Ese 315 Frank Yee 109374525

HW# 7

17% OS, $T_s^{comp} = T_s/1.5$

1) $\cancel{G}s = \dfrac{K(s+0.1)}{s^2(s+3)(s+8)}$

$$\zeta = \frac{-\ln(.17)}{\sqrt{\pi^2 + \ln^2(.17)}} = \frac{1.772}{3.607} = .491$$

a) plot RL

SR $T_s = 10.93s$

b) $K = 42.1$

$T_s^{comp} = 7.287s = \dfrac{4}{\sigma_d^{comp}}$

c) $\sigma_d^{comp} = .5489$

$$w_d^{comp} = w_d \frac{\sigma_d^{comp}}{\sigma_d} = 1.85 \frac{.5489}{1.04} = .9765$$

new pole : $-\sigma_d \pm j w_d = -.5489 \pm j.9765$

d) compensating zero

$$\theta = \left(\tan^{-1}\left(\frac{.9765}{-.5489+d}\right)+180\right) - 2\left[\tan^{-1}\left(\frac{.9765}{-.5489}\right)+180\right] - \left[\tan^{-1}\left(\frac{.9765}{3-.5489}\right)\right] - \left[\tan^{-1}\left(\frac{.9765}{8-.5484}\right)\right]$$

$\theta_c - 153.181 = (2K+1)180°$

$\theta_c = 180 - \theta = 180 + 153.181 = 333.1814$

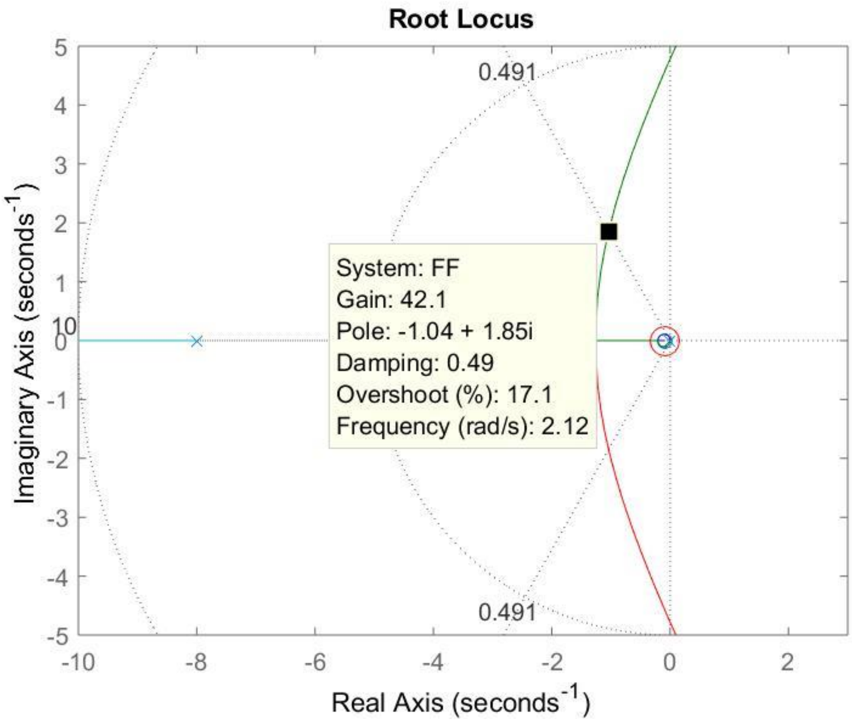
$\tan\theta_c = \dfrac{w_d}{z_0 - \sigma_d}$

