Channabasaveshwara Institute of Technology
(Affiliated to VTU, Belagavi & Approved by AICTE, New Delhi)
(**NAAC Accredited & ISO 9001:2015 Certified Institution**)
NH 206 (B.H. Road), Gubbi, Tumakuru – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

Power System Simulation Lab Manual

21EEL62

2023-24

Bachelor of Engineering

VI Semester

Name : _____

U S N : _____

Batch : _____ **Section :** _____

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Department of Electrical & Electronics Engineering

Power System Simulation Lab Manual

Version 3.0

September- 2023

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OUR VISION

To create centers of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

OUR MISSION

- To provide high quality technical and professionally relevant education in a diverse learning environment.

- To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.

- To prepare the next generation of skilled professionals to successfully compete in the diverse global market.

- To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.

- To offer a wide variety of off-campus education and training programmes to individuals and groups.

- To stimulate collaborative efforts with industry, universities, government and professional societies.

- To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

QUALITY POLICY

Our organization delights customers (students, parents and society) by providing value added quality education to meet the national and international requirements. We also provide necessary steps to train the students for placement and continue to improve our methods of education to the students through effective quality management system, quality policy and quality objectives.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION:

To be a department of excellence in electrical and electronics Engineering education and Research, thereby to provide technically competent and ethical professionals to serve the society.

MISSION:

- To provide high quality technical and professionally relevant education in the field of electrical engineering.

- To prepare the next generation of electrically skilled professionals to successfully compete in the diverse global market.

- To nurture their creative ideas through research activities.

- To promote research and development in electrical technology and management for the benefit of the society.

To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals in electrical sector.

'Instructions to the Candidates'

1. Students should come with thorough preparation for the experiment to be conducted.
2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
3. Experiment should be started only after the staff-in-charge has checked the circuit diagram.
4. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
5. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
6. Practical record should be neatly maintained.
7. The students should obtain the signature of the staff-in-charge in the observation/manual book after completing each experiment.
8. Theory regarding each experiment should be written in the practical record before procedure in your own words.

'Instructions to the students'

1. Come with Formal Dress code to lab always.
2. After entering to the lab Enter the movements register immediately.
3. Come prepared to the lab with relevant theory and Logic beyond the Program you have to do it.
3. While going out keeping chairs properly and enter in movements register.

Course Objectives:

- To explain the use of MATLAB package to assess the performance of medium and long transmission lines.
- To explain the use of MATLAB package to obtain the power angle characteristics of salient and non-salient pole alternator.
- To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
- To explain the use of MATLAB package to develop admittance and impedance matrices of interconnected power systems.
- To explain the use of Mi-Power package to solve power flow problem for simple power systems.• To explain the use of Mi-Power package to perform fault studies for simple radial power systems.
- To explain the use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.

Course outcomes:

At the end of the course the student will be able to:

- Develop a program in MATLAB to assess the performance of medium and long transmission lines.
- Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator.
- Develop a program in MATLAB to assess the transient stability under three phase fault at different locations in a of radial power systems.
- Develop programs in MATLAB to formulate bus admittance and bus impedance matrices of interconnected power systems. Use Mi-Power package to solve power flow problem for simple power systems.
- Use Mi-Power package to study unsymmetrical faults at different locations in radial power systems.
- Use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.

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21EEL62: Power System Simulation Lab

Sl.No	Name of the Experiment	Date			Manual Marks (Max 20)	Record Marks (Max. 05)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
Average								

Note: If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the observation and record will be evaluated for 50% of maximum marks

Syllabus

Semester :	VI	CIE Marks : 50
Course Code :	21EEL 62	SEE Marks :50
Teaching Hours/week	03	Exam Hours : 03
Credits : 02		

Sl. No		Experiments
1	Use of MATLAB package	Formation for symmetric π /T configuration for Verification of $AD - BC$ = 1, Determination of Efficiency and Regulation
2		Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
3		To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines
4		Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5		Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.
6		Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile
7	Use of Mi-Power package	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates.
8		Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses.
9		To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
10		Optimal Generation Scheduling for Thermal power plants by simulation.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

21EEL62: Power System Simulation Lab

Contents

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
POWER SYSTEM SIMULATION LABORATORY/17EEL76

COURSE OUTCOMES

At the end of the course the student will be able to:

CO1: Develop a program in MATLAB to assess the performance of medium and long transmission lines

CO2: Develop a program in MATLAB to obtain the power angle characteristics of salient and non- salient pole alternator & the transient stability under three phase fault at different locations in a of radial power systems

CO3: Develop programs in MATLAB to formulate bus admittance and bus impedance matrices of interconnected power systems.

CO4: Use Mi-Power package to solve power flow problem for simple power systems

CO5: Use Mi-Power package to study unsymmetrical faults at different locations in radial power Systems & to study optimal generation scheduling problems for thermal power plants.

The cognitive process dimension / The knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual				CO1		
Conceptual			CO2	CO3		
Procedural			CO4		CO5	
Meta- cognitive						

	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1								2	3	3
CO2	3	3	1	1								2	3	3
CO3	3	3	2	1								2	2	2
CO4	3	3	2	1								2	2	2
CO5	3	3	2	1								2	2	2

PROGRAM:

```
%program to calculate ABCD parameters for T network for Medium
line
clear all

length=140
Z=(0.2+0.408i)*length;
Y=(0+3.14e-6i)*length;

fprintf('\n Medium line T network');

fprintf('A B C D parameter for medium line T network');
A=1+((Y*Z)/2)
B=Z*(1+((Y*Z)/4))
C=Y
D=A

 check=(A*D)-(B*C)

k2=input('\n enter 1- to read Vr, Ir and compute Vs, Is\n 2-
to read Vs, Is and compute Vr, Ir');
switch k2,
    case 1
        vr=input('enter Vr/phase=');
        ir=input('enter ir/phase=');
        vr=vr*1e3/sqrt(3);
        vs=(A*vr+B*ir)/1e3;
        is=C*vr+D*ir;
        fprintf('\n Sending end voltage/ph=%f%+fi KV',
real(vs),imag(vs));
        fprintf('\n Sending end current/ph=%f%+fi Amp',
real(is),imag(is));
        vs=vs*1e3;
        case 2,
            vs=input('enter Vs/phase=');
        is=input('enter is/phase=');
        vs=vs*1e3/sqrt(3.0);
        vr=(D*vs-B*is)/1e3;
        ir=-C*vs+D*is;
        fprintf('\n Receiving end voltage/ph=%f%+fi KV',
real(vr),imag(vr));
        fprintf('\n Receiving end current/ph=%f%+fi Amp',
real(ir),imag(ir));
        vr=vr*1e3;
```

Exp: 1.a

ABCD PARAMETERS FOR T NETWORK.

AIM: i) Formation for symmetric π configuration.

   ii) Verification of AD - BC = 1.

   iii) Determination of Efficiency & regulation.

PROCEDURE:

- Enter the command window of the MATLAB.

- Create a new M – file by selecting File - New – M – File

- Type and save the program in the editor window.

- Execute the program by pressing Tools – Run.

- View the results.

Note 1:

1. For short line, length=40
2. For medium line, length=140

Note 2:

```
1. "short transmission network"
   fprintf('A B C D parameter for short transmission line');
   A=1
   B=Z
   C=0
   D=1

2. fprintf('A B C D parameter for medium line PI network');
   A=1+((Y*Z)/2)
   B=Z
   C=Y*(1+((Y*Z)/4))
   D=A
```

```
otherwise
        disp('wrong choice');
end
rec_pow=3*real(vr*conj(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Recieving end power=%.2fKVA',rec_pow);
fprintf('\n sending end power=%.2fKVA',send_pow);
fprintf('\n efficiency=%.2f%%',eff);
fprintf('\n voltage regulation=%.2f%%',reg);
```

EXPECTED RESULT for T network:

length =140

A B C D parameter for T network

A = 0.9874 + 0.0062i

B = 27.6485 +56.8476i

C = 0 +4.3960e-004i

D = 0.9874 + 0.0062i

check = 1.0000 + 0.0000i

 enter 1- to read Vr, Ir and compute Vs, Is

2- to read Vs, Is and compute Vr, Ir1

enter Vr/phase=132

enter ir/phase=174.96-131.22i

 Sending end voltage/ph=87.550333+6.787052i KV

 Sending end current/ph=173.570962-94.993743i Amp

 Recieving end power=40.00KVA

 sending end power=43.65KVA

 efficiency=91.63%

 voltage regulation=16.69%

EXPECTED RESULT for Pi network:

length = 140

A B C D parameter for medium line PI network

A = 0.9874 + 0.0062i

B = 28.0000 +57.1200i

C = -1.3527e-006 +4.3684e-004i

D = 0.9874 + 0.0062i

check = 1.0000 + 0.0000i

 enter 1- to read Vr, Ir and compute Vs, Is

2- to read Vs, Is and compute Vr, Ir2

enter Vs/phase=132+0i

enter is/phase=174.96-131.22i

 Receiving end voltage/ph=62.859251-5.850527i KV

 Receiving end current/ph=173.674054-161.787473i Amp

 Recieving end power=35.59KVA

 sending end power=40.00KVA

 efficiency=88.97%

 voltage regulation=22.25%

PROGRAM:

```
%program to calculate ABCD parameters for long line network
clc
clear all

length=300;
Z=(0.2+0.408i)*length;
Y=(0+3.14e-6i)*length;

fprintf('A B C D parameter for long transmission line network');

zc=sqrt(Z/Y);
gam=sqrt(Z*Y);
A=cosh(gam)
B=zc*sinh(gam)
C=1/zc*sinh(gam)
D=A

check=(A*D)-(B*C)

k2=input('\n enter 1- to read Vr, Ir and compute Vs, Is\n 2- to
read Vs, Is and compute Vr, Ir');
switch k2,
    case 1
        vr=input('enter Vr/phase=');
        ir=input('enter ir/phase=');
        vr=vr*1e3/sqrt(3);
        vs=(A*vr+B*ir)/1e3;
        is=C*vr+D*ir;
        fprintf('\n Sending end voltage/ph=%f%+fi KV',
real(vs),imag(vs));
        fprintf('\n Sending end current/ph=%f%+fi Amp',
real(is),imag(is));
        vs=vs*1e3;
        case 2,
            vs=input('enter Vs/phase=');
        is=input('enter is/phase=');
        vs=vs*1e3/sqrt(3.0);
        vr=(D*vs-B*is)/1e3;
        ir=-C*vs+D*is;
        fprintf('\n Receiving end voltage/ph=%f%+fi KV',
real(vr),imag(vr));
        fprintf('\n Receiving end current/ph=%f%+fi Amp',
real(ir),imag(ir));
        vr=vr*1e3;
    otherwise
        disp('wrong choice');
end
rec_pow=3*real(vr*conj(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Recieving end power=%.2fKVA',rec_pow);
fprintf('\n sending end power=%.2fKVA',send_pow);
fprintf('\n efficiency=%.2f%%',eff);
fprintf('\n voltage regulation=%.2f%%',reg);
```

Exp: 1.b

ABCD PARAMETERS FOR LONG TRANSMISSION NETWORK.

AIM: i) Formation for symmetric π configuration.

 ii) Verification of AD-BC = 1.

 iii) Determination of Efficiency & regulation.

PROCEDURE:

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

Note: For long line, length=300

EXPECTED RESULT for Pi network:
A B C D parameter for long transmission line network
A = 0.9428 + 0.0277i
B = 5.7712e+001 +1.2062e+002i
C = -8.7717e-006 +9.2398e-004i
D = 0.9428 + 0.0277i
check =   1.0000

 enter 1- to read Vr, Ir and compute Vs, Is
2- to read Vs, Is and compute Vr, Ir1
enter Vr/phase=132+0i
enter ir/phase=174.96-131.22i

 Sending end voltage/ph=97.773395+15.642655i KV
 Sending end current/ph=167.915908-48.443896i Amp
 Recieving end power=40.00KVA
 sending end power=46.98KVA
 efficiency=85.15%
 voltage regulation=37.75%

ROGRAM:

```
%power angle characteristics cylindrical rotor syn.m/c
%enter the values of x,v,Ia;
clc
clear all
x=0.3;
v=1.0;
e=1.2;
pm=abs(e)*abs(v)/x;
del=0:0.1:pi;
plot(del,pm*sin(del),'r');
title('power angle characteristics of cylindrical rotor
syn.m/c');
xlabel('Delta');
ylabel('power,p');
legend('pm*sin(delta)');
del=0:0.1:pi/2;
line(del,pm);
y=0:0.1:pm;
line(pi/2,y);
reg=(abs(e)-abs(v))/abs(v)*100;
fprintf('\n the excitation Voltage = %f%%\n',e);
fprintf('\n the peak power = %f%%\n',pm);
fprintf('\n the Voltage regulation = %f%%\n',reg);
```
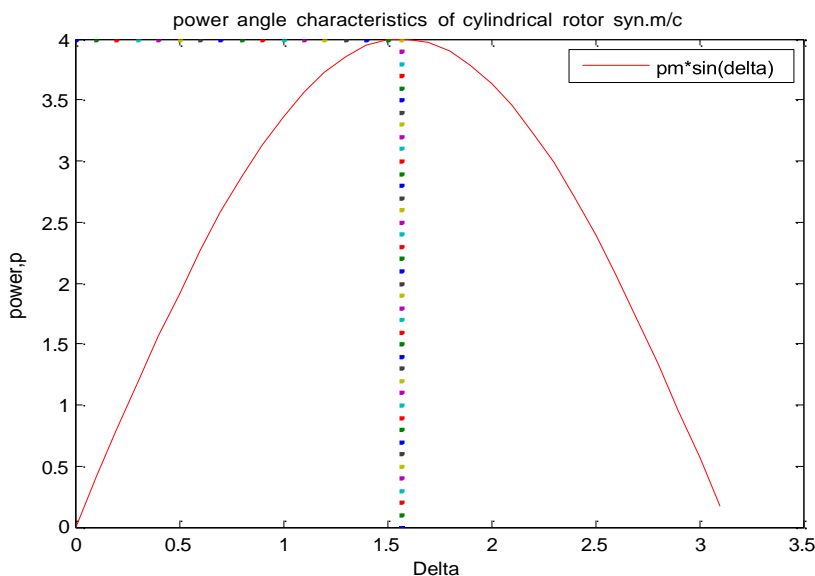
EXPECTED RESULT:

the excitation Voltage = 1.200000%

the peak power = 4.000000%

the Voltage regulation = 20.000000%

Exp:2a

DETERMINATION OF POWER ANGLE CURVE FOR NON- SALIENT POLE SYNCHRONOUS MACHINES.

AIM: To determine the power angle diagram , reluctance power, excitation, emf and regulation for non- salient pole synchronous machines,.

PROCEDURE:

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

Theory :

The steady state stability is basically concerned with the determination of the maximum

power flow possible through the power system, without loss of synchronism (stability). The

formation of power angle equation plays a vital role in the study of steady state stability. The

power angle equation for non salient pole machine is given by,

$$P = \frac{|V| \, |E| * \sin \delta}{(Xs + Xe)}$$

The above equation shows that the power P transmitted from the generator to the motor varies

with the sine of the displacement angle δ between the two rotors.

For salient pole machine,

$$P = \frac{|V| \, |E| * \sin \delta}{Xd} + \frac{|E| \, 2*(Xd-Xq)*\sin (2\delta)}{2*Xd*Xq}$$

PROGRAM:

```
clc
clear all
xd=1;
xq=0.6;
v=1.0;
ia=0.5000-0.3750i;
theta=abs(angle(ia));
del=atan((xq*abs(ia)*cos(theta))/(abs(v)+xq*abs(ia)*sin(theta))
);
e=abs(v)*cos(del)+xd*abs(ia)*sin(del+theta);
p=(e)*abs(v)/xd;
pr=abs(v)^2*(xd-xq)/(2*xd*xq);
del=0:0.01:pi;
line(del,0);
hold on;
pe=p*sin(del)+pr*sin(2*del);
plot(del,p*sin(del),del,pr*sin(2*del),del,p*sin(del)+pr*sin(2*d
el));
title('power angle characteristics of salient pole syn.m/c');
xlabel('Delta');
ylabel('power,p');
legend('p*sin(delta)','pr*sin(2*del)','p*sin(del)+pr*sin(2*del)
');
[pmax,k]=max(pe);
fprintf('\n maximum power = %f and the corresponding angle=
%f',pmax,del(k)*180/pi);
del=0:0.01:del(k);
line(del,pmax);
y=0:0.01:pmax;
line(del(k),y);
reg=(abs(e)-abs(v))/abs(v)*100;
text(-0.4,pmax,'pmax');
text(del(k),-0.1,'deltamax');
fprintf('\n the excitation Voltage = %f pu',abs(e));
fprintf('\n the Reluctance power = %f pu\n',pr);
fprintf('\n the Voltage regulation = %f%%\n',reg);
```

Exp:2b

DETERMINATION OF POWER ANGLE CURVE SALIENT POLE SYNCHRONOUS MACHINES.

AIM: To determine the power angle diagram , reluctance power, excitation, emf and regulation for salient pole synchronous machines,.

PROCEDURE:

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

EXPECTED RESULT:

maximum power = 1.581035 and the corresponding angle= 69.900851
 the excitation Voltage = 1.454468 pu
 the Reluctance power = 0.333333 pu
 the Voltage regulation = 45.446817%
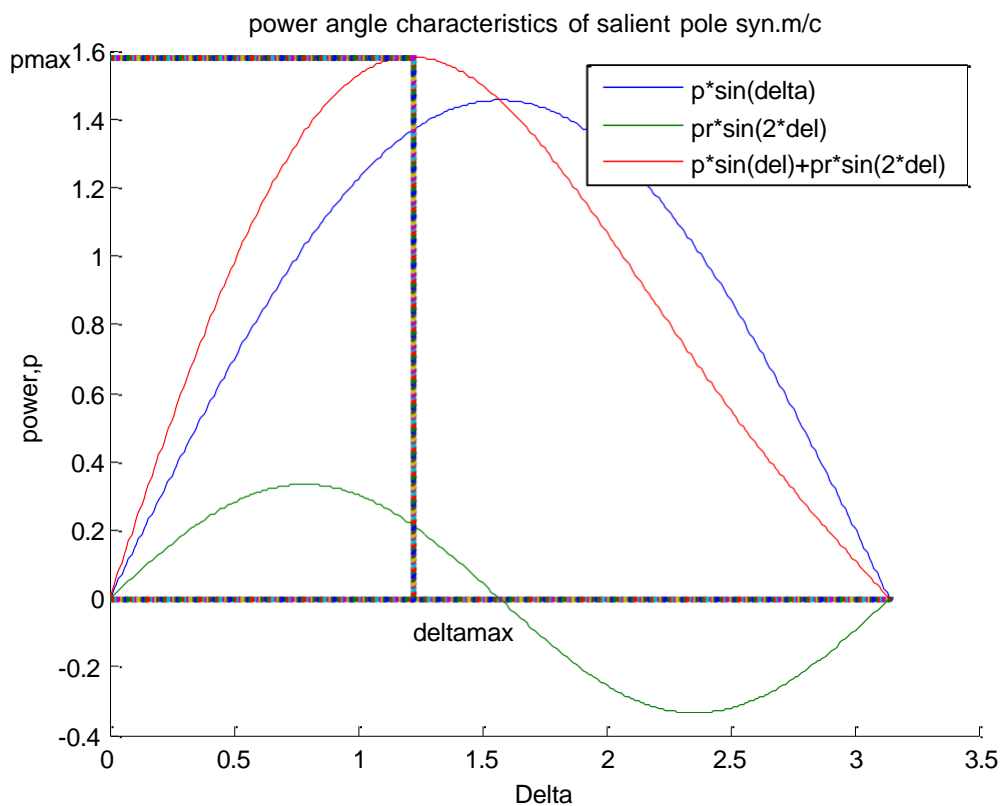
PROGRAM:

```
%FORMATION OF Ybus USING SINGULAR TRANSFORMATION METHOD
clc;
clear all;
close all;
a=input ('\n Enter the starting bus in first column, ending bus in
2nd column and impedance in 3rd column')
sb=a(:,1);
eb=a(:,2);
z=a(:,3)
lines=length(a)
for k=1:lines
    p=sb(k)
    q=eb(k)
    Acap(k,p)=-1
    Acap(k,q)=1
    A=Acap
    primz(k,k)=z(k)
end

primy=inv(primz)
b=(transpose(A))*primy
fprintf(' \n ----------YBUS------------')
y=b*A

V(1) =1.024532-0.08729i;
V(2)=1.02394-0.931i;
V(3)=1.01825-0.1074i;
V(4)=1.0476-0.049i;
V(5)=1.06+0i;
I=Ybus*V'
```

Note: if any bus is connected ground it has to done manually.

Exp: 3.a

FORMATION OF Y- BUS USING SINGULAR TRANSFORMATION
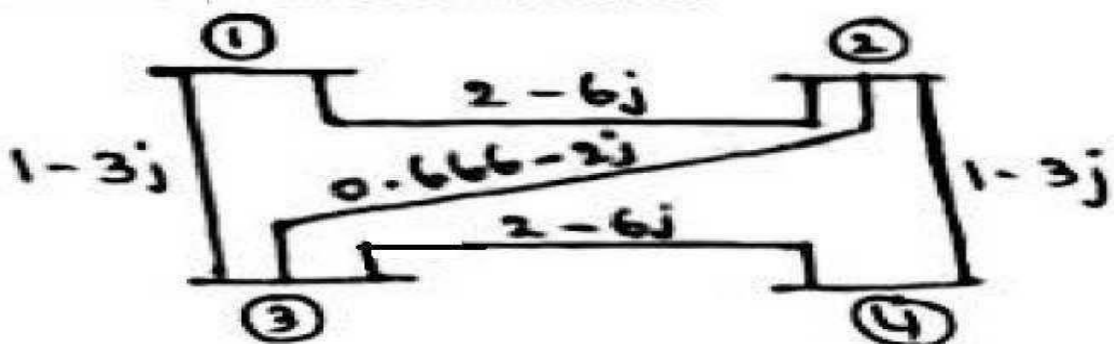
AIM: Y bus formation for systems, without mutual coupling, by singular

transformation.

THEORY:

FORMATION OF Y BUS MATRIX

Bus admittance is often used in power system studies. In most of the power system studies it is required to form y- bus matrix of the system by considering certain power system parameters depending upon the type of analysis.

Y-bus may be formed by inspection method only if there is no mutual coupling between the lines. Every transmission line should be represented by ｜ ｜ - equivalent. Shunt impedances are added to diagonal element corresponding to the buses at which these are connected. The off diagonal elements are unaffected. The equivalent circuit of Tap changing transformers is included while forming Y-bus matrix.

Generalized Y-bus = Yii................Yid

Ydi..............Ydd

where, Yii = Self admittance

Ydi = Transfer admittance

.

PROCEDURE:

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

PROGRAM:

```
clc;
clear all;
disp('-------- Y Bus formation ------');
x=input('Enter the no of nodes=');
for i=1:1:x
    for j=1:1:x
        if(i==j)
            a(i,j)=input(strcat('Enter the value of admittance
Y',int2str(i),int2str(0),'='));
        else
            a(i,j)=input(strcat('Enter the value of admittance
Y',int2str(i),int2str(j),'='));
        end
    end
end


    b=a;
    y=0;
    for i=1:1:x
        for j=1:1:x
            if i==j
                for k=1:1:x
                    y=y+b(i,k);
                end
                a(i,j)=y;
                y=0;
            else
             a(i,j)=-b(i,j);
            end

        end
    end
    b
    ybus=a
```

Exp: 3.b

FORMATION OF 'Y- BUS' BY INSPECTION METHOD.

