# Introduction:-

- The controller (an analogue/digital circuit, and software), is trying to keep the controlled variable such as temperature, liquid level, motor velocity, robot joint angle, at a certain value called the set point (SP).
- Controllers improve steady state accuracy by decreasing the steady state errors.
- Maximum overshoot of the system can be controlled using these controllers

Some definitions :-

- **Peak time :-**
- The peak time is the time required for the response to reach the first peak of the overshoot.
- **Overshoot :-**
- Overshoot is when a signal or function exceeds its target.
- **Steady state error:-**
- The difference between the desired final output and the actual one" when the system reaches a steady state

## Controllers:-

- A controller is one which compares controlled values with the desired values and has a function to correct the deviation produced.
- There are three basic types of contollers :

- Propotional controller { P controller }
- Derivative controller { D controller}
- Integral controller { I controller }

## P controller :-

- P controller stands for Proportional Control
- With proportional control, the actuator *applies a corrective force that is proportional to the amount of error*:

$$Output_p = K_p \times E$$

- $Output_p$ = system output due to proportional control
- $K_p$ = proportional constant for the system called gain
- $E$ = error, the difference between where the controlled variable should be and where it is. $E = SP - PV$.

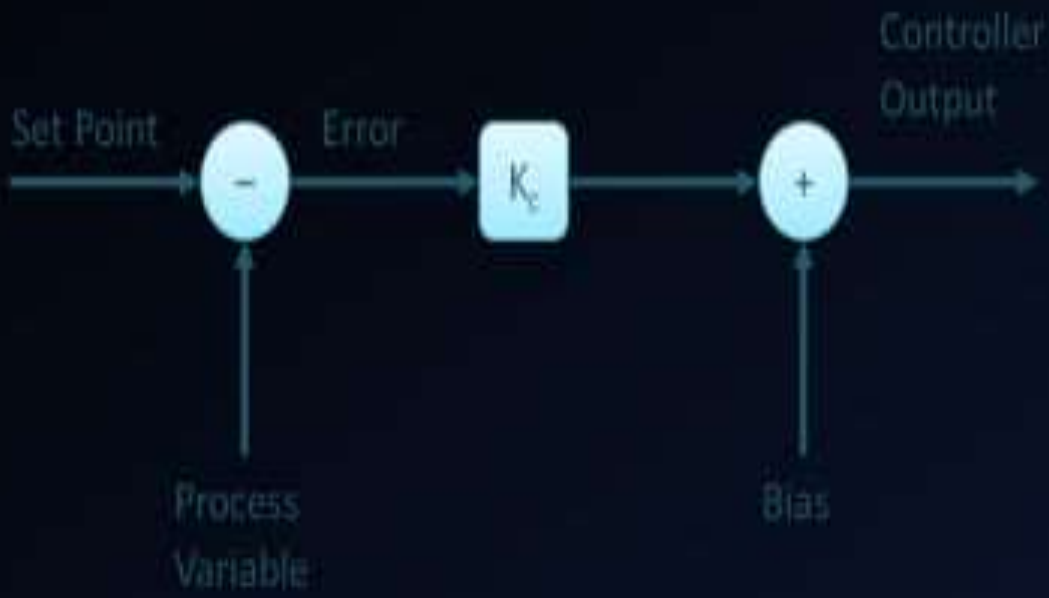
## P controller :-

- In a proportional controller the output (also called the actuating signal) is directly proportional to the error signal.

$$A(t) = K_p \times e(t)$$

- Where, $K_p$ is proportional constant also known as controller gain.
- $K_p$ should be kept greater than unity. If the value of $K_p$ is greater than unity, then it will amplify the error signal and thus the amplified error signal can be detected easily

# P controller :-




P controller

## PI controller :-

- PI controller stands for propotional integral controller.
- P-I controller is mainly used to eliminate the steady state error resulting from P controller.
- This controller is mostly used in areas where speed of the system is not an issue.
- it is a combination of proportional and an integral controller the output (also called the actuating signal) is equal to the summation of proportional and integral of the error signal.

