Chapter 2 .   SPECIFICATIONS

2.1   General Specifications

Table 2.1 shows the general specifications of GLOFA GM series.

<table>
<tr><th>No</th><th>Items</th><th colspan="6">Specifications</th><th>Standard</th></tr>
<tr><td>1</td><td>Operating ambient temperature</td><td colspan="6">0 ~ 55℃</td><td></td></tr>
<tr><td>2</td><td>Storage ambient temperature</td><td colspan="6">-25 ~ 75℃</td><td></td></tr>
<tr><td>3</td><td>Operating ambient humidity</td><td colspan="6">5 ~ 95%RH,   non-condensing</td><td></td></tr>
<tr><td>4</td><td>Storage ambient humidity</td><td colspan="6">5 ~ 95%RH,   non-condensing</td><td></td></tr>
<tr><td rowspan="8">5</td><td rowspan="8">Vibration</td><td colspan="6">Occasional vibration</td><td rowspan="8">IEC 1131-2</td></tr>
<tr><td>Frequency</td><td>Acceleration</td><td colspan="3">Amplitude</td><td>Sweep count</td></tr>
<tr><td>10≤f∠57 Hz</td><td>-</td><td colspan="3">0.075 mm</td><td rowspan="6">10 times in each direction for X, Y, Z</td></tr>
<tr><td>57 ≤f≤150 Hz</td><td>9.8㎨ {1G}</td><td colspan="3">-</td></tr>
<tr><td colspan="5">Continuous vibration</td></tr>
<tr><td>Frequency</td><td>Acceleration</td><td colspan="3">Amplitude</td></tr>
<tr><td>10≤f∠57 Hz</td><td>-</td><td colspan="3">0.035 mm</td></tr>
<tr><td>57≤f≤150 Hz</td><td>4.9㎨ {0.5G}</td><td colspan="3">-</td></tr>
<tr><td>6</td><td>Shocks</td><td colspan="6">*Maximum shock acceleration: 147 ㎨ {15G}
*Duration time :11 ms
*Pulse wave: half sine wave pulse(3 times in each of X, Y and Z directions)</td><td>IEC 1131-2</td></tr>
<tr><td rowspan="5">7</td><td rowspan="5">Noise immunity</td><td colspan="2">Square wave impulse noise</td><td colspan="4">±1,500 V</td><td></td></tr>
<tr><td colspan="2">Electrostatic discharge</td><td colspan="4">Voltage :4kV(contact discharge)</td><td>IEC 1131-2
IEC 801-2</td></tr>
<tr><td colspan="2">Radiated electromagnetic field</td><td colspan="4">27 ~ 500 MHz, 10 V/m</td><td>IEC 1131-2
IEC 801-3</td></tr>
<tr><td colspan="2" rowspan="2">Fast transient burst noise</td><td>Severity Level</td><td>All power modules</td><td>Digital I/Os (Ue ≥ 24 V)</td><td>Digital I/Os (Ue < 24 V) Analog I/Os communication I/Os</td><td rowspan="2">IEC 1131-2
IEC 801-4</td></tr>
<tr><td>Voltage</td><td>2 kV</td><td>1 kV</td><td>0.25 kV</td></tr>
<tr><td>8</td><td>Operating atmosphere</td><td colspan="6">Free from corrosive gases and excessive dust</td><td></td></tr>
<tr><td>9</td><td>Altitude for use</td><td colspan="6">Up to 2,000m</td><td></td></tr>
<tr><td>10</td><td>Pollution degree</td><td colspan="6">2 or lower</td><td></td></tr>
<tr><td>11</td><td>Cooling method</td><td colspan="6">Self-cooling</td><td></td></tr>
</table>

[Table 2.1] General specifications

REMARK

1) IEC(International Electrotechnical Commission)

: The international civilian organization which produces standards for electrical and electronics industry.

2) Pollution degree

: It indicates a standard of operating ambient pollution level.

The pollution degree 2 means the condition in which normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.

