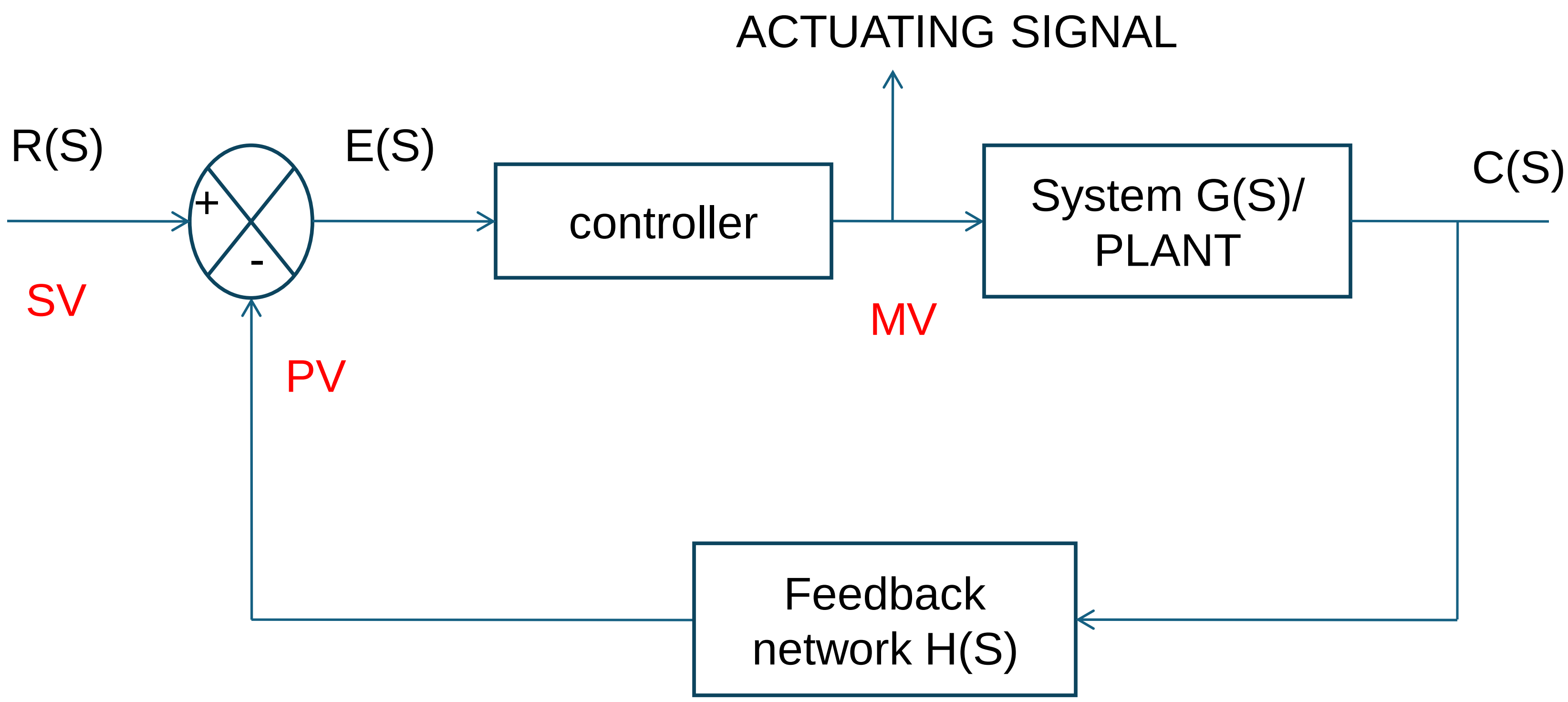
Unit-2

- The purpose of the proportional controller is to change the transient response as per the requirement.



