

Chapter 2 . SPECIFICATIONS

2.1 General Specifications

Table 2.1 shows the general specifications of MASTER-K series.

No	Items	Specifications						Standard
1	Operating ambient temperature	0 ~ 55 °C						
2	Storage ambient temperature	-25 ~ 70 °C						
3	Operating ambient humidity	5 ~ 95%RH, non-condensing						
4	Storage ambient humidity	5 ~ 95%RH, non-condensing						
5	Vibration	Occasional vibration						IEC 1131-2
		Frequency	Acceleration	Amplitude		Sweep count		
		10≤f∠57 Hz	-	0.075 mm		10 times in each direction for X, Y, Z		
		57 ≤f≤150 Hz	9.8m/s² {1G}	-				
		Continuous vibration						
		Frequency	Acceleration	Amplitude				
		10≤f∠57 Hz	-	0.035 mm				
		57≤f≤150 Hz	4.9m/s² {0.5G}	-				
6	Shocks	*Maximum shock acceleration: 147 m/s² {15G} *Duration time :11 ms *Pulse wave: half sine wave pulse(3 times in each of X, Y and Z directions)						IEC 1131-2
7	Noise immunity	Square wave impulse noise		± 1,500 V				
		Electrostatic discharge		Voltage :4kV(contact discharge)				IEC 1131-2 IEC 801-2
		Radiated electromagnetic field		27 ~ 500 MHz, 10 V/m				IEC 1131-2 IEC 801-3
		Fast transient burst noise		Severity Level	All power modules	Digital I/Os (Ue ≥ 24 V)	Digital I/Os (Ue < 24 V) Analog I/Os communication I/Os	IEC 1131-2 IEC 801-4
				Voltage	2 kV	1 kV	0.25 kV	
8	Operating atmosphere	Free from corrosive gases and excessive dust						
9	Altitude for use	Up to 2,000m						
10	Pollution degree	2 or lower						
11	Cooling method	Self-cooling						

[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

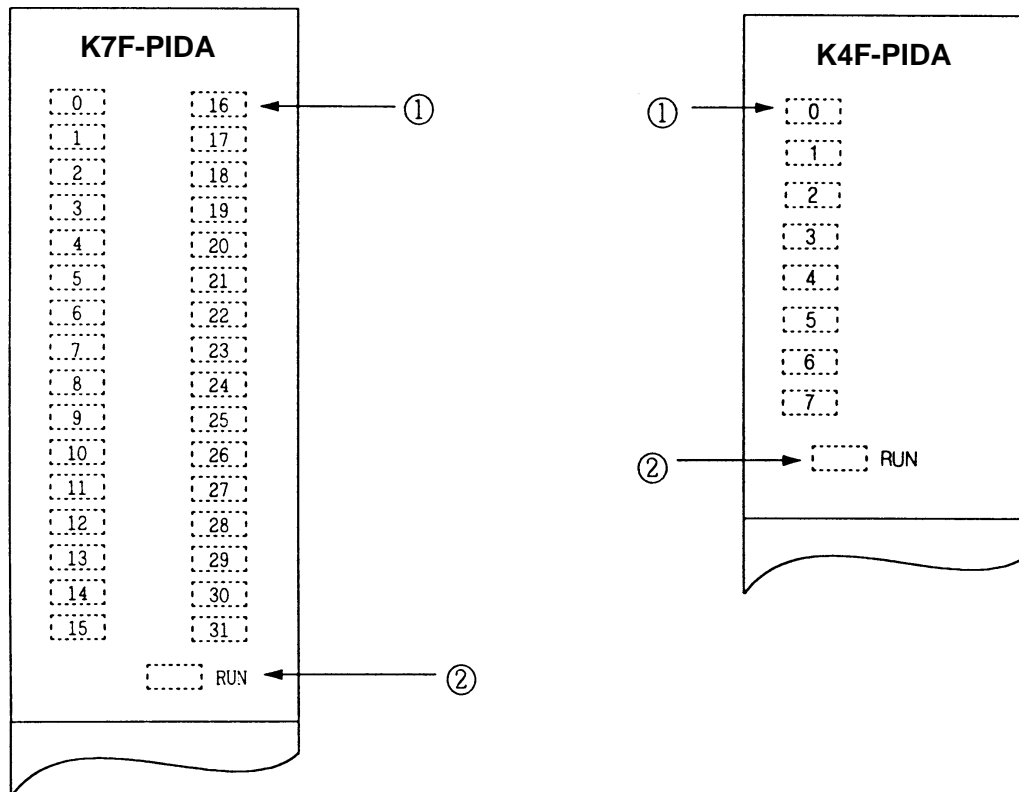
Table. 2.2 shows performance specifications of the PID control module.

