CMPE-432. Feedback Control Systems.
Homework #4.*

Spring 2010.

Due date April 21^{st}, 2010.

Root Locus:

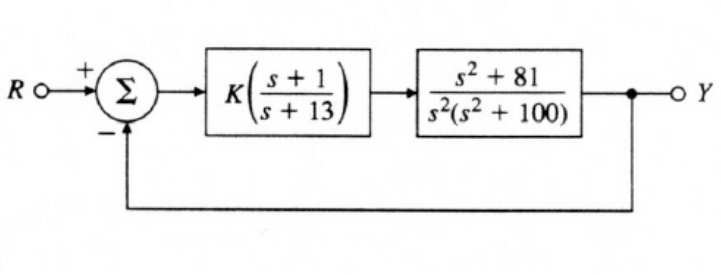
Problem 1

Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choice for $L(s)$. After completing your hand sketches verify your results using MATLAB:

1. $L(s) = \frac{s^2+2s+8}{s(s^2+6s+18)}$.
2. $L(s) = \frac{s+3}{s^2(s+18)}$.
3. $L(s) = \frac{s+2}{s^2(s+15)(s^2+2s+2)}$.

Problem 2

For the system in figure.



1. Find the locus of closed-loop roots with respect to K.
2. Is there a value of K that will cause all the roots to have a damping ratio greater than 0.5.
3. Find the values of K that yield closed-loop poles with the damping ratio $\zeta = 0.707$.
4. Use MATLAB to plot the response of the resulting design to a reference step.

*LUMS School of Science & Engineering, Lahore, Pakistan.

Problem 3

A simplified form of the open loop transfer function of an airplane with an autopilot in the longitudinal mode is:

$$G(s)H(s) = \frac{K(s+a)}{s(s-b)(s^2+2\zeta w_n s+w_n^2)}$$

Such a system involving an open loop pole in right-half s-plane may be conditionally stable. Sketch the root loci assuming $a, b > 0$, $\zeta = 0.5$ and $w_n = 4$. Find the range of gain K for stability.

Problem 4

The equation of motion for the DC motor is given as:

$$J_m\ddot{\theta}_m + (b + \frac{K_t K_e}{R_a})\dot{\theta}_m = \frac{K_t}{R_a} v_a.$$

Assuming that:

$$J_m = 0.01 kg.m^2.$$

$$b = 0.001 N.m.sec.$$

$$K_e = 0.02 V.sec.$$

$$R_a = 10\Omega.$$

$$K_t = 0.02 N.m/A.$$

First find the transfer function between the applied v_a and the motor speed $\dot{\theta}_m$. Then apply following controllers to the motor, sketch root locus for all cases and then discuss the variation in behavior of the plant due to control action.

1. P controller.
2. PI controller.
3. PID controller.
4. lead compensator.
5. lag compensator.
6. lead-lag compensator.

Assume constant values involved logically. You can consult text book for finding out the structures of these controllers.