

Scilab Manual for
Control System Design
by Prof Dilip Pawar
Instrumentation Engineering
Bharati Vidyapeeth College Of Engineering,
Navi Mumbai¹

Solutions provided by
Mr Dilip N. Pawar
Instrumentation Engineering
Bharati Vidyapeeth College Of Engineering, Navi Mumbai

June 19, 2026

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Scilab Manual and Scilab codes written in it can be downloaded from the "Migrated Labs" section at the website <http://scilab.in>

Contents

List of Scilab Solutions	3
1 State model for SISO and MIMO Systems	6
2 Similarity Transformation	8
3 Controllability and Observability	10
4 Pole-Placement with State Feedback	12
5 Lead Compensator Design by Root Locus	14
6 Lag Compensator Design by Root Locus	18
7 Time Delay or Transportation Lag	22
8 Lead Compensator Design by Bode Plot Technique	26
9 Lag Compensator Design by Bode Plot Technique	32
10 PID Controller Design	38
11 Servomechanism or Tracking Problem	41

List of Experiments

Solution 1.1	a	6
Solution 2.2	a	8
Solution 3.3	a	10
Solution 4.4	a	12
Solution 5.5	To design a Lead Compensator by Root Locus technique	14
Solution 6.6	To design a Lag Compensator by Root Locus technique	18
Solution 7.7	To Study the Effect of Time Delay on System Response	22
Solution 8.8	To design a Lead Comensator by Bode plot technique	26
Solution 9.9	To design a Lag Compensator by Bode plot technique	32

List of Figures

5.1	To design a Lead Compensator by Root Locus technique . . .	16
5.2	To design a Lead Compensator by Root Locus technique . . .	16
5.3	To design a Lead Compensator by Root Locus technique . . .	17
5.4	To design a Lead Compensator by Root Locus technique . . .	17
6.1	To design a Lag Compensator by Root Locus technique . . .	20
6.2	To design a Lag Compensator by Root Locus technique . . .	20
6.3	To design a Lag Compensator by Root Locus technique . . .	21
6.4	To design a Lag Compensator by Root Locus technique . . .	21
7.1	To Study the Effect of Time Delay on System Response . . .	24
7.2	To Study the Effect of Time Delay on System Response . . .	25
8.1	To design a Lead Comensator by Bode plot technique	29
8.2	To design a Lead Comensator by Bode plot technique	30
8.3	To design a Lead Comensator by Bode plot technique	30
8.4	To design a Lead Comensator by Bode plot technique	31
9.1	To design a Lag Compensator by Bode plot technique	35
9.2	To design a Lag Compensator by Bode plot technique	36
9.3	To design a Lag Compensator by Bode plot technique	36
9.4	To design a Lag Compensator by Bode plot technique	37
10.1	To design a PID Controller by using Ziegler Nichols tuning rules	39
10.2	To design a PID Controller by using Ziegler Nichols tuning rules	40
11.1	To apply integral control to servo problem to minimize the error	42

11.2 To apply integral control to servo problem to minimize the error	43
---	----

Experiment: 1

State model for SISO and MIMO Systems

Scilab code Solution 1.1 a

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 1 a): To obtain State – Space Model of given
  system
4
5 clc ;
6 clear all;
7
8
9 // Define the Numerator and Denominator Polynomials
  of Transfer Function, G(s)
10 num=poly([30 10], "s", "coeff"); //Defines the
  numerator of G(s)
11 den=poly([0 8 6 1], "s", "coeff"); //Defines the
  denominator of G(s)
12
13 // Obtain the Controllable Phase Variable Form
14 sys=cont_frm(num,den);
15 [A,B,C,D]=abcd(sys)
```

```
16 disp(D,"D",C,"C",B,"B",A,"A")
17
18 // Result
19
20 // A
21
22 // 0. 1. 0.
23 // 0. 0. 1.
24 // 0. -8. -6.
25
26 // B
27
28 // 0.
29 // 0.
30 // 1.
31
32 // C
33
34 // 30. 10. 0.
35
36 // D
37
38 // 0.
```

Experiment: 2

Similarity Transformation

Scilab code Solution 2.2 a

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 2 a): To obtain Similar State – Space Model
  of given system
4
5 clc ;
6 clear all;
7
8 // A system having the form  $\dot{x}=Ax+Bu$  and  $y=Cx+du$ ,
  where
9  $A=[-2,1;-3,0]$ ;  $B=[4;5]$ ;  $C=[1,0]$ ;  $D=0$ ; //and
10 //The transformation Matrix P is taken as –
11  $P = [2,1;4,3]$ ;
12 //the given system can be transformed to a similar
  system as –
13  $AA=inv(P)*A*P$ 
14  $BB=inv(P)*B$ 
15  $CC=C*P$ 
16 disp(C,"CC",B,"BB", A,"AA")
17 // Check the eigenvalues of both systems
18  $EV1=spec(A)$ ;  $EV2=spec(AA)$ ;
```

```
19 disp(EV2," Eigenvalues of System2", EV1," Eigenvalues
    of System1")
20 // If both eigenvalues are same then systems are
    similar
21
22 // Result
23
24 // AA
25 //
26 //  -2.    1.
27 //  -3.    0.
28 //
29 // BB
30 //
31 //   4.
32 //   5.
33 //
34 // CC
35 //
36 //   1.    0.
37 //
38 // Eigenvalues of System1
39 //
40 //  -1. + 1.4142136 i
41 //  -1. - 1.4142136 i
42 //
43 // Eigenvalues of System2
44 //
45 //  -1. + 1.4142136 i
46 //  -1. - 1.4142136 i
47 //
```

Experiment: 3

Controllability and Observability

Scilab code Solution 3.3 a

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 3 a): To Check the Controllability of given
   system by Gilbert's Test
4
5 clc ;
6 clear all;
7
8 // Let the system is described by state equations
9 A=[0,1,0;0,0,1;-6,-11,-6];
10 B=[0;0;1];
11 // Solution: -
12 // Gilbert's Test is required to find canonical
   state variable form as -
13 // Given system is in Phase Variable form, therefore
   Vander Monde Matrix is
14 // required as an Modal Matrix
15 // Find the eigenvalues and eigenvectors of matrix A
16 [V,D]=spec(A);
```