Items		Specifications	
		K7F-PIDA	K4F-PIDA
Setting range of PID constants	Proportional constant (P)	0.01 ~ 100.00 (When integral and derivative constants are set to 0.0 sec, proportional action is applied.)	
	Integral constant (I)	0.0 ~ 3000.0 sec (When integral constant is set to 0.0 sec, integral action shall not be applied.)	
	Derivative constant (D)	0.0 ~ 3000.0 sec (When derivative constant is set to 0.0 sec, derivative action shall not be applied.)	
Setting range : SV (Set Value)		0 ~ 16,000	
Input range : PV (Process Value)		0 ~ 16,000	
Output range : MV (Manipulated Value)		0 ~ 16,000	
Setting range : M_MV (Manually Manipulated Value)		0 ~ 16,000	
LED	RUN / STOP	RUN : The run LED of corresponding loops ON STOP : The run LED of corresponding loops OFF	
	NORMAL/ERROR	Normal : RUN LED ON Error : RUN LED flickering	
Number of PID control loops		32 loops	8 loops
Control action		Forward/Reverse action control is available.	
Control cycle		0.1 sec	
Processing type		Measured value derivative type (Pre-derivative type)	
Internal current consumption		0.3 A	0.2 A
Weight		370 g	190 g

[Table. 2.2 Performance Specifications]

2.3 Names of Parts and Functions

The following gives names of parts :



No.	Descriptions
①	Loop Run LED
	<p>It shows the PID control module run status.</p> <ul style="list-style-type: none"> ● ON : The corresponding loop is running. ● OFF : The corresponding loop is running. ● Flickering : Error status. Error Value is displayed.
②	RUN LED
	<p>It shows the PID module Operating status.</p> <ul style="list-style-type: none"> ● 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 (ΔMV) 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

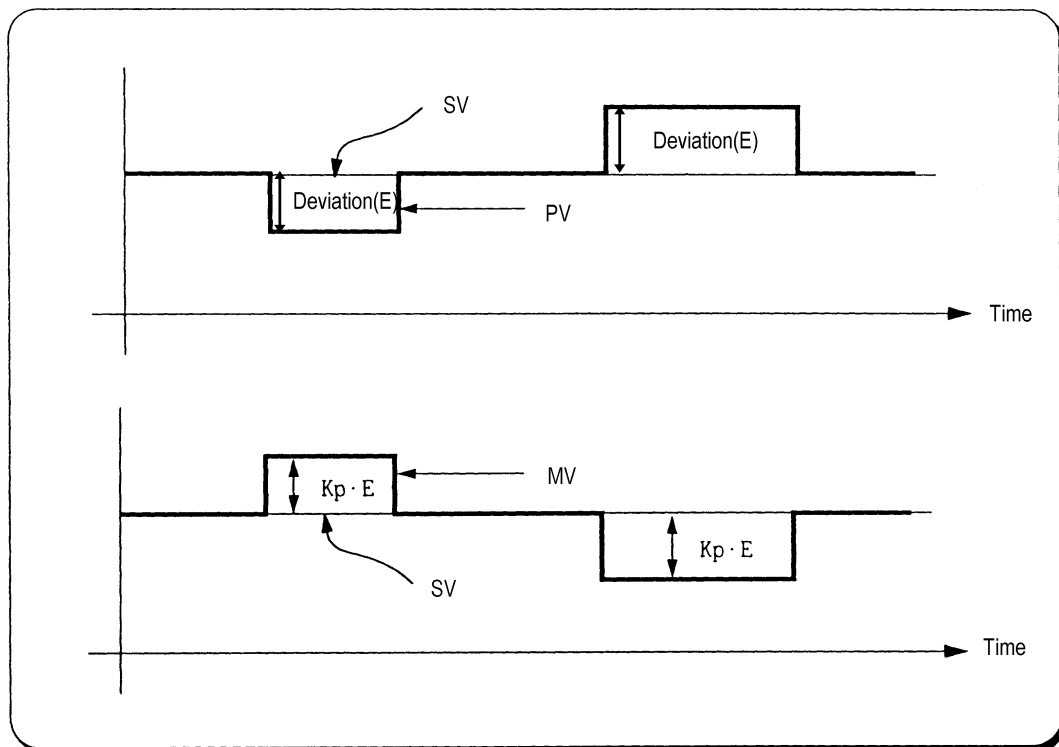
1) Proportional Action (P Action)

