Scilab Manual for
Digital Control And Instrumentation Laboratory
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Contents

List of Experiments

List of Figures

Experiment: 1

Simulation Of Single Phase Full Wave Controlled Rectifier

This code can be downloaded from the website wwww.scilab.in
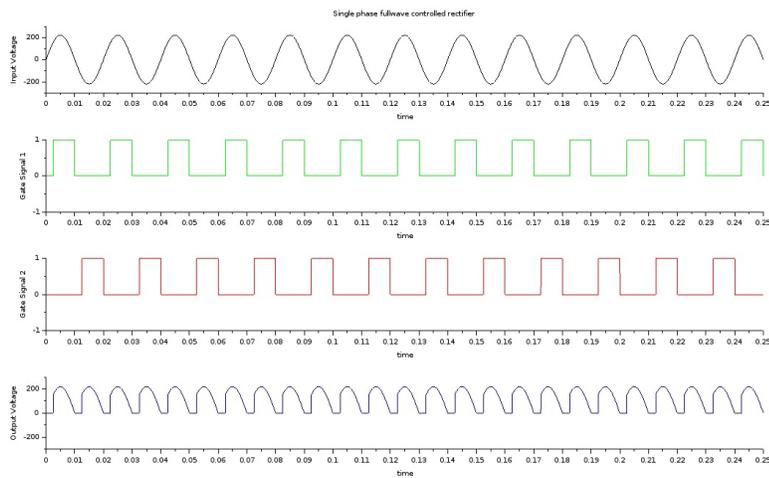
Figure 1.1: Single phase Full wave Controlled Rectifier

Experiment: 2

Simulation Of Single Phase Half Wave Controlled Rectifier

This code can be downloaded from the website wwww.scilab.in
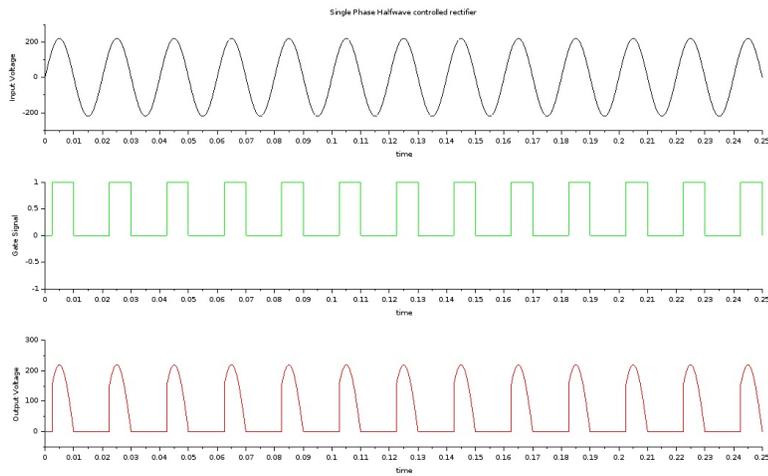
Figure 2.1: Single phase Half wave Controlled Rectifier

