VARDHAMAN COLLEGE OF ENGINEERING

(AUTONOMOUS)

Affiliated to **JNTUH**, Approved by **AICTE**, Accredited by **NAAC** with **A++** Grade, **ISO 9001:2015** Certified

Kacharam, Shamshabad, Hyderabad – 501218, Telangana, India

Department of Electrical and Electronics Engineering

Power System Switchgear and Protection (A6215)

LAB

OBSERVATION BOOK

Name of the Student: ………………………………………………………………

Roll Number: ………………………………………………………………………..

Year: ………………………. Sem: ………… Section: …………

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Kacharam, Shamshabad, Hyderabad – 501218, Telangana, India

B. Tech. EEE IV Year, I SEM **Regulation: VCE-R20**
Power System Switchgear and Protection LAB
Course Code: A6215 **L T P C: 2 0 2 3**

LIST OF EXPERIMENTS:

1. Determination of Bus Admittance Matrix (Y-Bus) using MATLAB.

2. Determination of Bus Impedance Matrix (Z-Bus) using MATLAB.

3. Load flow analysis using Gauss – Seidal Method using MATLAB.

4. Load flow analysis using Newton Raphson Method Using MATLAB.

5. Determination of symmetrical components using MATLAB.

6. Study of LG, LL, LLG, LLL, and LLLG faults using PSCAD.

7. PSCAD Simulation of a circuit breaker operation.

8. IDMT Characteristics of a fuse.

9. IDMT Characteristics of a circuit breaker.

10. LG Fault of a long transmission line.

11. Measurement of earth resistivity.

12. Protection of Transmission Line with distance relays using PSCAD.

Power System Switchgear and Protection Lab **Course Code: A6215**

CYCLE-I EXPERIMENTS

1. Study of LG, LL, LLG, LLL, and LLLG faults using PSCAD.
2. PSCAD Simulation of a circuit breaker operation.
3. Protection of Transmission Line with distance relays using PSCAD.

CYCLE-II EXPERIMENTS

1. Determination of Bus Admittance Matrix (Y-Bus) using MATLAB.
2. Determination of Bus Impedance Matrix (Z-Bus) using MATLAB.
3. Load flow analysis using Gauss – Seidal Method using MATLAB.
4. Load flow analysis using Newton Raphson Method Using MATLAB.
5. Determination of symmetrical components using MATLAB.

CYCLE-III EXPERIMENTS

1. IDMT Characteristics of a fuse.
2. IDMT Characteristics of a circuit breaker.
3. LG Fault of a long transmission line.
4. Measurement of earth resistivity.

EXPERIMENT 1- Determination of Bus Admittance Matrix (Y-Bus) using MATLAB

1.1 OBJECTIVE

Formation of bus admittance matrices of a power network using MATLAB from given data.

1.2 RESOURSE

MATLAB

1.3 THEORY

Y bus is an *N x N* matrix describing a linear power system with *N* buses. It represents the nodal admittance of the buses in a power system. In realistic systems which contain thousands of buses, the Y matrix is quite sparse. Each bus in a real power system is usually connected to only a few other buses through the transmission lines. The Y Matrix is also one of the data requirements needed to formulate a power flow study.

1.4 PROCEDURE

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File.
3. Type and save the program in the editor Window.
4. Execute the program by pressing Tools – Run.
5. View the results.

1.5 PROBLEM

Figure 1 shows the one line diagram of a simple four-bus system. Table 1 gives the line impedances identified by the buses on which these terminate. The shunt admittance at all the buses is assumed to be negligible. Form Y_{BUS}.

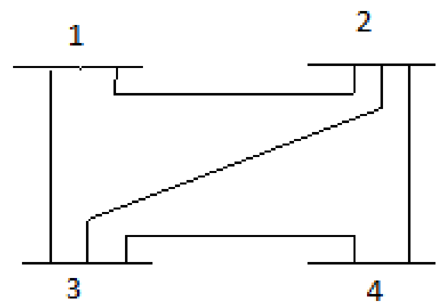


Figure.1.Four-bus system

S.No.	Line Bus to bus	X, pu	R, pu
1.	1-2	0.15	0.05
2.	1-3	0.30	0.10
3.	2-3	0.45	0.15
4.	2-4	0.30	0.10
5.	3-4	0.15	0.05

Table 1

1.6 PROGRAM

```
clear all;
clc;
display('----------Ybus formation code--------');
nbranch=input('enter the number of branches in system = ');
display('enter line data');
for n=1:1:nbranch

   fb=input('enter from bus = ');
   tb=input('enter to bus = ');
   r=input('enter value of resistance = ');
   x=input('enter value of reactance = ');
   B=input('enter the value of line charging admittance(b/2) = ');
   fprintf('\n\n')
   z=r+i*x;
   y=1./z;
   data(n,:)=[fb tb r x B y];
end
fb=data(:,1);
tb=data(:,2);
r=data(:,3);
x=data(:,4);
b=data(:,5);
y=data(:,6);

b=i*b;

nbus=max(max(fb),max(tb));
Y=zeros(nbus,nbus);
```

```
% off diagonal element

for k=1:nbranch
   Y(fb(k),tb(k))=Y(fb(k),tb(k))-y(k);
   Y(tb(k),fb(k))=Y(fb(k),tb(k));
end

% diagonal element

for m=1:nbus
   for n=1:nbranch
      if fb(n)==m
         Y(m,m)=Y(m,m)+y(n)+b(n);
      elseif tb(n)==m
         Y(m,m)=Y(m,m)+y(n)+b(n);
      end
   end
end

Y_bus=Y
Z_bus=Y_bus^-1
```

1.7 OUTPUT

```
Y_bus =

   3.0000 - 9.0000i   -2.0000 + 6.0000i   -1.0000 + 3.0000i        0

  -2.0000 + 6.0000i    3.6667 -11.0000i   -0.6667 + 2.0000i   -1.0000 + 3.0000i

  -1.0000 + 3.0000i   -0.6667 + 2.0000i    3.6667 -11.0000i   -2.0000 + 6.0000i

       0              -1.0000 + 3.0000i   -2.0000 + 6.0000i    3.0000 - 9.0000i

Z_bus =

   1.0e+15 *

   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i

   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i

   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i   0.0000 - 1.1259i

   0.0000 - 1.1259i   0.0000 - 1.1259i        0 - 1.1259i        0 - 1.1259i
```

1.8 RESULT

1.9 THEORETICAL CALCULATION:

Experiment -2. Determination of Bus Impedance Matrix (Z-Bus) using MATLAB.

2.1 OBJECTIVE

To determine the bus impedance matrix for the given power system network.

2.2 RESOURSE

MATLAB

2.3 THEORY

The Z-Matrix or bus impedance matrix is an important tool in power system analysis. Though, it is not frequently used in power flow study, unlike Y-bus matrix, it is, however, an important tool in other power system studies like short circuit analysis or fault study. The Z-bus matrix can be computed by matrix inversion of the Y-bus matrix. Since the Y-bus matrix is usually sparse, the explicit Z-bus matrix would by dense so memory intensive to handle directly.

2.4 PROCEDURE

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File.
3. Type and save the program in the editor Window.
4. Execute the program by pressing Tools – Run.
5. View the results.

