EEE481 Lab 4 Answer Sheet

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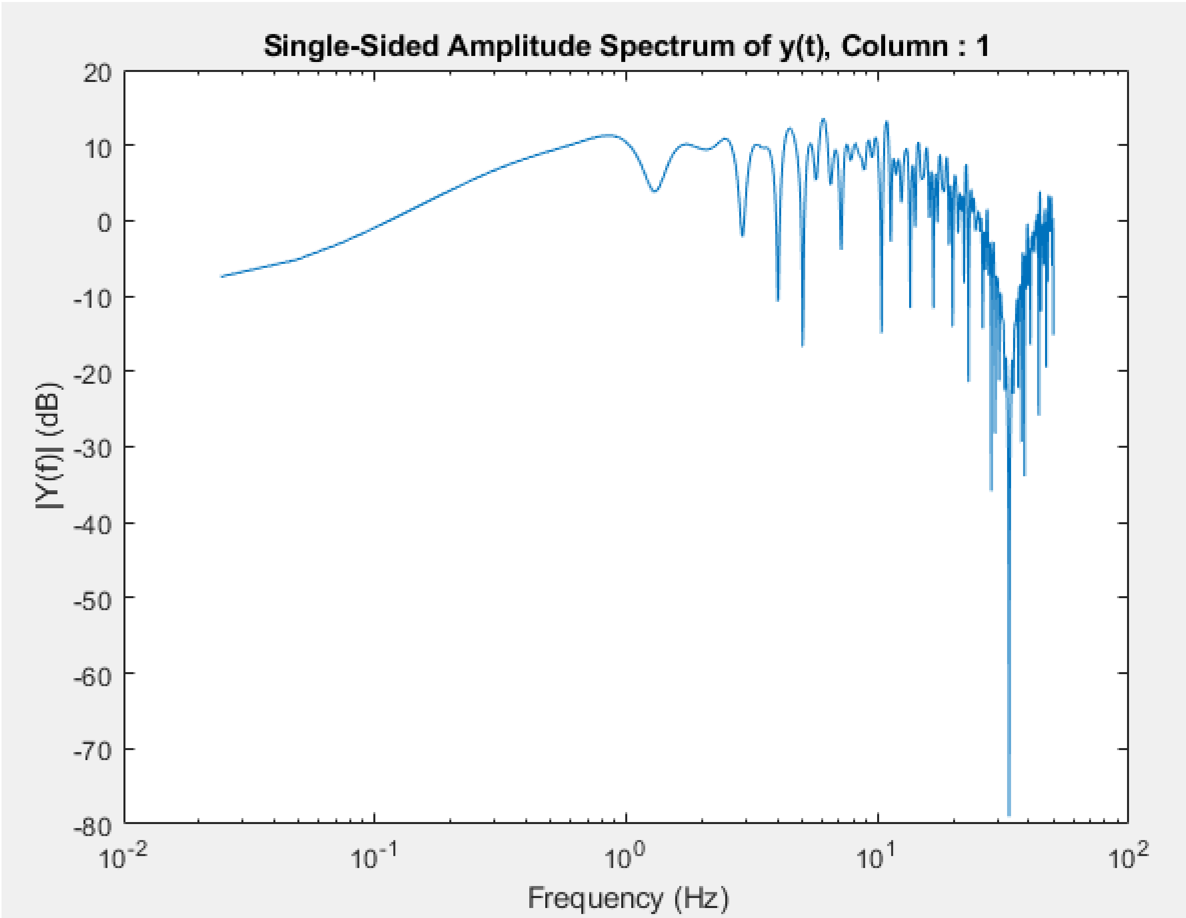
Lab Description

Write a paragraph explaining what you have learned from this lab exercise.