**AIM:**   Y bus formation for systems,by inspection method.

PROCEDURE:

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

Obtain Y$_{bus}$ by singular transformation method for the system having following data. Take bus 4 as ref bus

Element No.	1	2	3	4	5
Bus code (p-q)	1-2	2-3	3-4	1-4	2-4
Admittance (pu)	2	1.5	3	2.5	4

Line no	1	2	3	4	5
Bus code	0-1	1-2	2-3	3-0	2-0
Admittance	J1.4	J1.6	J2.4	J2.0	J1.8
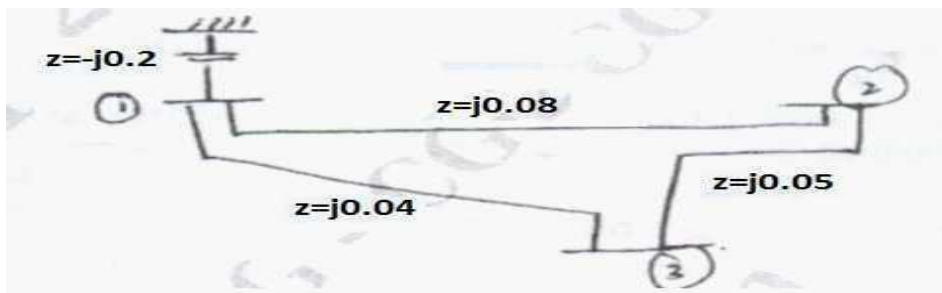
```matlab
%FORMATION OF Ybus USING SINGULAR TRANSFORMATON METHOD
%WITH MUTUAL COUPLING & WITHOUT LINE CHARGING:
%  p   q      Z     mno  mutual(imp)
 z=[0   1   0.6i     0        0
    0   2   0.5i     1       0.1i
    2   3   0.5i     0        0
    0   1   0.4i     1       0.2i
    1   3   0.2i     0        0];
p=z(:,1);
q=z(:,2);
Z=z(:,3);
mno=z(:,4);
zmc=z(:,5);
nbus=max(max(p),max(q));
Y=zeros(nbus);
nline=length(p);
A=zeros(nline,nbus);
for k=1:nline,
    if(q(k)==0)
        A(k,p(k))=1;
    elseif(p(k)==0)
        A(k,q(k))=-1;
    end
    if(p(k)~=0&q(k)~=0)
        A(k,p(k))=1;
        A(k,q(k))=-1;
    end
end
zpr=zeros(nline,nline);
for k=1:nline
    zpr(k,k)=Z(k);
    if(mno(k))
zpr(k,mno(k))=zmc(k);
        zpr(mno(k),k)=zmc(k);
    end
end
ypr=inv(zpr);
format short;
Ybus=A'*ypr*A
```

Exp: 3.c

AIM: FORMATION OF Ybus USING SINGULAR TRANSFORMATON METHOD WITH MUTUAL COUPLING & WITHOUT LINE CHARGING

PROCEDURE:

- Enter the command window of the MATLAB.
- Create a new M – file by selecting File - New – M – File
- Type and save the program in the editor window.
- Execute the program by pressing Tools – Run.

View the results

EXPECTED RESULT:

FORMATION OF Ybus USING SINGULAR TRANSFORMATION METHOD WITHOUT MUTUAL COUPLING:

Ybus =

12.9167 -38.6950i	-10.0000 +30.0000i	0	-1.6667 + 5.0000i	-1.2500 + 3.7500i
-10.0000 +30.0000i	12.9167 -38.6950i	-1.2500 + 3.7500i	-1.6667 + 5.0000i	0
0	-1.2500 + 3.7500i	3.7500 -11.2100i	-2.5000 + 7.5000i	0
-1.6667 + 5.0000i	-1.6667 + 5.0000i	-2.5000 + 7.5000i	10.8333 -32.4150i	-5.0000 +15.0000i
-1.2500 + 3.7500i	0	0	-5.0000 +15.0000i	6.2500 -18.6950i

I =

-24.8742 - 7.9772i

32.7204 +11.1076i

-2.7353 - 0.6013i

-4.2194 - 1.6135i

-0.9560 - 0.6148i

FORMATION OF Ybus USING SINGULAR TRANSFORMATON METHOD WITH MUTUAL COUPLING & WITHOUT LINE CHARGING:

Ybus =

0 - 8.0208i	0 + 0.2083i	0 + 5.0000i
0 + 0.2083i	0 - 4.0833i	0 + 2.0000i
0 + 5.0000i	0 + 2.0000i	0 - 7.0000i

PROGRAM:

```
clc
clear all
%program for swing curve when the fault is cleared
ps=0.9;e=1.1;v=1.0;m=0.00028;
xe=0.35;xL=0.2;
%function swing2(ps,e,v,m,xe,xL)
x1=xe+xL/2;
ch=input('enter 1-for fault at the beginning of line
\n 2-for fault at the middle of line ');
switch ch
case 1,
    x2=inf;
case 2,
    x2=(xe*xL+xe*xL/2+xL*xL/2)/(xL/2);
otherwise
    disp('wrong input');
end
x3=xe+xL;
dt=0.05;
%ct=ct/50; //conversion from cycles to sec
ct=input('\n enter clearing time in secs  ');
    k=ct/dt;
    r=ct-floor(k)*dt;
    if(r==0)
        fprintf('FAULT IS CLEARED AT THE BEGINNING OF
AN INTERVEL');
    else
        fprintf('FAULT IS CLEARED AT THE MIDDLE OF AN
INTERVEL');
end
    rr=180/pi;
    f=dt^2/m;
    deld=0;
    it=1;    t(it)=0;
    pm1=e*v/x1;
    del(it)=asin(ps/pm1);
    pm2=e*v/x2;
    pm3=e*v/x3;
        fprintf('\n   TIME        PMAX    DELTA');
    pm=pm1;
    pe=pm*sin(del(it));
    pa=(ps-pe);
```

Exp: 4a

PROGRAM FOR SWING CURVE WHEN THE FAULT IS CLEARED.

AIM: To determine the Swing curve when the fault is cleared

   i)   At the beginning of the Line

   ii)   At the middle of the line

PROCEDURE:

- Enter the command window of the MATLAB.

- Create a new M – file by selecting File - New – M – File

- Type and save the program in the editor window.

- Execute the program by pressing Tools – Run.

- View the results.

Theory:

Transient stability limit : Transient stability limit of a two-machine system is defined as the maximum power that can be transmitted from one machine to the other without loss of synchronism for a specified, sudden, severe, unrepeated shock.

The load angle or the torque angle δ depends upon the loading of the machine, larger the loading larger is the value of the torque angle. If some load is added or removed from the shaft of the synchronous machine the rotor will decelerate or accelerate respectively with respect to rotating magnetic field. The rotor swings with respect to the stator field. The equation describing the relative motion of the rotor with respect to the stator field as a function of time is known as swing equation. The swing equation is given below

Md2δ = Ps – Pe

dt2

Where Pe is Pm sin δ

M is the angular momentum of the rotor

δ is the torque angle

Ps is the power input

Pe is the electromagnetic power output

In case „δ‟ increases indefinitely it indicates instability where as if it reaches a maximum and starts decreasing,it shows that the system will not lose stability since the oscillations will be damped out with time.

For the stability of the system dδ = 0

dt

The system will be unstable if dδ > 0 for a sufficiently long time

dt

Swing curve:

The solution of swing equation gives the relation between rotor angle „δ‟ as a function of time „t‟ . The plot of „δ‟ versus „t‟ is called as swing curve. No analytical solution of this equation exists. However, techniques are available to obtain approximate solution of such differential equations by numerical methods and one must therefore resort to numerical computation techniques. In this program the swing equation is solved using Runge Kutta method

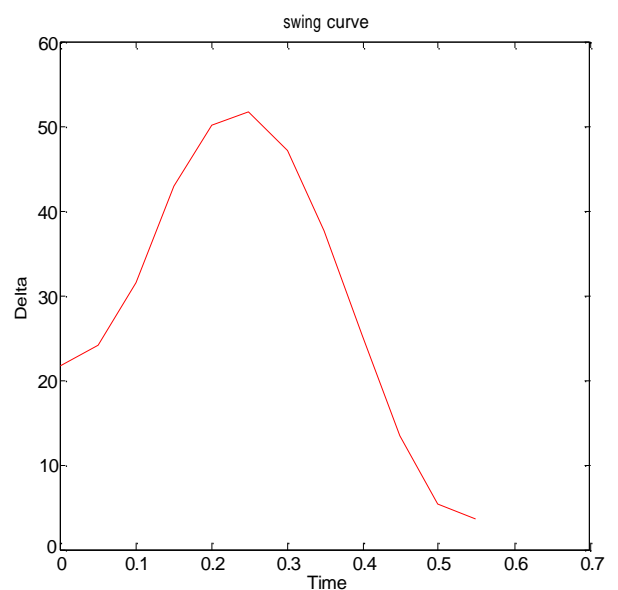```
fprintf('\n %5.3f   %5.2f   %5.2f',
t(it),pm,del(it)* rr);
     pm=pm2;

pe=pm*sin(del(it));
     pa=(ps-pe)/2;
     while(t(it)<=0.5)
         ft=f*pa/rr;
         deld=deld+ft;
         fprintf('\n %5.3f   %5.2f   %5.2f',
t(it),pm,del(it)* rr);
         it=it+1;
         t(it)=t(it-1)+dt;
         del(it)=del(it-1)+deld;
         pm=pm2;
         if(t(it)==ct)
                 pm=(pm2+pm3)/2;
             elseif(t(it)>ct)
                 pm=pm3;
             end
                 pe=pm*sin(del(it));
                 pa=ps-pe;
             end
plot(t,del*rr,'r');
title('swing curve');
xlabel('Time');
ylabel('Delta');
```

## EXPECTED RESULT:
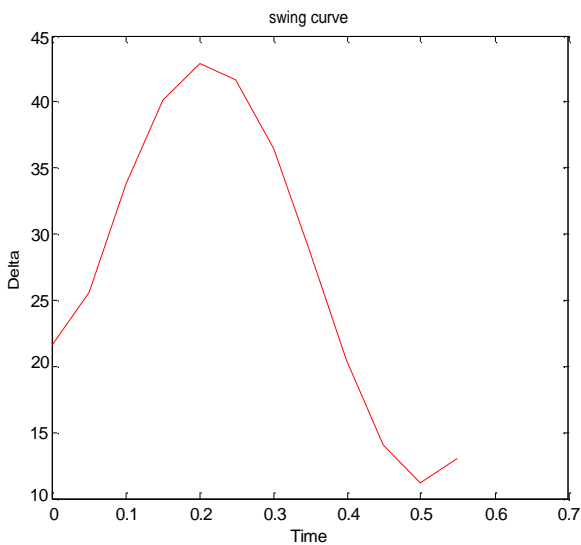


enter 1-for fault at the beginning of line      2-for fault at the middle of line  1

enter clearing time in secs 0.05

FAULT IS CLEARED AT THE
BEGINNING OF AN INTERVEL

| TIME | PMAX | DELTA |
|------|------|-------|
| 0.000 | 2.44 | 21.60 |
| 0.000 | 0.00 | 21.60 |
| 0.050 | 1.00 | 25.62 |
| 0.100 | 2.00 | 33.81 |
| 0.150 | 2.00 | 40.10 |
| 0.200 | 2.00 | 42.93 |
| 0.250 | 2.00 | 41.62 |
| 0.300 | 2.00 | 36.50 |
| 0.350 | 2.00 | 28.78 |
| 0.400 | 2.00 | 20.51 |
| 0.450 | 2.00 | 14.01 |
| 0.500 | 2.00 | 11.23 |

enter 1-for fault at the beginning of line

2-for fault at the middle of line  2

enter clearing time in secs  0.125

FAULT IS CLEARED AT THE MIDDLE
OF AN INTERVEL

| TIME | PMAX | DELTA |
|------|------|-------|
| 0.000 | 2.44 | 21.60 |
| 0.000 | 0.88 | 21.60 |
| 0.050 | 0.88 | 24.17 |
| 0.100 | 0.88 | 31.56 |
| 0.150 | 2.00 | 42.88 |
| 0.200 | 2.00 | 50.07 |
| 0.250 | 2.00 | 51.61 |
| 0.300 | 2.00 | 47.19 |
| 0.350 | 2.00 | 37.70 |
| 0.400 | 2.00 | 25.33 |
| 0.450 | 2.00 | 13.35 |
| 0.500 | 2.00 | 5.29 |

**PROGRAM:**

```
clc
clear all
%swing curve for sustained fault and critical clearing
time.
%ps=mech. power input xe=xg+xt, x1=reactance before
fault x2=reactance after fault
ps=0.9;e=1.1;v=1.0;m=0.00028;xe=0.35;xLi=0.2;
%function swing(ps,e,v,m,xe,xLi)
x1=xe+xLi/2;
ch=input('enter 1-for fault at the beginning \n 2-for
fault at the middle');
switch ch
    case 1
        x2=inf;
    case 2
        x2=(xe*xLi+xe*xLi/2+xLi*xLi/2)/(xLi/2);
    otherwise
        disp('wrong input');
end
dt=0.05;
rr=180/pi;
f=dt^2/m;
it=1;
t(it)=0;
deld=0;
pm1=e*v/x1;
del(it)=asin(ps/pm1);
fprintf('\n SUSTAINED FAULT');
fprintf('\n TIME PMAX DELTA');
fprintf('\n---------------------');
pm=pm1;
fprintf('\n %5.3f %5.2f %5.2f',t(it),pm,del(it)*rr);
pm2=e*v/x2;
pm=pm2;
pe=pm*sin(del(it));
pa=(ps-pe)/2;
t1=0;
while(t(it)<=0.5)
    ft=f*pa/rr;
    deld=deld+ft;
    if(t1-t(it)<=0.5)
        fprintf('\n %5.3f %5.2f
%5.2f',t(it),pm,del(it)*rr);
```

Exp: 4b

SWING CURVE FOR SUSTAINED FAULT AND CRITICAL CLEARING ANGLE & TIME.

AIM: To determine swing curve for sustained fault and critical clearing angle & time**.**

PROCEDURE:

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

```
        end
        it=it+1;
        t(it)=t(it-1)+dt;
        del(it)=del(it-1)+deld;
        pm=pm2;
        pe=pm*sin(del(it));
        pa=ps-pe;
    end
x3=xe+xLi;
%x3=0.55;
pm3=e*v/x3;
delm=pi-del(1);
cdc=(ps*(delm-del(1))+pm3*cos(delm)-
pm2*cos(del(1)))/(pm3-pm2);
delc=acos(cdc);
fprintf('\n critical clearing angle-%f',delc*rr);
it=1;
while(t(it)<0.5)
    if(del(it)>=delc)
        break;
    end
    it=it+1;
end
fprintf('\n critical clearing time-%f',t(it));
plot(t,del,'r');
title('swing curve');
xlabel('TIME');
ylabel('DELTA');
```

EXPECTED RESULT:
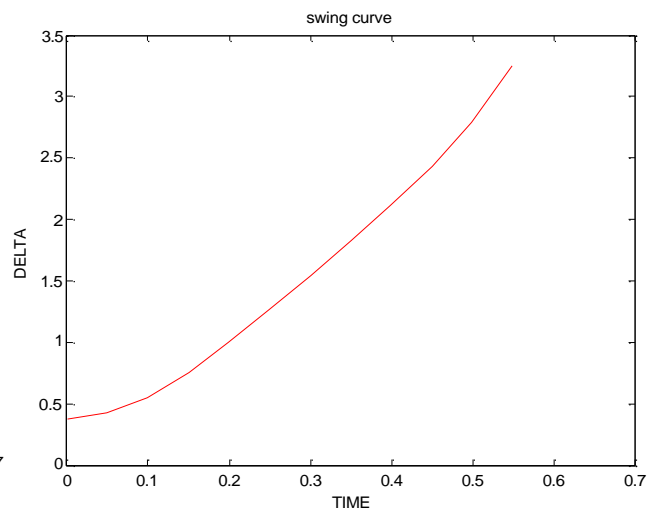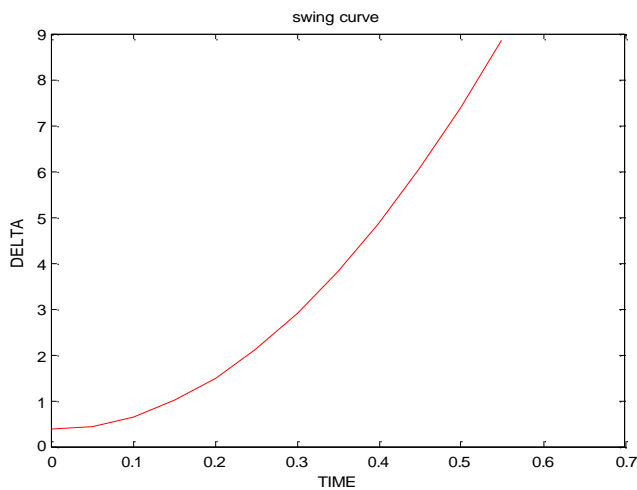
enter 1-for fault at the beginning
 2-for fault at the middle1

 SUSTAINED FAULT
 TIME PMAX DELTA

 0.000 2.44 21.60
 0.000 0.00 21.60
 0.050 0.00 25.62
 0.100 0.00 37.67
 0.150 0.00 57.76
 0.200 0.00 85.89
 0.250 0.00 122.05
 0.300 0.00 166.25
 0.350 0.00 218.48
 0.400 0.00 278.75
 0.450 0.00 347.05
 0.500 0.00 423.39
 critical clearing angle-81.684989
 critical clearing time-0.200000

enter 1-for fault at the beginning
 2-for fault at the middle2

 SUSTAINED FAULT
 TIME PMAX DELTA

 0.000 2.44 21.60
 0.000 0.88 21.60
 0.050 0.88 24.17
 0.100 0.88 31.56
 0.150 0.88 42.88
 0.200 0.88 56.88
 0.250 0.88 72.34
 0.300 0.88 88.34
 0.350 0.88 104.53
 0.400 0.88 121.15
 0.450 0.88 139.08
 0.500 0.88 159.89
 critical clearing angle-118.182332
 critical clearing time-0.400000

PROGRAM:

```matlab
clc
clear all

Z=input ('\n Enter the starting bus in first
column step No, from bus(fb) in 2nd column
and 3rd column to bus(tb) and 4th column
value of impedance')
[m n]= size(Z);
Zbus=[ ] ;%Let Zbus be a null matrix to
begin with
currentbusno=0;
for count = 1:m,
    [rows cols]=size(Zbus);
    fb=Z(count,2);
    tb=Z(count,3);
    value=Z(count,4);
    newbus=max(fb,tb);
    ref=min(fb,tb);
     % Type 1 Modification
    if newbus>currentbusno & ref==0
        Type=1
        Zbus=[Zbus zeros(rows,1)
             zeros(1,cols) value]
          currentbusno=newbus;
          continue
      end
     % Type 2 Modification
   if newbus>currentbusno & ref~=0
      Type=2
        Zbus=[Zbus Zbus(:,ref)
             Zbus(ref,:)
value+Zbus(ref,ref)]

          currentbusno=newbus
          continue
      end
```

Exp:5.

Z-BUS BUILDING ALGORITHEM

AIM: Formation of Z-bus, using Z-bus build Algorithm without mutual.

PROCEDURE:

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

EXPECTED RESULT

Type = 1

Zbus = 0.2500

Type = 2

Zbus =

   0.2500   0.2500

   0.2500   0.3500

Type = 2

Zbus =

   0.2500   0.2500   0.2500

   0.2500   0.3500   0.2500

   0.2500   0.2500   0.3500

Zbus =

   0.1458   0.1042   0.1458

   0.1042   0.1458   0.1042

   0.1458   0.1042   0.2458

Zbus =

   0.1397   0.1103   0.1250

   0.1103   0.1397   0.1250

   0.1250   0.1250   0.1750

```matlab
% Type 3 Modification
   if newbus<=currentbusno & ref==0
        Type=3
      a= Zbus
       b= Zbus(newbus,newbus)
        c=value
        d=Zbus(:,newbus)
        e=Zbus(newbus,:)
        Zbus=Zbus-
1/(Zbus(newbus,newbus)+value)*Zbus(:,newbus)
*Zbus(newbus,:)

        continue
      end
      % Type 4 Modification
   if newbus<=currentbusno & ref~=0
        Type=4
        Zbus=Zbus-
1/(value+Zbus(fb,fb)+Zbus(tb,tb)-
2*Zbus(fb,tb))*((Zbus(:,fb)-
Zbus(:,tb))*((Zbus(fb,:)-Zbus(tb,:)))))
        continue
      end
    end
```

Problem:

step	fb	tb	value(z)
1	1	0	0.25i
2	2	1	0.1i
3	3	1	0.1i
4	2	0	0.25i
5	2	3	0.1i
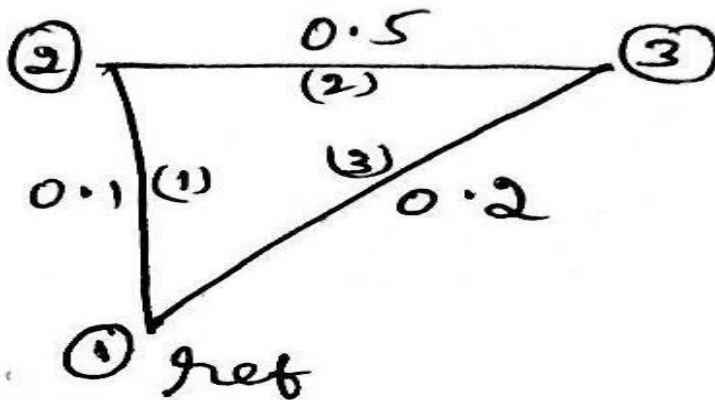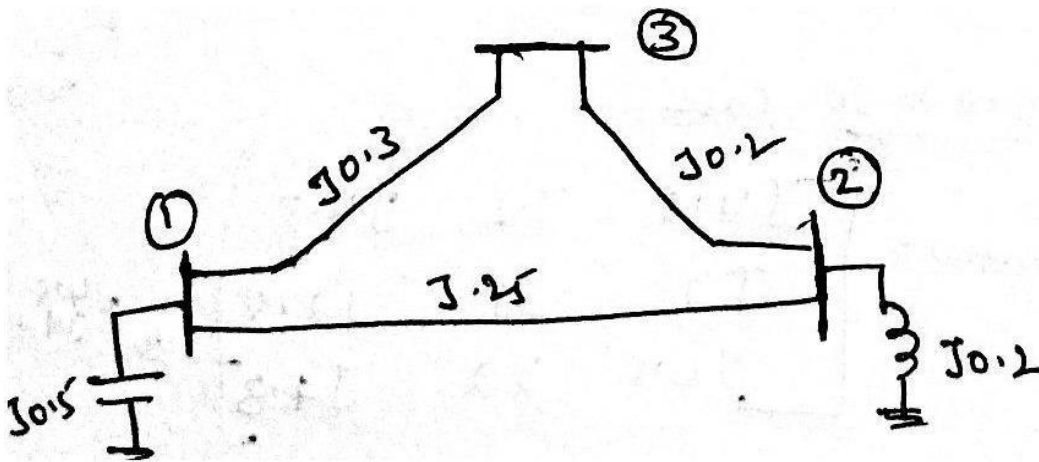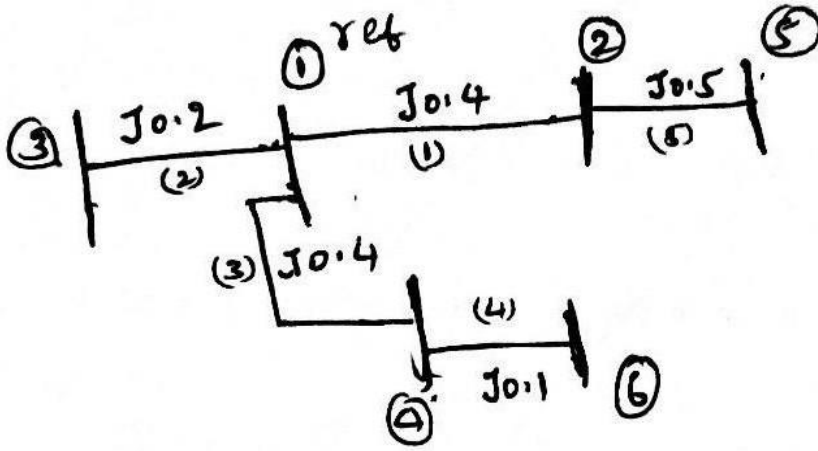
PROGRAM:

```matlab
% Formation of Jacobian matrix
clc
clear all
nb=3;
    Y=[65-45j -40+20i -25+25i;
        -40+20i 60-60i -20+40i;
        -25+25i -20+40i 45-65i];
 V = [1.0 0;1.0 0.0 ;1.0 0.0 ];
 J1 = zeros(nb-1,nb-1) ;
 J2 = zeros(nb-1,nb-1) ;
 J3 = zeros(nb-1,nb-1) ;
 J4 = zeros(nb-1,nb-1) ;


 for p = 2:nb
     Vp = V(p,1);
     delta_p = V(p,2) * pi/180;

     Ypp = abs(Y(p,p));
     theta_pp = angle(Y(p,p));

     V1 = V(1,1);
     delta_1 = V(1,2) * pi/180;
Yp1 = abs( Y(p,1) );
     theta_p1 = angle( Y(p,1));

    J1 (p-1,p-1) = Vp * V1 * Yp1 * sin( theta_p1 - delta_p + delta_1 );
    J2 (p-1,p-1) = 2*Vp*Ypp*cos(theta_pp) + V1*Yp1*cos(theta_p1 - delta_p + delta_1);
    J3 (p-1,p-1) = Vp*V1*Yp1*cos(theta_p1 - delta_p + delta_1);
    J4 (p-1,p-1) = -2*Vp*Ypp*sin(theta_pp) - Vp*Yp1*sin(theta_p1 - delta_p + delta_1);

     for q = 2:nb

         Vq = V(q,1) ;
         delta_q = V(q,2) * pi/180;

Ypq = abs ( Y(p,q) );
         theta_pq = angle( Y(p,q) );

        temp1 = -Vp * Vq * Ypq * sin( theta_pq - delta_p + delta_q) ;
        temp2 =  Vq * Ypq * cos( theta_pq - delta_p + delta_q) ;
        temp3 = -Vp * Vq * Ypq * cos( theta_pq - delta_p + delta_q) ;
        temp4 = -Vp * Ypq * sin( theta_pq - delta_p + delta_q) ;

          if q ~= p
             J1(p-1,q-1) = temp1 ;
             J1(p-1,p-1) = J1(p-1,p-1) - temp1 ;

             J2(p-1,q-1) = temp2 ;
             J2(p-1,p-1) = J2(p-1,p-1) + temp2 ;       cont…
```

Exp:6

FORMATION OF JACOBIAN FOR THE SYSTEM NOT EXCEEDING 4 BUSES (no PV BUSES) IN POLAR COORDINATES

Aim: A Three-Bus system is given. Form a Jacobian matrix for the system in polar coordinates.

PROCEDURE:

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

```
cont…
                J3(p-1,q-1) = temp3 ;
                J3(p-1,p-1) = J3(p-1,p-1) - temp3 ;

                J4(p-1,q-1) = temp4 ;
                J4(p-1,p-1) = J4(p-1,p-1) + temp4 ;

            end

        end
 end

 J = [J1 J2; J3 J4]
```
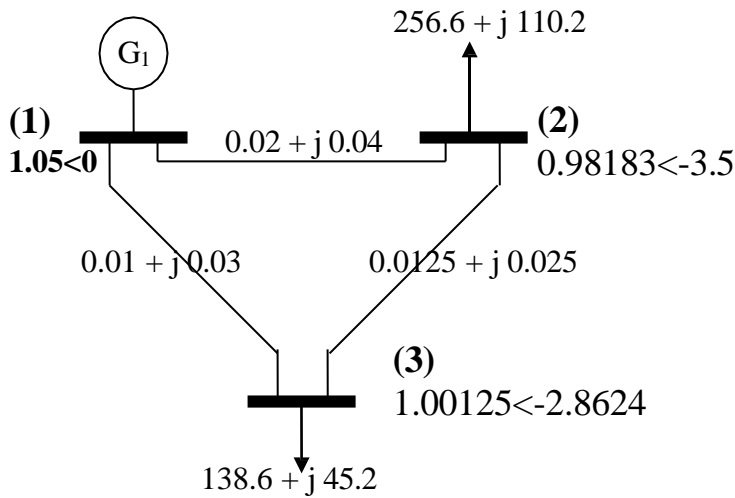
EXPECTED RESULT

```
J =

  60.0000  -40.0000   60.0000  -20.0000
 -40.0000   65.0000  -20.0000   45.0000
 -60.0000   20.0000   60.0000  -40.0000
  20.0000  -45.0000  -40.0000   65.0000
```

Case study:

Program:

```
clc;
clear;
linedata = [1  2  0.02      0.04  0
            1  3  0.01      0.03  0
            2  3  0.0125  0.025  0];
fr=linedata(:,1);
to=linedata(:,2);
R=linedata(:,3);
X=linedata(:,4);
B_half=linedata(:,5);
nb=max(max(fr),max(to));
nbr=length(R);

bus_data = [1  1.05          0
            2 0.98183  -3.5
            3  1.00125  -2.8624];
bus_no=bus_data(:,1);
volt_mag=bus_data(:,2);
angle_d=bus_data(:,3);

Z = R + j*X;                    %branch impedance
y= ones(nbr,1)./Z;              %branch admittance
Vbus=(volt_mag.*cos(angle_d*pi/180))+ (j*volt_mag.*sin(angle_d*pi/180));
%line current
for k=1:nbr
Ifr(k)=(Vbus(fr(k))-Vbus(to(k)))*y(k) + (Vbus(fr(k))*j*B_half(k));
Ito(k)=(Vbus(to(k))-Vbus(fr(k)))*y(k) + (Vbus(to(k))*j*B_half(k));
end
%line flows
% S=P+jQ
for k=1:nbr
```

Exp: 7.

DETERMINATION OF BUS CURRENTS, BUS POWER & LINE FLOWS FOR A SPECIFIED SYSTEM VOLTAGE (BUS) PROFILE.

AIM: Determination of bus currents, bus power and line flow for a specified system voltage (Bus) Profile

PROCEDURE:

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

```
Sfr(k)=Vbus(fr(k))*Ifr(k)';
Sto(k)=Vbus(to(k))*Ito(k)';
end
%line losses
for k=1:nbr
SL(k)=Sfr(k)+Sto(k);
end
%bus power
Sbus=zeros(nb,1);
for n=1:nb
    for k=1:nbr
        if fr(k)==n
            Sbus(n)=Sbus(n)+Sfr(k);
        elseif to(k)==n
            Sbus(n)=Sbus(n)+Sto(k);
        end
    end
end
%Bus current
%P+jQ=V*I'
Ibus=(Sbus./Vbus)';
fprintf('      OUTPUT DATA \n');
 fprintf('................................\n');
 fprintf('      Line Currents\n');
 fprintf('................................\n');
    for k=1:nbr
        fprintf(' I%d%d= %4.3f (+) %4.3f  \n',fr(k),to(k),real(Ifr(k)),imag(Ifr(k)));
        fprintf(' I%d%d= %4.3f (+) %4.3f \n', to(k),fr(k),real(Ito(k)),imag(Ito(k)));
    end
 fprintf('................................\n');

 fprintf('      Line Flows\n')
 fprintf('................................\n');
    for k=1:nbr
        fprintf(' S%d%d= %4.3f (+) %4.3f  \n',fr(k),to(k),real(Sfr(k)),imag(Sfr(k)));
        fprintf(' S%d%d= %4.3f (+) %4.3f \n', to(k),fr(k),real(Sto(k)),imag(Sto(k)));
    end
 fprintf('................................\n');
 fprintf('      Line Losses\n')
 fprintf('................................\n');
    for k=1:nbr
        fprintf(' SL%d%d= %4.3f (+) %4.3f  \n',fr(k),to(k),real(SL(k)),imag(SL(k)));
    end
    fprintf('................................ \n');
 fprintf('      Bus Power\n')
 fprintf('................................\n');
    for k=1:nb
        fprintf(' P%d= %4.3f (+) %4.3f  \n',k,real(Sbus(k)),imag(Sbus(k)));
    end
    fprintf('      Bus Current\n')
 fprintf('................................\n');
    for k=1:nb
```

```
    fprintf(' I%d= %4.3f (+) %4.3f  \n',k,real(Ibus(k)),imag(Ibus(k)));
  end
fprintf('_____ \n');
```

EXPECTED RESULT:

```
 OUTPUT DATA
- - - - - - - - - - - - - - - - - -
    Line Currents
- - - - - - - - - - - - - - - - - -
I12= 1.899 (+) -0.801
I21= -1.899 (+) 0.801
I13= 2.000 (+) -1.000
I31= -2.000 (+) 1.000
I23= -0.638 (+) 0.481
I32= 0.638 (+) -0.481
- - - - - - - - - - - - - - - - - -
    Line Flows
- - - - - - - - - - - - - - - - - -
 S12= 1.994 (+) 0.841
 S21= -1.909 (+) -0.671
 S13= 2.100 (+) 1.050
 S31= -2.050 (+) -0.900
 S23= -0.654 (+) -0.433
 S32= 0.662 (+) 0.449
- - - - - - - - - - - - - - - - - -
    Line Losses
- - - - - - - - - - - - - - - - - -
 SL12= 0.085 (+) 0.170
 SL13= 0.050 (+) 0.150
 SL23= 0.008 (+) 0.016
- - - - - - - - - - - - - - - - - -
    Bus Power
- - - - - - - - - - - - - - - - - -
 P1= 4.094 (+) 1.891
 P2= -2.563 (+) -1.104
 P3= -1.388 (+) -0.451
    Bus Current
- - - - - - - - - - - - - - - - - -
 I1= 3.899 (+) -1.801
 I2= -2.537 (+) 1.282
 I3= -1.362 (+) 0.519
- - - - - - - - - - - - - - - - - -
```

Power System

Simulation using

MiPower™

Exp: 8

LOAD FLOW STUDIES FOR A GIVEN POWER SYSTEM USING
SOFTWARE   PACKAGE

Figure below shows a single line diagram of a 5bus system with 2 generating units, 7 lines. Per unit transmission line series impedances and shunt susceptances are given on 100MVA Base, real power generation, real & reactive power loads in MW and MVAR are given in the accompanying table with bus1 as slack, obtain a load flow solution with Y-bus using Gauss-Siedel method and Newton Raphson method. Take acceleration factors as 1.4 and tolerances of 0.0001 and 0.0001 per unit for the real and imaginary components of voltage and 0.01 per unit tolerance for the change in the real and reactive bus powers**.**
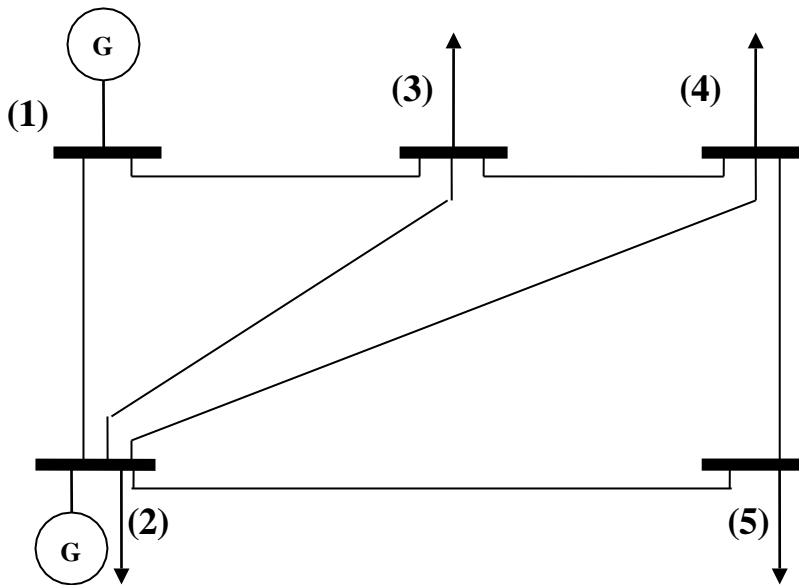
IMPEDANCES AND LINE CHARGING ADMITTANCES FOR THE SYSTEM

Table: 1.1		
Bus cone From-To	**Impedance R+jX**	**Line Charging B/2**
1-2	0.02+j0.06	j 0.030
1-3	0.08+j0.24	j 0.025
2-3	0.06+j0.18	j 0.020
2-4	0.06+j0.18	j 0.020
2-5	0.04+j0.12	j 0.015
3-4	0.01+j0.03	j 0.010
4-5	0.08+j0.24	j 0.025

GENERATION, LOADS AND BUS VOLTAGES FOR THE SYSTEM

Table: 1.2					
Bus No	Bus Voltage	Generation MW	Generation MVAR	Load MW	Load MVAR
1	1.06+j0.0	0	0	0	0
2	1.00+j0.0	40	30	20	10
3	1.00+j0.0	0	0	45	15
4	1.00+j0.0	0	0	40	5
5	1.00+j0.0	0	0	60	10

General procedure for using Mi-Power software
1. Double click on the **MiPower** icon present in the desktop.
2. Click ok and click on **MiPower** button, then select super user than click **ok**.
3. A blue screen MiPower window will appear, then double click on the ▤ power system editor to get MiGui window.

Load flow studies
1. Select menu option **Database** ⇒ **Configure.** Configure Database **dialog** is popped, Click **Browse** button.
2. **Open** dialog box is popped up, then browse the desired directory and specify the name of the database (file name).
3. Create the Bus-bar structure as given in the single line diagram.
   Note: since the voltages are mentioned in the PU, any KV can be assumed. So the base voltage is chosen as 220 KV
4. After creating the Buses draw the transmission line according to the single line diagram given.
5. Place the generator and enter it"s ratings on the respective Bus number mentioned in the single line diagram.
6. Similarly as generator place the load and its data.
7. Go to solve menu in that select load flow analysis, select case (as no 1), select study info..
8. Load flow studies window will appear in that select gauss seidel method (, then enter the accretion factor 1.4 or 1.6, then mention slack bus as Bus no 1, finally select print option as detailed results with data then press ok.
9. Click on execute button, then click on the report. Select standard finally click on OK.

**Procedure to enter the data for performing studies using MiPower**

MiPower - Database Configuration
Open Power System Network Editor. Select menu option **Database** ⇒ **Configure.** Configure Database **dialog** is popped up as shown below. Click **Browse** button.
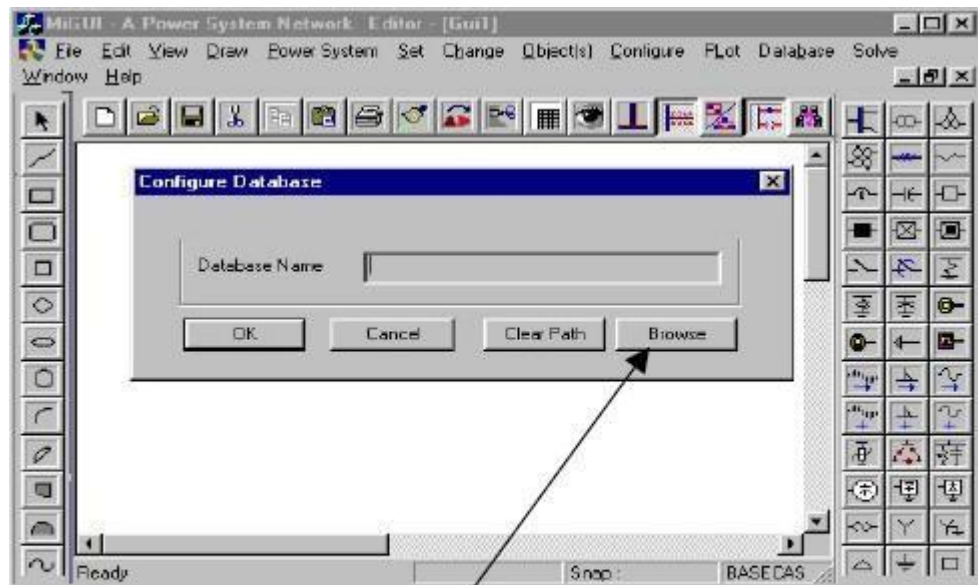
Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click **Open** button after entering the hired database name. **Configure Database** dialog will appear with path chosen.
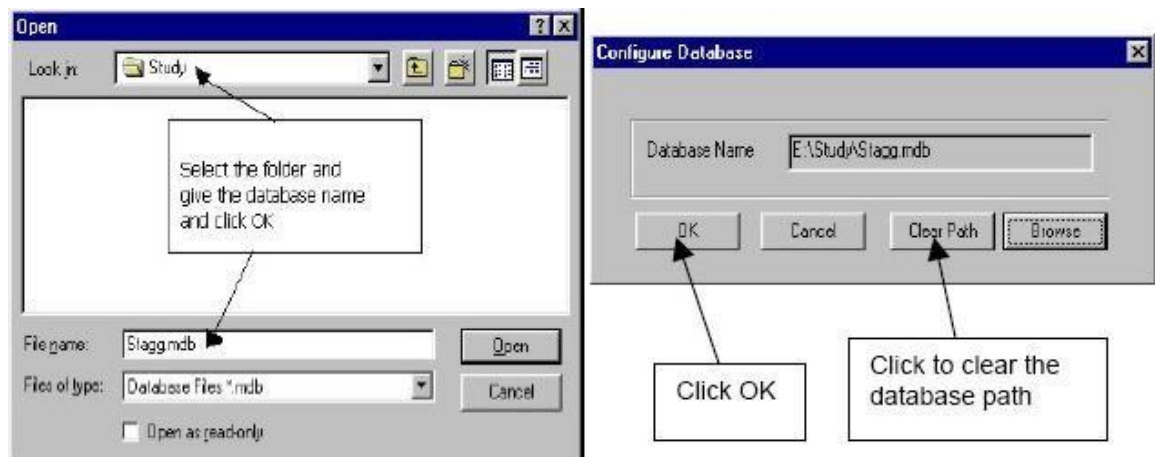
Note: Do not work in the MiPower directory.
Click **OK** button on the **Configure database** dialog. The dialog shown below appears.
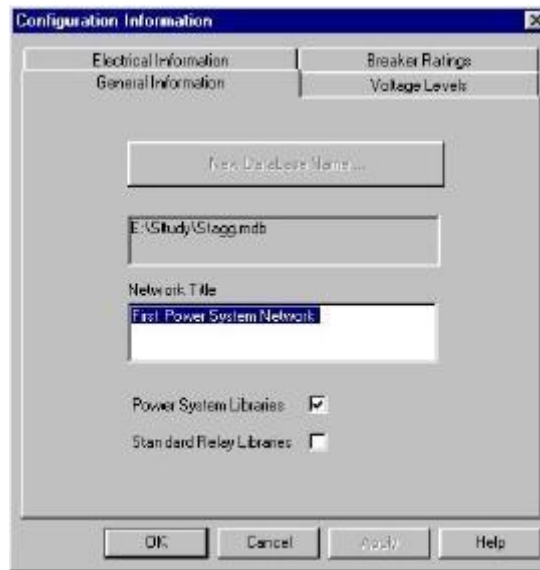
Uncheck the Power System Libraries and Standard Relay Libraries. For this example these standard libraries are not needed, because all the data is given on pu for power system libraries (like transformer, line\cable, generator), and relay libraries are required only for relay co-ordinate studies. If Libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab. Since the impedances are given on 100 MVA base, check the pu status. Enter the Base and Base frequency as shown below. Click on Breaker Ratings button to give breaker ratings. Click **OK** to create the database to return to Network Editor.
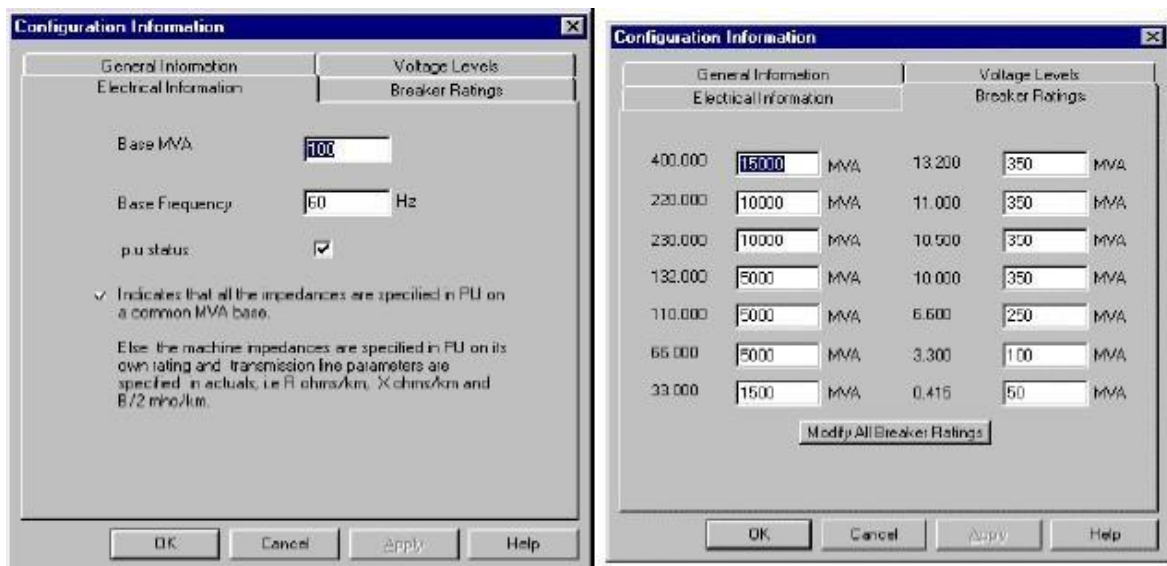
Bus Base Voltage Configuration

In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage**. The dialog shown below appears. If necessary change the **Base-voltages**, **color, Bus width** and click **OK**.

Procedure to Draw First Element - Bus

Click on **Bus** icon provided on power system tool bar. Draw a bus and a dialog appears prompting to give the Bus ID and Bus Name. Click OK.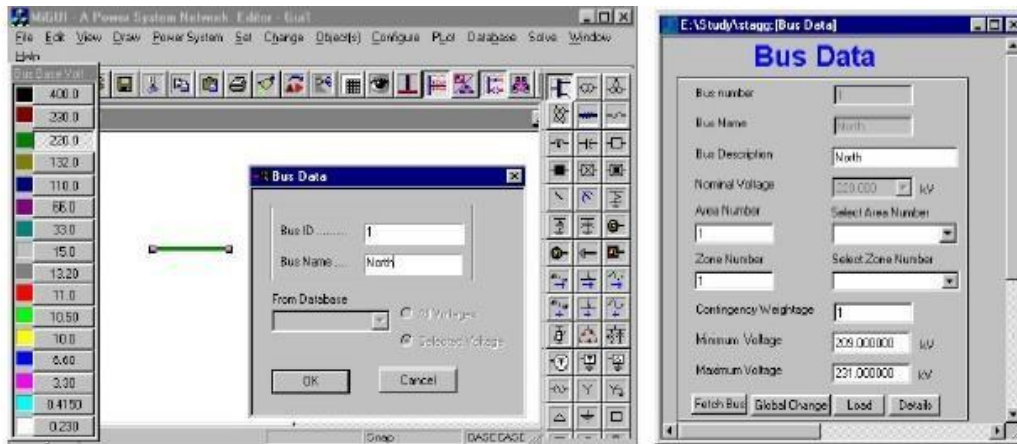 Database manager with corresponding **Bus Data** form will appear. Modify the Area number, Zone number and Contingency Weightage data if it is other than the default values. If this data is not furnished, keep the default values. Usually the minimum and maximum voltage ratings are ± 5% of the rated voltage. If these ratings are other than this, modify these fields. Otherwise keep the default values.

Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name field and the bus description field can be used to abbreviate the bus name. For example let us say the bus name is **Northeast**, then bus name can be given as **NE** and the bus description field can be **North East.**

After entering data click **Save** 🖫 which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

Bus Number	Bus Name	Nominal Voltage(kV)
2	South	220
3	Lake	220
4	Main	220
5	Elm	220

Note: Since the voltages are mentioned in pu, any kV can be assumed. So the base voltage is chosen as 220 kV.

Procedure to Draw Transmission Line

Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus double clicking LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element ID** dialog will appear.
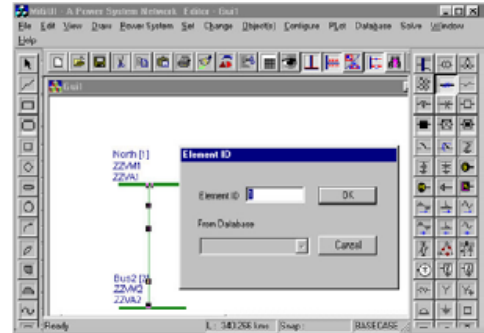
Enter **Element ID** number and click **OK**. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.

Enter **Structure Ref No.as 1** and click on **Transmission Line Library >>** button.
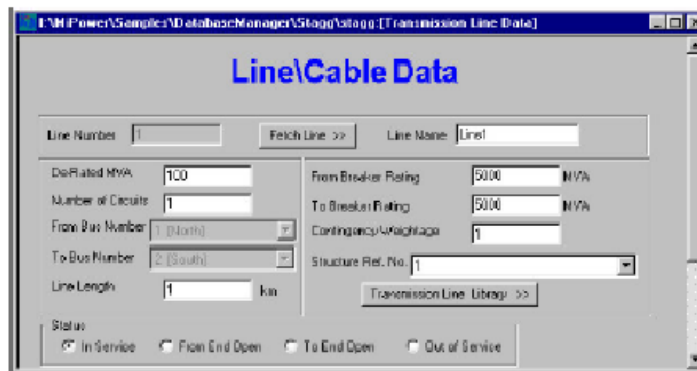
Line & Cable Library form will appear. Enter Transmission line library data in the form as shown below for Line1-2.
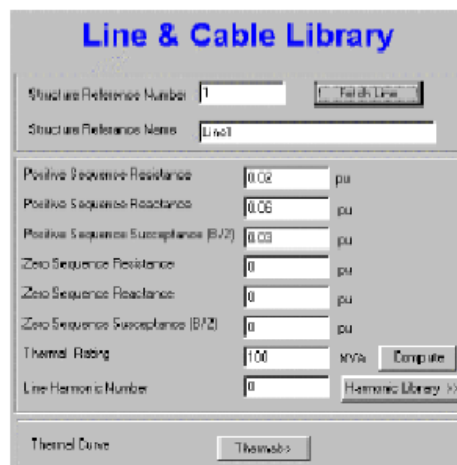
After entering data **Save** and Close. **Line\Cable Data** form will appear. Click **Save**, which invokes Network Editor to update next element. Data for remaining elements given in the following table.

Transmission Line Element Data

Line No	From Bus	To Bus	No. Of circuits	Structure Ref. No.
2	1	3	1	2
3	2	3	1	3
4	2	4	1	3
5	2	5	1	4
6	3	4	1	5
7	4	5	1	2

Transmission Line Library Data

Structure Ref No	Structure Ref Name	Resistance	Reactance	Line charging B/2	Thermal Rating
1	Line 1-2	0.02	0.06	0.03	100
2	Line1-3 & 4-5	0.08	0.24	0.025	100
3	Line2-3 & 2-4	0.06	0.18	0.02	100
4	Line2-5	0.04	0.12	0.015	100
5	Line3-4	0.01	0.03	0.01	100

Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Connect it to bus 1 by clicking the LMB on **Bus 1**. The **Element ID** dialog will appear. Enter ID number and click OK. Database with corresponding **Generator Data** form will appear. Enter details as shown below.
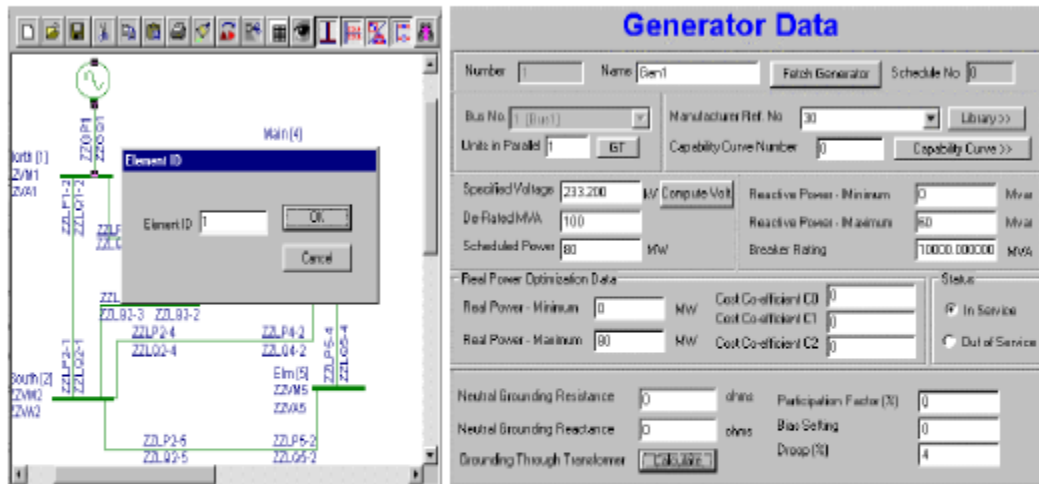
Since the specified voltage is given as 1.06 pu, click the **Compute Volt** button and give 1.06 value. Voltage will be calculated and appear in the specified voltage field.

Since generator at bus 1 is mention as slack bus, only specified voltage will have importance.

Note: *At slack bus, only voltage and angle are mentioned. Scheduled power, real power minimum and maximum constraints do not have much importance.*

If the bus is a PV bus (like bus 2), then scheduled power, specified voltage, minimum and maximum real and reactive power data is must.

Enter Manufacturer Ref. No.as 1 and click on **Generator Library** button. Generator library form will appear.
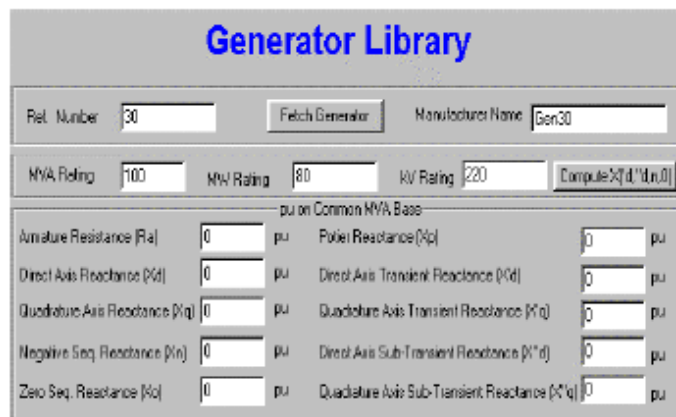
After entering data **Save** 🖫 and close. In Generator Data form click **Save** 🖫. **Network Editor** screen will be invoked. Similarly connect generator 2 at bus 2. Enter its details as given in the following table.

Generator 2 Element Data	
Manufacturer Ref.No	2
No. of Units parallel	1
Specified voltage	220
Derated MVA	50
Scheduled Power	40
Real Power Min.	0
Real Power Max.	40
Reactive Power Min	30
Reactive Power Max	30

Note: *Since in the data at bus 2, it is mentioned the Q generation as 30 MVAR. It means that generator has to generate 30 MVAR compulsorily. So mention Q min and Q max data as same (30) for this particular case. Thus bus has become PQ bus.*

Generator 2 Library Data	
MVA Rating	50
MW rating	40
kV rating	220
Manufacturer Name	Gen2

Procedure To Enter Load Data

Click on **Load** icon provided on power system tool bar. Connect load 1 at BUS2 by clicking the LMB on Bus 2. **Element ID** dialog will appear. Give ID No as 1 and say OK. **Load Data** form will appear. Enter load details as shown below. Then click **Save** button, which invokes Network Editor.
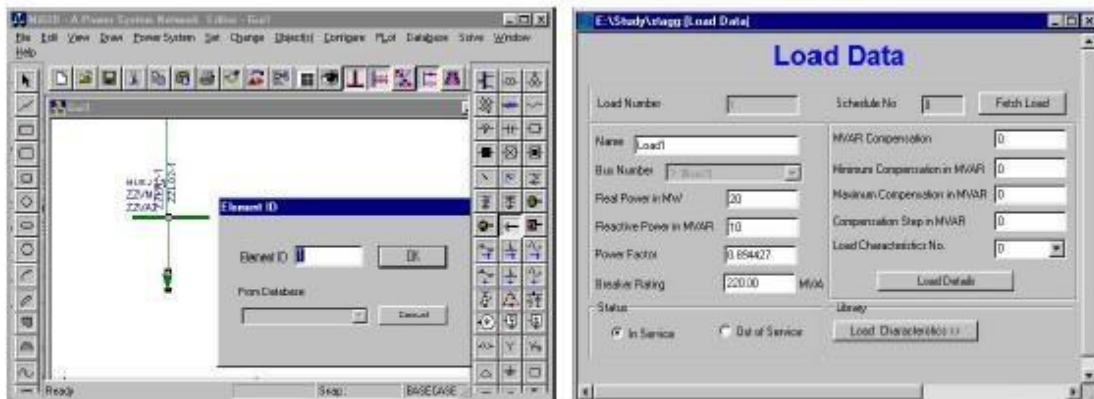
Connect other loads to buses 3, 4 and 5. Enter other load details as given in the following table.

Load Details			
Load No	Bus No	MW	MVAR
2	5	60	10
3	3	45	15
4	4	40	5

Solve Load Flow Analysis

Select Menu option **Solve→Load Flow Analysis.** Following dialog will appear.

When **Study Info** button is clicked, following dialog will open. Select Gauss-Siedel Method and enter acceleration factor as 1.4 and P-Tolerance and Q-Tolerance as 0.0001. Click OK.
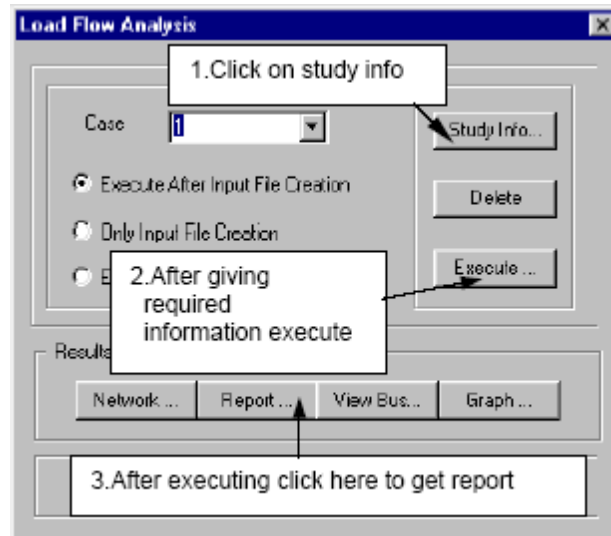
When **Study Info** button is clicked, following dialog will open. Select Gauss-Siedel Method and enter acceleration factor as 1.4 and P-Tolerance and Q-Tolerance as 0.0001. Click OK.
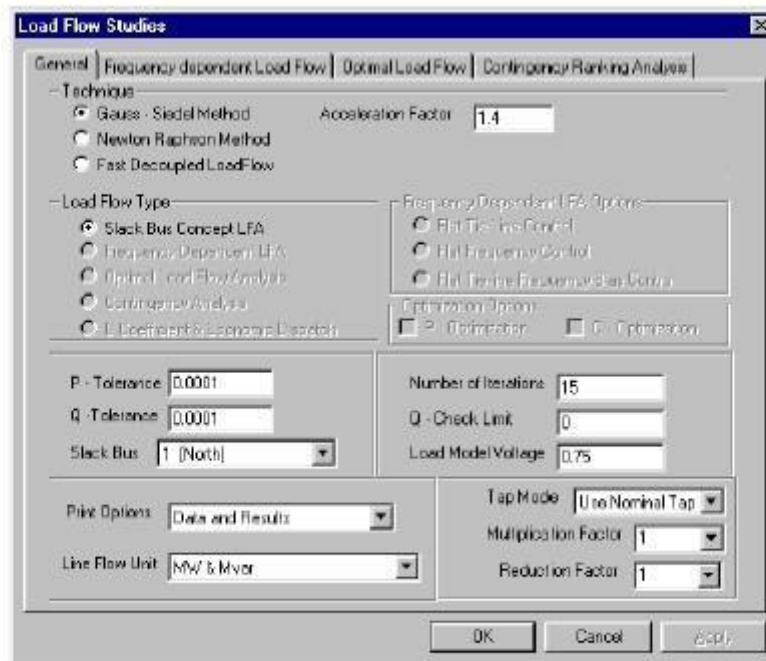
Execute load flow analysis and click on **Report** in load flow analysis dialog to view report. Repeat the procedure with P and Q tolerances as 0.01 for Newton Raphson Method.

Report

