

Scilab Manual for
Lab Practices II (M.E. Instrumentation &
Control)
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Contents

List of Scilab Solutions	3
1 To study various built in functions for finding determinant, inverse, eigen values and eigen vectors.	5
2 Obtain 1, 2, infinity norm and reduced row echeolon form of a given matrix.	8
3 To perform LU Decomposition on a given matrix.	11
4 To perform QR Decomposition on a given matrix.	13
5 To perform Single Value Decomposition on a given matrix.	15
6 To study Gram Schmidt Orthogonalization.	17
7 To compare closed loop response of a given system using P, PI and PID controller.	19
8 Design the controller for a given system using Model Reference Adaptive Control approach.	25
9 Design the controller for a given system using Lyapunov design approach.	27
10 Design the controller for a given system using variable structure control scheme.	33
11 To identify the parameters of a discrete time system using non recursive LS method.	38

List of Experiments

Solution 1.1	Lab01	.....	5
Solution 2.1	Lab02	.....	8
Solution 3.1	Lab03	.....	11
Solution 4.1	Lab04	.....	13
Solution 5.1	Lab05	.....	15
Solution 6.1	Lab06	.....	17
Solution 7.1	Lab07	.....	19
Solution 9.1	Lab09	.....	27
Solution 10.1	Lab10	.....	33
Solution 11.1	Lab11	.....	38
AP 1	fig settings	.....	40

List of Figures

7.1	Lab07	.....	23
7.2	Lab07	.....	24
8.1	Lab08	.....	26
9.1	Lab09	.....	31
9.2	Lab09	.....	32
10.1	Lab10	.....	36
10.2	Lab10	.....	37

Experiment: 1

To study various built in functions for finding determinant, inverse, eigen values and eigen vectors.

Scilab code Solution 1.1 Lab01

```
1 // Lab01: To study various built in functions for
  finding determinant ,
2 // inverse , eigen values and eigen vectors .
3
4 //           scilab – 5.5.2
5 //           Operating System : Windows 7, 32–bit
6
7 //


---


8
9 //Clean the environment
10 close ;
11 clear ;
12 clc ;
```

```

13
14 //


---


15
16 // Ex1.
17 //Declaration of given matrix
18 A=[3 2 0 ; 2 -1 7; 5 4 9];
19 disp(A,"Matirx A=","Ex1.:")
20
21 //Built-in fuctions to compute the determinant and
    inverse of a given matrix.
22 detA=det(A);
23 disp(detA, 'Determinant of A is=')
24 invA=inv(A);
25 disp(invA, 'Inverse of A is=')
26
27 //Built-in fuction to find eigen values of a given
    matrix.
28 eig_val=spec(A)
29 disp(eig_val, 'Eigen values of matrix A are=')
30
31 [eig_vec eig_val]=spec(A)
32 disp(eig_vec, 'Eigen vector form of matrix A is')
33 disp(eig_val, 'Diagonal form of eigen values of
    matrix A')
34
35 //


---


36
37 // Ex.2
38 //Declaration of given matrix
39 B=[-4 2 5; 7 -1 6; 2 3 7];
40 disp(B,"Matirx B=","Ex2.:")
41
42 //Built-in fuction to compute the determinant and
    inverse of a given matrix.

```

```
43 detB=det(B);
44 disp(detB, 'Determinant of B is=')
45 invB=inv(B);
46 disp(invB, 'Inverse of B is=')
47
48 //Built-in fuction to find eigen values of a given
    matrix.
49 eig_val=spec(B)
50 disp(eig_val, 'Eigen values of matrix B are=')
51
52 [eig_vec eig_val]=spec(B)
53 disp(eig_vec, 'Eigen vector form of matrix B is')
54 disp(eig_val, 'Diagonal form of eigen values of
    matrix B')
55
56 //
```

Experiment: 2

Obtain 1, 2, infinity norm and reduced row echeolon form of a given matrix.

