

Scilab Manual for  
Control System Design  
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# Experiment: 1

Obtain state model of the second order system cascaded with active lead circuit and show its step response.

Scilab code Solution 1.01 Lab 01

```
1 //  


---

  
2 // Lab. 01: Obtain state model of the second order  
3 // system cascaded with active  
4 // lead circuit. Show its step response.  


---

  
5  
6 //scilab -5.5.0  
7 //Operating System : OS X 10.9.3  
8  
9 //Clean the environment  
10 clc;
```

```

11 clear all;
12 clf;
13
14 // Compensator model
15 R1=1000; R2=5e3; C1=1e-6; C2=1e-5;
16 kc=5;
17 s=poly(0, 's');
18 g=kc*(R1*C1*s+1)/(R2*C2*s+1);
19
20 // System transfer function
21 g1=0.2/(s^2+1.7*s+1);
22
23 // Overall transfer function
24 sys=tf2ss(g*g1);
25
26 // Unit step response
27 t=linspace(0,10,1000);
28 y=csim('step',t,sys);
29 plot(t,y);
30 title('Unit step response of the electrical system',
        'fontsize',4)
31 xlabel('Time t','fontsize',2)
32 ylabel('Response y(t)','fontsize',2)
33 //set(gca(),"grid",[0.3 0.3])

```

---

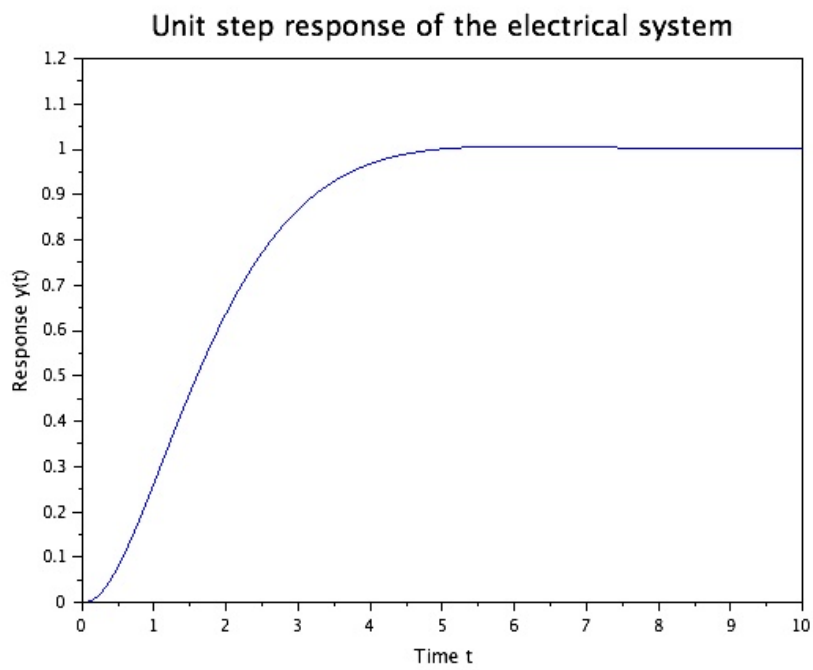


Figure 1.1: Lab 01

## Experiment: 2

Determine eigen values of the state model. Also convert the state model into transfer function.

Scilab code Solution 2.02 Lab02

```
1
2 //


---


3 // Lab. 02: Determine eigen values of the state
  model.
4 // Convert the state model into transfer function.
5 //


---


6
7 //scilab -5.5.0
8 //Operating System : OS X 10.9.3
9
10 //Clean the environment
```

```
11 clc;
12 clear all;
13 // clf;
14
15 // State space representation
16 A=[0 1 0; 0 0 1; -5 -25 -5];
17 B=[0; 25; -120];
18 C=[1 0 0];
19 D=0;
20
21 sys1=sslin('c',A,B,C,D);
22 mprintf('State space representation of the given
    system is')
23 disp(sys1)
24
25 // Eigen values of system matrix
26 eig_val=spec(A)
27 mprintf('Eigen values of the system matrix are')
28 disp(eig_val)
29
30 // Transfer function of the given system
31 g1=ss2tf(sys1)
32 mprintf('Transfer function representation of the
    given system is')
33 disp(g1)
```

---

## Experiment: 3

Transform the given system having distinct eigen values into controllable canonical and diagonal form.