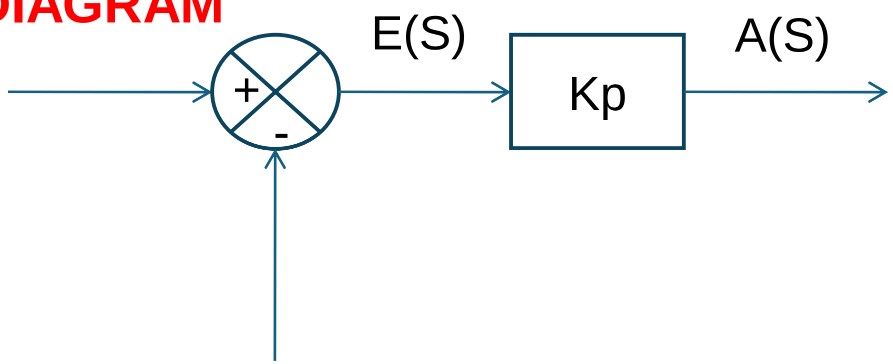
PROPORTIONAL CONTROLLER

- The proportional controller produces an output or an actuating signal which is proportional to error signal.

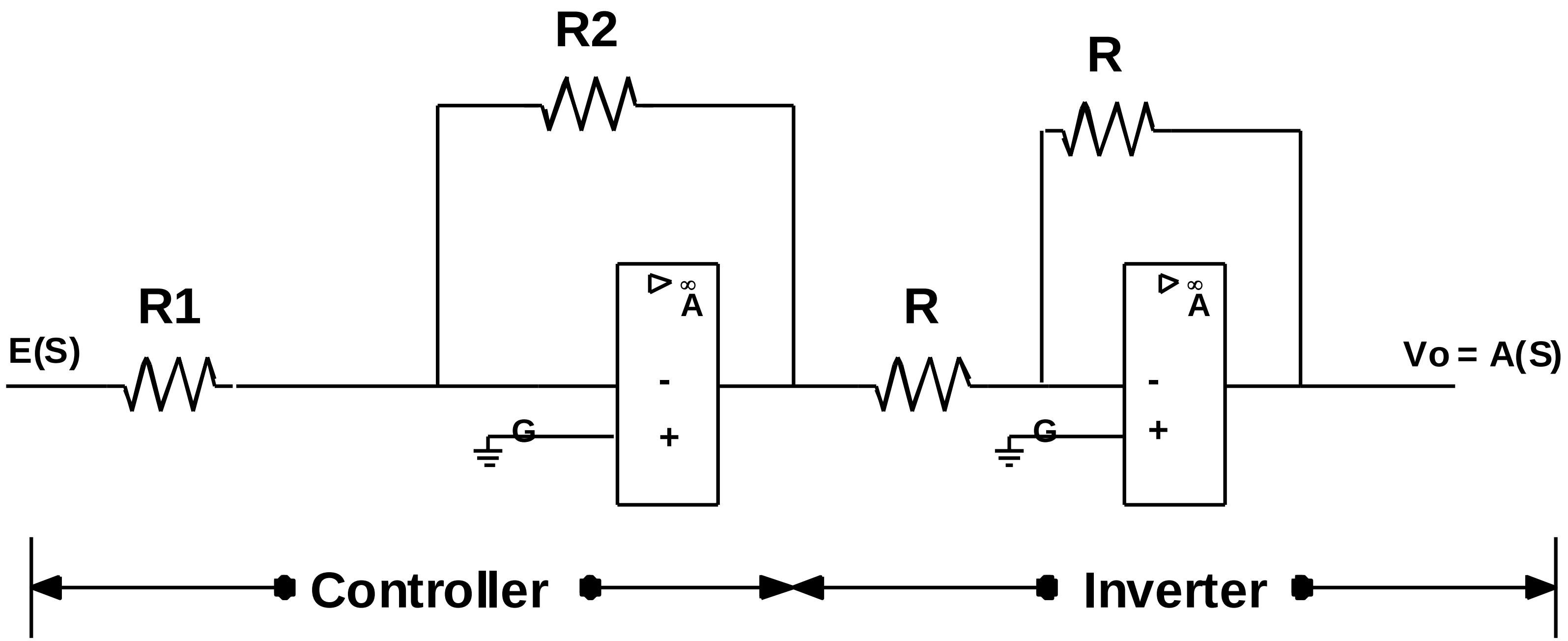
  i.e.; $a(t) \alpha e(t) \Rightarrow a(t) = K_P e(t)$

- where K_P is the proportional gain or constant.
- On taking Laplace Transform we get
- $A(S) = K_P E(S) \Rightarrow A(S)/E(S)=K_P$

BLOCK DIAGRAM



PRACTICAL CKT



A(S)/ E(S) = R2/R1 = Kp

- $G(S)/w.o.c = 1/s(s+10)$ => C.L.T.F = $1/s^2+10s+1$ => $w_n=1$ rad/sec and $\xi = 5$ => over damped => large rise time, less settling time.
- $G(S)/w.c = k_p/s(s+10)$ => C.L.T.F = $k_p/s^2+10s+k_p$ when $k_p=100$, $w_n=10$ rad/sec and $\xi= 0.5$ => under damped => moderate rise time and moderate settling time.
- By selecting the proper value of kp we can get the desired transient performance.
- Dis adv: 1. can not eliminate the complete error in the system.