```
17 // Forming the Vander Monde Matrix from the
    eigenvalues as -
18 d = diag(D); dd=(d.^2);
19 M=[1,1,1;d';dd'];
20 Minv=inv(M);
21 // Finding the Bcap
22 Bcap=Minv*B;
23 disp(Bcap,"Bcap")
24 // Check the contents of B vector, whether any
    element is zero,
25 // if not then system is controllable
26 // Result
27
28 // Bcap
29 //
30 //    0.5
31 //   -1.
32 //    0.5
```

Experiment: 4

Pole-Placement with State Feedback

Scilab code Solution 4.4 a

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 4 a): To find a gain matrix K, by using Pole-
    placement by state feedback
4
5 clc ;
6 clear all;
7
8 // Problem: Consider the system as
9 // .
10 //  $X = AX + Bu$ 
11 // where  $A = [0,1,0;0,0,1;-1,-5,-6]$ ;  $B = [0;0;1]$ ;
12 // By using state feedback control  $u = -Kx$ , it is
    desired to have the closed
13 // - loop poles at  $s_1 = -2+j*4$ ;  $s_2 = -2-j*4$ ; and  $s_3$ 
    = -10;
14 // Determine the state feedback-gain matrix K with
    SCILAB
15
```

```
16 // First define the given A, B matrices as -
17 A = [0,1,0;0,0,1;-1,-5,-6];
18 B = [0;0;1];
19 // Then define the closed - loop poles as -
20 s1=-2+%i*4; s2=-2-%i*4; s3=-10;
21 S=[s1,s2,s3];
22 // Then invoking commands 'ppol' as -
23 K=ppol(A,B,S)
24 disp(K,"K")
25
26 // Result
27
28 // K
29 //
30 // 199.    55.    8.
```

Experiment: 5

Lead Compensator Design by Root Locus

Scilab code Solution 5.5 To design a Lead Compensator by Root Locus technique

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 5: To design a Lead Compensator by Root-Locus
  technique
4
5 clc ;
6 clear all;
7
8
9
10 s=%s;
11 G=syslin('c',1/s^2) // Transfer Function of Un-
  compensated System
12 Gc=syslin('c',(s+1.15)/((s^2)*(s+4.2))) // Transfer
  Function of Compensated System
13 // Root - Locus of Un-Compensated System
14 figure(0)
15 clf, evans(G), xgrid(5, 1, 7)
```

```

16
17 // Root – Locus of Compensated System
18 figure(1)
19 clf, evans(Gc), xgrid(5, 1, 7)
20 replot([-4.5, -10, 0.5, 10])
21
22 // Step Response of Un–Compensated System
23 figure(2)
24 t= 0:0.1:100;
25 x=[csim('step',t,G/(1+G),[0;0;0])]';
26 plot2d(t',x),
27 xlabel("t", "fontsize", 2,"color", "blue");
28 ylabel("Amplitude", "fontsize", 2, "color", "blue");