Scilab code Solution 2.1 Lab02

```
1 // Lab02: Obtain 1, 2, infinity norm and reduced row
  echelon form
2 // of a given matrix.
3
4 //           scilab – 5.5.2
5 //           Operating System : Windows 7, 32-bit
6 //


---


7
8 //Clean the environment
9 close;
10 clear;
11 clc;
12
13 //
```

```

14
15 // Ex1.
16 //Declaration for given matrix
17 A=[0 1 0; 3 0 2; -12 7 -6];
18 disp(A,"Matirx A=","Ex1.:")
19
20 //1-norm of matrix
21 Nrm_1=norm(A,1);
22 disp(Nrm_1,'1-norm of a given matrix is:')
23
24 //2-norm of matrix
25 Nrm_2=norm(A,2);
26 disp(Nrm_2,'2-norm of a given matrix is:')
27
28 //inf. norm of matrix
29 Nrm_inf=norm(A,'inf');
30 disp(Nrm_inf,'Infinity norm of a given matrix is')
31
32 // Reduced row Echeolon Form of a matrix
33 Re=rref(A);
34 disp(Re,'Reduced row Echeolon Form of A is =')
35
36 //

```

```

37
38 // Ex2.
39 //Declaration for given matrix
40 B=[2 3 4 5; -7 4 3 -2; 0 0 1 3; 1 0 -5 -4];
41 disp(B,"Matirx B=","Ex2.:")
42
43 //1-norm of matrix
44 Nrm_1=norm(B,1);
45 disp(Nrm_1,'Norm 1 of a given matrix is')
46
47 //2-norm of matrix
48 Nrm_2=norm(B,2);

```

```
49 disp(Nrm_2,, 'Norm 2 of a given matrix is ')
50
51 //inf. norm of matrix
52 Nrm_inf=norm(B, 'inf');
53 disp(Nrm_inf,, 'Infinity norm of a given matrix is ')
54
55 // Reduced row Echeolon Form of a matrix
56 Re=rref(B);
57 disp(Re, 'Reduced row Echeolon Form of B is =')
58
59 //
```

Experiment: 3

To perform LU Decomposition on a given matrix.

Scilab code Solution 3.1 Lab03

```
1 // Lab03: To perform LU Decomposition on a given
  matrix.
2
3 //           scilab - 5.5.2
4 //           Operating System : Windows 7, 32-bit
5 //


---


6 //Clean the environment
7
8 close;
9 clear;
10 clc;
11
12 //


---


13
14 // Ex1.
```

```

15 //Declaration for given matrix
16 A=[1 2 3; 2 3 4; 3 4 6];
17 disp(A,"Matirx A=","Ex1.:")
18
19 //LU decomposition
20 [La Ua]=lu(A);
21 disp(La,'Lower tringular matrix La=')
22 disp(Ua,'Upper tringular matrix Ua=')
23
24 //

```

```

25
26 // Ex2.
27 //Declaration for given matrix
28 B=[3 5 7 7; 98 7 42 122; 100 25 90 160; 234 67 91
    97];
29 disp(B,"Matirx B=","Ex2.:")
30
31 //LU decomposition
32 [Lb Ub]=lu(B);
33 disp(Lb,'Lower tringular matrix Lb=')
34 disp(Ub,'Upper tringular matrix Ub=')
35
36 //

```

Experiment: 4

To perform QR Decomposition on a given matrix.

Scilab code Solution 4.1 Lab04

```
1 // Lab04: To perform QR Decomposition on a given
   matrix.
2
3 //           scilab – 5.5.2
4 //           Operating System : Windows 7, 32–bit
5 //


---


6
7 //Clean the environment
8 close;
9 clear;
10 clc;
11 //


---


12
13 //Ex1.
14 // Declaration for given matrix
```

```
15 A=[3 6; -2 5];
16 disp(A,"Matirx A=", "Ex1.:")
17
18 //QR decomposition
19 [Qa Ra]=qr(A);
20 disp(Qa,'Orthogonal matrix Qa=')
21 disp(Ra,'Upper tringular matrix Ra=')
22
23 //
```

```
24
25 //Ex2.
26 // Declaration for given matrix
27 B=[1 2 3 4; 1 3 3 5; 1 2 3 7];
28 disp(B,"Matirx B=", "Ex2.:")
29
30 //QR decomposition
31 [Qb Rb]=qr(B);
32 disp(Qb,'Orthogonal matrix Qb=')
33 disp(Rb,'Upper tringular matrix Rb=')
34
35 //
```

Experiment: 5

To perform Single Value Decomposition on a given matrix.