Experiment: 3

Simulation Of Three Phase Full Wave Controlled Rectifier

This code can be downloaded from the website wwww.scilab.in
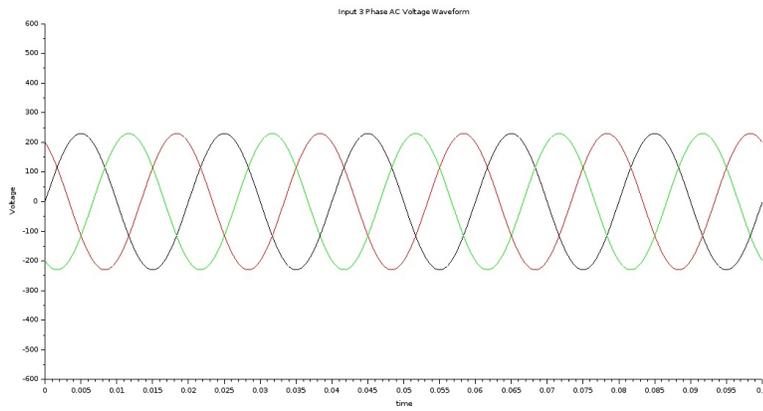
Figure 3.1: Three Phase Full Wave Controlled Rectifier
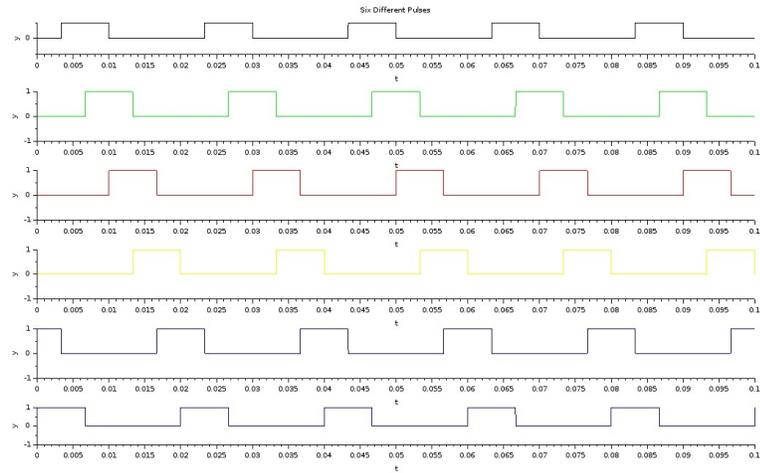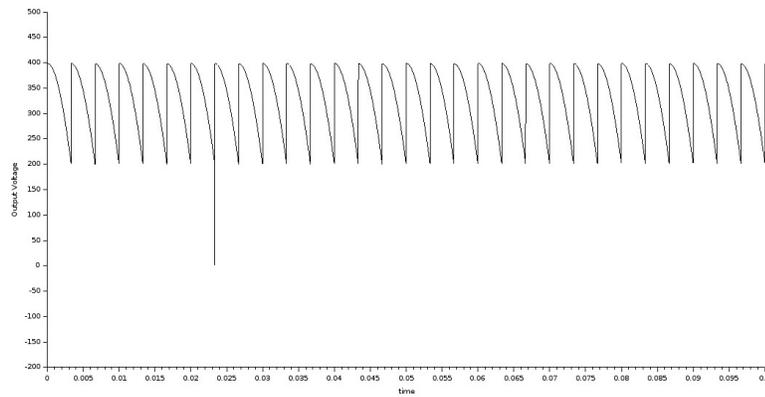
Figure 3.2: Three Phase Full Wave Controlled Rectifier

