User Manual

PSCT | Protection Analytic tool

HOW TO SOLVE

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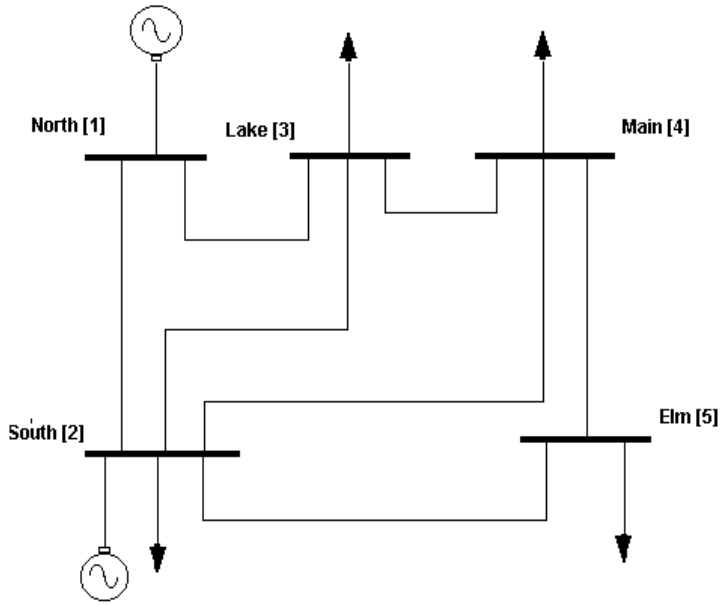
1. How to solve Load Flow

Figure shows a single line diagram of a 5 bus system with two generating units, seven lines. Per-unit transmission line series impedances and shunt susceptances are given on 100 MVA base in table 1.1. Real power generation, real and reactive power loads in MW and MVAR are given in table 1.2.

With **bus 1** as **slack**, use the following methods to obtain a load flow solution:

(a) Gauss-Siedel using Y-bus, with acceleration factors of 1.4 and tolerances of 0.0001 and 0.0001 per unit for the real and imaginary components of voltage.

(b) Newton-Raphson using Ybus, with tolerance of 0.01 per unit for the real and reactive bus powers.



Assume the base voltage for the bus as 220 kV and system frequency as 60 Hz.

Impedances and line charging for the sample system.

Table : 1.1		
Bus code From - To	**Impedance R+jX in pu**	**Line charging B/2 in pu**
1-2	0.02+j0.06	0.0+j0.030
1-3	0.08+j0.24	0.0+j0.025
2-3	0.06+j0.18	0.0+j0.02
2-4	0.06+j0.18	0.0+j0.02
2-5	0.04+j0.12	0.0+j0.015
3-4	0.01+j0.03	0.0+j0.010
4-5	0.08+j0.24	0.0+j0.025

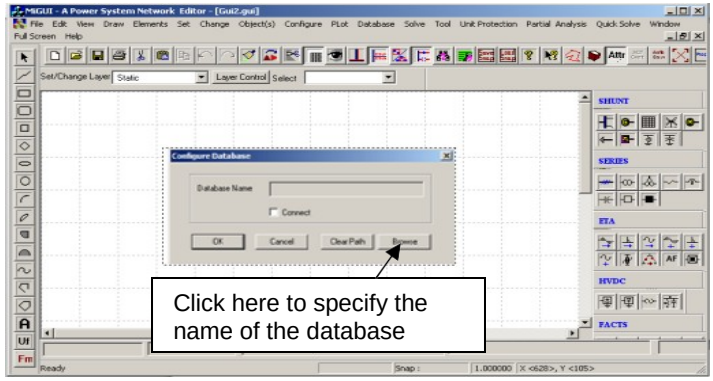
Generation, loads and bus voltages for sample system

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

Procedure to enter the data for performing studies using MiP-PSCT.

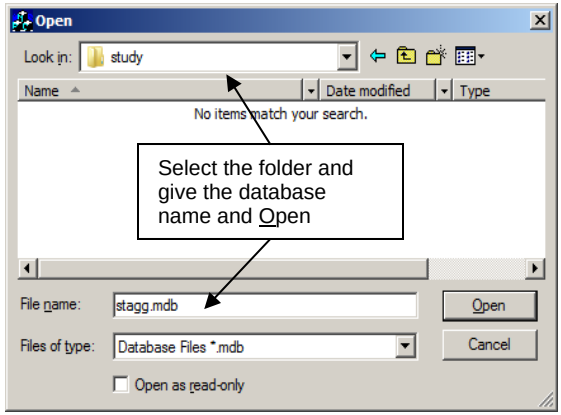
MiP-PSCT - Database Configuration

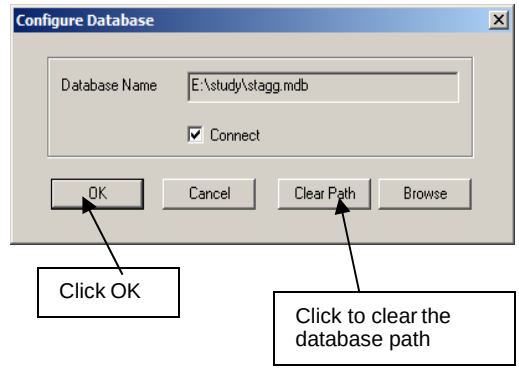
Open Power System Network Editor. Select menu option Database → **Configure**.



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

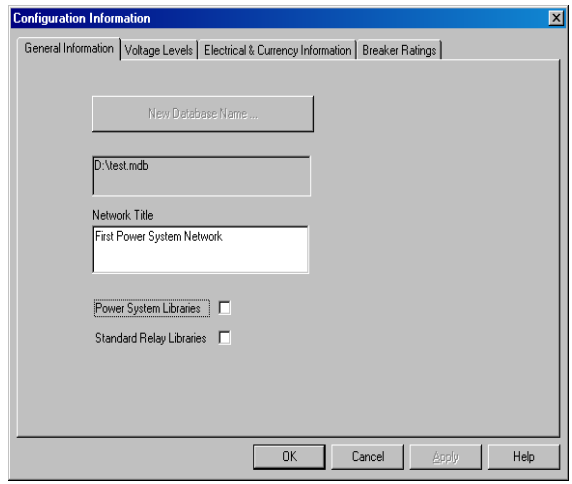
diagram. Click Open button after entering the desired database name. **Configure Database** dialog will appear with path chosen.



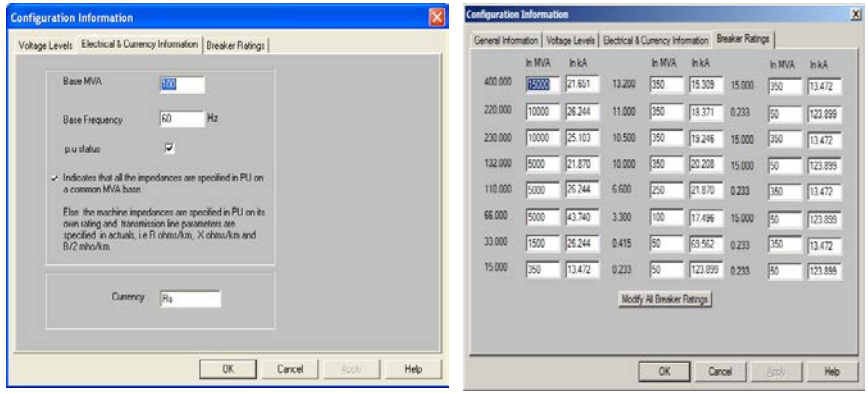


Note: Do not work in the MiP-PSCT directory.

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 impedances are given on 100 MVA base, check the pu status.

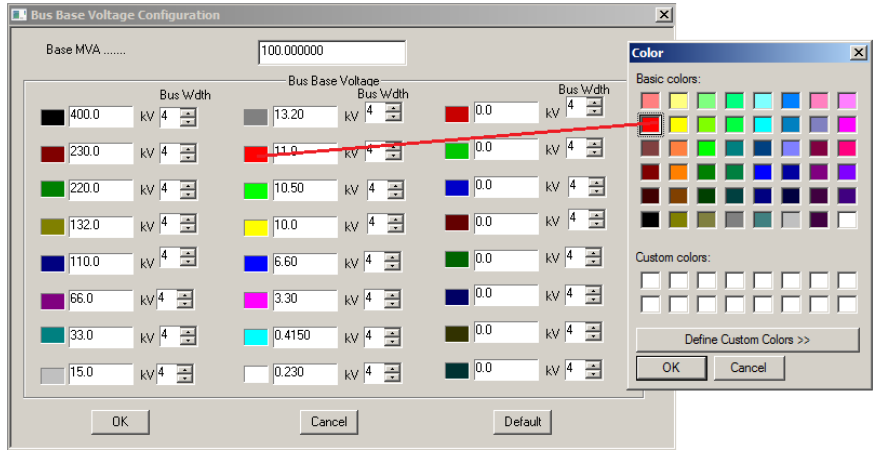


Enter the Base MVA and Base frequency as shown below. Click on Breaker Ratings button to give breaker ratings. Click OK button to create the database to return to Network Editor.



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.**

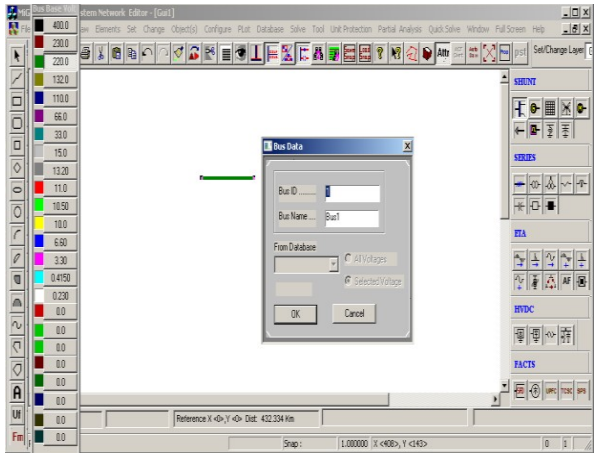


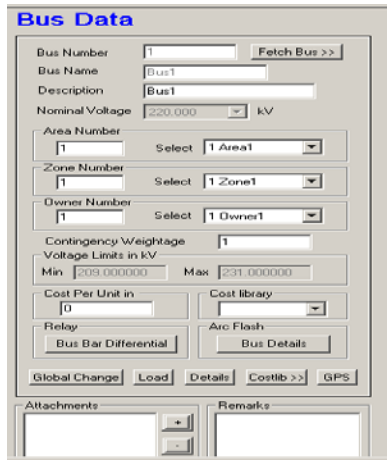
1.1 Procedure to Draw First Element - Bus

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** this invokes Network Editor. Follow the same procedure for remaining buses. Following table gives the data for other buses.

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

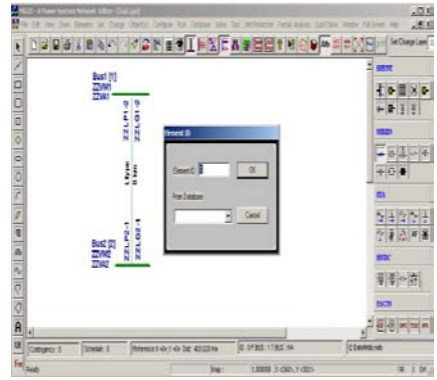
Note: Since the voltages are mentioned in pu, any kV can be assumed. So the base voltage is chosen as 220 kV.

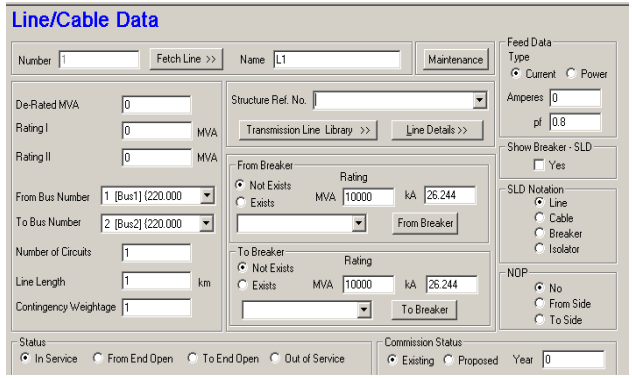
1.2 Procedure to Draw Transmission Line

Click on Transmission **Line** icon provided on power system toolbar. To draw the line click in between two buses and to connect to

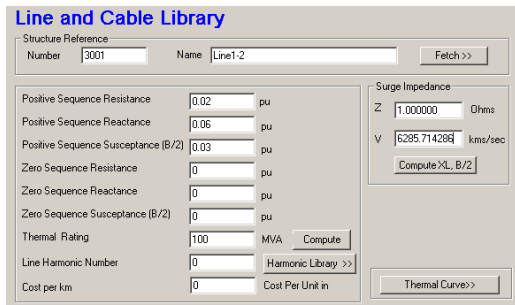
the from bus double clicking LMB (Left Mouse Button) on the

From Bus and join it to another bus by double clicking the mouse button on the **T o 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 3001** 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

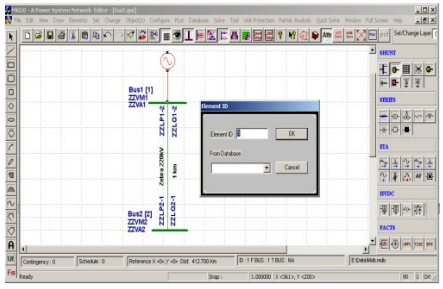
Line No	From Bus	To Bus	No. Of circuits	Structure Ref. No.
2	1	3	1	2
3	2	3	1	3
4	2	4	1	3
5	2	5	1	4
6	3	4	1	5
7	4	5	1	2

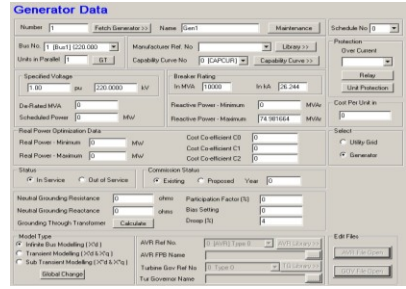
Transmission Line Library Data

Structure Ref No	Structure Ref Name	Resistance In pu	Reactance pu	Line charging B/2 in pu	Thermal Rating in MVA
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

1.3 Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Connect it to bus 1 by clicking the LMB on **Bus 1**. The **Element ID** dialog will appear. Enter ID number and click OK. Database with corresponding **Generator Data** form will appear. Enter details as shown below.





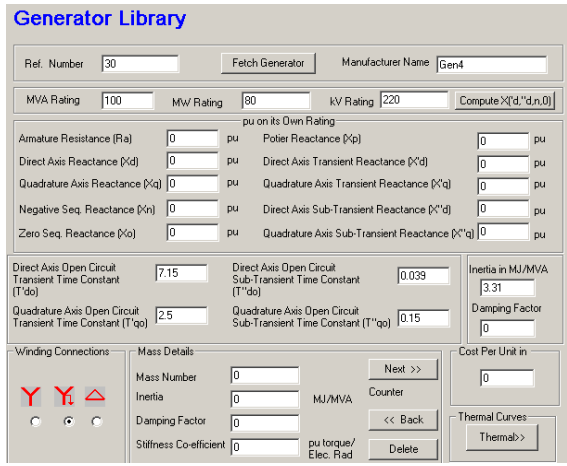
Since the specified voltage is given as 1.06 pu, enter the value. Voltage will be calculated and appear in the specified voltage field in kV

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

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

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

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



After entering data **Save** 🖫 and close**.** In **Generator Data** form click **Save**🖫**. Network Editor** Screen will be invoked. Similarly connect generator 2 at bus 2. Enter its details as given in the following table.

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

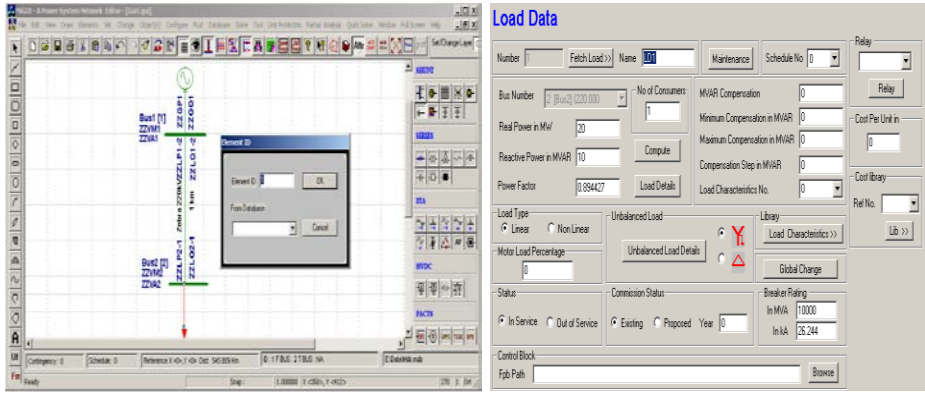
Reactive Power Min	30
Reactive Power Max	30

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

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

1.4 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.



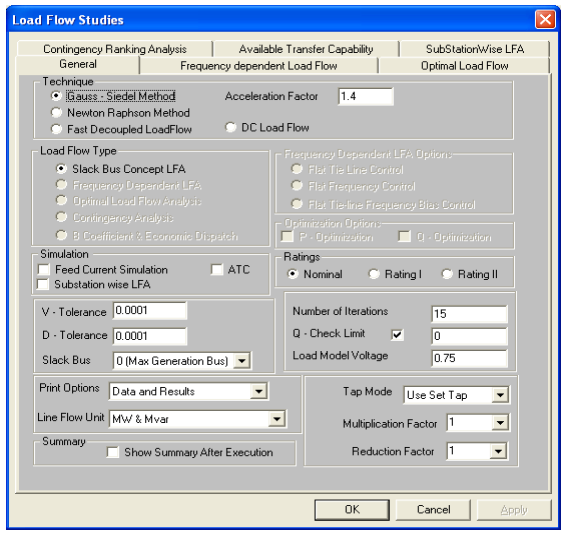
Connect other loads to buses 3, 4 and 5. Enter other load details as given in the following table.

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

1.5 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

```
--------------------------------------------------------------------------------
      LOAD FLOW BY GAUSS-SIEDEL METHOD
CASE NO :  1     CONTINGENCY  : 0  SCHEDULE NO : 0
CONTINGENCY NAME : Base Case              RATING CONSIDERED : NOMINAL
--------------------------------------------------------------------------------
VERSION NUMBER :  8.2
%%
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
Number of Shunt Connected Facts: 0   Power Forced Lines             :    0
Number of TCSC Connected       : 0   Number of SPS Connected        :    0
Number of UPFC Connected       : 0   Number of Wind Generators      :    0
Number of wtg Curves           : 0   Number of wtg Detailed Curves  :    0
Number of solar plants           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 p.u. Voltage
No Frequency Dependent Load Flow, Control Option:    0
Base MVA                                    :  100.0
Nominal System Frequency (Hz)               :   60.0
Frequency Deviation (Hz)                    :    0.0
Flows in MW and MVAr, Option                :    0
Slack Bus                                   :    0 (Max. Generation Bus)
Transformer Tap Control Option              :    0
Q Checking Limit  (Enabled)                 :    0
Real Power Tolerance (p.u.)                 :    0.00010
Reactive Power Tolerance (p.u.)             :    0.00010
Maximum Number of Iterations                :   15
Bus Voltage Below Which Load Model is Changed : 0.75000
Circuit Breaker Resistance  (p.u.)          :    0.00000
Circuit Breaker Reactance   (p.u.)          :    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 (KWH) : 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(p.u.)	VMAX(p.u.)	NAME
1	1	1	220.000	0.980	1.080	North
2	1	1	220.000	0.980	1.080	South
3	1	1	220.000	0.980	1.080	Lake
4	1	1	220.000	0.980	1.080	Main
5	1	1	220.000	0.980	1.080	Elm

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	LINE R(p.u.)	PARAMETER X(p.u.)	B/2(p.u.)	RATING MVA	KMS
3	1	1	North	2	South	0.02000	0.06000	0.03000	100	1.00
3	1	1	North	3	Lake	0.08000	0.24000	0.02500	100	1.00
3	1	2	South	3	Lake	0.06000	0.18000	0.02000	100	1.00
3	1	2	South	4	Main	0.06000	0.18000	0.02000	100	1.00
3	1	2	South	5	Elm	0.04000	0.12000	0.01500	100	1.00
3	1	3	Lake	4	Main	0.01000	0.03000	0.01000	100	1.00
3	1	4	Main	5	Elm	0.08000	0.24000	0.02500	100	1.00

Total Line Charging Susceptance (in p.u.) : 0.29000
Total Line Charging MVAr at 1 p.u. Voltage : 29.000
Number of Lines Opened on Both the Ends : 0
Total Line Charging susceptance of Existing Lines (in p.u.) : 0.29000
Total Line Charging MVAr at 1 p.u. Voltage of Existing Lines : 29.000

Total Capacitive Susceptance : 0.00000 p.u. - 0.000 MVAr
Total Inductive Susceptance : 0.00000 p.u. - 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

```
Sl.no. FROM   FROM      REAL   REACTIVE COMP   COMPENSATING MVAR VALUE   CHAR F/V
     NODE   NAME        *MW          MVAr          MVAr          MIN          MAX          STEP          NO.          NO.
STAT
------ -------- -------- -------- -------- -------- -------- -------- -------- -------- --------
  1          2    South   20.000   10.000    0.000    0.000    0.000    0.000    0    0
                                                3    0
  2          3    Lake    45.000   15.000    0.000    0.000    0.000    0.000    0    0
                                                3    0
  3          4    Main    40.000    5.000    0.000    0.000    0.000    0.000    0    0
                                                3    0
  4          5    Elm     60.000   10.000    0.000    0.000    0.000    0.000    0    0
                                                3    0
-------------------------------------------------------------------------------
Total Specified MW Generation          : 120.00000
Total Minimum MVAr Limit of Generator  : 30.00000
TOTAL Maximum MVAr Limit of Generator  : 90.00000
Total Specified MW Load                : 165.00000 Changed to  165.00000
Total Specified MVAr Load              :  40.00000 Changed to   40.00000
Total Specified MVAr Compensation      :   0.00000 Changed to    0.00000
-------------------------------------------------------------------------------
TOTAL (Including Out of Service Units)
Total Specified MW Generation          : 120.00000
TOTAL Minimum MVAr Limit of Generator : 30.00000
Total Maximum MVAr Limit of Generator  : 90.00000
Total Specified MW Load                : 165.00000 Changed to  165.00000
Total Specified MVAr Load              :  40.00000 Changed to   40.00000
Total Specified MVAr Compensation      :   0.00000 Changed to    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   North   80.000    0.0000   80.0000    4.0000    0.0000    0.0000
                                    1.0000    0.1000    0.0100
 2    2   South   80.000    0.0000   40.0000    4.0000    0.0000    0.0000
                                    1.0000    0.1000    0.0100
-------------------------------------------------------------------------------
Acceleration factor : 1.40
-------------------------------------------------------------------------------
Slack bus angle (degrees) :  0.00
-------------------------------------------------------------------------------
TOTAL NUMBER OF ISLANDS IN THE GIVEN SYSTEM        :  1
TOTAL NUMBER OF ISLANDS HAVING ATLEAST ONE GENERATOR : 1
SLACK BUSES CONSIDERED FOR THE STUDY
ISLAND NO. SLACK BUS NAME     SPECIFIED MW
---------- --------- -------- ------------
        1         1    North       80.000
-------------------------------------------------------------------------------
 Iteration count =    1  Error =   0.052538 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   129.535   -7.468    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) : 0
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 2    South   3    Lake    24.690    3.535   0.3513  -3.2385    24.7&
  4  1 2    South   4    Main    27.936    2.957   0.4413  -2.9660    27.5^
  5  1 2    South   5    Elm     54.824    7.346   1.1253  0.1756     52.8$
  6  1 3    Lake    4    Main    18.900   -5.167   0.0357 -1.9898     19.1&
  7  1  4   Main    5    Elm      6.334   -2.280   0.0307  -5.1178    6.8&
--------------------------------------------------------------------------------
! 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

BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO

ISLAND FREQUENCY SLACK-BUS CONVERGED(1)

1	60.00000	1	1

Summary of results

TOTAL REAL POWER GENERATION (CONVENTIONAL) : 169.535 MW
TOTAL REAL POWER INJECTION (-ve LOAD) : 0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) : 22.532 MVAr
GENERATION p.f. : 0.991

TOTAL REAL POWER GENERATION (WIND) : 0.000 MW
TOTAL REACT. POWER GENERATION (WIND) : 0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR) : 0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR) : 0.000 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 TCSC REACTIVE DRAWL : 0.000 MVAr

TOTAL SPS REACTIVE DRAWL : 0.000 MVAr

TOTAL UPFC INJECTION : 0.000 MVAr

TOTAL SHUNT FACTS INJECTION : 0.000 MVAr
TOTAL SHUNT FACTS DRAWAL : 0.000 MVAr

TOTAL REAL POWER LOAD : 165.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.) : 0.000 MW
TOTAL REACTIVE POWER LOAD : 40.000 MVAr
LOAD p.f. : 0.972
TOTAL COMPENSATION AT LOADS : 0.000 MVAr
TOTAL HVDC REACTIVE POWER : 0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC) : 4.584616 MW (4.584616+ 0.000000)
PERCENTAGE REAL LOSS (AC+DC) : 2.704
TOTAL REACTIVE POWER LOSS : -17.429226 MVAr

---Zone wise distribution

Description	Zone # 1
MW generation	169.5349
MVAr generation	22.5315

MW wind gen. 0.0000

MVAr wind gen. 0.0000

MW solar gen. 0.0000

MVAr solar gen. 0.0000

MW load 165.0000

MVAr load 40.0000

MVAr compensation 0.0000

MW loss 4.5846

MVAr loss -17.4292

MVAr - inductive0.0000

MVAr - capacitive 0.0000

Zone wise export(+ve)/import(-ve)

Zone # 1 MW & MVAr

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

1 -----

Area wise export(+ve)/import(-ve)

Area # 1 MW & MVAr

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

1 -----

Area wise distribution

Description Area # 1

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

MW generation 169.5349

MVAr generation 22.5315

MW wind gen. 0.0000

MVAr wind gen. 0.0000

MW solar gen. 0.0000

MVAr solar gen. 0.0000

MW load 165.0000

MVAr load 40.0000

MVAr compensation 0.0000

MW loss 4.5846

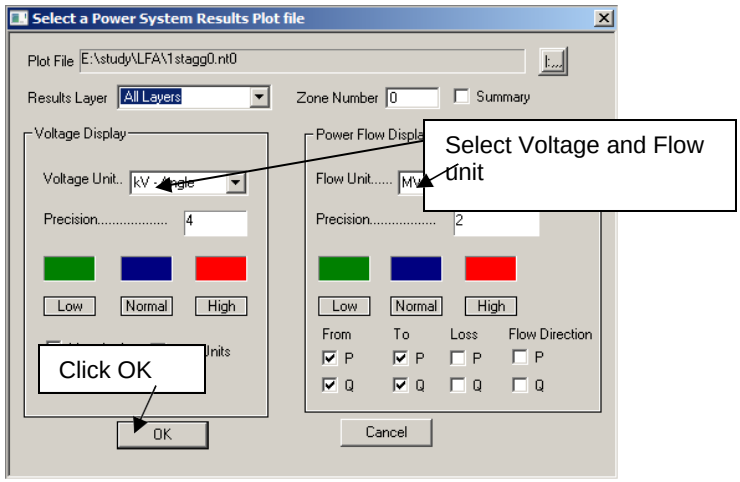
MVAr loss -17.4292

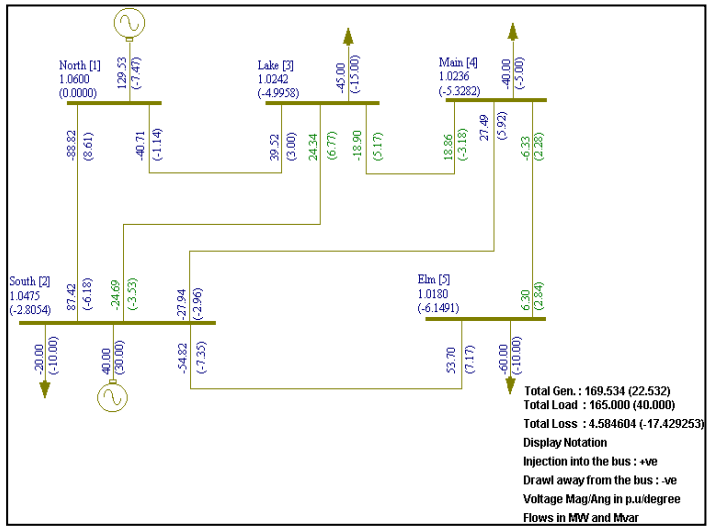
MVAr - inductive0.0000

MVAr - capacitive 0.0000

1.6 Procedure to plot the results on the Single Line Diagram

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



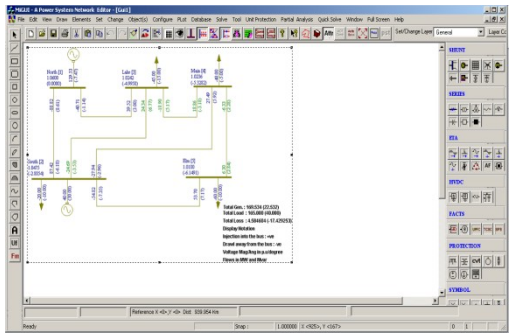


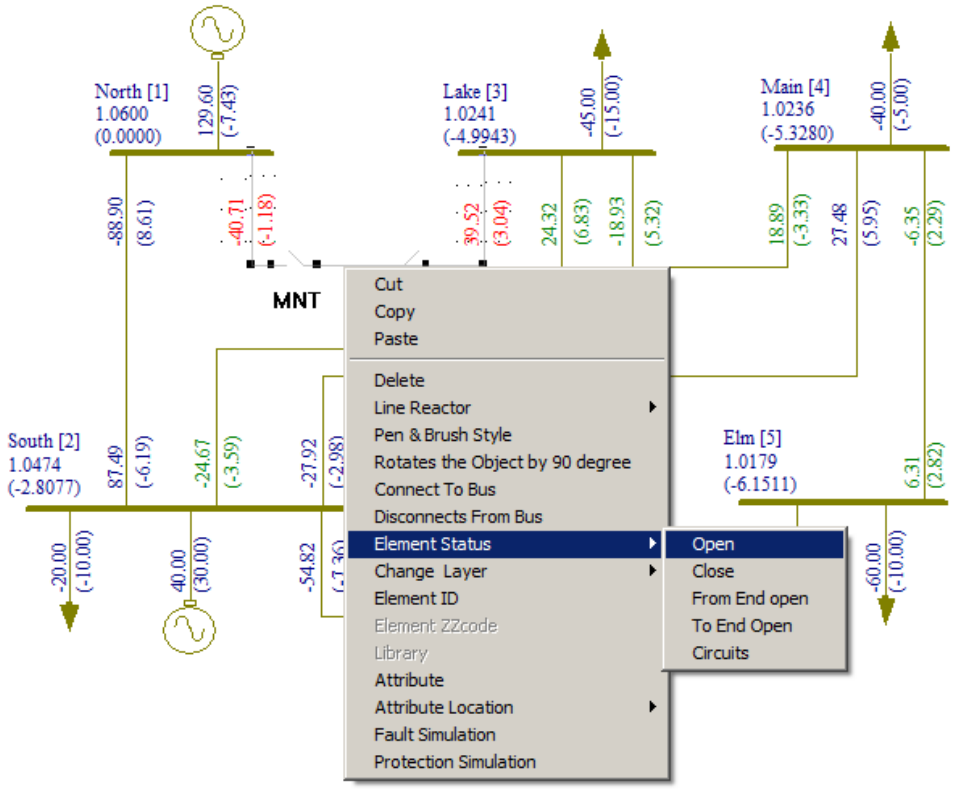
1.7 Quick Solve ->Load Flow (Shortcut method to perform Load flow analysis)

Select menu option **Quick Solve → Load Flow. Load flow analysis** is executed and automatically results are plotted on GUI.

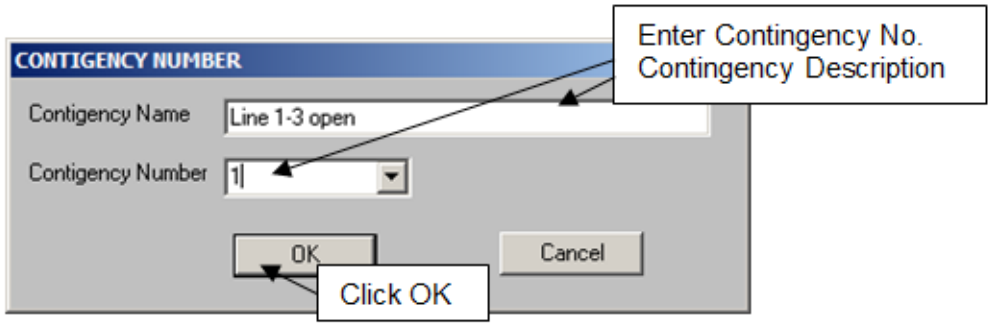
Contingency Analysis

1. Click RMB on the element to be opened (Out of service) and Select Menu option **Element Status→Open**





2. Select Menu option **Configure→Save Contingency** for saving contingency in database**.** Following dialog will appear



3. Execute Load Flow Analysis

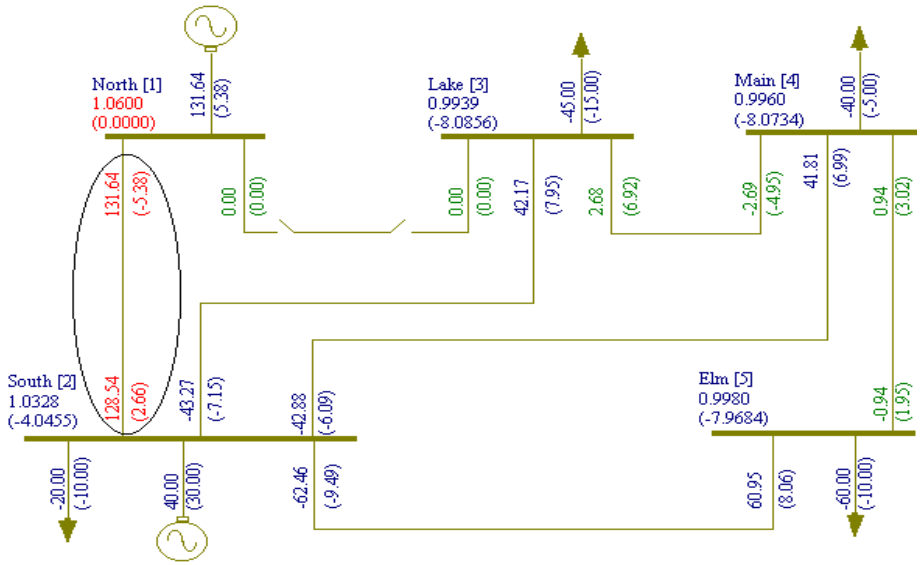
Load Flow Result: -

```
BUS VOLTAGES AND POWERS
NODE FROM       V-MAG  ANGLE  GEN MW    GEN MVAR OAD MW  LOAD MVAR COMP
MVAR
---- --------  ------ ------  -------- --------  --------  --------    ---
---
   1    North  1.0600   0.00   131.639    5.385     0.000    0.000
0.000#
   2    South  1.0328  -4.05    40.000   30.000    20.000   10.000
0.000
   3     Lake  0.9939  -8.09     0.000    0.000    45.000   15.000
0.000
   4     Main  0.9960  -8.07     0.000    0.000    40.000    5.000
0.000
   5      Elm  0.9980  -7.97     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)  :     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    North    2   South  131.639    5.385   3.0982   2.7238
124.3@
2  1    1    North    3     Lake      LINE IS OPEN
```

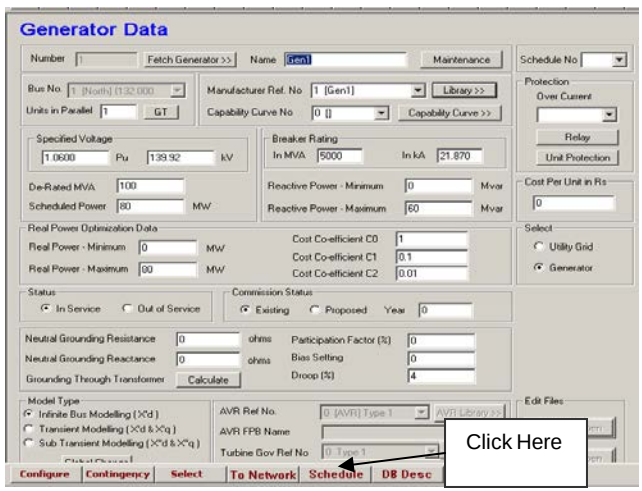
```
3  1    2    South    3    Lake   43.274    7.150   1.1019  -0.8034
42.5^
4  1    2    South    4    Main   42.883    6.093   1.0725  -0.8997
41.9^
5  1    2    South    5     Elm   62.463    9.495   1.5093   1.4339
61.2$
6  1    3     Lake    4    Main   -2.682   -6.922   0.0043  -1.9670
7.5&
7  1    4     Main    5     Elm   -0.938   -3.015   0.0009  -4.9674
3.2&
```

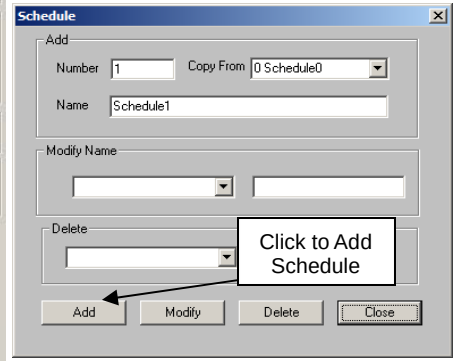
Procedure to add Different Generation Schedules:

1.

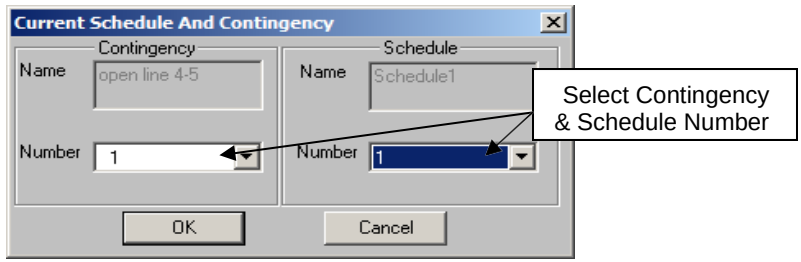


Select menu option Configure -> Schedule OR Double Click LMB on the Generator to invoke database manager**.** Following database form will *appear*



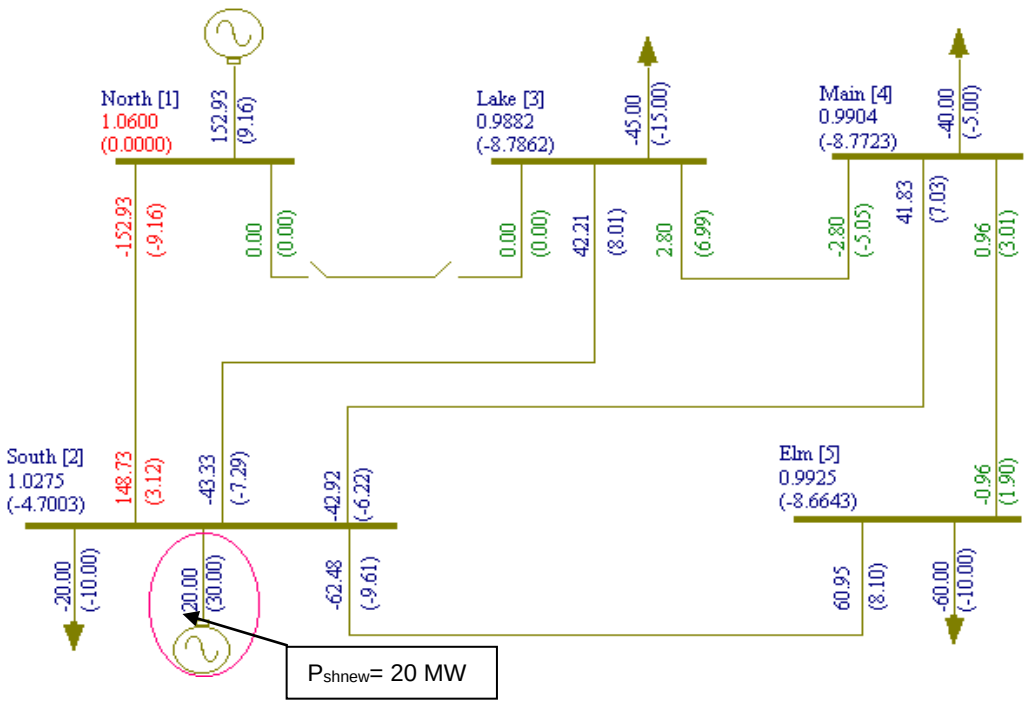


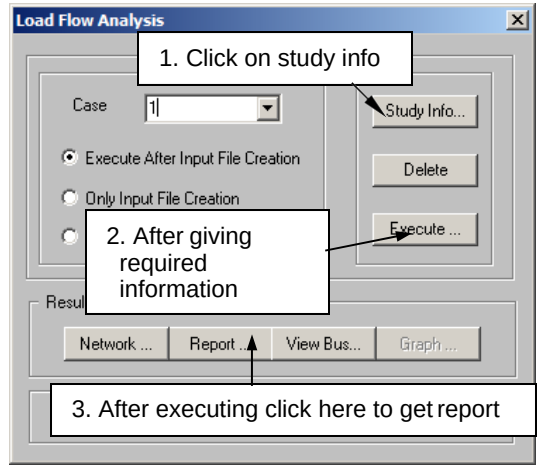
2. Close and Reopen Generator database to update the changes. Click on **Select** Button in Contingency & Schedule toolbar to switch between different Contingencies and Schedules. Following dialog box will appear.



3. Enter the schedule details in Generator Data form and **save**

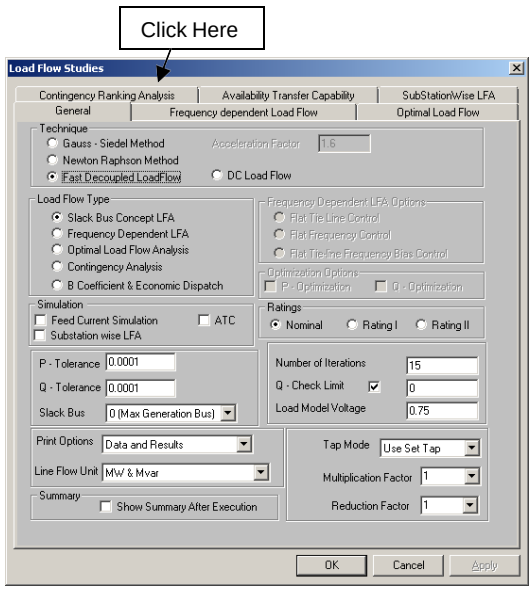
4. Execute Load Flow Analysis and plot the results on the Single line Diagram

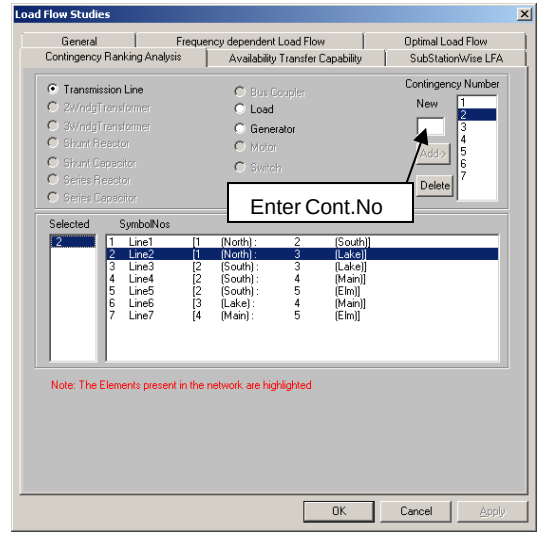




Procedure for Contingency Ranking Analysis:

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





2. When **Study Info** button is clicked, following dialog will open. Select Fast Decoupled Method -> Contingency Analysis and click on **Contingency Ranking Analysistab**

3. Enter the contingency number in **New** field and select elements from the **Symbol Nos**. table
4. Execute Load Flow analysis.

Report: -

```
CONTINGENCY RANKING
PIV: VOLTAGE PERFORMANCE INDEX
PIF: OVER LOAD PERFORMANCE INDEX
HIGH VALUE INDICATES LOAD FLOW UNABLE TO CONVERGE
-------------------------------------------------------------------------------------------------------------------
----
SLNO    FROM    NAME    TO     NAME    PIV         RANK    VOLT    PIF     RANK
LOAD
                                                            LESS
MORE
---- ---- -------- ---- -------- ---------- ---- ---- ---------- ---- ----------------------------------------------
-----
   1    1    North    2    South 2.482e+001    1    4   2.918e+000    1
1
   2    1    North    3     Lake 1.891e+000    7    0   2.287e+000    2
1
   3    2    South    3     Lake 2.505e+000    5    0   1.305e+000    7
0
   4    2    South    4     Main 2.434e+000    6    0   1.464e+000    4
0
   5    2    South    5      Elm 6.250e+000    2    1   2.068e+000    3
0
   6    3     Lake    4     Main 2.690e+000    3    0   1.462e+000    5
0
   7    4     Main    5      Elm 2.649e+000    4    0   1.361e+000    6
0
-------------------------------------------------------------------------------------------------------------------
----
```

1.8 Frequency Dependent Load Flow:

Frequency dependent load flow is done to find the variation of frequency due to load and generation mismatch.
The types of frequency dependent load flow are

(a) Flat Tie-Line control
(b) Flat Frequency control

In Flat tie line control the power generation is kept constant and a slight variation in frequency is allowed. If the load is more compared to generation there will be reduction of frequency and vice versa.

In Flat frequency control the frequency is kept constant and variation in power is allowed. Each generator is given a participation factor, which decides the power it shares when there is mismatch between load and generation due to frequency being kept constant.

Flat Tie-Line control:

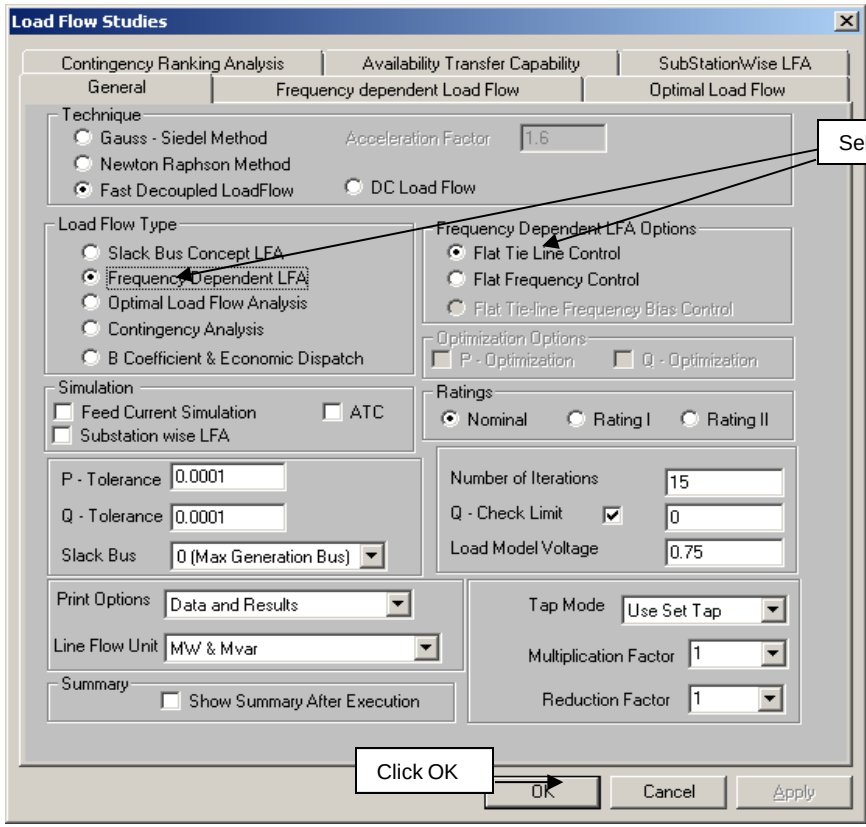
1. Execute LFA with FDLF->slack bus option in Load Flow Analysis study info

```
------------------------------------------------------------------------
--
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   129.584   -7.444     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  1.0179  -6.15     0.000    0.000     60.000   10.000
0.000
------------------------------------------------------------------------
--
```

2. Change the generator Schedule and P_{max} to that obtained in initial load flow also enter droop in percentage in generator data form.

