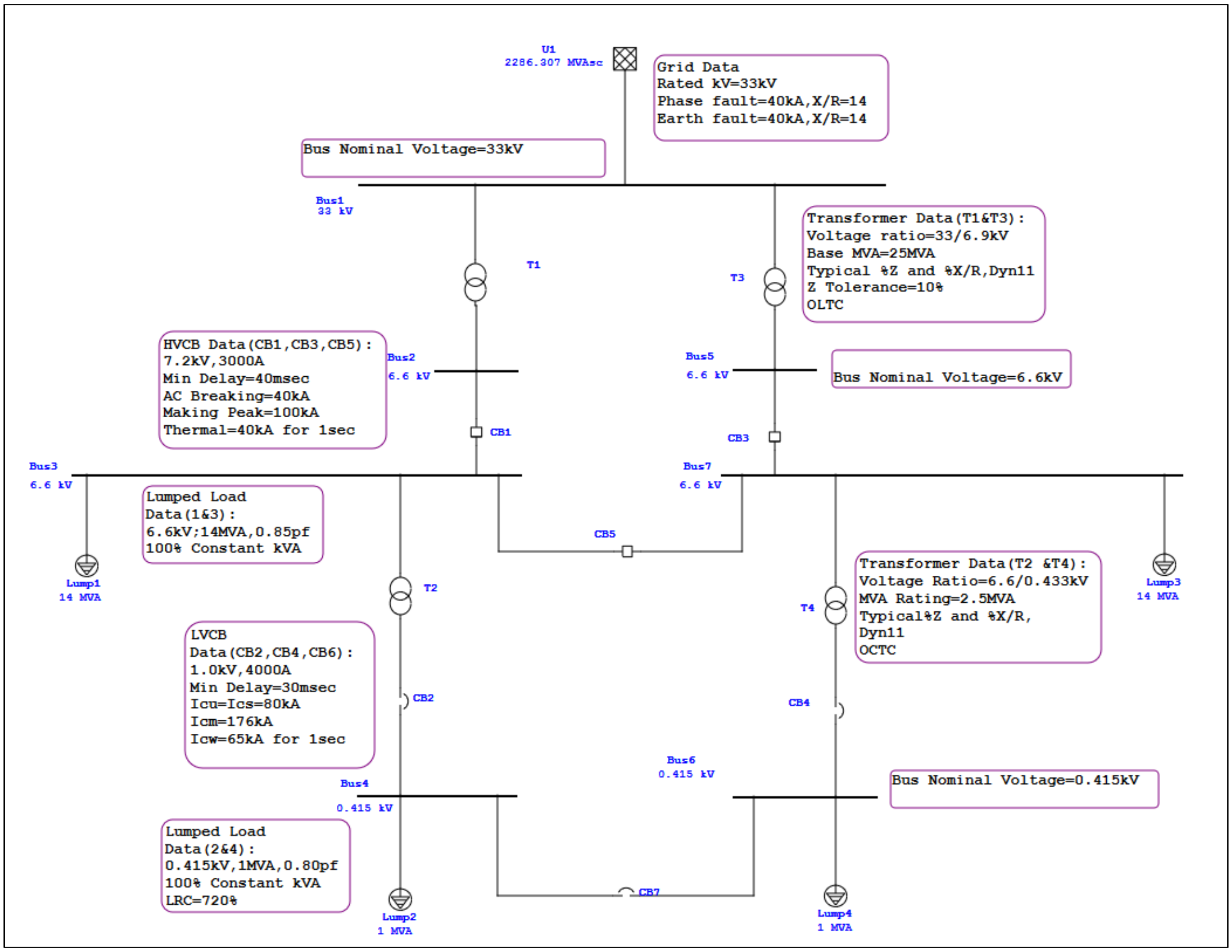
Load Flow Analysis

Purpose and Description

The purpose of this exercise is to perform load flow analysis/ power flow analysis on a double-ended normally open tie power system. Power factor improvement and power sharing between sources of power system & Transformer MVA sizing program will also be illustrated using an example.

