NUST School of Electrical Engineering and Computer Science

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Semester: 6th   Section: C

Department of Electrical Engineering

Control Systems EE-379

LAB 8: Open Loop Control

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LAB 8: Open Loop Control

1. Objectives

i. Understanding the open loop control system.
ii. Open loop control of DC Motor
iii. Open loop control of Inverted pendulum

Prerequisite

i. Lab 3 : System Modeling
ii. Lab 4 : Data Acquisition
iii. Lab 5: System response
iv. Lab 6: Model Verification

Open Loop Control of DC Motor

When we change the input voltage of DC motor its speed and position changes accordingly. Now we will see whether it is possible to control speed and position with no feedback (open loop).

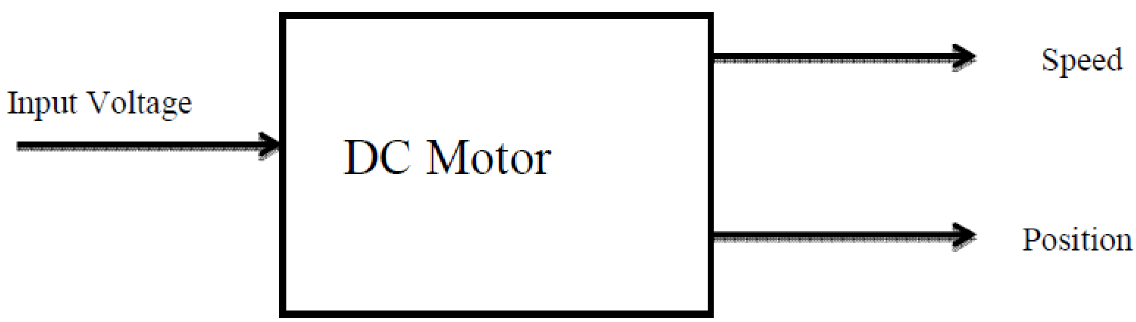

Figure 1

Speed Control in Open loop

Exercise 1: Maintain the speed of 92rad/s by applying the required voltage (Use hit and trail method and note every voltage in your log book).

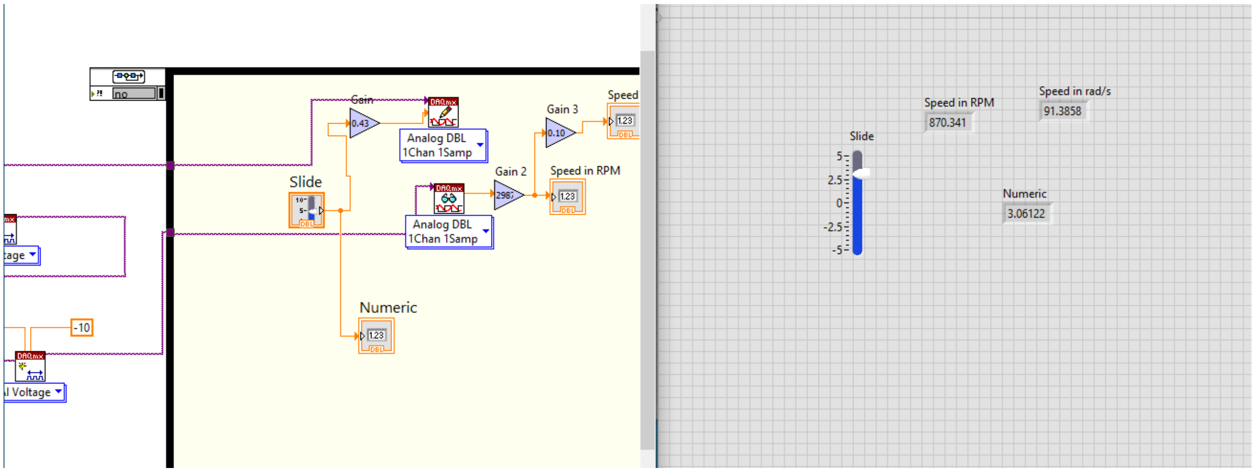

Figure 2

Exercise 2: Take the best reading from Exercise 1 and calculate the steady state response (for step input). Note all your calculations in Log book.

```
speed = 91.38; % rad/s
voltage = 3.06; %Volts
% Variables
J_eq = 1.843e-6;
m = 0.0270;
r = 0.0826;
K_g = 1;
J_m = 1.80e-4;
n_g = 1;
n_m = 0.69;
L = 0.0955;
g = 9.9;
K_t = 0.0334;
R = 8.7;
a = J_eq + m * r ^ 2 + n_g * K_g ^ 2 * J_m;
b = m * L * r;
c = (4/3) * m * L ^ 2;
d = m * g * L;
e = 2.7183;
f = (n_m * n_g * K_t * K_g) / R;

% Motor speed
num = [-c 0 f*d 0];
den = [(b^2-a*c) -e*c a*d e*d 0];
speed_tf = tf(num, den);

step(speed_tf)
```