Experiment: 4

Simulation Of Three Phase Half Wave Controlled Rectifier

This code can be downloaded from the website wwww.scilab.in
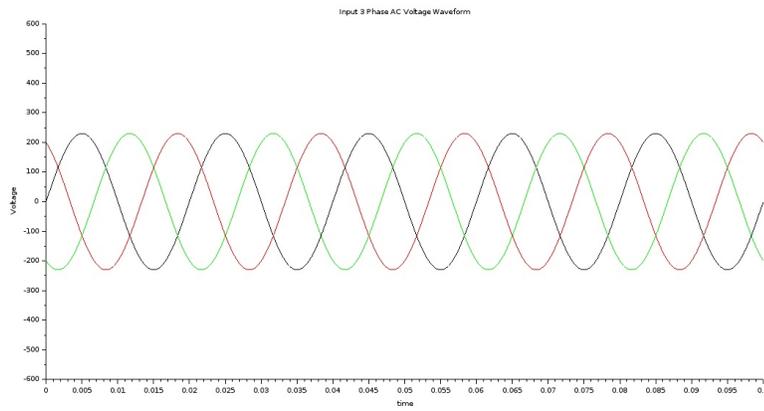
Figure 4.1: Three Phase Half Wave Controlled Rectifier
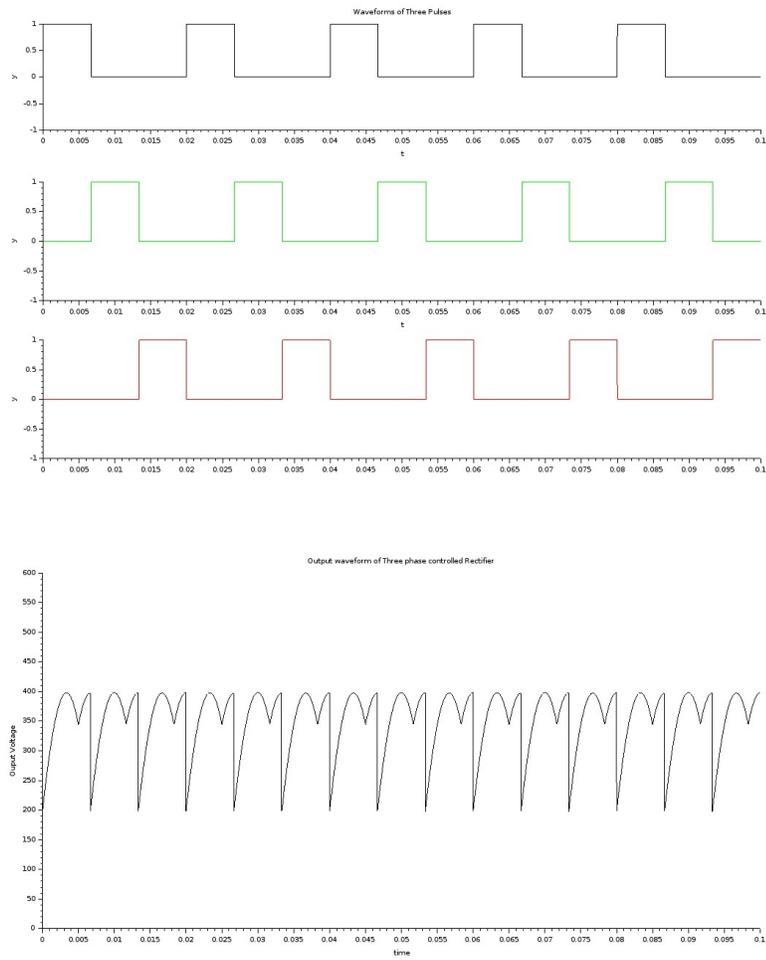
Figure 4.2: Three Phase Half Wave Controlled Rectifier

14

Experiment: 5

Frequency Response Of Single Area Power System

This code can be downloaded from the website wwww.scilab.in
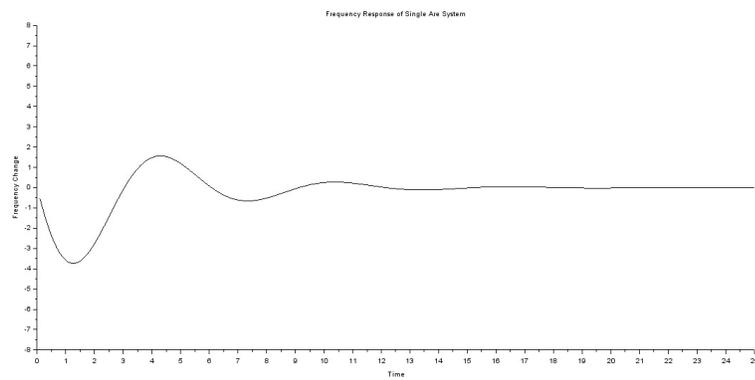
Figure 5.1: Single Area System

