

Scilab Manual for  
Digital Control And Instrumentation  
Laboratory  
by Prof Abragam Siyon Sing M  
Electrical Engineering  
St. Xavier'S Catholic College Of Engineering<sup>1</sup>

Solutions provided by  
Prof Abragam Siyon Sing M  
Electrical Engineering  
St. Xavier'S Catholic College Of Engineering

April 5, 2026

<sup>1</sup>Funded 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 Simulation Of Single Phase Full Wave Controlled Rectifier	5
2 Simulation Of Single Phase Half Wave Controlled Rectifier	7
3 Simulation Of Three Phase Full Wave Controlled Rectifier	9
4 Simulation Of Three Phase Half Wave Controlled Rectifier	12
5 Frequency Response Of Single Area Power System	15
6 Frequency Response Of Two Area Power System	17
7 Symmetrical Fault Analysis In Power Systems	19
8 Unsymmetrical Fault Analysis In Power Systems	25
9 Digital Simulation Of P, PI And PID Controllers.	31
10 Simulation Of The Performance Of Single Phase Transformer	34

# List of Experiments

Solution 7.10	Analysis of Symmetrical Fault . . . . .	19
Solution 8.9	Analysis of Unsymmetrical Fault . . . . .	25
Solution 9.4	Digital Simulation of P PI PID Controllers . . . . .	31
Solution 10.3	Performance Characteristics of Single Phase Transformer . . . . .	34

# List of Figures

1.1	Single phase Full wave Controlled Rectifier . . . . .	6
2.1	Single phase Half wave Controlled Rectifier . . . . .	8
3.1	Three Phase Full Wave Controlled Rectifier . . . . .	10
3.2	Three Phase Full Wave Controlled Rectifier . . . . .	11
4.1	Three Phase Half Wave Controlled Rectifier . . . . .	13
4.2	Three Phase Half Wave Controlled Rectifier . . . . .	14
5.1	Single Area System . . . . .	16
6.1	Two Area System . . . . .	18
7.1	Analysis of Symmetrical Fault . . . . .	23
7.2	Analysis of Symmetrical Fault . . . . .	24
8.1	Analysis of Unsymmetrical Fault . . . . .	29
8.2	Analysis of Unsymmetrical Fault . . . . .	30
9.1	Digital Simulation of P PI PID Controllers . . . . .	32
10.1	Performance Characteristics of Single Phase Transformer . .	35
10.2	Performance Characteristics of Single Phase Transformer . .	36