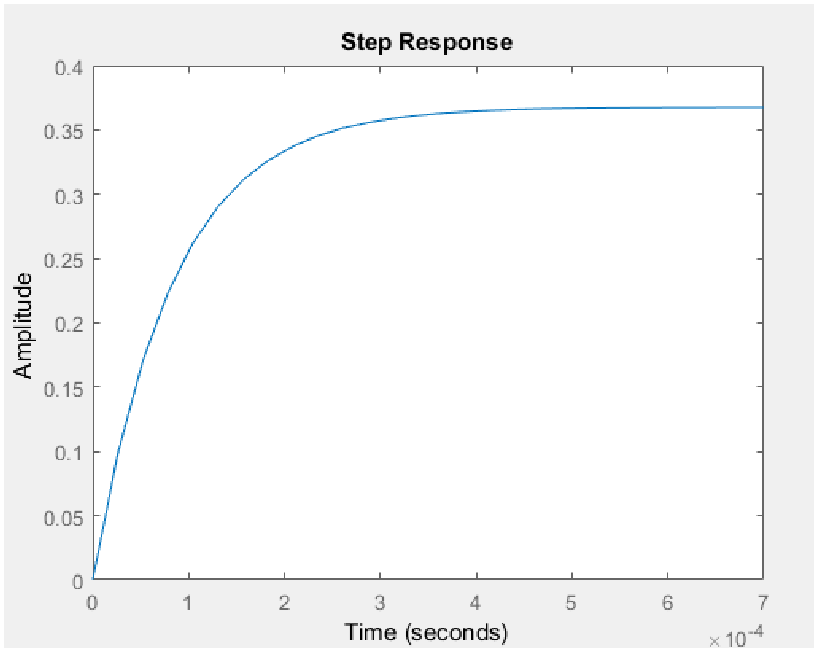

Figure 3

Exercise 3: Are the speeds obtained by experiment (exercise 1) and by calculation (exercise 2) same? If no what can be the possible reason.

The speeds obtained are not the same. The reason might be the difference in the transfer function.

Exercise 4: Apply the disturbance i.e. friction (by holding the motor with your hand) and try to maintain the desire speed. Comment on the obtained response.

When you apply friction to a motor by holding it with your hand, you are essentially creating an external disturbance that affects the motor's performance. The friction will introduce an opposing force that the motor has to work against to maintain its desired speed. As a result, the motor may start to slow down or even stall if the opposing force is too great.

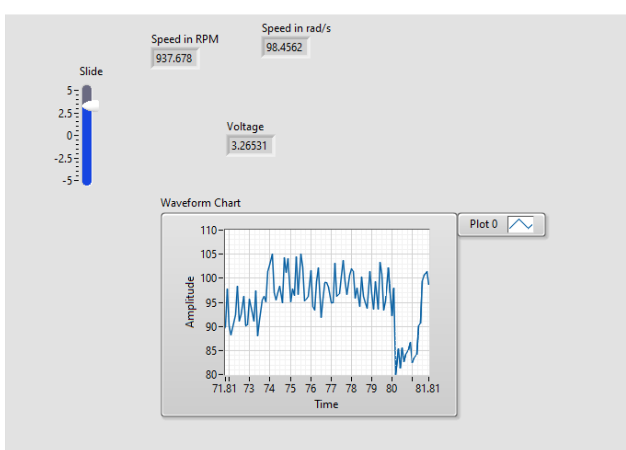

Figure 4

Exercise 5: Rotate the motor by 180_o by applying the required voltage (Use hit and trail method and note very voltage in your log book).