29 xgrid(5, 1, 7)
30 xtitle('Step Response of Un–Compensated System');//
    , 'X axis', 'Y axis');
31 // Step Response of Compensated System
32 figure(3)
33 t= 0:0.1:100;
34 x=[csim('step',t,Gc/(1+Gc),[0;0;0])]';
35 plot2d(t',x),
36 xlabel("t", "fontsize", 2,"color", "blue");
37 ylabel("Amplitude", "fontsize", 2, "color", "blue");
38 xtitle('Step Response of Compensated System');//, '
    X axis', 'Y axis');
39 xgrid(5, 1, 7)

```

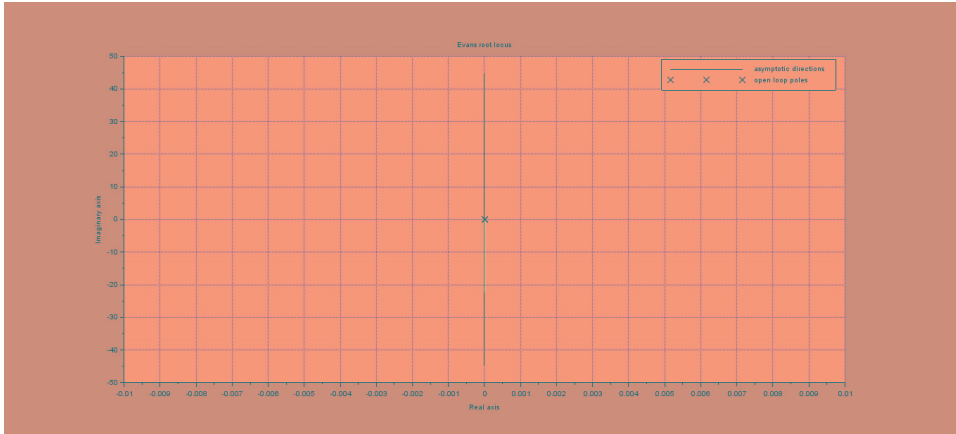


Figure 5.1: To design a Lead Compensator by Root Locus technique

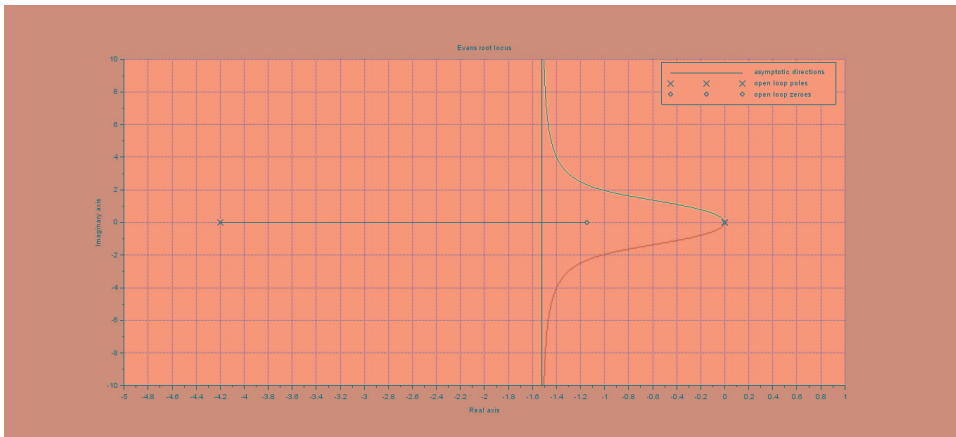


Figure 5.2: To design a Lead Compensator by Root Locus technique

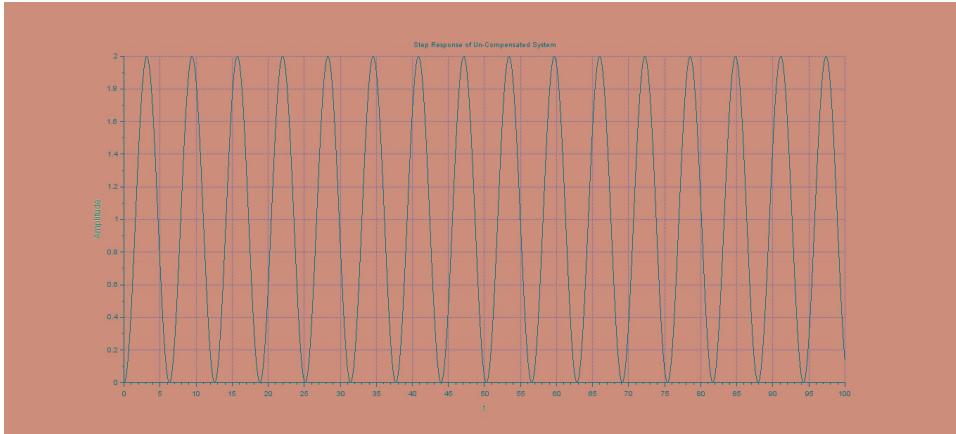


Figure 5.3: To design a Lead Compensator by Root Locus technique

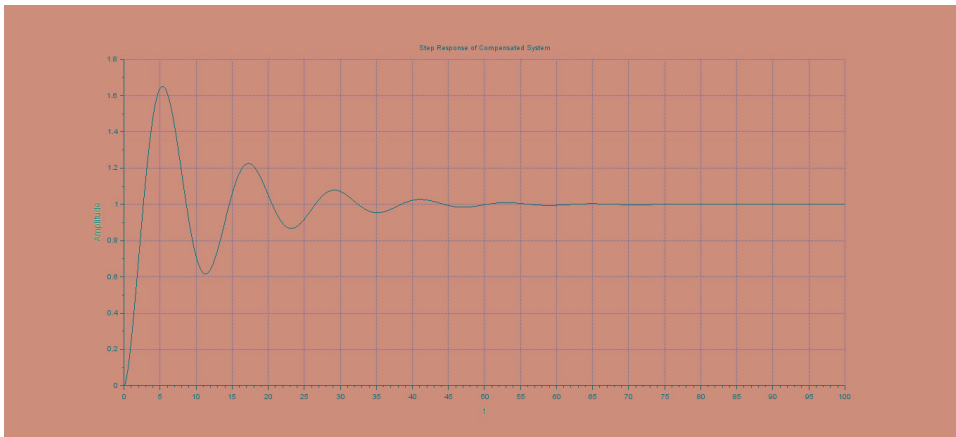


Figure 5.4: To design a Lead Compensator by Root Locus technique

Experiment: 6

Lag Compensator Design by Root Locus

Scilab code Solution 6.6 To design a Lag Compensator by Root Locus technique

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 6: To design a Lag Compensator by Root-Locus
  technique
4
5 clc ;
6 clear all;
7
8 s=%s;
9 G=syslin('c',1/(s*(s+1)*(s+4))) // Transfer Function
  of Un-Compensated System
10 Gc=syslin('c',(s+0.2)/((s+0.02)*s*(s+1)*(s+4))) //
  Transfer Function of Compensated System
11 // Root - Locus of Un-Compensated System
12 figure(0)
13 clf, evans(G), xgrid//(5, 1, 7)
14 replot([-4.5, -10, 0.5, 10])
15 // Step Response of Un-Compensated System
```

```

16 figure(1)
17 t= 0:0.1:100;
18 x=[csim('step',t,G/(1+G),[0;0;0])]';
19 plot2d(t',x),xgrid//(5, 1, 7)
20 xlabel("t", "fontsize", 2,"color", "blue");
21 ylabel("Amplitude", "fontsize", 2, "color", "blue");
22 xtitle( 'Step Response of Un-Compensated System');
23
24 // Root - Locus of Compensated System
25 figure(2)
26 clf, evans(Gc), xgrid//(5, 1, 7)
27
28 replot([-4.5,-6,0.5,6])
29 // Step Response of Compensated System
30 figure(3)
31 t= 0:0.1:100;
32 x=[csim('step',t,Gc/(1+Gc))]';
33 plot2d(t',x),xgrid//(5, 1, 7)
34 xlabel("t", "fontsize", 2,"color", "blue");
35 ylabel("Amplitude", "fontsize", 2, "color", "blue");
36 xtitle( 'Step Response of Compensated System');