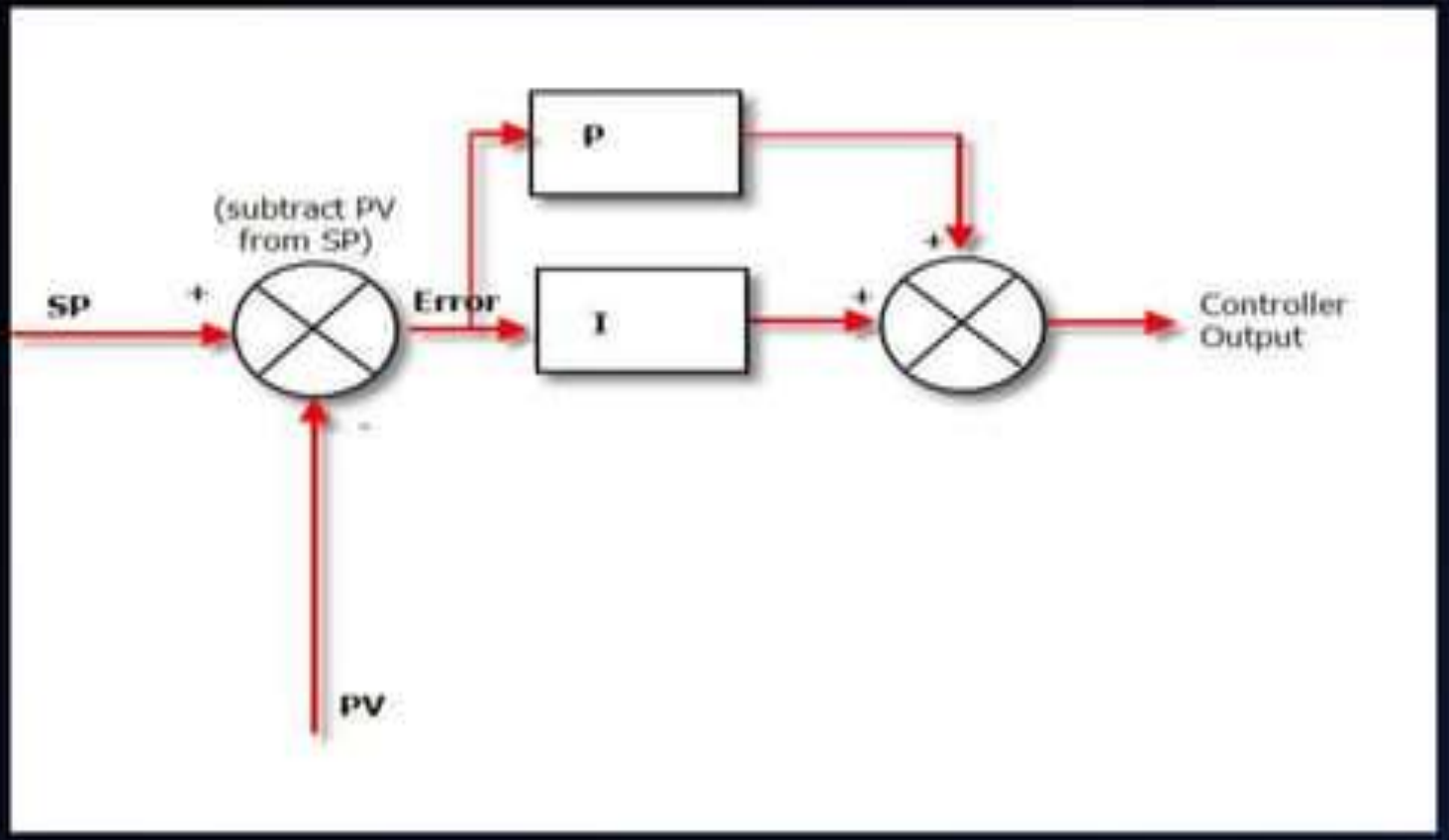
## PI controller :-

- A proportional and integral controller output is directly proportional to the summation of proportional of error and integration of the error signal.

$$A(t) = K_I \int_0^t e(t)dt + K_p e(t)$$

- Where, $K_I$ and $k_p$ proportional constant and integral constant respectively.

