Chapter 7 Usage of Various Functions

7.1 Built-in Functions

7.1.1 High-speed counter function

This chapter describes the specification, handling, and programming of built-in high speed counter of GM7. The built-in high speed counter of GM7 (Hereafter called HSC) has the following features;

3 counter functions as followings
- 1-phase up / down counter : Up / down is selected by user program
- 1-phase up / down counter : Up / down is selected by external B phase input
- 2-phase up / down counter : Up / down is automatically selected by the phase difference between A-phase and B.

Multiplication (1, 2, or 4) with 2-phase counter
- 2-phase pulse input multiplied by one : Counts the pulse at the leading edge of A-phase.
- 2-phase pulse input multiplied by two : Counts the pulse at the leading / falling edge of A-phase.
- 2-phase pulse input multiplied by four : Counts the pulse at the leading / falling edge of A-phase and B

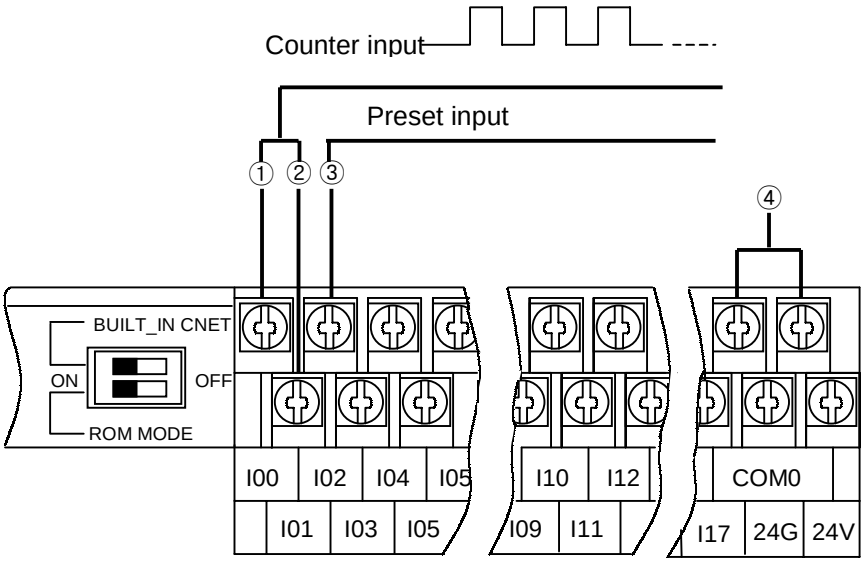
1) Performance Specifications

Items		Specifications
Input signal	Types	A-phase, B-phase, Preset
	Rated level	24VDC (15mA)
	Signal type	Voltage input
Counting range		0 ~ 16,777,215 (Binary 24 bits)
Max. counting speed		1-phase 16kHz/ 2-phase 8kHz
Up / Down selection	1-phase	Sequence program or B-phase input
	2-phase	Auto-select by phase difference of A-phase and B
Multiplication		1, 2, or 4
Preset input		Sequence program or external preset input

2) Input specification

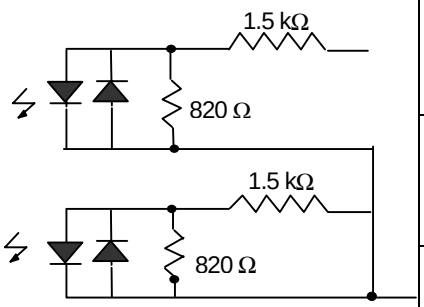
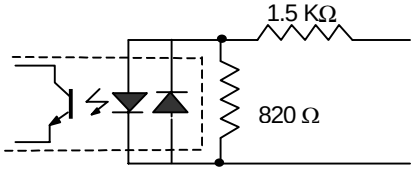
Items		Specifications
A / B phase	Rated input	24VDC (15mA)
	On voltage	14VDC or higher
	Off voltage	2.5VDC or lower
Preset input	Rated input	24VDC (15mA)
	On voltage	19VDC or higher
	Off voltage	6V or lower
	On delay time	Less than 1.5ms
	Off delay time	Less than 2ms

3) Names of wiring terminals



No.	Terminal No.	Names	Usage
①	I00	ϕ A 24V	A Phase input terminal
②	I01	ϕ B 24V	B Phase input terminal
③	I02	Preset 24V	Preset input terminal
④	COM0	Common input	Common terminal

4) External interface circuit

I/O	Internal circuit	Terminal No.	Signal name	Operation	Input warranted voltage
Input		I00	A-phase pulse Input (DC24V)	On	14 ~ 26.4 V
				Off	2.5V 이하
		I01	B-phase pulse Input (DC24V)	On	14 ~ 26.4 V
				Off	2.5V or lower
		COM0	COM (input common)	——	
Input		I02	Preset input (DC24V)	On	19 ~ 26.4 V
				Off	6V or lower
		COM0	COM (input Common)	——	

5) Wiring instructions

A high speed pulse input is sensitive to the external noise and should be handled with special care. When wiring the built-in high speed counter of GM7, take the following precautions against wiring noise.

(1) Be sure to use shielded twisted pair cables. Also provide Class 3 grounding.

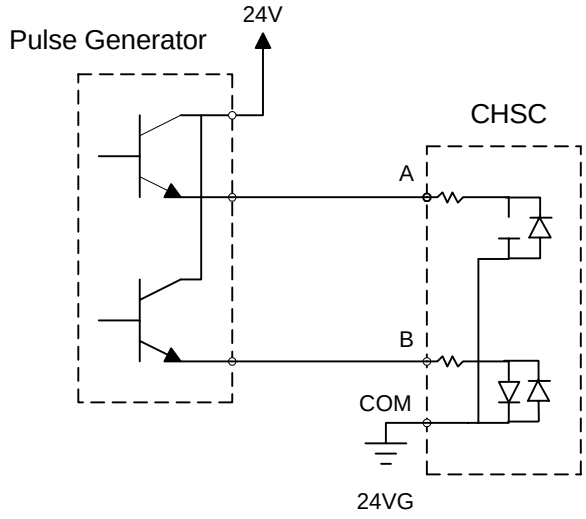
(2) Do not run a twisted pair cable in parallel with power cables or other I/O lines which may generate noise.

(3) Before applying a power source for pulse generator, be sure to use a noise-protected power supply.

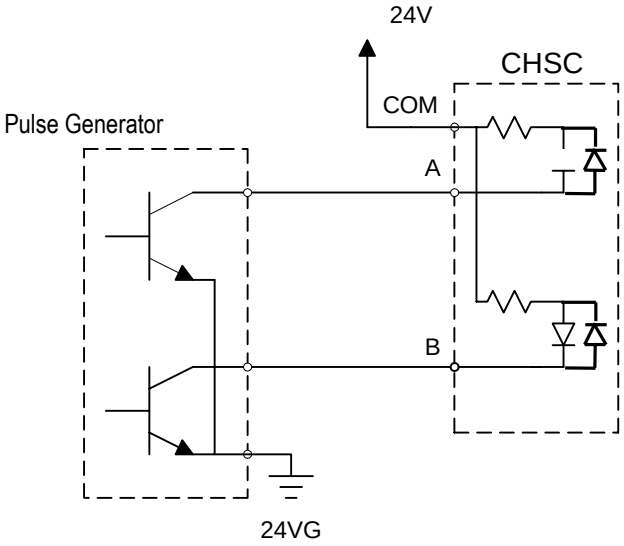
(4) For 1-phase input, connect the count input signal only to the phase A input; for 2-phase input, connect to phases A and B.

6) Wiring example

(1) Voltage output pulse generator

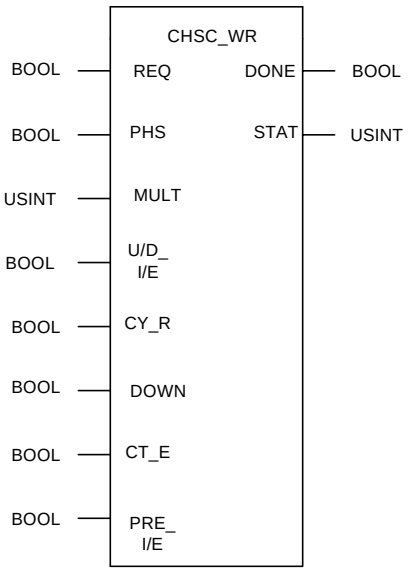


(2) open collector output pulse genernator



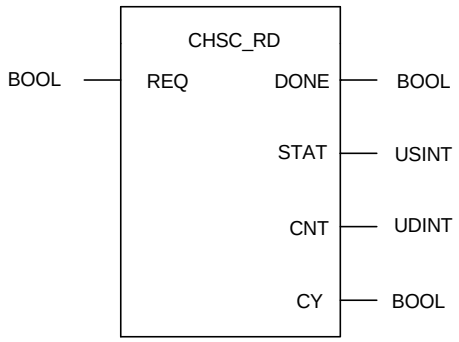
7) Function block

(1) Writing the operating information(CHSC_WR)

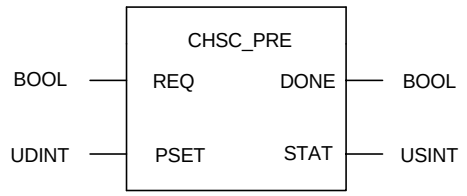
FUNCTION BLOCK	Description
	Input REQ : Request signal of F/B execution PHS : Operation modes selection 0 (1-phase counter), 1(2-phase counter) MULT : Assign the multiplication factor (MULT = 1, 2, or 4) U/D_I/E : Assign the count direction(up/down) selector 0 : Set by sequence program 1 : Set by B-phase input signal (1:up-count, 0:down-count) CY_R : Carry reset signal (1: reset). DOWN : Select the count direction (0:up/1:down) when the counter is set as 1-phase counter and up/down is selected by sequence program. (PHS=0 & U/D_I/E=0) CT_E : Counter enable signal (0 : Counter disable, 1 : Enable) PRE_I/E : Assign PRESET input 0 : PRESET by sequence program 1 : PRESET by external input at the PRESET terminal Output DONE : Turns on after the F/B is executed with no error. STAT : Indicate the operation status of F/B

- The MULT input will be dummy input when the HSC is set as 1-phase counter (PHS = 0). When the HSC is set as 2-phase counter, the U/D_I/E and DOWN input will be dummy input. (PHS = 1)
- The current value of HSC will be cleared as 0 when the CT_E (counter enable) is 0.

(2) Reading the current value and operation status of HSC(CHSC_RD)

FUNCTION BLOCK	Description
	**Input** REQ : Request signal for F/B execution **Output** DONE : Turns on after the F/B is executed with no error. STAT : Indicates the operation status of F/B CNT : The current value of HSC (0 ~ 16,777,215) CY : Carry flag (0 : OFF, 1 : ON)

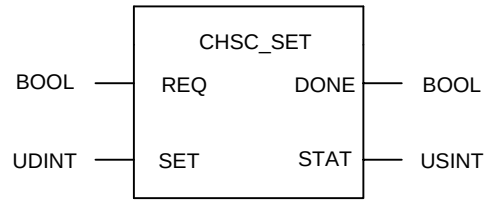
(3) Set the preset value of HSC(CHSC_PRE)

FUNCTION BLOCK	Description
	**Input** REQ : Request signal for F/B execution PSET : Set the preset value (0 ~ 16,777,215) **Output** DONE : Turns on after the F/B is executed with no error. STAT : Indicates the operation status of F/B

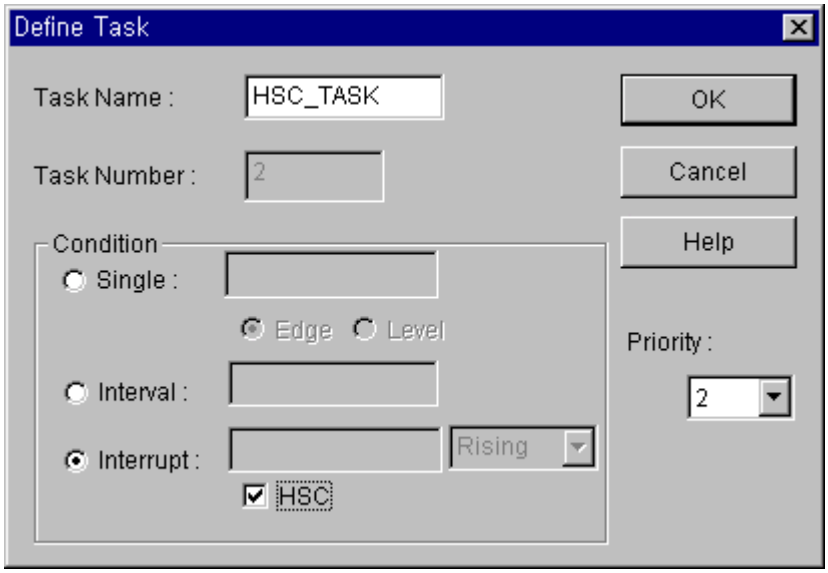
- When the PRE_I/E is set as 0 (Preset input by sequence program), the current value of HSC is changed as the signed preset value with the rising edge of REQ input.
- When the PRE_I/E is set as 1 (Preset input by external preset input), the current value of HSC is changed as the assigned preset value with the rising edge of external preset input. At this time, the REQ input of CHSC_PRE is ignored.
- The CY output is set off while the CHSC_PRE F/B is executing.
- The CHSC_PRE F/B is disabled while the CT_E input of CHSC_WR F/B is 0 (Counter disabled).

(4) Setting up comparison value

Assign a setting value to be compared with the current of HSC.

FUNCTION BLOCK	Description
	**Input** REQ : Request signal for F/B execution SET : Set a setting value (0 ~ 16,777,215) **Output** DONE : Turns on after the F/B is executed with no error. STAT : Indicates the operation status of F/B

Run a task program when the current value of HSC reaches to the setting value.
To run a task program, define a high speed counter task program as following figure, and write a task program.



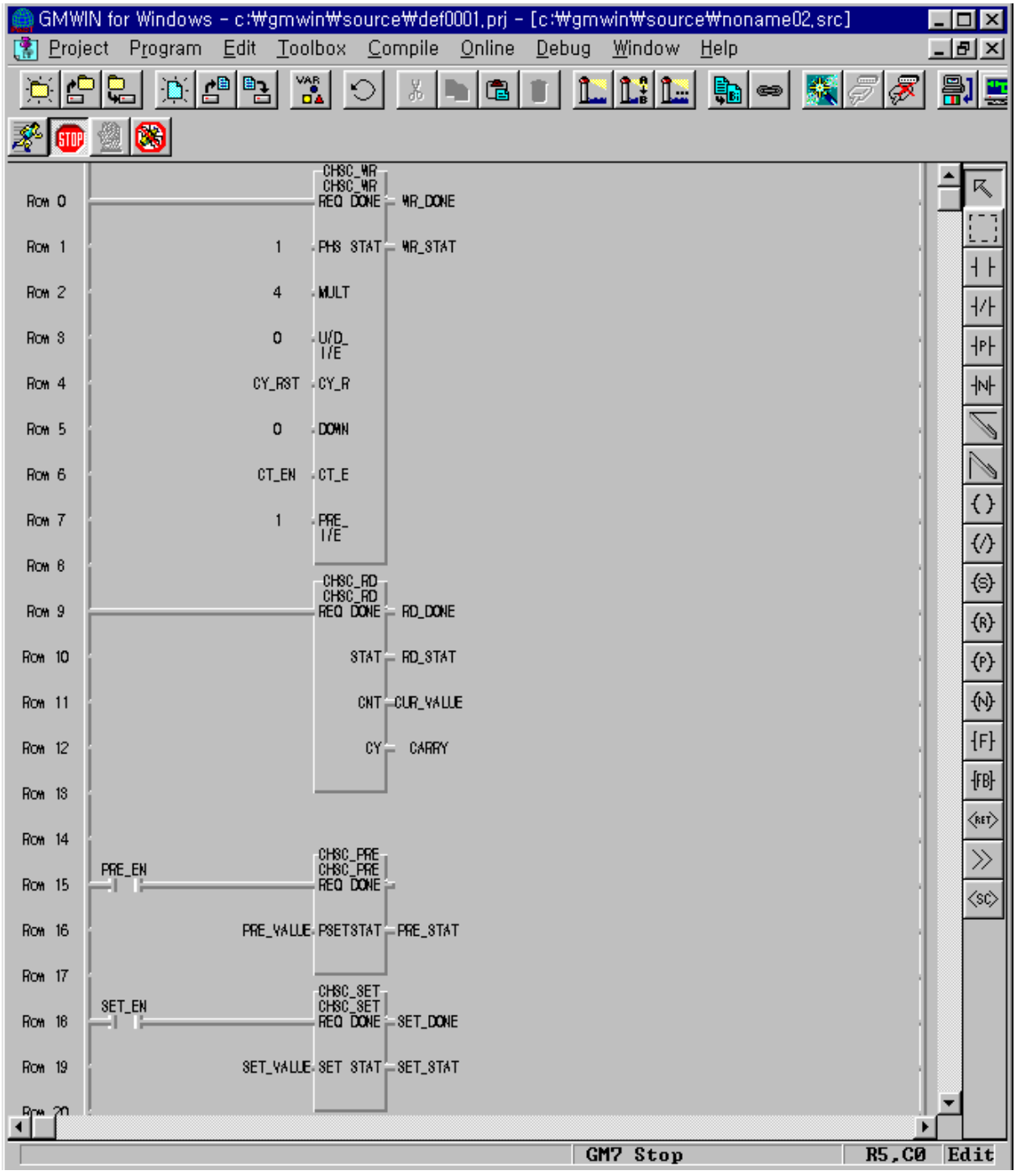
(5) Error code of F/B

The following table shows error codes appear at the STAT output.

Error code	Description
00	No error
01	-
02	Input data error at MULT input of CHSC_WR (When the number is not one of 1, 2, 4 on the 2-Phase Mode)
03	PSET (CHSC_PRE) or SET (CHSC_SET) is out of specified range (0 ~ 16,777,215).
04	Execute Preset command while the HSC is disabled status

8) Example of the program

This is an 4 multiplication example when the preset is designated by the external preset input.

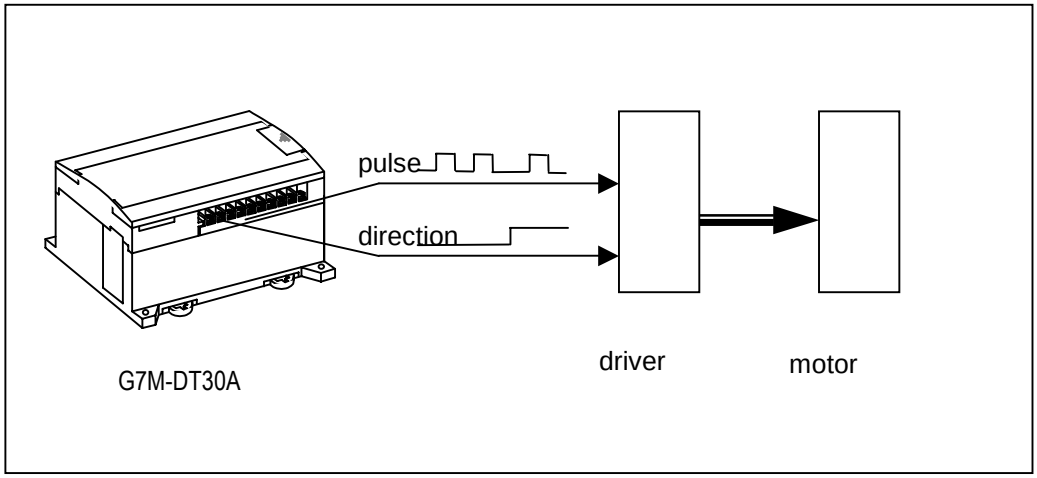


7.1.2. Pulse Output Function

In the transistor output type of GM7, the pulse output function - maximum 2Kpps - is internalized. By using this function with stepping motor or servo motor driver, GM7 is applicable to a simple positioning system.

1) Usage of the Pulse Output

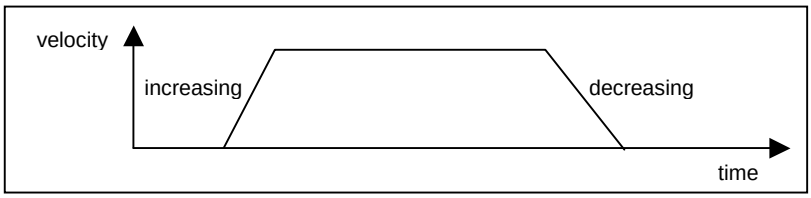
Transistor output type of GM7 outputs the signals of pulse and direction in an output contact point through the function block of the pulse output (PULS_OUT). The outputted pulse is connected to motor driver it is controlled position in the following figure.



Choose a mode from the pulse out function block (PULS_OUT) and operate following 3 modes

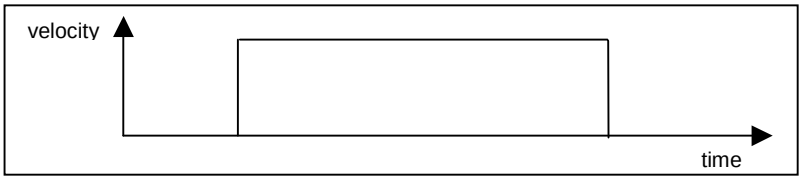
(1) Trapezoidal operation

The pulse output function operates in order of acceleration – uniform velocity – deceleration.



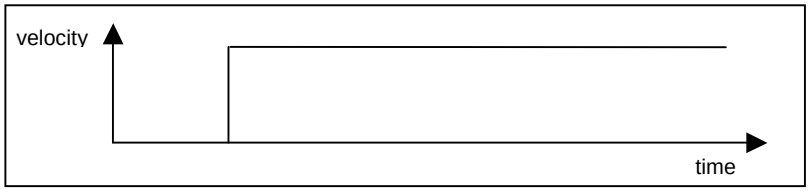
(2) Uniform velocity operation

Operates with the uniform velocity without increasing/decreasing operation



(3) Infinite operation

Operate infinitely without an increasing/decreasing operation until meet the emergency stop command.



