ELEE 4700/5700: Control Systems II

Professor Hill

University of Detroit Mercy, Fall 2012

Homework #7

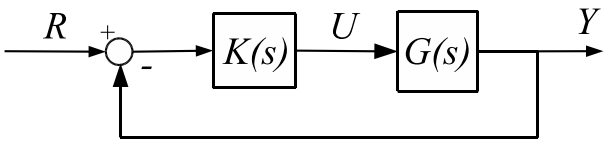
Assigned: November 1, 2012

Due: November 13, 2012 (This is a Tuesday)

Read sections 7-3, 7-5 to 7-7, 7-12, and 7-13 of the book.

Recommended example problems: A-7-5, A-7-25

1. (25 points) Recall the following unity feedback control system from last homework where the plant is $G(s) = \frac{1}{s(0.1s+1)(s+1)}$.



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

2. (15 points) Simulate in Simulink the step response of the unity feedback system of the previous problem for both the resulting lag compensator and the lead compensator from the last homework. Turn in plots of the resulting output $y(t)$ versus time and the associated control effort $u(t)$ versus time. Explain the tradeoffs between the two compensators.

3. (30 points) Use frequency response methods to design a lead-lag compensator for a unity feedback system where

$$G(s) = \frac{s+7}{s(s+5)(s+15)}$$

   and the following specifications are to be met: percent overshoot = 15%, peak time = 0.04 seconds, and steady-state error = 0.001 for a unit ramp input. Do not spend too much time iterating, the requirements do not need to be met exactly.

4. (30 points) Plot the Bode diagrams for each of the following transfer functions using MATLAB. Then (using the Bode diagrams) sketch by hand an approximation of the corresponding Nyquist plots.

$$G_a(s) = \frac{1}{s(s+2)(s+4)} \qquad G_b(s) = \frac{(s+5)}{(s+2)(s+4)}$$

5. (20 points) For an open-loop transfer function $G(s) = \frac{0.5}{s^3+s^2+s}$, sketch the Nyquist plot by hand. Then apply the MATLAB command **nyquist**. From this plot, determine the system's gain margin and phase margin.

6. (20 points) For an open-loop transfer function $G(s) = \frac{16(s+1)}{s(s+2)(s^2-4s+8)}$, plot the Nyquist diagram and find the number of clockwise encirclements of the -1 point (as usual you may need to shift poles on the imaginary axis). You may use MATLAB. Also find the the step response for the unity feedback system (with $G(s)$ in the forward path) and comment.

7. (10 points) Problem B-7-16, page 563.