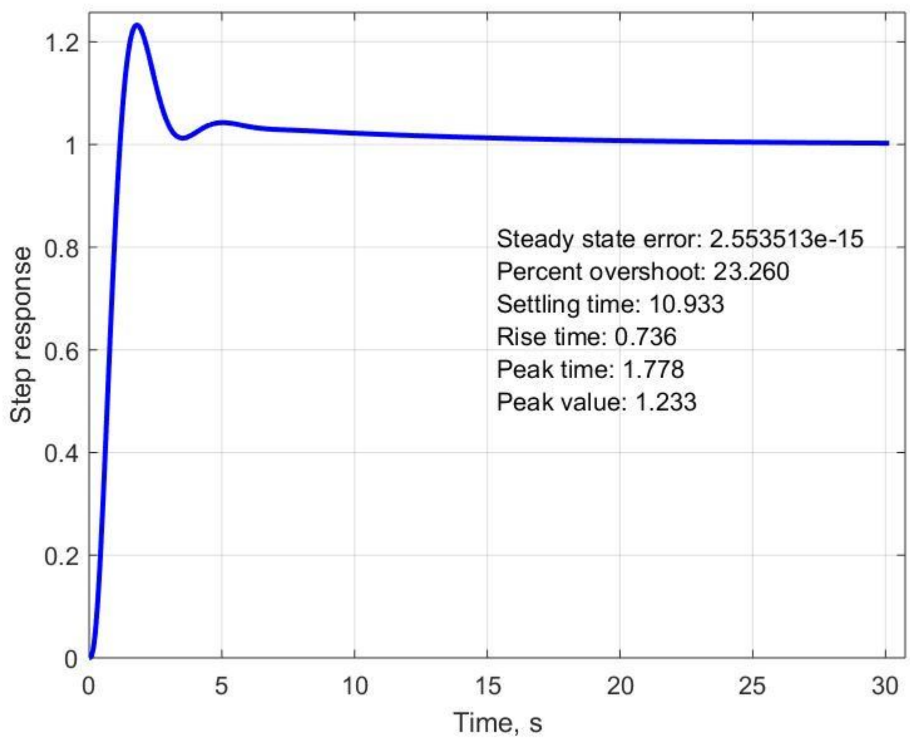
$$z_0 = \frac{w_d}{\tan\theta_c} + \sigma_d = \frac{.9765}{\tan(333.1814)} + (.5489) = -1.382$$

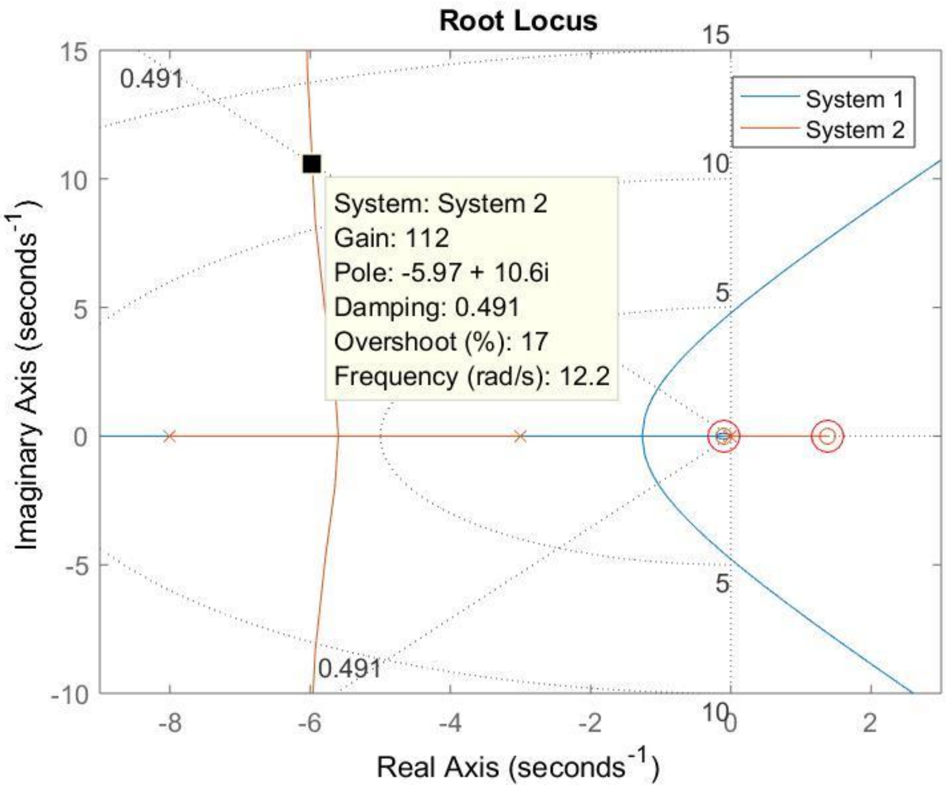
$$K = \frac{|s+3||s+8||s|^2}{|s+0.1||s-1.382|} \text{ for } -.5489 \pm j.9765 = \frac{(2.638)(7.515)(1.12)^2}{(1.075)(2.164)} = 10.7$$