```

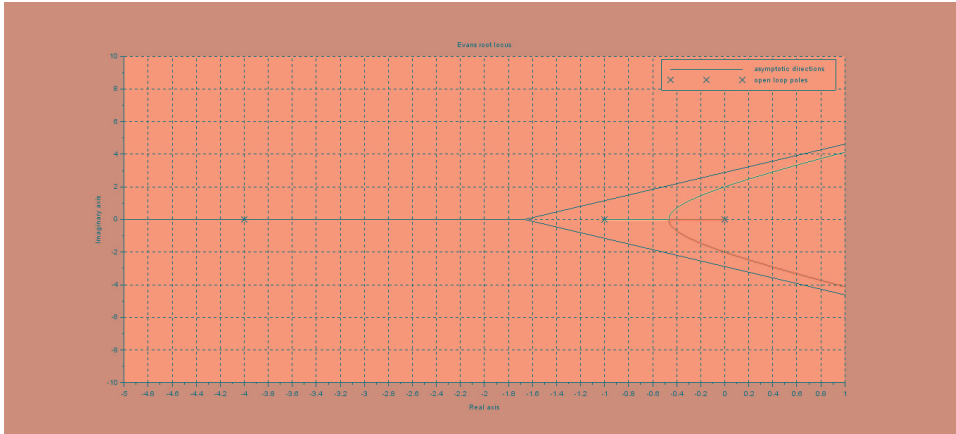


Figure 6.1: To design a Lag Compensator by Root Locus technique

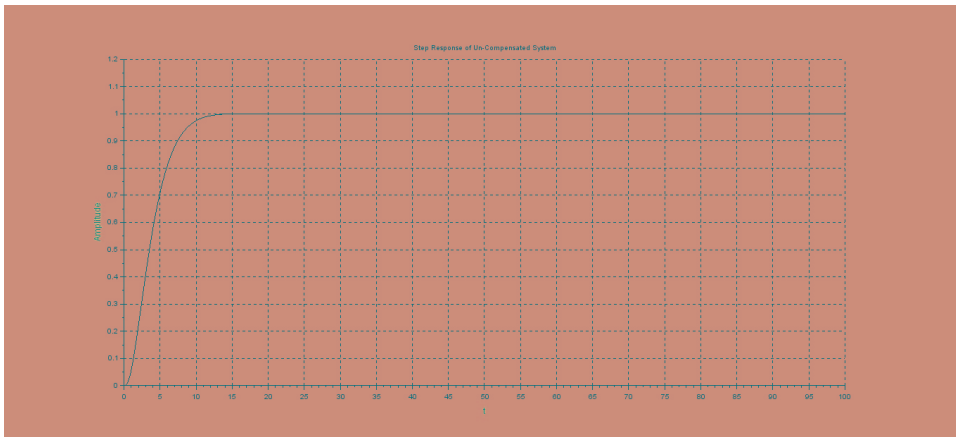


Figure 6.2: To design a Lag Compensator by Root Locus technique

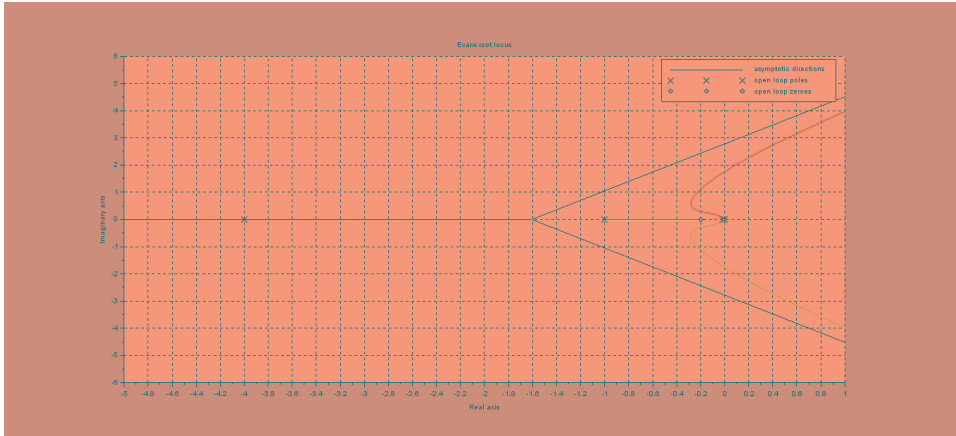


Figure 6.3: To design a Lag Compensator by Root Locus technique

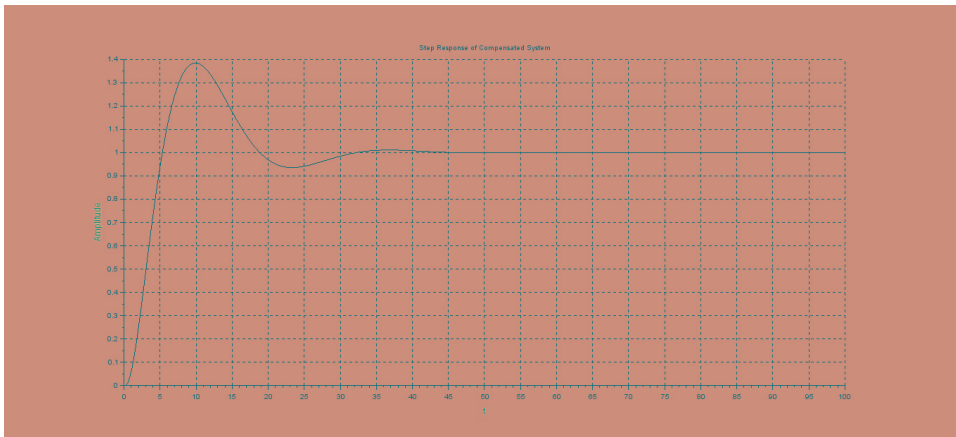


Figure 6.4: To design a Lag Compensator by Root Locus technique

Experiment: 7

Time Delay or Transportation Lag

Scilab code Solution 7.7 To Study the Effect of Time Delay on System Response

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Lab 7: To Study the Effect of Time Delay on
  System Response
4 clc ;
5 clear all;
6
7 // For T = 0, i.e. No Delay
8 s=poly(0, 's')
9 // Transfer Function of Open-Loop System with T=0
10 G1=syslin('c', exp(0)*10/((s)*(s+1)));
11 figure(0)
12 bode(G1,0.1,100)
13 [gm1,frg1]=g_margin(G1);
14 disp(gm1,"Gain Margin,T=0",frg1,"Phase Cut-off
  Frequency, T=0")
15 show_margins(G1)
16 [phm1,frp1]=p_margin(G1);
```

```

17 disp(phm1,"Phase Margin , T=0",frp1,"Gain Cut-off
    Frequency , T=0")
18 show_margins(G1)
19
20 // For Time Delay T = 0.1
21 T=0.1;
22 nTd=[1-T*s/2]; dTd=[1+T*s/2]; // Num and Den of Delay
    System by Pade
23 sysTd=syslin('c',nTd/dTd);
24 G2=syslin('c',(sysTd*10)/((s)*(s+1)));
25 figure(1)
26 bode(G2,0.1,100)
27 [gm2,frg2]=g_margin(G2);
28 disp(gm2,"Gain Margin , T=0.1",frg2,"Phase Cut-off
    Frequency , T=0.1")
29 show_margins(G2)
30 [phm2,frp2]=p_margin(G2);
31 disp(phm2,"Phase Margin , T=0.1",frp2,"Gain Cut-off
    Frequency , T=0.1")
32 show_margins(G2)
33
34 // Results
35 // Frequency Response Specifications of Un-
    Compensated System
36 //Phase Cut-off Frequency , T=0
37 //
38 // []
39 //
40 // Gain Margin ,T=0
41 //
42 // Inf
43 //
44 // Gain Cut-off Frequency , T=0
45 //
46 // 0.4908709
47 //
48 // Phase Margin , T=0
49

```

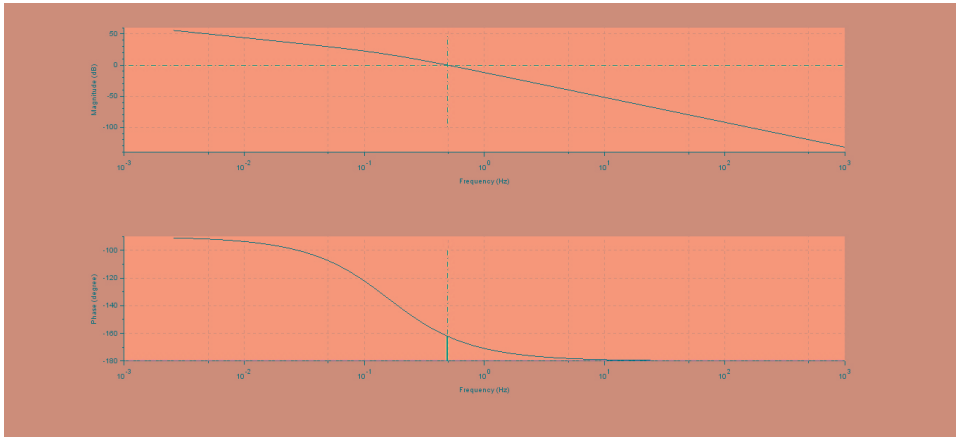


Figure 7.1: To Study the Effect of Time Delay on System Response