```
-------------------------------------------------------------------------------
Date and Time : Fri Jan 12 16:52:27 2001
-------------------------------------------------------------------------------
        LOAD FLOW BY GAUSS-SIEDEL METHOD
CASE NO :  1      CONTINGENCY  : 0   SCHEDULE NO : 0
CONTINGENCY NAME : Base Case

-------------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------------
LARGEST BUS NUMBER USED        :    5    ACTUAL NUMBER OF BUSES        :    5
NUMBER OF 2 WIND. TRANSFORMERS :    0    NUMBER OF 3 WIND. TRANSFORMERS :   0
NUMBER OF TRANSMISSION LINES   :    7
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :   0
NUMBER OF CIRCUIT BREAKERS     :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :   0
NUMBER OF SHUNT IMPEDANCES     :    0
NUMBER OF GENERATORS           :    2    NUMBER OF LOADS               :    4
NUMBER OF LOAD CHARACTERISTICS :    0    NUMBER OF UNDER FREQUENCY RELAY:   0
NUMBER OF GEN CAPABILITY CURVES:    0    NUMBER OF FILTERS             :    0
NUMBER OF TIE LINE SCHEDULES   :    0
NUMBER OF CONVERTORS           :    0    NUMBER OF DC LINKS            :    0

--------------------------------------------------------------------------------
LOAD FLOW WITH GAUSS-SEIDEL METHOD              :    5
NUMBER OF ZONES                                 :    1
PRINT OPTION                                    :    3 - BOTH DATA AND RESULTS PRINT
PLOT OPTION                                     :    1 - PLOTTING WITH PU VOLTAGE
NO FREQUENCY DEPENDENT LOAD FLOW, CONTROL OPTION:    0
BASE MVA                                        : 100.000000
NOMINAL SYSTEM FREQUENCY (Hzs)                  : 60.000000
FREQUENCY DEVIATION (Hzs)                       : 0.000000
FLOWS IN MW AND MVAR, OPTION                    : 0
SLACK BUS                                       :    1
TRANSFORMER TAP CONTROL OPTION                  :    0
Q CHECKING LIMIT   (ENABLED)                    :    0
REAL POWER TOLERANCE (PU)                       :  0.00010
REACTIVE POWER TOLERANCE (PU)                   :  0.00010
MAXIMUM NUMBER OF ITERATIONS                    :   15
BUS VOLTAGE BELOW WHICH LOAD MODEL IS CHANGED   :  0.75000
CIRCUIT BREAKER RESISTANCE   (PU)               :  0.00000
CIRCUIT BREAKER REACTANCE    (PU)               :  0.00010
TRANSFORMER R/X RATIO                           :  0.05000
--------------------------------------------------------------------------------
ANNUAL PERCENTAGE INTEREST CHARGES              :  15.000
ANNUAL PERCENT OPERATION & MAINTENANCE CHARGES  :   4.000
LIFE OF EQUIPMENT IN YEARS                      :  20.000
ENERGY UNIT CHARGE (KWHOUR) IN RUPEES           :   2.500
LOSS LOAD FACTOR                                :   0.300
COST PER MVAR IN LAKHS OF RUPEES                :   5.000
--------------------------------------------------------------------------------
ZONE WISE MULTIPLICATION FACTORS
ZONE   P LOAD   Q LOAD   P GEN    Q GEN SH REACT   SH CAP
----  --------  --------  --------  --------  --------  --------
  0    1.000    1.000    1.000    1.000    1.000    1.000
  1    1.000    1.000    1.000    1.000    1.000    1.000
--------------------------------------------------------------------------------
BUS DATA

BUS NO. STATUS ZONE   BUS KV  VMIN-PU  VMAX-PU    NAME
------- ------ ----  --------  --------  --------  --------
      1      1    1  220.000    0.950    1.050   North
      2      1    1  220.000    0.950    1.050   South
      3      1    1  220.000    0.950    1.050   Lake
      4      1    1  220.000    0.950    1.050   Main
      5      1    1  220.000    0.950    1.050    Elm

--------------------------------------------------------------------------------
```

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	R(P.U)	X(P.U.)	B/2(P.U.)	RATING MVA	KMS
3	1	1	North	2	South	0.02000	0.06000	0.03000	100	1.0
3	1	1	North	3	Lake	0.08000	0.24000	0.02500	100	1.0
3	1	4	Main	5	Elm	0.08000	0.24000	0.02500	100	1.0
3	1	2	South	3	Lake	0.06000	0.18000	0.02000	100	1.0
3	1	2	South	4	Main	0.06000	0.18000	0.02000	100	1.0
3	1	2	South	5	Elm	0.04000	0.12000	0.01500	100	1.0
3	1	3	Lake	4	Main	0.01000	0.03000	0.01000	100	1.0

```
TOTAL LINE CHARGING SUSCEPTANCE        :    0.29000
TOTAL LINE CHARGING MVAR AT 1 PU VOLTAGE :    29.000

TOTAL CAPACITIVE SUSCEPTANCE           :    0.00000 pu -    0.000 MVAR
TOTAL INDUCTIVE SUSCEPTANCE            :    0.00000 pu -    0.000 MVAR
```

GENERATOR DATA

SL.NO*	FROM NODE	FROM NAME*	REAL POWER(MW)	Q-MIN MVAR	Q-MAX MVAR	V-SPEC P.U.	CAP. CURV	MVA RATING	STAT
1	1	North	80.0000	0.0000	60.0000	1.0600	0	100.00	3
2	2	South	40.0000	30.0000	30.0000	1.0000	0	50.00	3

LOAD DATA

SLNO*	FROM NODE	FROM NAME*	REAL MW	REACTIVE MVAR	COMP MVAR	COMPENSATING MVAR MIN	MAX	VALUE STEP	CHAR NO STAT	F/V NO
1	2	South	20.000	10.000	0.000	0.000	0.000	0.000	0 3	0 0
2	5	Elm	60.000	10.000	0.000	0.000	0.000	0.000	0 3	0 0
3	3	Lake	45.000	15.000	0.000	0.000	0.000	0.000	0 3	0 0
4	4	Main	40.000	5.000	0.000	0.000	0.000	0.000	0 3	0 0

```
TOTAL SPECIFIED MW GENERATION        :  120.00000
TOTAL MIN MVAR LIMIT OF GENERATOR    :   30.00000
TOTAL MAX MVAR LIMIT OF GENERATOR    :   90.00000
TOTAL SPECIFIED MW LOAD              :  165.00000 reduced  165.00000
TOTAL SPECIFIED MVAR LOAD            :   40.00000 reduced   40.00000
TOTAL SPECIFIED MVAR COMPENSATION    :    0.00000 reduced    0.00000
```

GENERATOR DATA FOR FREQUENCY DEPENDENT LOAD FLOW

SLNO*	FROM NODE	FROM NAME*	P-RATE MW	P-MIN MW	P-MAX MW	%DROOP C0	PARTICI FACTOR C1	BIAS SETTING C2
1	1	North	80.000	0.0000	80.0000	4.0000 0.0000	0.0000 0.0000	0.0000 0.0000
2	2	South	40.000	0.0000	40.0000	4.0000 0.0000	0.0000 0.0000	0.0000 0.0000

```
Acceleration factor : 1.40
```

Iteration count =   1 Error =   0.052537 Bus =   2

Iteration count =   2 Error =   0.015724 Bus =   5

Iteration count =   3 Error =   0.007669 Bus =   5

```
Iteration count =    4  Error =   0.002768 Bus =    2

Iteration count =    5  Error =   0.002594 Bus =    5

Iteration count =    6  Error =   0.001050 Bus =    4

Iteration count =    7  Error =   0.000867 Bus =    3

Iteration count =    8  Error =   0.000394 Bus =    2

Iteration count =    9  Error =   0.000217 Bus =    3

Iteration count =   10  Error =   0.000117 Bus =    3

Iteration count =   11  Error =   0.000044 Bus =    2
---------------------------------------------------------------------------
BUS VOLTAGES AND POWERS

NODE FROM      V-MAG  ANGLE      MW      MVAR       MW      MVAR     MVAR
NO.  NAME      P.U. DEGREE      GEN       GEN     LOAD      LOAD     COMP
---- --------  ------ ------  -------- --------  -------- -------- --------
  1    North  1.0600   0.00   129.534   -7.469     0.000    0.000    0.000 #<
  2    South  1.0475  -2.81    40.000   30.000    20.000   10.000    0.000
  3     Lake  1.0242  -5.00     0.000    0.000    45.000   15.000    0.000
  4     Main  1.0236  -5.33     0.000    0.000    40.000    5.000    0.000
  5      Elm  1.0180  -6.15     0.000    0.000    60.000   10.000    0.000
---------------------------------------------------------------------------
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    0
NUMBER OF BUSES EXCEEDING MAXIMUM VOLTAGE LIMIT (# mark) :    1
NUMBER OF GENERATORS EXCEEDING MINIMUM Q LIMIT (< mark)  :    1
NUMBER OF GENERATORS EXCEEDING MAXIMUM Q LIMIT (> mark)  :    0

---------------------------------------------------------------------------
LINE FLOWS AND LINE LOSSES

SLNO CS FROM FROM      TO TO          FORWARD             LOSS            %
        NODE NAME    NODE NAME        MW     MVAR       MW     MVAR LOADING
---- -- ---- -------- ---- --------  -------- --------  -------- -------- -------
  1  1    1    North    2   South    88.825   -8.610    1.4093  -2.4345    84.2#
  2  1    1    North    3    Lake    40.710    1.141    1.1911  -1.8583    38.4^
  3  1    4     Main    5     Elm     6.334   -2.280    0.0307  -5.1178     6.8&
  4  1    2    South    3    Lake    24.690    3.535    0.3513  -3.2385    24.7&
  5  1    2    South    4    Main    27.936    2.957    0.4413  -2.9660    27.5^
  6  1    2    South    5     Elm    54.824    7.346    1.1253   0.1756    52.8$
  7  1    3     Lake    4    Main    18.901   -5.166    0.0357  -1.9898    19.1&
---------------------------------------------------------------------------
! NUMBER OF LINES LOADED BEYOND   125%              :    0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    0
# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    1
$ NUMBER OF LINES LOADED BETWEEN  50% AND  75% :    1
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    2
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    3
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
---------------------------------------------------------------------------
NEW SYSTEM FREQUENCY FOR ISLAND 1         :    60.000 Hzs


---------------------------------------------------------------------------
Summary of results
TOTAL REAL POWER GENERATION   :   169.534 MW
TOTAL REACT. POWER GENERATION :    22.531 MVAR

TOTAL SHUNT REACTOR INJECTION :     0.000 MW
TOTAL SHUNT REACTOR INJECTION :     0.000 MVAR

TOTAL SHUNT CAPACIT.INJECTION :     0.000 MW
TOTAL SHUNT CAPACIT.INJECTION :     0.000 MVAR

TOTAL REAL POWER LOAD         :   165.000 MW
TOTAL REACTIVE POWER LOAD     :    40.000 MVAR
TOTAL COMPENSATION AT LOADS   :     0.000 MVAR