Scilab code Solution 3.03 Lab3

```
1
2 //


---


3 // Lab. 03: Transform the given system having
4 // distinct eigen values into
5 // controllable canonical and diagonal form.


---


6
7 //scilab -5.5.0
8 //Operating System : OS X 10.9.3
9
10 //Clean the environment
```

```

11 clc;
12 clear all;
13 // clf;
14
15 // State space model
16 A=[-3 1; 1 -3];
17 B=[1;2];
18 C=[2 3];
19 D=0;
20
21 sys=sslin('c',A,B,C,D)
22 mprintf('State space representation of the given
    system is ')
23 disp(sys)
24
25
26 // Eigen values of system matrix
27 eig_val=spec(A)
28 mprintf('Eigen values of the system matrix are ')
29 disp(eig_val)
30
31 // Controllable canonical form
32 [Ac, Bc T]=ccan(A,B)
33 T=flipdim(T,2);
34 Ac=T\A*T;
35 Bc=T\B;
36 Cc=C*T;
37 Dc=D;
38 sysc=sslin('c',Ac,Bc,Cc,Dc)
39 mprintf('State space representation of the given
    system in Controllable canonical form is ')
40 disp(sysc)
41
42 // Diagonal form
43 [Ad M]=bdia(A);
44 Bd=M\B;
45 Cd=C*M;
46 Dd=D;

```

```
47 sysd=syslin('c',Ad,Bd,Cd,Dd)
48 mprintf('State space representation of the given
         system in Diagonal form is ')
49 disp(sysd)
```

---

## Experiment: 4

# Obtain the step and impulse response of the state model.

Scilab code Solution 4.04 Lab 04

```
1 //  


---

  
2 // Lab. 04: Obtain the step and impulse response of  
  the state model.  
3 //  


---

  
4  
5 //scilab -5.5.0  
6 //Operating System : OS X 10.9.3  
7  
8 //Clean the environment  
9 clc;  
10 clear all;  
11 clf;  
12  
13 // State space representation  
14 A=[-2 -1; -1 -1];
```

```

15 B=[1;1];
16 C=[0 2];
17 D=0;
18 x0=[0;5]; // Initial condition
19 sys=syslin('c',A,B,C,D)
20
21 // Response to a given input
22 figure(0)
23 t=linspace(0,20,1001);
24 temp=size(t);
25 u=ones(temp(1),temp(2)); // Exogenous signal(step)
26 y=csim(u,t,sys,x0)
27 plot(t,y)
28 title('Unit step response of the system','fontsize',
      ,4)
29 xlabel('Time t','fontsize',2)
30 ylabel('Response y(t)','fontsize',2)
31
32 // Response to a given input
33 figure(1)
34 t=linspace(0,10,1001);
35 y=csim('impuls',t,sys)
36 plot(t,y)
37 title('Impulse response of the system','fontsize',4)
38 xlabel('Time t','fontsize',2)
39 ylabel('Response y(t)','fontsize',2)

