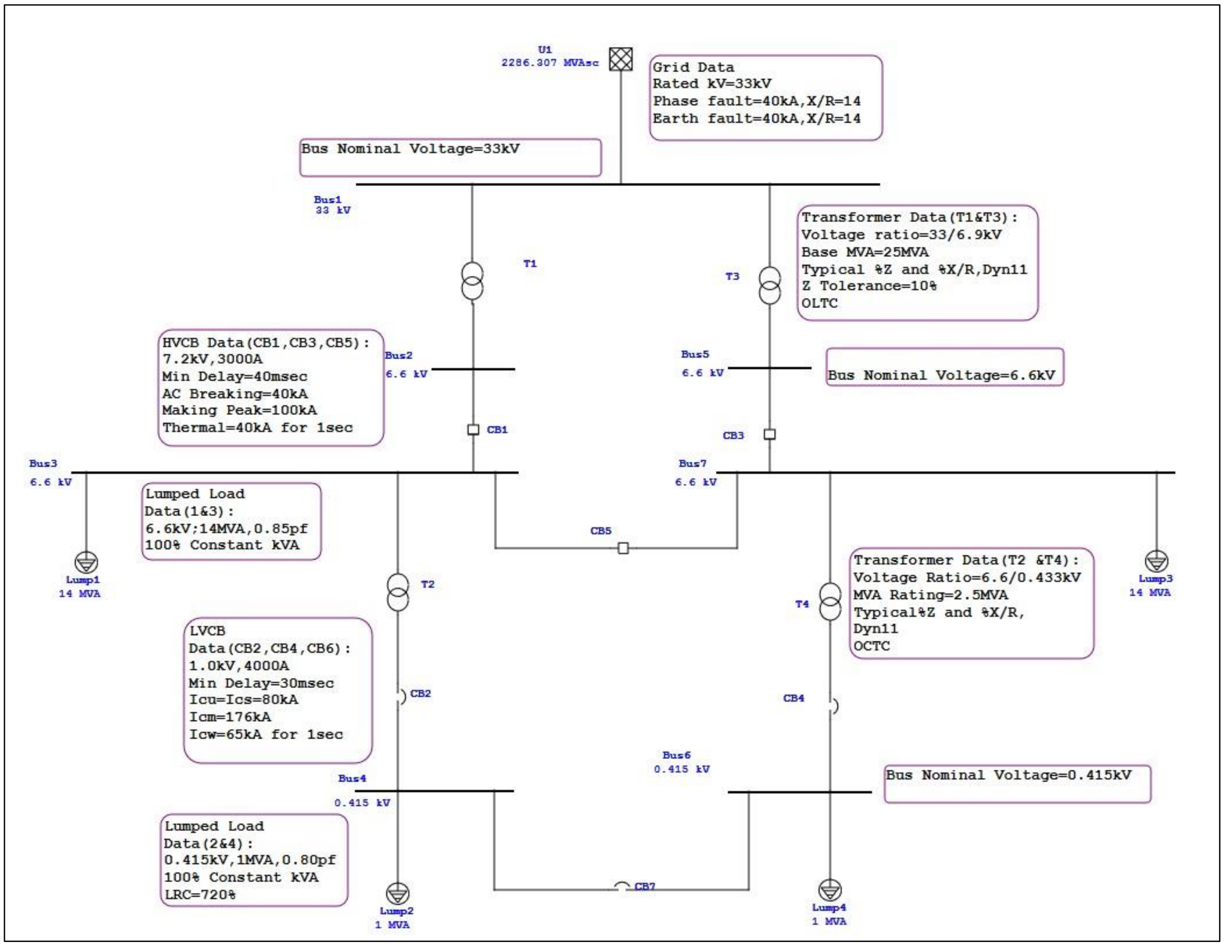
Short Circuit Analysis

Purpose and Description

The purpose of this exercise is to introduce Short Circuit Module interface by using the system modelled and thereby calculating the total short circuit currents as per IEC 60909 including contributions from individual motors, generators and utility ties in the system.