- (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:

$$MV = K_p \times E$$

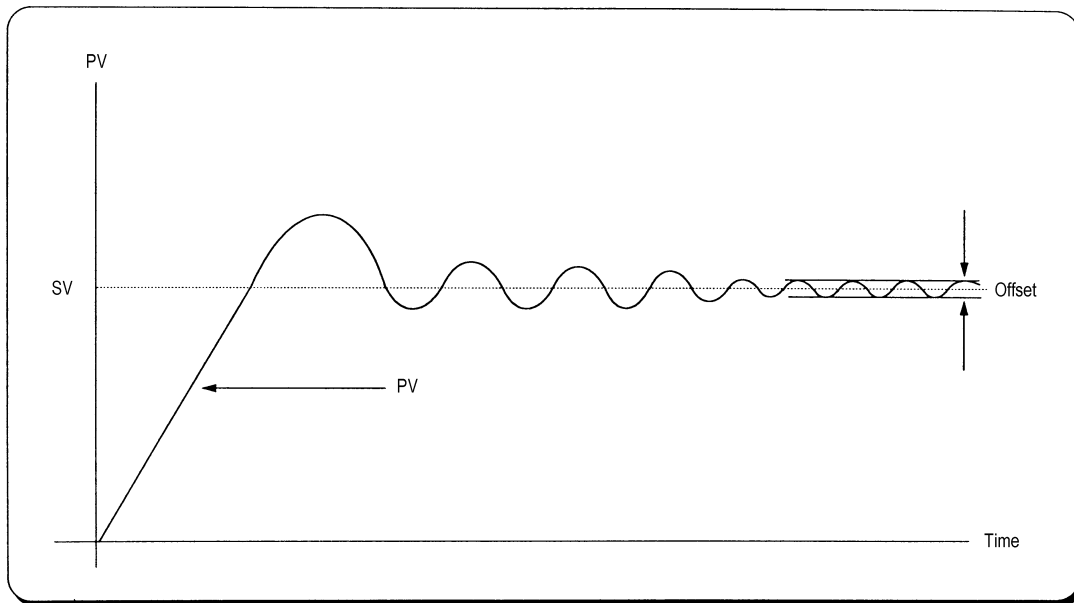
where K_p is a proportional constant and means gain.

- (3) When deviation occurs, the MV by P action is shown in Fig. 2.1.