```

50 //      17.964236
51 // Frequency Response Specifications of Compensated
    System
52
53 // Phase Cut-off Frequency , T=0.1
54 //
55 //      0.4971165
56 //
57 // Gain Margin , T=0.1
58 //
59 //      0.2093087
60 //
61 // Gain Cut-off Frequency , T=0.1
62 //
63 //      0.4908709
64 //
65 // Phase Margin , T=0.1
66 //
67 //      0.4310002

```

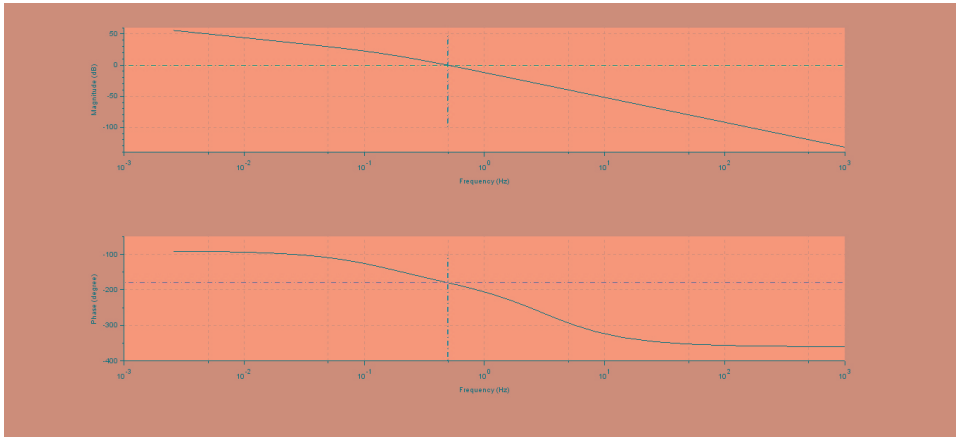


Figure 7.2: To Study the Effect of Time Delay on System Response

Experiment: 8

Lead Compensator Design by Bode Plot Technique

Scilab code Solution 8.8 To design a Lead Compensator by Bode plot technique

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Expt. No. 8: To design a Lead Compensator by Bode-
  plot technique
4
5 clc
6 close
7 clf();
8
9 s=poly(0, 's')
10 // Transfer Function of Open-Loop System
11 G=syslin('c',12/((s)*(s+1)))
12 figure(0)
13 bode(G,0.1,100)
14 [gm,frg]=g_margin(G);
15 disp(gm,"Gain Margin",frg,"Phase Cut-off Frequency")
16 show_margins(G)
17 [phm,frp]=p_margin(G);
```

```

18 disp(phm,"Phase Margin",frp,"Gain Cut-off Frequency"
    )
19 show_margins(G)
20
21 // Transfer Function of Open-Loop Compensated System
    , GGc
22 GGc=syslin('c',12*(1+0.385*s)/((s)*(s+1)*(1+0.125*s)
    ))
23
24 // Bode - Plot of Compensated System
25 figure(1)
26 bode(GGc,0.1,100)
27 [gm,frg]=g_margin(GGc);
28 disp(gm,"Gain Margin",frg,"Phase Cut-off Frequency")
29 show_margins(GGc)
30 [phm,frp]=p_margin(GGc);
31 disp(phm,"Phase Margin",frp,"Gain Cut-off Frequency"
    )
32 show_margins(GGc)
33
34 // Step Response of Coles-Loop Un-Compensated System
35 figure(2)
36 t= 0:0.1:10;
37 x=[csim('step',t,G/(1+G))];
38 plot2d(t,x),xgrid(5, 1, 7)
39 xlabel("t", "fontsize", 2,"color", "blue");
40 ylabel("Amplitude", "fontsize", 2, "color", "blue");
41 xtitle('Step Response of Un-Compensated System');
42
43 // Step Response of Close-Loop Compensated System
44 figure(3)
45 t= 0:0.1:10;
46 x=[csim('step',t,GGc/(1+GGc))];
47 plot2d(t,x),xgrid(5, 1, 7)
48 xlabel("t", "fontsize", 2,"color", "blue");
49 ylabel("Amplitude", "fontsize", 2, "color", "blue");
50 xtitle('Step Response of Compensated System');
51 // Results

```

```
52 // Frequency Response Specifications of Un-
    Compensated System
53 //Phase Cut-off Frequency
54 //
55 //     []
56 //
57 // Gain Margin
58 //
59 //     Inf
60 //
61 // Gain Cut-off Frequency
62 //
63 //     0.5399649
64 //
65 // Phase Margin
66 //
67 //     16.422908
68
69 // Frequency Response Specifications of Compensated
    System
70
71 // Phase Cut-off Frequency
72 //
73 //     []
74 //
75 // Gain Margin
76 //
77 //     Inf
78 //
79 // Gain Cut-off Frequency
80 //
81 //     0.720447
82 //
83 // Phase Margin
84 //
85 //     43.107374
```

