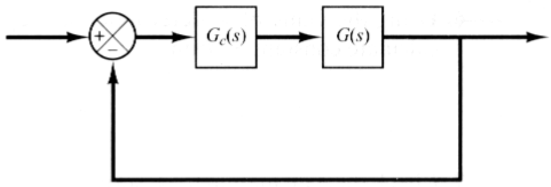
Control System Design: PD *Controller*

Control system diagram in unity feedback



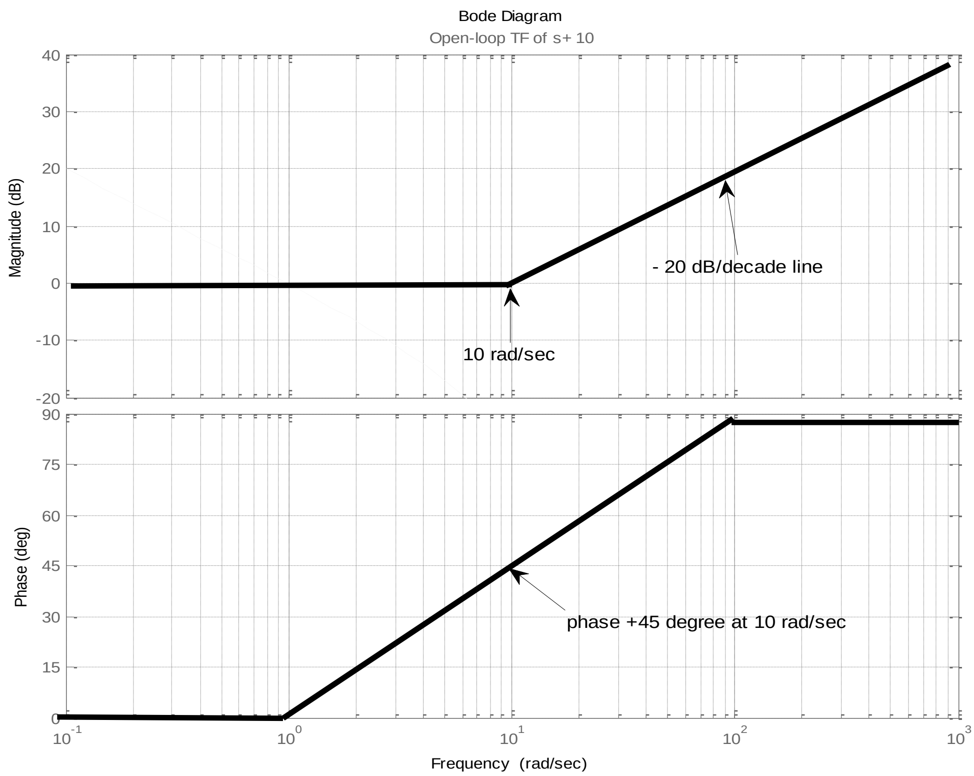
$G_C(s)$ – PD Controller; *$G(s)$* – Plant / Transfer function

PD controller techniques based on the frequency response approach

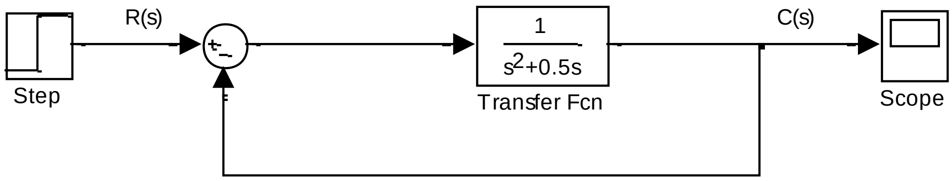
PD Controller transfer function

$$G_c(s) = K_c(s + z_c) = K_c z_c \left(\frac{1}{z_c} s + 1\right);$$

Bode diagram of open-loop transfer function is $G_o(s) = s + 10$



Example PD design; Desired system is K_v of 20 sec^{-1}, % overshoot is at least 20 percent .



