

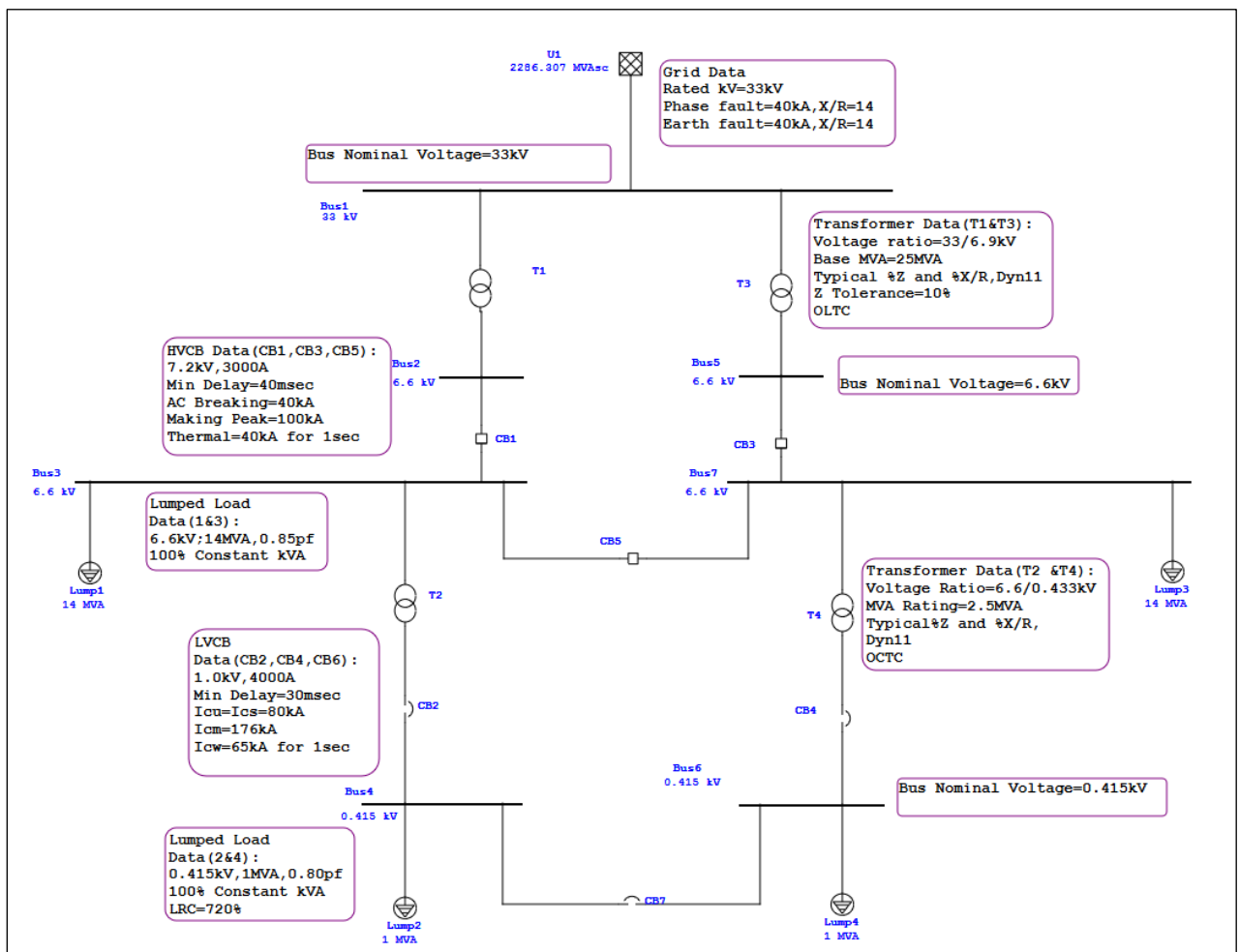
Load Flow Analysis

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.



ETAP Workshop Notes



Load Flow Analysis

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

	Gen. Cat.	%V	Vangle	MW	Mvar	%PF	Qmax	Qmin
1	Design	100	0					
2	Normal	100	0					
3	Shutdown	100	0					
4	Emergency	100	0					
5	Standby	100	0					
6	Startup	100	0					
7	Accident	100	0					
8	Summer Load	100	0					
9	Winter Load	100	0					
10	Gen Cat 10	100	0					

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.