2.2 Performance Specifications

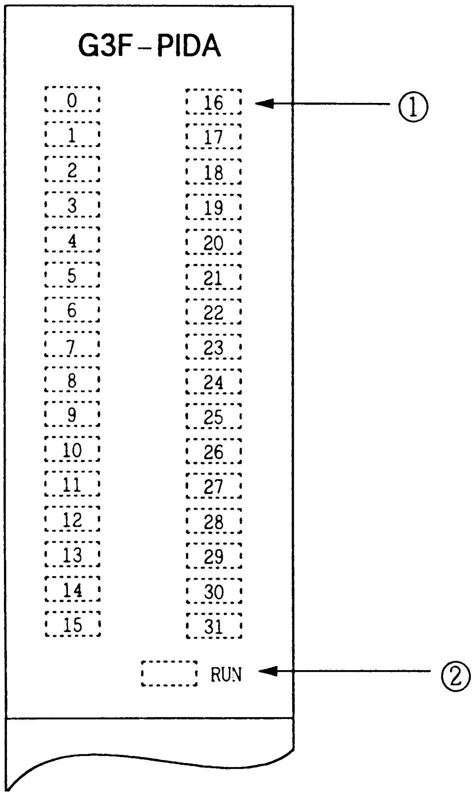
Table. 2.2 shows performance specifications of the PID control module.

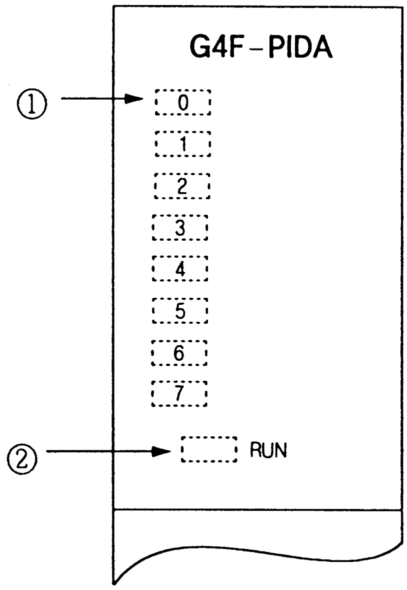
<table>
<tr><th colspan="2" rowspan="2">Items</th><th colspan="2">Specifications</th></tr>
<tr><th>G3F-PIDA</th><th>G4F-PIDA</th></tr>
<tr><td rowspan="3">Setting range of PID constants</td><td>Proportional constant (P)</td><td colspan="2">0.01 ~ 100.00
(When integral and derivative constants are set to 0.0 sec, proportional action is applied.)</td></tr>
<tr><td>Integral constant (I)</td><td colspan="2">0.0 ~ 3000.0 sec
(When integral constant is set to 0.0 sec, integral action shall not be applied.)</td></tr>
<tr><td>Derivative constant (D)</td><td colspan="2">0.0 ~ 3000.0 sec
(When derivative constant is set to 0.0 sec, derivative action shall not be applied.)</td></tr>
<tr><td colspan="2">Setting range : SV (Set Value)</td><td colspan="2">0 ~ 16,000</td></tr>
<tr><td colspan="2">Input range : PV (Process Value)</td><td colspan="2">0 ~ 16,000</td></tr>
<tr><td colspan="2">Output range : MV (Manipulated Value)</td><td colspan="2">0 ~ 16,000</td></tr>
<tr><td colspan="2">Setting range : M_MV
(Manually Manipulated Value)</td><td colspan="2">0 ~ 16,000</td></tr>
<tr><td rowspan="2">LED</td><td>RUN / STOP</td><td colspan="2">RUN : The run LED of corresponding loops ON
STOP : The run LED of corresponding loops OFF</td></tr>
<tr><td>NORMAL/ERROR</td><td colspan="2">Normal : RUN LED ON
Error : RUN LED flickering</td></tr>
<tr><td colspan="2">Number of PID control loops</td><td>32 loops</td><td>8 loops</td></tr>
<tr><td colspan="2">Control action</td><td colspan="2">Forward/Reverse action control is available.</td></tr>
<tr><td colspan="2">Control cycle</td><td colspan="2">0.1 sec</td></tr>
<tr><td colspan="2">Processing type</td><td colspan="2">Measured value derivative type
(Pre-derivative type)</td></tr>
<tr><td colspan="2">Internal current consumption</td><td>0.3 A</td><td>0.2 A</td></tr>
<tr><td colspan="2">Weight</td><td>370 g</td><td>190 g</td></tr>
</table>

[Table. 2.2 Performance Specifications]

2.3 Names of Parts and Functions

The following gives names of parts :





No.	Descriptions
①	Loop Run LED It shows the PID control module run status. ● ON : The corresponding loop is running. ● OFF : The corresponding loop is running. ● Flickering : Error status. Error Value is displayed.
②	RUN LED It shows the PID module Operating status. ● ON: Normal ● Flickering : Error