Determine and analysis of previous information

Open-loop TF is

; Type_______

Closed-loop TF is

Closed-loop poles are ____

Bandwidth frequency $(\omega_{BW}) =$ ____________rad/sec

Gain margin(GM) =______________ dB; Phase margin(PM) = ________________ degree

Static velocity error constant (K_v) = __________________ sec^{-1}

Settling time = ________________________________sec (5% error)

Step I: Determine total gain (K) of open-loop TF to satisfy the requirement on the given static velocity error constant (K_v)= 20

$$K_v = \lim_{s\to 0} sG_c(s)G(s) = \lim_{s\to 0} sK_c z_c\left(\frac{1}{z_c}s+1\right)\left(\frac{1}{(s+0.5)s}\right) = 20$$

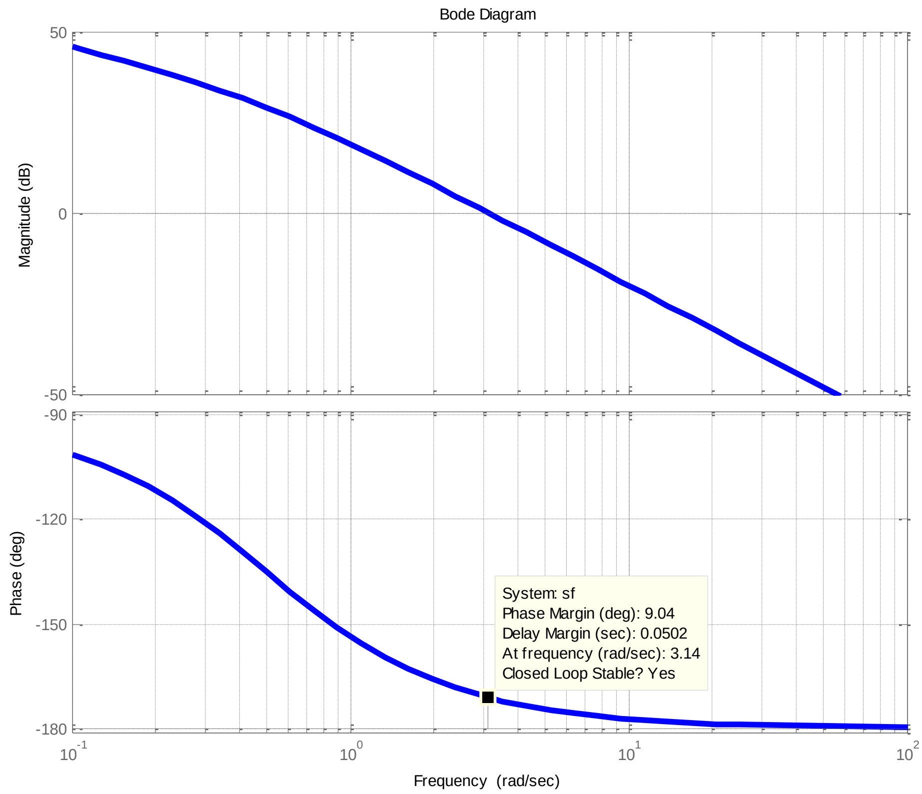
where $K_c z_c = K$, thus

$$K = 20(0.5) = 10 \rightarrow K = 10$$

New open-loop transfer function

$$G_0(s) = \frac{10}{s^2+0.5s}$$

Step II: Plot bode diagram of open-loop TF with new gain such as



Phase margin(PM)= _______deg. at _______ rad/sec; Gain margin(GM)= = _____dB at ______rad/sec