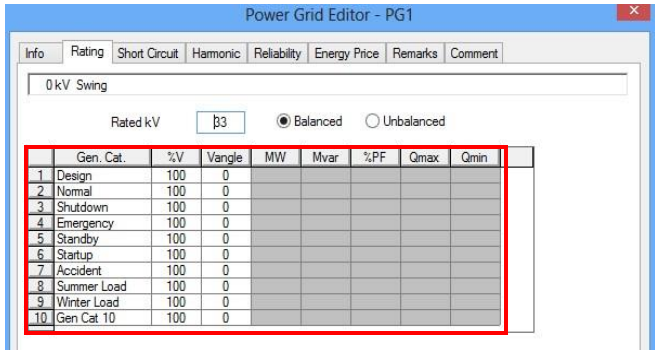
Procedure

1. Open LF-Example1 OTI file from 3D database folder shown below.

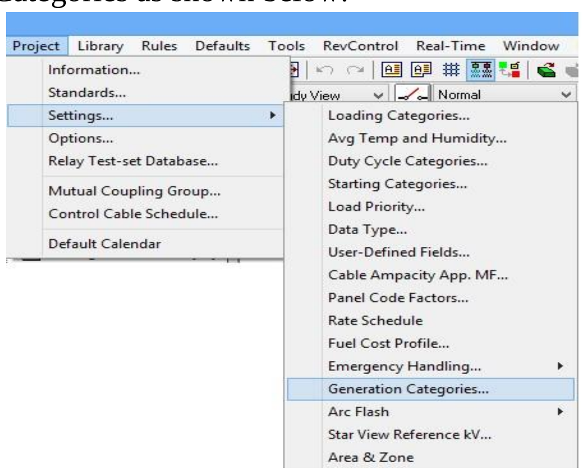


Load Flow Analysis

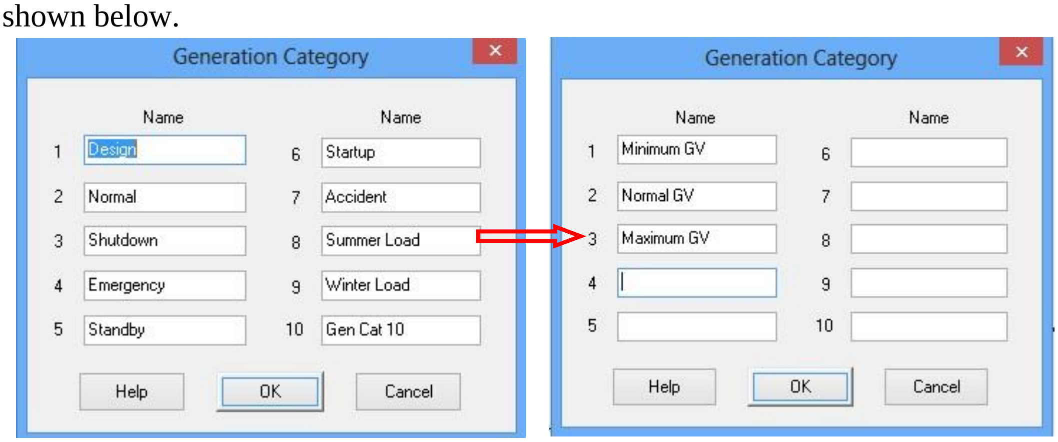
2. In the rating page of Power Grid, Various Generation categories are defined as shown below.



3. To rename the default generation categories, click on the Project menu, go to Settings and select Generation Categories as shown below.



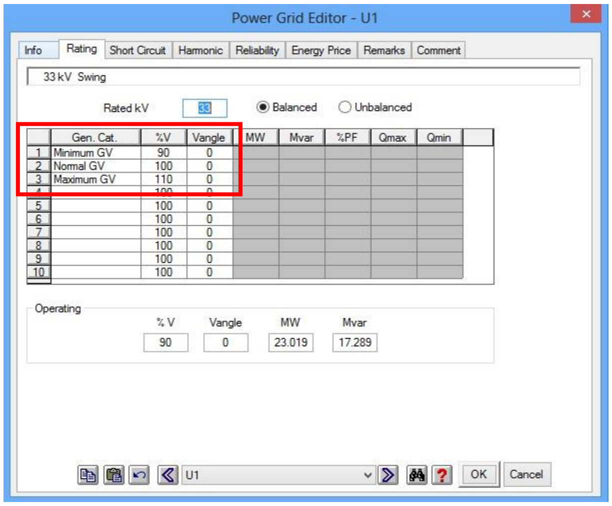
4. Delete pre-existing names & give the user defined names for Generation Categories as shown below.



