# EE5351: CONTROL SYSTEM DESIGN

## LABORATORY 03


NAME : BANDARA KMTON

REG.NO. : EG/2021/4432

GROUP NO. : CE 07


DATE : 20/01/2024

Summative Laboratory Form

| | |
|---|---|
| Semester | 05 |
| Module Code | EE5351 |
| Module Name | Control Systems Design |
| Lab Number | 03 |
| Lab Name | Laboratory Session 3 |
| Lab Conducted Date | 2024.11.05 |
| Report Submission Date | 2025.01.24 |

# Table of Contents

1 OBSERVATIONS .......... 5
2 References .......... 13

# Table of Figures

Figure 1: Simulink for the Question 3 5
Figure 2: Simulink for updated version from Q3 6
Figure 3: Time domain response for Q5 6
Figure 4: Code for Root locus of closed loop 7
Figure 5: Root Locus 7
Figure 6: Root Locus after increasing Omega 9
Figure 7: Comparison of the time responses 11
Figure 8:Designing Comapesator 12
Figure 9: Time domain response [**θm(t)**] of the closed loop position control system of DC motor 12

# 1 OBSERVATIONS

Question1)

I.
$$V_m = i_m R_m + L_m \frac{di_m}{dt} + e_b \quad \cdots \quad 1$$
$$e_b = k_m \omega_m \quad \cdots \quad 2$$
$$T_m = J_{eq} \frac{d\omega_m}{dt} \quad \cdots \quad 3$$
$$T_m = i_m k_t \quad \cdots \quad 4$$

II.

Considering the above equations t/f Given as:

$$\frac{\theta_m(S)}{V_m(S)} = \frac{k_t}{S[J_{eq}S(R_m+L_mS]+k_mk_t]}$$

By negliting the rotor inductance (Due to the Small value)

$$\frac{\theta_m(S)}{V_m(S)} = \frac{k_t}{S[J_{eq}R_mS+k_mk_t]}$$

$$\frac{\theta_m(S)}{V_m(S)} = \frac{0.042}{1.756\times10^{-4}S^2+1.764\times10^{-3}S}$$

III.

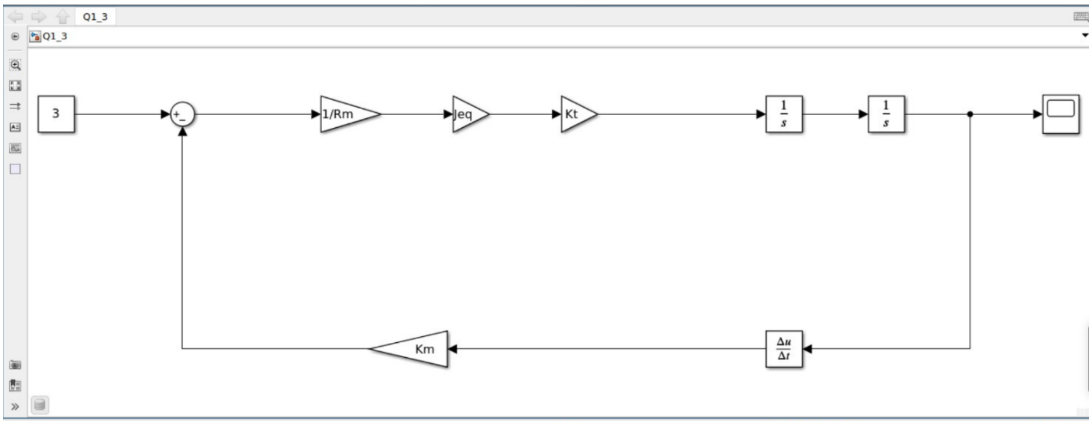


Figure 1: Simulink for the Question 3

IV. To get the closed loop transfer function

$$\frac{\theta_m(S)}{\theta_{ref}(S)} = \frac{G(S)}{1+G(S)}$$
$$\frac{\theta_m(S)}{\theta_{ref}(S)} = \frac{0.042}{1.756\times10^{-4}S^2+1.764\times10^{-3}S+0.042}$$

V.


Figure 3: Time domain response for Q5

Question2)

1.

