ATME COLLEGE OF ENGINEERING

13th KM Stone, Bannur Road, Mysore - 570028

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

(ACADEMIC YEAR 2023-24)

LABORATORY MANUAL

SUBJECT: Power System Simulation Laboratory

SUB CODE: 18EEL76

SEMESTER: VII

INSTITUTIONAL MISSION AND VISION

VISION:

- Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

MISSION:

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torchbearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

DEPARTMENT MISSION AND VISION

VISION:

- To create Electrical and Electronics Engineers who excel to be technically competent and fulfill the cultural and social aspirations of the society.

MISSION:

- To provide knowledge to students that builds a strong foundation in the basic principles of electrical engineering, problem solving abilities, analytical skills, soft skills and communication skills for their overall development.
- To offer outcome based technical education.
- To encourage faculty in training & development and to offer consultancy through research & industry interaction

Power System Simulation Laboratory

Course Objective

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

Course Outcomes:

After completion of the course, the students will be able to:

1. Develop a program in power system toolbox like OCTAVE to assess the performance of medium and long transmission lines and to solve bus admittance and bus impedance matrices of interconnected power systems.
2. Develop a program to obtain the power angle characteristics of salient and non-salient pole alternator and to assess the transient stability under three phase fault at different locations in a of radial power systems
3. Solve power flow problem for simple power systems using Mi-power Tool.
4. Interpret the unsymmetrical faults in radial power systems at different locations.
5. Analysis optimal generation scheduling problems for thermal power plants using Mi-power tool.

PROGRAMME OUTCOMES AND PROGRAMME EDUCATIONAL OBJECTIVES

Program outcomes (POs)

Engineering Graduates will be able to:

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

PEO1: To produce competent and ethical Electrical and Electronics Engineers who will exhibit the necessary technical and managerial skills to perform their duties in society.

PEO2: To make students continuously acquire and enhance their technical and socio-economic skills.

PEO3: To aspire students on R&D activities leading to offering solutions and excel in various career paths.

PEO4: To produce quality engineers who have the capability to work in teams and contribute to real time projects.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Graduates will develop the abilities to:

PSO1: Apply the concepts of Electrical & Electronics Engineering to evaluate the performance of power systems and also to control industrial drives using power electronics.

PSO2: Demonstrate the concepts of process control for Industrial Automation, design models for environmental and social concerns and also exhibit continuous self- learning.

Power System Simulation Laboratory

Subject Code	:	18EEL76	CIE+IA Marks	:	40
Hours/Week	:	03	Exam Hours	:	03
Total Hours	:	42	Exam Marks	:	60

SL No.	Experiment	PO	CO
1	Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation.	PO1,PO2,PO3,PO5, PO7,PO9,PO10,PO12	CO1
2	Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.	PO1,PO2,PO5,PO9,PO10	CO2
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.	PO1,PO2,PO5,PO9,PO10	CO2
4	Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method	PO1,PO2,PO5,PO9,PO10	CO1
5	Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.	PO1,PO2,PO5,PO9,PO10	CO1
6	Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile	PO1,PO2,PO5,PO9,PO10	CO1
7	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates	PO1,PO2,PO5,PO9,PO10	CO3
8	Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses.	PO1,PO2,PO5,PO9,PO10	CO3
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	PO1,PO2,PO5,PO9,PO10	CO4
10	Optimal Generation Scheduling for Thermal power plants by simulation.	PO1,PO2,PO5,PO9,PO10	CO5

List of Text Books

1. **Modern Power System Analysis** , D. P. Kothari, McGraw Hill, 4th Edition, 2011.

List of Reference Books

1. **Computer Methods in Power Systems Analysis**, Glenn W Stagg Ahmed H Ei – Abiad, McGraw Hill, 1st Edition, 1968
2. **Computer Techniques in Power System Analysis** , M.A. Pai, McGraw Hill, 2nd Edition, 2006
3. **Power System Analysis**, Hadi Sadat, TMH,2nd Edition.

Power System Simulation Laboratory [18EEL76]

EXPERIMENT 1: ABCD parameters: Formation for symmetric π/T configuration. Verification of $AD-BC=1$Determination of efficiency and regulation Duration: 3 Hours
Objective:
To calculate efficiency and voltage regulation for power system network.
Generic Skills / Outcomes:
On completion of the experiment the student will understand the regulation ranges and efficiency for network under different topology.
EXPERIMENT 2: Determination of power angle diagrams, reluctance power, excitation, emf and regulation for salient and non-salient pole synchronous machines,. Duration: 3 Hours
Objective:
To study the power angle characteristics of synchronous motors.
Generic Skills / Outcomes:
On completion of the experiment the student will understand excitation, emf and regulation of synchronous motor.
EXPERIMENT 3: To obtain swing curve and to determine critical clearing time and regulation for a single machine connected to infinity bus through a pair of identical transmissio n lines under3-phase fault on one of the lines for variation of inertia constant/line parameters /fault location/clearing time/pre-fault electrical output. Duration: 3 Hours
Objective:
To study the swing curve characteristics of motors. and analyze the fault occurrence.
Generic Skills / Outcomes:
On completion of the experiment the student will understand the configuration and functioning of machine under swing curve.
EXPERIMENT 4: Y Bus formation for power systems with and without mutual coupling, by singular transformation and inspection method. Duration: 3 Hours
Objective:
To determine the bus admittance for the given power system.
Generic Skills / Outcomes:
On completion of above experiment, student will know the Y bus formation of the power system using different methods
EXPERIMENT 5: Formation of Z-bus(without mutual coupling) using Z-bus building Algorithm . Duration: 3 Hours
Objective:
To determine the impedance matrices using Z-bus building algorithm
Generic Skills / Outcomes:
On completion of the experiment the student will known the algorithm for finding out Z.
EXPERIMENT 6:Determination of bus currents, bus power and line flow for a specified system voltage (Bus) Profile Duration:3Hours
Objective:
To obtain the bus currents, bus power and line flow for a specified system voltage (Bus) Profile
Generic Skills / Outcomes:
On completion of the experiment, student will know the calculation of bus currents, power and line flows
EXPERIMENT 7: Formation of Jacobian for a system not exceeding 4 buses (no PV buses) in polar coordinates Duration: 3 Hours

Objective:
To study the matrices' involved for the system to calculate voltage profile in terms of pu.
Generic Skills / Outcomes:
On completion of the experiment the student will understand the configuration and functioning of system in terms of reactance, resistance and voltage profile for network
EXPERIMENT 8: : Load flow analysis using Gauss Siedel method, NR method, Fast decoupled method for both pq and pv buses. Duration: 3 Hours
Objective:
To study the performance of network under NR method, GS and Fast decoupled method for power loss and reactive power calculations
Generic Skills / Outcomes:
Student will study the voltage profile of the network and calculate the iterations for P & Q values in various methods like GS, NR and Fast decoupled method.
EXPERIMENT 9: To determine fault currents and voltages in a single transmission line system with star-delta transformers at a specified location for LG, LLG. Duration: 3 Hours
Objective:
To study currents, voltage in power system at time of various faults on line or at bus.
Generic Skills / Outcomes:
Student will study various faults like LG, LLG at bus and line of the network.
EXPERIMENT 10: Optimal Generation Scheduling for Thermal power plants.Duration:3 Hours
Objective:
To schedule for loading on power plant generators.
Generic Skills / Outcomes:
Student will calculate the proper scheduling in terms of load and obtain the cost with respect to generation of various generators connected to system.

Prerequisite:

This subject requires prerequisite of Computer Techquices in Power System, Transmission & Distribution, Switchgear and Protection, Power System Analysis System

POWER SYSTEM SIMULATION LAB

Sub. Code : 18EEL76	**CIE Marks : 40**
Hrs/Week : 03	**Exam Hrs. : 03**
Total Hrs. : 42	**SEE Marks: 100**

Power system simulation using Octave/MATLAB

1. 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

Power system simulation using Mi-power package

7. Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordi
8. Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method 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.

Experiment No.1

Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation

Objective: To calculate efficiency and voltage regulation for power system network.

A) Program For Nominal PI Network:

```
%ABCD of eqt. PI Network
z=0.2+0.408i;y=0+3.14e-6i;
k1=input('\n Enter 1-for short line 2-for medium line 3-for long line
');
switch k1
case 1,
    length=40;
    Z=z*length;Y=y*length;
    A=1;B=Z;C=0;D=1;
case 2,
    length=140;
    Z=z*length;Y=y*length;
    A=1+Y*Z/2;
    B=Z;
    C=Y*(1+Y*Z/4);
    D=A;
case 3,
    length=300;
    zc=sqrt(z/y);
    gam=sqrt(z*y)*length;
    A=cosh(gam);
    D=A;
    B=zc*sinh(gam);
    C=1/zc*sinh(gam);
    fprintf('\n The equvalent PI cicuit constants:');
    zeq=z*length*sinh(gam)/gam;
    yeq=y*length/2*tanh(gam/2)/(gam/2);
    fprintf('\n      Zeq  = %15.4f %+15.4fi',real(zeq),imag(zeq));
    fprintf('\n      Yeq/2= %15.4f %+15.4fi',real(yeq),imag(yeq));
otherwise
    disp('wrong choice of tr.line');
end
fprintf('\nA,B,C and D constants : \n');
fprintf('------------------------------------------------------------');
fprintf('\nA = %15.4f %+15.4fi',real(A),imag(A));
fprintf('\nB = %15.4f %+15.4fi',real(B),imag(B));
fprintf('\nC = %15.4f %+15.4fi',real(C),imag(C));
fprintf('\nD = %15.4f %+15.4fi',real(D),imag(D));
fprintf('\n The product AD-BC=%f',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=132+0.0i;
    ir=174.96-131.22i;
    vr=vr*1e3/sqrt(3);
    vs=(A*vr+B*ir)/1e3;
```

```
    is=C*vr+D*ir;
    fprintf('\nSending end Voltage/ph=%f %+fi KV',real(vs),imag(vs));
    fprintf('\nSending 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=132+0.0i;
    is=174.96-131.22i;
    vs=vs*1e3/sqrt(3.0);
    vr=(D*vs-B*is)/1e3;
    ir=-C*vs+D*is;
    fprintf('\nReceiving end Voltage/ph=%f %+fi KV',real(vr),imag(vr));
    fprintf('\nReceiving 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;
%rec_pow=3*abs(vr)*abs(ir)*cos(angle(vr)-angle(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
%send_pow=3*abs(vs)*abs(is)*cos(angle(vs)-angle(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Receiving end power=%.2f KVA',rec_pow);
fprintf('\n Sending end power=%.2f KVA',send_pow);
fprintf('\n Efficiency=%.2f %%',eff);
fprintf('\n Voltage Regulation=%.2f%%',reg);
```

OutPut:

Enter 1-for short line 2-for medium line 3-for long line 1

A,B,C and D constants :

A = 1.0000 +0.0000i
B = 8.0000 +16.3200i
C = 0.0000 +0.0000i
D = 1.0000 +0.0000i

The product AD-BC=1.000000

Enter 1 - To read Vr, Ir and compute Vs , Is

2 - To read Vs, Is and compute Vr, Ir 1

Sending end Voltage/ph=79.751426 +1.805587i KV

Sending end Current/ph=174.960000 -131.220000i AMP

Receiving end power=40.00 KVA

Sending end power=41.15 KVA

Efficiency=97.21 %

Voltage Regulation=4.67%>>

B) Program For Nominal T Network:

```
%ABCD of eqt. T Network
z=0.2+0.408i;y=0+3.14e-6i;
k1=input('\n Enter 1-for short line 2-for medium line 3-for long line
');
switch k1
case 1,
    length=40;
    Z=z*length;Y=y*length;
    A=1;B=Z;C=0;D=1;
case 2,
    length=140;
    Z=z*length;Y=y*length;
    A=1+Y*Z/2;
    B=Z*(1+Y*Z/4);
    C=Y;
    D=(1+Y*Z/2);
case 3,
    length=300;
    zc=sqrt(z/y);
    gam=sqrt(z*y)*length;
    A=cosh(gam);
    D=A;
    B=zc*sinh(gam);
    C=1/zc*sinh(gam);
    fprintf('\n The equvalent T cicuit constants:');
    zeq=z*length/2*tanh(gam/2)/(gam/2);
    yeq=y*length*sinh(gam)/gam;
    fprintf('\n     Zeq/2= %10.4f %+10.4fi',real(zeq),imag(zeq));
    fprintf('\n     Yeq  = %10.4f %+10.4fi',real(yeq),imag(yeq));
otherwise
    disp('wrong choice of tr.line');
end
fprintf('\nA,B,C and D constants : \n');
fprintf('-----------------------------------------------------------------------');
fprintf('\nA = %10.4f %+10.4fi',real(A),imag(A));
fprintf('\nB = %10.4f %+10.4fi',real(B),imag(B));
fprintf('\nC = %10.4f %+10.4fi',real(C),imag(C));
fprintf('\nD = %10.4f %+10.4fi',real(D),imag(D));
fprintf('\n The product AD-BC=%f',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=132+0.0i;
    ir=174.96-131.22i;
    vr=vr*1e3/sqrt(3);
    vs=(A*vr+B*ir)/1e3;
    is=C*vr+D*ir;
    fprintf('\nSending end Voltage/ph=%f %+fi KV',real(vs),imag(vs));
    fprintf('\nSending 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=132+0.0i;

    is=174.96-131.22i;
    vs=vs*1e3/sqrt(3.0);
    vr=(D*vs-B*is)/1e3;
    ir=-C*vs+D*is;
    fprintf('\nReceiving end Voltage/ph=%f %+fi KV',real(vr),imag(vr));
    fprintf('\nReceiving 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;
%rec_pow=3*abs(vr)*abs(ir)*cos(angle(vr)-angle(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
%send_pow=3*abs(vs)*abs(is)*cos(angle(vs)-angle(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Receiving end power=%.2f KVA',rec_pow);
fprintf('\n Sending end power=%.2f KVA',send_pow);
fprintf('\n Efficiency=%.2f %%',eff);
fprintf('\n Voltage Regulation=%.2f%%',reg);
```

OutPut:

Enter 1-for short line 2-for medium line 3-for long line 1

A,B,C and D constants :

A = 1.0000 +0.0000i
B = 8.0000 +16.3200i
C = 0.0000 +0.0000i
D = 1.0000 +0.0000i
The product AD-BC=1.000000
Enter 1 - To read Vr, Ir and compute Vs , Is
2 - To read Vs, Is and compute Vr, Ir 1

Sending end Voltage/ph=79.751426 +1.805587i KV
Sending end Current/ph=174.960000 -131.220000i AMP
Receiving end power=40.00 KVA
Sending end power=41.15 KVA
Efficiency=97.21 %
Voltage Regulation=4.67%>>

Outcome: On completion of the experiment the student will understand the regulation ranges and efficiency for network under different topology.

Questions:

1. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (0-80km or 0-50 miles), determine the following
   - Regulation
   - Efficiency

   (The line impedance and admittance values are to be specified)

2. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (>80km – 24 km or > 50 miles to 150 miles), determine the following
   - Regulation
   - Efficiency

   (The line impedance and admittance values are to be specified)

3. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (>240km or >150 miles), determine the following
   - Regulation
   - Efficiency

   (The line impedance and admittance values are to be specified)

4. Given any two of the I/O parameters of a two port short transmission line system and for a given set of line parameters (Z & Y) and length________km(>240km or >150 miles),determine the following
   (i) ABCD constants and hence the generalized equivalent circuit
   (ii) Regulation, (iii) Efficiency

5. Determine the generalized circuit constants for a transmission line with the following
   Data:
   a. Line length:___________________km
   b. Line impedance :______________Ω/km
   c. Total shunt admittance :_____________________mho / km

Experiment No.2

POWER ANGLE DIAGRAMS

Determination of power angle diagrams for salient and non-salient pole synchronous machines, reluctance power, excitation emf & regulation.

Objective: To study the power angle characteristics of synchronous motors.

Example:

A 34.64 kV,60 MVA synchronous generator has a direct axis reactance of 13.5 ohms and quadrature axis reactance of 9.333 ohms is operating at 0.8 p.f determine the exitation e.m.f, regulation, reluctance power and also plot the power angle diagram.

A) Program For Salient pole Synchronous machine:

```
clc
clear
%Power Angle diagram for salient pole synchronous machines
%Power angle curve
P=input('Power in MW =');
pf=input('Power Factor =');
Vt=input('Line to Line Voltage in kV =');
Xd=input('Xd  in  Ohms  =');
Xq=input('Xq in Ohms =');
Vtph=Vt*1000/sqrt(3);                    % Per phase Voltage
pf_a=acos(pf);
Q=P*tan(pf_a);
I=(P-j*Q)*1000000/(3*Vtph);              % Current in Amps
delta=0:1:180;
delta_rad=delta*(pi/180);
if Xd~=Xq
   %Salient Pole Synchronous Motor
   Eq=Vtph+(j*I*Xq);
   Id_mag=abs(I)*sin(angle(Eq)-angle(I));
   Ef_mag=abs(Eq)+((Xd-Xq)*Id_mag);
   Exitation_emf=Ef_mag
   Reg=(Ef_mag-abs(Vtph))*100/abs(Vtph)
   PP=Ef_mag*Vtph*sin(delta_rad)/Xd;
   Reluct_Power=Vtph^2*(Xd-Xq)*sin(2*delta_rad)/(2*Xd*Xq);
   Net_Reluct_Power=3*Reluct_Power/1000000;
   Power_sal=PP+Reluct_Power;

   Net_Power_sal=3*Power_sal/1000000;
   plot(delta,Net_Reluct_Power,'K');
   hold on
   plot(delta,Net_Power_sal,'r');
   xlabel('\Delta(deg)-------- >');
   ylabel('Three Phase Power(pu)-------- >');
   title('Plot:Power Angle Curve for Salient Synchronous M/c');
   legend('Reluct Power','Salient Power');
end
grid;
```

INPUT REQUIRED AND OUTPUT EXPECTED:

Input:

1. Power in MW
2. Power factor
3. Line to Line Voltage level in kV
4. X_d in ohms
5. X_q in ohms

Output:

1. Exitation e.m.f in kV
2. Regulation in %
3. Plot of Delta v/s Reluctance Power for Salient pole & Non salient pole m/cs.

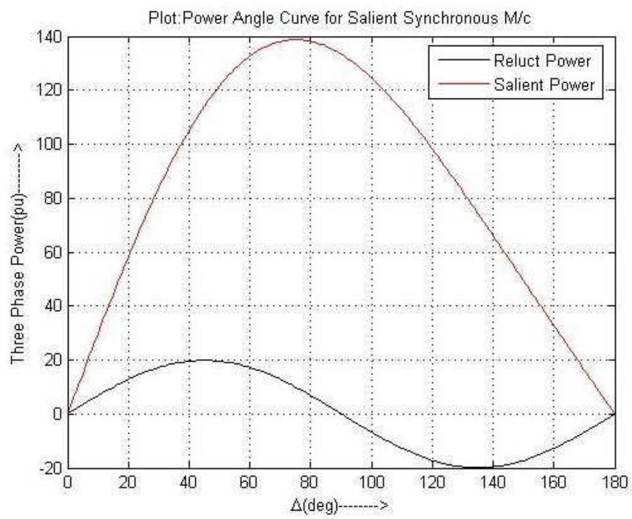
Input Data: from the keyboard: (Salient Pole)

P = 48	Power in MW
Pf = 0.8	Power Factor
V = 34.64	Line to Line Voltage in kV
X_d = 13.5	X_d in ohm
X_q = 9.33	X_q in ohm

Output:

Excitation EMF = 30000 Volts/ phase

Regulation = 50.0024 %



B) Program For Non-Salient pole Synchronous machine:

```
clc
clear
%Power Angle diagram for non-salient pole synchronous machines
%Power angle curve
P=input('Power in MW =');
pf=input('Power Factor =');
Vt=input('Line to Line Voltage in kV =');
Xd=input('Xd  in  Ohms  =');
Xq=input('Xq in Ohms =');
Vtph=Vt*1000/sqrt(3);                   % Per phase Voltage
pf_a=acos(pf);
Q=P*tan(pf_a);
I=(P-j*Q)*1000000/(3*Vtph);              % Current in Amps
delta=0:1:180;
delta_rad=delta*(pi/180);
  if Xd==Xq
      %Non-Salient Pole Synchronous Motor
      Ef=Vtph+(j*I*Xd);
      Exitation_emf=abs(Ef)
      Reg=(abs(Ef)-abs(Vtph))*100/abs(Vtph)
      Power_non=abs(Ef)*Vtph*sin(delta_rad)/Xd;
      Net_Power=3*Power_non/1000000;
      plot(delta,Net_Power);
      xlabel('\Delta(deg)-------- >');
      ylabel('Three Phase Power(MW)-------- >');
      title('Plot:Power Angle Curve for Non-Salient Synchronous M/c');
      legend('Non-Salient Power');
   end
   grid;
```

INPUT REQUIRED AND OUTPUT EXPECTED:

Input:

1. Power in MW
2. Power factor
3. Line to Line Voltage level in kV
4. X_d in ohms
5. X_q in ohms

Output:

1. Exitation e.m.f in kV
2. Regulation in %
3. Plot of Delta v/s Reluctance Power for Salient pole & Non salient pole m/cs

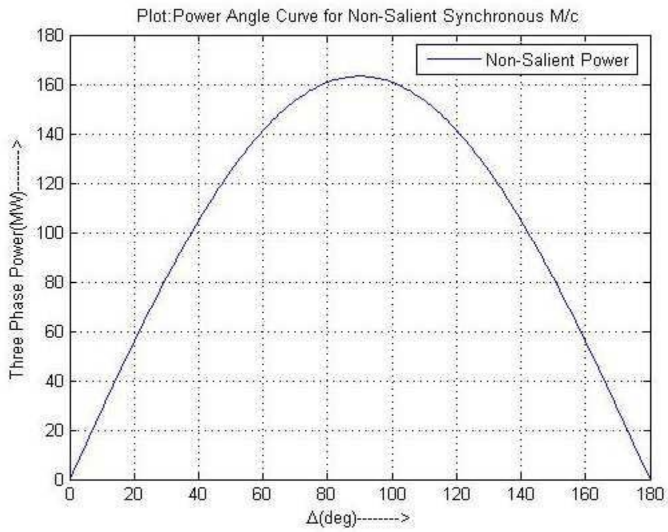
Input Data: from the keyboard: (Non-Salient Pole)

P = 48	Power in MW
Pf = 0.8	Power Factor
V = 34.64	Line to Line Voltage in kV
$X_d = 10$	X_d in ohm
$X_q = 10$	X_q in ohm

Output:

Excitation EMF = 27203 Volts/ phase

Regulation = 36.01 %



Outcome: On completion of the experiment the student will understand excitation, emf and regulation of synchronous motor.

Determination of power angle curve using Mi-Power Package

Objective: To study the power angle characteristics of synchronous motors.

Procedure to enter the data for performing studies using MiPower.

MiPower- Data base Configuration

1. To Solve power angle curve by using **MiPower** Package, Invoke **"MiPower Tools"** in the MiPower main screen and select **"Power Angle Curve"**

2. Select a Save option

3. Select location to save the file and give the file name

1. Enter the values of Terminal voltage, terminal angle, transient Reactance, Resistance, Reactance, Susceptance & Infinite bus voltage, angle.

5. A part of the output file is shown.

```
--------------------------------------------------------------------------------
Date and Time : Mon Jul 06 10:32:42 2009
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
GENERATOR TERMINAL VOLTAGE IN P.U.            : 1.000
GENERATOR TERMINAL VOLTAGE ANGLE IN DEGREES   : 17.455
INFINITE BUS VOLTAGE IN P.U.                  : 1.000
INFINITE BUS VOLTAGE ANGLE IN DEGREES         : 0.000
RESISTANCE OF THE NETWORK IN P.U.             : 0.000
REACTANCE OF THE NETWORK IN P.U.              : 0.300
SUSCEPTANCE OF THE NETWORK IN P.U.            : 0.000
TRANSIENT REACTANCE OF THE GENERATOR P.U.     : 0.200
--------------------------------------------------------------------------------
TRANSIENT INTERNAL VOLTAGE IN POLOR FORM    (    1.0499,      0.4963)

  ANGLE        POWER
  0.0000      -0.0000
  1.8000       0.0660
  3.6000       0.1318
  5.4000       0.1976
  7.2000       0.2632
  9.0000       0.3285
 10.8000       0.3935
 12.6000       0.4581
 14.4000       0.5222
 16.2000       0.5858
 18.0000       0.6489
 19.8000       0.7113
 21.6000       0.7730
 23.4000       0.8339
```

25.2000	0.8941
27.0000	0.9533
28.8000	1.0116
30.6000	1.0689
32.4000	1.1251
34.2000	1.1803
36.0000	1.2343
37.8000	1.2870
39.6000	1.3385
41.4000	1.3886
43.2000	1.4374
45.0000	1.4848
46.8000	1.5307
48.6000	1.5751
50.4000	1.6180
52.2000	1.6592
54.0000	1.6988
55.8000	1.7367
57.6000	1.7729
59.4000	1.8074
61.2000	1.8401
63.0000	1.8710
64.8000	1.9000
66.6000	1.9271
68.4000	1.9524
70.2000	1.9757
72.0000	1.9971
73.8000	2.0165
75.6000	2.0339
77.4000	2.0493
79.2000	2.0626
81.0000	2.0740
82.8000	2.0833
84.6000	2.0905
86.4000	2.0957
88.2000	2.0988
90.0000	2.0998
91.8000	2.0988
93.6000	2.0957
95.4000	2.0905
97.2000	2.0833
99.0000	2.0740
100.8000	2.0626
102.6000	2.0493
104.4000	2.0339
106.2000	2.0165
108.0000	1.9971
109.8000	1.9757
111.6000	1.9524
113.4000	1.9271

115.2000	1.9000
117.0000	1.8710
118.8000	1.8401
120.6000	1.8074
122.4000	1.7729
124.2000	1.7367
126.0000	1.6988
127.8000	1.6592
129.6000	1.6180
131.4000	1.5751
133.2000	1.5307
135.0000	1.4848
136.8000	1.4374
138.6000	1.3886
140.4000	1.3385
142.2000	1.2870
144.0000	1.2343
145.8000	1.1803
147.6000	1.1251
149.4000	1.0689
151.2000	1.0116
153.0000	0.9533
154.8000	0.8941
156.6001	0.8339
158.4001	0.7730
160.2001	0.7113
162.0001	0.6489
163.8001	0.5858
165.6001	0.5222
167.4001	0.4581
169.2001	0.3935
171.0001	0.3285
172.8001	0.2632
174.6001	0.1976
176.4001	0.1318
178.2001	0.0660
180.0000	-0.0000

Date and Time : Mon Jul 06 10:32:42 2009

----

1. To plot the graph Select graph
2. Click on to show 2nd Zone
3. Select X-axis angle & Y-axis Power & click on to plot

Outcome: On completion of the experiment the student will understand excitation, emf and regulation of synchronous motor.

Experiment No. 3

Solution of swing equation

Objective: To study the swing curve characteristics of motors. and analyze the fault occurrence.