2.4 PID Control Action

2.4.1 Processing type

1) Velocity type

Velocity type is a processing that in PID processing, the present Manipulated Value(MV) is obtained by adding the calculated variation of MV (∆MV) to the previous MV

$$MV_n = MV_{n-1} + \Delta MV_n$$

MV_n : Present Manipulated Value

MV_{n-1} : Previous Manipulated Value

ΔMV_n : Variation of the Previous Manipulated Value

2) Measured Value Derivative Type (Pre-derivative)

Measured value derivative processing, in PID processing, uses the process value(PV) for the derivative term. Generally, PID processing, when a deviation occurs, operates toward the direction in which the deviation will be reduced.
The deviation occurs due to alteration of set value(SV) or outside disturbances. Therefore, if the deviation is used in the derivative processing, the output of the derivative term changes rapidly when the deviation occur due to alteration of set value (SV). So, to prevent raid changes like that, this processing uses the process value(PV) for the derivative term.

$$MV_n = MV_{n-1} + K_p \times (E_n - E_{n-1}) + K_p \times S/K_I \times E_n + K_p \times K_d/S \times (2PV_n - PV_{n-1} - PV_{n-2})$$

MV_n : Present Manipulated Value

MV_{n-1} : Previous Manipulated Value

ΔMV_n : Variation of the Previous Manipulated Value

E_n : Present Deviation

E_{n-1} : Previous Deviation

K_p : Proportional Constant

K_i : Integral Constant

K_d : Derivative Constant

S : Control Cycle (100ms)

PV_n : Present Process Quantity (Present Value)

PV_{n-1} : One-step previous Process Quantity (Present Value)

PV_{n-2} : Two-step previous Process Quantity (Present Value)

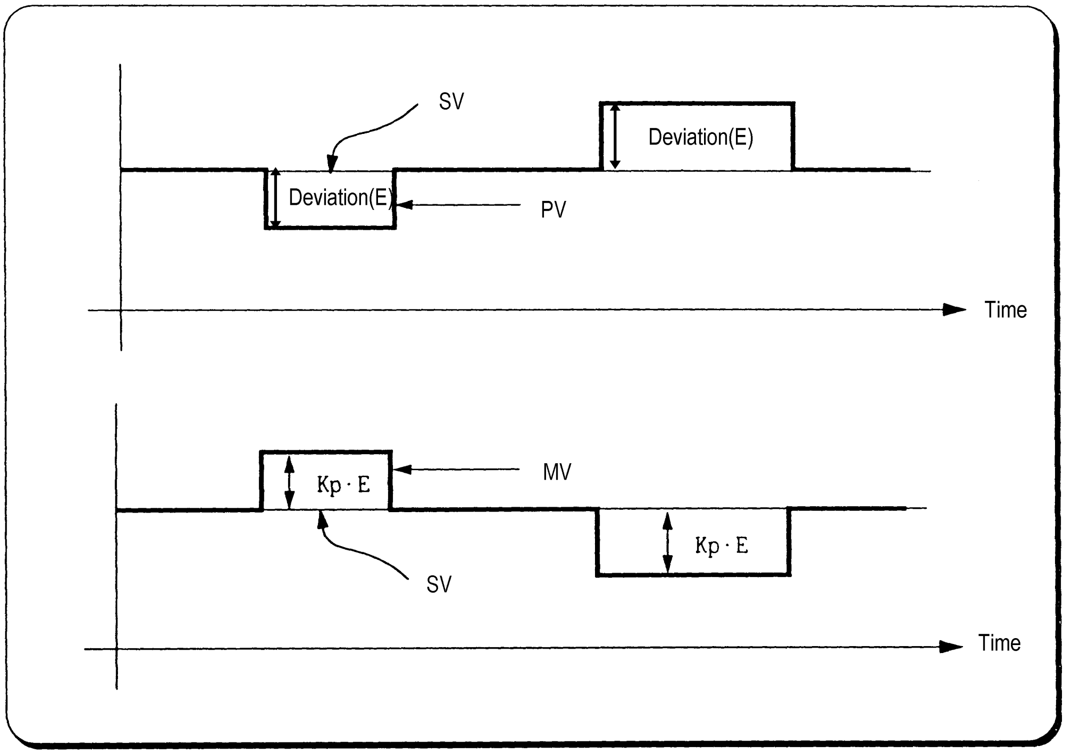
2.4.2 Control Action

1) Proportional Action (P Action)

(1) P action means a control action that obtains a MV which is proportional to the deviation (E: the difference between SV and PV).
(2) The expression which denotes the change relationship of E to MV in P action is shown as follows:

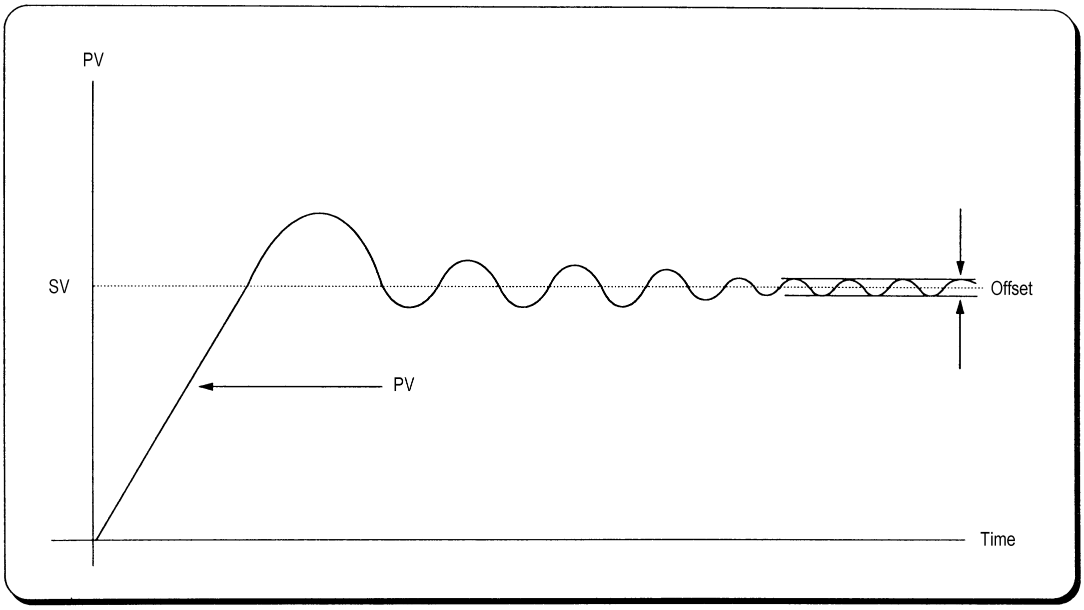
$$\boxed{MV = Kp \times E}$$

where Kp is a proportional constant and means gain.
(3) When deviation occurs, the MV by P action is shown in Fig. 2.1.

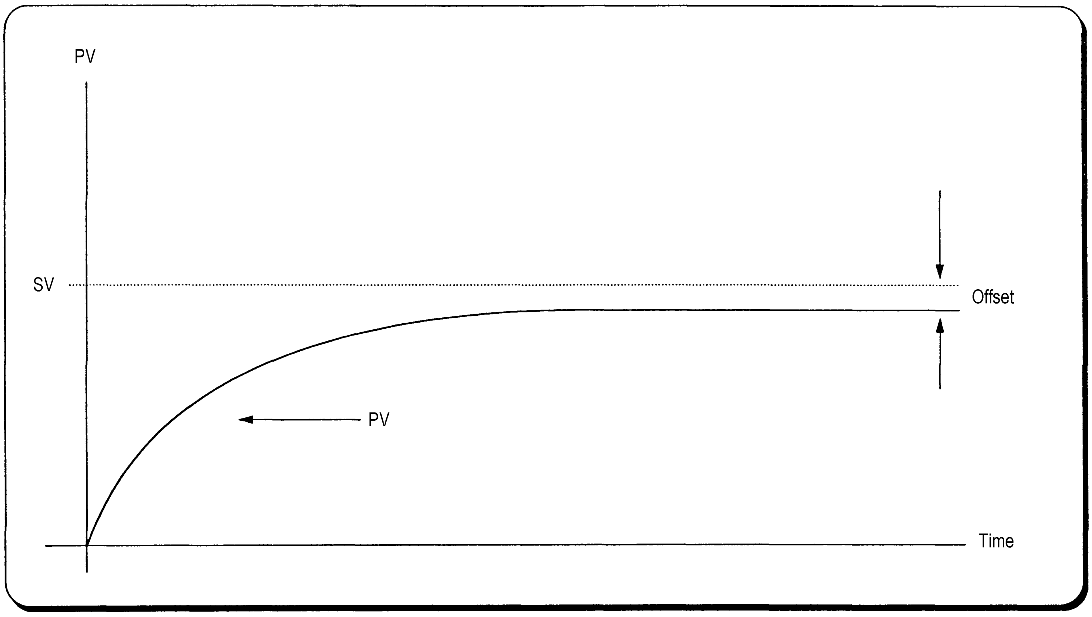


[Fig. 2.1] MV with the proportional action

(4) As shown in Fig. 2.1, the larger the proportional constant Kp the larger the MV, that is, the stronger the P action when the deviation(E) is same . Also, the smaller the Kp the smaller the MV after P action.
(5) If the Kp is too large, PV reaches SV swiftly but can make bad effects like oscillations shown in Fig. 2.2 and cause damage in control stability.
(6) If the Kp is too small, oscillations do not occur but the velocity with which PV reaches SV slows down and offset can happen as shown in Fig. 2.3.
(7) Manipulated Value varies within 0 to 16,000.