```

---

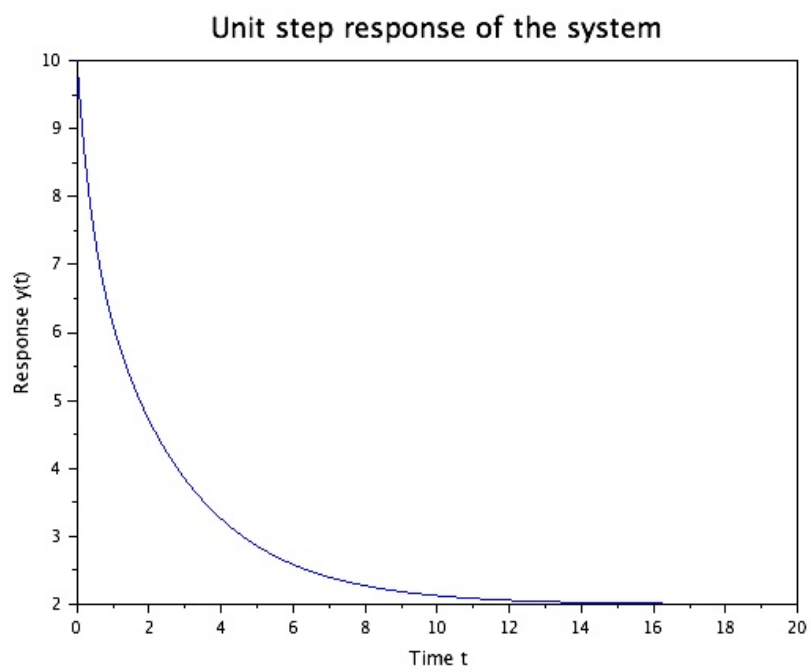


Figure 4.1: Lab 04

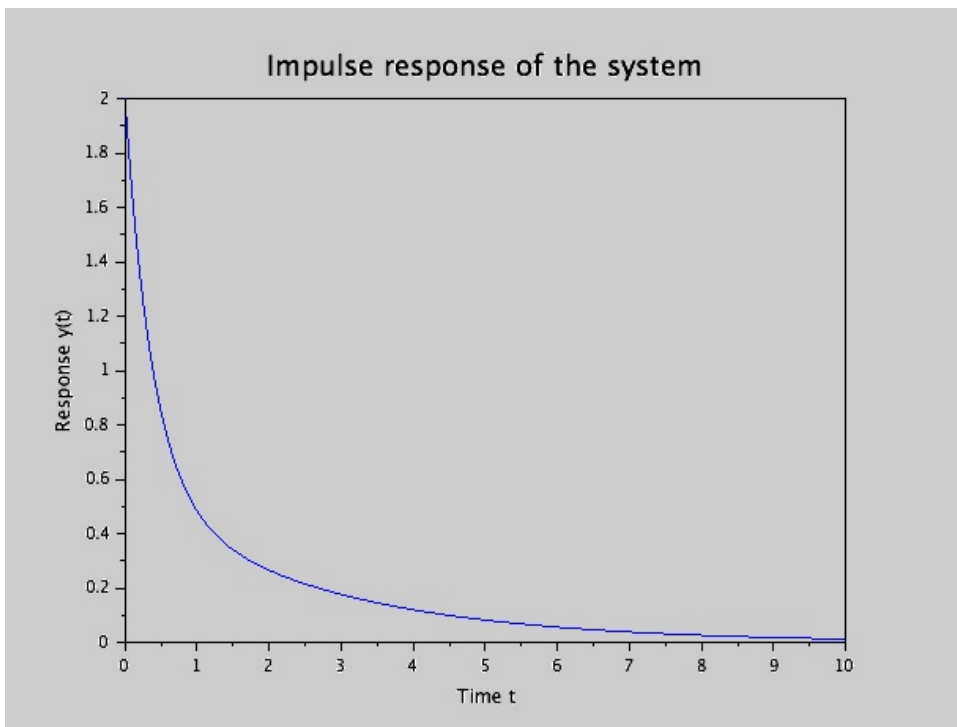


Figure 4.2: Lab 04

# Experiment: 5

Check for the controllability and observability of a given system.

Scilab code Solution 5.05 Lab05

```
1
2 //


---


3 // Lab. 05: Check for the controllability and
  observability of a given system.
4 //


---


5
6 //scilab -5.5.0
7 //Operating System : OS X 10.9.3
8
9 //Clean the environment
10 clc;
11 clear all;
12 //clf;
```

```

13
14 // State space representation
15 A=[-5 1 0; 0 -2 1; 0 0 -1];
16 B=[6 0 1]';
17 C=[1 0 0];
18 D=0;
19 sys=syslin('c',A,B,C,D)
20
21 // Controllability test
22 n=cont_mat(sys)
23 mprintf('Controllability matrix is ')
24 disp(n)
25
26 if rank(n)==3 then
27     disp('System is controllable')
28 else
29     disp('System is uncontrollable')
30 end
31
32 // Observability test
33 m=obsv_mat(sys)
34 mprintf('Observability matrix is ')
35 disp(m)
36
37 if rank(m)==3 then
38     disp('System is observable')
39 else
40     disp('System is unobservable')
41 end