3. Select. **Frequency dependent Load Flow→Flat Tie-Line control**

4. Execute Load Flow Analysis



Report:-

BUS VOLTAGES AND POWERS

NODE NO.	FROM NAME	V-MAG p.u.	ANGLE DEGREE	MW GEN	MVAr GEN	MW LOAD	MVAr LOAD	MVAr COMP
1	North	1.0600	0.00	129.595	-7.416	0.000	0.000	0.000 #<
2	South	1.0474	-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	1.0179	-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   88.869   -8.575   1.4106  -2.4304
84.2#
2  1    1    North  3     Lake   40.724    1.159   1.1920  -1.8553
38.4^
3  1    2    South  3     Lake   24.693    3.546   0.3515  -3.2376
24.7&
4  1    2    South  4     Main   27.935    2.962   0.4413  -2.9657
27.5^ 5  1    2    South  5      Elm   54.822    7.343   1.1252   0.1757
52.8$ 6  1    3     Lake  4     Main   18.874   -5.202   0.0356  -1.9898
19.1&
7  1    4     Main  5      Elm    6.333   -2.285   0.0307  -5.1175
6.8&
--------------------------------------------------------------------------
---
! 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
--------------------------------------------------------------------------
---
BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO
--------------------------------------------------------------------------
---
ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  59.99985           1       1
--------------------------------------------------------------------------
---
Summary of results
TOTAL REAL POWER GENERATION (CONVENTIONAL)   :    169.595 MW
TOTAL REAL POWER INJECTION (-ve LOAD)        :      0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :    22.584 MVAr
GENERATION p.f.                              :      0.991
TOTAL REAL POWER GENERATION (WIND)           :      0.000 MW
```

```
TOTAL REACT. POWER GENERATION (WIND)          :       0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR)           :       0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR)         :       0.000 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 TCSC REACTIVE DRAWL                     :       0.000 MVAr

TOTAL SPS REACTIVE DRAWL                      :       0.000 MVAr

TOTAL UPFC INJECTION                          :       0.000 MVAr

TOTAL SHUNT FACTS INJECTION                   :       0.000 MVAr
TOTAL SHUNT FACTS DRAWAL                      :       0.000 MVAr

TOTAL REAL POWER LOAD                         :     165.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.)            :       0.000 MW
TOTAL REACTIVE POWER LOAD                     :      40.000 MVAr
LOAD p.f.                                     :       0.972
TOTAL COMPENSATION AT LOADS                   :       0.000 MVAr
TOTAL HVDC REACTIVE POWER                     :       0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC)                 :    4.586907 MW (   4.586907+
0.000000)
PERCENTAGE REAL  LOSS (AC+DC)                 :       2.705
TOTAL REACTIVE POWER  LOSS                    : -17.420643 MVAr
```

5. Change (Increase / Decrease) Load Data.

Load	Bus. No	Initial MW	New MW
Load1	2	20	25

6. Execute Frequency dependent Load Flow Analysis

Report:-

```
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    134.739    -4.269      0.000     0.000     0.000
#<
 2     South  1.0453   -2.91     40.000    30.000     25.000    12.500     0.000
 3      Lake  1.0225   -5.08      0.000     0.000     45.000    15.000     0.000
 4      Main  1.0218   -5.41      0.000     0.000     40.000     5.000     0.000
 5       Elm  1.0159   -6.25      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   93.180   -5.980   1.5427  -2.0034
88.1#
2  1    1    North   3     Lake   41.560    1.711   1.2411  -1.6857
39.2^ 3  1    2    South   3     Lake   24.330    3.385   0.3412  -3.2419
24.3&
4  1    2    South   4     Main   27.642    2.839   0.4323  -2.9656
27.2^
5  1    2    South   5      Elm   54.673    7.301   1.1206   0.1830
52.8$
6  1    3     Lake   4     Main   19.308   -4.977   0.0370  -1.9732
19.5&
7  1    4     Main   5      Elm    6.480   -2.198   0.0322  -5.0805
7.0&
--------------------------------------------------------------------------
---
! 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
--------------------------------------------------------------------------
---
BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO
--------------------------------------------------------------------------
---
ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  59.84554           1       1
--------------------------------------------------------------------------
---
Summary of results
TOTAL REAL POWER GENERATION (CONVENTIONAL)   :    174.739 MW
TOTAL REAL POWER INJECTION (-ve LOAD)        :      0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :    25.731 MVAr
```

```
GENERATION p.f.                                 :       0.989

TOTAL REAL POWER GENERATION (WIND)              :       0.000 MW
TOTAL REACT. POWER GENERATION (WIND)            :       0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR)             :       0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR)           :       0.000 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 TCSC REACTIVE DRAWL                       :       0.000 MVAr

TOTAL SPS REACTIVE DRAWL                        :       0.000 MVAr

TOTAL UPFC INJECTION                            :       0.000 MVAr

TOTAL SHUNT FACTS INJECTION                     :       0.000 MVAr
TOTAL SHUNT FACTS DRAWAL                        :       0.000 MVAr

TOTAL REAL POWER LOAD                           :     170.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.)              :       0.000 MW
TOTAL REACTIVE POWER LOAD                       :      42.500 MVAr
LOAD p.f.                                       :       0.970
TOTAL COMPENSATION AT LOADS                     :       0.000 MVAr
TOTAL HVDC REACTIVE POWER                       :       0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC)                   :   4.747187 MW (  4.747187+
0.000000)
PERCENTAGE REAL  LOSS (AC+DC)                   :       2.717
TOTAL REACTIVE POWER  LOSS                      : -16.767246 MVAr
------------------------------------------------------------------------------
---
```

Observation:

To meet increased load demand of 5 MW at **BUS 2** without increase in Generation MW, frequency drops to **59.84 Hz** from its nominal frequency **60 Hz.**

Flat Frequency control:

1. Execute LFA with FDLF->slack bus option in Load Flow Analysis study info

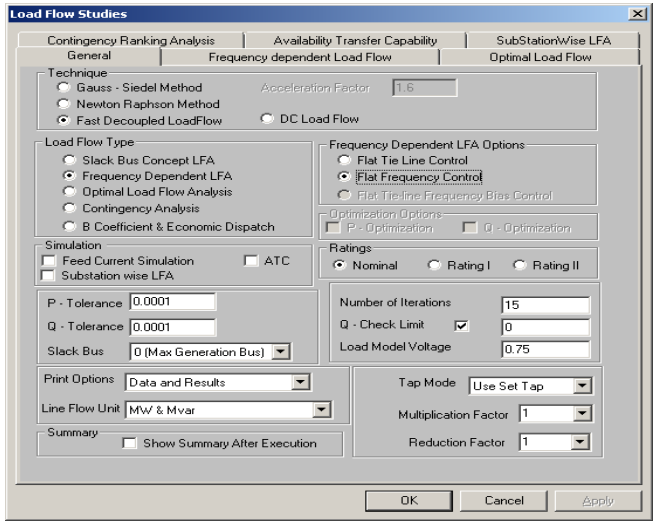
```
    ------------------------------------------------------------------------
    --
    BUS VOLTAGES AND POWERS

   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   129.584   -7.444   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  1.0179  -6.15     0.000    0.000    60.000   10.000
0.000
--------------------------------------------------------------------------
--
```

2. Change the generator Schedule and P_{max} to that obtained in initial load flow, also enter participation factor in generator data form. Participation factor for Gen1 = 25% and for Gen2 = 75%. Total participation factor for all generators is 100%.

Note: `Real power maximum for Gen1, Pmax = 150MW and for Gen2, Pmax = 60MW.`

3. Select. **Frequency dependent Load Flow→Flat Frequency control**



4. Execute Load Flow Analysis

Report:-

```
------------------------------------------------------------------------
---
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   129.590   -7.421     0.000    0.000    0.000
#<
 2    South  1.0474  -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  1.0179  -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   88.860   -8.580   1.4103  -2.4312
84.2#
2  1   1    North   3     Lake   40.723    1.158   1.1919  -1.8555
38.4^
3  1   2    South   3     Lake   24.695    3.546   0.3515  -3.2375
24.7& 4  1   2    South   4     Main   27.937    2.962   0.4414  -2.9655
27.5^
5  1   2    South   5      Elm   54.824    7.343   1.1253   0.1759
52.8$
6  1   3     Lake   4     Main   18.874   -5.202   0.0356  -1.9898
19.1&
7  1   4     Main   5      Elm    6.333   -2.285   0.0307  -5.1176
6.8&
------------------------------------------------------------------------
---

! 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

BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO

TOTAL AREA INTERCHANGE ERROR FOR ISLAND 1 :  -0.000432 MW
--------------------------------------------------------------------------
---
Summary of results
TOTAL REAL POWER GENERATION (CONVENTIONAL)   :    169.590 MW
TOTAL REAL POWER INJECTION (-ve LOAD)        :      0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :    22.579 MVAr
GENERATION p.f.                              :      0.991

TOTAL REAL POWER GENERATION (WIND)           :      0.000 MW
TOTAL REACT. POWER GENERATION (WIND)         :      0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR)          :      0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR)        :      0.000 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 TCSC REACTIVE DRAWL                    :      0.000 MVAr

TOTAL SPS REACTIVE DRAWL                     :      0.000 MVAr

TOTAL UPFC INJECTION                         :      0.000 MVAr

TOTAL SHUNT FACTS INJECTION                  :      0.000 MVAr
TOTAL SHUNT FACTS DRAWAL                     :      0.000 MVAr

TOTAL REAL POWER LOAD                        :    165.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.)           :      0.000 MW
TOTAL REACTIVE POWER LOAD                    :    40.000 MVAr
LOAD p.f.                                    :      0.972
TOTAL COMPENSATION AT LOADS                  :      0.000 MVAr
TOTAL HVDC REACTIVE POWER                    :      0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC)                :   4.586773 MW (4.586773+
0.000000)
PERCENTAGE REAL  LOSS (AC+DC)                :      2.705
TOTAL REACTIVE POWER  LOSS                   : -17.421289 MVAr
--------------------------------------------------------------------------
```

---**5.** Change (Increase / Decrease) Load Data.

Load	Bus. No	Initial MW	New MW
Load1	2	20	30

6. Execute Frequency dependent Load Flow Analysis with Flat Frequency Control
Report:-

```
------------------------------------------------------------------------
---
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   132.112   -2.027     0.000    0.000    0.000
#<
 2    South  1.0445  -2.83    47.566   30.000    30.000   15.000    0.000
 3     Lake  1.0219  -5.03     0.000    0.000    45.000   15.000    0.000
 4     Main  1.0211  -5.36     0.000    0.000    40.000    5.000    0.000
 5      Elm  1.0151  -6.19     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   90.941   -4.067    1.4722  -2.2272
85.9#
2  1    1    North   3     Lake   41.164    2.040   1.2232  -1.7500
38.9^
3  1    2    South   3     Lake   24.509    3.213   0.3464  -3.2314
24.5&
4  1    2    South   4     Main   27.786    2.704   0.4377  -2.9543
27.3^
5  1    2    South   5      Elm   54.746    7.244   1.1278   0.2012
52.9$
6  1    3    Lake    4     Main   19.104   -4.767   0.0363  -1.9781
19.3&
7  1    4    Main    5      Elm    6.415   -2.131   0.0317  -5.0875
6.9&
------------------------------------------------------------------------
---
! 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
```

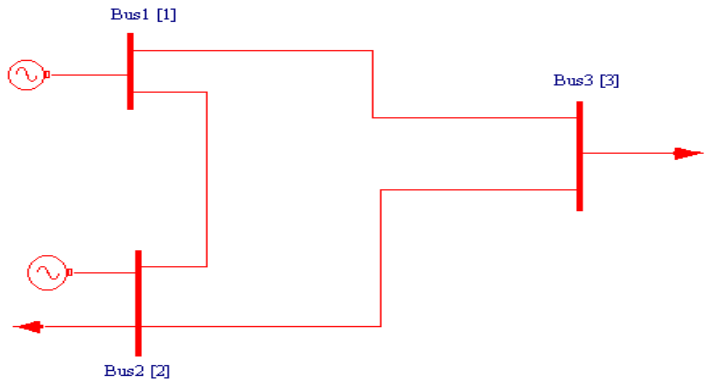
```
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    2
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    3
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
--------------------------------------------------------------------------
---
BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO
--------------------------------------------------------------------------
---
TOTAL AREA INTERCHANGE ERROR FOR ISLAND 1 :  10.087900 MW
--------------------------------------------------------------------------
---
Summary of results
TOTAL REAL POWER GENERATION (CONVENTIONAL)   :    179.678 MW
TOTAL REAL POWER INJECTION (-ve LOAD)        :      0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :     27.973 MVAr
GENERATION p.f.                              :      0.988

TOTAL REAL POWER GENERATION (WIND)           :      0.000 MW
TOTAL REACT. POWER GENERATION (WIND)         :      0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR)          :      0.000 MW

TOTAL REACT. POWER GENERATION (SOLAR)        :      0.000 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 TCSC REACTIVE DRAWL                    :      0.000 MVAr

TOTAL SPS REACTIVE DRAWL                     :      0.000 MVAr

TOTAL UPFC INJECTION                         :      0.000 MVAr

TOTAL SHUNT FACTS INJECTION                  :      0.000 MVAr
TOTAL SHUNT FACTS DRAWAL                     :      0.000 MVAr

TOTAL REAL POWER LOAD                        :    175.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.)           :      0.000 MW
TOTAL REACTIVE POWER LOAD                    :     45.000 MVAr
LOAD p.f.                                    :      0.968
TOTAL COMPENSATION AT LOADS                  :      0.000 MVAr
TOTAL HVDC REACTIVE POWER                    :      0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC)                :   4.675261 MW (  4.675261+
0.000000)
PERCENTAGE REAL  LOSS (AC+DC)                :      2.602
TOTAL REACTIVE POWER  LOSS                   :  -17.027382 MVAr
```

Observation:

To meet increased load demand of 10 MW at **BUS 2** with constant system frequency generation MW increases depending on the participation factors of generators.

1.9 Optimal Load Flow Analysis:

Figure shows a single line diagram of a 3 bus system with two generating units, three lines. Per-unit transmission line series impedances and shunt susceptances are given on 100 MVA base. Real power generation, real and reactive power loads in MW and MVAR are given in table Conduct the optimal load flow analysis.



Assume the base voltage for the bus as 11 kV and system frequency as 50 Hz.

Impedances and line charging for the sample system

Buscode	Admitance Ypq	Line charging Y'pq/2
1-2	1.47-j5.88	j0.15
1-3	2.94-j11.77	j0.07
2-3	2.75-j9.17	j0.04

Generation, loads and bus voltages for sample system

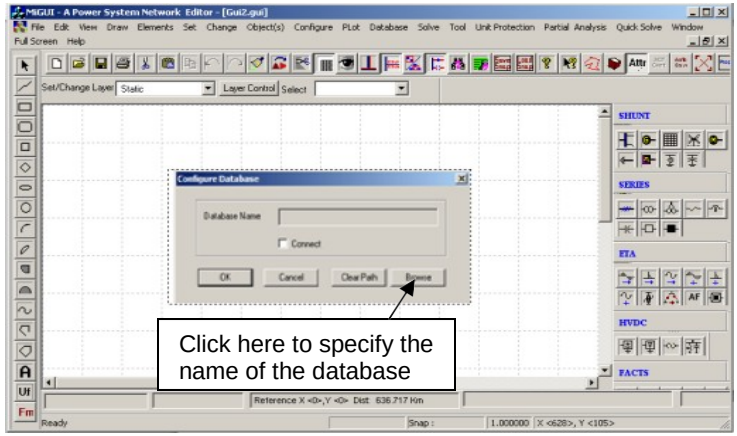
Table: 1.2					
Bus No	**Bus Voltage**	**Generation MW**	**Generation MVAR**	**Load MW**	**Load MVAR**
1	1.04+j0.0	0	0	0	0
2	1.02+j0.0	100	--	50	20
3	1.00+j0.0	0	0	250	150

Buscode	Inertia (H)	Xd'
1	160	0.1
2	3	0.3

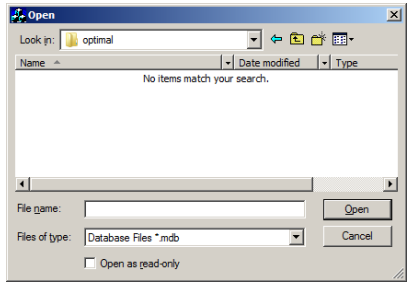
Procedure to enter the data for performing studies using MiP-PSCT.

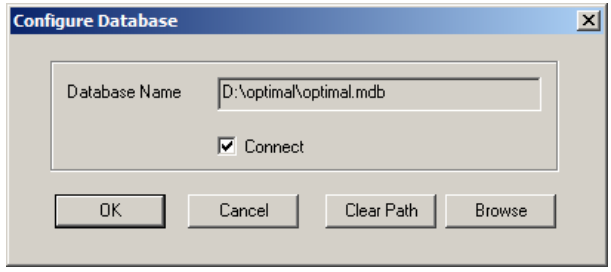
MiP-PSCT - Database Configuration

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.

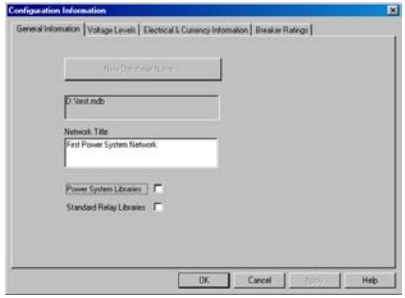


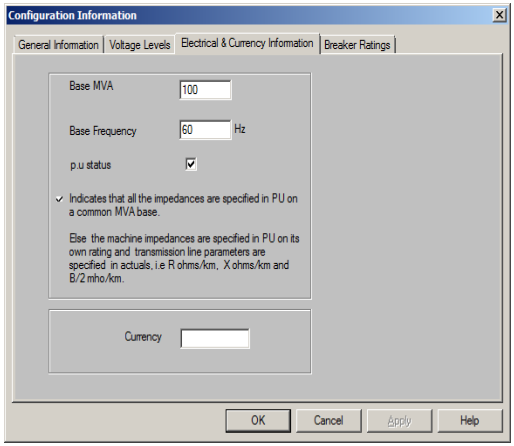


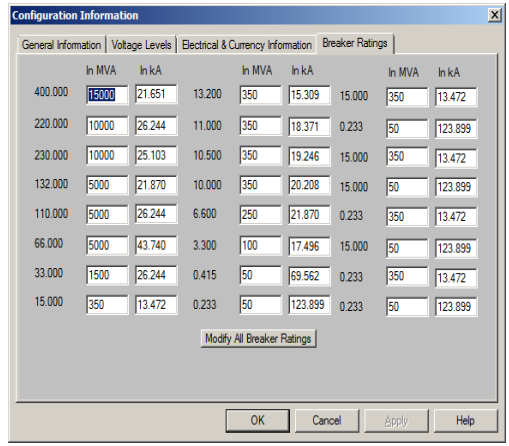
Note : Do not work in the MiP-PSCT directory

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.

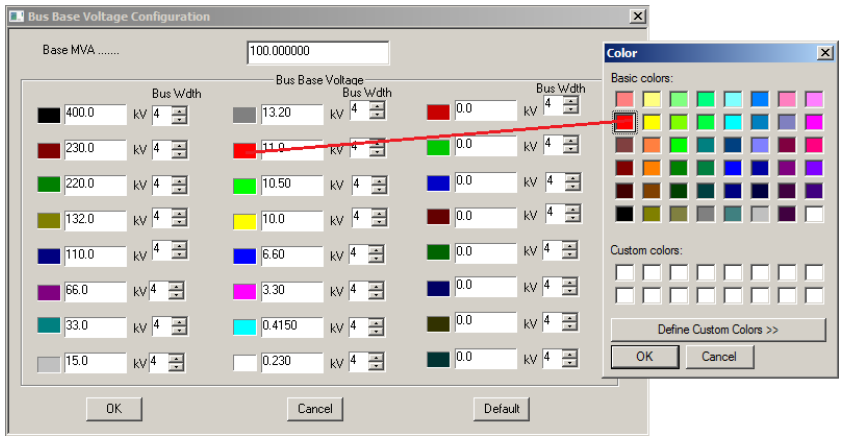






Bus Base Voltage Configuration

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



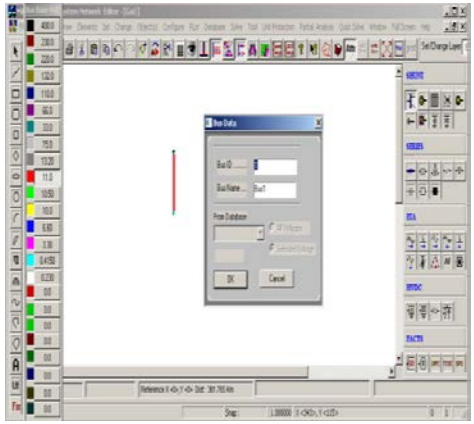
Procedure to Draw First Element - Bus

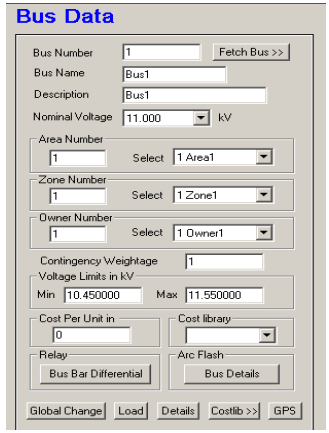
Click on **Bus** icon provided on power system tool bar. Draw a bus and a dialog appears prompting to give the Bus ID and Bus Name. Click OK. Database manager with corresponding **Bus Data** form will appear. Modify the Area number, Zone number and Contingency Weightage data if it is other than the default values. If this data is not

furnished, keep the default values. Usually the minimum and maximum voltage ratings are ± 5% of the rated voltage. If these ratings are other than this, modify these fields. Otherwise keep the default values.

Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name field and the bus

description field can be used to abbreviate the bus name. For example let us say the bus name is **Northeast**, then bus name can be given as NE and the bus description field can be **North East.**

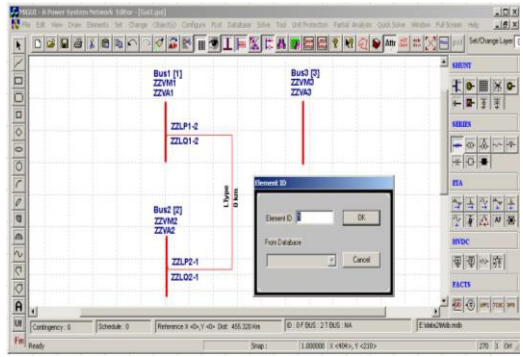




After entering data click **Save** 🖫 which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

Bus Number	Bus Name	Nominal Voltage (kV)
2	Bus2	11
3	Bus3	11

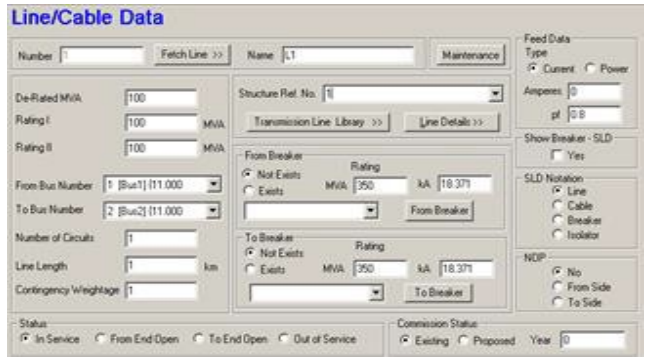
Note: Since the voltages are mentioned in pu, any kV can be assumed. So the base voltage is chosen as 11kV.



Procedure to Draw Transmission Line

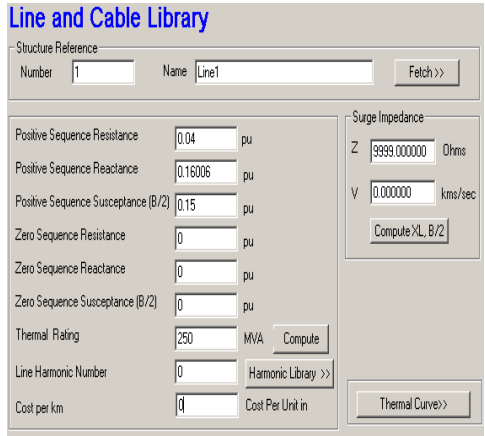
Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus double clicking LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element ID** 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

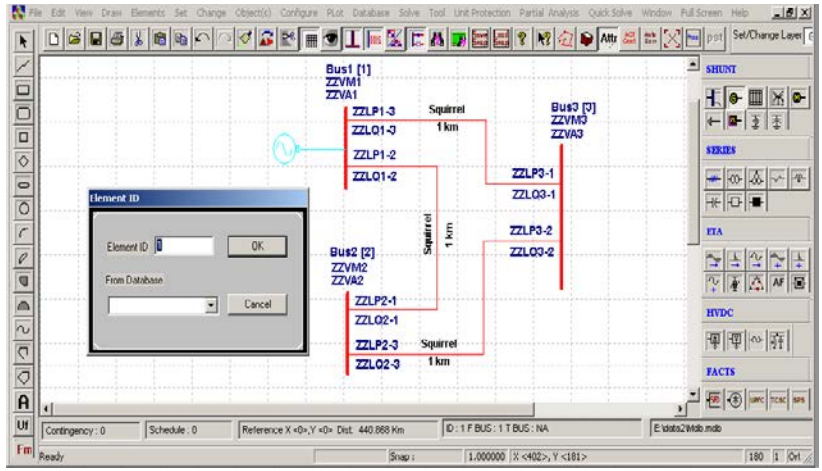
Transmission Line Library Data

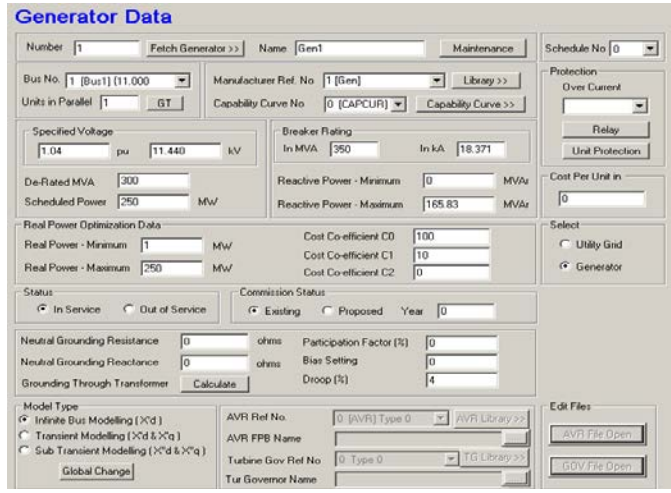
Buscode	Admitance Ypq	Line charging Y'pq/2
1-2	1.47-j5.88	j0.15
1-3	2.94-j11.77	j0.07
2-3	2.75-j9.17	j0.04

*** Thermal Rating 250MVA**

Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Connect it to bus 1 by clicking the LMB on **Bus 1**. The **Element ID** dialog will appear. Enter ID number and click OK. Database with corresponding **Generator Data** form will appear. Enter details as shown below.



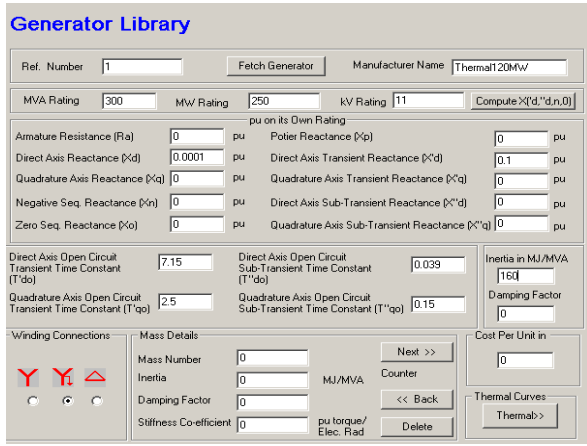


Since generator at bus 1 is mention as slack bus, only specified voltage will have importance.

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

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

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



After entering data **Save** 🖫 and close**.** In **Generator Data** form click **Save** 🖫**. Network Editor** Screen will be invoked. Similarly connect generator 2 at bus 2. Enter its details as given in the following table.

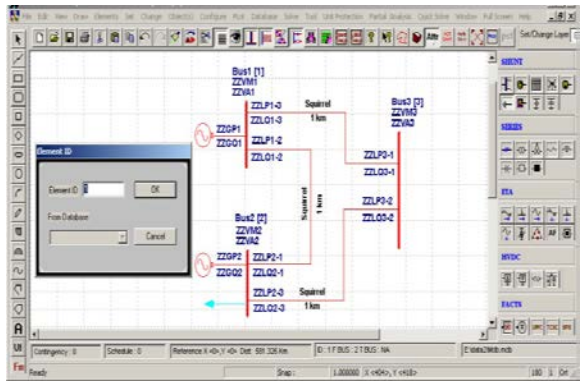
Generator 2 Element Data	
Manufacturer Ref.No	2
No. of Units parallel	1
Specified voltage	11
Derated MVA	250
Scheduled Power	100
Real Power Min.	0
Real Power Max.	200
Reactive Power Min	70
Reactive Power Max	70

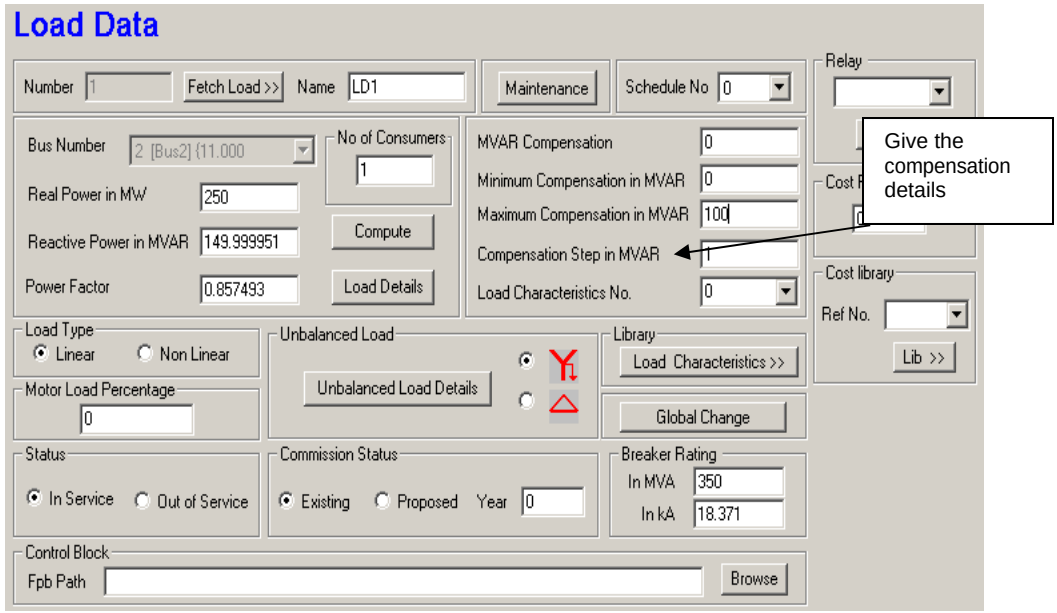
Note: *Since in the data at bus 2, it is mentioned the Q generation as 30 MVAR. It means that generator has to generate 30 MVAR compulsorily. So mention Q min and Q max data as same (70) for this particular case. Thus bus has become PQ bus.*

Generator 2 Library Data	
MVA Rating	250
MW rating	200
kV rating	11
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.



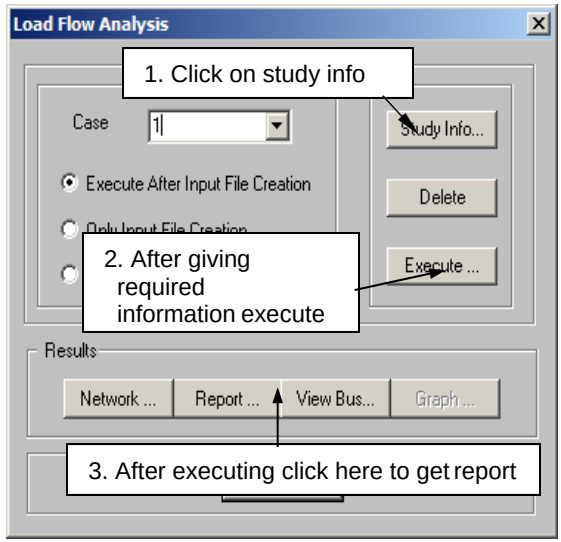


Connect other load to buses 3. Enter other load details as given in the following table.

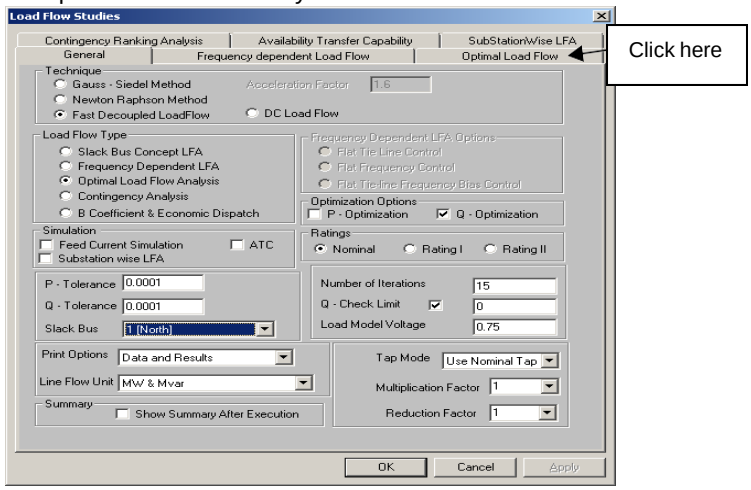
Load Details			
Load No	Bus No	MW	MVAR
2	3	50	20

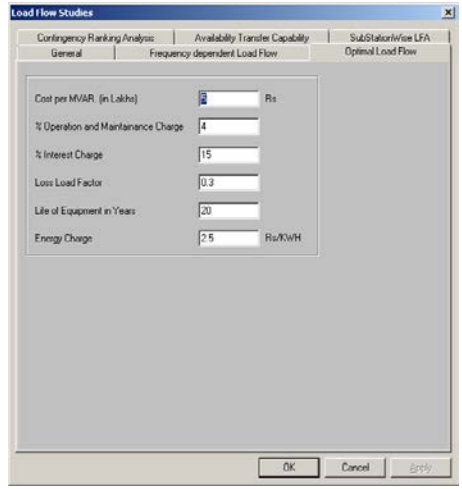
Solve Load Flow Analysis

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



When **Study Info** button is clicked, following dialog will open. Select Fast Decoupled Load Flow and enable Optimal Load Flow Analysis





Enter all the details and click ok. Then execute.

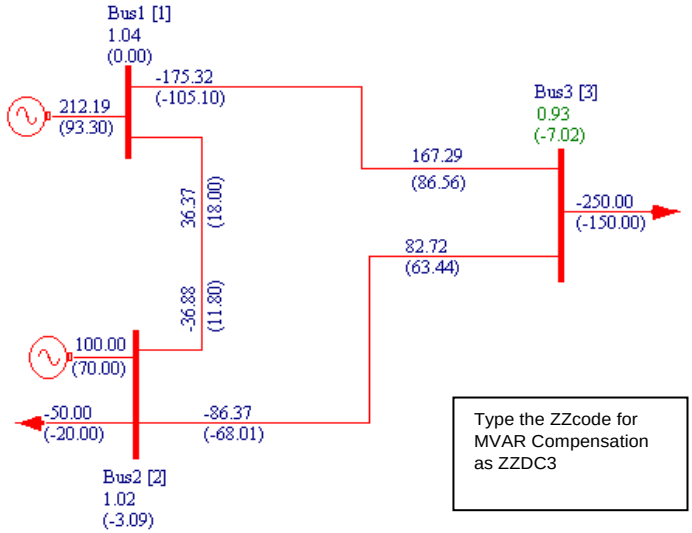
Report

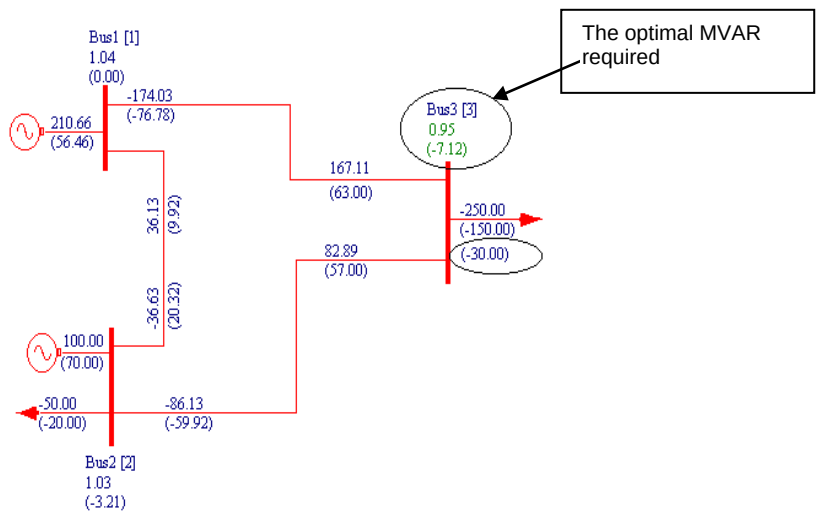
```
-------------------------------------------------------------------------
---
#NO BUS-NO BUS-NAME ORG-COMP ORG-VOLT FINAL-COMP FINAL-VOLT
                       MVAr     p.u.       MVAr       p.u.
--- ------ -------- -------- -------- ---------- ----------
  1      3     Bus3    0.000    0.927     30.000      0.949
  2      2     Bus2    0.000    1.020      0.000      1.034
-------------------------------------------------------------------------
---
ADDITIONAL COMPENSATION PROVIDED IN THE SYSTEM :     30.000 MVAr
ORIGINAL LOSS IN THE SYSTEM                    :     12.190 MW
CURRENT  LOSS IN THE SYSTEM                    :     10.657 MW
REDUCTION IN LOSS IN THE SYSTEM                :      1.533 MW
ANNUAL  INCOME  DUE  TO  REDUCTION  IN  LOSS    :    10072539  Rs
ANNUAL EXPENSE TOWARDS O&M                     :     600000 Rs
ANNUAL SAVING DUE TO COMPENSATION              :    9472539 Rs
PRESENT WORTH OF SAVING                        :   59291763 Rs
TOTAL  INVESTMENT  ON ADDITIONAL  CAPACITOR     :   15000000 Rs
NET PRESENT WORTH (SAVING)                     :   44291763 Rs
-------------------------------------------------------------------------
---
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   1.0400    0.00    210.657    56.462       0.000      0.000
0.000
  2       Bus2   1.0338   -3.21    100.000    70.000      50.000     20.000
0.000
  3       Bus3   0.9490   -7.12       0.000      0.000    250.000    150.000
30.000 @
------------------------------------------------------------------------
---
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    1
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    36.629   -20.323    0.5024 -30.2462
40.3^
 2   1     3    Bus3    1       Bus1 -167.112   -62.996    6.9160   13.7890
73.2$
 3   1    3    Bus3     2       Bus2   -82.888   -57.004    3.2388    2.9185
40.6^
------------------------------------------------------------------------
---
! NUMBER OF LINES LOADED BEYOND  125%          :    0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    0
# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    0
$ 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% :    0
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
------------------------------------------------------------------------
---
BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO
------------------------------------------------------------------------
---
ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  60.00000           1       1
------------------------------------------------------------------------
---
Summary of results
TOTAL REAL POWER GENERATION (CONVENTIONAL)   :    310.657 MW
TOTAL REAL POWER INJECTION (-ve LOAD)        :      0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :    126.462 MVAr
```

```
GENERATION p.f.                          :       0.926

TOTAL REAL POWER GENERATION (WIND)       :       0.000 MW
TOTAL REACT. POWER GENERATION (WIND)     :       0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR)      :       0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR)    :       0.000 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 TCSC REACTIVE DRAWL                :       0.000 MVAr

TOTAL SPS REACTIVE DRAWL                 :       0.000 MVAr

TOTAL UPFC INJECTION                     :       0.000 MVAr

TOTAL SHUNT FACTS INJECTION              :       0.000 MVAr
TOTAL SHUNT FACTS DRAWAL                 :       0.000 MVAr

TOTAL REAL POWER LOAD                    :     300.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.)       :       0.000 MW
TOTAL REACTIVE POWER LOAD                :     170.000 MVAr
LOAD p.f.                                :       0.870
TOTAL COMPENSATION AT LOADS              :      30.000 MVAr
TOTAL HVDC REACTIVE POWER                :       0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC)             :  10.657196 MW ( 10.657196+
0.000000)
PERCENTAGE REAL  LOSS (AC+DC)            :       3.431
TOTAL REACTIVE POWER  LOSS               : -13.538651 MVAr
```

The load flow results plotted before and after the Q-compensation (MVAR) is shown below.

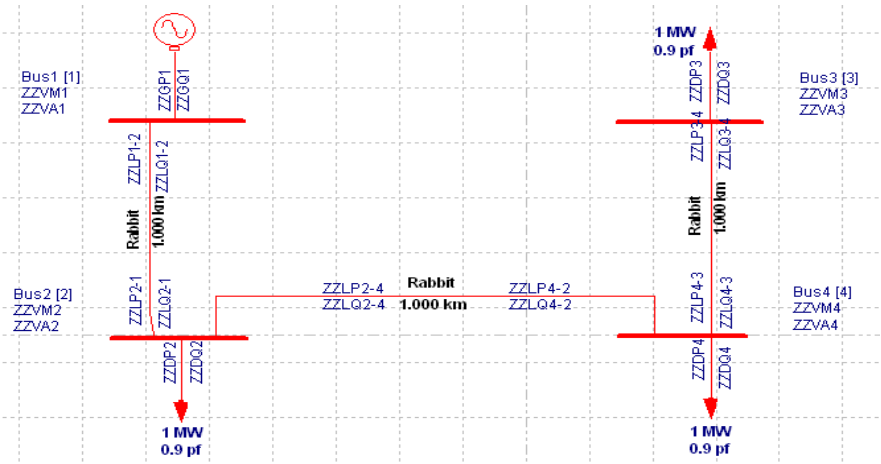




1.10 Feed Current Simulation

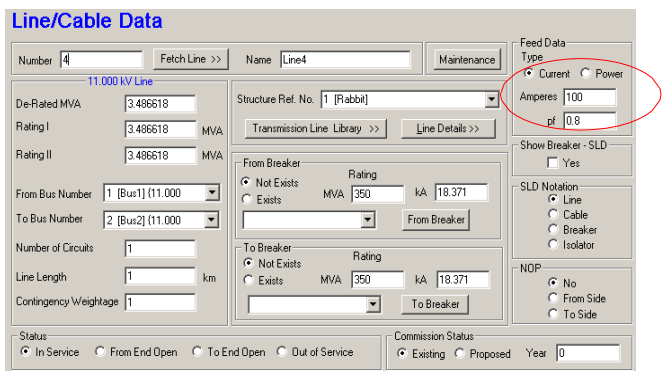
This simulation is for distribution network
Procedure for executing feed current simulation is given below for a sample network

1. Prepare GUI and database for the following 11 kV network

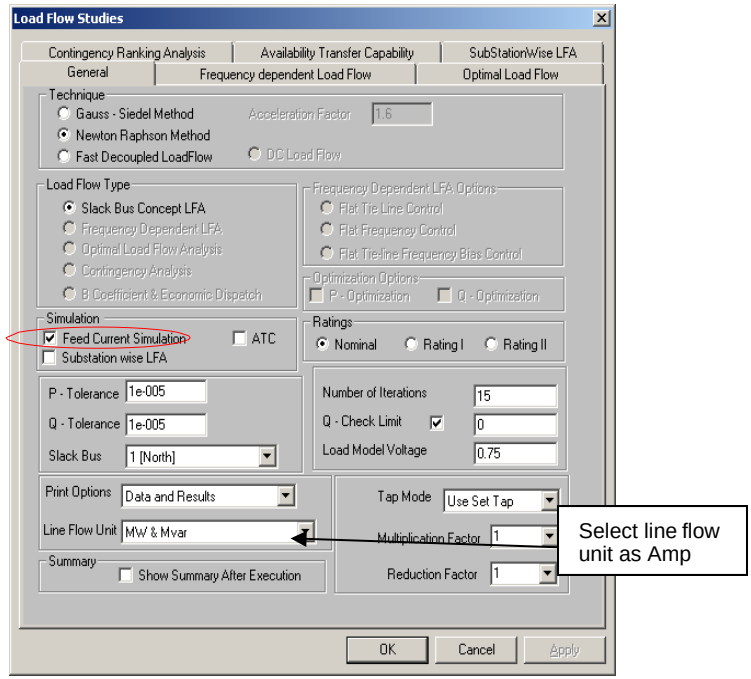


2. Execute normal load flow and plot the results on GUI as shown
3. Enter feed current data for the feeder 1-2 which is as shown below.

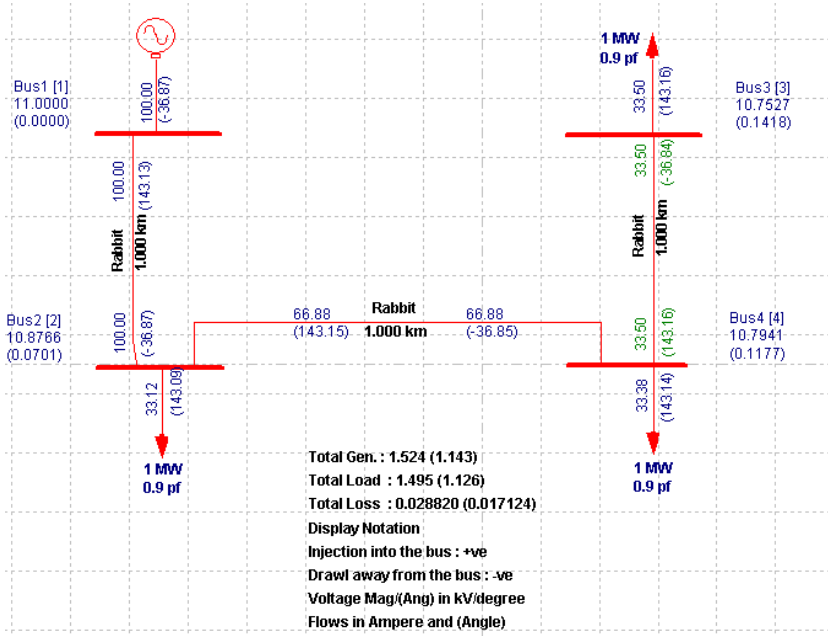
Feed Data : Current = 100 A and Power factor = 0.8



4. In Study info of Load flow analysis dialog select Feed current simulation option



5. Execute load flow analysis and plot the results on GUI. In plot LFA window select the power flow display option as Amp-Angle. Following diagram shows feed current simulation results plotted on SLD.


Bus1 [1]
11.0000
(0.0000)
100.00
(-36.87)
100.00
(143.13)
Rabbit
1.000 km
Bus2 [2]
10.8766
(0.0701)
100.00
(-36.87)
33.12
(143.09)
1 MW
0.9 pf
66.88
(143.15)
Rabbit
1.000 km
66.88
(-36.85)
1 MW
0.9 pf
33.50
(143.16)
Bus3 [3]
10.7527
(0.1418)
33.50
(-36.84)
Rabbit
1.000 km
33.50
(143.16)
Bus4 [4]
10.7941
(0.1177)
33.38
(143.14)
1 MW
0.9 pf
Total Gen. : 1.524 (1.143)
Total Load : 1.495 (1.126)
Total Loss : 0.028820 (0.017124)
Display Notation
Injection into the bus : +ve
Drawl away from the bus : -ve
Voltage Mag/(Ang) in kV/degree
Flows in Ampere and (Angle)

Report:

```
-------------------------------------------------------------------------
number 3  pspec 1.524205 qspece 1.143154 psum 3.000000 qsum 1.452966
 i 1 pmult force 0.508068 qmult force 0.786772
 k 2 after pload qload 0.050807 0.038105
 k 3 after pload qload 0.050807 0.038105
 k 4 after pload qload 0.050807 0.038105
Iteration count 0 maxp 0.050807 maxq 0.038105
-------------------------------------------------------------------------
--
Iteration count 1 maxp 0.001077 maxq 0.000963
-------------------------------------------------------------------------
--
Iteration count 2 maxp 0.000000 maxq 0.000001
-------------------------------------------------------------------------
--
Iteration count 3 maxp 0.000000 maxq 0.000000

number 3  pspec 1.524205 qspece 1.143154 psum 1.554081 qsum 1.160905
 i 1 pmult force 0.980776 qmult force 0.984709
 k 2 after pload qload 0.049830 0.037522
 k 3 after pload qload 0.049830 0.037522
 k 4 after pload qload 0.049830 0.037522
Iteration count 0 maxp 0.000977 maxq 0.000583
-------------------------------------------------------------------------
--
Iteration count 1 maxp 0.000000 maxq 0.000000
-------------------------------------------------------------------------
--

Iteration count 2 maxp 0.000000 maxq 0.000000
number 3  pspec 1.524205 qspece 1.143154 psum 1.523704 qsum 1.142786
 i 1 pmult force 1.000329 qmult force 1.000321
 k 2 after pload qload 0.049846 0.037535
 k 3 after pload qload 0.049846 0.037535
 k 4 after pload qload 0.049846 0.037535
Iteration count 0 maxp 0.000016 maxq 0.000012
-------------------------------------------------------------------------
--
Iteration count 1 maxp 0.000000 maxq 0.000000
-------------------------------------------------------------------------
--
Iteration count 2 maxp 0.000000 maxq 0.000000
-------------------------------------------------------------------------
--
Line-number From-Bus   Name     To-Bus     Name     MW         MVAR
----------- ---------- -------- ---------- -------- ---------- -------
--
     3          1     Bus1          2     Bus2      1.524      1.143
-------------------------------------------------------------------------
--
```

```
    BUS VOLTAGES AND POWERS

    NODE FROM     V-MAG   ANGLE       AMPS      ANG-DEG      AMPS      ANG-DEG
    AMPS
    NO.   NAME     P.U.     DEGREE      GEN         GEN          LOAD       LOAD
    COMP
    ---- --------  ------ ------  -------- --------  -------- -------- ---
    --
    1       Bus1   1.0000    0.00    100.001   -36.870       0.000   -90.000
    0.000
    2       Bus2   0.9888    0.07       0.000   -90.000      33.122   -36.910
    0.000
    3       Bus3   0.9775    0.14       0.000   -90.000      33.503   -36.838
    0.000
    4       Bus4   0.9813    0.12       0.000   -90.000      33.375   -36.862
    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    AMPS   ANG-DEG         MW        MVAR
    LOADING
    ---- -- ---- -------- ---- -------- -------- -------- -------- -------
    -
    1     1    2    Bus2   4   Bus4     66.879   -36.850    0.0083     0.0049
    36.5^
    2     1    3    Bus3   4   Bus4     33.503   143.162    0.0021     0.0012
18.3&
    3     1    1    Bus1   2   Bus2    100.001   -36.870    0.0185     0.0110
    54.6$
    ------------------------------------------------------------------------
    --
    ! NUMBER OF LINES LOADED BEYOND  125%          :    0
    @ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    0
    # NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    0
    $ NUMBER OF LINES LOADED BETWEEN  50% AND  75% :    1
    ^ 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
    ------------------------------------------------------------------------
    --
    ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
    ------ --------- ----------- ------------
         1  50.00000           1       0
```

```
Summary of results
TOTAL REAL POWER GENERATION   :      1.524 MW
TOTAL REAL POWER INJECT,-ve L :      0.000 MW
TOTAL REACT. POWER GENERATION :      1.143 MVAR
GENERATION pf                 :      0.800

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 TCSC REACTIVE DRAWL     :      0.000 MVAR

TOTAL SPS REACTIVE DRAWL      :      0.000 MVAR

TOTAL UPFC FACTS. INJECTION   :    0.0000 MVAR

TOTAL SHUNT FACTS.INJECTION   :      0.000 MVAR
TOTAL SHUNT FACTS.DRAWAL      :      0.000 MVAR

TOTAL REAL POWER LOAD         :      1.495 MW
TOTAL REAL POWER DRAWAL -ve g :      0.000 MW
TOTAL REACTIVE POWER LOAD     :      1.126 MVAR
LOAD pf                       :      0.799
TOTAL COMPENSATION AT LOADS   :      0.000 MVAR
TOTAL HVDC REACTIVE POWER     :      0.000 MVAR