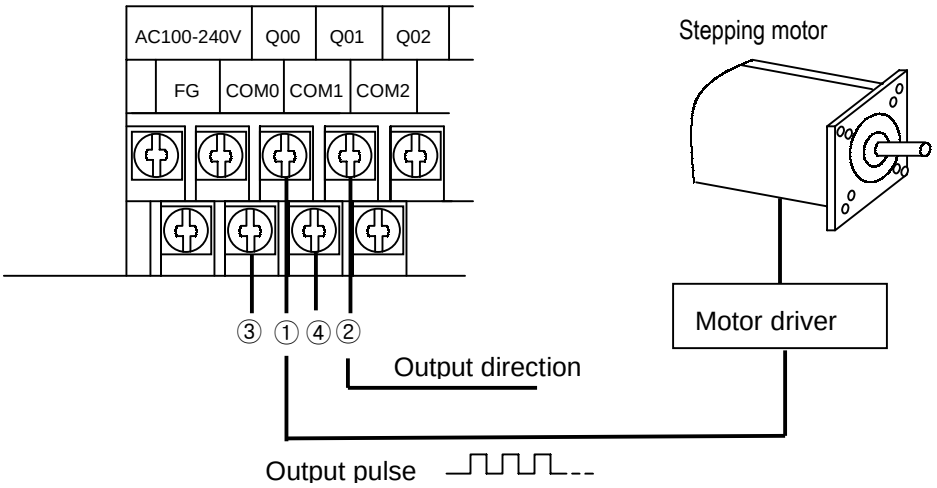
2) Functional Specification

Item	Specification
No. of output	1 point
Output type	Pulse
Output velocity	Max 2Kpps, Min 50pps
Output pulse	0 ~ 2147483647
Execution type of the increasing/decreasing velocity	Designation of acceleration
Type of the direction designation	Right/opposite direction pulse output
Load power supply	DC 12V/24V
Usable range of the load power supply	DC10.2 ~ 26.4V
Maximum load current	150mA
Initiative electric current	Less than 0.4A, 10ms
Maximum power dropdown under On	Less than DC 0.5V
Electric current leakage under Off	Less than 0.1mA
On delayed time	Less than 1ms
Off delayed time	Less than 1ms

Remark

1) Several points can be used for the pulse output point if they are not output at the same time. Thus it is possible that right direction pulse is output as %QX0.0.0, opposite direction pulse is output as %QX0.0.1.

3) Names of parts

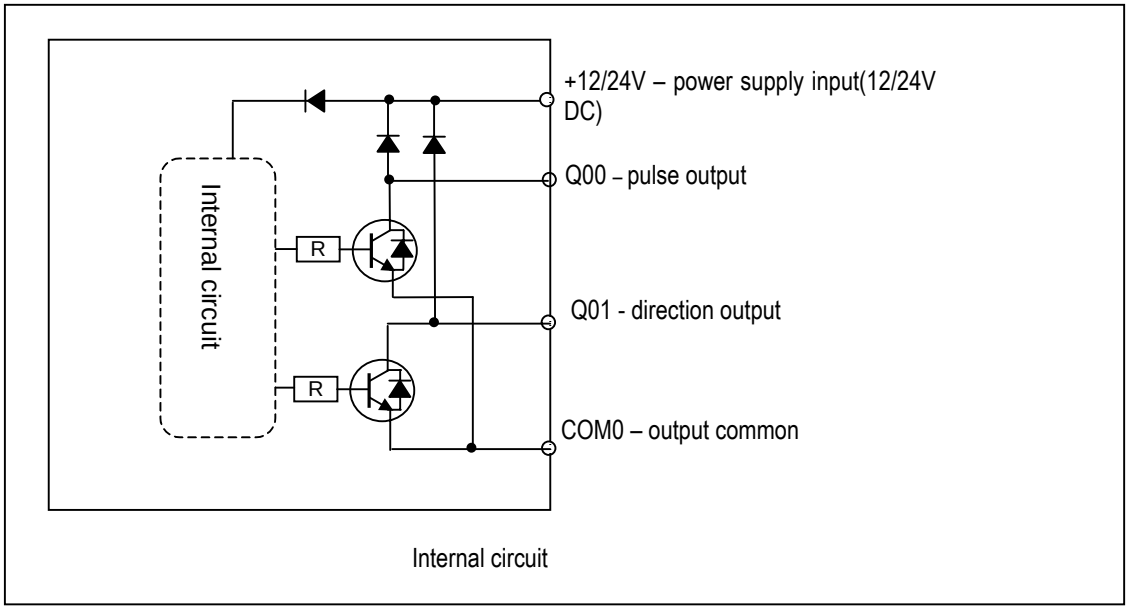


No.	Terminal No.	Names	Usage
①	Q00	Pulse output	Pulse output terminal of right direction
②	COM0	Common	Pulse output common terminal
③	Q01	Direction output	Direction output terminal
④	COM0	Common	Direction output common terminal

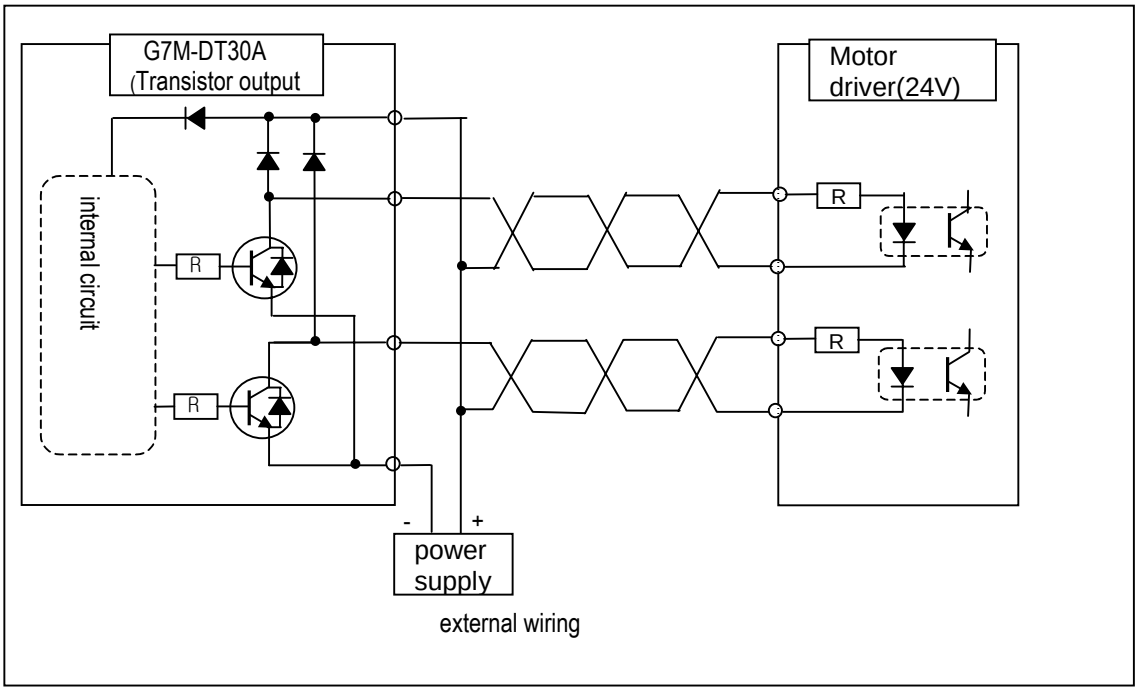
Remark

If the motor drive is not input direction, but is input right/opposite direction pulse (the opposite direction pulse can be output through using 2 function blocks (PULS_OUT) to Q01 contact point

4) Internal circuit and external wiring



Internal circuit



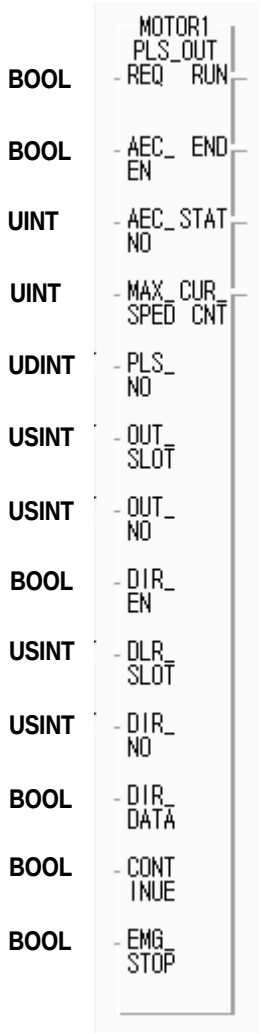
external wiring

Remark

Be careful about the counter plan of the noise during the wiring in the pulse output.
1) Use twisted pair shields wire for wiring and execute 3rd contact point.
2) Be sure to separate from the power supply line and I/O lines on which noise usually occurs.
3) Length of wire should be as short as possible.
4) Be sure to use the stable power supply for the pulse output and separate it from I/O power supply.

5) Function Block

(1) Pulse Output (PLS_OUT) Function Block

Function Block	Explanation
	**Input** REQ: Request to execute the function block (operating by rising edge) AEC_EN: designation of increasing/decreasing velocity operation 0: uniform velocity operation 1: increasing/decreasing velocity operation AEC_NO: Increasing/decreasing operating is direct proportion to the ratio of the inclination I/O velocity and setting up value *6) refers to operating exp. MAX_SPED: output cycle of the max. Pulse Range of setting up: 50~2000(pps) Can be set up by the multiple of 50 PLS_NO: No. of the pulse output Range of setting up: 0~4294967295 OUT_SLOT: designation slot number contact point for the pulse output OUT_NO: designation number of contact point for the pulse output DIR_EN: designation whether the usage of direction output or not. 0: No direction output 1: using direction output *6) refers to operating exp. DIR_SLOT: Designation slot number of contact point for direction signal output DIR_NO: Designation number of contact point for direction signal output DIR_DATA: Direction output data 0: right direction 1: opposite direction CONTINUE: Designation infinite operation 0: uniform velocity or I/D velocity operation 1: Infinite operation before stop order EMG_STOP: Stop order Immediate stop without decreasing velocity while EMG_STOP goes 1 during the operation **Output** RUN: remark status of pulse output 0: during stop 1: during pulse output END: remark status of operation 0: during pulse output 1: during stop CUR_CNT: remark no. of current pulse output

(2) Function Block Error List

Error status	Contents	Treatment
00	Normal	-
01	Other PLC_OUT F/B's pulsating.	Change the other PLC_OUT F/B's program.
02	Velocity designation error (more than 2000, not a multiple of 50, designated 0)	Velocity designation adjustment
03	The no. of I/D velocity pulse is bigger than no. of all pulse is to output.	Acceleration adjustment
04	No output contact point where is designated to the pulse output	Output contact point designation
05	No output contact point where is designated to the direction output	Output contact point designation

6) Operating explanation

(1) Increasing/Decreasing velocity inclination

It can be adapted for initiative point and end point of pulse output operation.
- Increasing velocity inclination: inclination, which is from velocity 0 to designated max. Output cycle.
- Decreasing velocity inclination: inclination, which is from designated, limited value of velocity-to-velocity 0.

Remark

Increasing velocity inclination and decreasing velocity inclination of GM7 pulse output are set up as the same. Set up proper value by the sort of motor because if I/D velocity increases, the arrival time to the designated max. Cycle also increases.

Condition 1)

Set up as AEC_NO = 1, MAX_SPED = 1000, PLS_NO = 5000.

I/D inclination is 1, output cycle of max. Pulse is 1000pps and the no. Of the output pulse Is 5000.

① If I/D velocity inclination is 1, 1 pulse is output on the 1st step (velocity: 50pps).
Pulse velocity is 50pps, so time consuming is 20ms.

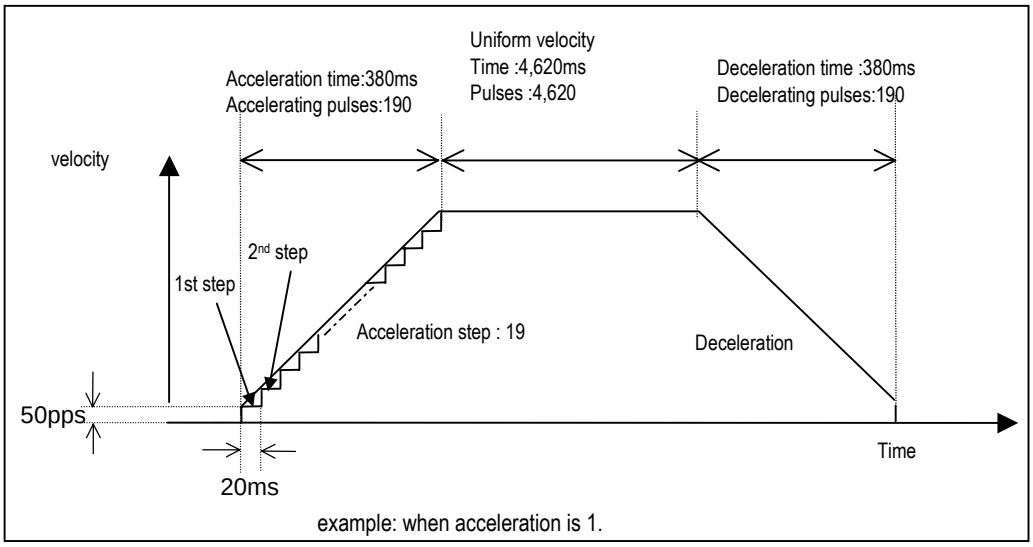
② 2 pulses are output on the 2nd step (velocity: 100pps) and time consumes 20ms

③ By calculation in the same way, the time to reach to 1000pps is
20ms * (20-1) = 380ms, and the no. of output pulses are 1+2+3...+18+19 = 190 units.

④ Decreasing velocity inclination is 1, thus 190 units of pulses are needed.

⑤ The no. of pulses in the uniform velocity region are 5000-190-190=4,620 units.

⑥ Whole spent time is 50,380ms



example: when acceleration is 1.

Condition 2

Set up as AEC_NO = 2, MAX_SPED = 1000, PLS_NO = 5000.

I/D inclination is 2, output cycle of max. pulse is 1000pps and the no. of the output pulse is 5000.

① If I/D velocity inclination is 2, 2 pulses are output on the 1st step(velocity: 50pps). Pulse velocity is 50pps. So time consuming is 40ms.

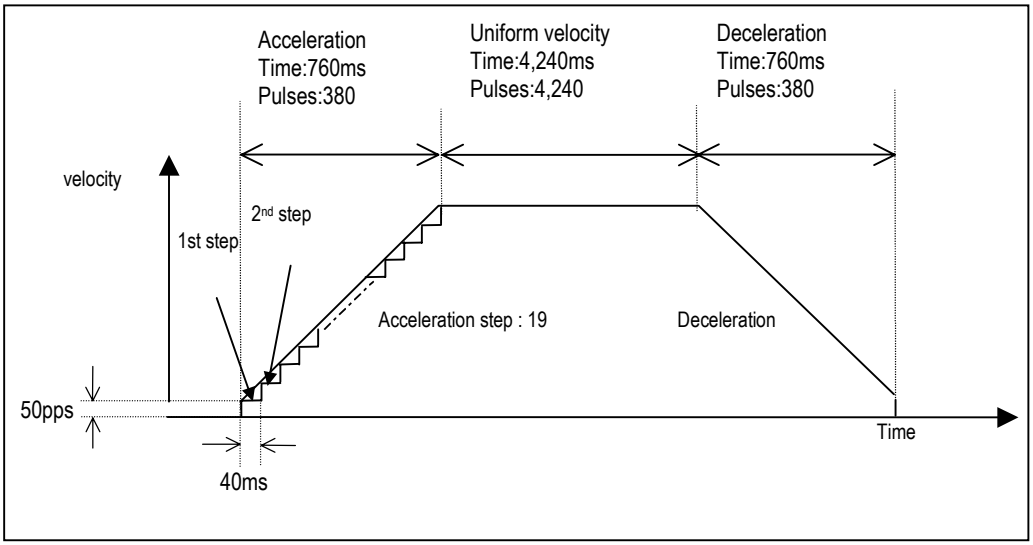
② 4 pulses are output on the 2nd step(velocity: 100pps) and time consumes 20ms

③ By calculation in the same way, the time to reach to 1000pps is 40ms * (20-1) = 760ms, and the no. of output pulses are 2+4+6...+36+38 = 380 units.

④ Decreasing velocity inclination is 2, thus 380 units of pulses are needed.

⑤ The no. of pulses in the uniform velocity region are 5000-380-380=4,240 units.

⑥ Whole spent time is 57,600ms



Example) Acceleration is 2.

Remark

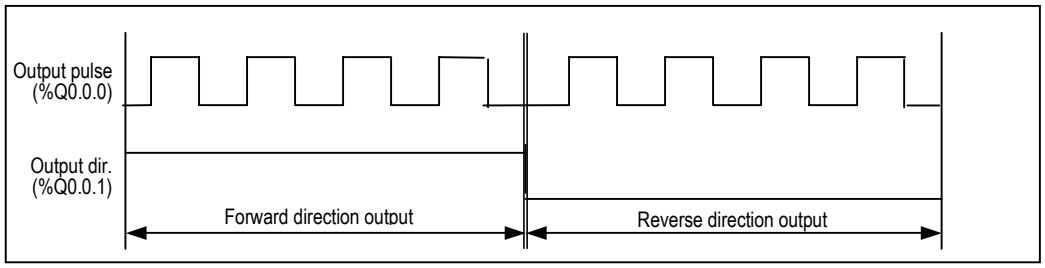
If the increasing velocity inclination goes bigger, the increasing time and pulse go bigger by direct proportion to inclination. Then be careful of an occurring of the function block error when the no. of I/D velocity pulse becomes bigger than the no. of whole pulse.

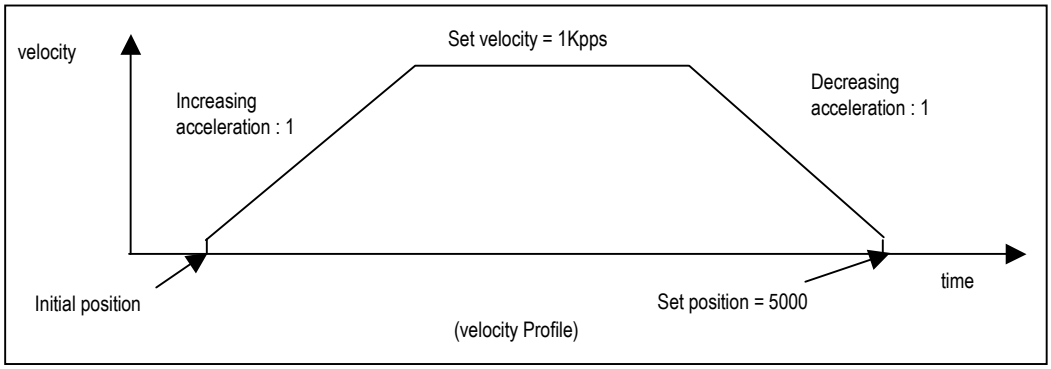
(2) Output Direction

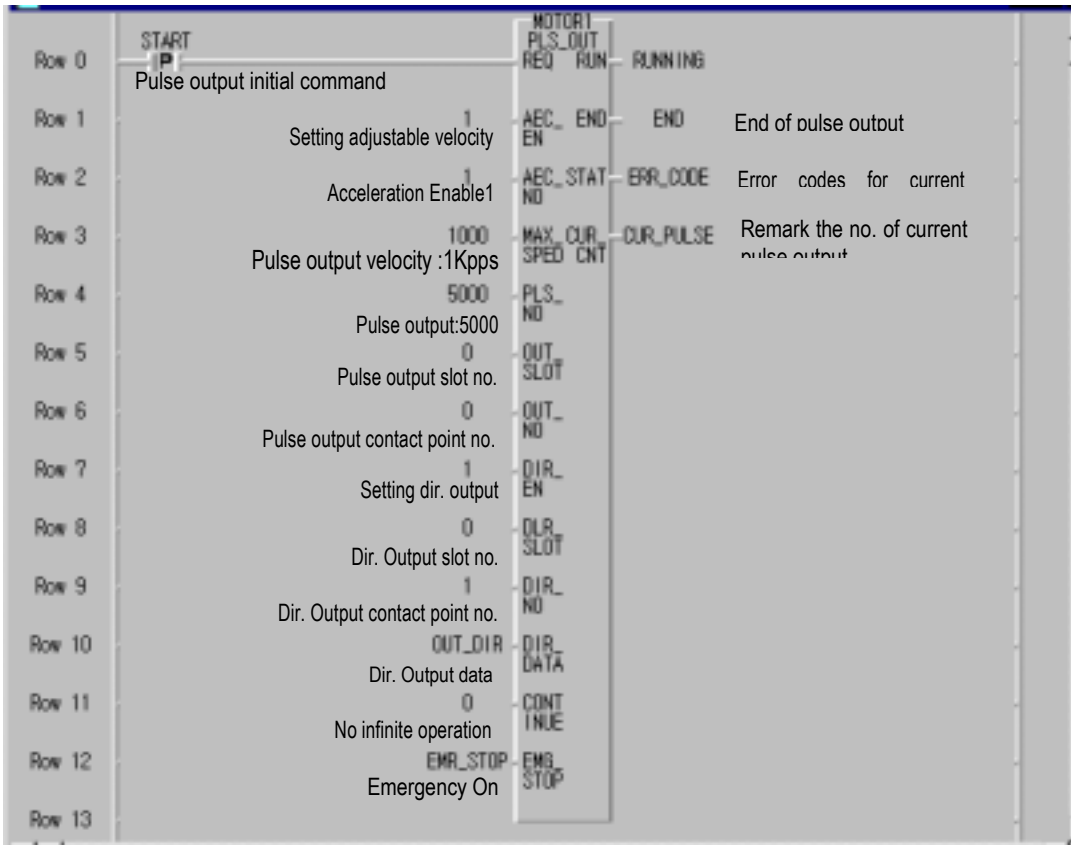
Input type of servo motor driver or stepping motor driver is subdivided into 2. Output direction of control can be selected in the pulse output function block.

a) Selecting method of output direction

(a) When driver gets input forward direction pulse and reverse direction pulse contact point, and the forward/reverse direction signals one levels.