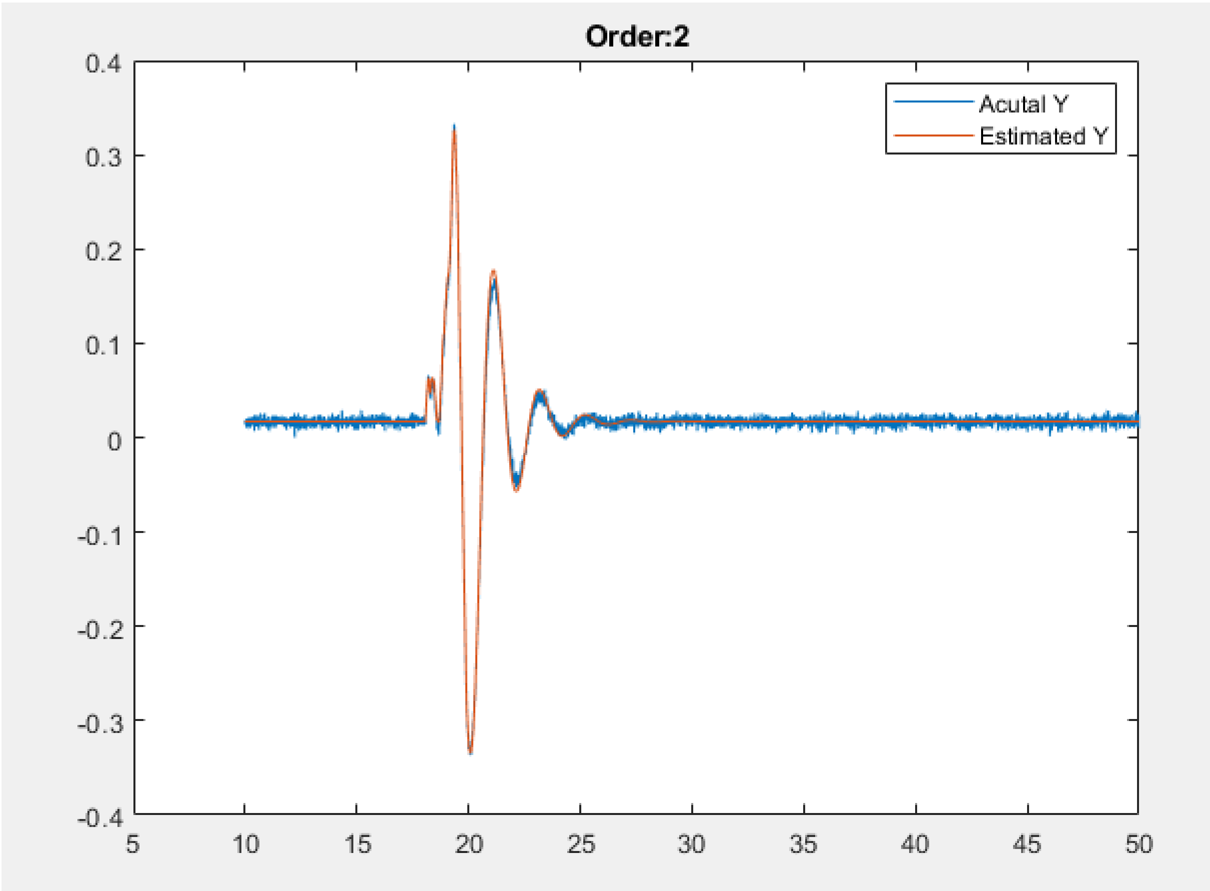
This was a very insightful lab experiment overall. First part of the experiment was where we learned how to identify the model of the system based on simple input commands and using advanced mathematics. It was interesting to trial and error on the guessing of the plant transfer function and more interesting to notice how accurate the output was to the guessed function once the one with minimum error was identified. Second part of the experiment was relatively simpler where we designed and tested the controller which was designed using the identified transfer function. The controller performed well, given the fact that the design was based on mere identification based on data.

Q1) Plot the FFT of the input signal. Does the input signal have sufficient energy is the frequencies of interest for the choice of closed-loop bandwidth of 20 rad/sec?



Yes, as seen in the plot the signal has enough energy at 20 rad/s!!

