type
	Electro-magnetic type
	Electrical type
	Reciprocating type
	Manual type

Valve body	
	General valve
	Angle valve
	Three way valve
	Butterfly valve
	Saunders valve
	Ball valve

CSV

Abbreviation for COMPUTER SV. It is a control mode in which the SV value can be changed from an upper layer computer.

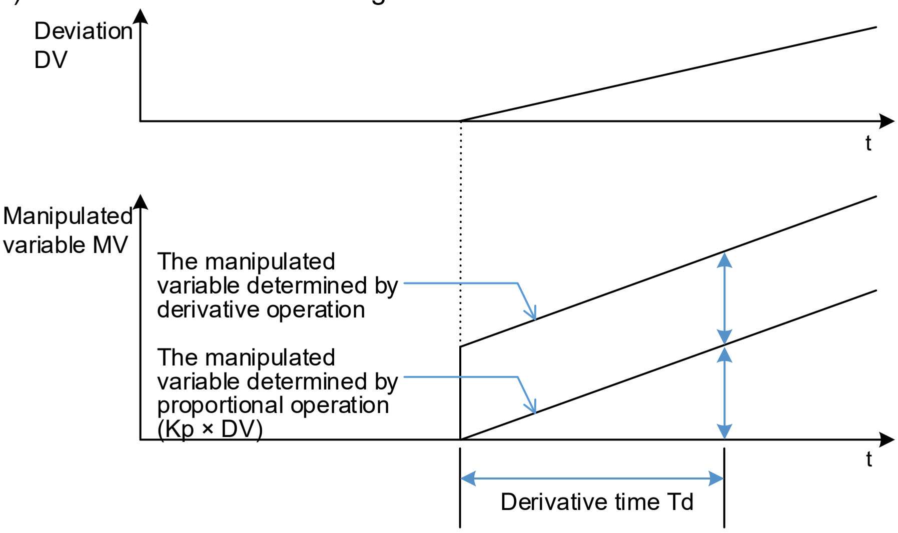
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

<D>

D operation

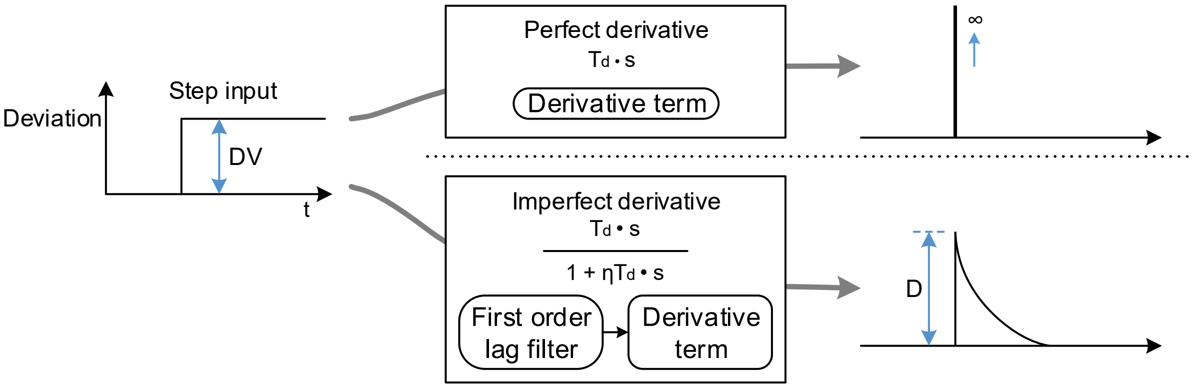
Derivative operation. This is an operation that adds the manipulated variable that is in proportion to the rate of change (difference between the current value and the last value) of deviation DV (difference between the process variable and setting value). The time interval from the moment when deviation occurs until the manipulated variable determined by the derivative operation becomes equal to the manipulated variable determined by the proportional operation is called derivative time "Td".

(1) When deviation is increasing at a constant rate



• Imperfect derivative

Performing derivative operations on the deviation as it can cause negative effects such as increasing high-frequency noise components, making the control system unstable. Another negative effect is not being able to provide enough effective energy to operate the operating terminal when the time range of the manipulated variable is narrow (deviation changes in steps results in momentary pulse waveform output). Therefore, imperfect derivatives using first order lag filters are used in the input of the derivative term of D operations. Derivative operations performed by the process CPU are imperfect derivatives.

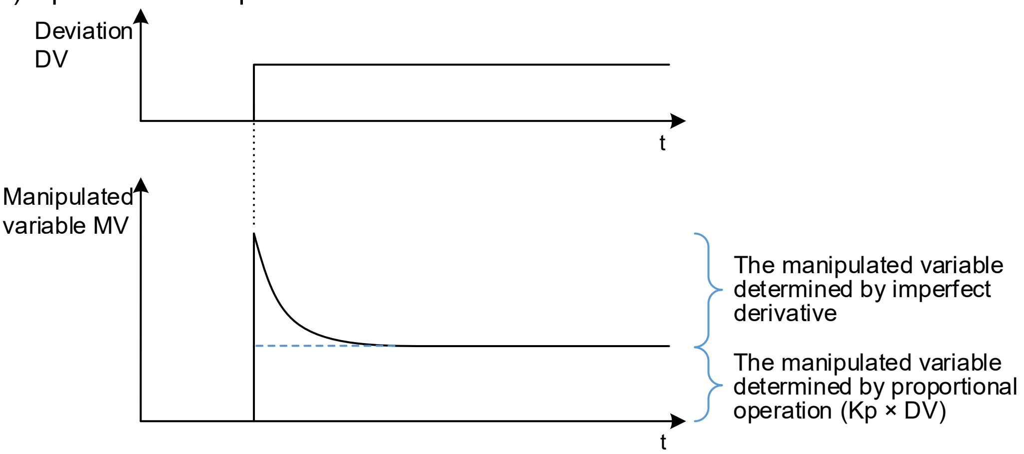


The output D of the derivative term when imperfect derivatives are used is shown below.

$$D = Kp \times DV \times \frac{MTD \times T_d}{MTD \times CT + T_d}$$

Kp: Proportional gain, DV: Deviation, MTD: Derivative gain (1/η), T_d: Derivative time, CT: Control cycle

(2) Operation for step deviation

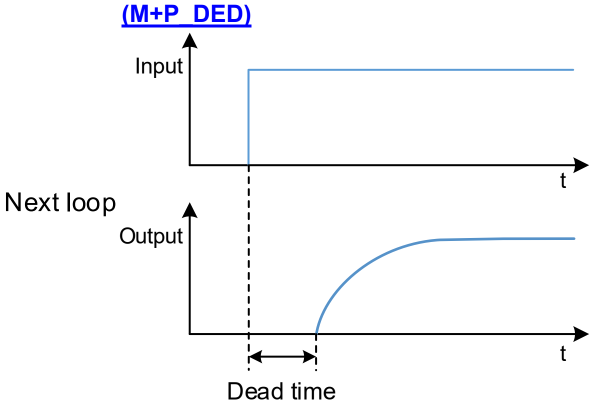


When derivative time is short	The derivation effect becomes smaller.
When derivative time is long	The derivation effect becomes larger, causing short-period hunting and the system may become unstable.

Dead time

Time interval between the output variable change and input variable change.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 9.4 Dead Time (M+P_DED)



DCS

A distributed digital control system with microcomputers.

DDC

A digital device with a regulator function.

Derivative operation/derivative time

→ D operation

Design temperature

When flow is measured by using different temperature from design specification temperature in the temperature/pressure correction of flow, the correction to convert the flow into the one in the design specification temperature is needed. Design temperature means the design specification temperature in such cases.

Design pressure

When flow is measured by using different pressure from design specification pressure in the temperature/pressure correction of flow, the correction to convert the flow into the one in the design specification pressure is needed. Design pressure means the design specification pressure in such cases.

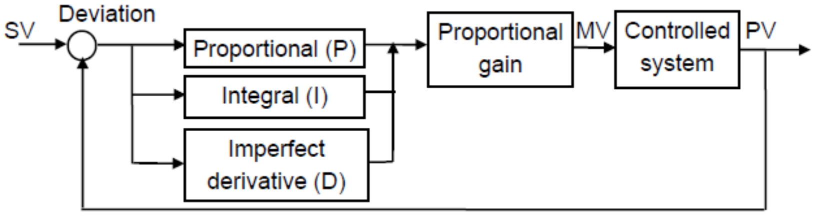
Deviation

The difference between the setting value SV and process variable PV

Deviation derivative type PID/PV-derivative type PID (PI-D control)/PV-proportional and -derivative type PID (I-PD control)

■ Deviation derivative type PID

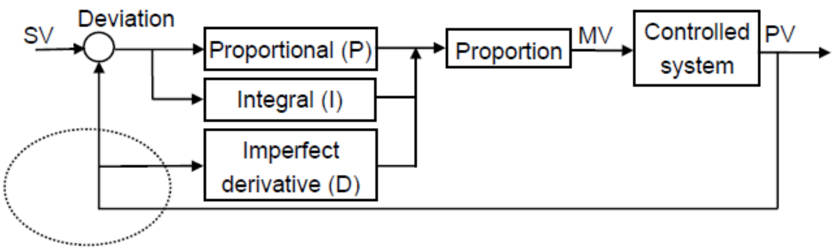
This control is suitable for applications such as program control and cascade control in the secondary loop because it has high performance on tracking of changes in the setting value (SV).



Tag FB	Parameter setting
M+M_2PID(_T), M+M_2PID_DUTY(_T), M+M_2PIDH_(T_)	α = 0, β = 0

■ PV-derivative type PID (PI-D control)

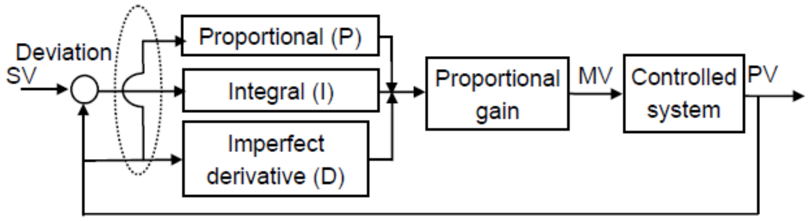
This control uses the process variable (PV) in the derivative term. In the deviation derivative type PID, there is a problem where the manipulated variable (MV) changes rapidly when the setting value (SV) changes rapidly because the influence of its derivative operation is too large. Therefore, using only the process variable (PV) in the derivative term avoids the influence of the sudden change of the setting value (SV). It is also called PV-derivative type PID or PI-D control.



Tag FB	Parameter setting
M+M_PID(_T), M+M_PID_DUTY(_T)	No setting
M+M_2PID(_T), M+M_2PID_DUTY(_T), M+M_2PIDH_(T_)	α = 0, β = 1

■ PV-proportional and -derivative type PID (I-PD control)

In comparison with the PV-derivative type PID, I-PD type uses the process variable (PV) in the proportional term in addition to the derivative term. This control is suitable for situations where response to changes in the setting value (SV) should be slow without shocking the operation terminal or process. However, the response to changes in the setting value (SV) becomes slow. It is also called I-PD control.

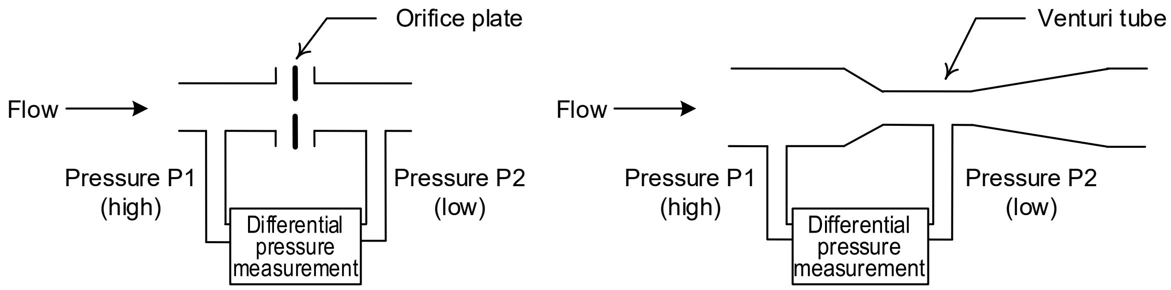


Tag FB	Parameter setting
M+M_IPD(_T)	No setting
M+M_2PID(_T), M+M_2PID_DUTY(_T), M+M_2PIDH_(T_)	α = 1, β = 1

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.1 Velocity Type PID Control (Enable Tracking for primary loop) (M+M_PID_T) to 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.17 I-PD Control (Enable Tracking for primary loop) (M+M_IPD_T)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.18 I-PD Control (Disable Tracking for primary loop) (M+M_IPD)

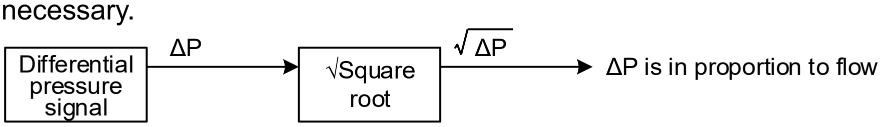
Differential pressure

Pressure measured based on pressure other than the atmosphere pressure or full vacuum. To differentiate it from other pressure, add diff. after the unit. (Example: 1 kg/cm^2 diff.)
It is applied to purposes such as flow measurement by using differential pressure.



