Analyzing Coefficients in Transfer Function

Course: ENGG*3410 Systems and Control Theory

Instructor: Dr. Biglarbegian

Student Names/Numbers:

Bilal Ayyache (0988616)

Suyash Singhal (0987450)

Date: 26/01/2019

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1. Introduction

The main objective of lab 2 is to explore transfer function operations using matlab. Through matlab, the main challenges was to define a transfer function and use that function to plot the step response. Using the step response, one can analyze a system and obtain characteristics such as order, poles, overshoot, and zeros. Obtaining such characteristics can help in understanding the behavior of the system. In matlab, transfer function can be used to sketch step response and the step response can be used to determine overshoot. Complex differential equations can be solved easily using Simulink simulation. Simulink allows users to solve differential equations using summers, gains, integrators, output blocks and input blocks.

2. System Analysis

2.1. Part 1

Using the transfer function G(s) = 5/(s+1) , the step response of the system was plotted using the code in figure 1. The order of the system was determined to be 5:

```
G = tf(5, [1, 1])
H = tf([1, 6, 5], [1, 6, 11, 6])
t = inv(1 + G.*H)
Ts = t.*G
figure(25)
step(Ts)
%order of system is 5
%find the poles and zeros of the system
b = [5 35 85 85 30];
a = [1 8 29 69 78 31];
fvtool(b, a, 'polezero')
[z,p,k] = tf2zp(b,a)
figure(53)
step(Ts)
```

Figure 1: Matlab code used

Using the following graph, the poles were calculated to be -3.94, -1, -1.032 + 2.6i, -1.032 – 2.6i, and zeros of the system are -1, -2, -3 .

```
z =

  -3.0000 + 0.0000i
  -2.0000 + 0.0000i
  -1.0000 + 0.0000i
  -1.0000 - 0.0000i


p =

  -3.9360 + 0.0000i
  -1.0320 + 2.6098i
  -1.0320 - 2.6098i
  -1.0000 + 0.0000i
  -1.0000 - 0.0000i


k =

     5
```

Figure 2: Zeros (z) and Poles(P) results

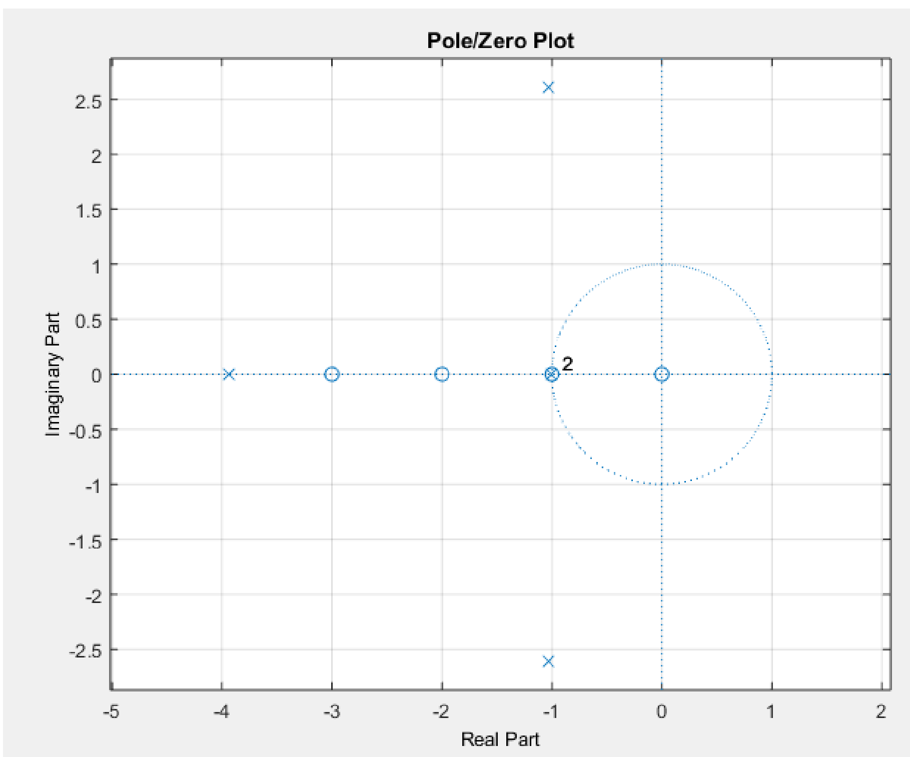


Figure 3: Graphical description of the poles

The percentage overshoot was calculated using the following formule: (Ymax – Yss) / yss * 100