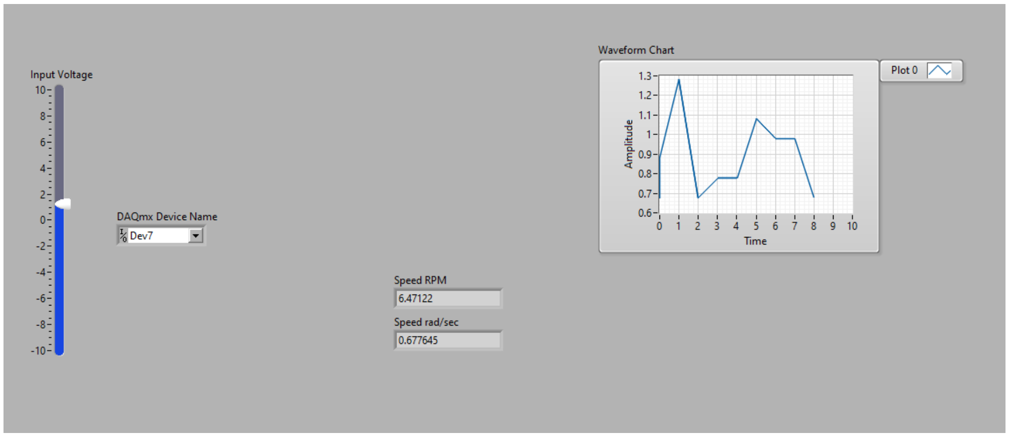

Figure 5

Exercise 6: Take the best reading from Exercise 5 and calculate the steady state response (for step input). Note all your calculations in Log book.

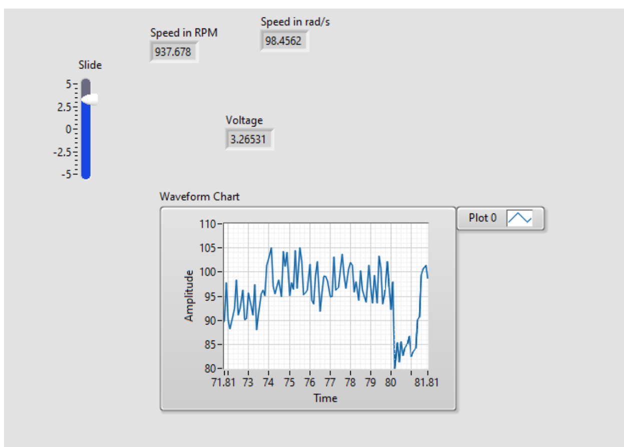

Figure 6

Exercise 7: Are the positions obtained by experiment (exercise 1) and by calculation (exercise 2) same? If no what can be the possible reason.
No the positions are not the same due to inherent errors in the system.

Exercise 8: Apply the disturbance i.e. friction (by holding the motor with your hand) and try to maintain the desire position. Comment on the obtained response.

A damped response is obtained in this case.

Open Loop Control of Inverted Pendulum

When we change the input voltage of driving unit (DC Motor) of inverted pendulum, arm angle changes accordingly. Now we will see whether it is possible to stabilize the pendulum with no feedback (open loop).

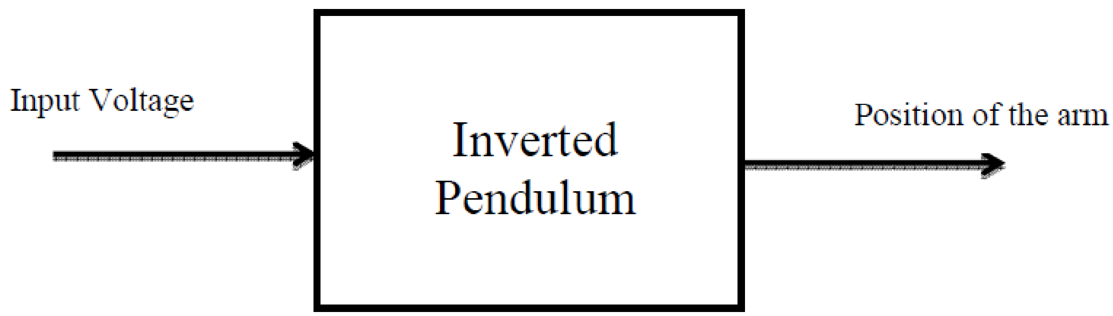

Figure 7

Exercise 9: Try to stabilize the pendulum by applying the required voltage. (Use hit and trail method and note very voltage in your log book).