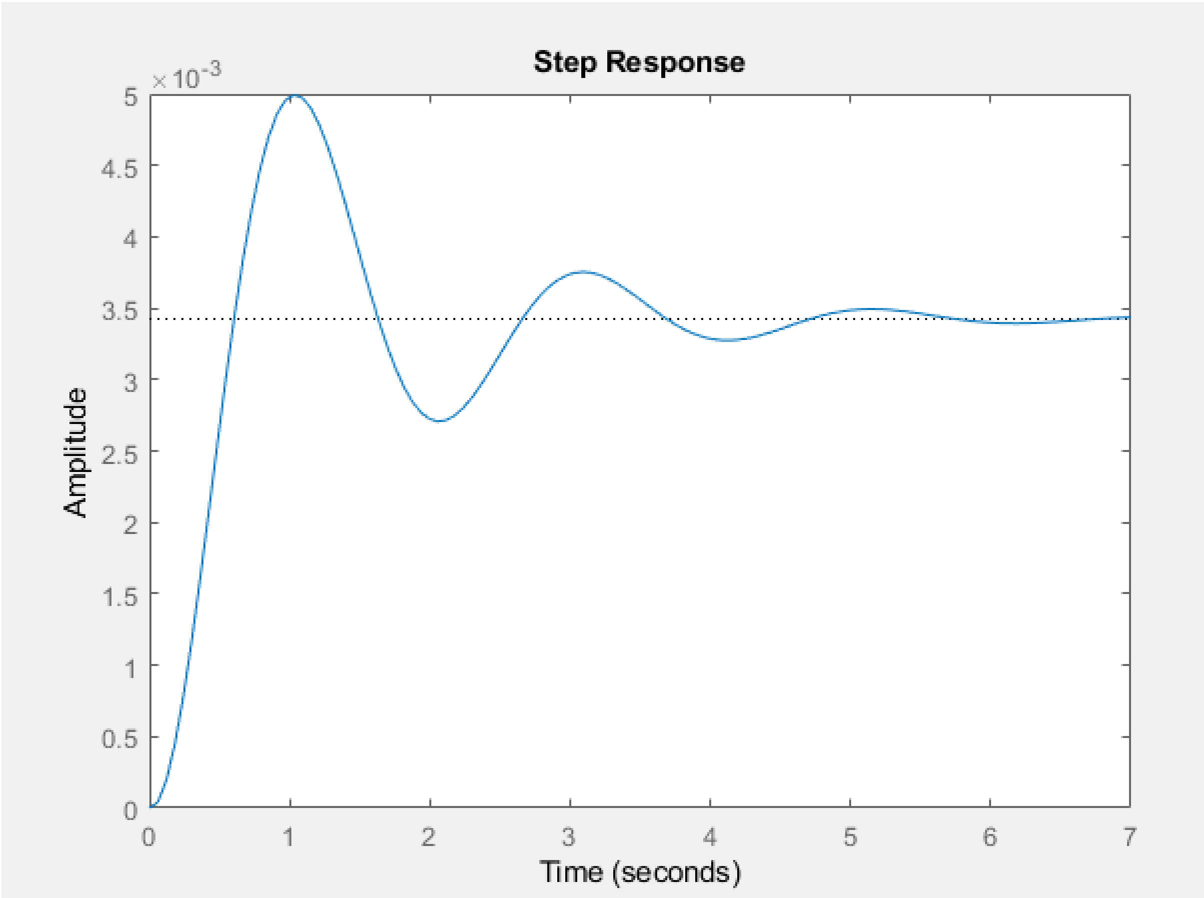
Q2) Plot actual Y and estimated Y.



Q3) What is the order of the final system? Write down transfer function of identified system

Final system is 2nd order. Transfer function is **(-0.0003333s + 0.03398)/(s^2 + 1.522 + 9.922)**

Q4) Plot step response of the identified system and mark its characteristics.




```
>> stepinfo(IdentifiedPlant2)

ans =

  struct with fields:

        RiseTime: 0.3992
    SettlingTime: 5.1712
     SettlingMin: 0.0027
     SettlingMax: 0.0050
       Overshoot: 45.7946
      Undershoot: 0
            Peak: 0.0050
        PeakTime: 1.0300
```

Q5) Show all calculations (in code) for control design and report the values for K_p K_i and K_d.