# **Experiment: 1**

## **Simulation Of Single Phase Full Wave Controlled Rectifier**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

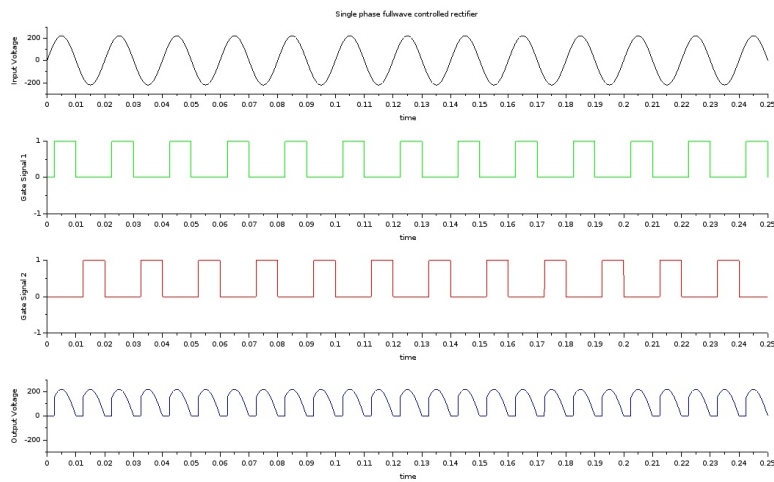


Figure 1.1: Single phase Full wave Controlled Rectifier

## **Experiment: 2**

# **Simulation Of Single Phase Half Wave Controlled Rectifier**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

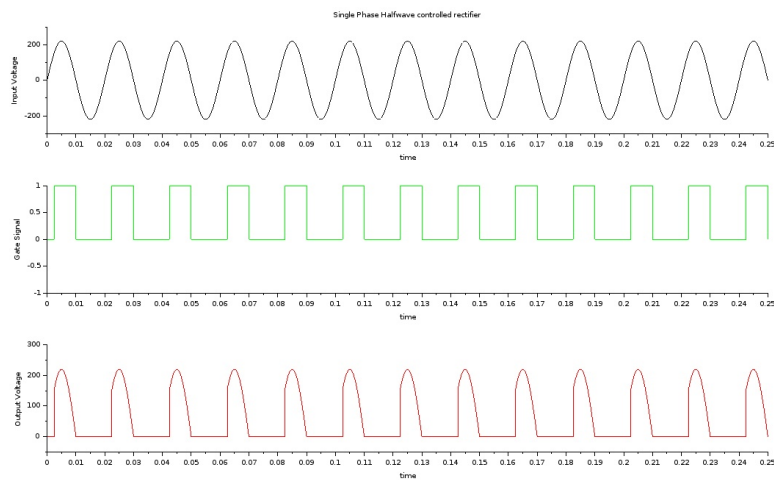


Figure 2.1: Single phase Half wave Controlled Rectifier

## **Experiment: 3**

# **Simulation Of Three Phase Full Wave Controlled Rectifier**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

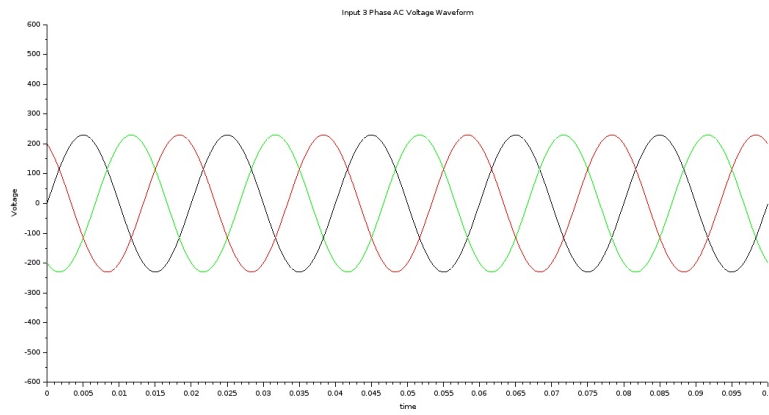
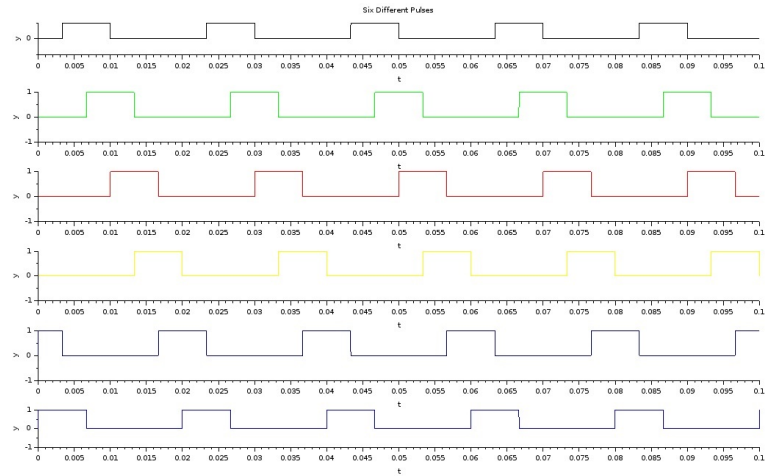