2.5 PROBLEM

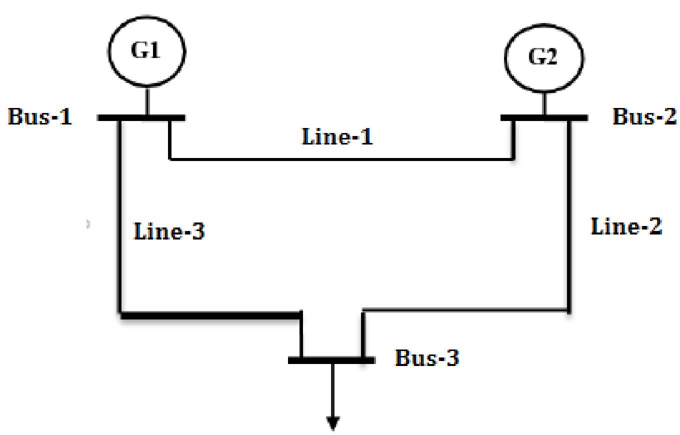


Fig.2. Power system network

Table. Line specifications

Line no.	Start bus	End bus	Series impedance (P.U.)	Half-line charging admittance (P.U.)	Rating MW
1	1	2	0.001 + j 0.015	0.001	60
2	2	3	0.002 + j 0.021	0.005	40
3	3	1	0.004 + j 0.046	0.0015	65

Shunt element Details

Bus	MVAR
3	50

2.6 PROGRAM

```
linedata = [1  1  2  0.001  0.015  0.001
2  2  3  0.002  0.021  0.0005
3  3  1  0.004  0.046  0.0015 ];
fb = linedata(:,1);
tb = linedata(:,2);
r = linedata(:,3);
x = linedata(:,4);
b = linedata(:,5);
z = r + i*x;
y = 1./z; b = i*b;
nbus = max(max(fb),max(tb));
nbranch = length(fb);
Y = zeros(nbus,nbus);
for k=1:nbranch
Y(fb(k),tb(k)) = Y(fb(k),tb(k))-y(k);
Y(tb(k),fb(k)) = Y(fb(k),tb(k));
end
for m =1:nbus
for n =1:nbranch
if fb(n) == m
Y(m,m) = Y(m,m) + y(n)+ b(n);
elseif tb(n) == m
Y(m,m) = Y(m,m) + y(n) + b(n);
end
end
end
Y
zbus = inv(Y)
```

2.7 OUTPUT:

Y =

0 + 0.0150i	0	0
0	0 + 0.0210i	0
0	0	0 + 0.0460i

zbus =

0 -66.6667i	0	0
0	0 -47.6190i	0
0	0	0 -21.7391i

2.8 RESULT

2.9 THEORETICAL CALCULATION:

EXPERIMENT 3- Load flow analysis Using GAUSS-SEIDAL METHOD Using MATLAB

3.1 OBJECTIVE

To carry out load flow analysis of the given power system network by Gauss Seidel method

3.2 APPARATUS

MATLAB

3.3 THEORY

Load flow analysis is the study conducted to determine the steady state operating condition of the given system under given conditions. A large number of numerical algorithms have been developed and Gauss Seidel method is one of such algorithm.

3.4 PROCEDURE

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File.
3. Type and save the program in the editor Window.
4. Execute the program by pressing Tools – Run.
5. View the results.

3.5 PROBLEM

For the power system shown in figure, solve for V2 and V3 using GS method. The bus data is given in table, values are in Pu.

Bus	Voltage	Gen		Load		Type
		Pg	Qg	Pl	Ql	(Remarks)
1	$1.20 \angle 0$	-	-	-	-	Slack bus
2	-	0.7	0.5	0.3	0.2	Load bus
3	-	0	0	0.6	0.4	Load bus

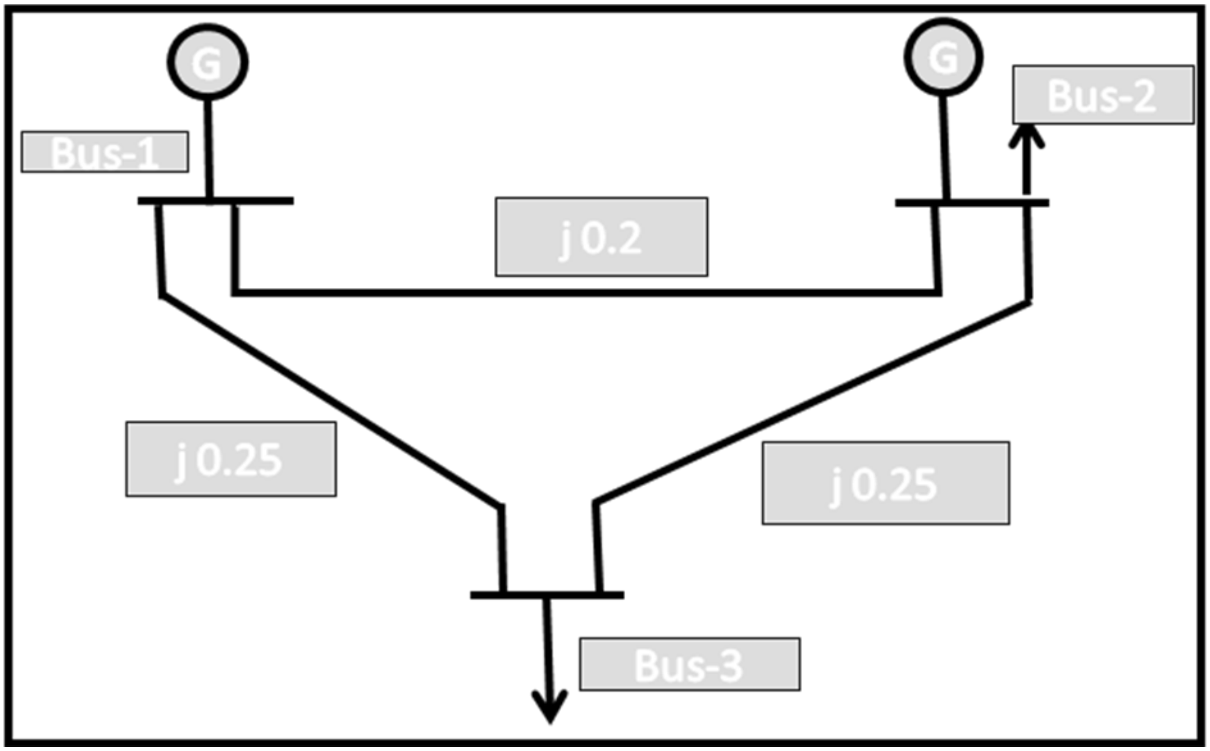


Fig.3.Three-bus system

3.6 MATLAB PROGRAM

```
clc;clear all
% Step1 : Obtain Power Injections Pi= Pg- Pl  & Qi=Qg-Ql
pi2=0.7-0.3;
qi2=0.5-0.2;
pi3=0-0.6;
qi3=0-0.4;
% Step2: Construct Y bus
Y=[-9i 5i 4i
   5i -9i 4i
   4i 4i -8i];
% Step 3 (a): Inital values for V2 and V3
V2=1; V3=1;
% Step3 (b): Iterative computation of V2 and V3
disp('Iterations   V2     d2     V3     d3')
for k=1:20
V2iter=1/Y(2,2)*((pi2-i*qi2)/conj(V2)-Y(2,1)*1.02- Y(2,3)*V3);
%Check for convergence
```

```
if(abs(V2iter-V2)<= 0.00001)
   return  % if the solution is obtained
end
% if it does not converge
V2=V2iter;
V3=1/Y(3,3)*((pi3-i*qi3)/conj(V3)-Y(3,1)*1.02- Y(3,2)*V2);
iter=[k abs(V2) angle(V2)*180/pi abs(V3)  angle(V3)*180/pi];
disp(iter)
end
```