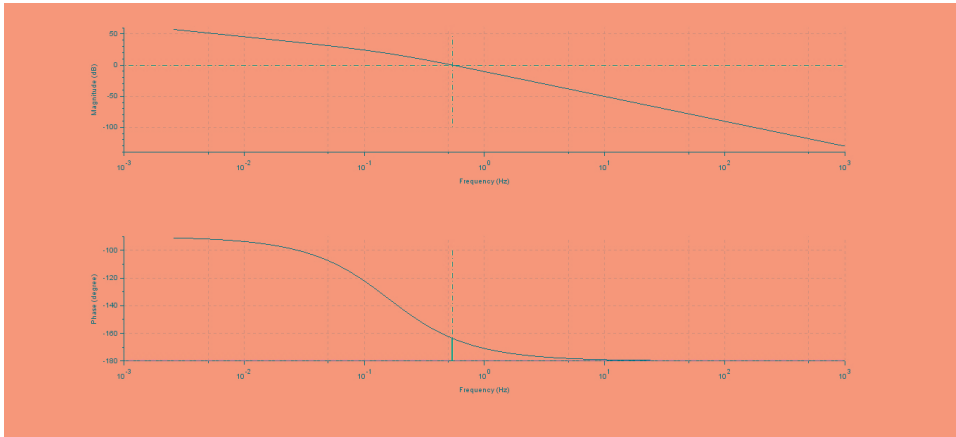


Figure 8.1: To design a Lead Comensator by Bode plot technique

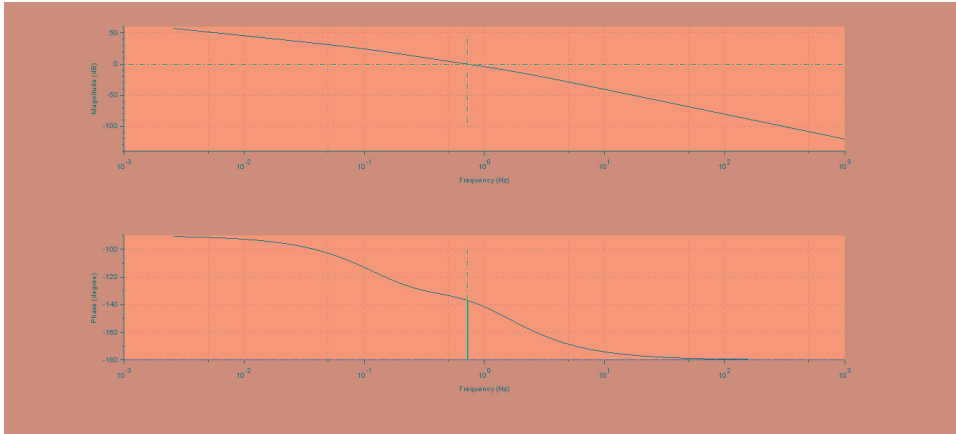


Figure 8.2: To design a Lead Comensator by Bode plot technique

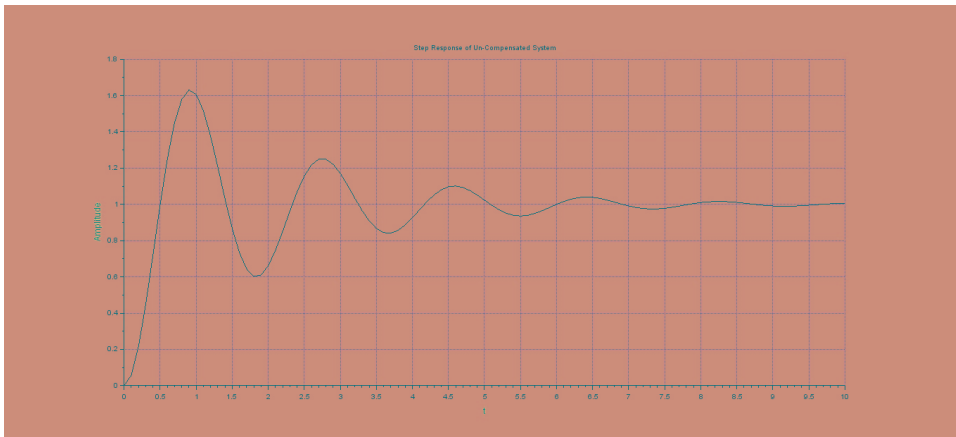


Figure 8.3: To design a Lead Comensator by Bode plot technique

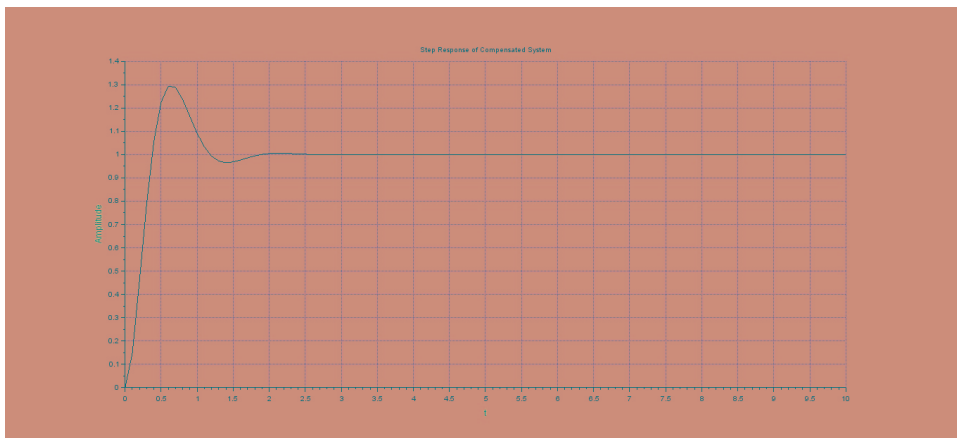


Figure 8.4: To design a Lead Comensator by Bode plot technique

Experiment: 9

Lag Compensator Design by Bode Plot Technique

Scilab code Solution 9.9 To design a Lag Compensator by Bode plot technique

```
1 // Scilab : 6.0.0
2 // OS: Windows 7, 64 bit
3 // Expt. No. 9: To design a Lag Compensator by Bode-
  plot technique
4
5 clc
6 close
7 clf();
8
9 s=poly(0, 's')
10 // Transfer Function of Open-Loop System
11 G=syslin('c',30/((s)*(0.1*s+1)*(0.2*s+1)))
12 figure(0)
13 // Bode - Plot of Un-Compensated System
14 bode(G,0.1,100)
15
16 [gm,frg]=g_margin(G);
17 disp(gm,"Gain Margin",frg,"Phase Cut-off Frequency")
```

```

18 show_margins(G)
19 [phm,frp]=p_margin(G);
20 disp(phm,"Phase Margin",frp,"Gain Cut-off Frequency"
    )
21 show_margins(G)
22
23 // Transfer Function of Open-Loop Compensated System
    , GGc
24 GGc=syslin('c',30*(1+3.33*s)/((s)*(0.1*s+1)*(0.2*s
    +1)*(1+33.3*s)))
25
26 // Bode - Plot of Compensated System
27 figure(1)
28 bode(GGc,0.1,100)
29
30 [gm,frg]=g_margin(GGc);
31 disp(gm,"Gain Margin",frg,"Phase Cut-off Frequency")
32 show_margins(GGc)
33 [phm,frp]=p_margin(GGc);
34 disp(phm,"Phase Margin",frp,"Gain Cut-off Frequency"
    )
35 show_margins(GGc)
36
37 // Step Response of Closed-Loop Un-Compensated
    System
38 figure(2)
39 t= 0:0.1:10;
40 x=[csim('step',t,G/(1+G))]';
41 plot2d(t',x),xgrid(5, 1, 7)
42 xlabel("t", "fontsize", 2,"color", "blue");
43 ylabel("Amplitude", "fontsize", 2, "color", "blue");
44 xtitle('Step Response of Un-Compensated System');
45
46 // Step Response of Closed-Loop Compensated System
47 figure(3)
48 t= 0:0.1:10;
49 x=[csim('step',t,GGc/(1+GGc))]';
50 plot2d(t',x),xgrid(5, 1, 7)

```

```

51 xlabel("t", "fontsize", 2, "color", "blue");
52 ylabel("Amplitude", "fontsize", 2, "color", "blue");
53 xtitle( 'Step Response of Compensated System' );
54
55 // Result
56 // Frequency Response Specifications of Un-
    Compensated System
57 //Phase Cut-off Frequency
58 //
59 //     1.1253954
60 //
61 // Gain Margin
62 //
63 //     -6.0205999
64 //
65 // Gain Cut-off Frequency
66 //
67 //     1.555363
68 //
69 // Phase Margin
70 //
71 //     -17.245408
72 // Frequency Response Specifications of Compensated
    System
73
74 // Phase Cut-off Frequency
75 //
76 //     1.0788163
77 //
78 // Gain Margin
79 //
80 //     13.24356
81 //
82 // Gain Cut-off Frequency
83 //
84 //     0.4129329
85 //
86 // Phase Margin