Figure 3.1: Three Phase Full Wave Controlled Rectifier



Output waveform of 3 Phase Full wave controlled rectifier

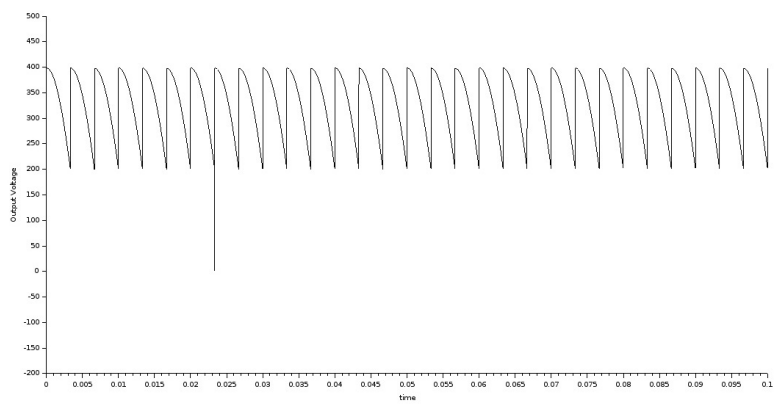


Figure 3.2: Three Phase Full Wave Controlled Rectifier

## **Experiment: 4**

# **Simulation Of Three Phase Half Wave Controlled Rectifier**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

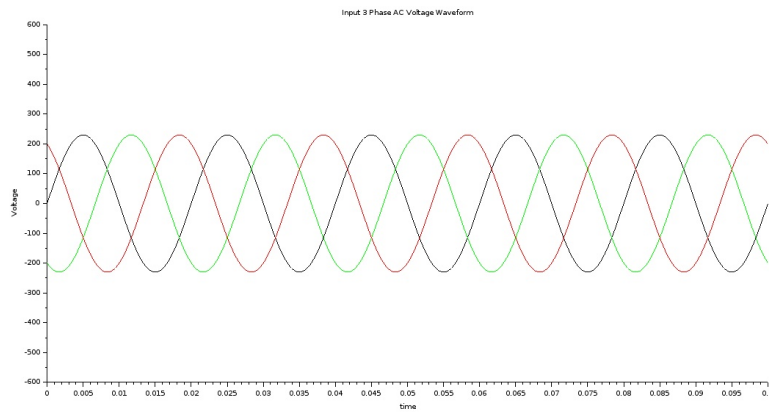


Figure 4.1: Three Phase Half Wave Controlled Rectifier

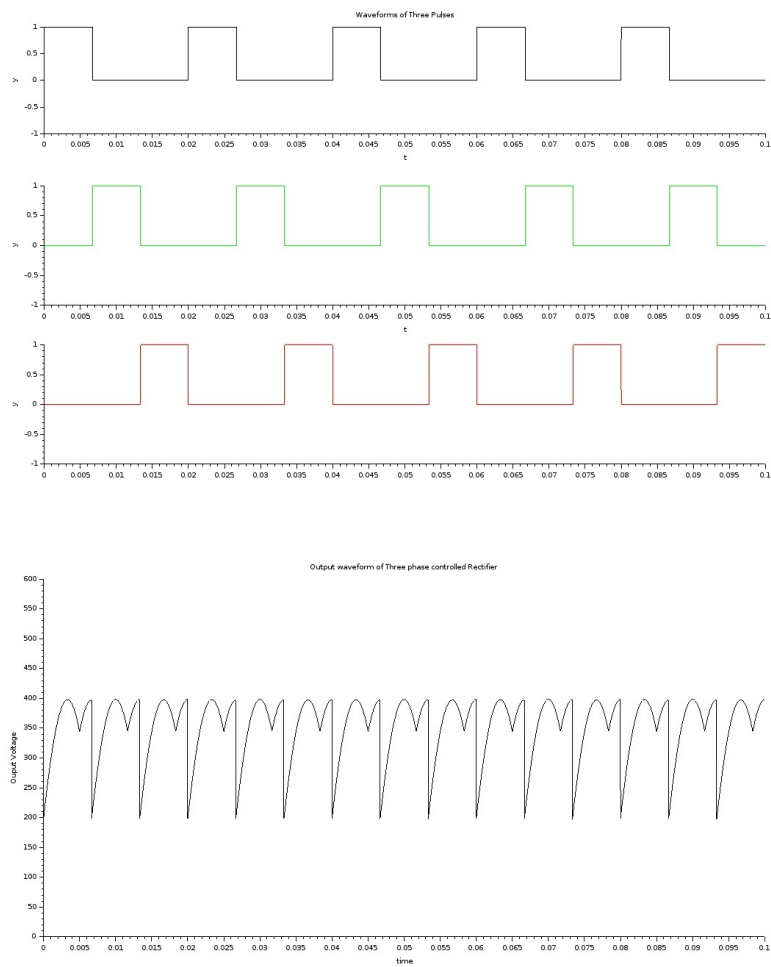


Figure 4.2: Three Phase Half Wave Controlled Rectifier

## **Experiment: 5**

# **Frequency Response Of Single Area Power System**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

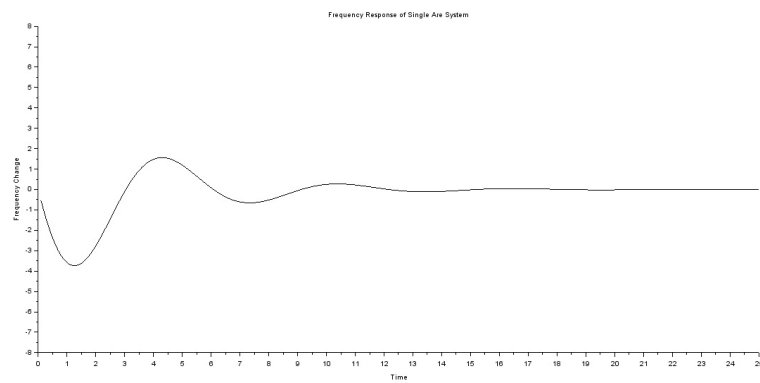


Figure 5.1: Single Area System

## **Experiment: 6**

# **Frequency Response Of Two Area Power System**

This code can be downloaded from the website [www.scilab.in](http://www.scilab.in)

