Department of Electrical Engineering and Computer Science

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Semester: 6th

Section: BEE 12C

EE-371: Linear Control Systems

Lab 9: Root Locus Based Design

Lab Instructor: Yasir Rizwan

Group Members

Name	Reg. No	Lab Report Marks	Viva Marks	Total
		10 Marks	5 Marks	15 Marks
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2 Model Verification

2.1 Objectives

The objectives of this lab are:

- Learn how to plot root locus in MATLAB.
- Learn how to use MATLAB to design a simple controller using the root locus.

2.2 Introduction

In this lab report, we will explore the use of MATLAB to plot root locus and design a simple controller. Root locus is a graphical method that helps to analyze the stability and performance characteristics of a closed-loop control system by plotting the location of the closed-loop poles as the gain of the system is varied. We will demonstrate how to plot root locus in MATLAB and use it to design a controller that meets certain performance requirements such as damping ratio, settling time, and overshoot. This report serves as a practical guide for students and engineers who want to understand the root locus method and its application in controller design using MATLAB.

2.3 Software

MATLAB is a high-level programming language and numerical computing environment. Developed by MathWorks, it provides an interactive environment for numerical computation, visualization, and programming. MATLAB is widely used in various fields, including engineering, science, and finance, due to its capabilities for matrix and vector operations, implementation of algorithms, and creation of graphical representations of data.

3 Lab Procedure

3.1 Exercise 1

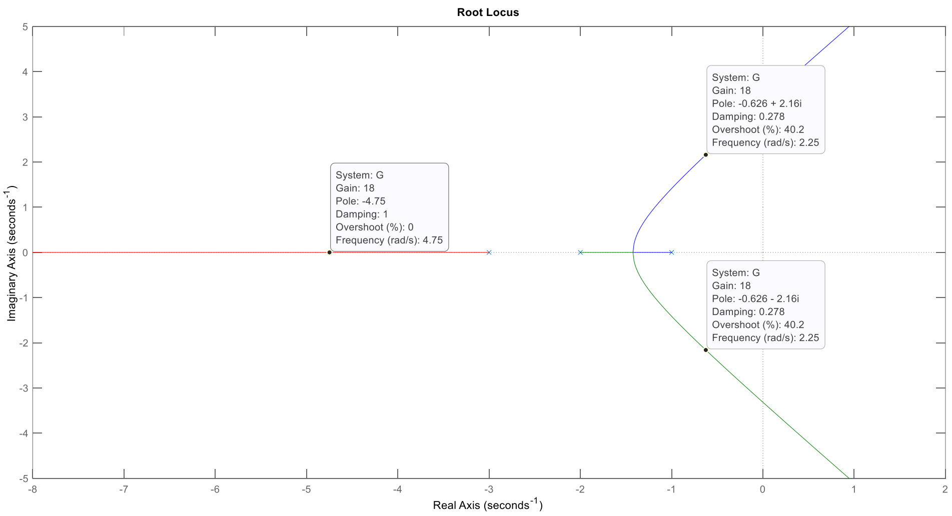
Consider the open loop system:

$$G(s) = \frac{s^2 + 4s + 4.25}{s^3 - s^2 - s + 15}$$

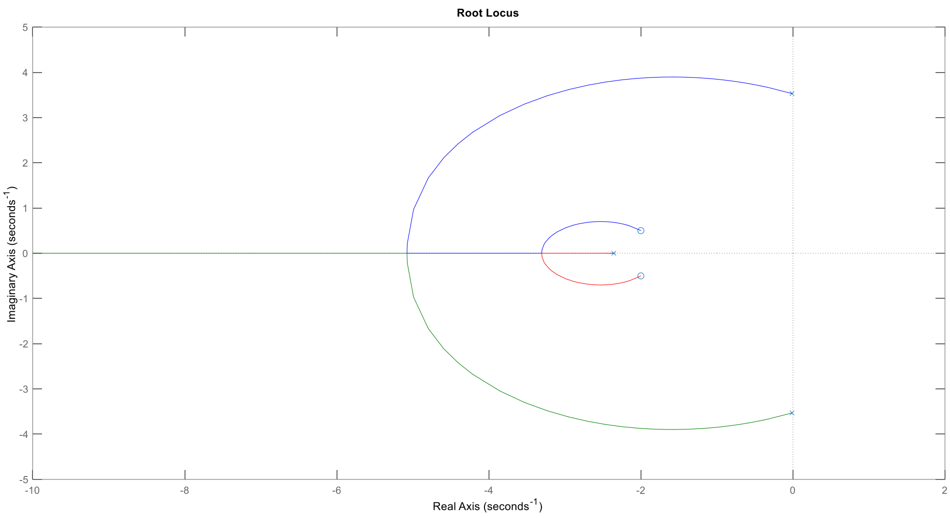
Plot the root locus for this system in MATLAB. Using the MATLAB root locus:

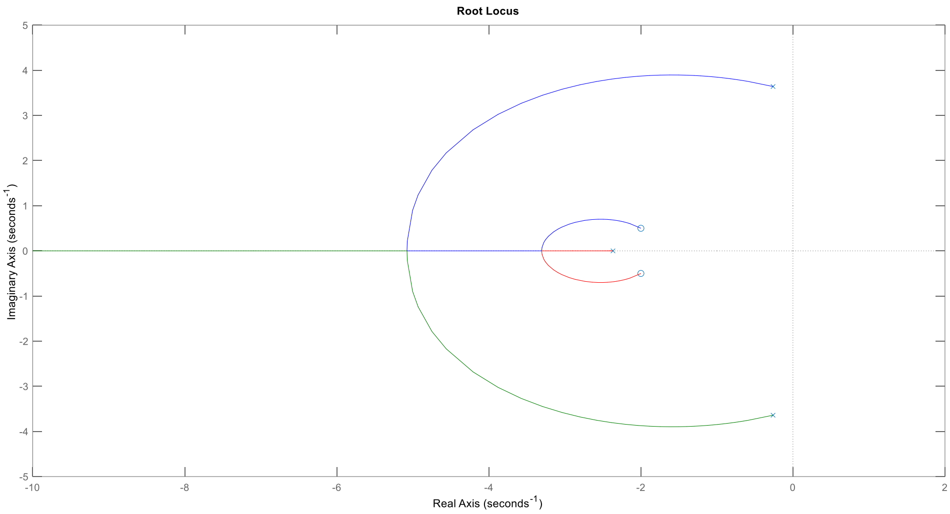
1. Find the values of the gain K for which the closed loop system will be stable.
2. Design a controller gain K such that the closed system is stable, and the dominant poles have an overshoot of 80%. Is a second order approximation valid for this value of K? Find the transfer function of the closed loop system.

```
close all
G = tf([1 4 4.25], [1 -1 -1 15])
figure
rlocus(G)
K = 3.38;
Gcl1 = feedback(series(K, G), 1)
figure
rlocus(Gcl1)
```




```
K = 3.89;
Gcl2 = feedback(series(K, G), 1)
figure
rlocus(Gcl2)
```



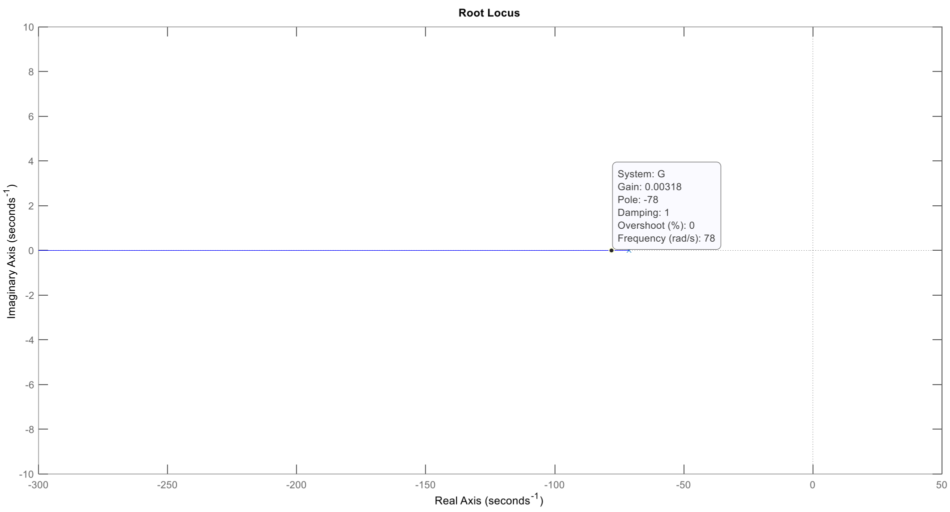


3.2 Exercise 2

Consider the first order model of the DC motor speed vs voltage, which you have derived in your earlier labs. You get a first order model if you neglect the inductance. Using the root locus, choose a value of K such that your settling time is 1/20 secs. Find the transfer function of the system.

```
close all
num = 0.0334;
den = [1.566e-5, 1.11556e-3];
G = tf(num, den)
stepinfo(G)

figure
rlocus(G)
K = 0.00332;
Gcl = feedback(series(K, G), 1)
stepinfo(Gcl)
```