A) Swing Curve (SUSTAINED FAULT)

```
%swing curve for sustained fault and critical clearing angle & 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;xl=0.3;
%function swing(ps,e,v,m,xe,xl)
x1=xe+xl/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*xl+xe*xl/2+xl*xl/2)/(xl/2);
otherwise
   disp('wrong input');
end
dt=0.001;
rr=180/pi;
f=dt^2/m;
it=1;
t(it)=0;
deld=0;
pm1=e*v/x1;
del(it)=asin(ps/pm1);
pm2=e*v/x2;
pm=pm2;
pe=pm*sin(del(it));
pa=(ps-pe)/2;
fprintf('\n     SUSTAINED FAULT');
fprintf('\n--------------------------------');
fprintf('\n   TIME      PMAX     DELTA');
fprintf('\n--------------------------------');
t1=0;
while(t(it)<=1.0)
    ft=f*pa/rr;
          deld=deld+ft;
    if(t1-t(it)<0.0001)
       fprintf('\n  %5.3f      %5.2f    %5.2f',t(it),pm,del(it)* rr);
      t1=t1+0.05;
    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
plot(t,del,'r');
title('swing curve');
xlabel('Delta');
ylabel('power ,p');
x3=xe+xl;
%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)<1.0)
   if (del(it)>=delc)
       break;
    end
    it=it+1;
 end
fprintf('\n critical clearing time-%f',t(it));
```

OUTPUT

enter 1-for fault at the beginning
    2-for fault at the middle **1**
    SUSTAINED FAULT

TIME	PMAX	DELTA
0.000	0.00	24.15
0.050	0.00	28.17
0.100	0.00	40.22
0.150	0.00	60.31
0.200	0.00	88.43
0.250	0.00	124.59
0.300	0.00	168.79
0.350	0.00	221.02
0.400	0.00	281.29
0.450	0.00	349.59
0.500	0.00	425.93
0.550	0.00	510.31
0.600	0.00	602.72
0.650	0.00	703.17
0.700	0.00	811.65
0.750	0.00	928.17
0.800	0.00	1052.72
0.850	0.00	1185.31
0.900	0.00	1325.93
0.950	0.00	1474.59

critical clearing angle-71.941682

critical clearing time-0.173000

B) Swing Curve (FAULT IS CLEARED)

```
%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*dt/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;
         pm=pm2;
         pe=pm*sin(del(it));
         pa=(ps-pe)/2;
         fprintf('\n   TIME        PMAX     DELTA');
         while(t(it)<=1.05)
      ft=f*pa/rr;
                 deld=deld+ft;
                 fprintf('\n  %5.2f       %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;
```

```
                 if(r==0)
                        if(t(it)<ct)

                                pm=pm2;
        elseif(t(it)==ct)
           pm=(pm2+pm3)/2;
        else
           pm=pm3;
        end
     end

if(r~=0)
   if(t(it)<ct)
                        pm=pm2 ;
      else
         pm=pm3;
      end
   end
                pe=pm*sin(del(it));
                 pa=ps-pe;
    end
plot(t,del,'r');
title('swing curve');
xlabel('Delta');
ylabel('power ,p');
pr=0;
    for k=2:it
       if (del(k)<del(k-1))
          pr=1;
          break;
       end
    end
    if(pr)
       text(0.5,1.0,'system is stable');
    else
       text(0.5,1.0,'system is unstable');
    end
```

OUTPUT

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

enter clearing time in secs **2**

FAULT IS CLEARED AT THE BEGINNING OF AN INTERVEL

TIME	PMAX	DELTA
0.00	0.00	21.60
0.05	0.00	25.62
0.10	0.00	37.67
0.15	0.00	57.76
0.20	0.00	85.89
0.25	0.00	122.05
0.30	0.00	166.25
0.35	0.00	218.48
0.40	0.00	278.75
0.45	0.00	347.05
0.50	0.00	423.39
0.55	0.00	507.76
0.60	0.00	600.17
0.65	0.00	700.62
0.70	0.00	809.10
0.75	0.00	925.62
0.80	0.00	1050.17
0.85	0.00	1182.76
0.90	0.00	1323.39
0.95	0.00	1472.05
1.00	0.00	1628.75

Outcome: On completion of the experiment the student will understand the configuration and functioning of machine under swing curve.

Questions:

1. The system having a single machine connected to an infinite bus has the following data.
   Pi =0.9 M= 0.016 (2.8×10^{-4} S / electrical Degree)
   E1 = 1.1 Transfer reactance before fault – Xo = 0.45 pu
   E2 = 1.0 Transfer reactance during fault – X1 = 1.25 pu
   Plot the swing curve (either using graph sheet or any grapher software) for sustained fault step by step method up to 1 second.

2. The system having a single machine connected to an infinite bus has the following data.Write and execute a program to plot the swing curve when the fault is cleared in
   0.125 seconds.
   Pi =0.9 M= 0.016 (2.8×10^{-4} S / electrical Degree)
   E1 = 1.1 Transfer reactance before fault – Xo = 0.45 pu
   E2 = 1.0 Transfer reactance during fault – X1 = 1.25 pu
   Transfer reactance after clearing the fault – X2 = 0.55 pu

Plot the swing curve (either using graph sheet or any grapher software) for a fault cleared in________(Typically 0.3 & 0.42 second) or_______cycle using step by step method .

Experiment No. 4

Formation of y_{bus} of a given power system by singular transformation

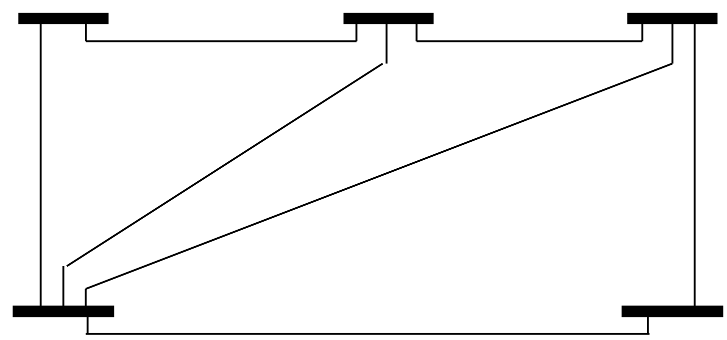
Objective:

To determine the bus admittance and impedance matrices for the given power system.
To obtain network solution using these matrices

To obtain certain specified columns of the bus impedance matrix Z or the half matrix Z using the factors of Y or inverse of Y.

a) Formation of Y_{bus} without mutual coupling

ONE LINE DIAGRAM OF 5 BUS POWER SYSTEM:



Impedances and line charging admittances for the power system:

Bus Code p-q	Impedance Zpq	Line charging admittance $Y^{l}pq/2$
1-2	0.02 + j 0.06	0.0 + j 0.060
1-3	0.08 + j 0.24	0.0 + j 0.05
2-3	0.06 + j 0.18	0.0 + j 0.04
2-4	0.06 + j 0.18	0.0 + j 0.04
2-5	0.04 + j 0.12	0.0 + j 0.03
3-4	0.01 + j 0.03	0.0 + j 0.02
4-5	0.08 + j 0.24	0.0 + j 0.05

```
%FORMATION OF ybus USING SINGULAR TRANSFORMATION METHOD
%WITHOUT MUTUAL COUPLING:
%  p q     Z          hlcY(ADM)
z=[1  2  0.02+0.06i  0.06i
   1  3  0.08+0.24i  0.05i
   2  3  0.06+0.18i  0.04i
   2  4  0.06+0.18i  0.04i
   2  5  0.04+0.12i  0.03i
   3  4  0.01+0.03i  0.02i
   4  5  0.08+0.24i  0.05i ];
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
```

Out Put:

Ybus =

```
  6.2500 -18.6400i  -5.0000 +15.0000i  -1.2500 + 3.7500i        0                 0
 -5.0000 +15.0000i  10.8333 -32.3300i  -1.6667 + 5.0000i  -1.6667 + 5.0000i  -2.5000 + 7.5000i
 -1.2500 + 3.7500i  -1.6667 + 5.0000i  12.9167 -38.6400i -10.0000 +30.0000i        0
      0             -1.6667 + 5.0000i -10.0000 +30.0000i  12.9167 -38.6400i  -1.2500 + 3.7500i
      0             -2.5000 + 7.5000i        0            -1.2500 + 3.7500i   3.7500 -11.1700i
```

b) Formation of Y_{Bus} with mutual coupling:

Program for Y_{bus} formation with mutual coupling:

```
%FORMATION OF ybus USING SINGULAR TRANSFORMATON METHOD
%WITH MUTUAL COUPLING & WITHOUT LINE CHARGING:
%  p  q    Z    mno  mutual(imp)
z=[0  1  0.3i    0      0
   2  0  1.0     0      0
   0  3  0.2i    0      0
   1  2  0.03i   5      -0.01i
   3  2  0.02i   4      -0.01i];
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:nbus,
    if(p(k)==0)
        A(q(k),q(k))=-1;
    elseif(q(k)==0)
        A(p(k),p(k))=1;
    else
    A(k,k)=1;
end
end
for k=1:nline-nbus
        A(nbus+k,p(nbus+k))=1;
    A(nbus+k,q(nbus+k))=-1;
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
```

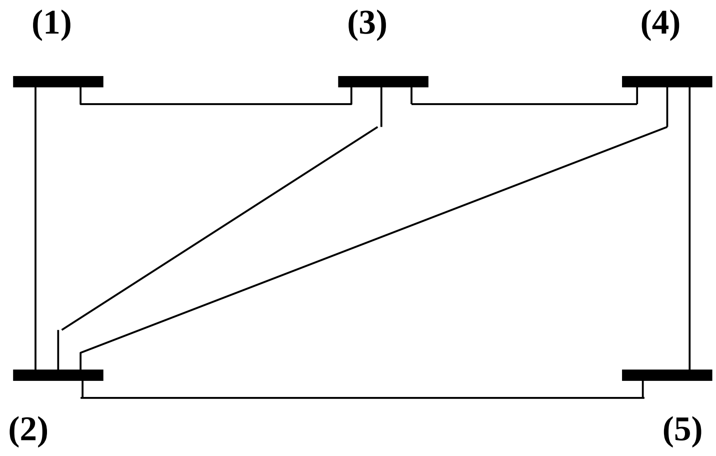
OutPut:

Ybus =

```
  1.0e+002 *
        0 - 0.4333i         0 + 0.6000i         0 - 0.2000i
        0 + 0.6000i    0.0100 - 1.4000i         0 + 0.8000i
        0 - 0.2000i         0 + 0.8000i         0 - 0.6500i
```

c) Formation of Y_{Bus} without mutual coupling by Inspection Method

One line diagram of 5 bus power system:



Impedances and line charging admittances for the power system:

Bus Code p-q	Impedance Zpq	Line charging admittance $Y^{l}pq/2$
1-2	0.02 + j 0.06	0.0 + j 0.060
1-3	0.08 + j 0.24	0.0 + j 0.05
2-3	0.06 + j 0.18	0.0 + j 0.04
2-4	0.06 + j 0.18	0.0 + j 0.04
2-5	0.04 + j 0.12	0.0 + j 0.03
3-4	0.01 + j 0.03	0.0 + j 0.02
4-5	0.08 + j 0.24	0.0 + j 0.05

Program for Y_{bus} formation without mutual coupling by Inspection method:

```
% p q        z        hlc(ADM)
z=[1  2  0.02+0.06i  0.06i
     1   3  0.08+0.24i  0.05i
     2  3  0.06+0.18i  0.04i
     2  4  0.06+0.18i  0.04i
     2  5  0.04+0.12i  0.03i
     3  4  0.01+0.03i  0.02i
     4  5  0.08+0.24i  0.05i];
%function yb(z);
fb=z(:,1);
tb=z(:,2);
Z=z(:,3);
hlc=z(:,4);
y=1./Z;
nbus=max(max(fb),max(tb));
Y=zeros(nbus);
nline=length(fb);
for k=1:nline,
    p=fb(k);q=tb(k);
    Y(p,p)=Y(p,p)+y(k)+hlc(k);
    Y(q,q)=Y(q,q)+y(k)+hlc(k);
    Y(p,q)=Y(p,q)-y(k);
    Y(q,p)=Y(p,q);
end
Ybus=Y
```

OutPut:

Ybus =

6.2500 -18.6400i -5.0000 +15.0000i -1.2500 + 3.7500i 0 0
-5.0000 +15.0000i 10.8333 -32.3300i -1.6667 + 5.0000i -1.6667 + 5.0000i -2.5000 + 7.5000i
-1.2500 + 3.7500i -1.6667 + 5.0000i 12.9167 -38.6400i -10.0000 +30.0000i 0
0 -1.6667 + 5.0000i -10.0000 +30.0000i 12.9167 -38.6400i -1.2500 + 3.7500i
0 -2.5000 + 7.5000i 0 -1.2500 + 3.7500i 3.7500 -11.1700i

Outcome: On completion of above experiment, student will known the algorithm used for determining Z or Y matrices of the power system.

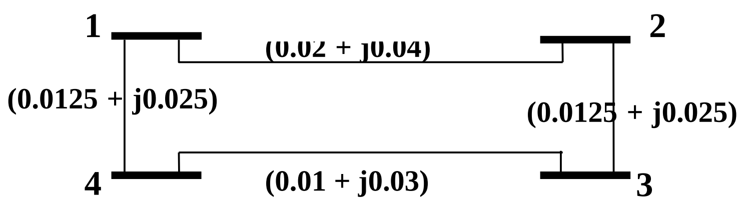
Questions:

1. Using singular transformation analysis, determine the bus admittance matrix of given test system.

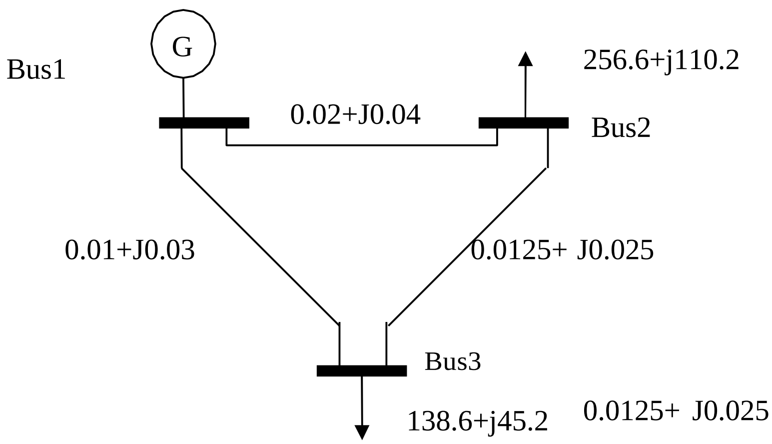
2. Using singular transformation analysis, determine Ybus for a given test system with mutual coupling of j0.01 pu between the line numbers ______ &________Neglect line charging.

3. Using singular transformation analysis, determine the bus admittance matrix of given test system .
4. Using singular transformation analysis, determine Ybus for a given test system with mutual coupling of j0.01 pu between the line numbers ______& _______

Refer below figure for Q.(1) – Q.(4)



4. For the power system shown below compute the elements of Bus admittance matrix using singular transformation and inspection



Experiment No.5

Z-Bus Building Algorithm

Objective: To determine the impedance matrices using Z-bus building algorithm

```
%Program for building Z bus by addition or link
%Zprim=[Element no.  from   to  Value]
Z= [     1 1 0 0.25
            2 2 1 0.1
            3 3 1 0.1
            4 2 0 0.25
            5 2 3 0.1];
[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
     % Type 3 Modification
  if newbus<=currentbusno & ref==0
        Zbus=Zbus-
1/(Zbus(newbus,newbus)+value)*Zbus(:,newbus)*Zbus(newbus,:)
        continue
      end
      % Type 4 Modification
  if newbus<=currentbusno & ref~=0
        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


   Zbus =

       0.2500

   Zbus =
```

```
    0.2500    0.2500
    0.2500    0.3500

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
```

Outcome: On completion of the experiment the student will known the algorithm for finding out Z

Experiment No. 6:

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

Objective: To determine the bus admittance and impedance matrices for the given power system.

```
%  p q        z        hlc(ADM)
z=[1  2  0.02+0.04i  0.00i
   1  3  0.01+0.03i  0.00i
   2 3 0.0125+0.025i 0.00i];
v(1)=1.05+0i;v(2)=0.98-0.06i;v(3)=1.0-0.05i;
fb=z(:,1);
tb=z(:,2);
Z=z(:,3);
ysh=z(:,4);
y=1./Z;
nbus=max(max(fb),max(tb));
nline=length(fb);
II=zeros(nbus,1);SG=zeros(nbus,1);loss=zeros(nline,1);totloss=0;
for k=1:nline
    p=fb(k);q=tb(k);
    I(p,q)=(v(p)-v(q))*y(k)+v(p)*ysh(k);
    II(p)=II(p)+I(p,q);
    SL(p,q)=v(p)*conj(I(p,q));
    SG(p)=SG(p)+SL(p,q);
    I(q,p)=(v(q)-v(p))*y(k)+v(q)*ysh(k);
    II(q)=II(q)+I(q,p);
    SL(q,p)=v(q)*conj(I(q,p));
    SG(q)=SG(q)+SL(q,p);
    loss(k)=loss(k)+SL(p,q)+SL(q,p);
    totloss=totloss+loss(k);
disp([p q SL(p,q) SL(q,p) loss(k)])
end
Bus_Currents=II
Bus_Generations = SG
Total_Losses = totloss
```

OUTPUT

bus currents
Bus no Current
1 3.900000 -1.800000i
2 -2.540000 +1.280000i
3 -1.360000 +0.520000i
Line flows

From bus	To bus	Lineflows	Line Loss
1	2	1.995000 +0.840000i	0.085000 +0.170000i
2	1	-1.910000 -0.670000i	0.085000 +0.170000i
1	3	2.100000 +1.050000i	0.050000 +0.150000i
3	1	-2.050000 -0.900000i	0.050000 +0.150000i
2	3	-0.656000 -0.432000i	0.008000 +0.016000i
3	2	0.664000 +0.448000i	0.008000 +0.016000i

Bus Generations
Bus no Generation
1 4.095000 +1.890000i
2 -2.566000 -1.102000i
3 -1.386000 -0.452000i

Total Losses=0.143000 +0.336000i

Outcome: To obtain network solution using these matrices

Experiment No. 7

Formation of Jacobian for the system not exceeding 4 buses (no pv buses) in polar coordinates using software package

Objective: To study the matrices' involved for the system to calculate voltage profile in terms of pu.

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. Consider bus 1 as slack bus. Obtain the load values.

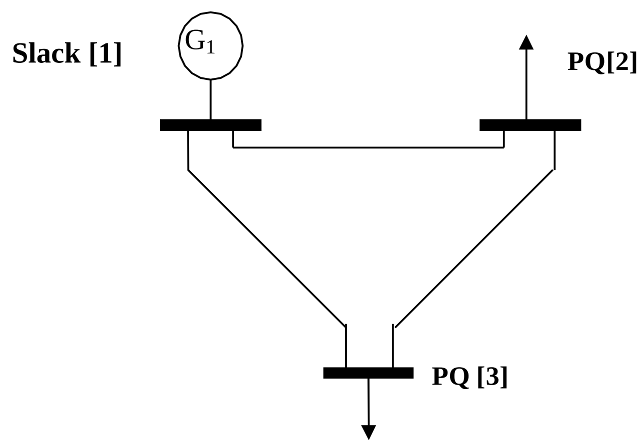


Table A

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

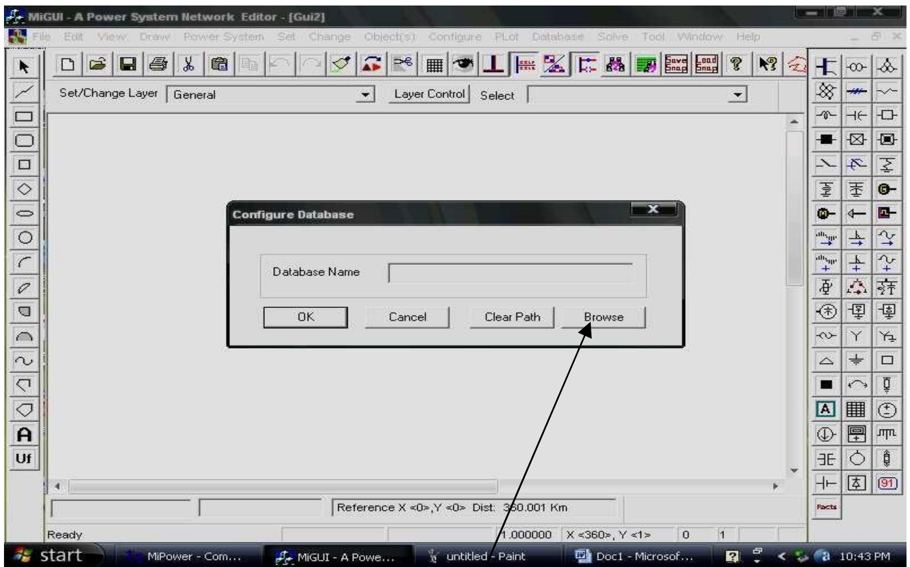
Table B

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

Procedure to enter the data for performing studies using MiPower.

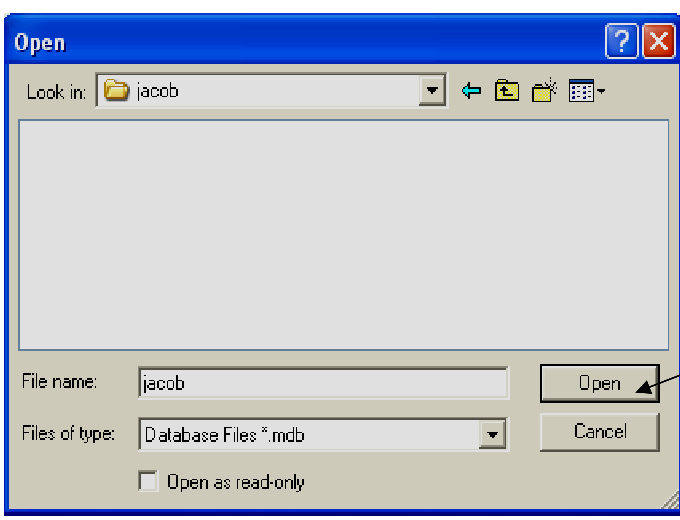
`MiPower- Data base Configuration

Open power system Network Editor. Select menu option **Database → Configure.** Configure Database **dialog** is opened up as shown below. Click **Browse** button

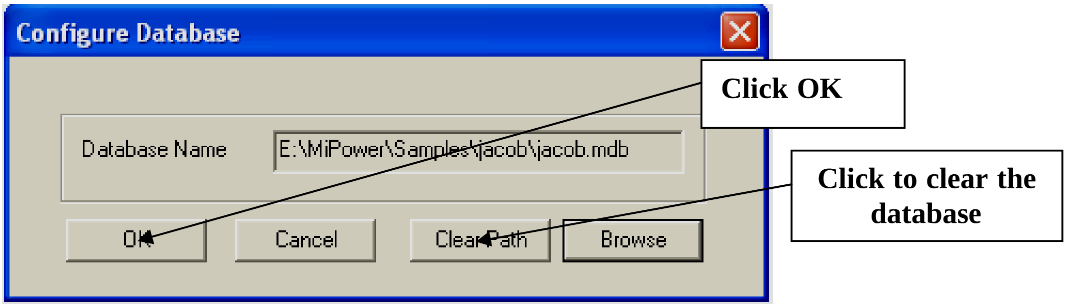


Click here to specify the name of the database

Open dialog box is opened up as shown below, where you are going to browse the desired directory and specify the name of the data base 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.