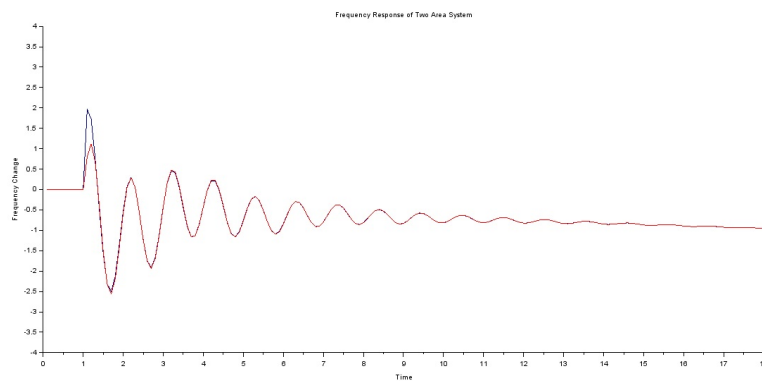


Figure 6.1: Two Area System

## Experiment: 7

# Symmetrical Fault Analysis In Power Systems

Scilab code Solution 7.10 Analysis of Symmetrical Fault

```
1 //Analysis of Symmetrical Fault in Power Systems//
2 //This program requires user input. A sample problem
   with user input and output is available in the
   result file
3 clc;
4 clear;
5 linedata=input('enter the line data values in the
   order of starting bus, Ending bus, resistance and
   reactance:')
6 f=input('enter the bus at wich fault occurs:')
7 fi=input('Enter the fault impedance:')
8 bv=input('enter the pre-fault bus voltage:')
9 sb=linedata(:,1) //Starting bus number of all the
   lines
10 eb=linedata(:,2) //Ending bus number of all the
   lines
11 z=linedata(:,3)+linedata(:,4)*%i //line impedance,
   Z=R+jX
12 zbus=[];
```

```

13 check=[];
14 nb=max(max(sb),max(eb))
15 for i=1:length(sb) //starting of impedance matrix
    calculation part//
16     m=sb(i);
17     n=eb(i);
18     mn=min(m,n);
19     nm=max(m,n);
20     ncheck=length(find(check==nm));
21     mcheck=length(find(check==mn));
22     [rows columns]=size(zbus);
23     if mn==0 & ncheck==0
24         zbus=[zbus zeros(rows,1);zeros(1,rows) z(i)
                ];
25         check=[check nm];
26         else if mcheck>0 & ncheck==0
27             zbus=[zbus zbus(:,mn);zbus(mn,:) zbus(mn
                    ,mn)+z(i)];
28             check=[check nm];
29             elseif mn==0 & ncheck>0
30                 zbus=[zbus zbus(:,nm);zbus(nm,:) zbus(nm
                    ,nm)+z(i)];
31                 zbusn=zeros(rows,rows);
32                 for r=1:rows
33                     for t=1:columns
34                         zbusn(r,t)=zbus(r,t)-(zbus(r,
                            rows+1)*zbus(rows+1,t))/(zbus
                                (rows+1,rows+1));
35                     end
36                 end
37                 zbus=zbusn
38             elseif mcheck>0 & ncheck>0
39                 zbus=[zbus zbus(:,nm)-zbus(:,mn);zbus(nm
                    ,:)-zbus(mn,:),z(i)+zbus(mn,nm)+zbus(
                        nm,nm)-2*zbus(nm,mn)];
40                 zbusn=zeros(rows,rows);
41                 for r=1:rows
42                     for t=1:columns

```

```

43             zbusn(r,t)=zbus(r,t)-(zbus(r,rows
                +1)*zbus(rows+1,t))/(zbus(rows
                +1,rows+1));
44             end
45         end
46         zbus=zbusn;
47     end
48 end
49 end //ending of impedance bus matrix calculation
    part//
50 disp(zbus,'the impedance matrix is:');
51 ifa=bv/(zbus(f,f)+fi) //calculation of fault
    current//
52 disp(ifa,'the fault current is:');
53 disp('Post fault voltages v1,v2,v3 respectively are:
    ');
54 for i=1:nb
55 v(i)=bv-(ifa*zbus(i,f)); //calculation of post fault
    bus voltages//
56 disp(v(i));
57 end
58 a=input('enter the starting bus to calculate the
    line flow:');
59 b=input('enter the ending bus to calculate the line
    flow:');
60 zs=input('enter the impedance between the above
    buses:');
61 i13=(v(a)-v(b))/zs; //calculation of line flow
    current//
62 disp(i13,'the line flow current is:');
63
64 //SAMPLE INPUT and OUTPUT
65
66 //enter the line data values in the order of
    starting bus, Ending bus, resistance and
    reactance:[1 0 0 0.1; 1 2 0 0.2; 2 0 0 0.1; 0 3 0
    0.1; 3 1 0 0.1]
67 //enter the bus at wich fault occurs:1

```

```

68 //Enter the fault impedance:0.08*%i
69 //enter the pre-fault bus voltage:2
70
71 // the impedance matrix is:
72
73 //      0.046875 i      0.015625 i      0.0375 i
74 //      0.015625 i      0.071875 i      0.0125 i
75 //      0.0375 i      0.0125 i      0.05 i
76
77 // the fault current is:
78
79 // - 15.763547 i
80
81 // Post fault voltages v1,v2,v3 respectively are:
82
83 //      1.2610837
84
85 //      1.7536946
86
87 //      1.408867
88 //enter the starting bus to calculate the line flow
      :1
89 //enter the ending bus to calculate the line flow:2
90 //enter the impedance between the above buses:0.2*%i
91
92 // the line flow current is:
93
94 //      2.4630542 i

```

---

enter the line data values in the order of starting bus, Ending bus, resistance and reactance:[1 0 0 0.1; 1 2 0 0.2; 2 0 0 0.1; 0 3 0 0.1; 3 1 0 0.1]

enter the bus at wich fault occurs:1

Enter the fault impedance:0.08\*%i

enter the pre-fault bus voltage:2

the impedance matrix is:

```
0.046875i  0.015625i  0.0375i
0.015625i  0.071875i  0.0125i
0.0375i    0.0125i   0.05i
```

the fault current is:

- 15.763547i

Post fault voltages v1,v2,v3 respectively are:

1.2610837

1.7536946

1.408867

enter the starting bus to calculate the line flow:1

enter the ending bus to calculate the line flow:2

enter the impedance between the above buses:0.2\*%i

the line flow current is:

2.4630542i

Figure 7.1: Analysis of Symmetrical Fault

*//Analysis of Symmetrical Fault in Power Systems//*

**Problem:** The one line diagram of a simple power system is shown below. Each generator is represented by an emf behind the transient reactance. All impedances are expressed in per unit on a common MVA base. All resistances and shunt capacitances are neglected. The generators are operating on no load at their rated voltage with their emfs in phase. A three phase fault occurs at bus 1 through a fault impedance of  $Z_f = j0.08$  per unit. Determine the fault current in per unit and the current flow from bus 1 to bus 2 after the occurrence of fault.