3.7 OUTPUT

Iterations	V2	d2	V3	d3
1.0000	1.0454	2.4366	0.9836	-3.0757
2.0000	1.0335	1.1297	0.9738	-3.7223
3.0000	1.0301	0.8641	0.9710	-3.8829
4.0000	1.0290	0.8022	0.9701	-3.9231
5.0000	1.0287	0.7876	0.9699	-3.9334
6.0000	1.0286	0.7841	0.9698	-3.9362
7.0000	1.0286	0.7832	0.9698	-3.9369

Note: From above GS Method converged at 7th iteration.

3.8 RESULT

3.9 THEORETICAL CALCULATION:

EXPERIMENT 4: LOAD FLOW ANALYSIS USING NEWTON RAPSHON METHOD USING MATLAB

4.1 OBJECTIVE:

To carry out load flow analysis of the given power system by Newton Raphson method.

4.2 RESOURCE:

MATLAB

4.3 PROCEDURE:

6. Enter the command window of the MATLAB.
7. Create a new M – file by selecting File - New – M – File.
8. Type and save the program in the editor Window.
9. Execute the program by pressing Tools – Run.
10. View the results.

4.4 PROBLEM:

Consider the three-bus system of given figure. Each of the three lines has a series impedance of 0.02+j0.08 pu and a total shunt admittance of j0.02 pu. The specified quantities at the buses are

Bus	P_D	Q_D	P_G	Q_G	Voltage Specification
1	2	1	Unspecified	Unspecified	V_1=1.04+j0 (slack bus)
2	0	0	0.5	1	Unspecified (PQ bus)
3	1.5	0.6	0	Q=?	V_3=1.04 (PVbus)