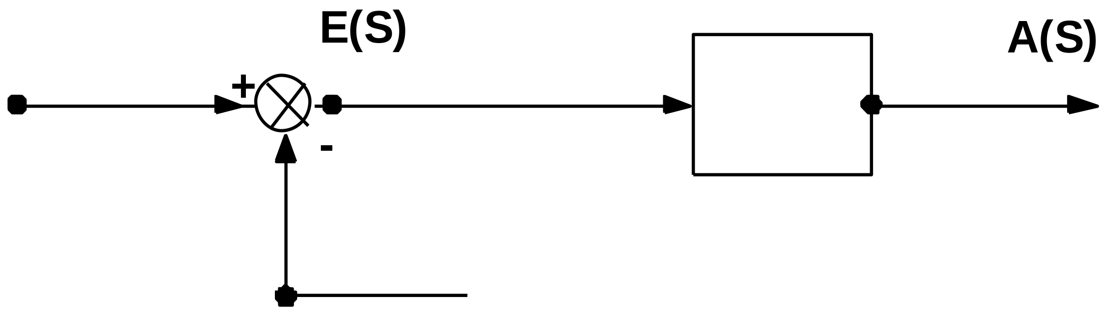
  2. As the kp value increases, wn is increases, hence the system becomes more oscillatory.

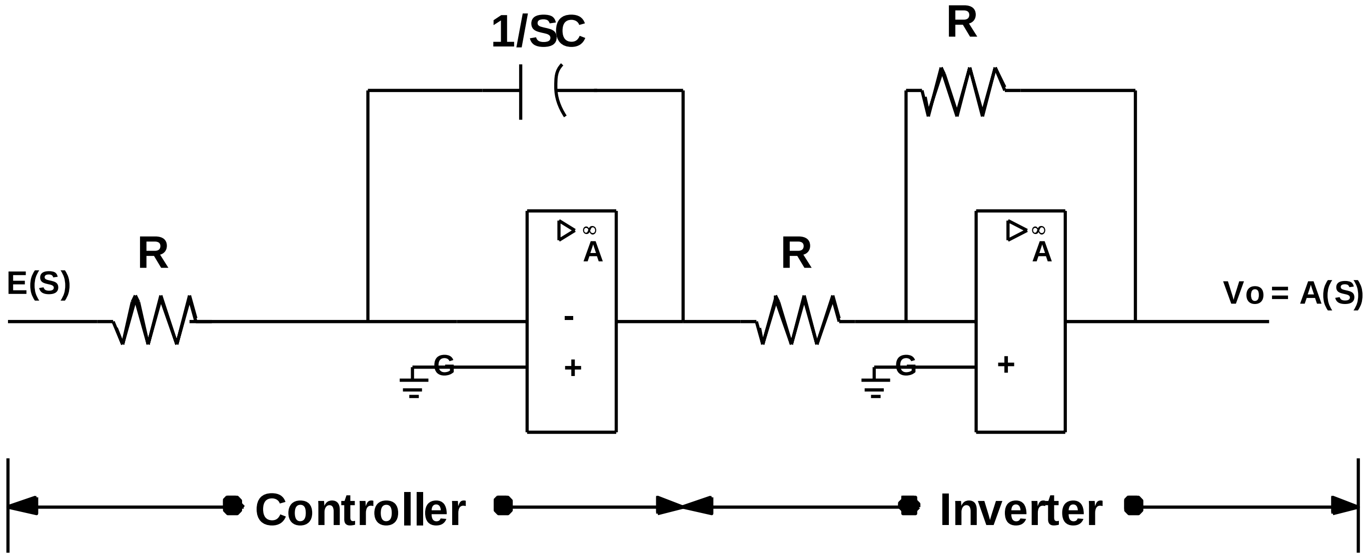
  3. The damping ratio decreases, hence Mp is increases, so the system becomes less stable