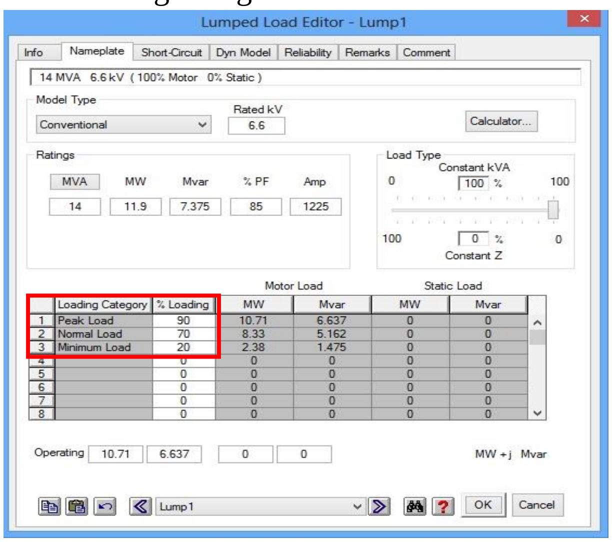
5. Similarly, repeat the above steps to rename the loading categories as Peak Load, Normal Load and Minimum Load.

Load Flow Analysis

6. Double click on Power Grid, go to Rating page and enter following data in %V column for respective Generation Categories.

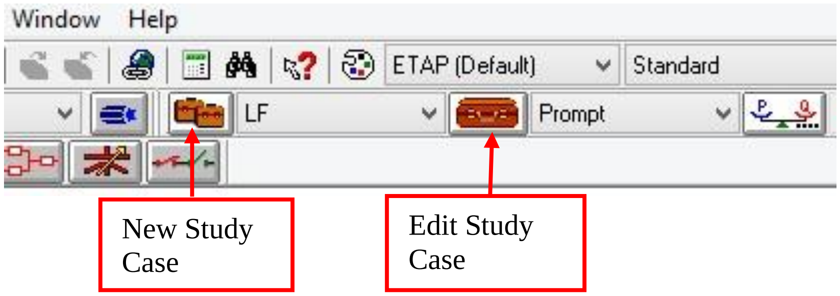


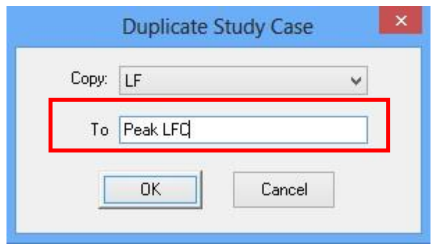
7. Double click on Lumped Load, go to Nameplate page and enter following data in % loading column for respective Loading Categories.



8. To create a new study case, click on “New Study case” with the name Peak LFC as shown below.

Load Flow Analysis





9. Select the study case Peak LFC using drop down menu and go to loading page. Select Loading Category as Peak Load and Generation Category as Minimum GV.
10. Go to Alert page of Peak LFC load flow study case and uncheck the option for marginal alerts.
11. Use default options for all other options in the Info page, Loading page, Adjustment page and Alert page of the load flow study case.
12. Select single out configuration from Configuration Manager drop down button.
13. Construct two more load flow study cases using matrix given below.

Load Flow Study Case matrix

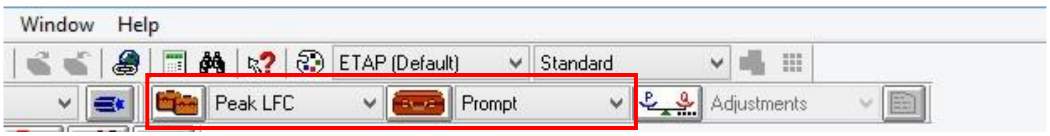
Study Case Name	Generation Category	Loading Category	Configuration	Marginal Alerts
Peak LFC	Minimum GV	Peak Load	Single out	Off
Normal LFC	Normal GV	Normal Load	Normal	Off
Minimum LFC	Maximum GV	Minimum Load	Normal	Off

14. Add following data according to each study case in Study remarks section available on the Info page of the Load Flow Study Case.

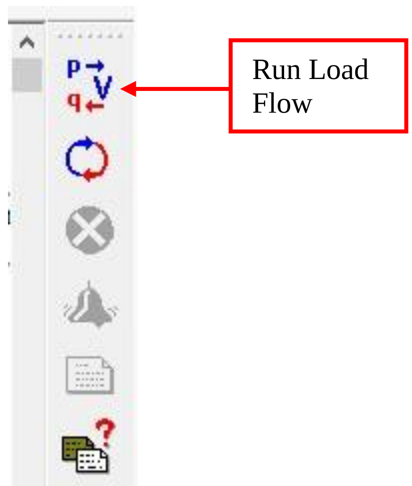
Study Case Name	Study Remarks
Peak LFC	Load = Peak, Configuration = Single Out, Grid = 90%V
Normal LFC	Load = Normal, Configuration = Normal, Grid = 100%V
Minimum LFC	Load = Minimum, Configuration = Normal, Grid = 110%V

