

ELEE 4700/5700: Control Systems II

Professor Hill

University of Detroit Mercy, Fall 2012

Homework #6

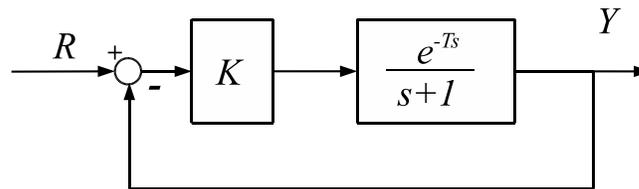
Assigned: October 25, 2012

Due: November 1, 2012

Read sections 7-7 to 7-11 of the book.

Recommended example problems: A-7-22 and A-7-24.

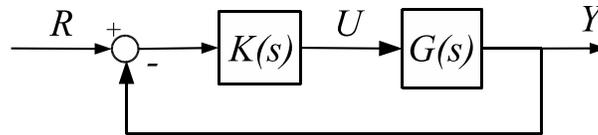
1. (20 points) Consider the following system. You may use MATLAB to assist you, but you must explain your reasoning.



- (a) For $T = 1$, determine the range of values of K that will provide stability.
- (b) For $K = 10$, determine the amount of delay T that can be added to the system before it goes unstable.
2. (20 points) Estimate the phase margin needed to achieve a maximum overshoot of 20%. For each of the following open-loop transfer functions, use a MATLAB generated Bode plot to estimate the value of the gain K needed to achieve the desired phase margin.

$$\frac{K}{s(s+6)(s+12)}, \quad \frac{K(s+4)}{s(s+8)(s+10)(s+12)}, \quad \frac{K(s+2)(s+7)}{s(s+4)(s+8)(s+10)(s+15)}$$

3. (35 points) A unity feedback control system is to be designed for the plant $G(s) = \frac{1}{s(0.1s+1)(s+1)}$ using frequency response methods.



Design $K(s)$ as a lead compensator to achieve a phase margin of around 45 degrees and a steady-state error of 0.25 to a unit ramp input.

4. (25 points) Consider the system from the previous problem for which you designed a lead compensator. The following PD compensator has been designed to achieve the same goals of a phase margin around 45 degrees and a steady-state error of 0.25 to a unit ramp input.

$$K(s) = 1.15s + 4$$

- Compare the Bode diagrams of the open-loop systems with lead and PD compensators.
- Now determine the closed-loop bandwidths of the system with the lead and PD compensators.
- Simulate the step response of the unity feedback system under lead and PD compensation. Turn in plots of the resulting output $y(t)$ versus time and the associated control effort $u(t)$ versus time. Compare the performance of the two compensators. Do your observations agree with your results from Part (a) and Part (b)? Explain.