INTEGRAL CONTROLLER

- The purpose is to decrease the steady state error.
- The Integral controller produces an output or an actuating signal which is proportional to integration of error signal.
- $a(t) \alpha \int e(t)\, dt \Rightarrow a(t)=K_I \int e(t)\, dt$
- where K_I is the integral gain.
- On taking Laplace transform we get
- $A(S)= K_I\, E(S)/S \Rightarrow A(S)/E(S)= K_I/S$

BLOCK DIAGRAM & PRACTICAL CKT





A(S)/ E(S)= (1/SC)/R = 1/SRC = Ki/S

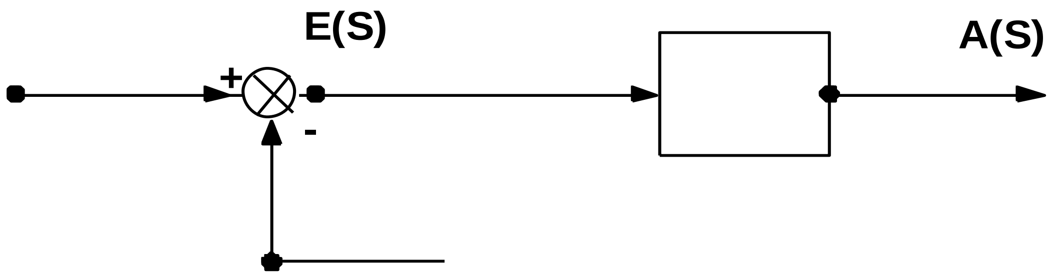
where Ki= 1/RC

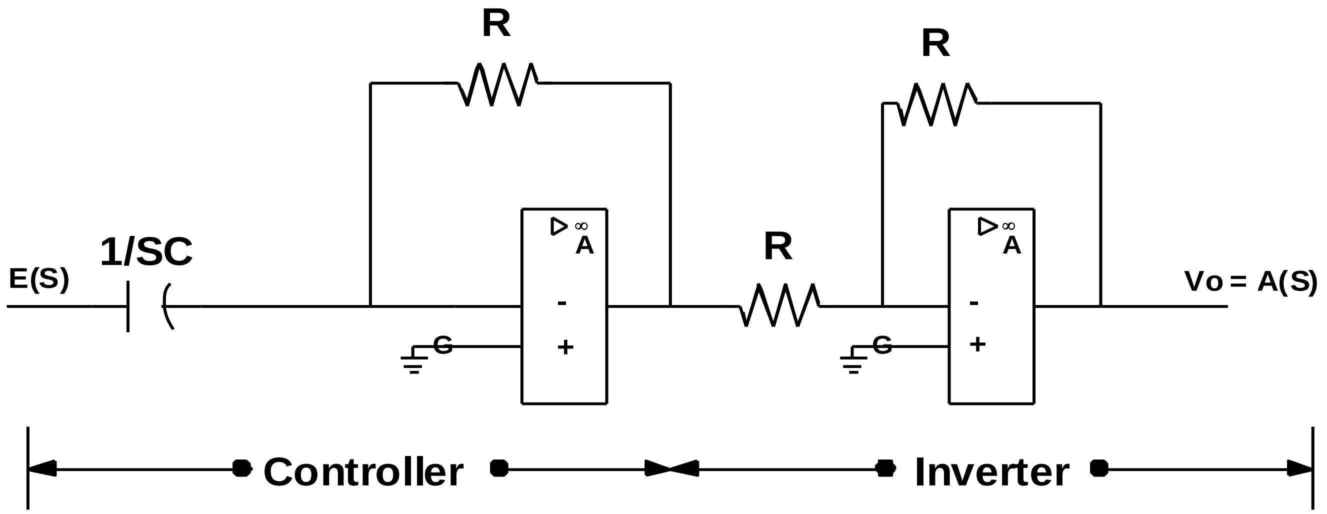
- The transfer function of the integral controller is K_I/S
- Let G(S)/w.o.c =1/s(s+10) => Type-1 => CE = $s^2+10s+1=0$ => Stable
- G(S)/w.c = $K_I/s^2(s+10)$ => Type-2 => e_{ss} decreases, but CE = $s^3+10s^2+K_I=0$ => un stable i.e: stability effected