Flow Q = $K \cdot \sqrt{\Delta P / \gamma}$
Differential pressure ΔP: (P1 - P2), K: Proportional constant, γ: Density

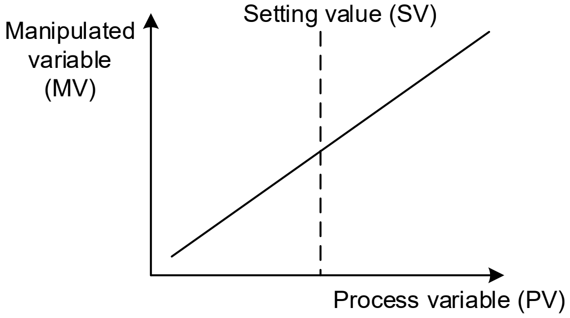
When flow is measured by using differential pressure, the proportional characteristics will be obtained through square root extraction of differential pressure data. Temperature/pressure correction is used if necessary.



→ Temperature/pressure correction

Direct action

In the PID control, an activity to increase the manipulated variable (MV) against increase of the process variable (PV) is called a direct action. (Example: Cooler)



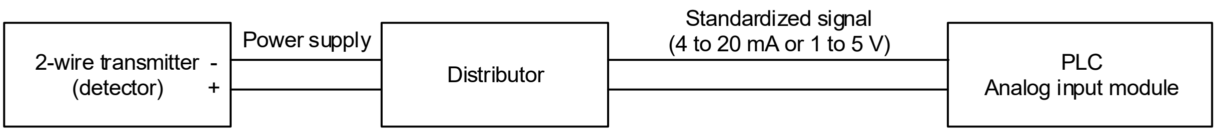
↔ Reverse action

Disable alarm

Alarm detection can be disabled for alarm items of tag alarm by configuring the disable setting.

Distributor

A signal distributor which supplies power to a 2-wire transmitter (detector) and outputs signals of 4 to 20 mA received from the transmitter (detector) to an analog input module or other devices in 4 to 20 mA or 1 to 5 V.



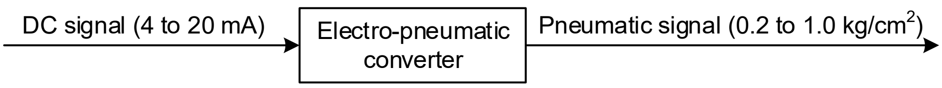
DV

Deviation. The difference between the setting value (SV) and process variable (PV).

<E>

Electro-pneumatic converter

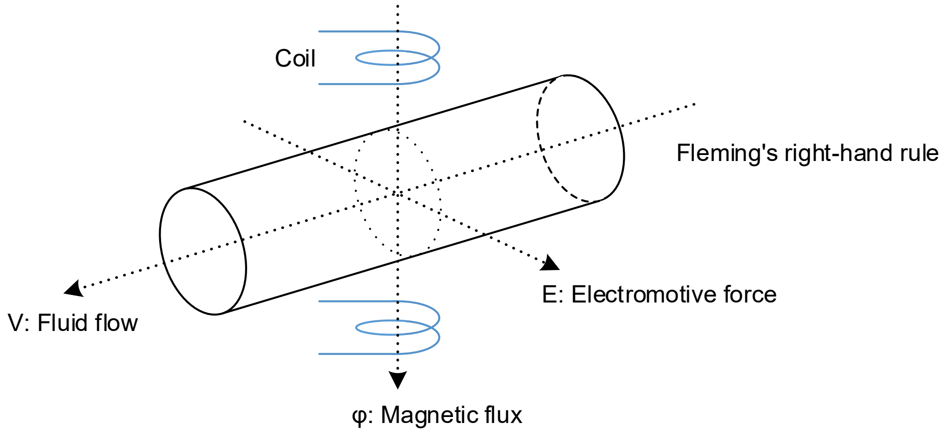
A converter which converts a standardized signal (electrical signal) to a standardized signal (pneumatic signal). Electro-pneumatic transducer.



↔ Pneumatic-electric converter

Electromagnetic flowmeter

When a conductive fluid flows across a magnetic field, an electromotive force is induced in proportion to the flow velocity. A flowmeter which detects the flow by this theory is called an electromagnetic flowmeter.



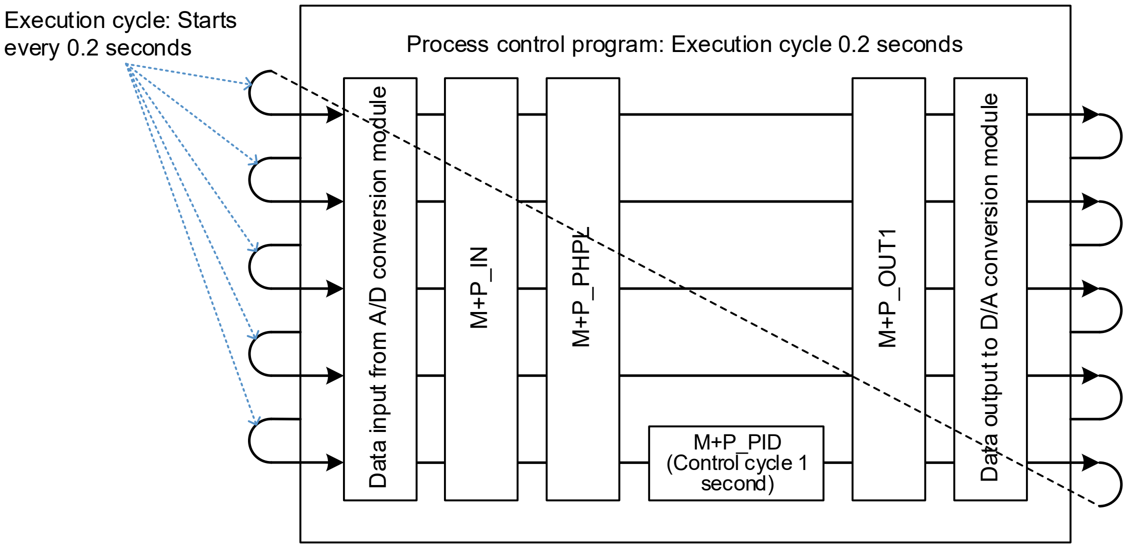
→ Flowmeter

Execution cycle

A process control program which consists of such as M+P_IN, M+P_PHPL, and M+P_OUT1 starts at a regular cycle. This cycle is called the execution cycle. For an FBD/LD program with GX Works3 process control extensions enabled, the execution cycle of high-speed (200 ms), normal speed (400 to 1000 ms), low-speed (1000 to 10000 ms) can be set. Set the timing of a control operation block such as M+P_PID and M+P_BPI as a control cycle (CT) separately from the execution cycle. Set the control cycle as integral multiple of the execution cycle.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.5 Program Execution Control

The following figure shows the relationship between the execution cycle and control cycle using an example of executing basic velocity PID control with a control cycle of 1.0 second within a process control program with an execution cycle of 0.2 seconds.



Setting the control cycle of the M+P_PID instruction to 1.0 second results in the PID operation being performed once every second.

Point

If the control cycle is not the integral multiple of execution cycle, the actual control cycle will be calculated by multiplying the execution cycle by the rounded value of the control cycle (CT) divided by the execution cycle (ΔT). (When the control cycle (CT) is set to 2.5 seconds and the execution cycle (ΔT) is set to 1 second, 2.5 (control cycle)/1.0 (execution cycle) = 2.5,. and the rounded value of this is 3. Therefore, the control cycle becomes 3 seconds, three times the execution cycle of 1 second.)

→ Control cycle

<F>

Filter

(1) First order lag filter

This is used as a filter for eliminating noise etc. of a process variable (PV). The first order lag operation is performed.

$$PVf = \frac{T1 \times PVf_{n-1}}{T1 + \Delta T} + \frac{\Delta T \times PV}{T1 + \Delta T}$$

T1: Time constant (sec.), ΔT: Execution cycle, PV: Present input value, PVf_{n-1}: Previous filter value

The process FB for lead-lag compensation (P_LLAG) is equivalent to this filter.

(2) Digital filter (index filter)
This is used as a filter for eliminating noise etc. of a process variable (PV).
The sum of the weights (PV filter coefficient) of current process variable and previous filter value is operated.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.1 Analog Input Processing (M+P_IN)

$PVf = PV + \alpha (PVf_{n-1} - PV)$

α: PV filter coefficient, PV: Present input value, PVf_{n-1}: Previous filter value

(3) Moving average filter
This filter outputs the average value of 'SN' pieces of input data that are sampled at the data collection interval.

Flowmeter

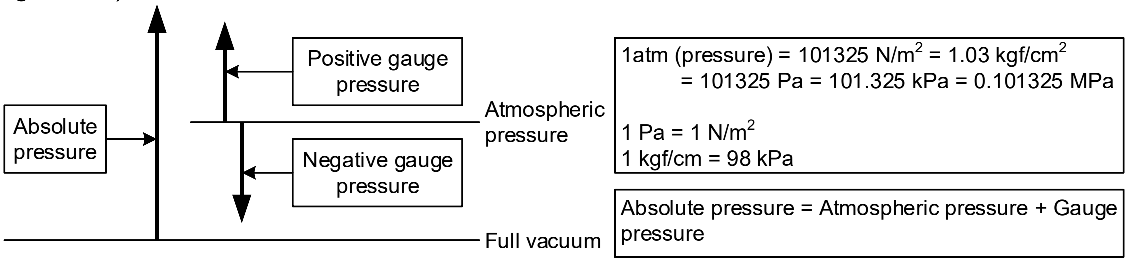
The following shows the representative types of flowmeters. Hydrometry is widely used in processes, along with manometry and thermometry.

Flow measuring method	Type	Measurement target
Volume hydrometry	Differential pressure type (orifice, venturi tube): Detects the flow based on the differential pressure.	Liquid ○, Gas ○, Steam ○
	Variable area type: Detects the flow based on the float position.	Liquid ○, Gas ○, Steam ○
	Electro-magnetic type: Detects the flow based on the electromotive force.	Liquid ○, Gas ×, Steam ×
	Supersonic type: Detects the flow based on the propagation time differences or Doppler effect.	Liquid ○, Gas ○, Steam Δ
Integrated volume hydrometry	Positive displacement (oval gear, Roots type): Detects the flow based on the number of revolutions.	Liquid ○, Gas ○, Steam ×
	Vortex (Karman vortex) type: Detects the flow based on frequencies of Karman vortex.	Liquid ○, Gas ○, Steam ○
	Turbine type: Detects the flow based on the number of revolutions.	Liquid ○, Gas ○, Steam Δ
Mass hydrometry	Coriolis type: Detects the flow based on Coriolis force.	Liquid ○, Gas Δ, Steam ×
	Thermal type: Detects the flow based on the temperature rise of fluid when heated.	Liquid Δ, Gas ○, Steam ×

<G>

Gauge pressure

Pressure volume described based on the atmosphere pressure (= 0), which is widely used. Pressure higher than atmosphere pressure is positive pressure, lower than atmosphere pressure is negative pressure. When differentiation from absolute pressure is needed, add G after the unit. (Example: 3 kg/cm^2 G)



→ Absolute pressure, Differential pressure

<H>

HH

→ High alarm/high high alarm

High selector

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.1 High Selector (M+P_HS(_E))

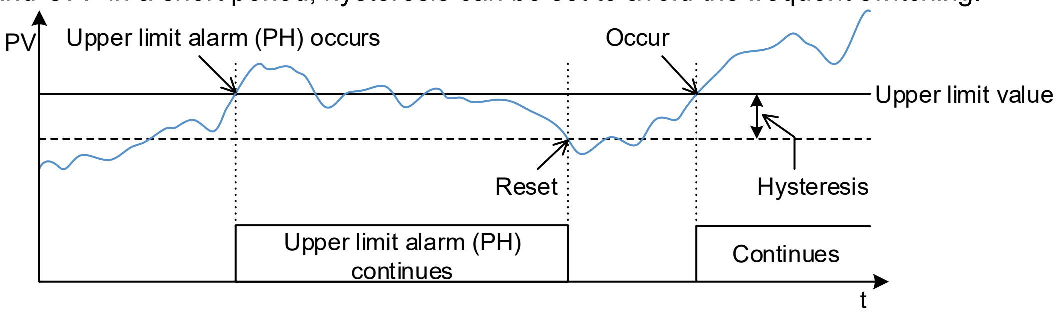
→ Selection control

High alarm/high high alarm

Upper limit alarm (PH)/upper upper limit alarm (HH)

Hysteresis

A characteristic which outputs different values depending on the directivity past record of input values.
In cases where the input value fluctuates near the limit and the alarm is frequently switched between ON and OFF in a short period, hysteresis can be set to avoid the frequent switching.