Q2_1.m

/MATLAB Drive/EE5351_L3_4432/Q2_1.m

```
% Define the open-loop transfer function for the DC motor position control system
% Numerator of the open-loop transfer function (system gain)
numerator = [0.042];
% Denominator of the open-loop transfer function
denominator = [17.556e-5, 1.764e-3, 0.042];
% Create the open-loop transfer function using numerator and denominator
G = tf(numerator, denominator);
% Plot the root locus to visualize how the poles move as the gain changes
figure;
rlocus(G);
title('Root Locus of DC Motor Position Control System');
grid on;
```

Figure 4: Code for Root locus of closed loop

2.

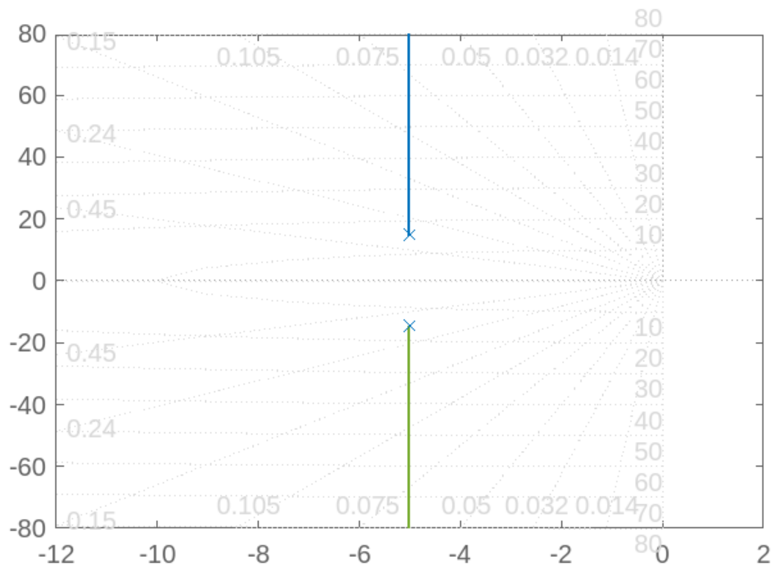


Figure 5: Root Locus

3. By considering the characteristic equation

$$2\varepsilon\omega_n \quad = \quad \frac{1.764\times10^{-3}}{1.756\times10^{-4}}$$

$\omega_n \quad = \quad 10.045$

4.

```
clc; clear; close all;

%% Define the Open-Loop Transfer Function for DC Motor Position Control
numerator = [0.042]; % System gain
denominator = [17.556e-5, 1.764e-3, 0.042]; % Denominator coefficients
G = tf(numerator, denominator);

%% Plot the Root Locus of the Open-Loop System
figure;
rlocus(G);
title('Root Locus of DC Motor Position Control System');
grid on;

%% Increase Natural Frequency by 10%
omega_n = 10.045;  % Current natural frequency (example value)
omega_n_new = 1.1 * omega_n;  % New desired natural frequency (increase by 10%)

% Now, we will modify the system to achieve the new natural frequency.
% We need to adjust the parameters of the system such that the new ωn is achieved.

% Adjust the denominator to increase ωn by 10%
denominator_new = denominator;
denominator_new(1) = denominator_new(1) * (omega_n_new / omega_n); % Adjust the first denominator term to scale with ωn

% Create the new transfer function
```

```
G_new = tf(numerator, denominator_new);

%% Plot the Root Locus of the Modified System
figure;
rlocus(G_new);
title('Root Locus After Increasing Natural Frequency by 10%');
grid on;
```

