EE 380 **Problem Set 8 Cover Sheet** **Fall 2014**

Last Name (Print): ______________________________

First Name (Print): ______________________________

ID number (Last 4 digits): _______________

Section: ____

Submission deadlines:

- Turn in the written solutions by 4:00 pm on Friday December 12 in the homework slot outside 121 EE East.

Problem	Weight	Score
30	20	
31	20	
32	20	
33	20	
34	20	
Total	100	

The solution submitted for grading represents my own analysis of the problem, and not that of another student.

Signature: ______________________________

Neatly print the name(s) of the students you collaborated with on this assignment.

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Reading assignment: Chapter 5 Reading assignment: Ch 6, section 6.9 and Ch 7, sections 7.1 through 7.5

Problem 30: (20 points)

1. (10 points) Using the root locus method, design a proportional plus integral controller

$$G_c(s) = K_p + \frac{K_I}{s}$$

for the feedback system in Figure 1 so that the closed-loop system meets the following design specifications.

- Zero steady-state error to a unit-step input.
- The peak-overshoot to a unit-step input must be less than 60%.

In order to receive full credit for this problem include the following items with your solution.

- A root locus sketch a long with an analysis showing how the parameters K_P and K_I are chosen.
- A simulation of the unit-step response of the closed-loop system that indicates the steady-state error and peak overshoot.

2. (10 points) Once again consider the closed-loop system in Figure 1. Using the root locus method, design a phase-lag controller

$$G_c(s) = K_o \frac{s+z}{s+p},$$

where $p < z$, for the feedback system in Figure 1 so that the following design specifications are met.

- The steady-state error to a unit-step input must be less then 2%.
- The peak-overshoot to a unit-step input must be less than 60%.

In order to receive full credit for this problem include the following items with your solution.

- A root locus sketch a long with an analysis showing how the parameters K_o, p, and z are chosen.
- A simulation of the unit-step response of the closed-loop system that indicates the steady-state error and peak overshoot.

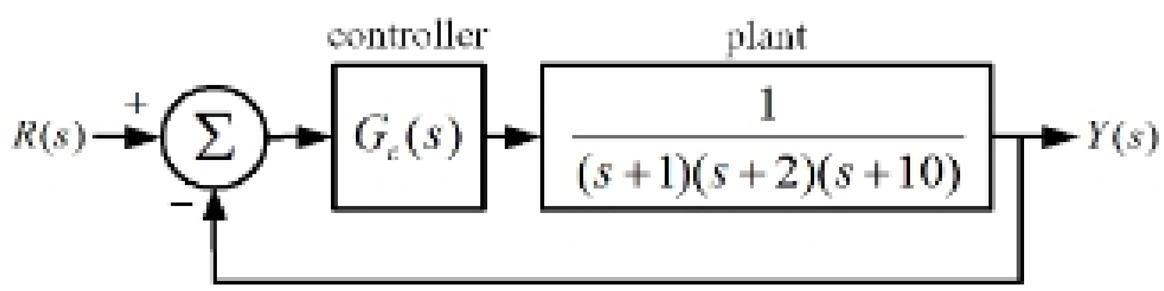

Figure 1: Feedback control system using cascade compensation.

Problem 31: (20 points)

The closed-loop system in Figure 2 contains a plant with transfer function

$$G_p(s) = \frac{100}{(s+1)(s^2+10s+100)}$$

and uses proportional control with

$$G_c(s) = K,$$

where $K \geq 0$. In this problem you will use the Routh-Hurwitz criterion and the concept of *gain margin* to determine the range of K for which the closed-loop system is stable.

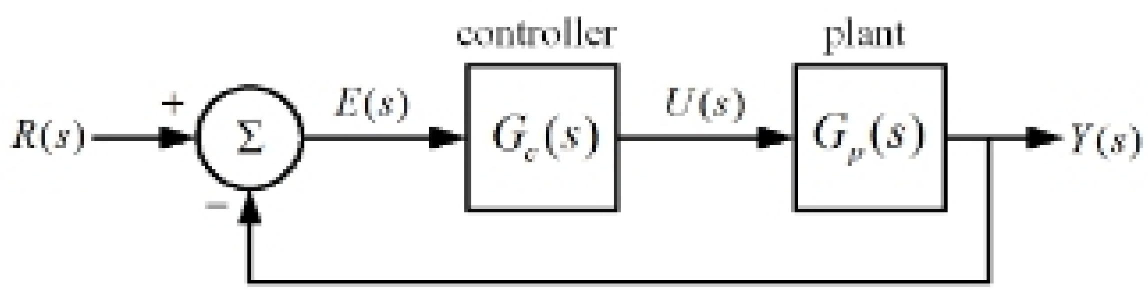

Figure 2: Closed-loop system with cascade compensation.

1. (4 points) Using the Routh-Hurwitz criterion, determine the largest positive gain K for which the closed-loop system is stable.
2. (6 points) Using MATLAB, generate the Bode magnitude and phase plots of the open-loop transfer function

$$\frac{B(s)}{E(s)} = G_c(s)G_p(s)$$

   for unity gain feedback, $G_c(s) = K = 1$.
3. (3 points) Using the Bode phase plot, determine the frequency at which the phase of the open-loop transfer function is -180°. This point is called the **phase crossover frequency** and is denoted by ω_{pc}.
4. (3 points) The **gain margin** GM is the number of decibels which must be added to the magnitude curve in order to make $|G_c(\jmath\omega_{pc})\, G_p(\jmath\omega_{pc})| = 0$ dB. With $K = 1$, determine the gain margin of the system shown in Figure 2.
5. (2 points) Verify your answers in parts (4) and (5) using the MATLAB command **margin(num,den)**, where **num** and **den** are the numerator and denominator polynomials of $G_c(s)G_p(s)$, respectively.
6. (2 points) Using the gain margin measured in part (5), determine the largest positive value of the gain K for which the system is closed-loop stable. Compare your result to that obtained using the Routh-Hurwitz criterion.