Generation Category	
Name	Name
1 Design	6 Startup
2 Normal	7 Accident
3 Shutdown	8 Summer Load
4 Emergency	9 Winter Load
5 Standby	10 Gen Cat 10

Generation Category	
Name	Name
1 Minimum GV	6
2 Normal GV	7
3 Maximum GV	8
4	9
5	10

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

ETAP Workshop Notes



Load Flow Analysis

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

33 kV Swing

Rated kV: 33

☒ Balanced ☐ Unbalanced

	Gen. Cat.	%V	Vangle	MW	Mvar	%PF	Gmax	Gmin
1	Minimum GV	90	0					
2	Normal GV	100	0					
3	Maximum GV	110	0					
4		100	0					
5		100	0					
6		100	0					
7		100	0					
8		100	0					
9		100	0					
10		100	0					

Operating: %V: 90, Vangle: 0, MW: 23.019, Mvar: 17.289

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

14 MVA 6.6 kV (100% Motor 0% Static)

Model Type: Conventional, Rated kV: 6.6

Ratings: MVA: 14, MW: 11.9, Mvar: 7.375, %PF: 85, Amp: 1225

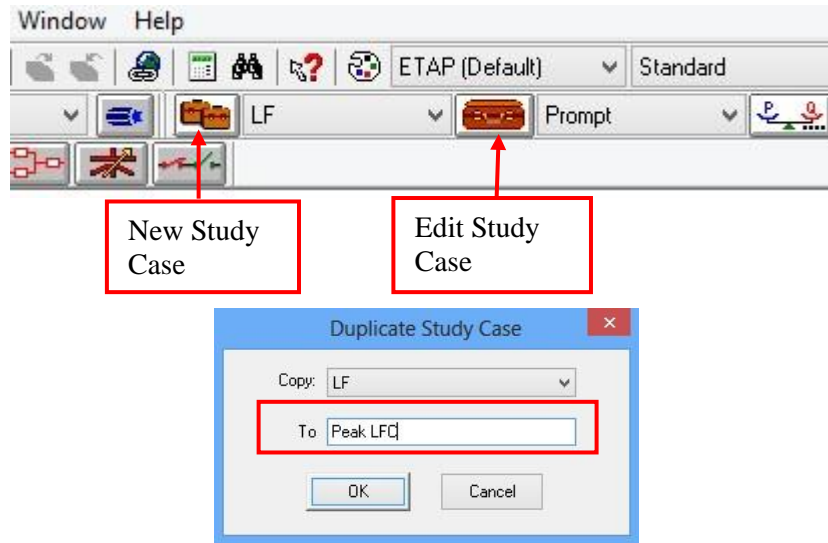
Load Type: Constant kVA, 100%

	Loading Category	% Loading	MW	Mvar	MW	Mvar
1	Peak Load	90	10.71	6.637	0	0
2	Normal Load	70	8.33	5.162	0	0
3	Minimum Load	20	2.38	1.475	0	0
4		0	0	0	0	0
5		0	0	0	0	0
6		0	0	0	0	0
7		0	0	0	0	0
8		0	0	0	0	0

Operating: MW: 10.71, Mvar: 6.637, 0, 0

- 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

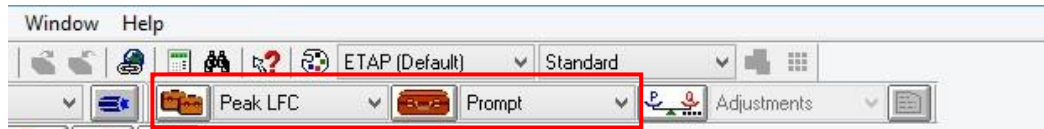
Study Case Name	Generation Category	Loading Category	Configuration	Marginal Alerts
Peak LFC	Minimum GV	Peak Load	Single out	Off
Normal LFC	Normal GV	Normal Load	Normal	Off
Minimum LFC	Maximum GV	Minimum Load	Normal	Off