```

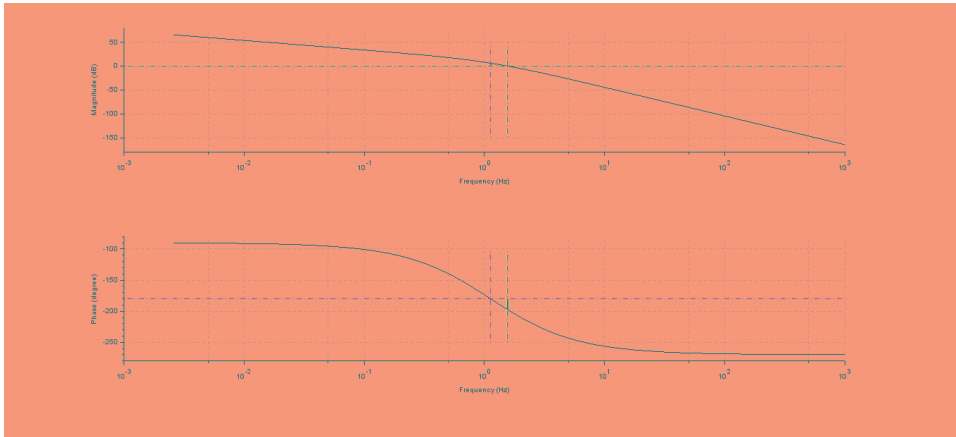


Figure 9.1: To design a Lag Compensator by Bode plot technique

87 //
 88 // 42.090918
 89 //

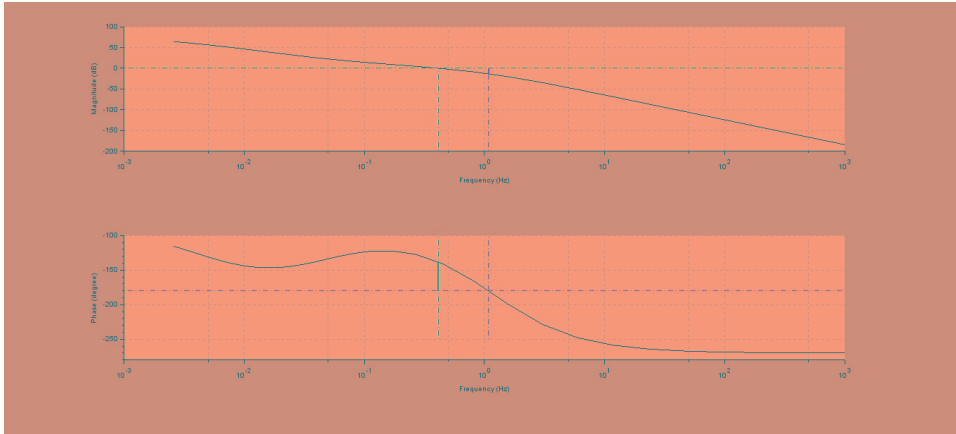


Figure 9.2: To design a Lag Compensator by Bode plot technique

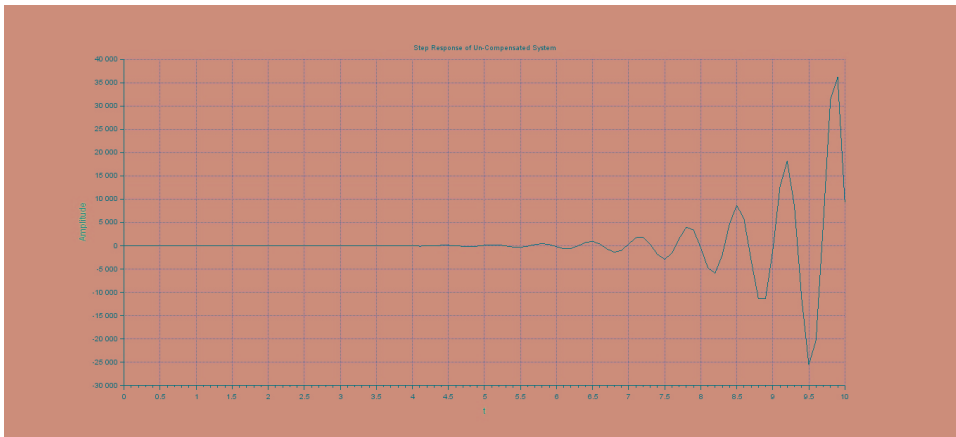


Figure 9.3: To design a Lag Compensator by Bode plot technique

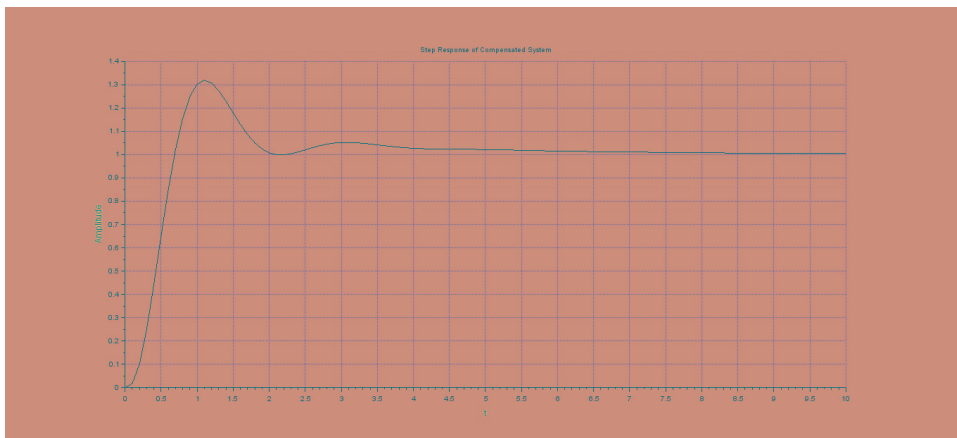


Figure 9.4: To design a Lag Compensator by Bode plot technique

Experiment: 10

PID Controller Design

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