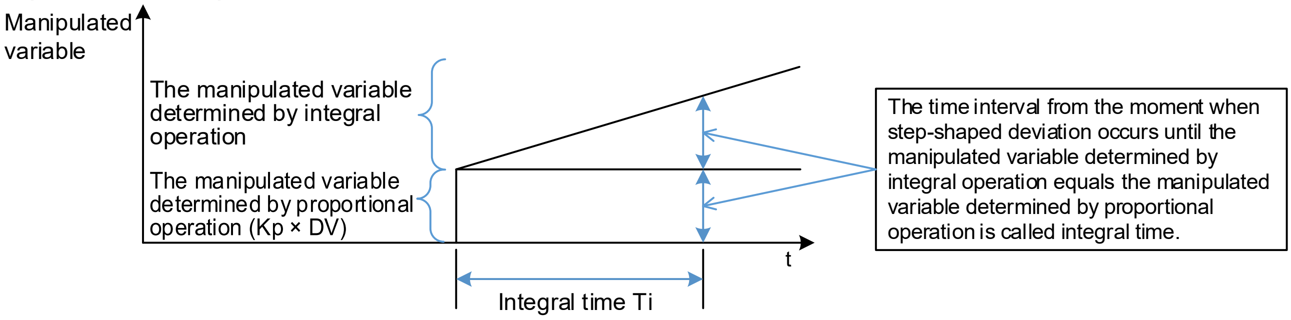
Hot start

A system which outputs values from the value immediately before the power is shut off at the time of a restart after a power failure of the control system.

↔ Cold start

I operation
Integral operation. This is an operation that continuously adds the manipulated variables, in order to eliminate deviation DV (difference between the process variable and setting value). It can eliminate the offset caused by the proportional operation. The time interval from the moment when deviation occurs until the manipulated variable determined by the integral operation becomes equal to the manipulated variable determined by the proportional operation is called integral time "Ti".

• Operation for step deviation



When integral time Ti is short	The integral effect becomes larger, and the time for eliminating offset becomes shorter. However, hunting occurs easily.
When integral time Td is long	The integral effect becomes smaller, and the time for eliminating offset becomes longer.

I/O mode
Operation modes to switch the connection status with the I/O (input/output) module. The mode types are NOR (NORMAL), SIM (SIMULATION), OVER(OVERRIDE), and TSTP (TAG STOP).

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB I/O modes

I-PD control
→ Deviation derivative type PID/PV-derivative type PID (PI-D control)/PV-proportional and -derivative type PID (I-PD control)

Identification
A process of finding a process parameter (PID constant) by using the step response method or other means.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 21.8 Auto Tuning

Industrial unit data
Measured data expressed in the actual industrial unit rather than expressed in percentage

Integral operation/integral time
→ I operation

Input override

A function which enables simulated input of the process variable (PV) when an input signal error occurs.

• Loop tag

A function to change the input value from the screen when the correct PV input signal cannot be obtained due to an issue such as a detection sensor error. However, external output is executed. (It is used when batch sequences are transitioned.)

• Status tag

A function to change the input status from the screen when the correct input status cannot be obtained due to an issue such as imperfect contact of the limit switch. However, external output is executed. (It is used when batch sequences are transitioned.)

→ I/O mode

<L>

Level meter

The following table shows the representative level meter types.

Measuring method	Type
Contact type	Differential pressure (liquid-operated) type, float (buoyancy) type, purge type, electrode type, and capacitance type
Non-contact type	Ultrasonic type and microwave type

LL

→ Low alarm/low low alarm

Lockout tag

A tag, which is displayed at the lockout tag position on a faceplate simulating a controller in an HMI screen, that indicates precautions for operations and restrictions according to the operation authority.

Loop

A control loop which constitutes a feedback loop such as PID control.

Loop tag

A tag which has a faceplate where loop control functions such as PID control are implemented.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17 LOOP TAG

→ Status tag

Low alarm/low low alarm

Lower limit alarm (PL)/lower lower limit alarm (LL)

Low selector

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.2 Low Selector (M+P_LS(_E))

→ Selection control

<M>

MAN/MANUAL

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 TAG FB Control modes

→ MANUAL mode

Major alarm

An alarm that occurs in the event of a serious error in a process which makes continued operation impossible, or a serious error in devices/equipment.

MANUAL mode

A mode that enables the setting of the manipulated variable (MV) to be changed manually by an operator when PID or other automatic control is being used.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 2.3 Tag FB Control modes

Manometer

A device which measures pressure. The following table shows the representative types. Manometer is widely used in processes, along with thermometry and hydrometry.

Electric type	Resistance type, piezoelectric type
Elastic type	Bourdon-tube, diaphragm, bellows type
Liquid column type	U-tube, single-pipe system

→ Gauge pressure, Absolute pressure

Mass flowmeter

A type of flowmeters which measures fluid mass. Because the density of fluid changes when the fluid temperature or pressure changes drastically, the temperature/pressure correction needs to be executed against volume flow, therefore, complicated systems and accidental error factors are caused. In this case, it is preferred to measure mass flow, and recently, use of a mass flowmeter has become increasingly common.

There are several types of mass flowmeter such as the Coriolis type, which utilizes the fact that the twisting power (Coriolis force) that occurs in a vibrating U-tube is proportional to the mass flow of the fluid which passes through the tube, and thermal type, which measures temperature rise of fluid in heating.

→ Flowmeter

Minor alarm

Alarm which does not become a severe obstacle to the operation.

MV

Manipulated variable

<O>

Optimum value adjustment method

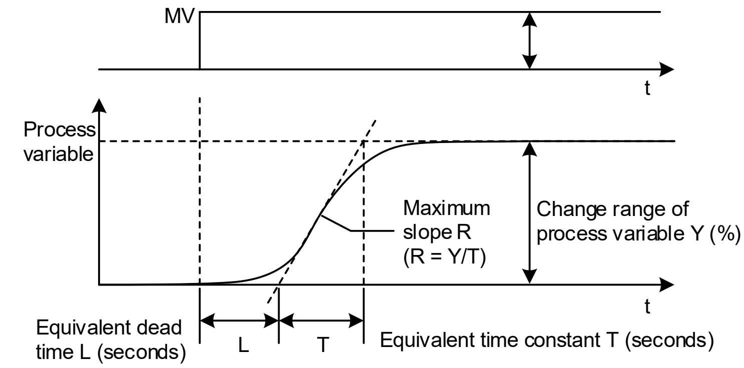
There are two optimum value adjustment methods: step response method and limit cycle method. The limit cycle method is less affected by process variable noise compared to the step response method, and stabilized tuning results can be obtained.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Related Functions of Process Auto tuning

■ Step response method

This method outputs step MV for the actual plant, and determines the constants by maximum slope and equivalent dead time.

(a) Setting constants by the step response method



Typical values of each constant

Control	Proportional gain	Integral time (seconds)	Derivative time (seconds)
P	$\frac{1}{R \times L} \times \frac{MV (\%)}{100}$		
PI	$\frac{0.9}{R \times L} \times \frac{MV (\%)}{100}$	3.33L	
PID	$\frac{1.2}{R \times L} \times \frac{MV (\%)}{100}$	2L	0.5L

Obtain the optimum value from the above formula, and perform the fine tuning.

(Example) When equivalent dead time L: 8 seconds, Equivalent time constant T: 16 seconds, Change range of process variable Y: 0.25%, Step manipulated variable: 20%, Maximum slope R = 0.25/16 = 0.016 for PI control

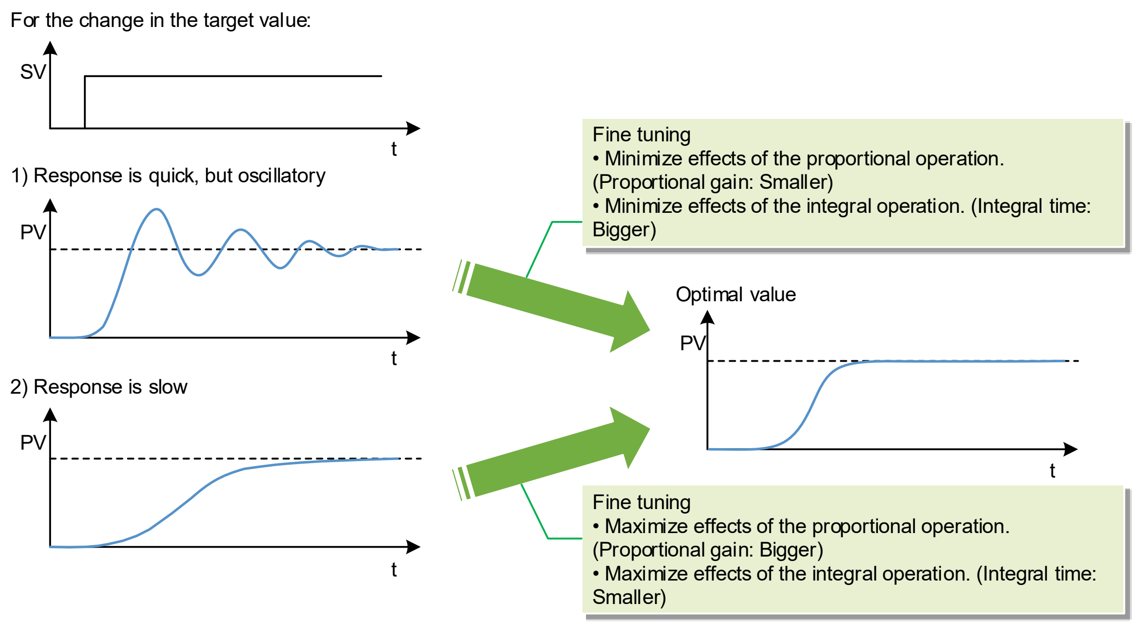
Based on the above chart: $\text{Proportional gain} = \frac{0.9}{R \times L} \times \frac{MV (\%)}{100} = \frac{0.9}{0.016 \times 8} \times \frac{20}{100} = 1.4$

Integral time = 3.33 L = 3.33 × 8 = 26.6 seconds

Derivative time = 0 seconds

(b) Fine tuning

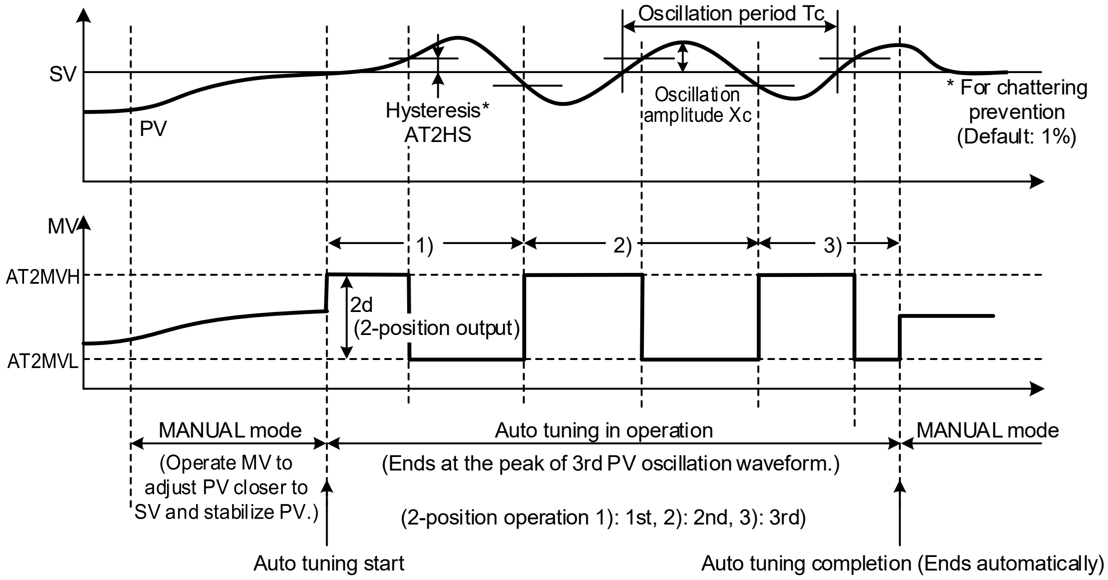
Obtain a value close to the optimum value, and perform the fine tuning.