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

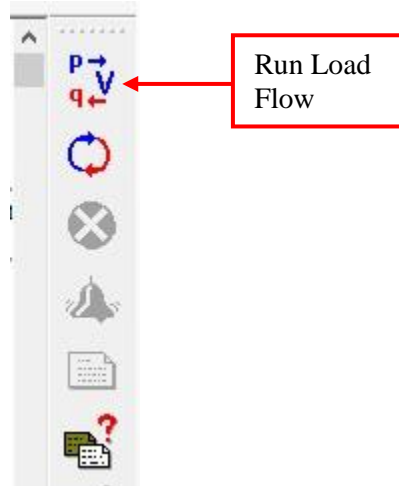
Study Case Name	Study Remarks
Peak LFC	Load = Peak, Configuration = Single Out, Grid = 90% V
Normal LFC	Load = Normal, Configuration = Normal, Grid = 100% V
Minimum LFC	Load = Minimum, Configuration = Normal, Grid = 110% V

Load Flow Analysis

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

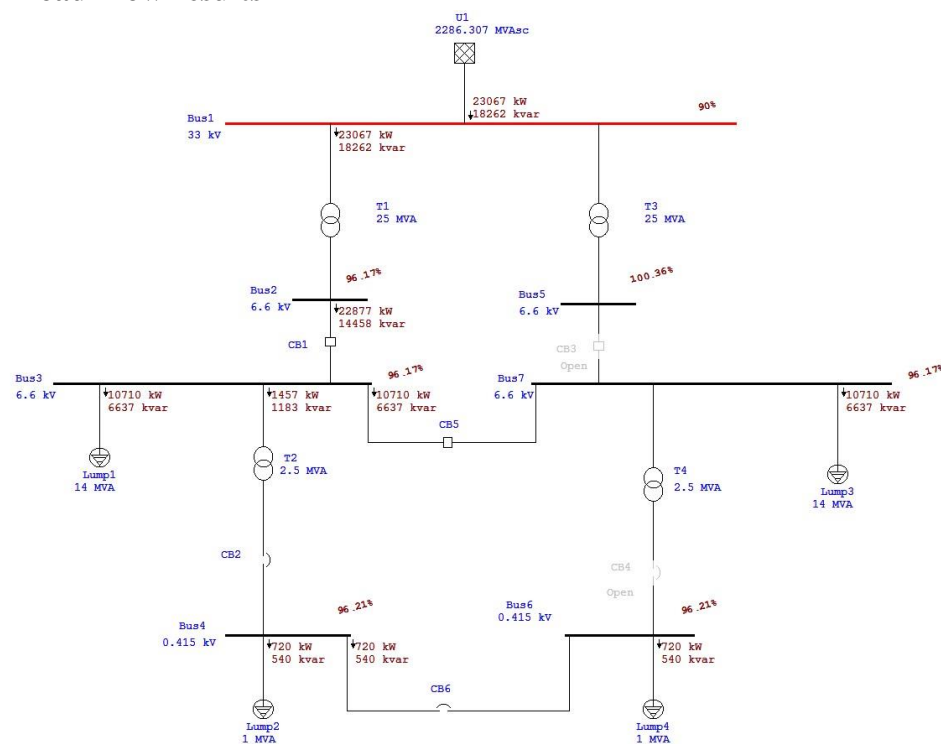


16. Run Load Flow as shown below.



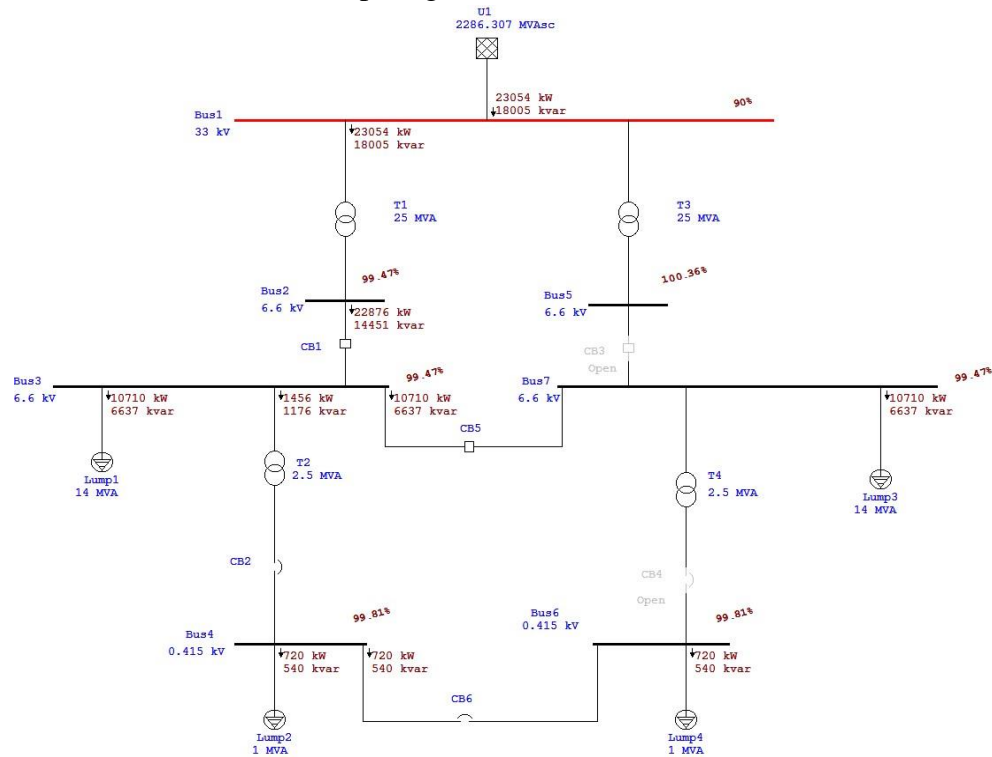
17. Edit the output file name to 'Peak LFC'.

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.

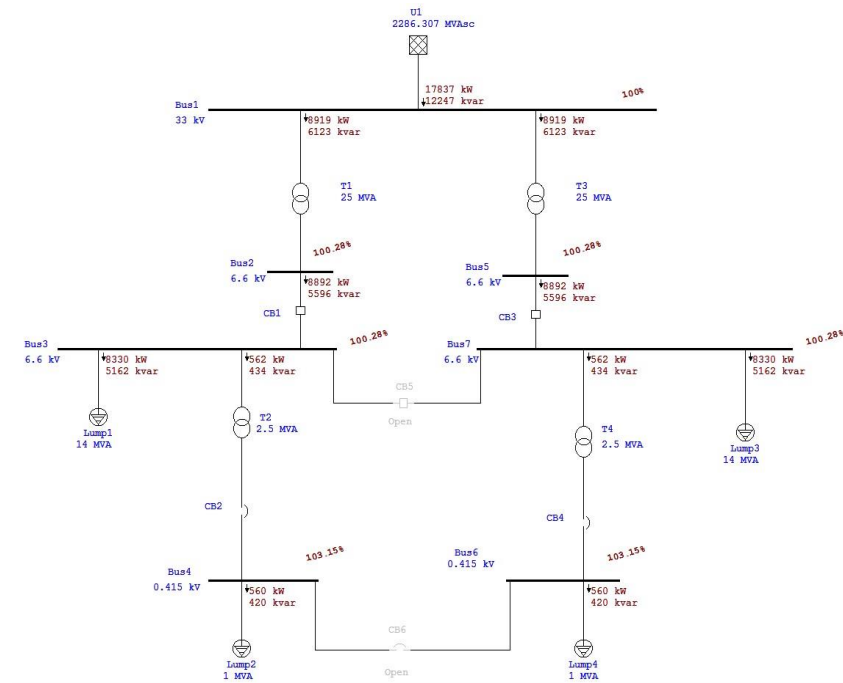
Study Case Name	Output Report Name
Peak LFC	Peak LFC
Normal LFC	Normal LFC
Minimum LFC	Minimum LFC