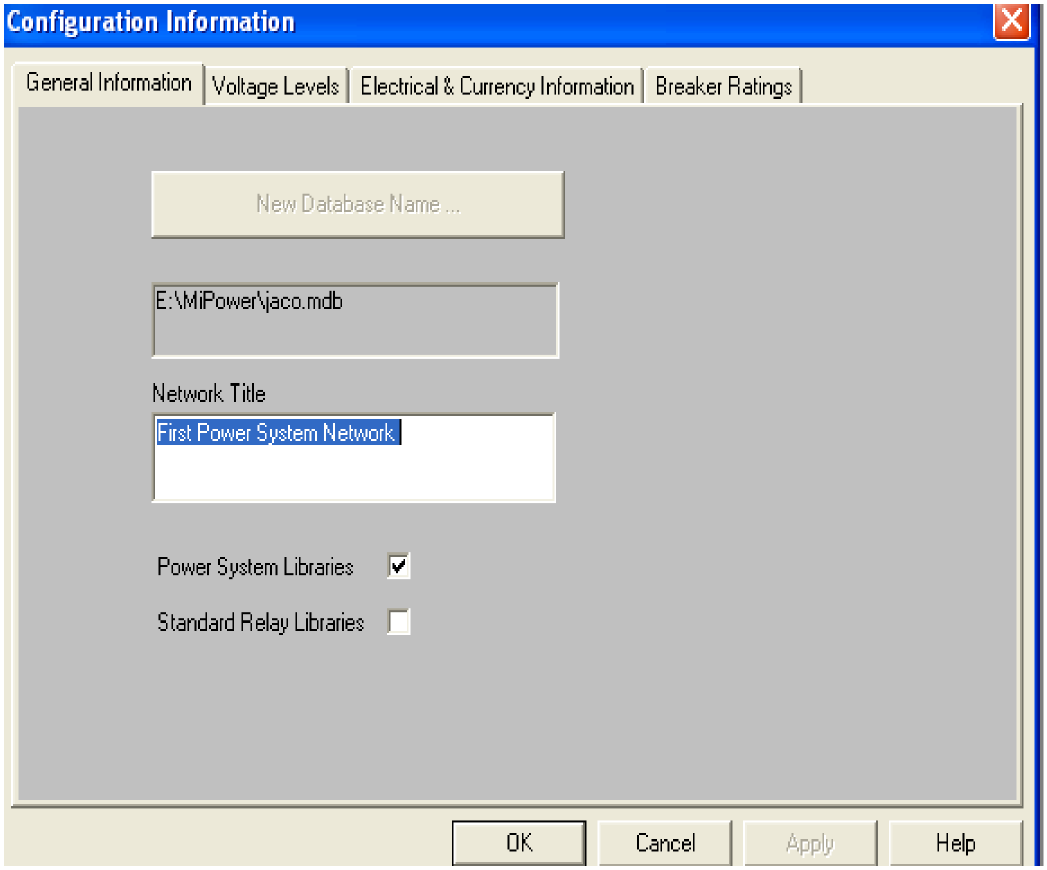
Click Here to open

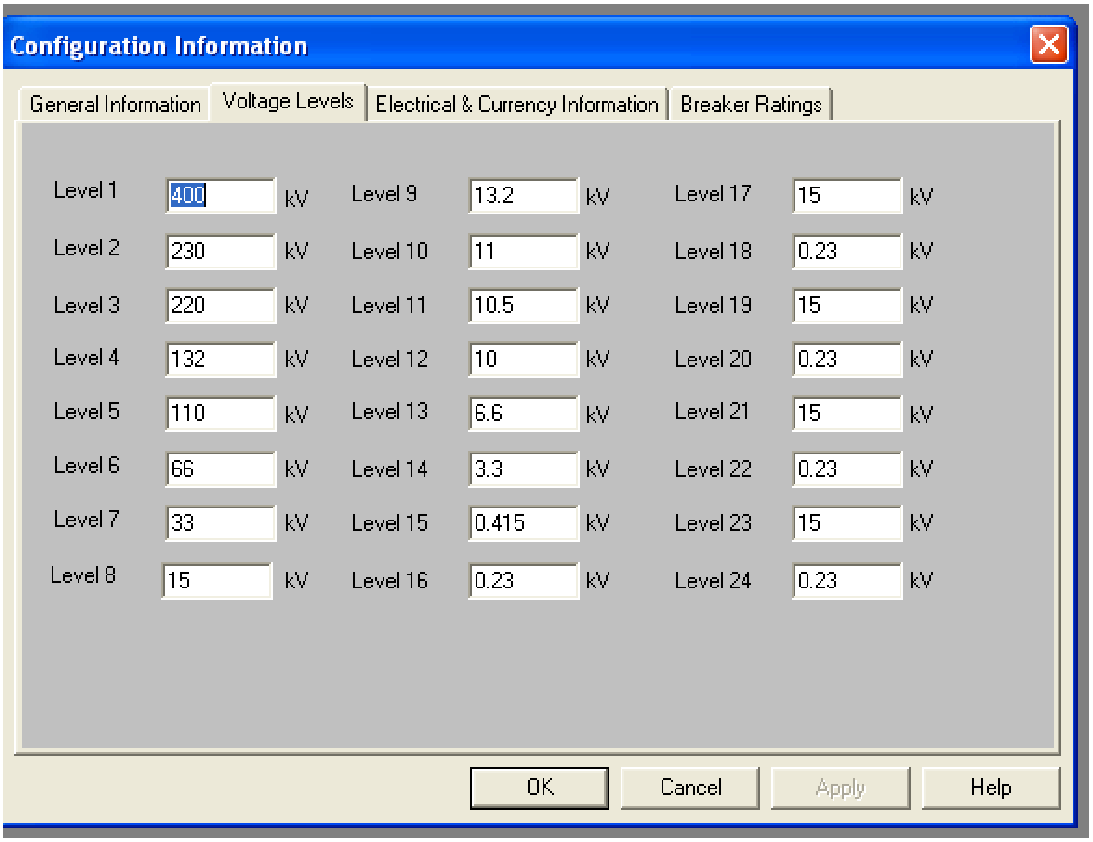


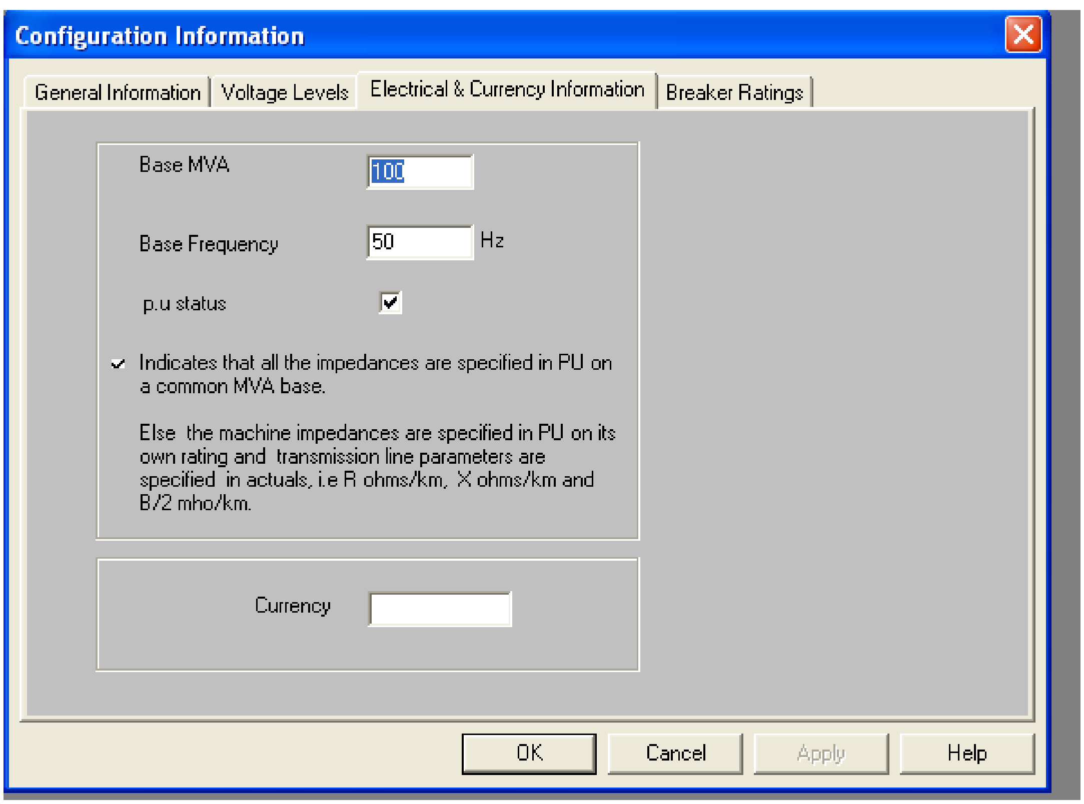
Note: Do not work in the MiPower directory

Click Ok button on the **configure database** dialog. The dialog as shown 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-ordination studies. If Libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab. Since the impedance are given on 100 MVA base, check the pu status. Enter the Base MVA and Base frequency as shown below. Click on Breaker Rating button to give breaker ratings. Click **OK** button to create the database to return to Network Editor.

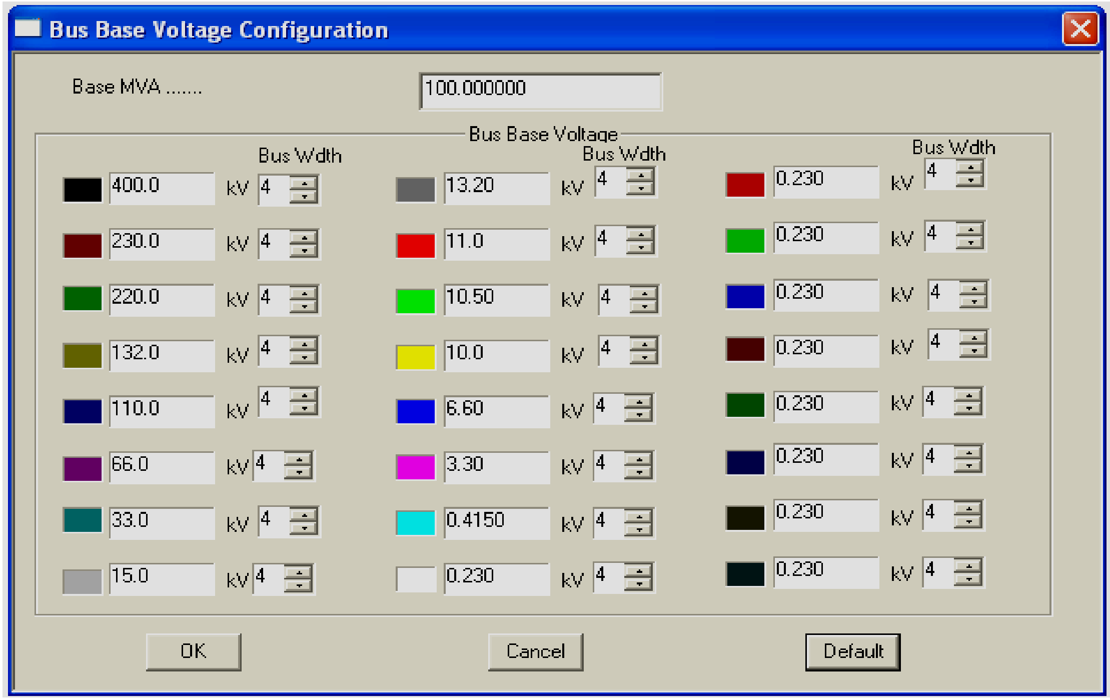

Configuration Information
General Information
Voltage Levels
Electrical & Currency Information
Breaker Ratings
New Database Name ...
E:\MiPower\jaco.mdb
Network Title
First Power System Network
Power System Libraries
Standard Relay Libraries
OK
Cancel
Apply
Help

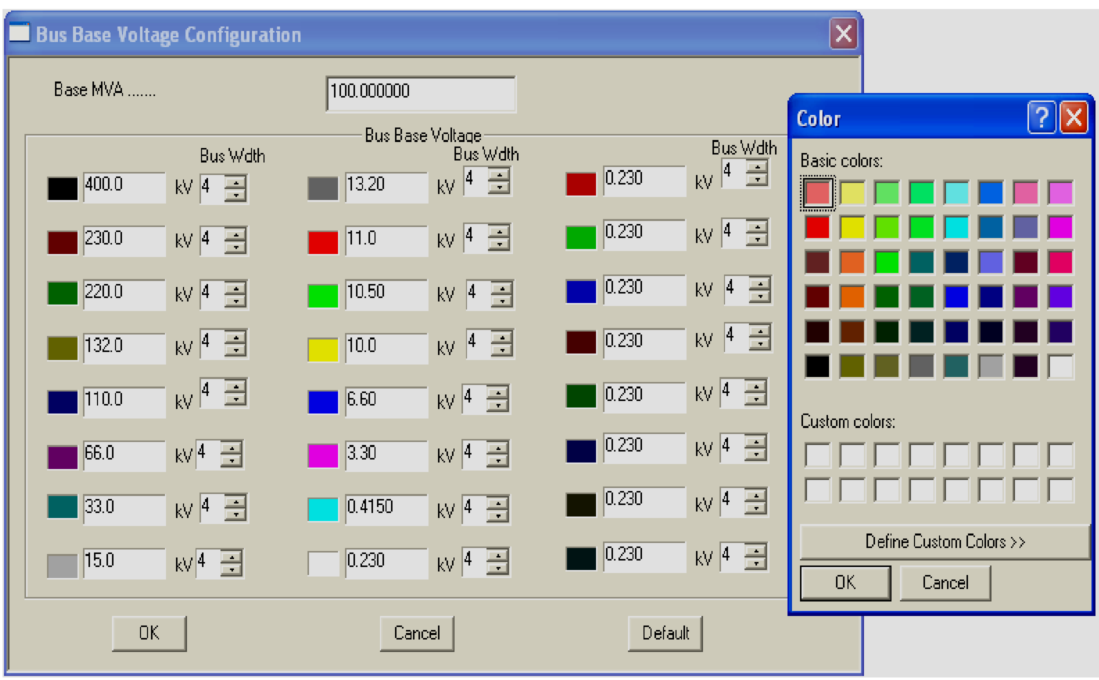

Configuration Information
General Information
Voltage Levels
Electrical & Currency Information
Breaker Ratings
Level 1 400 kV
Level 2 230 kV
Level 3 220 kV
Level 4 132 kV
Level 5 110 kV
Level 6 66 kV
Level 7 33 kV
Level 8 15 kV
Level 9 13.2 kV
Level 10 11 kV
Level 11 10.5 kV
Level 12 10 kV
Level 13 6.6 kV
Level 14 3.3 kV
Level 15 0.415 kV
Level 16 0.23 kV
Level 17 15 kV
Level 18 0.23 kV
Level 19 15 kV
Level 20 0.23 kV
Level 21 15 kV
Level 22 0.23 kV
Level 23 15 kV
Level 24 0.23 kV
OK
Cancel
Apply
Help


Configuration Information
General Information
Voltage Levels
Electrical & Currency Information
Breaker Ratings
Base MVA 100
Base Frequency 50 Hz
p.u status
Indicates that all the impedances are specified in PU on a common MVA base.
Else the machine impedances are specified in PU on its own rating and transmission line parameters are specified in actuals, i.e R ohms/km, X ohms/km and B/2 mho/km.
Currency
OK
Cancel
Apply
Help

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**

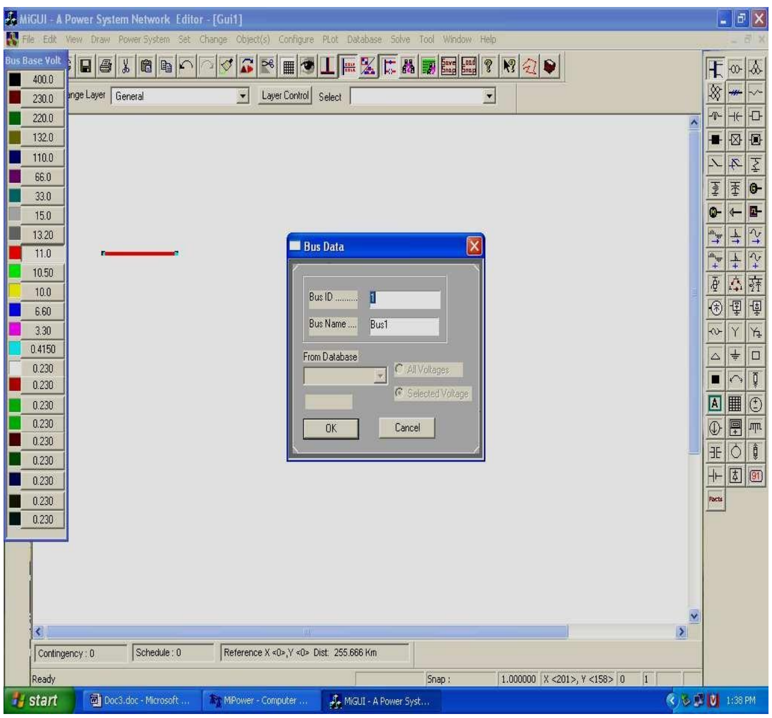


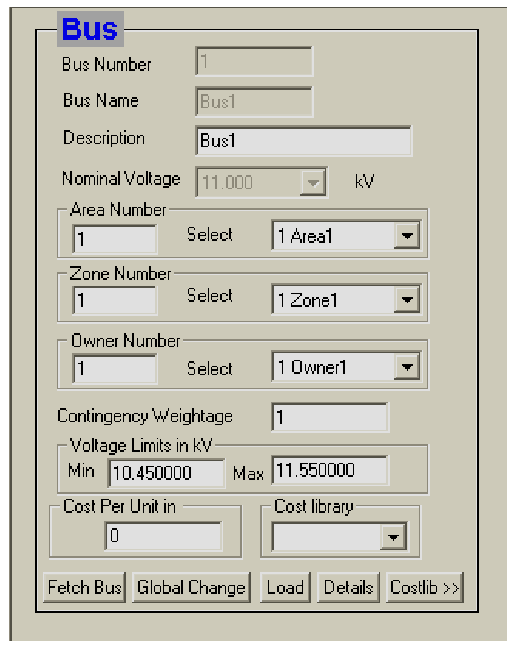


Procedure to Draw First Element – Bus

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 **Slack,** then bus name can be given as **Slack** and the bus description field can be **Slack**





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

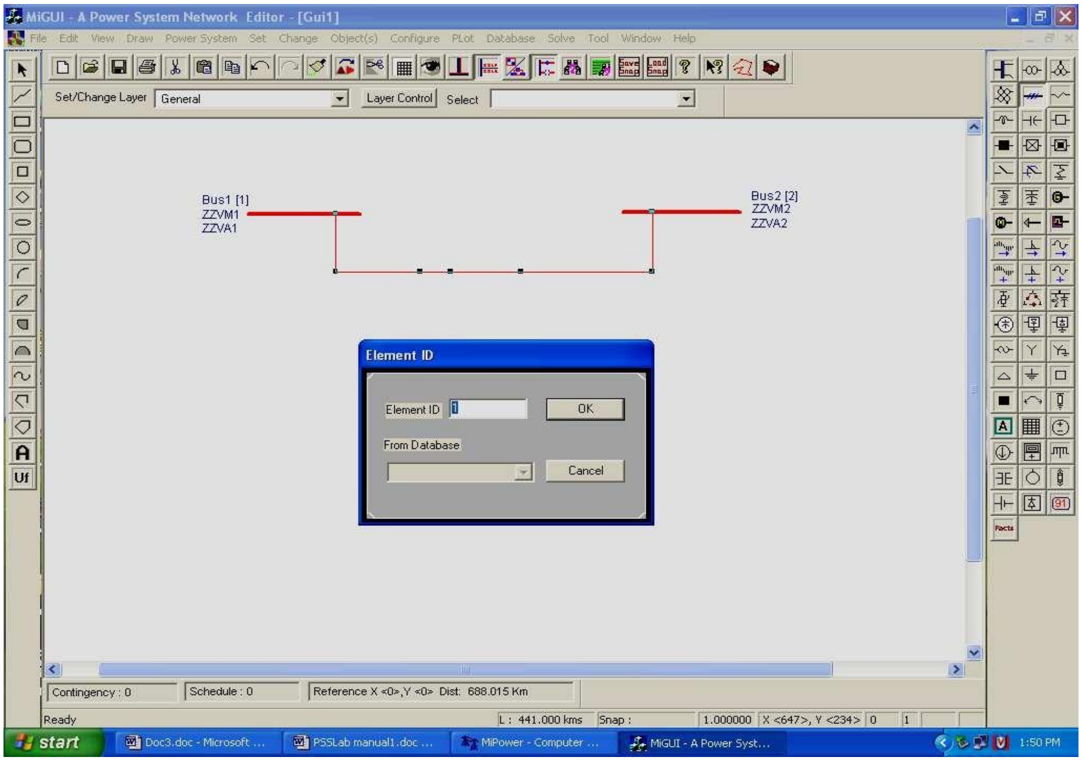
Bus Number	Bus Name	Nominal Voltage (KV)
1	Bus1	11
2	Bus2	11
3	Bus3	11

Note: Since the voltages are mentioned in pu, any KV con be assumed. So the base voltage is Chosen as 11KV

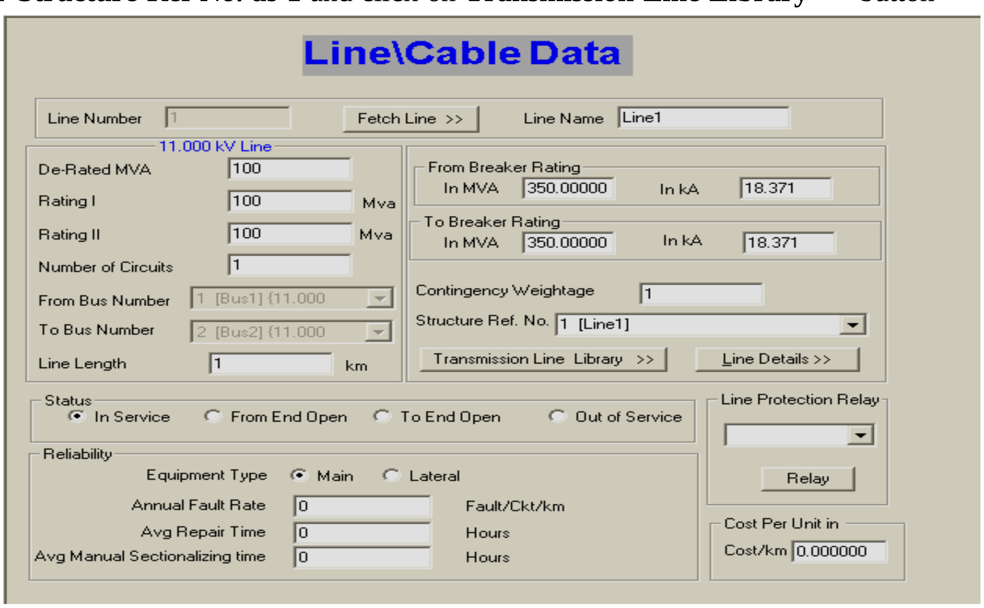
Procedure to Draw Transmission Line

Click on **Transmission line** icon provided on power system tool bar. To draw the line click in between two buses ans 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.

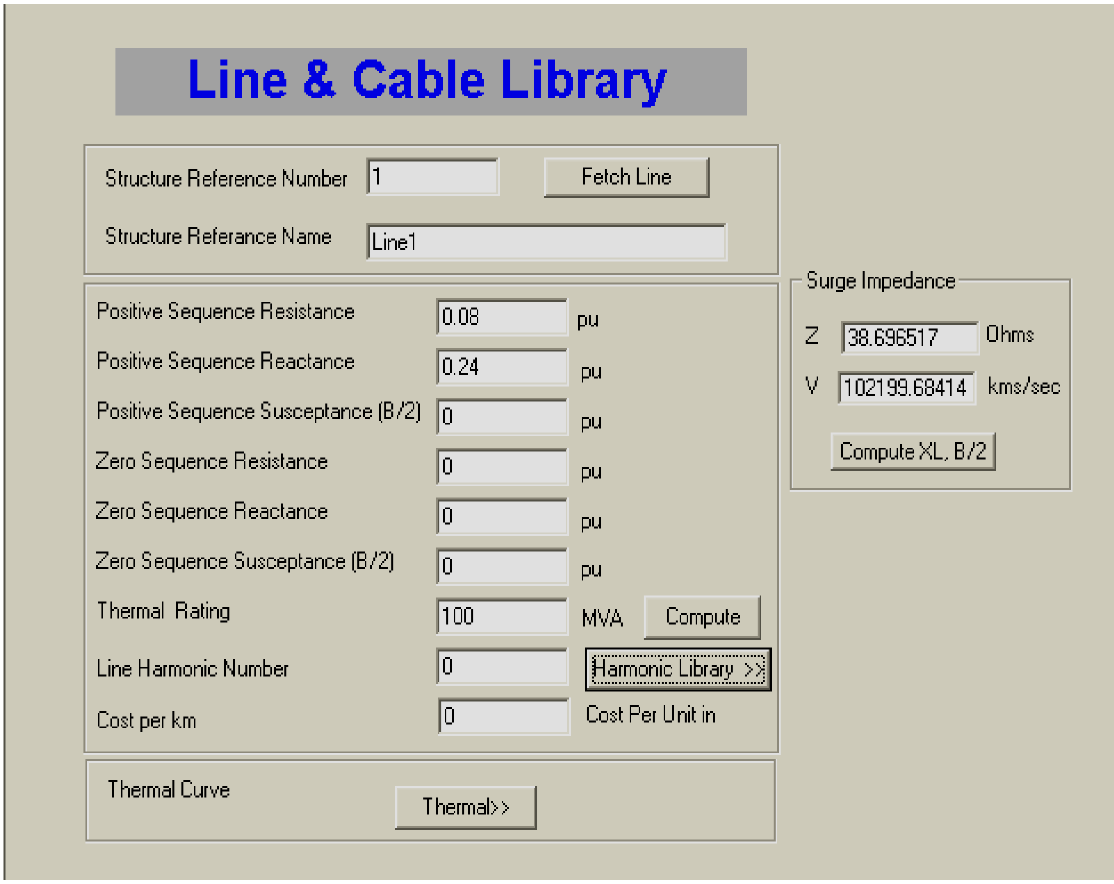
Enter **Element ID** number and click **OK.** Database manager with corresponding **Line \ cable Data** from will be open. Enter the details of that line as shown below.



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 **line 1-2.**



After entering data Space and close. Line\Cable Data form will appear. Click Save which invokes Network Editor to update next element. Data for remaining elements is given in the following table.

Transmission Line Element Data

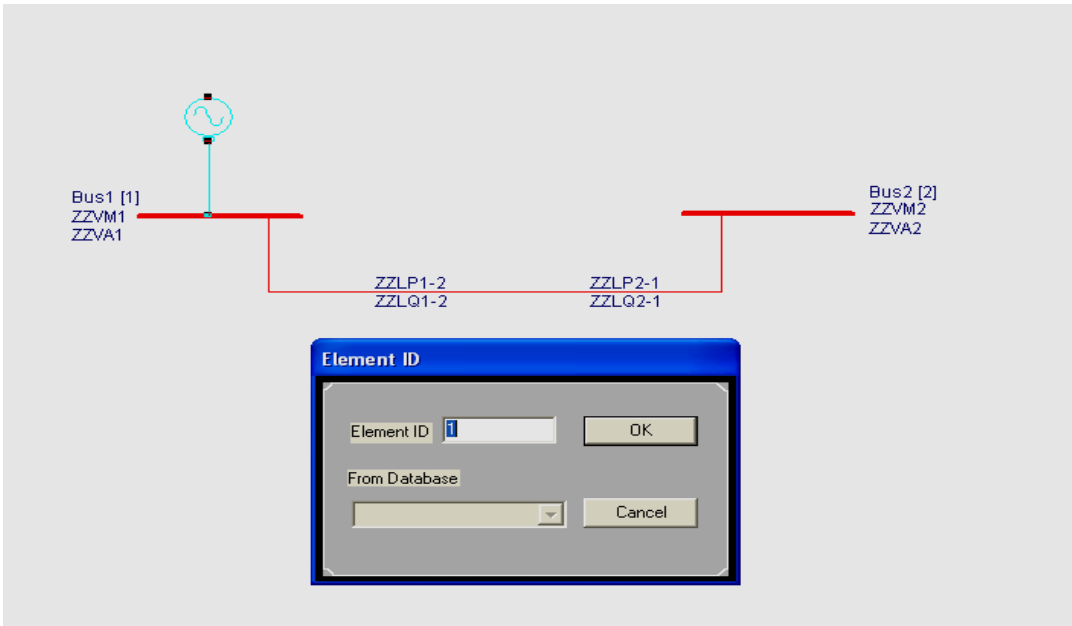
Line No	From Bus	To Bus	Structure Ref.No
1	1	2	1
2	1	3	2
3	2	3	3

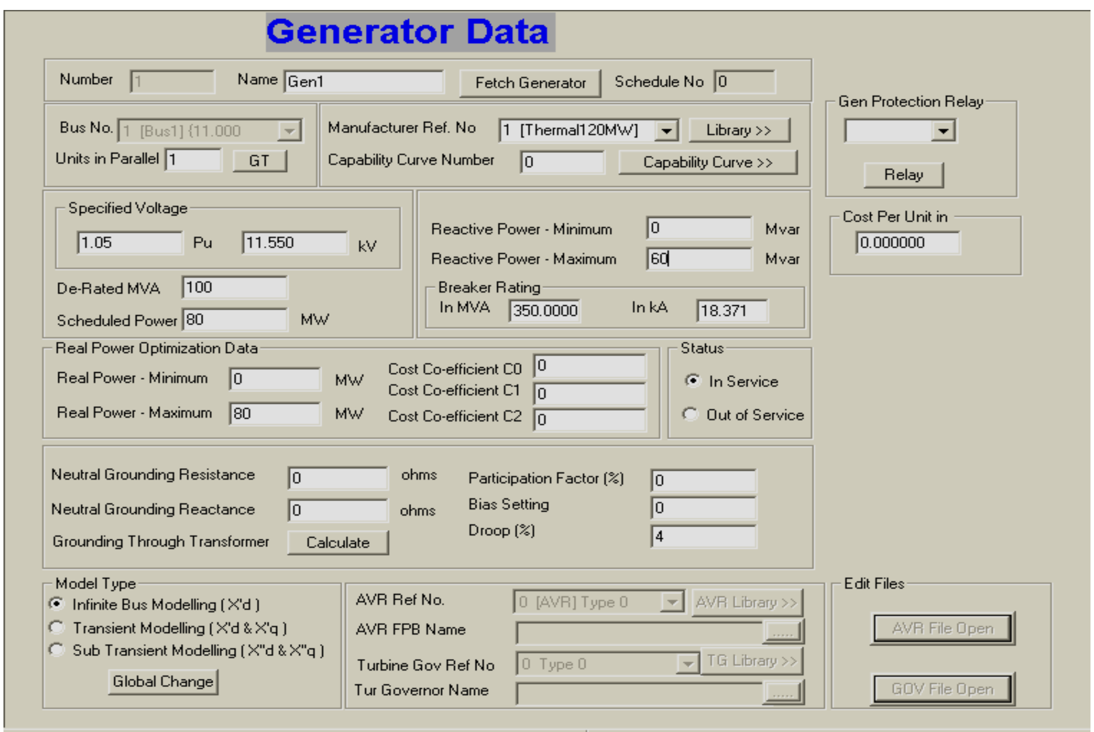
Transmission Line Library Data

Structure Ref No	Structure Ref Name	Resistance	Reactance	Line chargingB/2	Thermal rating
1	Line 1-2	0.08	0.24	0	100
2	Line 1-3	0.02	0.06	0	100
3	Line2-3	0.06	0.18	0	100

Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Conduct 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.