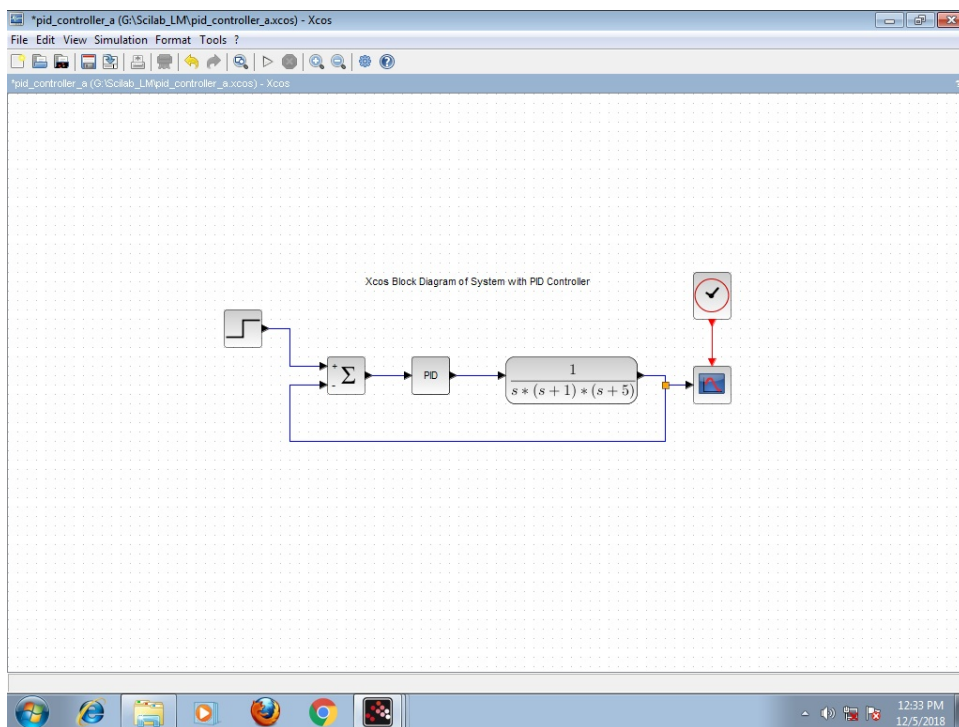


Figure 10.1: To design a PID Controller by using Ziegler Nichols tuning rules

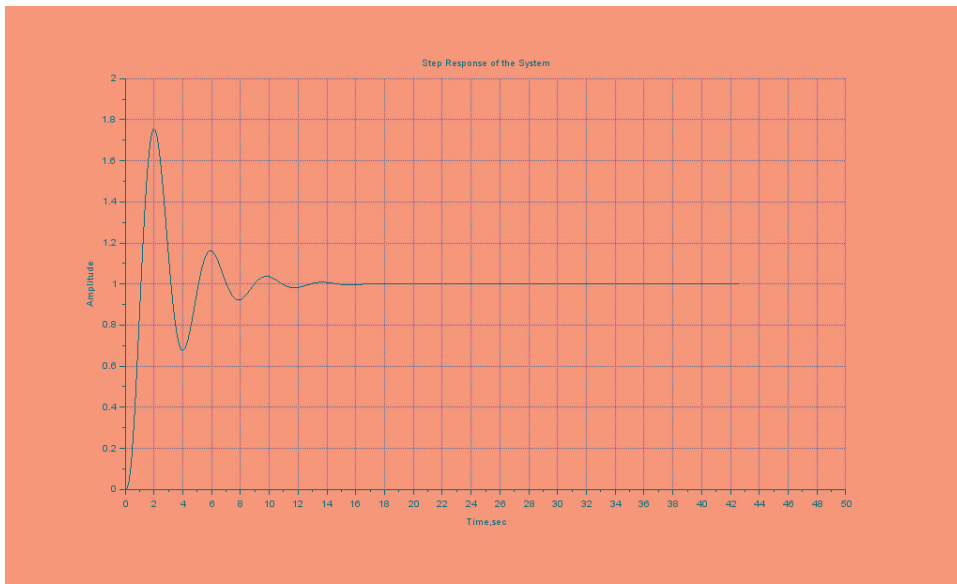


Figure 10.2: To design a PID Controller by using Ziegler Nichols tuning rules

Experiment: 11

Servomechanism or Tracking Problem

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

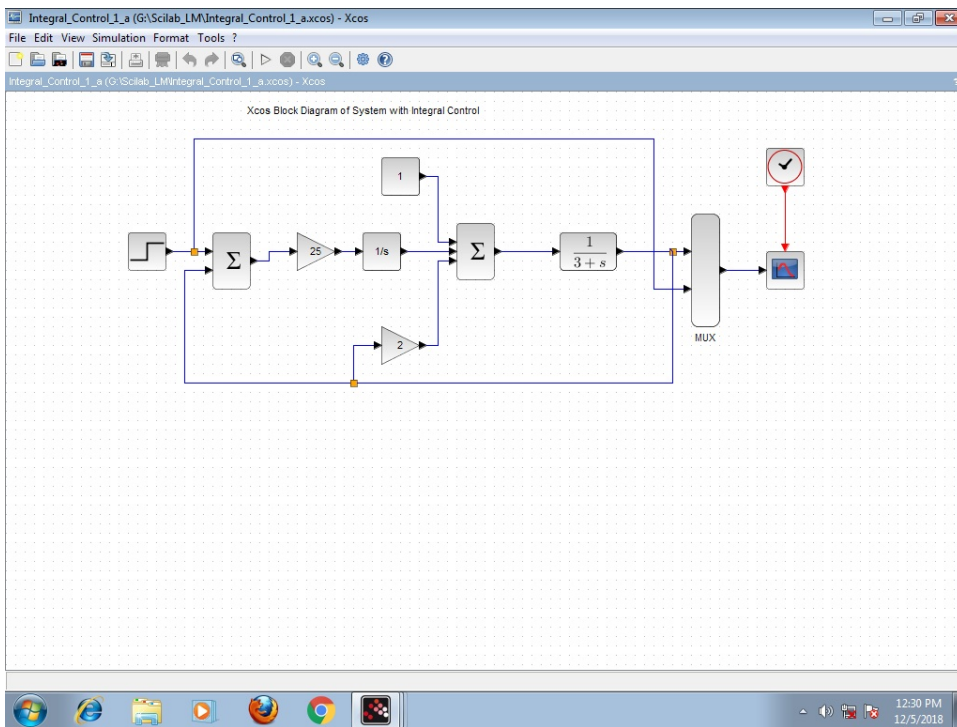


Figure 11.1: To apply integral control to servo problem to minimize the error

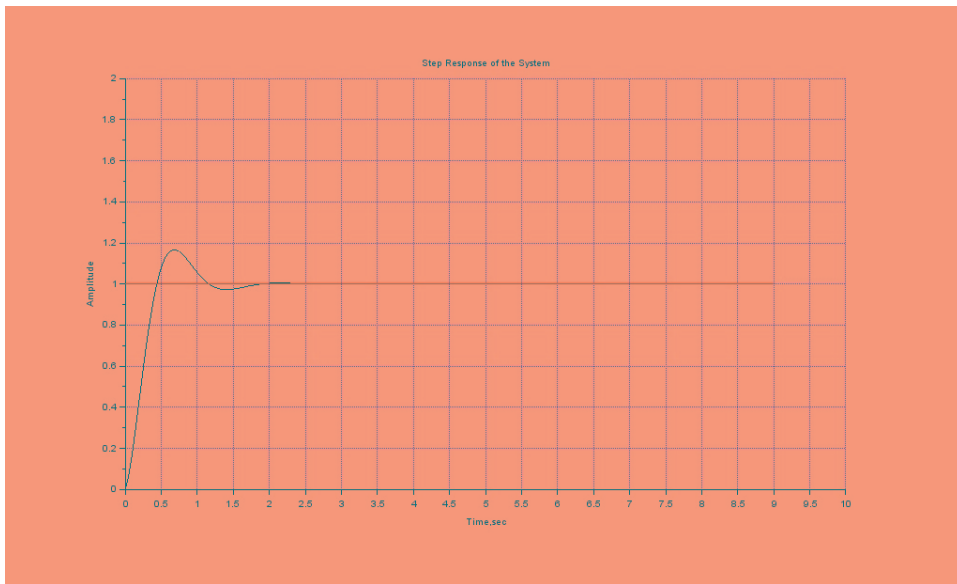


Figure 11.2: To apply integral control to servo problem to minimize the error