ETAP Workshop Notes

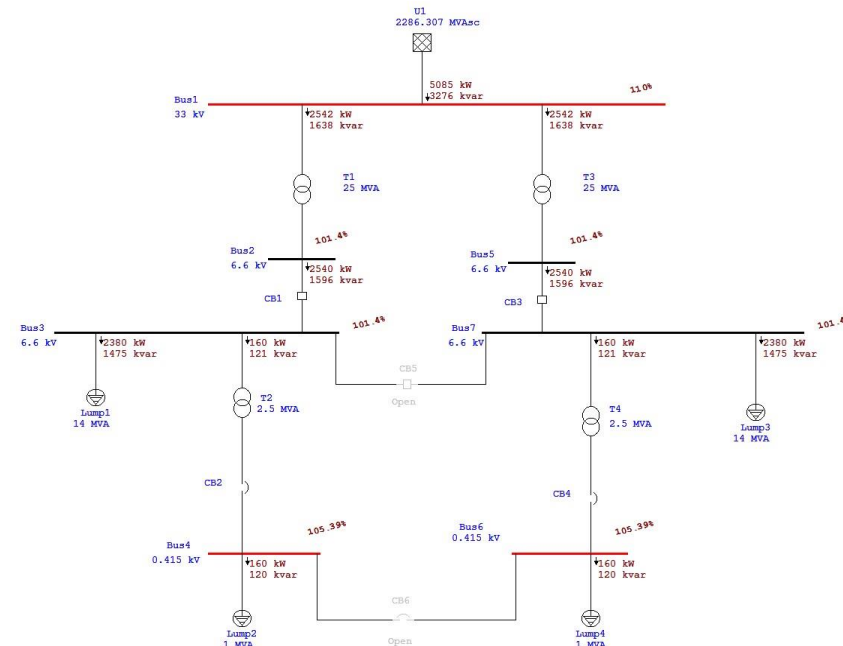


Load Flow Analysis

Normal Load Flow Results

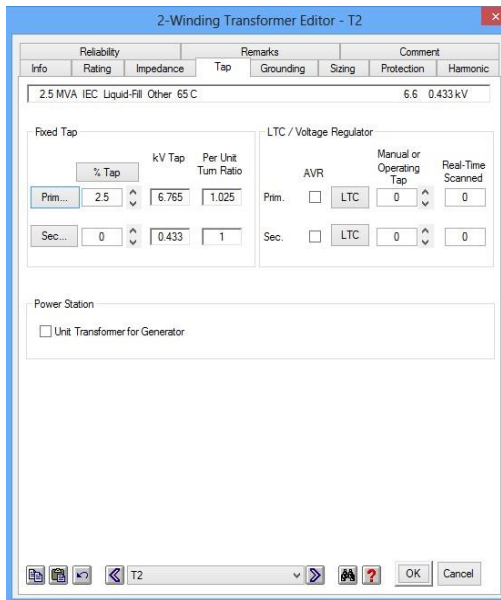


Minimum Load Flow Results



Load Flow Analysis

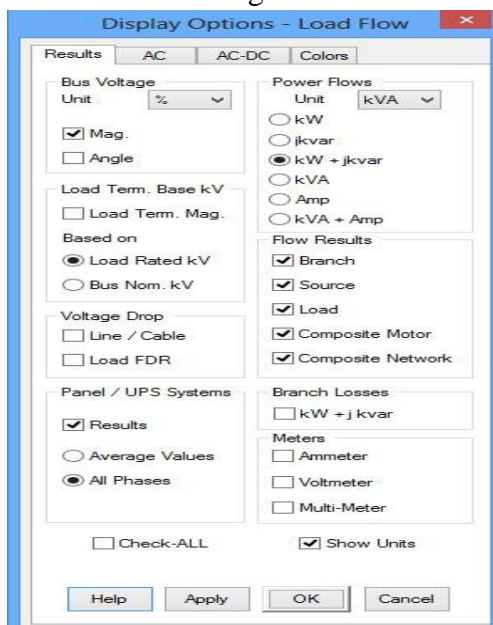
20. Adjust the tap position of Transformers T2 & T4 as shown.



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.



