Professor Fearing EECS128/Problem Set 5 Fall 2010

Due at 10:00 am, Thurs. Oct. 7 in homework box in 240 Cory Hall . Note: up to 2 students may turn in a single writeup.

Reading FPE Ch. 5, 6.1-6.2.

1. (25 pts) PD control

Consider open loop plant

$$G(s) = \frac{1}{s(s+10)}$$

with disturbance input $w(t)$. Design goals: i) steady state error in $y(t)$ due to unit step disturbance $w(t)$ should be less than 0.8, ii) damping ratio $\zeta = 0.7$. Using root locus techniques:

a) Show that proportional control $D(s) = k_p$ alone will meet the spec.

b) Show that a controller $D(s) = k_p + k_d s$ will meet the design specifications and find an acceptable set of values of k_p and k_d.

c) Turn in hand sketches of root locus plots (for PD use a fixed k_p and varying k_d), verify with MATLAB, and turn in.

2. (25 pts) Lag compensation

Consider open loop plant

$$G(s) = \frac{1}{s(s+2)}.$$

Design goals: i) steady state error in $e(t)$ due to unit ramp input $r(t)$ should be less than 0.2, ii) dominant poles of the closed-loop system are located at (or very close to) $s = -0.9 \pm j$. Using root locus techniques:

a) Show that a lag compensator $D(s) = k\frac{s+z}{s+p}$ with $z > p$ will meet the design specifications and find an acceptable set of values of k, p, and z.

b) Turn in hand sketches of root locus plots (for fixed p and z) and verify with MATLAB.

c) Verify ramp response using MATLAB, and turn in.

3. (30 pts) Bode Plot

Sketch the asymptotes of the Bode plot magnitude and phase for each of the following open-loop transfer functions. Verify sketch using MATLAB plot with same axes scales, and turn in.

a) $\frac{100}{s(s+300)}$ b) $\frac{1}{s^2+20s+10^4}$

c) $\frac{1}{s^2(s+200)}$ d) $\frac{s^2+10s+100}{s^2+40s+10^4}$

e) $\frac{s+100}{(s+1)(s+10)(s^2+2s+10^4)}$

4. (20 pts) Compensation Network

For the ideal op amp circuit below:

a) Determine the transfer function $T(s) = \frac{V_{out}(s)}{V_{in}(s)}$.

b) Hand sketch the Bode plot for magnitude and phase for R1 = 1K Ω , R2 = 10K Ω , C1 = 1000 nF , and C2 = 100 nF.

c) Verify sketch using MATLAB plot with same axes scales, and turn in.