It was found that, Ki = 1836 ; Kp = 2357; Kd = 357.6

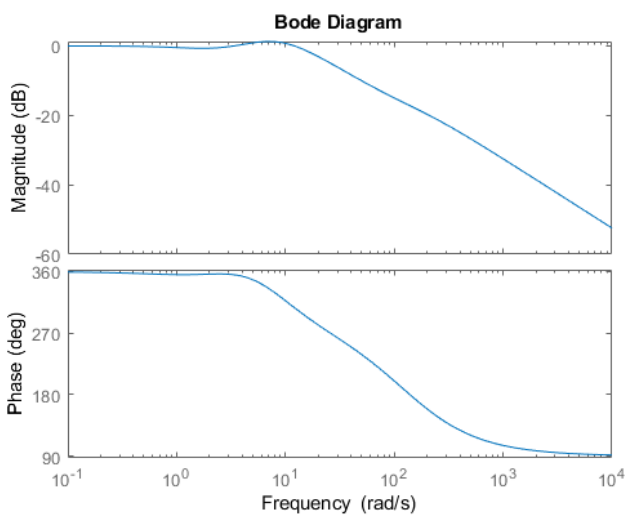
```
% Experiment 4.2- Abhigya Raval
clear all; clc

s = tf('s');
%  Givens

P = (-0.0003333*s + 0.03398)/(s^2 + 1.52*s + 9.922);

BW= 20;
PM = 60; Wgc = BW/1.5;
Ts = 0.01;

% Controller

tau = Ts/2;
zohLag = -Wgc*Ts/2*180/pi; %compute lag from ZOH
[~,phP]=bode(P,Wgc);%phase of plant
if phP>0
phP = mod(phP,360); % bring phP within +/-360
phP = phP-360; % provide negative shift
end
IntTau = tf(1,[tau 1 0]); % integrator and tau phase
(s(tau*s+1))
[~,phIntTau]=bode(IntTau,Wgc);

% phZ = (PM-180-phP-phIntTau)/2; %phase of each zero
phZ = (PM-180-phP-phIntTau-zohLag)/2; %phase of each zero

a = Wgc/tand(phZ);% compute zero location
% Get mag for PID with pseudo pole filter at Wgc
[mPintTauZ,~]=bode(P*IntTau*tf([1 2*a a^2],1),Wgc);
%(s+a)^2=tf([1 2*a a^2],1)
K = 1/mPintTauZ;%find K;

C_DT=K*(s+a)^2/(s*(tau*s+1)); % PID controller
TryCT = feedback(C_DT*P,1);

CdTustin = c2d(C_DT,Ts,'tustin');
Pzoh = c2d(P,Ts,'zoh');
L_DT=CdTustin*Pzoh;
allmargin(L_DT)
TryTus = feedback(L_DT,1);
```

```
figure(1)
step(TryCT,TryTus)
```

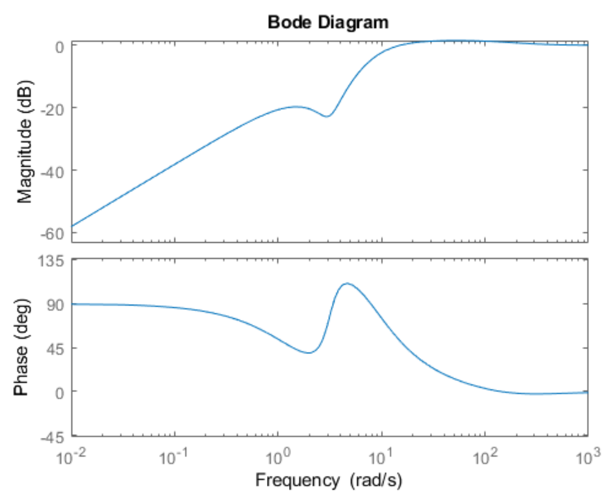
Q6) Show Open-loop transfer function, Closed loop Sensitivity and Complementary Sensitivity plots. Also list down all stability margins

```
>> P*C_DT

ans =

   -0.1192 s^3 + 11.54 s^2 + 61.61 s + 80.1
  -----------------------------------------
  0.005 s^4 + 1.008 s^3 + 1.57 s^2 + 9.922 s

Continuous-time transfer function.
```

```
ans =

  struct with fields:

      GainMargin: [6.2901e-12 5.4456]
     GMFrequency: [0 82.2426]
     PhaseMargin: 60.0145
     PMFrequency: 13.3422
     DelayMargin: 7.8506
     DMFrequency: 13.3422
          Stable: 1
```