Procedure:

1. Open LF-Example1 OTI file shown below.



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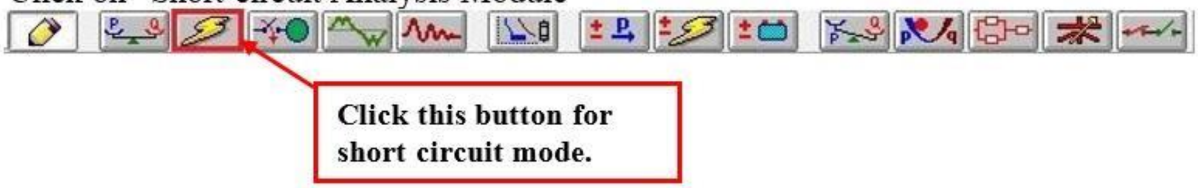
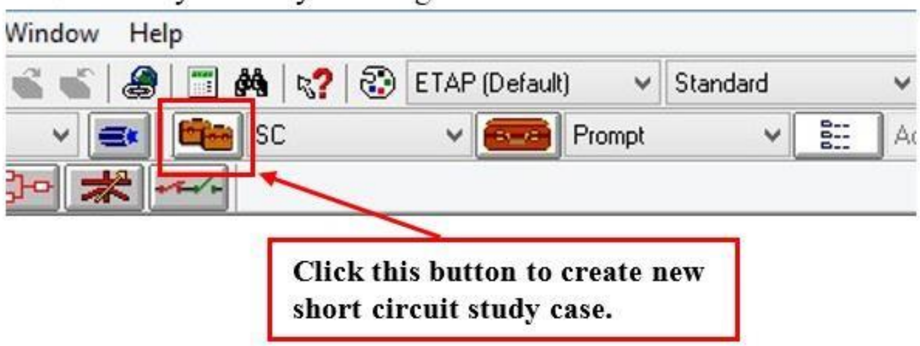
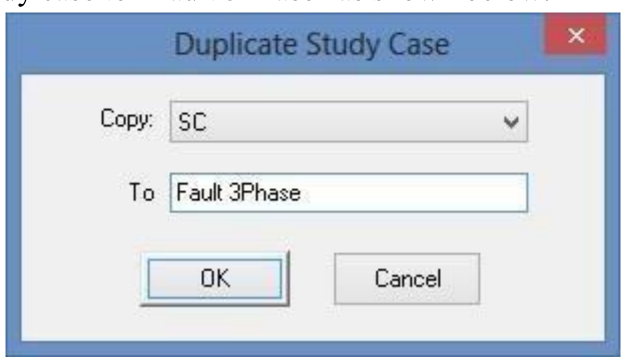
2. Click on “Short circuit Analysis Module” in Mode toolbar as shown.



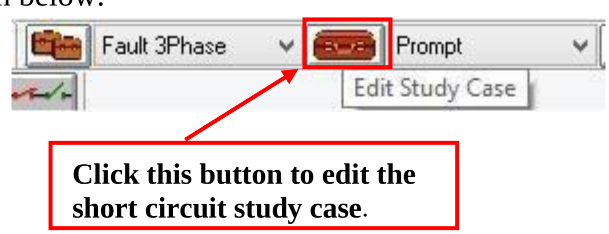
3. Create a New Study Case by clicking the toolbar as shown below.



4. Name the study case to “Fault 3Phase” as shown below.



5. Select “Fault 3Phase” from Short Circuit study case and proceed to Edit Study Case option as shown below.



6. **Of study case editor (or brief case) settings:**

Two pages are shown below where following information is need to be checked on:

i. Nominal transformer tap or impedance adjusted to tap

ii. Selection of C factor or voltage factor

iii. Selection of X/R method: A, B or C

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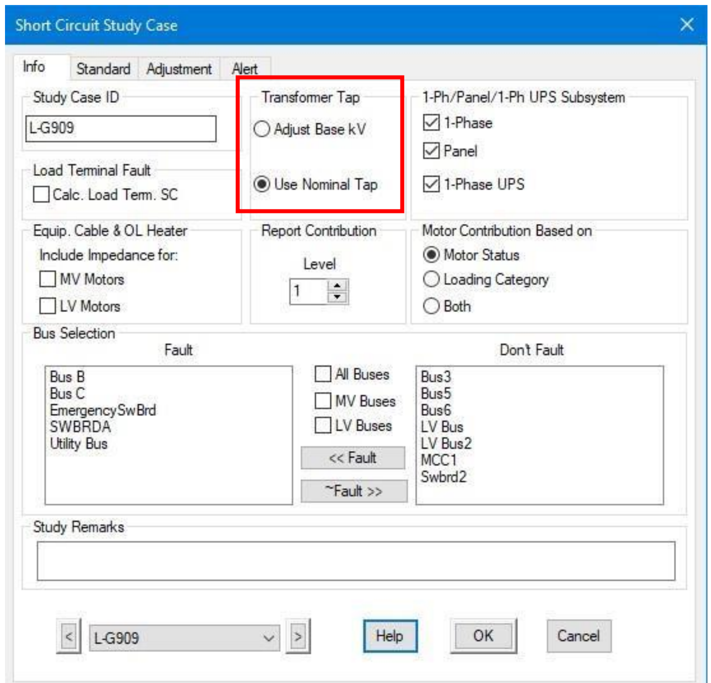
iv. Selection of Margins on alert page, for alert display