ETAP Workshop Notes



Load Flow Analysis

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

Scenario Wizard

Scenario ID: Peak LF

Parameters:

- System: Network Analysis
- Study Mode: LOAD FLOW
- Presentation: OLV1
- Study Type: Load Flow
- Base: Base
- Single out: ☒
- Peak LFC
- Output Report: Rpt Peak LFC

Get Real-Time Data: ☐

Preferences/Ini File: Edit

What-If Studies: Edit

Project and Library:

- ETAP Default Library: C:\ETAP 1250\lib\etaplib.1250.lib
- Project Specific Library: C:\ETAP 1260\lib\etaplib.1260.lib
- Project File: D:\User\Desktop\EDITING\EDITING

Remarks:

Output Data Comparison: ☐ Compare View

Benchmark File: Edit

< Peak LF > Help OK Cancel

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

Load Flow Analysis

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.

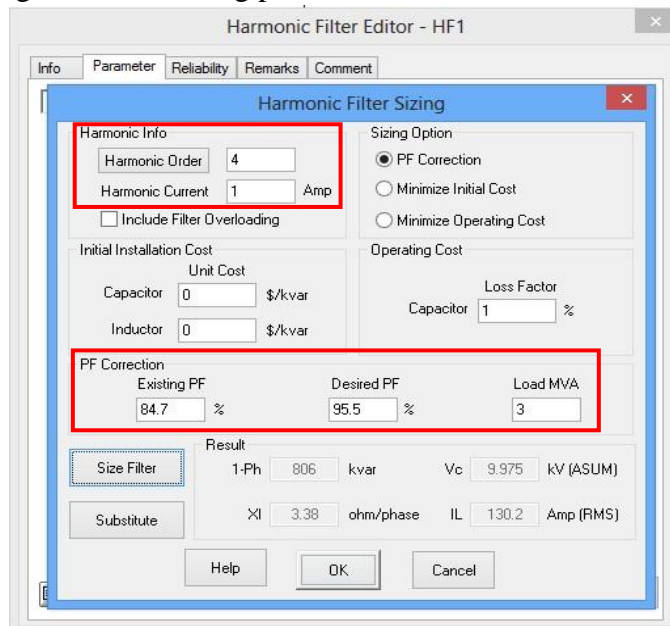
Capacitor location- 6.6 kV Buses No. of stages

- 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.

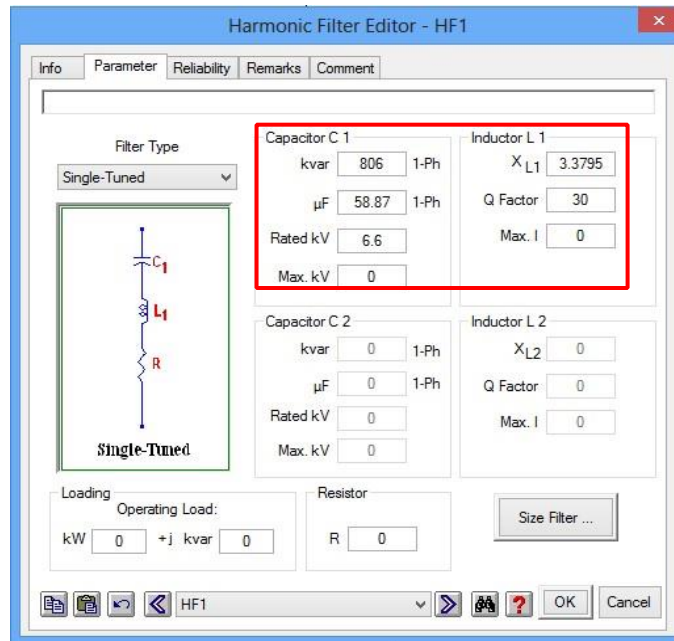


Load Flow Analysis

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)

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

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

$$Q_{\text{tuned}} = (h_{\text{tuned}} \times Q_1) \quad \dots \quad Q_1 = \frac{X_{L1}}{R}$$