Load Flow Analysis

15. Select Peak LFC study case using drop down menu and select the output report name as 'Prompt'.

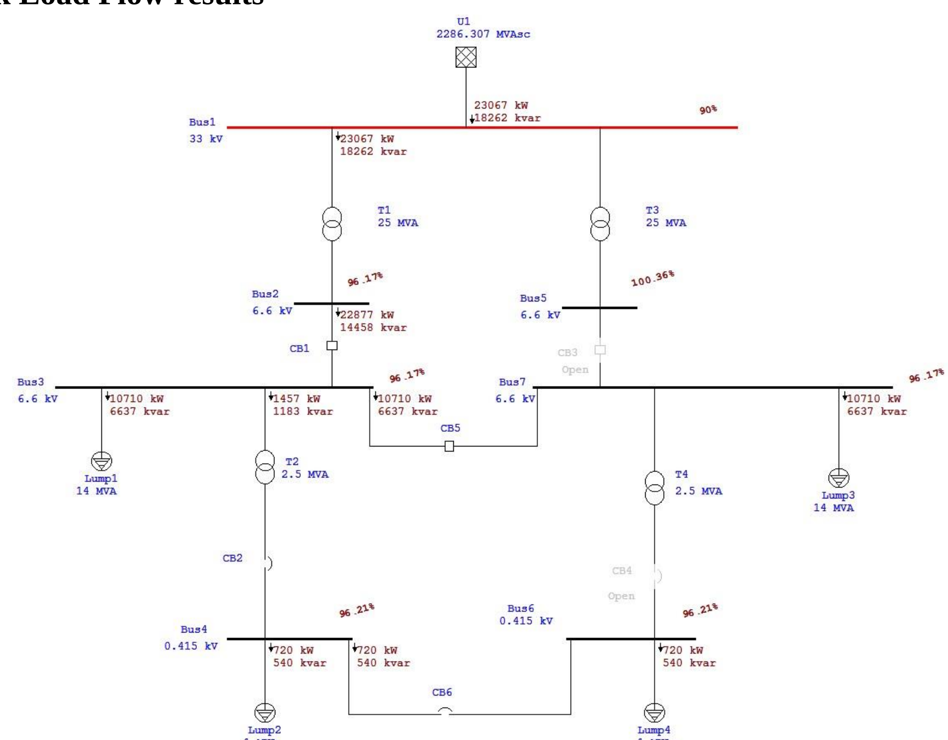


16. Run Load Flow as shown below.



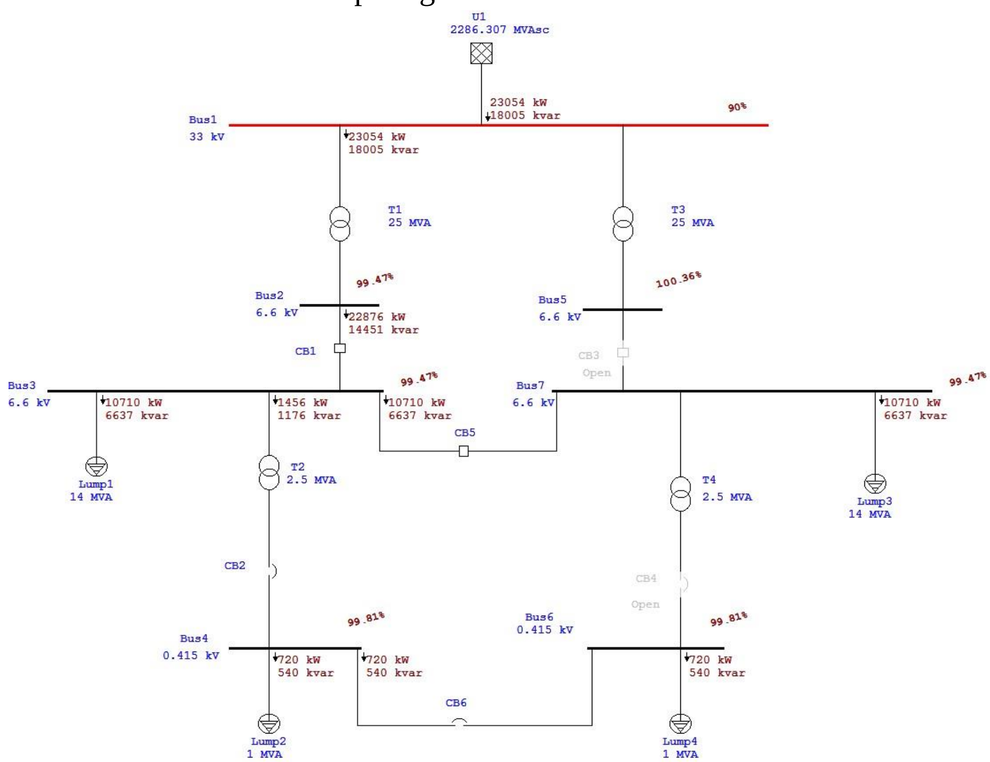
17. Edit the output file name to 'Peak LFC'.