```

---

# Experiment: 6

## Obtain state feedback gain matrix for the given system.

Scilab code Solution 6.06 Lab 06

```
1 //  


---

  
2 // Lab. 06: Obtain state feedback gain matrix for  
   the given system.  
3 //  


---

  
4  
5 //scilab -5.5.0  
6 //Operating System : OS X 10.9.3  
7  
8 //Clean the environment  
9 clc;  
10 clear all;  
11 clf;  
12  
13 // State space representation  
14 A=[0 1 0; 0 0 1; -1 -5 -6];
```

```
15 B=[0 0 1]';
16 C=[0 0 1];
17 D=0;
18
19 // Desired poles
20 Pd=[-1+2*i -1-2*i -10];
21
22 // State feedback gain matrix
23 K=ppol(A,B,Pd)
24
25 //Closed loop system
26 sys=syslin('c',A-B*K,B,C,D)
27
28 //Response of closed loop system
29 t=linspace(0,20,1001);
30 y=csim('step',t,sys)
31 plot(t,y)
32 title('Response of the closed loop system','fontsize
    ',4)
33 xlabel('Time t','fontsize',2)
34 ylabel('Response y(t)','fontsize',2)
```

---

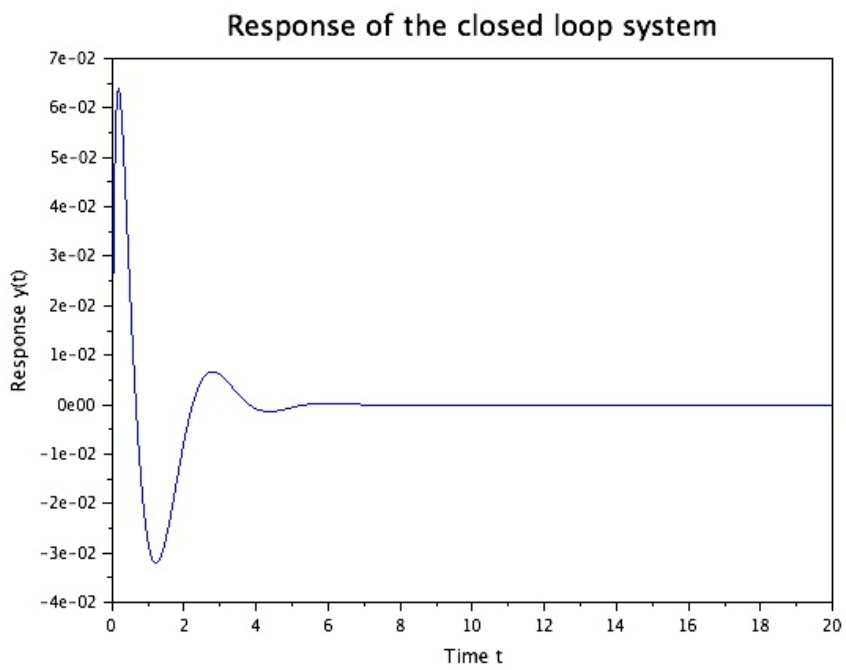


Figure 6.1: Lab 06

# Experiment: 7

## Design a full state observer for the system.

Scilab code Solution 7.07 Lab 07

```
1 //  
2 // Lab. 07: Design a full state observer for the  
3 // system.  
4  
5  
6 //scilab -5.5.0  
7 //Operating System : OS X 10.9.3  
8  
9 //Clean the environment  
10 clc;  
11 clear all;  
12 clf;  
13  
14 //State space model
```

```

15 A=[1 -1 2; 2 -1 3; -1 -2 4];
16 B=[1 1 0]';
17 C=[1 1 0];
18 D=0;
19
20 // Stabilizer design
21 // Desired poles
22 Pd=[-7 -5 -10];
23
24 // State feedback gain matrix
25 K=ppol(A,B,Pd)
26
27 // Computation of observer gain
28 obsr_pol=[-20+0.5*%i -20-0.5*%i -60];
29 L=ppol(A',C',obsr_pol)'
30
31 // Augmented system
32 temp=size(A);
33 Aa=[A-B*K      B*K; zeros(temp(1),temp(2))      A-L*C
    ];
34 temp=size(Aa);
35 Ba=zeros(temp(1),1);
36 Ca=eye(6,6);
37 sys=syslin('c',Aa,Ba,Ca,zeros(6,1))
38
39 // Observer error
40 figure(0)
41 t=linspace(0,0.6,1001);
42 x0=[0 0 0 1 1 1]';
43 temp=size(t);
44 u=zeros(temp(1),temp(2)); // Exogenous signal(step)
45 y=csim(u,t,sys,x0)
46 plot(t,y(4:6,:))
47 title('Observer error','fontsize',4)
48 xlabel('$t$', 'fontsize',2)
49 ylabel('$x(t)-\hat{x}(t)$', 'fontsize',2)
50 legend('$x_1$', '$x_2$', '$x_3$')