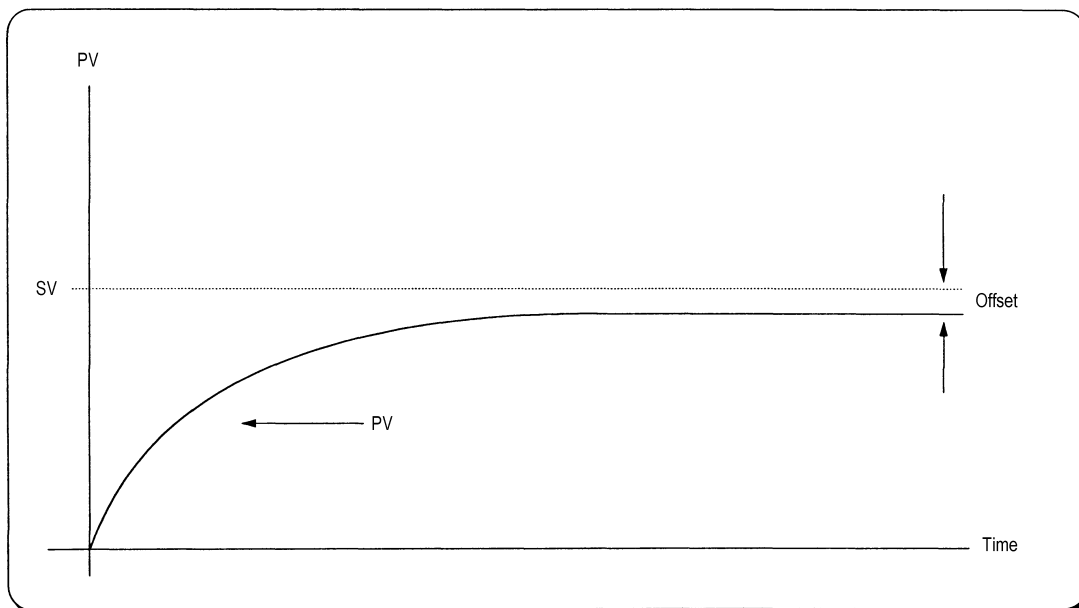


[Fig. 2.1] MV with the proportional action

- (4) As shown in Fig. 2.1, the larger the proportional constant K_p the larger the MV, that is, the stronger the P action when the deviation(E) is same. Also, the smaller the K_p the smaller the MV after P action.
- (5) If the K_p 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 K_p 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.



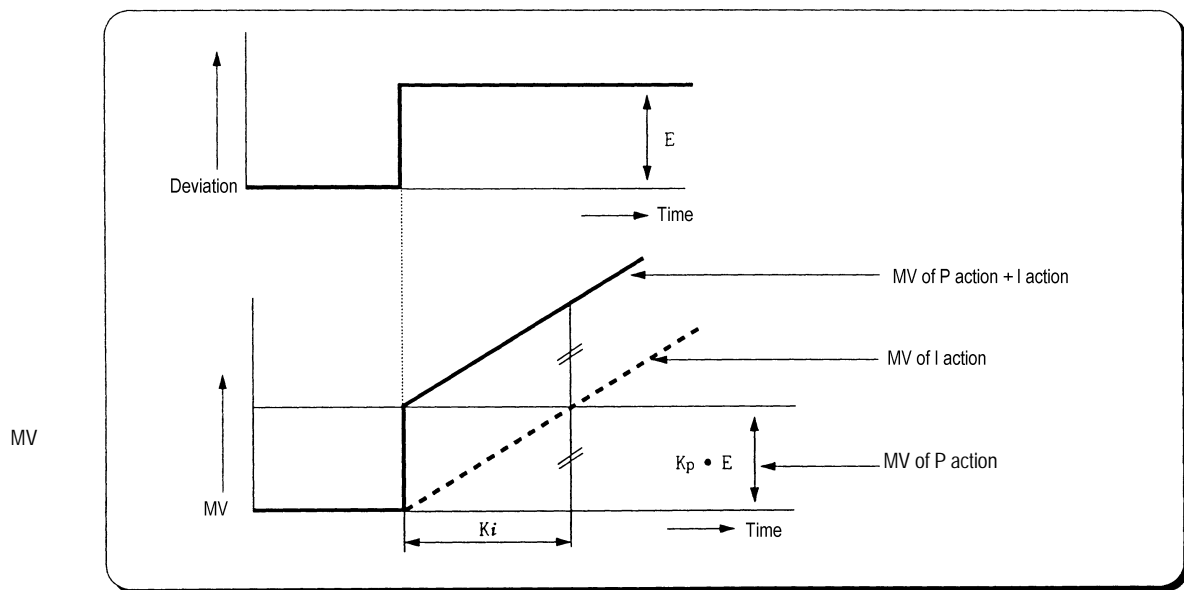
[Fig. 2.2] When the proportional constant K_p is large.