Peak Load Flow results



Load Flow Analysis

18. Change the Transformer tap range of T1& T3 from +10 to +12.5 for maximum tap range & -10 to -12.5 for minimum tap range and run Peak LFC.

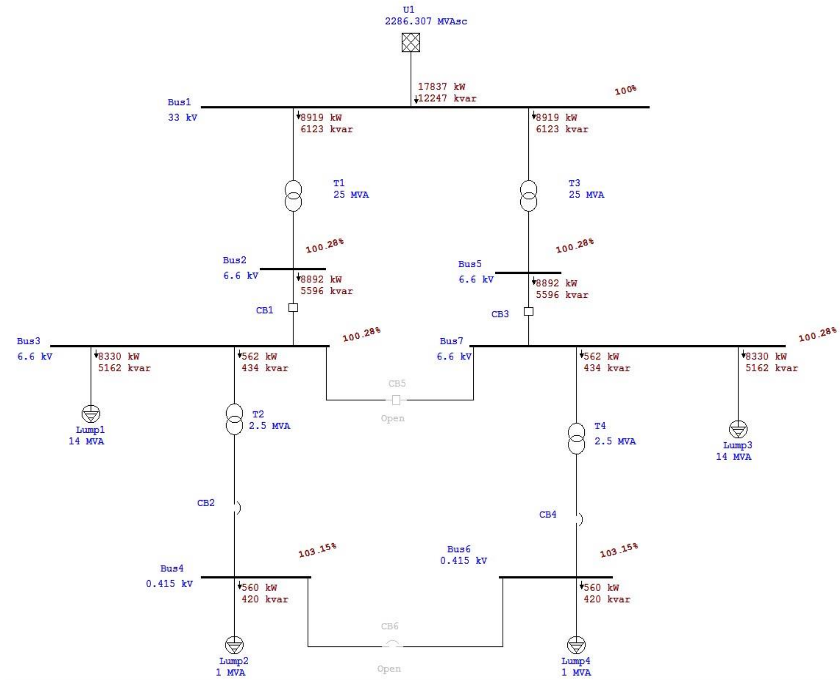


19. Similarly run other two load flow study case and generate following load flow reports as per study case.

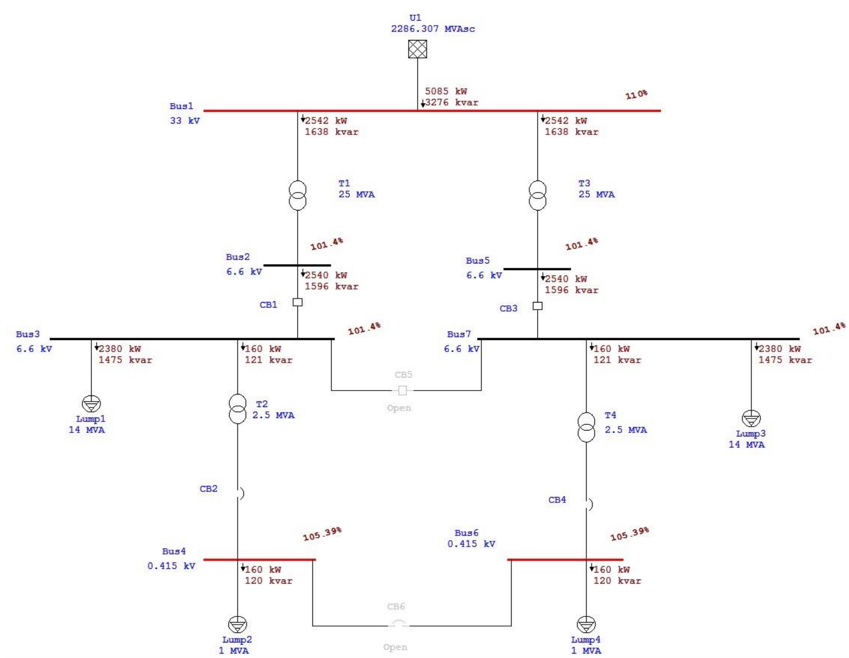
Study Case Name	Output Report Name
Peak LFC	Peak LFC
Normal LFC	Normal LFC
Minimum LFC	Minimum LFC