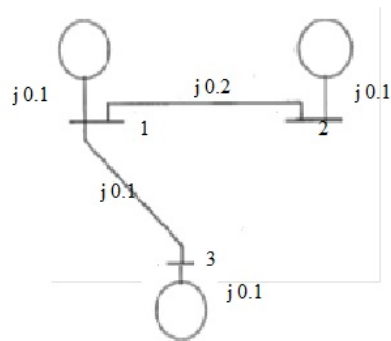


Figure 7.2: Analysis of Symmetrical Fault

## Experiment: 8

# Unsymmetrical Fault Analysis In Power Systems

Scilab code Solution 8.9 Analysis of Unsymmetrical Fault

```
1 //Analysis of Unsymmetrical Fault in Power Systems//
2 //This program requires user input. A sample problem
   with user input and output is available in the
   result file//
3 clc ;
4 clear;
5 a=input('Enter the positive ,negative and zero
   sequence of first generator in matrix form:')
6 PSG1=a(:,1); //positive sequence of Generator 1
7 NSG1=a(:,2); //negative sequence of Generator 1
8 ZSG1=a(:,3); //zero sequence of Generator 1
9 b=input('Enter the positive ,negative and zero
   sequence of first transformer in matrix form:')
10 PST1=b(:,1); //positive sequence of Transformer 1
11 NST1=b(:,2); //negative sequence of Transformer 1
12 ZST1=b(:,3); //zero sequence of Transformer 1
13 c=input('Enter the positive ,negative and zero
   sequence of first transmission line in matrix
   form:')
```

```

14 PSTL=c(:,1); //positive sequence of Transmission
    Line
15 NSTL=c(:,2); //negative sequence of Transmission
    Line
16 ZSTL=c(:,3); //zero sequence of Transmission Line
17 d=input('Enter the positive ,negative and zero
    sequence of second transformer in matrix form:')
18 PST2=d(:,1); //positive sequence of Transformer 2
19 NST2=d(:,2); //negative sequence of Transformer 2
20 ZST2=d(:,3); //zero sequence of Transformer 2
21 e=input('Enter the positive ,negative and zero
    sequence of second generator in matrix form:')
22 PSG2=e(:,1); //positive sequence of Generator 2
23 NSG2=e(:,2); //negative sequence of Generator 2
24 ZSG2=e(:,3); //zero sequence of Generator 2
25 MVAB=input('Enter the value of base MVA:');
26 KVB=input('Enter the value of base KV:');
27 z1=((PSG1*%i+PST1*%i)*(PSTL*%i+PST2*%i+PSG2*%i))/((
    PSG1*%i+PST1*%i)+(PSTL*%i+PST2*%i+PSG2*%i));//
    positive Sequence impedance
28 z2=((NSG1*%i+NST1*%i)*(NSTL*%i+NST2*%i+NSG2*%i))/((
    NSG1*%i+NST1*%i)+(NSTL*%i+NST2*%i+NSG2*%i));//
    Negative Sequence impedance
29 z0=((ZSG1*%i+ZST1*%i)*(ZSTL*%i+ZST2*%i+ZSG2*%i))/((
    ZSG1*%i+ZST1*%i)+(ZSTL*%i+ZST2*%i+ZSG2*%i));//
    Zero Sequence impedance
30 Ib=(MVAB*(10^6))/((1.732*KVB*(10^3)))//calculating
    base current
31 disp(z0,z2,z1,'The values of Positive(z1) Negative(
    z2) and Zero(z0) sequence impedances are
    respectively');
32 disp('OPTION','LG FAULT=1','LL FAULT=2','LLG FAULT=3
    ');
33 MENU=input('Enter the choice of fault:')
34 if MENU==1 //calculating Line to Ground fault
35     If=(3*(1))/(z0+z1+z2)
36     Faultycurrent=If*Ib;
37     disp(Faultycurrent,'The fault current is :');