TOTAL HVDC REACTIVE POWER     :     0.000 MVAR

TOTAL REAL POWER LOSS (AC+DC) :     4.585 MW (    4.585+    0.000)
PERCENTAGE REAL  LOSS (AC+DC) :     2.704
TOTAL REACTIVE POWER  LOSS    :   -17.429 MVAR

---------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------------
Zone wise distribution
Description          Zone # 1
--------------- ----------
MW generation        169.5343

MVAR generation       22.5314

MW load              165.0000

MVAR load             40.0000

MVAR compensation      0.0000

MW loss                4.5846

MVAR loss            -17.4293

MVAR - inductive       0.0000

MVAR - capacitive      0.0000

--------------------------------------------------------------------------------
Zone wise export(+ve)/import(-ve)
Zone #   1 MW & MVAR
------ -------- --------
     1        -----

--------------------------------------------------------------------------------
Date and Time : Fri Jan 12 16:52:28 2001
--------------------------------------------------------------------------------
```

Exercise Problems:
1. Using the available software package conduct load flow analysis for the given power system using Gauss-Siedel / Newton-Raphson / Fast decoupled load flow method. Determine
   (a) Voltage at all buses
   (b) Line flows
   (c) Line losses and
   (d) Slack bus power.
   Also draw the necessary flow chart (general flow chart)

2. Using the available software package conduct load flow analysis for the given power system using Gauss-Siedel / Newton-Raphson / Fast decoupled load flow method. Determine
   (a) Voltage at all buses
   (b) Line flows
   (c) Line losses and
   (d) Slack bus power.
   Also draw the necessary flow chart (general flow chart), Compare the results with the results obtained when (i) a line is removed (ii) a load is removed.

   Refer below question for Q.(1) & Q(2)
   Consider the 3 bus system of figure each of the line has a series impedence of
   $(0.02 + j0.08)$ p.u. & a total shunt admittance of j 0.02 p.u. The specified quantities at the buses are tabulated below on 100 MVA base.

Bus No.	Real Load Demand P_D	Reactive Load Demand Q_D	Real Power Generation P_G	Reactive Power Generation Q_G	Voltage Specification
1	2.0	1.0	Unspesified	Unspesified	$V_1 = (1.04 + j\,0)$ (Slack Bus)
2	0.0	0.0	0.5	1.0	Unspesified (PQ Bus)
3	0.5	0.6	0.0	$Q_{G3} = ?$	$V_3 = 1.04$ (PV Bus)

Controllable reactive power source is available at bus 3 with the constraint
  $0 \le Q_{G3} \le 1.5$ p.u.
Find the load flow solution using N R method. Use a tolerance of 0.01 for power mismatch.
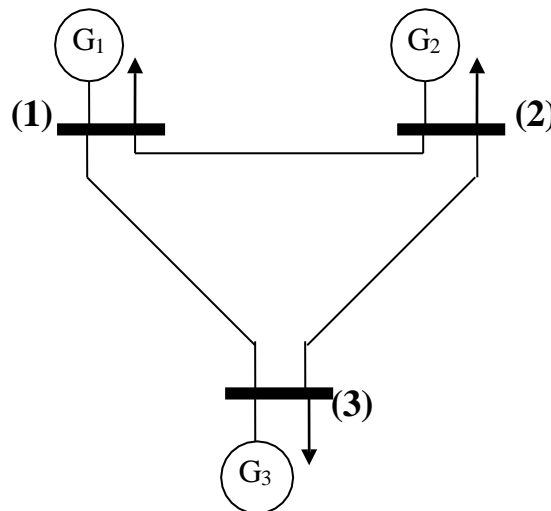
3. Figure shows the one line diagram of a simple three bus system with generation at bus 1, the voltage at bus 1 is $V_1 = 1.0 \angle 0^0$ pu. The scheduled loads on buses 2 and 3 are marked on diagram. Line impedances are marked in pu on a 100MVA base. For the purpose of hand calculations line resistances and line charging susceptances are neglected. Using Gauss-Seidel method and initial estimates of $V_2 = 1.0 \angle 0^0$ pu & $V_3 = 1.0 \angle 0^0$ pu. Conduct load flow analysis.
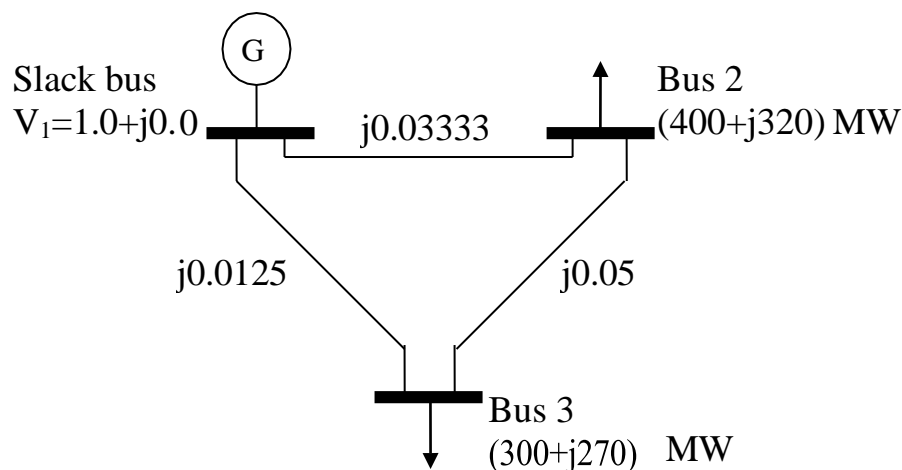
Exp: 9.

FAULT STUDIES FOR A GIVEN POWER SYSTEM USING SOFTWARE PACKAGE

Figure shows a single line diagram of a 6-bus system with two identical generating units, five lines and two transformers. Per-unit transmission line series impedances and shunt susceptances are given on 100 MVA base, generator's transient impedance and transformer leakage reactances are given in the accompanying table.

If a 3-phase to ground fault occurs at bus 5, find the fault MVA. The data is given below.

Bus-code p-q	Impedance Zpq	Line Charging Y'pq/2
3-4	0.00+j0.15	0
3-5	0.00+j0.10	0
3-6	0.00+j0.20	0
5-6	0.00+j0.15	0
4-6	0.00+j0.10	0

Generator details:
$G_1 = G_2 = 100MVA$, 11KV with $X''_d = 10\%$

Transformer details:
$T_1 = T_2 = 11/110KV$, 100MVA, leakage reactance = X = 5%

[All impedances are on 100MVA base**

Mi Power Data Interpretation:

SOLUTION:

In transmission line data, elements 3 – 4 & 5 – 6 have common parameters. Elements 3 - 5 & 4 – 6 have common parameters. Therefore 3 libraries are required for transmission line.

As generators G1 and G2 have same parameters, only one generator library is required. The same applies for transformers also.

General procedure for using Mi-Power software
1. Double click on the **MiPower** icon present in the desktop.
2. Click ok and click on **MiPower** button, then select super user than click **ok**.   Type your text
3. A blue screen MiPower window will appear, then double click on the [icon] power system editor to get MiGui window

Short Circuit Analysis
1. Select menu option **Database** ⇒ **Configure.** Configure Database **dialog** is popped, Click **Browse** button.
2. **Open** dialog box is popped up, then browse the desired directory and specify the name of the database (file name).
3. Create the Bus-bar structure as given in the single line diagram.
4. After creating the Buses draw the transmission line according to the single line diagram given.
5. Place the generator and transformer; enter its ratings on the respective Bus number mentioned in the single line diagram.
6. Similarly as generator place the load and its data.
7. Go to solve menu in that select Short Circuit analysis, select case (as no 1), select study info..
8. In short circuit data select: 3 phase to ground fault, then in option select „select buses" in that select which bus fault has to be created
9. Click on execute button and then click on the report. Select standard finally click on OK.

Procedure to enter the data for performing studies using Mi Power

Mi Power - Database Configuration

Open Power System Network Editor. Select menu option **Database→Configure**. Configure Database dialog is popped up. Click **Browse** button.
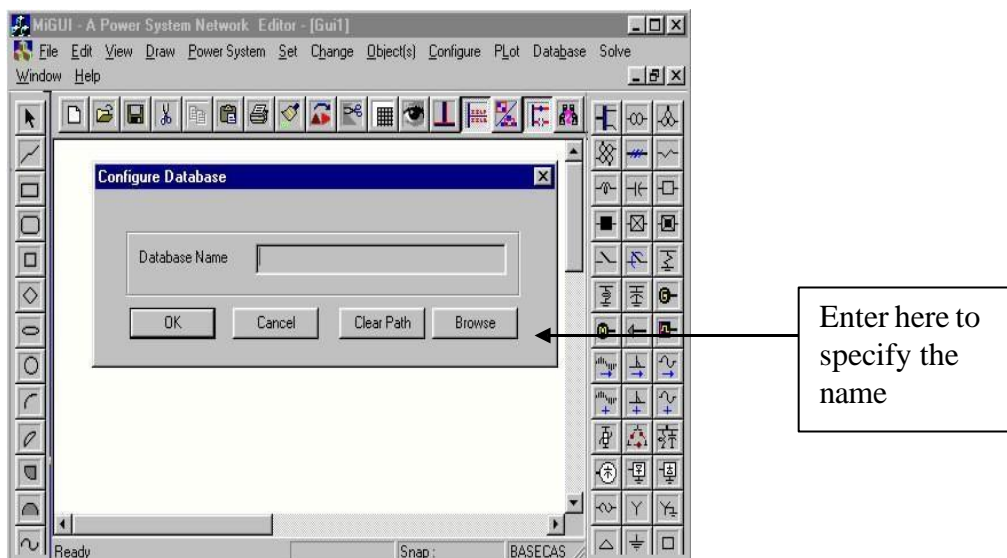
Enter here to specify the name

Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click **Open** button after entering the desired database name. **Configure Database** dialog will appear with path chosen.
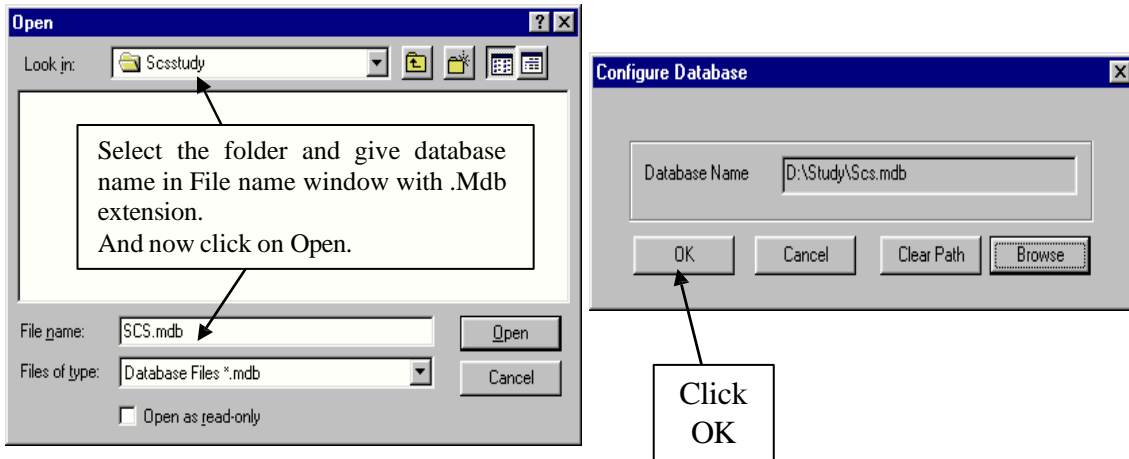
Click on **OK** button in the **Configure database** dialog, the following dialog appears.
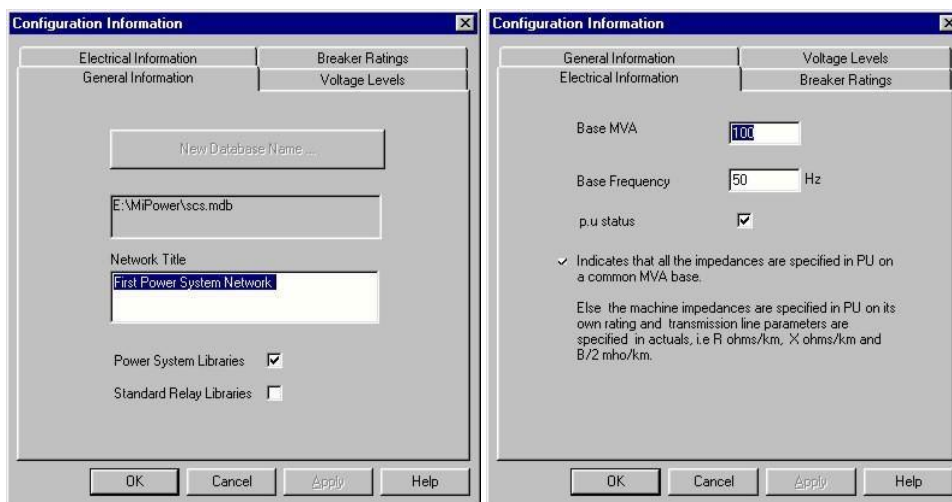
Uncheck the Power System Libraries and Standard Relay Libraries. For this example these standard libraries are not needed, because all the data is given on p u for power system libraries (like transformer, line\cable, generator), and relay libraries are required only for relay co-ordination studies. If Libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab.

Since the impedances are given on 100 MVA base, check the pu status. Enter the Base MVA and Base frequency as shown below. Click **Breaker Ratings** tab. If the data is furnished, modify the breaker ratings for required voltage levels. Otherwise accept the default values. Click **OK** button to create the database to return to Network Editor.

Bus Base Voltage Configuration
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure Base voltage.** Dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

Procedure to Draw First Element - Bus

Click on **Bus** icon provided on power system tool bar. Draw a bus and a dialog appears prompting to give the Bus ID and Bus Name. Click OK. Database manager with corresponding **Bus Data** form will appear. Modify the Area number, Zone number and Contingency Weightage data if it is other than the default values. If this data is not furnished, keep the default values. Usually the minimum and maximum voltage ratings are ± 5% of the rated voltage. If these ratings are other than this, modify these fields. Otherwise keep the default values.

Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name field and the bus description field can be used to abbreviate the bus name. For example let us say the bus name is **Northeast**, then bus name can be given as **NE** and the bus description field can be **North East.**

After entering data click save, which invokes Network Editor. Follow the same procedure for remaining buses. Following table gives the data for other buses.

Bus data						
Bus Number	1	2	3	4	5	6
Bus Name	Bus1	Bus2	Bus3	Bus4	Bus5	Bus6
Nominal voltage	11	11	110	110	110	110
Area number	1	1	1	1	1	1
Zone number	1	1	1	1	1	1
Contingency Weightage	1	1	1	1	1	1

**Procedure to Draw Transmission Line**

Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus, double click LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus** .**Element ID** dialog will appear.
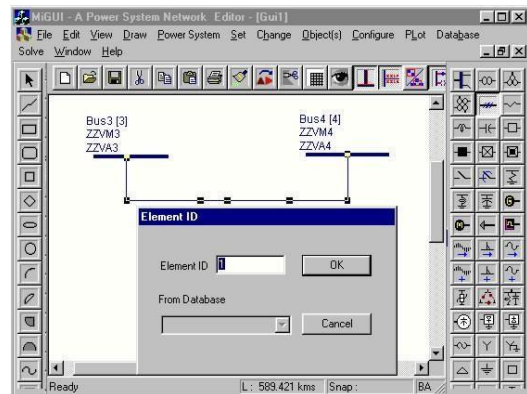
Enter **Element ID** number and click OK. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.

Enter **Structure Ref No. as 1** and click on **Transmission Line Library >>** button. **Line & Cable Library** form will appear. Enter transmission line library data in the form as shown for Line3-4.
After entering data, **Save** and Close**. Line\Cable Data** form will appear. Click **Save,** which invokes network editor. Data for remaining elements given in the following table. Follow the same procedure for rest of the elements.
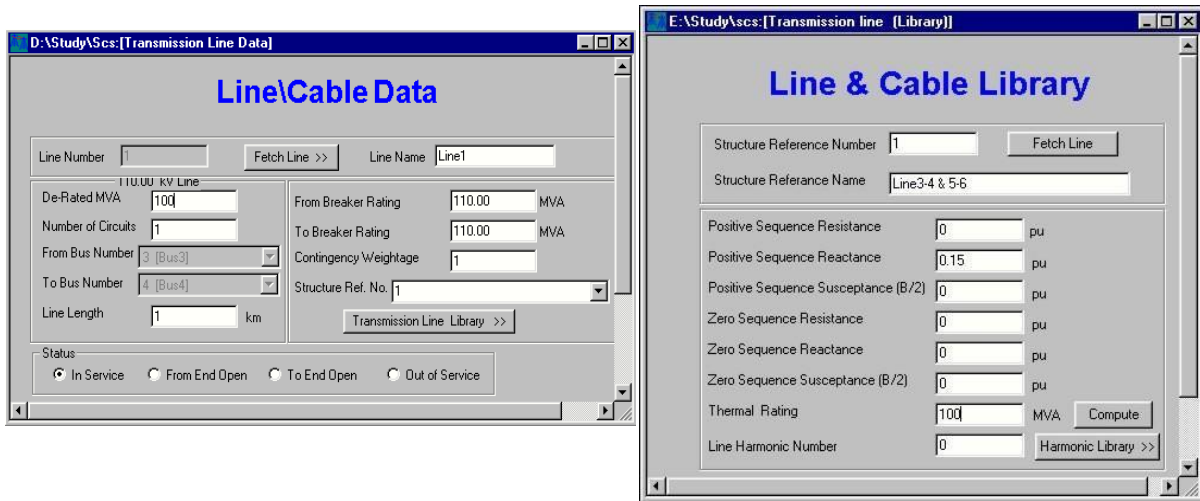
Transmission Line Element Data					
Line Number	1	2	3	4	5
Line Name	Line3-4	Line3-5	Line3-6	Line4-6	Line5-6
De-Rated MVA	100	100	100	100	100
No. Of Circuits	1	1	1	1	1
From Bus No.	3	3	3	4	5
To Bus No.	4	5	6	6	6
Line Length	1	1	1	1	1
From Breaker Rating	5000	5000	5000	5000	5000
To Breaker Rating	5000	5000	5000	5000	5000
Structure Ref No.	**1**	**2**	**3**	**2**	**1**
Transmission Line Library Data					
Structure Ref. No.		1	2	3	
Structure Ref. Name		Line3-4 & 5-6	Line3-5 & 4-6	Line3-6	
Positive Sequence Resistance		0	0	0	
Positive Sequence Reactance		0.15	0.1	0.2	
Positive Sequence Susceptance		0	0	0	
Thermal Rating		100	100	100	

 Procedure to Draw Transformer

Click on **Two Winding Transformer** icon provided on power system tool bar. To draw the transformer click in between two buses and to connect to the from bus, double click LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus Element ID** dialog will appear. Click **OK**.
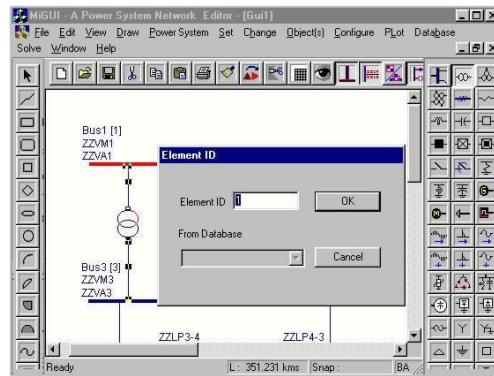
Transformer Element Data form will be open. Enter the **Manufacturer Ref. Number as 30.** Enter transformer data in the form as shown below. Click on **Transformer Library** >>button.
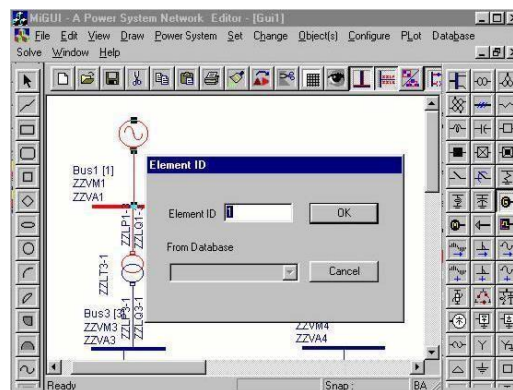
Transformer library form will be open. Enter the data as shown below. **Save** and **close** library screen.

Transformer element data form will appear. Click **Save** button, which invokes network editor. In the similar way enter other transformer details.

2nd Transformer details	
Transformer Number	2
Transformer Name	2T2
From Bus Number	6
To Bus Number	2
Control Bus Number	2
Number of Units in Parallel	1
Manufacturer ref. Number	30
De Rated MVA	100
From Breaker Rating	5000
To Breaker Rating	350
Nominal Tap Position	5

Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Draw the generator by clicking LMB (Left Mouse Button) on the **Bus1**. **Element ID** dialog will appear. Click **OK**.

Generator Data form will be opened. Enter the **Manufacturer Ref. Number** as **20.** Enter Generator data in the form as shown below.

Click on **Generator Library >>** button. Enter generator library details as shown below.

Save and **Close** the library screen. Generator data screen will be reopened. Click **Save** button, which invokes Network Editor. Connect another generator to Bus 2. Enter its details as given in the following table.
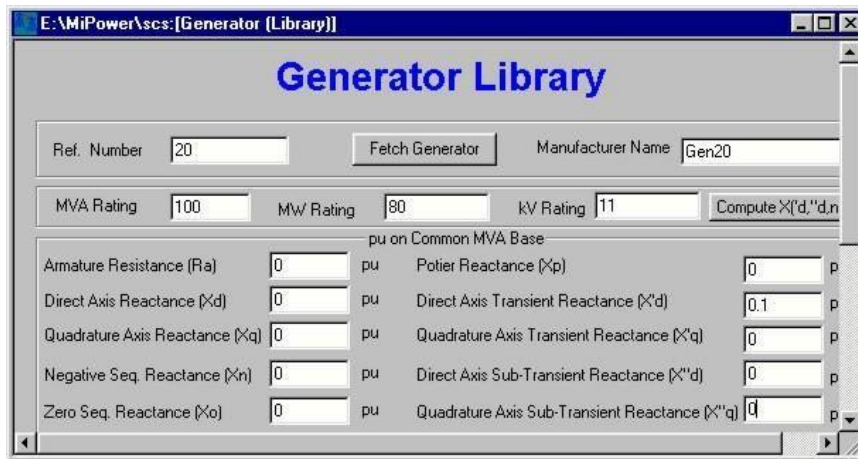
| 2nd Generator details	
Name	GEN-2
Bus Number	2
Manufacturer Ref. Number	20
Number of Generators in Parallel	1
Capability Curve Number	0
De-Rated MVA	100
Specified Voltage	11
Scheduled Power	20
Reactive Power Minimum	0
Reactive Power Maximum	60
Breaker Rating	350
Type of Modeling	Infinite

Note: To neglect the transformer resistance, in the multiplication factor table give the X to R Ratio as 9999.

TO solve short circuit studies choose menu option **Solve →Short Circuit Analysis** or click on **SCS** button on the toolbar on the right side of the screen. Short circuit analysis screen appears.
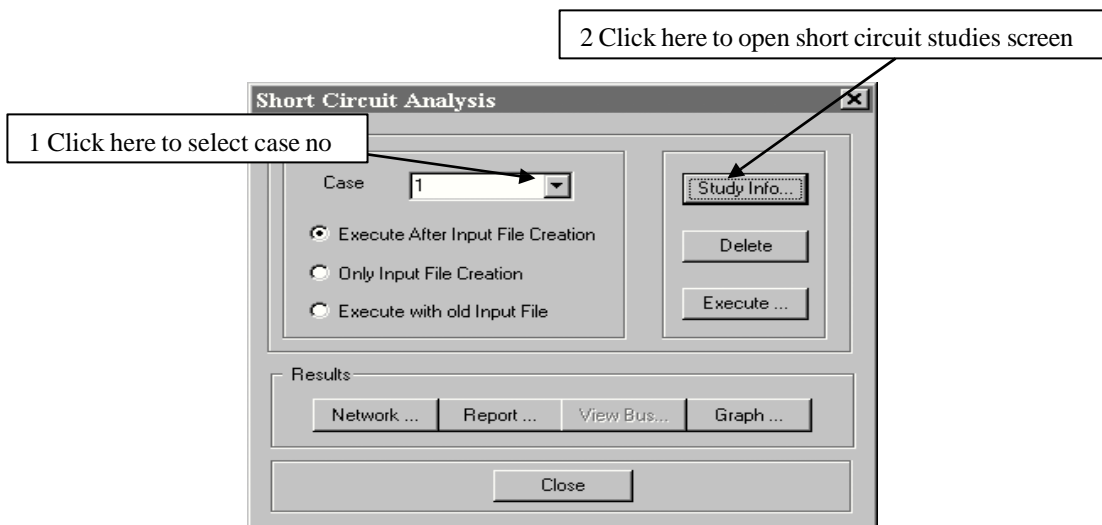
Study Information.
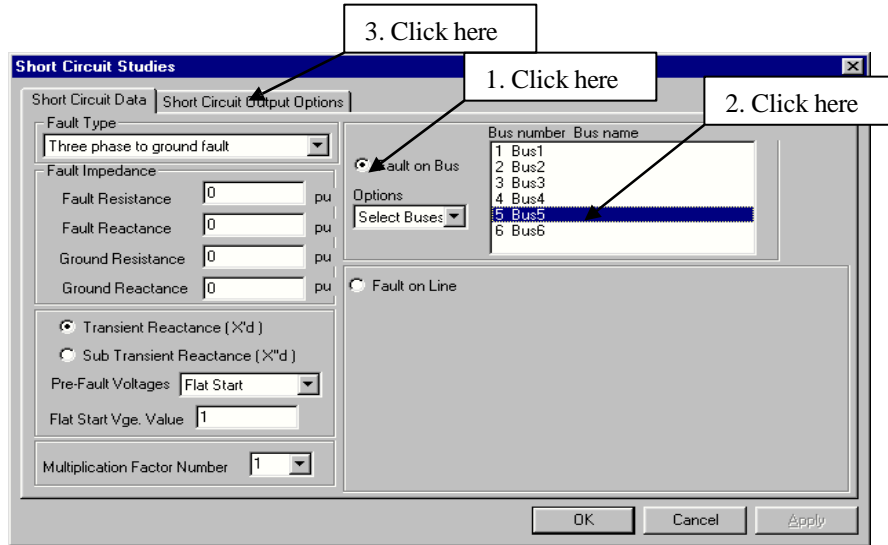
In **Short Circuit Output Options** select the following.
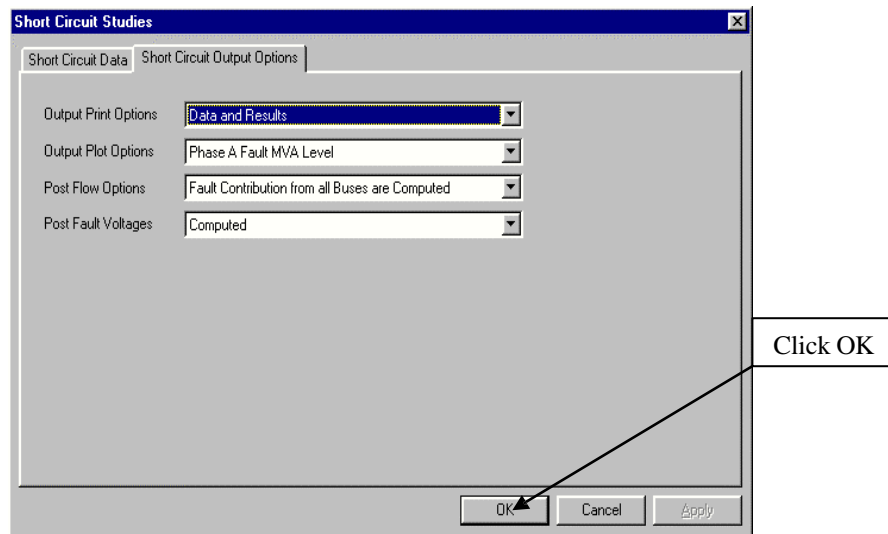
Afterwards click **Execute.** Short circuit study will be executed. Click on **Report** to view the report file.
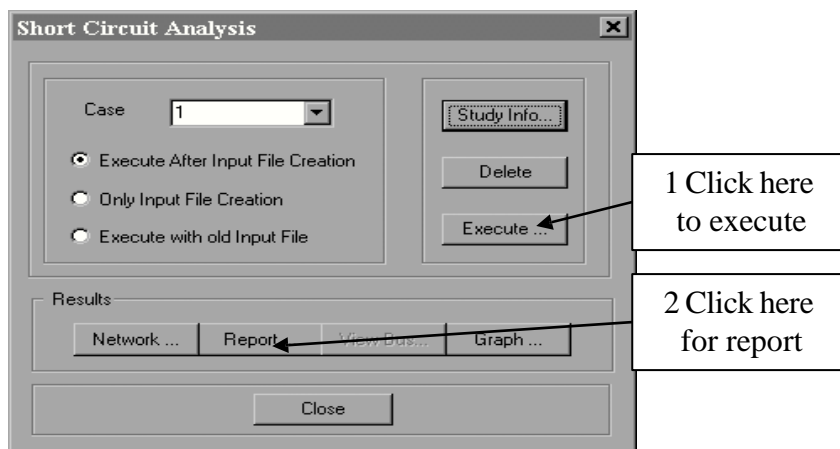
Part of the Report is shown below