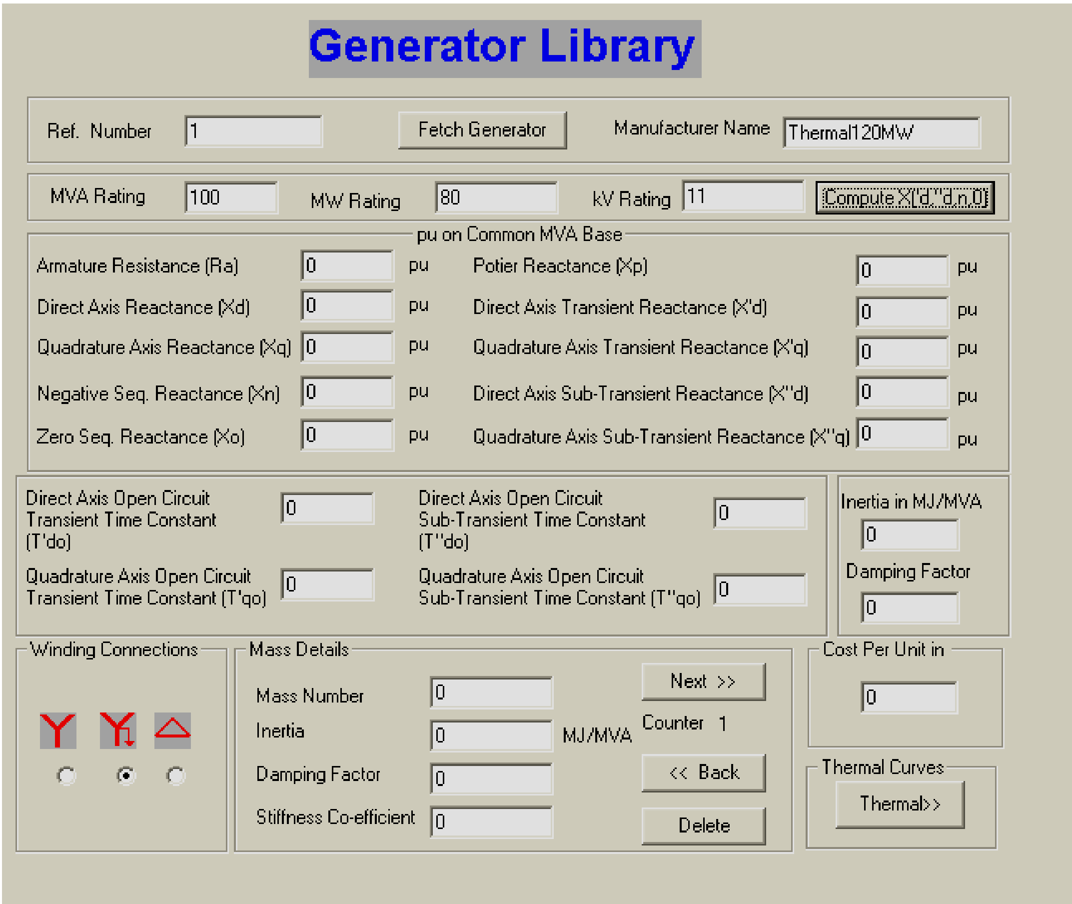


Since generator at bus1 is mention as slack bus, only specified voltage will have importance.

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 bus3), then scheduled power, specified voltage, minimum and maximum real and reactive power data is must.

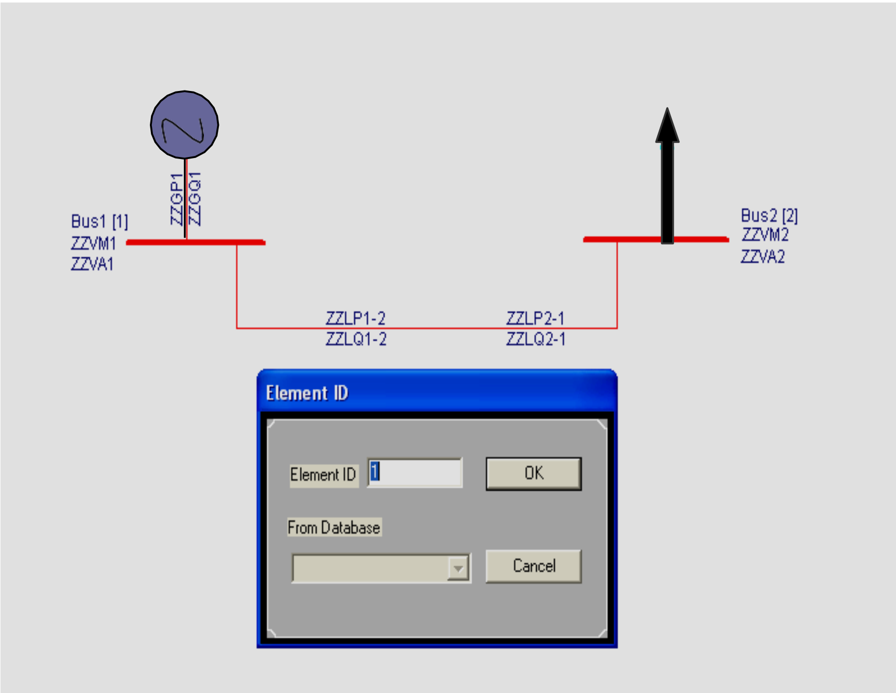
Enter Manufacturer Ref. No. as 1 and click on Generator Library button. Generator library form will appear.

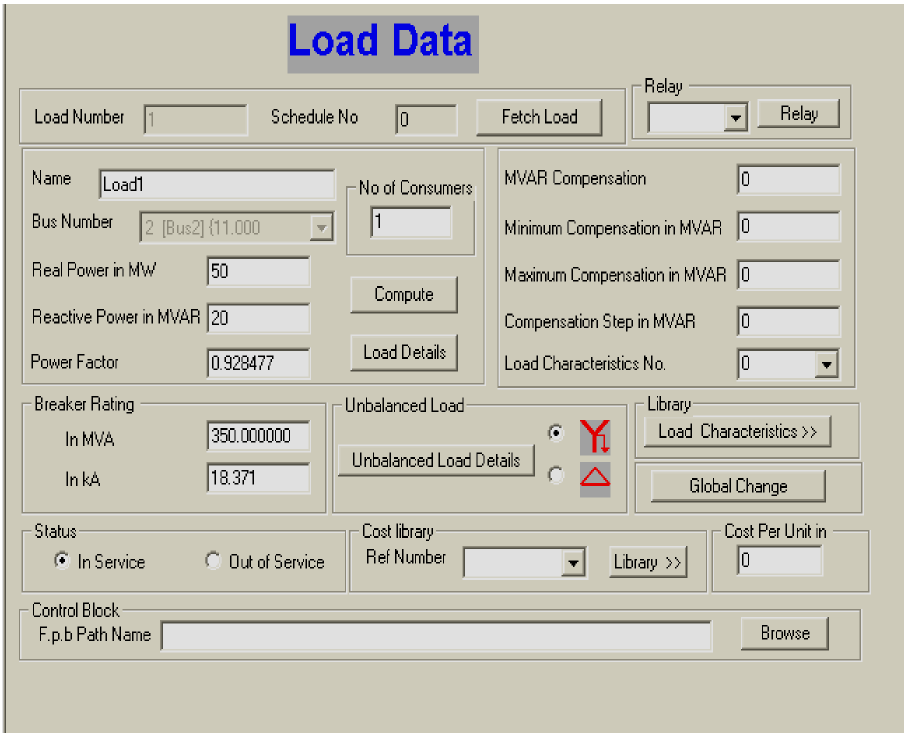


After entering data **Save** and close. In **Generator Data** form click **Save Network Editor** screen will be invoked.

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.



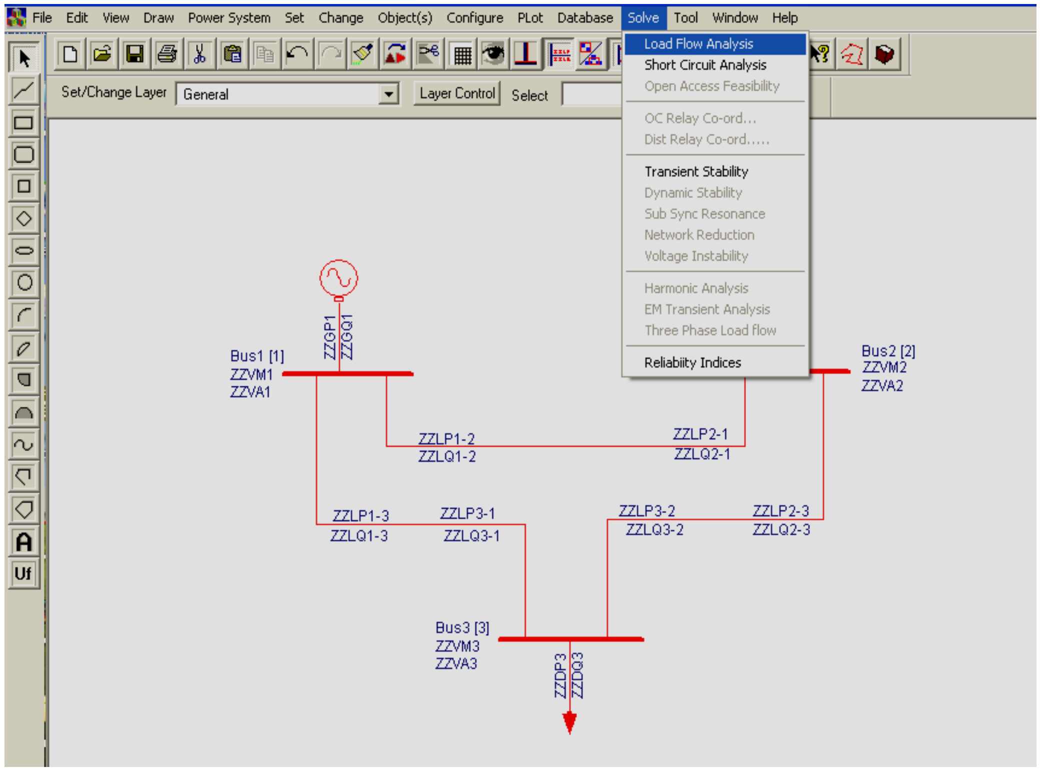


Load Data

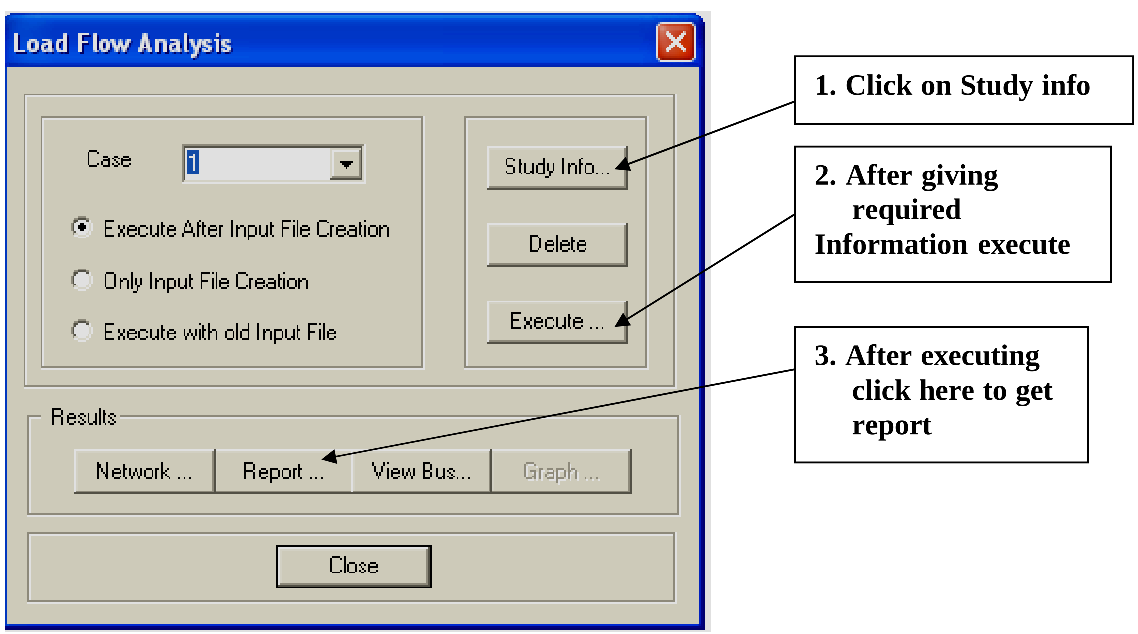
Bus No	Load MW	Load Mvar
1	0	0
2	50	20
3	60	25

Solve Load Flow Analysis

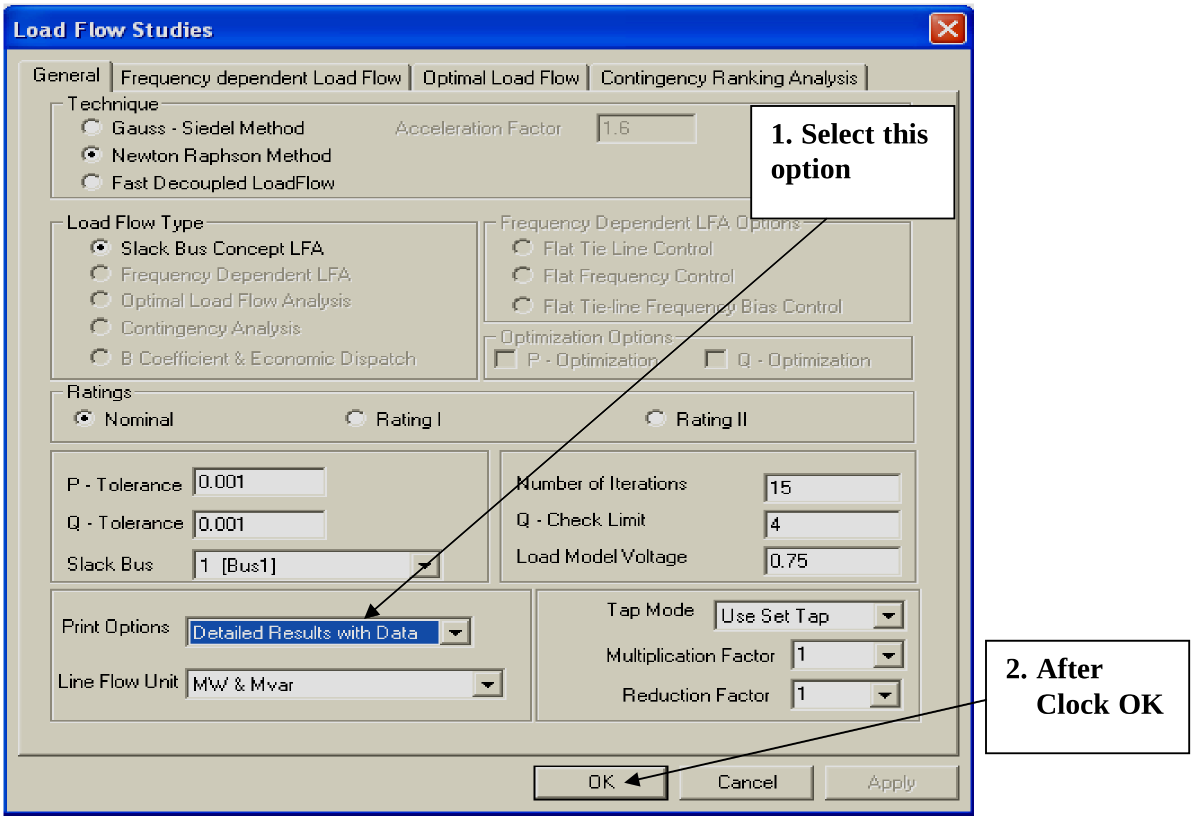
Select Menu option **Solve** ⟶ **Load Flow Analysis**.



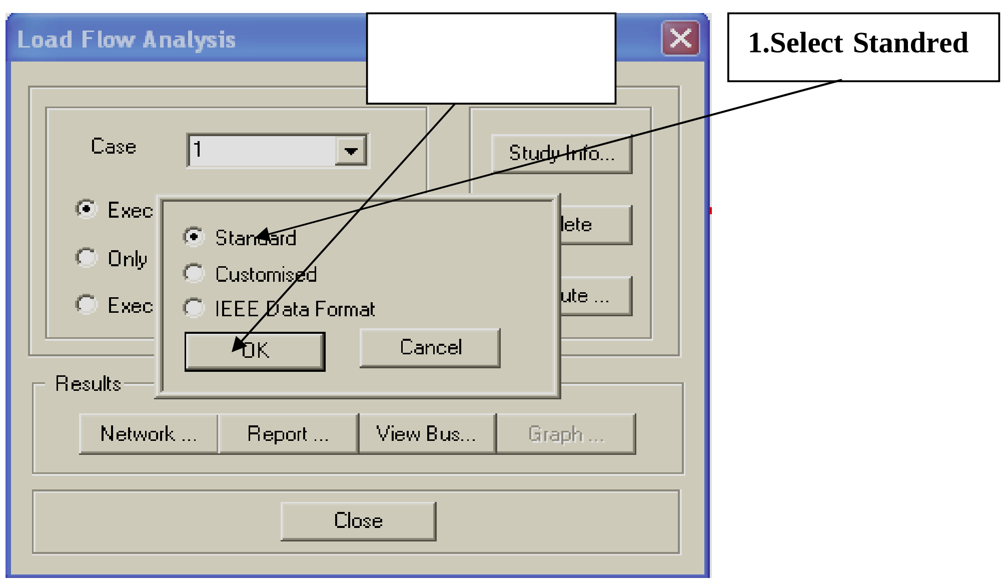
Follow in dialog will appear.

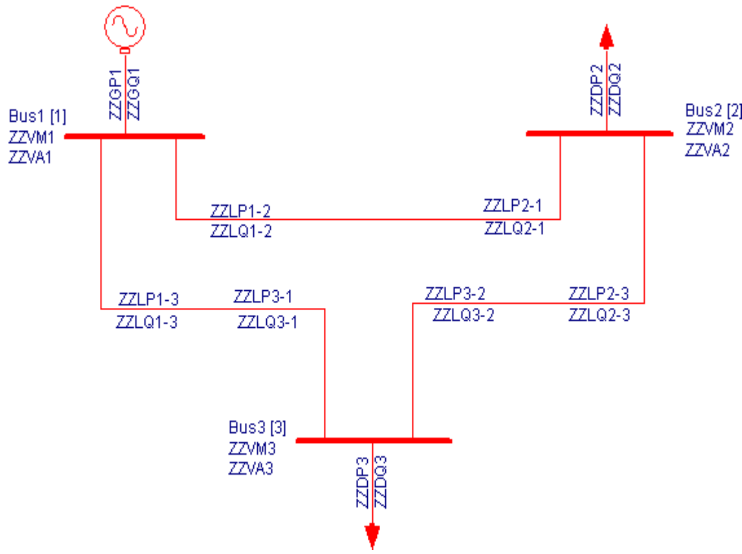


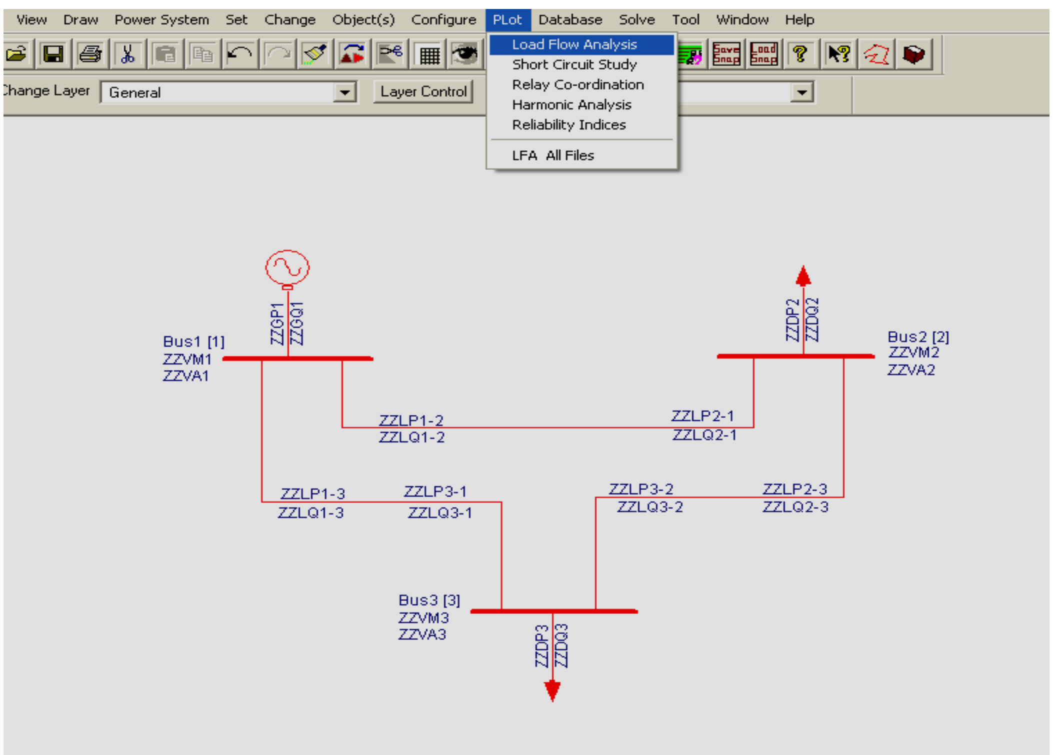
When **Study info** button is clicked, following dialog will open. Select Newton Raphson Method and enter P-Tolerance and Q- Tolerance as 0.001. Click OK. (Select print option as Deleted Result with data)

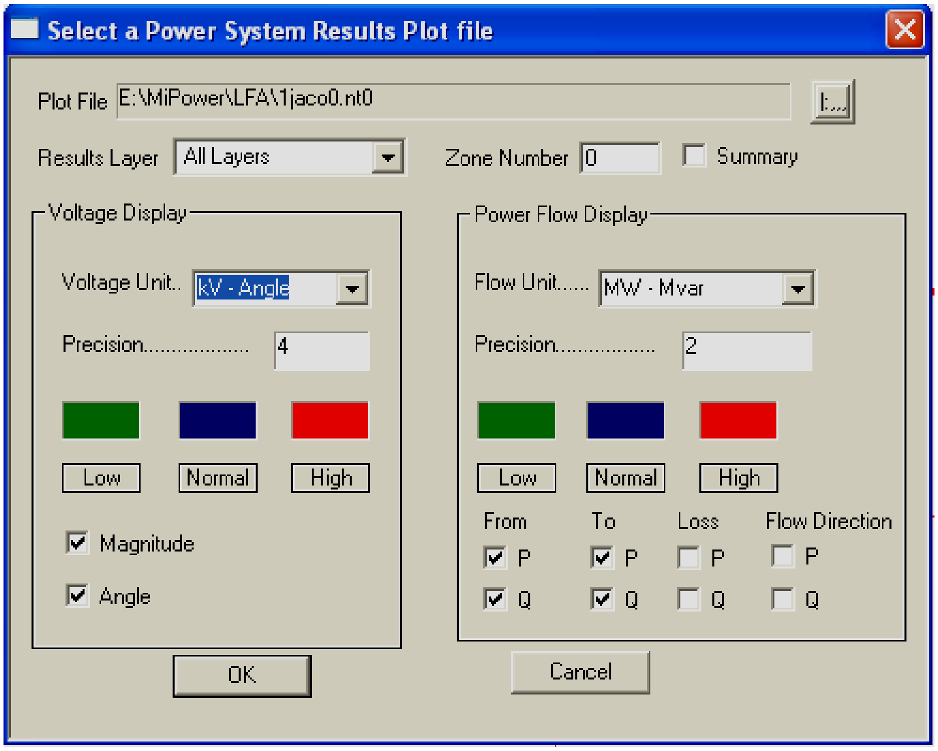


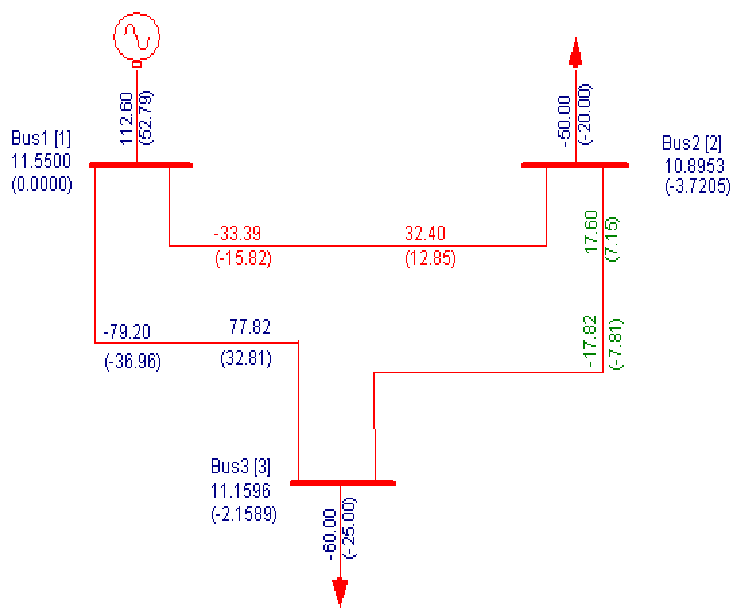
When report button is clicked following dialog box will open. Select standard and click on to OK




Bus1 [1]
ZZVM1
ZZVA1
ZZGP1
ZZGQ1
Bus2 [2]
ZZVM2
ZZVA2
ZZDP2
ZZDQ2
ZZLP1-2
ZZLQ1-2
ZZLP2-1
ZZLQ2-1
ZZLP1-3
ZZLQ1-3
ZZLP3-1
ZZLQ3-1
ZZLP3-2
ZZLQ3-2
ZZLP2-3
ZZLQ2-3
Bus3 [3]
ZZVM3
ZZVA3
ZZDP3
ZZDQ3


View Draw Power System Set Change Object(s) Configure PLot Database Solve Tool Window Help
Load Flow Analysis
Short Circuit Study
Relay Co-ordination
Harmonic Analysis
Reliability Indices
LFA All Files
Change Layer
General
Layer Control
Bus1 [1]
ZZVM1
ZZVA1
ZZGP1
ZZGQ1
Bus2 [2]
ZZVM2
ZZVA2
ZZDP2
ZZDQ2
ZZLP1-2
ZZLQ1-2
ZZLP2-1
ZZLQ2-1
ZZLP1-3
ZZLQ1-3
ZZLP3-1
ZZLQ3-1
ZZLP3-2
ZZLQ3-2
ZZLP2-3
ZZLQ2-3
Bus3 [3]
ZZVM3
ZZVA3
ZZDP3
ZZDQ3