[Fig. 2.2] When the proportional constant Kp is large.



[Fig. 2.3] When the proportional constant Kp is small.

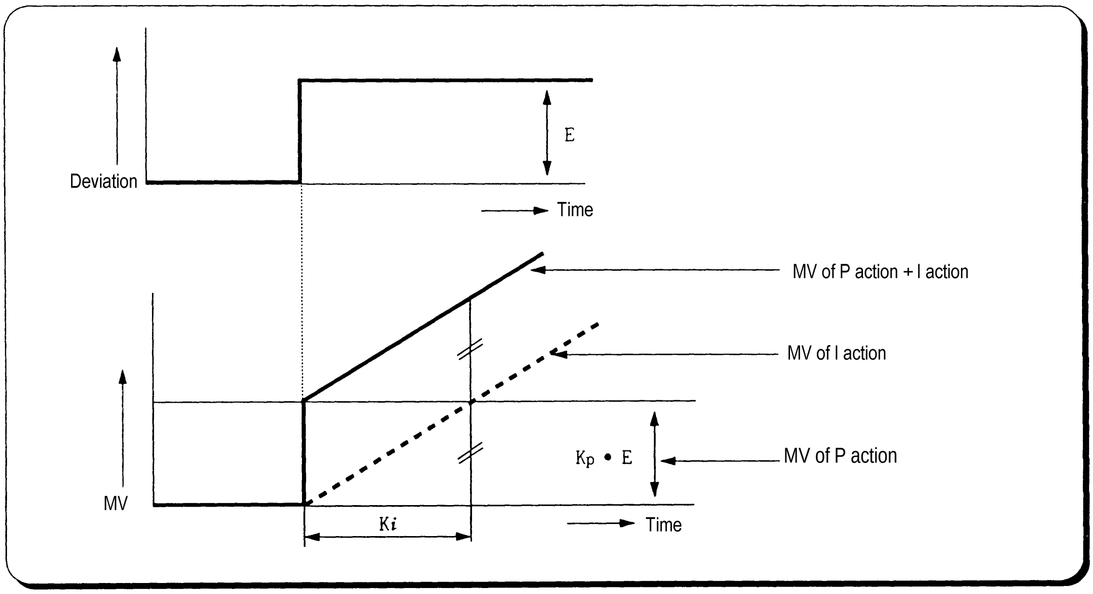
2) Integral Action (I Aaction)

(1) When a deviation(E) occurs between SV and PV, Integral action continuously adds the deviation to or subtracts it from the MV in accordance time in order to eliminate the deviation
When a deviation is small it is not expected that the MV will be changed by P action but I action will eliminate it.
Therefore, the offset which occurs in P action can be eliminated by I action.

(2) 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 Ki.

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

MV



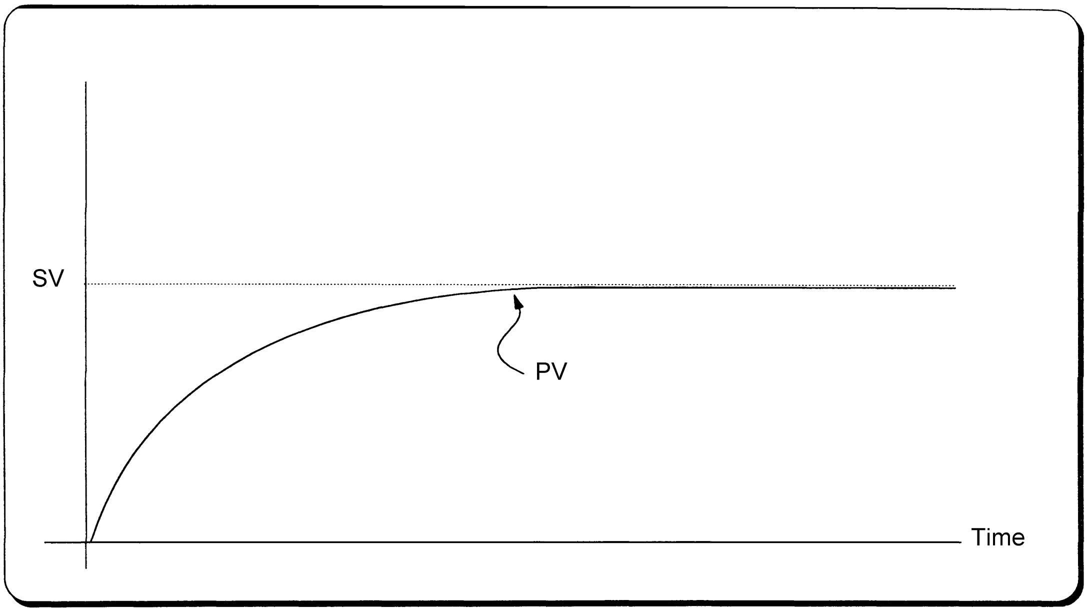
[Fig. 2.4] Integral action at a constant deviation