TOTAL REAL POWER LOSS (AC+DC) :   0.028820 MW (  0.028820+  0.000000)
PERCENTAGE REAL  LOSS (AC+DC) :      1.891
TOTAL REACTIVE POWER  LOSS    :   0.017124 MVAR
------------------------------------------------------------------------
```

Feed current simulation will work with all type of load flow. For the above sample it gives better results with NR method. For feed current only one feeder will be considered and below that feeder there may be a ring circuit.

Table of Contents

2. How to solve Short Circuit

Sample 6 bus system

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

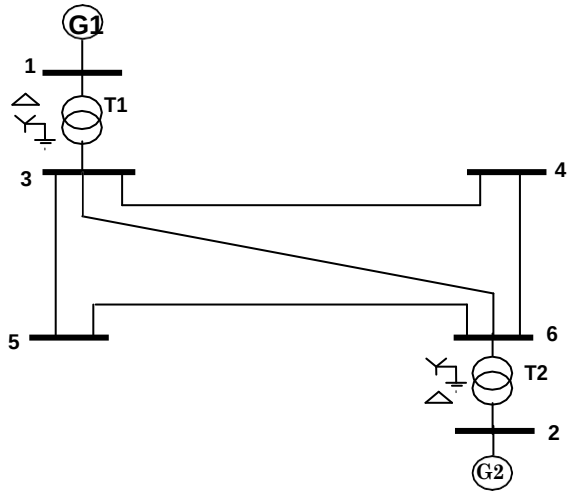


table.

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

Table 1: Transmission Line Data

Bus - code	Impedance Zpq	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 = 100 MVA, 11 kV with X'_d = 10 %

Transformer details

T1 = T2 = 11/110 kV, 100 MVA, leakage reactance = x = 5 %

** All impedances are on 100 MVA base

MiP-PSCT Data Interpretation:

SOLUTION:

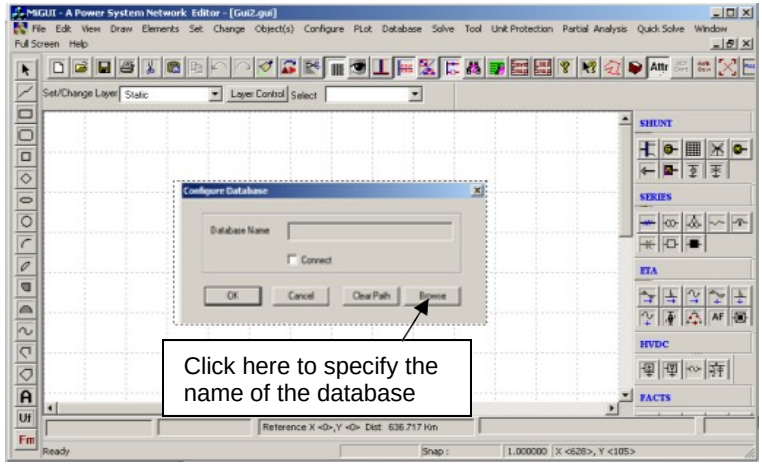
In transmission line data, elements 3 – 4 & 5 – 6 have common parameters. Elements 3 - 5 & 4 – 6 have common parameters. Therefore 3 libraries are required for transmission line.

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

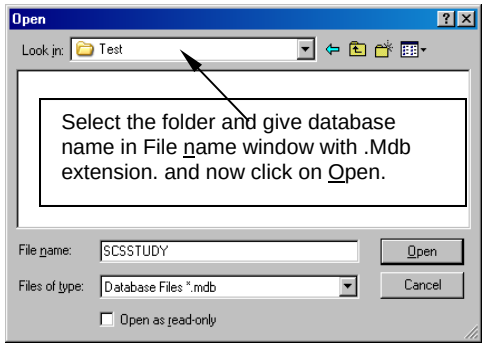
Procedure to enter the data for performing studies using MiP-PSCT

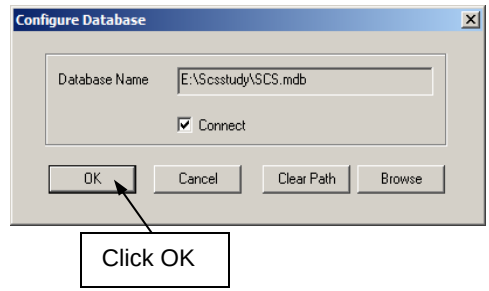
MiP-PSCT - Database Configuration

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

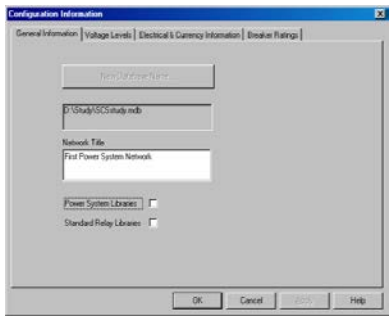


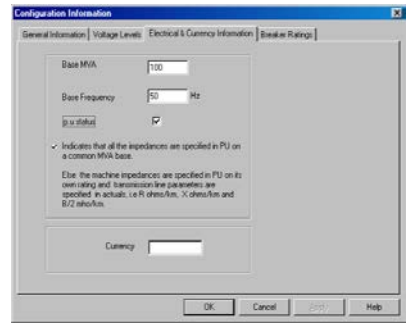
Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click Open button after entering the desired database name. Configure Database dialog will appear with path chosen.



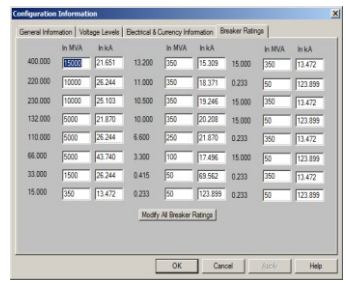


Click on **OK** button in the **Configure database** dialog, the following dialog appears.





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.

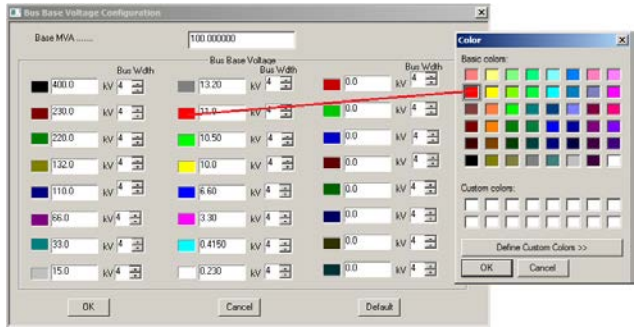


If Libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab. Since the impedances are given on 100 MVA base, check the pu status. Enter the Base MVA and Base frequency as shown below. Click **Breaker Ratings** tab. If the data is furnished, 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

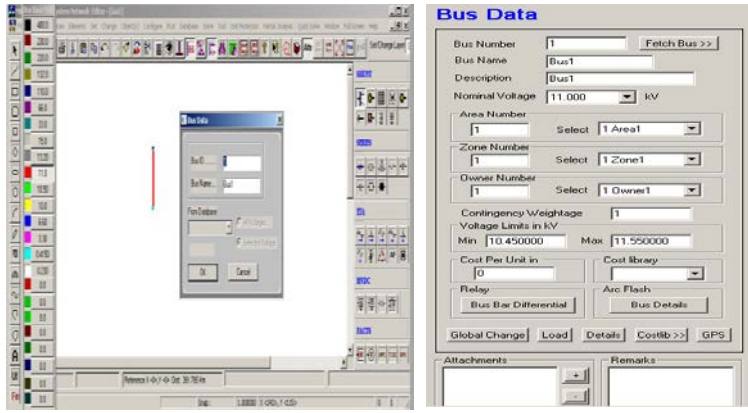
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage.** Dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

2.1 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.**

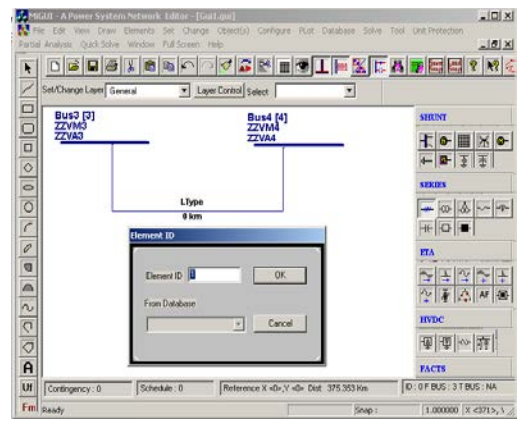


After entering data click **Save** 🖫**,** which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

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

2.2 Procedure to Draw Transmission Line

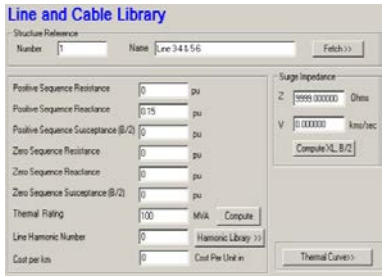
Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus, double click LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element ID** 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.

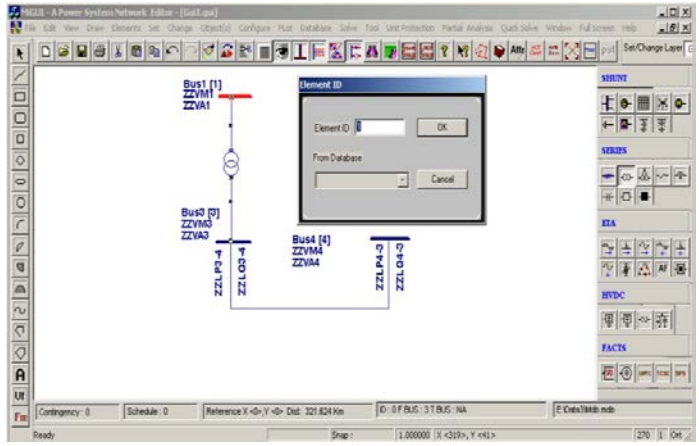


Transmission Line Element Data					
Line Number	1	2	3	4	5
Line Name	Line3-4	Line3-5	Line3-6	Line4-6	Line5-6
De-Rated MVA	100	100	100	100	100
No. of Circuits	1	1	1	1	1
From Bus No.	3	3	3	4	5
To Bus No.	4	5	6	6	6
Line Length in km	1	1	1	1	1
From Breaker Rating in kA	5000	5000	5000	5000	5000
To Breaker Rating in kA	5000	5000	5000	5000	5000
Structure Ref No.	**1**	**2**	**3**	**2**	**1**

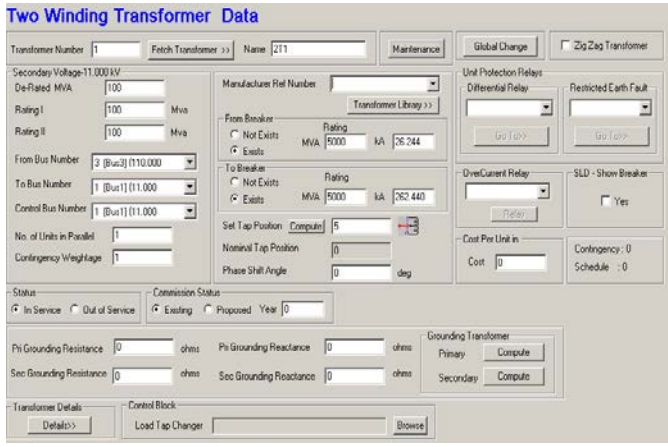
Transmission Line Library Data			
Structure Ref. No.	1	2	3
Structure Ref. Name	Line3-4 & 5-6	Line3-5 & 4-6	Line3-6
Positive Sequence Resistance in pu	0	0	0
Positive Sequence Reactance in pu	0.15	0.1	0.2
Positive Sequence Susceptance in pu	0	0	0
Thermal Rating in MVA	100	100	100

2.3 Procedure to Draw Transformer

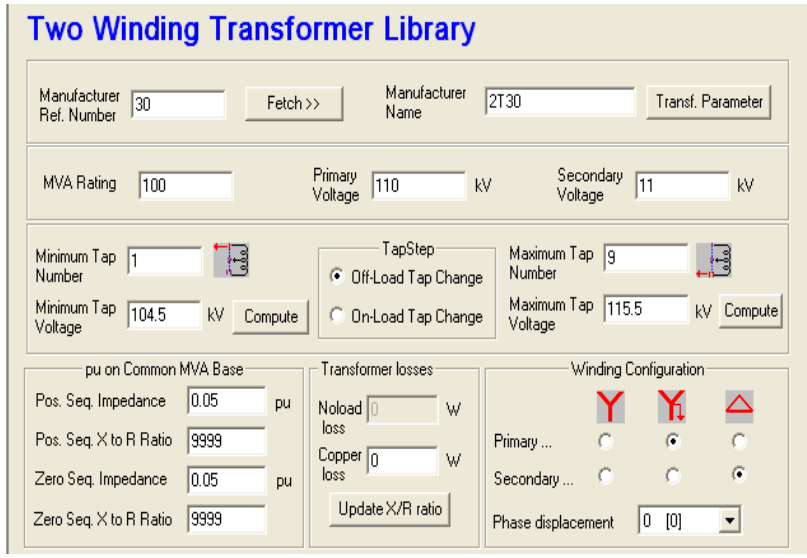
Click on **Two Winding Transformer** icon provided on power system tool bar. To draw the transformer click in between two buses and to connect to the from bus, double click LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element 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.

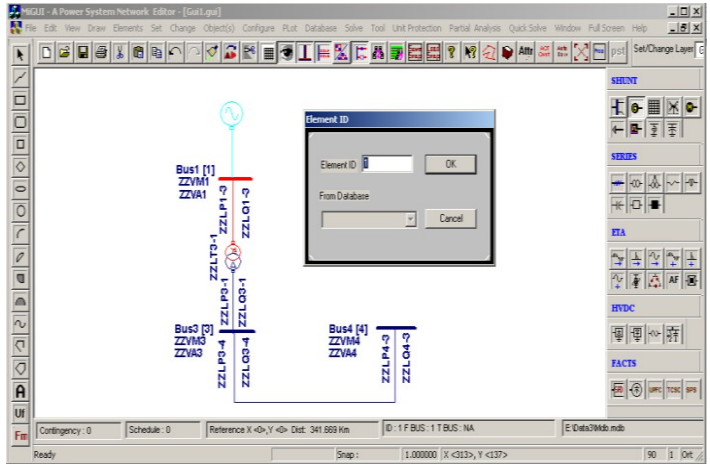


Transformer element data form will appear. Click **Save** 🖫 button, which invokes network editor. In the similar way enter other transformer details.

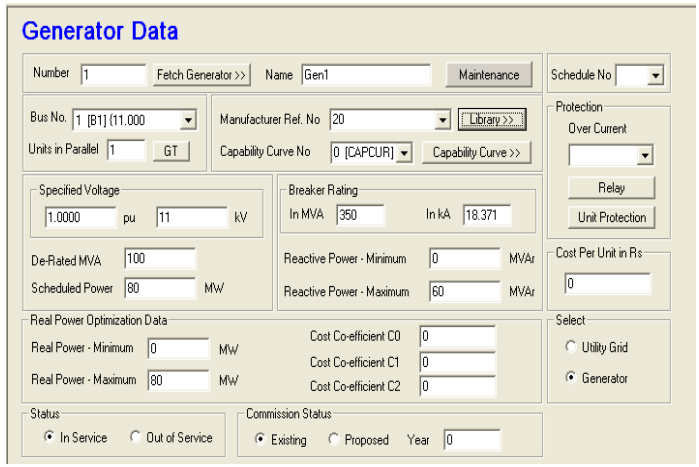
2nd Transformer details	
Transformer Number	2
Transformer Name	2T2
From Bus Number	6
To Bus Number	2
Control Bus Number	2
Number of Units in Parallel	1
Manufacturer ref. Number	30
De Rated MVA	100
From Breaker Rating in kA	5000
To Breaker Rating in kA	350
Nominal Tap Position	5

2.4 Procedure to Draw Generator

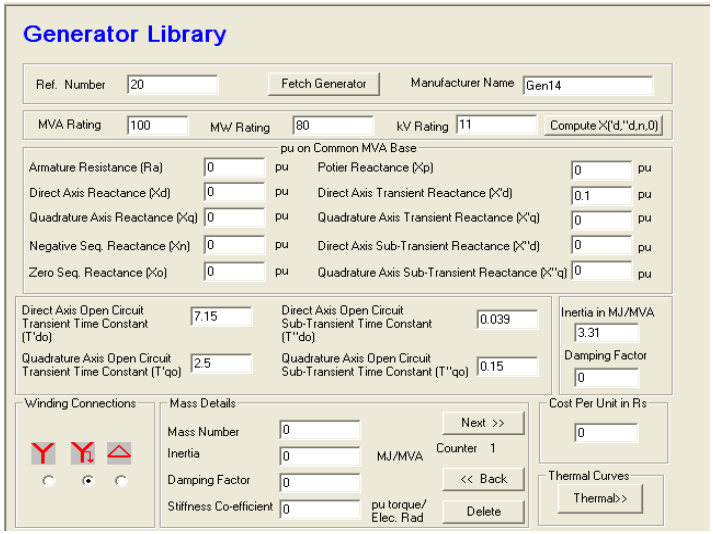
Click on **Generator** icon provided on power system tool bar. Draw the generator by clicking LMB (Left Mouse Button) on the **Bus1**. **Element ID** dialog will appear. Click **OK**.



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.

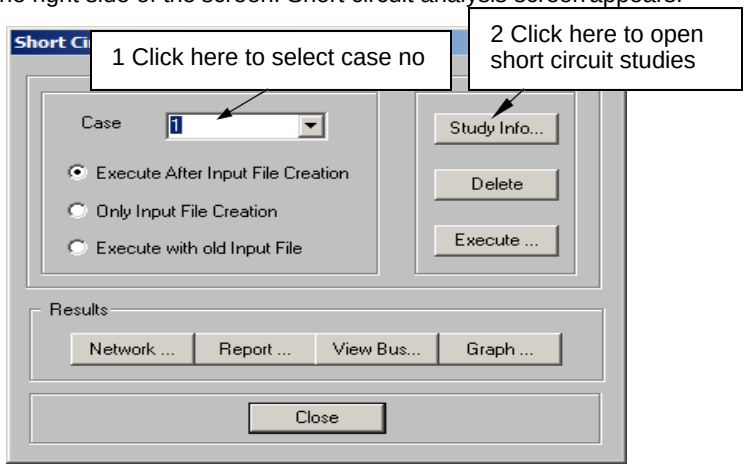


Save 🖫 and **Close** the library screen. Generator data screen will be reopened. Click **Save** 🖫 button, which invokes Network Editor. Connect another generator to Bus 2. Enter its details as given in the following table.

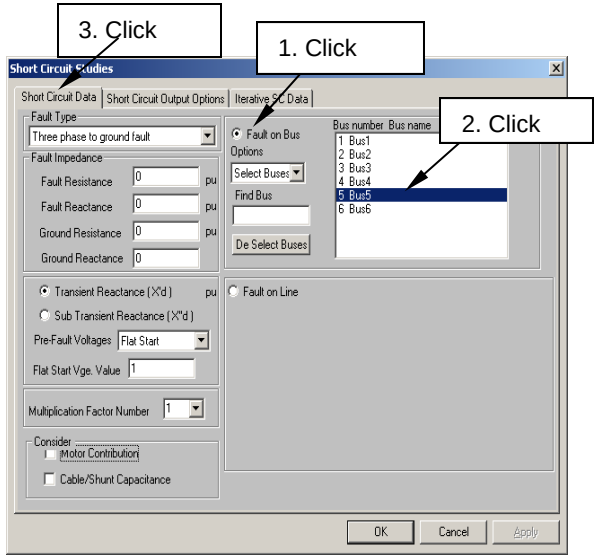
Name	GEN-2
Bus Number	2
Manufacturer Ref. Number	20
Number of Generators in Parallel	1
Capability Curve Number	0
De-Rated MVA	100
Specified Voltage in kV	11
Scheduled Power in MW	80
Reactive Power Minimum in MVAR	0
Reactive Power Maximum in MVAR	60
Breaker Rating in kA	350
Type of Modeling	Infinite

2.5 Solve Short Circuit Studies

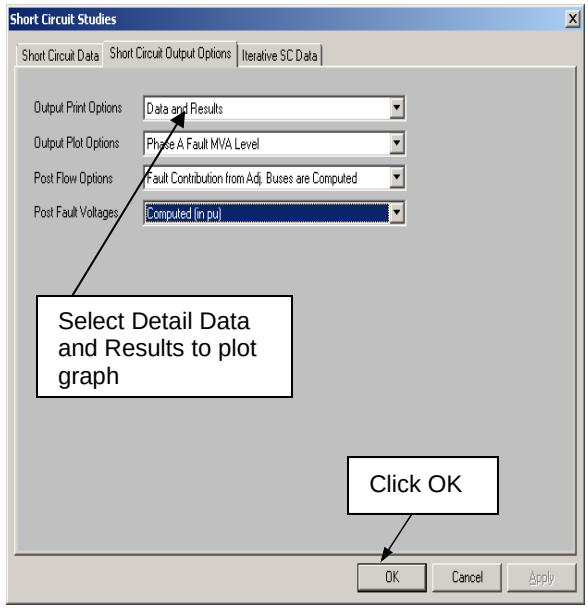
Choose menu option **Solve → Short Circuit Analysis** or click on **SCS** button on the toolbar on the right side of the screen. Short circuit analysis screen appears.



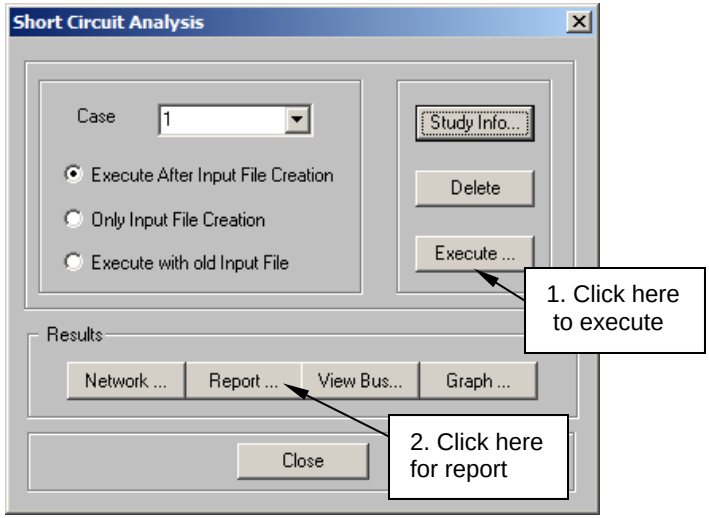
Study Information.



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.



2.6 Part of the Report is shown below

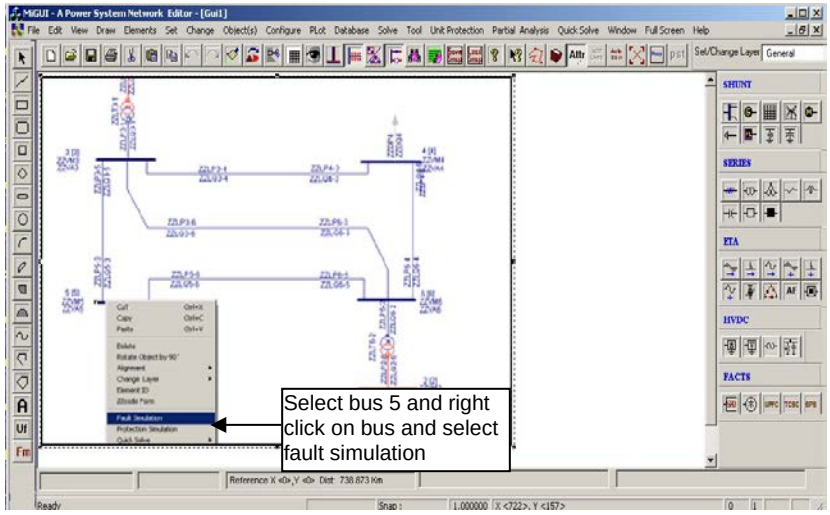
```
--------------------------------------------------------------------------------
FAULT AT BUS NUMBER     5 : NAME     Bus5
     CURRENT (AMPS/DEGREE)                        FAULT MVA
 SEQUENCE* (1,2,0)    PHASE (A,B,C)      SEQUENCE (1,2,0)    PHASE (A,B,C)
MAGNITUDE   ANGLE  MAGNITUDE   ANGLE        MAGNITUDE         MAGNITUDE
--------- ------- --------- -------        ---------         ---------
     3871  -89.47       3871  -89.47             738               738
        0  -90.00       3871  150.53               0               738
        0  -90.00       3871   30.53               0               738
R/X RATIO OF THE SHORT CIRCUIT PATH       :  0.0092
PEAK ASYMMETRICAL SHORT-CIRCUIT CURRENT :    10840 AMPS
PASCC = k x sqrt(2) x If , k =  1.9801
```

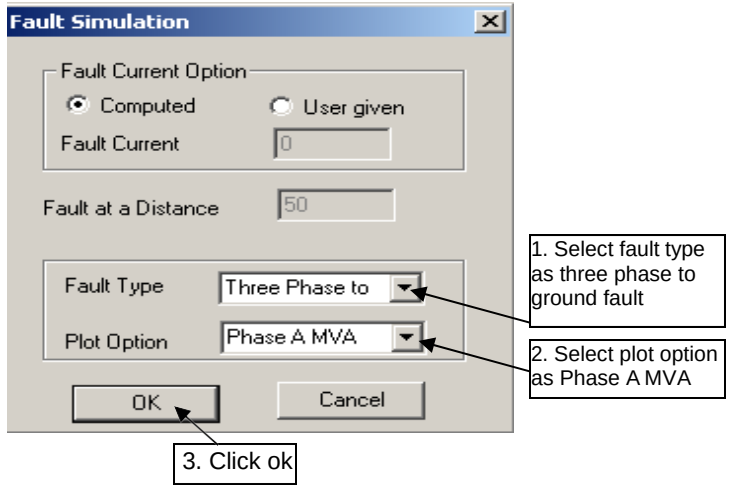
Sequence* (1.2,0) : Represents Positive , negative and zero sequence currents

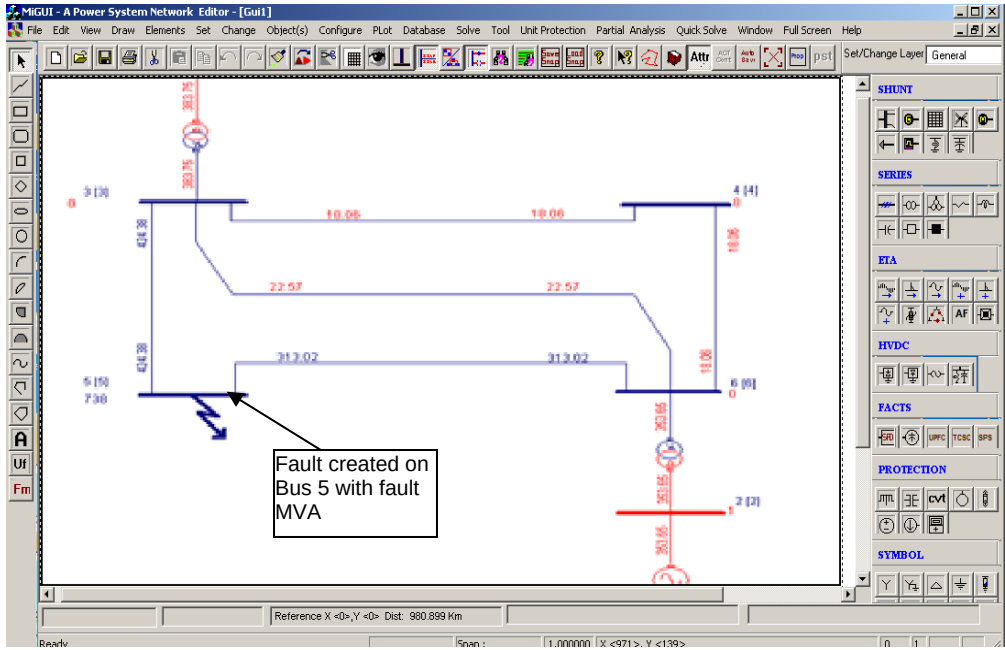
k=1.9801: explain

2.7 Procedure to execute fault simulation:

1. Select bus 5 and right click on bus as shown below
2. Select fault simulation and select fault type as three phase to ground fault
3. Select plot option as Phase A MVA and click ok
4. Fault symbol is created on GUI and result is also plotted automatically

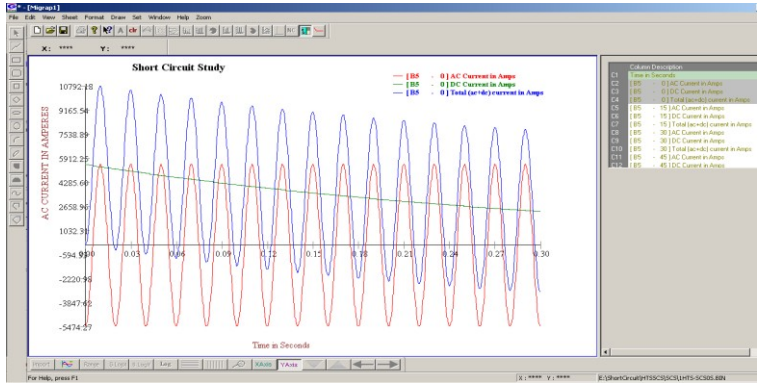



Fault Simulation
Fault Current Option
Computed
User given
Fault Current
0
Fault at a Distance
50
Fault Type
Three Phase to
Plot Option
Phase A MVA
OK
Cancel
1. Select fault type as three phase to ground fault
2. Select plot option as Phase A MVA
3. Click ok


MiGUI - A Power System Network Editor - [Gui1]
SHUNT
SERIES
ETA
HVDC
FACTS
PROTECTION
SYMBOL
Fault created on Bus 5 with fault MVA

Procedure to Plot Short Circuit Current Envelope:

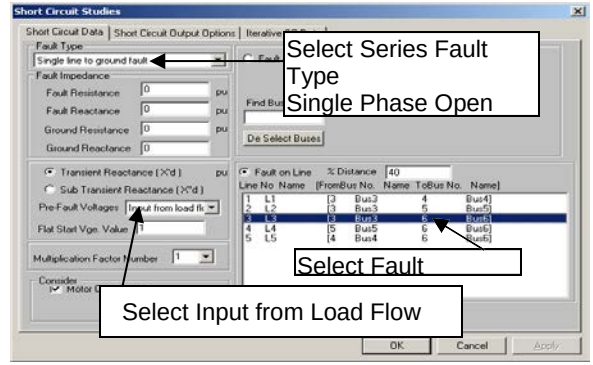
1. Click on Graph Button of Short Circuit Analysis Dialog Box



2.8 Procedure to Simulate open conductor faults:-

To perform open-conductor fault –

- Run a load flow study.
- In short circuit analysis info, select one phase open fault or two phase open fault.
- Select the line for open conductor fault.
- Select pre-fault voltages option as **input from load flow** and then execute short circuit studies.
- Select Solve→**Short Circuit Analysis**



Report: -

```
FAULT AT BUS NUMBER     3 : NAME       B3
      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
--------- -------  --------- -------          ---------          ---------
       95 -174.28          0    7.13             18.19               0.00
       72    5.78        149   82.09             13.72              28.41
       23    5.53        149  -70.62              4.47              28.46
-------------------------------------------------------------------------------
------
```

2.9 Quick Solve->Short circuit Analysis (Shortcut method to perform Short circuit analysis)

Go to **Quick Solve** menu →select **Short Circuit Study.** Short circuit analysis is executed and automatically results are plotted on GUI.

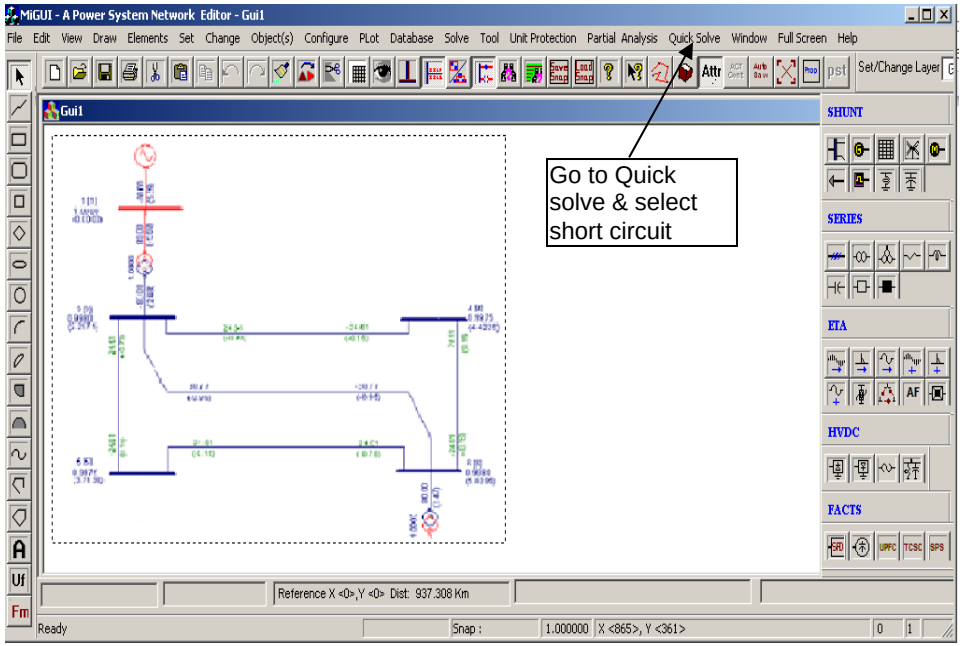
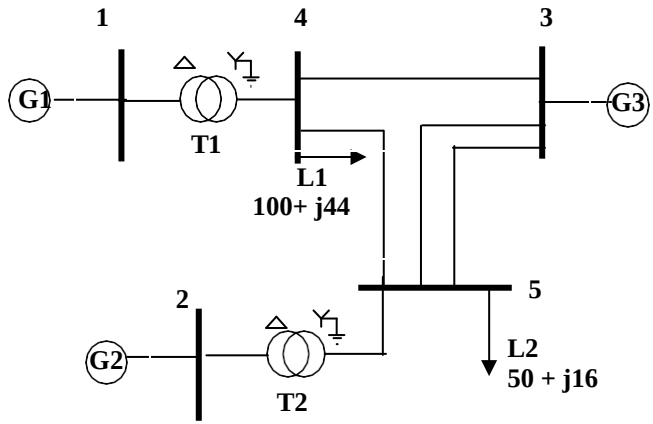


Table of Contents

3. How to solve Transient Stability

Figure shows a single line diagram of a 5-bus system with three generating units, four lines and two transformers and two loads. Per-unit transmission line series impedances and shunt susceptances are given on 100 MVA base, generator's transient reactance and transformer leakage reactances are given in the accompanying table.



Values given are on 100 MVA Base. Frequency = 60 Hz

If a 3 - phase fault occurs on line 4 - 5 near bus 4 and the fault is cleared by simultaneously opening the circuit breaker at the ends of the line 4-5 at 0.225 seconds (fault clearing time), plot the swing curve and comment on stability of machine 1 and machine 2

Transmission Line Details		
Bus - code	**Impedance**	**Line charging**
p-q	**Zpq in pu**	**Y'pq/2 in pu**
3 - 4	0.007 + j0.04	j0.041
3 -5(1)	0.008 + j0.047	j0.049
3 -5 (2)	0.008 + j0.047	j0.049
4 - 5	0.018 + j0.110	j0.113

Transformer Details:

T1 = 20/230 kV 400 MVA with Leakage reactance = 0.022 pu
T2 = 18/230 kV 250 MVA with Leakage reactance = 0.040 pu

Generator Details:

G1 = 400 MVA, 20 kV, X'd = 0.067 pu, H = 11.2 MJ / MVA
G2 = 250 MVA, 18 kV, X'd = 0.10 pu, H = 8.0 MJ / MVA
G3 = 1000 MVA, 230 kV, X'd = 0.00001 pu, H = 1000 MJ / MVA (Infinite Bus Modelling)

G3 is grid or slack bus and is represented as generator.

Generation and Load Details					
Bus Code 'p'	Generation		Load		Specified Voltage in pu
	MW	Mvar	MW	Mvar	
1	350	71.2	0	0	1.03
2	185	29.8	0	0	1.02
3	800	0	0	0	1.0
4	0	0	100	44	Unknown
5	0	0	50	16	Unknown

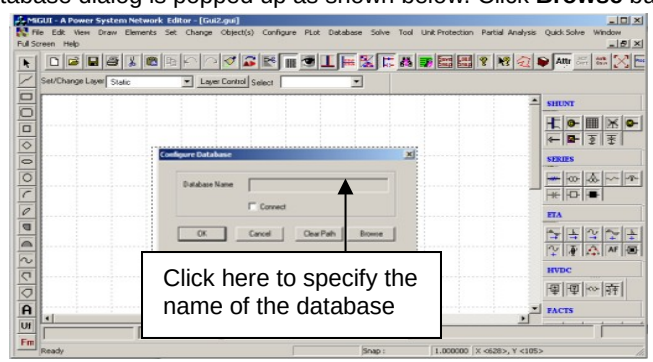
Interpretation according to MiP-PSCT:

- Observe transmission line details. You will find lines connected to nodes 3 and 5 have common parameters.
- No of transmission line libraries = 3
- No of generator libraries = 3 (Three different generators)
- No. of transformer libraries = 2 (two different transformers)

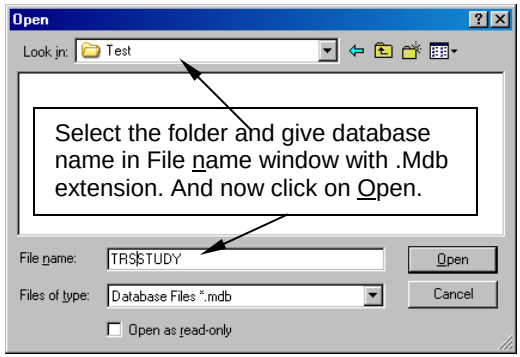
Procedure to enter the data for performing studies using MiP-PSCT. MiP-

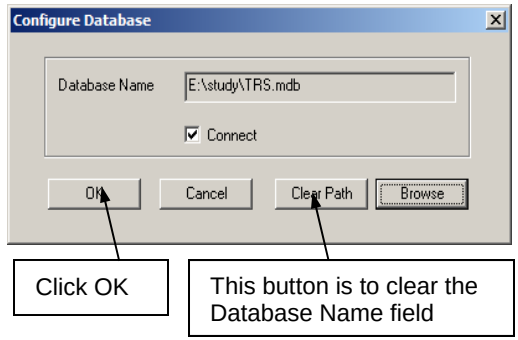
PSCT - Database Configuration

Open power system network editor. Select menu option **Database → Configure**. Configure Database dialog is popped up as shown below. Click **Browse** button.

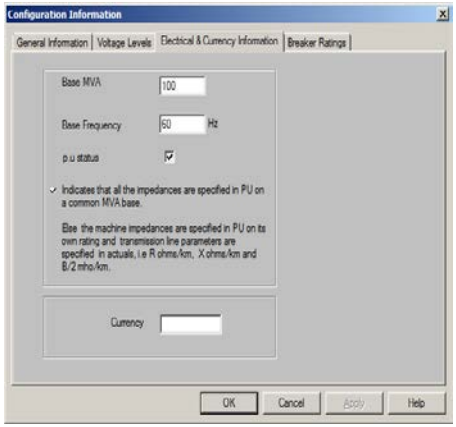


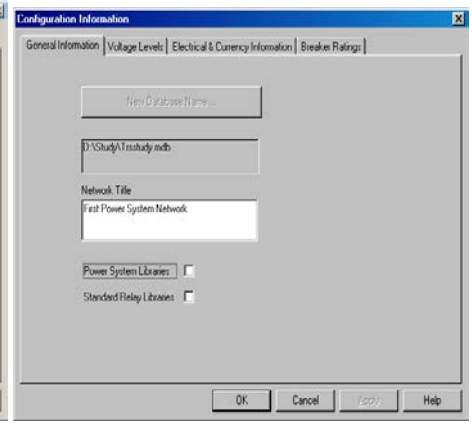
Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click **Open** button after entering the desired database name. **Configure Database** dialog will appear with path chosen.





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



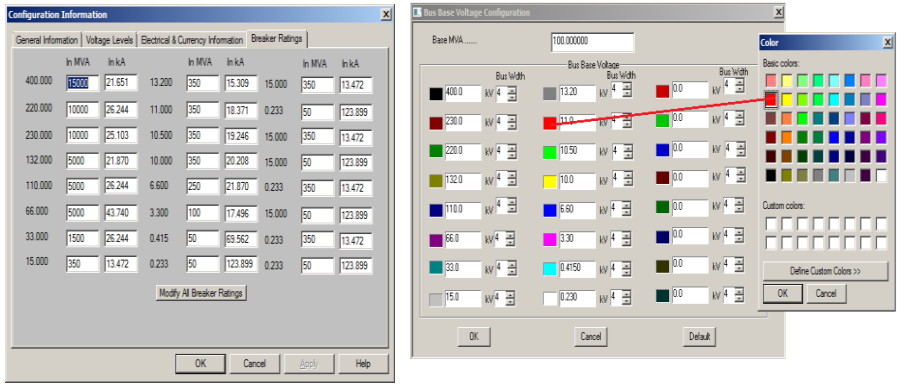


Uncheck the Power System Libraries and Standard Relay Libraries. For this example these standard libraries are not needed, because all the data is given on pu for power system libraries (like transformer, line\cable, generator), and relay libraries are required only for relay co-ordination studies. If Libraries are selected, standard libraries will be

loaded into the database. Click **Electrical Information** tab. Since the impedances are given on 100 MVA base check the pu status as shown below. Enter the Base MVA and Base frequency as shown above. Click on Breaker Ratings button to give breaker ratings. Click **OK** button to create the database to return to Network Editor.

Bus Base Voltage Configuration

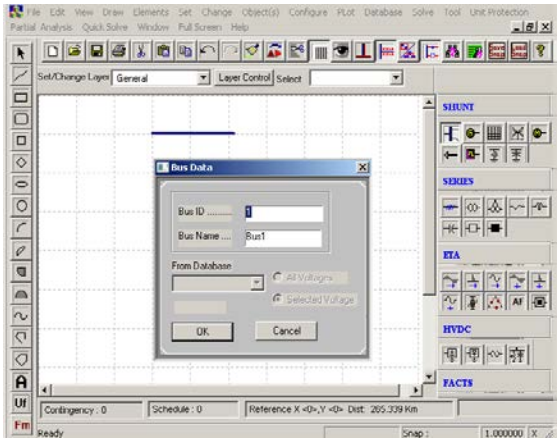
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage.** The dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

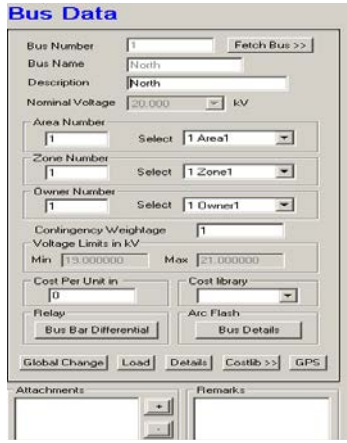


3.1 Procedure to Draw First Element – Bus

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 different, 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**



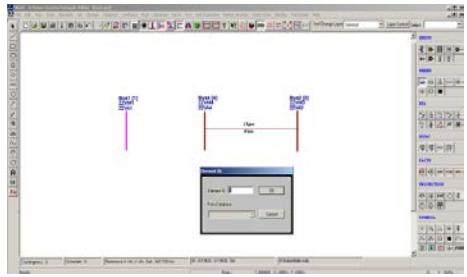


After entering data click **Save** which invokes **Network Editor**. Follow the same procedure for remaining buses. Following table gives the data for other buses.

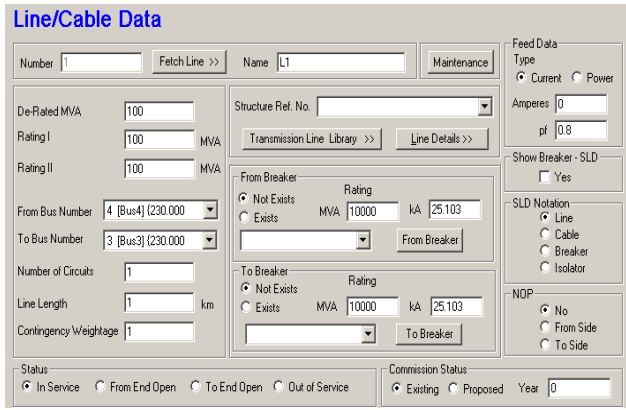
Bus Data					
Bus Number	1	2	3	4	5
Bus Name	Bus-1	Bus-2	Bus-3	Bus-4	Bus-5
Nominal voltage in kV	20	18	230	230	230
Area number	1	1	1	1	1
Zone number	1	1	1	1	1
Contingency weightage	1	1	1	1	1

3.2 Procedure to Draw Transmission Line

Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus double clicking LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element ID** dialog will appear.

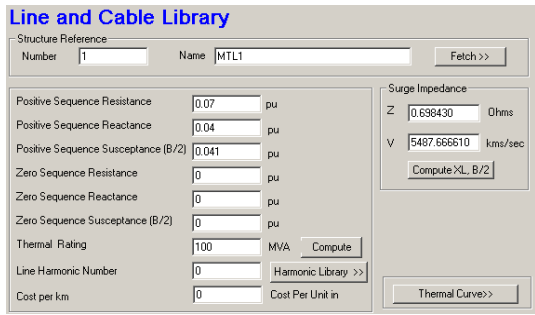


Enter **Element ID** number and click **OK**. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.



Enter **Structure Ref No.** as **1** and click on **Transmission Line Library >>** button. **Line & Cable Library** form will appear. Enter transmission line library data in the form as shown below for Line3-4. Enter other line libraries and element data details as per the following tables:

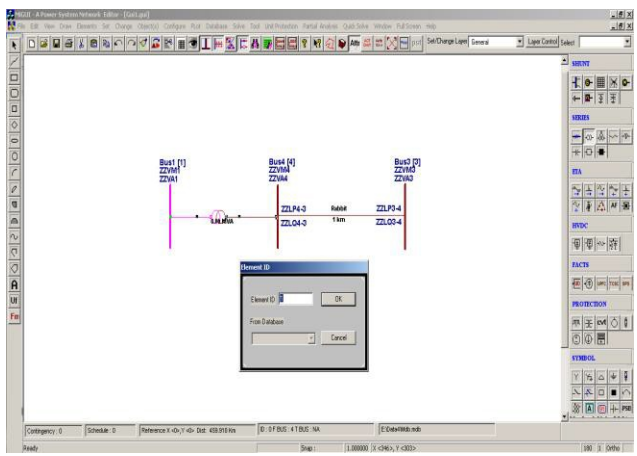
Transmission Line Libraries			
Structure Ref. No.	1	2	3
Structure Ref. Name	Line-3-4	Line-3-5	Line-4-5
Positive Sequence Resistance in pu	0.007	0.008	0.018
Positive Sequence Reactance in pu	0.040	0.047	0.110
Positive Sequence Susceptance in pu	0.041	0.049	0.113
Thermal Rating in MVA	100	100	100



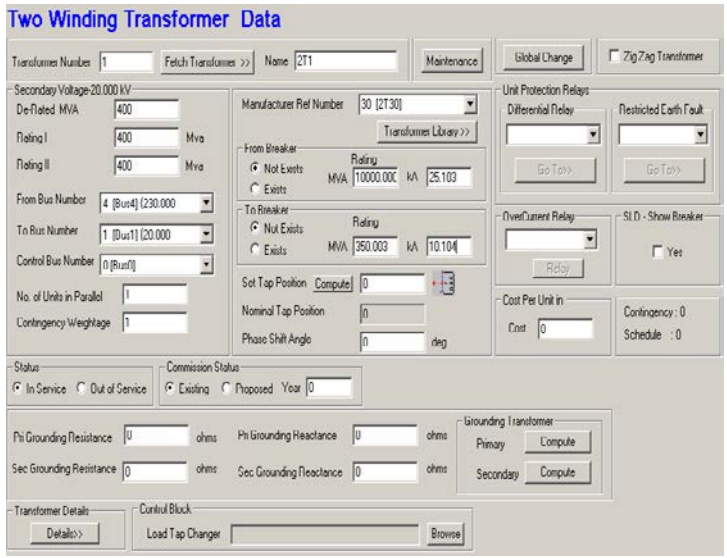
Transmission Line Element Data Details				
Line Number	1	2	3	4
Line Name	Line3-4	Line3-5	Line4-5	Line3-5
De-Rated MVA	100	100	100	10
No. Of Circuits	1	1	1	1
From Bus No.	4	3	4	3
To Bus No.	3	5	5	5
Line Length in km	1	1	1	1
From Breaker Rating in MVA	5000	5000	5000	5000
To Breaker Rating in MVA	5000	5000	5000	5000
Structure Reference No.	1	2	3	2

3.3 Procedure to Draw Transformer

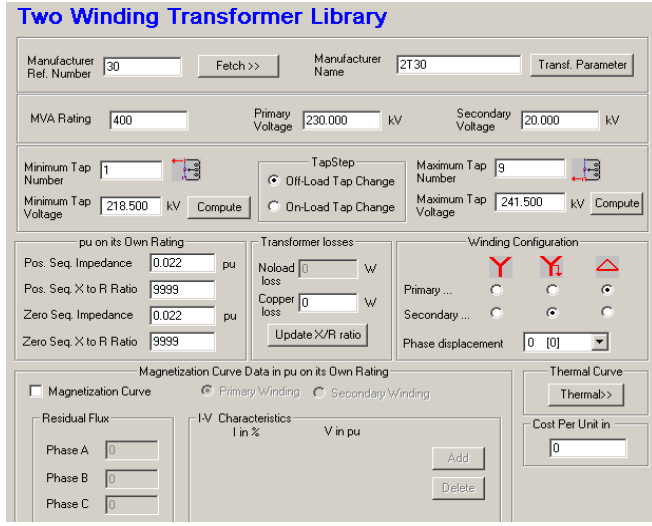
Click on **Two Winding Transformer** icon provided on power system tool bar. To draw the transformer click in between two buses and to connect to the from bus double clicking LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. The **Element ID** dialog will appear. Click **OK**.



Two Winding Transformer 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.



Enter transformer library details as shown below. Click **Save** 🖫 button and close the screen. Transformer element data form will appear. Click **Save** 🖫 button, which invokes Network Editor. In the similar way enter other transformer details.

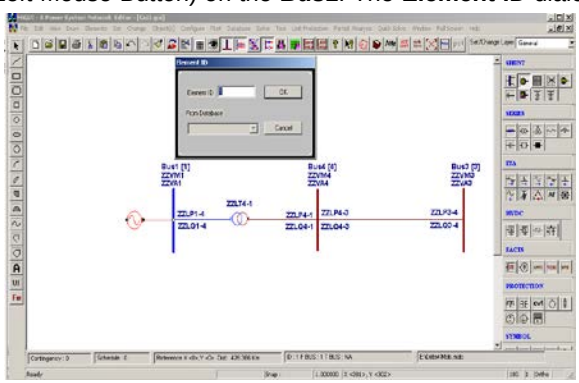


Transformer Library Details		
Manufacturer ref. No.	1	2
Manufacturer Name	2T30	2T31
MVA Rating	400	250
Primary Voltage in kV	230	230
Secondary Voltage in kV	20	18
Minimum Tap	1	1
Maximum Tap	9	9
Minimum Tap Voltage in kV	218.5 (230 * 0.95)	218.5 (230 * 0.95)
Maximum Tap Voltage in kV	241.5 (230 * 1.05)	241.5 (230 * 1.05)
Positive Sequence Impedance in pu	0.022	0.040
X/R* Ratio	9999 (R is Negligible)	9999 (R is Negligible)

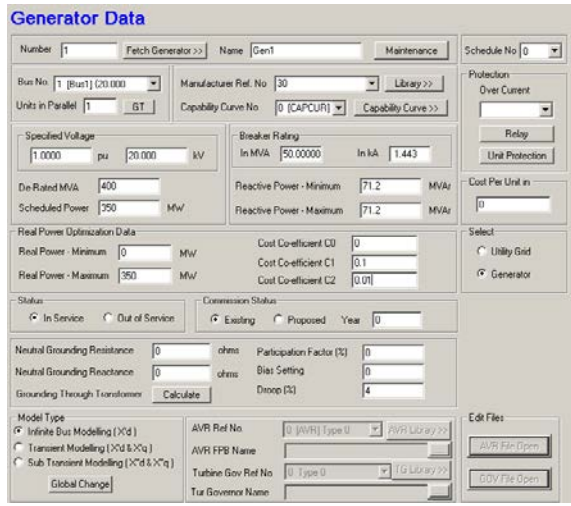
Transformer Element Detail		
Transformer Number	1	2
Transformer Name	2T1	2T2
From Bus Number	4	5
To Bus Number	1	2
Control Bus Number	1	2
Number of Units in Parallel	1	1
Manufacturer ref. Number	2T30	2T31
De Rated MVA	400	250
From Breaker Rating in MVA	5000	5000
To Breaker Rating in MVA	350	350
Nominal Tap Position	5	5

3.4 Procedure to Draw Generator

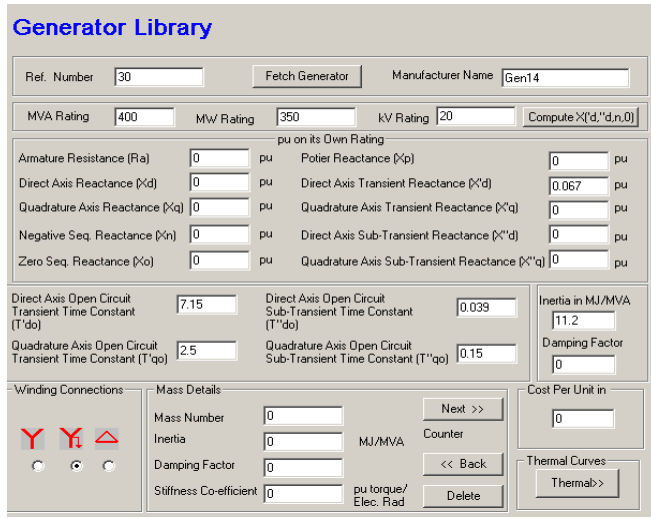
Click on **Generator** icon provided on power system tool bar. Draw the generator by clicking LMB (Left Mouse Button) on the **Bus1**. The **Element ID** dialog will appear. Click **OK**.



Generator Data form will be opened. Enter the **Manufacturer Reference No** as **30.** Enter generator data in the form as shown below.



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



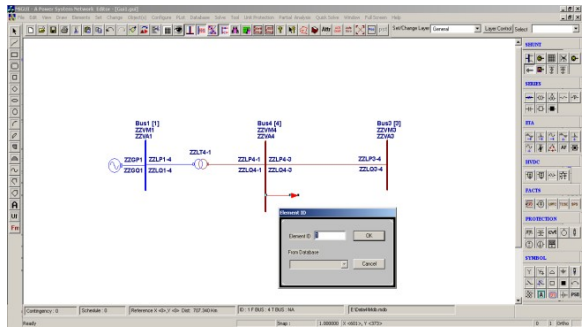
Enter other generator libraries and element details as per the following table.

Generator Library Details			
Reference Number	30	31	32
Manufacturer Name	BHEL-1	BHEL-2	BHEL-3
MVA Rating	400	250	1000
MW Rating	350	185	800
kV Rating	20	18	230
Ra	0	0	0
Xd	0	0	0
Xq	0	0	0
Xn	0	0	0
Xo	0	0	0
Xp	0	0	0
X'd	0.067	0.10	0.00001
X'q	0	0	0
X d	0	0	0
X q	0	0	0
Inertia MJ/MVA	11.2	8.0	1000

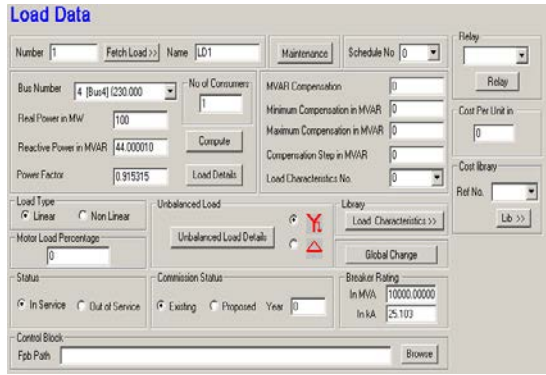
Generator Element Details			
Name	GEN-1	GEN-2	GEN-3
Bus Number	1	2	3
Manufacturer Ref. Number	30	31	32
Number of Generators in Parallel	1	1	1
Capability Curve Number	0	0	0
De-Rated MVA	400	250	1000
Specified Voltage in kV	20.6	18.36	230
Scheduled Power in MW	350	185	800
Reactive Power Minimum in MVAR	71.2	29.8	0
Reactive Power Maximum in MVAR	71.2	29.8	600
Breaker Rating in MVA	350	350	10000
Type of Modeling	Infinite	Infinite	Infinite

3.5 Procedure to Draw Load

Click on **Load** icon provided on power system tool bar. Draw the load by clicking LMB (Left Mouse Button) on the **Bus4**. The **Element ID** dialog will appear. Click **OK**.



Load Data form will be opened. Enter the load details as shown below.



Connect other load (50 + j16) to bus 5.

To solve load flow studies choose menu option Solve → **Load Flow Analysis** or click **LFA** button on the toolbar, which is on the right side of the screen. Load flow analysis screen appears.

3.6 Load flow results

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

INTERMEDIATE VOLTAGE AND POWER ERROR AT THE END OF EACH ITERATION:
NODE NAME     VOLT-MAG VOLT-ANG P-ERROR-MW Q-ERROR-MVAR
---- -------- -------- -------- ---------- ------------
   1     Bus1   1.0300    0.155     0.0099       0.0014
   2     Bus2   1.0200    0.112    -0.0003      -0.0001
   3     Bus3   1.0000    0.000  1180.5015      -0.0272
   4     Bus4   1.0175    0.082    -0.0032      -0.0002
   5     Bus5   1.0109    0.040    -0.0016       0.0001
Number of p iterations :   3 and Number of q iterations :   5
------------------------------------------------------------------------
---
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   1.0300    8.90    350.000    71.200       0.000      0.000
0.000
   2       Bus2   1.0200    6.39    185.000    29.800       0.000      0.000
0.000
   3     Bus3  1.0000   0.00  -380.502  -26.497     0.000    0.000   0.000
<
   4       Bus4   1.0175    4.68       0.000     0.000    100.000    44.000
0.000
   5       Bus5   1.0109    2.27       0.000     0.000     50.000    16.000
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)  :     1
NUMBER OF GENERATORS EXCEEDING MAXIMUM Q LIMIT (> mark)  :     0
------------------------------------------------------------------------
---
TRANSFORMER FLOWS AND TRANSFORMER LOSSES

SLNO CS FROM FROM    TO    TO         FORWARD            LOSS          %
        NODE NAME      NODE   NAME      MW       MVAR            MW      MVAR
LOADING
```

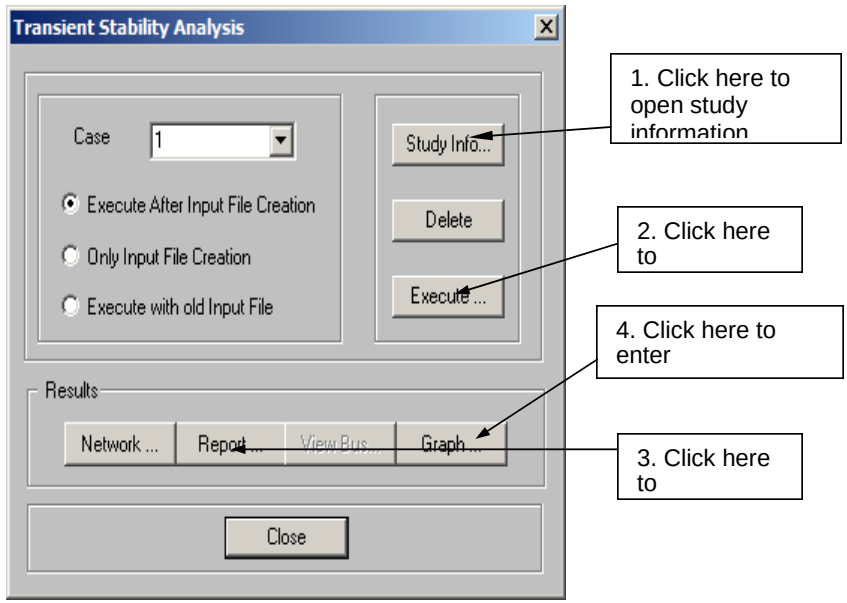
```
1   1     4      Bus4      1    Bus1 -349.987   -44.745     0.0026   26.4537
86.7# 2   1     5     Bus5      2     Bus2 -184.999   -16.300    0.0014 13.4998
73.5$
------------------------------------------------------------------------------
---
! NUMBER OF TRANSFORMERS LOADED BEYOND  125%           :     0
@ NUMBER OF TRANSFORMERS LOADED BETWEEN 100% AND 125% :     0
# NUMBER OF TRANSFORMERS LOADED BETWEEN  75% AND 100% :     1
$ NUMBER OF TRANSFORMERS LOADED BETWEEN  50% AND  75% :     1
^ NUMBER OF TRANSFORMERS LOADED BETWEEN  25% AND  50% :     0
& NUMBER OF TRANSFORMERS LOADED BETWEEN   1% AND  25% :     0
* NUMBER OF TRANSFORMERS LOADED BETWEEN   0% AND   1% :     0
------------------------------------------------------------------------------
---
LINE FLOWS AND LINE LOSSES

SLNO CS FROM FROM       TO  TO           FORWARD            LOSS          %
        NODE  NAME    NODE  NAME          MW       MVAR         MW       MVAR
LOADING
---- -- ---- -------- ---- -------- -------- -------- -------- -------- -
---
3   1     4     Bus4     3      Bus3   210.573    11.960    3.0157    8.8875
207.3! 4   1     3     Bus3     5      Bus5   -86.472   -11.712    0.6019   -
6.3713    87.3#
5   1     3     Bus3     5      Bus5   -86.472   -11.712    0.6019   -6.3713
87.3#
6   1     4     Bus4     5      Bus5    39.418   -11.215    0.2702 -21.5963
40.3^
------------------------------------------------------------------------------
---
! NUMBER OF LINES LOADED BEYOND  125%           :     1
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :     0

# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :     2
$ 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% :     0
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :     0
```

This will become the initial condition for transient stability analysis

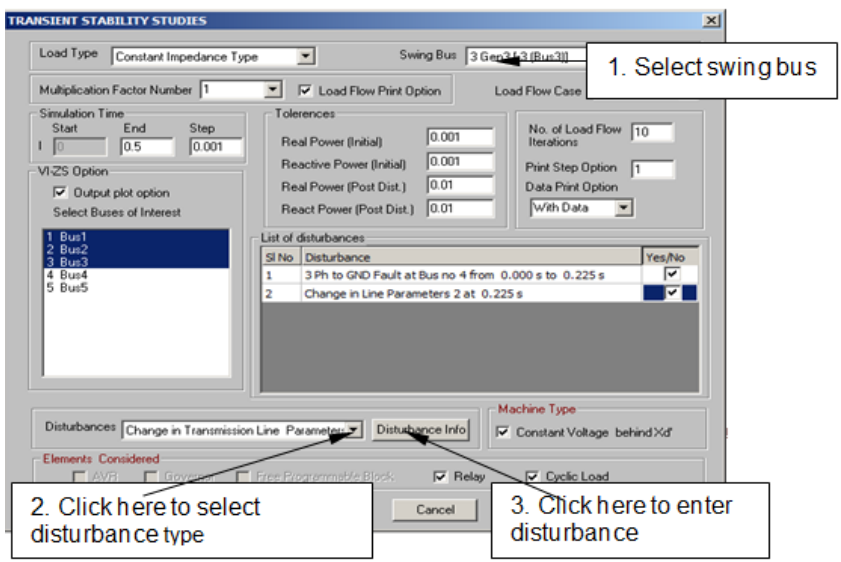
Note: You have to get the same results to conduct transient stability study.

3.7 Executing transient stability study

Click on **Solve →Transient stability analysis**.



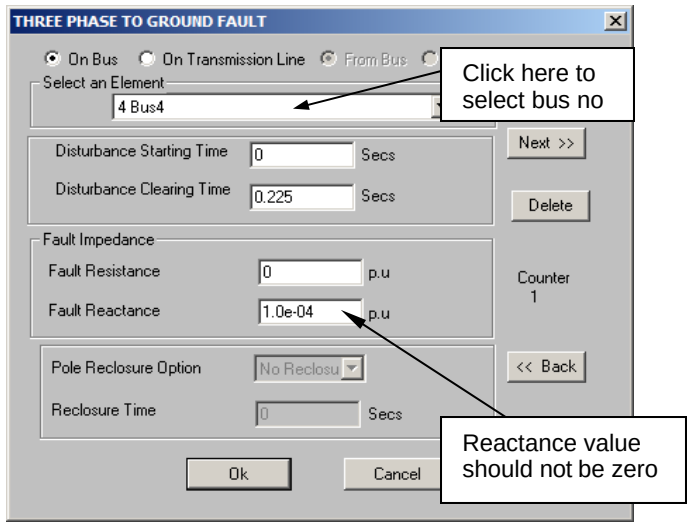
On **Transient Stability Studies** screen click on **Study Info**….button.



Enter all the details as shown:

To simulate 3 phase to ground fault, select the **Disturbances** as *Three Phase To Ground Fault* from the disturbance list and click on **Disturbance Info** button to enter the fault data.