Experiment: 6

Frequency Response Of Two Area Power System

This code can be downloaded from the website wwww.scilab.in
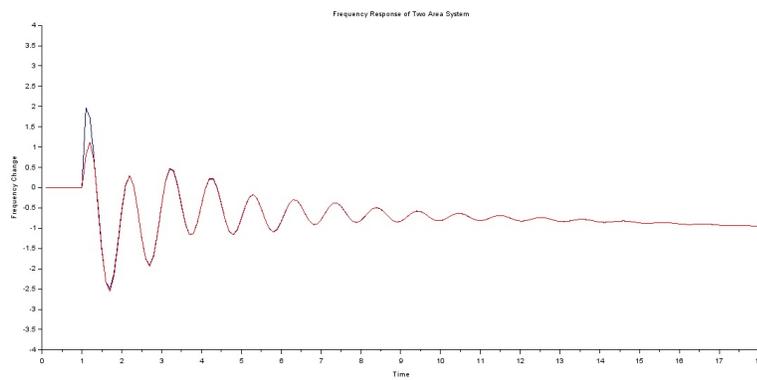
Figure 6.1: Two Area System

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=[];
```

```matlab
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
```

```scilab
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
```

21

```
68  //Enter  the  fault  impedance:0.08*%i
69  //enter  the  pre−fault  bus  voltage:2
70
71  //  the  impedance  matrix  is:
72
73  //     0.046875i      0.015625i      0.0375i
74  //     0.015625i      0.071875i      0.0125i
75  //     0.0375i        0.0125i        0.05i
76
77  //  the  fault  current  is:
78
79  //  − 15.763547i
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  //     2.4630542i
```

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

23

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.
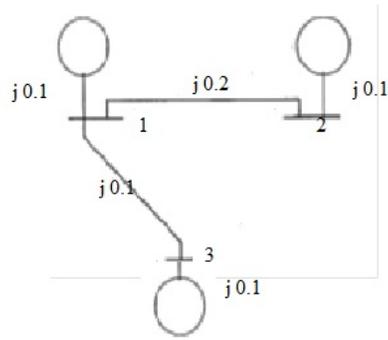
Figure 7.2: Analysis of Symmetrical Fault

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 positve ,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 positve ,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 positve ,negative and zero
       sequence of first transmission line in matrix
       form:')
```

```scilab
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 positve,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 impedence
28  z2=((NSG1*%i+NST1*%i)*(NSTL*%i+NST2*%i+NSG2*%i))/((
        NSG1*%i+NST1*%i)+(NSTL*%i+NST2*%i+NSG2*%i));//
        Negative Sequence impedence
29  z0=((ZSG1*%i+ZST1*%i)*(ZSTL*%i+ZST2*%i+ZSG2*%i))/((
        ZSG1*%i+ZST1*%i)+(ZSTL*%i+ZST2*%i+ZSG2*%i));//
        Zero Sequence impedence
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 :');
```

26

```scilab
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 positve,negative  and zero sequence of
        first generator in matrix form:[0.25 0.29 0.28]
55  //Enter the positve,negative and zero sequence of
        first transformer in matrix form:[0.48 0.47 0.49]
56  //Enter the positve,negative and zero sequence of
        first transmission line in matrix form:[0.20 0.22
         0.24]
57  //Enter the positve,negative and zero sequence of
        second transformer in matrix form:[0.18 0.22
        0.24]
58  //Enter the positive,negative and zero sequence of
        second generator in matrix form:[0.19 0.17 0.20]
59  //Enter the value of base MVA:100
60  //Enter the value of base KV:110
61
62  //The values of Positive(z1) Negative(z2) and Zero(
       z0) sequence impedances are respectively
63
64  //     0.3200769i
65
66  //     0.3383942i
67
```