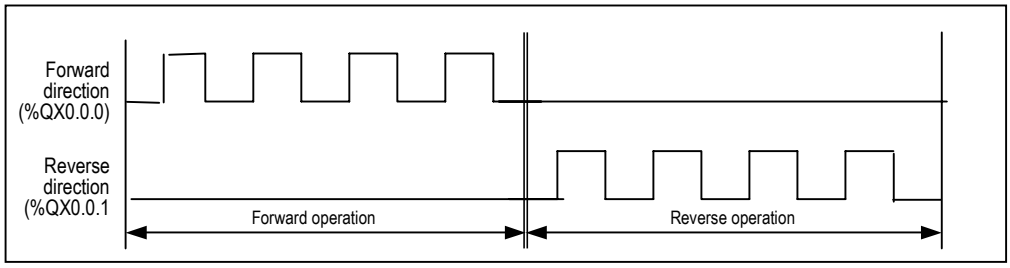


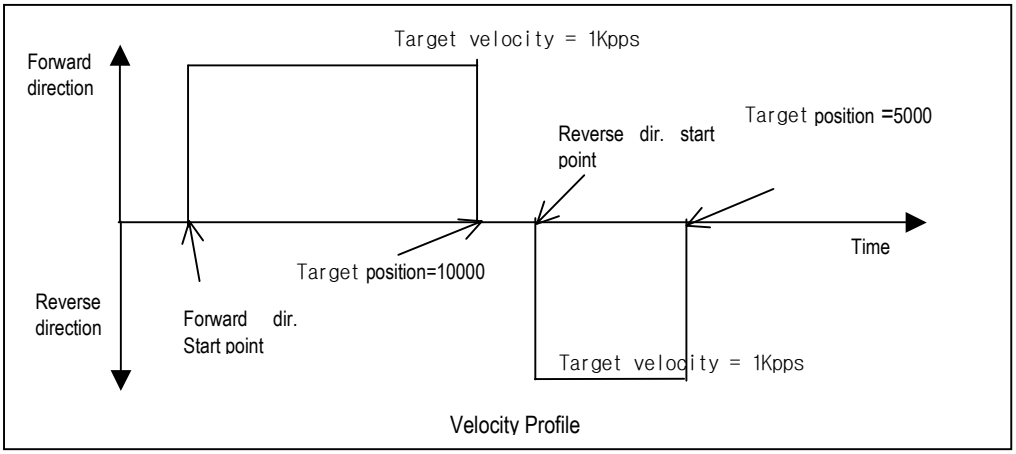




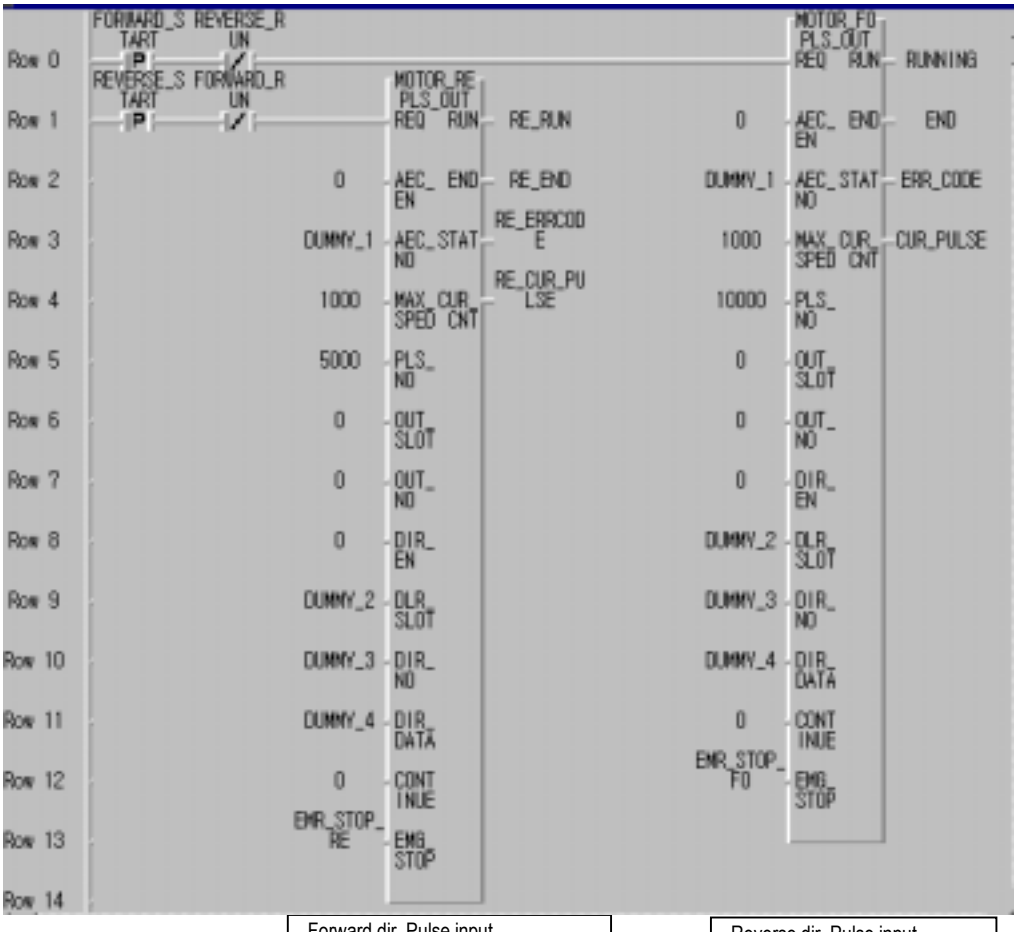
(Example of a program)

(b) Driver gets input forward direction pulse and reverse direction pulse through different contact points.





Velocity Profile



Forward dir. Pulse input

Reverse dir. Pulse input

(Example of a program)

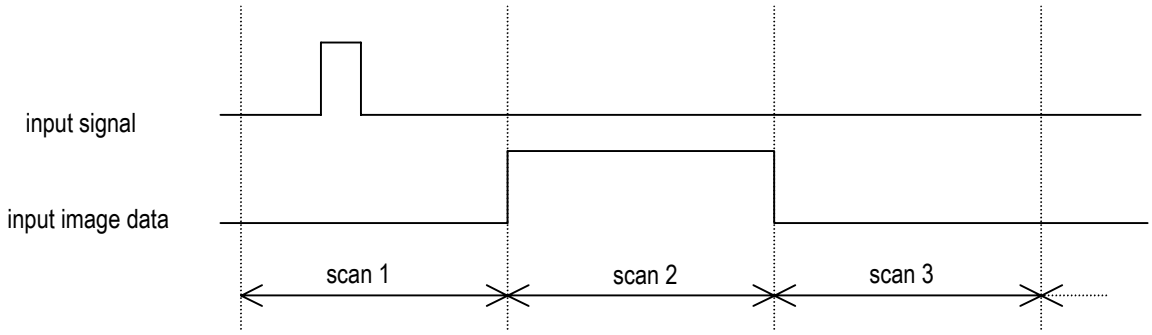
7.1.3. Pulse Catch Function

In the base unit, 8 points of pulse catch input contact points(%IX0.0.0 ~ %IX0.0.7) are internalized. Through using this contact point short pulse signal, short as 0.2ms, can be taken which can not be executed by general digital input.

1) Usage

When narrow width of pulse signal is input, a trouble occurs which can not be executed by general digital input, so the operation does not perform as user's intention. But in this case through pulse catch function even narrow interval of pulse signal as 0.2ms min can be executed.

2) Operating Explanation



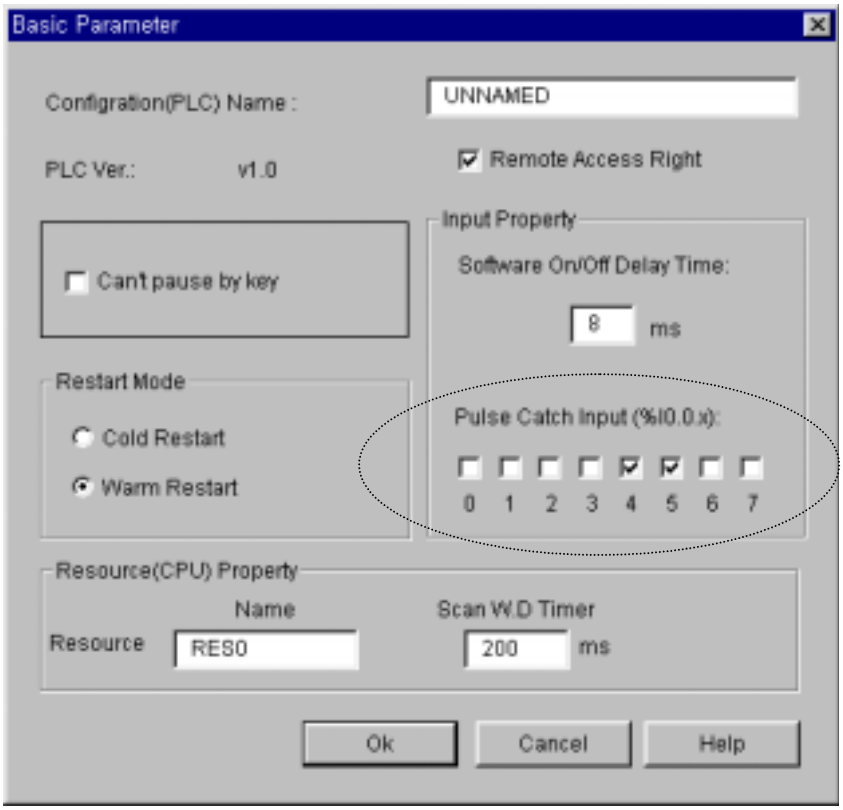
step	executing contents
scan1	CPU senses input when pulse signal, min. 0.2ms, is input, then saves the status.
scan2	used to turn on the region of input image
scan3	used to turn off the region of input image

3) using method

(1) click twice the basic parameter on the project window of GWMIN

(2) Select no. to use for pulse catch input of the basic parameter window.

For details of GMWIN refers to the manual.



Remark

1) 8 points can be used to designate the pulse catch input. The input address is from %IX0.0.0 to %IX0.0.7.
2) General digital input operates if it is not designated as pulse catch input.

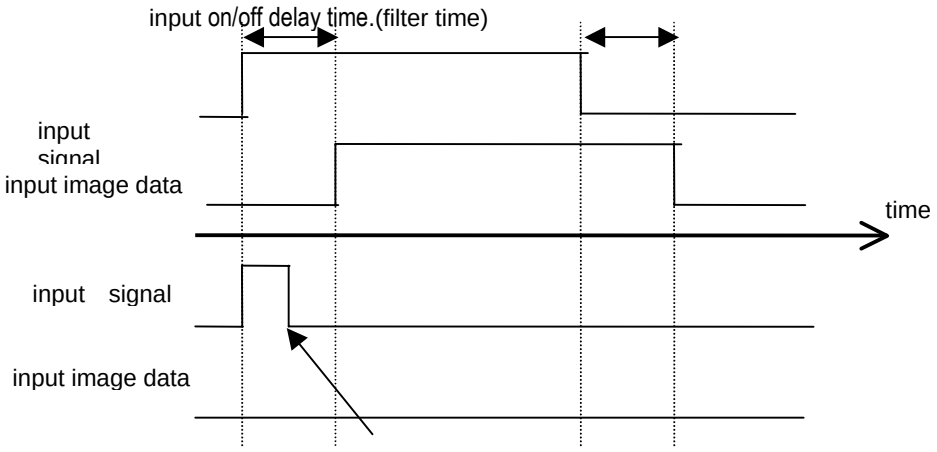
7.1.4. Input Filter Function

External input of GM7 selects input on/off delay time. from the range of 0-15ms of GMWIN. Credibility secured system may be established by adjustment of input correction no. through using environment.

1) Usage

Input signal status affects to the credibility of system in where noise occurs frequently or pulse width of input signal affects as a crucial factor. In this case the user sets up the proper input on/off delay time, then the trouble by miss operation of input signal may be prevented because the signal which is shorter than set up value is not adopted.

2) Operating Explanation



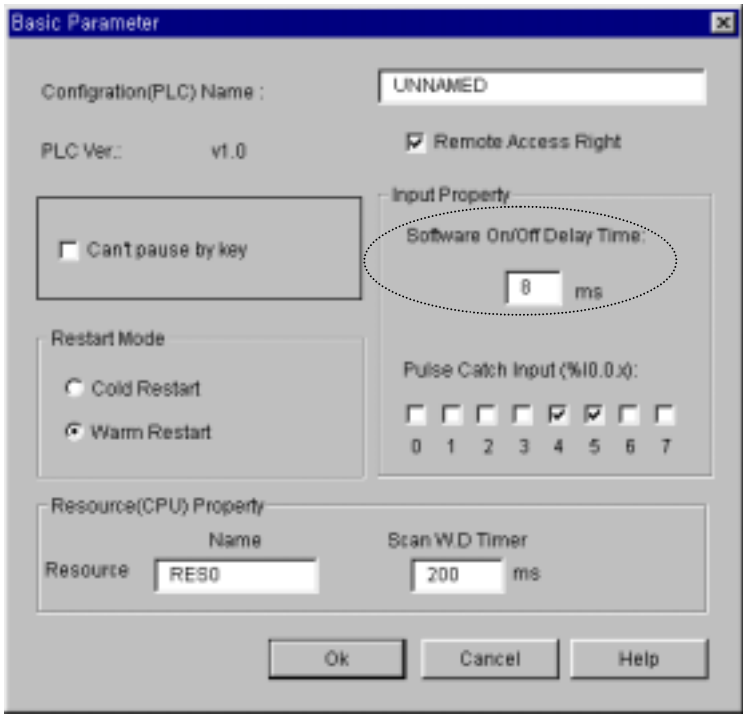
narrower width pulse than input correction no. is not considered as input signal

3) Using method

(1) Click twice the basic parameter on the project window of GMWIN.

(2) The value of filter can be set up as unit of 1ms to the input on/off delay time of the basic parameter window.(Input on/off delay time is set up as default value of 8ms)

(3) Set up input on/off delay time is conformed to all input is used.



7.1.5 PID control function

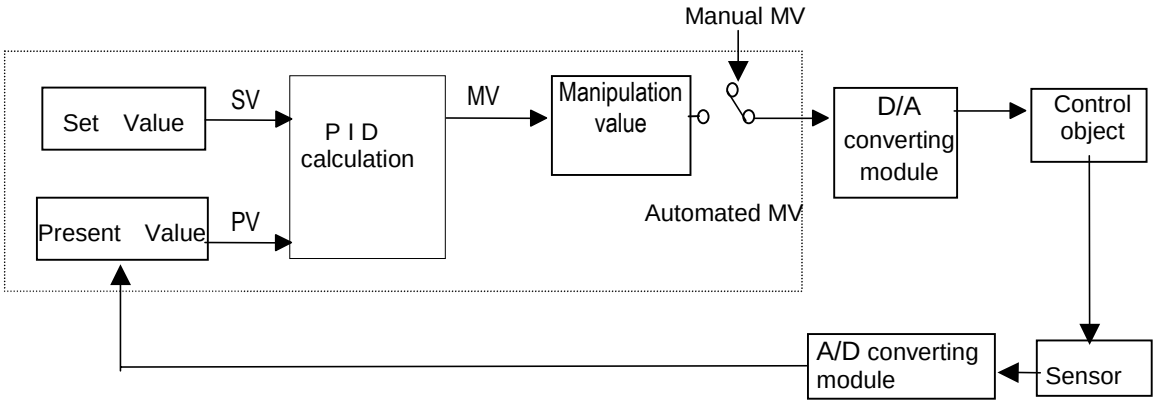
1) Introduction

This chapter will provide information about the built-in PID (Proportional Integral Differential) function of GM7 Basic Unit. The GM7 series does not have separated PID module like GM3 and GM4 series, and the PID function is integrated into the Basic Unit.

The PID control means a control action in order to keep the object at a set value (SV). It compares the SV with a sensor measured value (PV : Present Value) and when a difference between them (E : the deviation) is detected, the controller output the manipulate value (MV) to the actuator to eliminate the difference. The PID control consists of three control actions that are proportional (P), integral (I), and differential (D).

The characteristics of the PID function of GM7 is as following;

- the PID function is integrated into the CPU module. Therefore, all PID control action can be performed with F/B (Function Block) without any separated PID module.
- Forward / reverse operations are available
- P operation, PI operation, PID operation and On/Off operation can be selected easily.
- The manual output (the user-defined forced output) is available.
- By proper parameter setting, it can keep stable operation regardless of external disturbance.
- The operation scan time (the interval that PID controller gets a sampling data from actuator) is changeable for optimizing to the system characteristics.



<Figure 1-1> Flowchart of PID control system

2) Specification

(1) Control operation

a) Proportional operation (P operation)

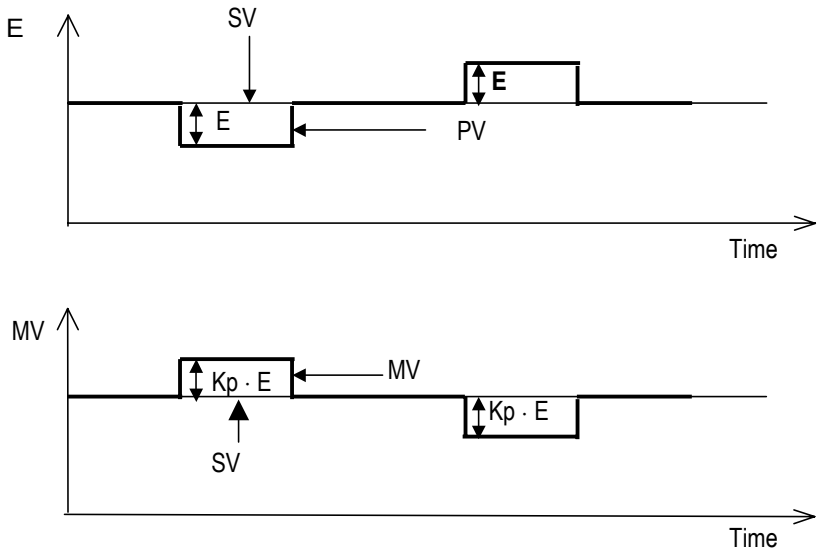
(a) P action means a control action that obtain a manipulate value which is proportional to the deviation (E : the difference between SV and PV)

(b) The deviation (E) is obtained by multiplying a reference value to the actual difference between SV and PV. It prevents the deviation from a sudden change or alteration caused by external disturbance. The formula of deviation is as following;

$$MV = Kp \times [b \times SV - PV]$$

Kp : the proportional constant (gain)
b: reference value
SV: set value
PV: present value

(c) When E happens, MV by P operation is like <Fig 2-1>



<Fig 2-1> MV by P operation

(d) If the Kp is too large, the PV reaches to the SV swiftly, but it may causes a bad effect like oscillations shown in the Fig. 2.2.

(e) If the Kp is too small, oscillation will not occur. However, the PV reaches to the SV slowly and an offset may appear between PV and SV shown in the Fig. 2.3.

(f) The manipulation value (MV) varies from 0 to 4,000. User can define the maximum value of MV (MV_MAX) and minimum value (MV_MIN) within the range 0 ~ 4,000.

(g) When an offset remains after the system is stabilized, the PV can be reached to the SV by adding a certain value. This value is called as bias value, and user can define the bias value

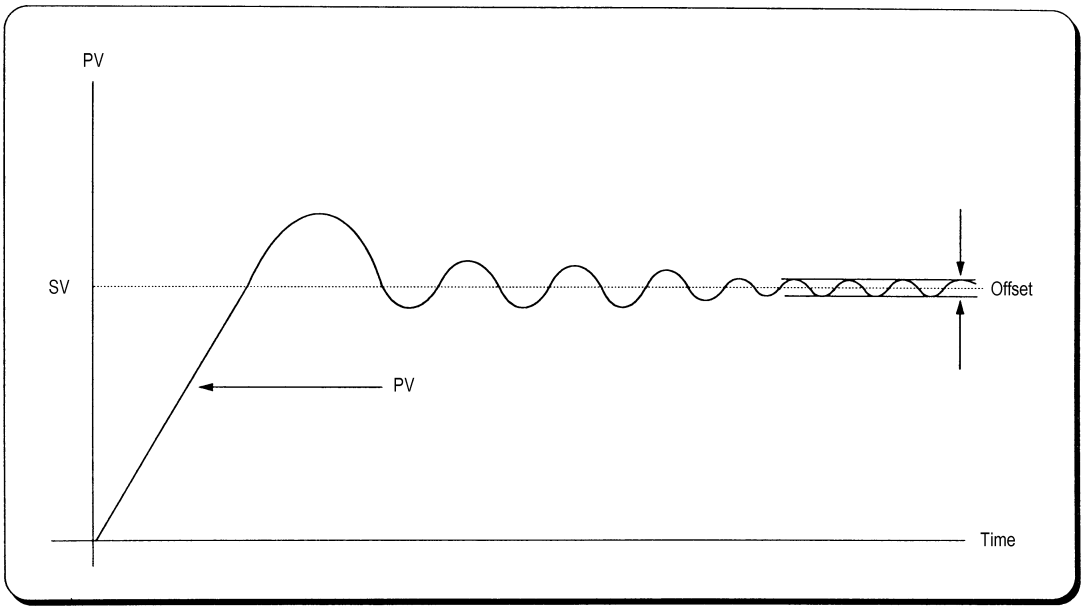


Fig. 2.2 When the proportional constant (Kp) is large

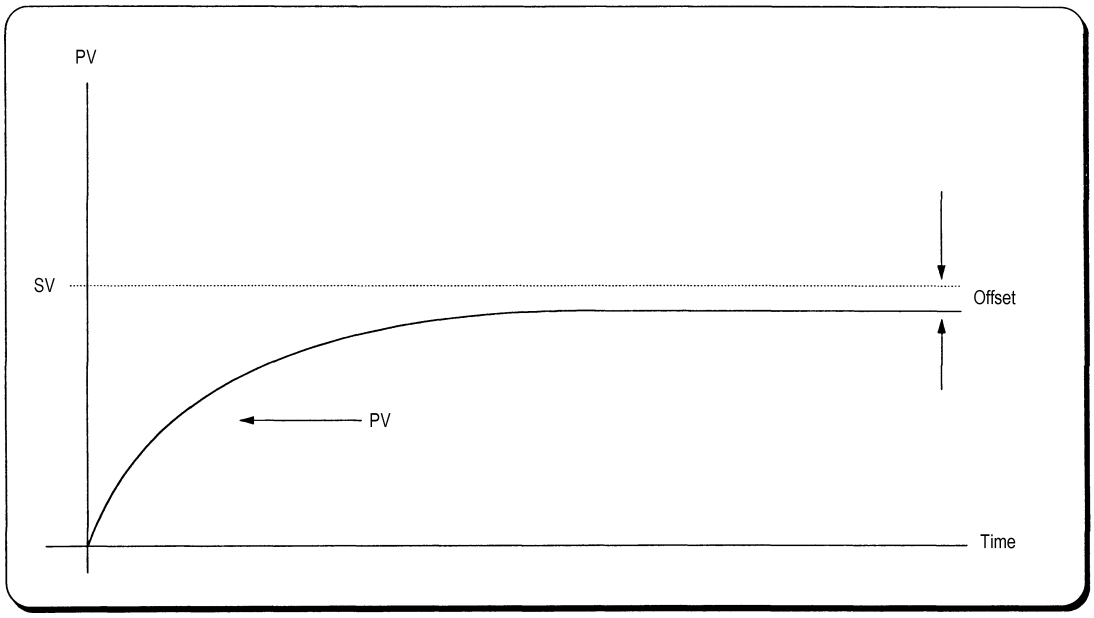


Fig. 2.3 When the proportional constant (Kp) is small

b) Integral operation (I operation)

(a) With integral operation, the manipulate value (MV) is increased or decreased continuously in accordance time in order to eliminate the deviation between the SV and PV. When the deviation is very small, the proportional operation can not produce a proper manipulate value and an offset remains between PV and SV. The integral operation can eliminate the offset value even the deviation is very small.
The period of the time from when the deviation has occurred in I action to when the MV of I action become that of P action is called Integration time and represented as Ti.