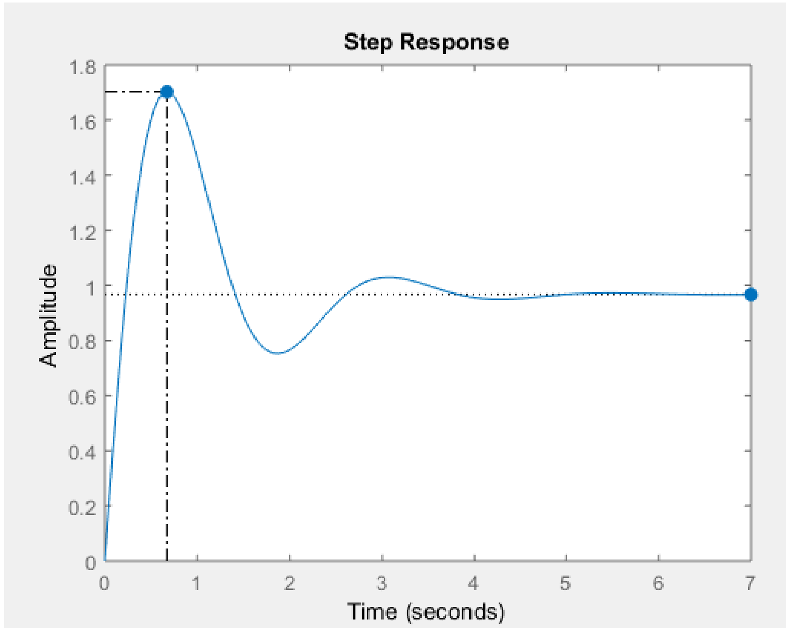


Figure 4: Step response of the system

The %OS was calculated to be 75.9% with a peak amplitude of 1.7 at 0.67 seconds

2.2. Part 2

To solve the following differential equation: $\ddot{y}(t) + 0.4\dot{y}(t) + 10y(t) = 100u(t)$

Simulink was used by connecting a summer, gainers, integrator, output block and an input block in the following manner (Input of the system was a step input U(t)):