Load Flow Analysis

Normal Load Flow Results

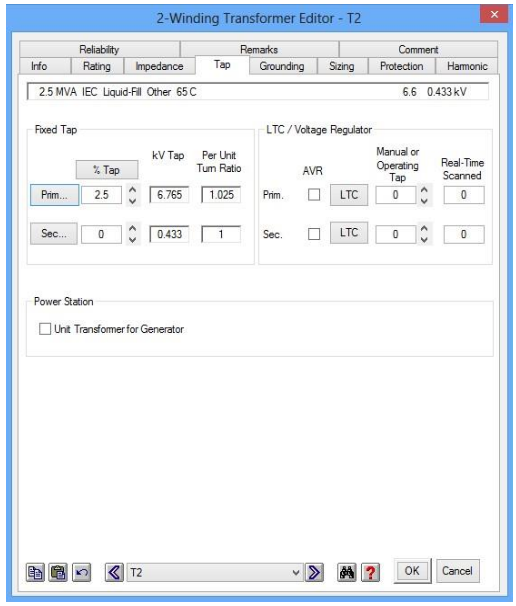


Minimum Load Flow Results

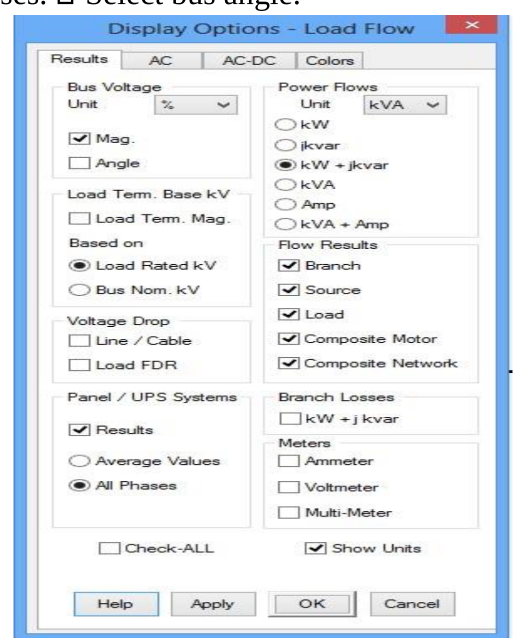


Load Flow Analysis

20. Adjust the tap position of Transformers T2 & T4 as shown.

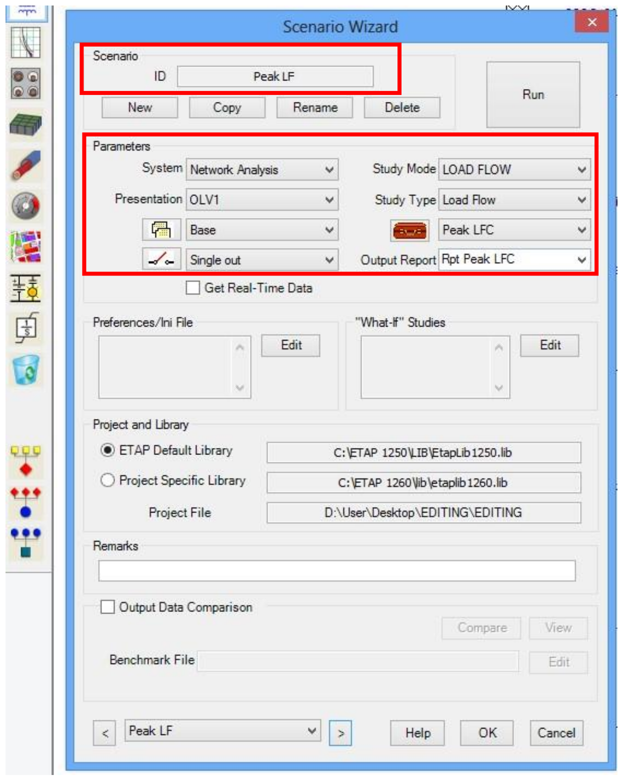


21. Run all the load flow cases and check for the alerts.
22. Click on display options and check the effect of following options.
    - Units: To see units display in load flow.
    - Select kW, jkvar display in k or Mega.
    - Select KVA, PF display in k or Mega.
    - Select A, PF display in k or Mega.
    - Select branch losses. Select bus angle.