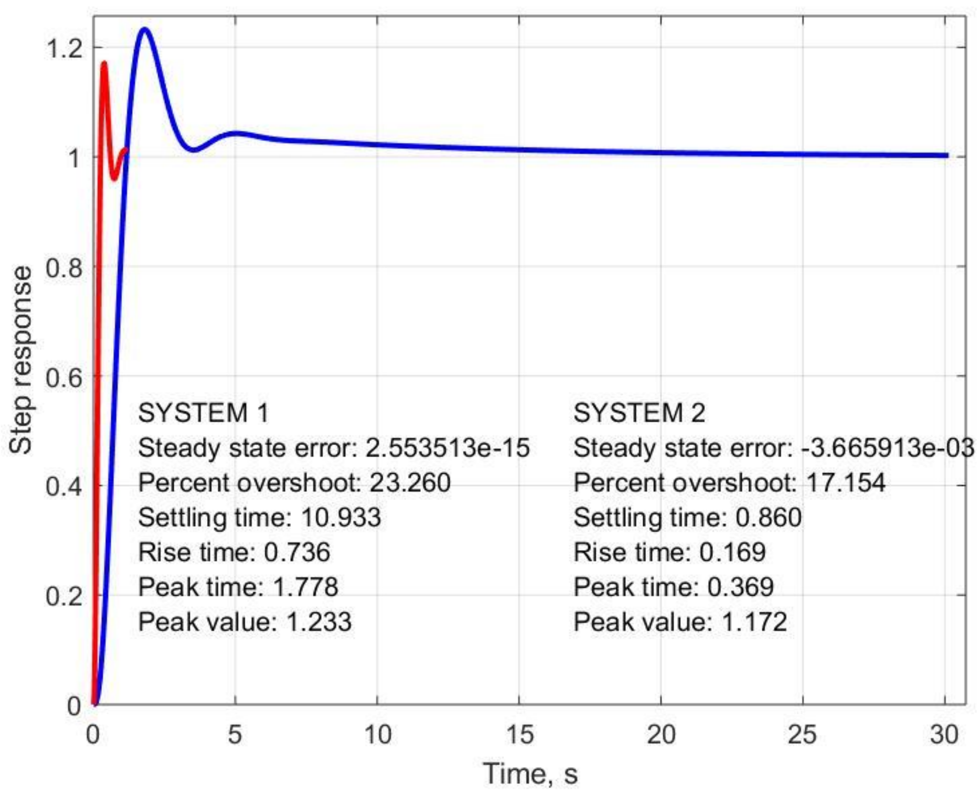
e) plot, $K = 88.1$

f) $G_c^{PD}(s) = s - 1.383$


Root Locus
System: FF
Gain: 42.1
Pole: -1.04 + 1.85i
Damping: 0.49
Overshoot (%): 17.1
Frequency (rad/s): 2.12
0.491
0.491
10
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})


Steady state error: 2.553513e-15
Percent overshoot: 23.260
Settling time: 10.933
Rise time: 0.736
Peak time: 1.778
Peak value: 1.233
Step response
Time, s


Root Locus
System 1
System 2
System: System 2
Gain: 112
Pole: -5.97 + 10.6i
Damping: 0.491
Overshoot (%): 17
Frequency (rad/s): 12.2
0.491
0.491
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})


SYSTEM 1
Steady state error: 2.553513e-15
Percent overshoot: 23.260
Settling time: 10.933
Rise time: 0.736
Peak time: 1.778
Peak value: 1.233
SYSTEM 2
Steady state error: -3.665913e-03
Percent overshoot: 17.154
Settling time: 0.860
Rise time: 0.169
Peak time: 0.369
Peak value: 1.172
Step response
Time, s

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HW#7

#2) $G(s) = \dfrac{K}{(s^2+4s+8)(s+10)}$ w 30% OS + $T_s = 1s$

$$\zeta = \frac{-\ln(.3)}{\sqrt{\pi^2 + \ln^2(.3)}} = \frac{1.204}{3.364} = .358$$

a) plot

b) $K = 83.8$

$T_s = 2.679$

$T_s^{comp} = 1s$, $1 = \dfrac{4}{\sigma_d^{comp}}$ $= 4$

$\sigma_d^{comp} = 4$

$$\omega_d^{comp} = \omega_d \frac{\sigma_d^{comp}}{\sigma_d} = \frac{3.8(4)}{1.52} = 10$$

new pole : $-\sigma_d \pm j\omega_d = -4 \pm j(10)$

c) compensating zero PD

s^2+4s+8, $x = \dfrac{-4 \pm \sqrt{16-4(8)}}{2} = \dfrac{-4 \pm \sqrt{-16}}{2} = \dfrac{-4 \pm j4}{2} = -2 \pm j2$

$$G(s) = \frac{K}{(s+2-j2)(s+2+j2)(s+10)}$$

$$\theta_c - \left[\tan^{-1}\left(\frac{10-2}{-4+2}\right)+180\right] - \left[\tan^{-1}\left(\frac{10+2}{-4+2}\right)+180\right] - \left[\tan^{-1}\left(\frac{10}{-4+10}\right)\right]$$