■ Limit cycle method

In the limit cycle method, the PV is temporarily oscillated by performing the 2-position operation (ON/OFF operation) output three times and constants are set by the PV amplitude and oscillation period.

(a) Generation and measurement of limit cycle waveform
The PV is oscillated by the 2-position operation output, and the amplitude Xc and oscillation period Tc are measured from the 2nd and 3rd waveform data whose oscillation waveform is stabilized.
The following diagram shows a waveform example of auto tuning. (When PV ≤ SV, and reverse action is performed at the start of auto tuning)



(b) Calculation of threshold sensitivity (Ku) and threshold period (Tu)
Use the following expression to calculate the threshold sensitivity (Ku) and threshold period (Tu) from the limit cycle results.

Threshold sensitivity $Ku = 4d / \pi\sqrt{Xc^2 - AT2HS^2}$

Xc: Oscillation amplitude
d: Amplitude of 2-position operation output
((AT2MVH - AT2MVL) / 2)

Threshold period Tu = Tc

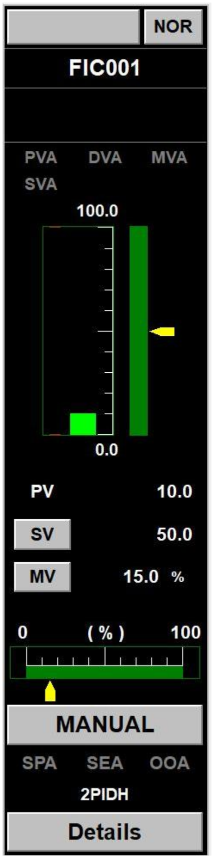
Tc: Oscillation period

(c) Calculation of optimum PID constant
Calculate the optimum PID constant from the threshold sensitivity (Ku) and threshold period (Tu).

Control type	Control operation	Proportional gain (Kp)	Integral time (Ti)	Derivative time (Td)	Empirical rule	Remarks
Constant-value control	PI	0.45Ku	0.83Tu	0	Ziegler Nichols's method	Improves the disturbance response.
	PID	0.6Ku	0.5Tu	0.125Tu		
Follow-up control	PI	0.3Ku	1.0Tu	0	CHR method	Suppresses the overshoot when the setting value is changed.
	PID	0.45Ku	0.6Tu	0.1Tu		

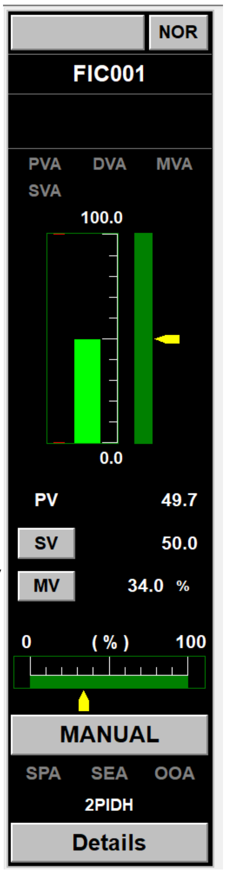
(d) Setting the upper limit (AT2MVH)/lower limit (AT2MVL) of 2-position operation output
The following is an example of setting the 2-position operation output which reduces impact on processing as much as possible when performing the auto tuning.

1) Set the control mode to the MANUAL mode, and set the SV to be used in the operation. Then, adjust the PV closer to the SV by operating the MV, and stabilize the PV.



(Example)
PV: 10.0
SV: 50.0
MV: 15.0

When a difference between PV and SV is large, operate MV to adjust PV closer to SV



PV: 49.7
SV: 50.0

Minimize the difference between PV and SV, and stabilize PV.

MV: 34.0

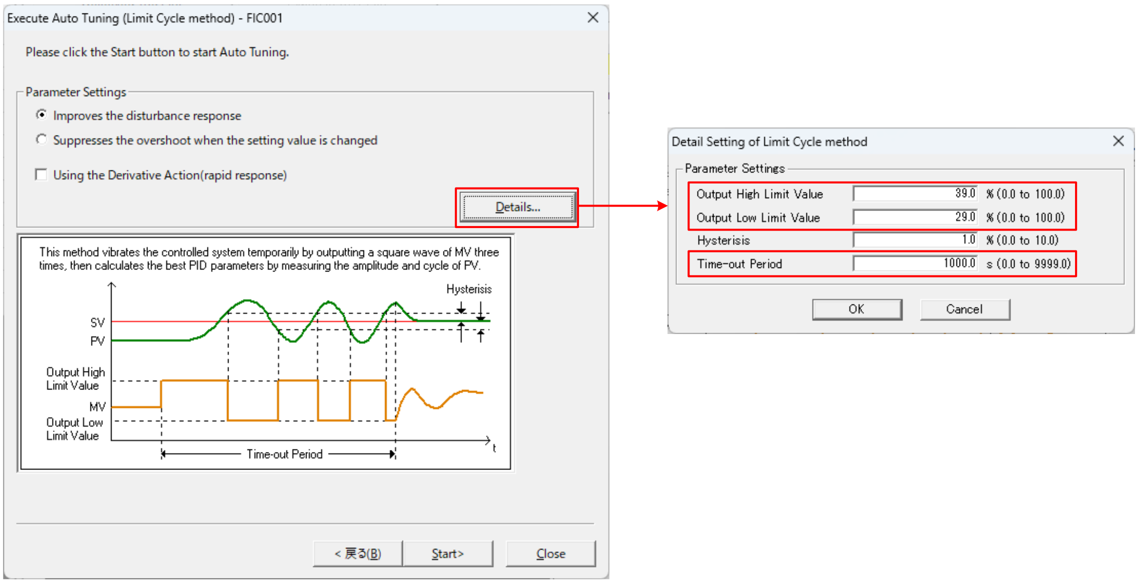
This MV is used as a standard.

2) Set the 2-position operation output according to the MV when the PV is stabilized as a standard. Specify a value for the amplitude d of the 2-position operation output not to impact the processing when the PV is oscillated up and down around the SV.

(Example) If the MV is 34% when the PV is stabilized and the amplitude d of the 2-position operation output is 5%, values for the output upper limit (AT2MVH) and output lower limit (AT2MVL) are as follows.

AT2MVH = MV + d = 34% + 5% = 39%
AT2MVL = MV - d = 34% - 5% = 29%

Set the above output upper limit (AT2MVH) and output lower limit (AT2MVL) in PX Developer Monitor Tool.
For the operation of auto tuning and how to display the screens below, refer to the following manual.
Reference: PX Developer Version 1 Operating Manual (Monitor Tool)

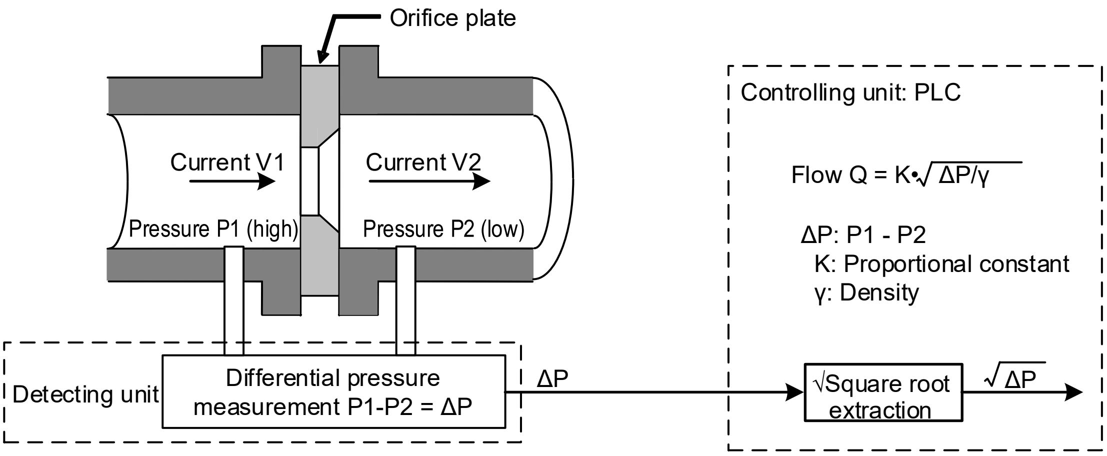


3) Consider processing characteristics, set a time-out period three times more than an oscillation period which is measured by the 2-position operation output.

(e) Fine tuning
Fine tuning of PID constants is the same as that for the step response method.

Orifice

A diaphragm (orifice plate) which is equipped in a conduit line for measuring differential pressure which occurs before and after throttling depending on the volume of flow.

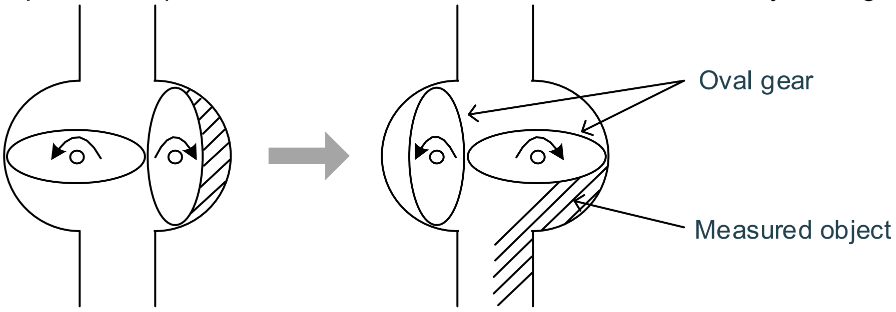


Output signal processing

Functions of the process control instruction such as: an output rate-of-change limiter, output limiter, output clamp, output value tracking, and output signal conversion.

Oval gear flowmeter

A positive displacement flowmeter which measures flow rate by turning oval gears.

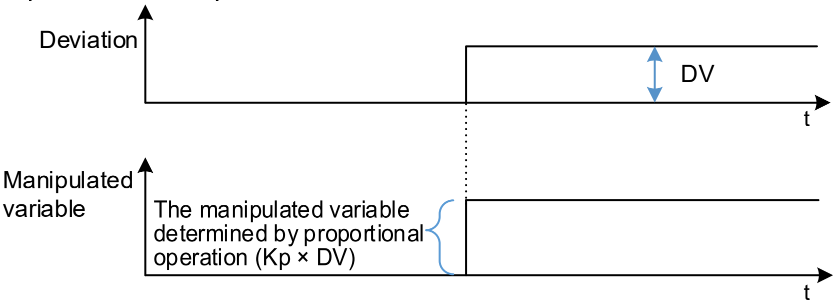


<P>

P operation

Proportional operation. This is an operation that adds the manipulated variable that is in proportion to deviation DV (difference between the process variable and setting value).

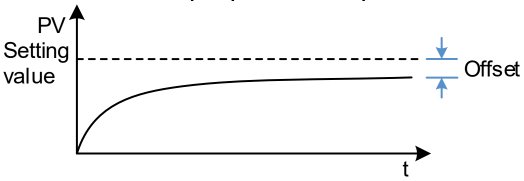
- Operation for step deviation

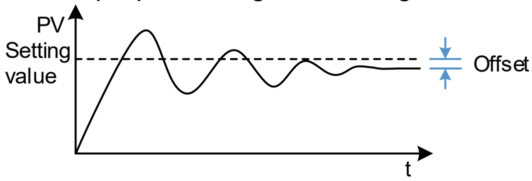


Manipulated variable = Proportional gain Kp × Deviation DV

When proportional gain Kp is small	The control operation becomes slower.
When proportional gain Kp is large	The control operation becomes faster and easy to cause hunting.

The constant error that occurs in relation to the setting value is called offset (residual deviation). Offset will occur in the proportional operation. The smaller the proportional gain, the larger the offset becomes.