```

---

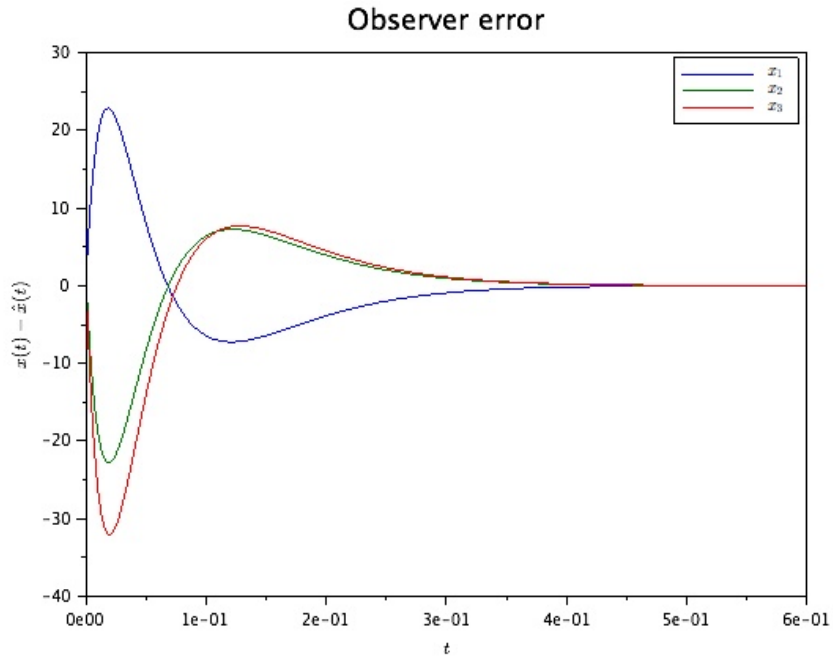


Figure 7.1: Lab 07

## Experiment: 8

Determine steady state error of the given system.

Scilab code Solution 8.08 Lab 08

```
1 //  
2 // Lab. 08: Determine steady state error of the  
   given system.  
3 //  
4  
5 //scilab -5.5.0  
6 //Operating System : OS X 10.9.3  
7  
8 //Clean the environment  
9 clc;  
10 clear all;  
11 clf;  
12  
13 //State space model  
14 a=[0 1;-7 -9];
```

```
15 b=[0 1]';
16 c=[4 1];
17 d=0;
18 sys=syslin('c',a,b,c,d)
19
20 //Error in response of the system
21 t=linspace(0,20,1001);
22 y=csim('step',t,sys)
23 plot(t,1-y)
24 title('Error in response','fontsize',4)
25 xlabel('Time t','fontsize',2)
26 ylabel('Response y(t)','fontsize',2)
27
28 // Steady state error computation
29 ess=1+c*inv(a)*b
```