Select a Power System Results Plot file
Plot File E:\MiPower\LFA\1jaco0.nt0
Results Layer All Layers
Zone Number 0
Summary
Voltage Display
Voltage Unit.. kV - Angle
Precision.................. 4
Low
Normal
High
Magnitude
Angle
Power Flow Display
Flow Unit...... MW - Mvar
Precision................. 2
Low
Normal
High
From
To
Loss
Flow Direction
P
Q
OK
Cancel


Bus1 [1]
11.5500
(0.0000)
112.60
(52.79)
-50.00
(-20.00)
Bus2 [2]
10.8953
(-3.7205)
-33.39
(-15.82)
32.40
(12.85)
17.60
(7.15)
-79.20
(-36.96)
77.82
(32.81)
-17.82
(-7.81)
Bus3 [3]
11.1596
(-2.1589)
-60.00
(-25.00)

Report

```
--------------------------------------------------------------------------------
Date and Time : Wed Jun 17 14:33:45 2009
--------------------------------------------------------------------------------
       LOAD FLOW BY NEWTON RAPHSON METHOD
CASE NO :  1     CONTINGENCY  : 0  SCHEDULE NO : 0
CONTINGENCY NAME : Base Case     RATING CONSIDERED : NOMINAL

  --------------------------------------------------------------------------------
  VERSION NUMBER :  6.1
  LARGEST BUS NUMBER USED        :    3    ACTUAL NUMBER OF BUSES          :    3
  NUMBER OF 2 WIND. TRANSFORMERS :    0    NUMBER OF 3 WIND. TRANSFORMERS  :    0
  NUMBER OF TRANSMISSION LINES   :    3
  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           :    1    NUMBER OF LOADS                 :    2
  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 NEWTON RAPHSON METHOD              :    6
NUMBER OF ZONES                                   :    1
PRINT OPTION                                      :    4 - DETAILED PRINT
PLOT OPTION                                       :    1 - PLOTTING WITH PU VOLTAGE
NO FREQUENCY DEPENDENT LOAD FLOW, CONTROL OPTION:    0
BASE MVA                                          : 100.000000
NOMINAL SYSTEM FREQUENCY (Hzs)                    : 50.000000
FREQUENCY DEVIATION (Hzs)                         : 0.000000
FLOWS IN MW AND MVAR, OPTION                      : 0
SLACK BUS                                         :    1
TRANSFORMER TAP CONTROL OPTION                    :    0
Q CHECKING LIMIT  (ENABLED)                       :    4
REAL POWER TOLERANCE (PU)                         :  0.00100
REACTIVE POWER TOLERANCE (PU)                     :  0.00100
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)                       :   2.500 Rs
   LOSS LOAD FACTOR                                  :   0.300
   COST PER MVAR IN LAKHS                            :   5.000 Rs
   --------------------------------------------------------------------------------
   ZONE WISE MULTIPLICATION FACTORS
```

ZONE	P LOAD	Q LOAD	P GEN	Q GEN	SH REACT	SH CAP	C LOAD
0	1.000	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	1.000

BUS DATA

BUS NO.	AREA	ZONE	BUS KV	VMIN-PU	VMAX-PU	NAME
1	1	1	11.000	0.950	1.050	Bus1
2	1	1	11.000	0.950	1.050	Bus2
3	1	1	11.000	0.950	1.050	Bus3

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	LINE PARAMETER R(P.U)	X(P.U.)	B/2(P.U.)	RATING MVA	KMS
3	1	1	Bus1	2	Bus2	0.08000	0.24000	0.00000	100	1.0
3	1	1	Bus1	3	Bus3	0.02000	0.06000	0.00000	100	1.0
3	1	2	Bus2	3	Bus3	0.06000	0.18000	0.00000	100	1.0

TOTAL LINE CHARGING SUSCEPTANCE : 0.00000
TOTAL LINE CHARGING MVAR AT 1 PU VOLTAGE : 0.000

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	Bus1	80.0000	0.0000	60.0000	1.0500	0	100.00	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	Bus2	50.000	20.000	0.000	0.000	0.000	0.000	0 3	0 0
2	3	Bus3	60.000	25.000	0.000	0.000	0.000	0.000	0 3	0 0

```
TOTAL SPECIFIED MW GENERATION        :   80.00000
TOTAL MIN MVAR LIMIT OF GENERATOR    :    0.00000
TOTAL MAX MVAR LIMIT OF GENERATOR    :   60.00000
TOTAL SPECIFIED MW LOAD              :  110.00000 reduced  110.00000
TOTAL SPECIFIED MVAR LOAD            :   45.00000 reduced   45.00000
TOTAL SPECIFIED MVAR COMPENSATION    :    0.00000 reduced    0.00000

-------------------------------------------------------------------------------
GENERATOR DATA FOR FREQUENCY DEPENDENT LOAD FLOW

SLNO*  FROM FROM      P-RATE     P-MIN      P-MAX    %DROOP    PARTICI     BIAS
       NODE NAME*         MW        MW         MW               FACTOR   SETTING
                                                          C0        C1        C2
------ ---- -------- --------- --------- --------- --------- --------- ---------
     1    1     Bus1   80.000    0.0000   80.0000    4.0000    0.0000    0.0000
                                                     0.0000    0.0000    0.0000
-------------------------------------------------------------------------------
Slack bus angle (degrees) :   0.00
-------------------------------------------------------------------------------

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------


OLD-NUMBER  NEW-NUMBER
----------  ----------
         1           1
         2           2
         3           3
NEW-NUMBER  OLD-NUMBER
----------  ----------
         1           1
         2           2
         3           3
-------------------------------------------------------------------------------
Y BUS IN OLD AND NEW NUMBERING
SLNO.    NEW-NUMBER    OLD-NUMBER      ADMITTANCE
         ROW COLUMN    ROW COLUMN YBUS.re    YBUS.im
----- ------ ------ ------ ------ ---------- ----------
    1      1      1      1      1     6.2500   -18.7500
    2      1      2      1      2    -1.2500     3.7500
    3      1      3      1      3    -5.0000    15.0000
    4      2      2      2      2     2.9167    -8.7500
    5      2      3      2      3    -1.6667     5.0000
    6      3      3      3      3     6.6667   -20.0000

-------------------------------------------------------------------------------
Iteration count = 0
-------------------------------------------------------------------------------
```

```
---------------------------------------------
Iteration count = 0
---------------------------------------------
JACOBIAN MATRIX
row col value 1 1        1.0000000000
row col value 1 2        0.0000000000
row col value 1 3        0.0000000000
row col value 1 4        0.0000000000
row col value 1 5        0.0000000000
row col value 1 6        0.0000000000
row col value 2 1        0.0000000000
row col value 2 2        8.9375000000
row col value 2 3       -4.9999995232
row col value 2 4        0.0000000000
row col value 2 5        2.8541672230
row col value 2 6       -1.6666666269
row col value 3 1        0.0000000000
row col value 3 2       -4.9999995232
row col value 3 3       20.7500000000
row col value 3 4        0.0000000000
row col value 3 5       -1.6666666269
row col value 3 6        6.4166688919
row col value 4 1        0.0000000000
row col value 4 2        0.0000000000
row col value 4 3        0.0000000000
row col value 4 4        1.0000000000
row col value 4 5        0.0000000000
row col value 4 6        0.0000000000
row col value 5 1        0.0000000000
row col value 5 2       -2.9791665077
row col value 5 3        1.6666666269
row col value 5 4        0.0000000000
row col value 5 5        8.5624990463
row col value 5 6       -4.9999995232
row col value 6 1        0.0000000000
row col value 6 2        1.6666666269
row col value 6 3       -6.9166665077
row col value 6 4        0.0000000000
row col value 6 5       -4.9999995232
row col value 6 6       19.2500019073
Iteration count 0 maxp 0.437500 maxq 0.499999
Power diff Correction vector
node      dp         dq     angle cor voltage cor
---- ---------- ---------- ---------- ----------
   1    0.00000    0.00000    0.00000    0.00000
   2   -0.43750   -0.01250   -0.06493   -0.00728
   3   -0.35000    0.50000   -0.03805    0.01603
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BUS VOLTAGES AT EACH ITERATION
Bus number Bus name Vmag   Vang (radians)
---------- -------- ------ -------------
         1     Bus1 1.0500        0.0000
         2     Bus2 0.9927       -0.0649
         3     Bus3 1.0160       -0.0381
```

```
--------------------------------------------------------
Iteration count = 1
--------------------------------------------------------
JACOBIAN MATRIX
row col value 1 1         1.0000000000
row col value 1 2         0.0000000000
row col value 1 3         0.0000000000
row col value 1 4         0.0000000000
row col value 1 5         0.0000000000
row col value 1 6         0.0000000000
row col value 2 1         0.0000000000
row col value 2 2         8.8122358322
row col value 2 3        -4.9961762428
row col value 2 4         0.0000000000
row col value 2 5         2.3963932991
row col value 2 6        -1.7872953415
row col value 3 1         0.0000000000
row col value 3 2        -5.0865092278
row col value 3 3        20.8744697571
row col value 3 4         0.0000000000
row col value 3 5        -1.5562800169
row col value 3 6         6.1810960770
row col value 4 1         0.0000000000
row col value 4 2         0.0000000000
row col value 4 3         0.0000000000
row col value 4 4         1.0000000000
row col value 4 5         0.0000000000
row col value 4 6         0.0000000000
row col value 5 1         0.0000000000
row col value 5 2        -3.3697500229
row col value 5 3         1.8159471750
row col value 5 4         0.0000000000
row col value 5 5         8.4957046509
row col value 5 6        -4.9173474312
row col value 6 1         0.0000000000
row col value 6 2         1.5449482203
row col value 6 3        -7.4840660095
row col value 6 4         0.0000000000
row col value 6 5        -5.1238174438
row col value 6 6        20.0961170197
Iteration count 1 maxp 0.004597 maxq 0.021902

Power diff Correction vector
node      dp          dq       angle cor  voltage cor
---- ---------- ---------- ---------- ----------
   1    0.00000    0.00000    0.00000    0.00000
   2   -0.00460   -0.01080   -0.00001   -0.00224
   3    0.00194   -0.02190    0.00037   -0.00152
--------------------------------------------------------------------------------
         1      Bus1 1.0500       0.0000
         2      Bus2 0.9905      -0.0649
         3      Bus3 1.0145      -0.0377
```

```
--------------------------------------------------
Iteration count = 2
--------------------------------------------------
JACOBIAN MATRIX
row col value 1 1        1.0000000000
row col value 1 2        0.0000000000
row col value 1 3        0.0000000000
row col value 1 4        0.0000000000
row col value 1 5        0.0000000000
row col value 1 6        0.0000000000
row col value 2 1        0.0000000000
row col value 2 2        8.7842254639
row col value 2 3       -4.9767746925
row col value 2 4        0.0000000000
row col value 2 5        2.3841221333
row col value 2 6       -1.7851545811
row col value 3 1        0.0000000000
row col value 3 2       -5.0680551529
row col value 3 3       20.8346157074
row col value 3 4        0.0000000000
row col value 3 5       -1.5519875288
row col value 3 6        6.1719846725
row col value 4 1        0.0000000000
row col value 4 2        0.0000000000
row col value 4 3        0.0000000000
row col value 4 4        1.0000000000
row col value 4 5        0.0000000000
row col value 4 6        0.0000000000
row col value 5 1        0.0000000000
row col value 5 2       -3.3614013195
row col value 5 3        1.8110588789
row col value 5 4        0.0000000000
row col value 5 5        8.4648323059
row col value 5 6       -4.9055895805
row col value 6 1        0.0000000000
row col value 6 2        1.5372178555
row col value 6 3       -7.4615569115
row col value 6 4        0.0000000000
row col value 6 5       -5.1167492867
row col value 6 6       20.0438308716
Iteration count 2 maxp 0.000016 maxq 0.000036
```

```
-------------------------------------------------------------------------------
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     Bus1 1.0500   0.00   112.596    52.786     0.000     0.000     0.000
   2     Bus2 0.9905  -3.72     0.000     0.000    50.000    20.000     0.000
   3     Bus3 1.0145  -2.16     0.000     0.000    60.000    25.000     0.000
-------------------------------------------------------------------------------
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    0
NUMBER OF BUSES EXCEEDING MAXIMUM VOLTAGE LIMIT (# mark) :    0
NUMBER OF GENERATORS EXCEEDING MINIMUM Q LIMIT (< mark)  :    0
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     Bus1    2     Bus2   33.393   15.821   0.9908   2.9723    35.2^
   2  1    1     Bus1    3     Bus3   79.204   36.965   1.3859   4.1576    83.2#
   3  1    2     Bus2    3     Bus3  -17.596   -7.149   0.2206   0.6619    19.2&
-------------------------------------------------------------------------------
! 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% :    0
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    1
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    1
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
-------------------------------------------------------------------------------
NEW SYSTEM FREQUENCY FOR ISLAND 1         :  50.000000 Hzs

-------------------------------------------------------------------------------
Summary of results
TOTAL REAL POWER GENERATION   :    112.596 MW
TOTAL REACT. POWER GENERATION :     52.786 MVAR
GENERATION pf                 :      0.905

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         :    110.000 MW
TOTAL REACTIVE POWER LOAD     :     45.000 MVAR
LOAD pf                       :      0.926
TOTAL COMPENSATION AT LOADS   :      0.000 MVAR
TOTAL HVDC REACTIVE POWER     :      0.000 MVAR

TOTAL REAL POWER LOSS (AC+DC) :   2.597241 MW (  2.597241+  0.000000)
PERCENTAGE REAL  LOSS (AC+DC) :      2.307
TOTAL REACTIVE POWER  LOSS    :   7.791727 MVAR

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

Outcome: On completion of the experiment the student will understand the configuration and functioning of system in terms of reactance, resistance and voltage profile for network.

Experiment No. 8

Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses

Exercise problem:

1. A four-bus system is given below. The bus admittance matrix and initial voltages at each bus are given. Taking bus 1 as slack bus. Calculate the jacobian elements of the system using NR method.

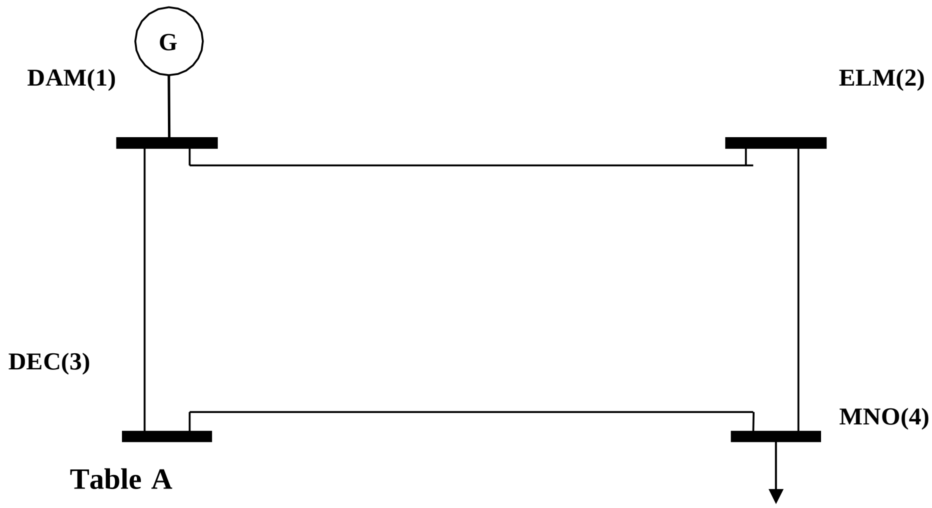


Table A

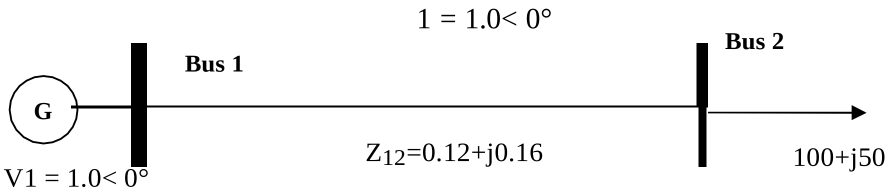
Bus Code (i-k)	Impedance (p.u) Z_{ik}	Line charging Admittance (p.u) Y_i
1-2	0.00+j0.15	0
3-4	0.00+j0.10	0
2-4	0.00+j0.20	0
1-3	0.00+j0.15	0

Table B

Bus No	Bus Voltage	Generation		Load	
		MW	Mvar	MW	Mvar
1	1.0+j0.0	--	--	0	0
2	1.0+j0.0	0	0	0	0
3	1.0+j0.0	0	0	0	0
4	1.0+j0.0	0	0		

2. For the system shown below with bus 1 slack bus V1 = 1.0< 0° pu. A load of 100MW at 50 Mvar is taken at bus 2, the line impedance is Z12 = 0.12+j0.16 pu on a base of 100Mva. Using NR method obtain voltage magnitude and phase angle of bus 2. Start with initial

   estimate of V2 = 1.0< 0° pu

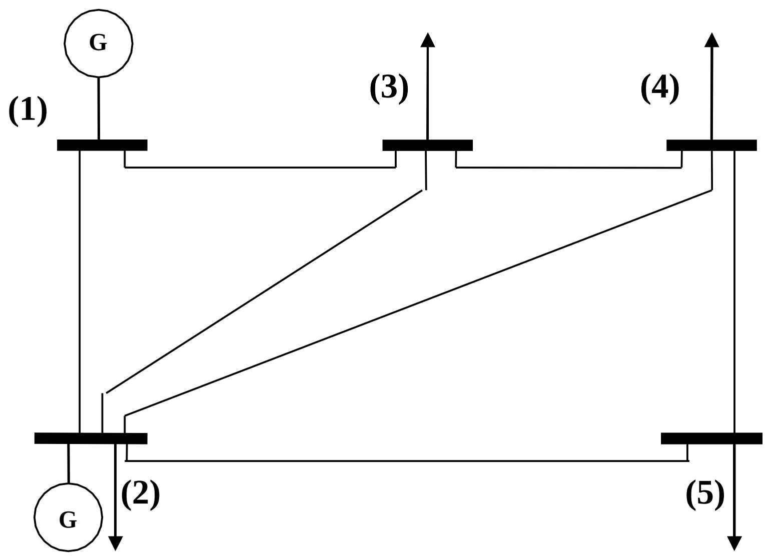


Experiment No. 8

Load flow studies for a given power system using software package

Objective: To study the performance of network under NR method, GS and Fast decoupled method for power loss and reactive power calculations

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.



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

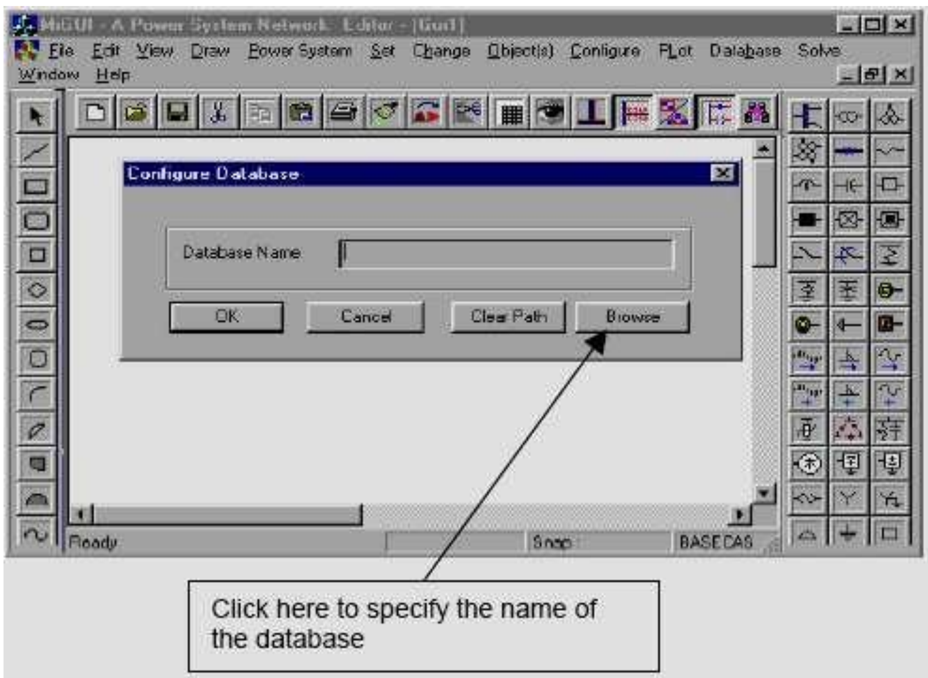
GENERATION, LOADS AND BUS VOLTAGES FOR THE SYSTEM

Table: 1.2					
Bus No	**Bus Voltage**	**Generation MW**	**Generation MVAR**	**Load MW**	**Load MVAR**
1	1.00+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

Procedure to enter the data for performing studies using MiPower.

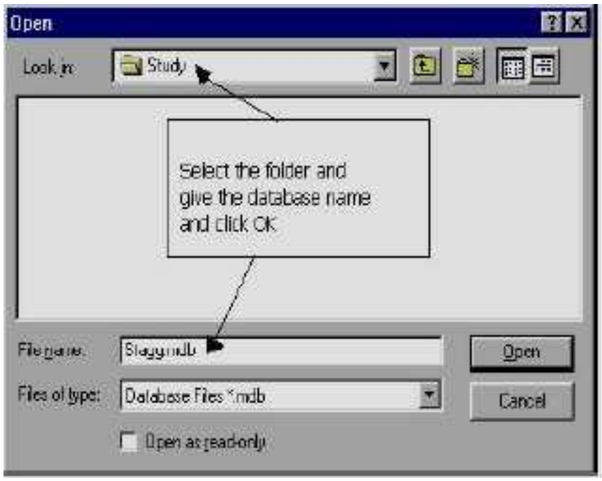
MiPower - Database Configuration

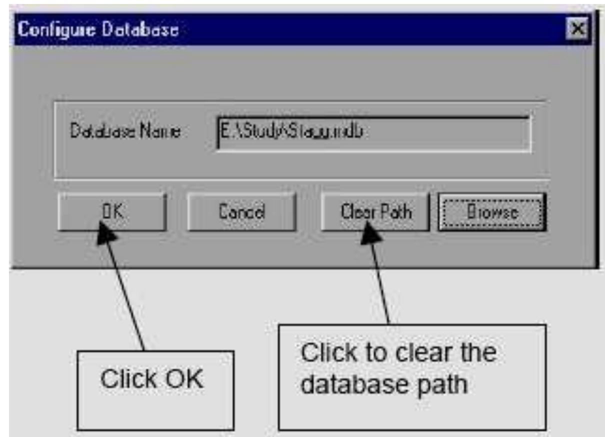
Open Power System Network Editor. Select menu option **Database → Configure**. Configure Database **dialog** is popped up as shown below. Click **Browse** button.



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 desired database name. **Configure Database** dialog will appear with path chosen.

Note : Do not work in the MiPower directory

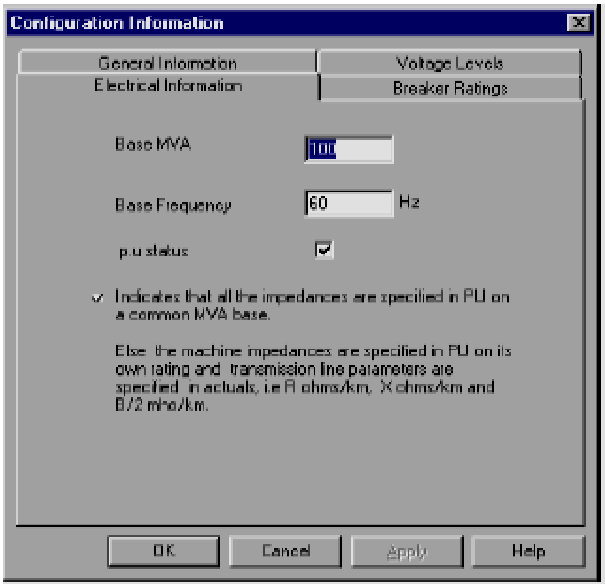




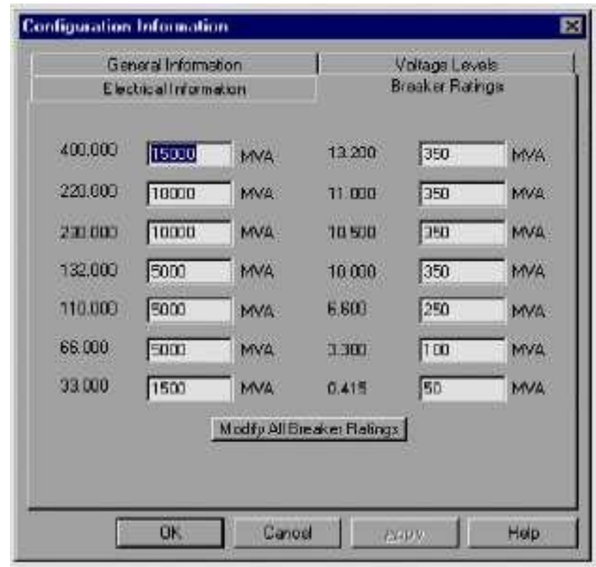
Click **OK** button on the **Configure database** dialog. The dialog shown below appears.

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-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 on Breaker Ratings button to give breaker ratings. Click **OK** button to create the database to return to Network Editor.

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.**



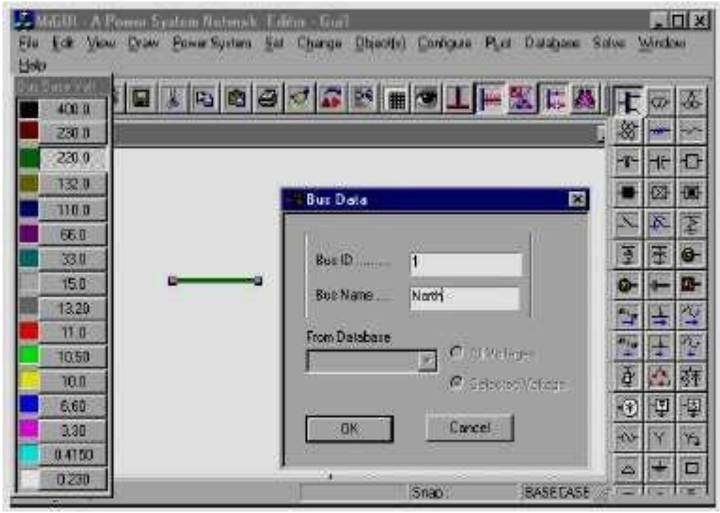
Bus Base Voltage Configuration



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** .

Procedure to Draw First Element - Bus



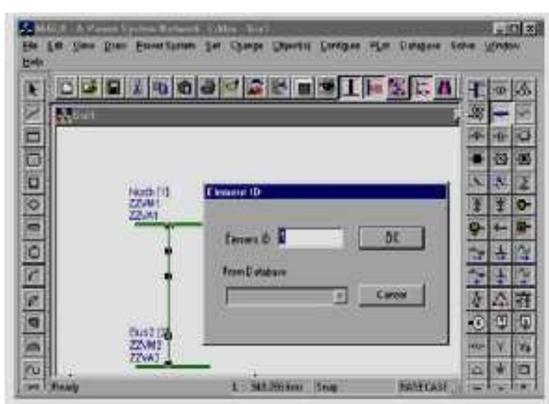
After entering data click **Save** which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

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

Note: Since the ... ase voltage is chosen as 220 kV.

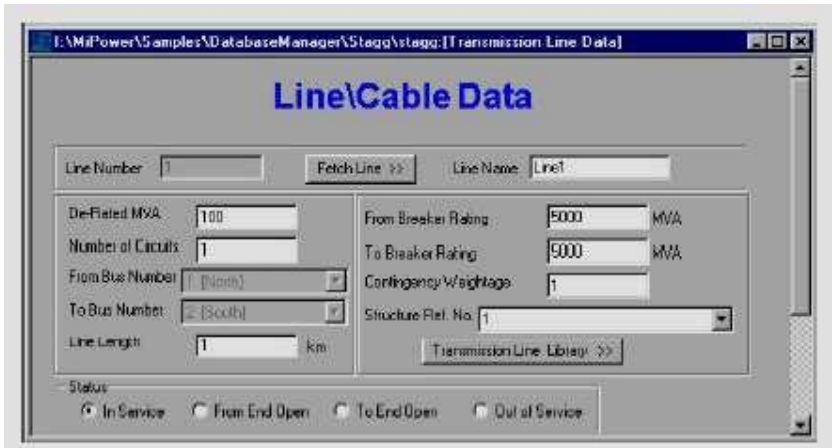
Procec

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.

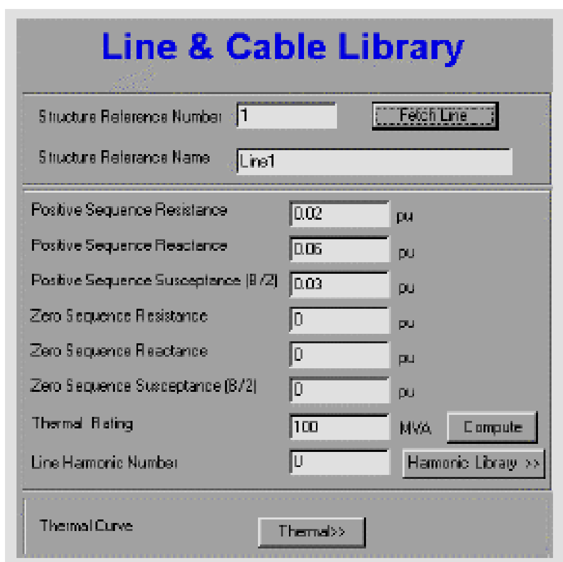


Enter **Element ID** number and click **OK**. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.

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

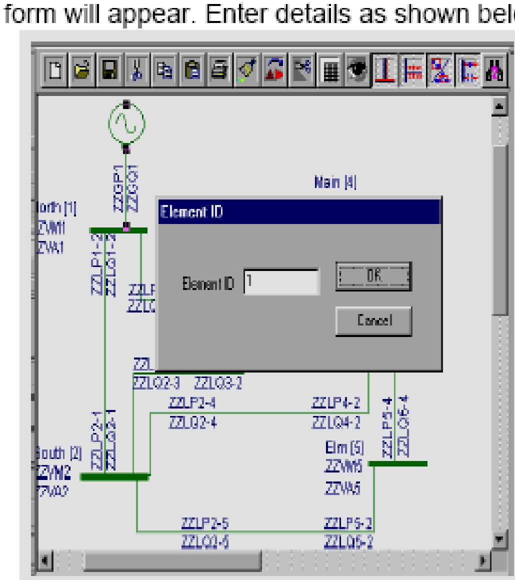
Transmission Line Library Data

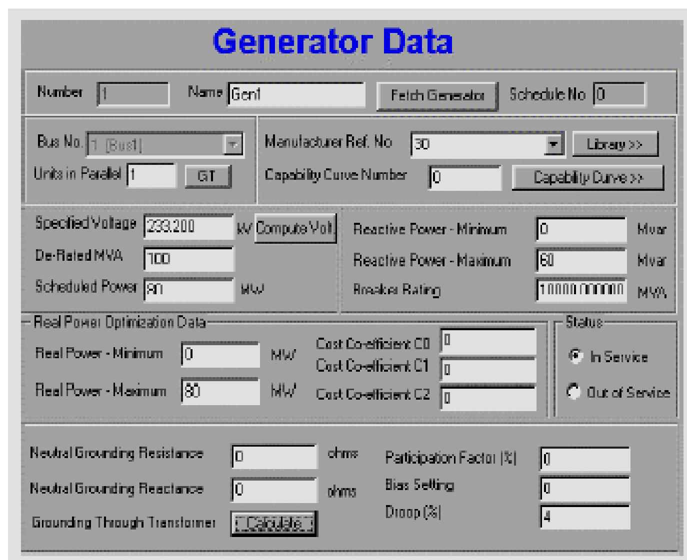
Structure Ref No	Structure Ref Name	Resistance	Reactance	Line charging B/2	Thermal Rating
1	Line 1-2	0.02	0.06	0.03	100
2	Line1-3 & 4-5	0.08	0.24	0.025	100
3	Line2-3 & 2-4	0.06	0.18	0.02	100
4	Line2-5	0.04	0.12	0.015	100
5	Line3-4	0.01	0.03	0.01	100

Procedure to Draw Generator

Enter Manufacturer Ref. No.as 1 and click on **Generator Library** button. Generator library form will appear.

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.



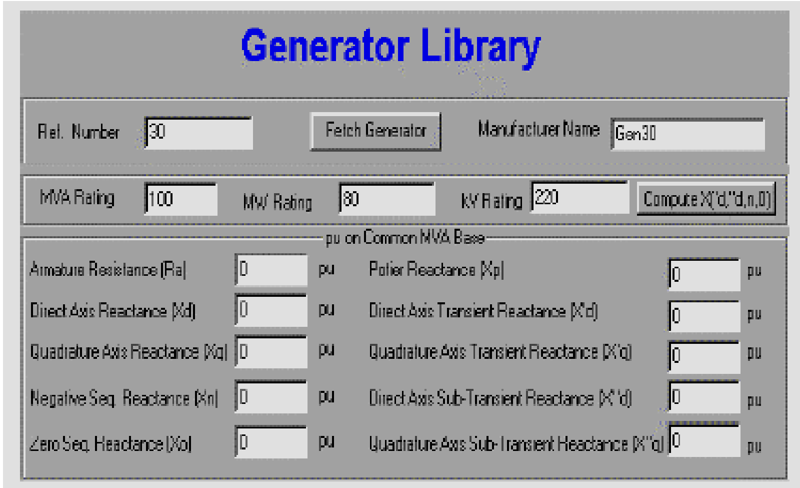


Since the specified voltage is given as 1.06 pu, click the **Compute Volt** button and give 1.06 value. Voltage will be calculated and appear in the specified voltage field.

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.



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.

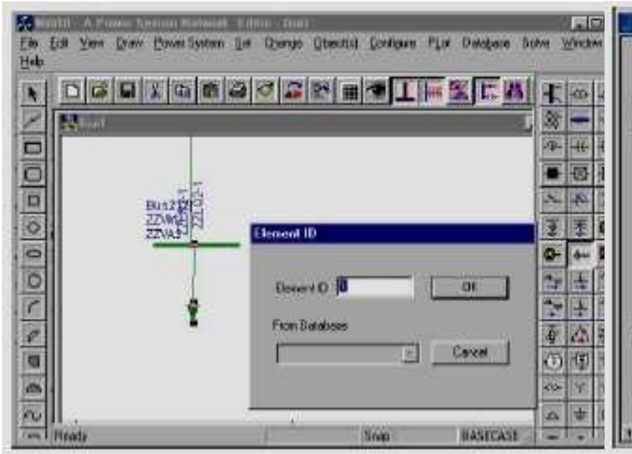
Generator 2 Element Data	
Manufacturer Ref.No	2
No. of Units parallel	1
Specified voltage	220
Derated MVA	50
Scheduled Power	40
Real Power Min.	0
Real Power Max.	40
Reactive Power Min	30
Reactive Power Max	30

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.

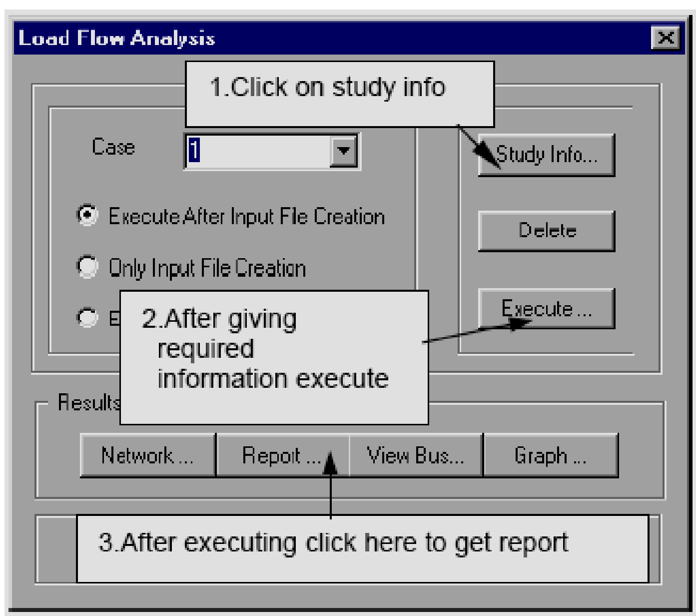



Connect other loads to buses 3, 4 and 5. Enter other load details as given in the following table.

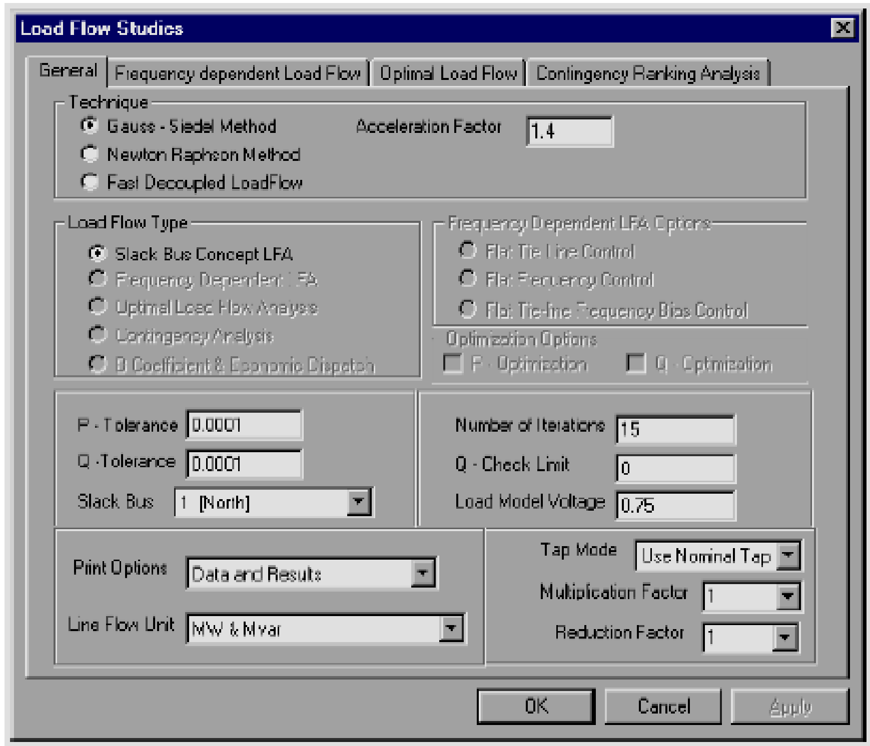
Load Details			
Load No	Bus No	MW	MVAR
2	5	60	10
3	3	45	15
4	4	40	5

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.



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*	LINE PARAMETER 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 VALUE MIN	MAX	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 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
 --------------------------------------------------------------------------------
```

