<u>EE5351:CONTROL SYSTEM DESIGN</u>

ASSIGNMENT 03

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Q1)

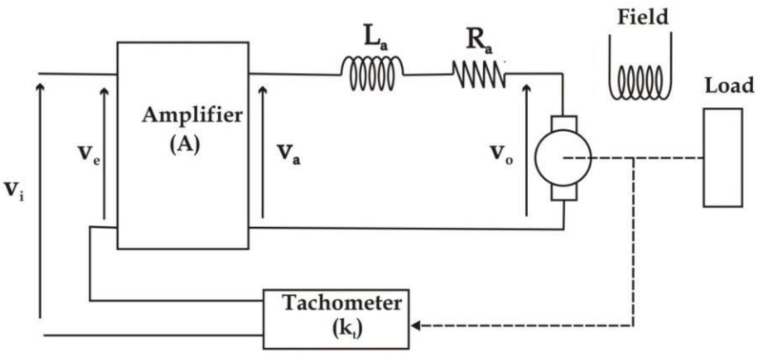

Figure 1: Sample DCMotor

Sample Data Set

Voltage constant of the motor (*kb*)	-	0.85V/rads-1
Torque constant of the motor (*km*)	-	0.9 Nm/A
Tachometer constant (*kt*)	-	0.15 V/rads-1
Inertia of the rotating parts of the motor (*J*)	-	0.85kgm2
Input DC voltage (*Vi*(t))	-	10.0V
Voltage gain of the amplifier (A)	-	100
Armature resistance and inductance	-1.3 Ω, 0.5 H respectively	

1. Assume that G_m as the transfer function of DC motor. Then assume the armechure current as I_a

$$V_a\,(t) = I_aR_a + L\frac{dI}{dt} + V_0$$
$$V_0 = k_b\varpi_m$$
$$T_m = k_mI_a$$

Now convert the time equations into the laplase domain

$$V_a\,(s) = I_aR_a + LSI + V_0$$
$$V_0 = k_b\varpi_m$$
$$T_m = k_mI_a$$
$$T_m = J\varpi_m$$

$$G_m = \frac{K_m}{jls^{2+jR_aS+K_ak_b}}$$

Assume the overall transfer function as G_s

$$G_s = \frac{AG_m}{1+k_t AG_m}$$

$$= \frac{Ak_m}{JL_a s^{2+J} R_a s + k_t Ak_m + k_t k_m}$$

By subsituing values

$$G_s = \frac{100\times0.9}{0.85\times0.5s^2+0.85\times1.3S+0.9\times(0.85+100\times0.015)}$$

$$= \frac{90}{0.425s^2+1.1S+2.11}$$

2. Sample code

```
% Define the transfer function numerator and denominator
numerator = 90;
denominator = [0.425, 1.105, 2.115];

% Create transfer function
G = tf(numerator, denominator);

poles = pole(G); %Find poles
zeros = zero(G); %Find zeros

%Display poles and zeros
disp('Poles:');
disp(poles);
disp('Zeros:');
disp(zeros);

% Plot the poles and zeros in the s-plane
pzmap(G);
title('Pole-Zero Plot');
grid on;
```

output

```
>> Q1_2
Poles:
  -1.3000 + 1.8129i
  -1.3000 - 1.8129i

Zeros:
>>
```