DERIVATIVE CONTROLLER

- The purpose is to improve the stability.
- The Derivative controller produces an output or an actuating signal which is proportional to differentiation of error signal.
- $a(t) \propto de(t)/dt \Rightarrow a(t) = K_D\, de(t)/dt$
- where K_D is the derivative gain.
- On taking the Laplace transform we get
- $A(S) = K_D\, S\, E(S) \Rightarrow A(S)/E(S) = K_D S$

BLOCK DIAGRAM & PRACTICAL CKT





A(S)/ E(S) = R/(1/SC)=SCR= KdS

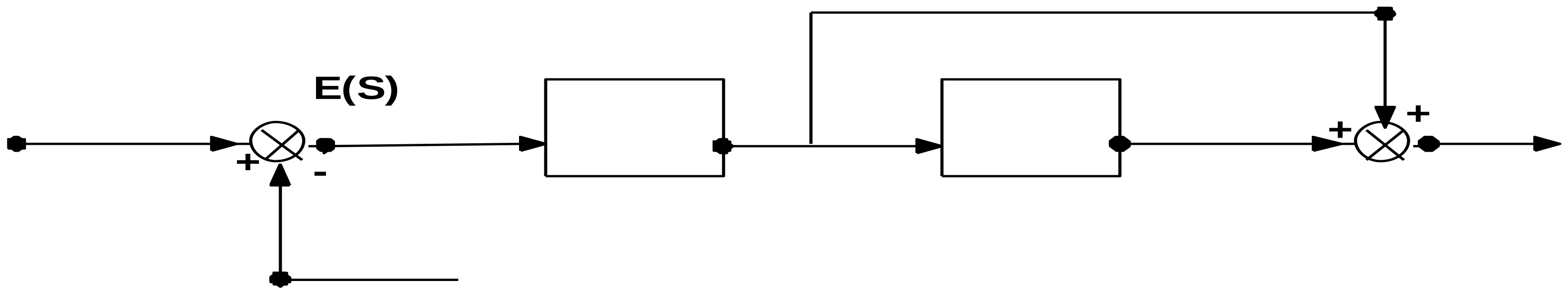
where Kd= RC

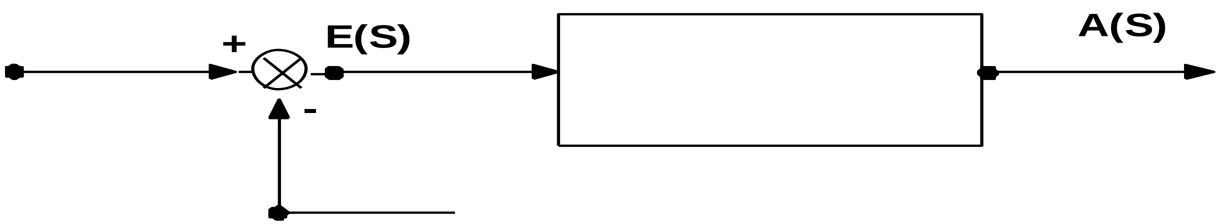
- The transfer function of the Derivative controller is $K_D S$
- Let G(S)/w.o.c =1/ $s^2(s+10)$ => Type-2 => CE = $s^3+s^2+1=0$ => Un stable.
- G(S)/w.c = $K_D S/s^2(s+10)$ => Type-1 => e_{ss} increases, CE = $s^2+10s+K_D = 0$ => Stable. i.e; stability improved.