(b) Integral action when a constant deviation has occurred is shown as the following Fig. 2.4.

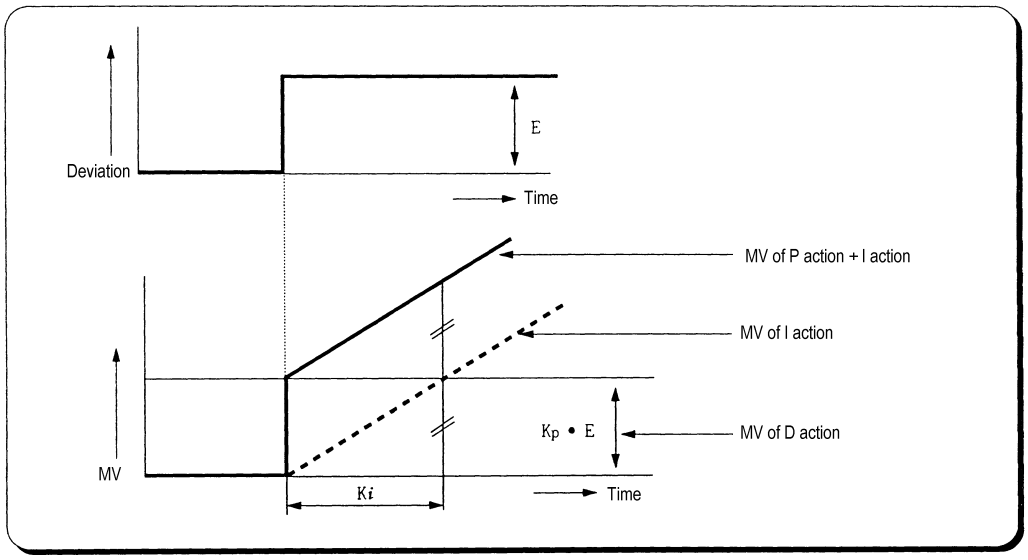


Fig. 2.4 The integral action with constant deviation

(c) The expression of I action is as following;

$$MV = \frac{Kp}{Ti}\int Edt$$

As shown in the expression, Integral action can be made stronger or weaker by adjusting integration time (Ki) in I action.
That is, the more the integration time (the longer the integration time) as shown in Fig. 2.5, the lesser the quantity added to or subtracted from the MV and the longer the time needed for the PV to reach the SV.
As shown in Fig. 2.6, when the integration time given is short the PV will approach the SV in short time since the quantity added or subtracted become increased. But, If the integration time is too short then oscillations occur, therefore, the proper P and I value is requested.

(d) Integral action is used in either PI action in which P action combines with I action or PID action in which P and D actions combine with I action.

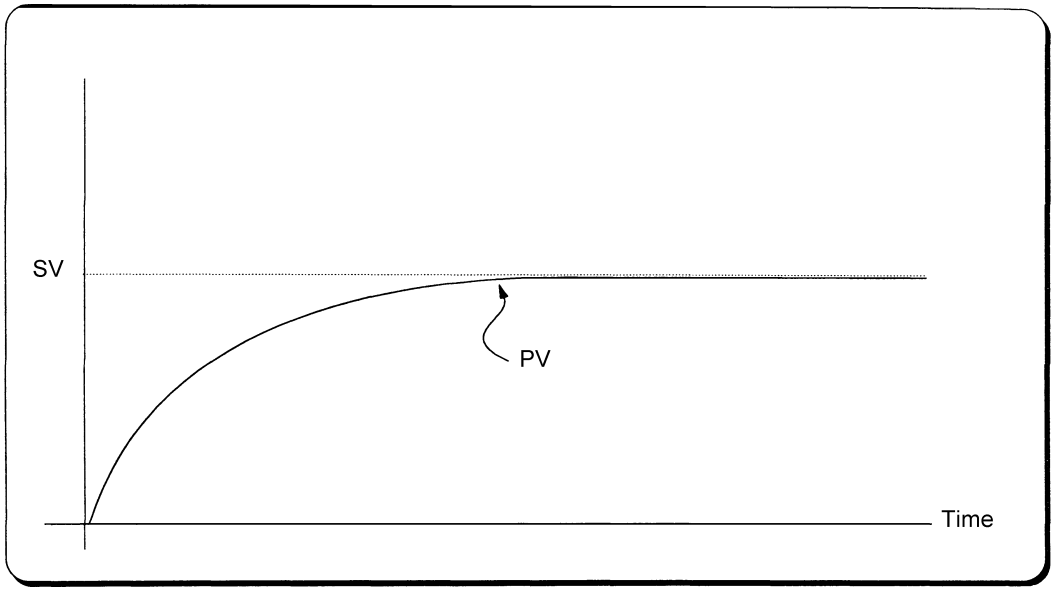


Fig. 2.5 The system response when a long integration time given

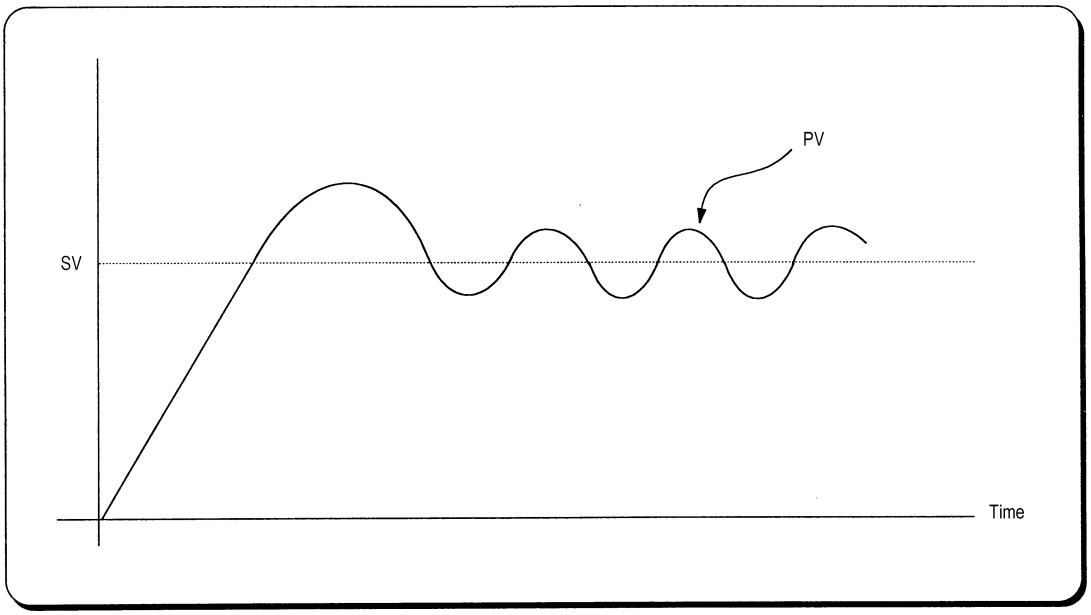


Fig. 2.6 The system response when a short integration time given

c) Derivative operation (D action)

(e) When a deviation occurs due to alteration of SV or external disturbances, D action restrains the changes of the deviation by producing MV which is proportioned with the change velocity (a velocity whose deviation changes at every constant interval) in order to eliminate the deviation.

- D action gives quick response to control action and has an effect to reduce swiftly the deviation by applying a large control action (in the direction that the deviation will be eliminated) at the earlier time that the deviation occurs.
- D action can prevent the large changes of control object due to external conditions.

(f) The period of time from when the deviation has occurred to when the MV of D action become the MV of P action is called derivative time and represented as Kd.

(g) The D action when a constant deviation occurred is shown as Fig. 2.7.

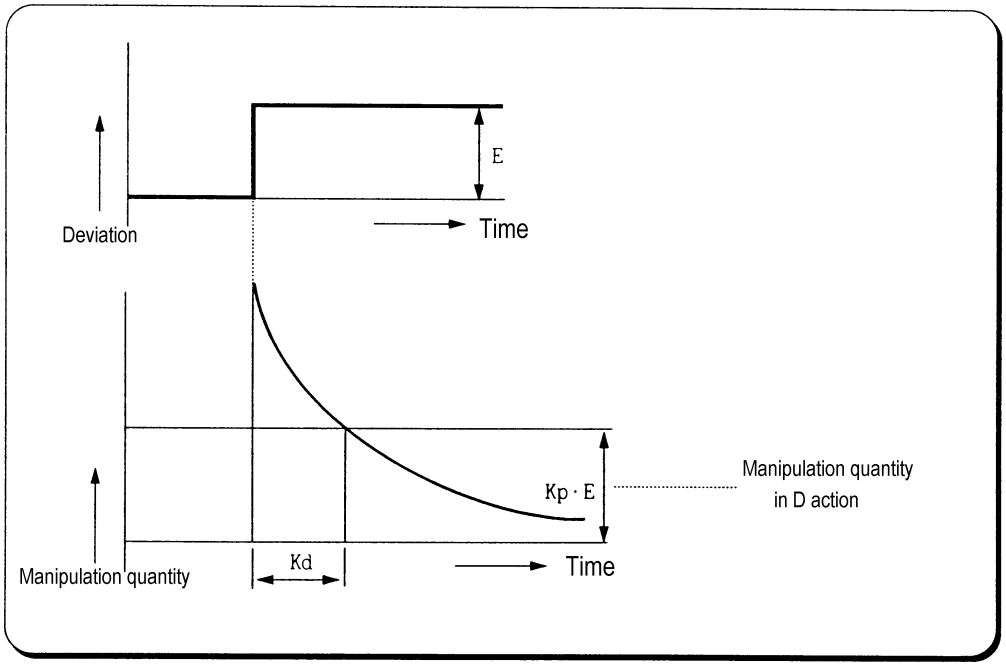


Fig. 2-7 Derivative action with a constant deviation

(h) The expression of D action is as following;

$$MV = Kp \times Td \frac{dE}{dt}$$

(i) Derivative action is used only in PID action in which P and I actions combine with D action.

d) PID action

(a) PID action controls the control object with the manipulation quantity produced by (P+I+D) action

(b) PID action when a given deviation has occurred is shown as the following Fig. 2.8.

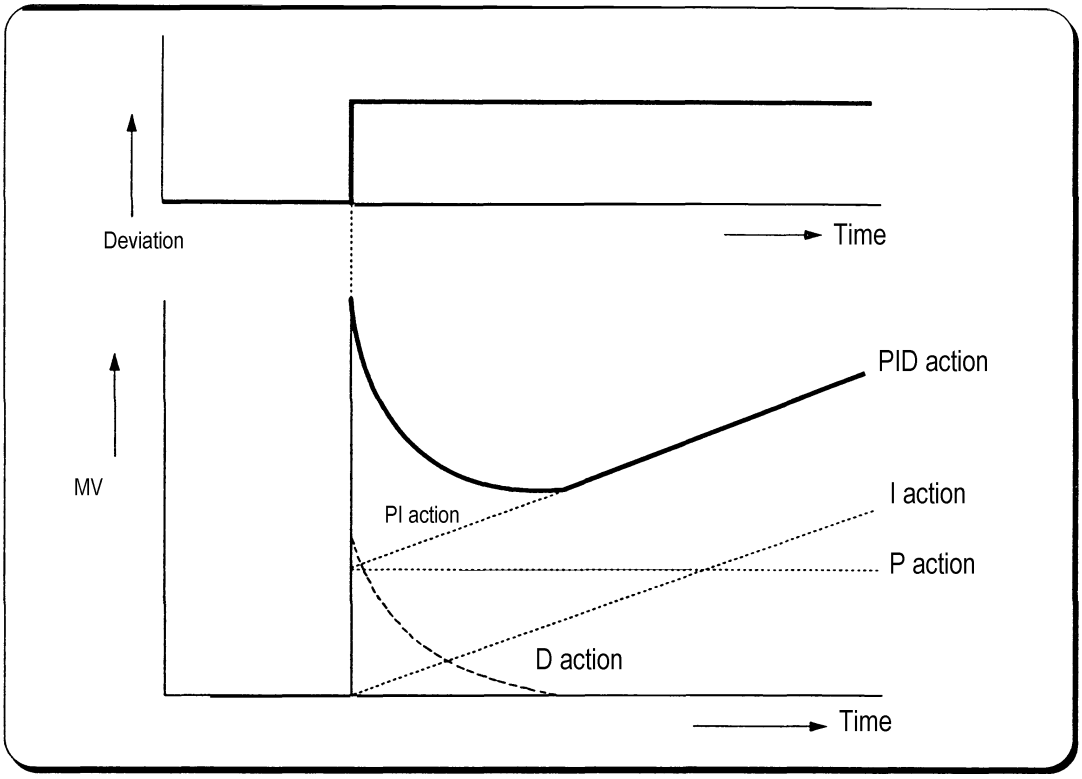


Fig. 2-8 PID action with a constant deviation

e) Forward / Reverse action

(c) PID control has two kind of action, forward action and reverse action. The forward action makes the PV reaches to SV by outputting a positive MV when the PV is less than SV.

(d) A diagram in which forward and reverse actions are drawn using MV, PV and SV is shown as Fig. 2.9.

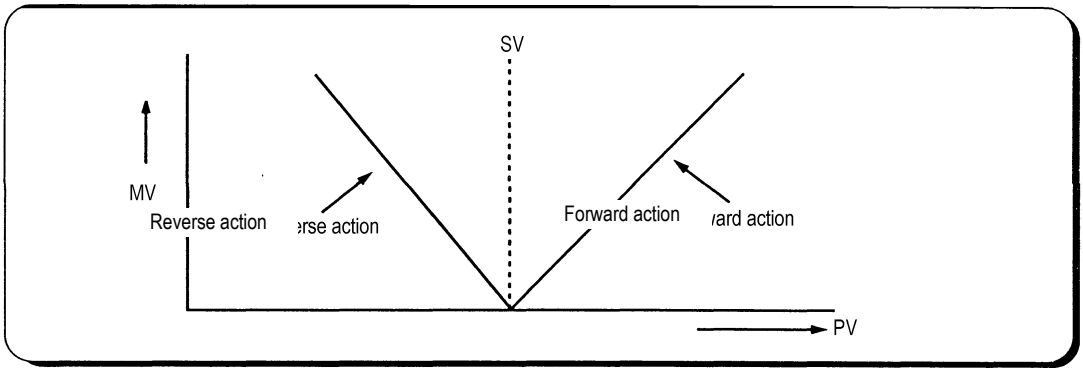


Fig. 2-9 MV of forward / reverse action

(e) Fig 2.10 shows examples of process control by forward and reverse actions, respectively.

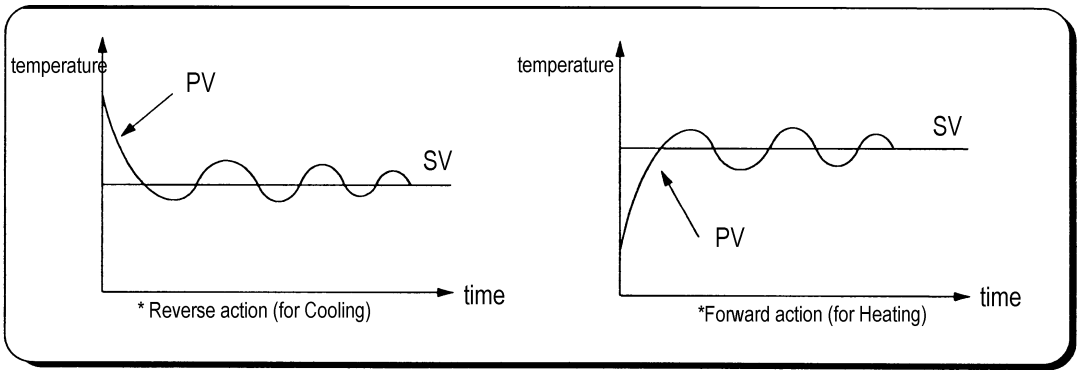


Fig. 2-10 PV of forward / reverse action

f) Reference value

In general feedback control system shown as the Figure 2-10, the deviation value is obtained by the difference of PV and SV. P, I, and D operations are performed based on this deviation value. However, each of P, I, and D operations use different deviation values according to the characteristics of each control actions. The expression of PID control is as following;

$$MV = K\left[Ep + \frac{1}{Ti}\int_0^t Ei(s)ds + Td\,\frac{dEd}{dt} \right]$$

MV : Manipulate value
K: Proportional gain
Ti: Integral time
Td: Derivative time
Ep: Deviation value for proportional action
Ei: Deviation value for integral action
Ed: Deviation value for derivative action

The deviation values of P, I, and D action is described as following equations;

$$Ep = b \times SV - PV$$
$$Ei = SV - PV$$
$$Ed = -PV$$

The b of the first equation is called as reference value. It can be varied according to the load disturbance of measurement noise.

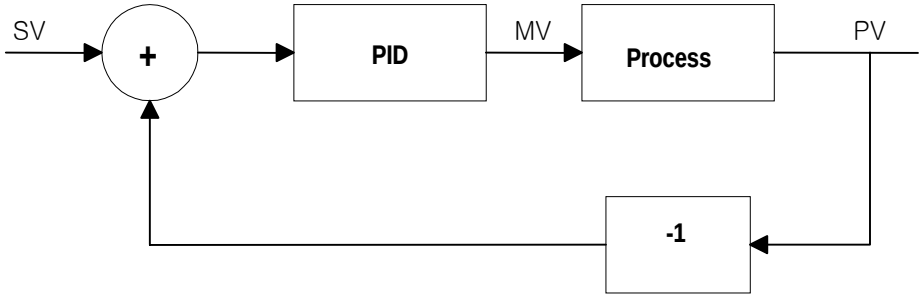


Fig. 2-11 Diagram of simple feedback system

The figure 2.11 shows the variation of PV according to the several different reference values (b). As shown in the Fig. 2.11, the small reference value produces small deviation value, and it makes the control system response be slow.
In general, control system is required to be adaptable to various external / internal changes. Especially, it should shows a stable transient response with the sudden change of the SV to be robust to load disturbances and/or measurement noise.