$$\theta_c - 262.535 = (2K+1)180°$$

$$\theta_c = -180 + 262.535 = 82.535$$

$$Z_D = \frac{\omega_d}{\tan\theta_c} + \sigma_d = \frac{10}{\tan(82.535)} + 4 = 5.310 \qquad G_c^{PD}(s) = s + 5.31$$

$$K = \frac{|s+2-j2||s+2+j2||s+10|}{|s+5.31|} \text{ for } -4+j10 = \frac{|8.246||12.166||11.66|}{110.091} = 116.$$

d) plot

$$G(s) = \frac{K}{(s^2+4s+8)(s+10)}$$

e) PI

$$G_c^{PI}(s) = \frac{s+z_1}{s}$$

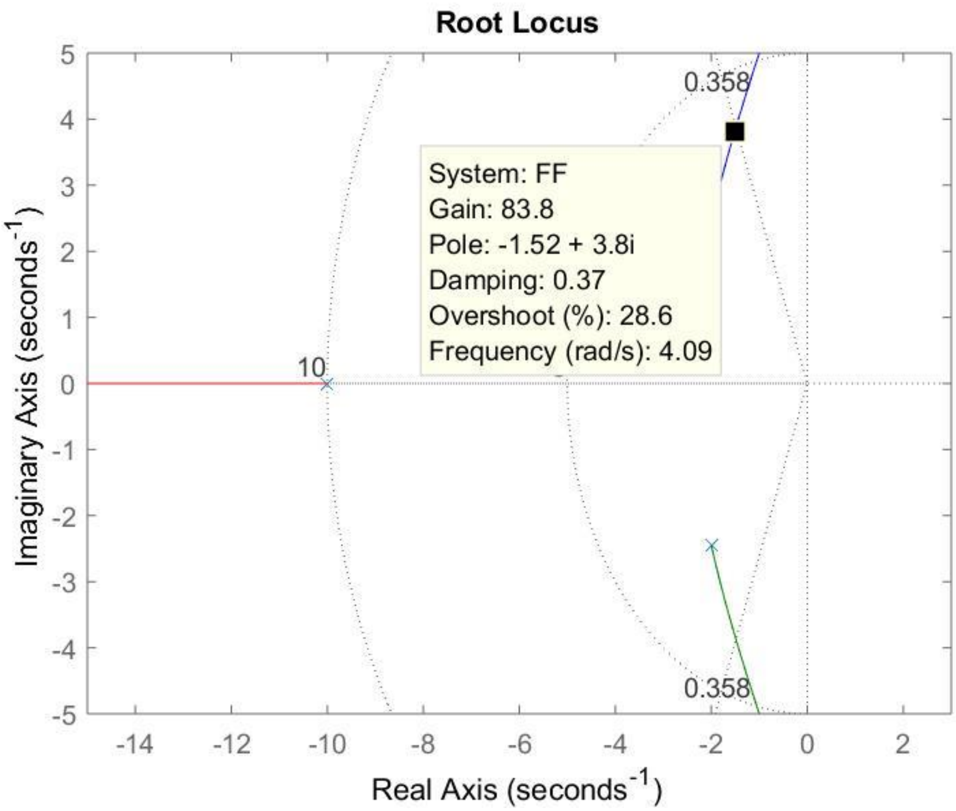
Type 0, $e(\infty) : \frac{1}{1+K_p}$

$$K_p = \frac{K}{(8)(10)} =$$

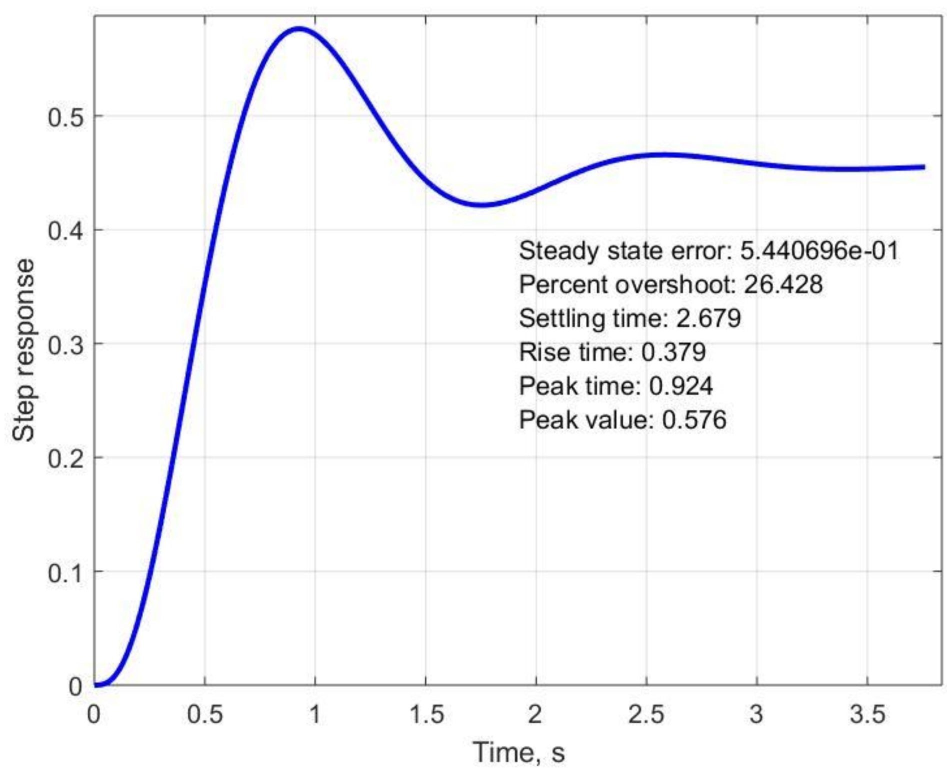
f) plot

6) PID open loop

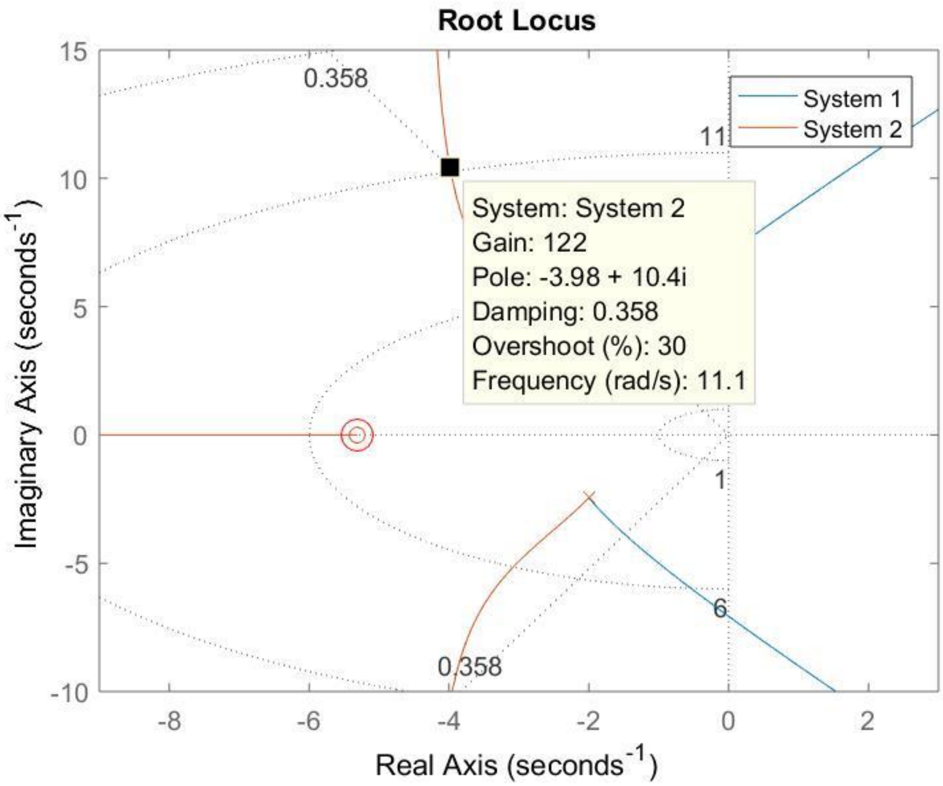
$$[G_c^{PD}(s)][G_c^{PI}(s)][K][G(s)] =$$