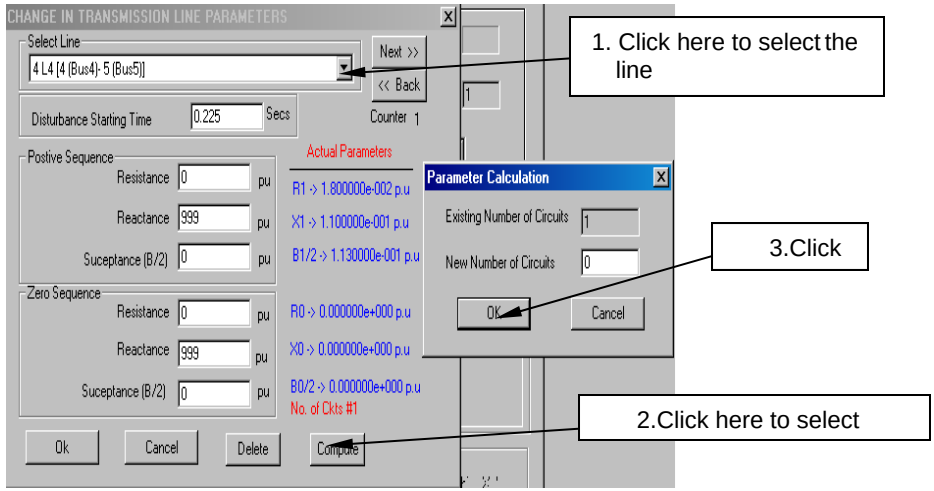
Fault is on bus 4 so select bus 4 from the Bus number list box.



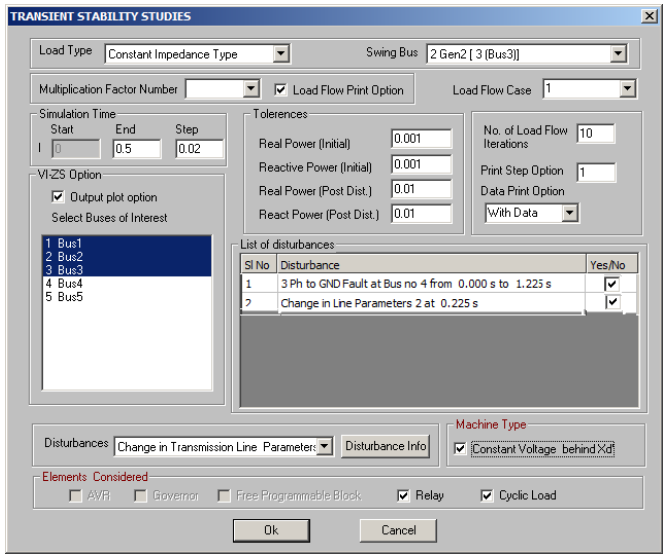
Click **OK** to return to previous form.

To account the effect of opening of breaker, in the disturbance list select *Change in transmission Line Parameters* and click on **Disturbance Info** button.

In this, select line between bus 4 and bus 5. Give disturbance starting time as 0.225 secs and make positive sequence resistance as zero and reactance very high accounting for opening of the line (let us say 9999).

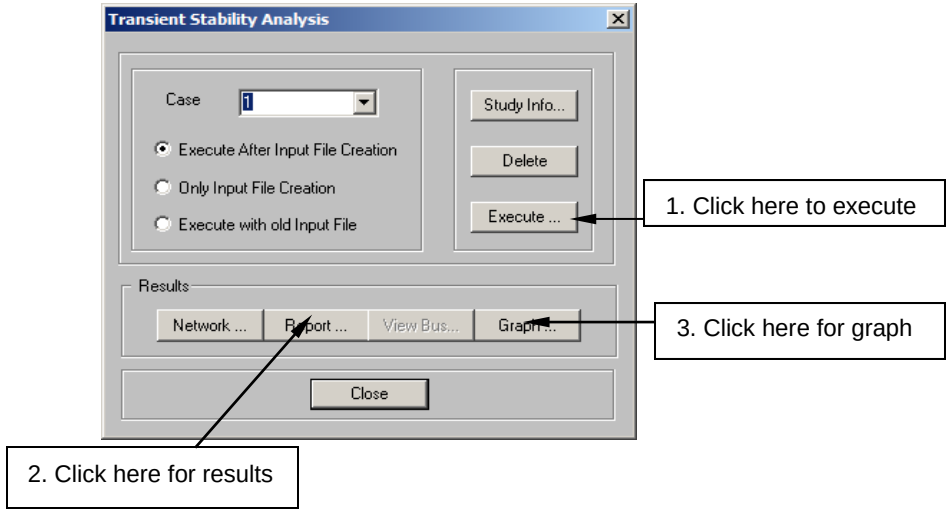


Finally you will return to the previous dialog. Here list of disturbances applied on the network are listed as shown below. Click **OK** button to return to **Solve** dialog.
On the **Solve** dialog box, click **Execute** button to execute transient stability study.



Results Observation:

The results can be observed by clicking **Report** button. The results can be best analysed using graph. For this click on **Graph** button.

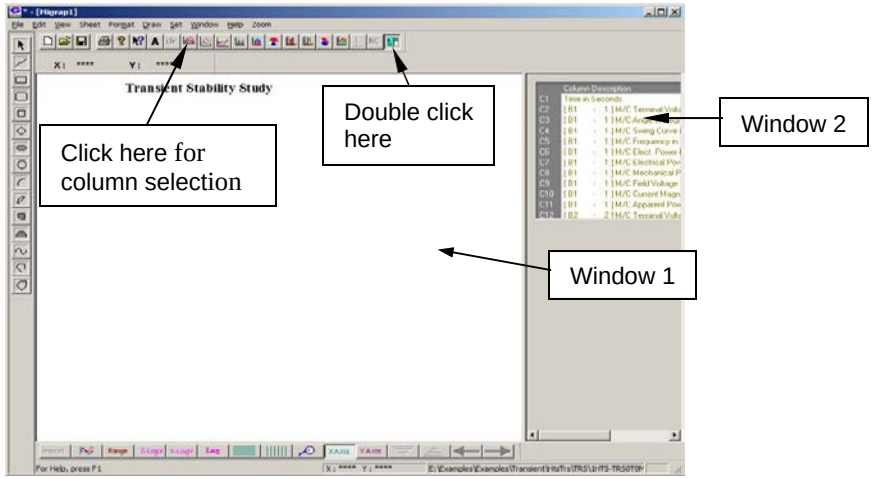


Part of Report is Shown below :

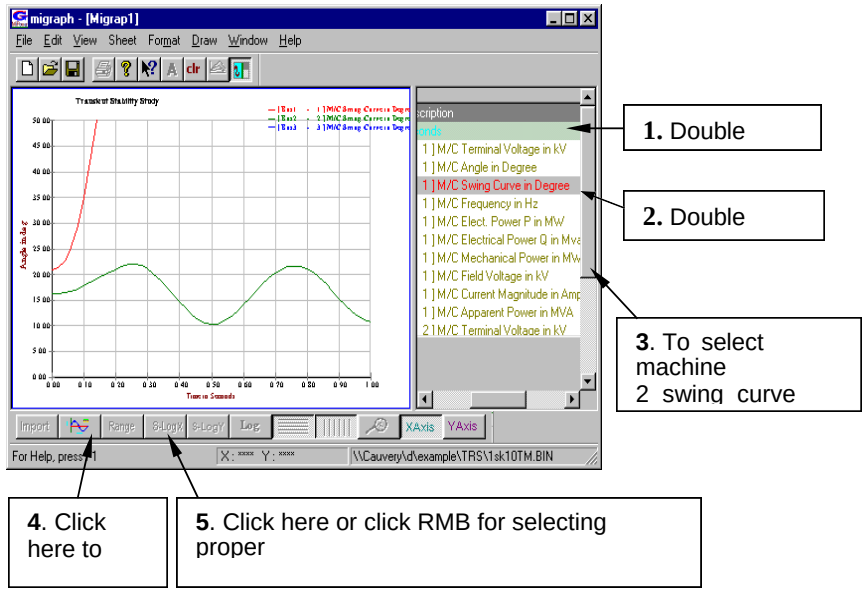
```
--------------------------------------------------------------------------
---
Time =   0.00000 Seconds
Intermediate results for Machines
GNo Name   Voltage Angle      Delta      Freq      Pgen      Qgen      Pmech
Efd/Slip
          pu       Degree    Degree    Hzs.     MW       MVAR     MW       pu/PU
--- -------- ------- -------- -------- ------- ------- ------- ------- --
---
  1   Bus1     1.03        8.9       20.8        60       350      71.2       350
1.1
  2   Bus2     1.02       6.39       16.2        60       185      29.8       185
1.06
  3   Bus3         1          0  -0.00218        60      -381    -26.5      -381
1
```

```
------------------------------------------------------------------------
---
Maximum rotor angle difference :   20.84325 b/w buses : 1 and 3
------------------------------------------------------------------------
---
3 phase fault  0.00000    4     Bus4
kp 1 kq 0 Iterations 10 dpmax 0.064557 dqmax 0.003461
------------------------------------------------------------------------
---
Time =   0.00100 Seconds
Intermediate results for Machines
GNo  Name   Voltage  Angle      Delta      Freq      Pgen      Qgen      Pmech
Efd/Slip
          pu          Degree     Degree     Hzs.       MW         MVAR       MW
pu/P.U.
--- -------- ------- -------- -------- ------- ------- ------- ------- --
---
1     Bus1    0.275      20.1      20.8        60      5.93       339       350
1.1
2     Bus2    0.908      6.55      16.2        60       162       129       185
1.06
3    Bus3        1 -0.00455   -0.0022        60       414 3.02e+003      -381
1
------------------------------------------------------------------------
---
Maximum rotor angle difference :   20.84410 b/w buses : 1 and 3
Island    1 Common system frequency60.000
------------------------------------------------------------------------
---
```

Click Graph button on **Solve** dialog box, Graph Utility screen will be open, which is shown below.



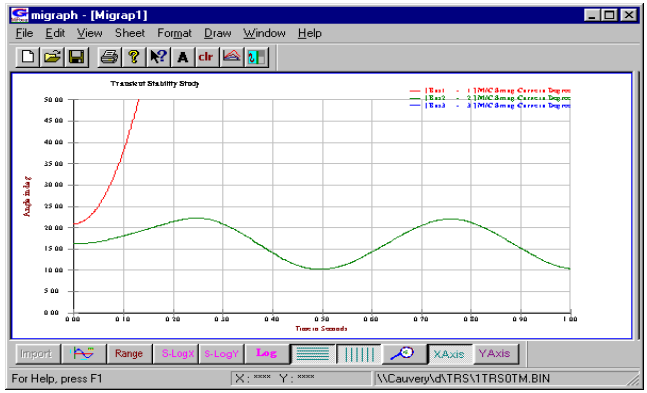
Graph editor will open the corresponding plot file of the study. Window 1 is used for displaying the graphs and window 2 holds the plot variables like time in seconds, swing curve of machines, machine internal angle, machine voltage, machine current etc. User has to choose plot variables in the 2nd window.



Final output is shown below

Comment: As seen from the graph

- Machine 1 turns out to be unstable and machine 2 is stable.

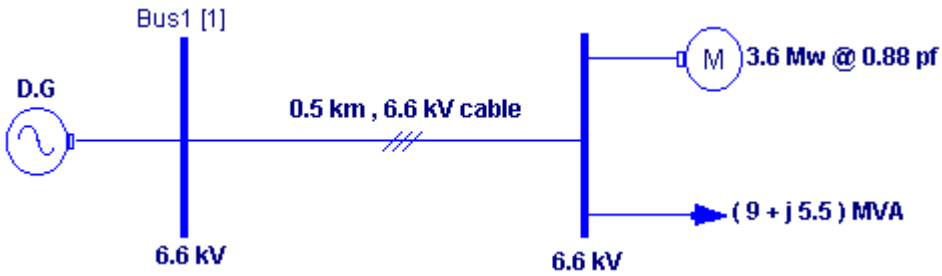


Exercise: For different clearing times conduct studies and observe the swing curves

Hint: Take clearing time = 0.05sec and execute transient stability.

3.8 Procedure to connect AVR, Governor designed using FPB module

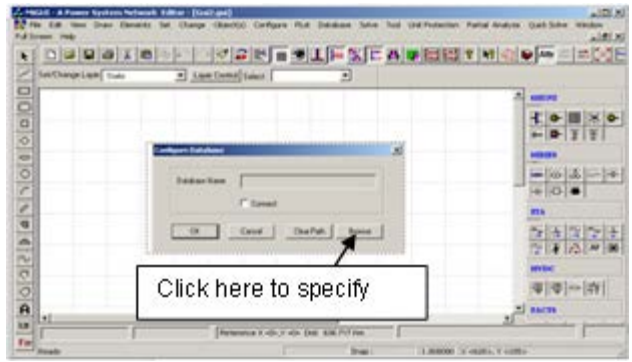
1. Draw Single Line Diagram and enter the element details in database manager



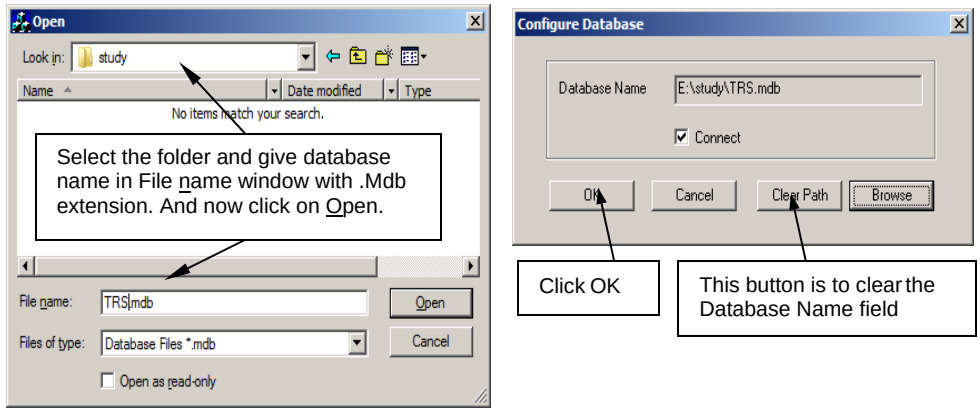
Procedure to enter the data for performing studies using MiP-PSCT. MiP-

PSCT - Database Configuration

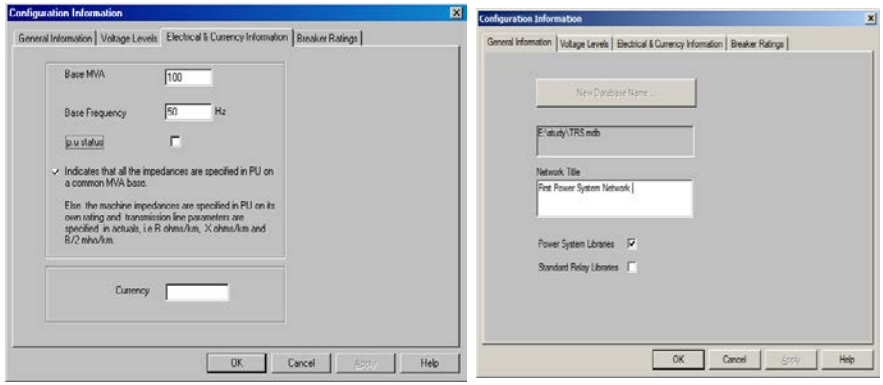
Open power system network editor. Select menu option **Database → Configure**. Configure Database dialog is popped up as shown below. Click **Browse** button.



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.



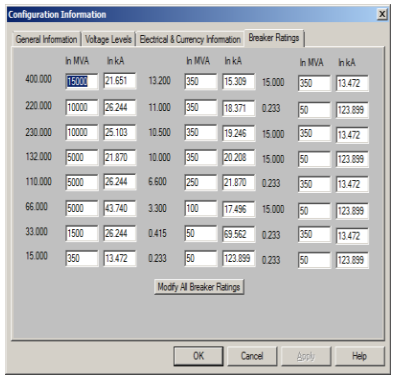
Click **OK** button on the **Configure Database** dialog. The dialog shown below appears.

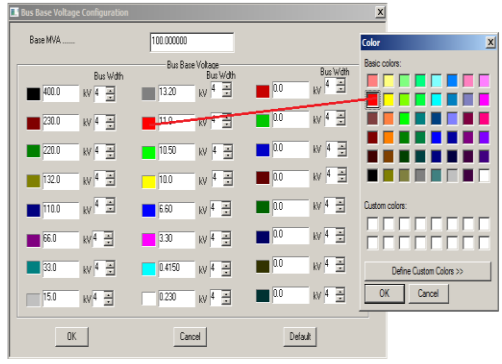


Check the Power System Libraries and uncheck Standard Relay Libraries . For this example these standard relay libraries are not needed, because relay libraries are required only for relay co-ordination studies. Power system Libraries are selected, standard libraries will be loaded into the database. Click **Electrical Information** tab. Since the impedances are given on its own base uncheck the pu status as shown above. Enter the Base MVA and Base frequency as shown above. Click on Breaker Ratings button to give breaker ratings. 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**. The dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

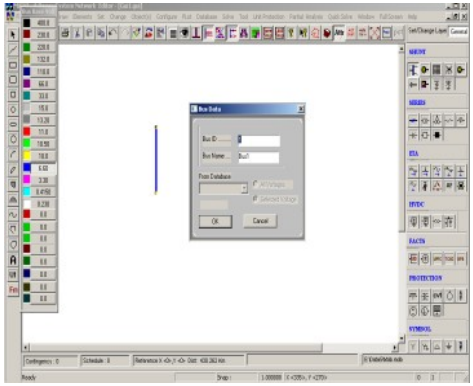


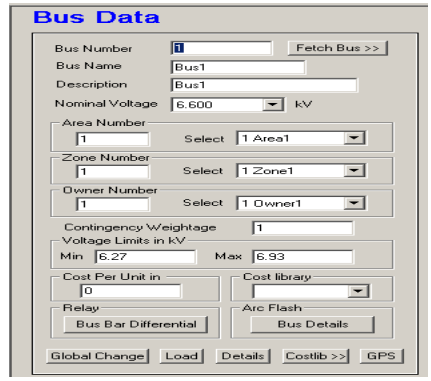


Procedure to Draw First Element - Bus

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 Weight age 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 different, 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.**

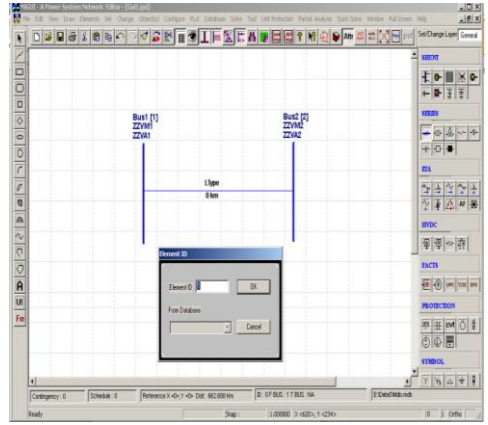




After entering data click **Save** 🖫 which invokes **Network Editor**. Follow the same procedure for remaining buses.

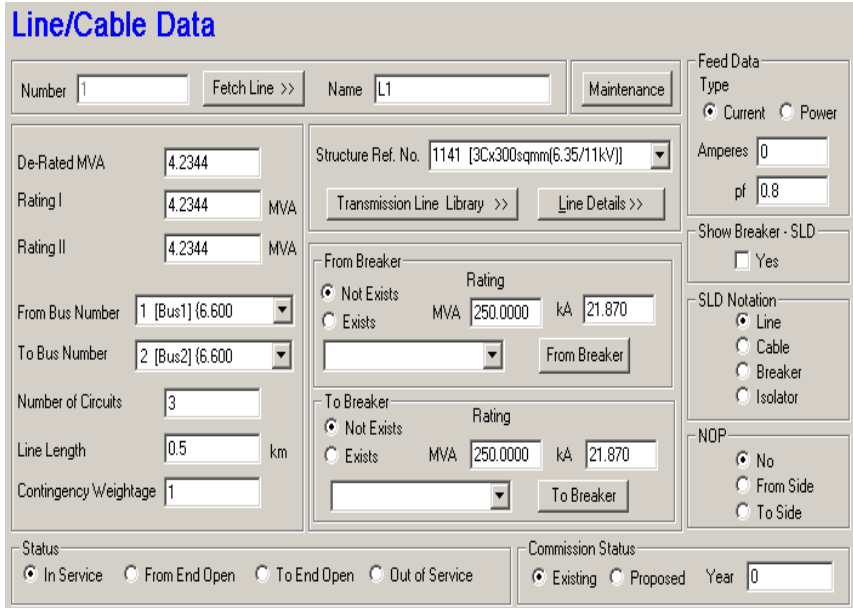
Procedure to Draw Transmission Line

Click on **Transmission Line** icon provided on power system tool bar. To draw the line click in between two buses and to connect to the from bus double clicking LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus.**. **Element ID** dialog will appear.



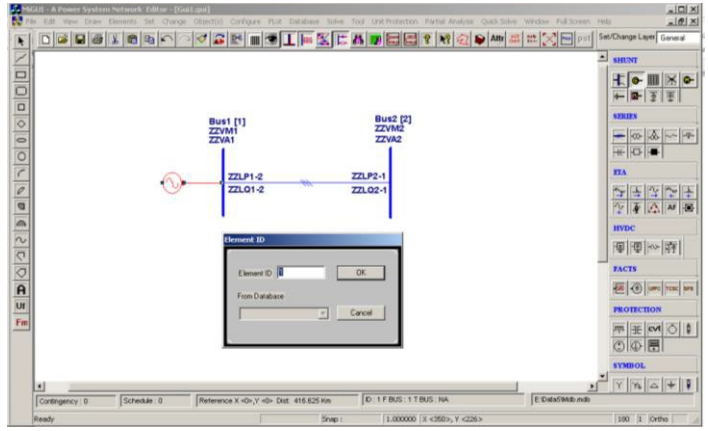
Enter **Element ID** number and click **OK**. Database manager with corresponding **Line\Cable Data** form will be open. Enter the details of that line as shown below.

Select **Structure Ref No.** As **1141** and click on **Save** 🖫

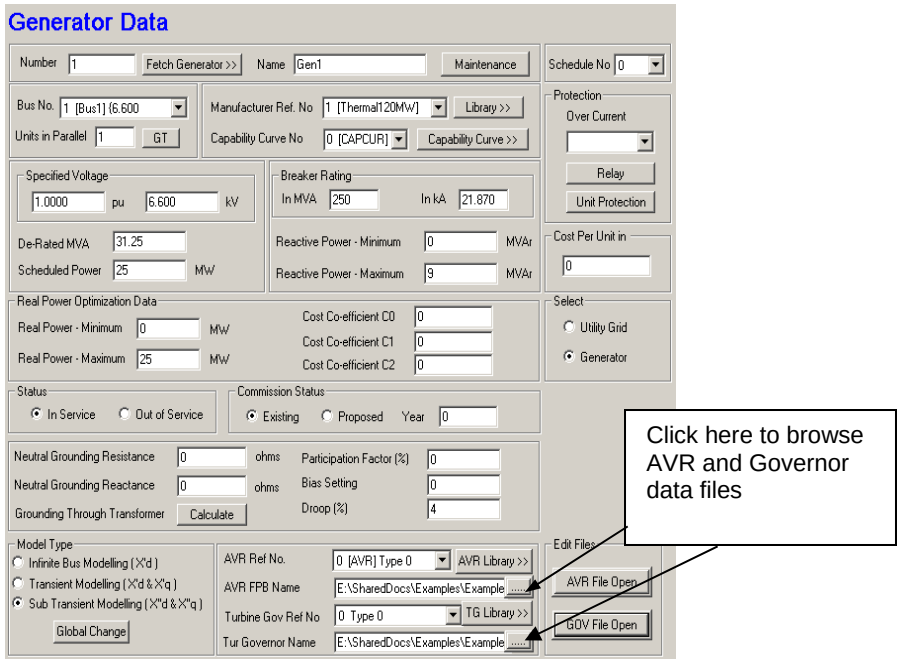


Procedure to Draw Generator

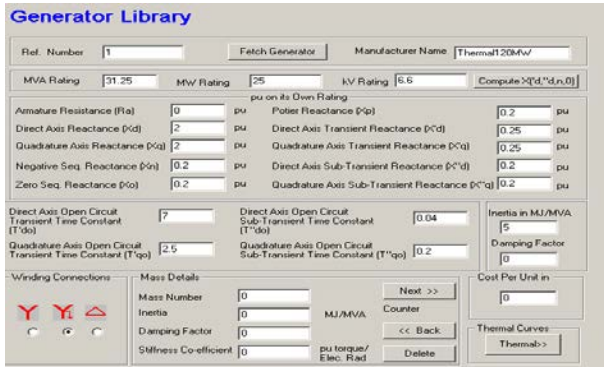
Click on **Generator** icon provided on power system tool bar. Draw the generator by clicking LMB (Left Mouse Button) on the **Bus1**. The **Element ID** dialog will appear. Click OK.



Generator Data form will be opened. Select the Manufacturer Reference No as 1[Thermal120MW]. Click on Save 🖫

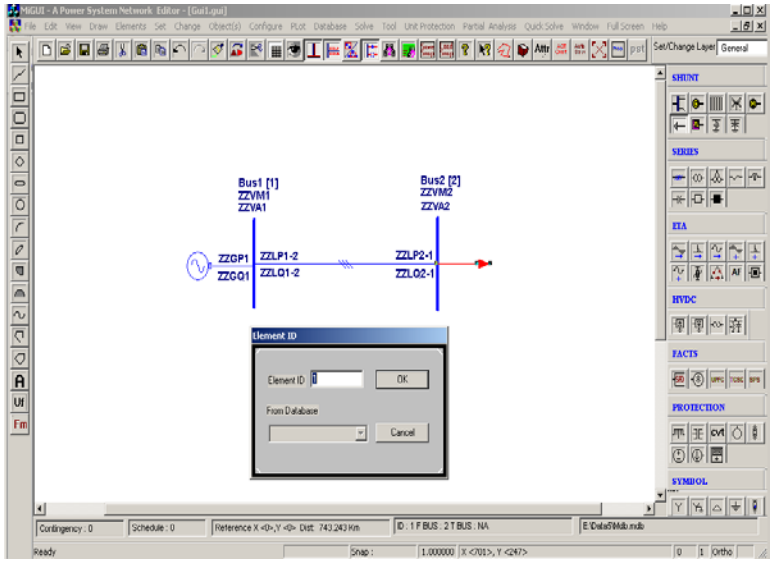


Generator Library Details:

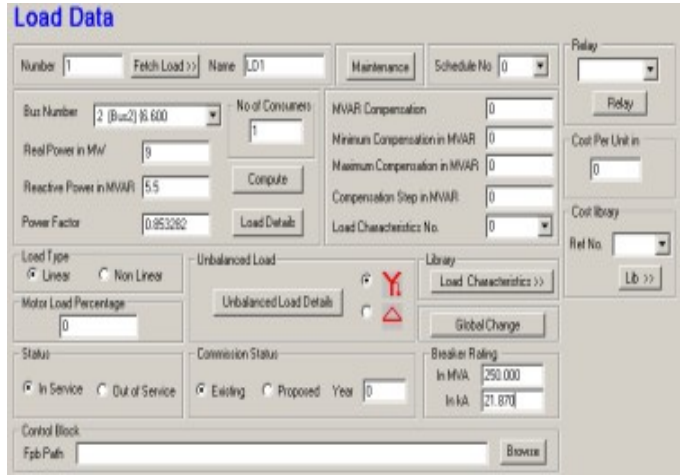


Procedure To Draw Load

Click on **Load** icon provided on power system tool bar. Draw the load by clicking LMB (Left Mouse Button) on the **Bus2**. The **Element ID** dialog will appear. Click **OK**.

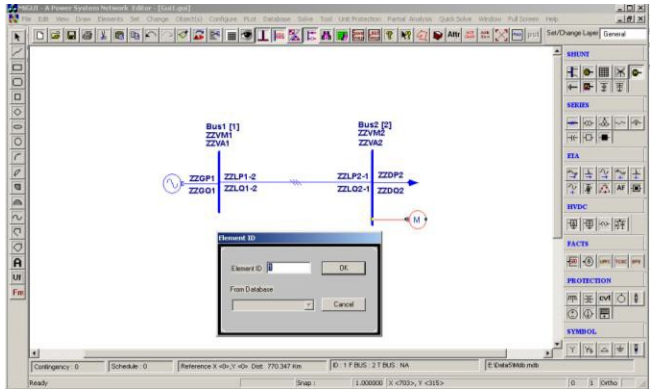


Load Data form will be opened. Enter the load details as shown below. Click on **Save**

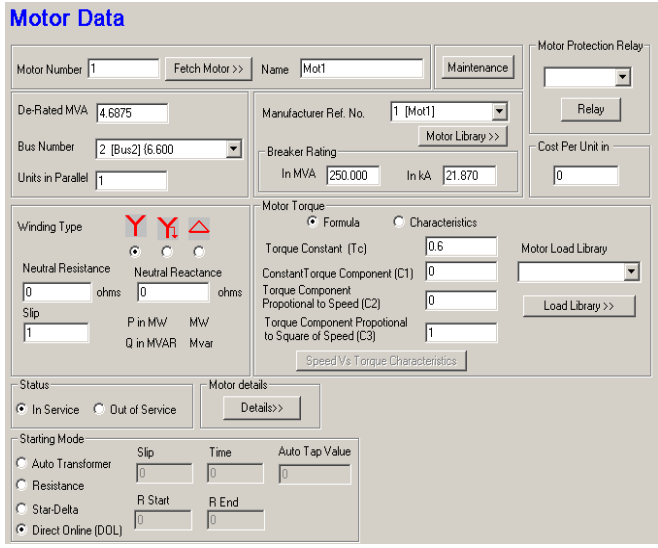


3.9 Procedure to Draw Motor

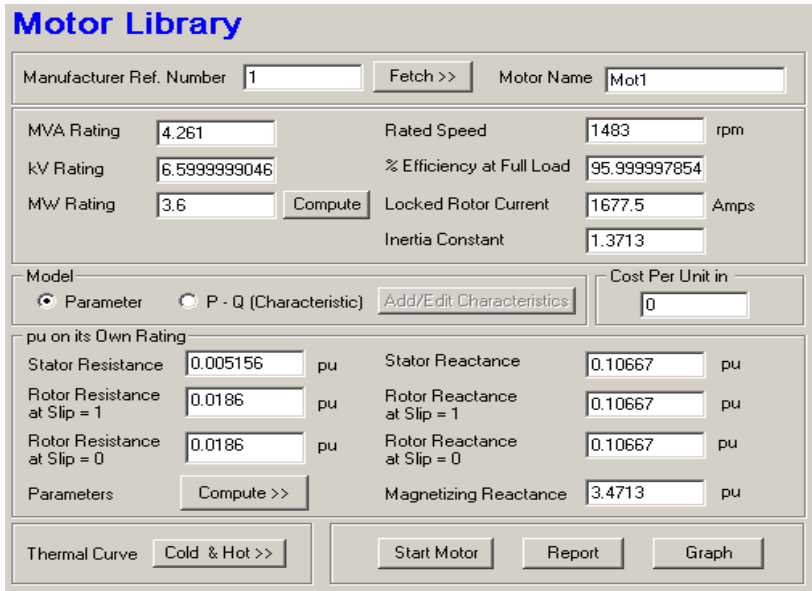
Click on **Motor** icon provided on power system tool bar. Draw the motor by clicking LMB (Left Mouse Button) on the **Bus2**. The **Element ID** dialog will appear. Click **OK**



Motor Data form will be opened. Enter the Motor details as shown below.

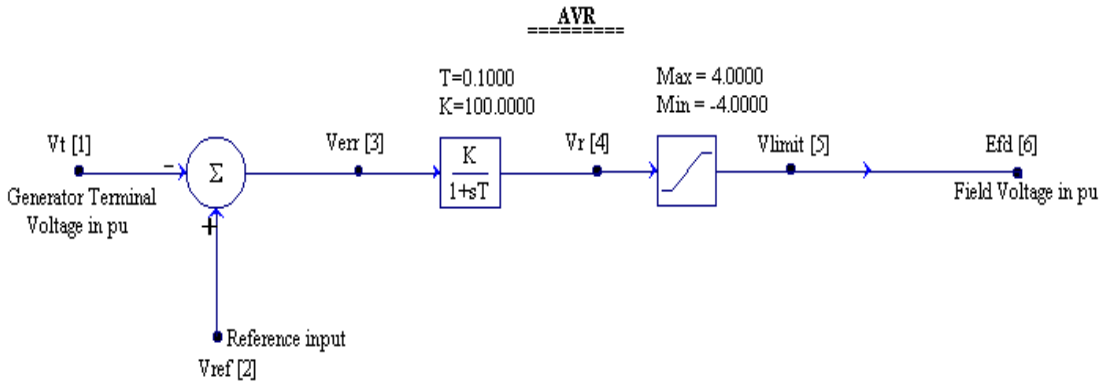


Click on **Motor Library >>** button. Enter motor library details as shown below.



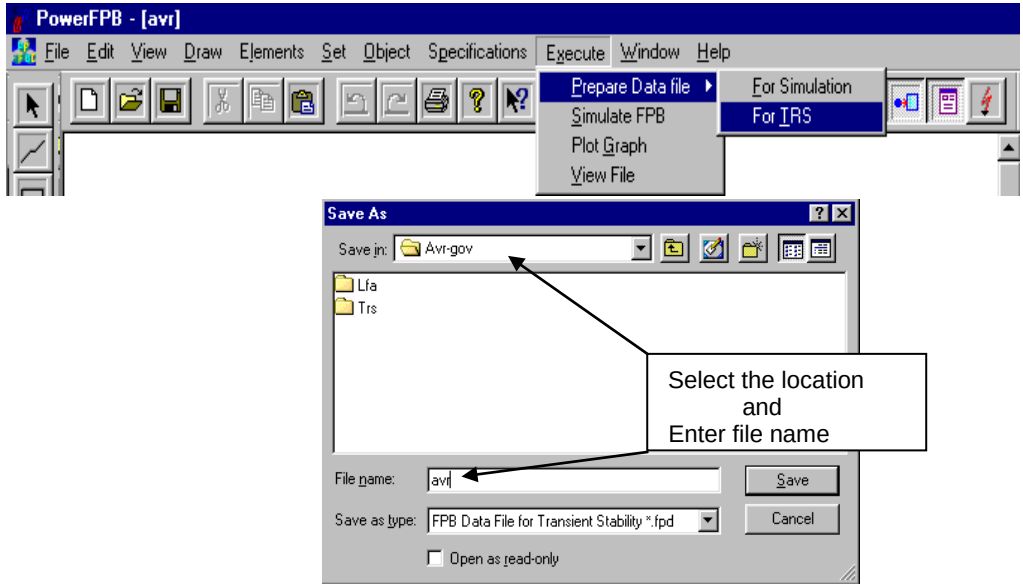
Click on **Save** 🖫 .Also **Save** 🖫 the motor data.

Design AVR using Free Programmable Blocks module of MiP-PSCT

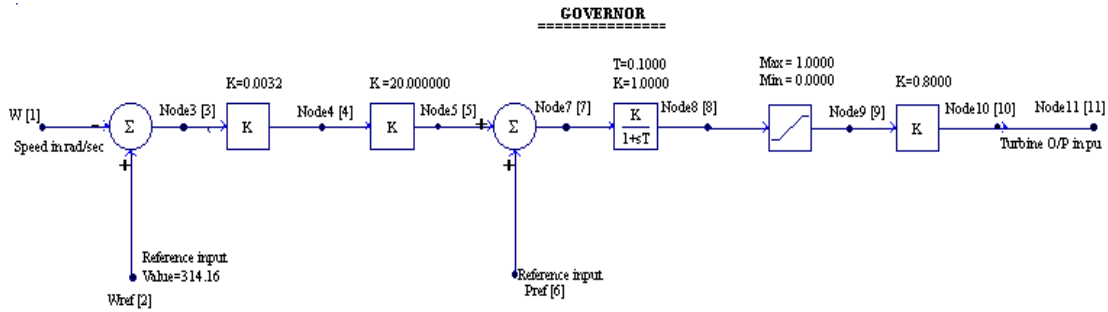


3.10 Procedure to generate AVR data file for Transient Stability Analysis

Select menu option **Execute → Prepare Data file → For TRS**



Similarly Design and generate Governor data file for Transient Stability Analysis



Browse these file name paths in **Generator Data**

Execute **Load Flow Analysis** to establish the initial condition

3.11 Load flow results

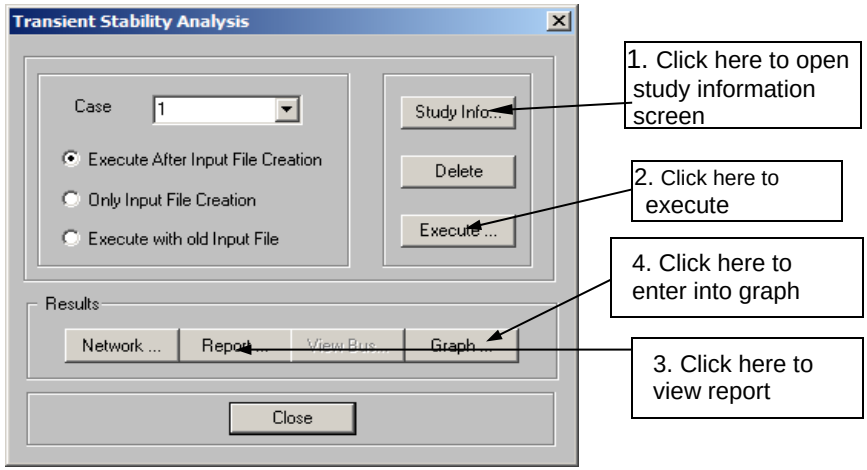
```
--------------------------------------------------------------------------------
---
ITERATION    MAX P BUS     MAX P    MAX Q

 BUS         MAX Q COUNT   NUMBER  PER UNIT       NUMBER  PER UNIT
 ---------    ---------   --------    ---------   --------
        1            2     0.090           2     0.097
        2            2     0.080           2     0.036
        3            2     0.001           2     0.001
        4            2     0.001           2     0.001
Number of p iterations :   3 and Number of q iterations :   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      Bus1   1.0000    0.00       9.140     5.607       0.000     0.000
0.000
   2      Bus2   0.9936   -0.02       0.000     0.000       9.000     5.500
0.000
--------------------------------------------------------------------------------
---
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    0
```

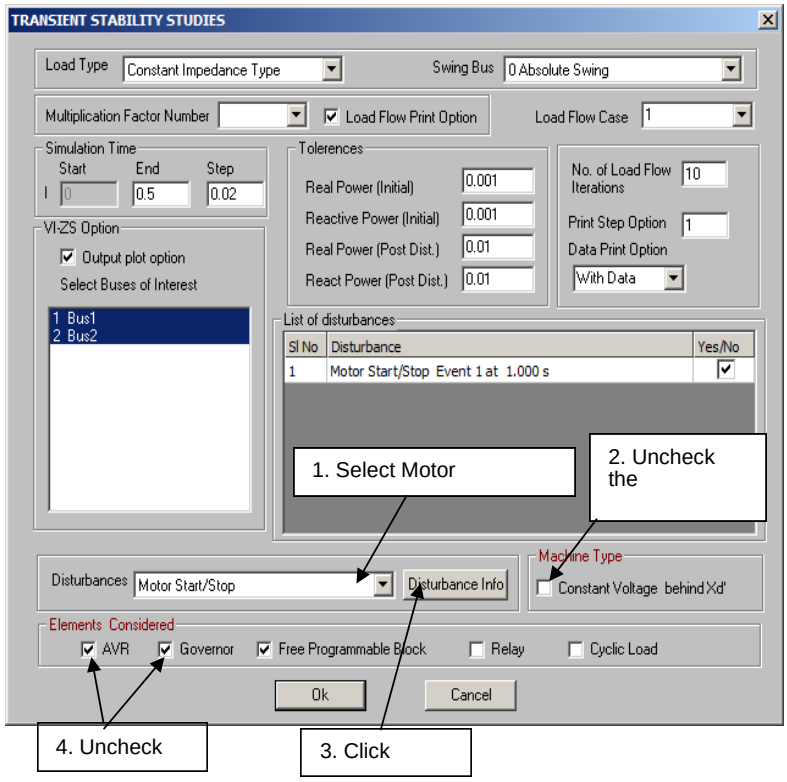
```
NUMBER OF BUSES EXCEEDING MAXIMUM VOLTAGE LIMIT (# mark) :    0
NUMBER OF GENERATORS EXCEEDING MINIMUM Q LIMIT (< mark) :     0
NUMBER OF GENERATORS EXCEEDING MAXIMUM Q LIMIT (> mark) :     0
--------------------------------------------------------------------------
---

LINE FLOWS AND LINE LOSSES

SLNO CS  FROM FROM        TO TO                FORWARD                LOSS
%
        NODE NAME    NODE NAME           MW       MVAR         MW       MVAR
LOADING
---- -- ---- -------- ---- -------- -------- -------- -------- -------- -
---
 1  3     1    Bus1     2      Bus2     9.140     5.607    0.0572    0.0286
84.4#
--------------------------------------------------------------------------
---! 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% :    0
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    0
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
--------------------------------------------------------------------------
---
ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  50.00000           1       0
--------------------------------------------------------------------------
---Summary of results

TOTAL REAL POWER GENERATION   :      9.140 MW
TOTAL REAL POWER INJECT,-ve L :      0.000 MW
TOTAL REACT. POWER GENERATION :      5.607 MVAR
GENERATION pf                 :      0.852


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 TCSC REACTIVE DRAWL     :      0.000 MVAR

TOTAL SPS REACTIVE DRAWL      :      0.000 MVAR

TOTAL UPFC FACTS. INJECTION   :    0.0000 MVAR

TOTAL SHUNT FACTS.INJECTION   :      0.000 MVAR
```

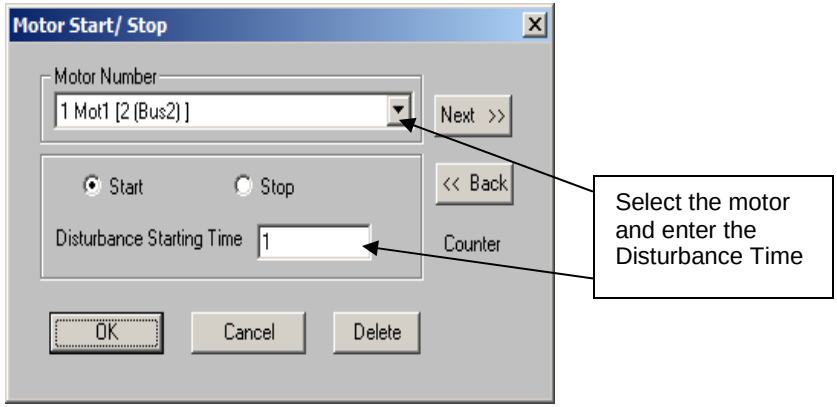
```
TOTAL SHUNT FACTS.DRAWAL      :       0.000 MVAR

TOTAL REAL POWER LOAD         :       9.000 MW
TOTAL REAL POWER DRAWAL -ve g :       0.000 MW
TOTAL REACTIVE POWER LOAD     :       5.500 MVAR
LOAD pf                       :       0.853
TOTAL COMPENSATION AT LOADS   :       0.000 MVAR
TOTAL HVDC REACTIVE POWER     :       0.000 MVAR

TOTAL REAL POWER LOSS (AC+DC) :    0.057220 MW (  0.057220+  0.000000)
PERCENTAGE REAL  LOSS (AC+DC) :    0.626
TOTAL REACTIVE POWER  LOSS    :    0.028631 MVAR
```

3.12 Executing transient stability study with AVR And Governor

Click on **Solve →Transient stability analysis**.

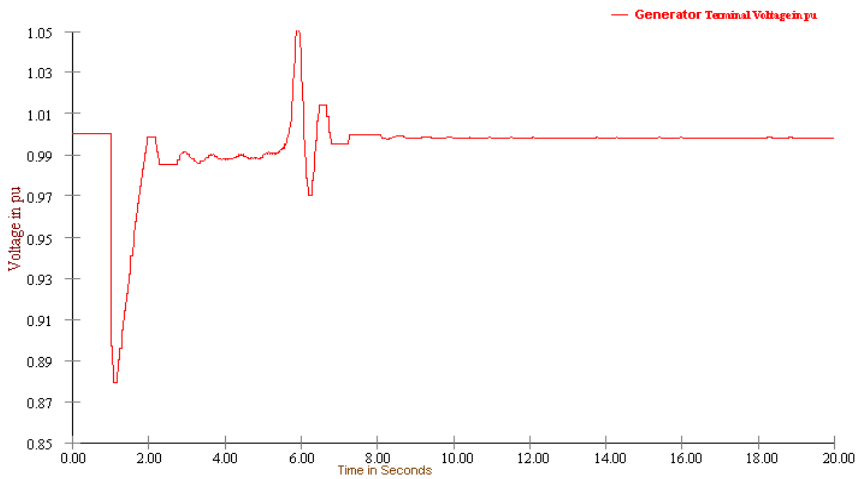



TRANSIENT STABILITY STUDIES
Load Type
Constant Impedance Type
Swing Bus
0 Absolute Swing
Multiplication Factor Number
Load Flow Print Option
Load Flow Case
1
Simulation Time
Start
End
Step
0.5
0.02
Tolerences
Real Power (Initial)
0.001
Reactive Power (Initial)
0.001
Real Power (Post Dist.)
0.01
React Power (Post Dist.)
0.01
No. of Load Flow Iterations
10
Print Step Option
1
Data Print Option
With Data
VI-ZS Option
Output plot option
Select Buses of Interest
1 Bus1
2 Bus2
List of disturbances
Sl No
Disturbance
Yes/No
1
Motor Start/Stop Event 1 at 1.000 s
1. Select Motor
2. Uncheck the
Disturbances
Motor Start/Stop
Disturbance Info
Machine Type
Constant Voltage behind Xd'
Elements Considered
AVR
Governor
Free Programmable Block
Relay
Cyclic Load
Ok
Cancel
4. Uncheck
3. Click


Motor Start/ Stop
Motor Number
1 Mot1 [2 (Bus2)]
Next >>
Start
Stop
<< Back
Disturbance Starting Time
1
Counter
OK
Cancel
Delete
Select the motor and enter the Disturbance Time

Click **OK** and **Execute** Transient Analysis

Effect of AVR on Generator terminal voltage



Effect of Governor on Generator frequency

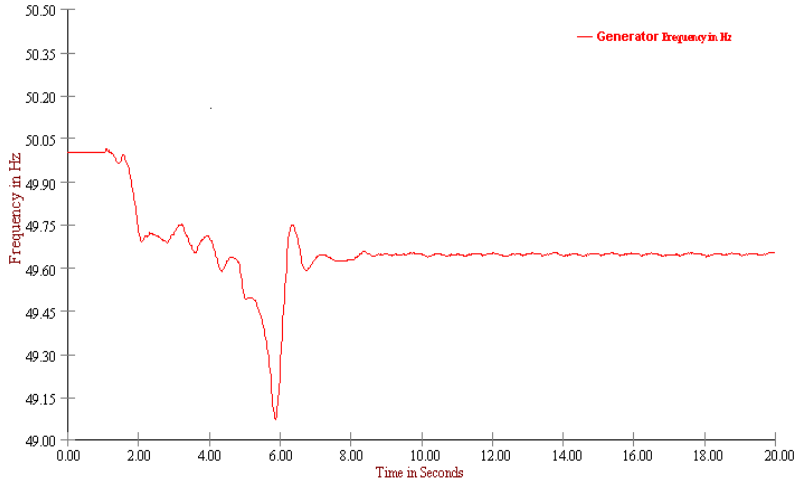


Table of Contents

4. How to solve Network Reduction

For a typical 24 Bus System with maximum generation as slack bus. Element parameters are specified in the element tables.

Generate a Single line diagram using MiP-PSCT Power system Network Editor simultaneously

Compute the Electrical parameters in p.u. on 100MVA base.

Do Load Flow Analysis in Fast decoupled method, tolerance of 0.001. Do

Ybus Network Reduction using following methods

Case1: Retaining all generator buses
Network reduced with retaining all the buses to which the generators are connected, such as 1,2,3 and 4.

Case2: Retaining all Generator buses and Zone 1 buses
Network reduced with retaining all the buses to which the generators are connected, and buses belonging to Zone1, such as 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.

Case3: Retaining all Zone 1 buses
Network reduced with retaining all the Zone1 buses, such as 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.

Case4: Network Reduction for Dynamic Stability study.
Network reduced with retaining all the buses to which the generators are connected taking the option Dynamic Stability

Bus data table

Sl. No	Bus Name	Area No	Zone No	kV rating
1	Bus1	3	1	11.000
2	Bus2	1	2	11.000
3	Bus3	1	2	11.000
4	Bus4	1	1	11.000
5	Bus5	1	1	220.000
6	Bus6	1	1	220.000
7	Bus7	1	1	220.000
8	Bus8	1	1	220.000
9	Bus9	1	1	220.000
10	Bus10	1	1	220.000
11	Bus11	1	1	220.000
12	Bus12	1	1	220.000

13	Bus13	1	1	220.000
14	Bus14	1	1	400.000
15	Bus15	1	1	400.000
16	Bus16	1	1	220.000
17	Bus17	1	1	220.000

18	Bus18	1	2	220.000
19	Bus19	1	2	220.000
20	Bus20	1	2	220.000
21	Bus21	1	2	220.000
22	Bus22	1	2	220.000
23	Bus23	1	2	220.000
24	Bus24	1	2	220.000

Transmission Line data Table

Sl. No.	From Bus	To Bus	Positive Sequence		
			Resistance R(P.U.)	Reactance X(P.U.)	Susceptance B/2(P.U.)
1	15	14	0.00430	0.04770	0.63700
2	7	11	0.02444	0.12226	0.10272
3	12	13	0.01321	0.06608	0.05552
4	13	11	0.00314	0.01570	0.05275
5	13	16	0.00578	0.02891	0.02429
6	16	11	0.00495	0.02478	0.02082
7	16	17	0.00248	0.01239	0.01041
8	5	6	0.00450	0.02251	0.30260
9	6	7	0.03716	0.18586	0.15616
10	6	13	0.05169	0.25856	0.21723
11	6	16	0.01530	0.07655	0.57882
12	6	8	0.01239	0.06195	0.20822
13	8	9	0.00363	0.01817	0.06107
14	8	10	0.00330	0.01652	0.05552
15	18	19	0.00537	0.02685	0.09022
16	19	5	0.01263	0.06319	0.21237
17	19	20	0.01131	0.05658	0.19016
18	20	24	0.01982	0.09913	0.08328
19	24	5	0.02494	0.12473	0.10480
20	22	23	0.03633	0.18173	0.15269
21	22	20	0.01734	0.08674	0.29149
22	22	21	0.00330	0.01652	0.01388

Transformer data table

From Bus	To Bus	Resistance R	Reactance X	MVA Rating
Bus4	Bus15	0.001402	0.02804	475.00
Bus14	Bus11	0.00063	0.01250	475.00
Bus5	Bus1	0.000694	0.013872	704.63
Bus2	Bus18	0.003484	0.06968	156.25
Bus3	Bus22	0.002804	0.05609	237.50

Generator data table

Generator	Gen1	Gen2	Gen3	Gen4
P-sch MW	563.7	125.0	190.0	380.0
P-rate MW	712	135	300	420
P-min MW	400	50	120	240
P-max MW	760	140	330	440
V-pu	1.02	1.02	1.02	1.02
Positive sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03409	0.07473	0.05247	0.02623
Negative sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03409	0.07479	0.05251	0.02626
Zero sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03413	0.07497	0.05264	0.02632
Inertia(H)	6.917	6.917	6.917	6.917

Generator Capability Curve

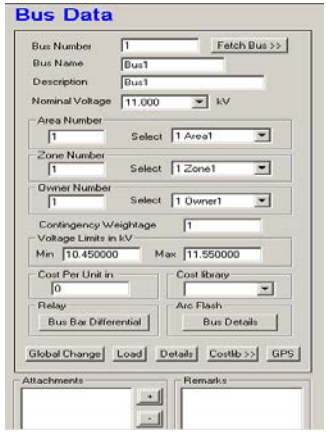
Point No.	P(pu)	Q-min (pu)	Q-max (pu)
1	0.0	-0.3	0.707
2	0.6	-0.2	0.6
3	0.9	-0.2	0.5
4	1.0	0.0	0.0

Load Data

Bus no.	P-load Mvar	Q-load Mvar	Q-comp Mvar
6	70	30	30
7	150	40	30
9	30	10	0
10	90	50	0
11	35	15	0
12	30	10	0
13	150	60	0
16	230	60	0
17	60	25	0
19	130	100	0
20	50	35	0
21	73	48	0
23	50	30	0
24	95	50	0

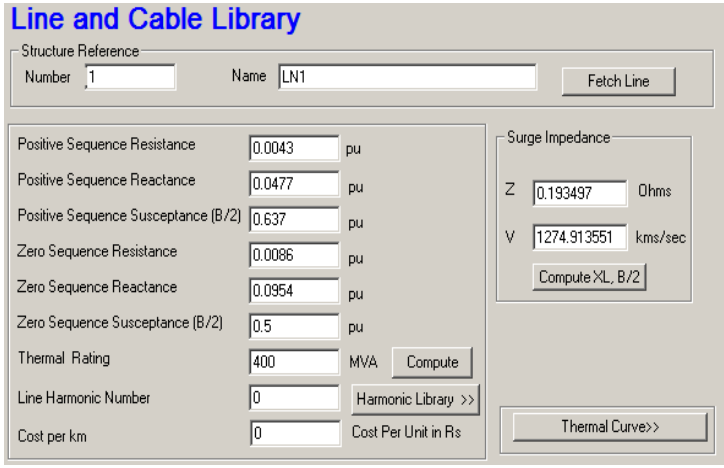
4.1 Procedure to enter Bus Data

Similarly enter other bus, as per details given in the bus data table.



4.2 Procedure to enter Transmission line details:

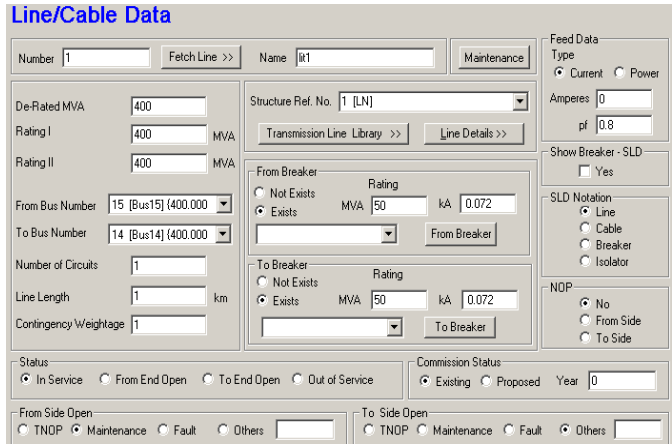
Select main menu **"Libraries → Series Elements → Transmission Line"**



Enter other **Transmission** data similarly, as per the data given in **Transmission line data table.**

Procedure to enter Element detail:

Select main menu **Elements → Series Elements → Transmission Line →**

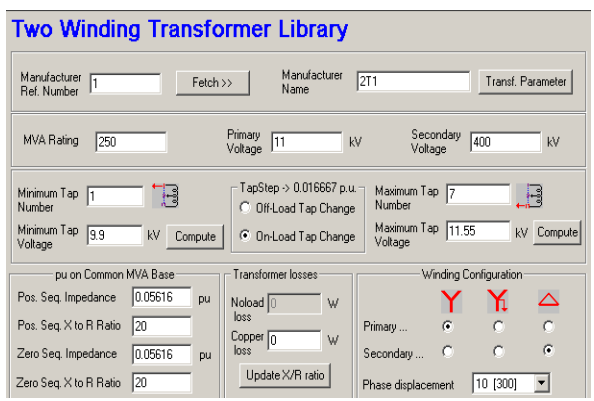


Enter remaining **Transmission line data** similarly according to the following table.