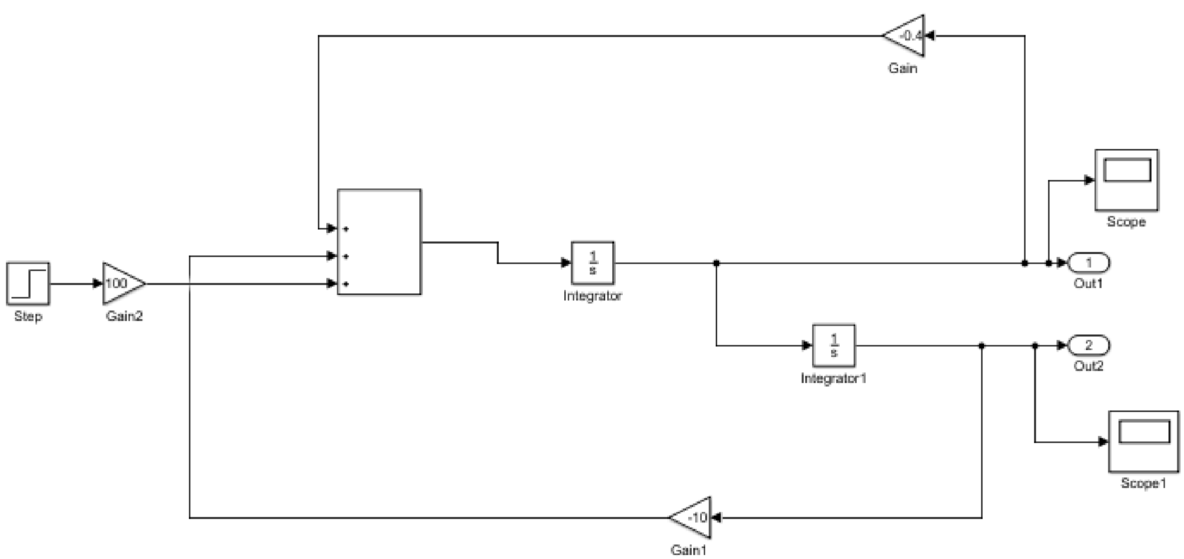


Figure 5: Simulink Block Diagram of System

The scope output was similar to the matlab code from the prelab 2, the graph below is the output:

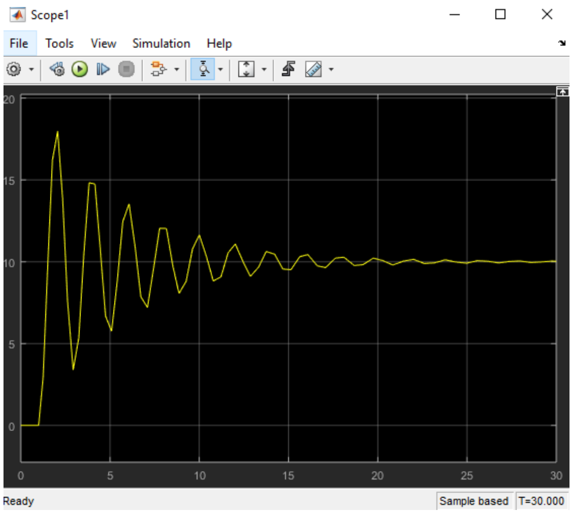


Figure 6: Scope output

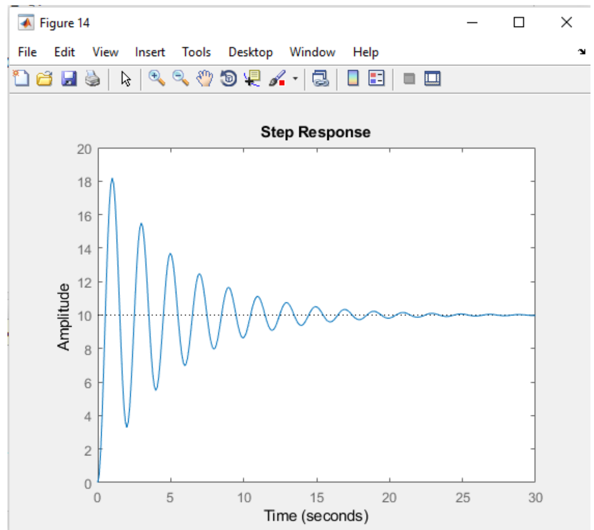


Figure 7: Matlab output

The step response of the system from the Simulink and the prelab were very similar which makes sense due to the similarities in the function used.

By comparing the graph from part 1 and the graph from part 2, we see that part 2 has more oscillations and takes more time to reach steady state. This is due to the large gain in the second system. The higher the gain the longer it takes to reach to steady state which means the more oscillations occur in the system.

2.3. Part 3

To model a mass spring- damper mechanical system, simulation was used using the following information: Mass of 1, K of 0.5, and C of 0.1. Gain coefficient is -0.1 and -0.5