(4) Expression of Integral Action is as follows:

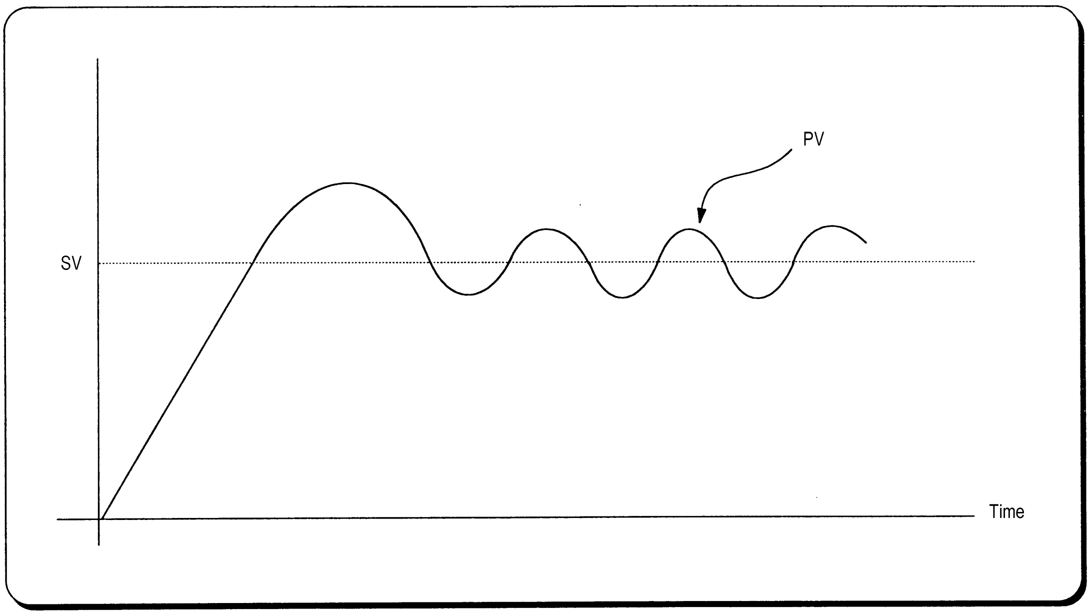
$$MV = P \times E + P \times \frac{1}{K_i} \times \int E dt$$

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 occurs, therefore, the proper P.I value is requested.

(5) 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]   When a long integration time is given.