P&I flow chart

A piping and instrumentation flow chart which shows the entire control system where elements such as piping, detector, operation terminal, and controller are represented in symbols

PI-D control

→ Deviation derivative type PID/PV-derivative type PID (PI-D control)/PV-proportional and -derivative type PID (I-PD control)

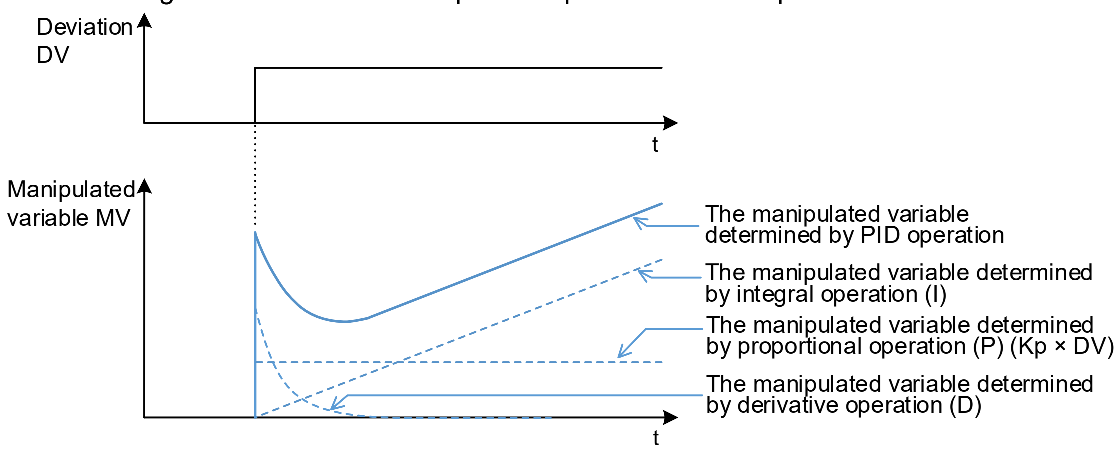
PID operation

This is a control operation which operates and outputs the manipulated variable MV to have the process variable PV approach the setting value SV rapidly and correctly by combining the P operation, I operation, and D operation. If not all the P, I, and D operations are included in the control, it is called the P control or PI control according to the operations included. The PI operation is mainly for flow control, pressure control, and temperature control. The PID operation is mainly for temperature control.

	Direct action	Reverse action
Deviation DV_n	$DV_n = PV_n - SV_n$	$DV_n = SV_n - PV_n$
Output variation ΔMV	$\Delta MV = \underbrace{K_p}_{\text{Gain}} \times \{\underbrace{(DV_n - DV_{n-1})}_{\text{Proportional}} + \underbrace{\frac{CT}{T_i} \times DV_n}_{\text{Integral}} + \underbrace{B_n}_{\text{Derivative}}\}$ Proportional, integral, and derivative term of ΔMV are as follows. (PID operational expression is the addition of proportional, integral, and derivative term.) • Proportional term: $\Delta MV = K_p \times (DV_n - DV_{n-1})$ • Integral term: $\Delta MV = K_p \times \frac{CT}{T_i} \times DV_n$ •Derivative term: $\Delta MV = K_p \times B_n$ (B_n as follows)	
B_n	$B_n = B_{n-1} + \frac{MTD \times T_d}{MTD \times CT + T_d} \times \{(PV_n - 2PV_{n-1} + PV_{n-2}) - \frac{CT \times B_{n-1}}{T_d}\}$	$B_n = B_{n-1} + \frac{MTD \times T_d}{MTD \times CT + T_d} \times \{-(PV_n - 2PV_{n-1} + PV_{n-2}) - \frac{CT \times B_{n-1}}{T_d}\}$

K_p: Proportional gain, T_i: Integral time, T_d: Derivative time, M_d: Derivative gain, CT: Control cycle
DV_n: Deviation, DV_{n-1}: Previous deviation value, PV_n: Process variable, PV_{n-1}: Previous process value, PV_{n-2}: Process value before last

• The following table shows the PID operation performed for step deviation.



PH

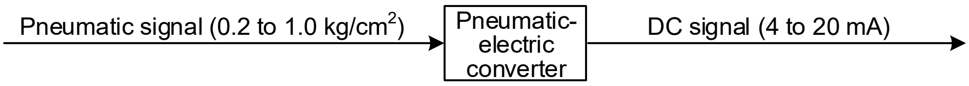
→ High alarm/high high alarm

PL

→ Low alarm/low low alarm

Pneumatic-electric converter

A converter which converts a standardized signal (pneumatic signal) to a standardized signal (electrical signal).



↔ Electro-pneumatic converter

Piping and instrumentation flow chart

→ P&I flow chart

Position type PID control

The position type PID control is an operational method to find the manipulated variable (MV) from the difference (deviation) between the PID operational method setting value (SV) and process variable (PV). On the other hand, the velocity type PID control is an operational method to find a change volume of the manipulated variable (ΔMV) from deviation.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.11 Position Type PID Control (Enable Tracking for primary loop/Disable Tracking from secondary loop) (M+M_PIDP_T) to 17.14 Position Type PID Control (Disable Tracking for primary loop/Enable Tracking from secondary loop) (M+M_PIDP_EX_)

→ Velocity type PID control

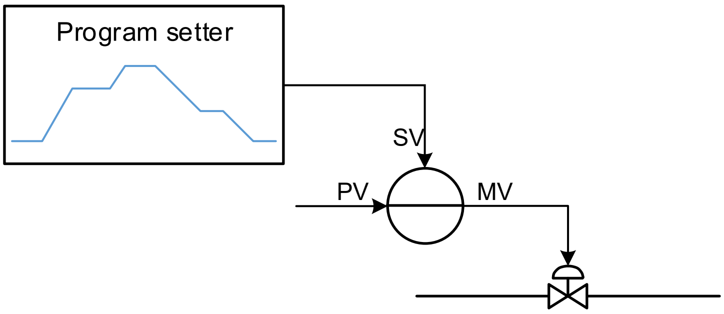
Pressure bias

Temperature/pressure correction operation is executed with absolute unit (absolute temperature, absolute pressure). Pressure bias is the correction values for converting design pressure/measured pressure to absolute pressure.

Program control

It is a control method in which setting values are changed by the pre-set program. It is used for the temperature control and other purposes. It is used in combination with a program setter and PID control.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.36 Program Setter (M+M_PGS)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.37 Multi-Point Program Setter (M+M_PGS2_)



Process control

Process control adjusts or controls the variables which influence the operation status of industrial processes to meet the specified setting value.

Process control flow chart

A flow chart which shows the entire control system where elements such as piping, detector, operation terminal, and controller are represented in symbols.

Proportional operation/proportional gain

→ P operation

Proportional band

A proportional band is an input variation range (%) in proportion to the change of output effective variation range of 0% to 100% in the proportional operation. For PLCs, proportional gain Kp is applied instead of a proportional band. Proportional band = 100/proportional gain Kp

→ Proportional operation/proportional gain

Pulse input module

A pulse input module counts measurement pulse signals from flowmeters and other devices.

Reference: MELSEC iQ-R Channel Isolated Pulse Input Module User's Manual (Startup)

Reference: MELSEC iQ-R Channel Isolated Pulse Input Module User's Manual (Application)

PV

Process variable

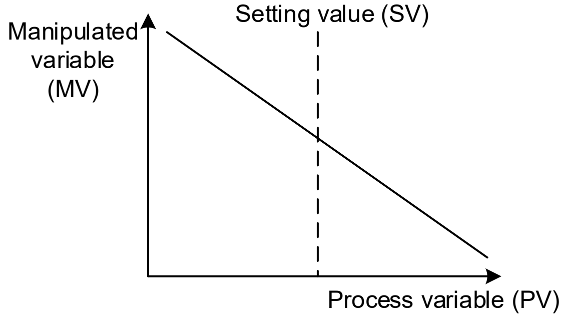
PV-derivative type PID (PI-D control)/PV-proportional and -derivative type PID (I-PD control)

→ Deviation derivative type PID/PV-derivative type PID (PI-D control)/PV-proportional and -derivative type PID (I-PD control)

<R>

Reverse action

In the PID control, an activity to increase the manipulated variable (MV) against decrease of the process variable (PV) is called a reverse action. (Example: Heater)



↔ Direct action

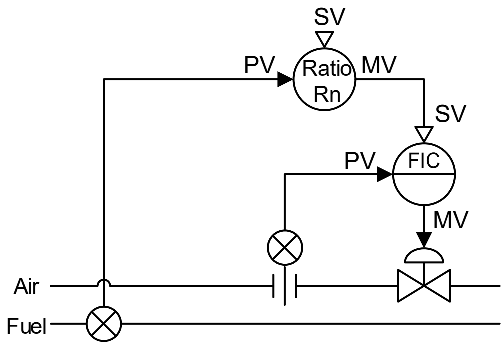
3

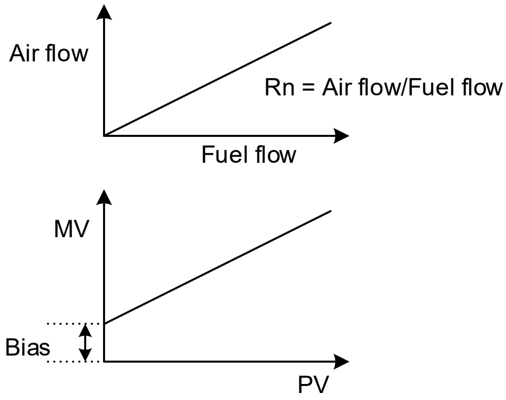
Ratio control

This control maintains the proportional relationship between two or more variables, such as a control where the SV changes in a constant ratio to other variables. (Example: Air-fuel ratio control)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.21 Ratio Control (Enable Tracking for primary loop) (M+M_R_T)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.22 Ratio Control (Disable Tracking for primary loop) (M+M_R)



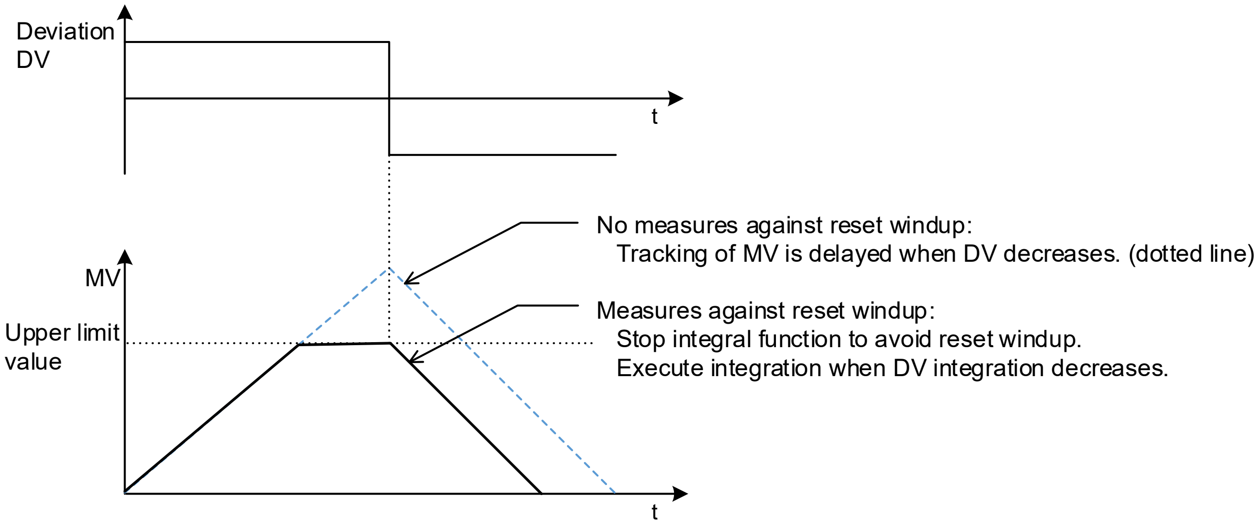


Reset windup

Reset windup is a problem where deviation is accumulated continuously when an integral element exceeds saturation limit in the case of excessive deviation. This is also called integrator windup. To ensure that the MV can be returned to the upper or lower limit when it exceeds the upper or lower limit and the system can respond immediately when the deviation reverses, it is necessary to implement measures against reset windup that stops the integral operation in the direction of the exceedance when the limit is exceeded.