Line No.	From Bus	To Bus	No. of circuits	Line Length in km	Structure reference no.
2	7	11	1	1	2
3	12	13	1	1	3
4	13	11	1	1	4
5	13	16	1	1	5
6	16	11	1	1	6
7	16	17	1	1	7
8	5	6	1	1	8
9	6	7	1	1	9
10	6	13	1	1	10
11	6	16	1	1	11
12	6	8	1	1	12
13	8	9	1	1	13
14	8	10	1	1	14
15	18	19	1	1	15
16	19	5	1	1	16
17	19	20	1	1	17
18	20	24	1	1	18
19	24	5	1	1	19
20	22	23	1	1	20
21	22	20	1	1	21
22	22	21	1	1	22

4.3 Procedure to enter Transformer details

Select menu option **Libraries** → **Series Element** → **Two winding Transformer**



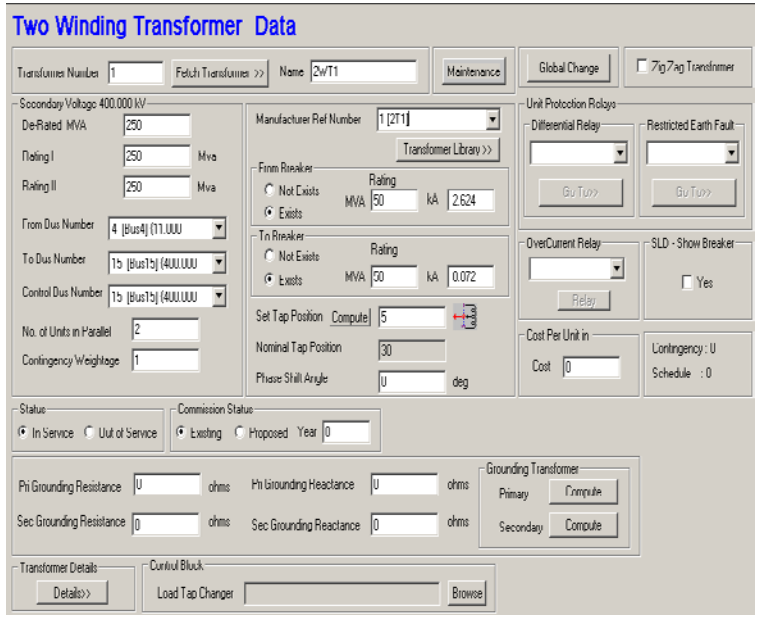
R and X data given in Transformer details table.
Impedance Z = $\sqrt{R^2 + X^2}$

Enter remaining **Transformer** details similarly according to the following table**.**

Manufacturer no.	2	3	4	5
Manufacturer name	14-11	5-1	2-18	3-22
MVA rating	475.00	704.63	156.25	237.50
Impedance	0.01252	0.11112	0.06977	0.05616
X/R Ratio	19.8413	19.988	20	20.0036
Primary kV	400	220	11	11
Secondary kV	220	11	220	220
Min Tap No	1	1	1	1
Max Tap No	7	13	7	7
Min Tap in kV	360	198	10.45	10.45
Max Tap in kV	420	231	12.1	12.1

Transformer Element details

Select menu option **Element ➔ Series Element ➔ Two winding Transformer**

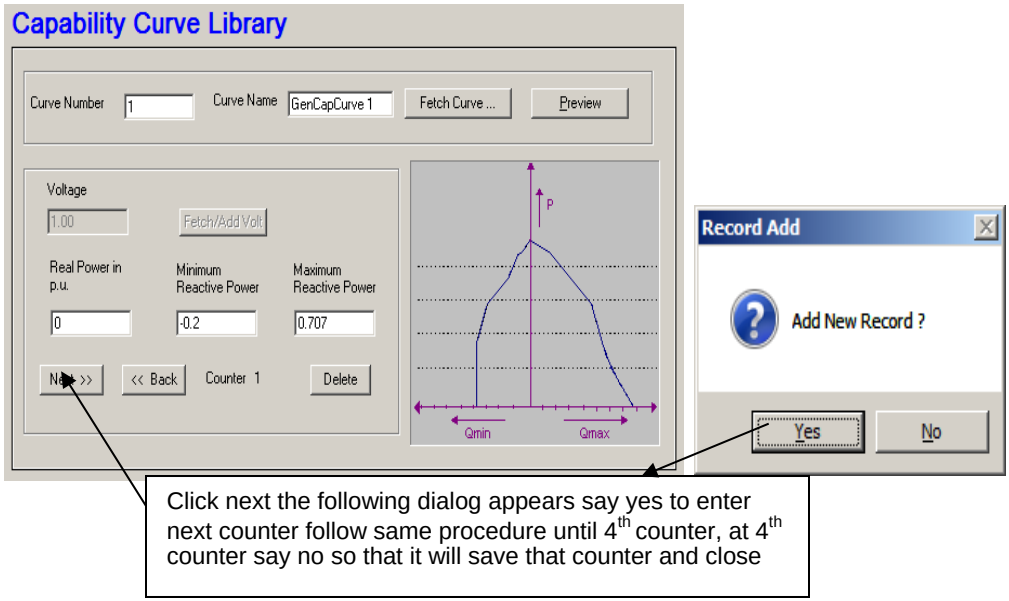


Enter other **Transformer** details similarly. Details as shown in the following table**.**

Transformer no.	2	3	4	5
Transformer name	2T2	2T3	2T4	2T5
From Bus number	14	5	2	3
To Bus number	11	1	18	22
Control Bus number	14	5	18	22
Manufacturer ref number	2	3	4	5
De-Rated MVA	475.00	704.63	156.25	237.50
Nominal Tap	5	9	3	3

4.4 Generator Capability Curve

Select menu option **Libraries ➔ Capability Curve**



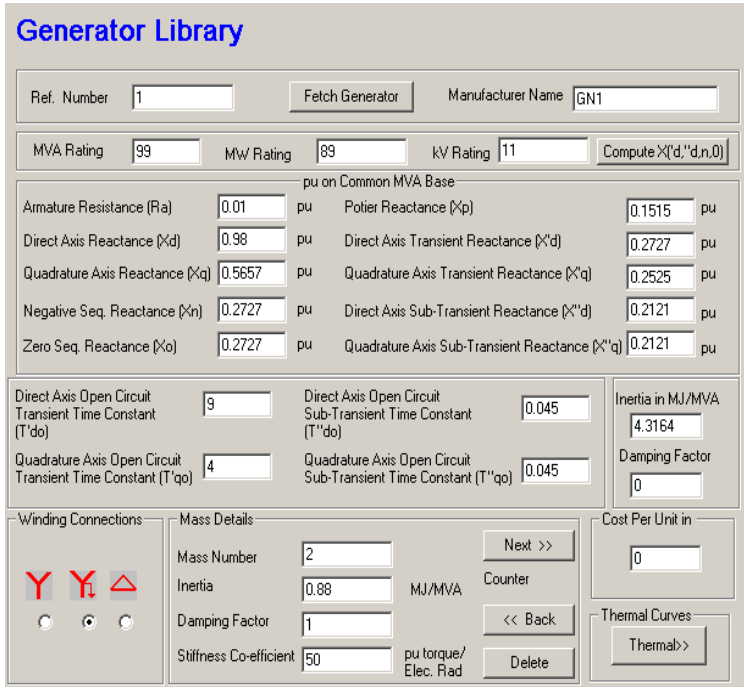
Click next the following dialog appears say yes to enter next counter follow same procedure until 4th counter, at 4th counter say no so that it will save that counter and close

Generator Capability curve detail

Point No.	P(pu)	Q-min (pu)	Q-max (pu)
2	0.6	-0.2	0.6
3	0.9	-0.2	0.5
4	1.0	0.0	0.0

4.5 Generator Details

Select menu option **Libraries ™ Shunt Elements ™ Generator**

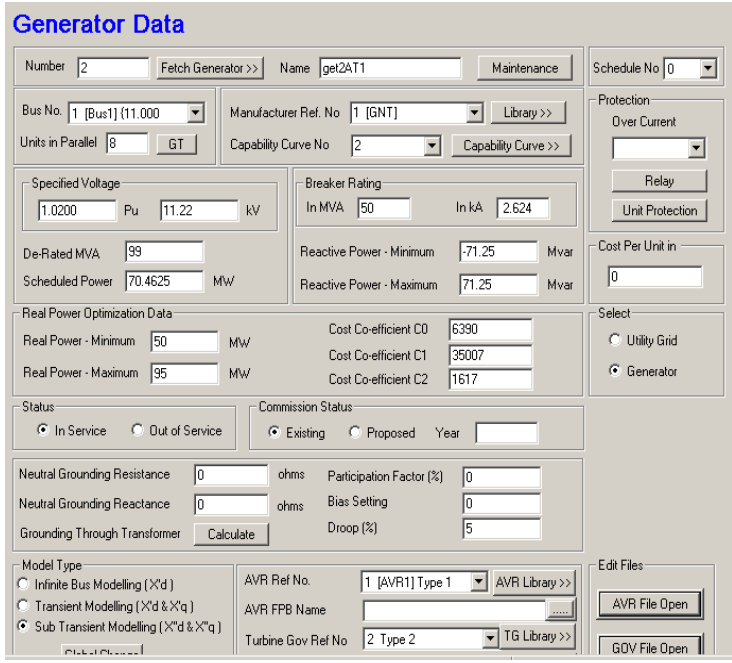


Enter other Generator details similarly. Data given in following table.

Generator	Gen1	Gen2	Gen3	Gen4
P-sch MW	563.7	125.0	190.0	380.0
P-rate MW	712	135	300	420
P-min MW	400	50	120	240
P-max MW	760	140	330	440
V-pu	1.02	1.02	1.02	1.02
Positive sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03409	0.07473	0.05247	0.02623
Negative sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03409	0.07479	0.05251	0.02626
Zero sequence				
R	0.00126	0.00073	0.00051	0.00026
X'd	0.03413	0.07497	0.05264	0.02632
Inertia(H)	6.917	6.917	6.917	6.917

Generator Element details

Select menu **option Elements ➔ Shunt Elements ➔ Generator**

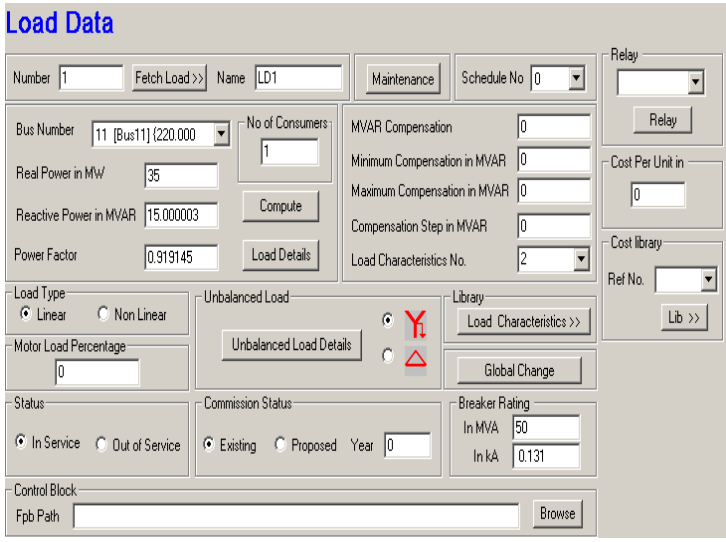


Enter remaining **Generators** similarly. Detail given in following table

Name	GEN-2	GEN-3	GEN-4
Bus Number	2	3	4
Manufacturer Reference Number	2	3	4
Number of Generators in Parallel	1	1	1
Capability Curve Number	1	1	1
De-Rated MVA	225	225	225
Specified Voltage	11.22	11.22	11.22
Scheduled Power	125	190	380
Reactive Power Minimum	-105	-330	-330
Reactive Power Maximum	95	330	330
Breaker Rating	350	350	350

4.6 Load details

Select menu option **Elements ➔ Shunt Elements ➔ Load**

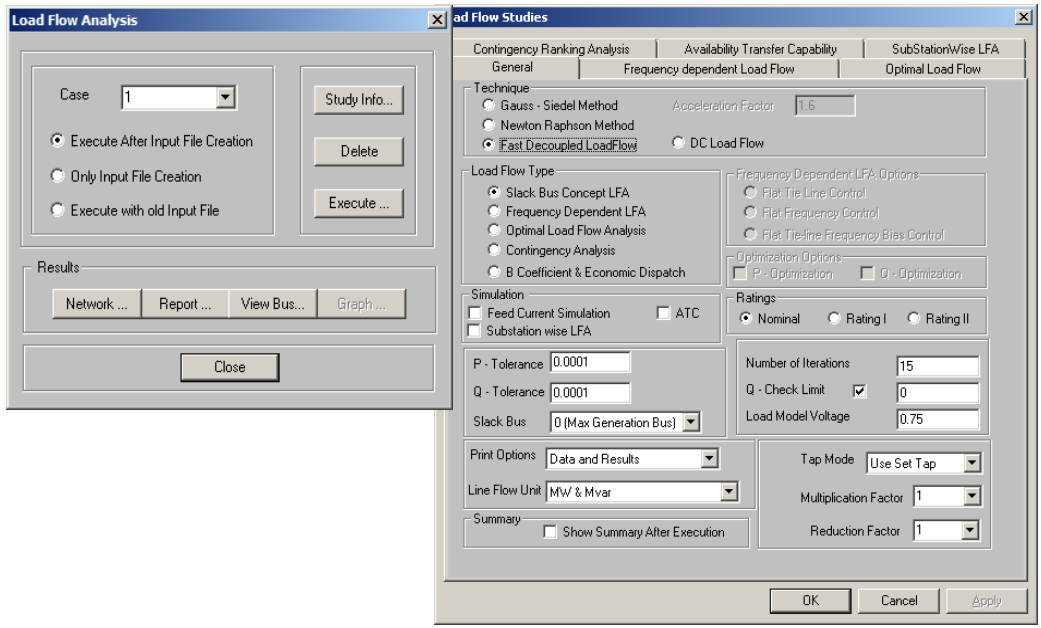


Enter remaining **loads** similarly. Details given in the following table

Bus no.	P-load MW	Q-load Mvar	Q-comp Mvar
6	70	30	30
7	150	40	30
9	30	10	0
10	90	50	0
11	35	15	0
12	30	10	0
13	150	60	0
16	230	60	0
17	60	25	0
19	130	100	0
20	50	35	0
21	73	48	0
23	50	30	0
24	95	50	0

4.7 Solving Load Flow

Select menu option "**Solve -> Load Flow".**



Report

Load flow results are given below.

BUS VOLTAGES AND POWERS

NODE NO.	FROM NAME	V-MAG P.U.	ANGLE DEGREE	MW GEN	MVAR GEN	MW LOAD	MVAR LOAD	MVAR COMP	
1	BUS1	1.0200	0.00	563.711	19.574	0.000	0.000	0.000	
2	BUS2	1.0200	1.61	125.000	22.496	0.000	0.000	0.000	
3	BUS3	1.0200	3.52	190.000	39.568	0.000	0.000	0.000	
4	BUS4	1.0200	3.91	380.000	35.241	0.000	0.000	0.000	
5	BUS5	1.0164	-4.32	0.000	0.000	0.000	0.000	0.000	
6	BUS6	1.0050	-10.41	0.000	0.000	70.244	30.104	30.000	
7	BUS7	0.9677	-19.85	0.000	0.000	146.636	39.103	30.000	
8	BUS8	0.9756	-14.54	0.000	0.000	0.000	0.000	0.000	
9	BUS9	0.9737	-14.85	0.000	0.000	29.453	9.818	0.000	
10	BUS10	0.9650	-15.33	0.000	0.000	87.820	48.789	0.000	
11	BUS11	0.9733	-15.09	0.000	0.000	34.351	14.722	0.000	
12	BUS12	0.9568	-17.67	0.000	0.000	29.103	9.701	0.000	
13	BUS13	0.9642	-16.52	0.000	0.000	146.276	58.510	0.000	
14	BUS14	0.9814	-12.32	0.000	0.000	0.000	0.000	0.000	
15	BUS15	1.0105	-2.00	0.000	0.000	0.000	0.000	0.000	
16	BUS16	0.9638	-16.86	0.000	0.000	224.238	58.497	0.000	
17	BUS17	0.9593	-17.27	0.000	0.000	58.310	24.296	0.000	
18	BUS18	1.0039	-3.23	0.000	0.000	0.000	0.000	0.000	
19	BUS19	0.9922	-5.08	0.000	0.000	129.295	99.458	0.000	
20	BUS20	0.9910	-5.83	0.000	0.000	49.687	34.781	0.000	
21	BUS21	0.9882	-3.03	0.000	0.000	72.398	47.604	0.000	
22	BUS22	0.9984	-2.42	0.000	0.000	0.000	0.000	0.000	
23	BUS23	0.9469	-7.40	0.000	0.000	48.171	28.903	0.000	@
24	BUS24	0.9726	-7.97	0.000	0.000	93.194	49.050	0.000	

NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) : 1
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

TRANSFORMER FLOWS AND TRANSFORMER LOSSES

SLNO	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	FORWARD MW	FORWARD MVAR	LOSS MW	LOSS MVAR	% LOADING	
1	2	4	BUS4	15	BUS15	380.000	35.241	1.9630	39.2592	74.8	$
2	1	14	BUS14	11	BUS11	371.856	53.910	0.9237	18.3278	76.6	#
3	8	5	BUS5	1	BUS1	-561.589	22.848	2.1224	42.4223	69.8	$
4	1	2	BUS2	18	BUS18	125.000	22.496	0.5402	10.8041	75.5	#
5	1	3	BUS3	22	BUS22	190.000	39.568	1.0151	20.3063	76.1	#

! NUMBER OF TRANSFORMERS LOADED BEYOND 125% : 0
@ NUMBER OF TRANSFORMERS LOADED BETWEEN 100% AND 125% : 0

```
# NUMBER OF TRANSFORMERS LOADED BETWEEN  75% AND 100% :    3
$ NUMBER OF TRANSFORMERS LOADED BETWEEN  50% AND  75% :    2
^ NUMBER OF TRANSFORMERS LOADED BETWEEN  25% AND  50% :    0
& NUMBER OF TRANSFORMERS LOADED BETWEEN   1% AND  25% :    0
* NUMBER OF TRANSFORMERS LOADED BETWEEN   0% AND   1% :    0
```

LINE FLOWS AND LINE LOSSES

SLNO	CS	FROM NAME	FROM NODE	TO NAME	TO NODE	FORWARD MW	FORWARD MVAR	LOSS MW	LOSS MVAR	% NODE LOADING
6	1	BUS15	15	BUS14	14	378.034	-4.006	6.1755	-57.8906	93.5#
7	1	BUS7	7	BUS11	11	-61.752	0.900	1.0242	-14.2262	55.3$
8	1	BUS12	12	BUS13	13	-29.102	-9.699	0.1253	-9.6166	26.7^
9	2	BUS13	13	BUS11	11	-153.297	-28.633	0.8128	-5.8370	67.4$
10	1	BUS13	13	BUS16	16	18.655	-4.839	0.0221	-4.4042	16.7&
11	1	BUS16	16	BUS11	11	-118.921	-13.271	0.7604	-0.0999	103.1@
12	1	BUS16	16	BUS17	17	58.415	22.899	0.1063	-1.3940	54.9$
13	4	BUS5	5	BUS6	6	477.840	-49.588	9.9609	-11.9946	98.5#
14	1	BUS6	6	BUS7	7	87.746	-6.062	2.8676	-16.0514	72.9$
15	1	BUS6	6	BUS13	13	41.800	-12.309	0.9417	-37.4225	41.5^
16	3	BUS6	6	BUS16	16	148.596	-26.153	3.5032	-94.7018	46.2^
17	2	BUS6	6	BUS8	8	119.493	6.806	1.8467	-31.6140	52.9$
18	2	BUS8	8	BUS9	9	29.486	-1.617	0.0338	-11.4338	13.3&
19	2	BUS8	8	BUS10	10	88.160	40.038	0.3407	-8.7495	43.4^
20	2	BUS18	18	BUS19	19	124.460	11.692	0.8483	-13.7340	53.0$
21	2	BUS19	19	BUS5	5	-27.772	-53.132	0.2321	-41.6860	25.2^
22	2	BUS19	19	BUS20	20	22.088	-20.899	0.0566	-37.1160	12.8&
23	1	BUS20	20	BUS24	24	38.691	3.175	0.3281	-14.4170	36.2^
24	1	BUS24	24	BUS5	5	-54.831	-31.457	0.9149	-16.1647	54.2$
25	1	BUS22	22	BUS23	23	49.205	5.164	1.0339	-23.7399	49.4^
26	2	BUS22	22	BUS20	20	67.132	-32.016	0.7855	-53.7550	31.0^
27	1	BUS22	22	BUS21	21	72.648	46.114	0.2494	-1.4903	73.1$

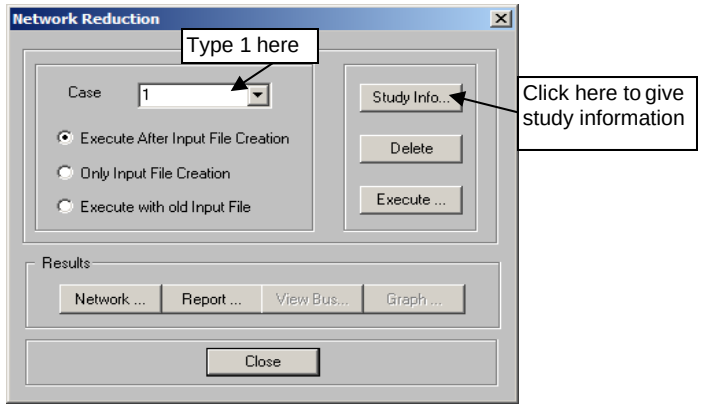
```
! NUMBER OF LINES LOADED BEYOND  125%          :    0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    1
# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    2
$ NUMBER OF LINES LOADED BETWEEN  50% AND  75% :    8
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    8
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    3
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
```

4.8 To solve Y-Bus Reduction (Network Reduction)

CASE 1: Retaining all generator buses

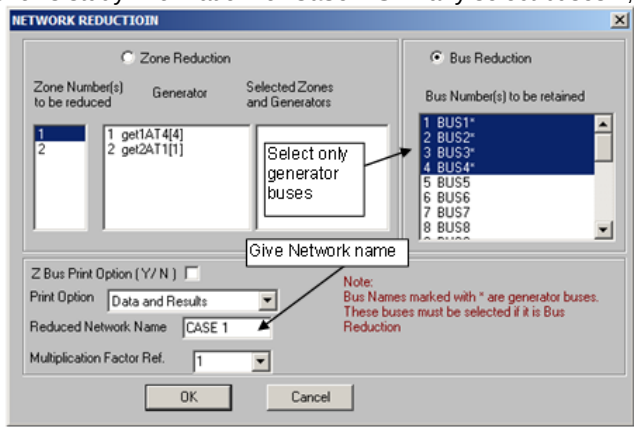
24 Bus sample systems are reduced with retaining all the buses to which the generators are connected, such as buses 1,2,3 and 4. All other connections are reduced as equivalent series impedance between the retained buses and shunt admittance at the retained buses.

Select menu option
"Solve -> Network Reduction"
Following screen appears



Study Information

Following screen shows study information for **Case 1**.Similarly select buses 1, 2, 3, & 4.



Click **OK** after entering information. **Execute** Network Reduction. Click **Report** button to view the **report**.

Network Reduction Report for case 1

```
NETWORK  REDUCTION
CASE NO :  11     CONTINGENCY  : 0  SCHEDULE NO : 0
CONTINGENCY NAME : Base Case

------------------------------------------------------------------------------
%%
TOTAL NUMBER OF BUSES          :   24    ACTUAL NUMBER OF BUSES         :   24
NUMBER OF 2 WIND. TRANSFORMERS :    5    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :   22
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    4
NUMBER OF LOADS                :   14
NUMBER OF FILTERS              :    0

NUMBER OF HVDC CONVERTORS      :    0

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


NUMBER OF ZONES         :  2

PRINT OPTION            :  3 (BOTH DATA AND RESULTS PRINT)
BASE MVA                :  100.000
NOMINAL SYSTEM FREQUENCY:   50.000
PREFAULT VOLTAGE OPTION :  1 (READ FROM THE FILE)
ZONE NUMBER RETAINED    :  0
ZBUS PRINT OPTION       :  0
```

```
YBUS REDUCTION OPTION   :  1 (NETWORK REDUCTION)
--------------------------------------------------------------------------------
   4
   1     2     3     4
--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                      :   0.000000
CIRCUIT BREAKER REACTANCE  (PU)                      :   0.000100
TRANSFORMER R/X RATIO                                :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR      :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS                : 3
TRANSMISSION LINE VOLTAGE - KV                       :  11.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  RES.  MULT.  FACTOR  :  0.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  REA.  MULT.  FACTOR  :  0.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  ADM.  MULT.  FACTOR  :  0.000000
TRANSMISSION LINE VOLTAGE - KV                       : 220.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  RES.  MULT.  FACTOR  :  2.500000
TRANSMISSION  LINE  ZERO  SEQUENCE  REA.  MULT.  FACTOR  :  2.500000
TRANSMISSION  LINE  ZERO  SEQUENCE  ADM.  MULT.  FACTOR  :  0.025000
TRANSMISSION LINE VOLTAGE - KV                       : 400.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  RES.  MULT.  FACTOR  :  2.500000
TRANSMISSION  LINE  ZERO  SEQUENCE  REA.  MULT.  FACTOR  :  2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :   0.025000

GENERATOR  NEGATIVE  SEQUENCE  RESISTANCE  MULT.  FACTOR  :  0.175000
GENERATOR  NEGATIVE  SEQUENCE  REACTANCE  MULT.  FACTOR  :  0.175000
GENERATOR  ZERO  SEQUENCE  RESISTANCE  MULT.  FACTOR  :  0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR     :    0.037500
LOAD    NEGATIVE SEQUENCE IMPEDANCE   MULT. FACTOR   :    0.810000
LOAD    ZERO SEQUENCE IMPEDANCE   MULT. FACTOR      :    1.600000
SERIES  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR :  1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BUS DATA
NODE STAT ZONE BUS-KV   NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MR
                                           PLOAD-MW QLOAD-MR QCOMP-MR
---- ---- ---- -------- -------- -------- -------- -------- --------
   1    1    1   11.000      BUS1   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000
   2    1    2   11.000      BUS2   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000
   3    1    2   11.000      BUS3   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000
   4    1    1   11.000      BUS4   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000
   5    1    1  220.000      BUS5   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000

   6    1    1  220.000      BUS6   0.0000    0.000    0.000     0.000
                                             0.000    0.000     0.000
```

```
   7    1    1  220.000      BUS7   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
   8    1    1  220.000      BUS8   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
   9    1    1  220.000      BUS9   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  10    1    1  220.000     BUS10   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  11    1    1  220.000     BUS11   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  12    1    1  220.000     BUS12   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  13    1    1  220.000     BUS13   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  14    1    1  400.000     BUS14   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  15    1    1  400.000     BUS15   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  16    1    1  220.000     BUS16   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  17    1    1  220.000     BUS17   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  18    1    2  220.000     BUS18   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  19    1    2  220.000     BUS19   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  20    1    2  220.000     BUS20   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  21    1    2  220.000     BUS21   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  22    1    2  220.000     BUS22   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  23    1    2  220.000     BUS23   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
  24    1    2  220.000     BUS24   0.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
--------------------------------------------------------------------------------
TRANSFORMER DATA

STAT CKTS FROM FROM       TO TO              POSITIVE              ZERO
          NODE NAME     NODE NAME       R(P.U)  X(P.U.) R(P.U.) X(P.U.)
                                           TAP     PHASE  FB-MVA  TB-MVA
---- ---- ---- -------- ---- -------- -------- -------- ------- ------- -- --
   3    2    4     BUS4   15     BUS15  0.00140  0.02804  0.00140  0.02804
                                        1.00000    0.000      50      50  S  D
   3    1   14    BUS14   11     BUS11  0.00063  0.01250  0.00063  0.01250
                                        1.00000    0.000      50      50  G  G
   3    8    5     BUS5    1      BUS1  0.00069  0.01387  0.00069  0.01387
                                        1.00000    0.000      50      50  G  G
   3    1    2     BUS2   18     BUS18  0.00348  0.06968  0.00348  0.06968
                                        1.00000    0.000      50      50  G  G
```

3	1	3	BUS3	22	BUS22	0.00280	0.05609	0.00280	0.05609		
						1.00000	0.000	50	50	G	G

TRANSMISSION LINE DATA

STAT	CKTS	FROM NODE	FROM NAME	TO NODE	TO NAME	RP(P.U) / RZ(P.U)	XP(P.U) / XZ(P.U)	BP/2(PU) / BZ/2(PU)	FC-MVA	TC-MVA
3	1	15	BUS15	14	BUS14	0.00430	0.04770	0.63700		
						0.00860	0.09540	0.50000	50	50
3	1	7	BUS7	11	BUS11	0.02444	0.12226	0.10272		
						0.07332	0.36677	0.07190	50	50
3	1	12	BUS12	13	BUS13	0.01321	0.06608	0.05552		
						0.03963	0.19825	0.03887	50	50
3	2	13	BUS13	11	BUS11	0.00314	0.01570	0.05275		
						0.00941	0.04714	0.03692	50	50
3	1	13	BUS13	16	BUS16	0.00578	0.02891	0.02429		
						0.01734	0.08674	0.01700	50	50
3	1	16	BUS16	11	BUS11	0.00495	0.02478	0.02082		
						0.01486	0.07434	0.01457	50	50
3	1	16	BUS16	17	BUS17	0.00248	0.01239	0.01041		
						0.00743	0.03717	0.00729	50	50
3	4	5	BUS5	6	BUS6	0.00450	0.02251	0.30260		
						0.01350	0.06753	0.21180	50	50
3	1	6	BUS6	7	BUS7	0.03716	0.18586	0.15616		
						0.11147	0.55759	0.10930	50	50
3	1	6	BUS6	13	BUS13	0.05169	0.25856	0.21723		
						0.15506	0.77567	0.15210	50	50
3	3	6	BUS6	16	BUS16	0.01530	0.07655	0.57882		
						0.04591	0.22964	0.40530	50	50
3	2	6	BUS6	8	BUS8	0.01239	0.06195	0.20822		
						0.03716	0.18586	0.14572	50	50
3	2	8	BUS8	9	BUS9	0.00363	0.01817	0.06107		
						0.01090	0.05452	0.04276	50	50
3	2	8	BUS8	10	BUS10	0.00330	0.01652	0.05552		
						0.00991	0.04956	0.03886	50	50
3	2	18	BUS18	19	BUS19	0.00537	0.02685	0.09022		
						0.01610	0.08054	0.06316	50	50
3	2	19	BUS19	5	BUS5	0.01263	0.06319	0.21237		
						0.03790	0.18958	0.14866	50	50
3	2	19	BUS19	20	BUS20	0.01131	0.05658	0.19016		
						0.03394	0.16975	0.13310	50	50
3	1	20	BUS20	24	BUS24	0.01982	0.09913	0.08328		
						0.05945	0.29738	0.05832	50	50
3	1	24	BUS24	5	BUS5	0.02494	0.12473	0.10480		
						0.07418	0.37420	0.07336	50	50
3	1	22	BUS22	23	BUS23	0.03633	0.18173	0.15269		
						0.10899	0.54520	0.10690	50	50
3	2	22	BUS22	20	BUS20	0.01734	0.08674	0.29149		

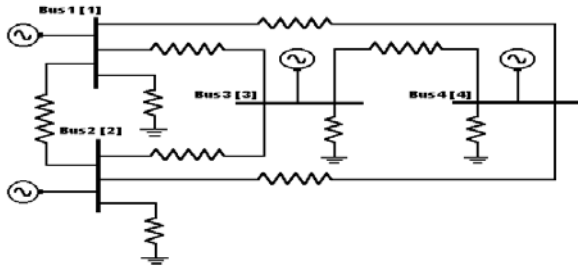
```
                                          0.05202  0.26021  0.20400     50     50
   3    1   22    BUS22   21    BUS21  0.00330  0.01652  0.01388

                                          0.00991  0.04956  0.00972     50     50

------------------------------------------------------------------------------
GENERATOR DATA

FROM FROM           POSITIVE         NEGATIVE           ZERO
NODE NAME       R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) CB-MVA
---- -------- -------- -------- -------- -------- -------- -------- ------


4     BUS4  0.00050  0.02625  0.00050  0.02625  0.00050  0.02625     50

1     BUS1  0.00125  0.03409  0.00125  0.03409  0.00125  0.03409     50
   2     BUS2  0.00100  0.07470  0.00100  0.07480  0.00100  0.07480     50
   3     BUS3  0.00050  0.03735  0.00050  0.03740  0.00050  0.03740     50

------------------------------------------------------------------------------ LOAD
DATA

NODE NAME
---- --------
  11    BUS11
  17    BUS17
   7     BUS7
  12    BUS12
  13    BUS13
   6     BUS6
   9     BUS9
  10    BUS10
  20    BUS20
  23    BUS23
  21    BUS21
  16    BUS16
  19    BUS19
  24    BUS24
Number of reduced buses: 4
Reduced bus array:
   1     2     3     4
------------------------------------------------------------------------------
------------------------------------------------------------------------------
POSITIVE SEQUENCE ADMITTANCE MATRIX ELEMENTS FOR THE GIVEN SYSTEM
------------------------------------------------------------------------------
ROW NO COLUMN NO       REAL  IMAGINARY
------ --------- ---------- ----------
     1         1    1.57674   -9.97533
     1         2   -0.55642    5.07156
     1         3   -0.48112    3.10001
     1         4   -0.54116    5.82485
     2         1   -0.55642    5.07156
     2         2    0.80100   -6.49955
```

```
     2         3    -0.16692     1.67456
     2         4    -0.08116     0.47480
     3         1    -0.48112     3.10001

     3         2    -0.16692     1.67456
     3         3     0.71590    -4.07908
     3         4    -0.06290     0.28943
     4         1    -0.54116     5.82485
     4         2    -0.08116     0.47480
     4         3    -0.06290     0.28943
     4         4     0.77828    -4.28315
--------------------------------------------------------------------------------
-------------------------------------------------------------------------------- NEGATIVE
SEQUENCE ADMITTANCE MATRIX ELEMENTS FOR THE GIVEN SYSTEM
--------------------------------------------------------------------------------
ROW NO COLUMN NO       REAL  IMAGINARY
------ --------- ---------- ----------
     1         1    1.57674   -9.97533


     1         2    -0.55642     5.07156
     1         3    -0.48112     3.10001
     1         4    -0.54116     5.82485
     2         1    -0.55642     5.07156
     2         2     0.80100    -6.49955
     2         3    -0.16692     1.67456
     2         4    -0.08116     0.47480
     3         1    -0.48112     3.10001
     3         2    -0.16692     1.67456
     3         3     0.71590    -4.07908
     3         4    -0.06290     0.28943
     4         1    -0.54116     5.82485
     4         2    -0.08116     0.47480
     4         3    -0.06290     0.28943
     4         4     0.77828    -4.28315
--------------------------------------------------------------------------------
-------------------------------------------------------------------------------- ZERO
SEQUENCE ADMITTANCE MATRIX ELEMENTS FOR THE GIVEN SYSTEM
--------------------------------------------------------------------------------
ROW NO COLUMN NO       REAL  IMAGINARY
------ --------- ---------- ----------
     1         1    1.85798     2.79557
     1         2    -0.38654     2.97755
     1         3    -0.20996     1.32202
     1         4    -0.00000    -0.00000
     2         1    -0.38654     2.97755
     2         2     0.54724    -3.25450
     2         3    -0.12810     0.93226
     2         4    -0.00000    -0.00000
     3         1    -0.20996     1.32202
     3         2    -0.12810     0.93226
     3         3     0.35595    -1.48148
     3         4    -0.00000    -0.00000
```

```
     4          1    -0.00000    -0.00000
     4          2    -0.00000    -0.00000
     4          3    -0.00000    -0.00000
     4          4     0.00000     0.00000

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
RETAINED ZONE :    0
NUMBER OF SERIES ELEMENTS IN THE REDUCED ZONES :    6
SERIES CONNECTIONS
SLNO FROM     NAME   TO     NAME      RP        XP        BP/2 RZ       XZ        BZ/2
---- ---- -------- ---- -------- --------- --------- ---- -------- --------- ----
   1    1     BUS1    2     BUS2 0.021376 0.194833  0.0 0.042877 0.330280  0.0
   2    1     BUS1    3     BUS3 0.048886 0.314993  0.0 0.117178 0.737806  0.0
   3    1     BUS1    4     BUS4 0.015813 0.170209  0.0 0.000000 9999.000  0.0
   4    2     BUS2    3     BUS3 0.058939 0.591298  0.0 0.144667 1.052787  0.0
   5    2     BUS2    4     BUS4 0.349794 2.046351  0.0 0.000000 9999.000  0.0
   6    3     BUS3    4     BUS4 0.717003 3.299303  0.0 0.000000 9999.000  0.0
--------------------------------------------------------------------------------
NUMBER OF SHUNT ELEMENTS IN THE REDUCED ZONES :    4
SHUNT CONNECTIONS IN (G+JB) FORMAT - PU
SLNO FROM     NAME     GP        BP        GZ        BZ
---- ---- -------- -------- -------- -------- --------
   1    1     BUS1 -0.00196  4.02109  1.26147  7.09515
   2    2     BUS2 -0.00350  0.72137  0.03259  0.65530


 3    3     BUS3  0.00497  0.98491  0.01788  0.77280
 4    4     BUS4  0.09307  2.30593 -0.00000 -0.00000
--------------------------------------------------------------------------------
```

Reduced system

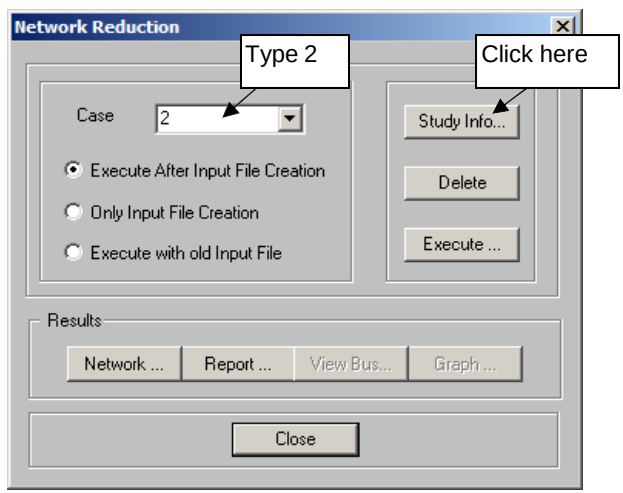
Retaining all generator buses



4.9 Procedure to do Case 2

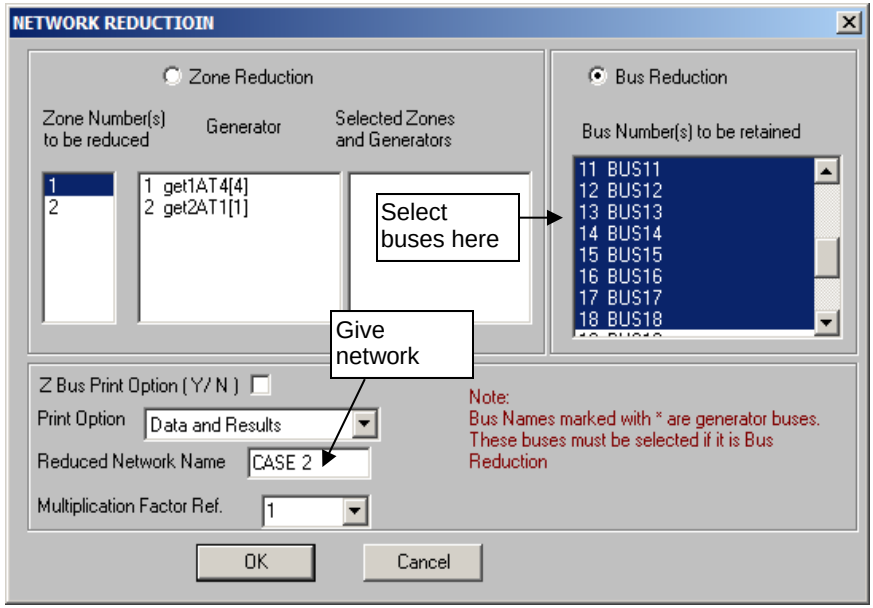
CASE 2 : Retaining all generator buses and zone 1 buses
Fig 1 24Bus system is reduced with retaining all the buses to which the generators are connected, and buses belonging to Zone1, such as 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17 are also retained. All connections in zone 2 are reduced as equivalent series impedance and shunt admittance.

Select menu option **Solve -> Network Reduction**

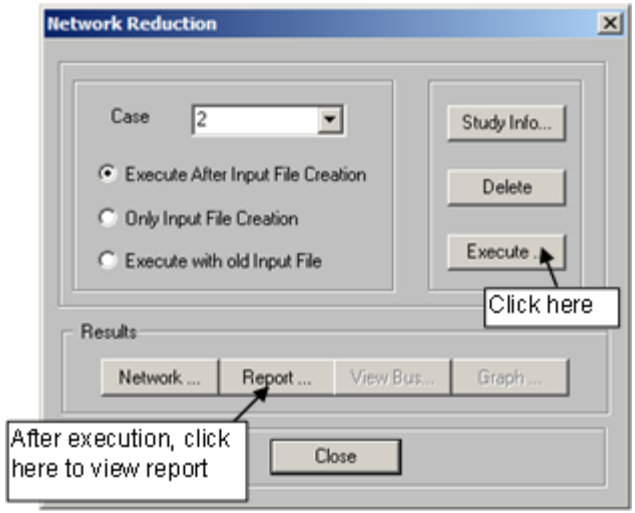


Study Information

Following study information screen will open. In that select zone 1 buses and all generator buses.



Executing and viewing the report:

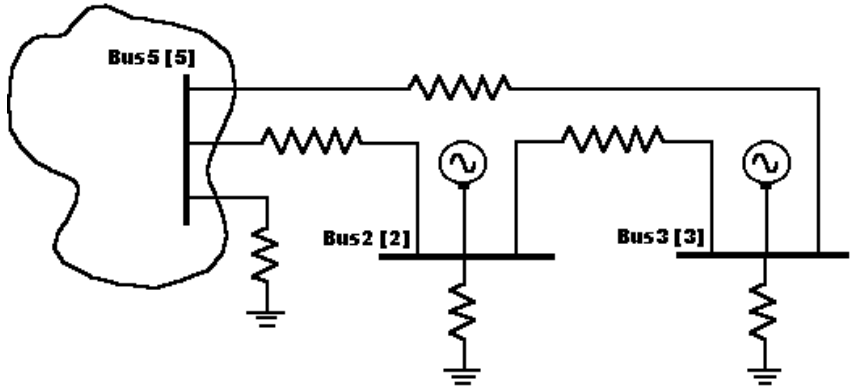


Network Reduction Report for case 2

```
NETWORK REDUCTION

CASE NO :  12     CONTINGENCY  : 0  SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
--------------------------------------------------------------------------------
%%
TOTAL NUMBER OF BUSES          :   24    ACTUAL NUMBER OF BUSES         :   24
NUMBER OF 2 WIND. TRANSFORMERS :    5    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :   22
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    4
NUMBER OF LOADS                :   14
NUMBER OF FILTERS              :    0

NUMBER OF HVDC CONVERTORS      :    0

--------------------------------------------------------------------------------
NUMBER OF ZONES         :  2
PRINT OPTION            :  3 (BOTH DATA AND RESULTS PRINT)
BASE MVA                :  100.000
NOMINAL SYSTEM FREQUENCY:   50.000
PREFAULT VOLTAGE OPTION : 1 (READ FROM THE FILE)
ZONE NUMBER RETAINED    :  0
ZBUS PRINT OPTION       :  0
YBUS REDUCTION OPTION   :  1 (NETWORK REDUCTION)
--------------------------------------------------------------------------------
  17
   1     2     3     4     5     6     7     8     9    10
  11    12    13    14    15    16    17
--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                     :   0.000000
CIRCUIT BREAKER REACTANCE  (PU)                     :   0.000100
TRANSFORMER R/X RATIO                               :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR     :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS               : 3
TRANSMISSION LINE VOLTAGE - KV                      :  11.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR   :   0.000000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR   :   0.000000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR   :   0.000000
TRANSMISSION LINE VOLTAGE - KV                      : 220.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR   :   2.500000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR   :   2.500000
```

```
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :    0.025000
TRANSMISSION LINE VOLTAGE - KV                       :  400.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR    :    2.500000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR    :    2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :    0.025000
GENERATOR NEGATIVE SEQUENCE RESISTANCE MULT. FACTOR  :    0.175000
GENERATOR NEGATIVE SEQUENCE REACTANCE  MULT. FACTOR  :    0.175000
GENERATOR ZERO SEQUENCE RESISTANCE MULT. FACTOR      :    0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR       :    0.037500
LOAD      NEGATIVE SEQUENCE IMPEDANCE  MULT. FACTOR  :    0.810000
LOAD      ZERO SEQUENCE IMPEDANCE  MULT. FACTOR      :    1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :    1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
-------------------------------------------------------------------
Number of reduced buses : 17
Reduced bus array :
   1     2     3     4     5     6     7     8     9    10
  11    12    13    14    15    16    17
-------------------------------------------------------------------------------
RETAINED ZONE :    0
NUMBER OF SERIES ELEMENTS IN THE REDUCED ZONES :    3
SERIES CONNECTIONS
SLNO FROM     NAME   TO     NAME     RP       XP       BP/2 RZ       XZ       BZ/2
---- ---- -------- ---- -------- -------- -------- ---- -------- -------- ----
   1    2     BUS2    3     BUS3 0.052959 0.698685  0.0 0.144805 1.117180  0.0
   2    2     BUS2    5     BUS5 0.021307 0.167338  0.0 0.053638 0.341475  0.0
   3    3     BUS3    5     BUS5 0.046777 0.270327  0.0 0.142020 0.762220  0.0
-------------------------------------------------------------------------------
NUMBER OF SHUNT ELEMENTS IN THE REDUCED ZONES :    3
SHUNT CONNECTIONS IN (G+JB) FORMAT - PU
SLNO FROM     NAME     GP       BP       GZ       BZ
---- ---- -------- -------- -------- -------- --------
   1    2     BUS2  0.02202  0.39125  0.01230  0.36643
   2    3     BUS3  0.02972  0.78283  0.01249  0.64382
   3    5     BUS5 -0.03960  1.19377 -0.01182  0.66770
-------------------------------------------------------------------------------
```

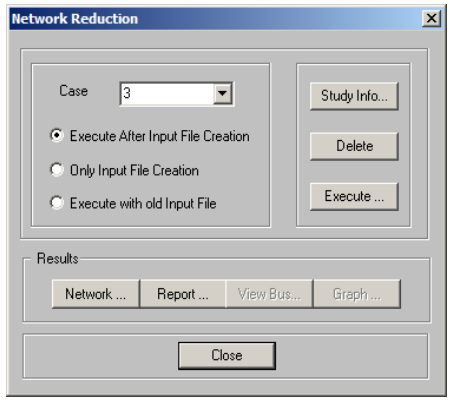
Reduced network retaining all generator buses and zone 1 buses is shown below.



4.10 Case 3 : Retaining all zone 1 buses

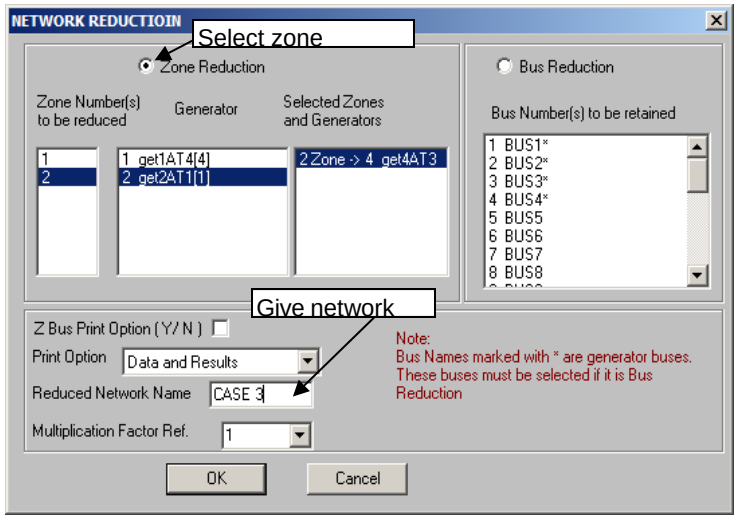
24 Bus Typical System Network reduced with retaining all the Zone1 buses, such as 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.

Select menu option **Solve ->Network Reduction**

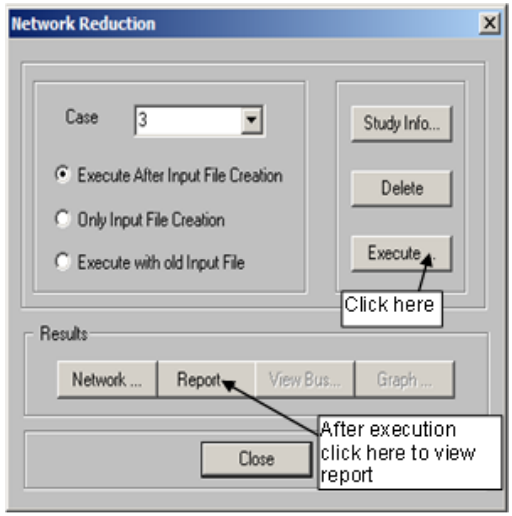


Study Information

Following study information screen will open.