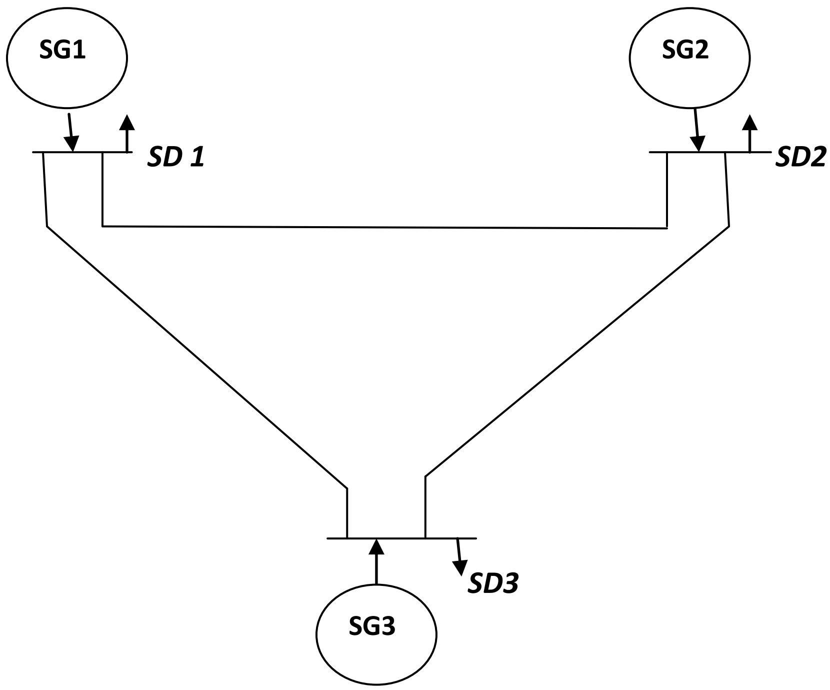


Figure.4.Three-Bus system

Controllable reactive power source is available at bus 3 with the constraint,

$0 \leq Q_{G3} \leq 1.5\ pu$

4.5 MATLAB PROGRAM:

```
n=3;

V=[1.04  1  1.04];

Y=[5.88228-j*23.50514   -2.9427+j*11.7676    -2.9427+j*11.7676

   -2.9427+j*11.7676    5.88228-j*23.50514   -2.9427+j*11.7676

   -2.9427+j*11.7676    -2.9427+j*11.7676    5.88228-j*23.50514];

type=ones(n,1);
typechanged=zeros(n,1);
Qlimitmax=zeros(n,1);
Qlimitmin=zeros(n,1);
Vmagfixed=zeros(n,1);
type(3)=2;
Qlimitmax(3)=1.5;
Qlimitmin(3)=0;
Vmagfixed(2)=1.04;
```

```
diff=10;
noofiter=1;
   Pspec=[inf 0.5 -1.5];
   Qspec=[inf 1 0];
   S=[inf+j*inf 0.5+j*1 -1.5+j*0];
while(diff>0.00001|| noofiter==1)
   eqcount=1;
   for i=2:n,
      Scal(i)=0;
      sumyv=0;
      for k=1:n,
         sumyv=sumyv+Y(i,k)*V(k);
      end
      Scal(i)=V(i)*conj(sumyv);
      P(i)=real(Scal(i));
      Q(i)=imag(Scal(i));
      if type(i)==2 || typechanged(i)==1,
         if (Q(i)>Qlimitmax(i) || Q(i)<Qlimitmin(i)),
            if (Q(i)<Qlimitmin(i)),
               Q(i)=Qlimitmin(i);
            else
               Q(i)<Qlimitmax(i);
            end
            type(i)=1;
            typechanged(i)=1;
         else
            type(i)=2;
            typechanged(i)=0;
         end
      end
      if type(i)==1,
         assoeqvar(eqcount)='P';
         assoeqbus(eqcount)=i;
         mismatch(eqcount)=Pspec(i)-P(i);
         assoeqvar(eqcount+1)='Q';
         assoeqbus(eqcount+1)=i;
         mismatch(eqcount+1)=Qspec(i)-Q(i);
         assocolvar(eqcount)='d';
         assocolbus(eqcount)=i;
```

```
          assocolvar(eqcount+1)='V';
          assocolbus(eqcount+1)=i;
          eqcount=eqcount+2;
        else
          assoeqvar(eqcount)='P';
          assoeqbus(eqcount)=i;
          assocolvar(eqcount)='d';
          assocolbus(eqcount)=i;
          mismatch(eqcount)=Pspec(i)-P(i);
          eqcount=eqcount+1;
        end
    end
    mismatch
    eqcount=eqcount-1;
    noofeq=eqcount;
    update=zeros(eqcount,1);
    Vprev=V
    abs(V);
    abs(Vprev);
    pause
    Vprev=V;
    for ceq=1:eqcount,
        for ccol=1:eqcount,
          am=real(Y(assoeqbus(ceq),assocolbus(ccol))*V(assocolbus(ccol)));
          bm=imag(Y(assoeqbus(ceq),assocolbus(ccol))*V(assocolbus(ccol)));
          ei=real(V(assoeqbus(ceq)));
          fi=imag(V(assoeqbus(ceq)));
          if assoeqvar(ceq)=='P' & assocolvar(ccol)=='d',
            if assoeqbus(ceq)~=assocolbus(ccol),
               H=am*fi-bm*ei;
            else
               H=-
Q(assoeqbus(ceq))+imag(Y(assoeqbus(ceq),assocolbus(ceq))*abs(V(assoeqbus(ceq)))^2);
            end
            Jacob(ceq,ccol)=H
          end
          if assoeqvar(ceq)=='P' & assocolvar(ccol)=='V',
            if assoeqbus(ceq)~=assocolbus(ccol),
               N=am*ei+bm*fi;
            else
```

```
N=P(assoeqbus(ceq))+real(Y(assoeqbus(ceq),assocolbus(ceq))*abs(V(assoeqbus(ceq)))^2);
            end
            Jacob(ceq,ccol)=N
          end
          if assoeqvar(ceq)=='Q' & assocolvar(ccol)=='d',
             if assoeqbus(ceq)~=assocolbus(ccol),
                  J=am*ei+bm*fi;
             else

J=P(assoeqbus(ceq))+real(Y(assoeqbus(ceq),assocolbus(ceq))*abs(V(assoeqbus(ceq)))^2);
             end
            Jacob(ceq,ccol)=J
          end
          if assoeqvar(ceq)=='Q' & assocolvar(ccol)=='V',
             if assoeqbus(ceq)~=assocolbus(ccol),
                  L=am*ei-bm*fi;
             else
                L=Q(assoeqbus(ceq))-
imag(Y(assoeqbus(ceq),assocolbus(ceq))*abs(V(assoeqbus(ceq)))^2);
             end
            Jacob(ceq,ccol)=L
          end
       end
    end
    Jacob
    pause
    update=inv(Jacob)*mismatch';
    noofeq=1;
    for i=2:n,
       if type(i)==1
          newchinangV=update(noofeq);
          newangV=angle(V(i))+newchinangV;
          newchinmagV=update(noofeq+1)*abs(V(i));
          newmagV=abs(V(i))+newchinmagV;
          V(i)=polarTorect(newmagV,newangV*180/pi);
          noofeq=noofeq+2;
       else
          newchinangV=update(noofeq);
           newangV=angle(V(i))+newchinangV;
```

```
         V(i)=polarTorect(abs(V(i)),newangV*180/pi);
        noofeq=noofeq+1;
      end
    end
    diff=min(abs(abs(V(2:n))-abs(Vprev(2:n))));
    noofiter=noofiter+1;
end
```

Output:

```
V =

1.0400      1.0400      1.0000      1.0123 + 0.0329i
```

4.6 RESULT:

4.7 PRE LAB QUESTIONS:

1. What are practical considerations of Newton Raphson method?
2. Write about the convergence of Newton Raphson method.
3. What are quasi Newton methods?

4.8 POST LAB QUESTIONS:

1. On which type of systems, can this method be applied?
2. How to solve linear and non linear equations?
3. What are the advantages and disadvantages of this method?

4.9 THEORETICAL CALCULATION:

EXPERIMENT-5 Determination of Symmetrical components using MATLAB

5.1 OBJECTIVE

To determine the symmetrical components using MATLAB

5.2 RESOURSE

MATLAB

5.3 PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File.
3. Type and save the program in the editor Window.
4. Execute the program by pressing Tools – Run.
5. View the results.

5.4 THEORY

When the system is unbalanced the voltages, currents and the phase impedances are in general unequal. Such a system can be solved by a symmetrical per phase technique, known as the method of symmetrical components. This method is also called a three-component method. The method of symmetrical components simplified the problems of the unbalanced three-phase system. It is used for any number of phases but mainly used for the three-phase system.

5.5 PROBLEM

Obtain the symmetrical components of a set of unbalanced currents I_a =1.4, I_b =1.0, I_c =0.7.

5.6 PROGRAM

```
% MATLAB Program to convert phase to symmetrical components
% Input Argument
% vabc =    [phase A magnitude, phase A angle (degree);
%           phase B magnitude, phase B angle (degree);
%           phase C magnitude, phase C angle (degree)]
vabc=input('Enter phase quantities == ')
[x, y]=pol2cart((pi*vabc(1,2))/180,vabc(1,1));
pa = complex(x,y);
[x, y]=pol2cart((pi*vabc(2,2))/180,vabc(2,1));
pb = complex(x,y);
[x, y]=pol2cart((pi*vabc(3,2))/180,vabc(3,1));
pc = complex(x,y);

a = -0.5+0.866i;
a2 = -0.5-0.866i;
A1 = [1 1 1;1 a a2;1 a2 a]/3;
mag = abs(A1*[pa;pb;pc]);
ang = (angle(A1*[pa;pb;pc])*180)/pi;
```

```
% Output Argument
% v012 =    [zero sequence magnitude, zero sequence angle (degree);
%           positive sequence magnitude, positive sequence angle(degree);
%           negative sequence magnitude, negative sequence angle(degree)]
v012 = horzcat(mag, ang)
```

5.7 OUTPUT

```
v012 =

   0.5389    104.7485
   0.7317    4.8332
   0.5694    45.6502
```

5.8 RESULT

5.9. THEORETICAL ALCULATION:

EXPERIMENT-6: Study of LG, LL, LLG, LLL AND LLLG faults using PSCAD

6.1 OBJECTIVE

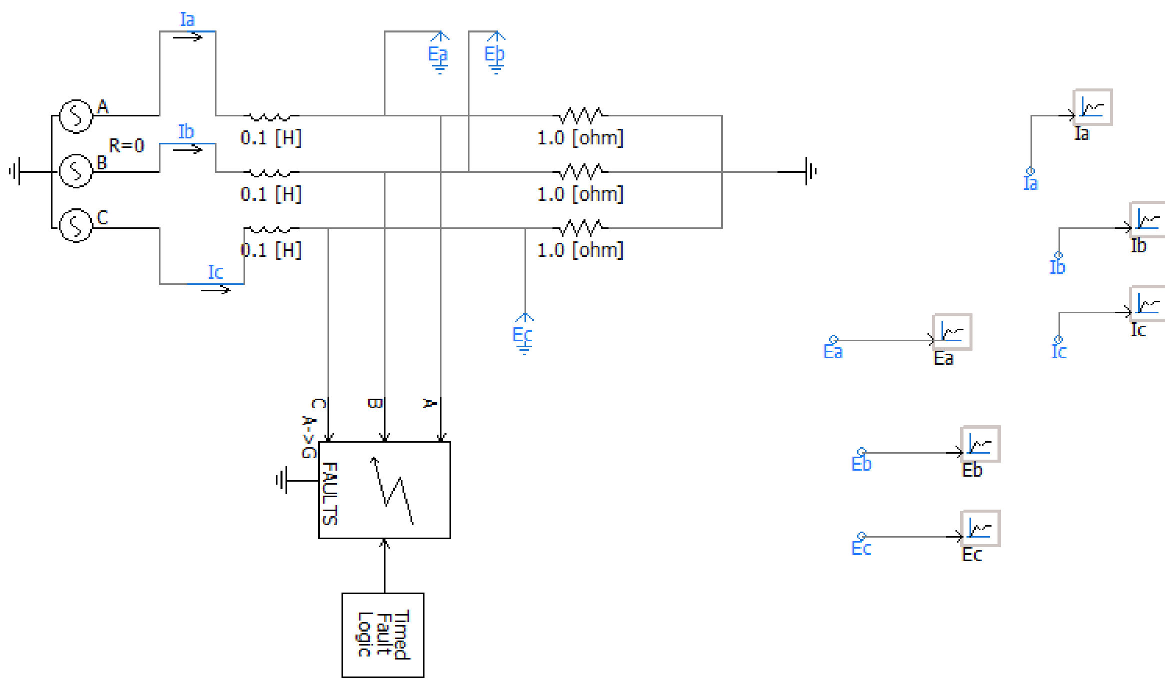
This Experiment is aimed to:

1. To design a three phase transmission line with suitable line parameters
2. Observe the change in phase current with different faults.

6.2 RESOURCES

PSCAD Software

6.3 CIRCUIT DIAGRAM



6.4 PROCEDURE

1. Design the above circuit diagram using PSCAD Software.
2. Observe the fault currents and voltages for three phases (LG, LL, LLG, LLL, and LLLG).
3. Repeat step 2 for different time periods.

6.5 TABULAR COLUMN

S.No.	Fault type	Ia	Ib	Ic	Ea	Eb	Ec
1	LG fault						
2	LLG fault						
3	LL fault						
4	LLL fault						
5	LLLG fault						

6.6 RESULT

6.7 PRE LAB QUESTIONS

1. What are different faults?
2. Which is severe fault?
3. What are symmetrical and asymmetrical faults?

6.8 POST LAB QUESTIONS

1. What you observed during faults?
2. What are positive and negative sequence currents?
3. Which fault has more frequency in symmetrical networks?

EXPERIMENT-7: PSCAD Simulation of Circuit Breaker operation

7.1 OBJECTIVE

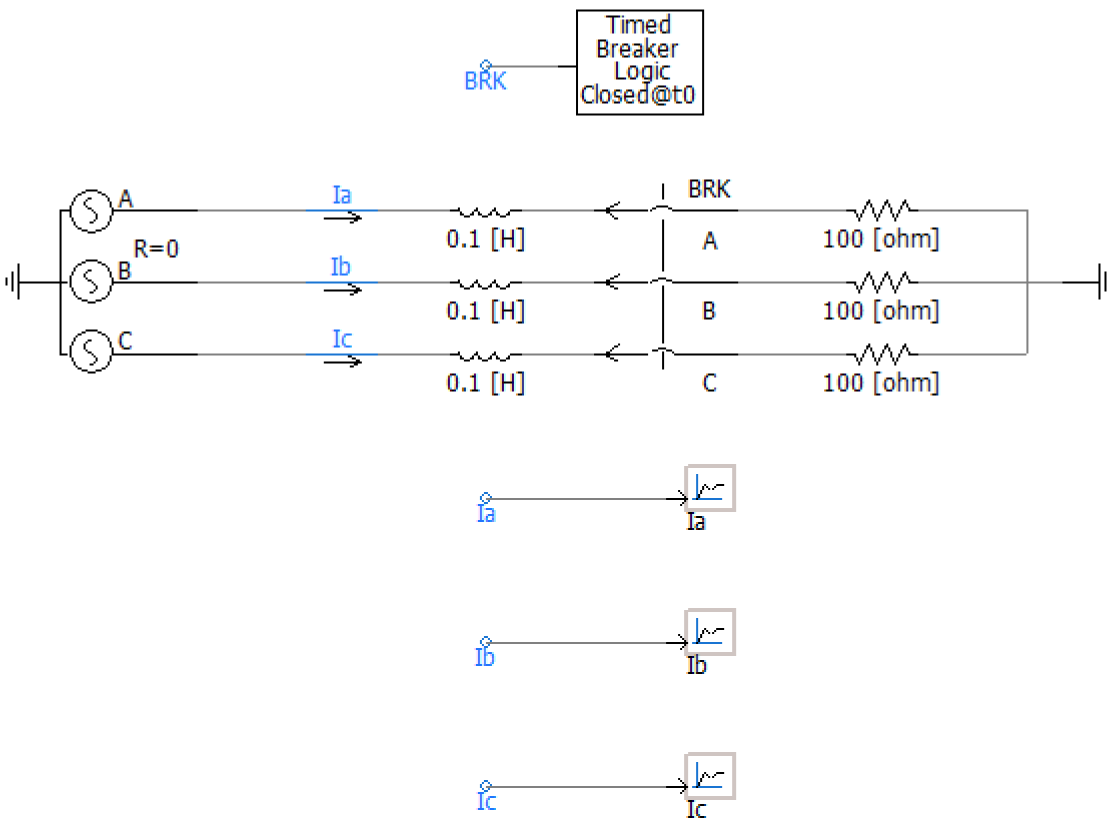
This experiment is aimed to:

1. To design a three phase transmission line with circuit breaker
2. Observe the characteristics of circuit breaker with different time operations.

7.2 RESOURCES

PSCAD Software

7.3 CIRCUIT DIAGRAM



7.4 PROCEDURE

1. Design the above circuit diagram using PSCAD Software.
2. Observe the circuit breaker operation with open conditions for three phases.
3. Observe the circuit breaker operation with closed conditions for three phases.
4. Repeat step 2 and 3 for different time periods.

7.5 TABULAR COLUMN

S.No	**Open of CB in any phase**			**Closed of CB in any phase**		
	Ia	Ib	Ic	Ia	Ib	Ic
1						
2						

7.6 RESULT

EXPERIMENT 8- INVERSE DEFINITE MINIMUM TIME CHARACTERISTICS OF FUSE

8.1 OBJECTIVE

This experiment is aimed to:

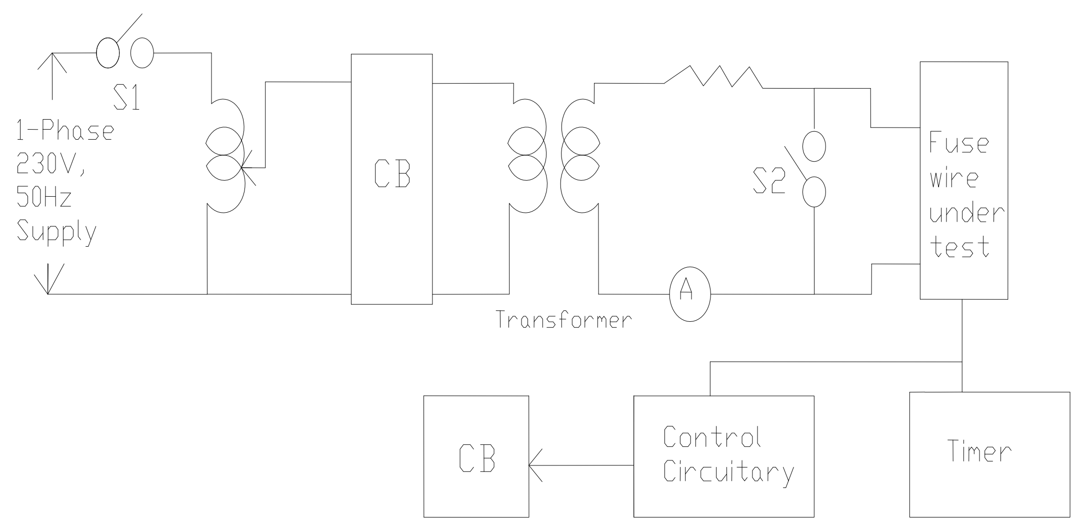
i. To determine the characteristics of fuse wire.