Scilab code Solution 5.1 Lab05

```
1 // Lab05: To perform Singular Value Decomposition on
  a given matrix.
2
3 //          scilab - 5.5.2
4 //          Operating System : Windows 7, 32-bit
5 //


---


6
7 //Clean the environment
8 close;
9 clear;
10 clc;
11
12 //
```

```
13
14 //Ex1.
15 // Declaration for given matrix
16 A=[3 6; -2 5];
17 disp(A,"Matirx A=", "Ex1.:")
18
19 //Singular value decomposition
20 [Ua Sa Va]=svd(A);
21 disp(Ua, 'Orthogonal matrix Ua=')
22 disp(Va, 'Orthogonal matrix Va=')
23 disp(Sa, 'Singular value matrix Sa=')
24
25 //
```

```
26
27 //Ex2.
28 // Declaration of another matrix
29 B=[1 2 3 4; 1 3 3 5; 1 2 3 7];
30 disp(B,"Matirx B=", "Ex2.:")
31
32 //Singular value decomposition
33 [Ub Sb Vb]=svd(B);
34 disp(Ub, 'Orthogonal matrix Ub=')
35 disp(Vb, 'Orthogonal matrix Vb=')
36 disp(Sb, 'Singular value matrix Sb=')
37
38 //
```

Experiment: 6

To study Gram Schmidt Orthogonalization.

Scilab code Solution 6.1 Lab06

```
1 // Lab06: To study Gram Schmidt Orthogonalization.
2
3 //           scilab - 5.5.2
4 //           Operating System : Windows 7, 32-bit
5
6 //


---


7
8 //Clean the environment
9 close;
10 clear;
11 clc;
12
13 //


---


14
15 // Declaration of given matrix
```

```
16 a=[1 2 1; 0 2 1; 2 3 0; 1 1 1];
17 [m n]=size(a);
18 q=zeros(m,n);
19 r=zeros(n,n);
20
21 for j=1:n
22     v=a(:,j)
23     for i=1:j-1
24         r(i,j)=q(:,i)*a(:,j)
25         v=v-r(i,j)*q(:,i)
26     end
27     r(j,j)=norm(v)
28     q(:,j)=v/r(j,j)
29 end
30
31 disp(v, 'v=')
32 disp(r, 'r=')
33 disp(q, 'q=')
34
35 //
```

Experiment: 7

To compare closed loop response of a given system using P, PI and PID controller.

Scilab code Solution 7.1 Lab07

```
1 // Lab07: To compare closed loop response of a given
  system using
2 // P, PI and PID controller.
3
4 //           scilab – 5.5.2
5 //           Operating System : Windows 7, 32-bit
6 //


---


7
8 //Clean the environment
9 xdel(winsid()); //close all graphics Windows clear ;
10 clear;
11 clc;
12
13 //
```

```

14  ///// Transfer function
15  s=%s; // or
16  s=poly(0, 's');
17  sys=syslin('c', (1)/(s^2+10*s+20))
18
19  //step response
20  t=0:0.05:2.5;
21  v=csim('step', t, sys);
22  plot2d(t, v, 2)
23
24  //Title, labels and grid to the figure
25  //figure handel settings
26  f=get("current_figure"); //Current figure handle
27  f.background=8; //make the figure window background
    white
28  l=f.children(1);
29  l.background=8 ;//make the text background white
30  id=color('grey');
31  xgrid(id);
32  //custom script for setting figure properties
33  title('Response of given system to a step', 'fontsize
    ', 3)
34  xlabel('Time t (sec.)', 'fontsize', 2)
35  ylabel('Amplitude', 'fontsize', 2)
36
37  //

```

```

38
39  // Response of the system with proportional
    controller
40  Kp=10;
41  sys_P=syslin('c', (Kp)/(s^2+10*s+20+Kp));
42
43  //step response
44  figure;
45  t=0:0.05:2.5;

```

```

46 v=csim('step',t,sys_P);
47 plot2d(t,v,2)
48
49 //Title, labels and grid to the figure
50 //figure handel settings
51 f=get("current_figure"); //Current figure handle
52 f.background=8; //make the figure window background
    white
53 l=f.children(1);
54 l.background=8 ;//make the text background white
55 id=color('grey');
56 xgrid(id);
57 title('Response of given system with Proportional
    controller','fontsize',3)
58 xlabel('Time t (sec.)','fontsize',2)
59 ylabel('Amplitude','fontsize',2)
60 xstring(1,0.31,"Steady state error=(1-0.335)
    *100=66.5%")
61
62 //