---

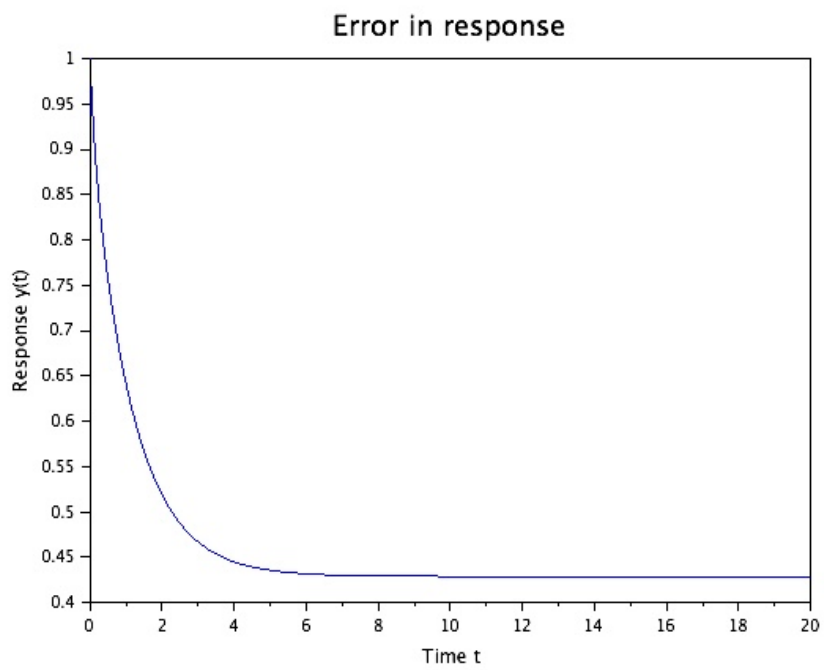


Figure 8.1: Lab 08

# Experiment: 9

## Compensation of system using lead compensator designed via root locus technique.

Scilab code Solution 9.09 Lab 09

```
1 //  
-----  
2 // Lab. 09: Compensation of system using lead  
   compensator designed via root  
3 //locus technique.  
4 //  
-----  
5  
6 //scilab -5.5.0  
7 //Operating System : OS X 10.9.3  
8  
9 //Clean the environment  
10 clc;  
11 clear all;  
12 clf;
```

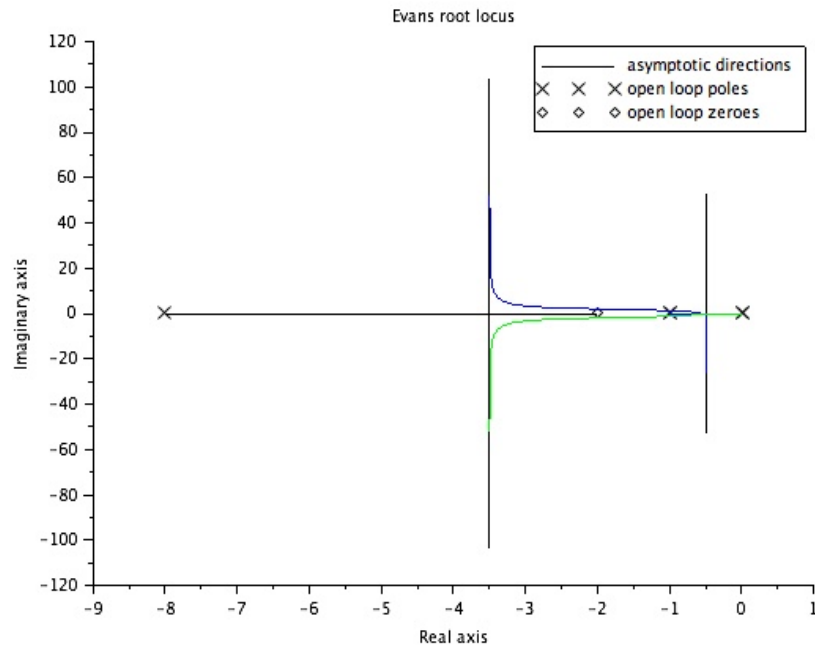


Figure 9.1: Lab 09

```

13
14 //System transfer function and its root locus
15 s=poly(0, 's ');
16 g=1/(s*(s+1));
17 evans(g)
18
19 //Designed compensator
20 gc=(s+2)/(s+8);
21
22 //Root locus of compensated system
23 evans(g*gc)

```

---

## Experiment: 10

Design a lead compensator for the given system using bode plot.

Scilab code Solution 10.10 Lab 10

```
1 //  
-----  
2 // Lab.10: Design a lead compensator for the given  
   system using bode plot.  
3 // System is  $g=K/s(s+2)$ . Design specifications:  $K_v$   
    $=20 \text{ sec}^{-1}$  and  $PM=45 \text{ deg}$ .  
4 //  
-----  
5  
6 //scilab -5.5.0  
7 //Operating System : OS X 10.9.3  
8  
9 //Clean the environment  
10 clc;  
11 clear all;
```

```

12 clf;
13
14 //Desired specifications
15 Phi_s=45;
16 K=40;
17
18 //Uncompensated system
19 s=poly(0, 's');
20 g=syslin('c', 40/(s*(s+2)));
21
22 //Bode plot of the uncompensated system
23 bode(g, 0.001, 1000)
24 title('uncompensated system')
25 gm=g_margin(g)
26 pm=p_margin(g)
27 eps1=10;
28 Phi_m=(Phi_s-pm+eps1)*%pi/180
29 alpha=(1-sin(Phi_m))/(1+sin(Phi_m))
30 gain_phi_m=-10*log10(1/alpha)
31
32 // Observed frequency at gain_phi_m
33 wc2=9.3
34
35 // Corner frequency
36 w1=wc2*sqrt(alpha)
37 w2=wc2/sqrt(alpha)
38 Gc=(s+w1)/(s+w2)
39
40 //The bode plot of compensated system
41 figure(1);
42 bode(Gc*g, 0.001, 1000),
43 title('Compensated system')