23. Create following scenarios using Scenario Wizard

Scenario Name	Configuration	Load Flow Case	Output Report Name
Peak LF	Single Out	Peak LFC	Peak LFC
Normal LF	Normal	Normal LFC	Normal LFC
Minimum LF	Normal	Minimum LFC	Minimum LFC



24. Check the results of different load flow scenarios created using Scenario Wizard against results obtained earlier using load flow calculation.

Power Factor Improvement Capacitors

Purpose and Description

The purpose of this exercise is to improve 33 kV grid power factor to 95% - 100% for all load flow cases.

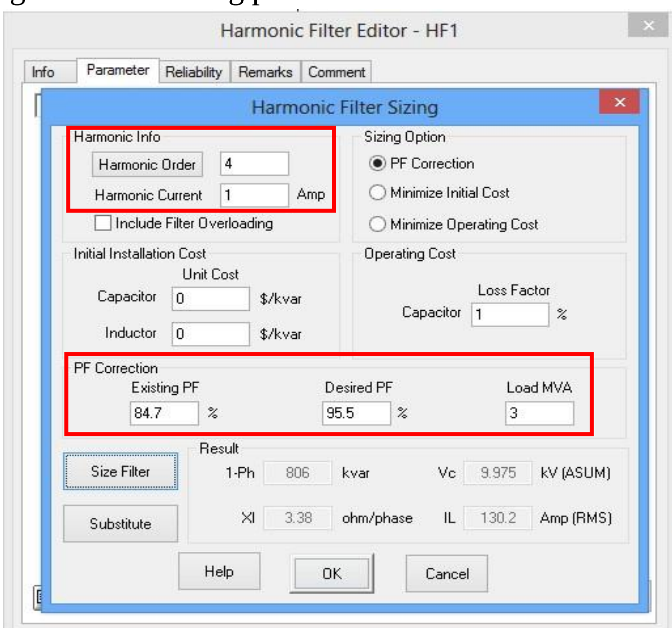
Capacitor location- 6.6 kV Buses **No. of stages**

- Stage 1 for Minimum load flow
- Stage 2 for Normal & Peak load flow

Procedure

Procedure for stage 1 – Power Factor Improvement for Minimum Load Flow

1. Run Minimum Load Flow.
2. Check the PF at the 6.6 kV bus and transformer incomer Bus1. Hint – Change the display options in load flow to check MVA/kVA and power factor.
3. Add the difference between power factor at Bus2 and Bus1 to desired pf of 95%.
4. Connect a harmonic filter to Bus3.
5. Double click on Harmonic Filter, go to Parameter page and click on Size Filter.
6. In Size filter page enter following parameters and click on Size Filter button.



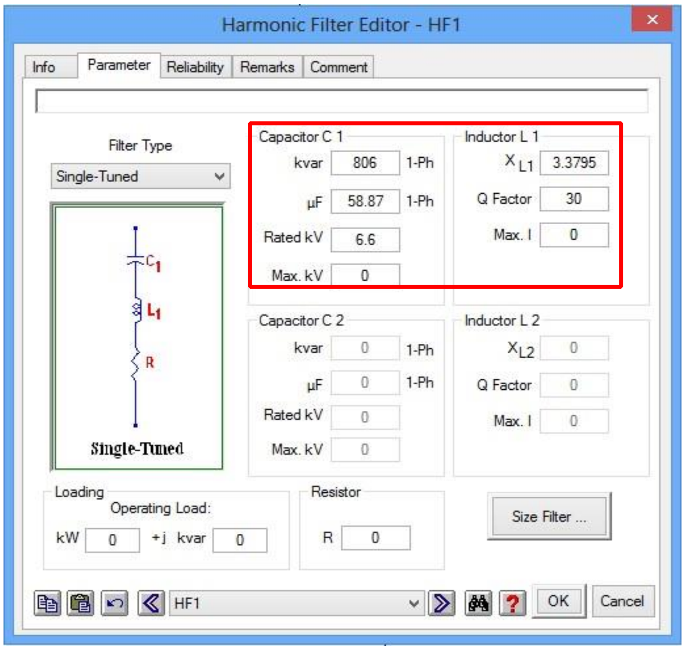
Load Flow Analysis

Note

- Load MVA is taken as the MVA load supplied by 33/6.9 kV transformer secondary side.
- Desired PF = 95 + (PF of Bus2 – PF of Bus1).

7. After Sizing the filter, substitute the values using the Substitute button available on the Harmonic Filter Sizing page.
8. In Parameter page of the Harmonic Filter enter Inductor Q factor as 30 as shown below.

