ELEE 4700/5700: Control Systems II

Professor Hill

University of Detroit Mercy, Fall 2010

Homework #3

Assigned: September 20, 2012

Due: September 27, 2012

Read sections 5.5, 5.7, and 5.8

Recommended example problems: A-5-3, A-5-4, A-5-9, A-5-22, A-5-23, A-5-24

1. (20 points) Consider the four transfer functions given below.

$$G_A = \frac{1}{s+1}, \qquad G_B = \frac{5}{s+5}, \qquad G_C = \frac{5}{s^2+2s+5}, \qquad G_D = \frac{125}{s^2+10s+125}$$

   (a) Predict the shape of the unit step response for each of the four given transfer functions.

   (b) Predict the shape of the unit step response for each of the following two transfer functions.

$$G_1 = \frac{25}{(s+1)(s^2+10s+125)}, \qquad G_2 = \frac{25}{(s+5)(s^2+2s+5)}$$

   (c) Verify your predictions from part(b) employing the MATLAB command **step**.

2. (15 points) Problem B-5-23, page 267.

3. (25 points) Consider the plant

$$G(s) = \frac{s+8}{s^3+19s^2+108s+180}$$

   under proportional, PD, and PID regulation with $K_P = 260$, $K_I = 130$, and $K_D = 5$.

   (a) For each of the above controllers, determine the closed-loop transfer function and the associated poles and zeros. You may use MATLAB to do all of your calculations. The commands **feedback** and **zpk** may be helpful.

   (b) Employing the MATLAB **step** command, plot the step response of each of the closed-loop systems described above. Qualitatively discuss the effect of adding the derivative and integral action to the compensator. Do your results agree with the pole and zero locations found in Part (a)? Explain.

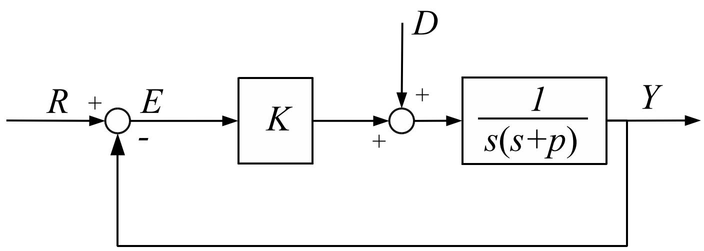
4. (15 points) Consider the type 1 system shown in Problem 4 where $K = 2$ and $p = 1$.

   (a) Determine the steady-state error generated by a unit step reference.

   (b) Now consider that a disturbance enters the system between the controller and the plant. Determine the steady-state error generated by a unit step disturbance.

   (c) How could the system be changed to improve its disturbance rejection properties? Explain.

5. (25 points) A single loop feedback control system is shown below. We desire to select the gain K and the parameter p so that the time-domain specifications will be satisfied.



   (a) It is desired that the system's response to a unit step settle to within 2% of the final value in less than 8 seconds and that the maximum percent overshoot be less than 5%. Plot the region of the complex plane where the closed-loop poles must be located.

   (b) Find the closed-loop transfer function $Y(s)/R(s)$.

   (c) Find a gain K and parameter p so that the closed loop poles are equal to $-1 \pm j1$. Are these poles located in the desired region found in Part (a)?