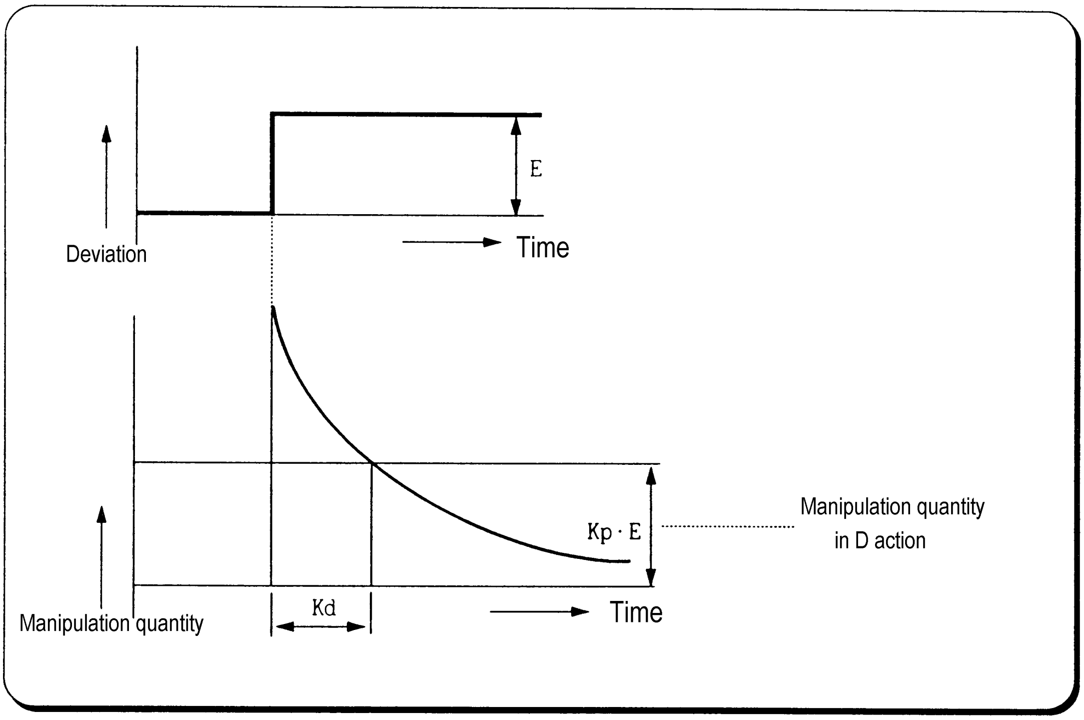


[Fig. 2.5]   When a short integration time is given.

3) Derivative Action (D Action)

(1) 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.

(2) 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.
(3) The D action when a given deviation occurred is shown as Fig. 2.7.



[Fig. 2.7] Derivative action at a constant deviation

(4) The expression of D action is represented as follows:

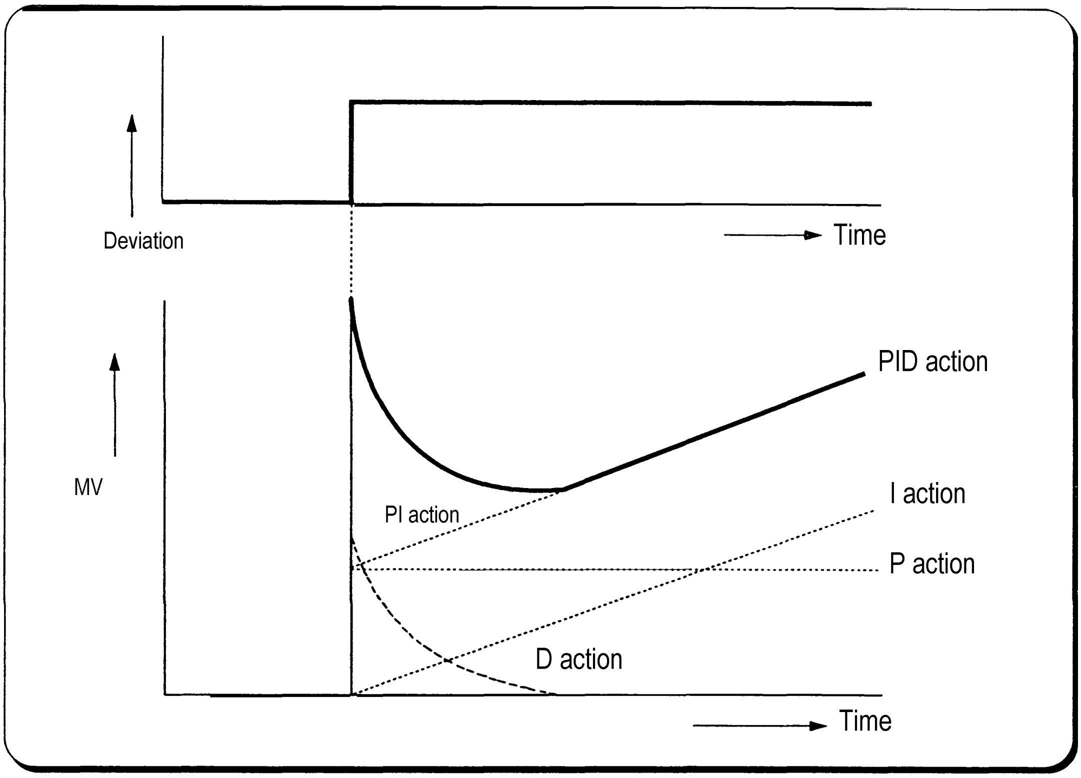
$$MV = K_p \times E + K_p \times \frac{dE}{dt}$$

- In this expression, an output proportional with the variation rate of deviation is added to P action quantity.
- If the derivative time is increased then P action is strengthened.
- D action is applied when a change of deviation occurs and the deviation at normal state become 0. D action, therefore, do not reduce offset.