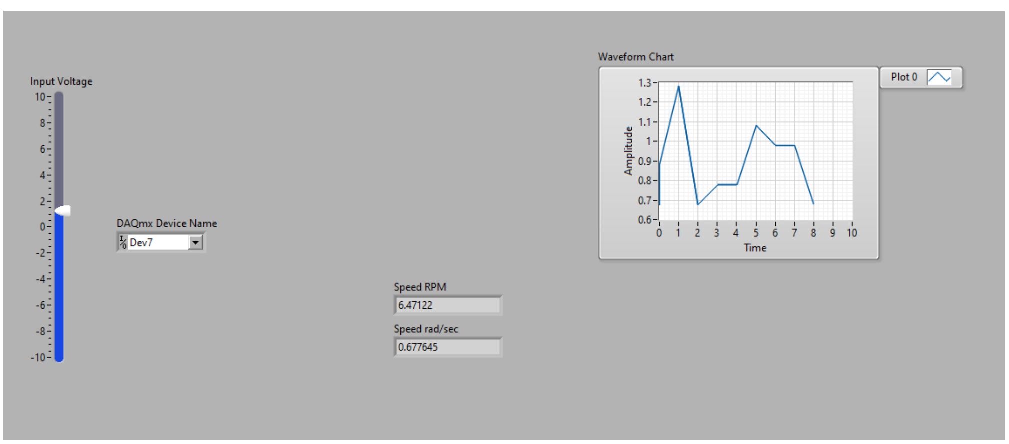

Figure 8

Exercise 10: Take the best reading from Exercise 9 and calculate the steady state response (for step input). Note all your calculations in Log book.

```
speed_ss = ss(speed_tf);
position_ss = ss(position_tf);
arm_ss = ss(arm_tf);
figure
step(speed_tf)
grid
title('Motor Speed Step Response')
```

```
figure
step(position_tf)
grid
title('Motor Position Step Response')
figure
step(arm_tf)
grid
title('Pendulum Arm Angle Step Response')
```

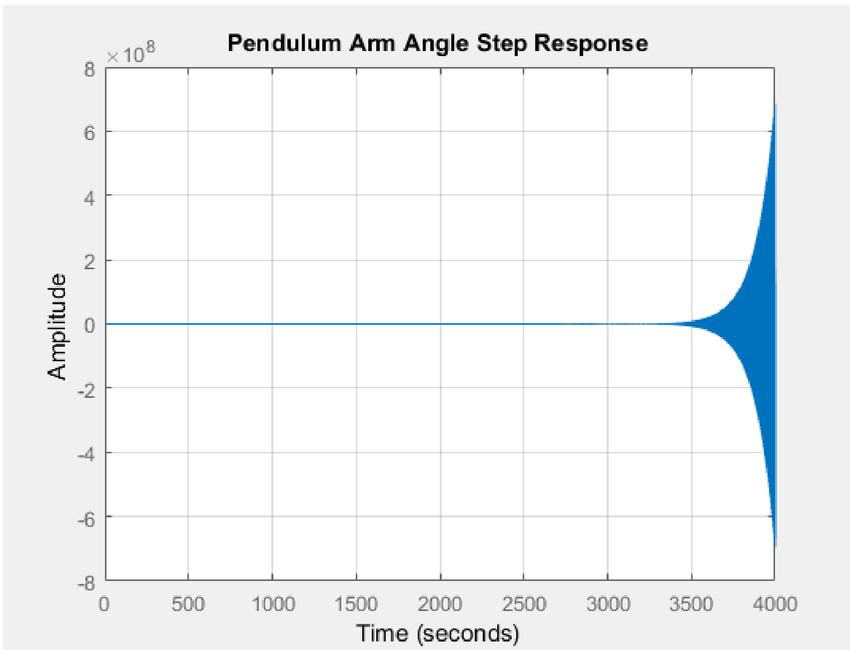

Figure 9

Exercise 11: Why is it not possible to stabilize the inverted pendulum in open loop.
(Hint: Plot pole-zero plot and comment)
An inverted pendulum is an unstable system where the center of mass of a pendulum is placed above its pivot point, and the system is acted upon by external forces. Open-loop control refers to a control system where the input signal is not adjusted based on the output, i.e., there is no feedback control.

It is not possible to stabilize the inverted pendulum in open loop because the system is inherently unstable, and it has a pair of complex conjugate poles with a positive real part. These poles lie in the right half-plane of the pole-zero plot, indicating that the system is unstable and will oscillate if left uncontrolled.

In open-loop control, the controller does not receive any feedback from the system, so it cannot adjust the input signal to compensate for any disturbances. As a result, the system will oscillate uncontrollably, making it impossible to stabilize the inverted pendulum.

Exercise 12: Why it is not possible to get the desired response in open loop with disturbance applied?

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It is not possible to stabilize the inverted pendulum in open loop because the system is inherently unstable, and it has a pair of complex conjugate poles with a positive real part. These poles lie in the right half-plane of the pole-zero plot, indicating that the system is unstable and will oscillate if left uncontrolled.

Conclusion:

In this lab we gained thorough experience of evaluating the performance of real time open loop systems. It was concluded that it is not possible to stabilize the open loop system if it is inherently unstable, and it has a pair of complex conjugate poles with a positive real part. If the poles lie in the right half-plane of the pole-zero plot, indicating that the system is unstable and will oscillate if left uncontrolled.