ECE 388

Automatic Control

LAB 7

Root Locus

Objectives: The relative stability and the transient performance of a closedloop system are directly related to the location of the closed-loop roots of the characteristic equation in the s-plane. The objective of this exercise is to study graphical method for sketching the locus of roots in the s-plane as a parameter is varied and has been utilized extensively in control engineering practice.

List of Equipment/Software

MATLAB, Simulink

TASKS:

1) We consider the basic feedback loop with the open-loop transfer function

$$G_1(s) = \frac{K}{s(s^2 + 2s + 5)}$$

a. Sketch the root locus of for $G_1(s)$. Hint: Also find the intersection of the root locus with the imaginary axis.
b. Assume you want one pole at s = −2. Find the corresponding gain **K**.
c. For the gain calculated in part **b**, find the other two poles of the closed loop. Is the closed loop stable for this choice of K?
d. Verify your results using the command **rlocus** in Matlab.
e. Simulate a reference step response of the feedback loop for K calculated in part b.

2) We consider the basic feedback loop with the open-loop transfer function

$$G_2(s) = \frac{K(s+1)(s+3)}{s(s^2 + 3s + 5)}$$

a. Sketch the root locus of for $G_2(s)$. What can you say about internal stability of the closed-loop system?
b. How does the root locus plot change if the zero of $G_2(s)$ at −1 is located at +1 instead? What can you say about internal stability of the closed-loop system?
c. Verify your results using Matlab. Determine the closed-loop poles for 3 different values of K. (1,10,100)??
d. Simulate a reference step response of the feedback loop for K calculated in part b.

3) We consider the following plant transfer function in the basic feedback control loop

$$G_3(s) = \frac{2}{(s+1)(s+5)}$$

We want to use a controller with the transfer function

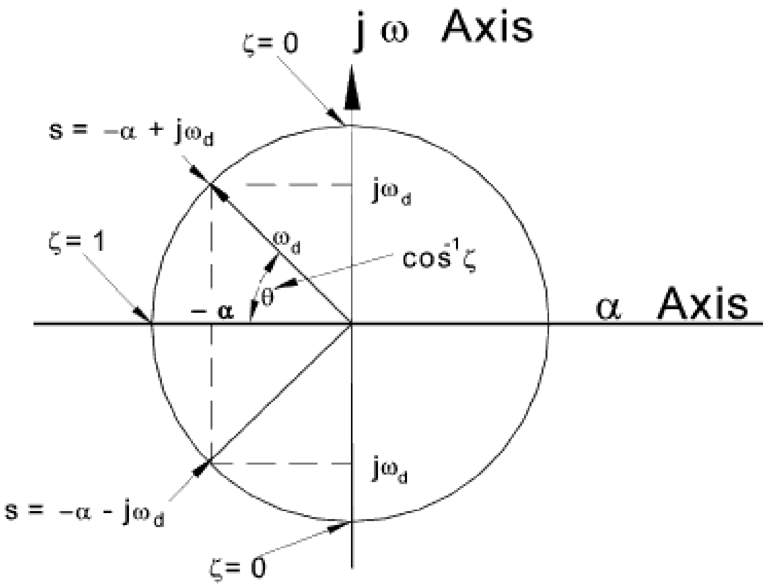
$$C(s) = \frac{K_p(s+a)}{s}$$

and we want to achieve damping to be between 0.6-0.7.

Note that:

$$s^2 + 2\xi\omega_n s + \omega_n{}^2$$

Where ξ is damping ratio and ω_n is the undamped natural frequency.



a. Choose "**a**" such that the controller zero cancels the slowest plant pole.

b**.** Sketch the root locus plot of $C(s)G_3(s)$.

c. Sketch the performance specification in your root locus plot.

d. Mark the part of the root locus plot that fulfills the performance specification.

e. Use Matlab to find a value of K such that the closed loop fulfills the performance specification.

f. Simulate a reference step response for the value of K in e.