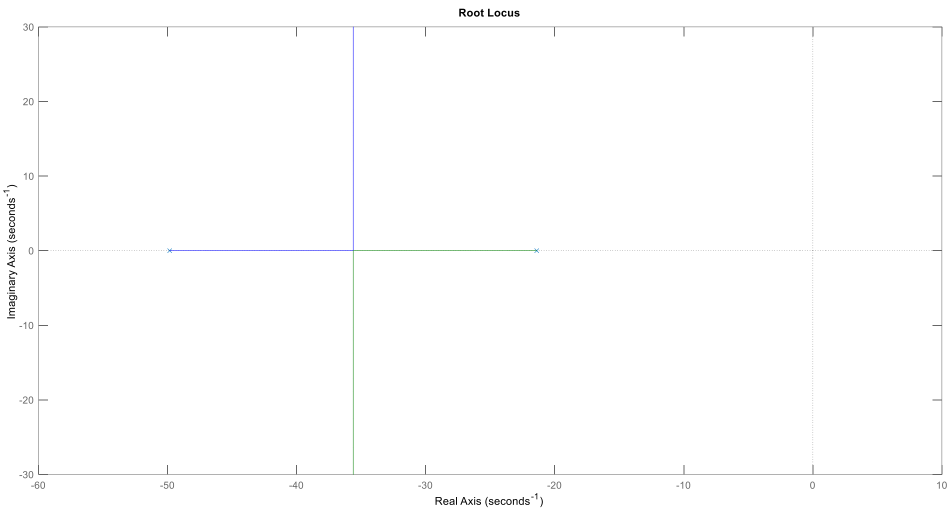

```
       RiseTime: 0.0308
  TransientTime: 0.0549
   SettlingTime: 0.0549
    SettlingMin: 27.0809
    SettlingMax: 29.9203
      Overshoot: 0
     Undershoot: 0
           Peak: 29.9203
       PeakTime: 0.1028
```

3.3 Exercise 3

Consider the first order model of the DC motor position vs voltage that you have derived in your earlier labs. Using the root locus, choose a value of K such that your closed loop system is stable and has a settling time of 1/5 secs. Find the transfer function of the closed loop system.

```
close all
num = 0.0334;
den = [1.566e-5, 1.11556e-3, 0];
G = tf(num, den)
stepinfo(G)
figure
rlocus(G)

K = 0.5;
Gcl = feedback(series(K, G), 1)
stepinfo(Gcl)
figure
rlocus(Gcl)
```




```
        RiseTime: 0.1168
   TransientTime: 0.2090
    SettlingTime: 0.2090
     SettlingMin: 0.9032
     SettlingMax: 1.0000
       Overshoot: 0
      Undershoot: 0
            Peak: 1.0000
        PeakTime: 0.4971
```