Outcome: Student will study the voltage profile of the network and calculate the iterations for P & Q values in various methods like GS, NR and Fast decoupled method.

Exercise problems:

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)

3. 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.

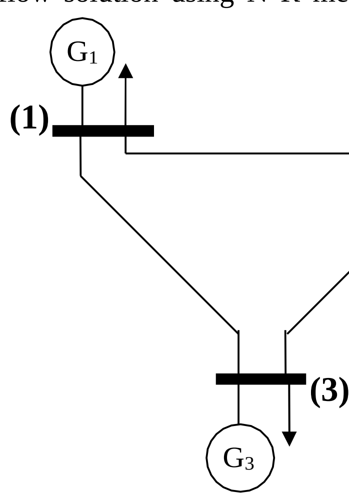
   Also draw the necessary flow chart (general flow chart), Compare the results with results obtained when (i) a line is removed (ii) a load is removed.

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

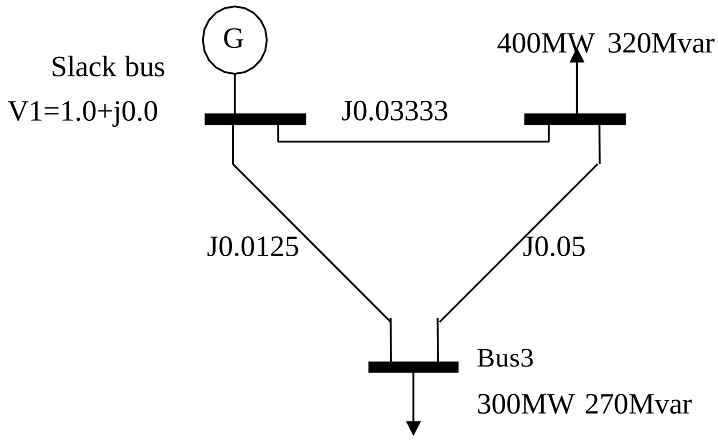
Consider the 3 bus system of figure each of the line has a series impedance of (0.02 + j0.08) p.u. & a total shunt admittance of j 0.02 p.u. The specified quantities at the buses are tabulated below on 100 MVA base.

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	Unspecified	Unspecified	$V_1 = (1.04 + j\,0)$ (Slack Bus)
2	0.0	0.0	0.5	1.0	Unspecified (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 $0 \leq Q_{G3} \leq 1.5$ 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 bus1, the voltage at bus 1 is V1 = 1.0< 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 V2 = 1.0< 0° pu & V3 = 1.0< 0° pu. Conduct load flow analysis

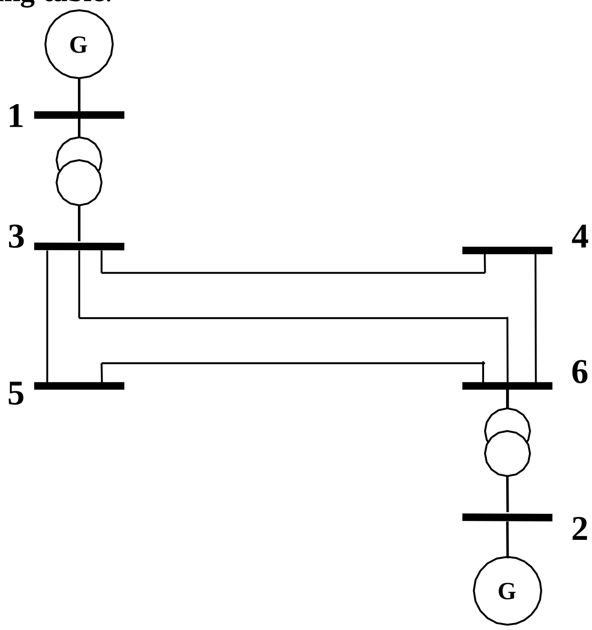


Experiment No. 9

Fault studies for a given power system using Software package

Objective: To study currents, voltage in power system at time of various faults on line or at bus.

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 o n 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

Procedure to enter the data for performing studies using MiPower.

MiPower- Data base Configuration

<u>MiPower Data Interpretation:</u>

SOLUTION:

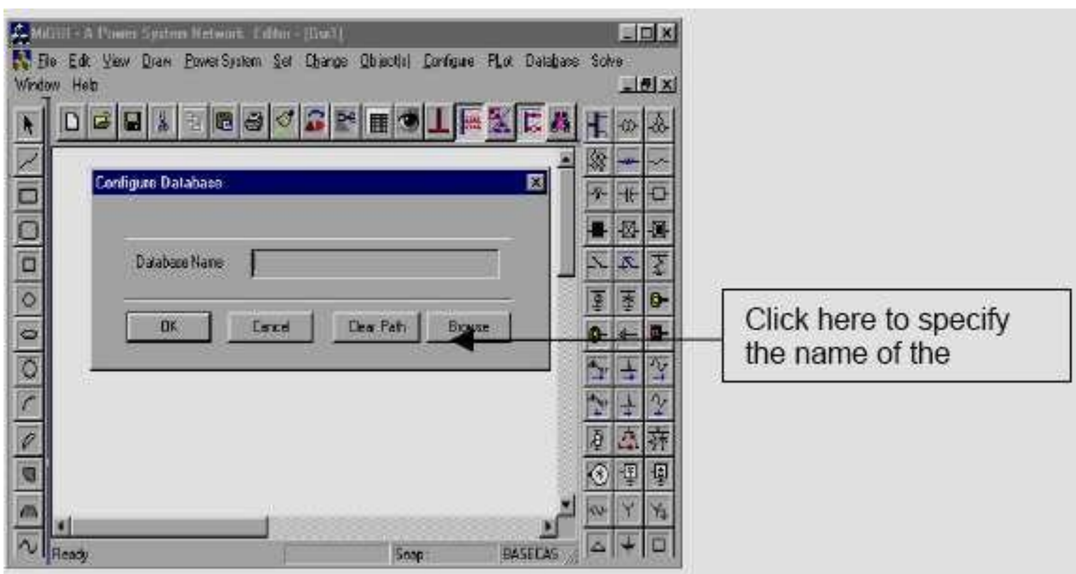
In transmission line data, elements 3 – 4 & 5 – 6 have common parameters. Elements 3 - 5 & 4 – 6 have common parameters. Therefore 3 libraries are required for transmission line.

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

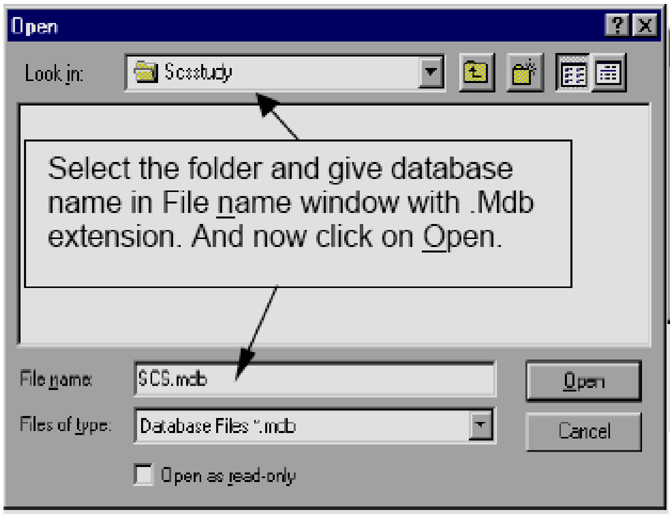
Procedure to enter the data for performing studies using MiPower

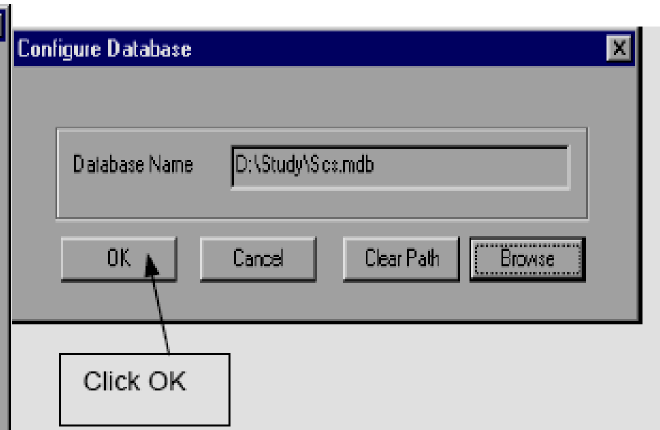
MiPower - Database Configuration

Open Power System Network Editor. Select menu option **Database → Configure**. Configure Database dialog is popped up. Click **Browse** button.

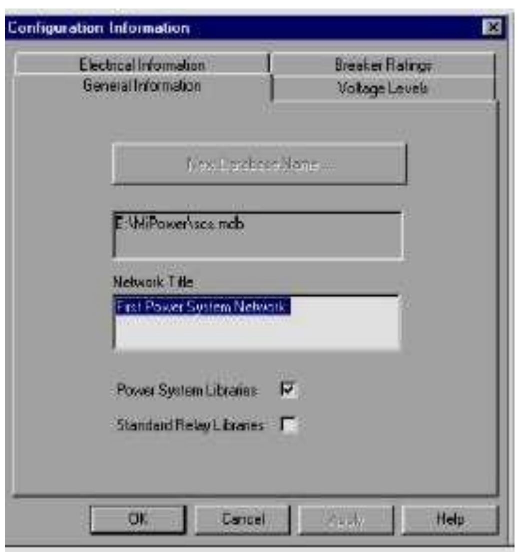


Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click **Open** button after entering the desired database name. **Configure Database** dialog will appear with path chosen.

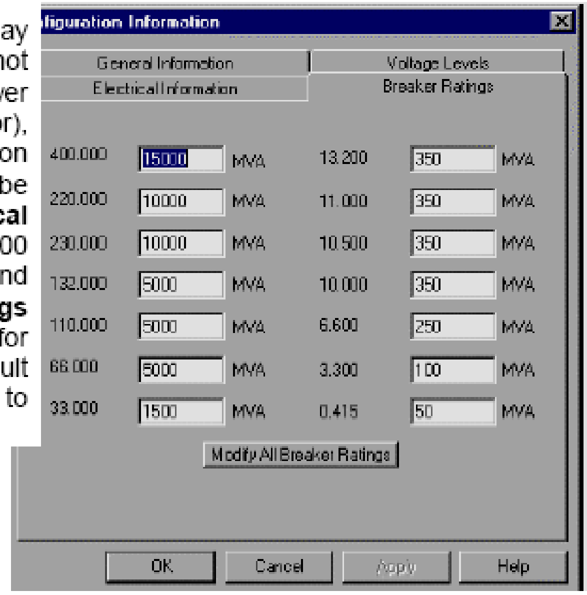




Click on **OK** button in the **Configure database** dialog, the following dialog appears.



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 pu 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.



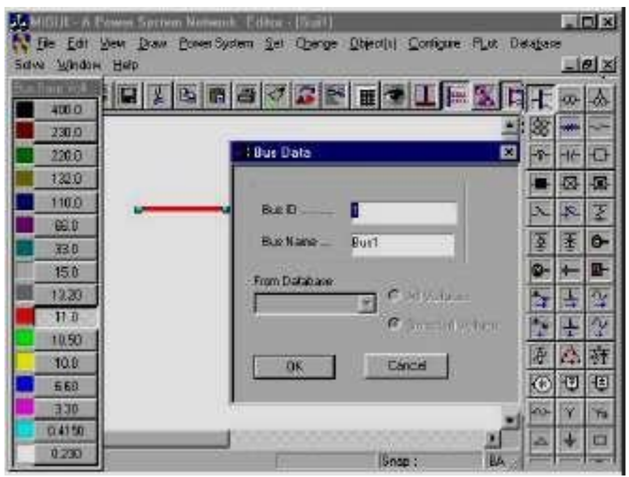
Bus Base Voltage Configuration

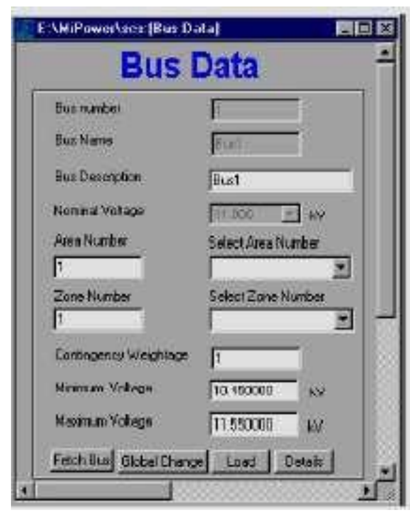
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage.** Dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

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.**



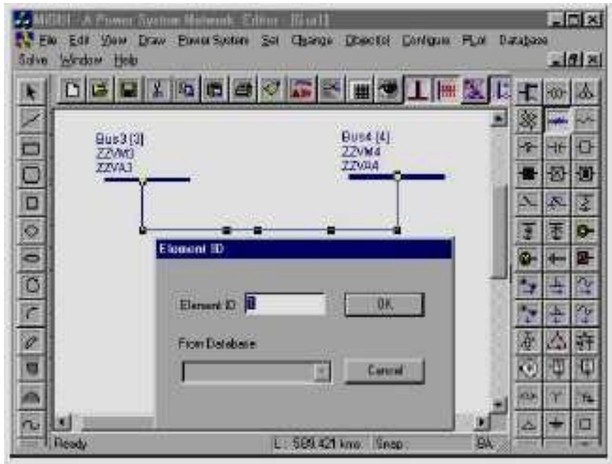


After entering data click **save**, which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

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

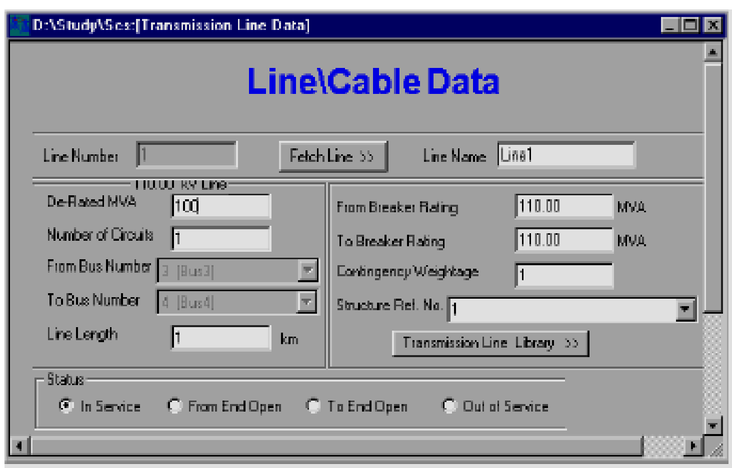
Procedure to Draw Transmission Line

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.

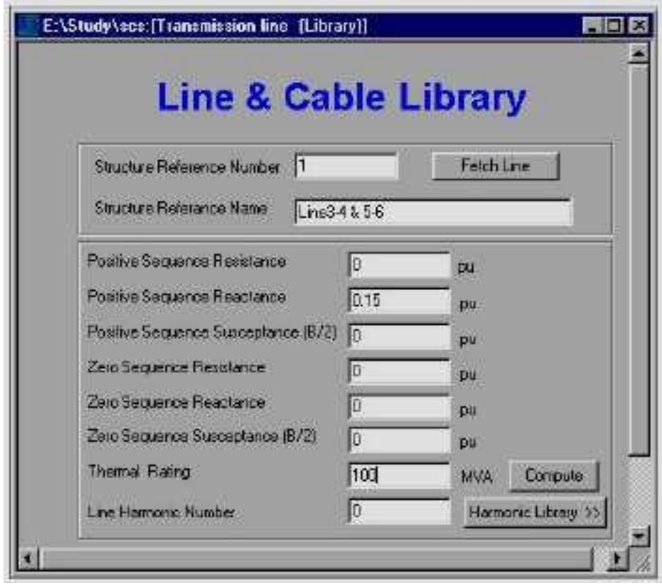


Enter **Element ID** number and click OK. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.