Measures against reset windup is implemented for the process CPU.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 14.4 Output Processing-3 with Mode Switching (With Input Addition and Compensation) (M+P_OUT3_) Reset windup

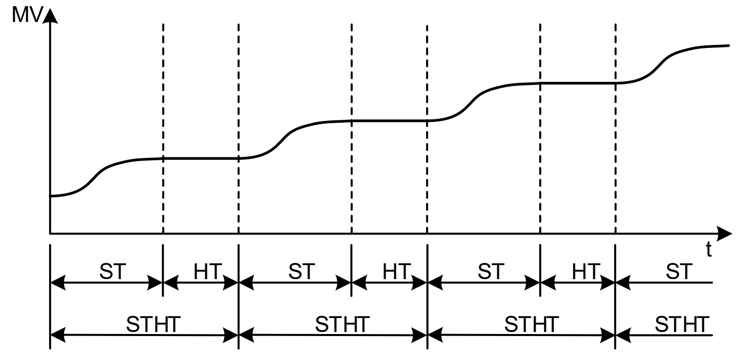


Sample PI control

When the PID control is applied on a system whose dead time is long, the MV will be continuously updated before the MV effect is confirmed. The sample PI control executes only for the control execution time in every control cycle, and then holds the output after that.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.15 Sample PI Control (Enable Tracking for primary loop) (M+M_SPI_T)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.16 Sample PI Control (Disable Tracking for primary loop) (M+M_SPI)



ST: Operating time, HT: Hold time (STHT-ST), STHT: Sampling interval

Secondary loop

Secondary loop of the cascade control

→ Cascade control

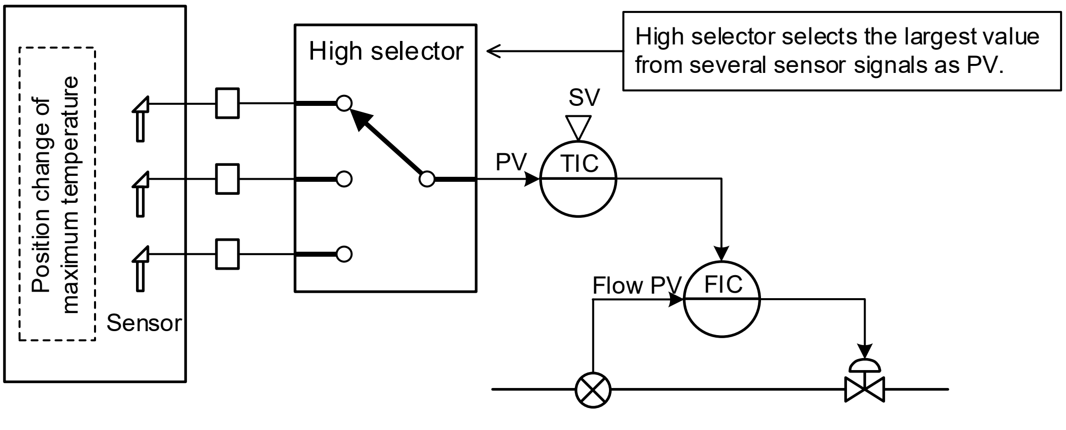
Selection control

(1) This is a control method that selects the necessary signals (high selector, low selector, intermediate selector, etc.) among multiple sensor signals or operation signals to control the system. As shown in the following diagram, when the highest temperature position changes, the control is performed by selecting the highest temperature among two or more measurement points.

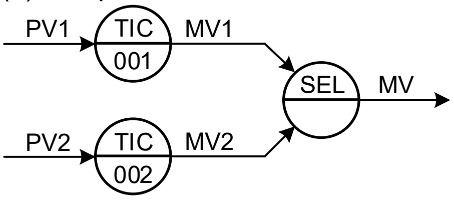
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.1 High Selector (M+P_HS(_E))

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.2 Low Selector (M+P_LS(_E))

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 5.3 Middle Selector (M+P_MID(_E))



(2) The process in which the value is selected at the output side is called the override control.



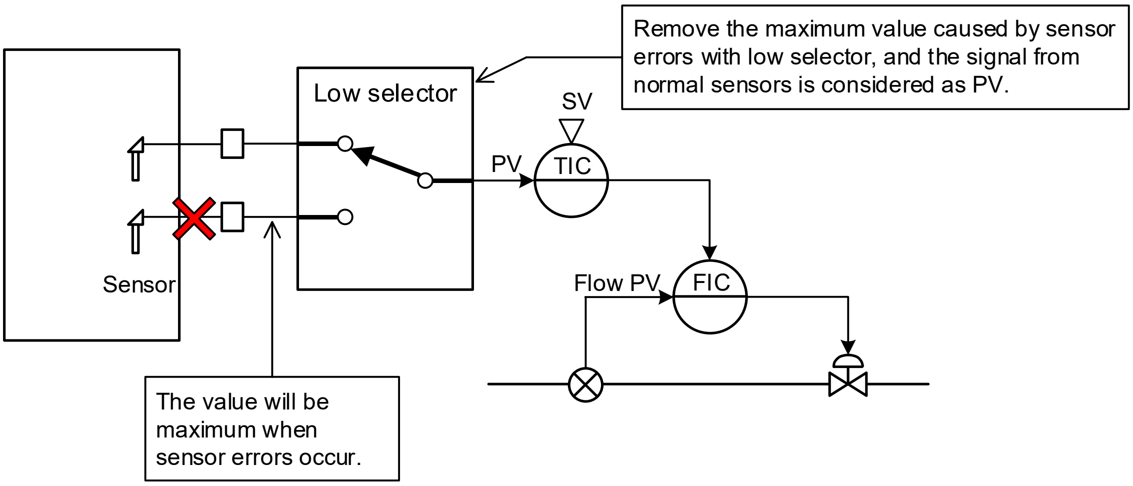
→ 1.7 Output Programs and Loop Processing Output override (low selector)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Override function (OVERRIDE mode)

(3) The redundancy of the system is realized by installing two or more sensors and selecting the normal one considering sensor wire breaks and failures.

In addition, the redundancy of the PV can be realized by connecting multiple sensors, combining the low, high, and intermediate selectors according to the status when burnout occurs (whether the signal from the sensor is the maximum or minimum when burnout occurs) and obtaining the normal sensor signals.

• Example when the input signal from the sensor becomes the maximum when a sensor failure such as a wire break occurs



SIMULATION mode

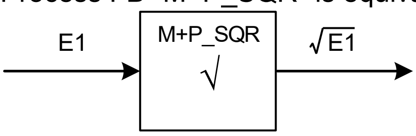
A mode to perform a simulation test using simulation I/O data instead of actual I/O data.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) APPENDICES 3 Simulation function (SIMULATION mode)

→ I/O mode

Square root extraction

√ (root) calculation function. When measuring flow through differential pressure of an orifice or venturi tube, signals obtained from the sensor has square-root characteristic. This control linearizes the signals. Process FB "M+P_SQR" is equivalent to this function.



→ Orifice, Differential pressure

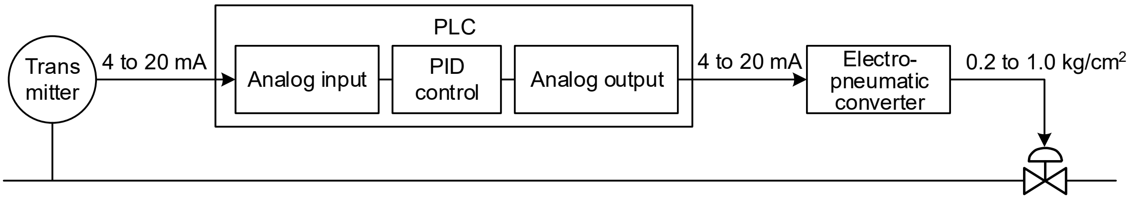
Solenoid valve

A solenoid valve opens/closes a valve with electromagnetic force.

Standardized signal

An input/output process control signal (such as a process variable signal and an operation signal) whose range is standardized.
Even at the lower limit of the process variable, a failure or a disconnection of transmitter or converter can be detected by applying 4 mA current.

Signal type	Signal range
Current signal	4 to 20 mA DC
Voltage signal	1 to 5 V DC
Pneumatic signal	0.2 to 1.0 kg/cm^2



Status tag

A tag which contains a faceplate with the ON/OFF control function such as start/stop of an electric motor or open/close of a solenoid valve.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 18 STATUS TAG
→ Loop tag

SV

Setting value

<T>

Tag

Tags for identification attached to process control equipment.

Tag number

Tag numbers are unique management numbers used for identifying process control equipment. A tag number is composed of the variable symbols, function symbols, and others. It is prescribed by JIS Z8204.

(Example) T I C 001

Variable symbol
- Indicates process variable.

Function symbol
- Indicates functions such as instruction, correction, and alarm.
  For two or more functions, indicate in the order of: I, R, C, T, Q, S, Z.

Individual number
- A number to identify measurement and control loop.

The following table describes the variable symbols and function symbols.

	Variable symbol	Function symbol
A	-	Alarm
C	-	Correction
D	Density or specific gravity	-
F	Instantaneous flow	-
G	Position or length	-
H	Manual operation	-
I	-	Instruction
K	Time	-
L	Level such as liquid level	-
M	Humidity or moisture	-
P	Pressure or vacuum	-
Q	Quality (Ex. Composition, concentration, conductivity)	Integration
R	Radiation	Record
S	Speed, rotating speed, frequency	Switch
T	Temperature	Transmission
V	Viscosity	-
W	Weight or force	-
Z	-	Safety or emergency

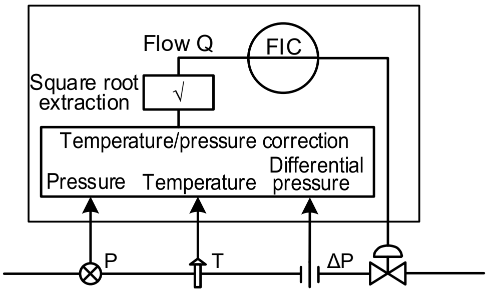
From the information in the list, you can see that the above example "TIC001" is a "001" tag for equipment that performs "instruction or correction" of "temperature".

Temperature bias

Temperature/pressure correction operation uses absolute unit (absolute temperature, absolute pressure). Temperature bias is a corrected value to convert design temperature/measured temperature to absolute temperature.

Temperature/pressure correction

When the fluid conditions (temperature, pressure), of which the differential pressure is measured by equipment which has a diaphragm such as orifice, are not the same as the design conditions, it shall be corrected. Correction shall be performed by multiplying the process variable by the temperature/pressure correction coefficient.
In addition, when equipment with a diaphragm such as orifice is used, the obtained value is square of the flow. Therefore, use it in combination with the square root extraction.



$$\text{Flow Q} = \text{Temperature correction} \times \text{Pressure correction} \times \text{Coefficient} \cdot \sqrt{\text{Differential pressure}}$$

$$= \sqrt{\frac{\text{Design temperature}}{\text{Measured temperature}}} \times \sqrt{\frac{\text{Measured pressure}}{\text{Design pressure}}} \times \text{Coefficient} \cdot \sqrt{\text{Differential pressure}}$$

$$= \sqrt{\frac{T}{T'}} \times \sqrt{\frac{P'}{P}} \times \text{Coefficient} \cdot \sqrt{\Delta P}$$

* T, T': Absolute temperature P, P': Absolute pressure

(Reference) Example of gas temperature/pressure correction
Q0: Measured flow rate (process variable of flowmeter),
T0: Design temperature (°C), T1: Measured temperature (°C)
P0: Design pressure (kPa), P1: Measured pressure (kPa)

When: temperature/pressure correction is {(T0 + 273.15) / (T1 + 273.15)} × {(P1 + 101.3) / (P0 + 101.3)}, correction formulas to calculate Q1 = actual flow rate (after temperature/pressure correction), are as shown below.

Type	Output characteristic of flowmeter	Correction formula
Differential pressure type flowmeter (orifice, venturi tube)	Square-root characteristic	$Q1 = \sqrt{Q0} \times \sqrt{\text{Temperature/pressure correction}}$
	Linear characteristic (when square-root characteristic is converted to linear characteristic before being output)	$Q1 = Q0 \times \sqrt{\text{Temperature/pressure correction}}$
Area flowmeter	Linear characteristic	$Q1 = Q0 \times \sqrt{\text{Temperature/pressure correction}}$
Vortex flowmeter (Karman vortex)	Linear characteristic	$Q1 = Q0 \times \text{Temperature/pressure correction}$

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 6.6 Temperature/Pressure Correction (M+P_TPC)

Thermometer

A device which measures temperature. Representative types are described in the following table. Many thermometers are used in process control.

Contact type	Thermocouple (B, S, R, K, E, J)	-180°C to 1550°C (Temperature range as reference)
	Resistance bulb (pt, 3-wire type, 4-wire type)	-180°C to 500°C
	Thermistor	-50°C to 200°C
Non-contact type	Optical pyrometer	700°C to 3000°C
	Radiation thermometer	-50°C to 4000°C

Tight shut/full open

This function is used to fully open or close the control valve without fail.