```
FAULT AT BUS NUMBER      5 : NAME      Bus5
        CURRENT (AMPS/DEGREE)                          FAULT MVA
 SEQUENCE (1,2,0)      PHASE (A,B,C)       SEQUENCE (1,2,0)      PHASE (A,B,C)
MAGNITUDE   ANGLE   MAGNITUDE   ANGLE        MAGNITUDE             MAGNITUDE
--------- -------  --------- -------        ---------             ---------
     3870  -90.00      3870  -90.00             737                   737
        0  -90.00      3870  150.00               0                   737
        0  -90.00      3870   30.00               0                   737
R/X RATIO OF THE SHORT CIRCUIT PATH       :   0.0000
PEAK ASYMMETRICAL SHORT-CIRCUIT CURRENT :    10947 AMPS
PASCC = k x sqrt(2) x If , k =   2.0000
------------------------------------------------------------------------------
```

Exercise: Simulate single line to ground fault, line to line fault for the above case.

Exercise problems:

1. Using the available software package determine (a) fault current (b) post fault voltages at all buses (c) fault MVA , when a line to ground fault with / with out Zf =_____occurring at__bus for a given test system.(Assume pre fault voltages at all buses to be 1 pu) compare the results with the symmetrical fault.

2. Using the available software package determine (a) fault current (b) post fault voltages at all buses (c) fault MVA , when a line to line & ground fault with / with out Zf =__ occurring at_____bus for a given test system.(Assume pre fault voltages at all buses to be 1 pu) compare the results with the symmetrical fault.

Refer below question for Q.(1) & Q(2)

Reactance of all transformers and transmission lines	= 0.1 pu
Zero sequence reactance of transmission line	= 0.25 pu
Negative sequence reactance of generator	= Subtransient reactace
Zero sequence reactance of generator	= 0.1 pu
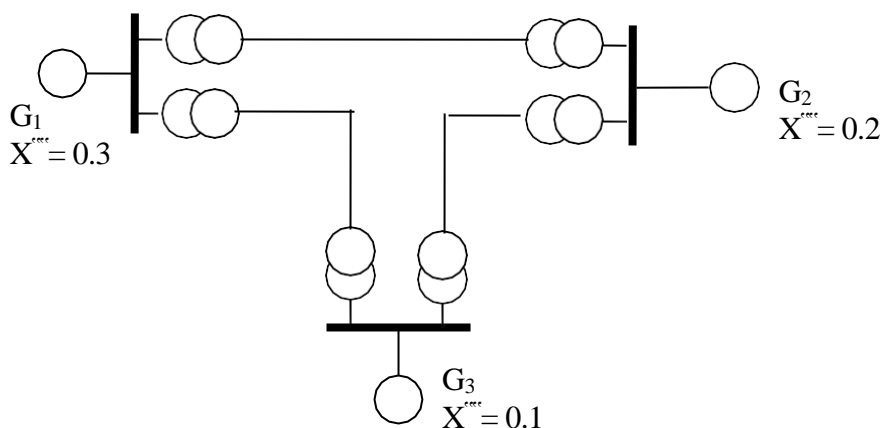
3. For the given circuit, find the fault currents, voltages for the following type of faults at Bus3.
1. Single Line to Ground Fault
2. Line to Line Fault
3. Double line to Ground Fault
For the transmission line assume $X_1 = X_1$, $X_0 = 2.5 X_L$

Bus 1   Bus 2   Bus 3

Δ **Y**

G

$X^{''}_d = 0.3$ $X_t = 0.1$ $X_L = 0.4$
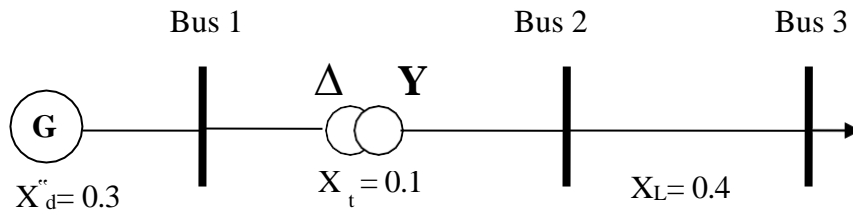
4. For the given circuit, find the fault currents, voltages for the following type of faults at Specified location.

     1. Single Line to Ground Fault
     2. Double line to Ground Fault
     3. Line to Line Fault

Bus 1   Bus 2   Bus 3   Bus 4

Δ **Y**   **Y** Δ

G₁   G₂

100MVA   100MVA $X_1 = X_2 = 20\Omega$ 100MVA

13.8 kV   13.8kV/138kV $X_0 = 60\Omega$ 13.8 kV

$X^{''''} = 0.15$ $X = 0.1pu$ $X^{''''} = 0.2$

$X_2 = 0.17$ $X_2 = 0.21$

$X_0 = 0.05$ $X_0 = 0.1$

                                                        $X_n = 0.05pu$
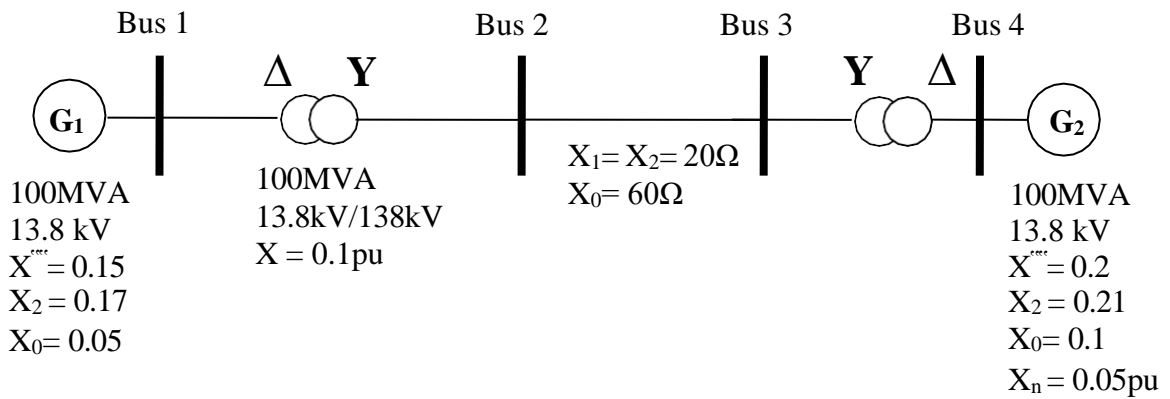
Exp: 10.

OPTIMAL GENERATOR SCHEDULING FOR THERMAL POWER PLANTS USING SOFTWARE PACKAGE

How to solve Economic dispatch using B-coefficient method.

Problem:
Cost equation and loss co-efficient of different units in a plant are given. Determine economic generation for a total load demand of 240 MW.

Unit No	Cost of fuel input in RS/hr	
1	$C1 = 0.05P_1^2 + 20\ P_1 + 800$	$0 <= P_1 <= 100$
2	$C2 = 0.06P_2^2 + 15\ P_2 + 1000$	$0 <= P_2 <= 100$
3	$C2 = 0.07P_3^2 + 18\ P_3 + 900$	$0 <= P_3 <= 100$

Loss Co-efficient:
$B_{11} = 0.0005$; $B_{12} = 0.00005$; $B_{13} = 0.0002$;
$B_{22} = 0.0004$; $B_{23} = 0.00018$; $B_{33} = 0.0005$;
$B_{21} = B_{12}$; $B_{23} = B_{32}$; $B_{13} = B_{31}$;

1. To solve Economic Despatch by using **MiPower** Package, invoke "**MiPower Tools**" in the MiPower main screen and select "*Economic dispatch by B-Coefficient* ".

General procedure for using Mi-Power software

Economic dispatch

1. Double click on the **MiPower** icon present in the desktop.
2. Click ok and click on **MiPower** button, then select super user than click **ok**.
3. Click on tools menu and select economic dispatch by B-coefficient.
4. Click on new button create a new file, and save it.
5. Enter the value of load demand, number of generators and B-Coefficient and save.
6. Enter initial lamda value as 5.
7. Click on save and then execute.

      Note: B-coefficient $B_{00} = B_{01} = B_{10} = B_{02} = B_{20} = B_{30} = B_{03} = 0$

Click here to select Economic dispatch by B-Coefficient
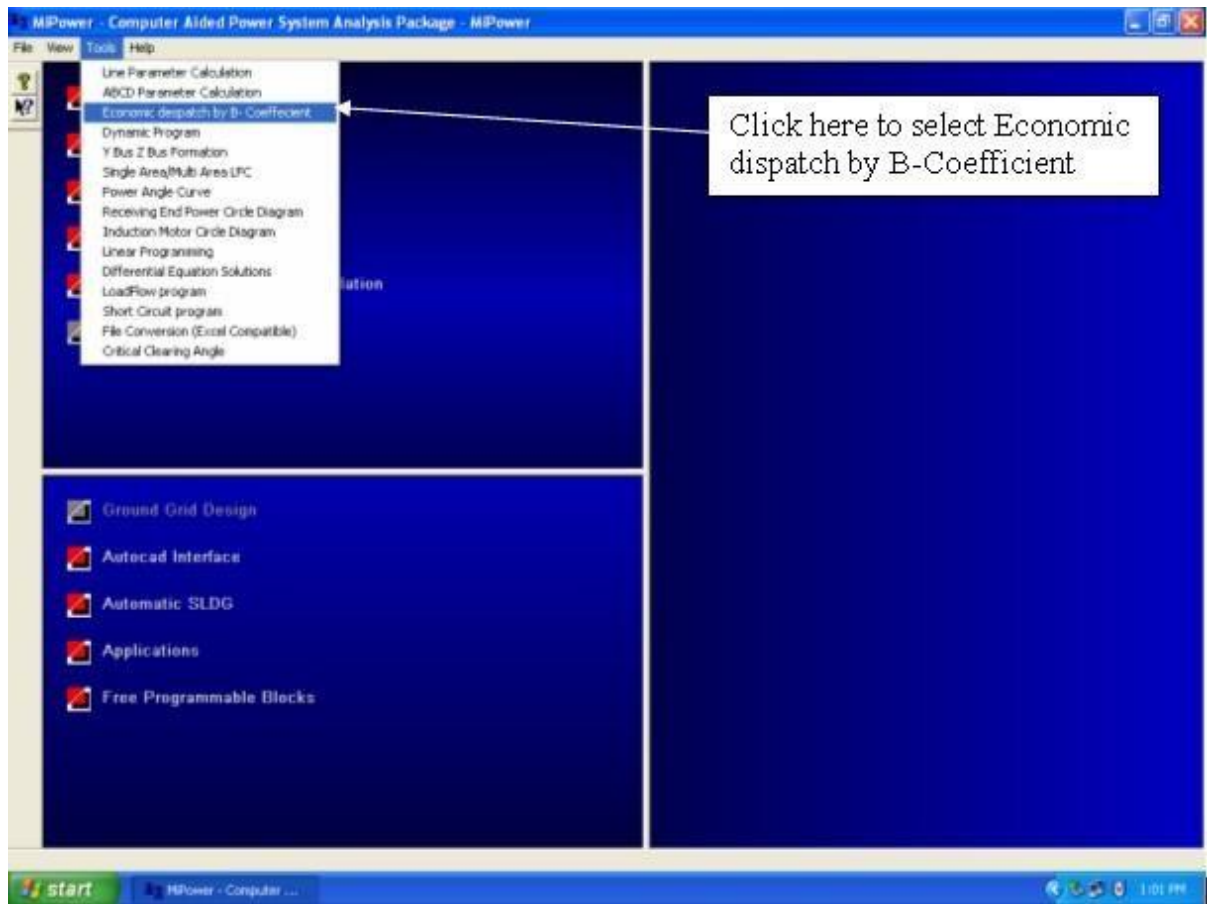
Click here to open an existing file

Click here create new file

2. Select new to create new file.
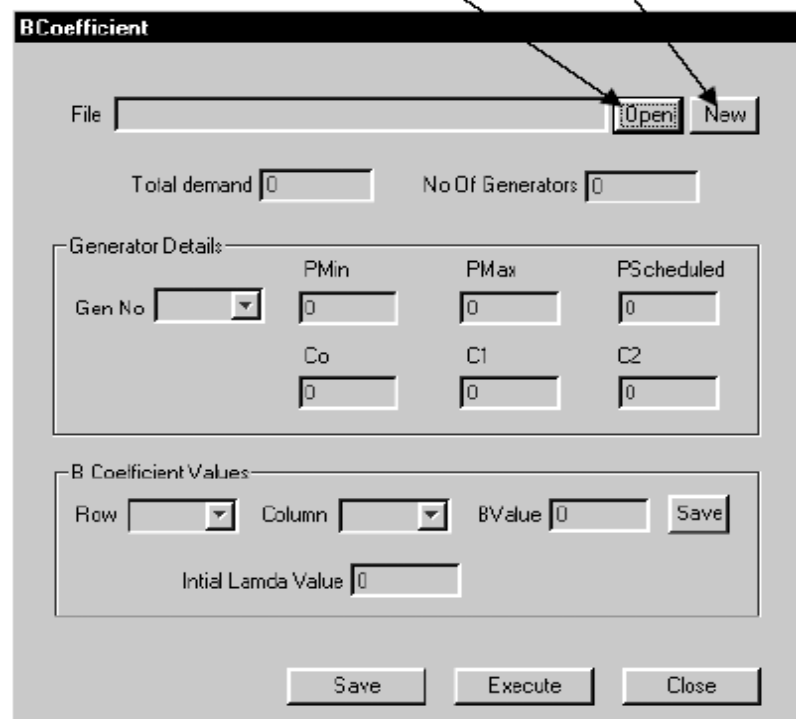
3. Select location to save the file and give the file name.
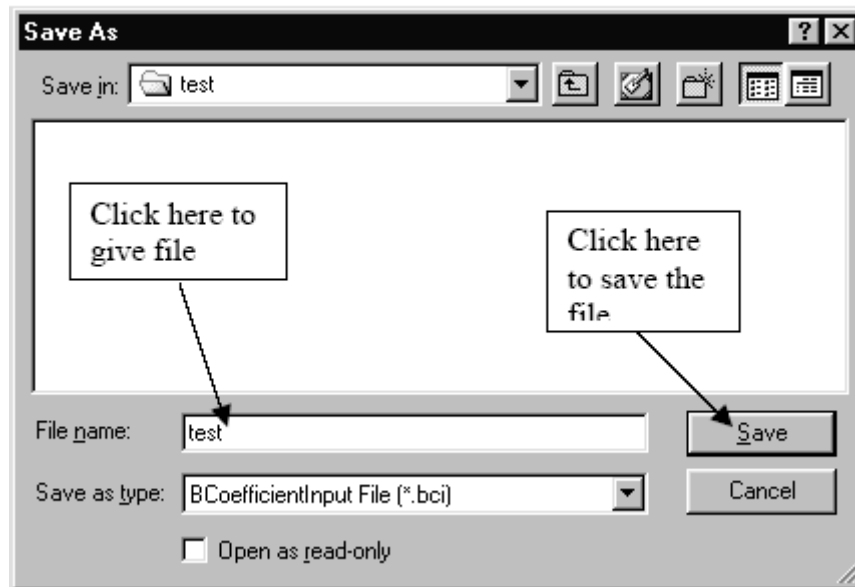
4. Enter the values of total demand as 240 MW and No of generators as 3. Select Generator number as 1 in generator details and enter corresponding values of Pmin, Pmax, Pscheduled and Corresponding C_0, C1, C2 values.
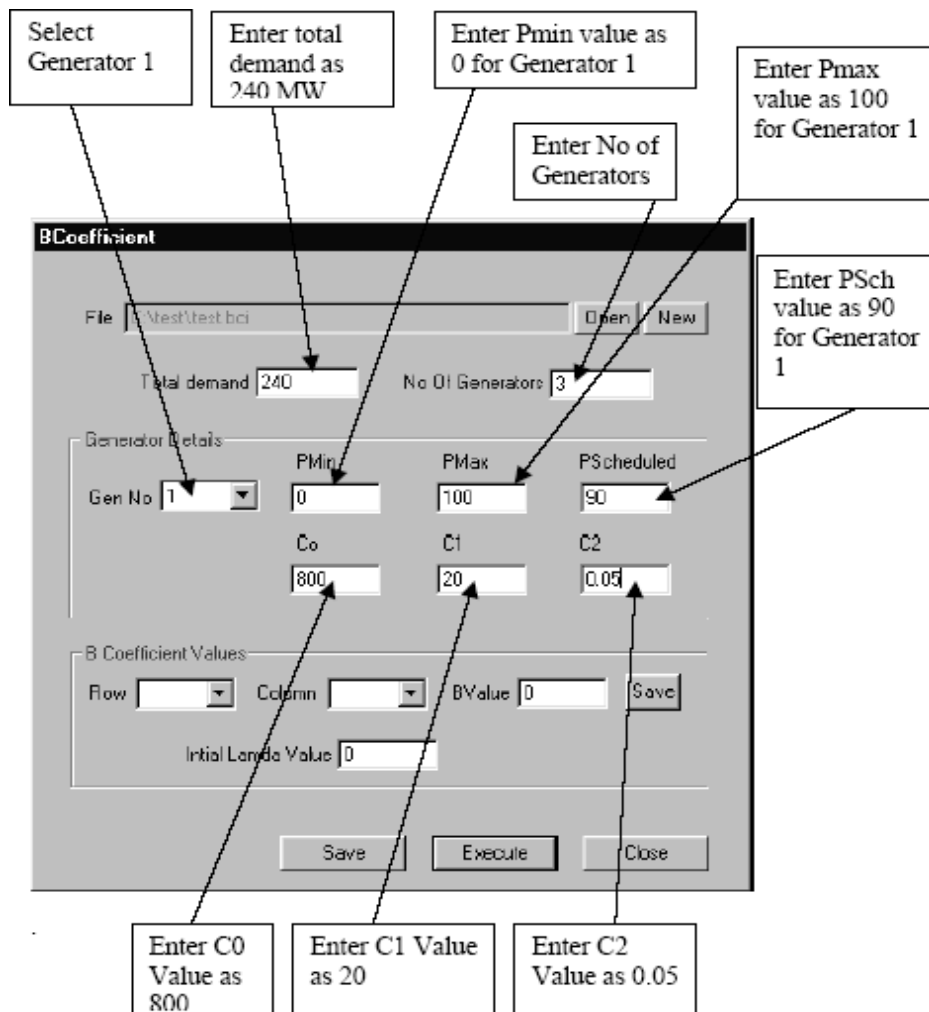
Similarly enter the values of P_{min}, P_{max} and P_{sch}, and C_0, C_1 and C_2 values for other two generators as

Generator Number	P_{min}	P_{max}	P_{sch}	C_0	C_1	C2
2	0	100	90	1000	15	0.06
3	0	100	90	900	18	0.07

5. Enter initial value of Lamda as 5 .Enter the values of B11 as 0.0005 and save the value.

Similarly enter the values of B_{12} to B_{31} as

Variable	Value
B_{12}	0.00005
B_{13}	0.0002
B_{21}	0.00005
B_{22}	0.0004
B_{23}	0.00018
B_{31}	0.0002
B_{32}	0.00018
B_{33}	0.0005

And save the values.

6.Click on save button to save all values. Now click on execute to run economic dispatch study.

Click here to save all values

Click here to Execute and view output file

Click here to close

7. A part of the output file is as shown.

ECOMAMIC DESPATCH USING B-COEFFICENT MATRIX AND PENALTY FACTOR

Values of B-Coeff Matrix are