Executing and Viewing the Report



Network Reduction Report for Case 3:

NETWORK REDUCTION

CASE NO : 13 CONTINGENCY : 0 SCHEDULE NO : 0

CONTINGENCY NAME : Base Case

```
--------------------------------------------------------------------------------
%%
TOTAL NUMBER OF BUSES          :   24    ACTUAL NUMBER OF BUSES         :   24
NUMBER OF 2 WIND. TRANSFORMERS :    5    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :   22
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    4
NUMBER OF LOADS                :   14
NUMBER OF FILTERS              :    0

NUMBER OF HVDC CONVERTORS      :    0

--------------------------------------------------------------------------------
NUMBER OF ZONES         :  2
PRINT OPTION            :  3 (BOTH DATA AND RESULTS PRINT)
BASE MVA                :  100.000
NOMINAL SYSTEM FREQUENCY:   50.000
PREFAULT VOLTAGE OPTION : 1 (READ FROM THE FILE)
ZONE NUMBER RETAINED    :  1
ZBUS PRINT OPTION       :  0


YBUS REDUCTION OPTION   :  1 (NETWORK REDUCTION)
--------------------------------------------------------------------------------
NUMBER OF GENERATORS IN THE EXTERNAL SYSTEM   :    2
RETAINED GENERATOR BUS IN THE EXTERNAL SYSTEM :    3

--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                      :   0.000000
CIRCUIT BREAKER REACTANCE  (PU)                      :   0.000100
TRANSFORMER R/X RATIO                                :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR      :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS                : 3
TRANSMISSION LINE VOLTAGE - KV                       :  11.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR    :   0.000000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR    :   0.000000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :   0.000000
TRANSMISSION LINE VOLTAGE - KV                       : 220.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR    :   2.500000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR    :   2.500000
```

```
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :    0.025000
TRANSMISSION LINE VOLTAGE - KV                       :  400.000000
TRANSMISSION LINE ZERO SEQUENCE RES. MULT. FACTOR    :    2.500000
TRANSMISSION LINE ZERO SEQUENCE REA. MULT. FACTOR    :    2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :    0.025000

GENERATOR NEGATIVE SEQUENCE RESISTANCE MULT. FACTOR  :    0.175000
GENERATOR NEGATIVE SEQUENCE REACTANCE  MULT. FACTOR  :    0.175000
GENERATOR ZERO SEQUENCE RESISTANCE MULT. FACTOR      :    0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR       :    0.037500
LOAD      NEGATIVE SEQUENCE IMPEDANCE  MULT. FACTOR  :    0.810000
LOAD      ZERO SEQUENCE IMPEDANCE  MULT. FACTOR      :    1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :    1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
BUS DATA
NODE  STAT  ZONE BUS-KV   NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MR
                                             PLOAD-MW QLOAD-MR QCOMP-MR
---- ---- ---- -------- -------- -------- --------- -------- --------
   1    1    1   11.000      BUS1   1.0200     0.000  563.710   19.590
                                               0.000    0.000    0.000
   2    1    2   11.000      BUS2   1.0200     1.609  125.000   22.500
                                               0.000    0.000    0.000
   3    1    2   11.000      BUS3   1.0200     3.521  190.000   39.570
                                               0.000    0.000    0.000
   4    1    1   11.000      BUS4   1.0200     3.906  380.000   35.270
                                               0.000    0.000    0.000
   5    1    1  220.000      BUS5   1.0164    -4.319    0.000    0.000
                                               0.000    0.000    0.000
   6    1    1  220.000      BUS6   1.0050   -10.410    0.000    0.000
                                              70.240   30.100   30.000
   7    1    1  220.000      BUS7   0.9676   -19.848    0.000    0.000
                                             146.630   39.100   30.000
   8    1    1  220.000      BUS8   0.9756   -14.538    0.000    0.000
                                               0.000    0.000    0.000
   9    1    1  220.000      BUS9   0.9737   -14.852    0.000    0.000
                                              29.450    9.820    0.000


  10    1    1  220.000     BUS10   0.9650   -15.333    0.000    0.000
                                              87.820   48.790    0.000
  11    1    1  220.000     BUS11   0.9733   -15.094    0.000    0.000
                                              34.350   14.720    0.000
  12    1    1  220.000     BUS12   0.9567   -17.674    0.000    0.000
                                              29.100    9.700    0.000
  13    1    1  220.000     BUS13   0.9641   -16.518    0.000    0.000
                                             146.270   58.510    0.000
  14    1    1  400.000     BUS14   0.9814   -12.324    0.000    0.000
                                               0.000    0.000    0.000
  15    1    1  400.000     BUS15   1.0104    -2.002    0.000    0.000
```

```
                                                    0.000    0.000    0.000
  16    1    1  220.000    BUS16    0.9638   -16.860    0.000    0.000

                                                  224.240   58.500    0.000
  17    1    1  220.000    BUS17    0.9593   -17.271    0.000    0.000
                                                   58.310   24.300    0.000
  18    1    2  220.000    BUS18    1.0039    -3.226    0.000    0.000
                                                    0.000    0.000    0.000
  19    1    2  220.000    BUS19    0.9922    -5.084    0.000    0.000
                                                  129.290   99.460    0.000
  20    1    2  220.000    BUS20    0.9910    -5.827    0.000    0.000
                                                   49.690   34.780    0.000
  21    1    2  220.000    BUS21    0.9882    -3.029    0.000    0.000
                                                   72.400   47.600    0.000
  22    1    2  220.000    BUS22    0.9984    -2.423    0.000    0.000
                                                    0.000    0.000    0.000
  23    1    2  220.000    BUS23    0.9470    -7.400    0.000    0.000
                                                   48.170   28.900    0.000
  24    1    2  220.000    BUS24    0.9726    -7.973    0.000    0.000
                                                   93.190   49.050    0.000
--------------------------------------------------------------------------------
TRANSFORMER DATA

STAT CKTS FROM FROM       TO TO              POSITIVE
                        ZERO NODE NAME  NODE NAME
                        R(P.U)  X(P.U.) R(P.U.) X(P.U.)
                                           TAP    PHASE  FB-MVA  TB-MVA
---- ---- ---- -------- ---- -------- -------- -------- ------- ------- -- --
   3    2    4     BUS4   15     BUS15  0.00140  0.02804  0.00140  0.02804
                                        1.00000    0.000      50      50  S  D
   3    1   14    BUS14   11     BUS11  0.00063  0.01250  0.00063  0.01250
                                        1.00000    0.000      50      50  G  G
   3    8    5     BUS5    1      BUS1  0.00069  0.01387  0.00069  0.01387
                                        1.00000    0.000      50      50  G  G
   3    1    2     BUS2   18     BUS18  0.00348  0.06968  0.00348  0.06968
                                        1.00000    0.000      50      50  G  G
   3    1    3     BUS3   22     BUS22  0.00280  0.05609  0.00280  0.05609
                                        1.00000    0.000      50      50  G  G

--------------------------------------------------------------------------------
TRANSMISSION LINE DATA

STAT CKTS FROM FROM       TO TO
          NODE NAME     NODE NAME      RP(P.U)  XP(P.U) BP/2(PU)
                                       RZ(P.U)  XZ(P.U) BZ/2(PU) FC-MVA TC-MVA
---- ---- ---- -------- ---- -------- -------- -------- -------- ------ ------
   3    1   15    BUS15   14     BUS14  0.00430  0.04770  0.63700
                                        0.00860  0.09540  0.50000     50     50


   3    1    7     BUS7   11     BUS11  0.02444  0.12226  0.10272
                                        0.07332  0.36677  0.07190     50     50
   3    1   12    BUS12   13     BUS13  0.01321  0.06608  0.05552
```

						0.03963	0.19825	0.03887	50	50
3	2	13	BUS13	11	BUS11	0.00314	0.01570	0.05275		
						0.00941	0.04714	0.03692	50	50
3	1	13	BUS13	16	BUS16	0.00578	0.02891	0.02429		
						0.01734	0.08674	0.01700	50	50
3	1	16	BUS16	11	BUS11	0.00495	0.02478	0.02082		
						0.01486	0.07434	0.01457	50	50
3	1	16	BUS16	17	BUS17	0.00248	0.01239	0.01041		
						0.00743	0.03717	0.00729	50	50
3	4	5	BUS5	6	BUS6	0.00450	0.02251	0.30260		
						0.01350	0.06753	0.21180	50	50
3	1	6	BUS6	7	BUS7	0.03716	0.18586	0.15616		
						0.11147	0.55759	0.10930	50	50
3	1	6	BUS6	13	BUS13	0.05169	0.25856	0.21723		
						0.15506	0.77567	0.15210	50	50
3	3	6	BUS6	16	BUS16	0.01530	0.07655	0.57882		
						0.04591	0.22964	0.40530	50	50
3	2	6	BUS6	8	BUS8	0.01239	0.06195	0.20822		
						0.03716	0.18586	0.14572	50	50
3	2	8	BUS8	9	BUS9	0.00363	0.01817	0.06107		
						0.01090	0.05452	0.04276	50	50
3	2	8	BUS8	10	BUS10	0.00330	0.01652	0.05552		
						0.00991	0.04956	0.03886	50	50
3	2	18	BUS18	19	BUS19	0.00537	0.02685	0.09022		
						0.01610	0.08054	0.06316	50	50
3	2	19	BUS19	5	BUS5	0.01263	0.06319	0.21237		
						0.03790	0.18958	0.14866	50	50
3	2	19	BUS19	20	BUS20	0.01131	0.05658	0.19016		
						0.03394	0.16975	0.13310	50	50
3	1	20	BUS20	24	BUS24	0.01982	0.09913	0.08328		
						0.05945	0.29738	0.05832	50	50
3	1	24	BUS24	5	BUS5	0.02494	0.12473	0.10480		
						0.07418	0.37420	0.07336	50	50
3	1	22	BUS22	23	BUS23	0.03633	0.18173	0.15269		
						0.10899	0.54520	0.10690	50	50
3	2	22	BUS22	20	BUS20	0.01734	0.08674	0.29149		
						0.05202	0.26021	0.20400	50	50
3	1	22	BUS22	21	BUS21	0.00330	0.01652	0.01388		
						0.00991	0.04956	0.00972	50	50

GENERATOR DATA

FROM NODE	FROM NAME	POSITIVE R(P.U)	POSITIVE X(P.U.)	NEGATIVE R(P.U.)	NEGATIVE X(P.U.)	ZERO R(P.U.)	ZERO X(P.U.)	CB-MVA
4	BUS4	0.00050	0.02625	0.00050	0.02625	0.00050	0.02625	50
1	BUS1	0.00125	0.03409	0.00125	0.03409	0.00125	0.03409	50
2	BUS2	0.00100	0.07470	0.00100	0.07480	0.00100	0.07480	50
3	BUS3	0.00050	0.03735	0.00050	0.03740	0.00050	0.03740	50

```
LOAD DATA
NODE NAME
---- --------
  11    BUS11
  17    BUS17
   7     BUS7
  12    BUS12
  13    BUS13
   6     BUS6
   9     BUS9
  10    BUS10
  20    BUS20
  23    BUS23
  21    BUS21
  16    BUS16
  19    BUS19
  24    BUS24
--------------------------------------------------------------------------------

EXTERNAL GENERATOR DATA
SLNO BUSNO NAME     INERTIA-H-PU
---- ----- -------- ------------
   1     2     BUS2       11.413
   2     3     BUS3       11.413
Number of reduced buses : 4
Reduced bus array :
  26    25    19    24
--------------------------------------------------------------------------------
RETAINED ZONE:    1
NUMBER OF SERIES ELEMENTS IN THE REDUCED ZONES:    3
SERIES CONNECTIONS
SLNO FROMNAME        TO    NAME     RP       XP     BP/2        RZ
XZ       BZ/2
---- ---- ------- ----- -------- -------- -------- -------  ----------- -
---------- ------
   1   26     GEN3   19    BUS19 0.005764 0.110167  0.0     0.035423
0.769343  0.0
   2   26     GEN3   24    BUS24 0.032432 0.587300  0.0     0.062020
1.347783  0.0
   3   19    BUS19   24    BUS24 0.035152 0.187472  0.0     0.099468
0.620119  0.0
--------------------------------------------------------------------------------
---------
NUMBER OF SHUNT ELEMENTS IN THE REDUCED ZONES :    3
SHUNT CONNECTIONS IN (G+JB) FORMAT - PU
SLNO FROM    NAME     GP       BP       GZ       BZ
---- ---- -------- -------- -------- -------- --------
   1   19    BUS19  1.90970 -0.24798  2.10356 -5.24444
   2   24    BUS24  1.31295 -0.34366  1.20133 -0.48369
   3   26     GEN3  0.82939 -0.61373  0.91642 -0.43791
--------------------------------------------------------------------------------
------
EQUIVALENT GENERATOR INERTIA CONSTANT - PU :   22.82422
```

```
EQUIVALENT GENERATOR REAL POWER       - MW :   315.55176
EQUIVALENT GENERATOR REACTIVE POWER - MVAR :    86.34813
EQUIVALENT GENERATOR TERMINAL VOLTAGE MAG  :     1.00000


EQUIVALENT GENERATOR TERMINAL VOLTAGE ANG-D:     6.99663
EQUIVALENT GENERATOR RESISTANCE  PU        :     0.00000
EQUIVALENT GENERATOR REACTANCE   PU        :     0.00001
```

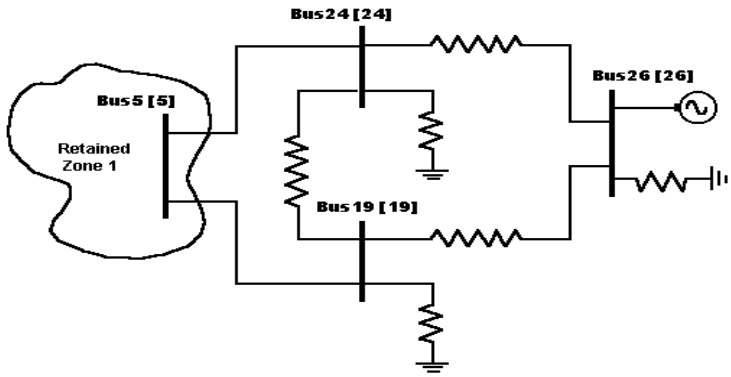
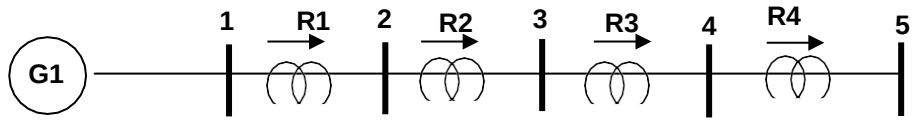


Table of Contents

5. How to solve Relay Co-ordination

Perform relay co -ordination study for the radial system shown below.



The relay make is as follows

Relay rated current = 5 Amps

Plug setting = 50% to 250% in steps of 25%

Time setting multiplier = 0.05 to 1.0 in steps of 0.01

Relay details

Relay Name	R1	R2	R3	R4
Primary Rating (1,2,3,4)	800	400	200	100
Secondary Rating in A	5	5	5	5
Load Current in A	800	400	200	100
Relay type	3sec	3sec	3sec	3sec

Transmission line details on 100 MVA base:

Bus - code	Impedance Zpq in pu	Line charging in pu
p-q	Zpq	Y'pq/2
1-2	0.00 + j0.1	0
2-3	0.00 + j0.1	0
3-4	0.00 + j0.1	0
4-5	0.00 + j0.1	0

Generator Details:
G1 = 100 MVA, 11kV

Maximum fault level = 1000 MVA.
Interpretation according to MiP-PSCT:

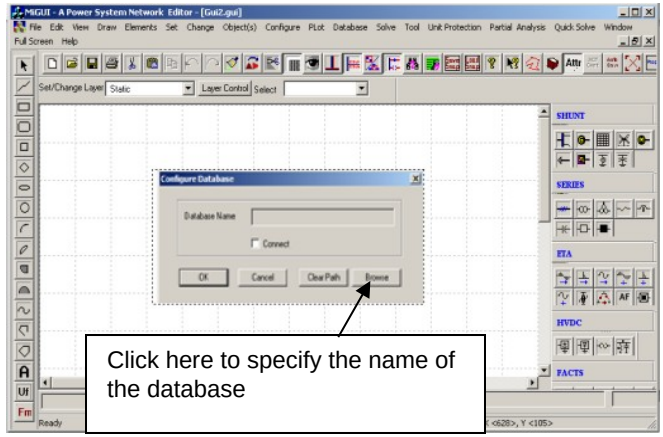
Observe transmission line details. You find that all lines have similar parameters.
Therefore no. of transmission line libraries = 1
No of generator libraries = 1

As all the relays are of 3 sec type, no of relay libraries = 1

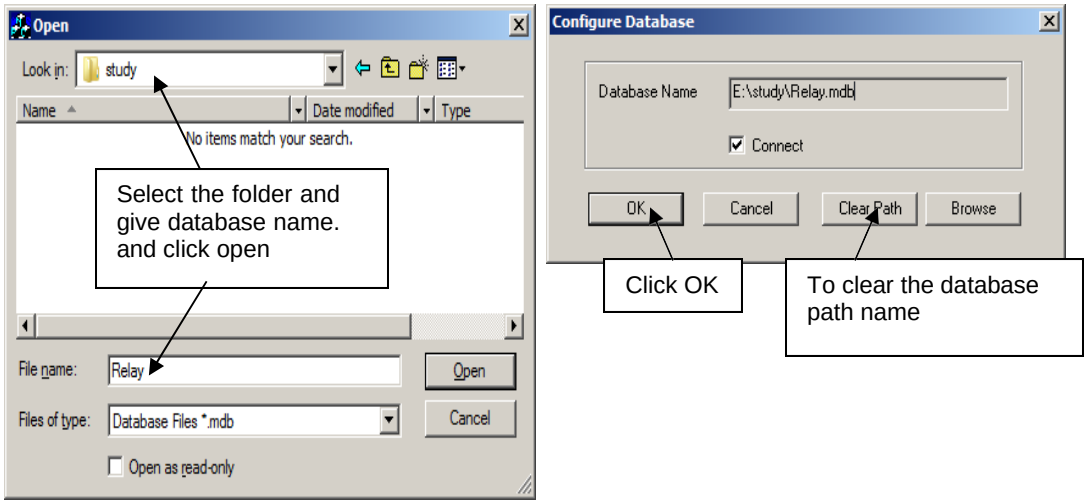
Procedure to enter the data for performing studies using MiP-PSCT.

MiP-PSCT - Database Configuration

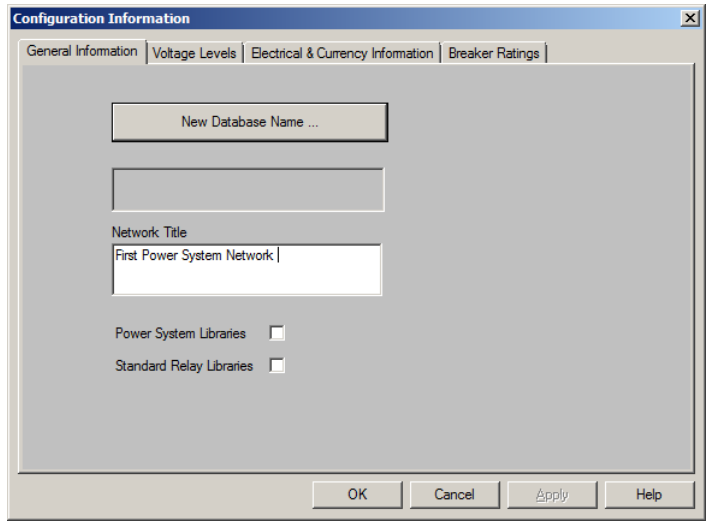
Open power system network editor. Select menu option **Database → Configure**. Configure Database dialog is popped up as shown below. Click Browse button.



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.

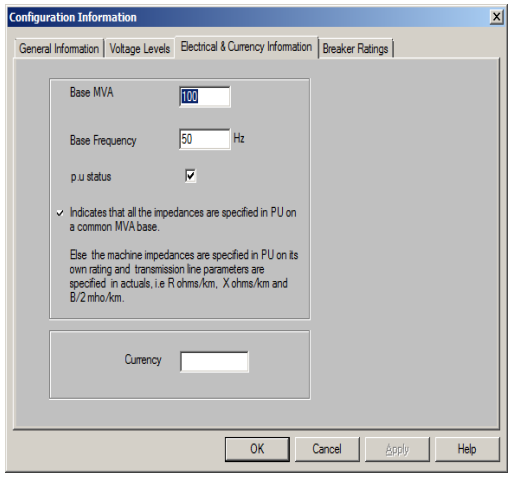


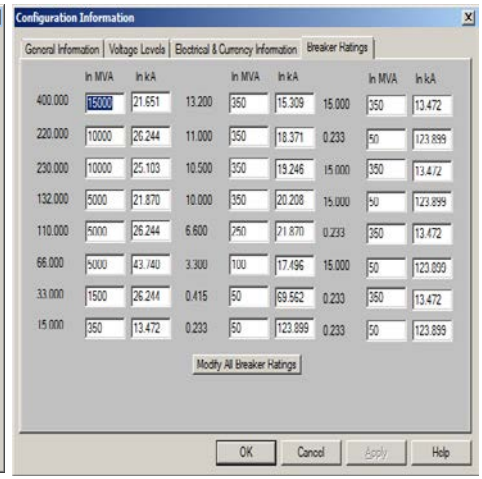
Click OK button on the **Configure database** dialog, the dialog shown below appears.



Uncheck the Power System Libraries and Check Standard Relay Libraries. 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

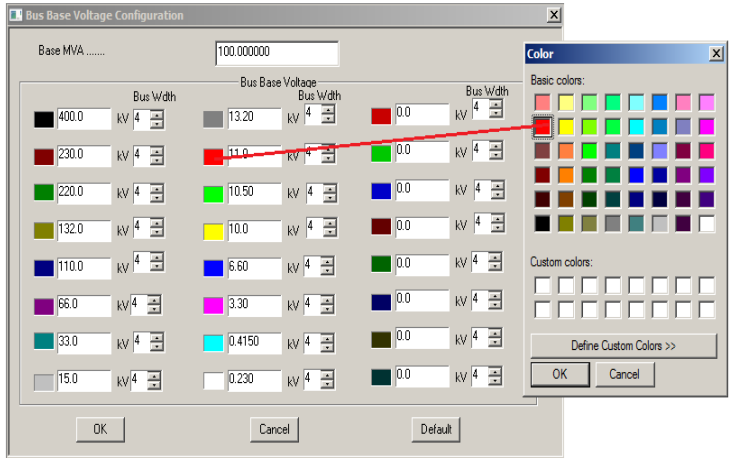
as shown below. Enter the Base MVA and Base frequency as shown below. Click **OK** button to create the database to return to Network Editor.





Bus Base Voltage Configuration

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

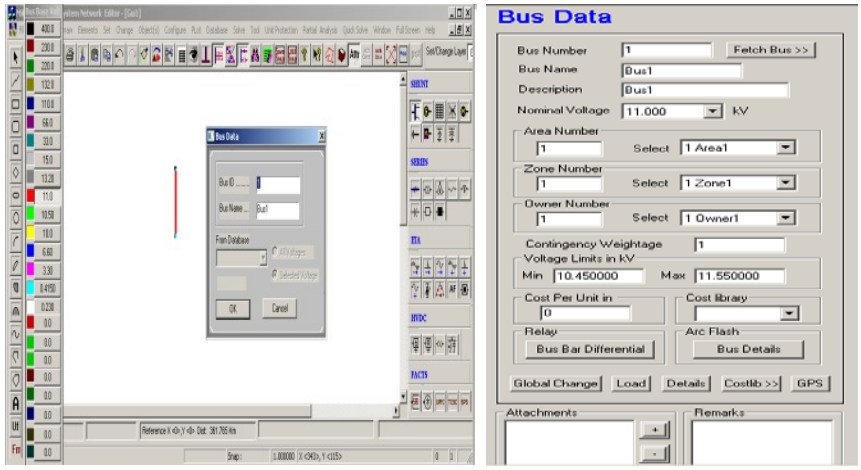


5.1 Procedure to Draw First Element - Bus

Click on Bus icon provided on power system tool bar. Draw a bus and a dialog appears prompting to give the Bus ID number 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.

Calculation of Xd, Xd', Xd" :

For maximum fault level, Xd = Xd' = Xd" = 100 / 1000 = 0.1 pu = Xn = X0

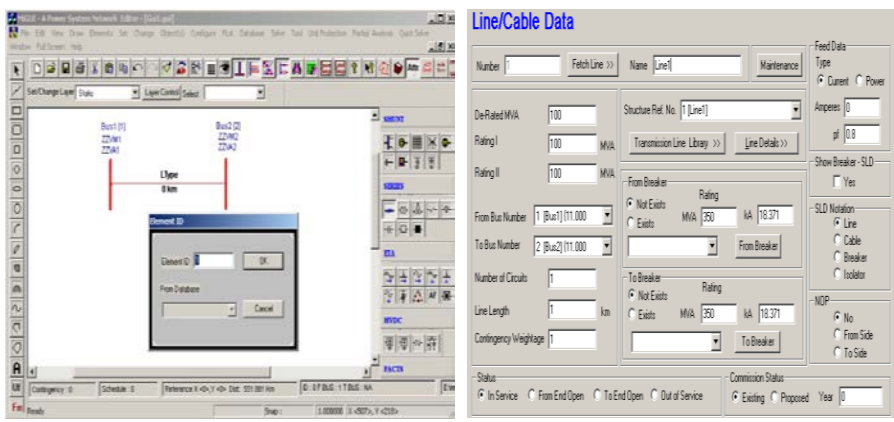
Bus Data					
Bus Number	1	2	3	4	5
Bus Name	Bus-1	Bus-2	Bus-3	Bus-4	Bus-5
Nominal voltage in kV	11	11	11	11	11
Area number	1	1	1	1	1
Zone number	1	1	1	1	1
Contingency weightage	1	1	1	1	1

5.2 Procedure to Draw Transmission Line

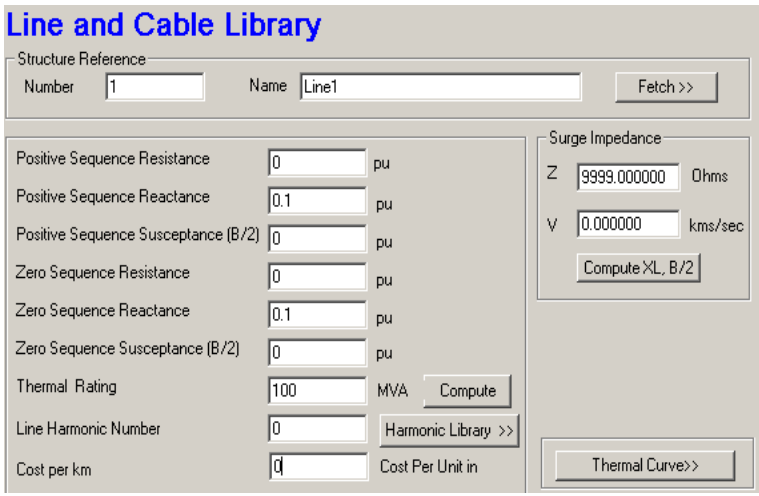
Click on Transmission **Line** icon provided on power system tool bar. Draw the line by double clicking LMB (Left Mouse Button) first on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. The **Element ID** dialog will appear.

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. Enter **Structure Ref No. as 1** and click on **Transmission Line Library >>** button. **Line & Cable Library** form will appear.



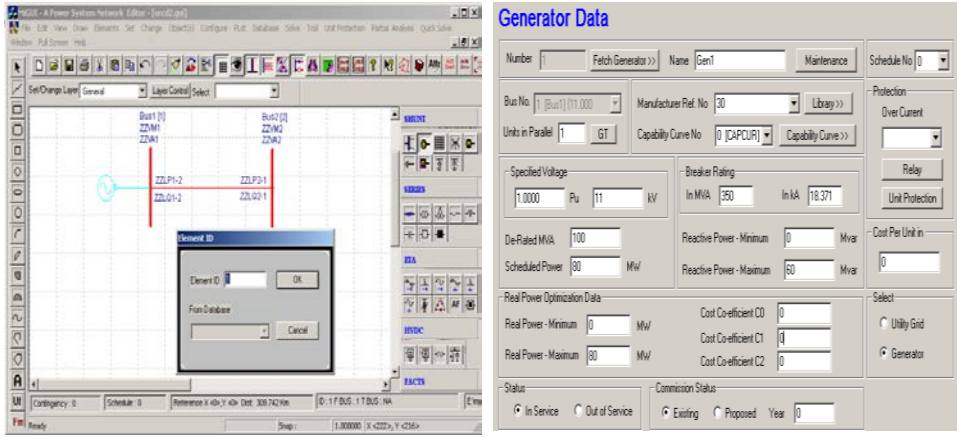
Enter transmission line library data in the form as shown below for Line1-2.



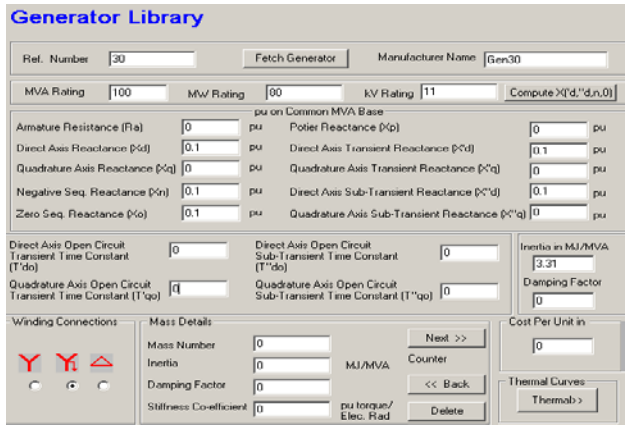
Element Details				
Line Number	1	2	3	4
Line Name	Line1-2	Line2-3	Line3-4	Line4-5
De-Rated MVA	100	100	100	100
No. Of Circuits	1	1	1	1
From Bus No.	1	2	3	4
To Bus No.	2	3	4	5
Line Length in km	1	1	1	1
From Breaker Rating in MVA	5000	5000	5000	5000
To Breaker Rating in MVA	5000	5000	5000	5000
Structure Reference No.	1	1	1	1

5.3 Procedure to Draw Generator

Click on **Generator** icon provided on power system tool bar. Connect it to Bus 1 by clicking the LMB on Bus 1. **Element ID** dialog will appear. Enter ID number and click OK. Database with corresponding **Generator Data** form will appear. Enter details as shown below.



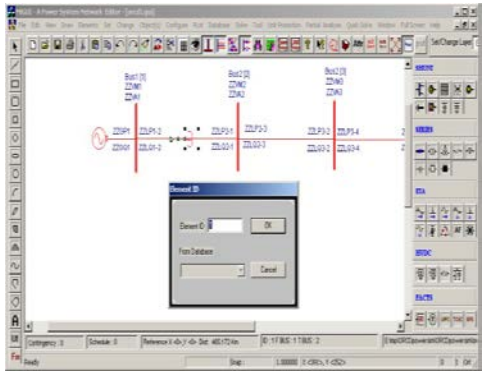
Enter Manufacturer Ref. No. as 30 and click on **Generator Library** button. Generator library form will appear. Click compute button to enter 3 phase and SLG fault level as 1000 MVA.

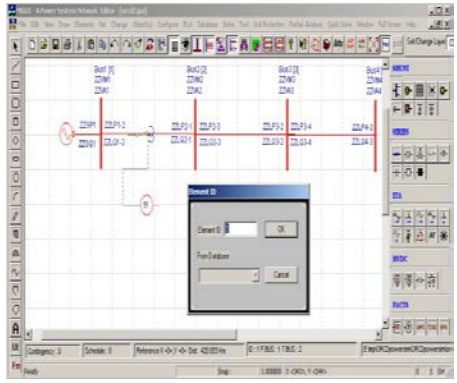


After entering data **Save** 🖫 and **close.** In **Generator Data** form, click **Save** 🖫**. Network Editor** screen will be invoked.

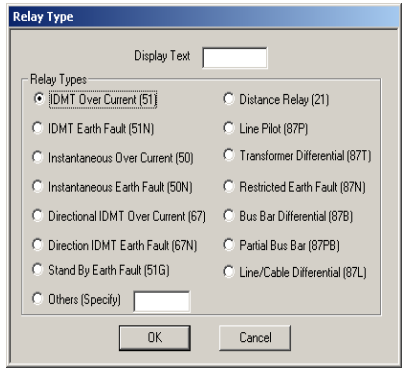
5.4 Procedure to Draw Relay

Select current transformer from power system tool bar and place it on from side of the line as shown in the following diagram. Select relay element from power system tool bar or from the main menu select **Power system->Relay** and click on GUI. Relay type dialog appears



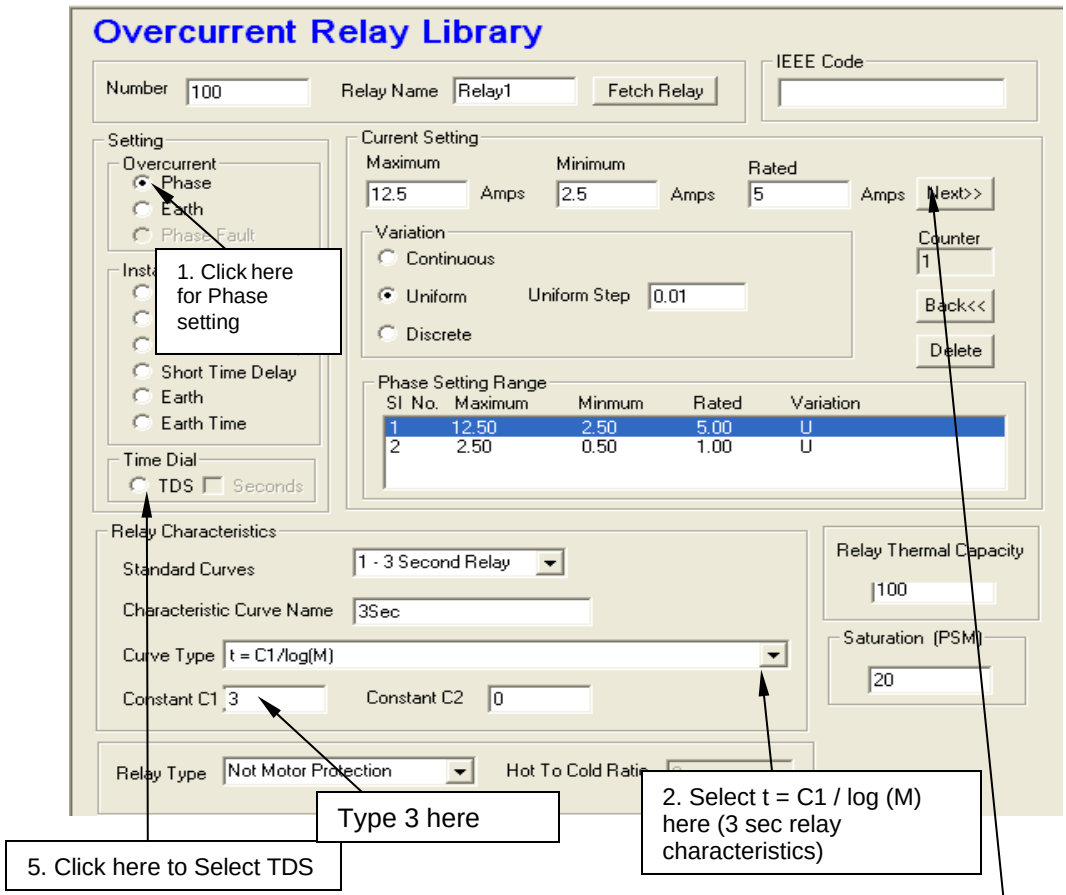


Select IDMT Over Current (51) and click OK. Terminate the relay on current transformer which invokes Relay Database form.

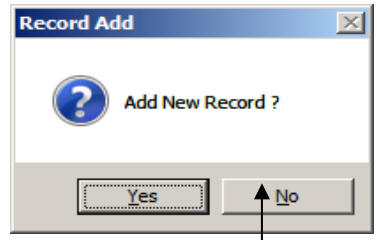


Select menu option **Libraries -> Protection ->Relay Database.**

Enter relay number as 100 and other details as shown below



When Next button on relay database form is clicked, record add dialog box appears.



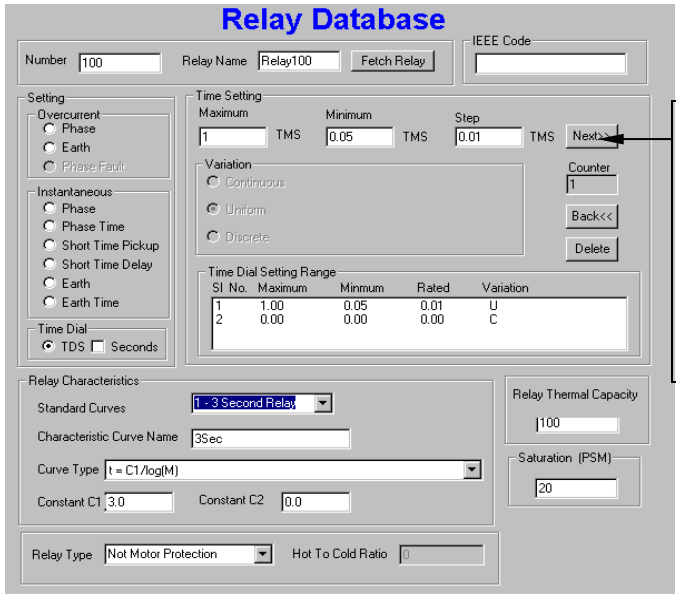
If you have one more setting click **Yes** to add next setting.
If not, say **No** first setting will be saved

Relay rated current = 5 Amps

Current setting Max = 250 % of % 5 amps = 2.5 x 5 = 12.5
Min = 50 % of % 5 amps = 0.5 x 5 = 2.5

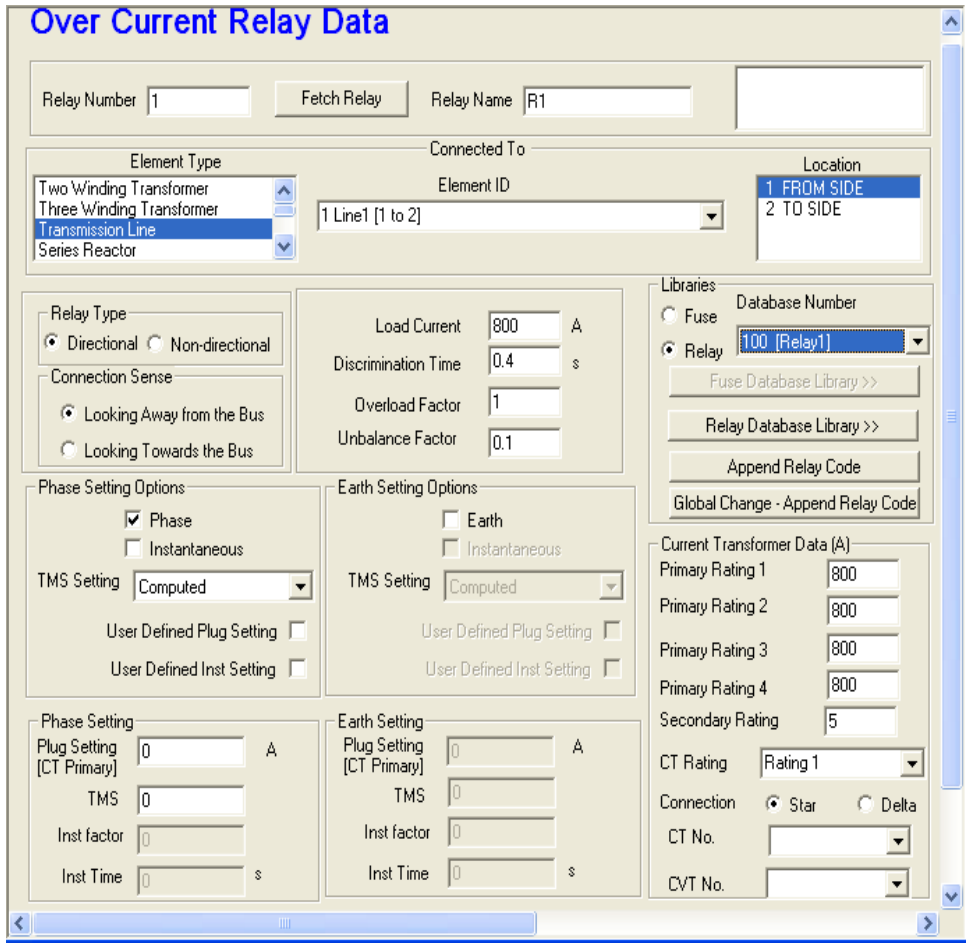
Uniform variation step = 0.25

Enter time dial setting as below



Click Next, a dialog displayed as above, to **Add** record. If No button is clicked first setting will be **Saved.**

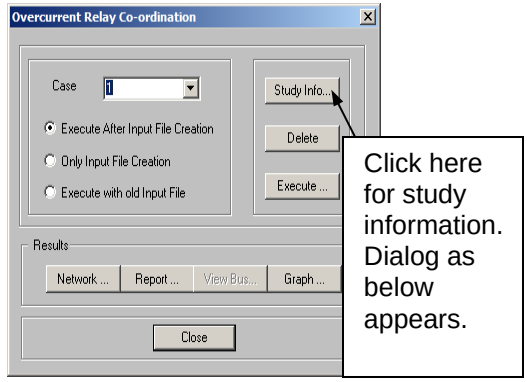
Time setting multiplier = 0.05 to 1.0 in steps of 0.01
After entering the details save it and close it Over current Relay Data form appears. Enter the IDMT1 relay data as shown below. Select relay database library number 100 from the drop down list.

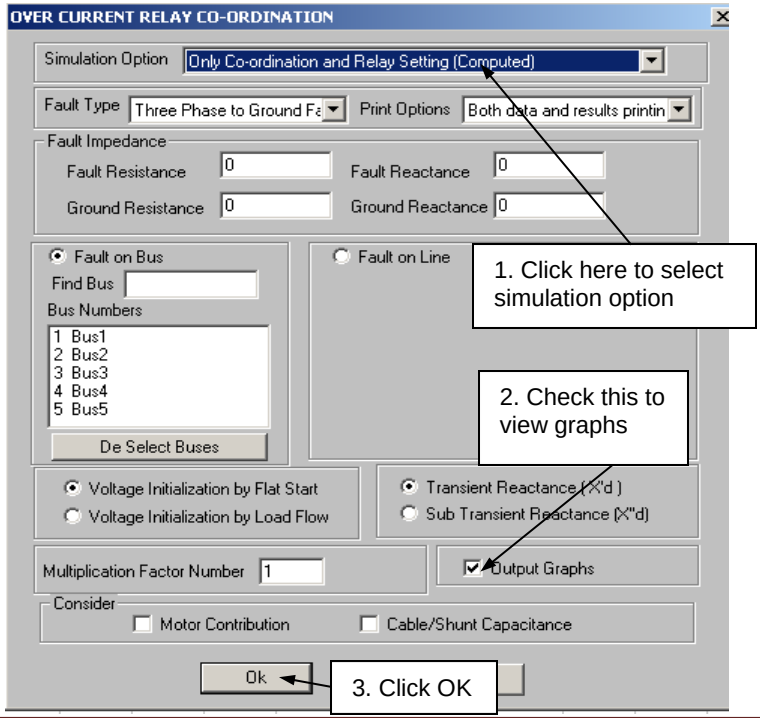


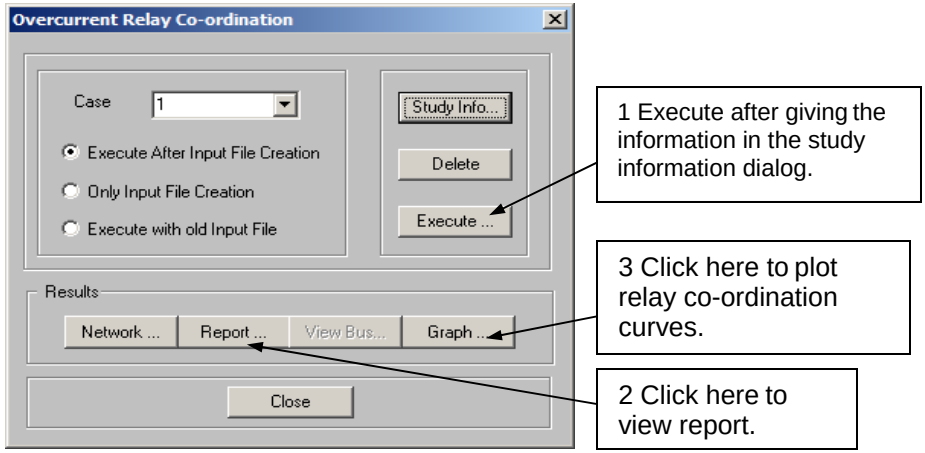
After entering the details click save button which invokes Network editor. Enter other three relays details.

5.5 Executing Over Current Relay Co - ordination

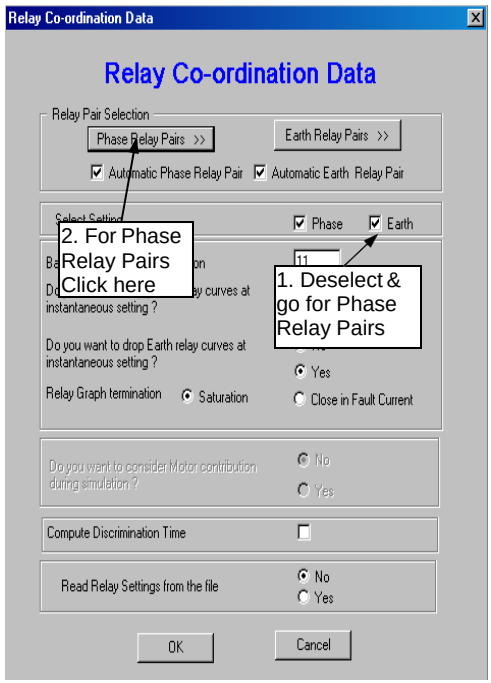
Select the menu option **Solve → Over Current Relay Co-ordination**

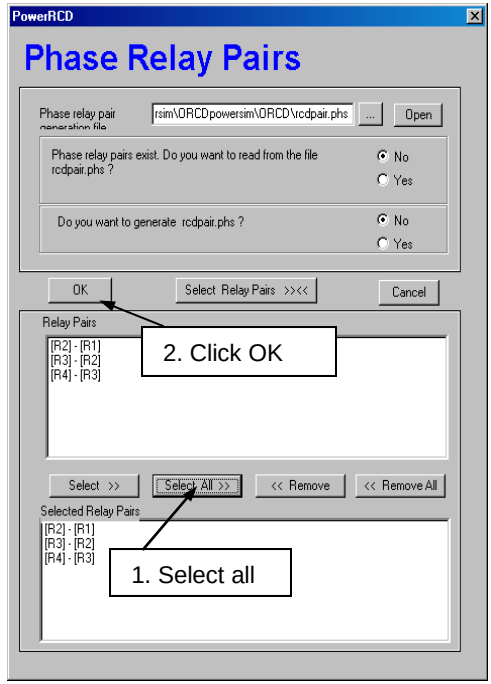






Then click on execute button. While executing, following dialogs will be displayed.





The relay co - ordination will be executed. Go to graph and plot Current in X - axis and Time in Y - Axis**.**

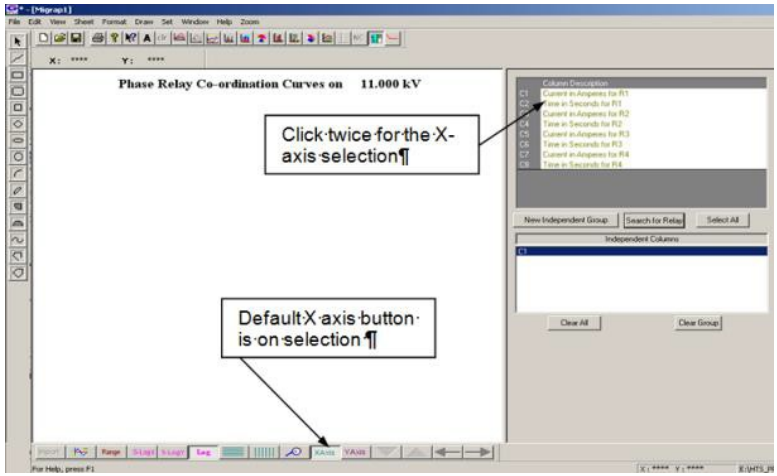
Results of Relay Co - ordination: (For maximum fault condition)

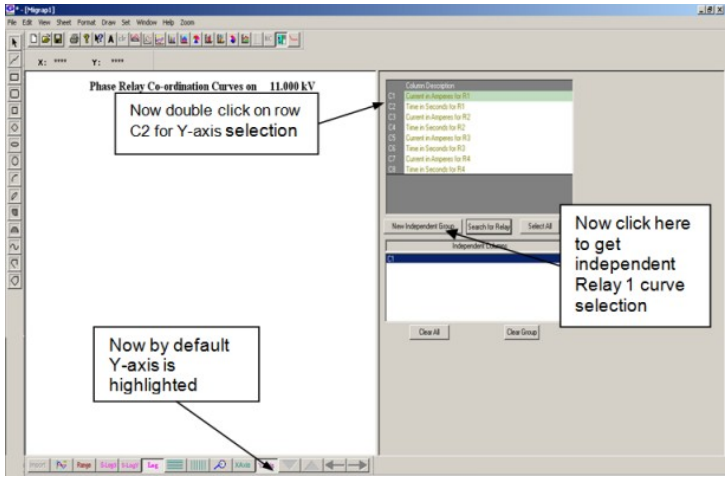
RELAY SETTINGS FOR PHASE FAULTS

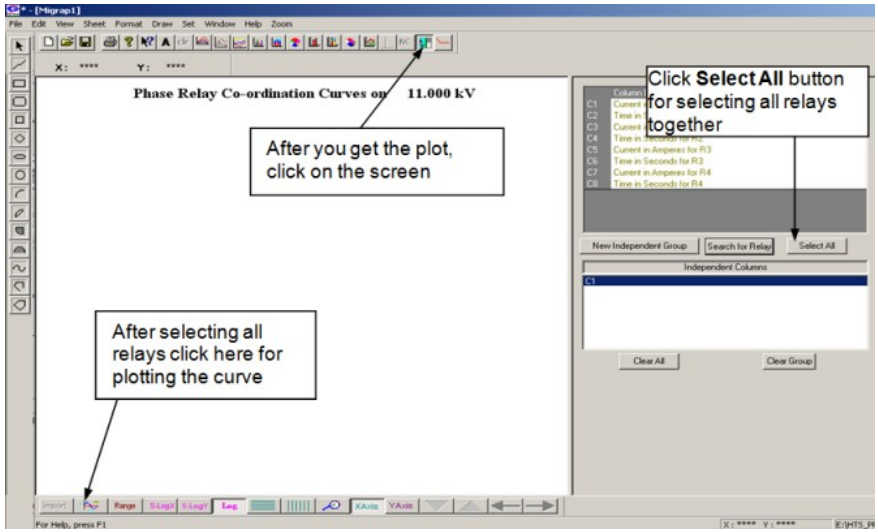
RELAY NAME	CLOSE IN FAULT CURRENT (Amps)	PLUG SETTING RATIO (Amps)		RELAY CAPACITY	REMARKS
R1	52486.3881	800.0000	65.608	100.00	Within Limit
R2	26243.1941	400.0000	65.608	100.00	Within Limit
R3	17495.4627	200.0000	87.477	100.00	Within Limit
R4	13121.5970	100.0000	131.216	100.00	Exceeds Limit

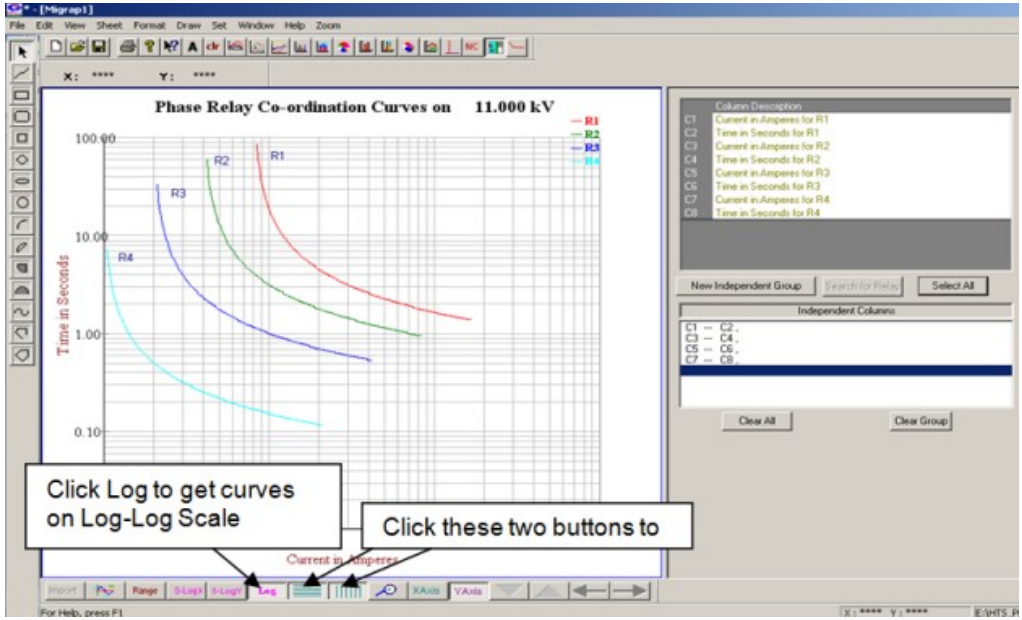
SL. NO.	RELAY NAME	From Bus FOR CLOSE	To Bus FAULT	CT PRIM CHOSEN (Amps)	CT SEC REMOTE	PLUG SETTING (%)	PLUG SETTING (PRIM) (A)	PRIMARY RELAY SETTING (%)	NAME
PLUG SETTING (SEC)	T.D.S CLOSE IN OP. TIME (A)	CURRENT IN FAULT (Amps)	Secs)	BUS FAULT CURRENT (Amps)	(Secs)				
1	R1	1	2	800	5	100.00	800.00		
5.00	0.59	52486.39	1.3605	26243.19	1.3605			R2	
*****	Relay1 3S-RELAY								
2	R2	2	3	400	5	100.00	400.00		
5.00	0.41	26243.19	0.9454	17495.46	0.9454			R3	
*****	Relay1 3S-RELAY								
3	R3	3	4	200	5	100.00	200.00		
5.00	0.23	17495.46	0.5303	13121.60	0.5303			R4	
*****	Relay1 3S-RELAY								
4	R4	4	5	100	5	100.00	100.00		
5.00	0.05	13121.60	0.1153	DOES NOT BACK-UP				****	
*****	Relay1 3S-RELAY								

To plot relay co-ordination curves click on **Graph** as shown in **Over-Current Relay Co-ordination** dialog.



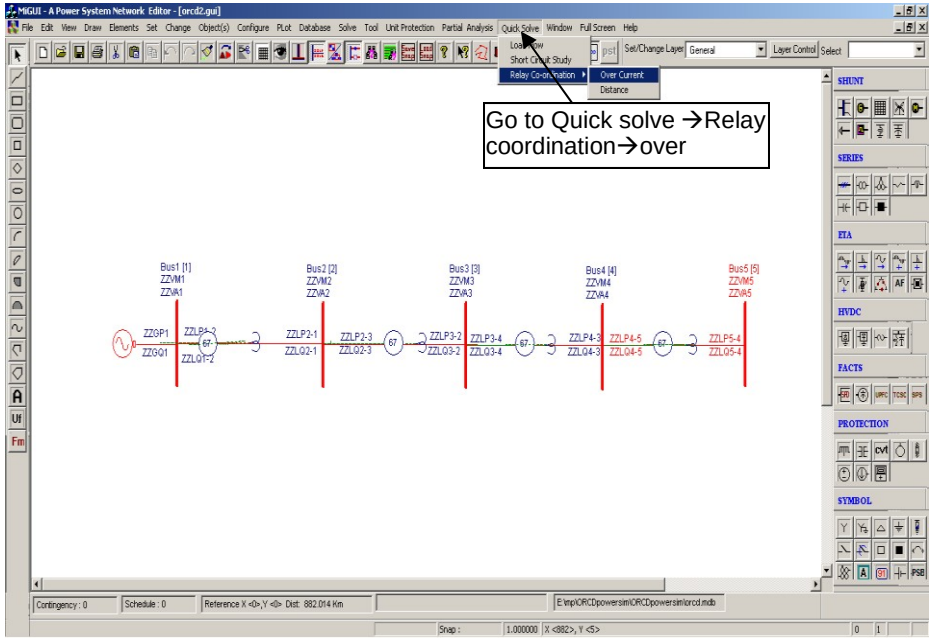



Phase Relay Co-ordination Curves on 11.000 kV
After you get the plot, click on the screen
Click Select All button for selecting all relays together
After selecting all relays click here for plotting the curve


Phase Relay Co-ordination Curves on 11.000 kV
Time in Seconds
100.00
10.00
1.00
0.10
R1
R2
R3
R4
Click Log to get curves on Log-Log Scale
Click these two buttons to

5.6 Quick Solve (Shortcut method for Executing Over Current Relay Co – ordination)

Select menu option: **Quick Solve → Relay Co-ordination→ Overcurrent**

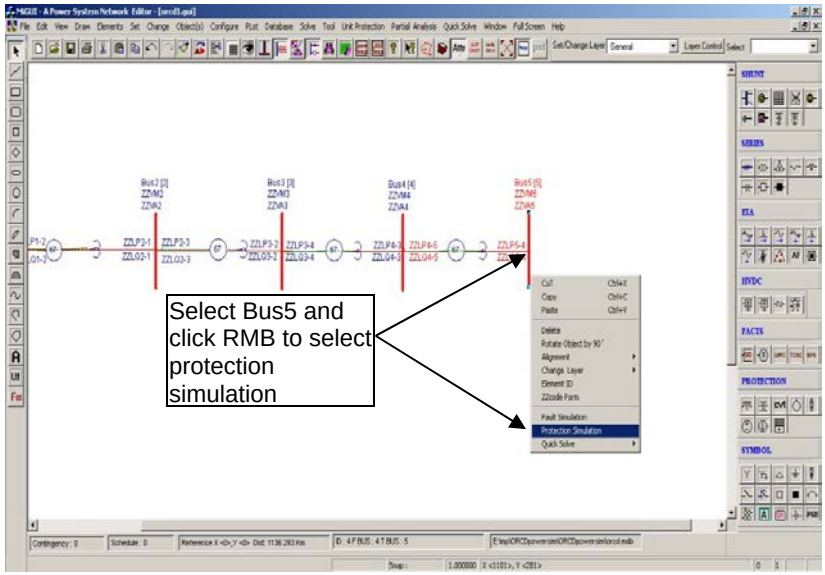


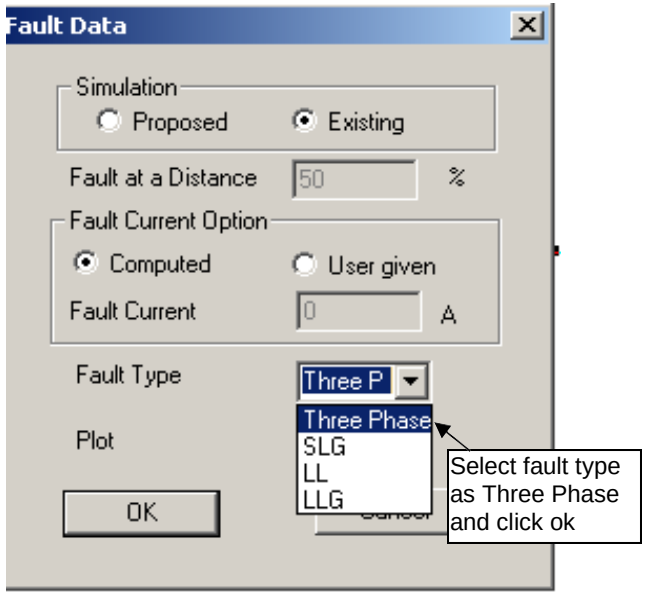
5.7 Protection Simulation

After executing relay coordination, protection simulation can be performed to see which relay operates first when fault is created on a bus or a line.