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**

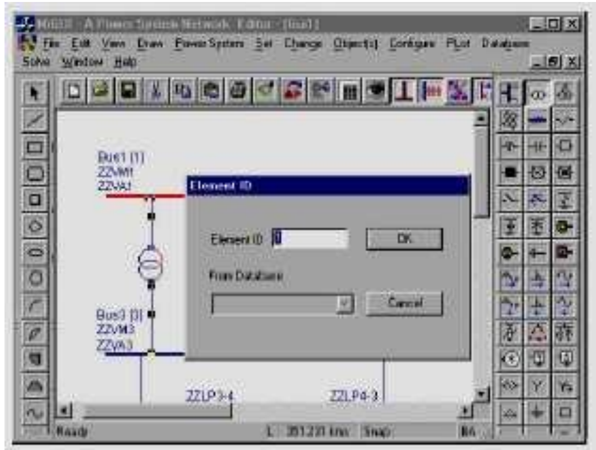
Transmission Line Library Data			
Structure Ref. No.	1	2	3
Structure Ref. Name	Line3-4 & 5-6	Line3-5 & 4-6	Line3-6
Positive Sequence Resistance	0	0	0
Positive Sequence Reactance	0.15	0.1	0.2
Positive Sequence Susceptance	0	0	0
Thermal Rating	100	100	100

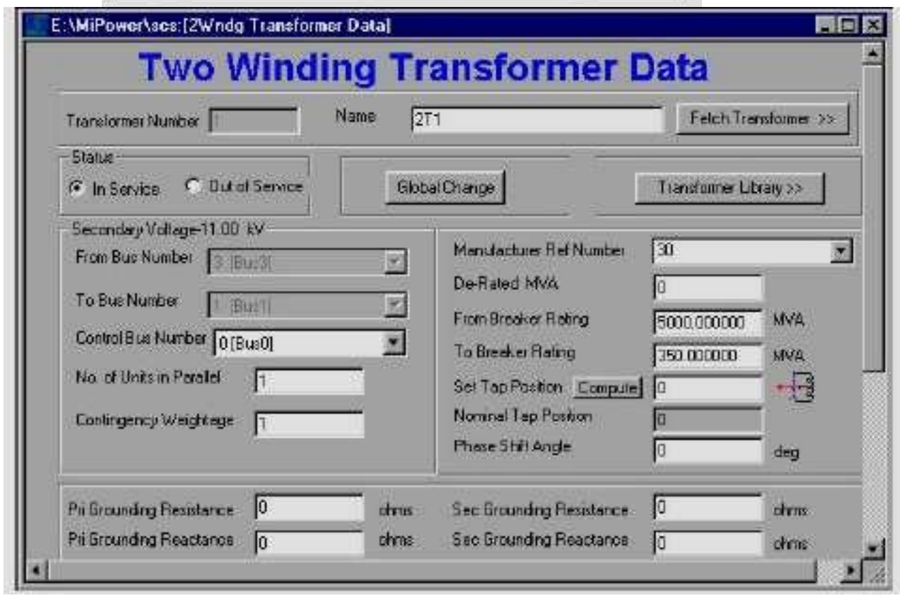
Procedure to Draw Transformer

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.



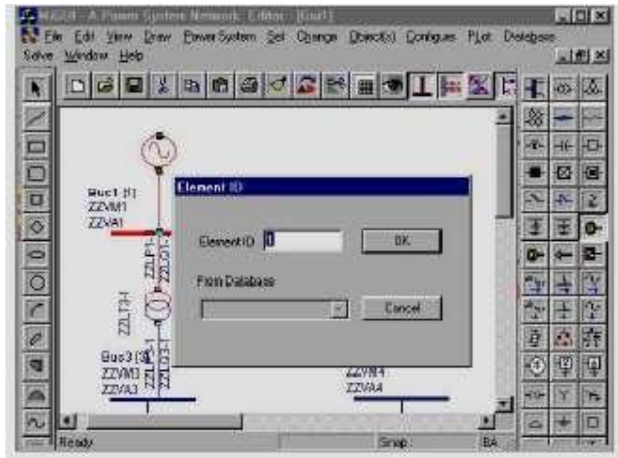


Transformer element data form will appear. Click **Save** 🖫 button, which invokes network editor. In the similar way enter other transformer details.

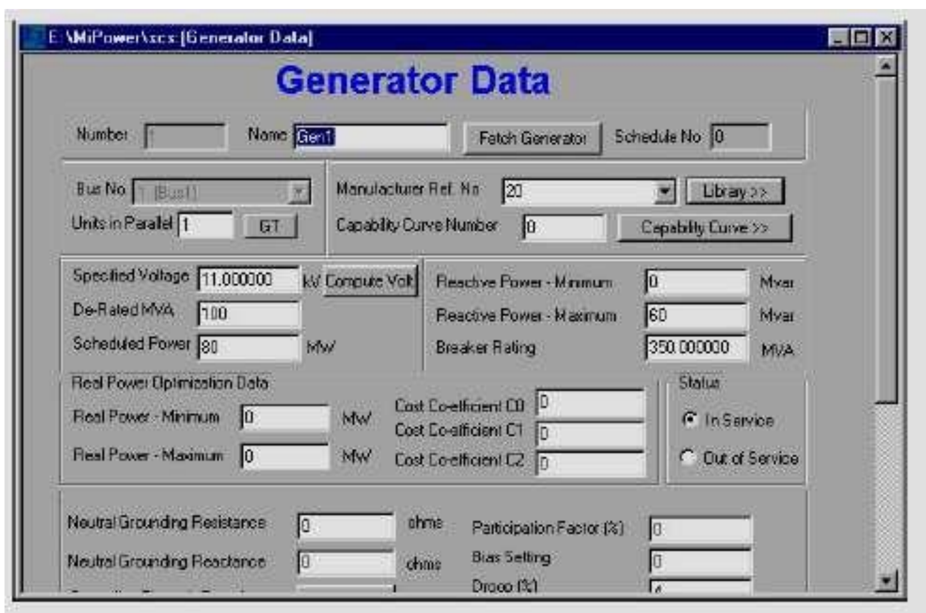
2nd Transformer details	
Transformer Number	2
Transformer Name	2T2
From Bus Number	6
To Bus Number	2
Control Bus Number	2
Number of Units in Parallel	1
Manufacturer ref. Number	30
De Rated MVA	100
From Breaker Rating	5000
To Breaker Rating	350
Nominal Tap Position	5

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**.

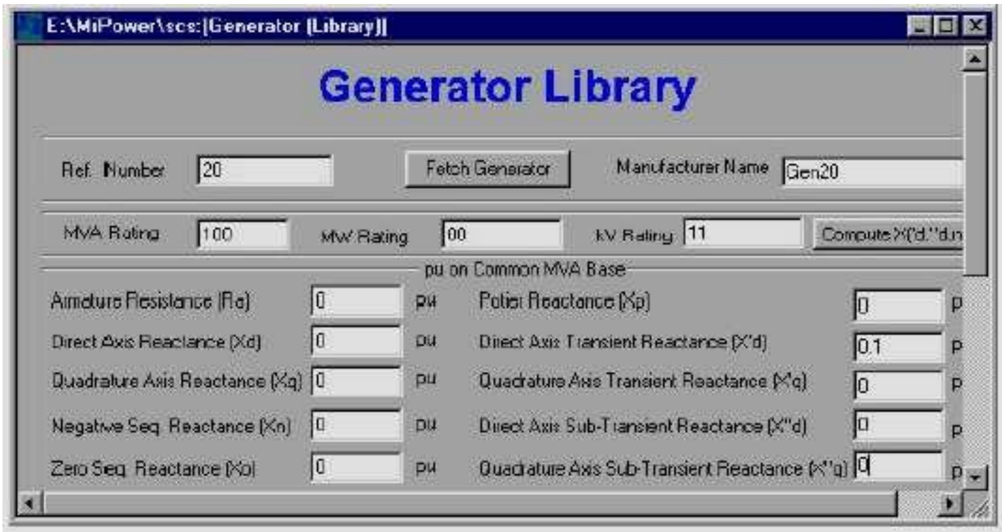


Generator Data form will be opened. Enter the **Manufacturer Ref. Number** as **20.** Enter Generator data in the form as shown below.



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

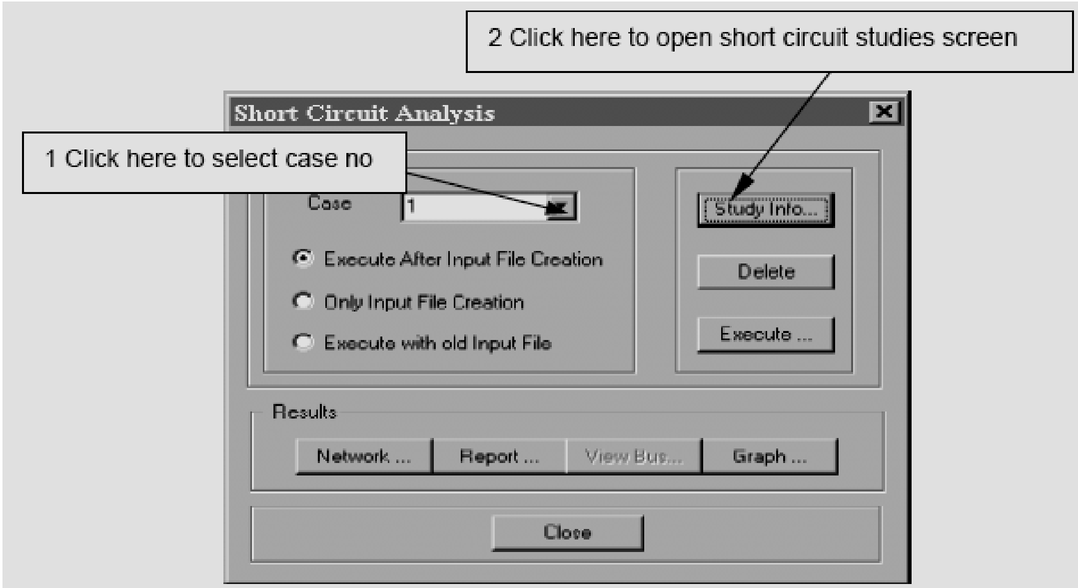
Save and **Close** the library screen. Generator data screen will be reopened. Click **Save** button, which invokes Network Editor. Connect another generator to Bus 2. Enter its details as given in the following table.



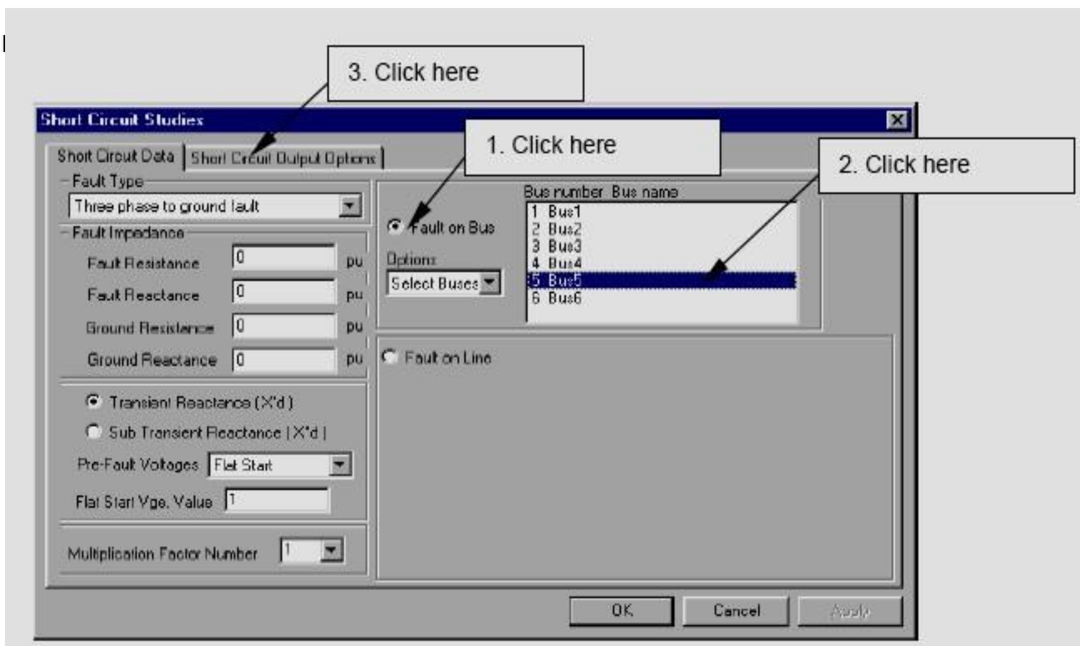
Name	GEN-2
Bus Number	2
Manufacturer Ref. Number	20
Number of Generators in Parallel	1
Capability Curve Number	0
De-Rated MVA	100
Specified Voltage	11
Scheduled Power	80
Reactive Power Minimum	0
Reactive Power Maximum	60
Breaker Rating	350
Type of Modeling	Infinite

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

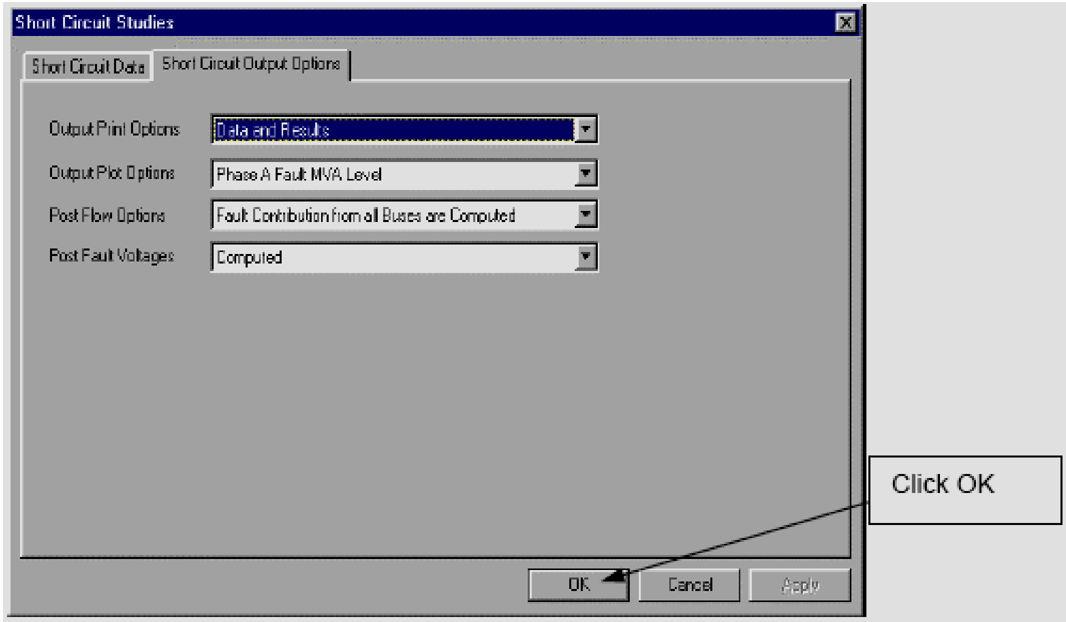
TO solve short circuit studies choose menu option **Solve → Short Circuit Analysis** or click on **SCS** button on the toolbar on the right side of the screen. Short circuit analysis screen appears.



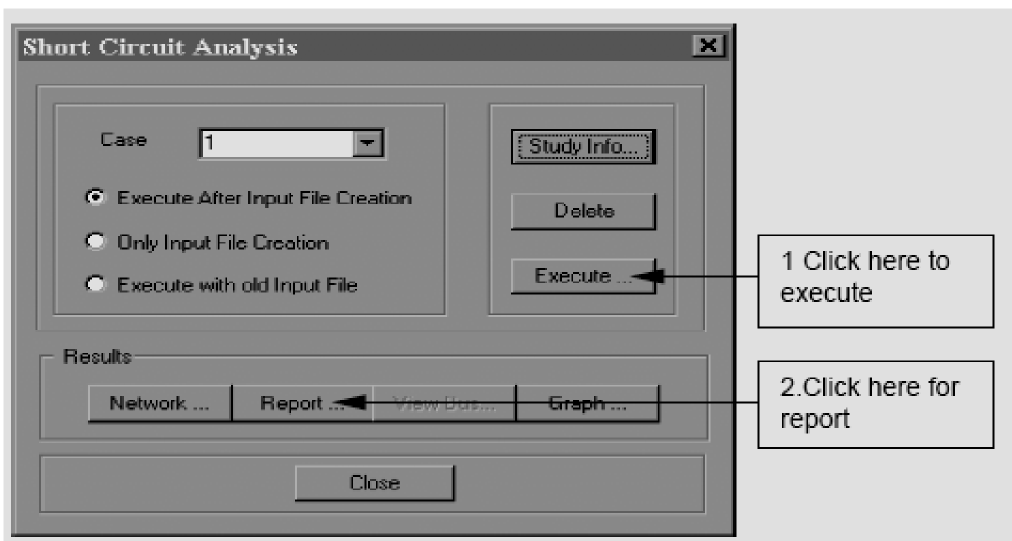
Study Information.



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.

Outcome: Student will study various faults like LG, LLG at bus and line of the network.

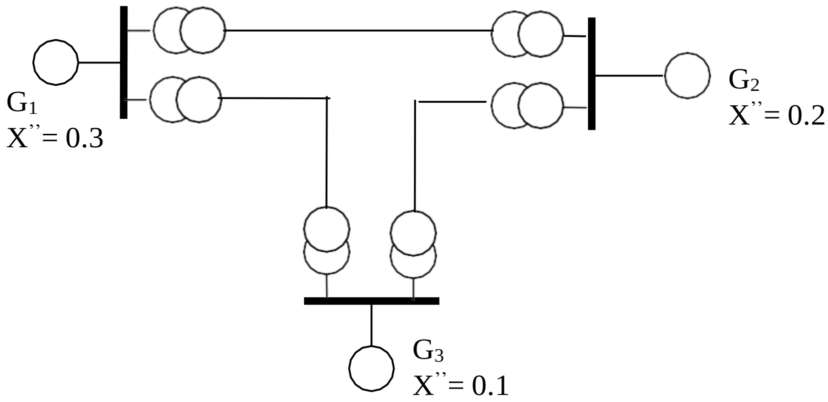
Exercise problems:

4. 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.

5. 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.

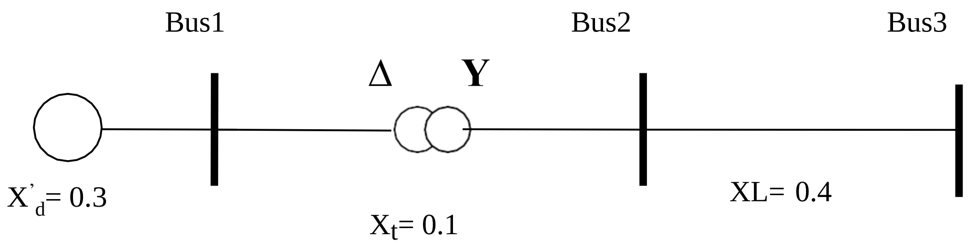
Refer below question for Q.(1) & Q(2)

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 reactance
Zero sequence reactance of generator	= 0.1 pu

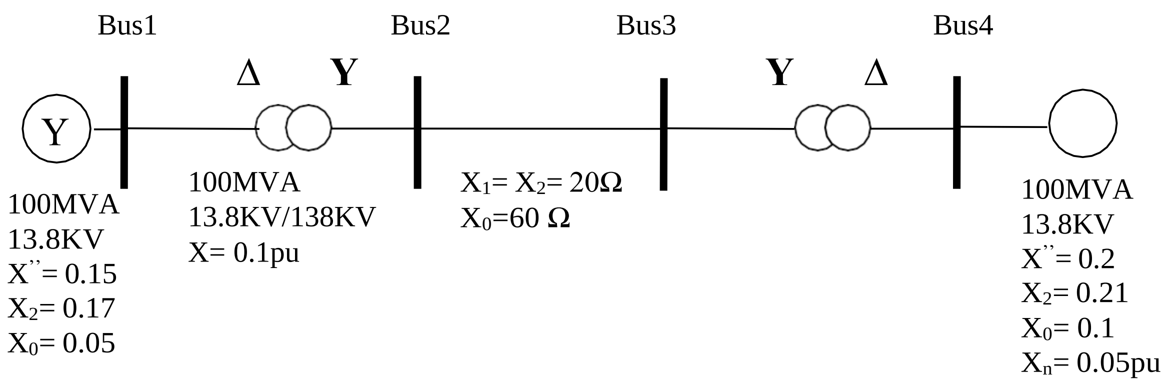


6. For the given circuit, find the fault currents, voltages for the following type of faults at Bus3.
    1. Single Line to Ground Fault
    2. Line to Line Fault
    3. Double line to Ground Fault

For the transmission line assume $X_1 = X_1$,$X_0 = 2.5\ X_L$



7. 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



Experiment No. 10

Calculation of penalty factors and solution of co-ordination equations for economic operation of a power system using software package.

Objective: To schedule for loading on power plant generators.

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	$C2=0.07P_3^2 + 18 P_3 + 900$ $0 < = P_3 < = 100$

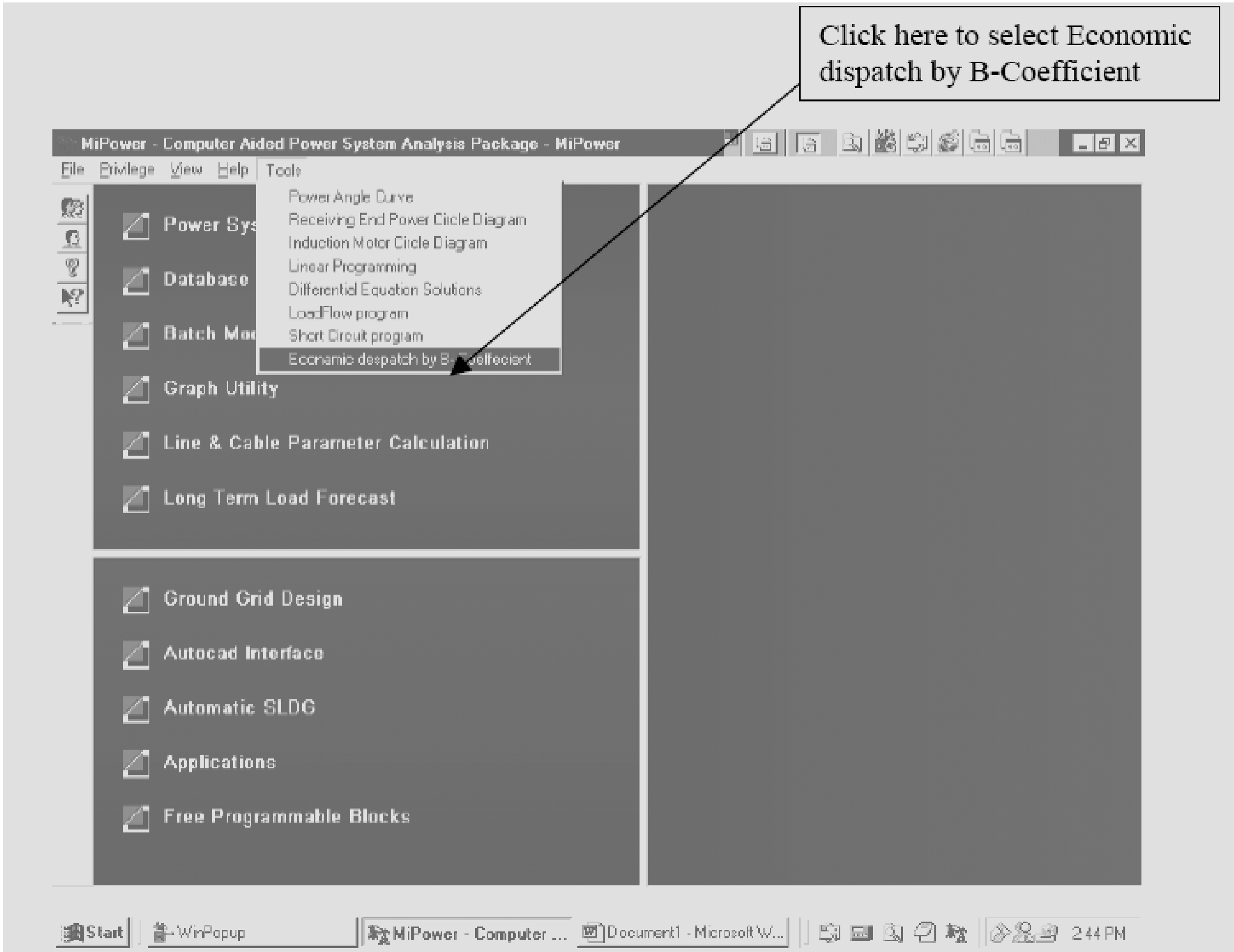
Loss Co-efficient:

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

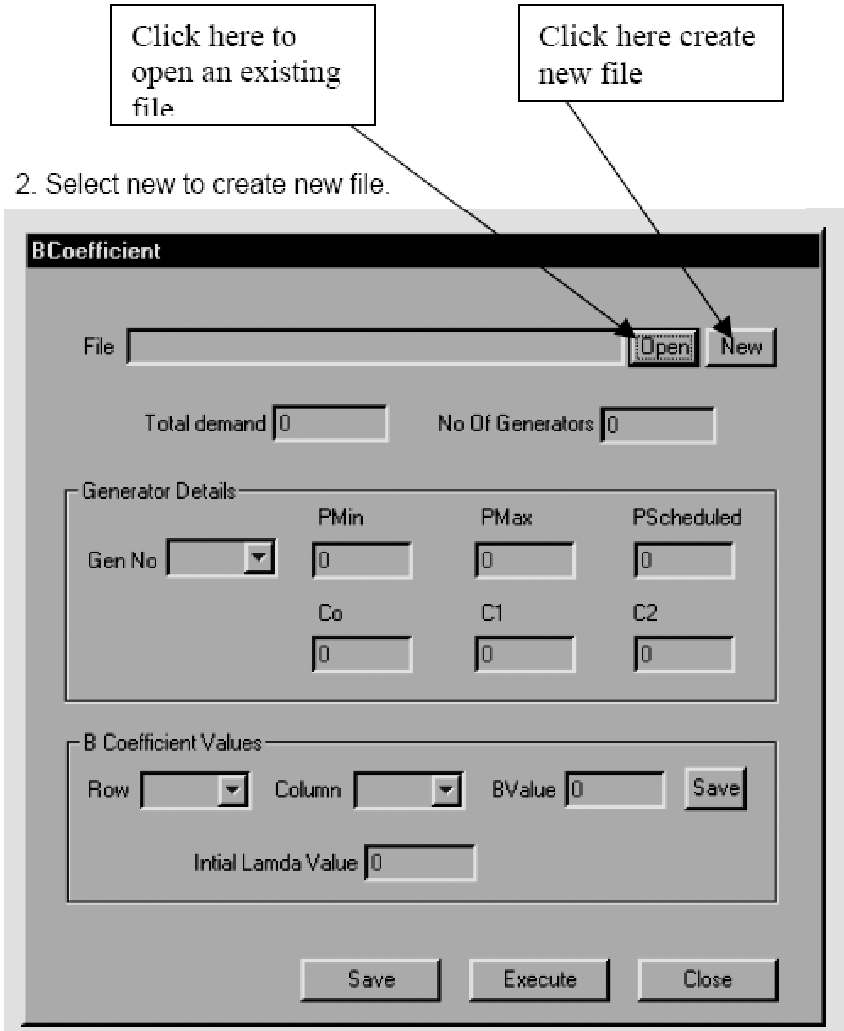
$B_{22}=0.0004$; $B_{23}=0.00018$; $B_{33}=0.0005$;

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

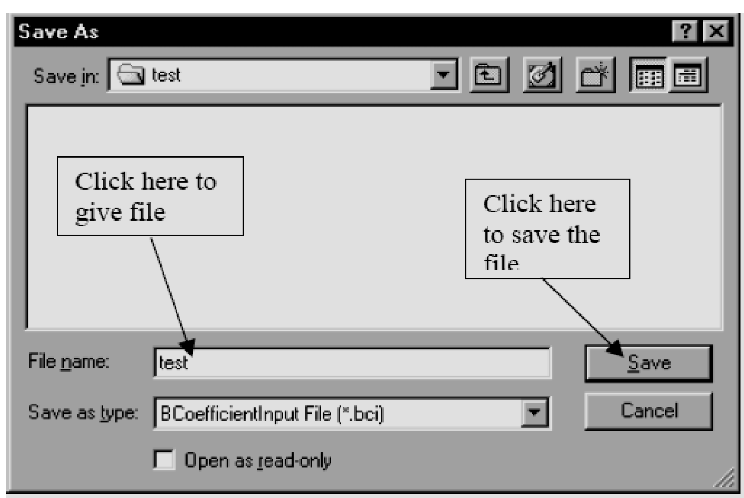
1. To solve Economic Despatch by using **MiPower** Package, invoke "**MiPower Tools"** in the MiPower main screen and select *"Economic dispatch by B-Coefficient* ".