```

```

38 end
39 if MENU==2//Calculating Line to Line Fault
40     If=((-1.732*(%i))*(1))/(z1+z2)
41     Faultycurrent=If*Ib;
42 disp(Faultycurrent,'The fault current is :');
43 end
44 if MENU==3//calculating Line-Line-Ground fault
45     z=(z0*z2)/(z0+z2);
46     Ia1=(1)/(z1+z);
47     Ia0=(-1+(Ia1*z1))/z0);
48     If=3*Ia0;
49     Faultycurrent=If*Ib;
50     disp(Faultycurrent,'The fault current is :');
51 end
52
53 //Sample Input and Output
54 //Enter the positive,negative and zero sequence of
55 //first generator in matrix form:[0.25 0.29 0.28]
56 //Enter the positive,negative and zero sequence of
57 //first transformer in matrix form:[0.48 0.47 0.49]
58 //Enter the positive,negative and zero sequence of
59 //first transmission line in matrix form:[0.20 0.22
60 //0.24]
61 //Enter the positive,negative and zero sequence of
62 //second transformer in matrix form:[0.18 0.22
63 //0.24]
64 //Enter the positive,negative and zero sequence of
65 //second generator in matrix form:[0.19 0.17 0.20]
66 //Enter the value of base MVA:100
67 //Enter the value of base KV:110
68
69 //The values of Positive(z1) Negative(z2) and Zero(
70 //z0) sequence impedances are respectively
71
72 // 0.3200769 i
73
74 // 0.3383942 i
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99

```

```
68 //      0.3611034 i
69
70 // LLG FAULT=3
71
72 // LL FAULT=2
73
74 // LG FAULT=1
75
76 // OPTION
77 //Enter the choice of fault:1
78
79 // The fault current is :
80
81 //  - 1544.4068 i
```

---

Enter the positive,negative and zero sequence of first generator in matrix form:[0.25 0.29 0.28]  
Enter the positive,negative and zero sequence of first transformer in matrix form:[0.48 0.47 0.49]  
Enter the positive,negative and zero sequence of first transmission line in matrix form:[0.20 0.22 0.24]  
Enter the positive,negative and zero sequence of second transformer in matrix form:[0.18 0.22 0.24]  
Enter the positive,negative and zero sequence of second generator in matrix form:[0.19 0.17 0.20]  
Enter the value of base MVA:100  
Enter the value of base KV:110

The values of Positive(z1) Negative(z2) and Zero(z0) sequence impedances are respectively

0.3200769i

0.3383942i

0.3611034i

LLG FAULT=3

LL FAULT=2

LG FAULT=1

OPTION

Enter the choice of fault:1

The fault current is :

- 1544.4068i

Figure 8.1: Analysis of Unsymmetrical Fault

//Analysis of Unsymmetrical Fault in Power Systems//

Determine the line to line fault, line to ground fault and double line to ground fault currents for the given impedance of positive, negative and zero sequences.

COMPONENTS	Positive Sequence Impedance (Z1)	Negative Sequence Impedance (Z2)	Zero Sequence Impedance (Z3)
Generator 1	0.25	0.29	0.28
Generator 2	0.19	0.17	0.20
Transformer 1	0.48	0.47	0.49
Transformer 2	0.18	0.22	0.23
Transmission Line	0.20	0.22	0.24

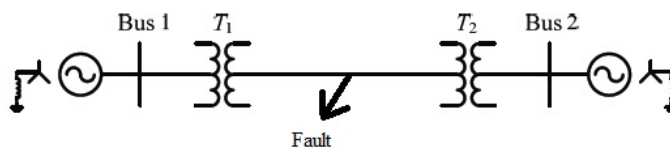


Figure 8.2: Analysis of Unsymmetrical Fault

## Experiment: 9

# Digital Simulation Of P, PI And PID Controllers.

Scilab code Solution 9.4 Digital Simulation of P PI PID Controllers

```
1 //Digital Simulation of P, PI, PD, and PID
  controllers
2 //Scilab Version 5.5.2 ; OS:Windows
3
4 //Program for Open Loop control system
5 num=poly([20], 's', 'coeff'); //Numerator input
6 den=poly([30 20 2], 's', 'coeff'); //Denominator input
7 q=syslin('c', num/den) //Ratio of the numerator to the
  denominator
8 t=0:0.05:2.5; //time interval
9 p=csim('step', t, q);
10 subplot(221)
11 plot2d(t, p);
12 xlabel('Time(Sec)')
13 ylabel('Amplitude')
14 xtitle('Digital Simulation of Open Loop control
  system')
```