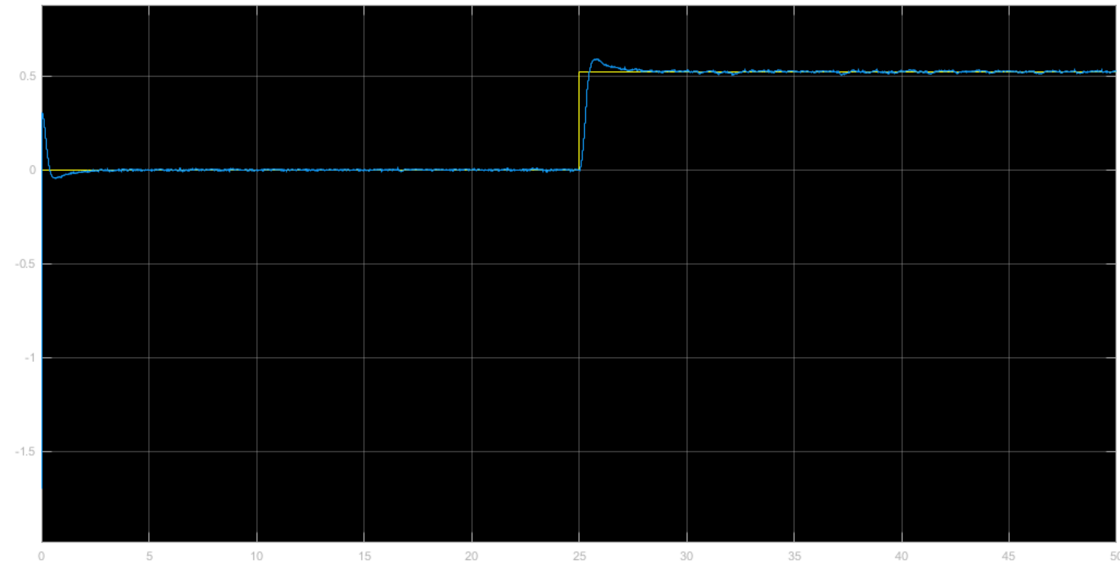
Sensitivity



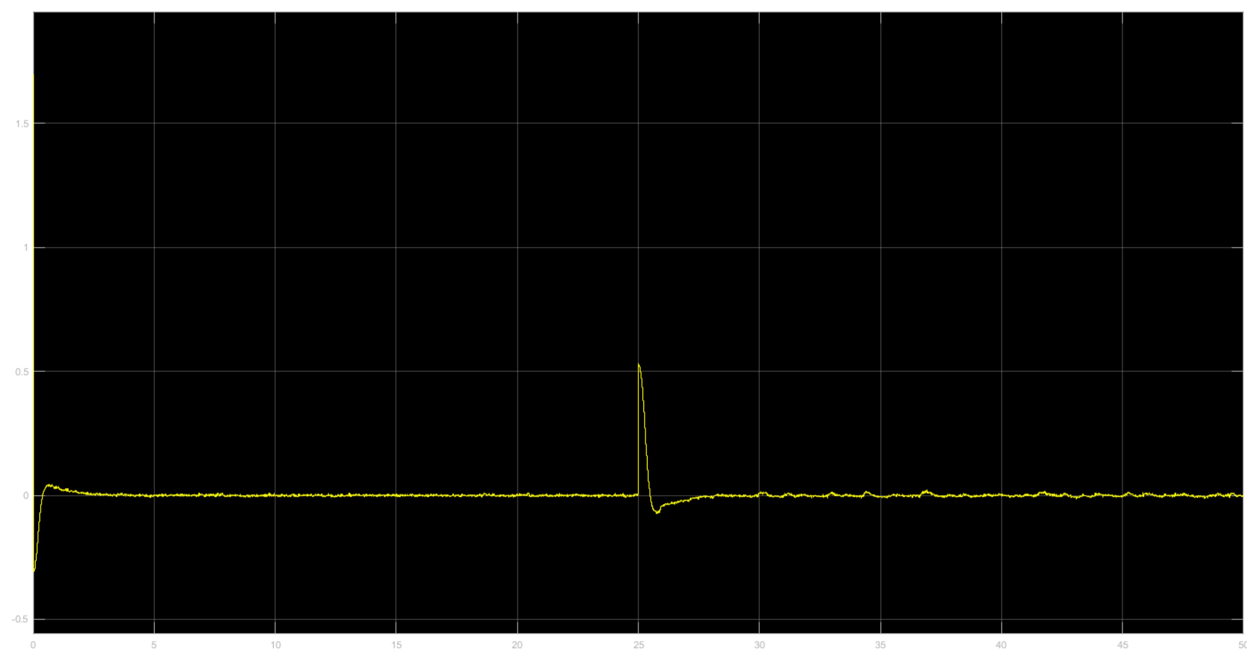
Complementary Sensitivity

Q7) Show plots for the step response when a step of 50 is applied at the reference (800C to 850C). and plot control input (PWM value)

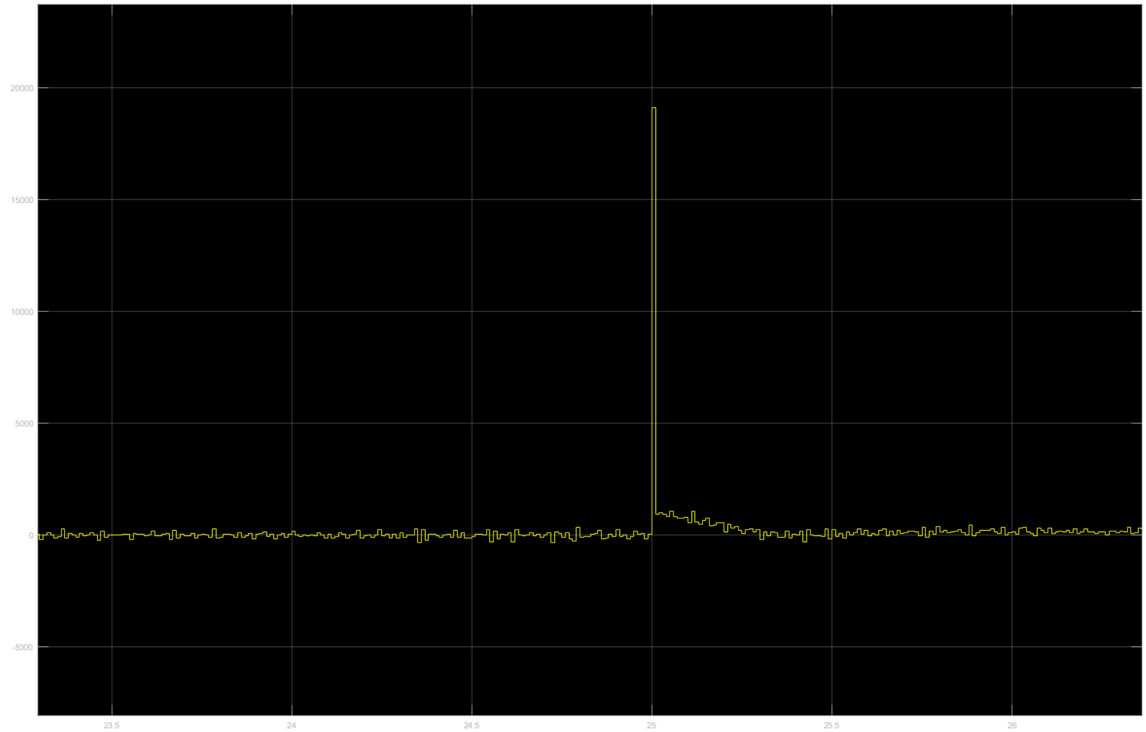
This question was a little confusing since there is not context to the step asked for. I have put all the control signals here, just in case. Thank you.



Step response at 25 seconds from 0 to pi/6



Error to controller



Controller to signal conditioner

LAB 4: LAB REPORT GRADE SHEET

Name ________________________________

Instructor Assessment

Grading Criteria	Max Points	Points Lost
Template		
Neatness, Clarity, and Concision	3	
Lab Description	4	
Lab Report	50	
Answers to Questions		
Q1	9	
Q2	9	
Q3	9	
Q4	9	
Q5	9	
Q6	9	
Q7	9	
Lab Score (out of 100)	**Points Lost**	
	Late Lab	
	Lab Score	