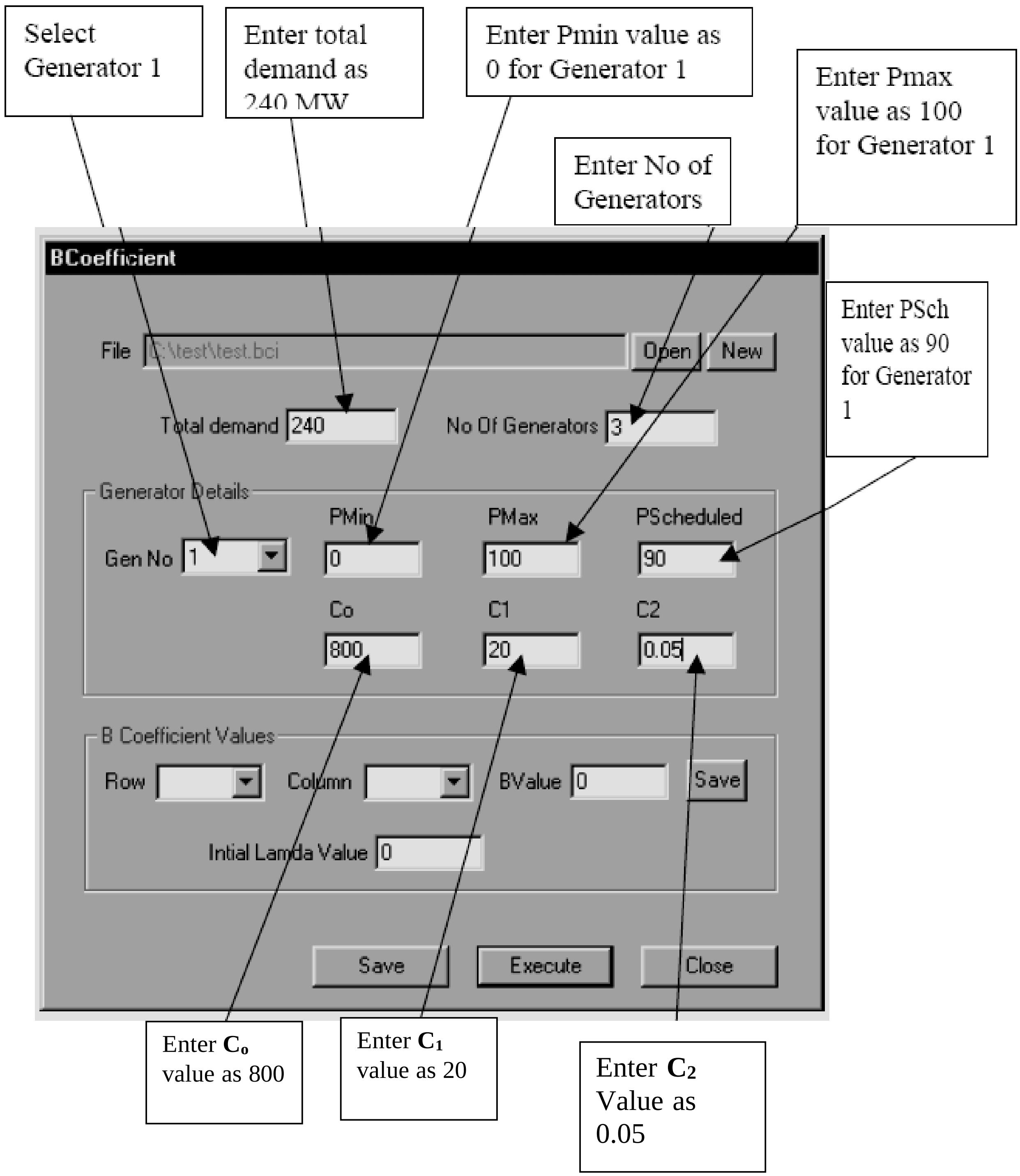
2. Select new to create new file.



3. Select location to save the file and give the file name.



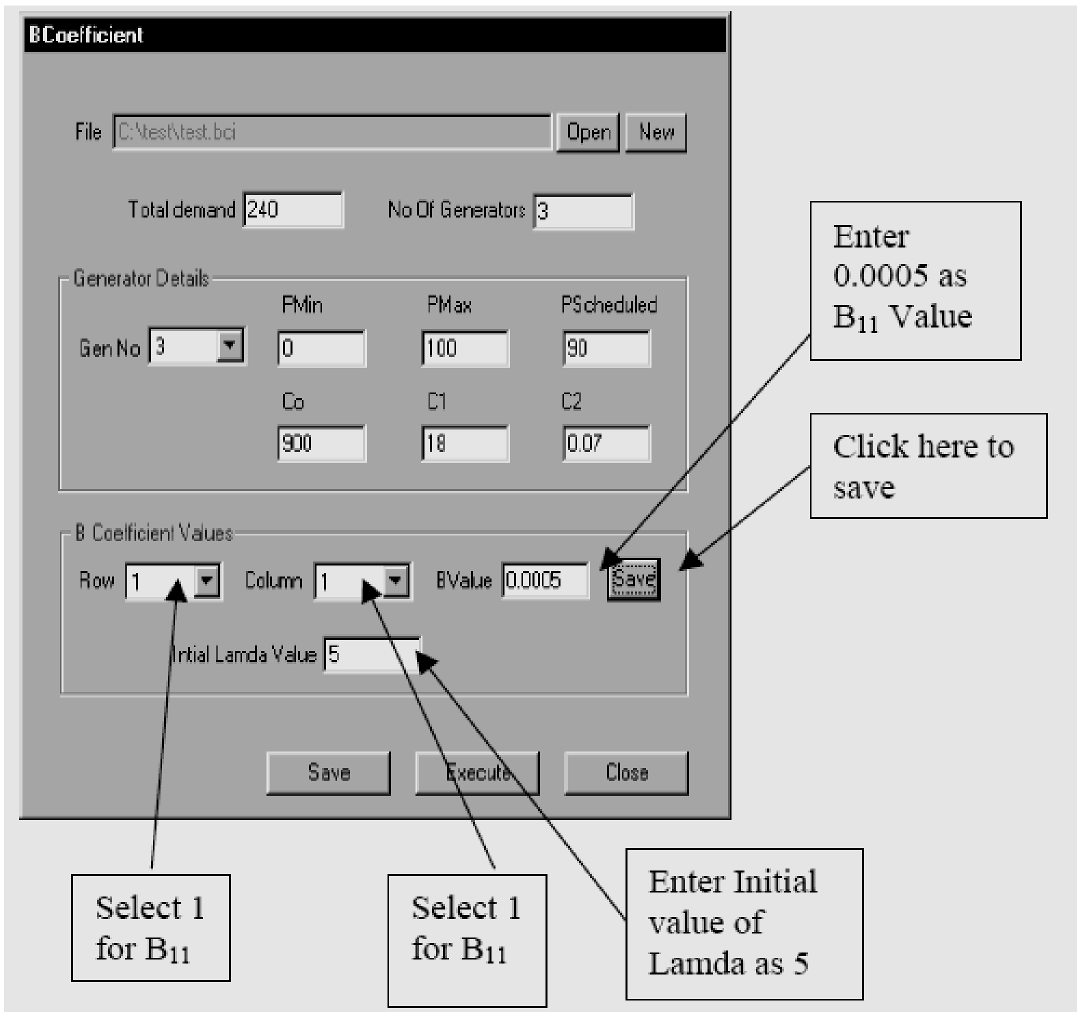
4. Enter the values of total demand as 240 MW and No of generators as 3. Select Generator number as 1 in generator details and enter corresponding values of Pmin, Pmax, Pscheduled and Corresponding C_0, C1, C2 values.



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.

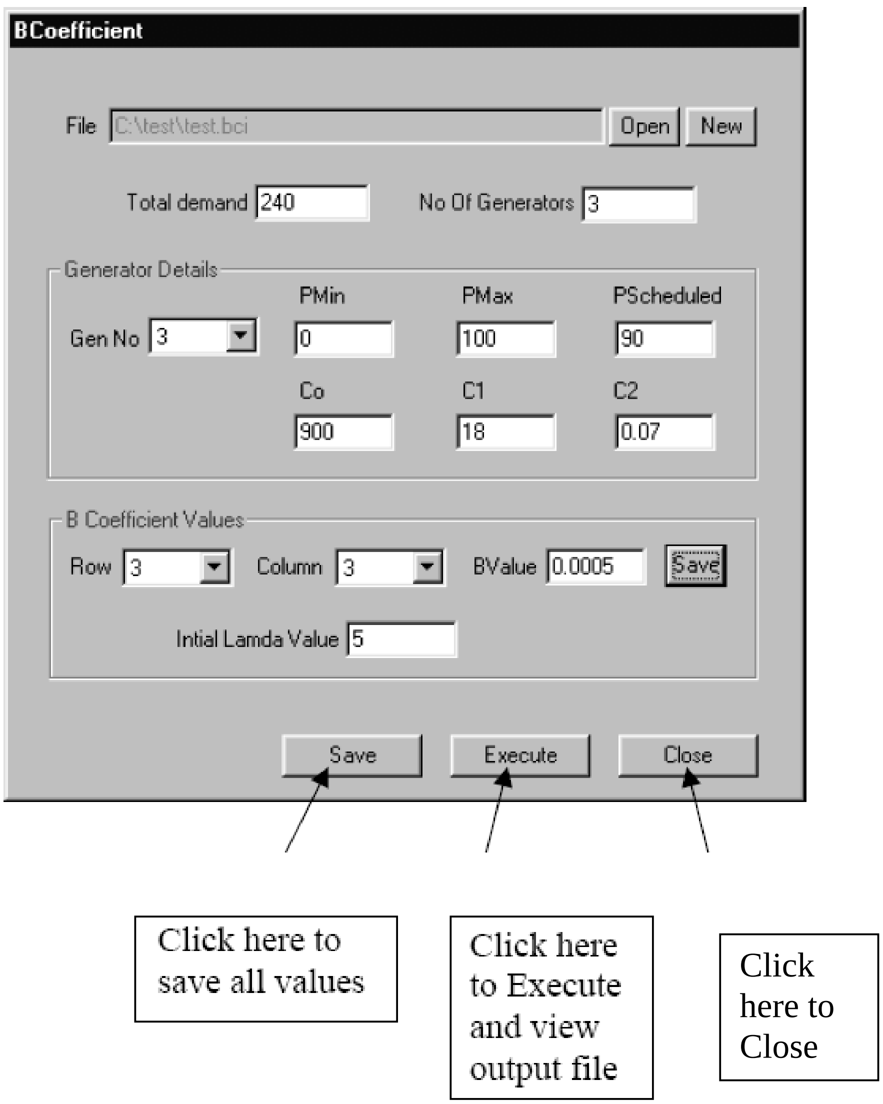


Similarly enter the values of B_{12} to B_{31} as

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.



Outcome: Student will calculate the proper scheduling in terms of load and obtain the cost with respect to generation of various generators connected to system.

```
-------------------------------------------------------------------------------------------
Final Total generation cost is Rs   8489.398438
```

```
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
```

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

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

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

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

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

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

$C_{g1} = 30 + 12 P_1 + 0.025 P_1^2$ 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.

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.(14) & Q(15)

A)

Unit No.	Cost of Fuel input in Rs./ hr.
1	$C_1 = 800 + 20\,P_1 + 0.05\,P_1^2 \quad 0 \le P_1 \le 100$
2	$C_2 = 1000 + 15\,P_2 + 0.06\,P_2^2 \quad 0 \le P_2 \le 100$
3	$C_3 = 900 + 18\,P_3 + 0.07\,P_3^2 \quad 0 \le P_3 \le 100$

Loss (or B) Co- efficients :

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

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

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

B)

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

Loss (or B) Co- efficients :

$B_{11} = 0.005 \quad B_{12} = B_{21} = -0.0012 \quad B_{22} = 0.002$

VIVA QUESTIONS

FORMATION OF Z BUS & Y BUS:

1. What is meant by graph and sub graph?
2. Define tree and co-tree of a network?
3. What is meant by cut set and basic cut set?
4. What is ment by bus incidence matrix (A)?
5. Write the performance equation of an element both in impedance form and in admittance form.

DETERMINATION OF ABCD CONSTANTS:

1. Define Regulation and efficiency of transmission line.
2. Write the expression for Vs and Is in terms of Vr, Ir and ABCD constants.

SWING EQUATION:

1. Write the swing equation for a synchronous m/c connected to an infinite bus and explain the terms.
2. What is swing curve and what are its uses?
3. What are the assumptions made in the solution of swing equation?

LOAD FLOW STUDIES:

1. What is load flow analysis?
2. How the bases are classified in load flow studies?
3. What is the data required to carry out load flow analysis?
4. What is the significance of slack bus?
5. What are the methods of load flow analysis?
6. Write down the equation for the calculation of voltage at any bus in Gauss & Gauss sidle iterative method.
7. What are acceleration factors? What for they are used?
8. What are the advantages of NR method over Gauss seidel method of load flow analysis?
9. What is meant by Fast decoupled load flow analysis?

FAULT STUDIES:

1. What are the various types of faults that occur normally on power system?
2. What are the parameters considered for a fault study?
3. How the sequence networks are connected for (i) L-L-G fault (ii) LL fault (iii) L-G fault.
4. Write down the fault current equation for (i) single line to ground fault (ii) double line to ground fault (iii) LL fault
5. What are the limitations of ungrounded system?
6. Write zero sequence equivalent for (i) Y-Y (ii) Y-Δ (iii) Δ –Δ (iv)Y-Y

ECONOMIC OPERATION OF POWER SYSTEM:

1. What do you mean by Economic operation of a power system?
2. Name the performance characteristic curves of a turbo generator boiler unit.
3. What are heat rate, incremental fuel rate and incremental fuel cost of a unit?
4. Write down the co-ordination equation for economic operation of generators in a thermal plant when (i) transmission losses are neglected (ii) transmission losses are considered.
5. What is penalty factor? Write down the total transmission loss formula in terms of B Co-efficient.

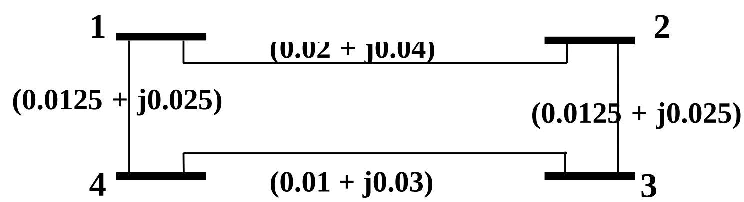
QUESTION BANK

1. Using singular transformation analysis, determine the bus admittance matrix of given test system.

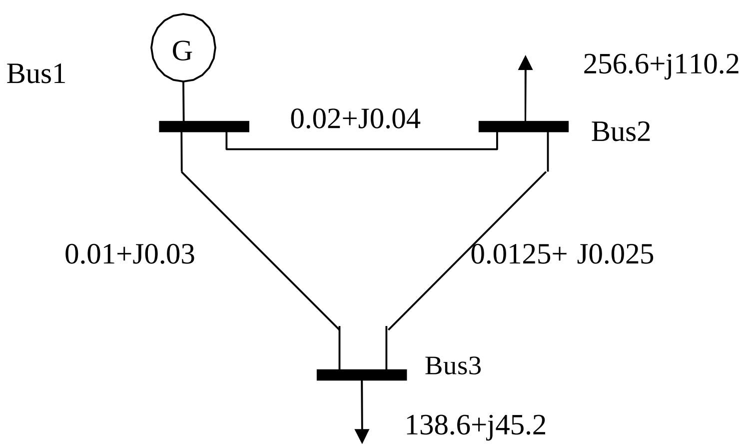
2.Using singular transformation analysis, determine Ybus for a given test system with mutual coupling of j0.01 pu between the line numbers ______&________Neglect line charging.

2. Using singular transformation analysis, determine the bus admittance matrix of given test system .
3. Using singular transformation analysis, determine Ybus for a given test system with mutual coupling of j0.01 pu between the line numbers______& _______

Refer below figure for Q.(1) – Q.(4)



4. For the power system shown below compute the elements of Bus admittance matrix using singular transformation and inspection



6. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (0-80km or 0-50 miles), determine the following
   - Regulation
   - Efficiency

(The line impedance and admittance values are to be specified)

7. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (>80km – 24 km or > 50 miles to 150 miles), determine the following
   . Regulation
   . Efficiency
   (The line impedance and admittance values are to be specified)

8. Given any two of the I/O parameters given either (Vs, Is) or (Vr ,Ir) of a two port short transmission line network (>240km or >150 miles), determine the following
   . Regulation
   . Efficiency
   (The line impedance and admittance values are to be specified)

9. Given any two of the I/O parameters of a two port short transmission line system and for a given set of line parameters (Z & Y) and length________km(>240km or >150 miles),determine the following
   (i) ABCD constants and hence the generalized equivalent circuit
   (ii) Regulation, (iii) Efficiency

10. Determine the generalized circuit constants for a transmission line with the following
    Data:
    a. Line length:___________________km
    b. Line impedance :_______________Ω/km
    c. Total shunt admittance :_____________________mho / km

11. The system having a single machine connected to an infinite bus has the following data.
    Pi =0.9 M= 0.016 (2.8×10^{-4} S / electrical Degree)
    E1 = 1.1 Transfer reactance before fault – Xo = 0.45 pu
    E2 = 1.0 Transfer reactance during fault – X1 = 1.25 pu
    Plot the swing curve (either using graph sheet or any grapher software) for sustained fault step by step method up to 1 second.

12. The system having a single machine connected to an infinite bus has the following data.Write and execute a program to plot the swing curve when the fault is cleared in 0.125 seconds.
    Pi =0.9 M= 0.016 (2.8×10^{-4} S / electrical Degree)
    E1 = 1.1 Transfer reactance before fault – Xo = 0.45 pu
    E2 = 1.0 Transfer reactance during fault – X1 = 1.25 pu
    Transfer reactance after clearing the fault – X2 = 0.55 pu

    Plot the swing curve (either using graph sheet or any grapher software) for a fault cleared in_________(Typically 0.3 & 0.42 second) or________cycle using step by step method .

13. 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)

14. 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.

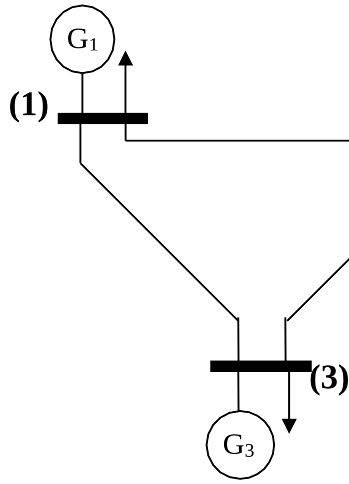
Refer below question for Q.(13) & Q(14)

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 $0 \leq Q_{G3} \leq 1.5$ p.u.

Find the load flow solution using N R method. Use a tolerance of 0.01 for power mismatch.



15. 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.

16. 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.(15) & Q(16)

A)

Unit No.	Cost of Fuel input in Rs./ hr.	
1	$C_1 = 800 + 20\,P_1 + 0.05\,P_1^2$	$0 \le P_1 \le 100$
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 :

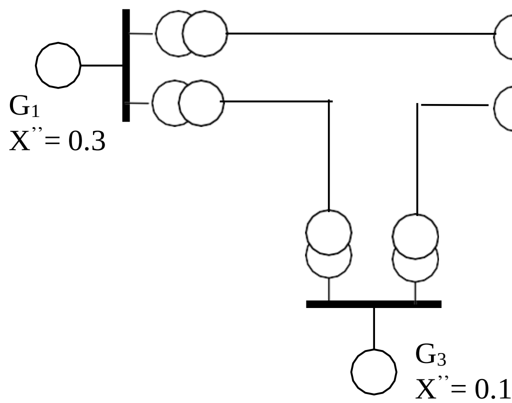
$B_{11} = 0.005$ $B_{12} = B_{21} = -0.0012$ $B_{22} = 0.002$

17. 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_______vus for a given test system.(Assume pre fault voltages at all buses to be 1 pu) compare the results with the symmetrical fault.

18. 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.(17) & Q(18)

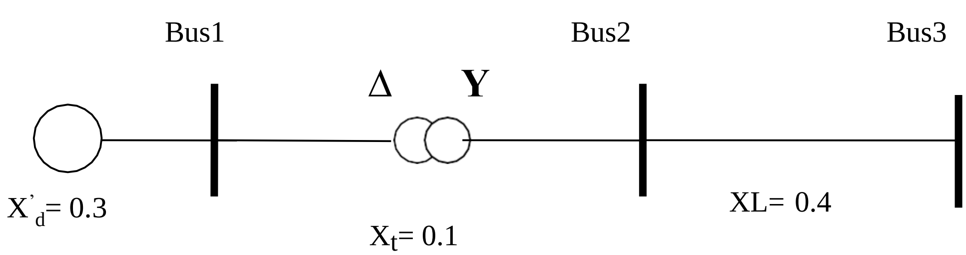
Reactance of all transformers and transmission lines	= 0.1 pu
Zero sequence reactance of transmission line	= 0.25 pu
Negative sequence reactance of generator	= Subtransient reactance
Zero sequence reactance of generator	= 0.1 pu



19.For the given circuit, find the fault currents, voltages for the following type of faults at Bus3.

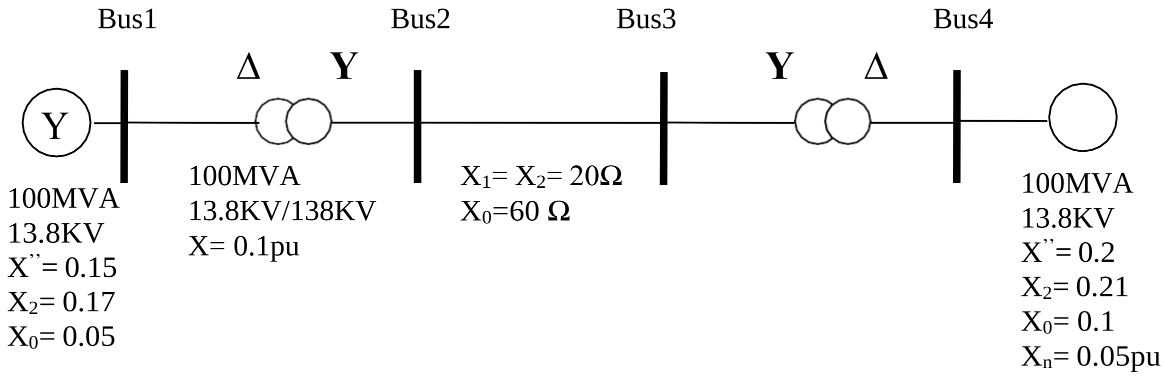
1. Single Line to Ground Fault
2. Line to Line Fault
3. Double line to Ground Fault

For the transmission line assume $X_1= X_1$,$X_0= 2.5\ X_L$



20.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



21. A four-bus system is given below. The bus admittance matrix and initial voltages at each bus are given. Taking bus 1 as slack bus. Calculate the jacobian elements of the system using NR method.

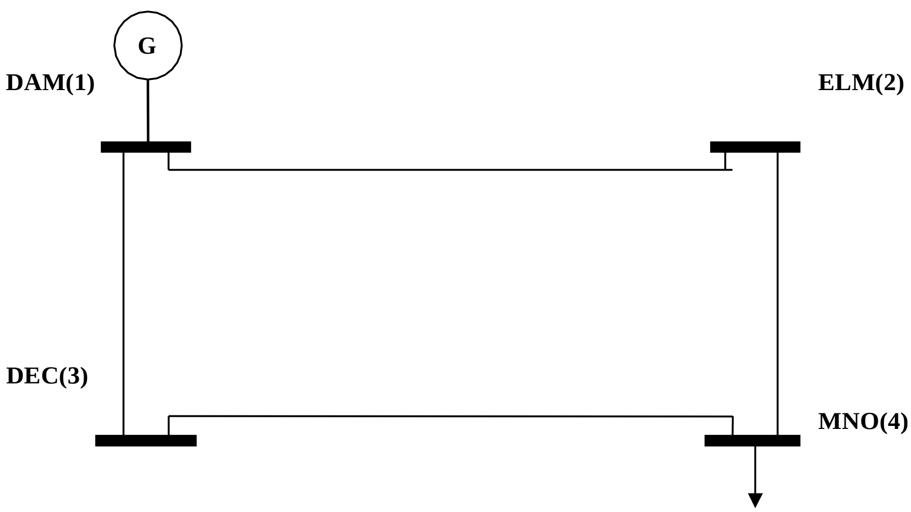


Table A

Bus Code (i-k)	Impedance (p.u) Z_{ik}	Line charging Admittance (p.u) Y_i
1-2		0
3-4		0
2-4		0
1-3		0

Table B

Bus No	Bus Voltage	Generation		Load	
		MW	Mvar	MW	Mvar
1	1.0+j0.0	--	--	0	0
2	1.0+j0.0	0	0	0	0
3	1.0+j0.0	0	0	0	0
4	1.0+j0.0	0	0		

22. For the system shown below with bus 1 slack bus V1 = 1.0< 0° pu. A load of 100MW at 50 Mvar is taken at bus 2, the line impedance is Z12 = 0.12+j0.16 pu on a base of 100Mva. Using Nr method obtain voltage magnitude and phase angle of bus 2. Start with initial estimate of

V2 = 1.0< 0° pu