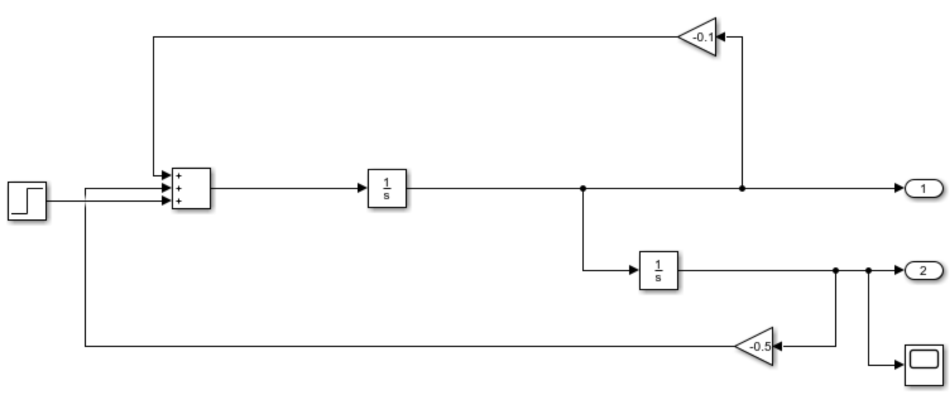


Figure 8: Step impulse as an input

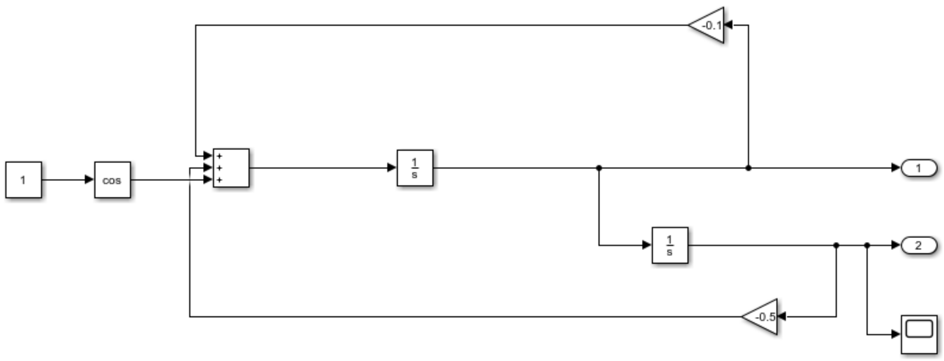
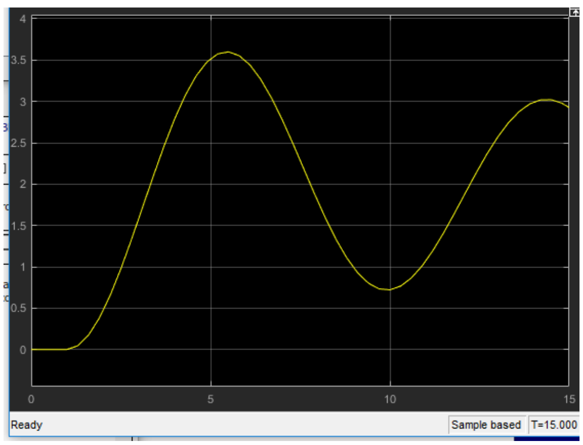


Figure 9: Cos(x) as an input

The simulation was ran for 15 second to obtain the following graphs



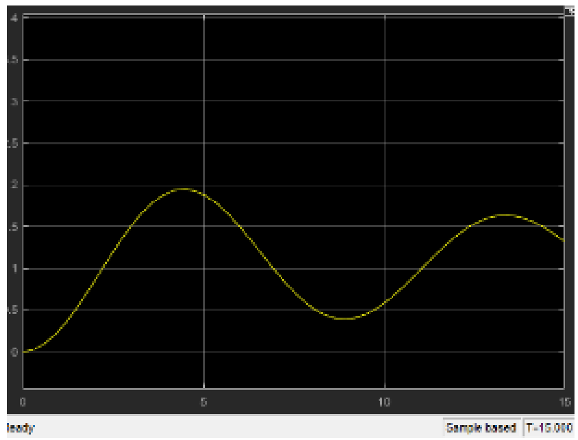


Figure 10: Output when input is Step

Figure 11: Output when input is Cos

3. Conclusion

In lab 2, matlab was used to calculate the step response of the system using the transfer function. Overshoot value was calculated using the peak amplitude obtained from the step response graph. Through lab 2, Simulink was used to model a spring damper system which was very similar to the transfer function used during the prelab, as both transfer function are second order. In this lab, it was possible to analyze the different transfer functions with different coefficients by looking at the graphs and understanding the different behavior when different coefficients where used in the system. Such property is very important to understand for a systems engineer when modelling a system as it helps him understand how the system will behave and act.

References

Norman S. Nise Control Systems Engineering: 7th edition Wiley, 2018.