Experiment No. 1

G11 EE208

Group Members:

Shreyash Andhale	:	2019EEB1141
Snehal Dhavale	:	2019EEB1200
Manaswi Nandyala	:	2020EEB1185

Date of Submission: 16th Jan 2022

Objective: To compare both the cases in which a second order analog OLTF of an oven temperature is given and PD controller is to be considered in a cascade and feedback with the help of step responses including percentage overshoot, peak time, settling time and steady state error.

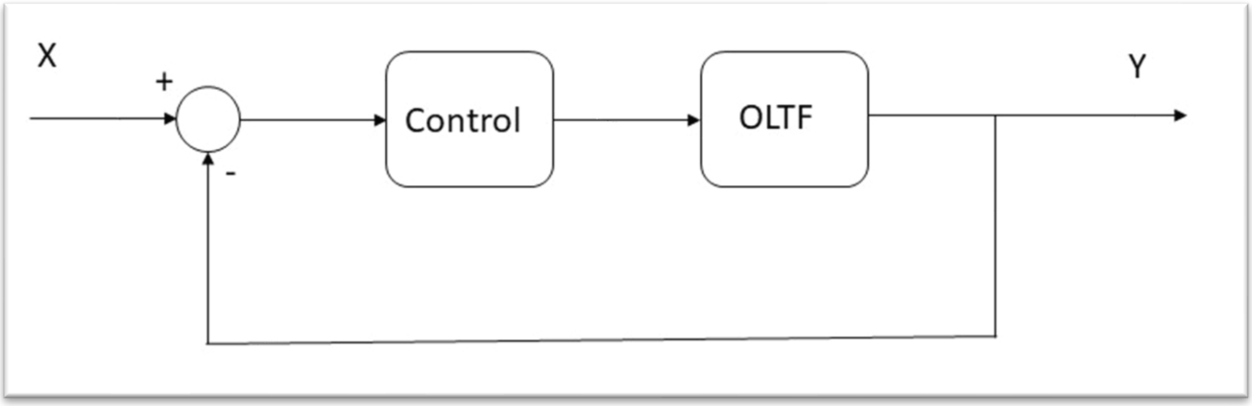
$G_{OL}(s) = \frac{K}{s^2+3s+10}$ (OLTF)

$G_c(s) = 80(s+5)$ (PD control)

Case A: PD controller is in cascade.

Case B: PD controller is in feedback.

Case A:

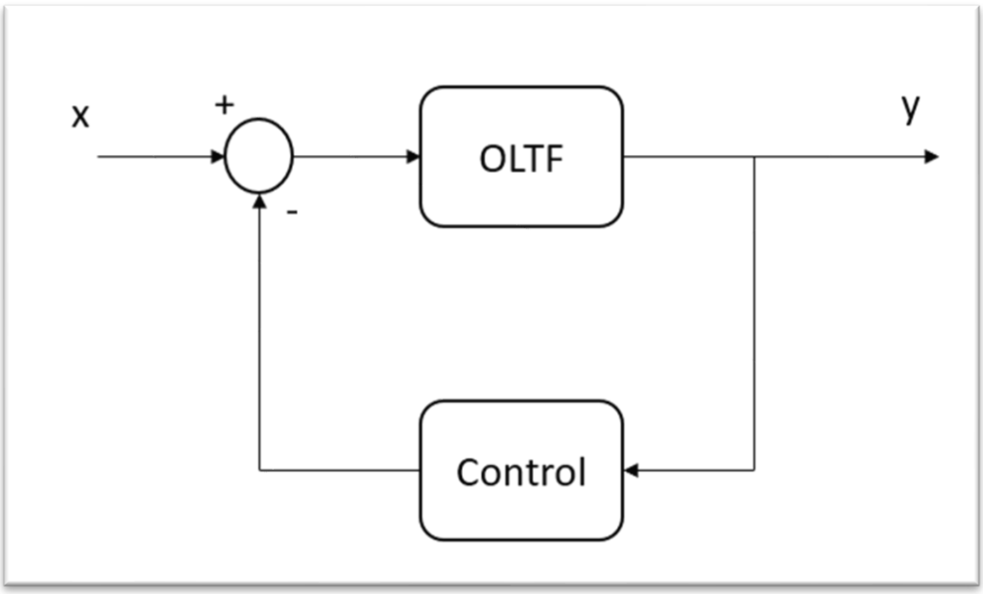


CLTF = $\frac{GOL(s)*Gc(s)}{1+GOL(s)*Gc(s)*1}$

We get,

CLTF = $\frac{80K(s+5)}{s^2+(80K+3)s+400K+10}$

Case B:



CLTF = $\frac{GOL(s)}{1+GOL(s)*Gc(s)}$

We get,

CLTF = $\frac{K}{s^2+(80K+3)s+400K+10}$

MATLAB Code for Experiment:

For Case A:

```
K1 = input("Enter Open Loop gain K1 = ");
G11 = K1*tf(1,[1,3,10]);  %Open Loop transfer function
G12 = 80*tf([1,5],1);    %PD controller
sys1 = feedback(G11*G12,1); %Unity negative feedback
A =stepinfo(sys1);
controlSystemDesigner(sys1)
```

```
%<name> for Cascade system

for K1=linspace(0,20,1000)
    G11 = K1*tf(1,[1,3,10]);  %Open Loop transfer function
    G12 = 80*tf([1,5],1);    %PD controller
    sys1 = feedback(G11*G12,1); %Unity negative feedback
    A =stepinfo(sys1);
    u = A.<name>; hold on;
    plot(K1,u,'r.')
end
```

in above <name> can be Overshoot, Peak, PeakTime, SettlingTime and RiseTime

```
%Steady state error for Cascade system
for K1=linspace(0,2,1000)
    sse = 1/(40*K1+1); hold on;
    plot(K1,sse,'r.')
end
```

For Case B:

```
%for PD as a feedback


K2 = input("Enter Open Loop gain K2 = ");
G21 = K2*tf(1,[1,3,10]);  %Open Loop transfer function
G22 = 80*tf([1,5],1);    %PD controller
sys2 = feedback(G21,G22,-1); %Controller as a negative feedback
B=stepinfo(sys2);
controlSystemDesigner(sys2)
```

```
%<name> graph vs K plot in feedback
```

```
for K2=linspace(0,3,1000)
    G21 = K2*tf(1,[1,3,10]);  %Open Loop transfer function
    G22 = 80*tf([1,5],1);    %PD controller
    sys2 = feedback(G21,G22,-1); %PD controller as a negative feedback
    B =stepinfo(sys2);
    w = B.<name>; hold on;
    plot(K2,w,'r.')
end
```