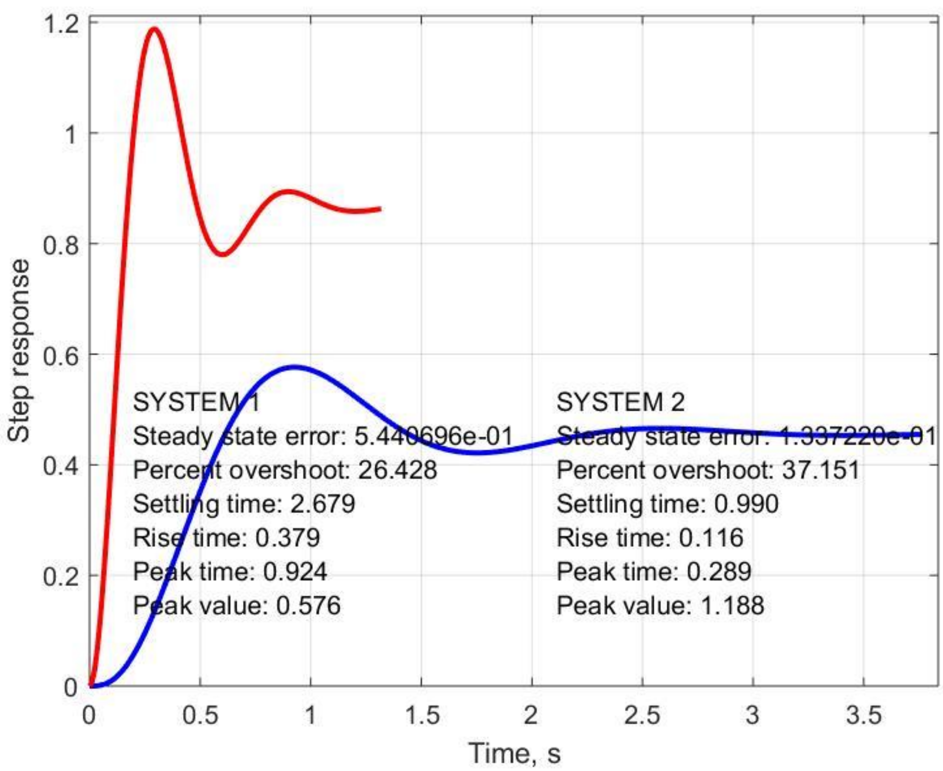


Root Locus
System: FF
Gain: 83.8
Pole: -1.52 + 3.8i
Damping: 0.37
Overshoot (%): 28.6
Frequency (rad/s): 4.09
0.358
10
0.358
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)



Steady state error: 5.440696e-01
Percent overshoot: 26.428
Settling time: 2.679
Rise time: 0.379
Peak time: 0.924
Peak value: 0.576
Step response
Time, s


Root Locus
System 1
System 2
System: System 2
Gain: 122
Pole: -3.98 + 10.4i
Damping: 0.358
Overshoot (%): 30
Frequency (rad/s): 11.1
0.358
11
1
6
0.358
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)


SYSTEM 1
Steady state error: 5.440696e-01
Percent overshoot: 26.428
Settling time: 2.679
Rise time: 0.379
Peak time: 0.924
Peak value: 0.576
SYSTEM 2
Steady state error: 1.337220e-01
Percent overshoot: 37.151
Settling time: 0.990
Rise time: 0.116
Peak time: 0.289
Peak value: 1.188
Step response
Time, s

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#3) $G(s) = \dfrac{K}{s(s+4)(s+8)}$ 20% OS, $T_p = .8$, $e_{ss} = .01$

$$\zeta = \frac{\ln(.2)}{\sqrt{\pi^2 + \ln^2(.2)}} = \frac{1.609}{3.53} = .456$$

a) plot
$K = 74$

b)
$$T_p = \frac{\pi}{w_d} = \frac{\pi}{2.49} = 1.261$$

$$T_p^{comp} = .8$$

$$w_d\ comp = \frac{\pi}{T_p\,comp} = \frac{\pi}{.8} = 3.927 \quad , \quad \sigma_d^{comp} = \sigma_d\left(\frac{w_d^{comp}}{w_d}\right) = 1.28\left(\frac{3.927}{2.49}\right)$$

$$= 2.019$$

new pole

$$-\sigma_d \pm j w_d = -2.019 \pm j\,3.927$$

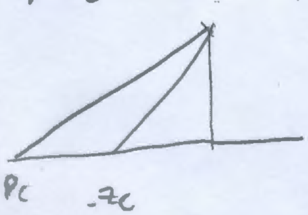
zero of PD controller

$$\theta_c - \left[\tan^{-1}\left(\frac{3.927}{-2.019}\right) + 180\right] - \left[\tan^{-1}\left[\frac{3.927}{4-2.019}\right]\right] - \left(\tan^{-1}\left(\frac{3.927}{8-2.019}\right)\right)$$

$$\theta_c - 213.728 = (2k+1)180^\circ \quad \Rightarrow \quad \theta_c = -180^\circ + 213.728 = 33.73^\circ$$

$$z_0 = \frac{w_d}{\tan\theta_c} + \sigma_d = \frac{3.927}{\tan(33.728)} + 2.019 = 7.901 \quad , \quad G_c^{PD}(s) = s + 7.901$$

c) $z_c^{lead} = 40$, $\theta_2 = \tan^{-1}\dfrac{w_d}{z_c^{lead} - \sigma_d} = \tan^{-1}\left(\dfrac{3.927}{40 - 2.019}\right) = -5.339^\circ$

