2.14/2.140 Problem Set 9

Assigned: Thurs. April 26, 2007
Due: Thurs. May 3, 2007, in class
Reading: F,P,E Sections 7.1–7.6

The following problems are assigned to both 2.14 and 2.140 students.

Problem 1 F,P,E Problem 7.4

Problem 2 F,P,E Problem 7.15, part a only

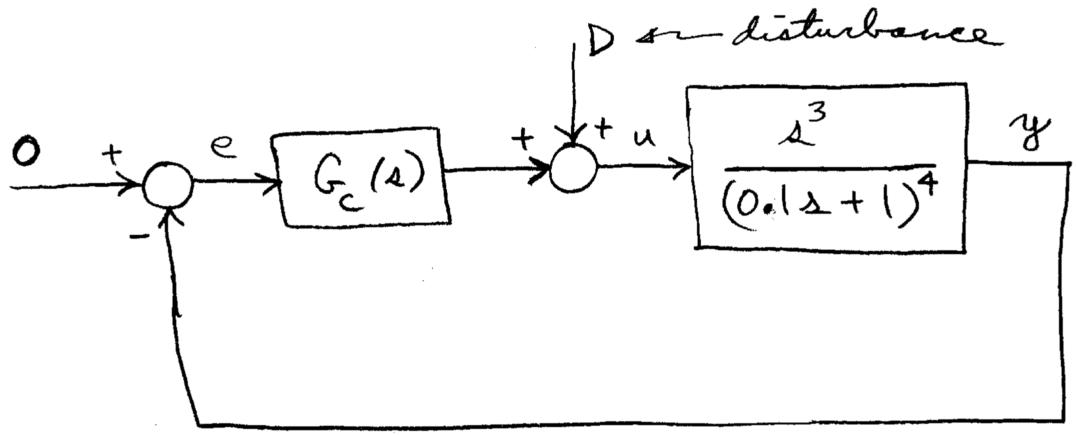
Problem 3 On problem set 8, you developed state feedback gains for the system of F,P,E Problem 7.20. For the gains which place the poles as specified in part a) of the problem, make a Bode plot of the return ratio transfer function $L(s)$ of the loop broken at the input u. What are the crossover frequency and phase margin for this loop?

Problem 4 F,P,E Problem 7.45

Problem 5 F,P,E Problem 7.47

Problem 6 This problem expands on problem 3 from Quiz 2, and will help you get ready for Lab 4. In order to understand the issues of controllers for AC-coupled loops, please scan through the paper *A Vibration Isolation Platform* which is available on the course web page. The paper describes the system you will be controlling in Lab 4. The system considered here is a simplified version of such a vibration isolation system.

Consider the AC-coupled feedback loop shown below, which uses the plant from Quiz 2 with a more general controller $G_c(s)$.



Note that this system is a regulator, in that the reference input is zero. A disturbance D acts on the input to the plant.

1. Make a Bode plot and Nyquist diagram of the plant transfer function. Note that this system will of necessity have two crossover frequencies when put in a feedback loop.

2. This problem concentrates on the low frequency crossing as the magnitude rises through unity. We wish to have the low-frequency crossover occur at 1 rad/sec, with a phase margin of at least 20 degrees. This means that no point on the Nyquist diagram should come within 20 degrees of encircling the -1 point. Based on your Nyquist diagram, what does this require the phase of the return ratio to be at 1 rad/sec?

3. Suppose we use a double lag compensator with the transfer function

$$K\left(\frac{Ts+1}{\alpha Ts+1}\right)^2 \tag{1}$$

   Please choose the design parameters to obtain the desired low-frequency crossover specification. For your design, what are the low-frequency and the high-frequency crossover frequencies and phase margins? How do the closed-loop poles correspond with the two unity gain crossings and phase margins?

4. For your design, please make Bode plots of the return ratio as well as the closed-loop response $Y(s)/D(s)$.

The following problems are assigned to only 2.140 students. Students in 2.14 are welcome to work these, but no extra credit will be given.

Problem G1 F,P,E Problem 7.25

Problem G2 F,P,E Problem 7.49