```
 0.0005000  0.0000500  0.0002000
 0.0000500  0.0004000  0.0001800
 0.0002000  0.0001800  0.0005000
```

Scheduled Generations are

```
 Genp 90.000000 MW
 Genp 90.000000 MW
 Genp 90.000000 MW
```
----

total_loss 18.306000 MW

Initial Cost of generation at bus 1 = 3005.000006 Rs for 90.000000 MW
Initial Cost of generation at bus 2 = 2835.999989 Rs for 90.000000 MW
Initial Cost of generation at bus 3 = 3087.000002 Rs for 90.000000 MW

Iter count 39   Lambda 32.339989   Total gen 255.925873 Total   loss 15.978104
Total load 240.000000   Delta power -0.052231

Initial Total generation cost 8928.000000 Rs
Final Cost of generation at Generator 1 = 2807.234673 Rs for 83.098381 MW
Final Cost of generation at Generator 2 = 3099.999987 Rs for 100.000000 MW
Final Cost of generation at Generator 3 = 2582.163687 Rs for 72.827484 MW

Final Total generation cost is Rs   8489.398438

Cost Coefficient C0

This field specifies the constant cost coefficient C0 in rupees for the generator. This cost is independent of generation.

Generation Cost = Co + C1 MW + C2 (MW)(MW) Rs / hour

Co = Fixed cost (Capital Cost) in Rs/hour, which includes plant installation cost, fuel cost in controllable generator units, generating costs in base loaded units

C1 = Cost in Rs / MW / hour

C2 = Cost in Rs / (MW) (MW) / hour

Exercise Problems:

1. Data given:
Total No. of Generators   2
Total Demand   : 100MW

GENERATOR RATINGS:
 GENERATOR 1:   Pscheduled = 70 MW ; Pmin= 0.0MW; Pmax= 100MW

$$C_0 = 50 ; C_1 = 16 ; C_2 = 0.015$$

$$C_{g1} = 50 + 16 P_1 + 0.015 P_1^2 \text{ Rs / hr}$$

GENERATOR 2:   Pscheduled = 70 MW; Pmin= 0.0MW; Pmax= 100MW

$$C_0 = 30 ; C_1 = 12 ; C_2 = 0.025$$

$$C_{g1} = 30 + 12 P_1 + 0.025 P_1^2 \text{ Rs / hr}$$

Loss (or B) Co- efficients :
$B_{11} = 0.005;$ $B_{12} = B_{21} = 0.0012;$ $B_{22} = 0.002$

2. Given the cost equation and loss Co-efficient of different units in a plant determine economic generation using the available software package for a total load demand of _____MW (typically 150 MW for 2 units and 250 MW for 3 Units) neglecting transmission losses.

3. Given the cost equation and loss Co-efficient of different units in a plant determine penalty factor, economic generation and total transmission loss using the available software package for a total load demand of _____ MW (typically 150 MW for 2

units and 250 MW for 3 Units) .

Refer below questions for Q(2) & Q(3)

A)

Unit No.	Cost of Fuel input in Rs./ hr.	
1	$C_1 = 800 + 20 P_1 + 0.03 P_1^2$	$0 \le P_1 \le 100$
2	$C_2 = 1000 + 15 P_2 + 0.06 P_2^2$	$0 \le P_2 \le 100$
3	$C_3 = 900 + 18 P_3 + 0.07 P_3^2$	$0 \le P_3 \le 100$

Loss (or B) Co- efficients :

$B_{11} = 0.0005$ $B_{12} = 0.00005$ $B_{13} = 0.0002$

$B_{22} = 0.0004$ $B_{23} = 0.00018$ $B_{33} = 0.0005$

$B_{21} = B_{12}$ $B_{32} = B_{23}$ $B_{13} = B_{31}$

B)

Unit No.	Cost of Fuel input in Rs./ hr.	
1	$C_1 = 50 + 16 P_1 + 0.015 P_1^2$	$0 \le P_1 \le 100$
2	$C_2 = 30 + 12 P_2 + 0.025 P_2^2$	$0 \le P_2 \le 100$

Loss (or B) Co- efficients :
$B_{11} = 0.005$ $B_{12} = B_{21} = -0.0012$ $B_{22} = 0.002$

PROGRAM:

```
clc
clear all
% enter Y-bus of the system
Y=[3-12i -2+8i         -1+4i          0
  -2+8i  3.66-14.664i -0.666+2.664i -1+4i
  -1+4i  -0.666+2.664i 3.66-14.664i  -2+8i
   0      -1+4i        -2+8i              3-12i];
%enter no. of buses, slack bus no, no.of pq buses, no of pv buses
nbus=4;
sbno=1;
npq=2;
npv=1;
% assume bus no 1 as slack bus, next npq buses as pq buses and the
remaining as pv buses
%enter slack bus voltage
v(1)=1.06+0i;
%assume voltages at all other buses as 1+j0
v(2)=1;v(3)=1;v(4)=1;
%enter p & q at all pq buses
 P(2)=-0.5;P(3)=-0.4;Q(2)=-0.2;Q(3)=-0.3;
 %enter p ,vsp and q limits at pv buses
 P(4)=0.3;
 vsp(4)=1.04;Qmin(4)=0.1;Qmax(4)=1.0;
 %enter accuracy of convergence
 acc=0.001;
for it=1:5
%to find voltages at pq buses
    for p=2:npq+1,
        v1(p)=v(p);
        pq=(P(p)-Q(p)*i)/conj(v(p));
        ypq=0;
 for q=1:nbus
if(p==q) continue;
          end
          ypq=ypq+Y(p,q)*v(q);
        end
     v(p)=(pq-ypq)/Y(p,p);
    end
%to find voltages at pv buses
    for p=npq+2:nbus,
        v1(p)=v(p);
        s=0;
        for q=1:nbus,
            if(p~=q)
                s=s+Y(p,q)*v(q);
            else
                vp=v(q);
```

Additional Experiments

1. GAUSS-SEIDEL METHOD

AIM: To perform load flow analysis using Gauss- Seidel method (only pq bus)

PROCEDURE:

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

```
                ang=angle(v(q));
                v(q)=complex(vsp(q)*cos(ang),vsp(q)*sin(ang));
                s=s+Y(p,q)*v(q);
            end
        end
        Qc(p)=-1*imag(conj(v(p))*s);
        if(Qc(p)>=Qmin(p)& Qc(p)<=Qmax(p))
             pq=(P(p)-Qc(p)*i)/conj(v(p));
            ypq=0;
            for q=1:nbus
                if(p==q) continue;
                end
                ypq=ypq+Y(p,q)*v(q);
            end
            v(p)=(pq-ypq)/Y(p,p);
            ang=angle(v(p));
            v(p)=complex(vsp(p)*cos(ang),vsp(p)*sin(ang));
    else
             if(Qc(p)<Qmin(p))
                 Q(p)=Qmin(p);
            else
                 Q(p)=Qmax(p);
            end
            pq=(P(p)-Q(p)*i)/conj(vp);
            ypq=0;
            for q=1:nbus
                if(p==q) continue;
                end
                ypq=ypq+Y(p,q)*v(q);
            end
            v(p)=(pq-ypq)/Y(p,p);
        end
    end
    %to find the votages at all buses and Q at pv busses
    fprintf('\nThe votages at all buses and Q at pv busses after
iteration no %d',it);
    for p=1:npq+1
    fprintf('\nV(%d)=%.4f
at%.2fdeg',p,abs(v(p)),angle(v(p))*180/pi);
    end
    for p=npq+2:nbus
    fprintf('\nV(%d)=%.4f at%.2fdeg
Q(%d)=%+.3f\n',p,abs(v(p)),angle(v(p))*180/pi,p,Qc(p));
    end
    %to check for convergence
    for p=2:nbus
        diff(p)=abs(v(p)-v1(p));
    end
    err=max(diff);
    if(err<=acc)
```

```
        break;
    end
end
```

EXPECTED RESULT:

The votages at all buses and Q at pv busses after iteration no 1

V(1)=1.0600 at0.00deg

V(2)=1.0124 at-1.61deg

V(3)=0.9933 at-1.48deg

V(4)=1.0400 at-0.66deg Q(4)=+0.425

The votages at all buses and Q at pv busses after iteration no 2

V(1)=1.0600 at0.00deg

V(2)=1.0217 at-1.99deg

V(3)=1.0162 at-1.86deg

V(4)=1.0400 at-0.85deg Q(4)=+0.208

The votages at all buses and Q at pv busses after iteration no 3

V(1)=1.0600 at0.00deg

V(2)=1.0259 at-2.09deg

V(3)=1.0175 at-1.94deg

V(4)=1.0400 at-0.91deg Q(4)=+0.185

The votages at all buses and Q at pv busses after iteration no 4

V(1)=1.0600 at0.00deg

V(2)=1.0261 at-2.11deg

V(3)=1.0175 at-1.98deg

V(4)=1.0400 at-0.95deg Q(4)=+0.185

Circuit diagram:
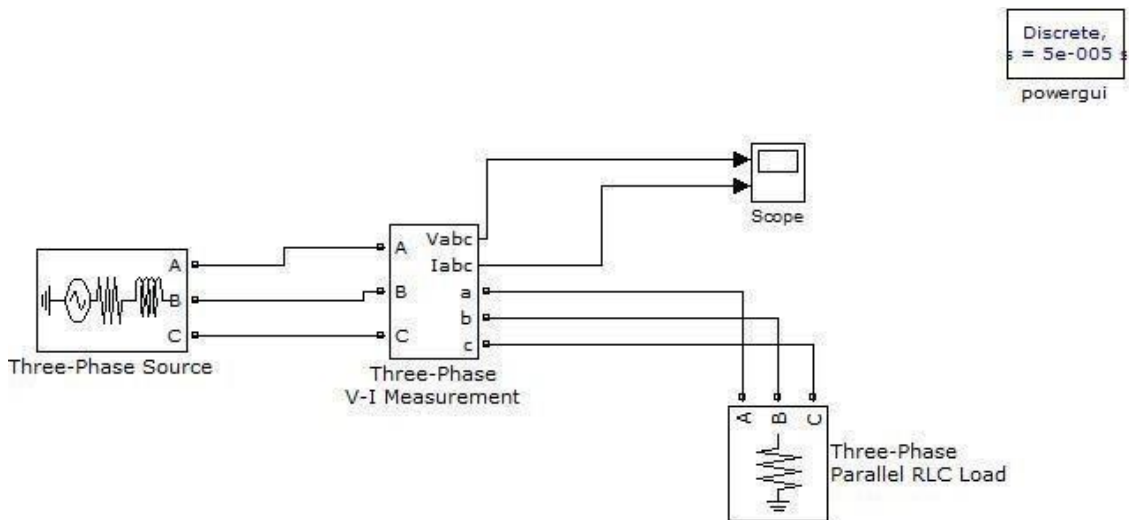
Fig: Simulink model for voltage and current measurement

Procedure:

1. Open Matlab-->Simulink--> File ---> New---> Model

2. Open Simulink Library and browse the components

3. Connect the components as per circuit diagram

4. Set the desired voltage and required frequency

5. Simulate the circuit using MATLAB

6. Plot the waveforms.

Graph:
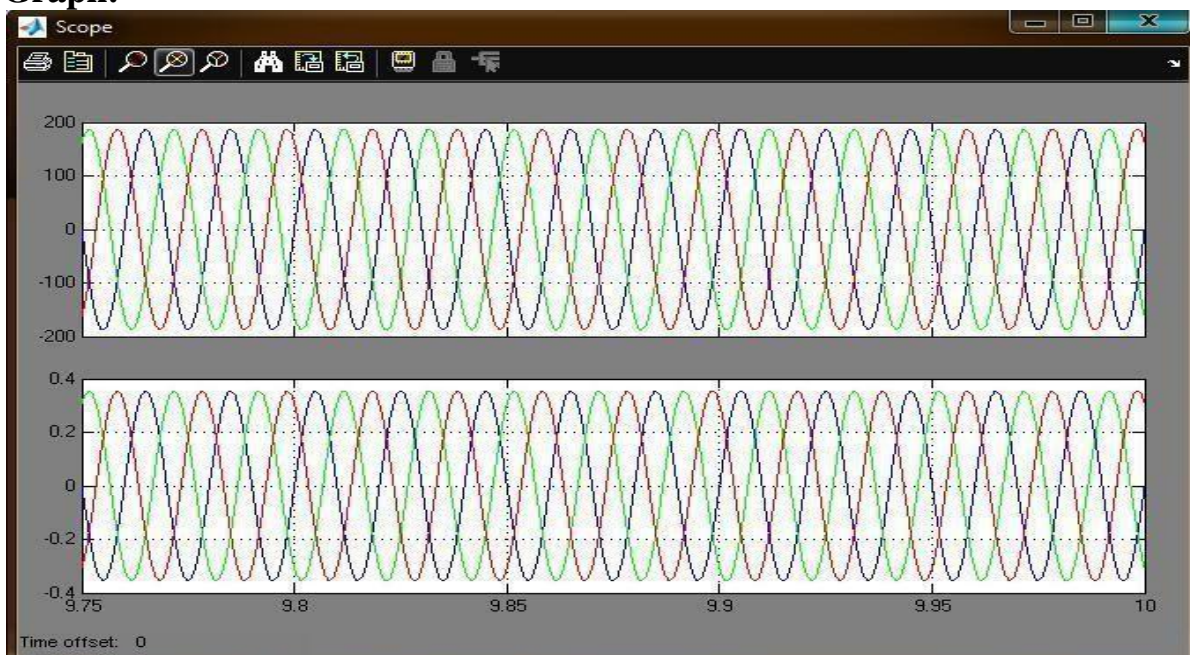
2. INUSOIDAL VOLTAGES AND CURRENTS

Aim: To determine sinusoidal voltages and currents
**Apparatus:** MATLAB
Theory : The RMS Voltage of an AC Waveform

The RMS value is the square root of the mean (average) value of the squared function of the instantaneous values. The symbols used for defining an RMS value are VRMS or I RMS.

The term RMS, refers to time-varying sinusoidal voltages, currents or complex waveforms were the magnitude of the waveform changes over time and is not used in DC circuit analysis or calculations were the magnitude is always constant. When used to compare the equivalent RMS voltage value of an alternating sinusoidal waveform that supplies the same electrical power to a given load as an equivalent DC circuit, the RMS value is called the "effective value" and is presented as: Veffor Ieff.

In other words, the effective value is an equivalent DC value which tells you how many volts or amps of DC that a time-varying sinusoidal waveform is equal to in terms of its ability to produce the same power. For example, the domestic mains supply in the United Kingdom is 240Vac. This value is assumed to indicate an effective value of "240 Volts RMS". This means then that the sinusoidal RMS voltage from the wall sockets of a UK home is capable of producing the same average positive power as 240 volts of steady DC voltage as shown below.

RMS Voltage Equivalent
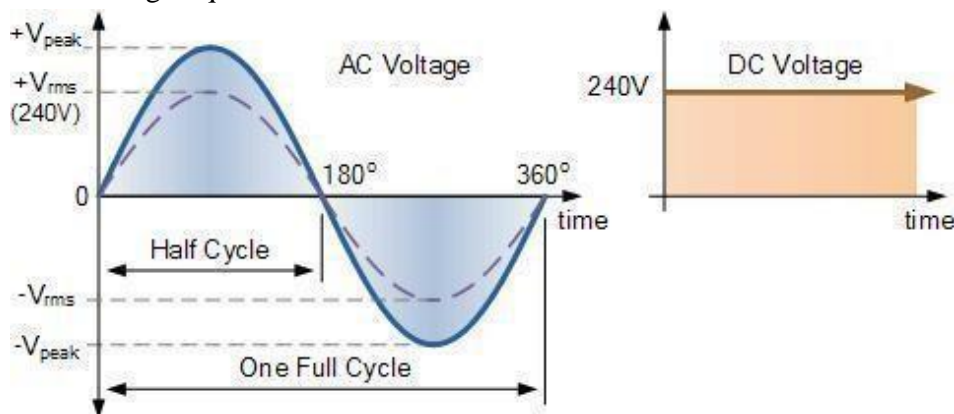
3. Load flow analysis for a 3bus system using Newton Raphson Method/Gauss seidel method

Aim: Load flow analysis using Newton Raphson Method/Gauss seidel method.

Apparatus Required: P.C loaded with Mipower package.

Theory: Load flow solution is a solution of a network under steady state condition subjected to certain inequality constraints under which the system operates. These constraints can be in the form load nodal voltages, reactive power generation of the generators, the tap setting of the tap changing transformer under load conditions.

The load flow solution gives the nodal voltages and phase angles and hence the power injection at all the buses and power flows through interconnecting power channels (through transmission line). Load flow solution is essential for designing a new power system and for planning extension of the existing one for increased load demand. These analysis require the calculations numerous load flows under both normal and abnormal operating conditions. Load flow solution also gives the initial conditions of the systems in the transient behavior of the system is to be obtained.

Load flow solution for power network can be worked out both ways accordingly as it is operating under balanced and unbalanced conditions.

The following treatment will be for a system operating under balanced conditions. For such a system single phase representation is adequate. A load flow solution of the power system requires mainly the following steps.

1) formulation or network equation

2) Suitable mathematical technique for solution of the equation.

3) The load and hence the generation are continuously varying in a real power system. We will assume here that loads and hence generations are fixed at a particular value over a suitable period of time. Example (½ hr)

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3) The load and hence the generation are continuously varying in a real power system. We will assume here that loads and hence generations are fixed at a particular value over a suitable period of time. Example (½ hr)

Bus classification

In a power system each bus or a node is associated with four quantities

a) real power

b) reactive power

c) bus voltage magnitude

d) phase angle of the voltage

In a load flow solution two out of four quantities are specified and remaining two are required to be obtained. Depending upon which quantities are specified buses are classified as

1) generator bus

2) slack bus

3) load bus

Generator bus (voltage controlled bus)

Any bus of the system at which voltage magnitude is kept constant is called voltage controlled bus. At each bus to which there is a generator connected, the megawatt generation can be controlled by adjusting the prime mover and the voltage magnitude can be controlled by adjusting the generator excitation. Therefore at each generator bus

we may properly specify Pgi and │Vi│. Thus at the bus I angle delta and Qgi are the unknown quantities. Therefore it is also called as PV Bus.

Load bus (PQ bus)

At each non generator bus called bus both Pgi and Qgi are zero and real power Pdi and reactive power Qdi are drawn from the system by the load. The two unknown quantities are voltage magnitude and voltage angle (V and δ)

Slack bus

The losses remain unknown until the load flow solution is complete. It is for this reason generally one of the generator buses is made to take the additional real and reactive power to supply transmission losses that is why this bus is known as slack bus or swing bus. At this bus the voltage magnitude V and phase angle δ are specified where as Pgi and Qgi are unknown. The voltage angle of the slack bus serves as a reference for the angles of all other bus voltages.

Techniques of solving load flow problems

The development of any method for the load flow studies on the digital computer requires the following main consideration

1) mathematical formulation of the load flow problem

2) application of numerical technique to solve these problems

 The mathematical formulation of load flow problem is a system of non linear algebraic equations The non-linear algebraic equations can be solved by the solution techniques such as iterative methods

1) Gauss method

2) Gauss- Seidel method

3) Newton Raphson method

Gauss Seidel method

In this method the value of bus voltages calculated for any bus immediately replace the previous values in the next step while in case of gauss method the calculated bus voltage replace the earlier value only at the end of iteration. Due to this Gauss Siedel method converges faster than that of Gauss method. This method solves the power flow equation in rectangular co-ordinates until the differences in the bus voltages from one iteration another are sufficiently small.

Newton Raphson method

It's a powerful method of solving non-linear algebraic equation. It works faster and is sure to converge in most of the cases as compared to the GS method. It is indeed a practical method of load flow solution of large power networks. Its only drawback is the large requirement of computer memory. Convergence can be considerably speeded up by performing the first iteration through the GS method and using the values so obtained for starting the NR iterations. This method solves the polar form of the power flow equations until δp and δq mismatches, at all buses fall within the tolerance.

Fast Decoupled NR method

When solving large scale power transmission systems strategy for improving computational efficiency and reducing computer storage requirements is the decoupled load flow method. Incorporation of approximations of the decoupled method into the jacobian matrix makes the elements of the sub matrices J12 and J21 zero.

Therefore the modified jacobian now consists of the sub matrices J11 and J22.However J11 and J22 are still interdependent. The complications in solving J11 and J12 can be overcome by introducing further simplifications which are justified by the physics of transmission line power flow. Such a method is called as fast de coupled method.

<u>Problem 1:</u>

Each line has a series impedance of 0.02+j0.08 pu. Total shunt admittance of j0.02 pu. The specified quantities of the line buses are tabulated below on 100MVA base.

BUS	Real load demand	Reactive Load demand	Real Power Gen Pg	Reactive Power Gen Qg	Voltage specification
1	2 pu	1 pu	Unspecified	Unspecified	1.04 ∟ 0 slack bus
2	0 pu	0	0.5	1	Unspecified
3	1.5 pu	0.6 pu	0	Qg3=? (0-1.5pu)	1.04(pv)

<u>Output:</u>

Base case:

BUS DATA

BUS NO	STATUS	ZONE	BUS KV	VMIN-PU	VMAX-PU	NAME
1	1	1	110.000	0.950	1.050	BUS1
2	1	1	110.000	0.950	1.050	BUS2
3	1	1	110.000	0.950	1.050	BUS3

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	NAME	TO NODE	NAME	R(P.U)	X(P.U.)	B/2(P.U.)	MVA	KMS
3	1	1	BUS 1	2	BUS 2	0.02000	0.08000	0.01000	100	1.0
3	1	1	BUS 1	3	BUS 3	0.02000	0.08000	0.01000	100	1.0
3	1	2	BUS 2	3	BUS 3	0.02000	0.08000	0.01000	100	1.0

TOTAL LINE CHARGING SUSCEPTANCE : 0.06000
TOTAL LINE CHARGING MVAR AT 1 PU VOLTAGE: 6.000

TOTAL CAPACITIVE SUSCEPTANCE   : 0.00000 PU - 0.000 MVAR
TOTAL INDUCTIVE SUSCEPTANCE   : 0.00000 PU - 0.000 MVAR

GENERATOR DATA

SL.NO	FROM NODE	FROM NAME	REAL POWER(MW)	Q MIN MVAR	Q MAX MVAR	V-SPE PU	CAP CURV	MVA RATING	STAT
1	1	BUS1	800.0000	0.0000	600.0000	1.0400	0	1000.00	3
2	2	BUS2	50.0000	100.0000	86.6030	1.0400	0	100.00	3
3	3	BUS3	0.0000	0.0000	150.0000	1.0400	0	100.00	3

LOAD DATA

