Homework Assignment 2

Assigned September 9, 2008.
Due in lecture September 18, 2008.

Note that you must include all of your work to obtain full credit. Also the paper you submit must be your own work. To copy someone else’s homework is cheating, which is not permitted and will result in a score of 0 for both the original and the copy.

1. Consider the block diagram shown in Figure AP4.7 in editions 9, 10, and 11 of the textbook. Suppose that the controller has transfer function
\[ G_c(s) = K_c(1/s), \]  
the system dynamics are
\[ G_d(s) = (K_d + 2)/(s^2 + 2s), \]  
and the sensor has transfer function
\[ H(s) = (50 + K_s)/(s + 50). \]

(a) Find the transfer function from the input to the output.
(b) Find the transfer function from the disturbance input to the output.
(c) Find the transfer function from the sensor noise to the output.

2. Consider the same system as in the previous problem.

(a) Find the sensitivity of the closed loop transfer function to changes in \( G_c(s) \)
(b) Find the sensitivity of the closed loop transfer function to changes in \( G_d(s) \)
(c) Find the sensitivity of the closed loop transfer function to changes in \( H(s) \)
(d) Find the sensitivity of the closed loop transfer function to changes in \( K_s \)

3. Consider the transfer function
\[ G(s) = \frac{9}{s^2 + Ks + 9}. \]
Investigate the step response for \( K \in \{1/3, 3, 9\} \) analytically, and using Matlab. Plot all three responses on the same plot. Prepare a table containing percent overshoot, settling time, and steady-state error. Be careful to use equations for these quantities only in regions where they are valid.

4. Consider the transfer functions
\[ T_1(s) = \frac{1}{s^2 + s/2 + 1}, \]
\[ T_2(s) = \frac{K}{(s^2 + s/2 + 1)(s + K)}. \]
Use Matlab to investigate the step response for \( K \in \{0.1, 1, 10\} \). Plot all three responses on the same plot. Show that the percent overshoot, settling time, and steady state error you observe are reasonable by using rules of thumb given in the textbook. (Some of them may not agree. In those cases you should figure out why the rule of thumb is not applicable.)