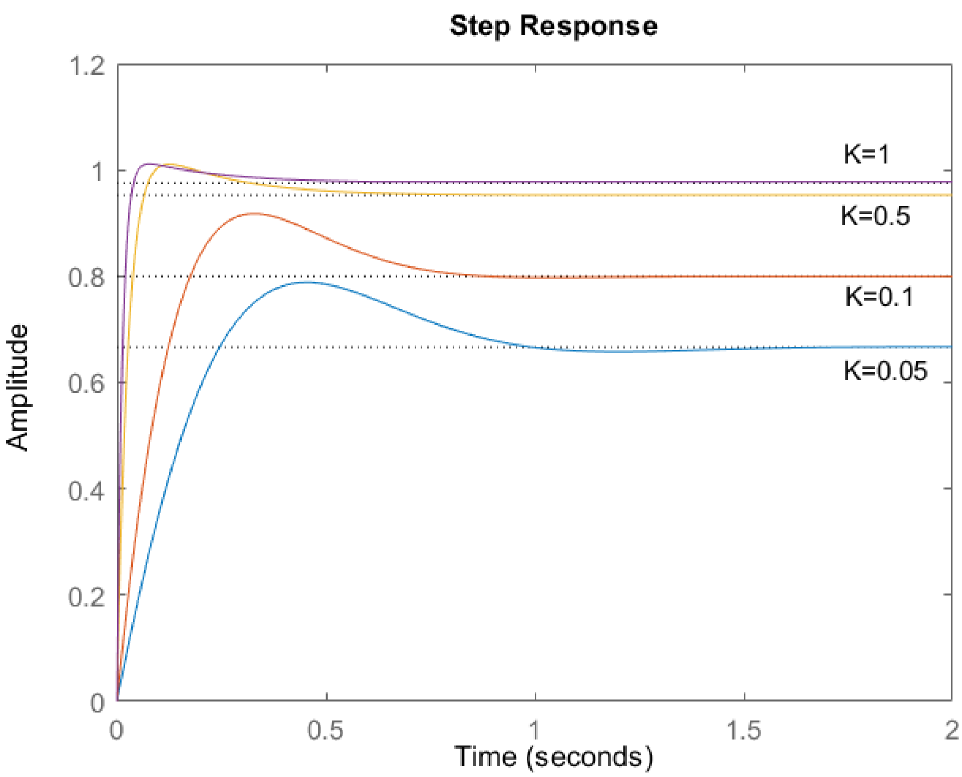
in above <name> can be Overshoot, Peak, PeakTime, SettlingTime and RiseTime

```
%Steady state error for feedback system
for K2=linspace(0,10,1000)
    sse = (339*K2+10)/(400*K2+10); hold on;
    plot(K2,sse,'r.')
end
```

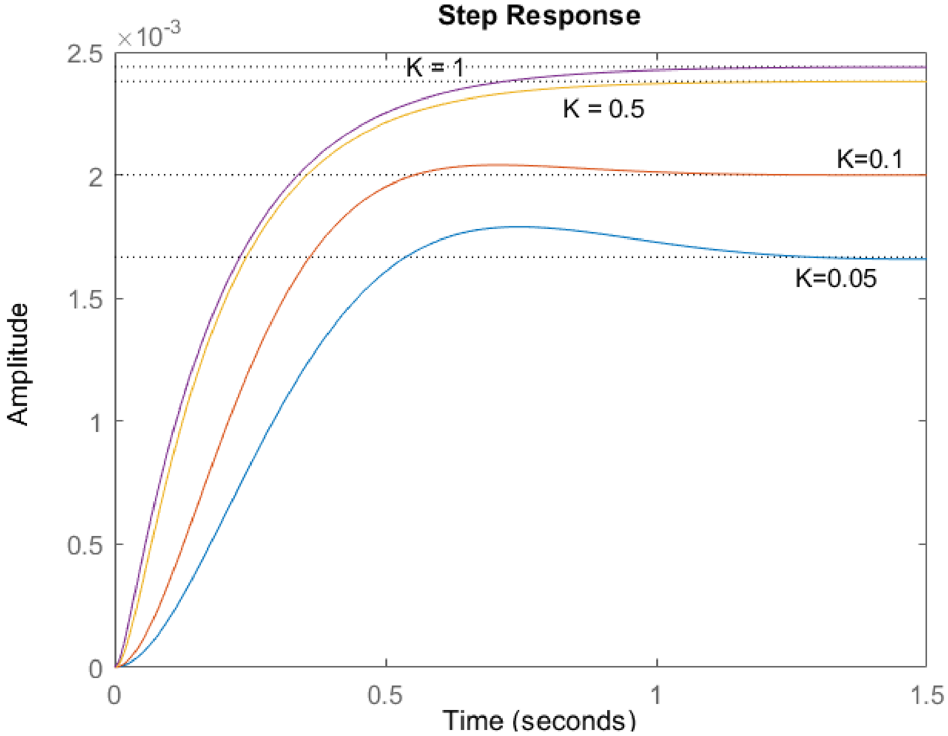
OBSERVATIONS:

Step Response of both cases: K = 0.05, 0.1, 0.5 ,1

Case A: K = 0.05, 0.1, 0.5 ,1



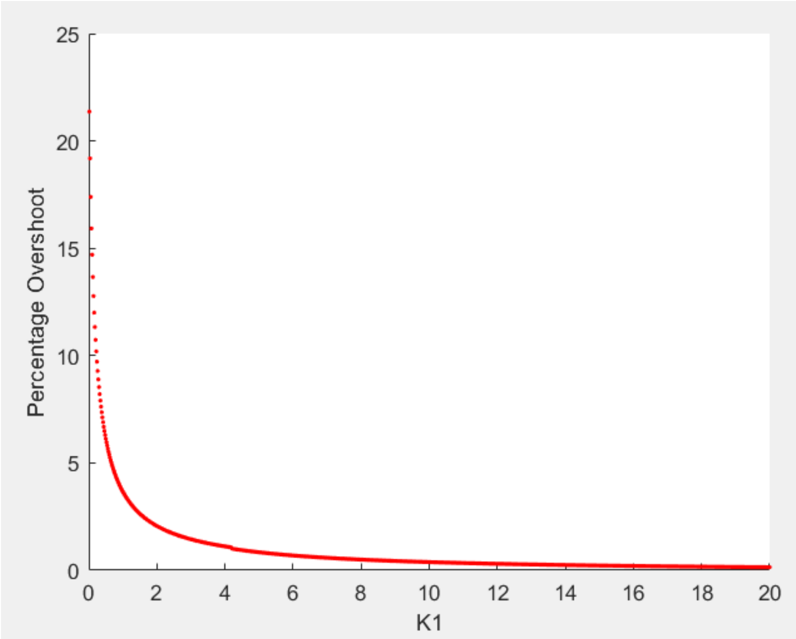
For case B:



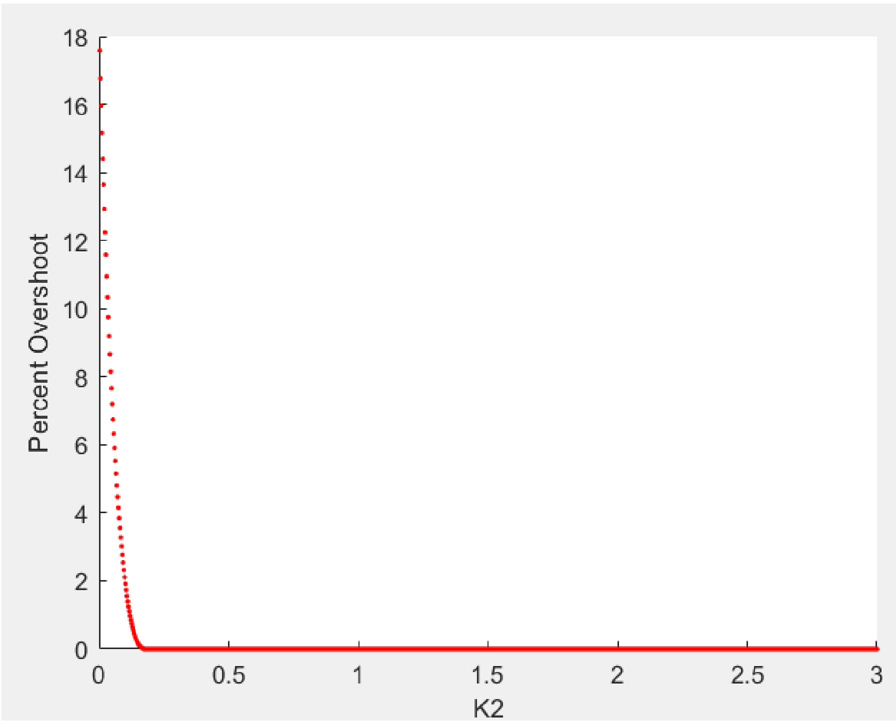
Observed: From the Step Response of both cases, we can observe that, as OL gain is increased the percent overshoot decreases, etc. There are a lot of differences in both of the cases when we compare it with the system parameters like percent overshoot, peak time, settling time, rise time, etc. Step response in case A can achieve the steady state value in less time than case B.