27

```
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 positve,negative and zero sequence of first generator in matrix form:[0.25 0.29 0.28]
Enter the positve,negative and zero sequence of first transformer in matrix form:[0.48 0.47 0.49]
Enter the positve,negative and zero sequence of first transmission line in matrix form:[0.20 0.22 0.24]
Enter the positve,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

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
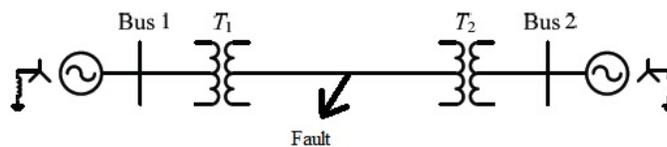
Figure 8.2: Analysis of Unsymmetrical Fault

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')
```
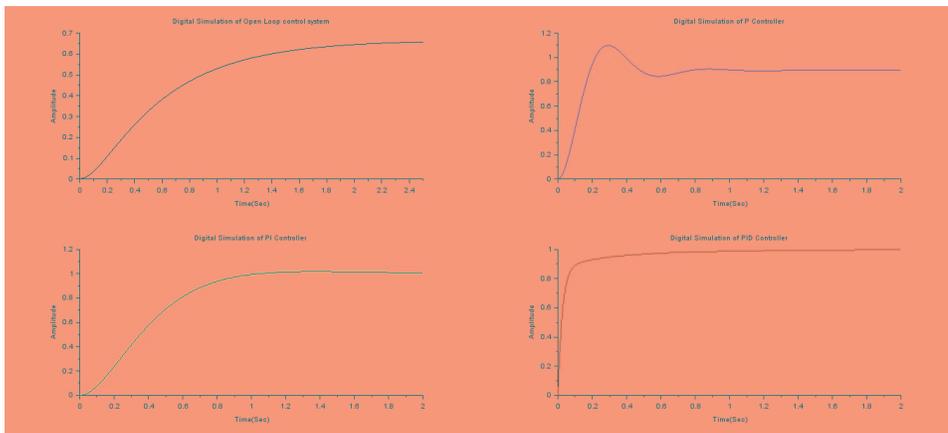
Figure 9.1: Digital Simulation of P PI PID Controllers

```
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 Charatceristics 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 Tansformer 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 Circut 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
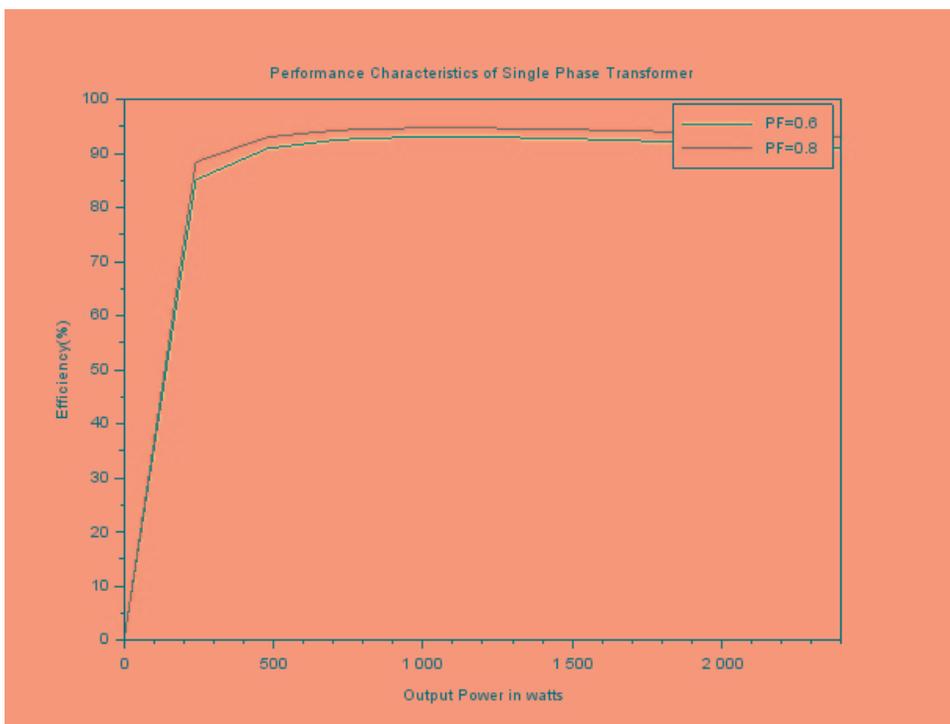
35

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 Circut Test')
18 v0=sv//open circuit voltage
19 i0=0.01*sc//for practical case, there will be
      negligible amount ofopen 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 Circut 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 Circut Test

73
74  // The Iron Loss from Open circuit Test W0 = Wi =

75
76  //     30.

77
78  // Short Circut 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  //efficieny curve will be obtained in figure
```