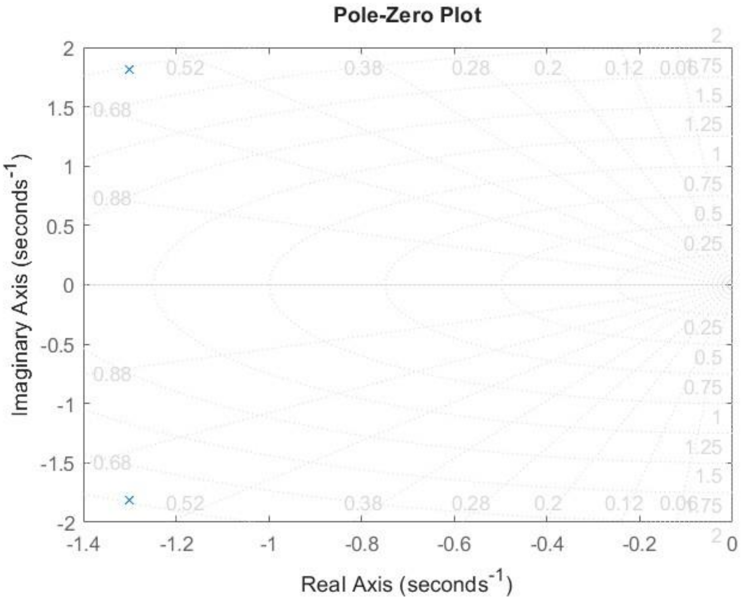

Figure 2:Pole zero plot of Splane

3. Sample code

```
% Define the transfer function numerator and denominator
numerator = 900;
denominator = [0.425, 1.105, 2.115];

% Create the transfer function
G = tf(numerator, denominator);

% Define the time vector
t = 0:0.01:10; % time vector from 0 to 10 seconds with a step of 0.01

% step response
[y, t] = step(G, t);

% Plot the step response
step(G, t);
grid on;
title('Step Response of the System');

% Calculate and display the steady-state value
steady_state_value = y(end);
disp(['The steady-state value of the step response : ', num2str(steady_state_value)]);
```

output

```
>> Q1_3
The steady-state value of the step response : 425.5316
```

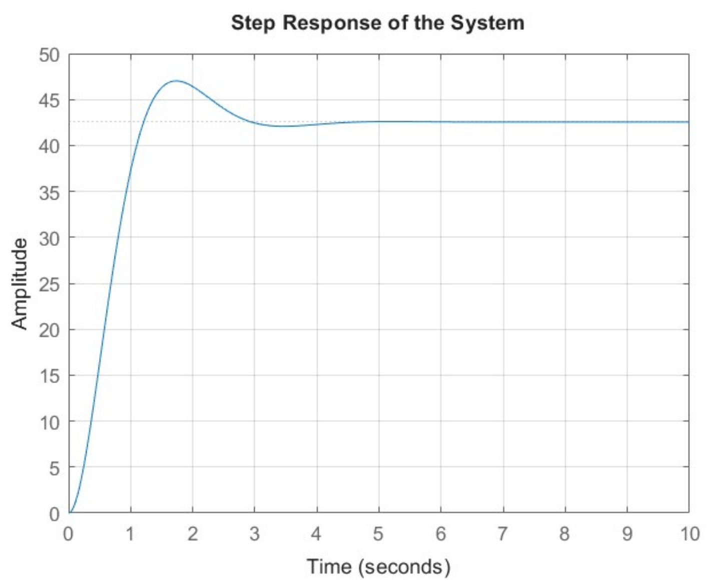

Figure 3:Step Response of the system

4. Considering the transfer function we can simplify it as follows.

$$G_s = \frac{211.756}{s^2+2.6S+4.976}$$

So it shows that the characteristic equation as :

$s^2 + 2.6S + 4.976 = 0$

$\omega_n{}^2 = 4.976$

$\omega_n = 2.23$

$2\varepsilon\omega_n = 2.6$

$\varepsilon = 0.583$

$M_p = e^{\frac{-\pi\varepsilon}{\sqrt{1-\varepsilon}}}$

$= 0.105$

So it can be taken the o/p as follows

$\omega(s) = G(s) x V(s)$

$= \frac{90}{0.425s^2+1.1S+2.11} x \frac{10}{s}$

$= \frac{900}{s(0.425s^2+1.1S+2.11)}$

For that the sample mathlab code

```
% Define the transfer function numerator adn denominator

numerator = 900;

denominator = [0.425 1.105 2.115 0]; % Multiply by s


% Using residue to find the partial fraction expansion

[residues, poles, direct_terms] = residue(numerator, denominator);


% Display the results

disp('Residues:');

disp(residues);

disp('Poles:');

disp(poles);

disp('Direct Terms:');

disp(direct_terms);
```

from that it given the o/p as

>> Q1_4

Residues:

1.0e+02 *

-2.1277 + 1.5257i

-2.1277 - 1.5257i

4.2553 + 0.0000i

Poles:

-1.3000 + 1.8129i

-1.3000 - 1.8129i

0.0000 + 0.0000i

- ω_s $=\left[\frac{4.2553}{s}+\frac{-2.1277+1.5257i}{s+1.3-1.8129i}+\frac{-2.1277-1.5257i}{s+1.3i+1.8129i}\right]\times 10^2$

  $=\left[\frac{4.2553}{s}-\frac{4.26s+11.034}{s^2+2.6s+4.976}\right]\times 10^2$

From inverse laplase domain

- ω_t $=[4.2553u(t)-4.26e^{-1.3t}\cos(1.813t)-3.03e^{-1.3t}\sin(1.813t)]\times 10^2$

  to find the ω_{ss} it can be used final value theorem because all the poles are located in the left half of the s plane.