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

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

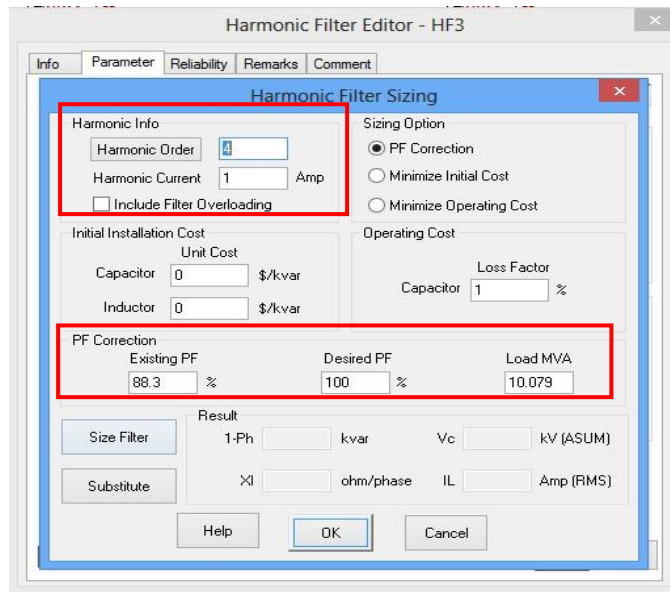
9. Copy the harmonic filter connected to Bus3 and paste it on Bus7.
10. Run the minimum load flow again to check that the power factor at the Bus1 is more than 95%.

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.



The image shows the 'Harmonic Filter Editor - HF3' dialog box. It has tabs for Info, Parameter, Reliability, Remarks, and Comment. The 'Parameter' tab is active. The 'Harmonic Filter Sizing' section is highlighted with a red box. It contains the following fields:

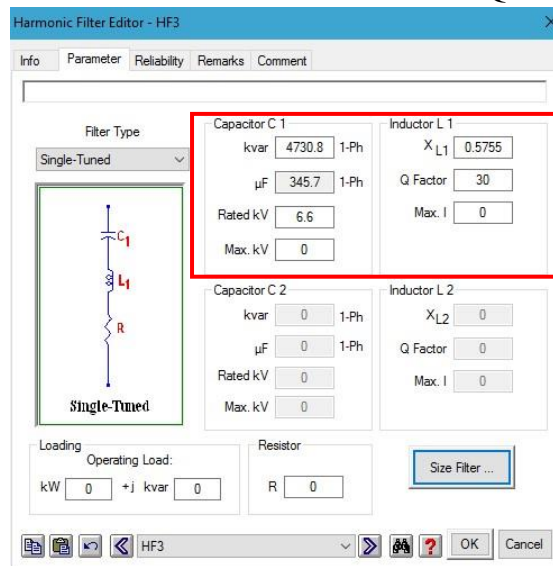
- Harmonic Info:**
 - Harmonic Order: 1
 - Harmonic Current: 1 Amp
 - ☐ Include Filter Overloading
- Sizing Option:**
 - ☒ PF Correction
 - ☐ Minimize Initial Cost
 - ☐ Minimize Operating Cost
- Initial Installation Cost:**
 - Capacitor Unit Cost: 0 \$/kvar
 - Inductor Unit Cost: 0 \$/kvar
- Operating Cost:**
 - Capacitor Loss Factor: 1 %
- PF Correction:**
 - Existing PF: 88.3 %
 - Desired PF: 100 %
 - Load MVA: 10.079
- Result:**
 - 1-Ph: kvar, Vc: kV (ASUM)
 - XI: ohm/phase, IL: Amp (RMS)

Buttons at the bottom include Size Filter, Substitute, Help, OK, and Cancel.

Note:

Desired PF = $98 + (\text{PF of Bus2} - \text{PF of Bus1})$. 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.



The image shows the 'Harmonic Filter Editor - HF3' dialog box, specifically the 'Parameter' tab. The 'Filter Type' is set to 'Single-Tuned'. The 'Capacitor C1' and 'Inductor L1' sections are highlighted with a red box. The 'Capacitor C1' section contains the following fields:

- kvar: 4730.8
- 1-Ph: 1-Ph
- μF: 345.7
- Rated kV: 6.6
- Max. kV: 0

The 'Inductor L1' section contains the following fields:

- X_{L1}: 0.5755
- Q Factor: 30
- Max. I: 0

Below these sections, there are fields for 'Capacitor C2' and 'Inductor L2', both set to 0. The 'Loading' section shows 'Operating Load' as 0 kW + j 0 kvar. The 'Resistor' section shows 'R' as 0. A 'Size Filter ...' button is located at the bottom right. The bottom of the dialog box has a status bar with 'HF3' and buttons for OK and Cancel.



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?