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

2) Integral Action (I Action)

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



[Fig. 2.4] Integral action at a constant deviation

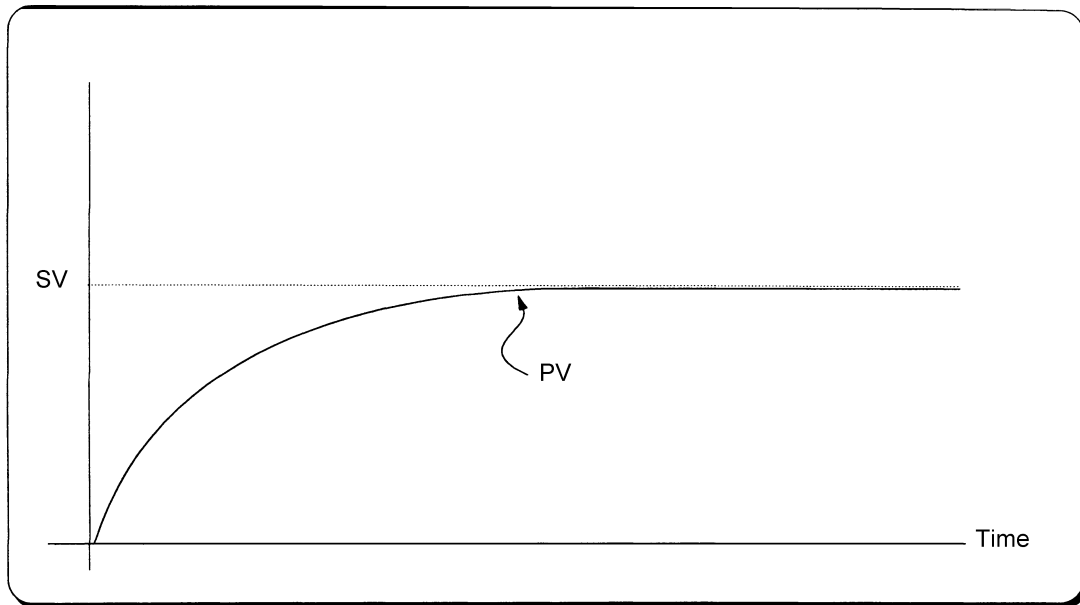
- (4) Expression of Integral Action is as follows:

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

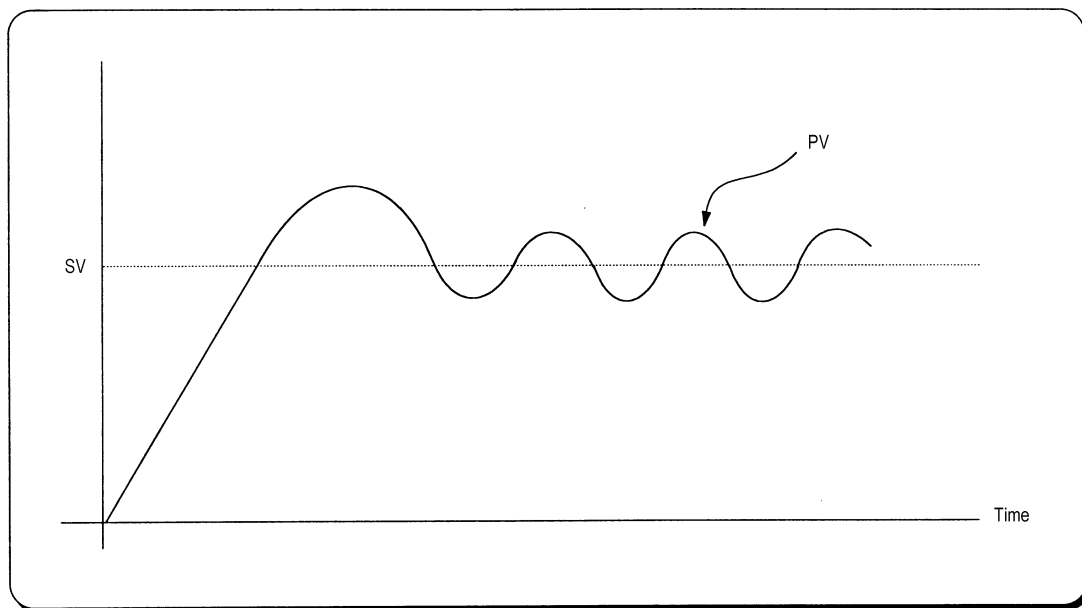
As shown in the expression, Integral action can be made stronger or weaker by adjusting integration time (K_i) in I action.