```
SLNO  FROM   FROM       REAL   REACTIVE   COMP COMPENSATING MVAR VALUE CHAR F/V
*     NODE   NAME*      MW     MVAR       MVAR   MIN   MAX   STEP  NO  NO
                                          STAT
---- ---- -------- -------- -------- -------- ------- ------- ------- ---- ----
 1  1   BUS1 200.000 100.000  0.000  0.000  0.000  0.000  0  0
                                        3   0
```

PROGRAM:

```
%FORMATION OF Ybus USING SINGULAR TRANSFORMATION METHOD
%WITHOUT MUTUAL COUPLING:
%  p q    Z          hlcY(ADM)
 z=[5  4  0.02+0.06i  0.03i
    5  1  0.08+0.24i  0.025i
    4  1  0.06+0.18i  0.02i
    4  2  0.06+0.18i  0.02i
    4  3  0.04+0.12i  0.015i
    1  2  0.01+0.03i  0.01i
    2  3  0.08+0.24i  0.025i];
fb=z(:,1);
tb=z(:,2);
Z=z(:,3);
hlcy=z(:,4);
y=1./Z;
nbus=max(max(fb),max(tb));
Y=zeros(nbus);
nline=length(fb);
nlb=nline+nbus;
A=zeros(nlb,nbus);
for k=1:nbus
    A(k,k)=1;
end
for k=1:nline
A(nbus+k,fb(k))=1;
    A(nbus+k,tb(k))=-1;
end
sh=zeros(nbus);
for k=1:nline
    sh(fb(k))=sh(fb(k))+hlcy(k);
    sh(tb(k))=sh(tb(k))+hlcy(k);
end
ypr=zeros(nlb,nlb);
for k=1:nbus
    ypr(k,k)=sh(k);
end
for k=1:nline
    ypr(nbus+k,nbus+k)=y(k);
end
format short;
Ybus=A'*ypr*A
V(1) =1.024532-0.08729i;
V(2)=1.02394-0.931i;
V(3)=1.01825-0.1074i;
V(4)=1.0476-0.049i;
V(5)=1.06+0i;
I=Ybus*V'
```

Exp: 4.

FORMATION OF Y- BUS USING SINGULAR TRANSFORMATION METHOD WITH AND WITHOUT MUTUAL COUPLING,

AIM: Y bus formation for systems, without mutual coupling, by singular

transformation.

THEORY:

FORMATION OF Y BUS MATRIX

Bus admittance is often used in power system studies. In most of the power system studies it is required to form y- bus matrix of the system by considering certain power system parameters depending upon the type of analysis.

Y-bus may be formed by inspection method only if there is no mutual coupling between the lines. Every transmission line should be represented by ‖ ‖ - equivalent. Shunt impedances are added to diagonal element corresponding to the buses at which these are connected. The off diagonal elements are unaffected. The equivalent circuit of Tap changing transformers is included while forming Y-bus matrix.

> Generalized Y-bus = Yii................Yid
>   Ydi..............Ydd

> where, Yii = Self admittance
>   Ydi = Transfer admittance

.

PROCEDURE:

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

Viva Questions

1. What is Single line diagram?
2. What are the components of Power system?
3. What is a bus?
4. What is bus admittance matrix?
5. What is bus impedance matrix?
6. What is load flow study?
7. What are the information that obtained from a load flow study?
8. What is the need for load flow study?
9. What are quantities that are associated with each bus in a system?
10. What are the different types of buses in a power system?
11. Define Voltage controlled bus.
12. What is PQ-bus?
13. What is Swing (or Slack) bus?
14. What is the need for Slack bus?
15. What are the iterative methods mainly used for the solution of load flow problems?
16. Why do we go for iterative methods to solve load flow problems?
17. What do you mean by flat voltage start?
18. When the generator bus is treated as load bus?
19. What will be the reactive power and bus voltage when the generator bus is treated as load bus?
20. What are the advantages and disadvantages of Gauss-Seidel method?
21. How approximation is performed in Newton-Raphson method?
22. What is Jacobian matrix?
23. What are the advantages and disadvantages of Newton-Raphson method?
24. What is the need for voltage control in a Power system?
25. What is the reason for changes in bus voltage?
26. What is infinite bus?
27. How the reactive power of a generator is controlled?
28. What is the draw back in series connected capacitor?
29. What is synchronous capacitor?
30. What is tap changing transformer? How Voltage control is achieved in it?
31. What is regulating transformer?
32. What is Booster transformer?
33. What is off-nominal transformer ratio?
34. What is meant by a fault?
35. Why fault occurs in a power system?
36. How the faults are classified?
37. List the various types of Shunt and Series faults.
38. List the Symmetrical and unsymmetrical faults.
39. Name any two methods of reducing short-circuit current.
40. Name the main difference in representation of power system for load flow and short circuit studies.
41. Write the relative frequency of occurrence of various types of faults.
42. What is meant by fault calculation?
43. What is the need for short circuit studies or fault analysis?
44. What is the reason for transients during short circuits?
45. What is meant by doubling effect?
46. Define DC off-set current.
47. What is synchronous reactance?

48.   Define sub transient reactance?
49.   Define transient reactance?
50.   What is the significance of sub transient reactance in short circuit studies?
51.   What is the significance of transient reactance in short circuit studies?
52.   Why the armature current decreases when the flux diminishes?
53.   Give one application of sub transient reactance.
54.   Name the fault in which positive, negative and zero sequence component currents are equal.
55.   Name the fault in which positive and negative sequence component currents together is equal and zero sequence current in magnitude
56.   Define negative sequence impedance.
57.   Name the faults which do not have zero sequence current flowing.
58.   Name the faults involving ground.
59.   Define positive sequence impedance
60.   In what type of fault the positive sequence component of current is equal in magnitude but opposite in phase to negative sequence components of current?
61.   In which fault negative and zero sequence currents are absent?
62.   Define stability.
63.   Define steady state stability.
64.   Define transient stability.
65.   What is steady state stability limit?
66.   What is transient stability limit?
67.   How stability studies are classified? What are they?
68.   Define synchronizing coefficient.
69.   Define swing curve.
70.   What is the use of swing curve?
71.   Define power angle.
72.   For the swing equation M d2δ/dt2 = Pa, What will be the value of Pa during steady state operation?
73.   Name the two ways by which transient stability study can be made in a system where one machine is swinging with respect to an infinite bus.
74.   Define critical clearing time and critical clearing angle.
75.   List the methods of improving the transient stability limit of a power system.
76.   State equal area criterion.
77.   Define efficiency of lines.
78.   Define regulation of lines.
79.   In Which method, for a long transmission line, for a particular receiving end voltage, when sending end voltage is calculated, it is more than the actual value.
80.   What will be the power factor of the load if, in a short transmission line, resistance and inductive reactance are found to be equal and regulation appears to be zero.
81.   In which of the models of Transmission lines, is the full charging current assumed to flow over half the length of the line only?
82.   What is infinite line?
83.   What is Short Transmission line?
84.   What is Medium Transmission line?
85.   What is Long Transmission line?

MODEL QUESTIONS

1. Formation of Jacobian for a system not exceeding 4 buses * (no PV buses) in polar. A Three-Bus system is given below. The system parameters are given in the Table A and the load and generation data in Table B . Line impedances are marked in per unit on a 100MVA Base, and line charging susceptances are neglected. Taking bus 1 as Slack bus. Obtain the load
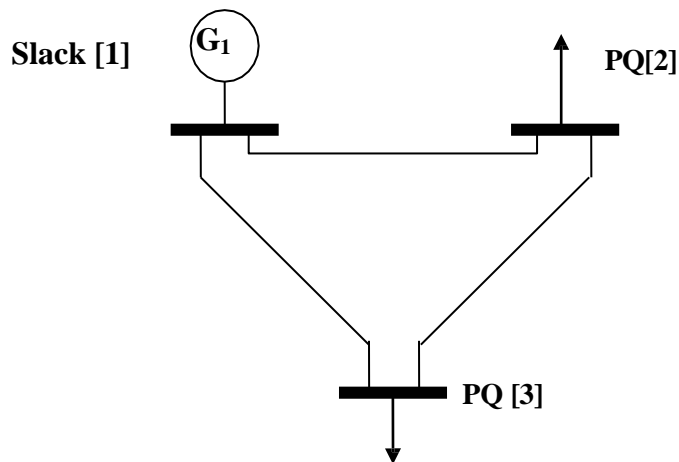
Bus No	Bus Voltage	Generation		Load	
		MW	Mvar	MW	Mvar
1	1.05+j0.0	--	--	0	0
2	--	0	0	50	20
3	--	0	0	60	25

Bus Code (i-k)	Impedance (p.u) Z_{ik}	Line charging Admittance (p.u) Y_i
1-2	0.08+j0.24	0
1-3	0.02+j0.06	0
2-3	0.06+j0.18	0

2. Figure below shows a single line diagram of a 5bus system with 2 generating units, 7 lines. Per unit transmission line series impedances and shunt susceptances are given on 100MVA Base, real power generation, real & reactive power loads in MW and MVAR are given in the accompanying table with bus1 as slack, obtain a load flow solution with Y-bus using Gauss-Siedel method and Newton Rapson method. Take acceleration factors as 1.4 and tolerances of 0.0001 and 0.0001 per unit for the real and imaginary components of voltage and 0.01 per unit tolerance for the change in the real and reactive bus powers.
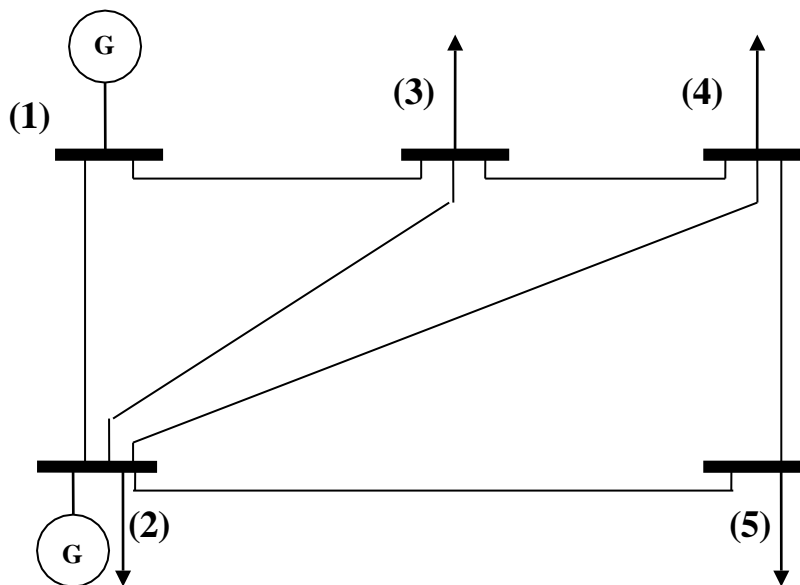
Table: 1.1		
Bus code From-To	Impedance R+jX	Line Charging B/2
1-2	0.02+j0.06	j 0.030
1-3	0.08+j0.24	j 0.025
2-3	0.06+j0.18	j 0.020
2-4	0.06+j0.18	j 0.020
2-5	0.04+j0.12	j 0.015
3-4	0.01+j0.03	j 0.010
4-5	0.08+j0.24	j 0.025

Table: 1.2					
Bus No	Bus Voltage	Generation MW	Generation MVAR	Load MW	LoadMV AR
1	1.00+j0.0	0	0	0	0
2	1.00+j0.0	40	30	20	10
3	1.00+j0.0	0	0	45	15
4	1.00+j0.0	0	0	40	5
5	1.00+j0.0	0	0	60	10

3. Determine the power angle curve and obtain the Graph for the given detail

    - Terminal Voltage = 1 p.u
    - Terminal Angle = 17.455 degree
    - Infinite bus voltage = 1 p.u
    - Xe = 0.2 p.u
    - X1 = 0.3

4. Cost equation & loss co-efficients of different units in a plant are given. Determine economic Generation for a total load demand of 240MW.

$$C_1 = 0.05\ P_1^2 + 20P_1 + 800 \qquad 0 <= P_1 <= 100$$
$$C_2 = 0.06P_2^2 + 15P_2 + 1000 \qquad 0 <= P_2 <= 100$$
$$C_3 = 0.07P_3^2 + 18P_3 + 900 \qquad 0 <= P_3 <= 100$$

Loss co-efficients:

$B_{11} = 0.0005;$ $B_{12} = 0.00005;$ $B_{13} = 0.0002;$

$B_{22} = 0.0004;$ $B_{23} = 0.00018;$ $B_{33} = 0.0005;$

$B_{21} = B_{12};$ $B_{23} = B_{32};$ $B_{13} = B_{31}$

5. Cost equation & loss co-efficients of different units in a plant are given. Determine economic Generation for a total load demand of 440MW

$$C_1 = 0.04\ P_1^2 + 20P_1 + 800 \qquad 0 <= P_1 <= 100$$
$$C_2 = 0.02P_2^2 + 15P_2 + 1000 \qquad 0 <= P_2 <= 100$$
$$C_3 = 0.07P_3^2 + 18P_3 + 900 \qquad 0 <= P_3 <= 100$$

Loss co-efficients:

$B_{11} = 0.0005;$ $B_{12} = 0.00005;$ $B_{13} = 0.0002;$

$B_{22} = 0.0004;$ $B_{23} = 0.00018;$ $B_{33} = 0.0005;$

$B_{21} = B_{12};$ $B_{23} = B_{32};$ $B_{13} = B_{31}$

6. Write a program to find ABCD parameters for short line. Calculate Vr& Ir for the given Vs and Is or Calculate Vs& Is for the given Vr and Ir.

    Z=0.2+0.408i; Y=0+3.14e-6i.Vs=132 Is=174.96- 131.22i

7. Write a program to find ABCD parameters for long line network Calculate Vr & Ir for the given Vs and Is or Calculate Vs& Is for the given Vr and Ir.

    Z=0.2+0.408i; Y=0+3.14e-6i. Vs=132 Is=174.96-131.22i

8. Write a program to find ABCD parameters for medium line PI network Calculate Vr &
   Ir for the given Vs and Is or Calculate Vs& Is for the given Vr and Ir.
   Z= 2+0.408i; Y=0+3.14e-6i. Vs=132 Is=174.96- 131.22i

9. Write a program to find ABCD parameters for medium line T network Calculate Vr &
   Ir for the given Vs and Is or Calculate Vs& Is for the given Vr and Ir.
   Z= 2+0.408i; Y=0+3.14e-6i. Vs=132 Is=174.96- 131.22i

10. Write a program to form Y-bus using singular transformation method
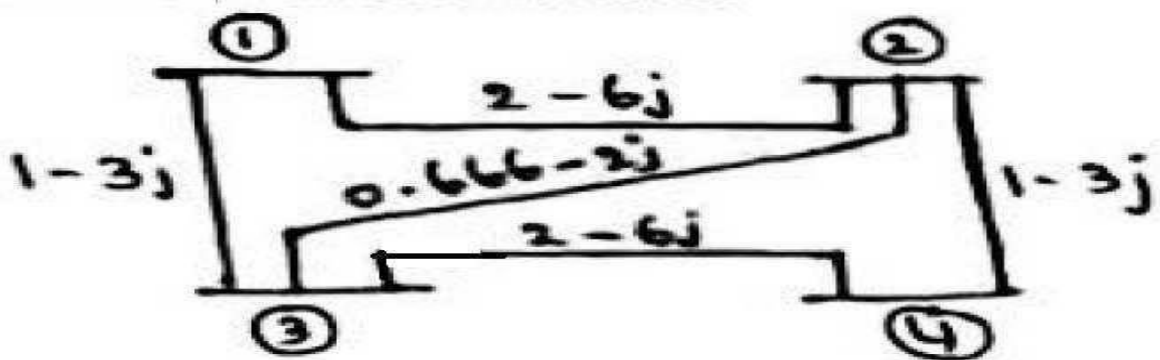
11. Write a program to form Y-bus using singular transformation method
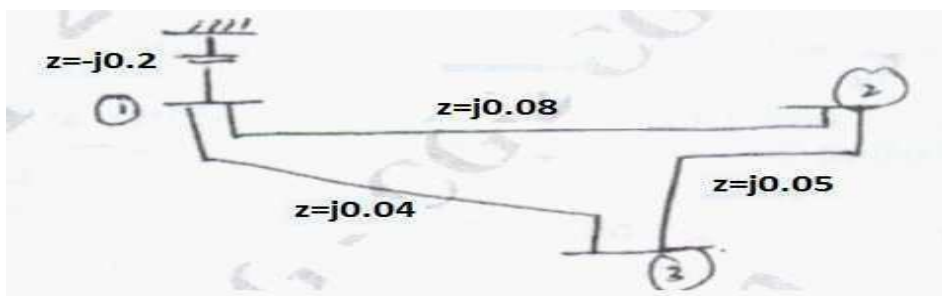
12. Figure shown below represents the single line diagram of 6-bus system with two identical Generating units, five lines and two transformers per unit transmission line series impedances and shunt susceptances are given on 100MVA base, generator's transient impedance and Transformer leakage reactances are given in accompanying table.
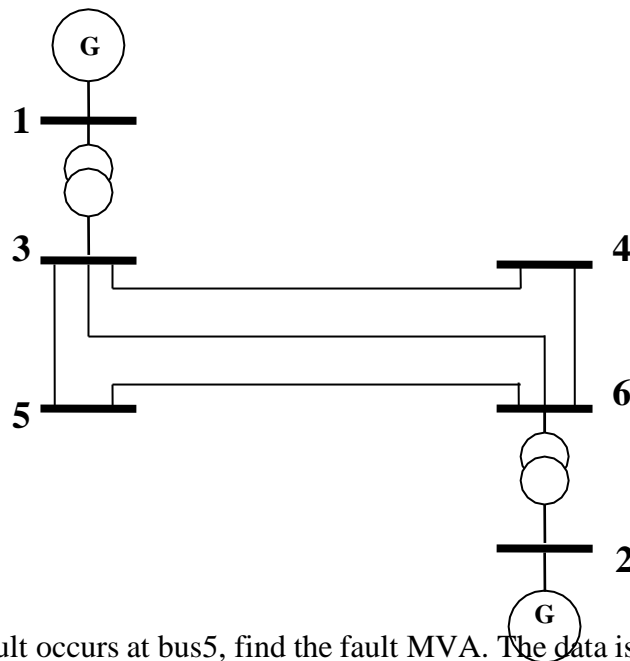
If a 3-phase to ground fault occurs at bus5, find the fault MVA. The data is given below.

Bus-code	Impedance	Line Charging
p-q	Zpq	Y''pq/2
3-4	0.00+j0.15	0
3-5	0.00+j0.10	0
3-6	0.00+j0.20	0
5-6	0.00+j0.15	0
4-6	0.00+j0.10	0

Generator details:

G1=G2=100MVA, 11KV with X''d=10%

Transformer details:

T1=T2= 11/110KV , 100MVA, leakage reactance= X = 5%

All impedances are on 100MVA base

13. Write a program to form Y-bus using singular transformation method

Obtain Y$_{bus}$ by singular transformation method for the system having following data. Take bus 4 as ref bus

Element No.	1	2	3	4	5
Bus code (p-q)	1-2	2-3	3-4	1-4	2-4
Admittance (pu)	2	1.5	3	2.5	4

14. Write a program to form Y-bus using singular transformation method with mutual coupling.

$$
\begin{array}{cccc}
\text{p} \quad \text{q} & \text{Z} & \text{mno} & \text{mutual} \\
Z= [\ 0\ \ 1 & 0.6i & 0 & 0 \\
0\ \ 2 & 0.5i & 1 & 0.1i \\
2\ \ 3 & 0.5i & 0 & 0 \\
0\ \ 1 & 0.4i & 1 & 0.2i \\
1\ \ 3 & 0.2i & 0 & 0]; \\
\end{array}
$$

15. Write a program to form Y-bus using Inspection method

Obtain Y$_{bus}$ by singular transformation method for the system having following data. Take bus 4 as ref bus

Element No.	1	2	3	4	5
Bus code (p-q)	1-2	2-3	3-4	1-4	2-4
Admittance (pu)	2	1.5	3	2.5	4

16. Write a program to form Y-bus using Inspection method
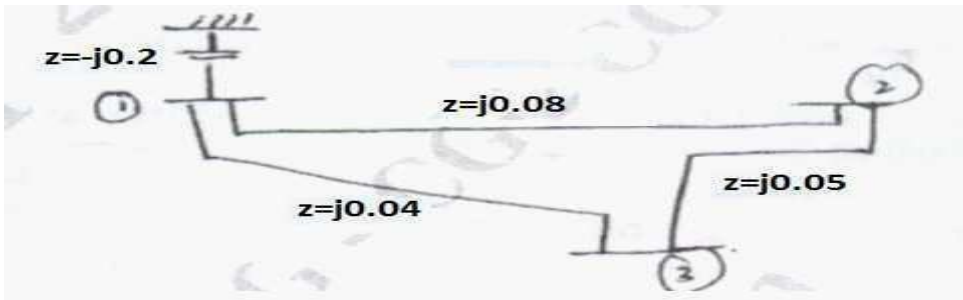
17. Write a program to obtain swing curve when the fault is cleared

Ps=0.9,e=1,v=1,m=0.00028,xe=0.35,xl=0.2

18. Write a program to obtain swing curve for the sustained fault

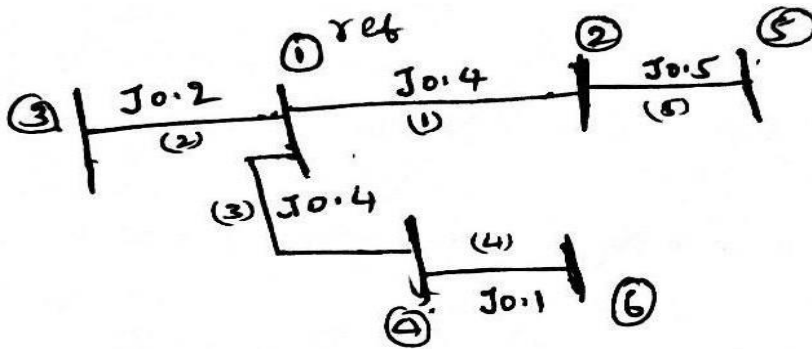Ps=0.9,e=1,v=1,m=0.00028,xe=0.35,xl=0.3

19. Write a program for Determination of bus currents, bus power &line flows for a specified system voltage (bus) profile.

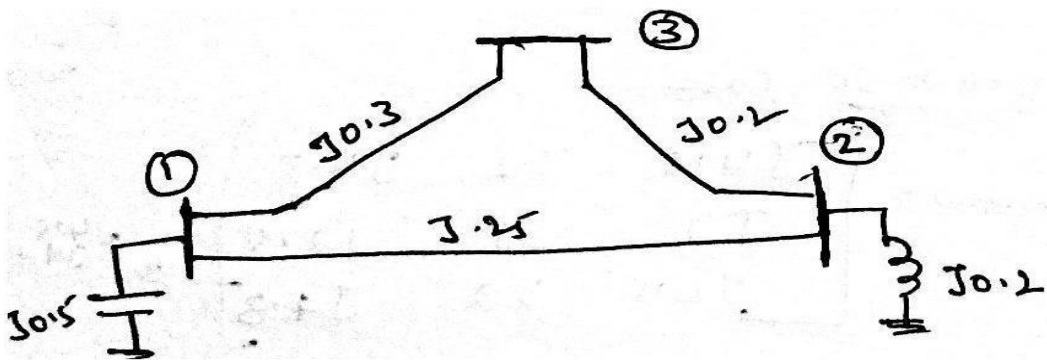INPUT Data:

Input= [3   3

1   2   0.02   0.04   0

1   3   0.01   0.03   0

2   3   0.0125   0.025   0

1   1.05   0

2 0.98183 -3.5

3 1.00125 -2.8624]

20. Write program for the formation of Zbus using Zbus building algorithm

21. Write program for the formation of Zbus using Zbus building algorithm

22. Write program for the formation of Zbus using Zbus building algorithm