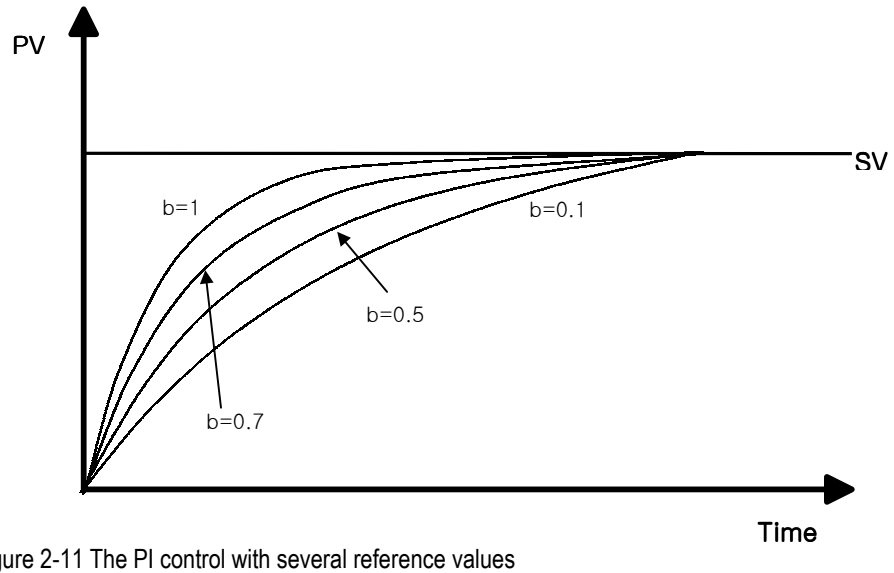
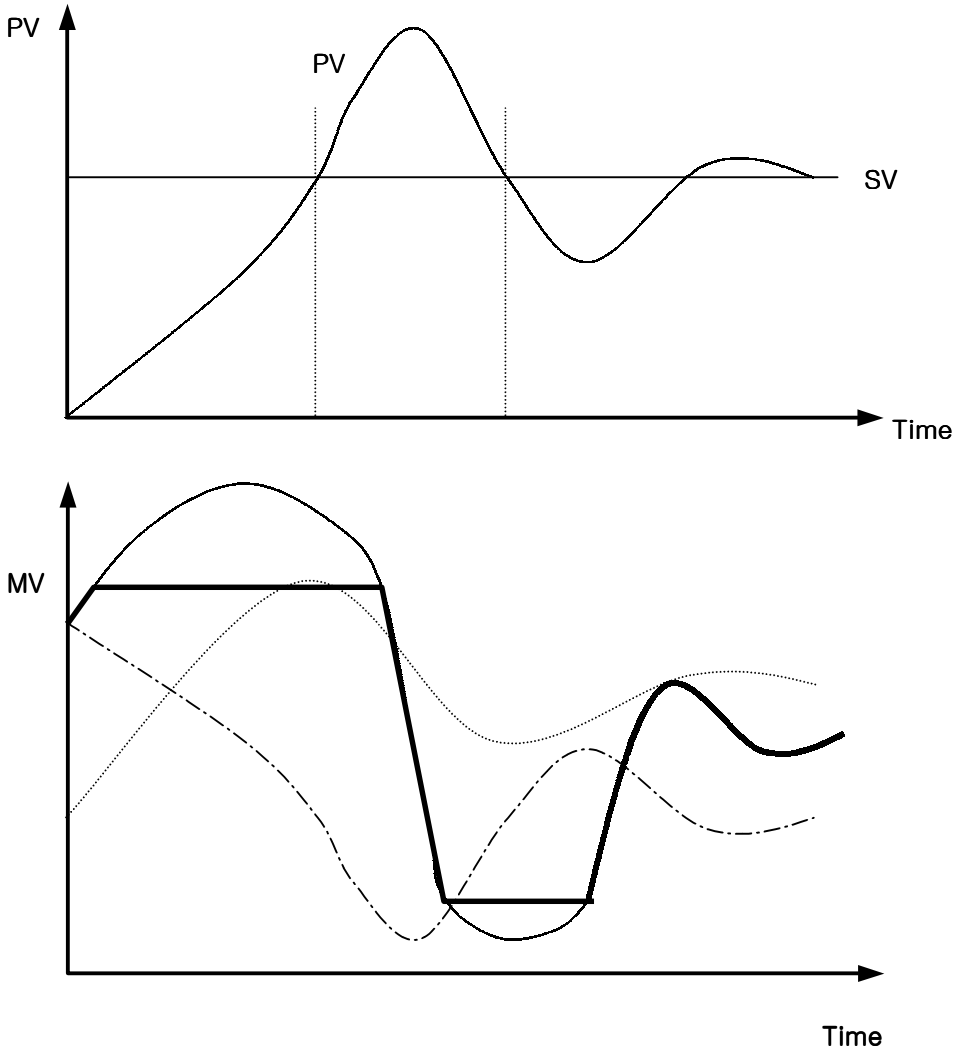


Figure 2-11 The PI control with several reference values

g) Integral windup

All devices to be controlled, actuator, has limitation of operation. The motor has speed limit, the valve can not flow over the maximum value. When the control system has wide PV range, the PV can be over the maximum output value of actuator. At this time, the actuator keeps the maximum output regardless the change of PV while the PV is over the maximum output value of actuator. It can shorten the lifetime of actuator.
When the I control action is used, the deviation term is integrated continuously. It makes the output of I control action very large, especially when the response characteristic of system is slow.
This situation that the output of actuator is saturated, is called as 'windup'. It takes a long time that the actuator returns to normal operating state after the windup was occurred.
The Fig. 2-12 shows the PV and MV of PI control system when the windup occurs. As shown as the Fig. 2-12, the actuator is saturated because of the large initial deviation. The integral term increase until the PV reaches to the SV (deviation = 0), and then start to decrease while the PV is larger than SV (deviation < 0). However, the MV keeps the saturated status until the integral term is small enough to cancel the windup of actuator. As the result of the windup, the actuator will output positive value for a while after the PV reached to the SV, and the system show a large overshoot. A large initial deviation, load disturbance, or mis-operation of devices can cause windup of actuator.



There are several methods to avoid the windup of actuator. The most popular two methods are adding another feedback system to actuator, and using the model of actuator. The Fig. 2-13 shows the block diagram of the anti-windup control system using the actuator model.
As shown in the Fig. 2-13, the anti-windup system feedback the multiplication of gain (1/Tt) and Es to the input of integral term. The Es is obtained as the difference value between actuator output (U) and manipulation value of PID controller (MV). The Tt of the feedback gain is tracking time constant, and it is in inverse proportion with the resetting speed of integral term. Smaller Tt will cancel the windup of actuator faster, but too small Tt can cause anti-windup operation in derivative operation. The Fig. 2-14 shows several Tt value and PV in the PI control system.

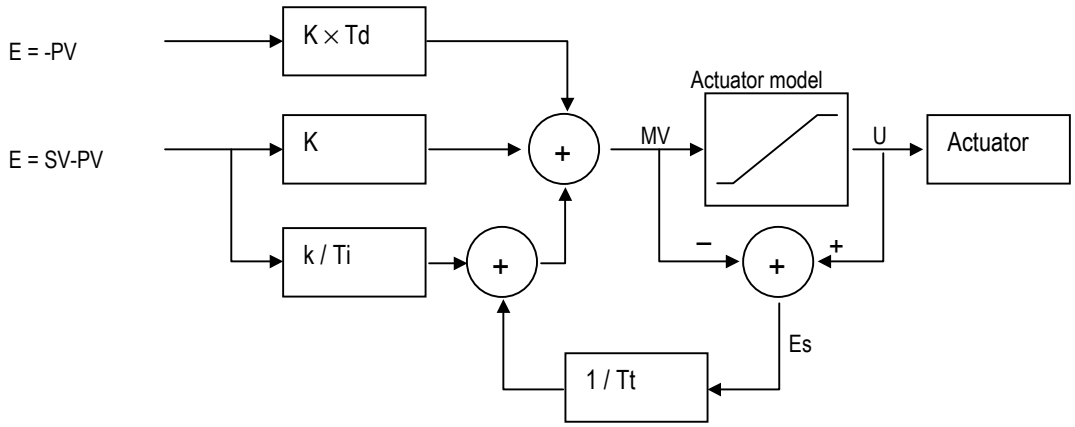


Fig. 2-13 The block diagram of anti-windup control system

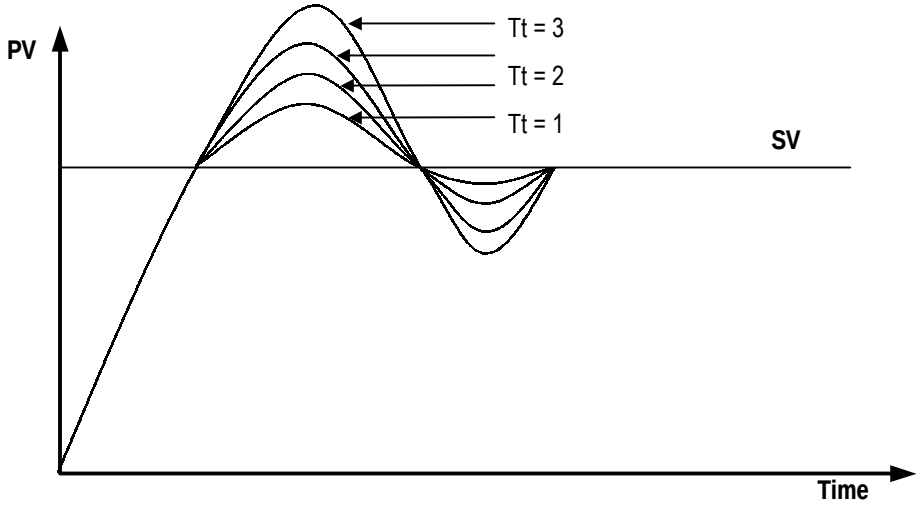


Fig. 2-14 The PV output characteristics with different Tt values.

(2) Realization of PID control on the PLC

In this chapter, it will described that how to get the digitized formula of the P, I, and D terms. Then, the pseudo code of PID control will be shown.

a) P control

The digitized formula of P control is as following;

$$P(n) = K[b \times SV(n) - PV(n)]$$ n : sampling number

K : proportional gain constant
b : reference value
SV : set value
PV : present value

b)I control

The continuous formula of I control is as following;

$$I(t) = \frac{K}{Ti}\int_0^t e(s)ds$$ I(t) : integral term

K : proportional gain constant
Ti : integral time
e(s) : deviation value
By deviation about t, we can obtain;

$$\frac{dI}{dt} = \frac{K}{Ti} e$$ e = (SV – PV) : deviation value

The digitized formula is as following;

$$\frac{I(n+1) - I(n)}{h} = \frac{K}{Ti} e(n)$$ h : sampling period

$$I(n+1) = I(n) + \frac{Kh}{Ti} e(n)$$

c) D control

The continuous formula of derivative term is as following;

$$\frac{Td}{N} \times \frac{d}{dt} D + D = -KTd \frac{dy}{dt}$$

N : high frequency noise depression ration
y : the object to be controlled (PV)

The digitized formula is as following (Use Tustin approximation method)

$$D(n) = \frac{2Td - hN}{2Td + hN} D(n-1) - \frac{2KTdN}{2Td + hN} \left[y(n) - y(n-1) \right]$$

d) Pseudo code of PID control

The pseudo code of PID control is as following;

- Step 1 : Get constants that are used for PID operation

$$Bi = K \times \frac{h}{Ti}$$: integral gain

$$Ad = \frac{(2 \times Td - N \times h)}{(2 \times Td + N \times h)}$$: derivation gain

$$Bd = \frac{(2 \times K \times N \times Td)}{(2 \times Td + N \times h)}$$

$$A0 = \frac{h}{Tt}$$: anti-windup gain

- Step 2 : Read SV and PV value
  PV = adin(ch1)
- Step 3: Calculate the proportional term.
  P = K × (b × SV – PV)
- Step 4 : Update the derivative term. (initial value of D = 0)
  D = As × D – Bd × (PV – PV_old)
- Step 5 : Calculate the MV. (initial value of I = 0)
  MV = P + I + D
- Step 6 : Check the actuator is saturated or not.
  U = sat(MV, U_low, U_high)
- Step 7 : Output the MV value to the D/A module
- Step 8 : Update the integral term.
  I = I + bi × (SV – PV) + A0 × (U – MV)
- Step 9 : Update the PV_old value.
  PV_old = PV

3) Function block

For the PID operation of GM7, following 2 function blocks are included in the GMWIN software. (version 3.3 or later)

No	Name	Description
1	PID7CAL	Perform the PID operation
2	PID7AT	Perform the auto tuning operation

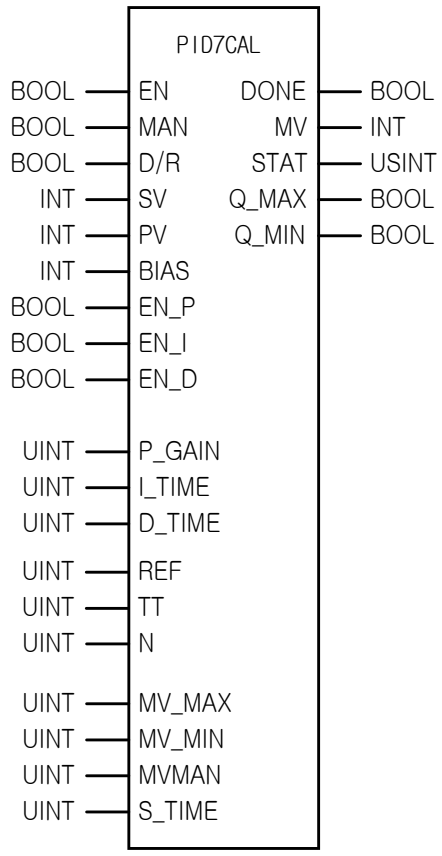
Remarks

1.GM7 PID function blocks do not support array type.

2.Refer the GMWIN manual for the registration and running of function block.

(1) The function block for PID operation (PID7CAL)

a) Description of F/B

Function block	Description
	**Input** EN : enable signal of the PID6CAL F/B MAN : manual operation mode (0 : auto, 1 : manual) D / R : select direction of operation (0 : forward, 1 : reverse) SV(*1) : set value data input (input range : 0 ~ 4000) PV(*1) : present value data input BIAS (*2): feed forward or offset value input for disturbance compensation (input range : 0 ~ 4000) EN_P(*3) : enable signal of proportional control (0 : disable, 1 : enable) EN_I(*3) : enable signal of integral control (0 : disable, 1 : enable) EN_D(*3) : enable signal of derivative control (0 : disable, 1 : enable) P_GAIN(*4) : the proportional gain constant (range : 0.01 ~ 100.00) I_TIME(*5) : the integration time (range : 0.0 ~ 2000.0) D_TIME(*5) : the deviation time (range : 0.0 ~ 2000.0) MV_MAX : the maximum value of MV (range : 0 ~ 4000) MV_MIN : the minimum value of MV (range : 0 ~ 4000) MVMAN : the input data of manual operation mode (range : 0 ~ 4000) S_TIME(*6) : operation scan time (range : 0.1 ~ 10) REF(*7) : the reference value (range : 0.1 ~ 1) TT(*8) : tracking time constant (range : 0.01 ~ 10.00) N(*9) : high frequency noise depression ratio (range : 1 ~ 10) **Output** DONE : completion flag of PID operation MV : output manipulation value (range : 0 ~ 4000) STAT : error code output Q_MAX : shows MV is limited with maximum value Q_MIN : shows MV is limited with minimum value

(*1) SV (setting value : the designated value) and PV (process value : present value) of GM7 PID operation have the range 0 ~ 4000. The range is set with the consideration of the resolution of A/D and D/A module of GM7 series (12 bits) and offset value.
(*2) The BIAS data is used for the compensation of offset in the proportional control.
(*3) In GM7, only the following 4 operation modes are available. Other operation modes, such as PD or I, are not permitted.

No.	EN_P	EN_I	EN_D	Operation
1	1 (enable)	0 (disable)	0 (disable)	P operation
2	1 (enable)	1 (enable)	0 (disable)	PI operation
3	1 (enable)	1 (enable)	1 (enable)	PID operation
4	0 (disable)	0 (disable)	0 (disable)	On/Off operation

(*4) The GM7 can handle only integer, not the floating point type. Therefore, to enhance the accuracy of PID operation, the PID6CAL function block is designed to input the P_GAIN data as the 100 times scaled up. For example, if the designated P_GAIN is 98, actual input data of P_GAIN should be 9800. If the designated P_GAIN is 10.99, input 1099 to the P_GAIN.
(*5) I_TIME and D_TIME are 10 times scaled up. For example, input 18894 if the designated I_TIME value is 1889.4. The range of actual input is 0 ~ 20000.
(*6) S_TIME is the period of reading data (sampling), and also 10 times scaled up. Generally, it should be synchronized with external trigger input (EN input of function block) to perform proper PID operation. The range of sampling time is 0.1 ~ 10 seconds, and actual input range is 0 ~ 100.
(*7) REF may be useful parameter according to the control system type, especially velocity, pressure, or flux control system. The REF input is also 10 times scaled up, and the actual range is 0 ~ 10.
(*8) TT (tracking time constant) parameter is used to cancel anti-windup operation. The range of TT is 0.01 ~ 10 and the actual input range that are 100 times scaled up is 0 ~ 1000.
(*9) N (high frequency noise depression ratio) parameter is used for derivative control operation, and shows the ratio of high frequency noise depression. If there is a lot of high frequency noise in the control system, select the N value as higher value. Otherwise, leave the N parameter as 1. The range of N is 0 ~ 10 and it is not scaled up, so input the designated value directly.

b) The error code of PID7CAL F/B

The following table shows error codes and descriptions of PID7CAL function block.

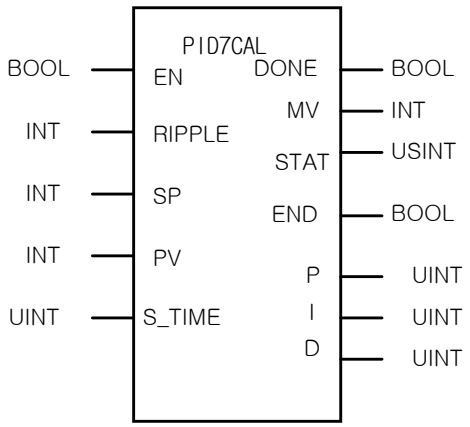
Error code (STAT output)	Description	Countermeasure
0	Normal operation	
1	SV is out of range	Change the SV within 0 ~ 4000
2	MVMAN is out of range	Change the MVMAN within 0 ~ 4000
3	P_GAIN is out of range	Change the P_GAIN within 0 ~ 10000
4	I_TIME is out of range	Change the I_TIME within 0 ~ 20000
5	D_TIME is out of range	Change the D_TIME within 0 ~ 20000
6	S_TIME is out of range	Change the S_TIME within 0 ~ 100
7	REF is out of range	Change the REF within 0 ~ 10
8	TT is out of range	Change the TT within 0 ~ 1000
9	N is out of range	Change the N within 0 ~ 1000
10	EN_I and/or EN_D is set as 1 when EN_P is 0	Only P, PI, and PID controls are available. Please change the setting of EN_P, EN_I, and EN_D.

Remark

1. Please be careful to input 100 times scaled up values for P_GAIN and TT.
2. I_TIME, D_TIME, S_TIME, and REF are 10 times scaled up, not 100 times.

(2) Auto tuning function block (PID7AT)

a) Description of F/B

Function block	Description
	**Input** EN : enable input of function block SV(*1) : set value (goal value) data input (range : 0 ~ 4000) PV (*1): present value input (range : 0 ~ 4000) S_TIME(*2) : scan time input (sampling interval) (range : 0 ~ 100) RIPPLE(*3) : select the wave form to be used for auto tuning operation. Select 1 in general case. **Output** DONE : Turn on whenever the auto tuning operation is completed. END : Turns on when the F/B operation is completed with no error, and keep the status until next F/B execution STAT : shows the error code MV : the manipulated value of current loop on which the auto tuning operation is performed. (range : 0 ~ 4000) P : the proportional gain constant obtained by auto tuning operation. (range : 0.01 ~ 100.00) I : the integral time constant obtained by auto tuning operation. D : the derivative time constant obtained by auto tuning operation

*1)SV (setting value : the designated value) and PV (process value : present value) of GM7 PID operation have the range 0 ~ 4000. The range is set with the consideration of the resolution of A/D and D/A module of GM7 series (12 bits) and offset value. When setting the SV or PV, please be careful convert the analog value of control object (temperature, velocity, etc.) to digital value that are the output of A/D convert module. For example, assume that PID control is used for temperature control with Pt100 (operation range : 0 °C ~ 250 °C), and the goal value is 100 °C. The equivalent digital output of A/D module (voltage output range : 1 ~ 5V) is 1600 if the A/D module outputs 0 (1V) with 0 °C, and 4000(5V) with 250 °C. Therefore, the input of SV should be 1600, not 2.

*2)S_TIME is the period of reading data (sampling), and 10 times scaled up for more precious operation. Generally, it should be synchronized with external trigger input (EN input of function block) to perform proper PID operation. The range of sampling time is 0.1 ~ 10 seconds, and actual input range is 0 ~ 100.

*3)The GM7 perform auto-tuning operation based on the frequency response method. PID parameters are obtained by On/Off operation during 1 cycle of PV variation. The RIPPLE parameter shows at which cycle the CPU module will perform auto-tuning operation. If 0 is selected, the CPU will get PID parameters during the first cycle of PV variation. If 1 is selected, the second cycle will be used. (refer Fig. 3-1 for detailed information) Other choice of RIPPLE parameter is not allowed. In general case, select 1 for proper auto-tuning operation. The On/Off operation will be occur at the 80% of PV value.

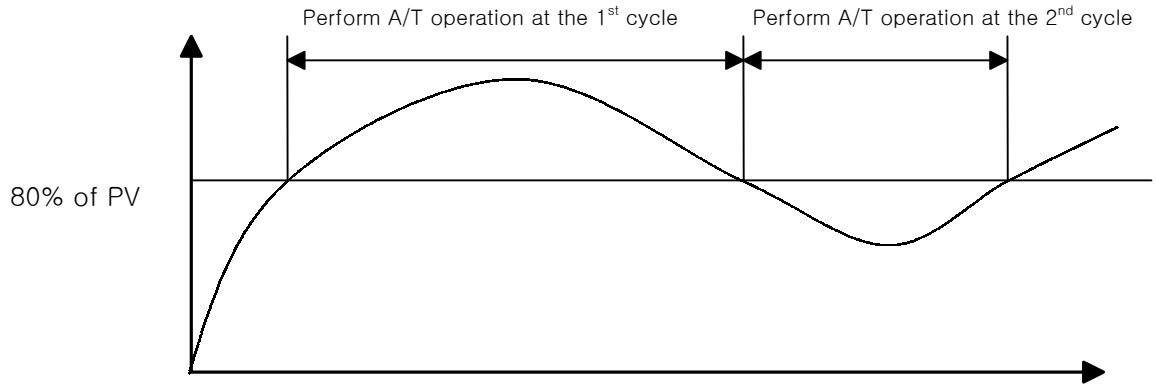


Fig.3-1 The ripple parameter

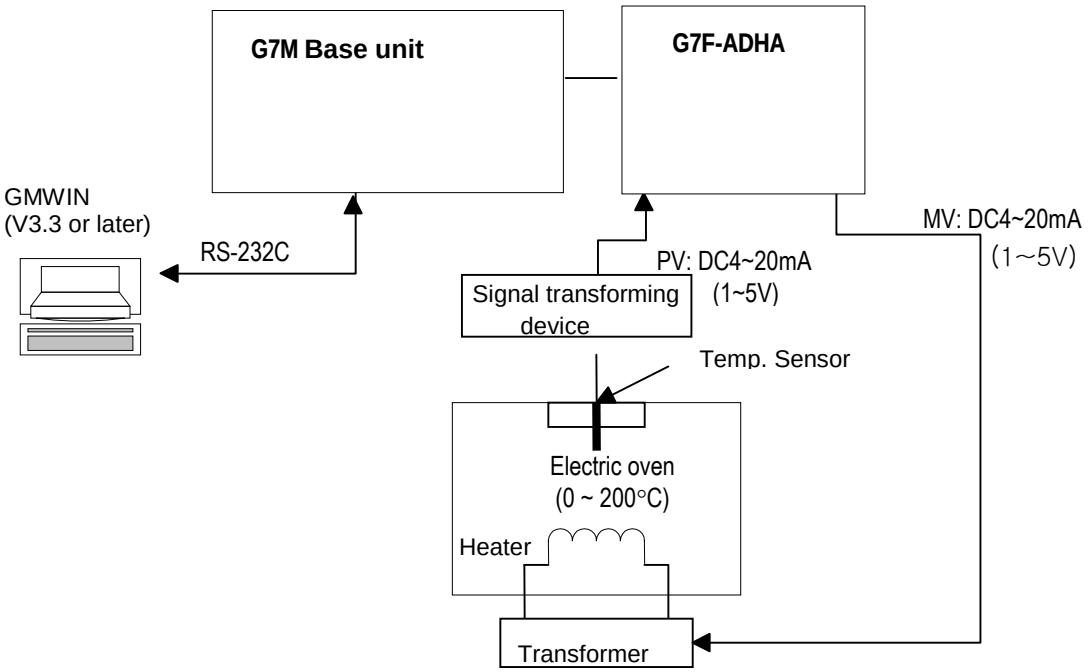
a) Error codes of auto-tuning function block (PID7AT)

The following table shows error codes and descriptions of PID7AT function block.