Reference: Tight shut/full open in MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) 14.4 Output Processing-3 with Mode Switching (With Input Addition and Compensation) (M+P_OUT3_)

Reference: Tight shut/full open in MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instructions) Appendix 17.40 Heating and Cooling Output (M+M_HTCL_T_)

→ Tight shut/full open (tag type MWM)

Time proportioning control

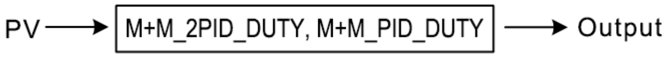
The time proportioning control changes the ON/OFF ratio of the output in proportion to the PID operation result, controls devices such as a heater.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.3 Velocity Type PID Control and DUTY Output (Enable Tracking for primary loop) (M+M_PID_DUTY_T)

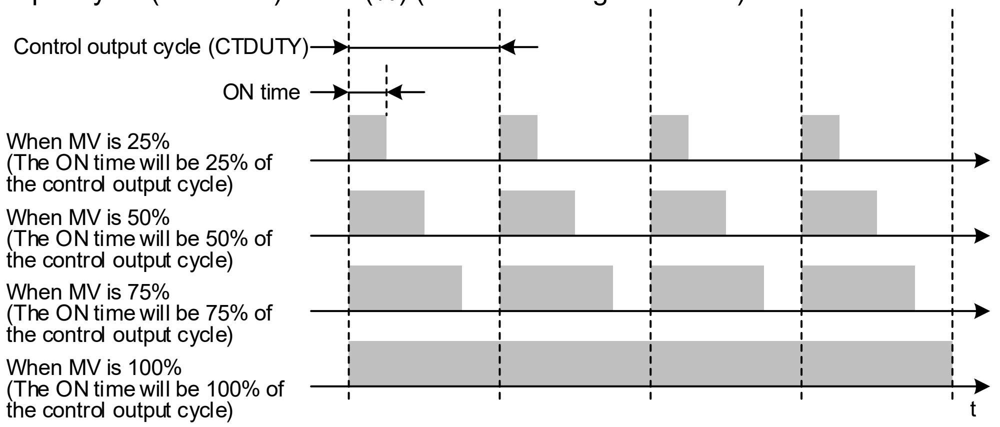
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.4 Velocity Type PID Control and DUTY Output (Disable Tracking for primary loop) (M+M_PID_DUTY)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.7 2-degree-of-freedom PID Control and DUTY O/P (Enable Tracking for primary loop) (M+M_2PID_DUTY_T)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.8 2-degree-of-freedom PID Control and DUTY O/P (Disable Tracking for primary loop) (M+M_2PID_DUTY)



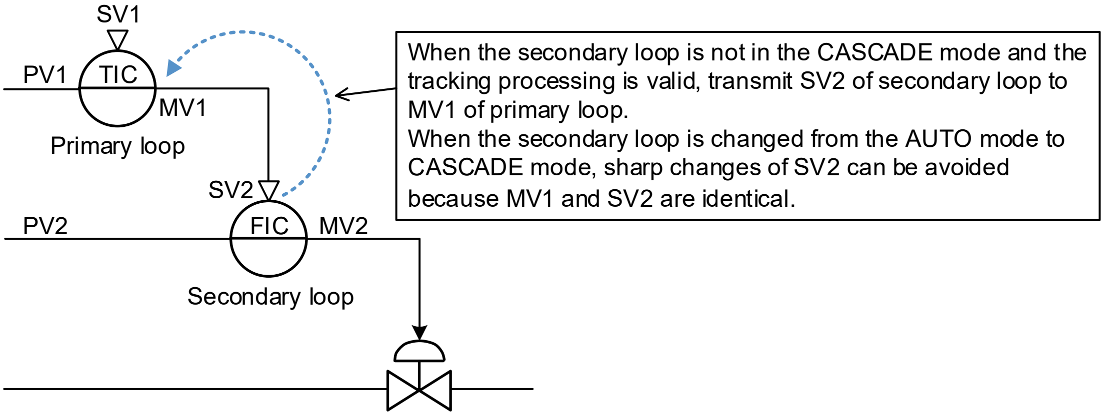
The ON/OFF output is in proportion to the MV.
The relationship between the MV and output: Output bit ON time of each control output cycle = Control output cycle (CTDUTY) × MV (%) (Refer to the figure below.)

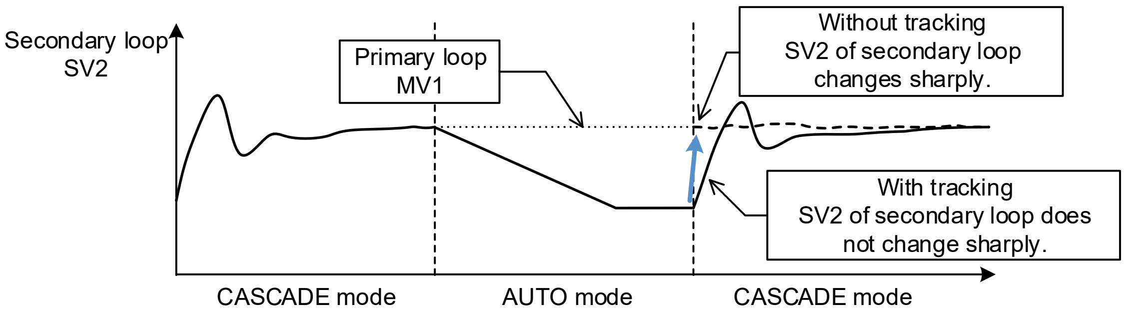


Tracking

Tracking is a function to make a specific signal follow another signal so that the signals match.
The following shows an example of using the tracking function.

(1) Tracking example of cascade loop
In the control loop that forms a cascade loop, the SV of the secondary control loop is transferred to the MV of the primary control loop to prevent sudden changes in the SV value during the switching of control modes in the secondary control loop.





Recommended mode change of the secondary loop: CASCADE ←→ AUTO ←→ MAN. (It is necessary to change to the AUTO mode before changing between the MANUAL mode and CASCADE mode.)

Tuning trend

A trend screen which displays a tuning status of loops in real time. It displays the PV, SV, and MV.

<V>

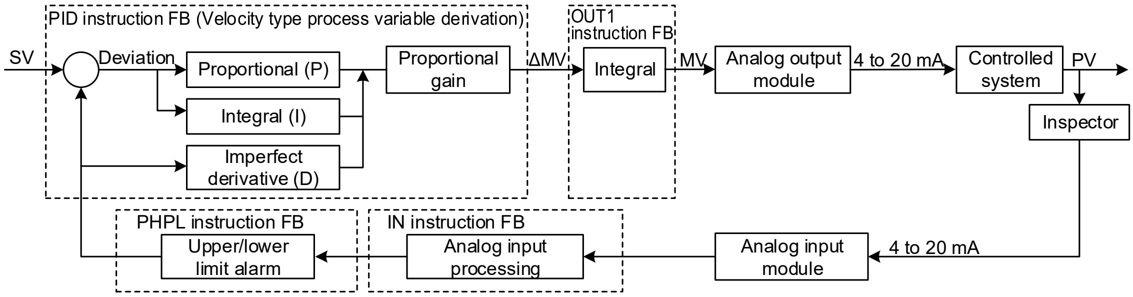
Velocity type PID control

The velocity type PID control is an operation method to obtain find a change volume of the manipulated variable (ΔMV) from the difference between the PV and SV. Since the velocity type PID calculates the change in the manipulated variable ΔMV based on the difference from the previous value, it adds ΔMV from the PID calculation in the subsequent OUT processing to output the manipulated variable MV. Compared to the position type PID, velocity type is more convenient in operation of bumpless manual-auto switching, prevention of reset windup, ease of complex control, and slow change when gain is changed. Hereby the velocity type has become the mainstream choice.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.1 Velocity Type PID Control (Enable Tracking for primary loop) (M+M_PID_T)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.2 Velocity Type PID Control (Disable Tracking for primary loop) (M+M_PID)

Current MV = Previous MV + Current change ΔMV

Example of velocity PV-derivative type PID using a PLC FB instruction (such as M+M_PID)



<W>

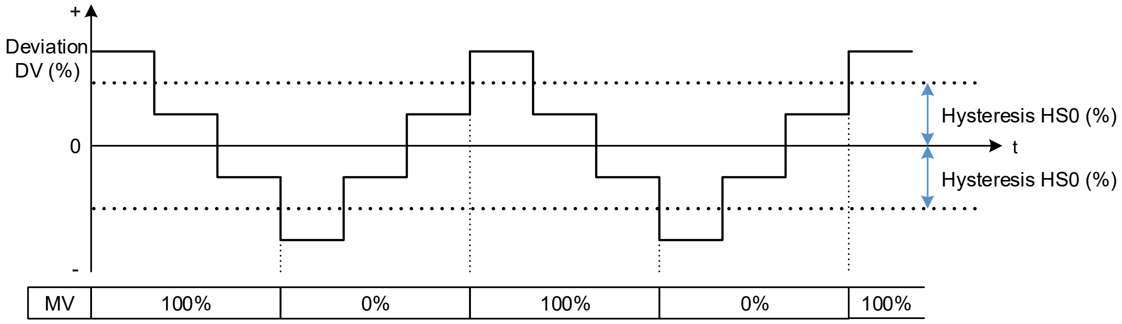
Watchdog timer error alarm

An alarm which occurs when a status answer back time takes longer than the specified time after the control command such as open/close is output. A disconnection of control line, control power OFF, and contactor failure are possible causes.

2 position ON/OFF control

This is a method that outputs two steps of MV signals for deviation to control the system.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.23 2 position ON/OFF Control (Enable Tracking for primary loop) (M+M_ONF2_T)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.24 2 position ON/OFF Control (Disable Tracking for primary loop) (M+M_ONF2)



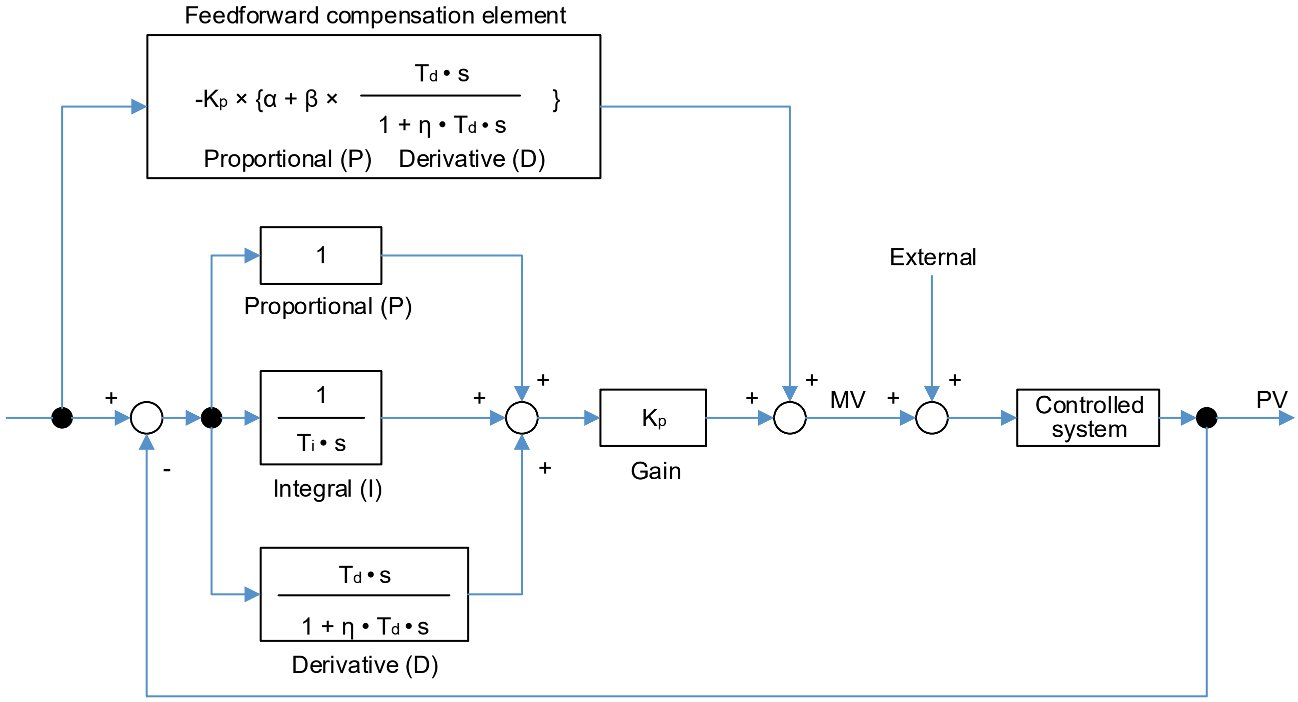
Direct action: DV (%) = PV (%) - SV (%)
Reverse action: DV (%) = SV (%) - PV (%)
SV (%) = {(SV - Lower limit of engineering variable) / (Upper limit of engineering variable - Lower limit of engineering variable)} × 100
PV (%) = {(PV - Lower limit of engineering variable) / (Upper limit of engineering variable - Lower limit of engineering variable)} × 100
Hysteresis (%) is the percentage of the value obtained by (Upper limit of engineering variable - Lower limit of engineering variable).

2-degree-of-freedom PID Control

2-degree-of-freedom PID control is a control method which allows optimization for both disturbance response and target tracking characteristics, compared to the conventional PID control. The 2-degree-of freedom parameters α and β are used in this control. (When both α and β are 0, the control is the same as the conventional PID control.)