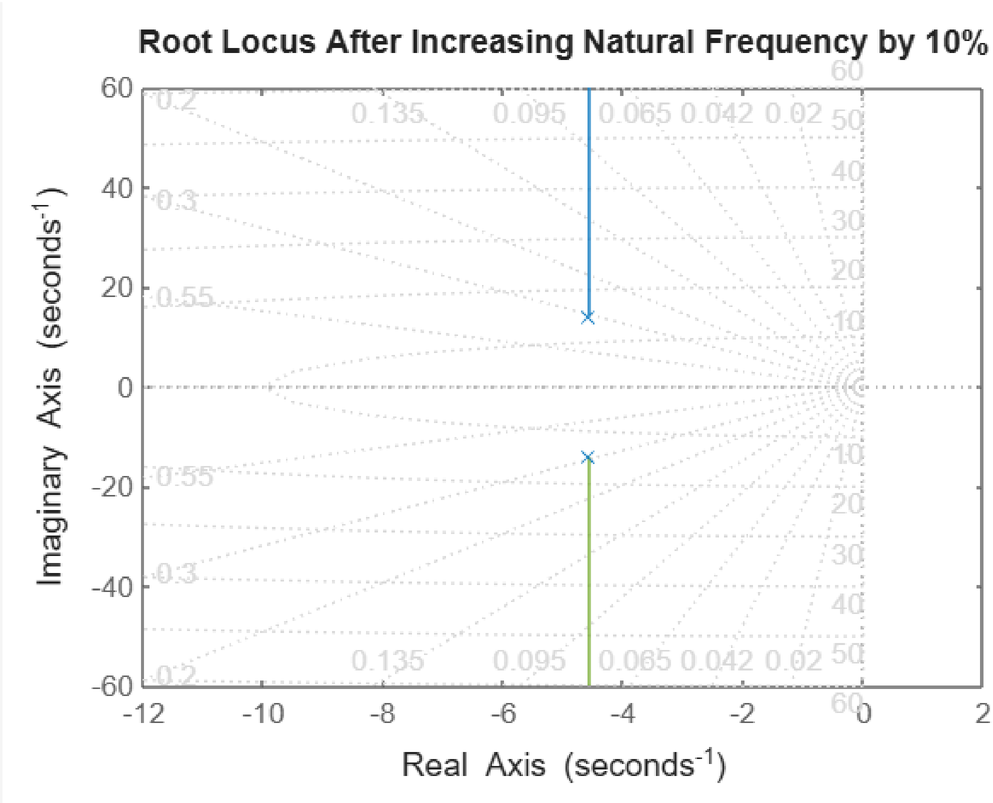


Figure 6: Root Locus after increasing Omega

5.

```
clc; clear; close all;

%% Define the Open-Loop Transfer Function for DC Motor Position Control
numerator = [0.042]; % System gain
denominator = [17.556e-5, 1.764e-3, 0.042]; % Denominator coefficients
G = tf(numerator, denominator);

%% Plot the Root Locus of the Open-Loop System
```

```
figure;

rlocus(G);

title('Root Locus of DC Motor Position Control System');

grid on;


%% Increase Natural Frequency by 10%

omega_n = 10.045;  % Current natural frequency (example value)

omega_n_new = 1.1 * omega_n;  % New desired natural frequency (increase by
10%)


% Now, we will modify the system to achieve the new natural frequency.

% We need to adjust the parameters of the system such that the new ωn is achieved.


% Adjust the denominator to increase ωn by 10%

denominator_new = denominator;

denominator_new(1) = denominator_new(1) * (omega_n_new / omega_n); %
Adjust the first denominator term to scale with ωn


% Create the new transfer function

G_new = tf(numerator, denominator_new);


%% Plot the Root Locus of the Modified System

figure;

rlocus(G_new);

title('Root Locus After Increasing Natural Frequency by 10%');

grid on;


% Calculate and plot the time response of both systems

figure;

step(G, 'b', G_new, 'r'); % Original in blue, Modified in red

title('Comparison of Time Responses: Original vs Modified System');

legend('Original System', 'Modified System');

grid on;
```