For Percent Overshoot (maximum amount by which the response overshoots the steady state value)

Case A:



Case B:



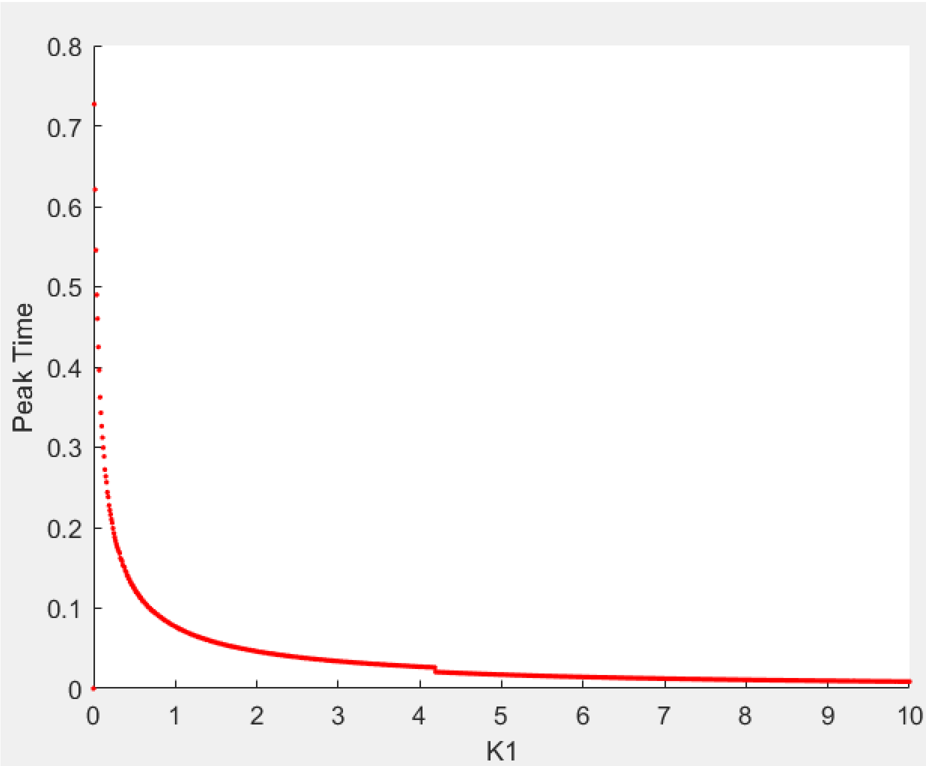
K	Percent Overshoot for Case A	Percent Overshoot for Case B
0.05	18.2456	7.3524
0.1	14.7048	2.0479
0.5	6.1319	0

1	3.6644	0
5	0.8392	0

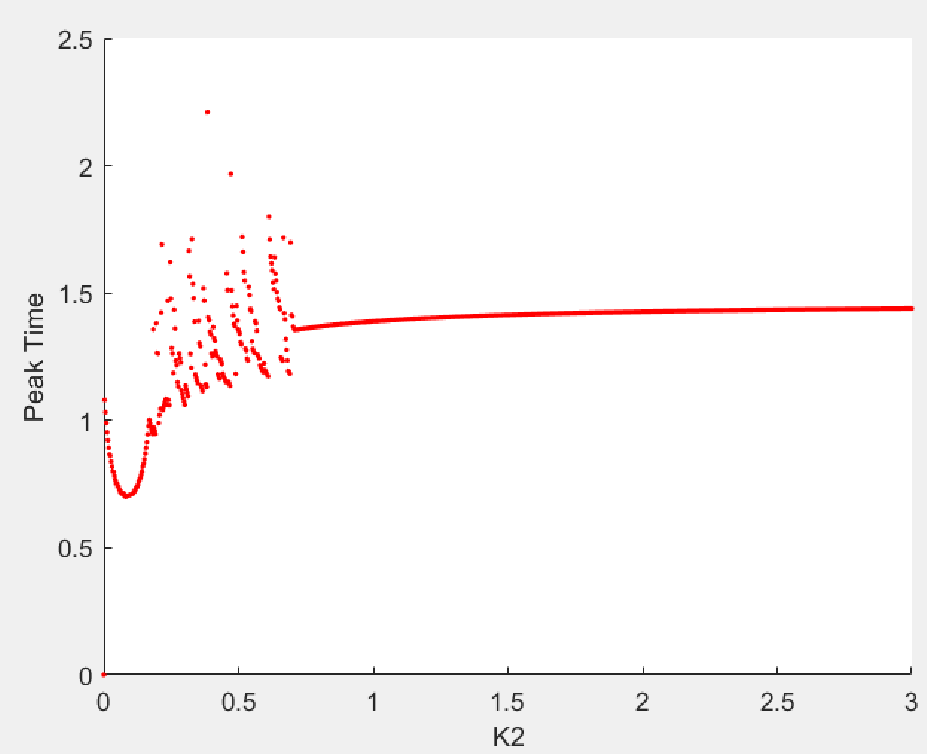
Observed: As we can see from the graphs and the table, percent overshoot decreases with increase in K in both cases. But in case B, the percent overshoot becomes zero for value of K>=0.2 while in case A, the percent overshoot decreases exponentially. For the system to be stable, the overshoot should be less. A system is desirable with small overshoot.

For **Peak Time** (Time taken for response to rise from 0 to peak value)

Case A:



Case B:

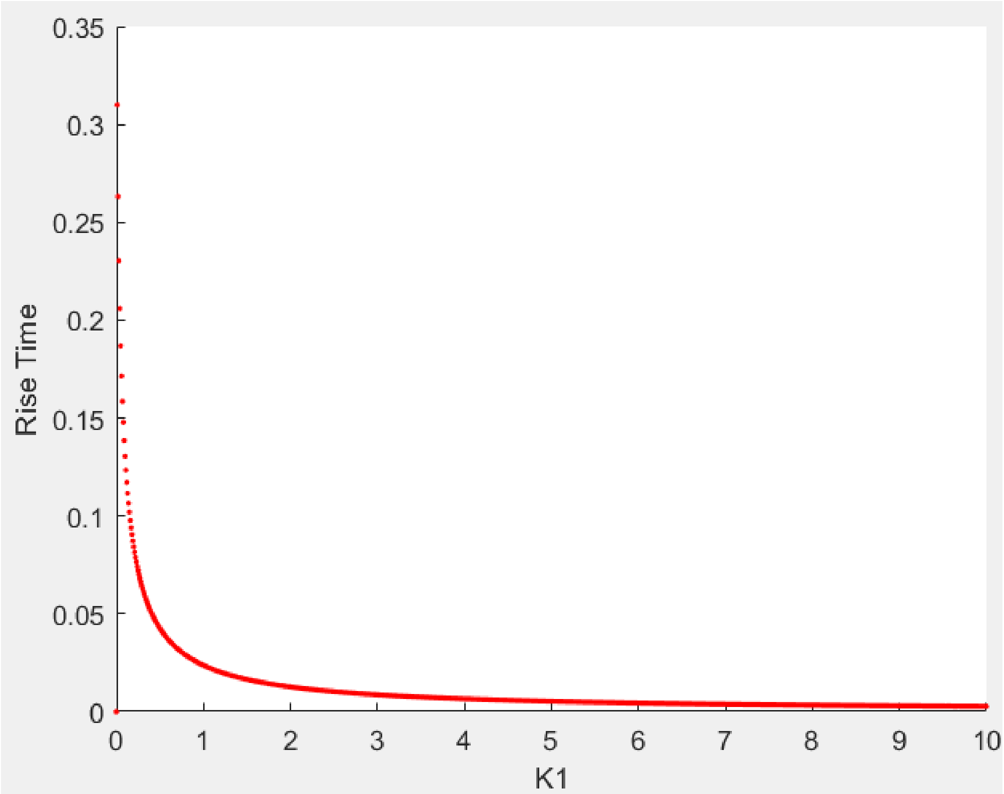


K	Peak Time for Case A	Peak Time for Case B
0.05	0.4605	0.7500
0.1	0.3265	0.7033
0.5	0.1257	1.3526
1	0.0770	1.3881
2	0.0464	1.4271
5	0.0172	2.0879

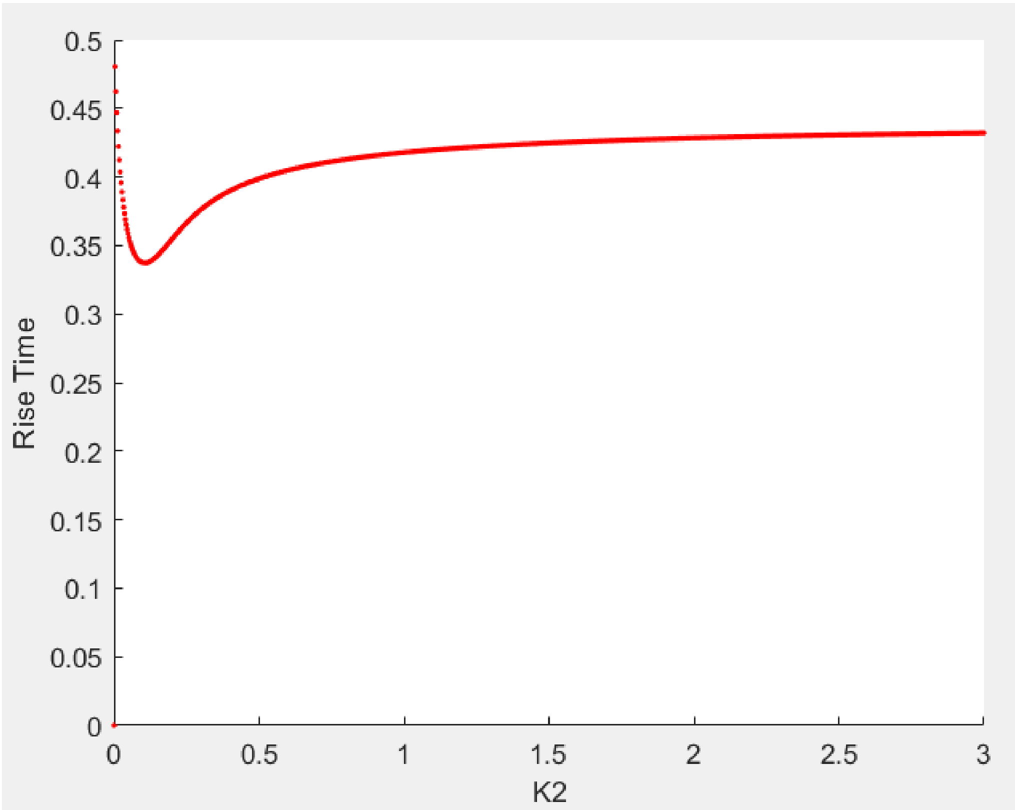
Observed: In case A, the peak time decreases exponentially with respect to the value of K. In case B, the peak time does not follow pattern when K is increased up to 0.8, then it starts to rise and becomes constant.

For **Rise Time** (time taken by response to rise from 0 to steady state value)

Case A:


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Rise Time
0
1
2
3
4
5
6
7
8
9
10
K1

Case B:

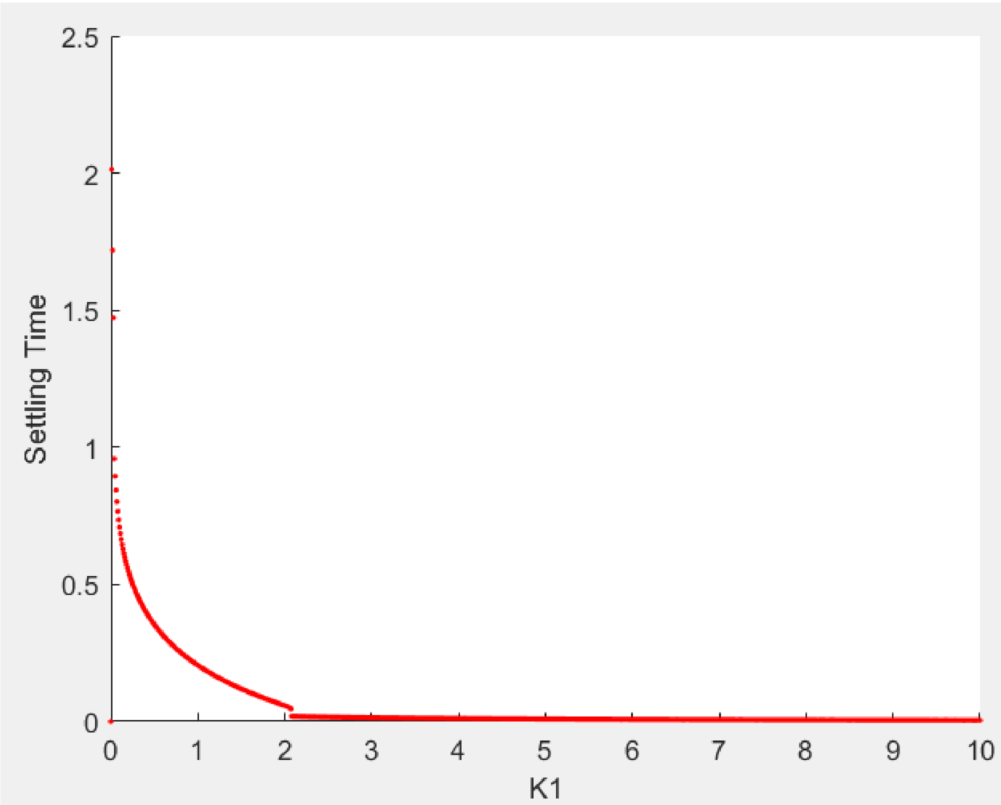

0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Rise Time
0
0.5
1
1.5
2
2.5
3
K2

K	Rise Time Case A	Rise Time for Case B
0.05	0.1870	0.3566
0.1	0.1306	0.3374
0.5	0.0425	0.3988
1	0.0237	0.4179
5	0.0053	0.4350