  ω_{ss} $=\lim_{t\to\infty}\left[[4.2553u(t)-4.26e^{-1.3t}\cos(1.813t)-3.03e^{-1.3t}\sin(1.813t)]\times 10^2\right]$

  $=\underline{\underline{425.53\text{rad}s^{-1}}}$

So the overshoot equation is given as

$$M_p = \frac{\omega_{MP}-\omega_{SS}}{\omega_{SS}} \quad ; M_p = e^{\frac{-\pi\varepsilon}{\sqrt{1-\varepsilon}}} = 0.105$$

$$0.105 = \frac{\omega_{MP}-4.2553\times10^2}{4.2553\times10^2}$$

$$\omega_{MP} = \underline{\underline{4.702\times 10^2 \text{rad}s^{-1}}}$$

5. T_P

$$= \frac{\pi}{\omega\times\sqrt{1-\varepsilon^2}}$$

$$= \frac{\pi}{2.23\times\sqrt{1-0.583^2}}$$

$$= \underline{\underline{1.73s}}$$

6.

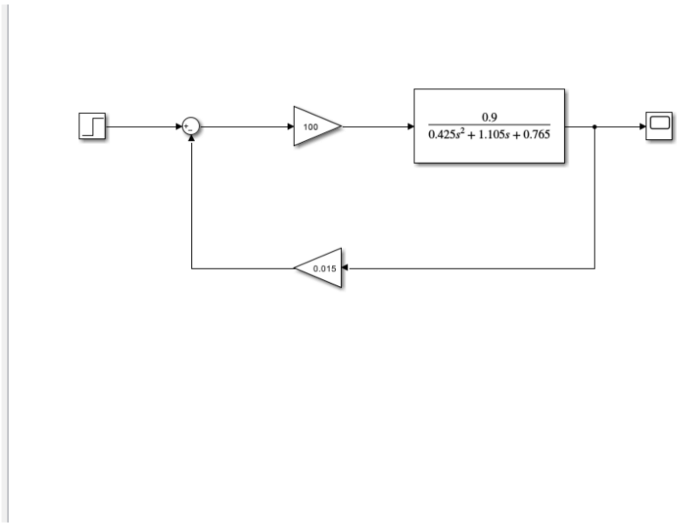

Figure 4:Figure of the Simulink system

7.

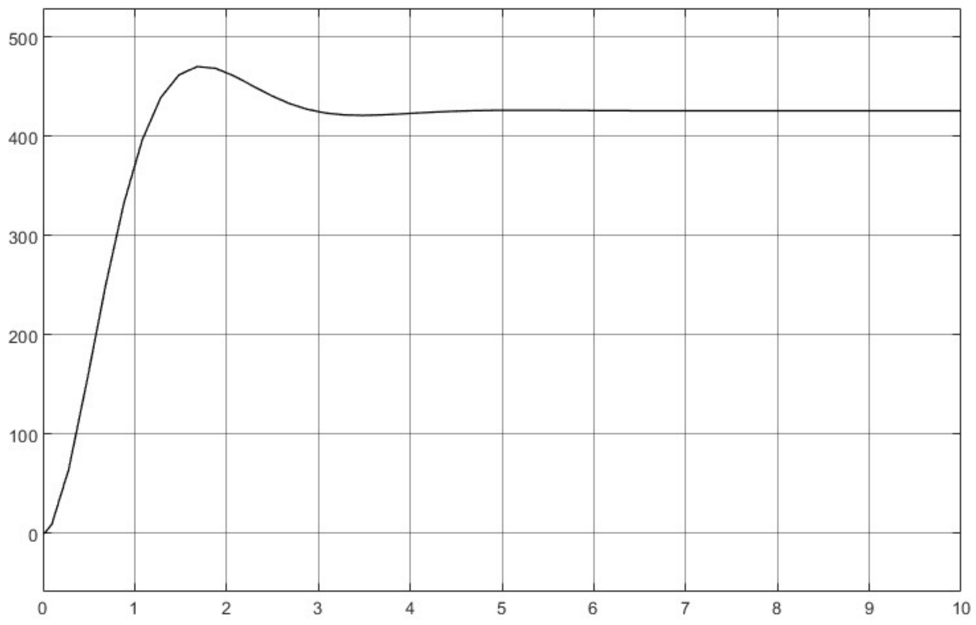

Figure 5:Final Output

8. By looking at the figure2 it is clear that ll the poles are located in the left hand side. Thus it is clear that the system is stable.