```

```

63 // Response of the system with proportional plus
    integral (PI) controller
64 Kp=25;
65 Ki=60;
66 sys_PI=syslin('c',(Kp*s+Ki)/(s^3+10*s^2+(20+Kp)*s+Ki
    ));
67
68 //step response
69 figure;
70 t=0:0.05:2.5;
71 v=csim('step',t,sys_PI);
72 plot2d(t,v,2)
73
74 //Title, labels and grid to the figure
75 //figure handel settings
76 f=get("current_figure"); //Current figure handle

```

```

77 f.background=8; //make the figure window background
    white
78 l=f.children(1);
79 l.background=8 ;//make the text background white
80 id=color('grey');
81 xgrid(id);
82 title('Response of given system with Proportional
    plus integral...
83 controller ', 'fontsize', 3)
84 xlabel('Time t (sec.)', 'fontsize', 2)
85 ylabel('Amplitude', 'fontsize', 2)
86 xstring(1, 0.93, "Steady state error=(1-1)*100=0%")
87
88 //

```

```

89 // Response of the system with proportional plus
    integral plus
90 //derivative (PID) controller
91 Kp=25;
92 Ki=60;
93 Kd=1;
94 sys_PID=syslin('c', (Kd*s^2+Kp*s+Ki)/(s^3+(10+Kd)*s
    ^2+(20+Kp)*s+Ki));
95
96 //step response
97 figure;
98 t=0:0.05:2.5;
99 v=csim('step', t, sys_PID);
100 plot2d(t, v, 2)
101
102 //Title, labels and grid to the figure
103 //figure handel settings
104 f=get("current_figure"); //Current figure handle
105 f.background=8; //make the figure window background
    white
106 l=f.children(1);
107 l.background=8 ;//make the text background white

```

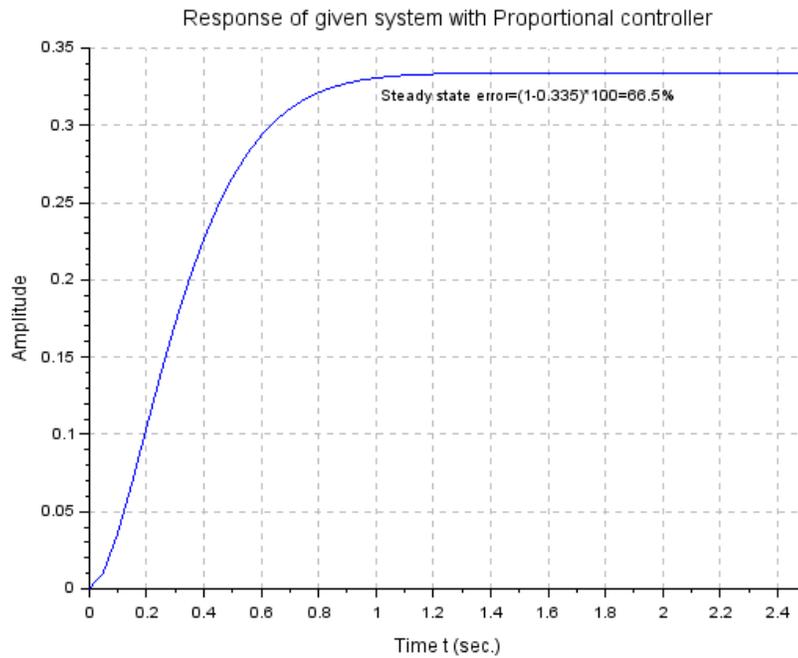


Figure 7.1: Lab07

```

108 id=color('grey');
109 xgrid(id);
110
111 title('Response of given system with Proportional
        plus integral...
        plus derivative controller','fontsize',3)
112 xlabel('Time t (sec.)','fontsize',2)
113 ylabel('Amplitude','fontsize',2)
114 xstring(1,0.93,"Settling time improved to 1.6 sec.")
115 //