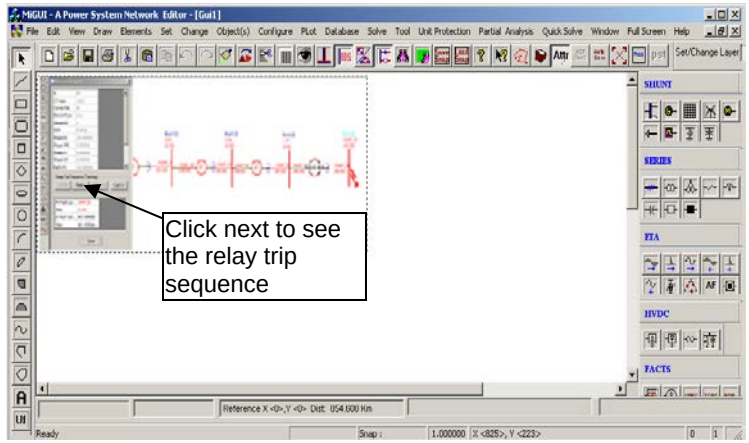
Procedure to perform Protection Simulation:

Select the last bus i.e., Bus5, right click on the bus and select protection simulation as shown below. Select fault type as three phase and click ok. Element property window appears on the screen, go on clicking next to see the relay trip sequence. The last relay (R4) operates first since it is near to the fault and back up for that will be R3 followed by R2 and finally R1


Select Bus5 and click RMB to select protection simulation


Fault Data
Simulation
Proposed
Existing
Fault at a Distance
50
%
Fault Current Option
Computed
User given
Fault Current
0
A
Fault Type
Three P
Three Phase
SLG
LL
LLG
Plot
OK
Select fault type as Three Phase and click ok

Fault symbol will appear on faulted bus as shown below. As per the backup trip sequence of the relays can be viewed on the GUI by clicking the next button of the element property window



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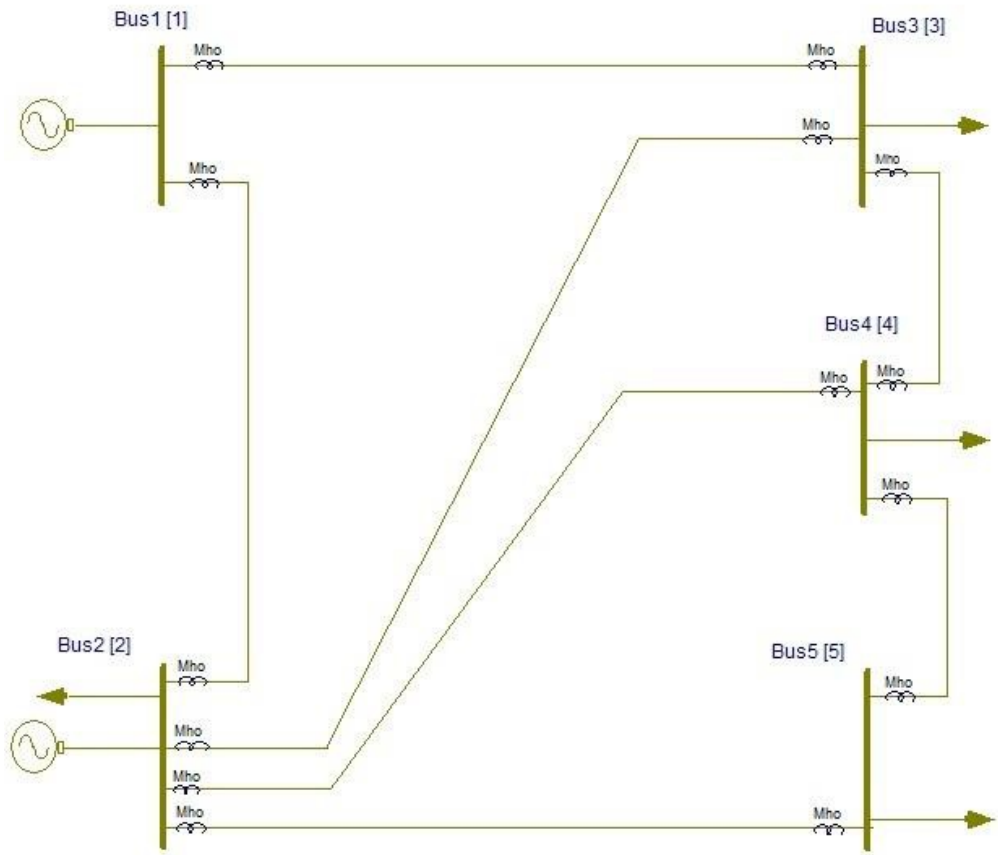
6. How to solve Distance Relay Co-Ordination

Perform distance relay co -ordination study for the system shown below.



Relay details are given below

Relay Name	Zone1 Reach(%)	Zone2 Reach(%)	Zone3 Reach(%)	Zone4 Reach(%)	Zone2 time disc (sec)	Zone3 time disc (sec)	Zone4 time disc (sec)
DISRL1	80	40	100	20	0.5	0.8	1
DISRL2	80	40	100	20	0.5	0.8	1
DISRL3	80	40	100	20	0.5	0.8	1
DISRL4	80	40	100	20	0.5	0.8	1
DISRL5	80	40	100	20	0.5	0.8	1
DISRL6	80	40	100	20	0.5	0.8	1
DISRL7	80	40	100	20	0.5	0.8	1
DISRL8	80	40	100	20	0.5	0.8	1
DISRL9	80	40	100	20	0.5	0.8	1
DISRL10	80	40	100	20	0.5	0.8	1
DISRL11	80	40	100	20	0.5	0.8	1
DISRL12	80	40	100	20	0.5	0.8	1
DISRL13	80	40	100	20	0.5	0.8	1
DISRL14	80	40	100	20	0.5	0.8	1

Relay Name	CT Rating (Amps)	PT Rating (kV/Volt)	Connected Zone 1 Line	Connected Zone 2 Line	Connected Zone 3 Line	Location
DISRL1	400/5	132/110	1-2	2-5	2-3	From Side
DISRL2	400/5	132/110	1-2	1-3	1-3	To Side
DISRL3	400/5	132/110	1-3	3-4	2-3	From Side
DISRL4	400/5	132/110	1-3	1-2	1-2	To Side
DISRL5	400/5	132/110	2-3	3-4	1-3	From Side
DISRL6	400/5	132/110	2-3	1-2	2-4	To Side
DISRL7	400/5	132/110	2-4	3-4	1-3	From Side
DISRL8	400/5	132/110	2-4	1-2	2-3	To Side
DISRL9	400/5	132/110	2-5	4-5	4-5	From Side
DISRL10	400/5	132/110	3-4	4-5	2-4	From Side

DISRL11	400/5	132/110	3-4	1-3	2-3	To Side
DISRL12	400/5	132/110	4-5	2-5	2-5	From Side
DISRL13	400/5	132/110	4-5	3-4	2-4	To Side
DISRL14	400/5	132/110	2-5	1-2	2-3	To Side

Transmission line details: Table B

	Positive sequence		Zero sequence	
Bus- code	**Impedance Zpq in pu**	**Line charging B/2 in pu**	**Impedance Zpq in pu**	**Line charging B/2 in pu**
1-2	0.02009+j0.05997	0.03000	0.04017+j0.11995	0.2316
1-3	0.08000+j0.23996	0.02499	0.15496+j0.48209	0.01874
2-3	0.05997+j0.17998	0.02004	0.11995+j0.36731	0.01503
2-4	0.05997+j0.17998	0.02004	0.11995+j0.36731	0.01503
2-5	0.03994+j0.12001	0.01500	0.08035+j0.24105	0.01125
3-4	0.00999+j0.02996	0.01000	0.02009+j0.05992	0.00750
4-5	0.08000+j0.23996	0.02499	0.15496+j0.48209	0.01874

Generator details: Table C

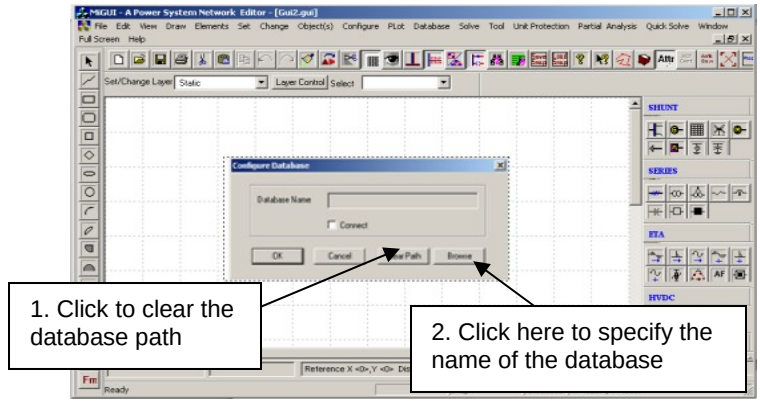
Bus no	MVA	MW	MVAR
Bus1	100	80	60
Bus2	100	80	60

Load details: Table D

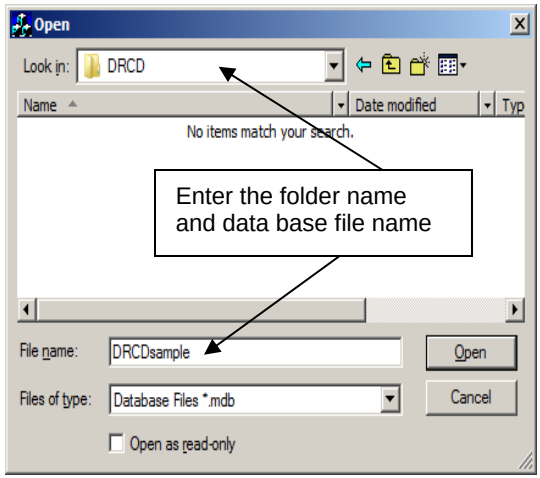
Bus no	MW	P.F
Bus2	80	0.85
Bus3	50	0.85
Bus4	50	0.85
Bus5	50	0.85

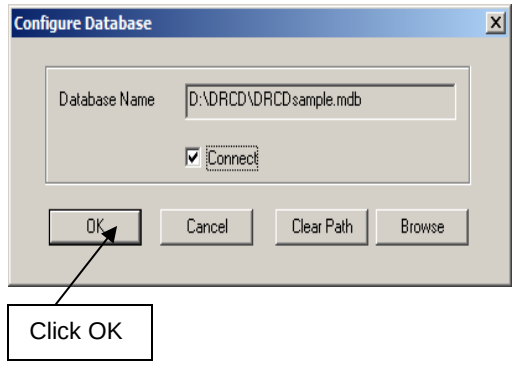
Procedure follows:

Open power system network editor. Select menu option **Database → Configure**. Configure Database dialog is popped up as shown below. Click **Browse** button.

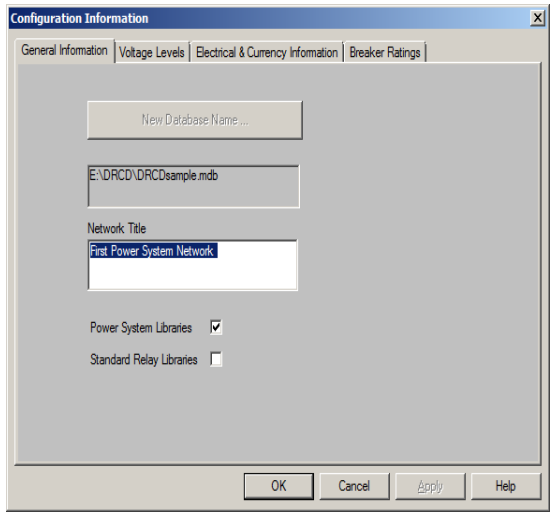


Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click **Open** button after entering the desired database name. **Configure Database** dialog will appear with path chosen.

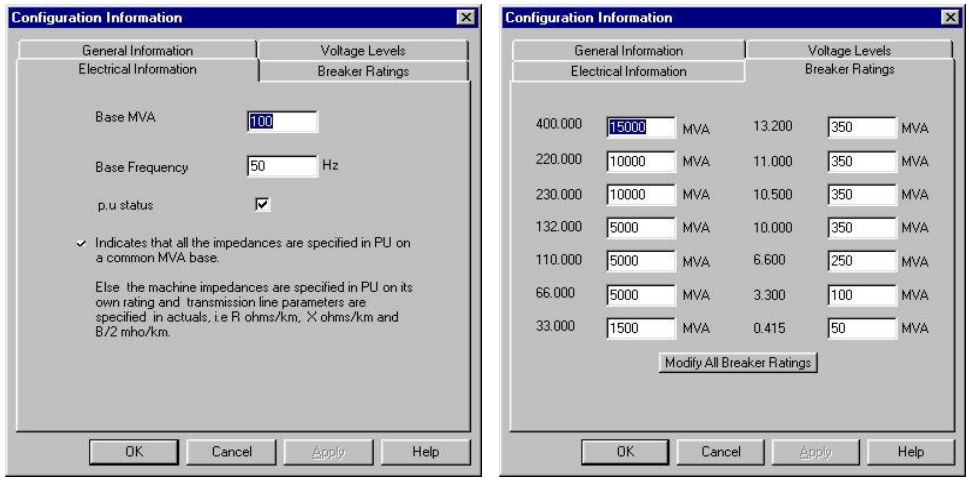




Click OK button on the **Configure database** dialog, the dialog shown below appears.

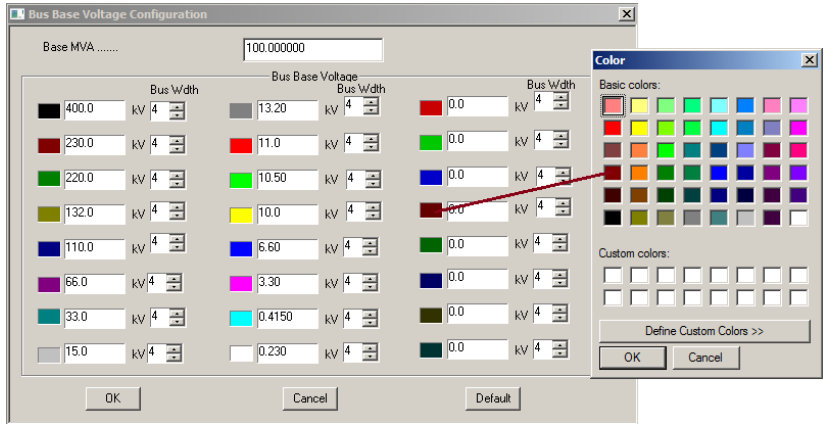


Uncheck the Power System Libraries and Check Standard Relay Libraries. If libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab. Since the impedances are given on 100 MVA base check the pu status as shown below. Enter the Base MVA and Base frequency as shown below. Click **OK** button to create the database to return to Network Editor.



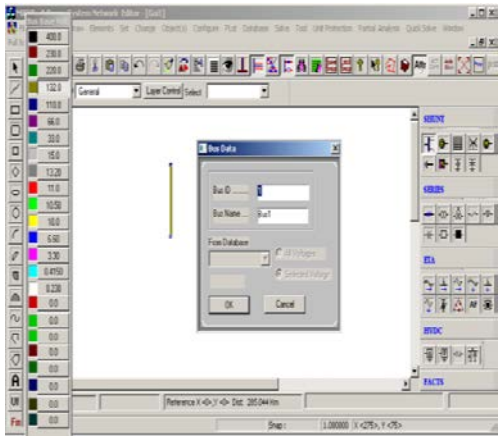
Bus Base Voltage Configuration

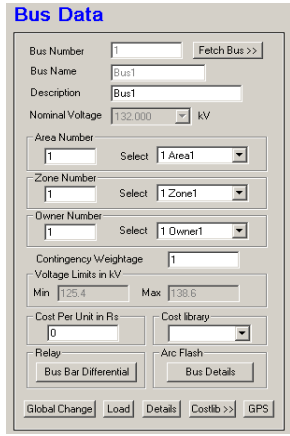
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage.** The dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click OK**.**



6.1 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 number 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.

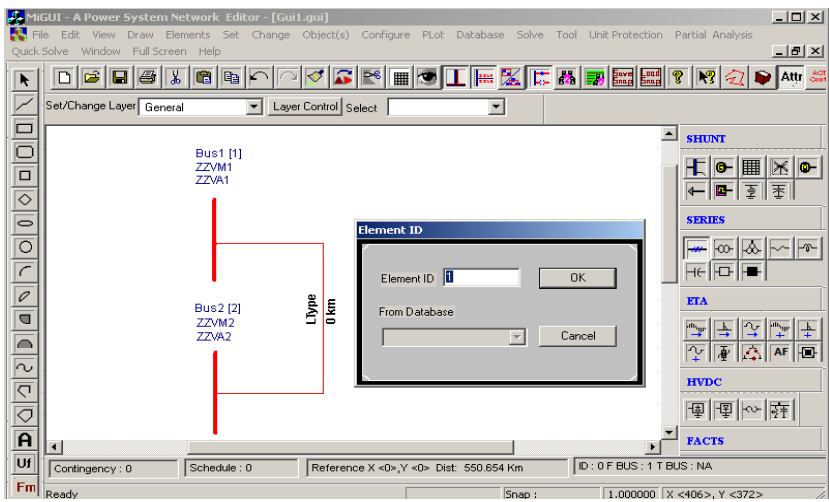
Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name fiel d and the bus description field can be used to abbreviate the bus name. For example let us say the bus name is Northeast, then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

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

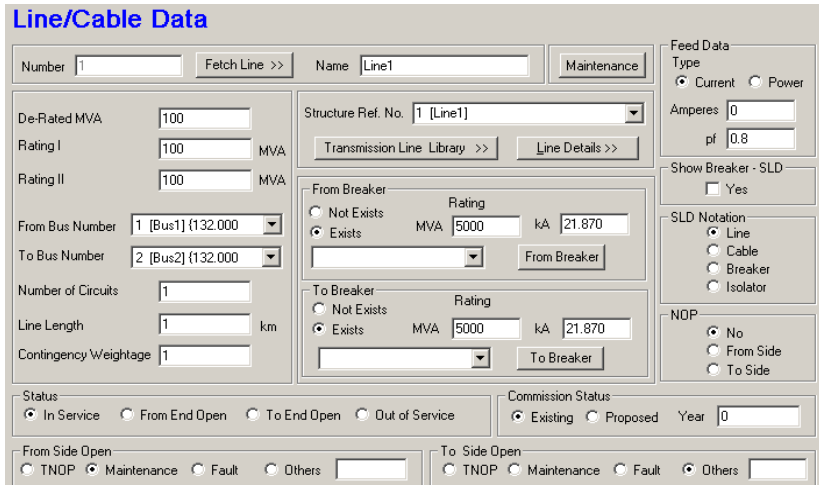
Bus Number	2	3	4	5
Bus Name	Bus-2	Bus-3	Bus-4	Bus-5
Nominal voltage kV	132	132	132	132

6.2 Procedure to Draw Transmission Line

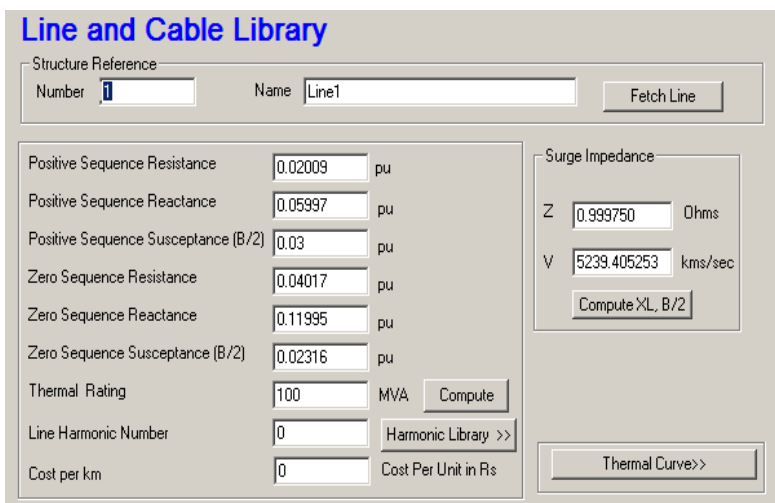
Click on Transmission **Line** icon provided on power system tool bar. Draw the line by double clicking LMB (Left Mouse Button) first on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. The **Element ID** dialog will appear.



Enter **Element ID** number and click OK. Database manager with corresponding **Line\Cable Data** form will be open.



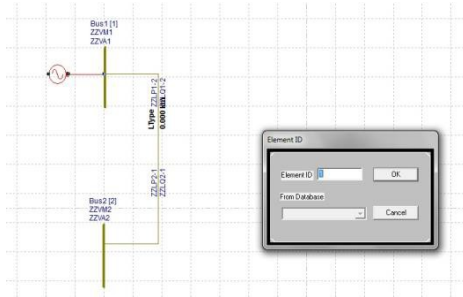
Enter the details of that line as shown. Enter **Structure Ref No.as 1** and click on **Transmission Line Library >>** button. **Line & Cable Library** form will appear. Enter transmission line library data in the form as shown below for Line1



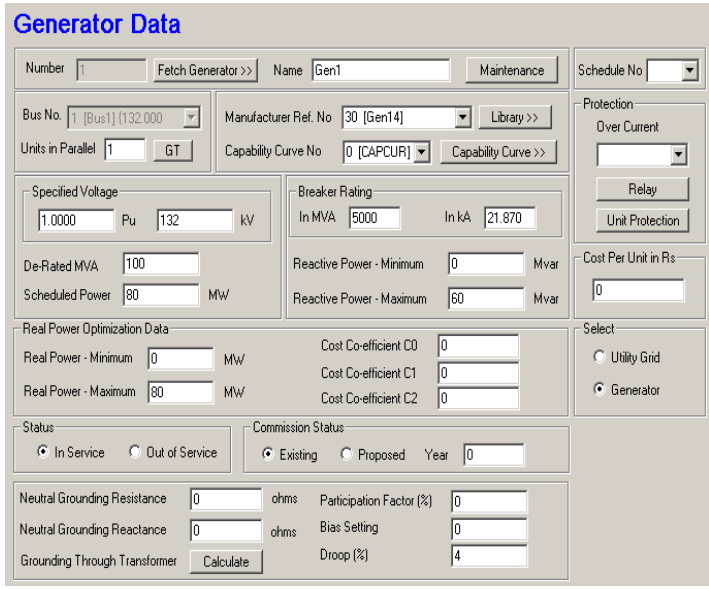
After entering data click **Save** 🖫**,** which invokes **Cable\Line data** and **Save** 🖫**.** Follow the same procedure for remaining lines.

6.3 Procedure to Draw Generator

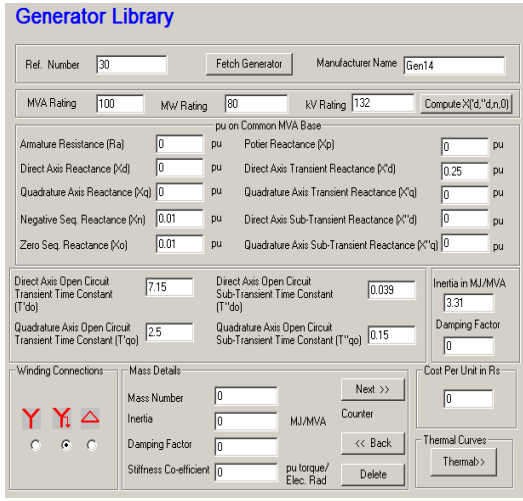
Click on Generator icon provided on power system tool bar. Connect it to Bus 1 by clicking the LMB on Bus 1. Element ID dialog will appear. Enter ID number and click OK. Database with corresponding Generator Data form will appear. Enter details as shown.



Enter Manufacturer Ref. No. as 30 and click on **Generator Library** button. Generator library form will appear.

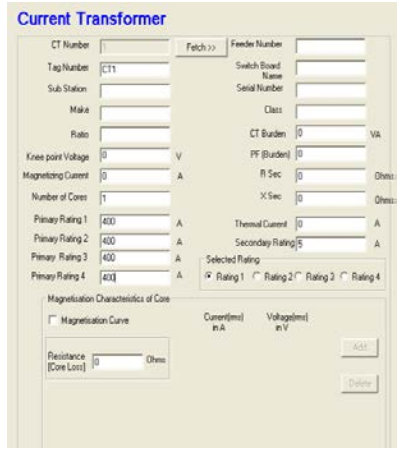


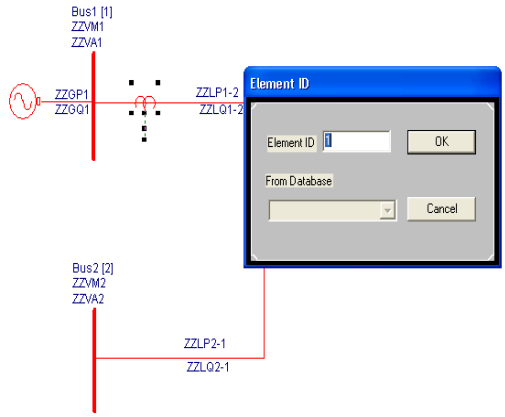
After entering data **Save** 🖫 and **close.** In **Generator Data** form, click **Save** 🖫**. Network Editor** Screen will be invoked.



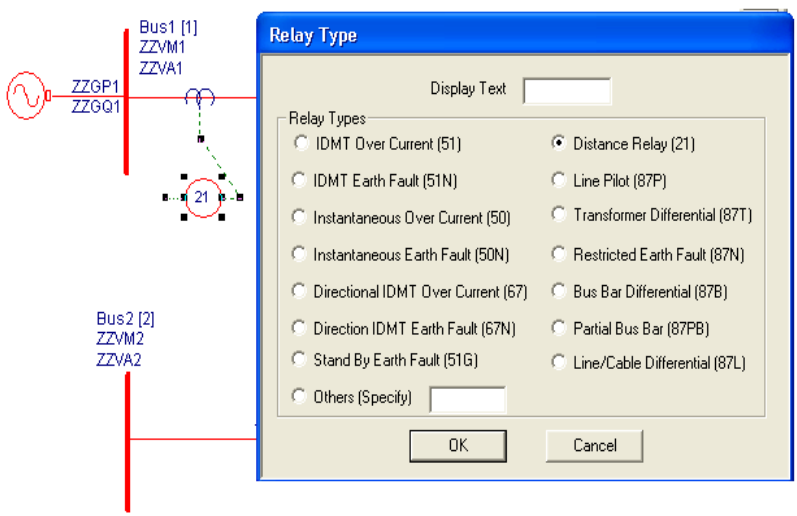
6.4 Procedure to Draw Relay

Select **current transformer** from power system tool bar and place it on from side of the line as shown in the following diagram. Click on **Distance Relay** icon provided on power system tool bar. Put it on the transmission line as shown below.

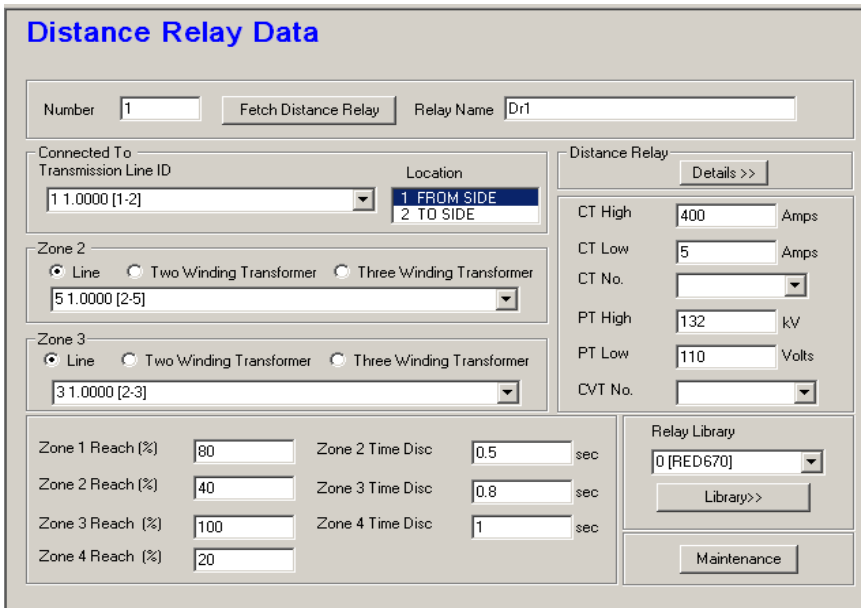




Then select relay from power system tool bar, it will invoke Relay Type -> select Distance Relay

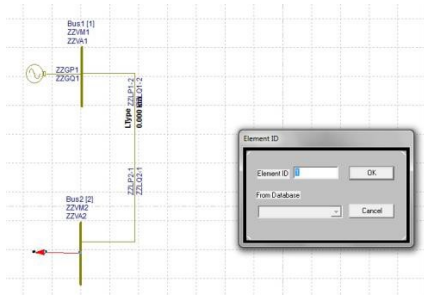


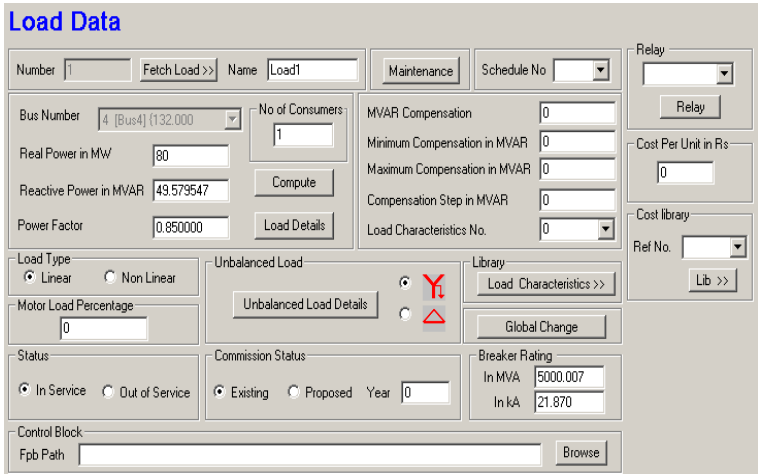
Then it will invoke Distance Relay Database



6.5 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.

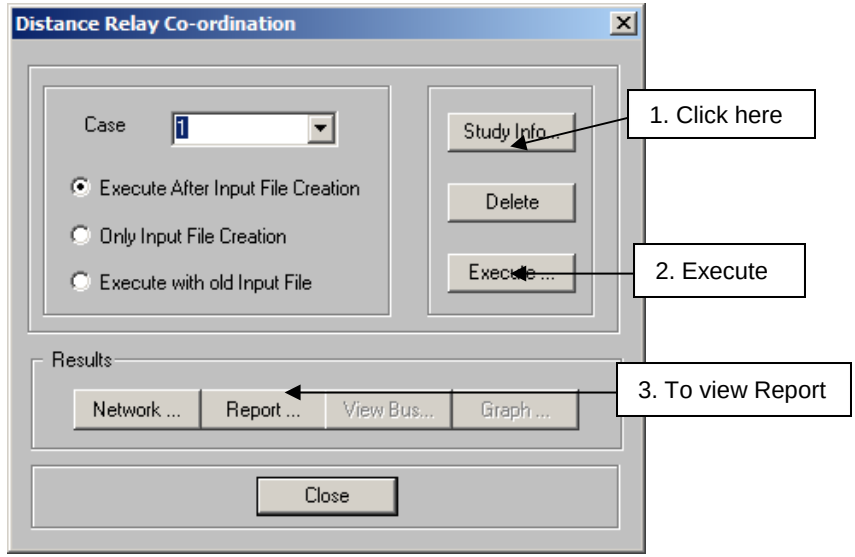


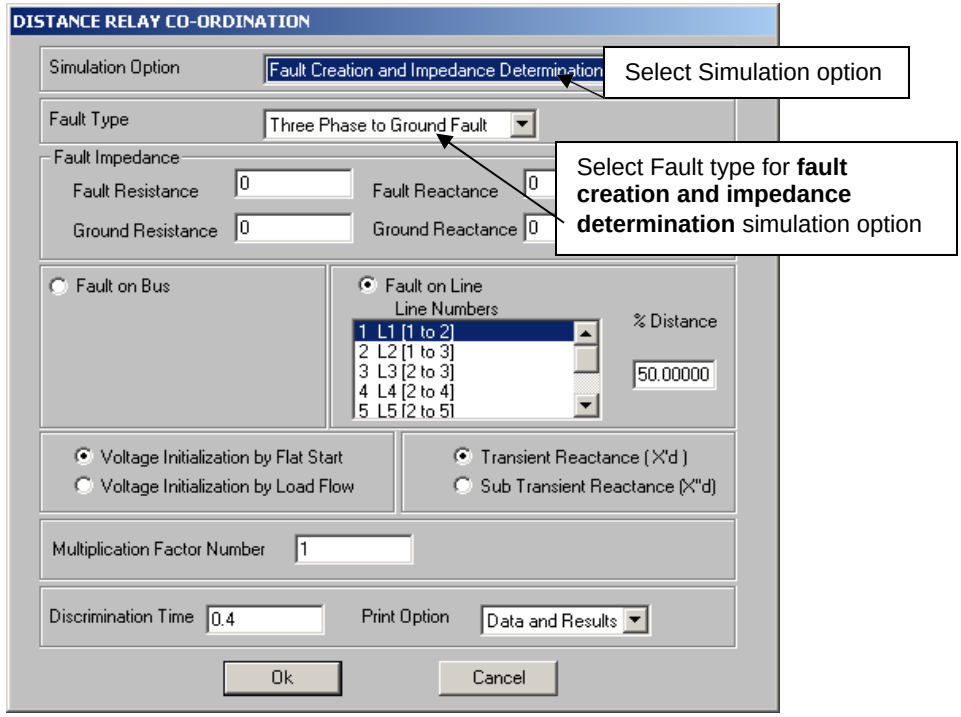


Connect other loads at other buses. Enter other load details as given in the following **Table D.**

6.6 Executing Distance Relay Co - ordination

Select the menu option **Solve → Distance Relay Co-ordination**


Distance Relay Co-ordination
Case
1
Execute After Input File Creation
Only Input File Creation
Execute with old Input File
Study Info...
Delete
Execute ...
Results
Network ...
Report ...
View Bus...
Graph ...
Close
1. Click here
2. Execute
3. To view Report



Note: If fault creation and impedance determination simulation option is selected then fault line number and distance are to be selected and then execute distance relay coordination

```
--------------------------------------------------------------------------
------
        DISTANCE RELAY CO-ORDINATION
       CASE NO  :   1                SCHEDULE
NO : 0 CONTINGENCY NAME : Base Case
--------------------------------------------------------------------------
------
VERSION NUMBER :  8.0
%% First Power System Network
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 BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :
0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :
2
NUMBER OF MOTORS               :    0    NUMBER OF LOADS                :
4
NUMBER OF FILTERS              :    0
NUMBER OF HVDC CONVERTORS      :    0
NUMBER OF PARTIAL BUS BAR DIFFERENTIAL RELAYS :    0
--------------------------------------------------------------------------
------
NUMBER OF ZONES                :    1
PRINT OPTION                   :    3 (BOTH DATA AND RESULTS PRINT)
GRAPH OPTION                   :    0 (NO GRAPH FILE GENERATION)
BASE MVA                       :  100.000
NOMINAL SYSTEM FREQUENCY Hz    :   50.000
PREFAULT VOLTAGE OPTION        :    0 (VOLTAGE OF 1.0 PU IS ASSUMED)
--------------------------------------------------------------------------
------
FAULT  RESISTANCE  -  PHASE   :     0.000000  (PU)
FAULT  REACTANCE   -  PHASE   :     0.000000  (PU)
FAULT  RESISTANCE  -  GROUND   :    0.000000  (PU)
FAULT REACTANCE  - GROUND      :    0.000000 (PU)
--------------------------------------------------------------------------
------
CIRCUIT BREAKER RESISTANCE (PU)                     : 0.000000e+000
CIRCUIT BREAKER REACTANCE  (PU)                     : 1.000000e-004
TRANSFORMER R/X RATIO                               :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR     :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS               :   1
TRANSMISSION LINE VOLTAGE - KV                      : 132.000000
TRANSMISSION  LINE  ZERO  SEQUENCE  IMP.  MULT.  FACTOR  :  2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR   :   0.800000

GENERATOR  NEGATIVE  SEQUENCE  RESISTANCE  MULT.  FACTOR  :  0.175000
GENERATOR  NEGATIVE  SEQUENCE  REACTANCE  MULT.  FACTOR  :  0.175000
GENERATOR  ZERO  SEQUENCE  RESISTANCE  MULT.  FACTOR  :  0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR     :    0.037500
LOAD    NEGATIVE SEQUENCE IMPEDANCE   MULT. FACTOR   :    0.810000
LOAD    ZERO SEQUENCE IMPEDANCE   MULT. FACTOR     :    1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
--------------------------------------------------------------------------
---
BUS DATA
NODE STAT ZONE BUS-KV   NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MVAR
                                           PLOAD-MW QLOAD-MVAR QCOMP-MVAR
---- ---- ---- -------- -------- -------- -------- -------- --------
```

```
   1    1    1  132.000      Bus1   1.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
   2    1    1  132.000      Bus2   1.0000    0.000    0.000    0.000

                                               0.000    0.000    0.000
   3    1    1  132.000      Bus3   1.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
   4    1    1  132.000      Bus4   1.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
   5    1    1  132.000      Bus5   1.0000    0.000    0.000    0.000
                                               0.000    0.000    0.000
------------------------------------------------------------------------
---
TRANSMISSION LINE DATA

STAT CKTS FROM FROM       TO TO
          NODE NAME     NODE NAME      RP(P.U)  XP(P.U) BP/2(PU) THERMAL
                                       RZ(P.U)  XZ(P.U) BZ/2(PU) RATING
MVA
---- ---- ---- -------- ---- -------- -------- -------- -------- -------
   3    1    1     Bus1    2     Bus2  0.02009  0.05997  0.00000
                                       0.04017  0.11995  0.00000  100.00
   3    1    1     Bus1    3     Bus3  0.08000  0.23996  0.00000
                                       0.15496  0.48209  0.00000  100.00
   3    1    2     Bus2    3     Bus3  0.05997  0.17998  0.00000
                                       0.11995  0.36731  0.00000  100.00
   3    1    2     Bus2    4     Bus4  0.05997  0.17998  0.00000
                                       0.11995  0.36731  0.00000  100.00
   3    1    2     Bus2    5     Bus5  0.03994  0.12001  0.00000
                                       0.08035  0.24105  0.00000  100.00
   3    1    3     Bus3    4     Bus4  0.00999  0.02996  0.00000
                                       0.02009  0.05992  0.00000  100.00
   3    1    4     Bus4    5     Bus5  0.08000  0.23996  0.00000
                                       0.15496  0.48209  0.00000  100.00
------------------------------------------------------------------------
---
GENERATOR DATA

FROM FROM       POSITIVE         NEGATIVE           ZERO          MVA
NODE NAME    R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) RATING
STAT
---- -------- -------- -------- -------- -------- -------- -------- -----
- -
   1     Bus1  0.00000  0.25000  0.00000  0.01000  0.00000  0.01000  100
3
   2     Bus2  0.00000  0.25000  0.00000  0.01000  0.00000  0.01000  100
3
------------------------------------------------------------------------
---
LOAD DATA

NODE NAME     STATUS
```

```
---- -------- ------
   2     Bus2      3
   3     Bus3      3
   4     Bus4      3
   5     Bus5      3


------------------------------------------------------------------------
---
GENERATOR DATA FOR MINIMUM GENERATION

FROM FROM       POSITIVE         NEGATIVE           ZERO          MVA

NODE NAME    R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) RATING
STAT
---- -------- -------- -------- -------- -------- -------- -------- -----
- -
   1     Bus1  0.00000  0.25000  0.00000  0.01000  0.00000  0.01000
100 3
   2     Bus2  0.00000  0.25000  0.00000  0.01000  0.00000  0.01000
100 3
------------------------------------------------------------------------
---
CO-ORDINATION TYPE                      :    0 (DISTANCE RELAY CO-ORDIN)
------------------------------------------------------------------------
---
NUMBER OF DISTANCE RELAYS               :   14
------------------------------------------------------------------------
---
SIMULATION STATUS                       :    1 (SIMULATION)
------------------------------------------------------------------------
---
  The entries in different columns of Distance relay data
  are as follows -

RELAY NAME : Name of the relay, the size should not exceed 8 characters.
ELMN-NUMB   : Series element number on which the relay is located.
LINE-LNTH   : The length of the transmission line on which the relay is
              located.
FOR/REV     : 1 if relay is located on from side of the series element.
              2 if relay is located on to side of the series element.
CTPRI       : Current transformer primary rating in amperes.
CTSE        : Current transformer secondary rating in amperes.
PTPR        : Potential transformer primary rating in kV.
PTSE        : Potential transformer secondary rating in volts.
LOAD IMP
R (P.U)     : Apparent load resistance in p.u determined using load flow
              results.
X (P.U)     : Apparent load reactance in p.u determined using load flow
              results.
Z1 REACH    : Percentage of the primary line impedance for which the
              relay should operate instantaneously.
Z2 REACH    : Percentage of shortest line impedance in the adjacent
```

```
section
              for which the relay provides backup protection.
Z3 REACH : Percentage of the longest line impedance connected to the
              remote bus of the shortest adjacent section for which the
              relay provides backup protection.
Z2 DIS TIME : The co-ordination time interval between zone1 and zone2
              in seconds.

Z3 DIS TIME : The co-ordination time interval between zone2 and zone3
              in seconds.
RELAY DBASE : The relay type number.
------------------------------------------------------------------------
---
DISTANCE RELAY DATA

RELAY      ELMN LINE  FOR/ CTPR CTSE PTPR PTSE   LOAD IMP Z1 REACH Z2
REACH
 NAME      NUMB LNTH  REV  AMPS  AMP   KV VOLT   R(P.U) X(P.U)  PERCENT
PERCENT
                                                 Z3 REACH Z2 DIS   Z3 DIS
Z4 REACH Z4     RELAY
                                                  PERCENT   TIME     TIME
PERCENT  TIME   DBASE
------------------- ---- ----- ---- ---- ---- ---- ---- -------- ------
--------
                Dr1    1  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
20    1.000        0
                Dr2    1  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
20    1.000        0
                Dr3    2  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
29    1.000        0
                Dr4    2  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
20    1.000        0
                Dr5    3  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
20    1.000        0
                Dr6    3  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                   100  0.500    0.800
20    1.000        0
```

```
                Dr7    4  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
                Dr8    4  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
                Dr9    5  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
```

```
                Dr10    6  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
                Dr11    6  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
                Dr12    7  1.00    1  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0
                Dr13    7  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        0

                Dr14    5  1.00    2  400    5  132  110  999.990 999.99
80       40
                                                100  0.500    0.800
20    1.000        2
--------------------------------------------------------------------------
---
DISCRIMINATION TIME                     :    0.40
--------------------------------------------------------------------------
---
NUMBER OF FAULTS SIMULATED              :    1
--------------------------------------------------------------------------
---
SERIES ELEMENT PERCENT FAULTTYPE
    NUMBER     LINE
-------------- ------- ---------
             1   50.00         1 (3 PHASE TO GROUND FAULT)
--------------------------------------------------------------------------
---
              RELAY ELEMENT FROM BUS FROM BUS TO BUS   TO BUS RELAY
LOCATION
                NAME  NUMBER   NUMBER     NAME NUMBER     NAME
(FROM/TO)
                                                         BUS NAME
```

```
-------------------- -------- -------- -------- ------ -------- ----------
---
                Dr1       1        1     Bus1      2     Bus2
Bus1
                Dr2       1        1     Bus1      2     Bus2
Bus2
                Dr3       2        1     Bus1      3     Bus3
Bus1
                Dr4       2        1     Bus1      3     Bus3
Bus3
                Dr5       3        2     Bus2      3     Bus3
Bus2

                    Dr6       3        2     Bus2      3     Bus3
Bus3
                    Dr7       4        2     Bus2      4     Bus4
Bus2
                    Dr8       4        2     Bus2      4     Bus4
Bus4
                    Dr9       5        2     Bus2      5     Bus5
Bus2
                   Dr10       6        3     Bus3      4     Bus4
Bus3

                   Dr11       6        3     Bus3      4     Bus4
Bus4
                   Dr12       7        4     Bus4      5     Bus5
 Bus4

                   Dr13       7        4     Bus4      5     Bus5
Bus5
                   Dr14       5        2     Bus2      5     Bus5
Bus5
-------------------------------------------------------------------------
--
Number of phase relays 14 Number of earth fault relays 0

DISTANCE RELAY PAIRS
--------------------
PRIMARY           RELAY NAME BACK UP           RELAY NAME
-------  -------------------  -------  -------------------
      5                  Dr5        1                  Dr1
      7                  Dr7        1                  Dr1
      9                  Dr9        1                  Dr1
      3                  Dr3        2                  Dr2
      6                  Dr6        3                  Dr3
     10                 Dr10        3                  Dr3
      1                  Dr1        4                  Dr4
      4                  Dr4        5                  Dr5
     10                 Dr10        5                  Dr5
      2                  Dr2        6                  Dr6
      7                  Dr7        6                  Dr6
      9                  Dr9        6                  Dr6
```

11	Dr11	7	Dr7
12	Dr12	7	Dr7
2	Dr2	8	Dr8
5	Dr5	8	Dr8
9	Dr9	8	Dr8
13	Dr13	9	Dr9
8	Dr8	10	Dr10
12	Dr12	10	Dr10
4	Dr4	11	Dr11
6	Dr6	11	Dr11
14	Dr14	12	Dr12
8	Dr8	13	Dr13
11	Dr11	13	Dr13
2	Dr2	14	Dr14
5	Dr5	14	Dr14
7	Dr7	14	Dr14

Computed Phase and Earth relay reach (set Values) are given below

PHASE/ZERO SEQUENCE REACH (COMPUTED)

RELAY NAME	ZONE1 SETTING PH-PH	ZONE2 SETTING PH-PH	ZONE3 SETTING PH-PH	ZONE4 SETTING PH-PH	ZONE1 SETTING PH-E	ZONE2 SETTING PH-E	ZONE3 SETTING PH-E	ZONE4 SETTING PH-E	ZONE2 TIME (s)	ZONE3 TIME (s)	ZONE4 TIME (s)
Dr1	0.5877	1.3223	5.1421	-0.147	1.1755	2.6500	10.3030	-0.294	0.500	1.300	2.300
Dr2	0.5877	1.9099	5.8765	-0.147	1.1755	3.8222	11.8398	-0.294	0.500	1.300	2.300
Dr3	2.3506	3.0849	6.2433	-0.852	4.7057	6.1758	12.4983	-1.706	0.500	1.300	2.300
Dr4	2.3506	3.2321	5.8765	-0.588	4.7057	6.4699	11.8399	-1.176	0.500	1.300	2.300
Dr5	1.7629	2.3504	5.5087	-0.441	3.5907	4.7821	11.1046	-0.898	0.500	1.300	2.300
Dr6	1.7629	2.4975	5.8765	-0.441	3.5907	5.0762	11.8399	-0.898	0.500	1.300	2.300
Dr7	1.7629	2.3504	5.5087	-0.441	3.5907	4.7821	11.1046	-0.898	0.500	1.300	2.300
Dr8	1.7629	2.4975	5.8765	-0.441	3.5907	5.0762	11.8399	-0.898	0.500	1.300	2.300
Dr9	1.1754	2.6445	6.6111	-0.294	2.3612	5.3043	13.3219	-0.590	0.500	1.300	2.300
Dr10	0.2935	1.2483	4.7742	-0.073	0.5873	2.5295	9.7109	-0.147	0.500	1.300	2.300
Dr11	0.2935	1.2483	4.7742	-0.073	0.5873	2.5295	9.7109	-0.147	0.500	1.300	2.300
Dr12	2.3506	3.5259	6.6111	-0.588	4.7057	7.0627	13.3219	-1.176	0.500	1.300	2.300
Dr13	2.3506	3.0849	6.2433	-0.588	4.7057	6.1758	12.4983	-1.176	0.500	1.300	2.300
Dr14	1.1754	1.7631	5.1421	-0.294	2.3612	3.5393	10.3030	-0.590	0.500	1.300	2.300

ZONE1		ZONE2		ZONE3		ZONE4		REMARKS
EARTH SETTING		EARTH SETTING		EARTH SETTING		EARTH SETTING		
0.3800	1.120	0.8400	2.520	3.2100	9.8000	0.1000	0.290	RES\REACT
0.3800	1.120	1.1900	3.640	3.6900	11.2600	0.1000	0.290	RES\REACT
1.4500	4.480	1.9000	5.880	3.8300	11.9000	0.5300	1.630	RES\REACT
1.4500	4.480	1.9900	6.160	3.6500	11.2700	0.3700	1.120	RES\REACT
1.1200	3.420	1.4900	4.550	3.4300	10.5700	0.2900	0.860	RES\REACT
1.1200	3.420	1.5800	4.830	3.6600	11.2700	0.2900	0.860	RES\REACT
1.1200	3.420	1.4900	4.550	3.4300	10.5700	0.2900	0.860	RES\REACT
1.1200	3.420	1.5800	4.830	3.6600	11.2700	0.2900	0.860	RES\REACT
0.7500	2.250	1.6600	5.050	4.1700	12.6600	0.1900	0.570	RES\REACT
0.1900	0.560	0.8000	2.410	3.0300	9.2300	0.0500	0.150	RES\REACT
0.1900	0.560	0.8000	2.410	3.0300	9.2300	0.0500	0.150	RES\REACT
1.4500	4.480	2.1800	6.720	4.1100	12.6800	0.3700	1.120	RES\REACT
1.4500	4.480	1.9000	5.880	3.8300	11.9000	0.3700	1.120	RES\REACT
0.7500	2.250	1.1200	3.360	3.2000	9.8000	0.1900	0.570	RES\REACT

PHASE/ZERO ZONE REACH (SET VALUES)

RELAY NAME	RELAY TYPE	QUANTITY	ZONE1 PHASE SETTING		ZONE2 PHASE SETTING		ZONE3 PHASE SETTING		ZONE4 PHASE SETTING	
Dr1	RED670	RES\REACT	0.1900	0.5600	0.4200	1.260	1.6300	4.8800	0.0500	0.150
Dr2	RED670	RES\REACT	0.1900	0.5600	0.6100	1.820	1.8700	5.5800	0.0500	0.150
Dr3	RED670	RES\REACT	0.7500	2.2300	0.9800	2.930	1.9800	5.9300	0.2800	0.810
Dr4	RED670	RES\REACT	0.7500	2.2300	1.0300	3.070	1.8600	5.5800	0.1900	0.560
Dr5	RED670	RES\REACT	0.5600	1.6800	0.7500	2.230	1.7500	5.2300	0.1500	0.430
Dr6	RED670	RES\REACT	0.5600	1.6800	0.7900	2.370	1.8600	5.5800	0.1500	0.430
Dr7	RED670	RES\REACT	0.5600	1.6800	0.7500	2.230	1.7500	5.2300	0.1500	0.430
Dr8	RED670	RES\REACT	0.5600	1.6800	0.7900	2.370	1.8600	5.5800	0.1500	0.430
Dr9	RED670	RES\REACT	0.3800	1.1200	0.8400	2.510	2.0900	6.2800	0.1000	0.290
Dr10	RED670	RES\REACT	0.1000	0.2800	0.4000	1.190	1.5100	4.5300	0.0300	0.100
Dr11	RED670	RES\REACT	0.1000	0.2800	0.4000	1.190	1.5100	4.5300	0.0300	0.100
Dr12	RED670	RES\REACT	0.7500	2.2300	1.1200	3.350	2.1000	6.2800	0.1900	0.560
Dr13	RED670	RES\REACT	0.7500	2.2300	0.9800	2.930	1.9800	5.9300	0.1900	0.560
Dr14	REL521	RES\REACT	0.3800	1.1200	0.5600	1.680	1.6300	4.8800	0.1000	0.290

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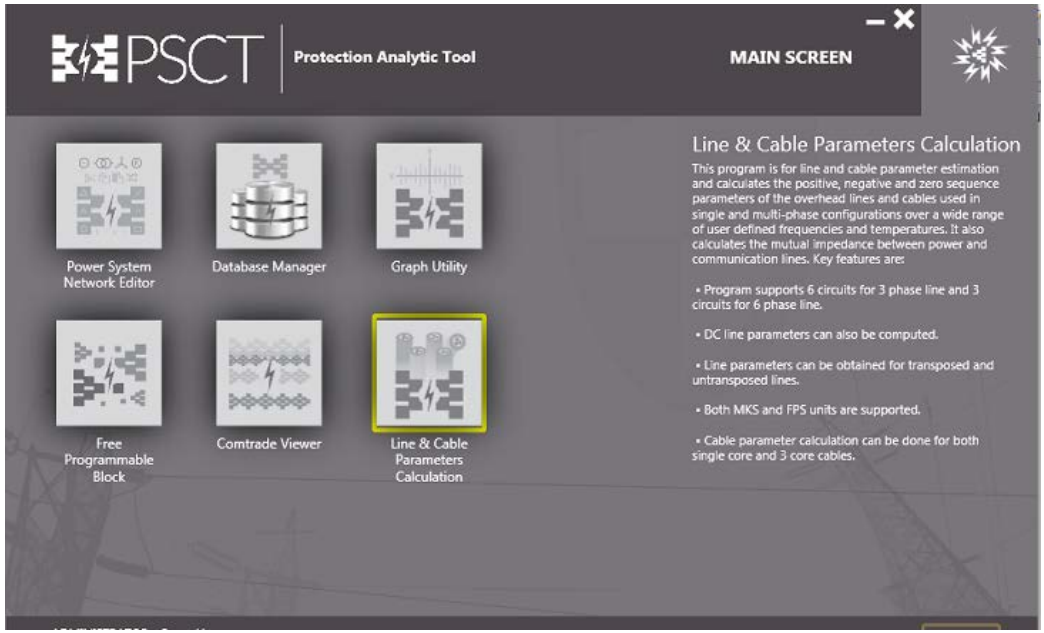
7. How to solve Line-Cable Parameter Calculation

7.1 Line Parameter Calculation

No of circuits	1
No of ground wires	1
No of bundles/ph	1
Length of line	1m
Spacing between bundle conductor	0m
Earth resistivity	100ohm-m
Operating frequency	50Hz

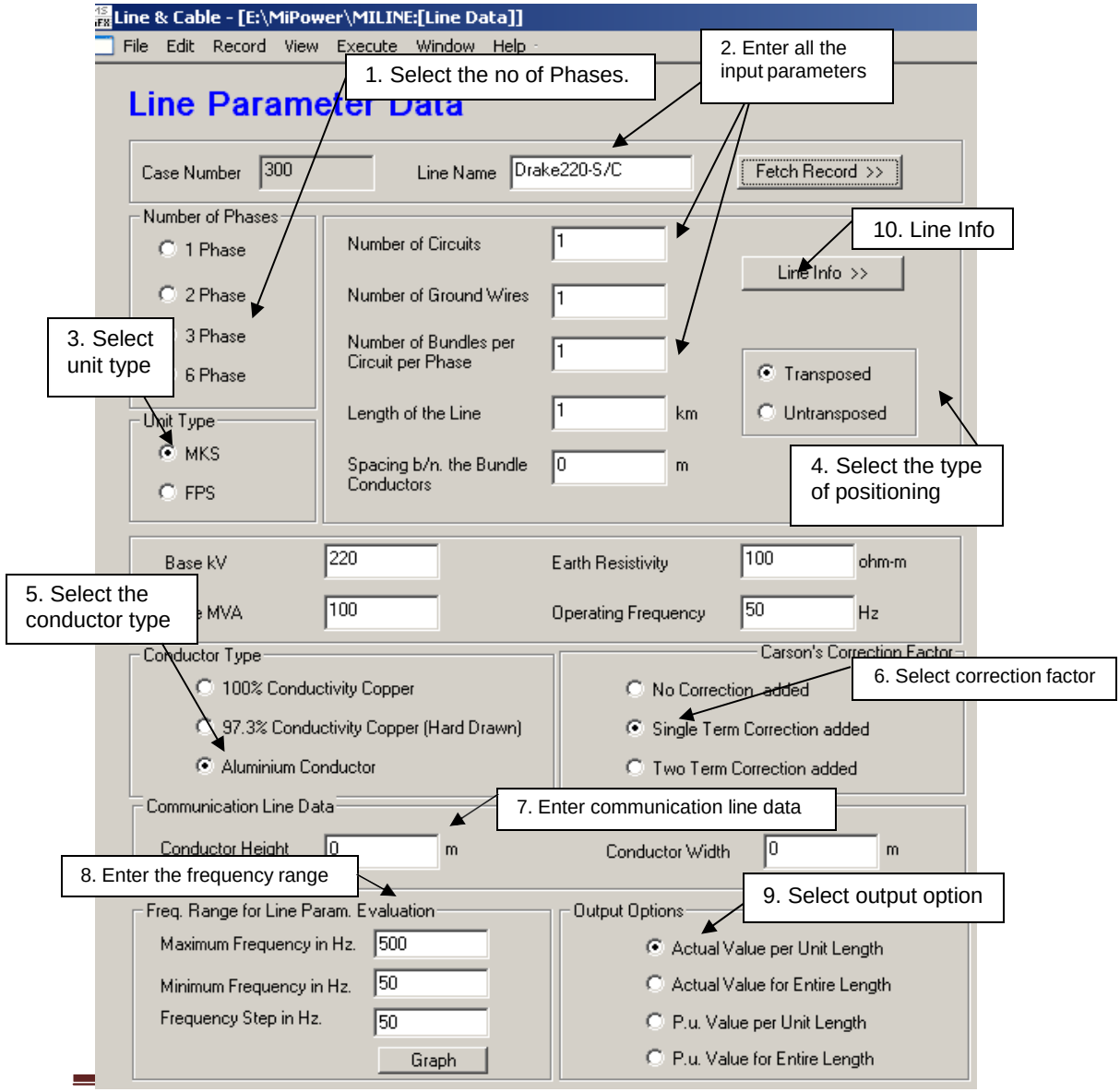
* 100MVA base at 220kV

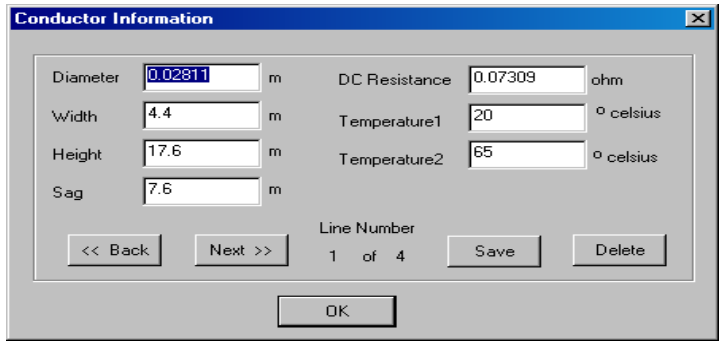
To solve line and cable parameter calculation by using MiP-PSCT package invokes " **Line & Cable Parameter Calculation"** in the MiP-PSCT main screen.