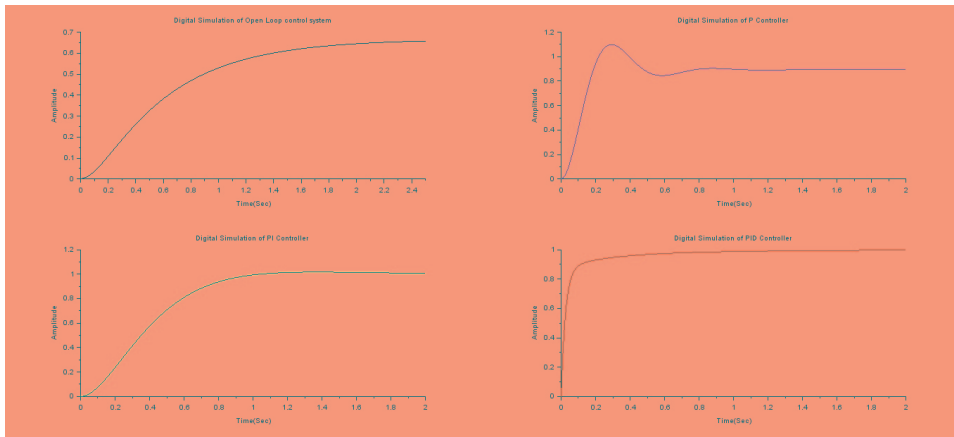


Figure 9.1: Digital Simulation of P PI PID Controllers

```

15
16 // Program for P Controller
17 kp=250;
18 num=poly([kp], 's', 'coeff');
19 den=poly([30+kp 20 2], 's', 'coeff');
20 q=syslin('c', num/den)
21 t=0:0.01:2;
22 p=csim('step', t, q);
23 subplot(222)
24 plot2d(t, p, style=color("red"));
25 xlabel('Time(Sec)')
26 ylabel('Amplitude')
27 xtitle('Digital Simulation of P Controller')
28
29 // Program for PI Controller
30 kp=40;
31 ki=80;
32 num=poly([ki kp], 's', 'coeff');
33 den=poly([ki 30+kp 20 2], 's', 'coeff');
34 q=syslin('c', num/den)
35 t=0:0.01:2;
36 p=csim('step', t, q);
37 subplot(223)

```

```
38 plot2d(t,p,style=color("blue"));
39 xlabel('Time(Sec)')
40 ylabel('Amplitude')
41 xtitle('Digital Simulation of PI Controller')
42
43 // Program for PID Controller
44 kp=400;
45 kd=70;
46 ki=400;
47 num=poly([ki kp kd], 's', 'coeff');
48 den=poly([ki 30+kp 20+kd 2], 's', 'coeff');
49 q=syslin('c',num/den)
50 t=0:0.01:2;
51 p=csim('step',t,q);
52 subplot(224)
53 plot2d(t,p,style=color("green"));
54 xlabel('Time(Sec)')
55 ylabel('Amplitude')
56 xtitle('Digital Simulation of PID Controller')
```

---

# Experiment: 10

## Simulation Of The Performance Of Single Phase Transformer

**Scilab code Solution 10.3** Performance Characteristics of Single Phase Transformer

```
1 //Program to Find the Performance Characteristics of
   Single Phase Transformer By Conducting Open
   Circuit test and Short Circuit Test
2 //This program requires user input. A sample problem
   with user input and output is available in the
   result files.
3 //Scilab Version 5.5.2 ; OS:Windows
4 clc;
5 clear;
6 //Getting the Rated values of Single Phase
   Transformer
7 disp('Name Plate Details')
8 cap=input('Enter the rated capacity of Tansformer in
   KVA:')
```

**Question**

Obtain the Performance Characteristics of a Single Phase Transformer for 0.6 and 0.8 lagging power factors with the following data:

Capacity = 3 KVA, Voltage ratio = 230 / 115 V

```
Scilab 5.5.2 Console

Name Plate Details
Enter the rated capacity of Transformer in KVA:3000
Enter the primary voltage of a Single Phase Transformer(HV) in Volts:230

The Primary current of transformer =

    13.043478
Enter the Secondary voltage of a Single Phase Transformer(LV) in Volts:115

The secondary current of transformer =

    26.086957

Open Circuit Test

The Iron Loss from Open circuit Test W0 = Wi =

    30.

Short Circuit Test

The Copper Loss from Open circuit Test Wsc = Wcu =

    150.
Enter the power factor = [0.6 0.8]

Output      Eff/PF=0.6      EFF/PF=0.8
0.          0.          0.
240.        85.106383  88.39779
480.        90.909091  93.023256
720.        92.544987  94.302554
960.        93.023256  94.674556
1200.       93.023256  94.674556
1440.       92.783505  94.488189
1680.       92.409241  94.196804
1920.       91.954023  93.841642
2160.       91.447925  93.445814
2400.       90.909091  93.023256
```

