ENGR 4220/5220: Control Systems

Professor Hill

University of Detroit Mercy, Winter 2014

Homework #11
Assigned: March 27, 2014
Due: April 3, 2014

Read Sections 10-8 and 10-9 of the book.
Recommended example problems: A-10-11, A-10-12, A-10-13, A-10-14

1. (40 points) Consider a feedback system with the following open-loop transfer function where it is desired to find K such that the closed-loop system has a damping ratio ζ of 0.707.

$$G_{OL}(s) = \frac{K(s^2 - 4s + 20)}{(s+2)(s+4)}$$

   (a) Indicate where in the complex plane the closed-loop poles must lie to satisfy the given requirement.

   (b) Draw the root locus for the given feedback system by hand.

   (c) Indicate on the root locus where the closed-loop poles must be located. Find K that places the closed-loop poles at this location. Hint, the real and imaginary parts of the poles will be related by geometry. Also assume K is positive.

   (d) What percent overshoot is indicated by a ζ of 0.707? If you found the step response for this closed-loop system would you expect this percent overshoot to actually occur?

2. (25 points) Plot the approximate root locus for the following open-loop transfer function:

$$G(s) = \frac{K}{s(s^2 + 8s + 32)}$$

3. (35 points) Consider a feedback system with the following open-loop transfer function.

$$G(s) = \frac{K(s+10)}{s(s+2)(s+8)}$$

   (a) Draw a rough sketch of the root locus for the given feedback system by hand.

   (b) Based on your root locus, estimate the minimum possible settle that can be achieved by this closed-loop system and explain how you arrived at your estimate. Use MATLAB to determine the gain K that would achieve this minimum settling time and what the actual closed-loop poles are corresponding to this value of K. You may find the command **rlocus** or **rlocfind** helpful.

   (c) How closely do you think the actual closed-loop system will come to achieving your estimated minimum settling time? Justify your answer.