Error code (STAT output)	Description	Countermeasure
0	Normal operation	
1	SV is out of range	Change the SV within 0 ~ 4000
2	PV is out of range	It may caused by fault of A/D module. Check the A/D module.
3	S_TIME is out of range	Change the S_TIME within 0 ~ 100
32	Ripple is out of range	Change the Ripple to 0 Or 1.

4) Program Example

(1) System configuration



(2) Initial setting

a) PID operation parameters

(a) Auto / Manual operation setting: Auto
(b) Forward / Reverse operation: Forward
(c) SV setting: 1600 (100°C)
(d) BIAS setting: 0 (If only P control is used, input proper value other 0)
(e) EN_P, EN_I, EN_D setting: EN_P=1, EN_I=1, EN_D=1 (PID operation)
(f) REF, TT, N: REF=10, TT=5-, N=1
(g) MV_MAX, MV_MIN, MVMAN: MV_MAX=4000, MC_MIN=0, MAMAN=2000
(h) S_TIME: S_TIME=100 (sampling time = 10 seconds)

b) Auto-tuning parameters

(a) PV setting: 1600 (100°C)
(b) S_TIME: S_TIME=100 (sampling time = 10 seconds)

c) A/D module setting

(c) Channel setting: use channel 0
(d) Output data type: – 48 ~ 4047
(e) Input processing: Sampling

d) D/A module setting

(f) Channel setting: use channel 0

(3) Program Explanation

a) Use only PID operation (without A/T function)

(g) Convert the measured temperature (0 ~ 250°C) to current signal (4 ~ 20mA), and input the current signal to the channel 0 of A/D module. Then, the A/D module converts the analog signal to digital value (0 ~ 4000)
(h) PID6CAL function block will calculate manipulate value (MV : 0 ~ 4000) based on PID parameter settings (P_GAIN, I_TIME, D_TIME, etc.) and PV from A/D module. Then, the calculated MV is output to the channel 0 of D/A module.
(i) D/A module will convert the MV (0 ~ 4000) to analog signal (4 ~ 20mA) and output to the actuator (power converter).

b) Use PID operation with A/T function

(j) Convert the measured temperature (0 ~ 250°C) to current signal (4 ~ 20mA), and input the current signal to the channel 0 of A/D module. Then, the A/D module converts the analog signal to digital value (0 ~ 4000)

(k) A/T function block will calculate manipulate value (MV : 0 ~ 4000) based on the SV and PV from A/D module. Simultaneously, the A/T module will calculate P,I and D parameters.

(l) The END output of A/T module will be 1 when the A/T operation is completed. Then, PID module will start operation with PID parameters that are calculated by A/T module.

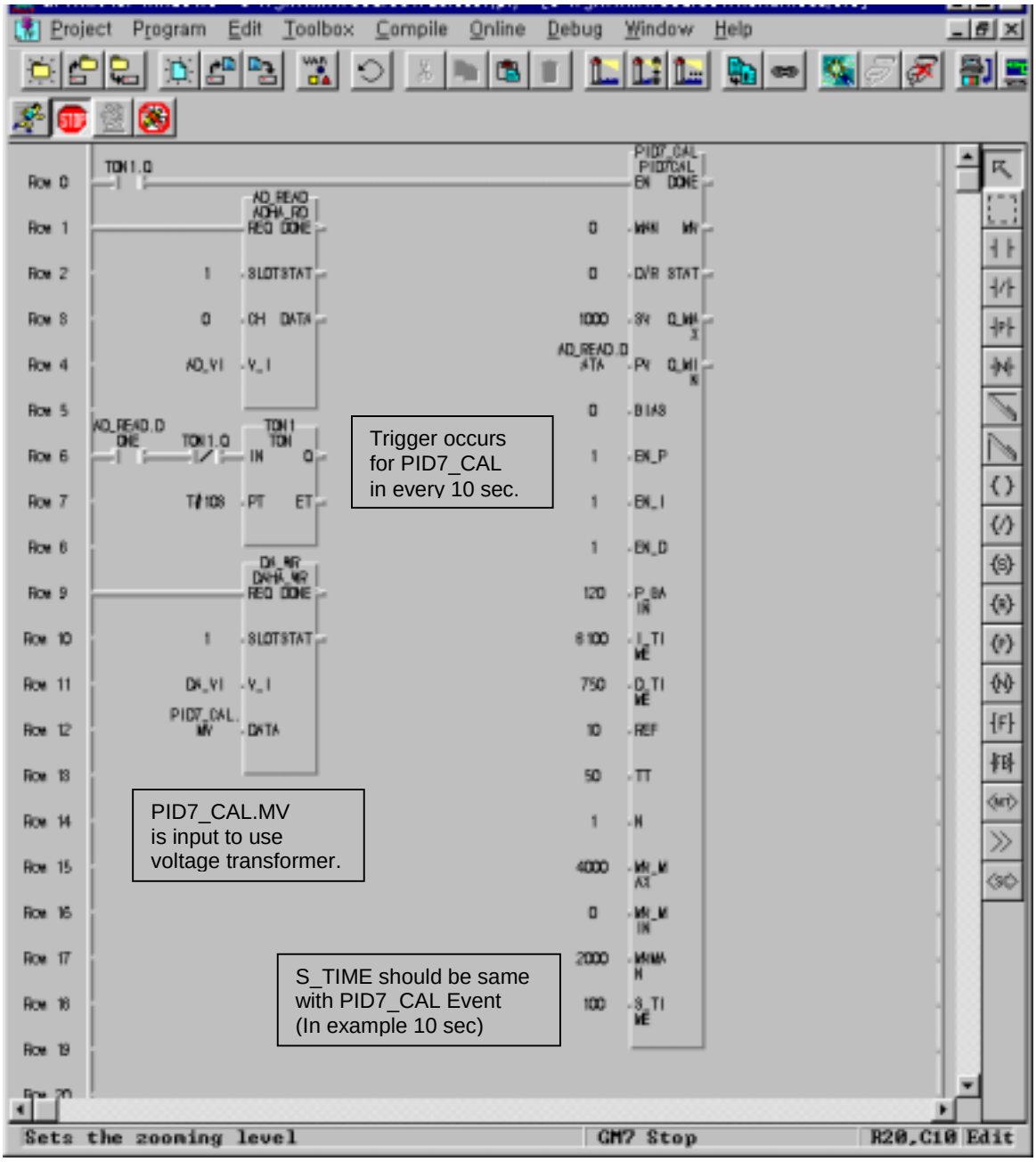
(m) D/A module will convert the MV (0 ~ 4000) to analog signal (4 ~ 20mA) and output to the actuator (power converter).

Remark

G7F-ADHA module is supplied 2channels for A/D exchange and 1channel for D/A exchange module.

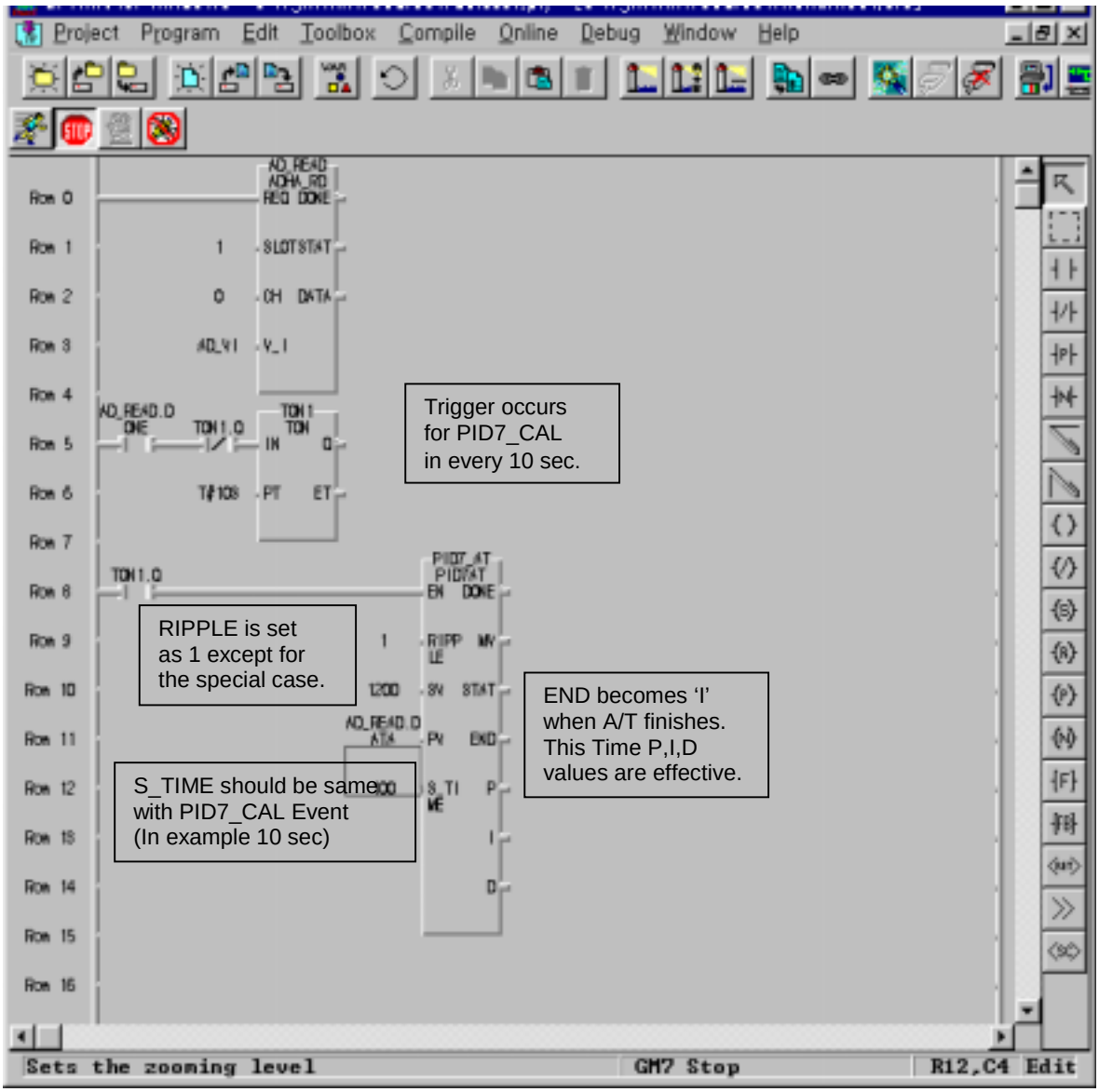
(4) Program

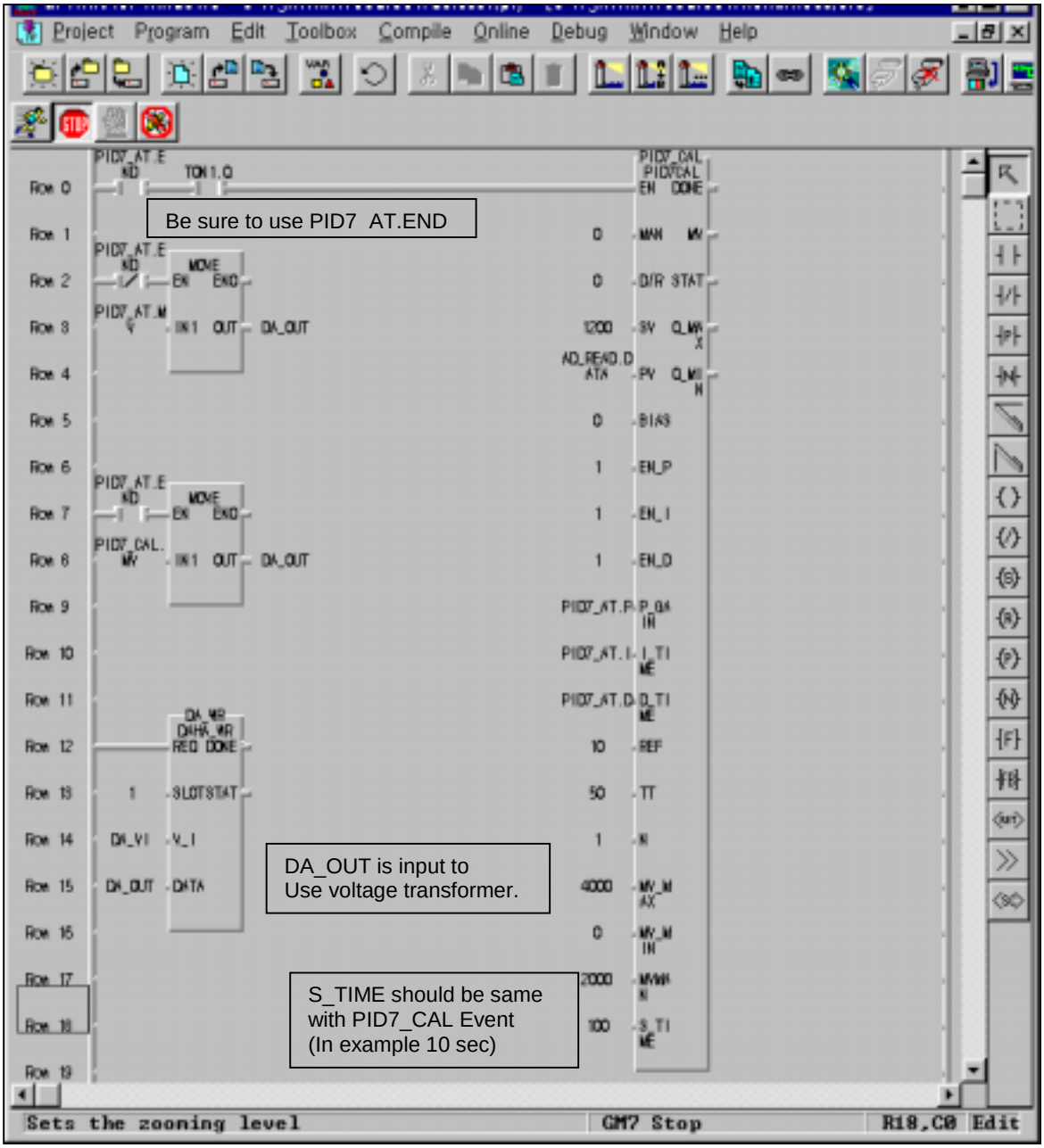
a) In case of using PID function only.



b) In case of using combined function of PID operation and Auto tuning.

This program is an example of PID operation performing with computed P,I,D values by the auto tuning performing. It is performed in 80% of auto tuning SV, PID process is performed from 80% of SV.




Project Program Edit Toolbox Compile Online Debug Window Help
Be sure to use PID7 AT.END
DA_OUT is input to
Use voltage transformer.
S_TIME should be same
with PID7_CAL Event
(In example 10 sec)
Sets the zooning level
GM7 Stop
R18,C0
Edit

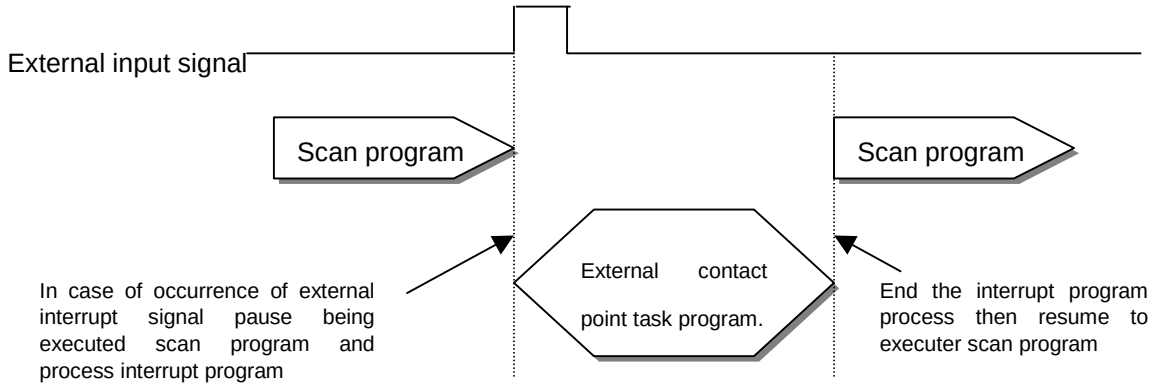
7.1.6 External Interrupt Function

In GM7 Series can perform max 8 points of external contact task by using input of base unit without special interrupt module.

1) Usage

This function is useful to execute a task program has been set to an external input signal.

2) Operating Explanation



3) Function

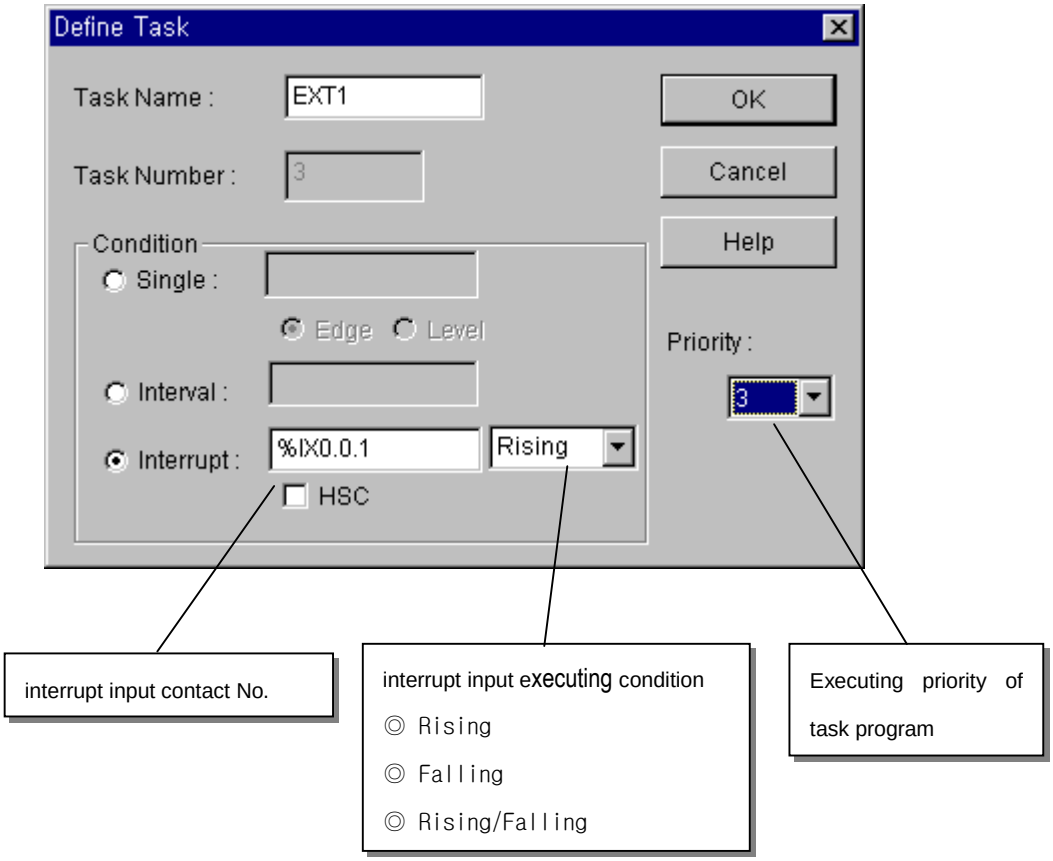
(1) Max. 8 points can be used to external interrupt input within %IXO.0.0 to%IX0.0.7.

(2) Inputting 8points of base unit are set functions like following.

	00	01	02	03	04	05	06	07
High speed counter	A-phase Input	B-phase Input	Preset Input	-	-	-	-	-
External interrupt task	●	●	●	●	●	●	●	●
Time driven task	-	-	-	-	-	-	-	-
Internal interrupt task	-	-	-	-	-	-	-	-
8points are available								

(3) Max, 8points of external contact point task are available to use. But the no. of them is decreased by using other task.

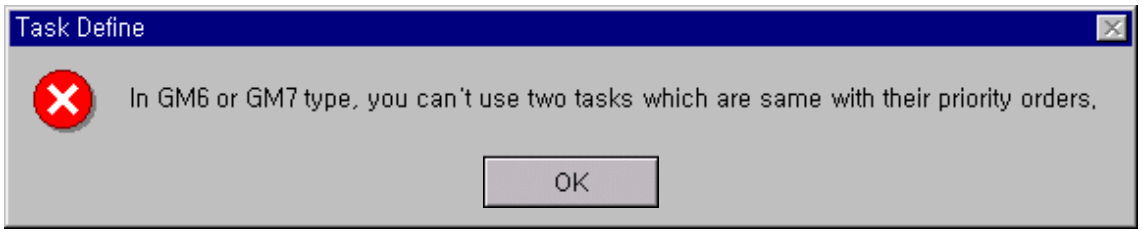
(4) Designate contact point, no. of priority and movement condition of the task program which is moved by interrupt inputting.



(5) Execute priority of task program. For the details, refer to GMWIN manual.

Remark

1) In case of GM7, executing priority of task can not be set equally, the following message occurs if the priority is set equally.



7. 2 Special module

7.2.1 A/D· D/A Combination module

1) Performance specifications

The performance specification of the analog mixture module are following.