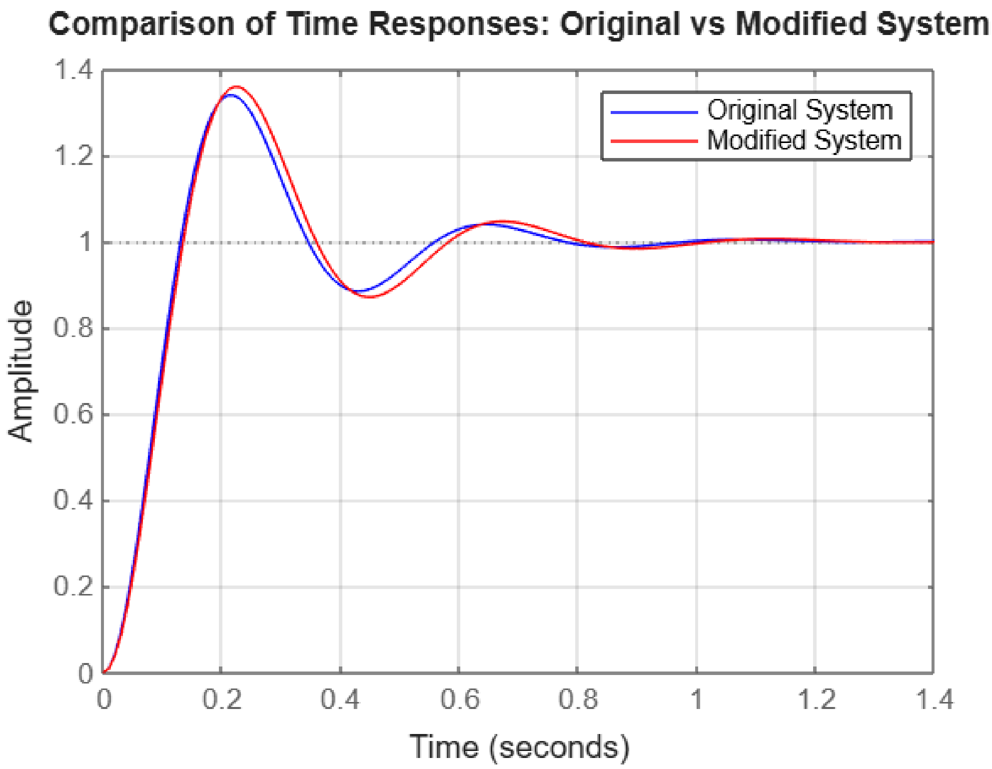


Figure 7: Comparison of the time responses

Question3)

1.

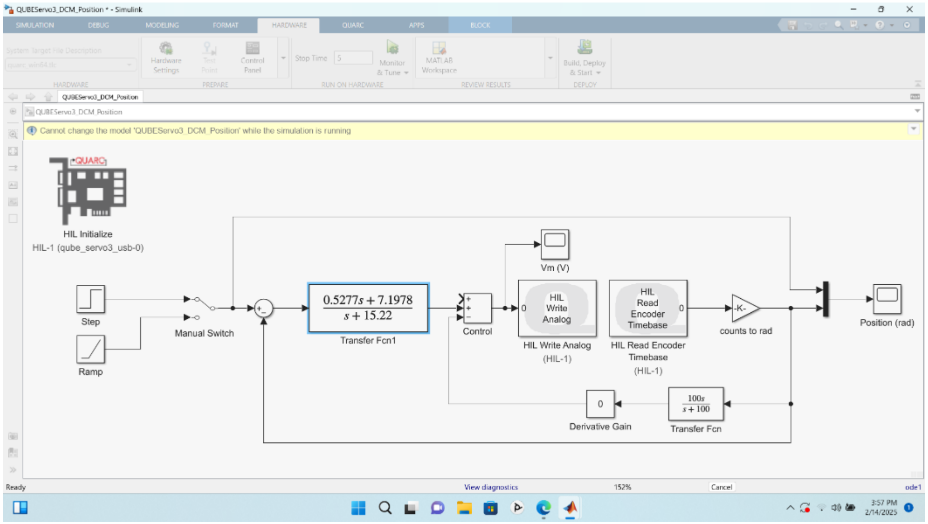


Figure 8:Designing Comapesator

2.

Figure 9: Time domain response **[θm(t)]** of the closed loop position control system of DC motor

# 2 References


[1] “Tutorials Point,” [Online]. Available: https://www.tutorialspoint.com/control_systems/control_systems_construction_root_locus.htm.

[2] “Mathwworks,” [Online]. Available: https://in.mathworks.com/help/control/ref/dynamicsystem.rlocus.html.

[3] [Online]. Available: https://www.geeksforgeeks.org/control-systems-controllers/.