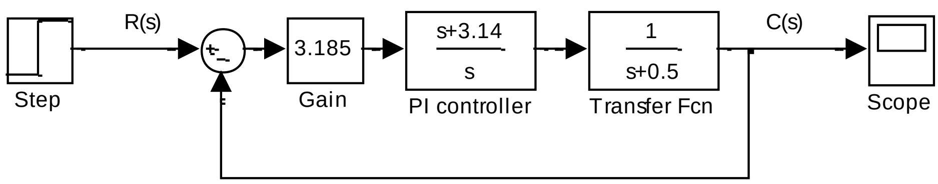
<u>Step III:</u> Select zero part of PD controller at 3.14 rad/sec (PM = 9.04 degree). This frequency can be plus 45 degree at 3.14 rad/sec. (Thus, Total PM is 9.04+45 = 54.04 degree approximately)

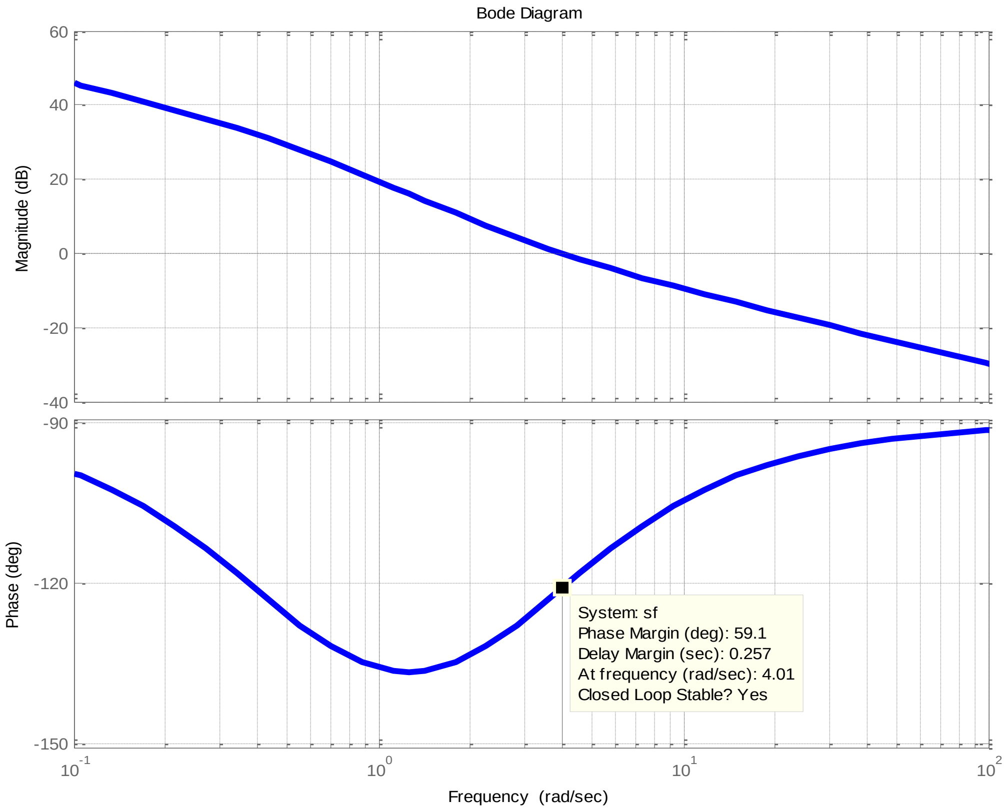
$$z_c = 3.14$$

$$K_c z_c = K = 10 \rightarrow K_c = 3.185$$

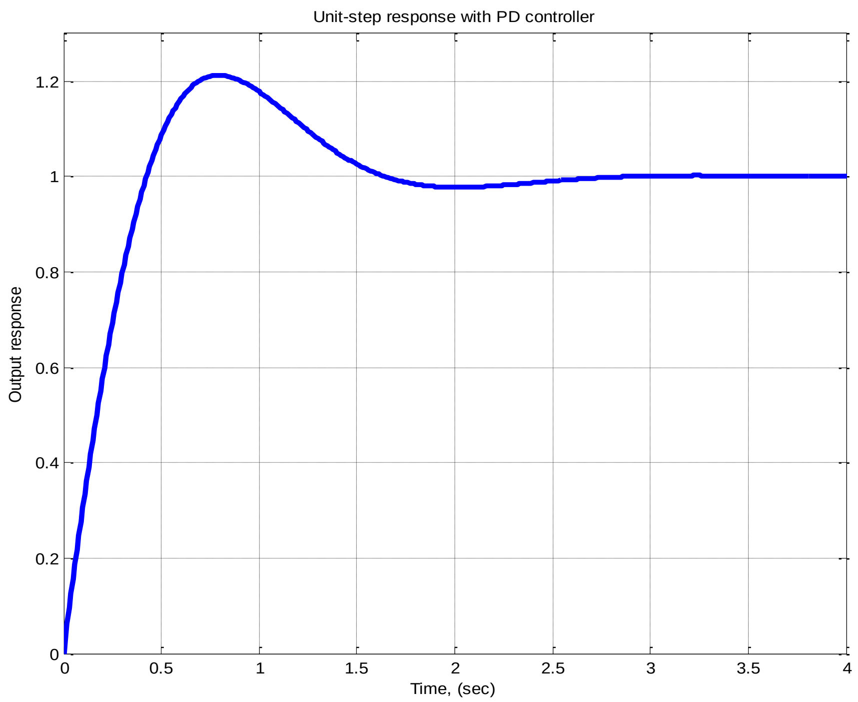