i. Nominal transformer tap or impedance adjusted to tap ratio:
In ETAP, there are two options available for selecting transformer Tap:

1. Adjust Base kV
2. Use Nominal Tap



Typically **nominal tap method** should be used for IEC 60909study.

ii. Study case editor page '<u>standard</u>' for selection of standard user defined C factor or Voltage factor & X/R method:

Select IEC standard for performing short circuit calculation as per standard IEC-60909. C factor default values are as per standard IEC-60909, it is Ok as in ETAP, unless this need to be changed. For the user defined C factor check box shown below need to be clicked.

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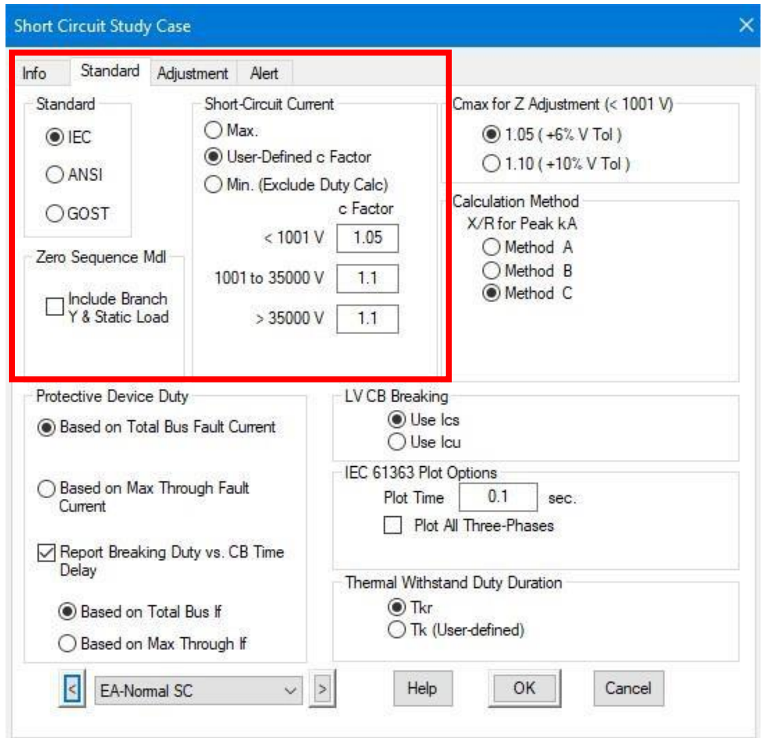
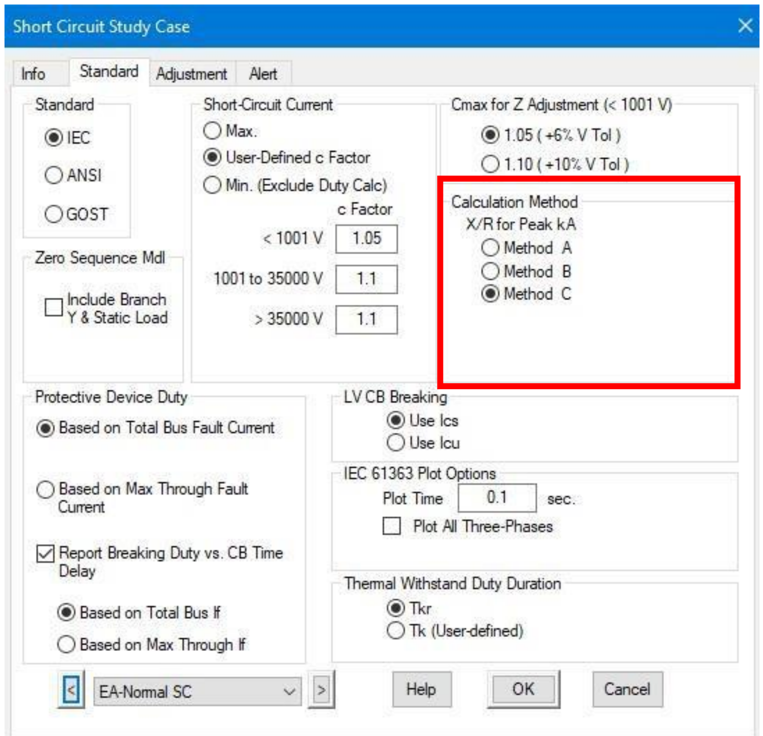