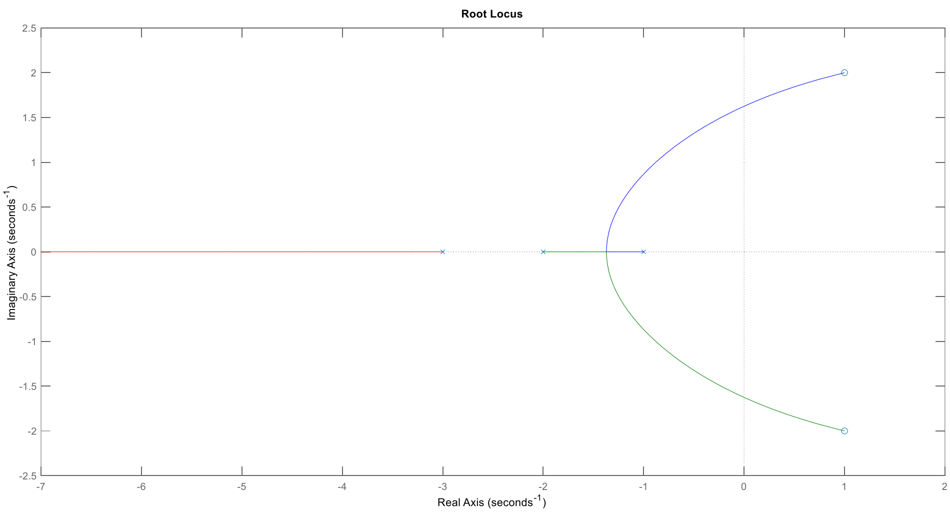
3.4 Exercise 4

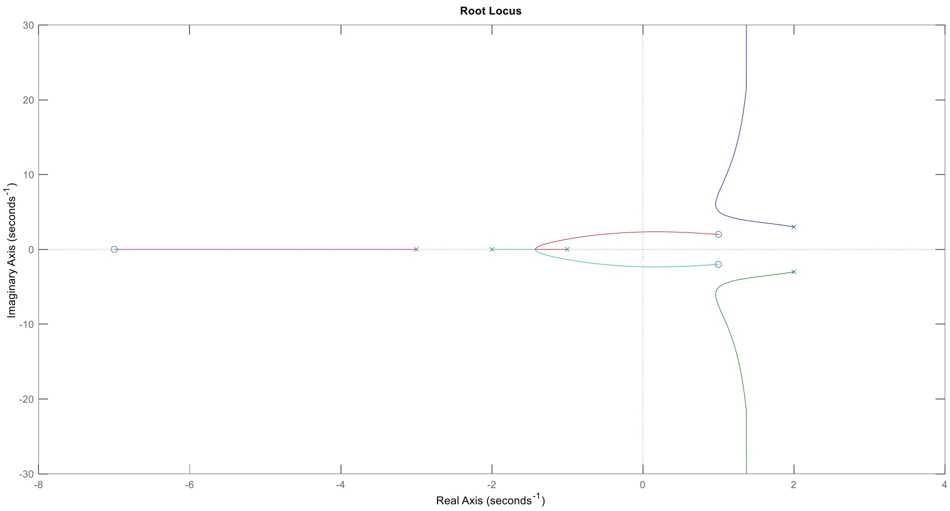
Sketch and verify the root locus of the following transfer functions.

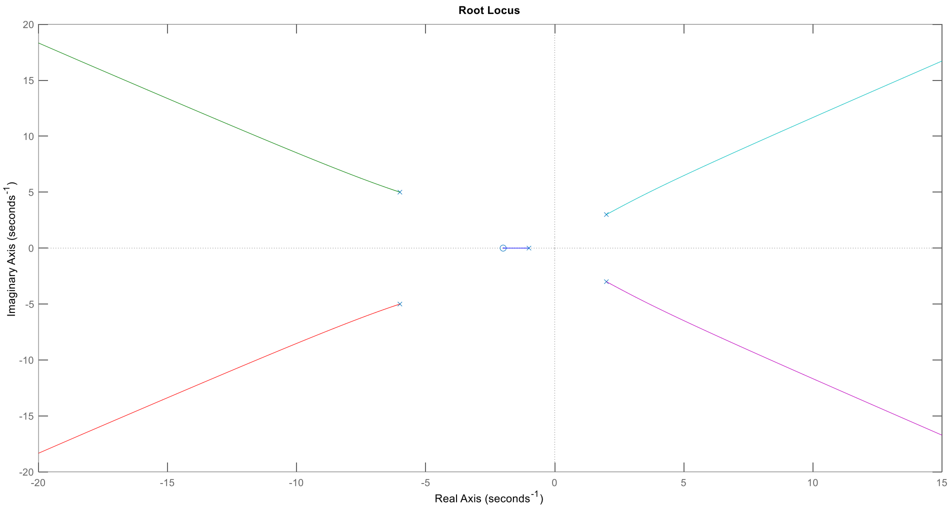
$$G(s) = \frac{(s^2 - 2s + 5)}{(s+1)(s+2)(s+3)}$$

$$G(s) = \frac{(s+7)(s^2 - 2s + 5)}{(s+1)(s+2)(s+3)(s^2 - 4s + 13)}$$

$$G(s) = \frac{(s+2)}{(s+1)(s^2 + 12 + 61)(s^2 - 4s + 13)}$$







4 Conclusion

In conclusion, this lab report has provided a comprehensive overview of the root locus method and its application in controller design using MATLAB. We have demonstrated how to plot root locus in MATLAB and use it to design a simple controller that meets specific performance criteria. By using MATLAB, we have shown that root locus plots can be generated quickly and efficiently, allowing for the analysis of the stability and performance characteristics of a closed-loop control system. The root locus method is a powerful tool in control system engineering that provides valuable insights into the behavior of a system in terms of its poles and zeros.