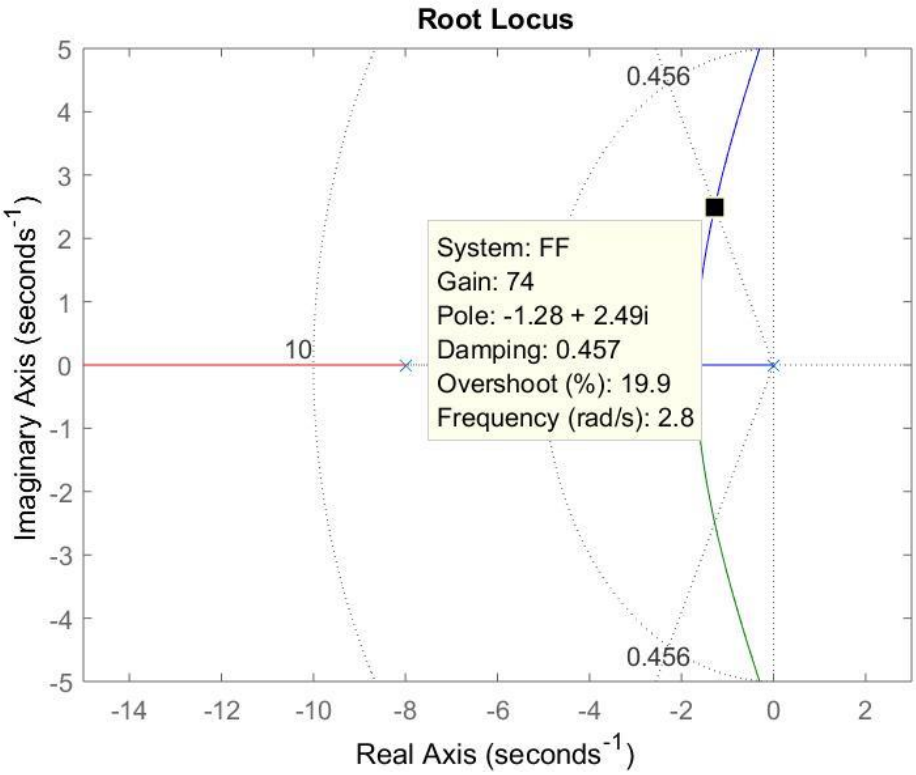


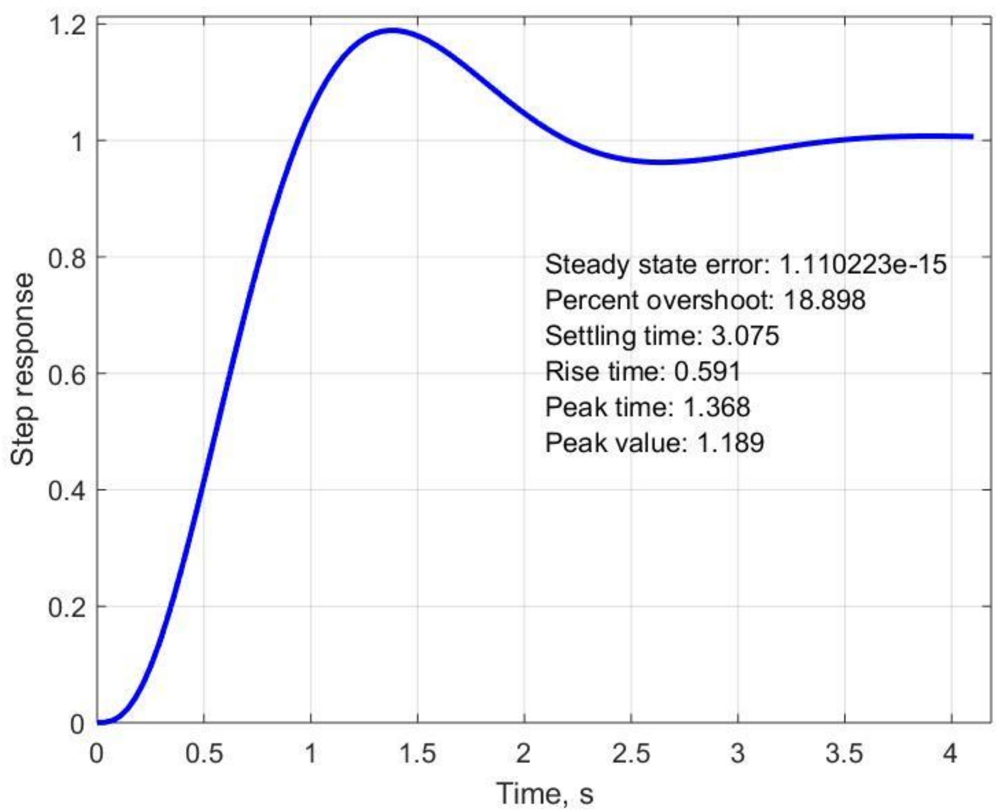
$$\theta_1 = \theta_2 - \theta_c = -5.339^\circ - 33.73^\circ = -39.069^\circ$$