ii. Determine the fuse constant and fusing factor

8.2 RESOURCES

1.	Input Voltage	:	230Vac
2.	Output Current	:	50A ac MAX. (Intermittent)
3.	Output current ranges	:	1A, 2A, 5A, 10A, 20A, 50A
4.	Zero current detector	:	<300mA

8.3 CIRCUIT DIAGRAM



8.4 PROCEDURE

1. Connect the Fuse. Fuse is ON condition. Time interval meter selection switch in TIM position.
2. Connect the power card. Bring dimmer to zero position.
3. Switch on the mains using Mains on switch S1. Select the current range, ranges available 1A, 2A, 5A, 10A, 20A, 50AShort switch position S2 in short condition. Push TEST START BUTTON.
4. Adjust the dimmer ammeter shows current greater than approx. 1.3 times the rated current of Fuse.
5. Push TEST STOP/ RESET BUTTON. Don't disturb the dimmer.
6. Bring the short switch in "OPEN" position.2 Push TEST START BUTTON results ammeter shows the current, Time interval starts counting.
7. The time taken for the TRIP the FUSE is noted.
8. Repeat the procedure for different values of currents.
9. Similarly repeat the above procedure for different values of different lengths.
10. Plot the graphs.

8.5 TABULAR COLUMN

S.NO	Length of Fuse wire, L=6cm	
	Load current(A)	Melting time(sec)
1.		
2.		
3.		

8.6 CALCULATIONS

Minimum fusing current, $I = k * d^n$ ----- (1)

Where k = fuse constant

d = diameter of wire in mm

n = prece`s constant = (3/2)

Take log on both sides of equation (1)

$$\ln l = \ln k + \ln d$$

$$n = \frac{\ln l - \ln k}{\ln d}$$

$$Fusing\ factor = \frac{Minimum\ fusing\ current}{current\ Rating\ of\ fuse}$$

And note down the readings in a tabular form given below.

#	Fuse rating(A)	Fuse dia (mm)	Fuse length(cm)	Minimum fusing current (A)	Melting time(sec)	In d	In I
1.							
2.							

8.7 GRAPH

- The graph of In I versus d is plotted and intercept on y-axis (ordinate) gives value of K while slope tanø = ln I/ln d gives value of n

8.8 RESULT

- Slope=Prece's constant,n=
- Fuse constant,k=
- Fusing factor=

8.9 Pre Lab Questions:

1. Discuss the purpose of protection.
2. To ensure satisfactory co-ordination between relay and fuse, the primary current setting of the relay should be approximately how many times the current rating of the fuse.
3. Define IDMT.

8.10 Post Lab Questions:

1. Discuss the effect of time multiplier setting?
2. Discuss the effect of time plug setting?
3. What are the precautions to be taken while dealing with fuse?

EXPERIMENT 9-IDMT CHARACTERISTICS OF MINIATURE CIRCUIT BREAKER

9.1 OBJECTIVE

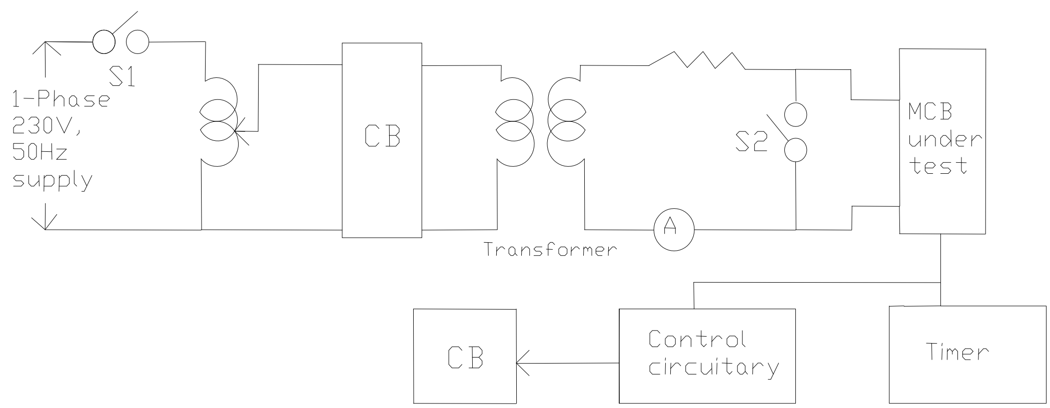
This experiment is aimed to:

i. Test different current ratings MCB
ii. Draw the characteristics of MCB testing unit.

9.2 RESOURCES

1.	Input Voltage	:	230Vac
2.	Output Current	:	50A ac MAX. (Intermittent)
3.	Output current ranges	:	1A, 2A, 5A, 10A, 20A, 50A
4.	Zero current detector	:	<300ma

9.3 CIRCUIT DIAGRAM



9.4 PROCEDURE

1. Connect the MCB.MCB is ON condition. (any one of the MCB)
2. Time interval meter selection switch in TIM position.
3. Connect the power card. Bring variac to zero position. Switch on the mains using S1 switch. Select the current range, ranges available 1A, 2A, 5A, 10A, 20A, 50A.Short switch S2 in short condition. Push TEST START BUTTON.
4. Adjust the dimmer ammeter shows current greater than approx. 1.3 times the rated current of MCB.
5. Push TEST STOP/ RESET BUTTON. Bring the short switch in “OPEN” position.2
6. Push TEST START BUTTON results ammeter shows the current, Time interval starts counting.
7. Note down the time taken for the MCB to TRIP.

8. Repeat the above procedure for different values of current ratings of MCB.
9. Plot the graphs.

9.5 TABULAR COLUMN

S.NO.	MCB=1A/2A/3A/4A/5A/6A	
	Load current(A)	Trip time(sec)
1.		
2.		
3.		
4.		

9.6 GRAPH

Draw the graph between Load current (a) and trip time (sec)

9.7 RESULT

The trip time for MCB is:

9.8 PRE LAB QUESTIONS

1. Discuss how circuit breaker operates?
2. Discuss about SF6 CB?
3. Define radial feeder

9.9 POST LAB QUESTIONS

1. What are the advantages of relays
2. What is meant by current setting on a relay?
3. What is the major difference between circuit-breaker and relay?

EXPERIMENT-10: LG FAULT OF A LONG TRANSMISSION LINE

10.1 OBJECTIVE:

This experiment is conducted:

i. To see the response of a long transmission line under Line-Ground fault condition.

ii. To analyze the variation of the power of a long transmission line under Line-Ground fault condition.