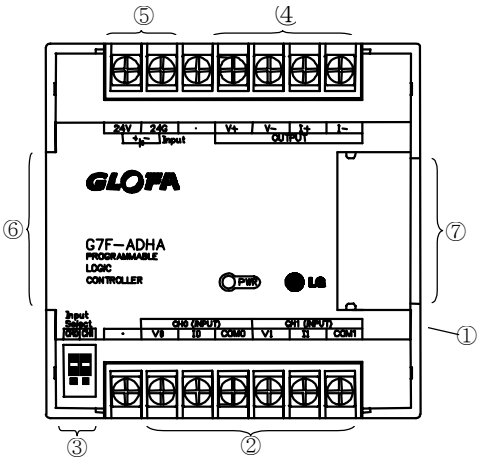
Item		Specifications			
Analog Input	Input range	Voltage	DC 0～10V (input resistance more than 1 MΩ)		
		Current	DC 0～20 mA (input resistance 250Ω)		Classified by function block
			DC 4～20 mA (input resistance 250Ω)		
	Digital output	12Bit(-48~4047)			
	Voltage/Current selection	1.Setting by jumper pin for V/I selection on upper part of product (Up: voltage, Down: Current) 2. Voltage/current selected by the program 3. When current input is used, short the V and I terminal			
	No. of channel	2Channels/1module			
	Absolute max. input	Voltage	DC +12V		
		Current	DC +24 mA		
Analog output	Output range	voltage	DC 0～10V (External load resistance 2 kΩ～1 MΩ)		
		Current	DC 0～20 mA (External load resistance 510Ω)		Classified by function block
			DC 4～20 mA (External load resistance 510Ω)		
	Digital Input	12Bit(-48~4047)			
	Voltage/Current selection	Separated from terminal			
	No, of channel	1Channel/1module			
	Absolute max. output	Voltage	DC +12V		
		Current	DC +24 mA		
Common	Max. resolution	Voltage	DC0～10V	2.5 mV (1/4000)	
		Current	DC0～20 mA	5 μA (1/4000)	
			DC4～20 mA	6.25 μA (1/3200)	
	Accuracy	± 0.5% [Full scale]			
	Max. conversion speed	2 ms/CH + scan time			
	Insulation	Photo coupler insulation between I/O terminals and PLC power supply (No isolation between channels)			
	Connect terminal	9 Points 2 terminals			
	Internal current Consumption	20 mA			
	External power supply	DC 21.6 ～ 26.4V, 80 mA			
	Weight	240g			

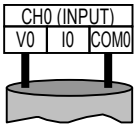
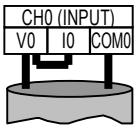
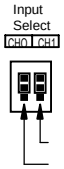
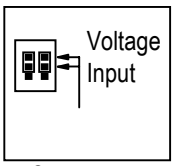
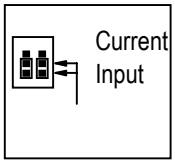
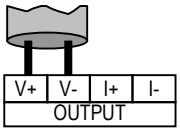
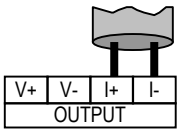
Remark

1) Offset/gain value can't be changed, it is fixed.
2) Analog inputting is set the current since this is manufactured.
3) Extend to use max.2 Modules

2) Names of parts and functions

Explain about names of parts and functions



No	Contents.
①	RUN LED Indicate the operating status the G7F-ADHA
②	Analog input terminal Voltage Input  Current input  When current input is used, short the V and I terminal.
③	Jumper pin of analog input  Right is CH.1selecting left is CH. 0 selecting  Connect upper parts by jumper pins  Connect lower parts by jumper pins.
④	Analog output terminal Voltage output  Current output  ▶ Only one type of output (Current or Voltage)is available on a module
⑤	External power input terminal ▶ External voltage 24VDC needs to this terminal.
⑥	Extension cable ▶ This cable is used to connect while analog mixture module is used..
⑦	Extension cable connector The connector connects extension cable when extended module is used.

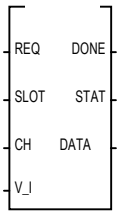
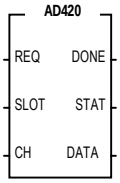
3) Function block

(1)Type of function block and funtion

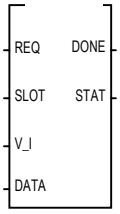
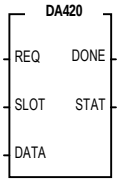
Function block	Function	Remark
ADHA_RD	Reading A/D conversion value	DC 0～10V / DC 4～20 ㎃ Input only
AD420		DC 4～20 ㎃ current input only
DAHA_WR	Writing D/A conversion value	DC 0～10V / DC 4～20 ㎃ output only
DA420		DC 4～20 ㎃ current output only

(2) Reading A/D conversion value (ADHA_RD, AD420)

Single type of function block for reading the module is performed for only one channel and the specified channel is used to read output variable of data displayed from A/D converted digital value.

Types of function block	Classification	Variable	Data type	Contents
	Input	REQ	BOOL	Execution request region of function block ● If connected condition on then region is completed and 0 turns to 1, then function block of reading module is executed while the program is performing
		SLOT	USINT	Location no. of slot ● Setting range:1 to 3
		CH	BOOL	Designation region of using channel ● Setting range:0to1
		V_I	BOOL	Designation region of Analog input type. Setting range:0 or 1(0: Current selecting, 1:Voltage selecting) ★ AD420 isn't used in function block.
	Output	DONE	BOOL	Indicating region of A/D conversion value. ● If reading function block is completed to execute without an error then 1 is output and maintains 1 until next execution comes, but if an error occurs, 0 is output and if becomes operation stop status.
		STAT	USINT	Area marking error status ● When error occurs, output error numbers.
		DATA	INT	Area outputting A/D conversion value ● Data output range: -48 ～ 4047

(3) Writing D/A conversion value (DAHA_WR, DA420)

Type of function block	I/O	Variables	Data type	Contents
	Input	REQ	BOOL	Execution request region of function block ● If connected condition on this region is completed and 0 turns to 1 then function block of writing module is executed while the program is performing.
		SLOT	USINT	Location no. of slot ● Setting range:1 to 3
		V_I	BOOL	Designation region of analog output type ● Setting range:0 or 1(0: I selecting, 1: V selecting) ★ DA420 isn't used in function block.
		DATA	INT	Input region of D/A conversion ● Setting range:0 to 4000
	Output	DONE	BOOL	Indicating region of function block ● If writing function block is completed to execute without an error then 1 is output and maintains 1 until nest execution comes, but if an error occurs, 0 is output and it becomes operation stop status
		STAT	USINT	Area for marking error status, that outputs error number when error occurs in execution of function block.

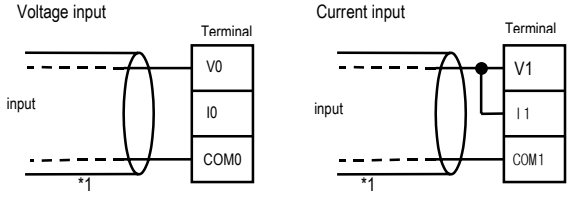
4) Wiring

(1) Caution for wiring

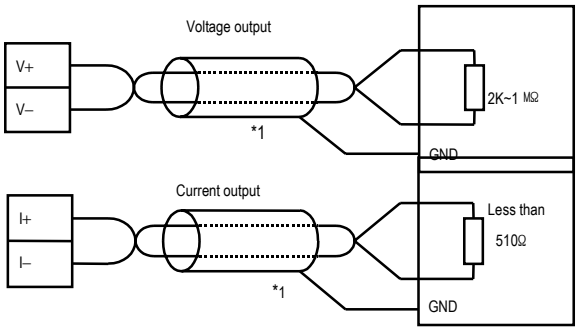
- ▶ Make sure that external input signal of the mixture module of AC and analog I/O is not affected by induction noise or occurs from the AC through using another cable.
- ▶ Wire is adopted with consideration about peripheral temperature and electric current allowance. Thicker than Max. size of wire AWG22 (0.3 ㎟) is better.
- ▶ If wire is put near to high temp. radiated device or contacted with oil for a long time, it may cause of electric leakage so that it gets broken or miss-operation during wiring.
- ▶ Be sure to connect with care of polarity while connecting to external 24V DC power supply.
- ▶ In case of wiring with high voltage line or generation line, it makes induction failure so then it may cause of miss-operation and out of order.

(2) Wiring example

a) Analog input



b) Analog output

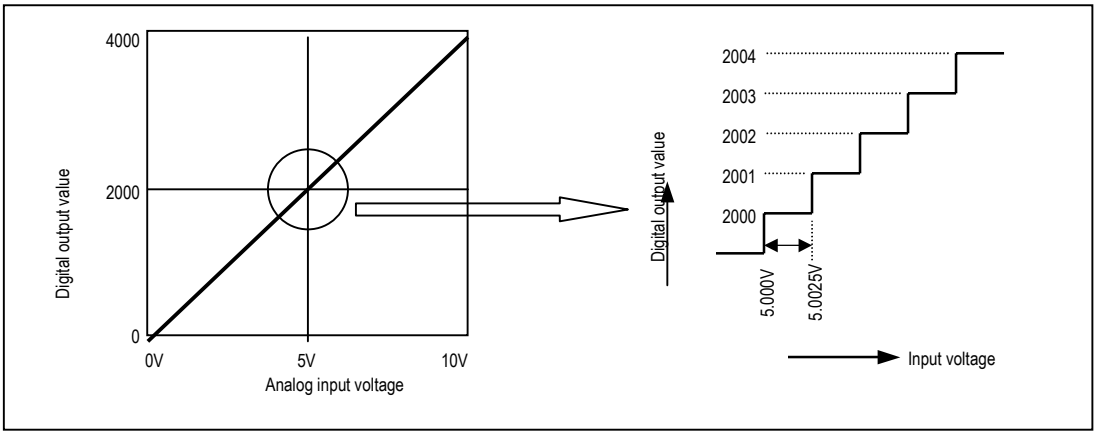


*1 : Be sure to use two-core twisted shield wire.
* Be careful to use that analog output is 1 channel.

5) I/O converstion characteristics

(1) Analog input characteristics

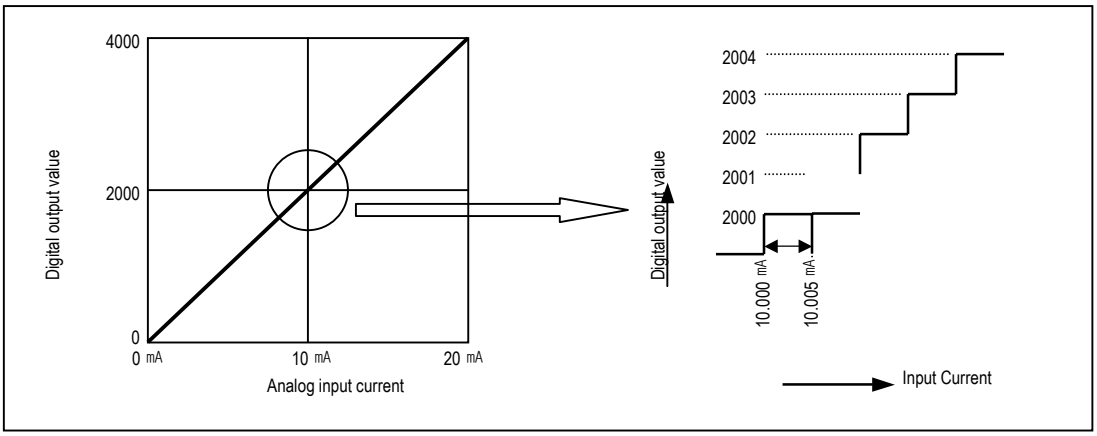
a) Voltage input



A/D conversion characteristics (voltage input)

In voltage input, digital amount 0 is output by 0V input and 4,000 is output by 10V input. Therefore input 2.5mV equals to digital amount 1, but value less than 2.5mV can't be converted.

b) Current input

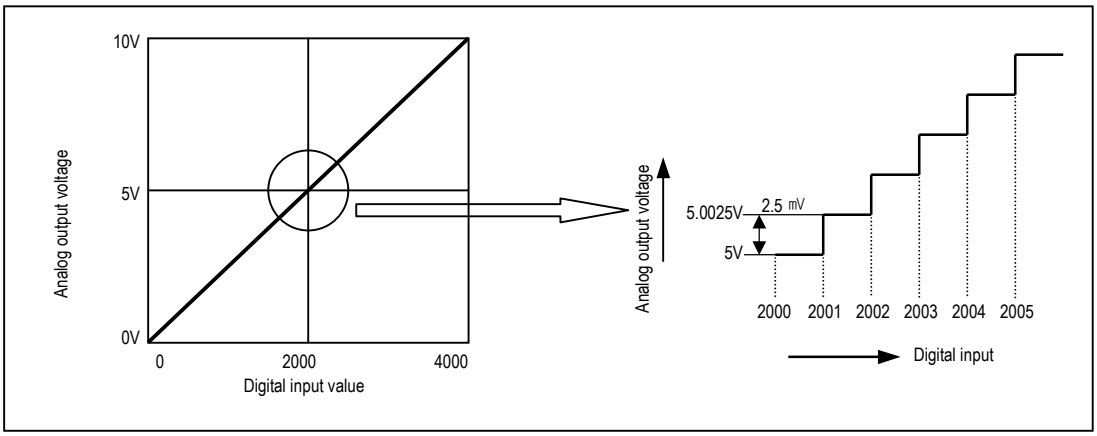


A/D conversion characteristics (Current input)

Current input 0mA becomes output 0, 10mA does 2000 and 20mA does 4000. therefore input 5 ㎂ equals to digital amount 1, but value less tan 5 ㎂ can't be converted. So abandon it.

(2) Analog output characteristics

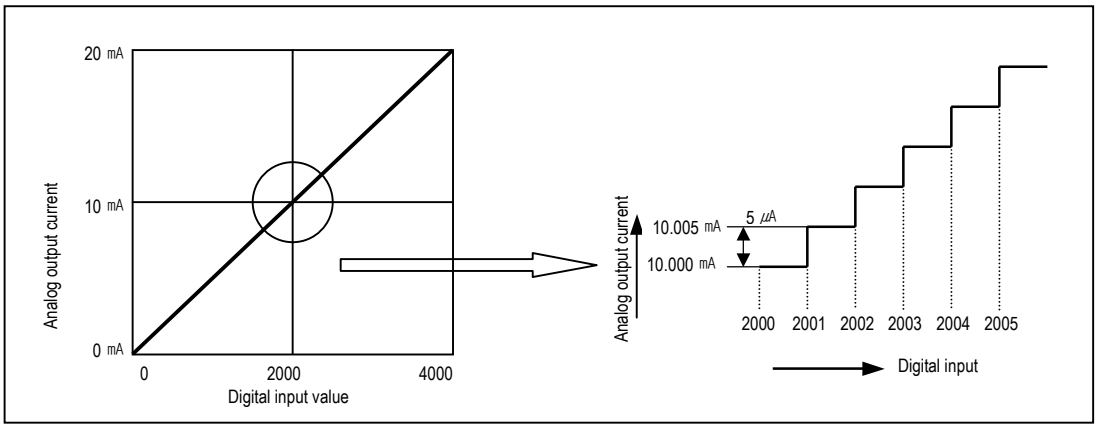
a) Voltage output



D/A conversion characteristic (voltage output)

Input of digital amount 0 outputs analog amount 0V, 4000 does 10V. Digital input 1 equals to 2.5mV of analog amount.

b) Current output



D/A conversion characteristic (Current output)

In current output, digital amount 0 exchanges to 0mA, and 4,000 does 20mA. Analog amount of digital input 1 equals to 5 μA.

5) Program example

(1) Distinction program of A/D conversion value

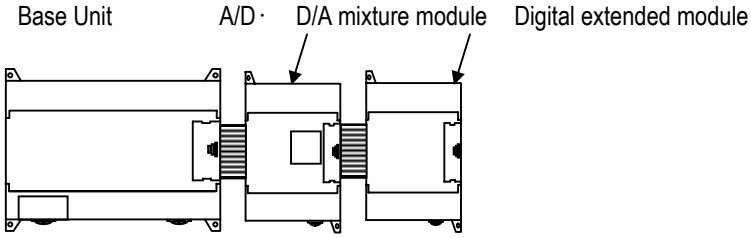
a) Program explanation

-When digital value of channel 0 is less than 2000, %Q0.2.0 is on.

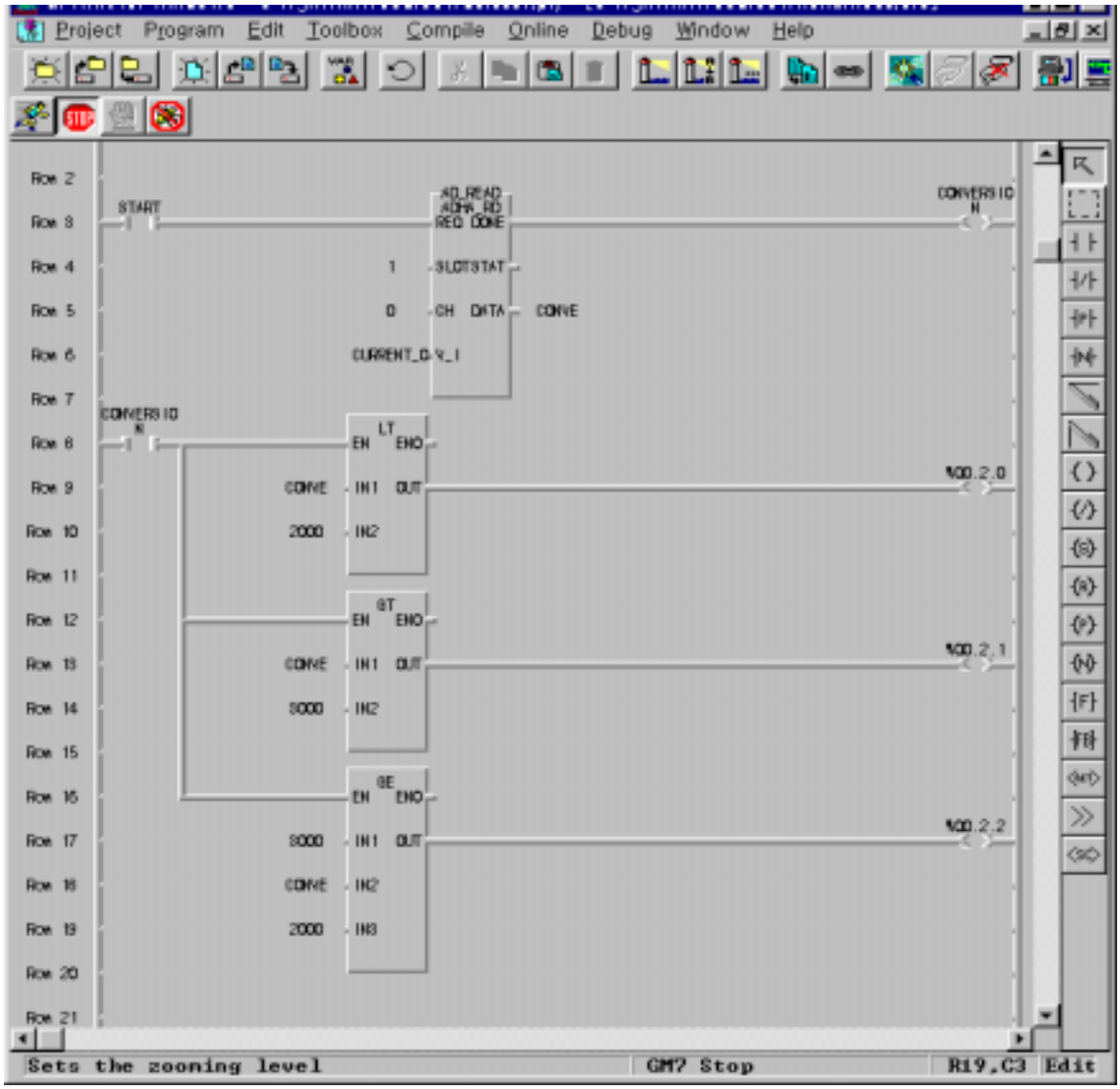
-when digital value of channel 0 is more than 3000, %Q0.2.1 is on.

-When digital value of channel 0 is more or same than 2000 or lesser than 3000, %Q0.2.2 is on.

b) System configuration



c) Program



(2) Program which controls speed of inverter by analog output voltage of 5 steps

a) Program explanation

-.When %IX0.0.0 becomes On, 2000 (5V) is output.

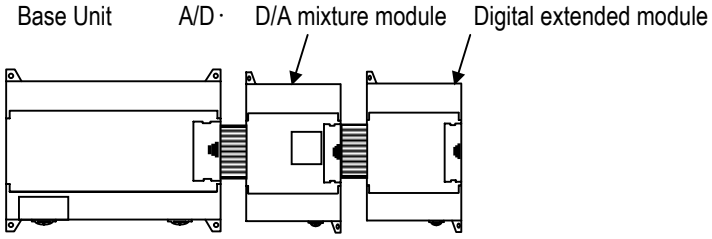
-. When %IX0.0.1 becomes On, 2400 (6V) is output.

-.When %IX0.0.2 becomes On, 2800 (7V) is output.