Load Flow Analysis



Note

- ETAP requests for fundamental frequency Q that is Q_1 for the Inductor L1 of Harmonic Filter.
- Q factor is X/R of coil (inductor)

At tuned value, $Q_{tuned} = \frac{h_{tuned} \times X_{L1}}{R}$

Where X_{L1} is reactance in ohm of reactor at fundamental then

$$Q_{tuned} = \left[(h_{tuned} \times Q_1)\right] \qquad \ldots\ Q_1 = \frac{X_{L1}}{R}$$

$$Q_1 = \frac{Q_{tuned}}{h_{tuned}}$$

(Q tuned is usually 30, 60, 100 or 175)

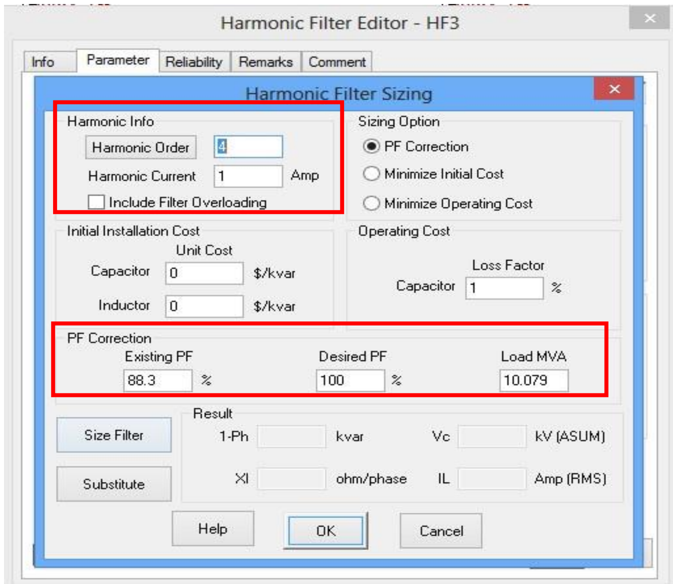
9. Copy the harmonic filter connected to Bus3 and paste it on Bus7.
10. Run the minimum load flow again to check that the power factor at the Bus1 is more than 95%.

Procedure for stage 2 – Power Factor Improvement for Normal and Peak Load Flow

1. Run the normal load flow with stage 1 filters ON.
2. Check if PF at Bus2 or Bus1 is below 95%.
3. Check the PF at the Bus2 and transformer incomer i.e. Bus1. Hint – Change the display options in load flow to check MVA/kVA and pf.
4. Add the difference between power factor at Bus2 and Bus1 to desired pf of 98%.
5. Add an additional harmonic filter to Bus3.
6. Double click on Harmonic Filter, go to Parameter page and click on Size Filter.

Load Flow Analysis

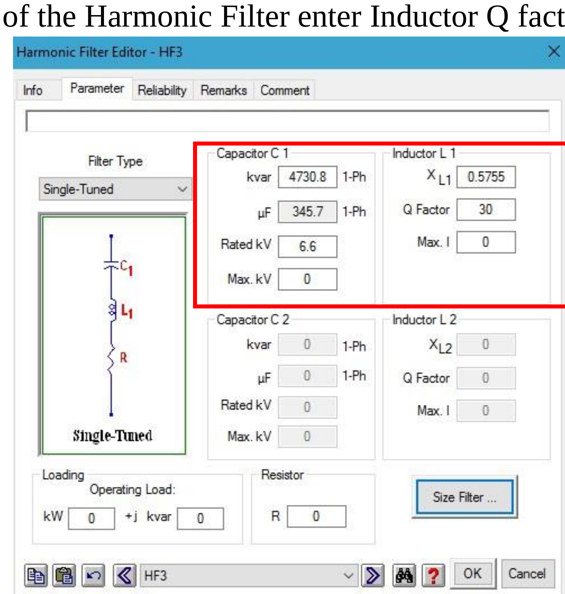
7. In Size filter page, enter following parameters and click on Size Filter button.



Note:

Desired PF = 98 + (PF of Bus2 –PF of Bus1). But the value used is 100% as this will be helpful in Peak load flow case as well.

8. After Sizing the filter substitute the values using the Substitute button available on the Harmonic Filter Sizing page.
9. In Parameter page of the Harmonic Filter enter Inductor Q factor as 30 as shown below.



Load Flow Analysis

10. Run Normal and Peak Load Flow with stage 1 and stage 2 harmonic filters to check the power factor at 33kV bus is more than 95%.
11. Run the Minimum load flow with stage 1 and stage 2 harmonic filters and check the power factor at 33 kV bus.
    Hint – Is it required to use the harmonic filter in stage 2 for Minimum Load Flow case?