10.2 RESOURCES:

Sl. No	Equipment
1	Power system Simulator, Refer appendix for details
2	Patch Chords
3	Ammeter, Voltmeter and Power analyzers

10.3 PROCEDURE:

1. Prepare line and connect the power analyzers on sending and receiving ends.
2. Select line capacitance through selector switch in position-1.
3. short circuit the terminals of the receiving end
4. Set the sending end voltage to 220V, measure the voltage at receiving end at no-load.
5. Repeat for different line capacitances.
6. Refer sample tables provided below for support.

10.4 TABULAR COLUMN:

Measured Parameters (receiving end short condition)

Selector Position	Capacitance	Sending End				Receiving End			
		Vs	Is	Cosθ	θ	Vr	Ir	Cosθ	θ
1	0.8								
2	1								
3	1.8								

10.5 RESULT:

10.6 PRE LAB QUESTIONS:

1. Which fault is highly dangerous?
2. Which fault occurs most frequently?
3. What is meant by fault?

10.7 POST LAB QUESTIONS:

1. With increase in number of phases, what happens to the effect of fault?
2. What are used in detecting faults?
3. What are used in clearing faults?

EXPERIMENT - 11: MEASUREMENT OF EARTH RESISTIVITY

11.1 OBJECTIVE:

These experiments are aimed to:

i. Measure the earth resistance/ resistivity under wet and dry conditions.
ii. Assessment the earth resistance/ resistivity at various places.

11.2 RESOURCES:

Sl. No	Equipment
1.	Earth Tester
2.	Four Sets of Spikes & Wires
3.	Hammer

11.3 CIRCUIT DIAGRAM:

METHOD 1:

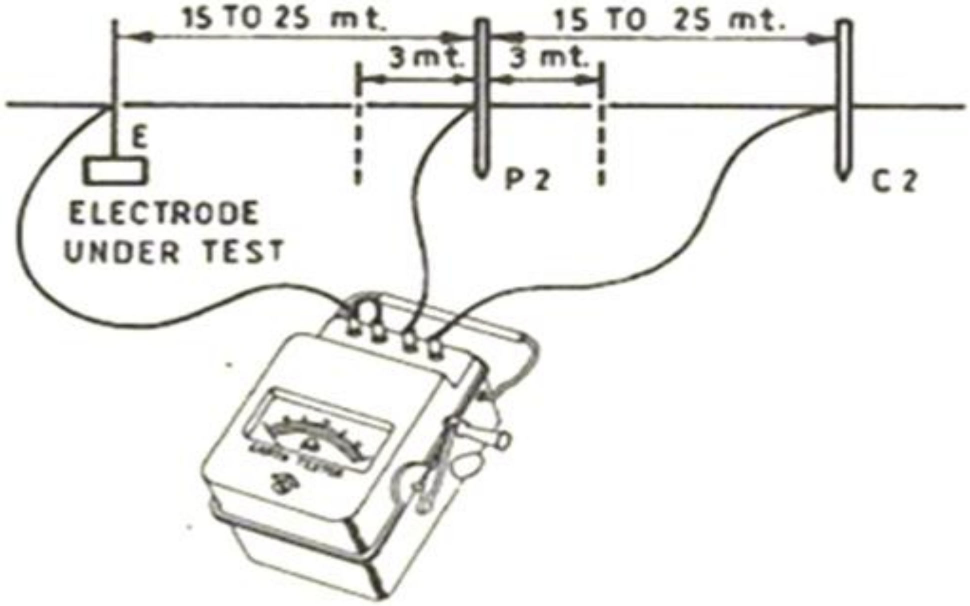


Fig. Earth Resistance Measurement

11.4 PROCEDURE

1. Connect the instrument for the particular test required as shown in Fig.1.
2. Set the RANGE SELECTOR to highest range, if any. Rotate the generator handle at 160 RPM and observe the ohmmeter deflection.
3. If the ohmmeter deflection is very low, change the RANGE SELECTOR to the next lower range.

4. Join together terminals C1 & P1 and connect a lead from them to the Earth electrode under test E as shown in Fig., 1.
5. Keep this lead as short as possible, since its resistance will be included in the test. This lead resistance can be eliminated by connecting separate leads to the electrode E from C1 & P1 instead of shorting them together.
6. Alternatively the lead resistance can be determined and deducted from the total resistance. This is carried out by removing the lead from electrode E after the test and connecting it to P2 & C2 joined together. Its true resistance is then measured by the EARTH TESTER. The earth electrode resistances measured as described previously.
7. Now, replace the bare soil with soil of 2% moisture (added with water droplets).
8. Repeat the above mentioned steps from 1-5.
9. Values are noted in the Table.1.

11.5 TABULAR COLUMN:

Sl. No	**Distance to Potential Electrode in Meter**	**Resistance measured in earth tester(Ω)**		**Resistivity(Ω-m)**	
		Practical	**Theoretical**	**Practical**	**Theoretical**
1					
2					
3					

11.6 RESULTS:

11.7 PRE LAB QUESTIONS:

1. Why earthling is required?
2. What is the near value of earth resistance?
3. What happens to earth resistance if salt water is added to it?

11.8 POST LAB QUESTIONS:

1. What is the resistivity of soil in our college?
2. How would rain affect the resistance of soil?
3. How do the minerals and metallic objects in soil affect the resistivity of the soil?

EXPERIMENT-12: Protection of Transmission Line with distance relays using PSCAD.

12.1 OBJECTIVE

This experiment is aimed to:

1. To examine the distance protection scheme in long transmission line.

12.2 RESOURCES

PSCAD Software

12.3 CIRCUIT DIAGRAM

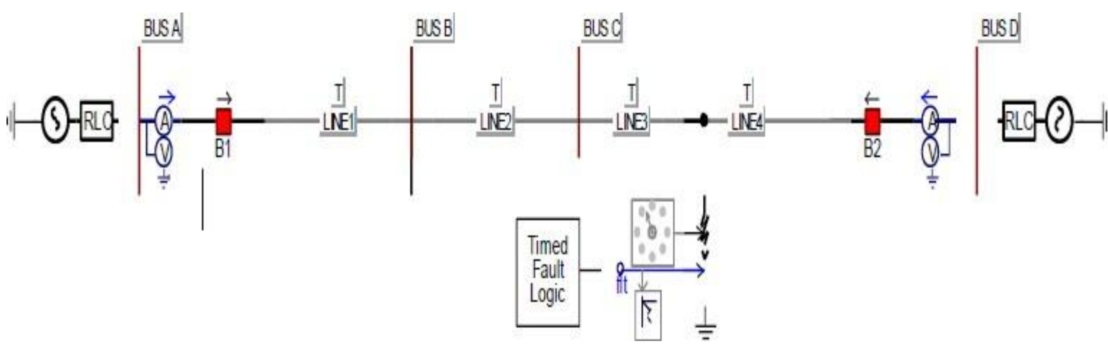


Fig. Distance protection scheme in long transmission line

12.4 PROCEDURE

1. Design the above circuit diagram using PSCAD Software.
2. Measure readings in each element.
3. Observe the wave forms

L-G faults at different distances from the relay location.