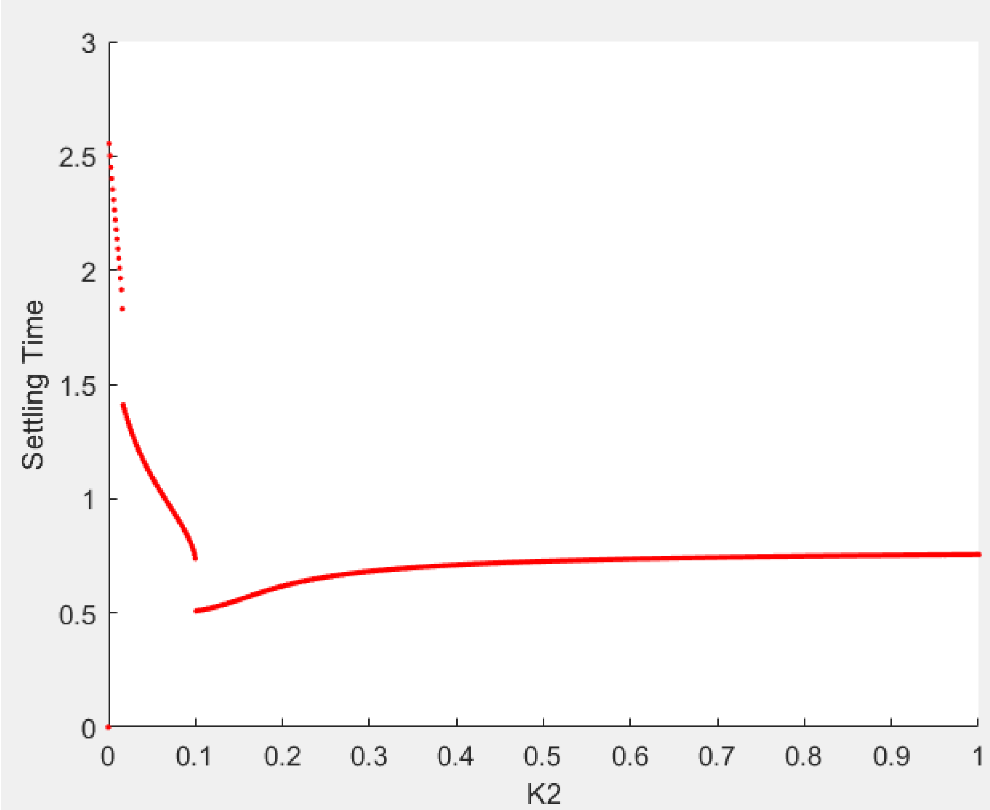
Observed: As we can see from the graphs and table, in case A the rise time decreases exponentially, but in case B, the rise time decreases until K<0.1. Then it starts increasing and becomes constant after K>3. The lesser the rise time, more fast the system will respond. Here Case A is more desirable with proper K value.

Settling time (time taken by oscillations to die away):

Case A:



Case B:

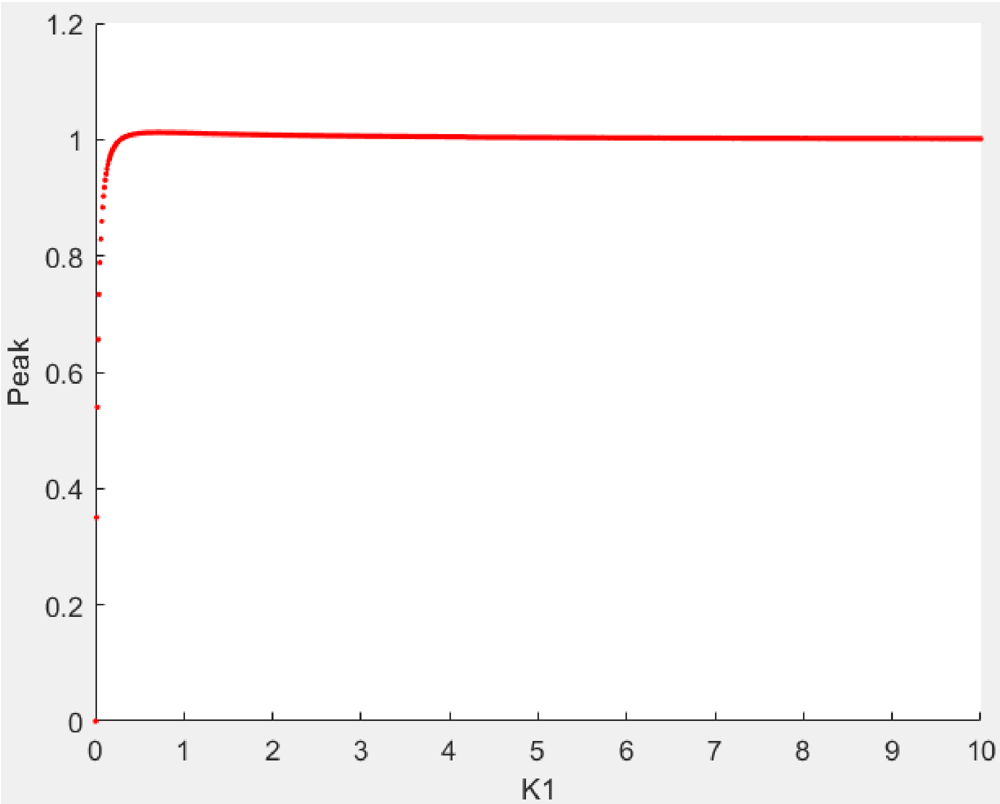


K	Settling Time Case A	Settling Time for Case B
0.05	0.8951	1.0953
0.1	0.7093	0.7394
0.2	0.5492	0.6166
0.5	0.3531	0.7254
1	0.2051	0.7550
5	0.0088	0.7771

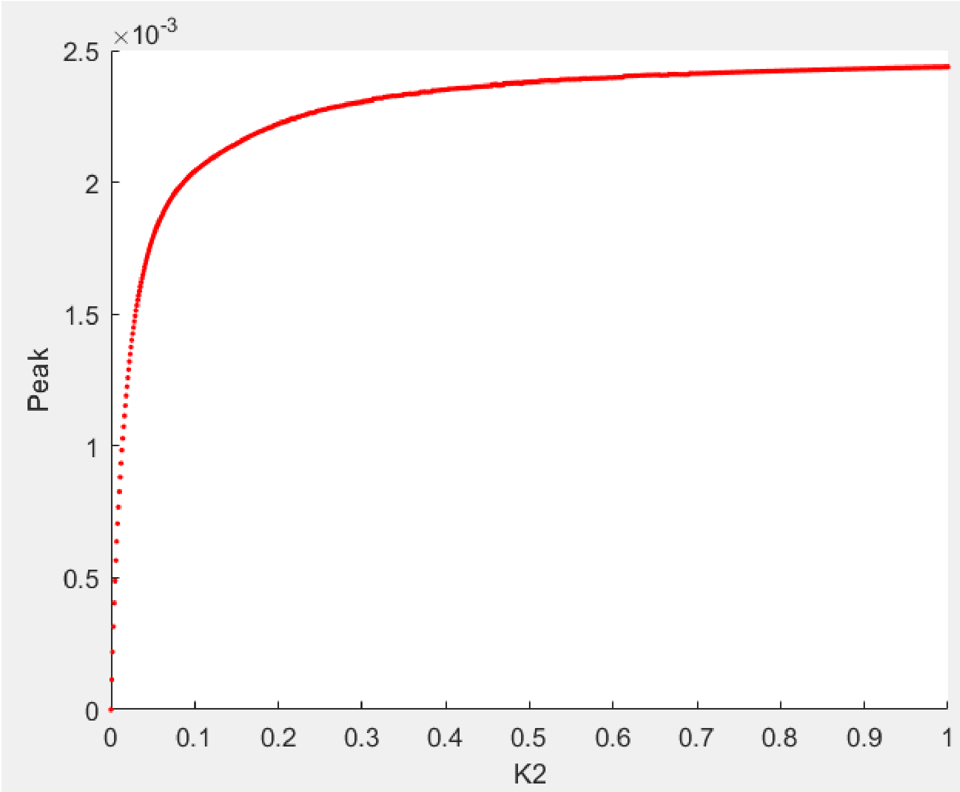
Observed: Settling time decreases with increase in K for both the cases, but the settling time for case B becomes constant, that means there will always be some oscillations in the output and steady state error will be higher than in case A.