(5) D action is used in either PD action in which P action combines with D action or PID action in which P and I actions combine with D action.

4) PID Action

(1) PID action controls the control object with the manipulation quantity produced by (P+I+D) action.
(2) PID action when a given deviation has occurred is shown as the following Fig. 2.8.



[Fig. 2.8] PID action at a constant deviation

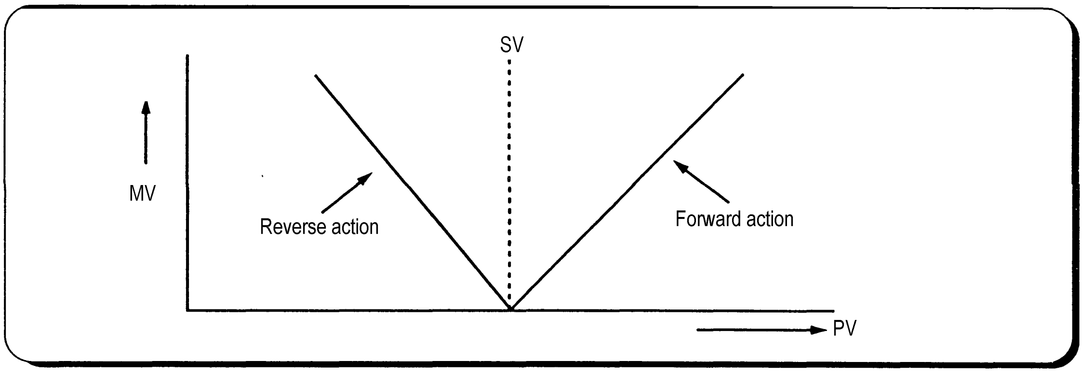
5) PID Processing Expression

PID expressions are of measured value derivative type.

Expressions	Parameters names
	MVn : Present Manipulated Value
	MVn-1 : One-step-previous Manipulated Value
$E_n = SV - PV_n$	**En** : Present deviation
	En-1 : Previous deviation
	Kp : Proportional constant
$MV_n = MV_{n-1} + K_p \times (E_n - E_{n-1})$	**Ki** : Integral constant
$+ K_p \times S/K_I \times E_n$	**Kd** : Derivative constant
$+ K_p \times K_d/S \times (2PV_n - PV_{n-1} - PV_{n-2})$	**S** : Control cycle (100 ms)
	PVn : Process value
	PVn-1 : One-step-previous Process Value
	PVn-2 : Two-step-previous Process value

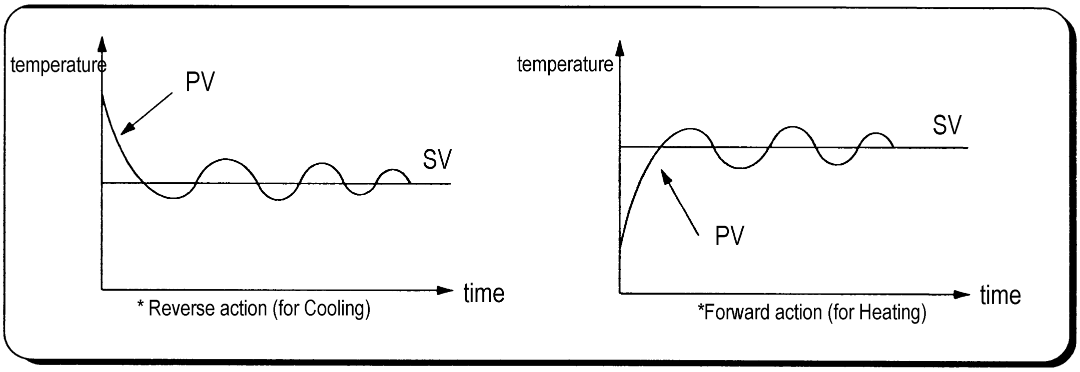
6) Forward/Reverse Actions

(1) PID control has two kinds of action, forward action and reverse action.
  a) Forward action makes PV reach SV by outputting MV when PV is less than SV.
  b) Reverse action makes PV reach SV by outputting MV when PV is more than SV.
(2) A diagram in which forward and reverse actions are drawn using MV, PV and SV is shown as Fig. 2.9.



[Fig. 2.9] Forward and reverse action with MV, PV and SV

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



[Fig. 2.9] Examples of process control by forward and reverse actions