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.



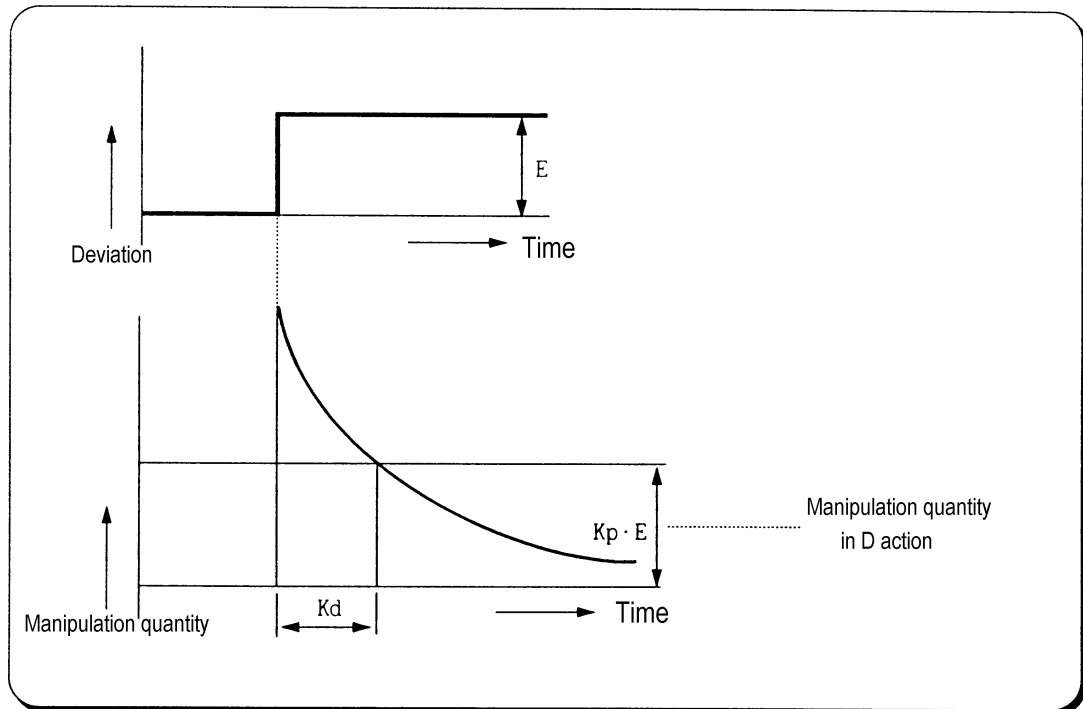
[Fig. 2.5] When a long integration time is given.



[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 K_d .
- (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:

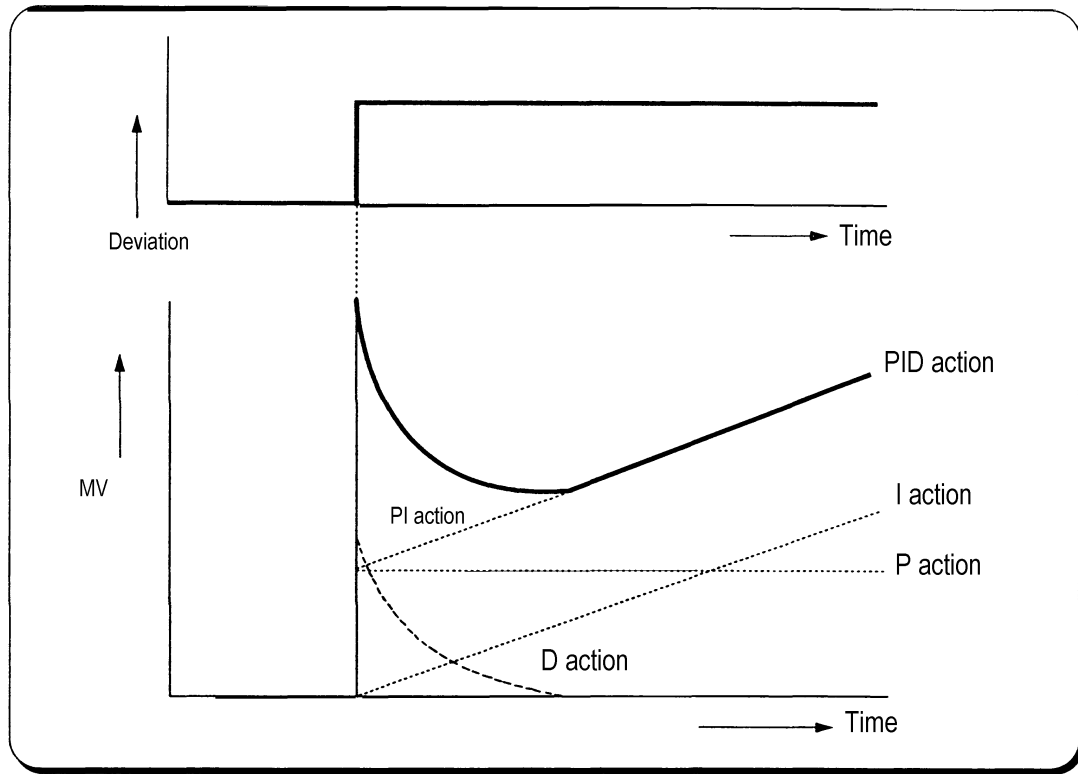
$$MV = K_p \times E + K_p \times \frac{dE}{dt}$$