Figure 10.1: Performance Characteristics of Single Phase Transformer

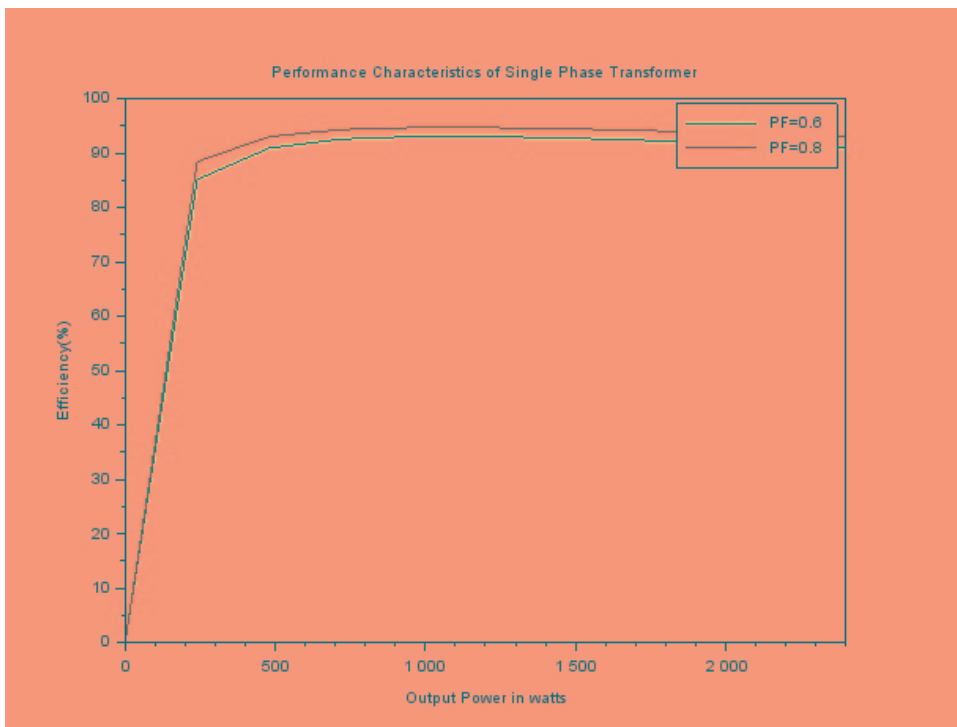


Figure 10.2: Performance Characteristics of Single Phase Transformer

```

9  pv=input('Enter the primary voltage of a Single
    Phase Transformer(HV) in Volts:')
10 pc=cap/pv//calculation of primary current , capacity/
    Primary voltage
11 disp(pc, 'The Primary current of transformer =')
12 sv=input('Enter the Secondary voltage of a Single
    Phase Transformer(LV) in Volts:')
13 sc=cap/sv//calculation of secondary current ,
    capacity/secondary voltage
14 disp(sc, 'The secondary current of transformer =')
15 //open Circuit Test
16 //For open circuit test , Consider the LV side as
    primary , HV side is kept open
17 disp('Open Circuit Test')
18 v0=sv//open circuit voltage
19 i0=0.01*sc//for practical case , there will be
    negligible amount of open circuit current
20 w0=v0*i0//calculation of Primary power , voltage*
    current
21 disp(w0, 'The Iron Loss from Open circuit Test W0 =
    Wi = ')
22 //Short Circuit Test
23 //For Short circuit test , Consider the HV side as
    primary , LV side is shorted
24 disp('Short Circuit Test')
25 vsc=pv*0.05//for practical case , there will be
    negligible amount of short circuit voltage
26 isc=pc//short circuit current
27 wsc=vsc*isc//calculation of secondary power , voltage
    *current
28 disp(wsc, 'The Copper Loss from Open circuit Test
    Wsc = Wcu = ')
29 //Predetermine the efficiency
30 t=1;
31 pf=input('Enter the power factor = ')
32 for j=1:length(pf)
33 //l=input('Enter the fraction of load = ')
34 i=1;

```

```

35 for l=0:0.1:1
36 op(i)=cap*l*pf(j)
37 //disp(op, 'Output Power of Transformer is ')
38 //total loss in a transformer = copper loss + Iron
    loss
39 los(i)=w0+(wsc*l^2)
40 ip(i)=op(i)+los(i)
41 //disp(ip, 'Input Power of Transformer is ')
42 eff(i,t)=(op(i)/ip(i))*100
43 i=i+1;
44 //disp(eff, 'Efficiency of Transformer is ')
45 end
46 //plotting the curve of the Performannce
    Characteristics of transformer
47 //between Output power and Efficiency for different
    values of fraction of load
48 t=t+1;
49 end
50 disp([op    eff(:,1)    eff(:,2)], 'Output    Eff/PF
    =0.6    EFF/PF=0.8 ')
51 plot(op,eff(:,1),op,eff(:,2));
52 legend('PF=0.6', 'PF=0.8');
53 xlabel('Output Power in watts')
54 ylabel('Efficiency (%)')
55 title('Performance Characteristics of Single Phase
    Transformer')
56
57 //SAMPLE INPUT and OUTPUT
58
59 //Name Plate Details
60 //Enter the rated capacity of Tansformer in KVA:3000
61 //Enter the primary voltage of a Single Phase
    Transformer(HV) in Volts:230
62
63 //The Primary current of transformer =
64
65 //    13.043478
66 //Enter the Secondary voltage of a Single Phase

```

```

Transformer(LV) in Volts:115
67
68 // The secondary current of transformer =
69
70 //      26.086957
71
72 // Open Circuit Test
73
74 // The Iron Loss from Open circuit Test W0 = Wi =
75
76 //      30.
77
78 // Short Circuit Test
79
80 // The Copper Loss from Open circuit Test Wsc = Wcu
    =
81
82 //      150.
83 //Enter the power factor = [0.6 0.8]
84
85 //Output      Eff/PF=0.6      EFF/PF=0.8
86
87 //      0.      0.      0.
88 //      240.      85.106383      88.39779
89 //      480.      90.909091      93.023256
90 //      720.      92.544987      94.302554
91 //      960.      93.023256      94.674556
92 //      1200.      93.023256      94.674556
93 //      1440.      92.783505      94.488189
94 //      1680.      92.409241      94.196804
95 //      1920.      91.954023      93.841642
96 //      2160.      91.447925      93.445814
97 //      2400.      90.909091      93.023256
98
99 //efficiency curve will be obtained in figure

```

---