Voltage range	Range for C factor	Maximum value of C factor	Minimum value of C factor
< 1001 V	0.95 to 1.10	1.1	0.95
1001 to 35000 V	1.00 to 1.10	1.1	1
> 35000 V	1.00 to 1.10	1.1	1

iii. X/R method:

ETAP briefcase for this selection is as below.

Default calculation method used in Etap is method C which is more appropriate method for calculation.



Peak short-circuit current (i_p) calculation:

In peak short circuit current calculation, two separate methods are used for non-meshed and meshed networks.

a. Short circuits in non-meshed networks

For three-phase short circuits fed from non-meshed networks, the contribution to the peak shortcircuit current from each branch can be expressed by:

$$\boxed{i_p = \sqrt{2}\, k I''_k}$$

……… (Refer: Equation No 54 of IEC 60909-0 standard)

Where *k* is a function of the system R/X ratio at the fault location, and shall be obtained from Fig (i) (i.e. figure 15 of IEC 60909-0 standard) or can be calculate by using below formulae:

$$\boxed{\kappa = 1{,}02 + 0{,}98e^{-3R/X}}$$

……….. (Refer: Equation No 55 of IEC 60909-0 Standard)

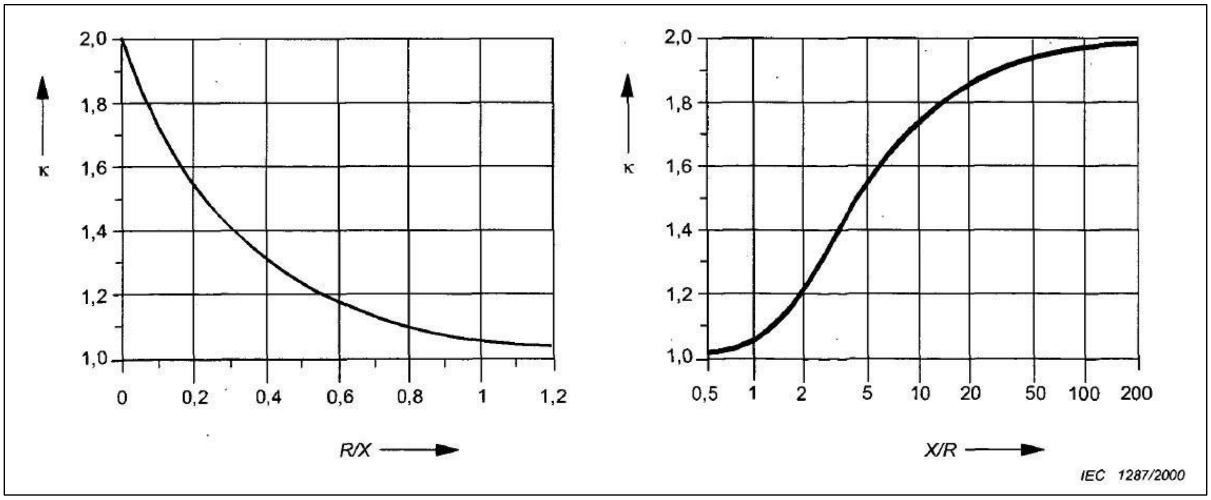


Fig (i)

b. Short circuits in non-meshed networks

In meshed networks, the above equation (equation no: 54 of IEC 60909 standard) of determining peak fault current shall be used with *k* determined using one of the following methods A, B, or C.