```

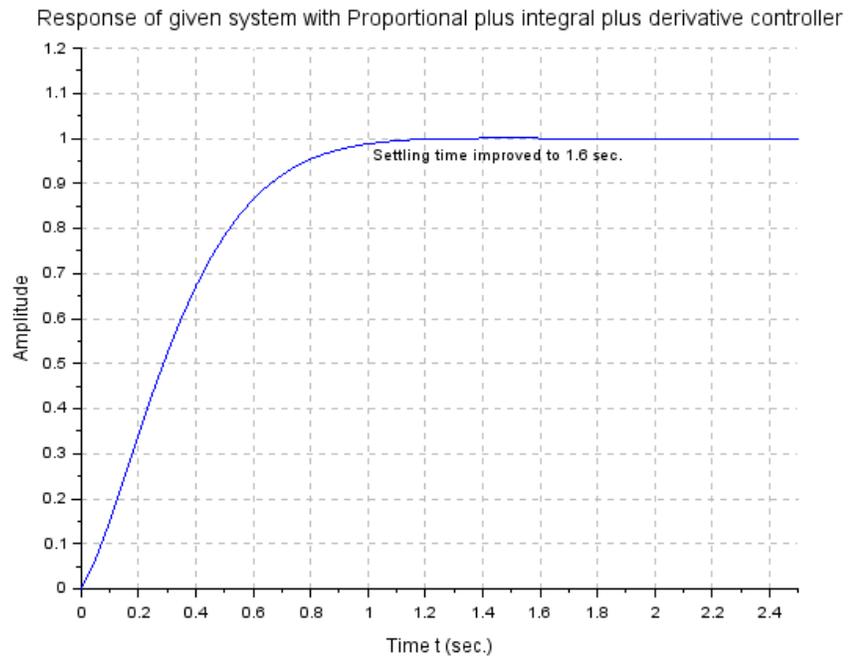


Figure 7.2: Lab07

Experiment: 8

Design the controller for a given system using Model Reference Adaptive Control approach.

This code can be downloaded from the website www.scilab.in

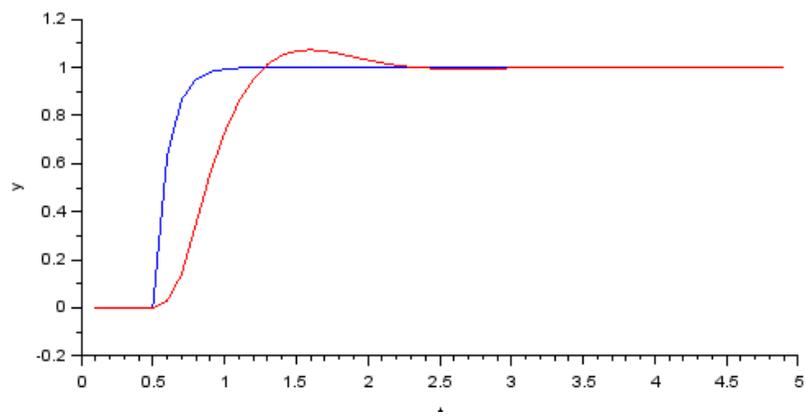


Figure 8.1: Lab08

Experiment: 9

Design the controller for a given system using Lyapunov design approach.

Scilab code Solution 9.1 Lab09

```
1 // Lab09: Design the controller for a given system
  using
2 // Lyapunov design approach.
3
4
5 //           scilab – 5.5.2
6 //           Operating System : Windows 7, 32-bit
7 //


---


8
9 //Clean the environment
10 xdel(winsid()); //close all graphics Windows clear ;
11 clear;
12 clc;
13
```

```

14 //


---


15 //system dicription
16 A=[0 1;0.5 -0.5]
17 B=[0 1]';
18 C=[1 0];
19 D=0;
20
21 //system model
22
23 sys=syslin ('c',A,B,C,D);
24 //


---


25
26 //controller design
27 //here alpha1=1.5, alpha2=2;
28 alpha1=1.5;
29 alpha2=2;
30 b2=2;
31 //by design
32 k1=1+alpha1;
33 k2=abs(alpha2)+3 // condition is k2>|alpha2|
34 K=inv(b2)*[k1 k2];
35
36 //


---


37 //closed loop system model
38
39 Ac=A-B*K
40 sysc=syslin ('c',A-B*K,B,C,D);
41
42 //


---


43

```

```

44 //Simulation
45
46 x0=[1 0.5]'; //initial Condition
47 t=0:0.1:5; //simulation time
48 u=zeros(1,length(t)); //no input
49 [y x]=csim(u,t,sys,x0); //open loop system
50
51 tc=0:0.1:20; //simulation time
52 uc=zeros(1,length(tc)); //no input
53 [yc xc]=csim(uc,tc,sysc,x0); //closed loop system
54
55 //