```

---

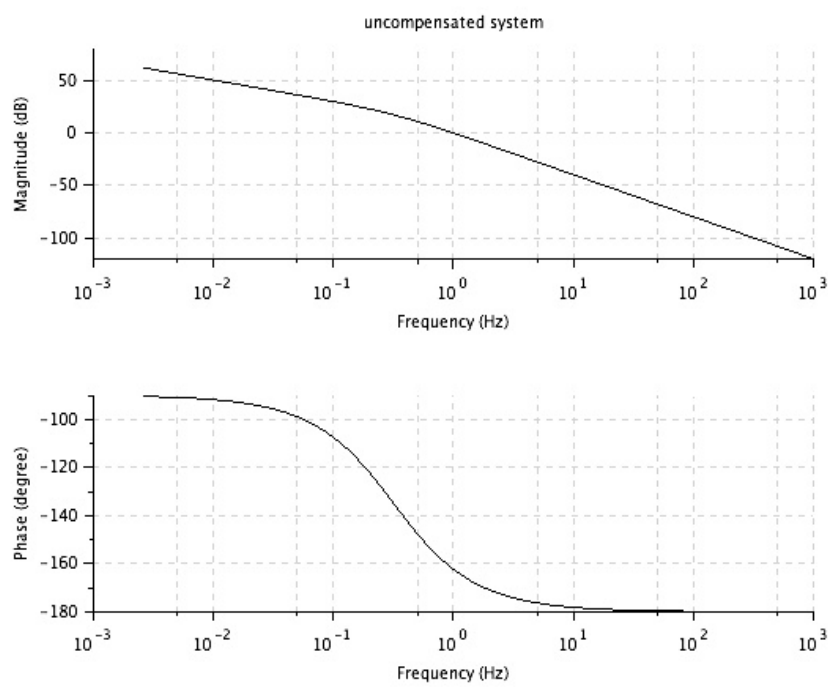


Figure 10.1: Lab 10

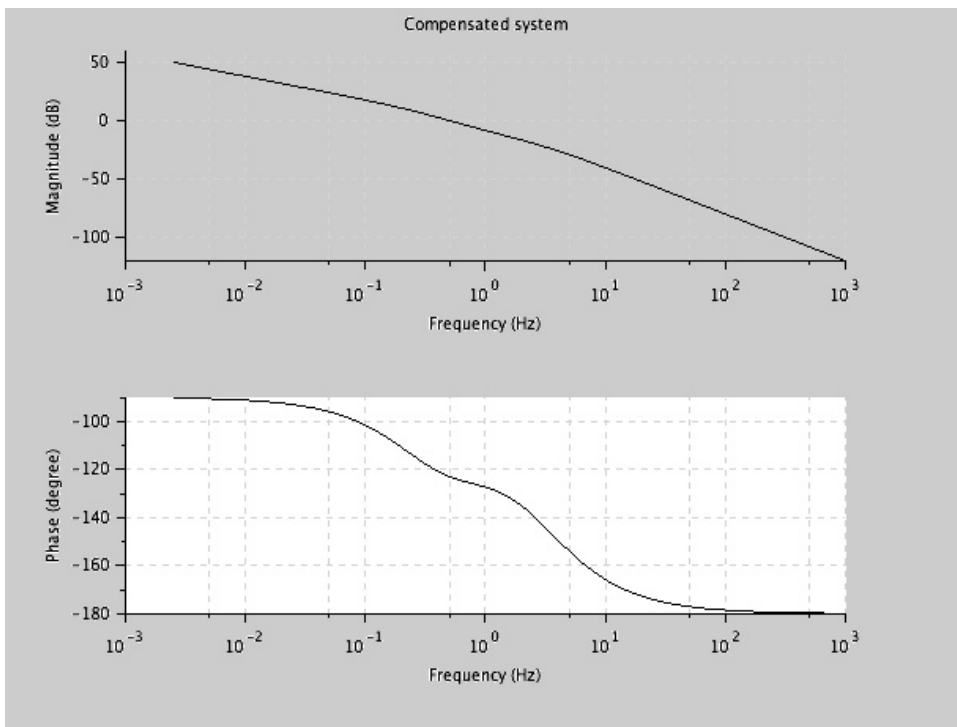


Figure 10.2: Lab 10