* In the conventional PID control, the optimum PID constants for target tracking for the changes in the SV and those for disturbance response differ. This causes an antinomy such as when the optimum value is set for one side, the value is not optimum for the other side.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.5 2-degree-of-freedom PID Control (Enable Tracking for primary loop) (M+M_2PID_T)
Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.6 2-degree-of-freedom PID Control (Disable Tracking for primary loop) (M+M_2PID)



Process CPU 2-degree-of-freedom PID operation expression

	Direct action	Reverse action
Deviation DV_n	$DV_n = PV_n - SV_n$	$DV_n = SV_n - PV_n$
Output variation ΔMV	$\Delta MV = K_p \times \{(1-\alpha) \times (Dv_n - DV_{n-1}) + \frac{CT}{T_i} \times DV_n + (1-\beta) \times B_n + \alpha \times C_n + \beta \times D_n\}$	
B_n	$B_n = B_{n-1} + \frac{MTD \times T_d}{MTD \times CT + T_d} \times \{(DV_n - 2DV_{n-1} + DV_{n-2}) - \frac{CT \times B_{n-1}}{T_d}\}$	
C_n	$C_n = PV_n - PV_{n-1}$	$C_n = -(PV_n - PV_{n-1})$
D_n	$D_n = D_{n-1} + \frac{MTD \times T_d}{MTD \times CT + T_d} \times \{(PV_n - 2PV_{n-1} + PV_{n-2}) - \frac{CT \times D_{n-1}}{T_d}\}$	$D_n = D_{n-1} + \frac{MTD \times T_d}{MTD \times CT + T_d} \times \{-(PV_n - 2PV_{n-1} + PV_{n-2}) - \frac{CT \times D_{n-1}}{T_d}\}$

K_p: Proportional gain, T_i: Integral time, T_d: Derivative time, M_d: Derivative gain, CT: Control cycle
DV_n: Deviation, DV_{n-1}: Previous deviation value, DV_{n-2}: Deviation value before last, PV_n: Process variable, PV_{n-1}: Previous process variable, PV_{n-2}: Process variable before last
α: 2-degree-of-freedom PID parameter (feedforward proportional), β: 2-degree-of-freedom PID parameter (feedforward derivative)

In 2-degree-of-freedom PID, characteristics can be changed by adjusting α and β after the constants of P, I, and D are determined.

When α is 0 and β is 0: Deviation PID

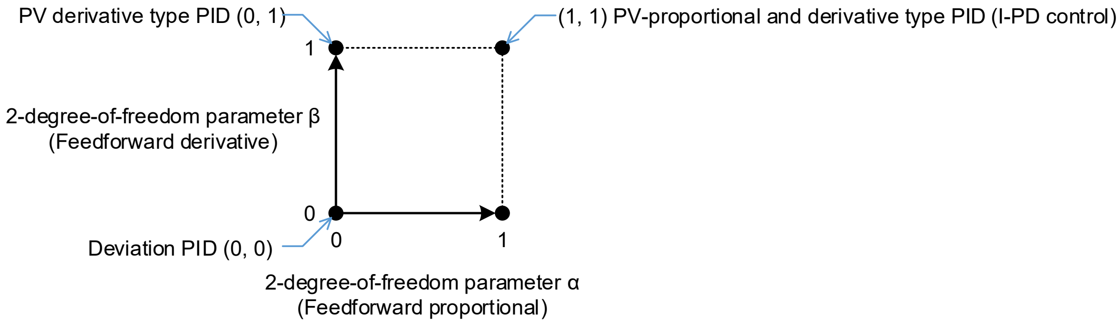
As the derivative operation is performed on deviation (difference between the setting value and process variable), the target tracking performance for the changes in the setting value is high. This is effective when used as a secondary PID in the cascade control.

When α is 0 and β is 1: PV-derivative type PID

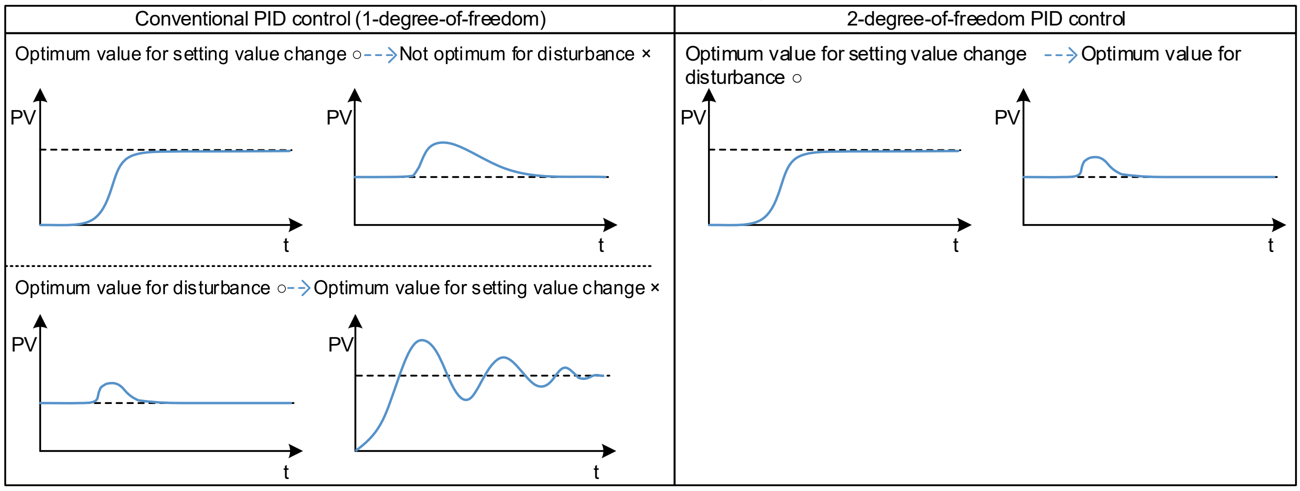
As the derivation operation is performed on the process variable, disturbance response performance is high, compared to the derivative PID. On the other hand, the target tracking performance for the changes in the setting value is low.

When α is 1 and β is 1: PV-proportional and -derivative type PID

As both the proportional and derivative operations are performed on the process variable and the integral operation is performed on deviation (difference between the setting value and process variable), the target tracking performance for the changes in the setting value is low, compared to the PV-derivative type PID. Because the manipulated variable does not change suddenly when there is a change in the setting value, this control is effective when overshoot is completely unacceptable or when response should be slow without shocking the operation terminal or process.



• Response of conventional PID control (1-degree-of-freedom) and 2-degree-of-freedom PID control



• Adjustment method of 2-degree-of-freedom PID control

(1) Calculate the PID constants by using auto tuning.

(2) Finely tune the PID constants (basic parameters of PID: Kp, Ti, and Td) to optimize the response performance for disturbance if necessary.

• Proportional gain Kp
If Kp is tuned down, the manipulated variable will become smaller, and it will take a long time to be stable.
If Kp is tuned up, the manipulated variable will become larger, and there may be oscillation in response due to the enhancement of compensation operation.

• Integral time Ti
If Ti is tuned up, the integral effect will become smaller, and it will take a long time to be stable.
If Ti is tuned down, the integral effect will become smaller, and there may be oscillation in response due to the enhancement of compensation operation. (Oscillation period is long.)

• Derivative time Td
If Td is tuned down, the derivative effect will become smaller, and derivation will be effective only for a short period of time.
If Td is tuned up, the derivative effect will become larger, short-period oscillation will occur, and sometimes the system will be unstable.

(3) While maintaining the optimum disturbance response, adjust the 2-degree-of-freedom parameters (α and β) to optimize the target tracking response.

• 2-degree-of-freedom parameter α
If α is tuned up, the manipulated variable for the setting value change will become smaller, and it will take a long time to be stable.
If α is tuned down, the manipulated variable for the setting value change will become larger, and there may be oscillation in response due to the enhancement of compensation operation.

• 2-degree-of-freedom parameter β
If β is tuned up, the derivative effect for the setting value change will become smaller, and derivation will be effective only for a short period of time.
If β is tuned down, the derivative effect for the setting value change will become larger, short-period oscillation will occur, and sometimes the system will be unstable.

The response performance for the setting value change when α is changed is as follows.
Fast: $\alpha = 0$, Medium: $\alpha = 0.65$, Slow: $\alpha = 1$
(Here $\beta = 1$. The derivative operation for the setting value change makes manipulated variable change sharply (kick), which can shock the operation terminal and process. Therefore, it is common to set β to 1 to disable the derivative operation for the setting value change.)

2-degree-of-freedom advanced PID control

The 2-degree-of-freedom advanced PID control tag FB (M+M_2PIDH_) is an advanced tag FB made by adding functions, such as the MV compensation, PV compensation, temperature/pressure correction, tag stop, PV tracking, preset MV, MV rate-of-change limiter, and cascade direct, to the 2-degree-of-freedom PID control tag FB (M+M_2PID). From simple controls to advanced controls such as the variable gain PID control, compensation operation, correction operation, and feedforward control, this tag FB can be used in a wide range of controls. The following table shows the main internal functions.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.9 2-degree-of-freedom Advanced PID Control (Enable Tracking for primary loop) (M+M_2PIDH_T)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.10 2-degree-of-freedom Advanced PID Control (Disable Tracking for primary loop) (M+M_2PIDH_T)

Process amount input area	PID operation area	Operation output area
• Range check (Sensor error detection) • Input limiter • Digital filter • Temperature/pressure correction • Square root extraction • Broken line correction • First order lag filter • PV compensation • ΔPV compensation • Processing at a sensor error • Upper upper limit/upper limit /lower limit/lower lower limit check • PV rate-of-change check • Alarm detection prohibition	• SV rate-of-change limiter • SV upper/lower limiter • PV tracking (PV → SV) • Deviation check • 2-degree-of-freedom PID operation • Alarm detection prohibition • Auto tuning • Integration stop switch • Derivation stop switch • Loop stop/execution	• ΔMV compensation • ΔMV variable gain compensation • ΔMV integration • MV compensation • Preset MV output • MV hold • MV tracking • MV rate-of-change, upper/lower limiter • Anti-reset windup • MV reverse • Output conversion • Alarm detection prohibition • Processing at a sensor error • Cascade direct

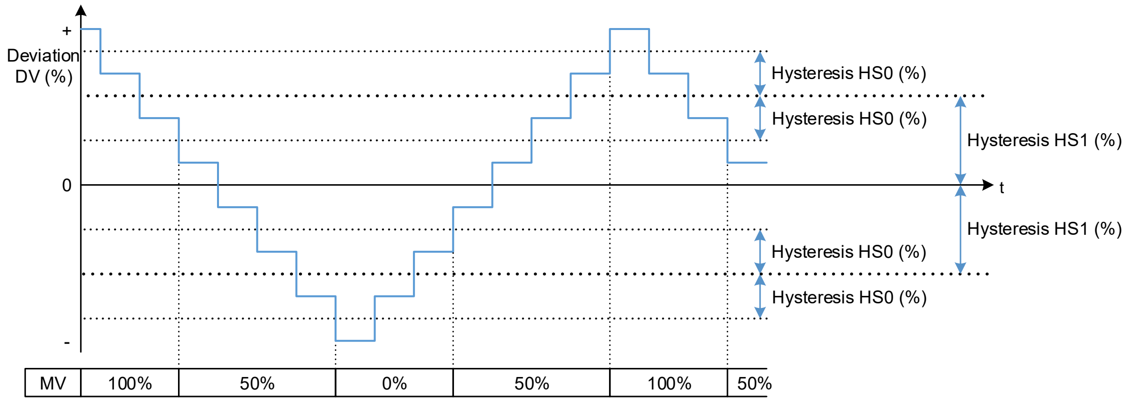
<3>

3 position ON/OFF control

This is a control method that outputs three steps of MV signals for deviation to control the system.

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.25 3 position ON/OFF Control (Enable Tracking for primary loop) (M+M_ONF3_T)

Reference: MELSEC iQ-R Programming Manual (Process Control Function Blocks/Instruction) 17.26 3 position ON/OFF Control (Disable Tracking for primary loop) (M+M_ONF3_T)



Direct action: DV (%) = PV (%) - SV (%)
Reverse action: DV (%) = SV (%) - PV (%)

SV (%) = {(SV - Lower limit of engineering variable) / (Upper limit of engineering variable - Lower limit of engineering variable)} × 100
PV (%) = {(PV - Lower limit of engineering variable) / (Upper limit of engineering variable - Lower limit of engineering variable)} × 100
Hysteresis (%) is the percentage of the value obtained by (Upper limit of engineering variable - Lower limit of engineering variable).

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