Peak

Case A:



Case B:



K	Peak for Case A	Peak for Case B
0.05	0.7883	0.0018
0.1	0.9176	0.0020
0.2	0.9843	0.0022
0.5	1.0108	0.0024
1	1.0114	0.0024
5	1.0034	0.0025

Observed: In case A, the peak value is achieved in a very short time than case B for a certain value of K.

Steady State Error:

Steady state error can be calculated by taking limits s tending to 0.

For Case A:

Steady State Value = SSV = $\lim_{s \to 0} \frac{80K(s+5)}{s^2+(80K+3)s+400K+10}$

$= \frac{40K}{40K+1}$

Steady State Error = 1 – SSV

SSE= $\frac{1}{40K+1}$

For Case B:

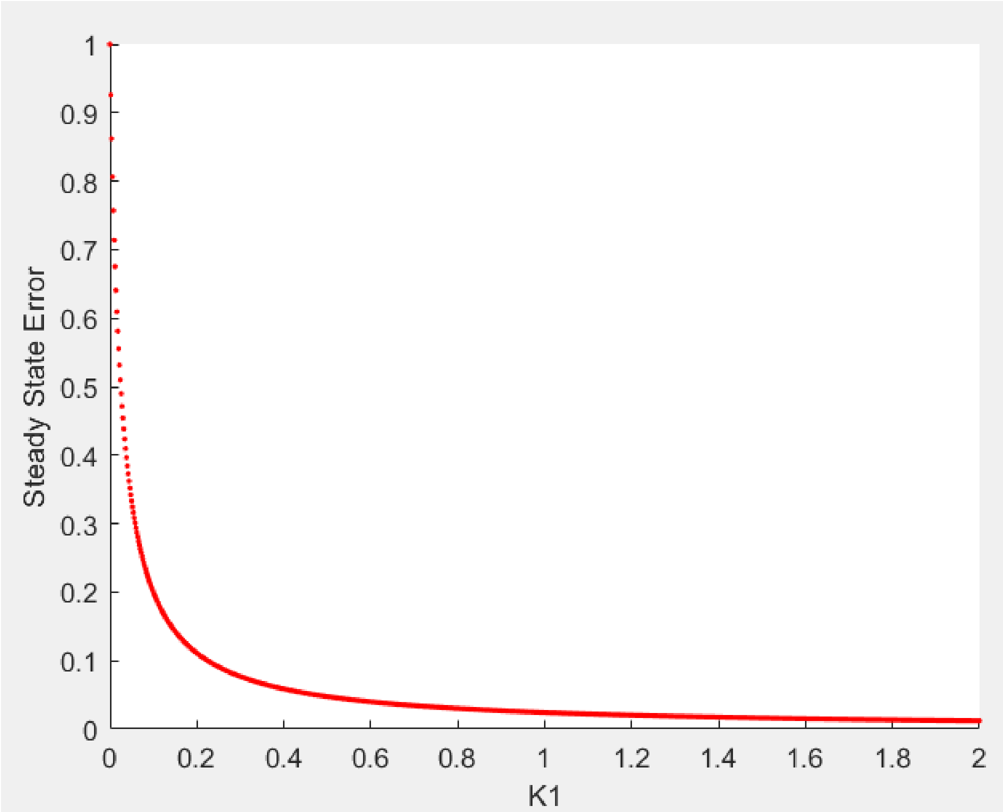
SSV = $\lim_{s \to 0} \frac{K}{s^2+(80K+3)s+400K+10}$

$= \frac{K}{400K+10}$

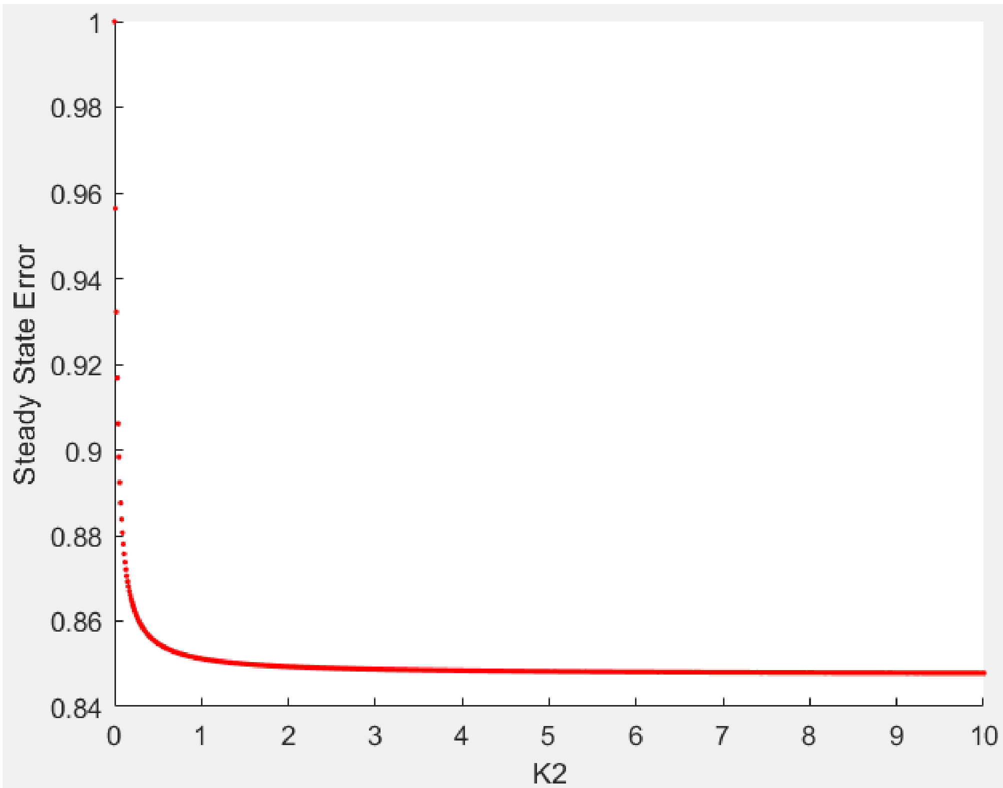
SSE = 1 – SSV

SSE = $\frac{399K+10}{400K+10}$

Case A:



Case B:

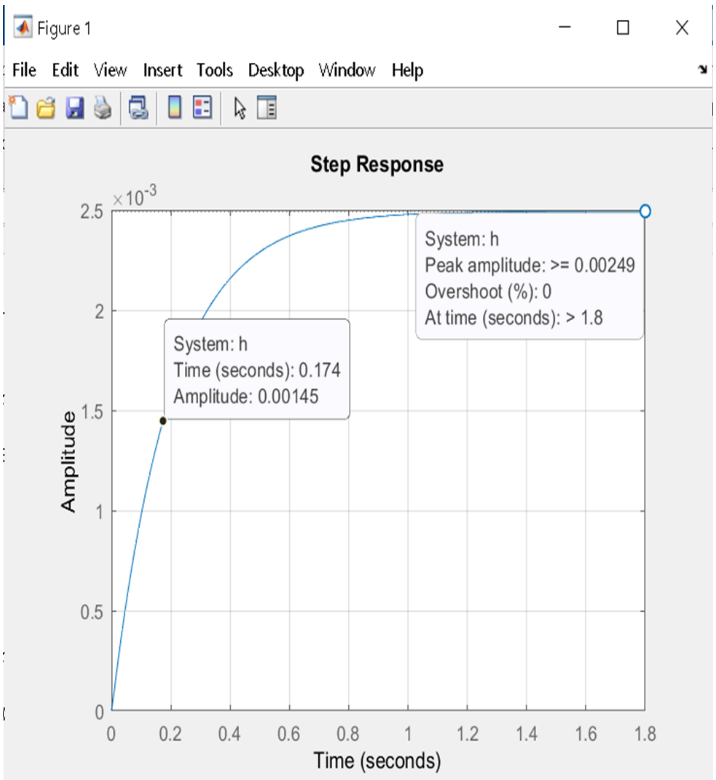


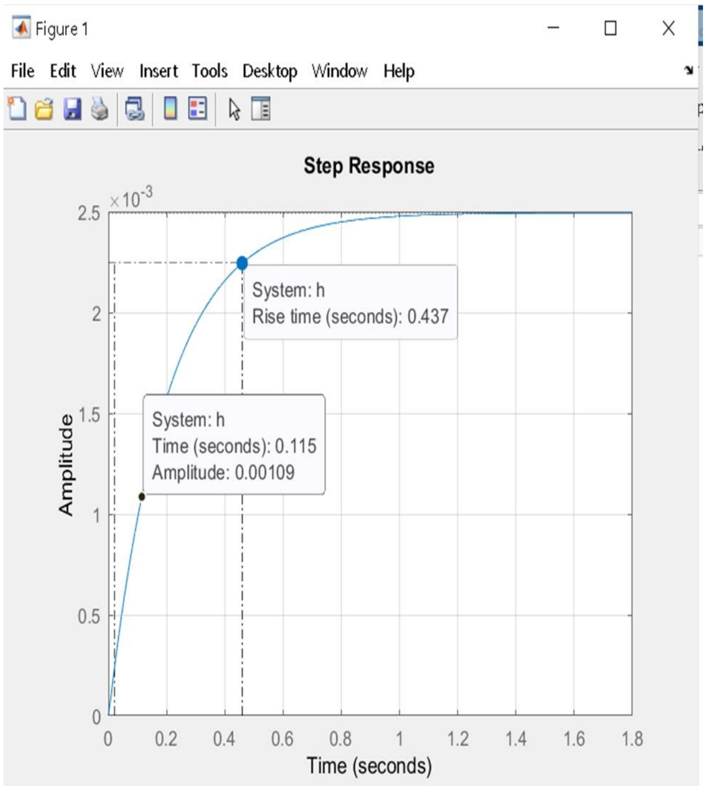
K	SSE for Case A	SSE for Case B
0.05	0.3333	0.8983
0.1	0.2000	0.8780
0.2	0.1111	0.8644
0.5	0.0476	0.8548
1	0.0244	0.8512
5	0.0050	0.8483

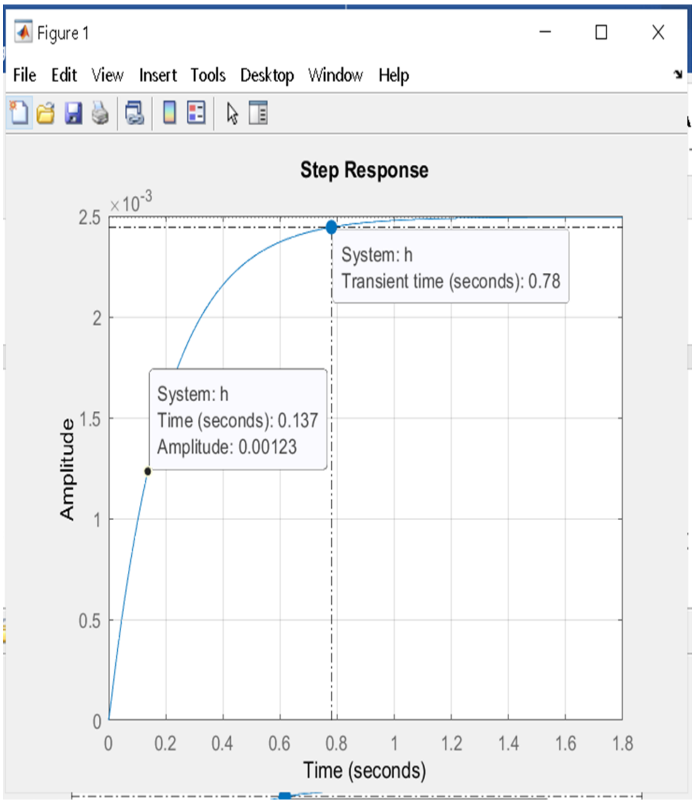
Observed: As we can see, the steady state error in case B is more as compared to case A as we discussed earlier. SSE decreases exponentially in both cases, but case B give a constant SSE after very high value of K which is not desirable for system to give an undesirable output.

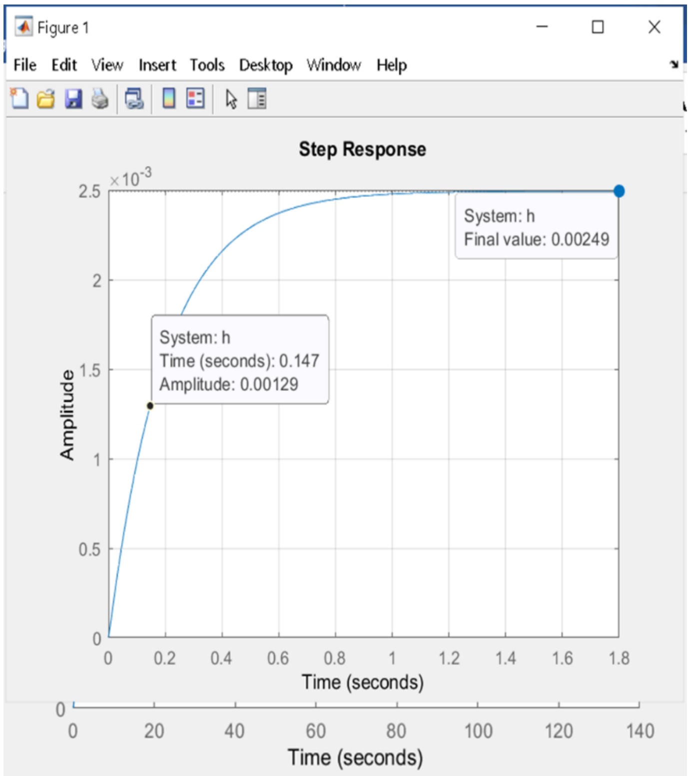
Some simulations to observe peak amplitude, rise time, transient time, steady state errors for k=10 and k=1000 (feedback configuration)