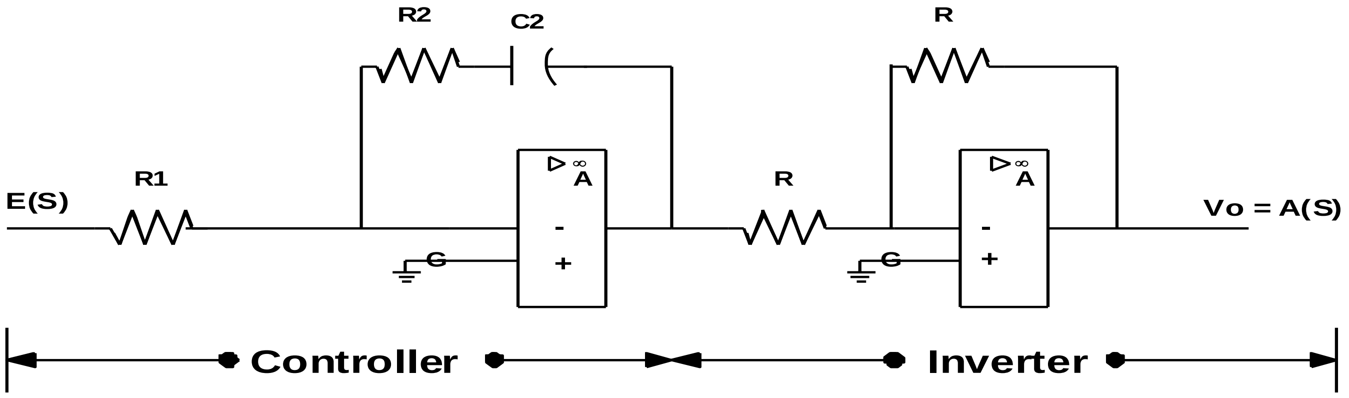
PI CONTROLLER

- The purpose is to decrease the steady state error without effecting the stability.
- The proportional Integral controller produces an output or an actuating signal which is proportional to error plus integration of error signal.
- $a(t) \propto [e(t) + \int e(t)dt]$ => $a(t) = K_P e(t) + K_I \int e(t)dt$
- on Taking the Laplace transform we get
- $A(S) = E(S)[K_P + K_I/S]$ => $A(S)/E(S) = K_P + K_I/S$

BLOCK DIAGRAM &PRACTICAL CKT







A(S)/E(S)= R2+1/SC2=R2/R1+1/SR1C2= Kp + Ki/s

Where Kp = R2/R1, Ki= 1/R1C2, = Kp /Ti

Ti= Integral time

- The transfer function of the PI controller is = (K_P+K_I/S) = $[SK_P+K_I/S]$.
- Let G(s)/w.o.c = 1/s(s+10) => Type-1 => CE = $s^2+10s+1=0$ => Stable.
- G(S)/w.c = $SK_P+K_I/s^2(s+10)$ => Type-2 => e_{ss} decreases, also CE = $s^3+10s^2+sK_P+K_I=0$ => Stable. i.e; stability is not effected.
- Effects of PIC: 1. The system becomes more stable.

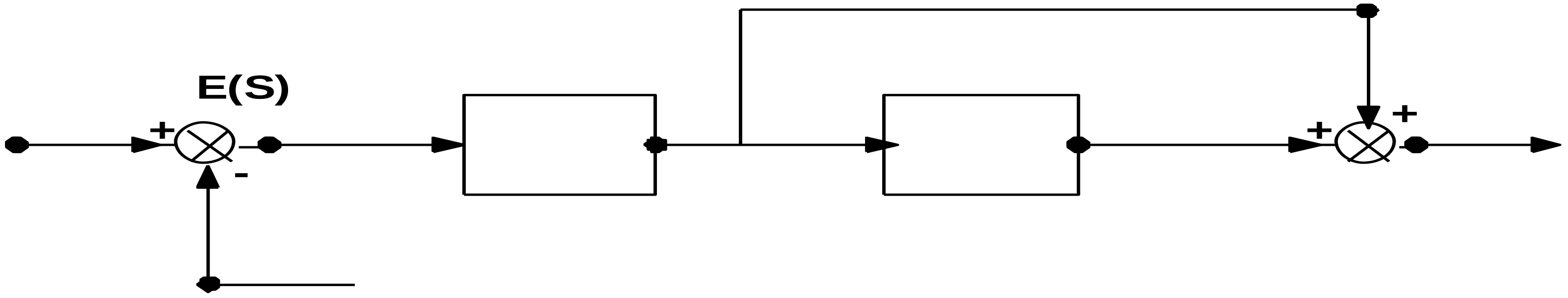
2. steady state performance is improved because PIC act as a LPF

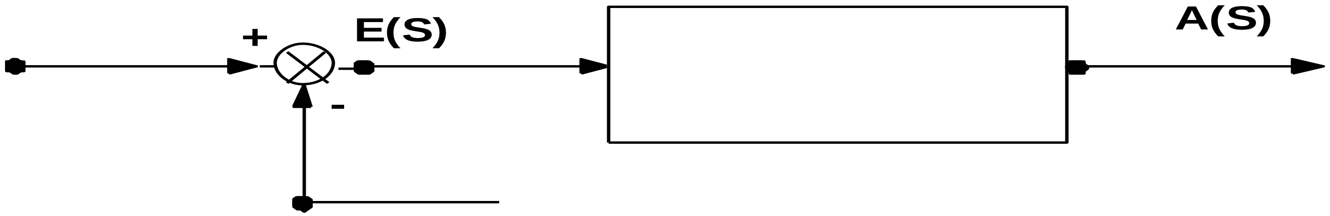
3. Noise is filtered out because of LPF (anti-aliasing filter).