Open **view menu**, select **cable** or **line** which ever is necessary.

Line Parameter Calculation:





After entering all the data click on **Save** and to add next record click on **Next**

Conductor Information:

	Conductor 1	Conductor 2	Conductor 3	Conductor 4
Diameter in meter	0.02811	0.02811	0.02811	0.00945
Width in meter	4.4	4.4	-4.4	0
Height in meter from ground level	17.6	25.6	21.6	27.4
Sag in meter	7.6	7.6	7.6	0
DC Resistance in ohm	0.07309	0.07309	0.07309	3.375
Temperature1 in °Celsius	20	20	20	20
Temperature2 in Degree Celsius	65	65	65	20

Invoke **Execute**⟶ **Line parameter calculation**. A part of the report is shown.

```
--------------------------------------------------------------------------------
        LINE PARAMETER CALCULATION
      CASE NO:   300                SCHEDULE NO: 0
--------------------------------------------------------------------------------
NUMBER OF PHASES PER CIRCUIT    :    3
NUMBER OF CIRCUITS              :    1
NUMBER OF GROUND WIRES          :    1
NUMBER OF CONDUCTORS PER BUNDLE :    1
LINE TRANSPOSITION STATUS       :    1 (TRANSPOSED)
```

```
 BASE MVA                          :  100.000
 BASE KV                           :  220.000

UNIT TYPE                          :    0 (MKS SYSTEM)
OUT TYPE                           :    0  - Ohm(Mho)/km
CONDUCTOR MATERIAL TYPE            :    2  - ALUMINUM
FREQUENCY                          :   50.000 hertz
BUNDLE SPACE                       :  0.00000 meter
EARTH RESISTIVITY                  :  100.000 ohm-meter
LINE LENGTH                        :    1.000 km
CARSON CORRECTION OPTION           :    1  - SINGLE TERM CORRECTION
FREQUENCY STARTING VALUE           :    50.00 Hzs
FREQUENCY ENDING VALUE             :    50.00 Hzs
FREQUENCY STEP VALUE               :    50.00 Hzs
-------------------------------------------------------------------------
NOTATION USED FOR CONDUCTOR INFORMATION
RDC : DC resistance of conductor in ohms at T1 degree Celsius.
T1  : Temperature in degree Celsius at which RDC value is provided.
T2  : Temperature in degree Celsius at which resistance to be computed.
CD  : Diameter of the conductor in the given units.
CH  : Height of the conductor above ground in given units.
CW  : Distance between conductor and centre of the tower in given units.
Sag : Conductor sag at the mid way of the span in given units.
-------------------------------------------------------------------------
------
COND.   RDC         T1         T2         CD         CH         CW   Sag
(no.)* (ohm) (degree-c) (degree-c)    (metre)    (metre)    (metre) (mtr)
------ ---------- ---------- ---------- ---------- --------- ---------- -
---
1    0.07309   20.00000   65.00000    0.02811   17.60000    4.40000
7.600
2    0.07309   20.00000   65.00000    0.02811   25.60000    4.40000
7.600
3    0.07309   20.00000   65.00000    0.02811   21.60000   -4.40000
7.600
4    3.37500   20.00000   20.00000    0.00945   27.40000    0.00000
0.000
-------------------------------------------------------------------------
---
COMMUNICATION LINE HEIGHT FROM GROUND         :    0.00000 metre
COMMUNICATION LINE WIDTH FROM CENTRE OF TOWER :    0.00000 metre
-------------------------------------------------------------------------
---
COMPUTED VALUES ARE FOR AC SYSTEM
-------------------------------------------------------------------------
---
```

```
SERIES PHASE IMPEDANCE MATRIX FOR ALL THE CONDUCTORS IN SELECTED UNIT
CONVENTION (A1 B1 C1),(A2 B2 C2),...,(G1 G2..)

1.363704e-001+j7.133706e-001  4.935159e-002+j2.838968e-001  4.935159e-
002+j2.838968e-001
4.935159e-002+j2.838968e-001

4.935159e-002+j2.838968e-001  1.363704e-001+j7.133706e-001  4.935159e-
002+j2.838968e-001
4.935159e-002+j2.838968e-001


4.935159e-002+j2.838968e-001  4.935159e-002+j2.838968e-001  1.363704e-
001+j7.133706e-001
4.935159e-002+j2.838968e-001

4.935159e-002+j2.838968e-001  4.935159e-002+j2.838968e-001  4.935159e-
002+j2.838968e-001
3.424352e+000+j7.818725e-001

------------------------------------------------------------------------
------
SERIES PHASE IMPEDANCE MATRIX AFTER GROUND WIRE ELIMINATION IN SELECTED
UNIT
CONVENTION (A1 B1 C1),(A2 B2 C2),...

1.562888e-001+j7.006396e-001  6.927006e-002+j2.711659e-001  6.927006e-
002+j2.711659e-001

6.927006e-002+j2.711659e-001  1.562888e-001+j7.006396e-001  6.927006e-
002+j2.711659e-001

6.927006e-002+j2.711659e-001  6.927006e-002+j2.711659e-001  1.562888e-
001+j7.006396e-001
------------------------------------------------------------------------
---
SERIES SEQUENCE IMPEDANCE MATRIX AFTER GROUND WIRE ELIMINATION IN
SELECTED UNIT
CONVENTION (0 1 2),(0 1 2),...

2.948289e-001+j1.242972e+000  0.000000e+000-j1.851916e-008
0.000000e+000+j1.851916e-008

-9.259582e-009-j2.777874e-008  8.701877e-002+j4.294737e-001  -9.259582e-
009+j2.314895e-008
```

```
0.000000e+000-j4.629791e-009  -9.259582e-009+j2.777874e-008  8.701876e-
002+j4.294738e-001
-------------------------------------------------------------------------
---
SERIES SEQUENCE IMPEDANCE MATRIX - EQUIVALENT CIRCUIT (0 1 2) IN SELECTED
UNIT
CONVENTION (0 1 2)

2.948290e-001+j1.242972e+000  9.259582e-009+j9.259582e-009  1.851916e-
008+j4.629791e-008

0.000000e+000-j0.000000e+000  8.701876e-002+j4.294737e-001  -1.851916e-
008+j9.259582e-009


0.000000e+000+j9.259582e-009  -9.259582e-009+j9.259582e-009  8.701876e-
002+j4.294738e-001
-------------------------------------------------------------------------
---
SHUNT PHASE ADMITTANCE MATRIX FOR ALL THE CONDUCTORS IN SELECTED UNIT
CONVENTION (A1 B1 C1),(A2 B2 C2),...,(G1 G2..)

0.000000e+000+j2.409543e-006  0.000000e+000-j3.164514e-007
0.000000e+000-j3.164514e-007
0.000000e+000-j2.527685e-007

0.000000e+000-j3.164514e-007  0.000000e+000+j2.409543e-006
0.000000e+000-j3.164514e-007
0.000000e+000-j2.527685e-007

0.000000e+000-j3.164514e-007  0.000000e+000-j3.164514e-007
0.000000e+000+j2.409543e-006
0.000000e+000-j2.527685e-007

0.000000e+000-j2.527685e-007  0.000000e+000-j2.527685e-007
0.000000e+000-j2.527684e-007
0.000000e+000+j1.975512e-006
-------------------------------------------------------------------------
---
SHUNT PHASE ADMITTANCE MATRIX AFTER GROUND WIRE ELIMINATION IN SELECTED
UNIT
CONVENTION (A1 B1 C1),(A2 B2 C2),...

0.000000e+000+j2.409543e-006  0.000000e+000-j3.164514e-007
0.000000e+000-j3.164513e-007
```

```
0.000000e+000-j3.164514e-007  0.000000e+000+j2.409543e-006
0.000000e+000-j3.164514e-007

0.000000e+000-j3.164513e-007  0.000000e+000-j3.164514e-007
0.000000e+000+j2.409543e-006
------------------------------------------------------------------------
---
SHUNT SEQUENCE ADMITTANCE MATRIX AFTER GROUND WIRE ELIMINATION IN
SELECTED UNIT
CONVENTION (0 1 2),(0 1 2),...

-2.393917e-014+j1.776640e-006  7.064500e-014-j0.000000e+000  -3.532250e-
014+j7.064500e-014

-7.064500e-014-j7.064500e-014  5.298375e-014+j2.725994e-006  7.064500e- 014-
j1.412900e-013


7.064500e-014-j3.532250e-014  -1.412900e-013-j3.532250e-014  -4.001377e-
014+j2.725994e-006
------------------------------------------------------------------------
---
SHUNT SEQUENCE ADMITTANCE MATRIX - EQUIVALENT CIRCUIT (0 1 2) IN SELECTED UNIT
CONVENTION (0 1 2)

-2.393917e-014+j1.776640e-006  7.064500e-014-j3.532250e-014  -7.064500e-
014+j3.532250e-014

-3.532250e-014-j3.532250e-014  6.374607e-014+j2.725994e-006  1.412900e- 013-
j1.412900e-013

3.532250e-014-j1.766125e-014  -1.412900e-013-j3.532250e-014  -5.319072e-
014+j2.725994e-006
------------------------------------------------------------------------
---
A,B,C and D constants :
A =    0.9999994040 +j    0.0000001186
B =    0.0870187283 +j    0.4294736385 (Ohm)
C =   -0.0000000000 +j    0.0000027260 (Mho)
D =    0.9999994040 +j    0.0000001186
------------------------------------------------------------------------
---
ATTENUATION CONSTANT (Line-to-Line mode)        :    0.00011 neper/km
PHASE CONSTANT (Line-to-Line mode)              :    0.00109 rad/km
```

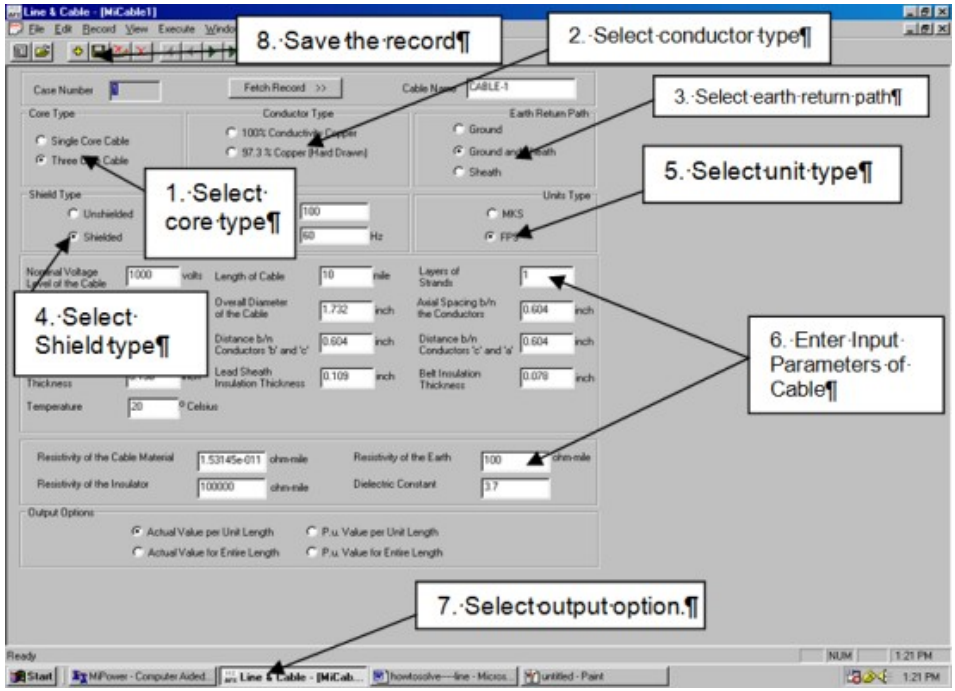
```
CHARACTERISTIC WAVELENGTH (Line-to-Line mode) 5777.68708 Km
                                                .
PROPAGATION VELOCITY (Line-to-Line mode)        : 288884.35377 km
SURGE IMPEDANCE (REAL, including losses)        :  398.93393 Ohms
SURGE IMPEDANCE (IMAGINARY, including losses)   :  -40.00894 Ohms
ATTENUATION CONSTANT (Line-to-Ground mode)      :    0.00018 neper/km
PHASE CONSTANT (Line-to-Ground mode)            :    0.00150 rad/km
CHARACTERISTIC WAVELENGTH (Line-to-Ground mode) : 4199.11477 km
PROPAGATION VELOCITY (Line-to-Ground mode)      : 209955.73869 km
------------------------------------------------------------------------
---
MUTUAL INDUCTANCE IN SELECTED UNIT
BETWEEN  PHASE  LINE  1  &  COMMUNICATION  LINE  0.26713
BETWEEN  PHASE  LINE  2  &  COMMUNICATION  LINE  0.23835
BETWEEN PHASE LINE 3 & COMMUNICATION LINE    0.25123
------------------------------------------------------------------------
---
% Line parameters per circuit
%CS Type Rp           Xp           Bp/2
%       Rz           Xz           Bz/2

LN  0    8.701877e-002 4.294737e-001 1.362997e-006
         2.948289e-001 1.242972e+000 8.883201e-007
------------------------------------------------------------------------
---
```

7.2 Cable Parameter Calculation:

Calculate the cable parameters for the aluminum shielded 3-core cable with ground and sheath as the path for earth return with the details given below.

Nominal voltage level of the cable	1kV	Lead sheath thickness	0.156 inch
Length of cable	10mile	Lead sheath insulation thickness	0.109 inch
Layer of strands	1	Belt insulation thickness	0.078 inch
Diameter of single strands	0.0973 inch	Temperature	20deg-cel
Overall diameter of cable	1.732 inch	Resistivity of the cable material	1.532e-11ohm-mile
Axial spacing b/n the conductor	0.604 inch	Resistivity of the insulator	100000 ohm-mile
Distance b/n conductor ‘a’ & ‘b’	0.604 inch	Resistivity of the earth	100 ohm-mile
Distance b/n conductor ‘b’ & ‘c’	0.604 inch	Dielectric constant	3.7
Distance b/n conductor ‘c’ & ‘a’	0.604 inch		



Invoke **Execute** ⟶ **Cable parameter calculation**. The report is shown below.

```
--------------------------------------------------------------------------------
        CABLE PARAMETER CALCULATION

CASE NO  :   1                SCHEDULE NO : 0
--------------------------------------------------------------------------------
------
Temperature at which the R is calculated   :     20.0 degree celsius
Units                                      :        1 (FPS system)
Diameter of the strand                     :    0.0973 inch
Number of layers of stranded conductors    :        1
Length of the conductor                    :   10.000 mile
Resistivity at zero degree celsius         : 1.53145e-011 ohm-mile
Lead sheath insulation                     :   0.1090 inch
Axial spacing between conductors           :   0.6040 inch
Frequency                                  :     60.0 hertz
Number of cores                            :        3
```

```
Resistivity of the insulation                : 100000.0 ohm-mile
Diameter over insulation                     :   1.7320 inch
Conductor Insulation Thickness               :   0.1560 inch
Return path                                  : Through both ground and
sheath
Return path                                  : Through  ground
Conductor type                               :        2
(Material used for the conductor  - Aluminium)
Distance among conductor centers  (a-b)      :   0.6040 inch
Distance among conductor centers  (b-c)      :   0.6040 inch
Distance among conductor centers  (c-a)      :   0.6040 inch
System voltage                               :     1000 volts
Earth resistivity                            :    100.0 ohm-m
Dielectric constant                          :      3.7
Shield                                       :        1
(3 core ,shielded cable)
Belt insulation                              :   0.0780 inch
Output option                                :   0  - Ohm(Mho)/mile
Base MVA                                     :    100.000
------------------------------------------------------------------------
------
POSITIVE SEQUENCE IMPEDANCE    :   0.98961+j0.20265

POSITIVE SEQUENCE SUSCEPTANCE :   0.00008

NEGATIVE SEQUENCE IMPEDANCE    :   0.98961+j0.20265

NEGATIVE SEQUENCE SUSCEPTANCE :   0.00008

ZERO SEQUENCE IMPEDANCE        :   2.89518+j1.87208

ZERO SEQUENCE SUSCEPTANCE      :   0.00008
```

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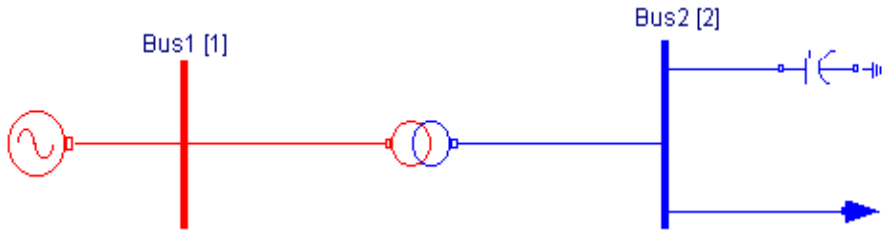
8. How to solve EMTA

For the two bus system shown below conduct Electro-magnetic Transient Analysis for a three phase to ground fault at Bus 2



Generator details

315 MVA, 11 kV with $X_d = X_q = 2$, $X'_d = X'_q = 0.3$, $X''_d = X''_q = 0.2$, $X_n = X_0 = X_p = 0.2$

Transformer details

315 MVA, 220/11 kV, leakage reactance = x = 14 %

Load details

200MW at 0.8 p.f lag

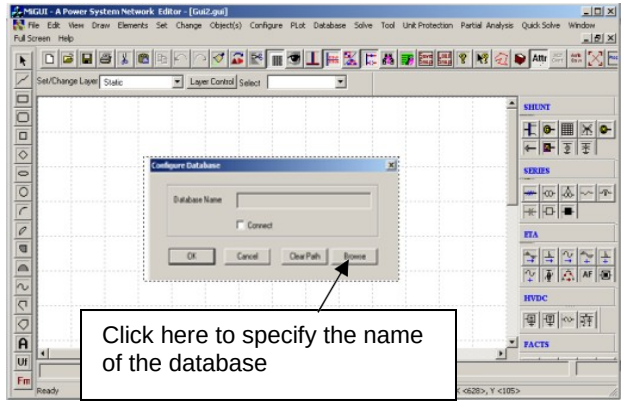
Shunt capacitor data: 5MVA,220kV, susceptance=1

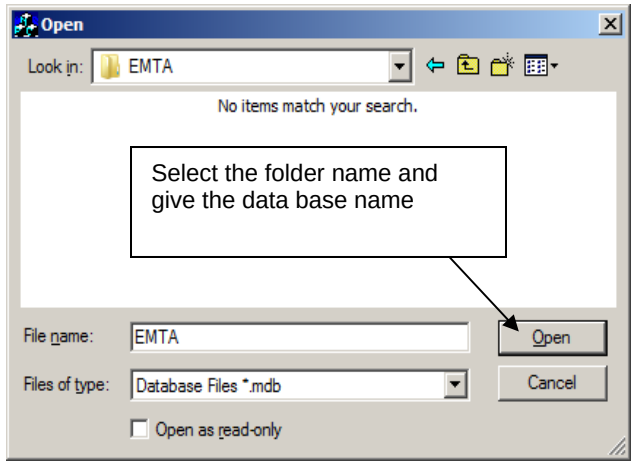
MiP-PSCT - Database Configuration

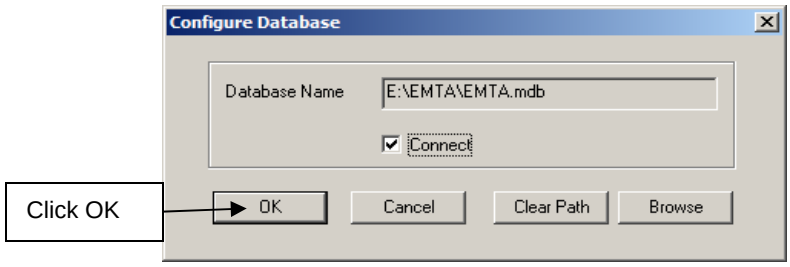
Open Power System Network Editor. Select menu option **Database → Configure**. Configure Database dialog is popped up. Click **Browse** button.

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**

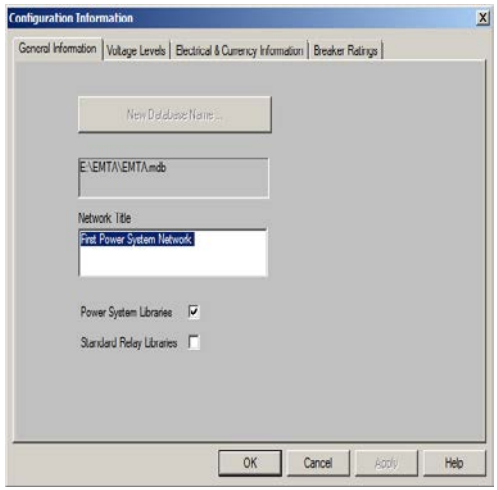
Database dialog will appear with path chosen.

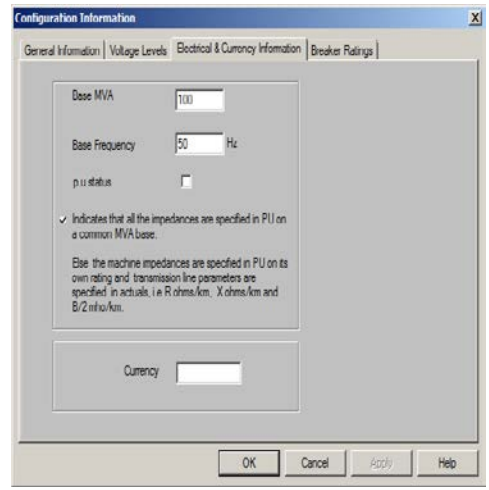




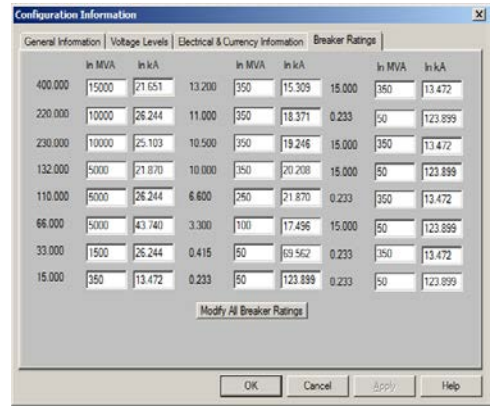


Click on **OK** button in the **Configure database** dialog, the following dialog appears.





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.**

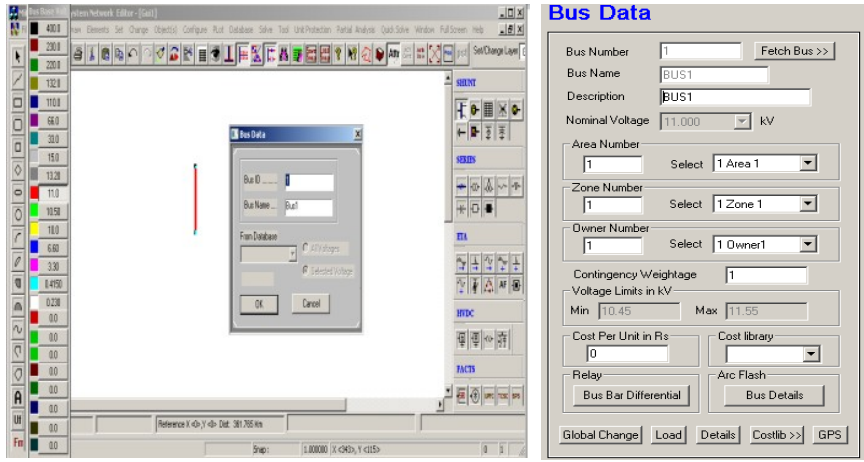
Dialog shown below appears. If necessary change the **Base-voltages, color, Bus width** and click **OK.**

8.1 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.

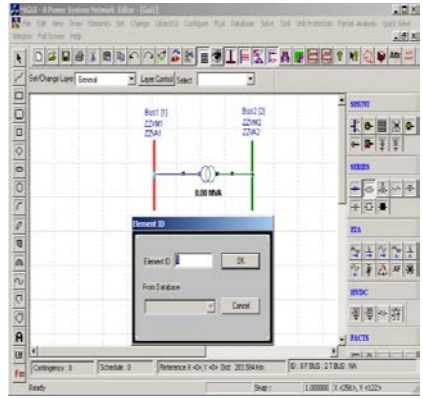
Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name field and the bus description field can be used to abbreviate the bus name. For example let us say the bus name is **Northeast**,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



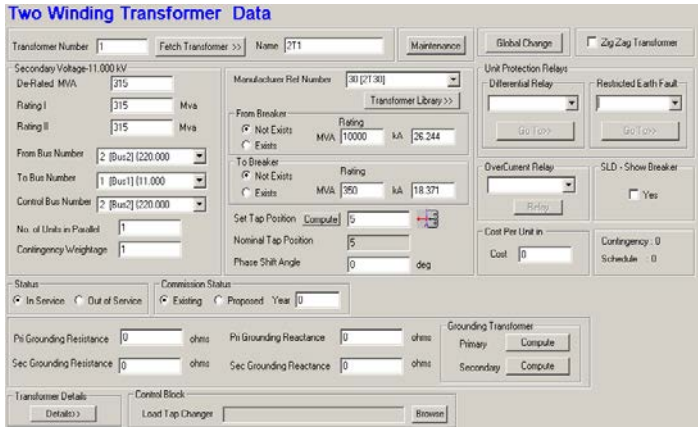
After entering data click **save** 🖫**,** which invokes **Network Editor**. Follow the same procedure for second bus with bus voltage as 220 kV.

8.2 Procedure to Draw Transformer

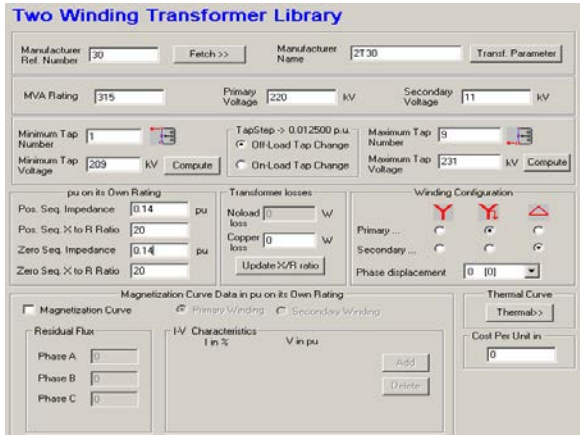
Click on **Two Winding Transformer** icon provided on power system tool bar. To draw the transformer click in between two buses and to connect to the from bus, double click LMB (Left Mouse Button) on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. **Element 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.

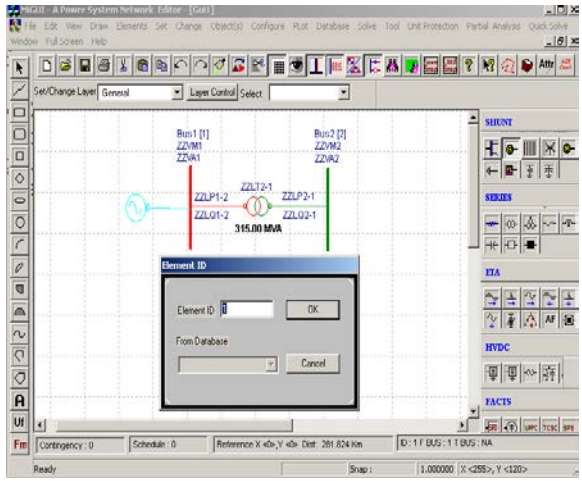


Transformer library form will be open. Enter the data as shown below. **Save** 🖫 and **close** library screen.
Transformer element data form will appear. Click **Save** 🖫 button, which invokes network editor. In the similar way enter other transformer details.

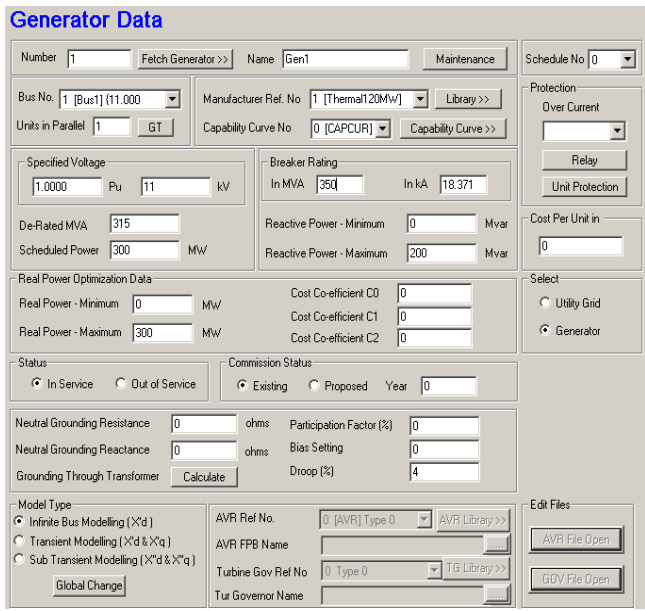


8.3 Procedure to Draw Generator

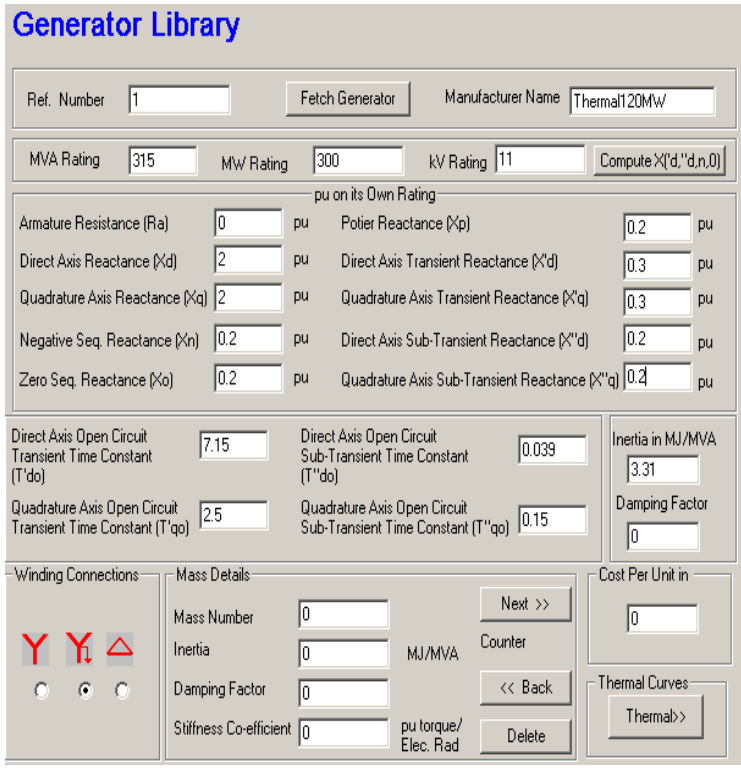
Click on **Generator** icon provided on power system tool bar. Draw the generator by clicking LMB (Left Mouse Button) on the **Bus1**. **Element ID** dialog will appear. Click **OK.**



Generator Data form will be opened. Enter the **Manufacturer Ref. Number** as **1.** Enter Generator data in the form as shown below.



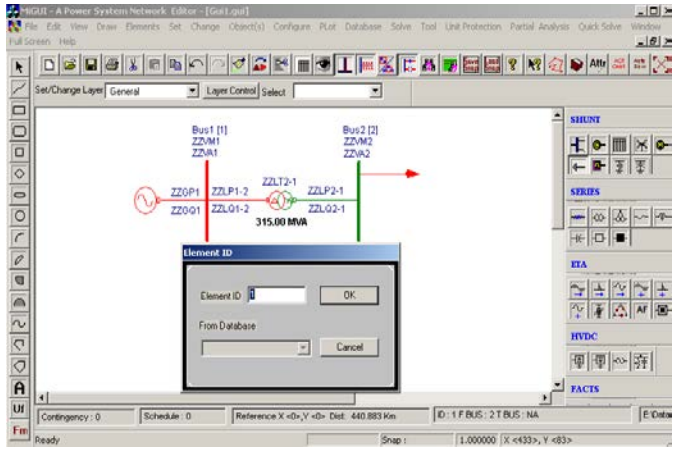
Click on **Generator Library >>** button. Enter generator library details as shown below.

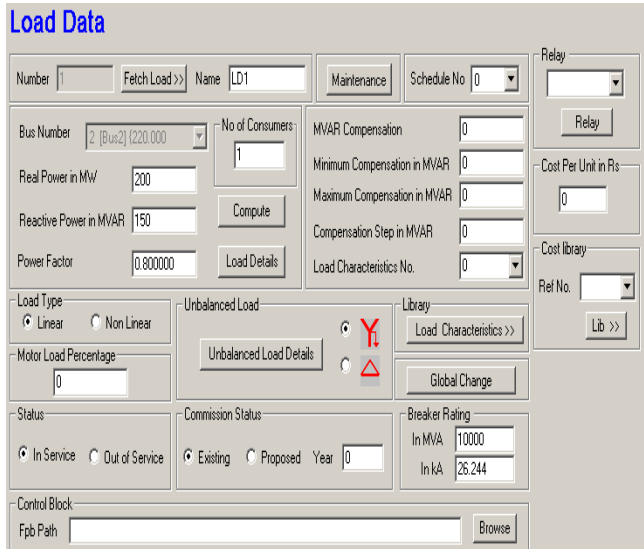


Save 🖫 and **Close** the library screen. Generator data screen will be reopened. Click **Save** 🖫 button, which invokes Network Editor.

8.4 Procedure to enter Load Data

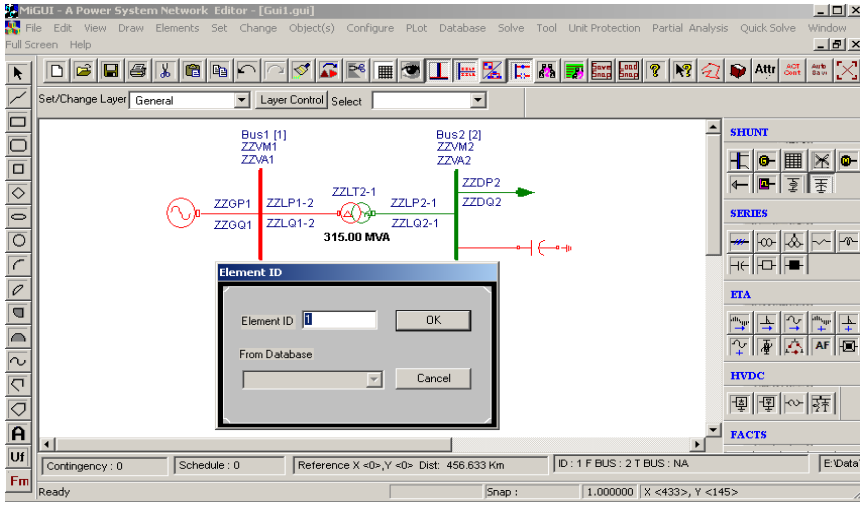
Click on **Load** icon provided on power system tool bar. Connect load 1 at BUS2 by clicking the LMB on Bus 2. **Element ID** dialog will appear. Give ID No as 1 and say OK. **Load Data** form will appear. Enter load details as shown below. Then click **Save** button, which invokes Network Editor.



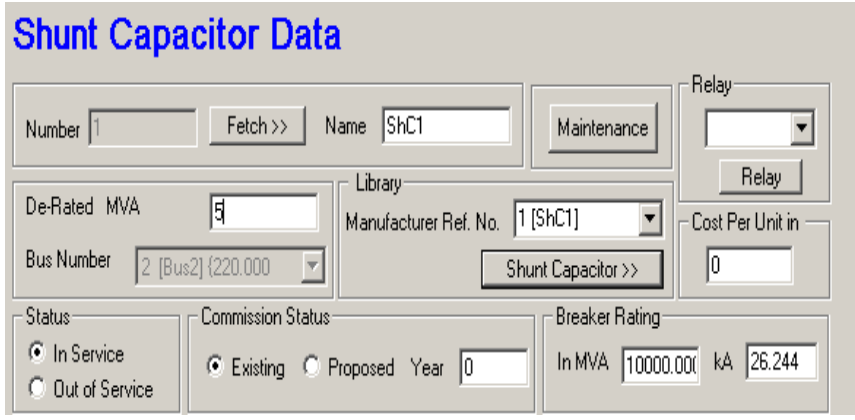


8.5 Procedure to Draw Shunt Capacitor

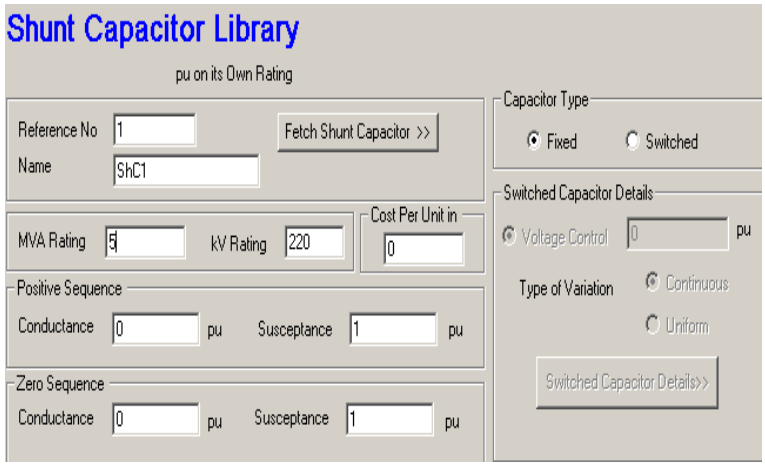
Click on Shunt **Reactor** icon provided on power system tool bar. To draw the shunt reactor click on the Bus. **Element ID** dialog will appear.



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



Enter **Structure Ref No. as 1 [MANF1]** and click on **Shunt Capacitor Library >>** button.

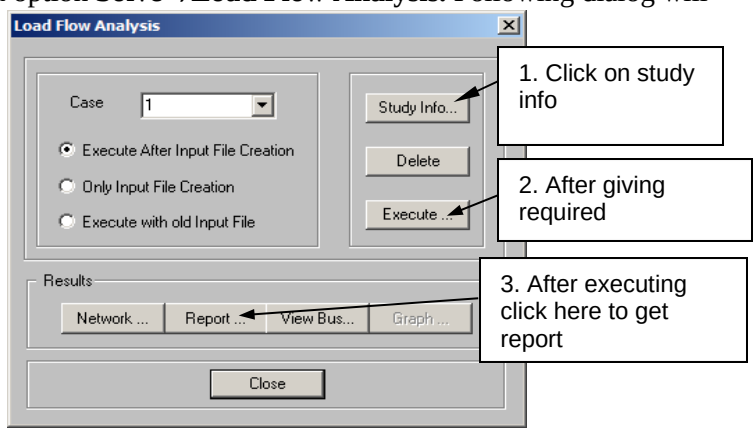


Shunt Capacitor Library form will appear. Enter Shunt Capacitor Library data in the form as shown below for MANF1

After entering data **save** 🖫and **Close. Shunt Reactor Data** form will appear. Click **Save** 🖫**,** which invokes Network Editor to update next element.

8.6 Solve Load Flow Analysis

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



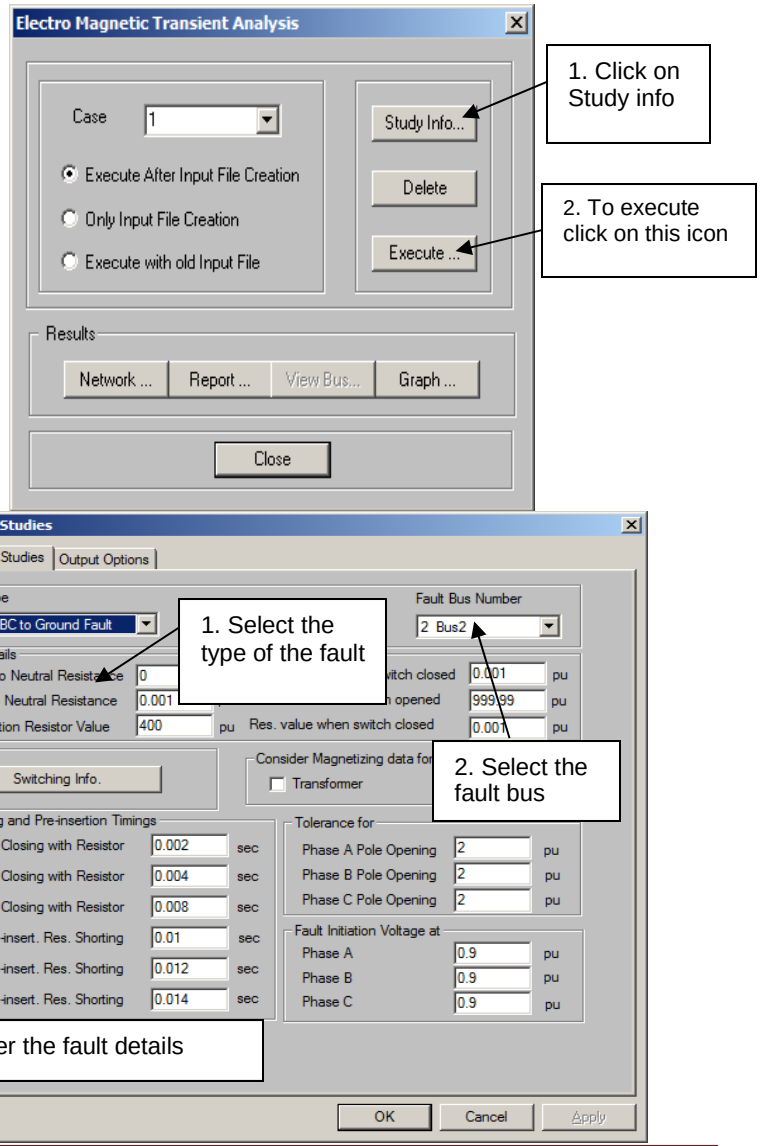
Load flow Results:

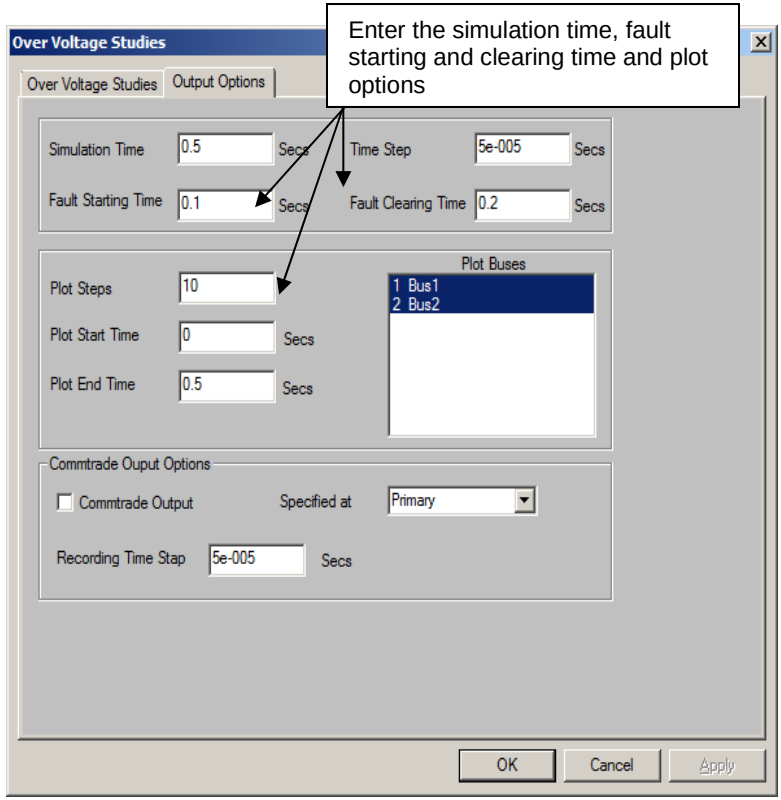
```
------------------------------------------------------------------------
------
BUS VOLTAGES AND POWERS

NODE  FROM         V-MAG   ANGLE          MW       MVAR          MW       MVAR
MVAR
NO.   NAME           P.U. DEGREE         GEN        GEN        LOAD       LOAD
COMP
---- --------  ------ ------  -------- --------  -------- -------- ------
--
   1       Bus1   1.0000    0.00    201.536   177.731       0.000      0.000
0.000
   2       Bus2   0.9206   -5.33       0.000     0.000    200.000   150.000
0.000 @
------------------------------------------------------------------------
------
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    1
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
------------------------------------------------------------------------
------
TRANSFORMER FLOWS AND TRANSFORMER LOSSES

SLNO CS  FROM FROM         TO TO                  FORWARD               LOSS
%
        NODE NAME      NODE NAME            MW      MVAR        MW      MVAR
LOADING
   1  1     2      Bus2     1      Bus1 -199.934 -145.680    1.6026   32.0512
85.3#
------------------------------------------------------------------------
------
! NUMBER OF TRANSFORMERS LOADED BEYOND  125%          :    0
@ NUMBER OF TRANSFORMERS LOADED BETWEEN 100% AND 125% :    0
# NUMBER OF TRANSFORMERS LOADED BETWEEN  75% AND 100% :    1
$ NUMBER OF TRANSFORMERS LOADED BETWEEN  50% AND  75% :    0
^ NUMBER OF TRANSFORMERS LOADED BETWEEN  25% AND  50% :    0
& NUMBER OF TRANSFORMERS LOADED BETWEEN   1% AND  25% :    0
* NUMBER OF TRANSFORMERS LOADED BETWEEN   0% AND   1% :    0
------------------------------------------------------------------------
------
! NUMBER OF LINES LOADED BEYOND  125%          :    0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    0
# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    0
$ NUMBER OF LINES LOADED BETWEEN  50% AND  75% :    0
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    0
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    0
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
```

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

SHUNT CAPACITOR AND REACTOR INJECTION
NODE FROM       V-MAG  ANGLE       MW      MVAR
NO.  NAME        P.U. DEGREE       GEN       GEN
---- --------  ------ ------  -------- --------
   2     Bus2   0.921  -5.33    -0.000    4.238
------------------------------------------------------------------------------
------


ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  50.00000           1       0
------------------------------------------------------------------------------
------
Summary of results
TOTAL REAL POWER GENERATION   :    201.536 MW
TOTAL REAL POWER INJECT,-ve L :    0.000 MW
TOTAL REACT. POWER GENERATION :    177.731 MVAR
GENERATION pf                 :    0.750
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 :     4.238 MVAR

TOTAL  TCSC  REACTIVE  DRAWL    :     0.000  MVAR

TOTAL  SPS  REACTIVE  DRAWL     :     0.000  MVAR

TOTAL UPFC FACTS. INJECTION   :    -0.0000 MVAR

TOTAL SHUNT FACTS.INJECTION   :      0.000 MVAR
TOTAL SHUNT FACTS.DRAWAL      :      0.000 MVAR

TOTAL REAL POWER LOAD         :    200.000 MW
TOTAL REAL POWER DRAWAL -ve g :    0.000 MW
TOTAL REACTIVE POWER LOAD     :    150.000 MVAR
LOAD pf                       :      0.800
TOTAL COMPENSATION AT LOADS   :      0.000 MVAR
TOTAL HVDC REACTIVE POWER     :      0.000 MVAR

TOTAL REAL POWER LOSS (AC+DC) :   1.602559 MW (  1.602559+  0.000000)
PERCENTAGE REAL  LOSS (AC+DC) :      0.795
TOTAL REACTIVE POWER  LOSS    :  32.051174 MVAR
------------------------------------------------------------------------------
---
```

8.7 Electromagnetic Transient Analysis:

Select Menu option **Solve→ Electromagnetic Transient Analysis.** Following dialog will appear.

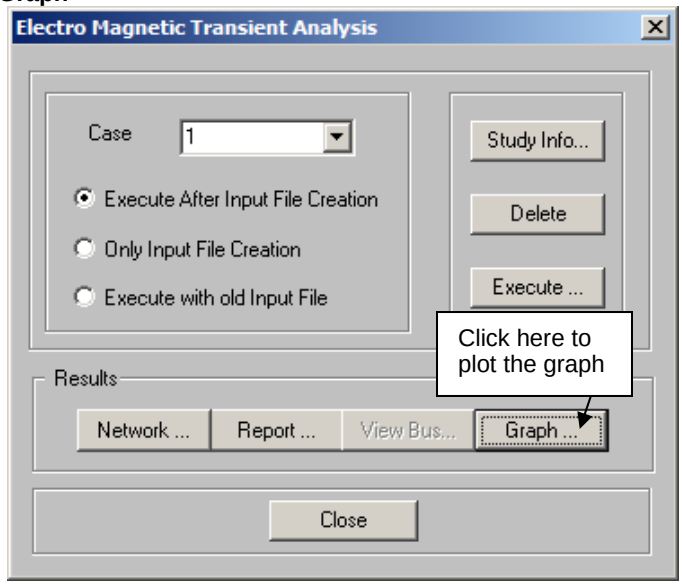


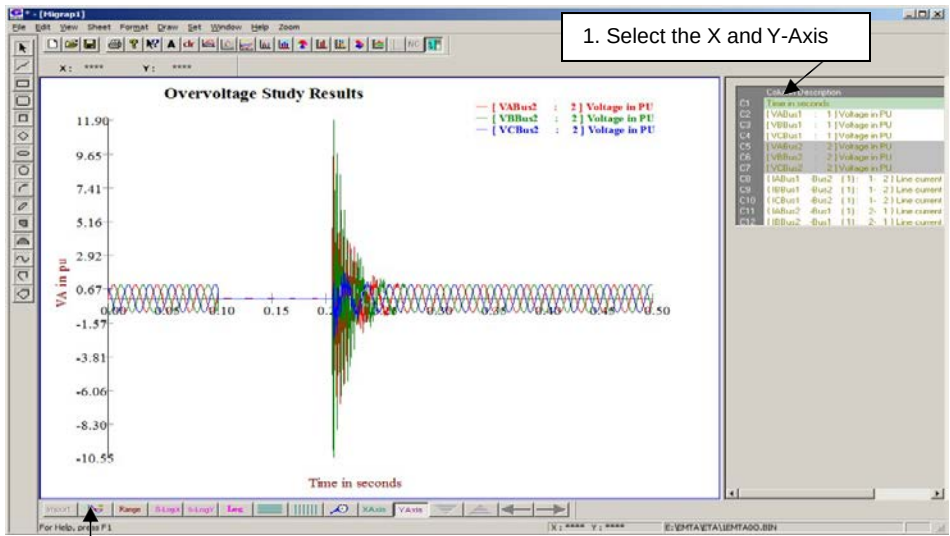


RESULTS:

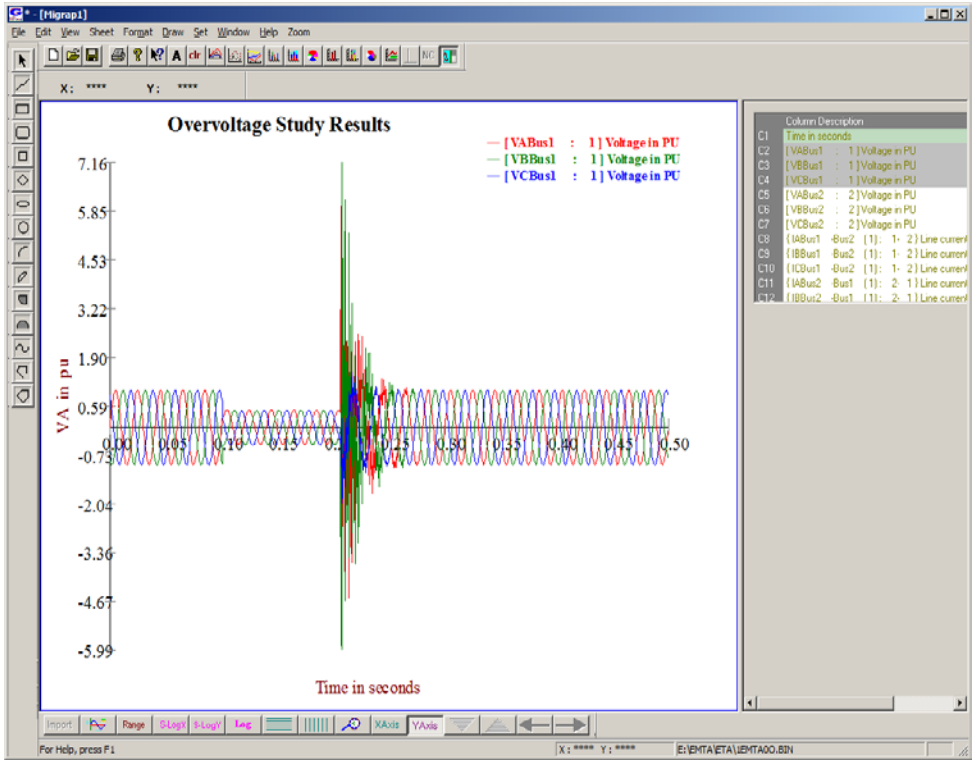
```
------------------------------------------------------------------------
-----
BUS  NAME     VA-PEAK  A-PEAK-T VB-PEAK  B-PEAK-T VC-PEAK  C-PEAK-T
                PU    mili Sec    PU     mili Sec    PU    mili Sec
---- -------- -------- -------- -------- -------- -------- --------
 CASE-1  : tmin =  0.00000, tmax =  0.50000
================================================
   1     Bus1  6.99001 206.90000 -7.37604 206.85000 -2.13945 207.40000
            62.78048             -66.24759             -19.21536
   2     Bus2 11.26962 206.90000 -12.64490 206.85000 -2.86584 207.40000
          2024.35340            -2271.39389             -514.78928
========================================================================
=====
```

8.8 Plot Graph





Voltage at bus no 2

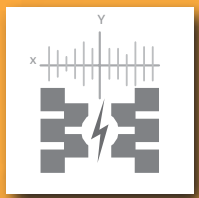


Voltage at bus no 1

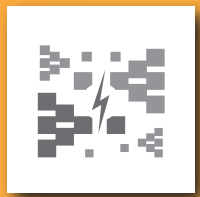
Protection Suite

PSCT | *Protection Analytic tool*

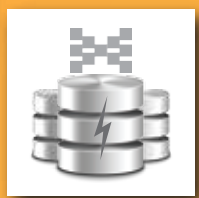
Power System Network Editor



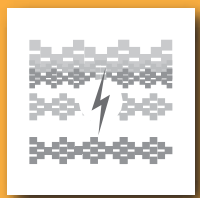
Graph Utility



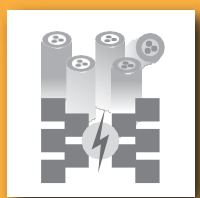
Free Programmable Block



Database Manager



COMTRADE Viewer



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