- ▶ 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

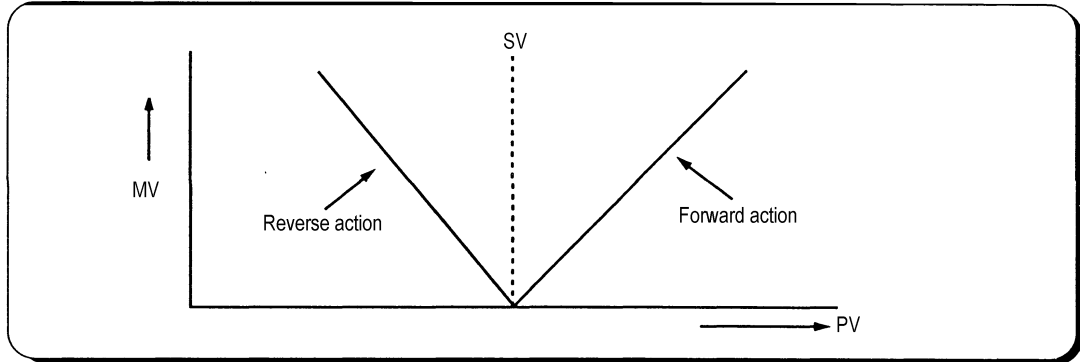
5) PID Processing Expression

PID expressions are of measured value derivative type.

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

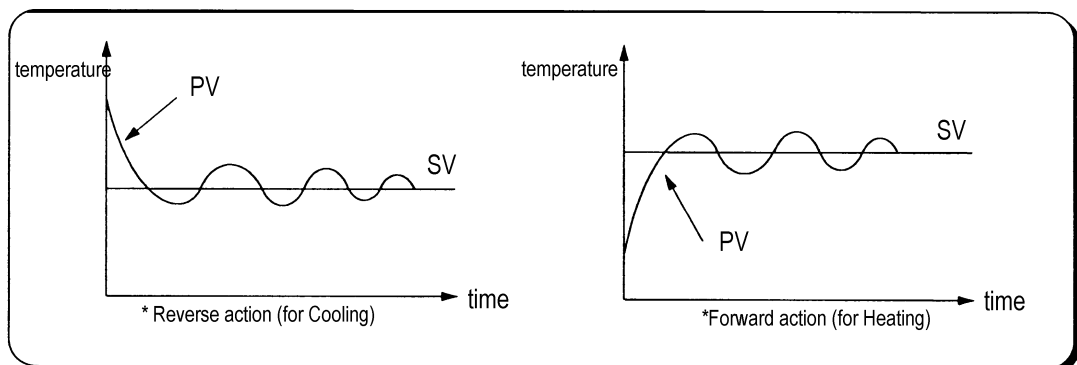
6) Forward/Reverse Actions

- (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