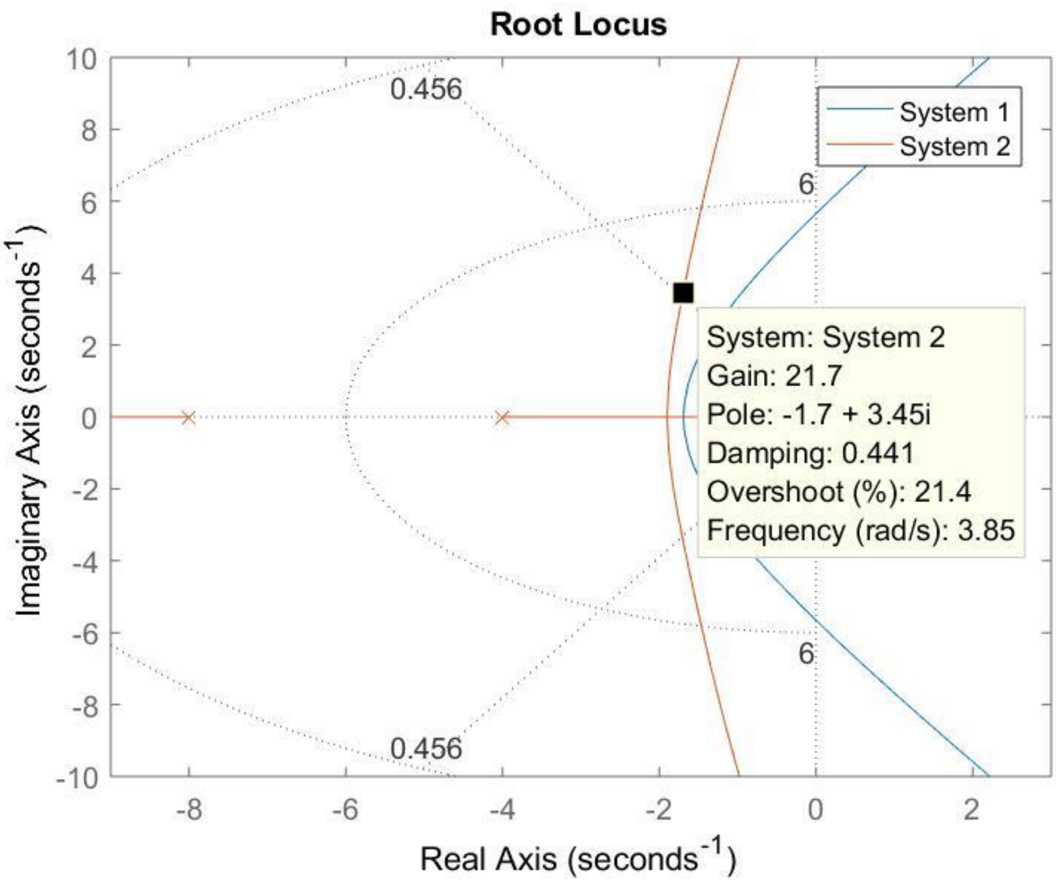
$$p_c^{lead} = \sigma_d + \frac{w_d}{\tan\theta_1} = 2.019 + \frac{3.927}{\tan(-39.069^\circ)} = -4.837$$

$$G_c^{lead} = \frac{s-40}{s-4.837}$$

loop gain
$$K = \frac{|s-4.837||s||s+4||s+8|}{|s-40|} = 26.025$$


Root Locus
0.456
System: FF
Gain: 74
Pole: -1.28 + 2.49i
Damping: 0.457
Overshoot (%): 19.9
Frequency (rad/s): 2.8
10
0.456
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})


Steady state error: 1.110223e-15
Percent overshoot: 18.898
Settling time: 3.075
Rise time: 0.591
Peak time: 1.368
Peak value: 1.189
Step response
Time, s



Root Locus
System 1
System 2
0.456
6
System: System 2
Gain: 21.7
Pole: -1.7 + 3.45i
Damping: 0.441
Overshoot (%): 21.4
Frequency (rad/s): 3.85
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)