```

```

56
57 //Open and closed loop state responses
58 plot(t',x'); //open loop
59
60 //Title , labels and grid to the figure
61
62 //figure handel settings
63 f=get("current_figure"); //Current figure handle
64 f.background=8; //make the figure window background
    white
65 l=f.children(1);
66 l.background=8 ;//make the text background white
67 id=color('grey');
68 xgrid(id);
69
70 title('Open loop state responses','fontsize',3)
71 xlabel('$t$ (sec.)$', 'fontsize',3)
72 ylabel (["$x_1(t)$", "$x_2(t)$"], 'fontsize',3)
73 h=legend("$x_1(t)$", "$x_2(t)$",4);
74 h.font_size=3;
75 h.fill_mode='off'
76
77 figure,
78 plot(tc',xc'); //closed loop

```

```

79 //Title , labels and grid to the figure
80 exec .\fig_settings.sci; // custom script for
    setting figure properties
81 title('Closed loop state responses','fontsize',3)
82 xlabel('$t$ (sec.)$', 'fontsize',3)
83 ylabel (["$x_1(t)$", "$x_2(t)$"] , 'fontsize',3)
84 h=legend("$x_1(t)$", "$x_2(t)$");
85 h.font_size=3;
86 h.fill_mode='off'
87
88 //

```

```

89
90 //Open and closed loop state trajectories
91 figure ,
92 plot(x(1,:),x(2,:), 'r—');
93 plot(xc(1,:),xc(2,:));
94 zoom_rect([-1 -1 2 3])
95
96 //Title , labels and grid to the figure
97
98 //figure handel settings
99 f=get("current_figure"); //Current figure handle
100 f.background=8; //make the figure window background
    white
101 l=f.children(1);
102 l.background=8 ;//make the text background white
103 id=color('grey');
104 xgrid(id);
105 title('Open and Closed loop state trajectories', '
    fontsize',3)
106 xlabel("$x_1(t)$", 'fontsize',3);
107 ylabel (" $x_2(t)$", 'fontsize',3);
108 f=gca();
109 f.x_location = "origin"
110 f.y_location = "origin"
111 h=legend("Oen loop", "Closed loop",4);

```

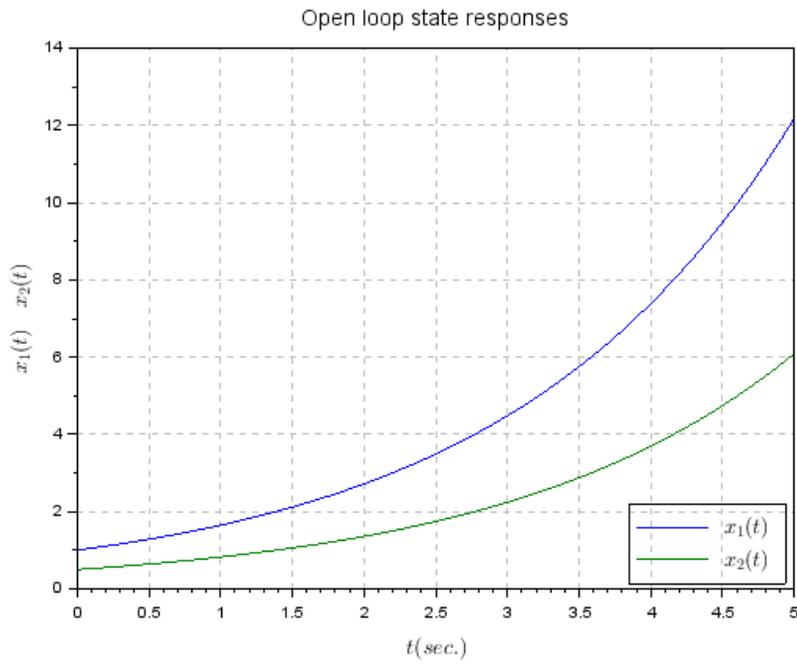


Figure 9.1: Lab09

```

112 h.font_size=2;
113 h.fill_mode='off'
114
115 //

```

check Appendix [AP 1](#) for dependency:

fig_settings.sci

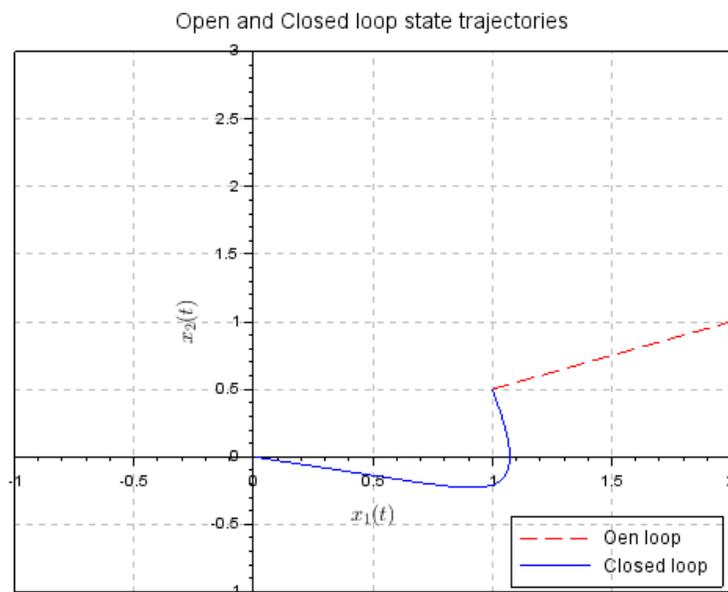


Figure 9.2: Lab09

Experiment: 10

Design the controller for a given system using variable structure control scheme.

Scilab code Solution 10.1 Lab10

```
1 // Lab10: Design the controller for a given system
  using
2 // variable structure control scheme.
3
4
5 //           scilab – 5.5.1
6 //           Operating System : Windows 7, 32–bit
7 //


---


8
9 //Clean the environment
10 xdel(winsid()); //close all graphics Windows clear ;
11 clear;
12 clc ;
13
14 //
```

```

15
16 //system dicription
17 xi=0.7;
18 alpha=1;
19 c=-xi/2+sqrt(xi^2/4+alpha)
20
21 //

22
23 //Simulation
24 importXcosDiagram("Lab10.xcos")
25 xcos_simulate(scs_m,4);
26 scs_m.props.context
27
28 //

29
30 //State responses
31 figure ,
32 plot(x1.time,x1.values,2);
33 plot(x2.time,x2.values,'r—');
34 //Title, labels and grid to the figure
35 exec .\fig_settings.sci; // custom script for
    setting figure properties
36 title('State responses of the system with VSC',
    fontsize',3)
37 xlabel("$t$ sec.$", 'fontsize',3);
38 ylabel("$x_1(t)$,\ $x_2(t)$", 'fontsize',3);
39 h=legend("Oen loop","Closed loop",1);
40 h.font_size=2;
41 h.fill_mode='off'
42
43 //

```

```
44
45 //State trajectory
46 figure ,
47 plot(x1.values,x2.values);
48 //Title, labels and grid to the figure
49 exec .\fig_settings.sci; // custom script for
    setting figure properties
50 title('State trajectory of the system with VSC',
    fontsize',3)
51 xlabel("$x_1$", 'fontsize',3);
52 ylabel("$x_2$", 'fontsize',3);
53 f=gca();
54 f.x_location = "origin"
55 f.y_location = "origin"
56
57 //
```

This code can be downloaded from the website www.scilab.in

check Appendix [AP 1](#) for dependency:

`fig_settings.sci`

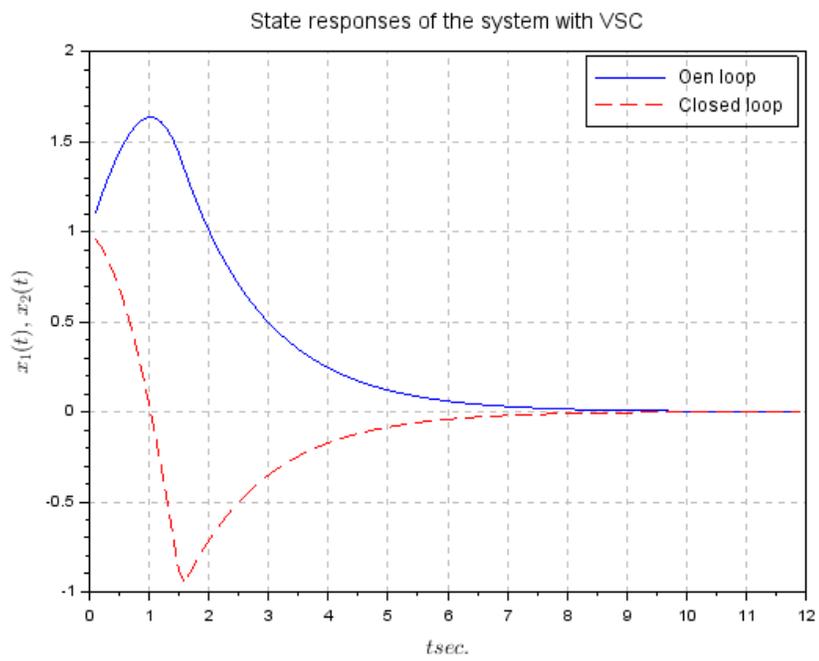


Figure 10.1: Lab10

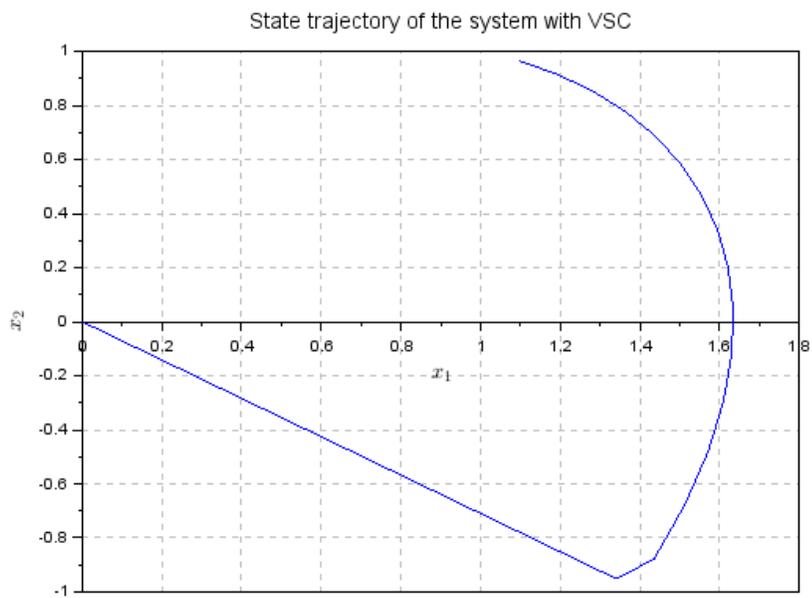


Figure 10.2: Lab10

Experiment: 11

To identify the parameters of a discrete time system using non recursive LS method.

Scilab code Solution 11.1 Lab11

```
1 // Lab.11: Identify the parameters of a discrete
  time system using
2 // non-recursive LS method.
3
4 xdel(winsid()); //close all graphics Windows clear ;
5 clear;
6 clc ;
7 //


---


8 //system model
9 s=poly(0, 's');
10 num=s+1;
11 den=s^2+1.6*s+1;
12 sys=syslin('c', num/den);
13 //
```

```

14 // Discretization of a given system
15 Ts=0.2; // Sampling time
16 sysd=dscr(sys,Ts);
17 sysd_tf=ss2tf(sysd);
18 //

```

```

19 // System Identification
20 t=0:Ts:2;
21 // ramp input is used as with the step input psi
    becomes singular,
22 // because input columns in psi are repeated
23 u=t;
24 y=flts(u,sysd_tf);
25
26 for i=1:1:5
27 Y(i)=y(i+3);
28 psi(i,1:4)=[-y(i+2) -y(i+1) u(i+2) u(i+1)];
29 end
30 theta=inv(psi'*psi)*psi'*Y;
31 // identified system
32 num=[theta([4,3])];
33 den=[theta([2,1]); 1];
34 num_z=poly(num,'z','coeff')
35 den_z=poly(den,'z','coeff')
36 sysd_id=num_z/den_z;
37 disp(sysd_tf,'sysd_tf=', 'The discrete model of the
    system is ');
38 disp(sysd_id,'sysd_id=', 'The identified system is ');
39 //

```

Appendix

```
Scilab code AP 11 //figure handel settings
2 f=get("current_figure"); //Current figure handle
3 f.background=8; //make the figure window background
  white
4 l=f.children(1);
5 l.background=8 ;//make the text background white
6 id=color('grey');
7 xgrid(id);
fig settings
```