# PI controller :-



# PID controller :-

- PID stands for propotional integrated derivative.
- A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems.
- A PID controller attempts to correct the error between a measured process variable and a desired setpoint by calculating and then outputting a corrective action that can adjust the process accordingly.

# PID controller :-

- The foundation of the system is proportional control. Adding integral control provides a means to eliminate steady-state error, but increases overshoot.
- Derivative control increases stability by reducing the tendency to overshoot.
- It consists of three controllers :-

- Integral control
- Proportional control
- Derivative control

# PID controller :-

$$Output_{PID} = K_P \times E + K_I \times \sum (E \times \Delta t) + K_D \times \left( \frac{\Delta E}{\Delta t} \right)$$

$Output_{PID}$ = output from PID controller

$K_p$ = proportional control gain

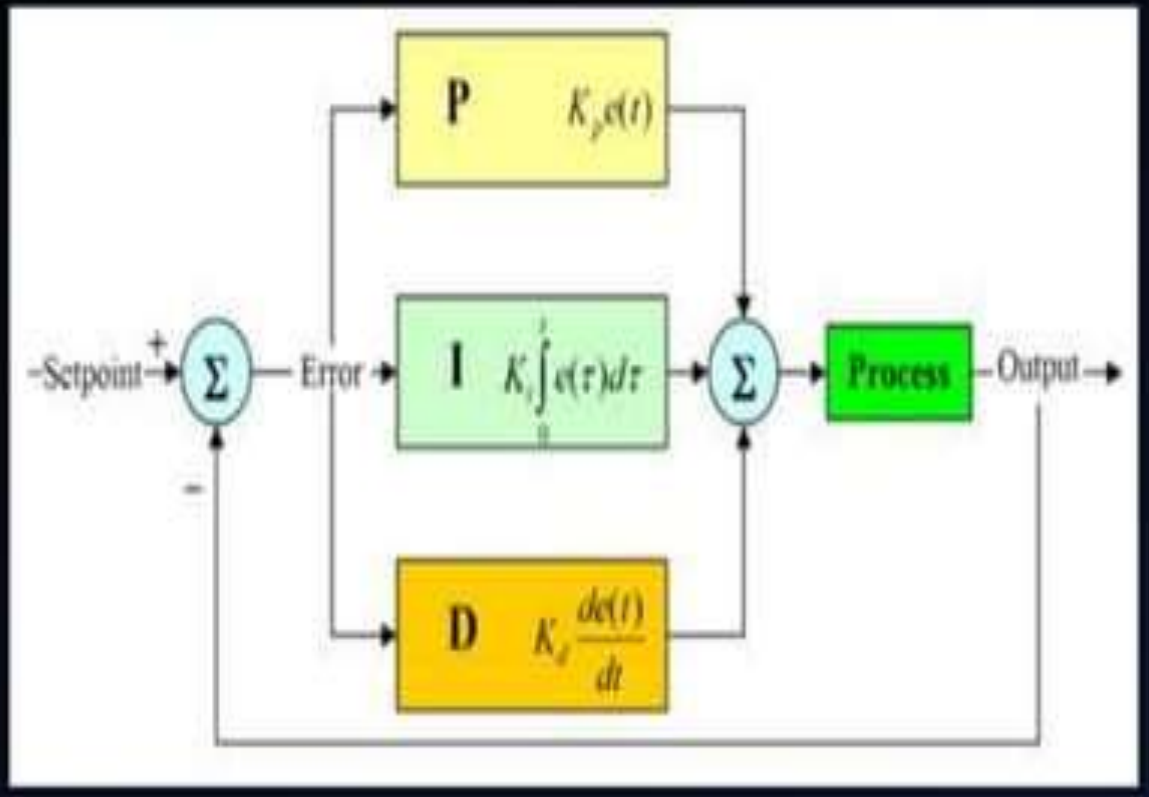
$K_I$ = integral control gain

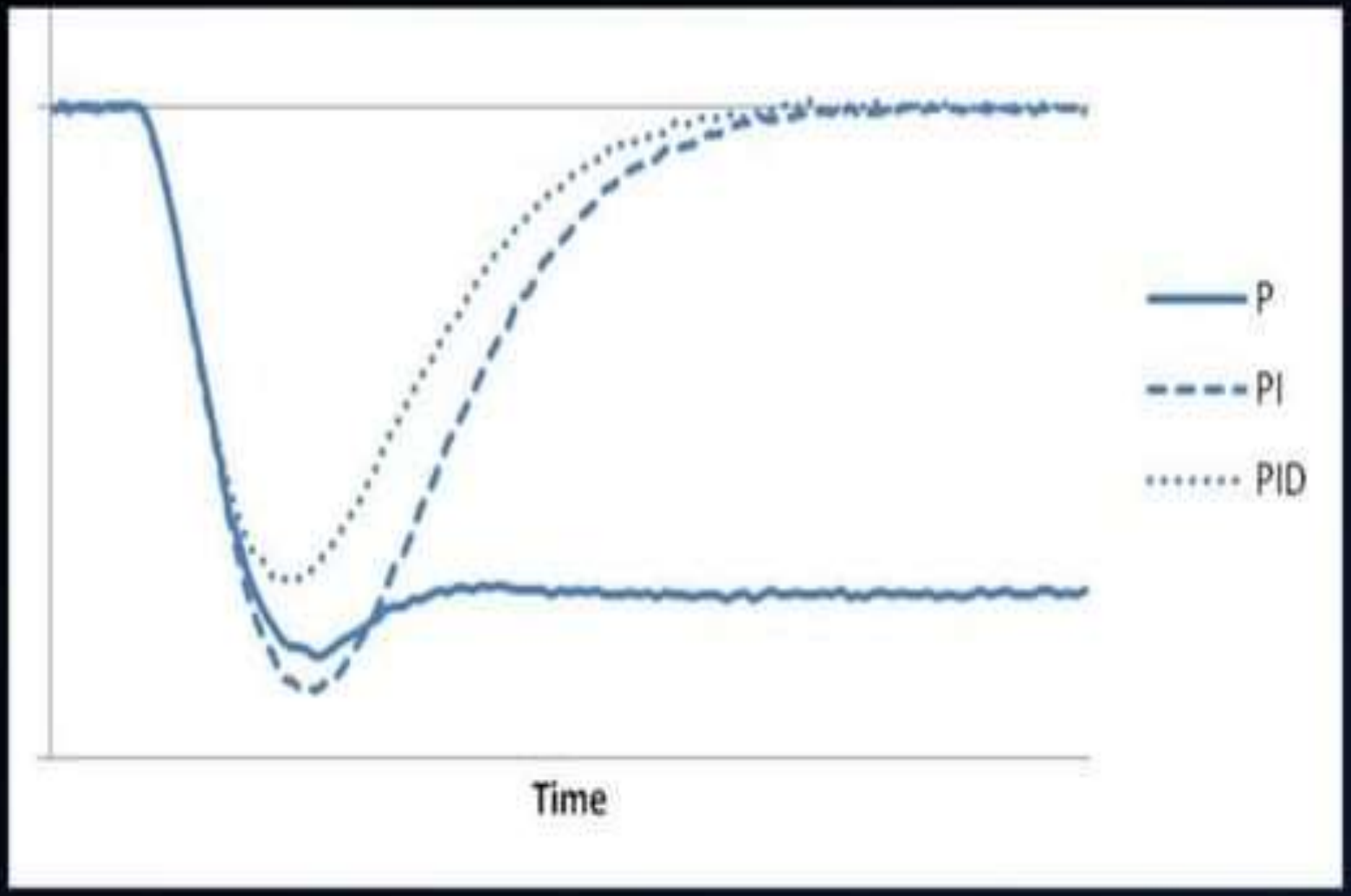
$K_D$ = derivative control gain

$E$ = error (deviation from set point)

$\sum(E \times \Delta t)$ = sum of all past errors (area under the error/time curve)

# PID Controller :-




P
PI
PID
Time

Thank you