A] k=10









B] k=1000

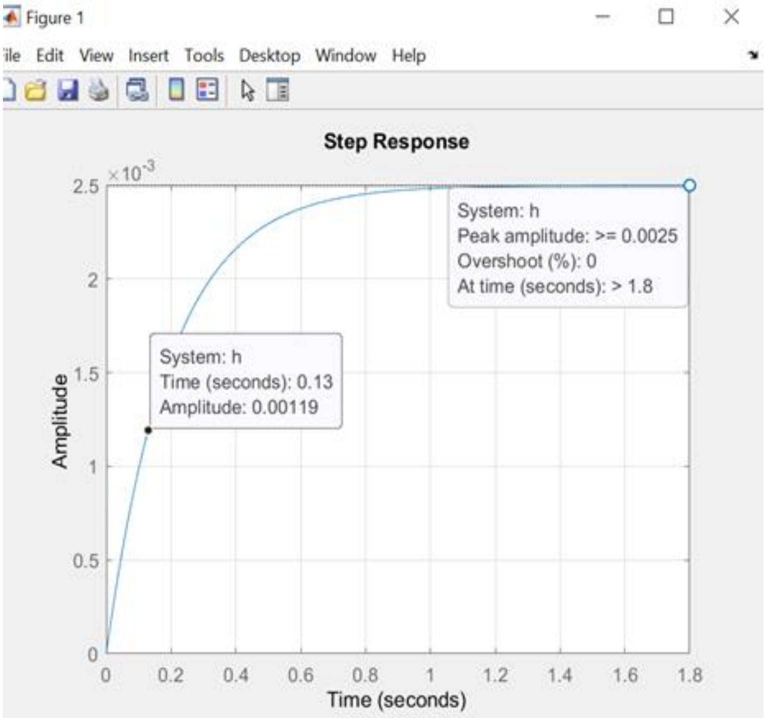


Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
System: h
Peak amplitude: >= 0.0025
Overshoot (%): 0
At time (seconds): > 1.8
System: h
Time (seconds): 0.13
Amplitude: 0.00119
Amplitude
Time (seconds)

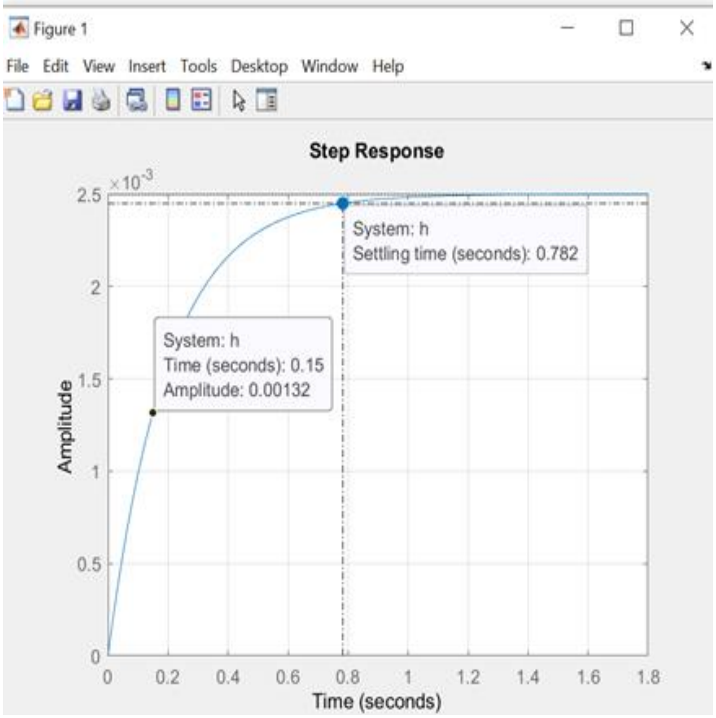


Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
System: h
Settling time (seconds): 0.782
System: h
Time (seconds): 0.15
Amplitude: 0.00132
Amplitude
Time (seconds)

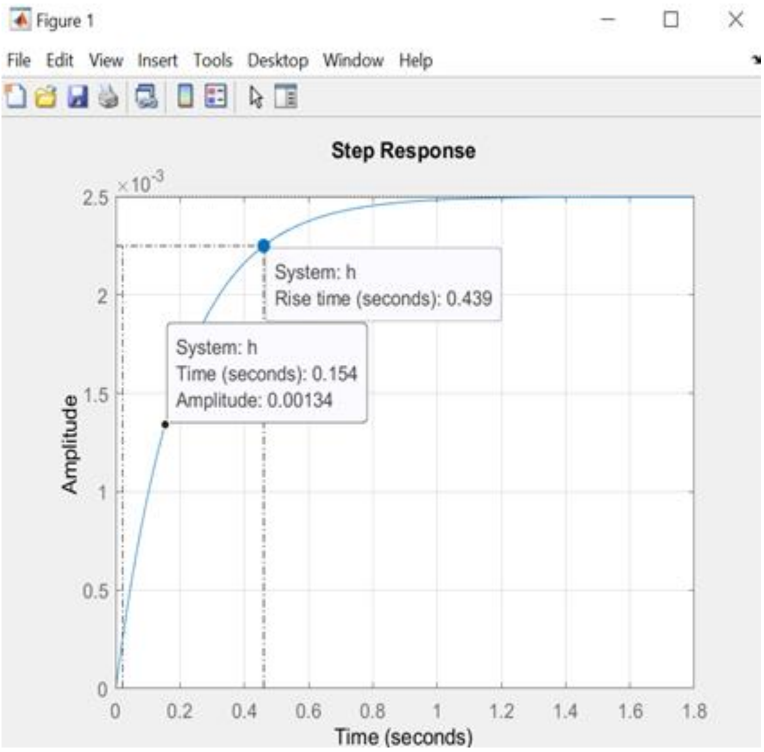


Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
System: h
Rise time (seconds): 0.439
System: h
Time (seconds): 0.154
Amplitude: 0.00134
Amplitude
Time (seconds)

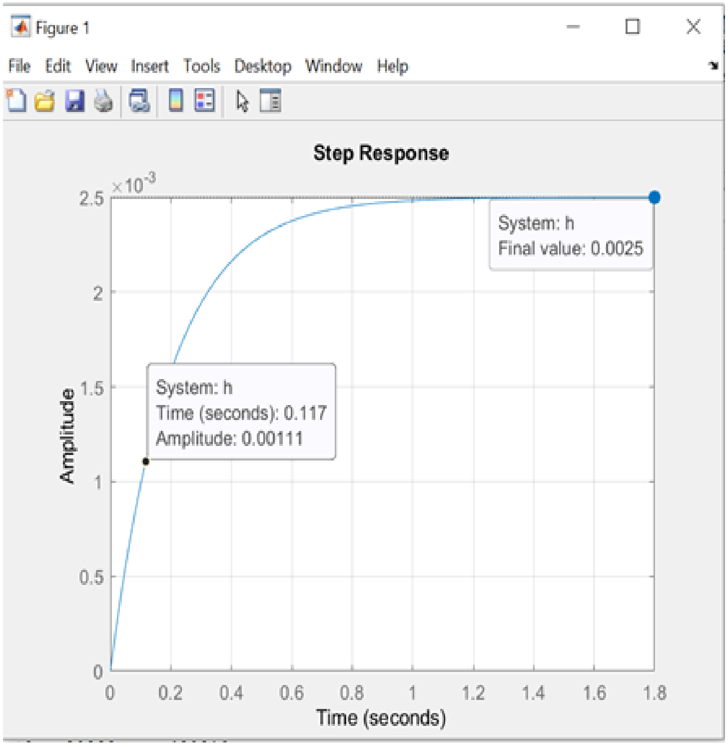


Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
System: h
Final value: 0.0025
System: h
Time (seconds): 0.117
Amplitude: 0.00111
Amplitude
Time (seconds)

Result: We have successfully compared the second order analog control system having CL root loci identical. We have compared the step responses, percentage overshoot, peak time, settling time, peak and steady state error as well as rise time.