The new open-loop transfer function is

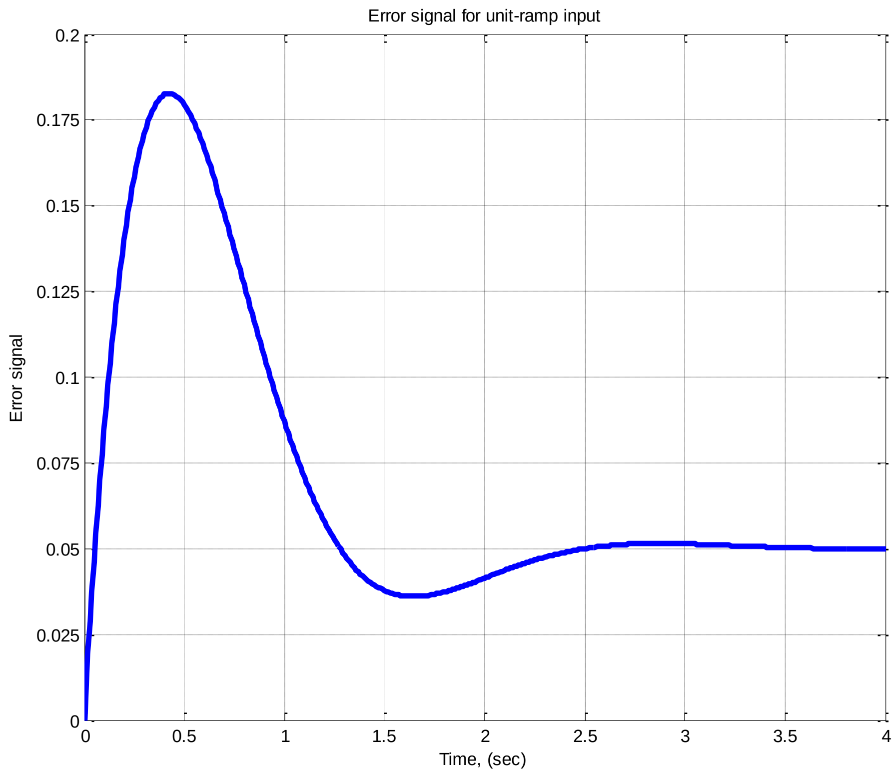
$$G_c G(s) = 3.185 \cdot (s + 3.14) \cdot \left(\frac{1}{(s+0.5)s} \right)$$





Phase margin(PM)= _______deg. at _______ rad/sec; Gain margin(GM)= = _____dB at ______rad/sec




Error signal for unit-ramp input
Error signal
Time, (sec)
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
0.5
1
1.5
2
2.5
3
3.5
4