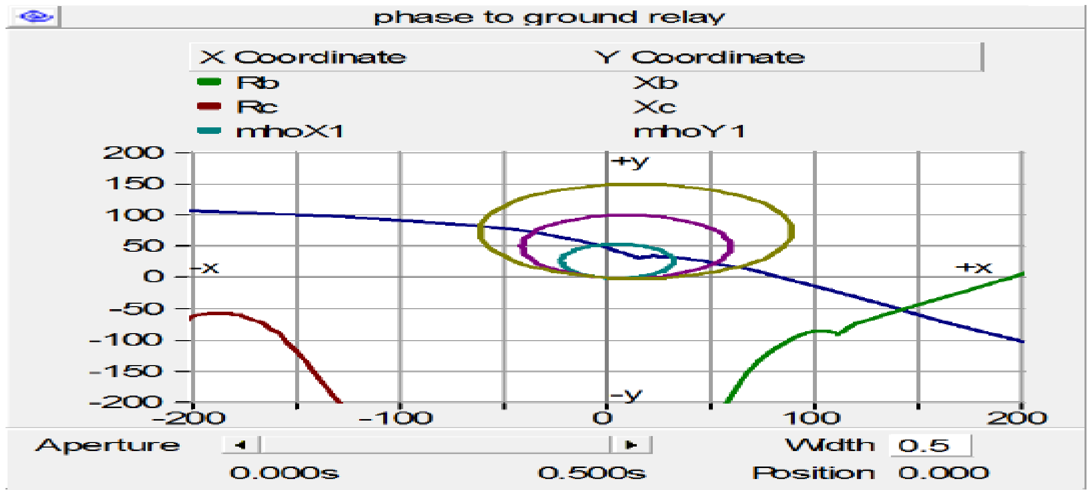


Fig. Distance protection scheme graph

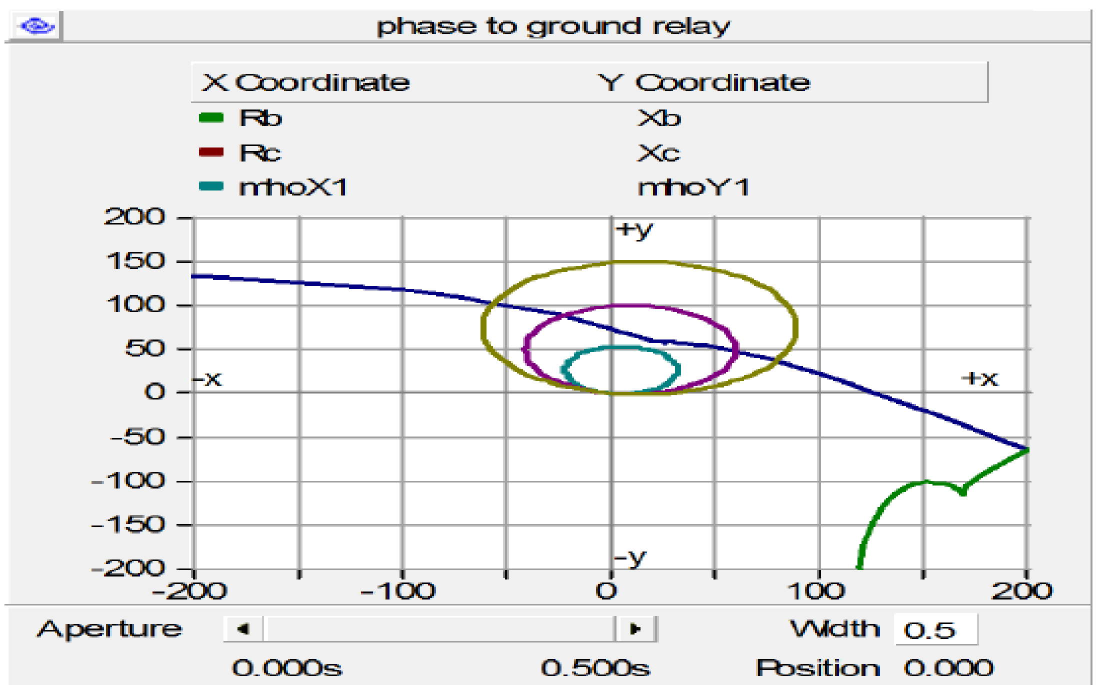


Fig. Fault at 20 km from Bus-B, Zone 2

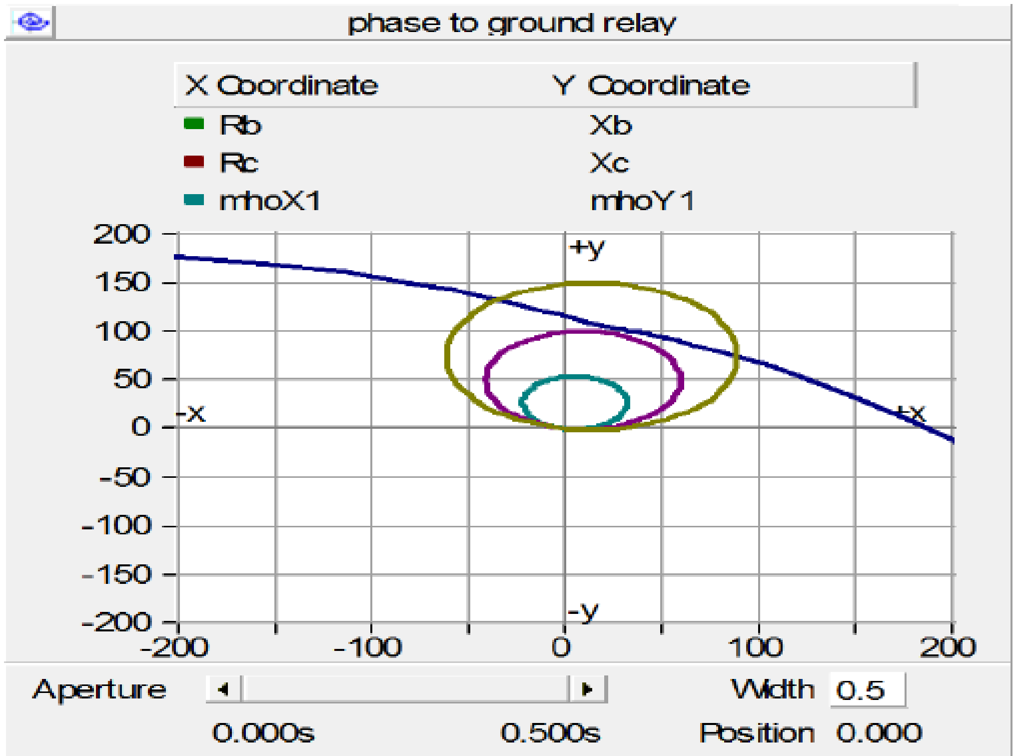


Fig. Fault at 12 km from Bus-C, Zone 3

12.5 RESULT:

12.6 PRE LAB QUESTIONS:

1. Where Impedance relay, Reactance relay and Mho relays are employed?
2. What is the basic principle of distance protection? How it works?
3. What is the difference between impedance and mho characteristic?

12.7 POST LAB QUESTIONS:

1. Why do we use relays in the power systems?
2. What are the basic distance protection zones? Why different zones should be defined?