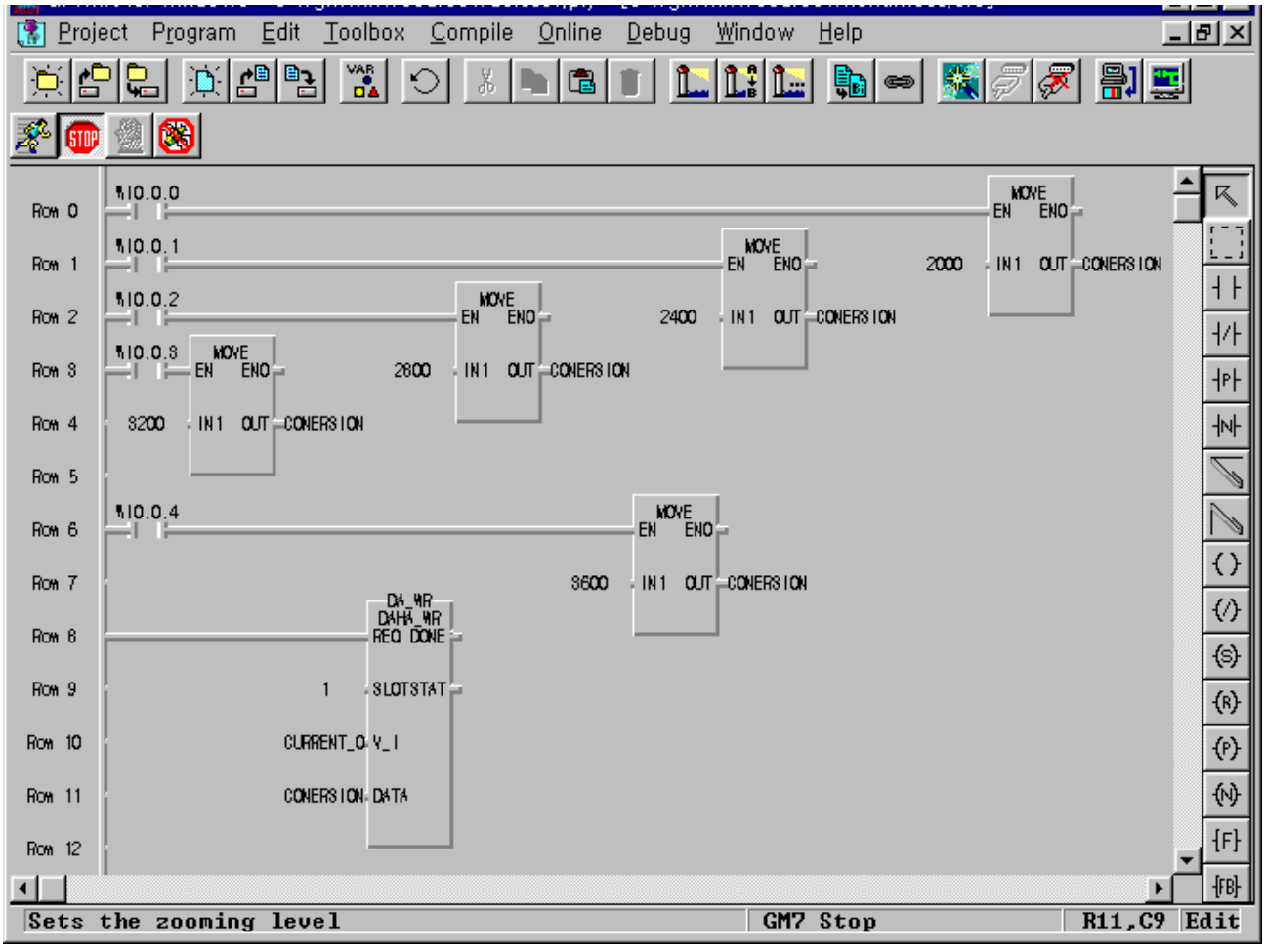
-.When %IX0.0.3 becomes On, 3200 (8V) is output.

-.When %IX0.0.4 becomes On, 3600 (9V) is output.

b) System configuration



c) Program



4) 7.2.2 A/D Conversion module

1) Performance specifications

The performance specifications of the analog input module are following.

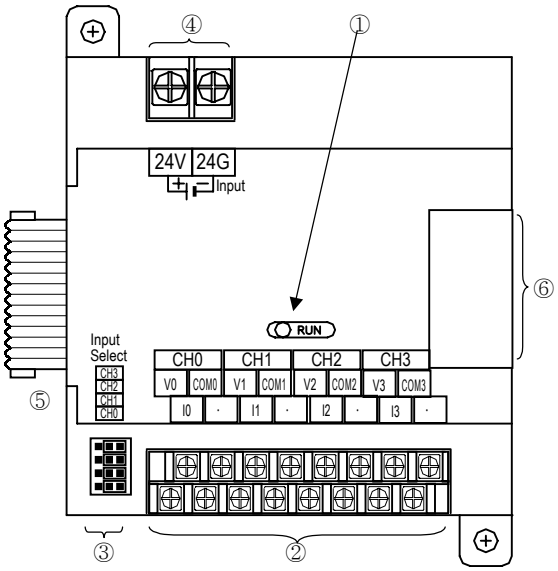
Item		Specification
Analog input	Voltage	0～10VDC (input resistance more than 1 ㏁)
	Current	DC 4～20 ㎃ (input resistance 250Ω) DC 0～20 ㎃ (input resistance 250Ω)
	Voltage/Current Selection	1.Setting by input terminal (When current input is used, short the V and I terminal) 2.The function block which is used are different by input range
Digital output		12bit binary (0～4000)
Maximum resolution	0～10VDC	2.5 ㎷ (1/4000)
	DC 0～20 ㎃	5 ㎂ (1/4000)
	DC 4～20 ㎃	5 ㎂ (1/3200)
Overall accuracy		± 0.5% [Full Scale]
Max. conversion speed		2 ㎳/CH + scan time
Max. absolute input		Voltage : ± 15V, Current : ± 25 ㎃
Number of analog input point		4channels/module
Isolation		Between input terminal and PLC power supply : Photo coupler isolation (No isolation between channels)
Terminal connected		2 points/16 points terminal block
Current Consumption	+5V	100mA
External Power supply	Voltage	DC 21.6 ~ 26.4V
	Current consumption	100 ㎃
Weight		200g

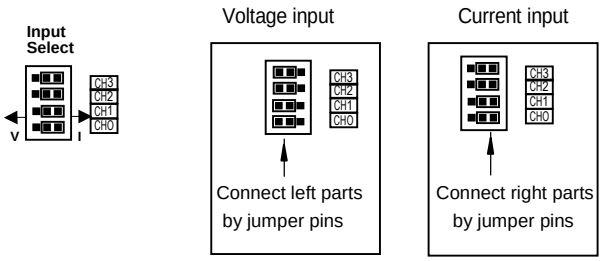
Remark

- ▶ Offset/Gain value can't be changed, because it is fixed
- ▶ Analog inputting is set the current since this is manufactured.
- ▶ It is possible to use to extend max.2 Modules
- ▶ The A/D conversion module is possible only to use in more than GM7 ROM V1.3

2) Names of parts and functions

The Names of parts and functions of the analog input module are following.



No	Contents
①	RUN LED Indicate the operating status the G7F-AD2A
②	Analog input terminal Voltage input / Current input  ▶ When current input is used, short the V and I terminal.
③	Jumper pin of analog input 
④	External power input terminal ▶External voltage 24VDC needs to this terminal.
⑤	Extension cable ▶This cable is used to connect while analog input module is used..
⑥	Extension cable connector ▶The connector connects extension cable when extended module is used.

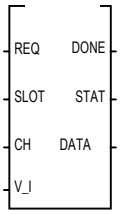
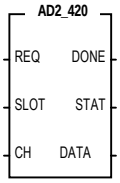
3) The Function Block

(1) Type of Function Block and function

Function block	Remark
AD2_RD	DC 0～10V / DC 4～20 ㎃ input only(single type)
AD2A_RD	DC 0～10V / DC 4～20 ㎃ input only(array type)
AD2_420	DC 4～20 ㎃ input only(single type)
AD2A_420	DC 4～20 ㎃ input only(array type)

(2) Reading the A/D conversion value(single type) : AD2_RD, AD2_420

Single type of function block for reading the module is performed for only one channel and the specified channel is used to read output variable of data displayed from A/D converted digital value.

Types of function block	Classification	Variable	Data type	Contents
	Input	REQ	BOOL	Execution request region of function block ● If connected condition on then region is completed and 0 turns to 1, then function block of reading module is executed while the program is performing
		SLOT	USINT	Location no. of slot ● Setting range:1 to 3
		CH	BOOL	Designation region of using channel ● Setting range:0 to 3
		V_I	BOOL	Designation region of Analog input type. ● Setting range:0 or 1(0: Current selecting, 1:Voltage selecting) ★ It isn't used in function block AD2_420
	Output	DONE	BOOL	Indicating region of function block execution complete ● If reading function block is completed to execute without an error then 1 is output and maintains 1 until next execution comes, but if an error occurs, 0 is output and if becomes operation stop status.
		STAT	USINT	Area marking error status ● When error occurs, output error numbers.
		DATA	INT	Area outputting A/D conversion value ● Data output range: 0 ～ 4000

(3) Reading the A/D conversion value(array type) : AD2A_RD, AD2A_420

Single type of function block for reading the module is performed for only one channel and the specified channel is used to read output variable of data displayed from A/D converted digital value.

Types of function block	Classification	Variable	Data type	Contents
	input	REQ	BOOL	Execution request region of function block ● If connected condition on this region is completed and 0 turns to 1 then function block of writing module is executed while the program is performing.
		SLOT	USINT	Location no. of slot ● Setting range:1 to 3
		CH	BOOL [Array]	Designation region of using channel ● Setting range:0 to 3 ● The number of element is 4, this number means channel number
		V_I	BOOL [Array]	Designation region of Analog input type. ●Setting range:0 or 1(0: Current selecting, 1:Voltage selecting) ● The number of element is 4, this number means channel number ★ It isn't used in function block AD2_420
	output	DONE	BOOL	Indicating region of function block execution complete ● If writing function block is completed to execute without an error then 1 is output and maintains 1 until nest execution comes, but if an error occurs, 0 is output and it becomes operation stop status
		STAT	USINT	Area for marking error status, that outputs error number when error occurs in execution of function block.

		DATA	INT [Array]	Area outputting A/D conversion value ● Data output range: 0 ~ 4000 ● The number of element is 4, this number means channel number

(4) Error code on the function block

This shows errors and resolutions in accordance with them

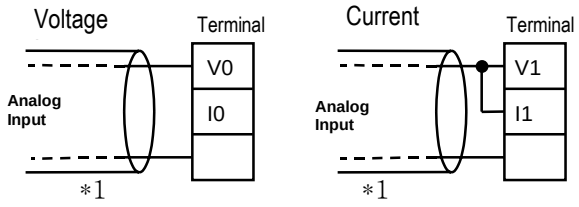
STAT No.	Descriptions	Measures
0	Operating with no fault	-
3	The slot location number is exceeding the proper setting range	Set the right number to the slot loading the A/D conversion module
4	The A/D conversion module on the slot is empty	Load the A/D conversion module to the specified slot
5	The module loaded isn't the A/D module	Load the A/D conversion module to the specified slot
6	The channel number is exceeding the proper range	Specify the available channel correctly

4)Wiring

(1) Caution for wiring

▶ Make sure that external input signal of the mixture module of AC and analog I/O is not affected by induction noise or occurs from the AC through using another cable.
▶ Wire is adopted with consideration about peripheral temperature and electric current allowance. Thicker than Max. size of wire AWG22 (0.3 ㎟) is better.
▶ If wire is put near to high temp. radiated device or contacted with oil for a long time, it may cause of electric leakage so that it gets broken or miss-operation during wiring.
▶ Be sure to connect with care of polarity while connecting to external 24V DC power supply.
▶ In case of wiring with high voltage line or generation line, it makes induction failure so then it may cause of miss-operation and out of order.

(2) Wiring

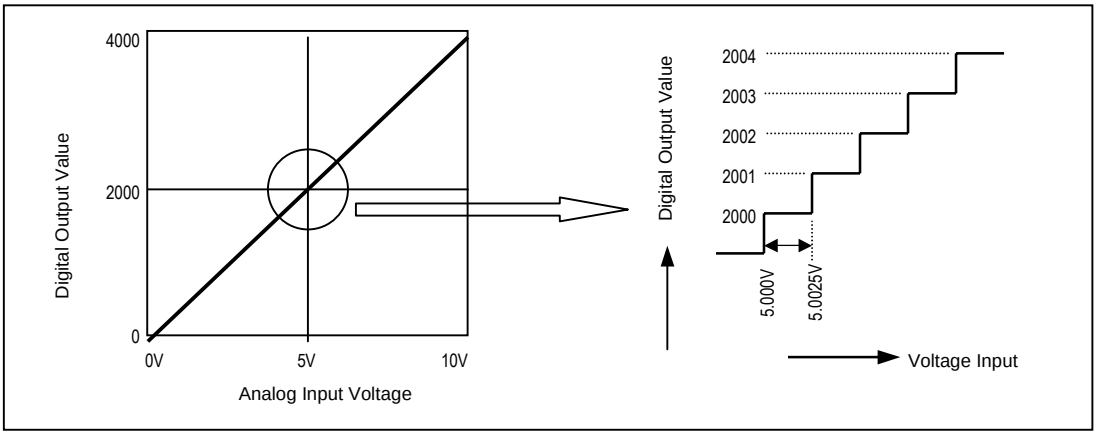


*1 : Be sure to use two-core twisted shield wire.

5) Analog/Digital conversion characteristics

(1) Analog input characteristics

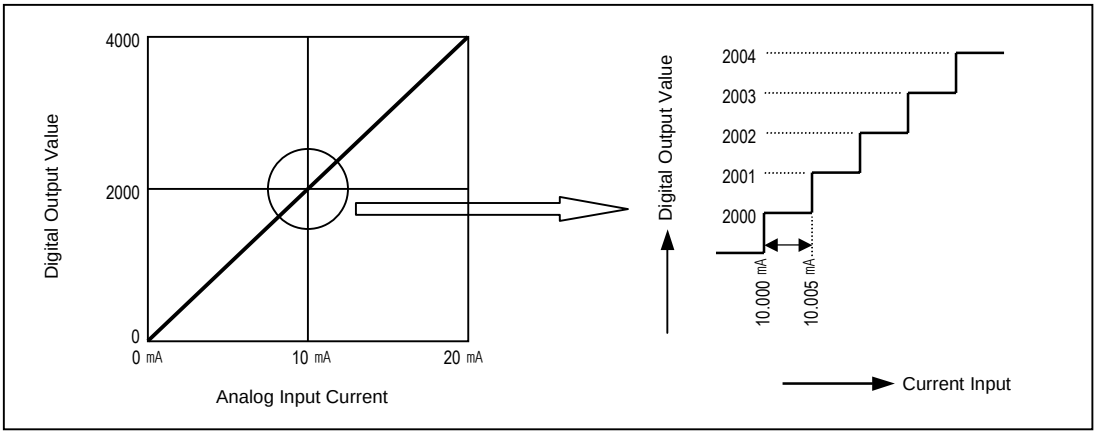
a) Voltage input



A/D Conversion Characteristics (Voltage Input)

In voltage input, digital amount 0 is output by 0V input and 4,000 is output by 10V input. Therefore input 2.5mV equals to digital amount 1, but value less than 2.5mV can't be converted.

b) Current input



A/D Conversion Characteristics (Current Input 0～20 ㎃)

Current input 0mA becomes output 0, 10mA does 2000 and 20mA does 4000. therefore input 5 ㎂ equals to digital amount 1, but value less tan 5 ㎂ can't be converted. So abandon it.

6) Program exemple.

(1) Distinction program of A/D conversion value

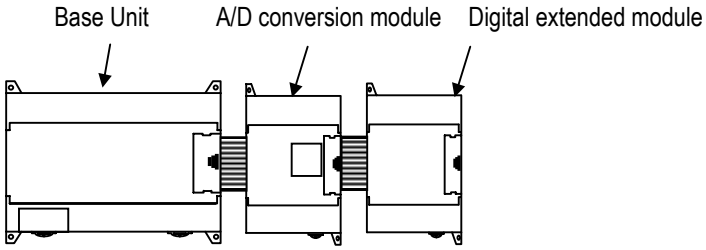
a) Program explanation

-When digital value of channel 0 is less than 2000, %Q0.2.0 is on.

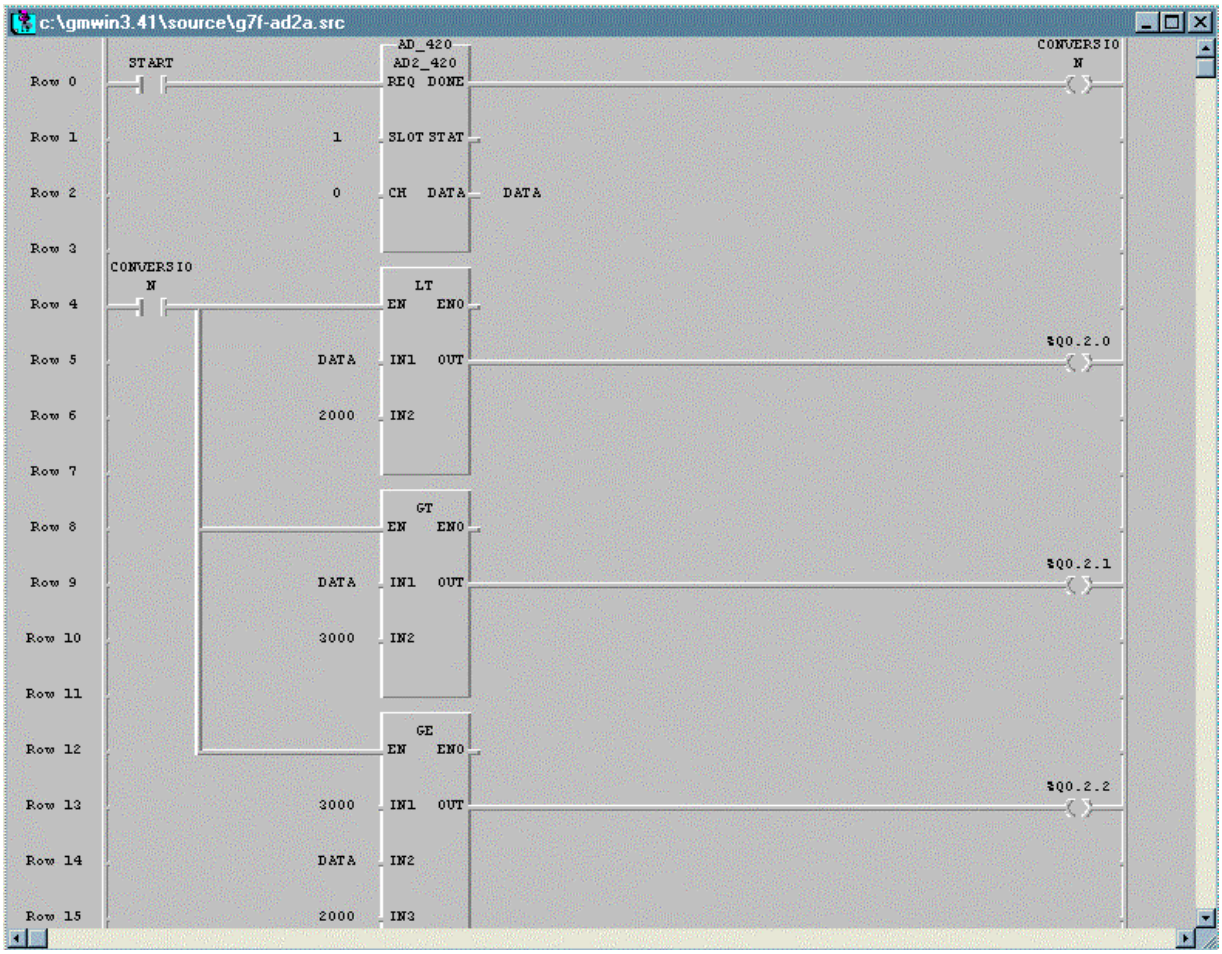
-when digital value of channel 0 is more than 3000, %Q0.2.1 is on.

-When digital value of channel 0 is more or same than 2000 or lesser than 3000, %Q0.2.2 is on.

b) The system configuration



c) program



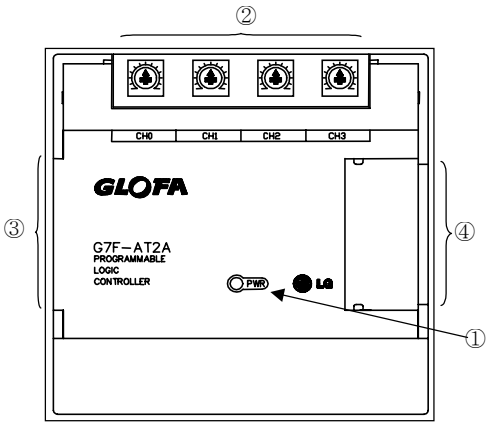
7.2.3 Analog timer

1) Performance specification

The performance specification of the analog timer module are following.

Item	Specification
Number of channels	4
Output value range	8 Bit (Digital output range: 0 ~ 200)
Setting type	Setting by variable resistance
Accuracy of timer	± 2.0% (Accuracy about max. value)
Operation method	Reading by means of using executive function block (AT2RD)
Internal current consumption	50 mA
Number of module installment	Max 3 modules
Weight	200g

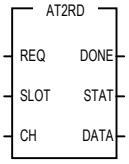
2) Names of parts and functions



No.	Name	Contents
①	RUN LED	Indicate the operating status the G7F-AT2A. On: normal operating Off: DC 5V power off or the G7F-AT2A module fault
②	Channel	Setting up the length of timer through variable resistance to every channel.
③	Extension cable	
④	Extension cable connection terminal	

3) Function block

(1) Function of the function block

Function block type	Classification	Variable	Data type	Contents
	Input	REQ	BOOL	Executing request region of function block. · If condition, which is connected this region, is completed, then 0 becomes 1 and function block gets executed.
		SLOT	USINT	location no of slot · Region to write slot no. which analog timer module is installed. · Setting range: 1 to 3.
		CH	USINT	Designating region of using channel · Designating region for no. of using timer. · Setting range: 0 to 3
	Output	DONE	BOOL	Complete status of function block execution. · When input condition of function block is 1, if it is completed to execute, then '0→ 1' is output. But when input condition is 0 and output changes to '1→ 0,' then related timer becomes operating stop status.
		STAT	USINT	Indication region of error status · Region for output of error no. when error occurs while function block execution.
		DATA	USINT	Digital value output of timer. Output range: 0 to 200.

(2) Error list, which is occurred on, output variable STAT

No.	Contents	Remedy
3	Setting range excess of slot location no.	Designate right slot no. which is installed with analog timer module.
4	Empty analog timer module of designated slot.	Installing analog timer module to designated slot.
5	Another module is installed which is different from analog timer module.	Installing analog timer module to designated slot.
6	Setting region excess of channel	Correct using channel no. designation.

4) Variable resistance handling

(1) Set up extension G7F-AT2A to CPU module and allow power supply then make program by means of analog timer module executive function block AT2RD, after that download it to CPU module.

(2) Change CPU module to RUN mode and monitor output variable DATA value of function block AT2RD then control variable resistance of channel which is set up on function block of G7F-AT2A.

(3) Then output value becomes small if variable resistance turns left. And value of DATA becomes big, if it turns right.

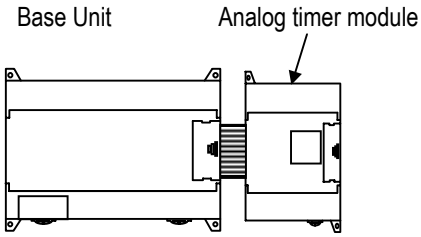
(4) When expected timer value is output as data, stops controlling variable resistance.

5) Program example

(1) Program explanation

Program which controls on-delay time of output contact point within 0 to 20 sec. By analog timer module.

(2) System configuration



(3) Program