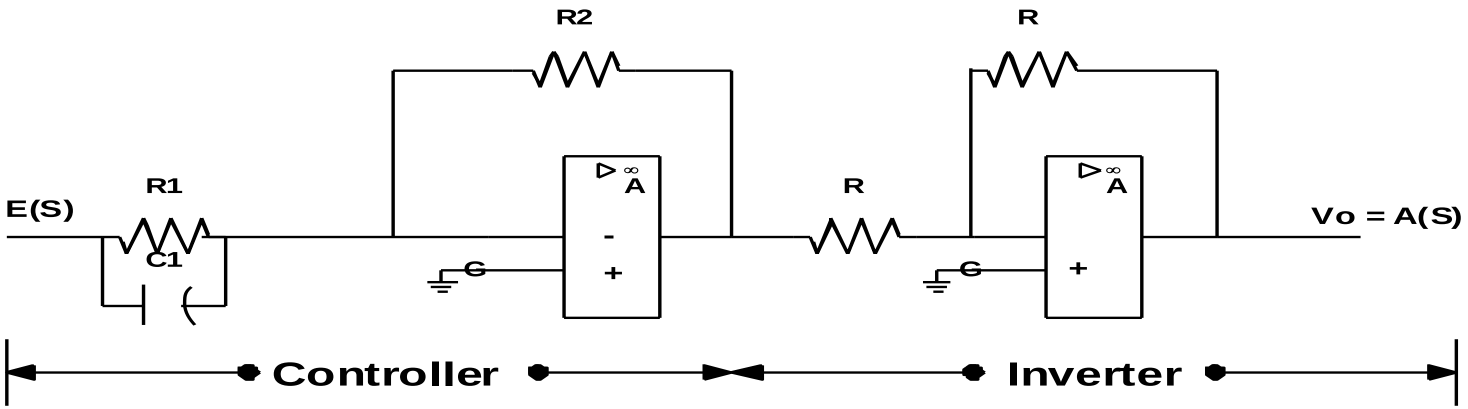
PD CONTROLLERS

- The purpose is to improve the stability without effecting the steady state error.
- The Proportional Derivative controller produces an output or an actuating signal which is proportional to error plus differentiation of error signal.
- $a(t) \alpha [e(t)+de(t)/dt]$ => $a(t)= K_P e(t)+ K_D de(t)/dt$
- on Taking the Laplace transform we get
- $A(S)=E(S)[K_P+K_DS]$ => $A(S)/E(S)= K_P+K_DS$.

BLOCK DIAGRAM & PRACTICAL CKT







A(S)/ E(S)= R2/ R1/(SR1C1+1) = R2(SR1C1+1)/R1= R2/R1+SR2C1

= Kp+KdS where Kp= R2/R1, Kd= R2C1=KpTd

Td= Differential time

- Transfer function of the PD controller is K_P+K_DS.
- Let G(S)/w.o.c = $1/s^2(s+10)$ => Type-2 => CE=$s^3+10s^2+1=0$ => Unstable
- G(S)/w.c = $SK_D+K_P/ s^2(s+10)$ => Type-2 => No change in s.s error, also CE=$s^3+10s^2+sK_D+K_P=0$ => Stable.

PID CONTROLLERS

- PID controller improves the stability as well as decrease the steady state error. i.e.; it will overcomes the limitations of all the above controllers.
- The Proportional Integral Derivative controller produces an output or an actuating signal which is proportional to error plus integration plus differentiation of error signal.
- $a(t) \alpha [e(t) + \int e(t)dt + de(t)/dt]$ => $a(t) = K_P e(t) + K_I \int e(t)dt + K_D\, de(t)/dt$
- on Taking the Laplace transform we get
- $A(S) = E(S)[K_P + K_I/S + K_D S]$ => $A(S)/E(S) = K_P + K_I/S + K_D S$

BLOCK DIAGRAM &PRACTICAL CKT