- **Method A - *Uniform ratio R/X or X/R***
  For this method the value of the *k* factor is determined from Fig (i) taking the smallest ratio of R/X or the largest ratio of X/R of all the branches of the network. It is only necessary to choose the branches which carry partial short-circuit currents at the nominal voltage corresponding to the short-circuit location and branches with transformers adjacent to the short-circuit location. Branches may be a series combination of several elements.

- **Method B - *R/X or X/R ratio at the short circuit location***

  The value of the *k* factor is determined by multiplying the *k* factor by a safety factor of 1.15, which covers inaccuracies caused after obtaining the R/X ratio from a network reduction with complex impedances.

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$$i_{p(b)} = 1{,}15\kappa_{(b)} \sqrt{2}\, I''_k$$

.... (Refer: Equation No 58 of IEC 60909-0 standard)

As long as R/X remains smaller than 0.3 or X/R smaller than 3.33 in all branches, it is not necessary to use the factor 1.15. It is not necessary for the product 1.15 * $k_{(b)}$ to exceed 1.8 in low-voltage networks or to exceed 2.0 in medium- and high-voltage networks.
The factor $k_{(b)}$ is found from figure (i) for the ratio R_k/X_k given by the short-circuit impedance $Z_k = R_k + jX_k$ at the short-circuit location F, calculated for frequency f = 50 Hz or 60 Hz.

- **Method C -** ***Equivalent frequency fc***

The value of the *k* factor is calculated using a frequency-altered R/X. R/X is calculated at a lower frequency and then multiplied by a frequency-dependent multiplying factor.

In this method, an equivalent impedance Zc, of the system as seen from the short-circuit location is calculated assuming a frequency& = 20 Hz (for a nominal frequency off = 50 Hz) or fc = 24 Hz (for a nominal frequency off = 60 Hz). The R/X or X/R ratio is then determined according to below equations:

$$\frac{R}{X} = \frac{R_c}{X_c} \cdot \frac{f_c}{f}$$

$$\frac{X}{R} = \frac{X_c}{R_c} \cdot \frac{f}{f_c}$$

(Refer: Equation No 59a & 59b of IEC 60909-0 standard)

Where
$Z_c = R_c + jX_c$ is the equivalent impedance of the system as seen from the short-circuit location for the assumed frequency fc;
R_c is the real part of Z_c (R, is generally not equal to the R at nominal frequency)
Xc is the imaginary part of Zc, (Xc is generally not equal to the X at nominal frequency).

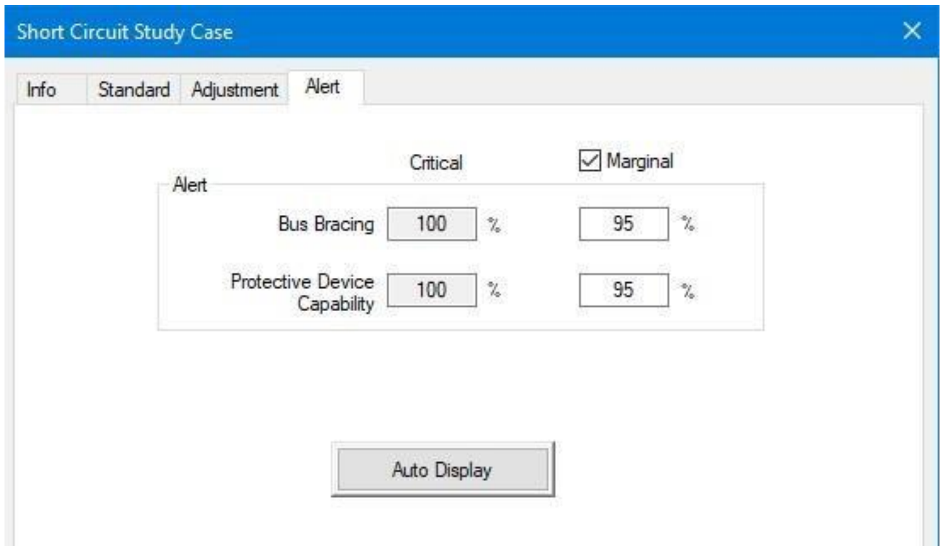
Depending on the product f * t; where f is the frequency and t is the time, the equivalent frequency fc should be as follows:

$f \cdot t$	<1	<2,5	<5	<12,5
f_c/f	0,27	0,15	0,092	0,055

Method C is most appropriate method adopted in most cases of IEC 60909 short circuit calculations.

iv.Alert Page

The alert page of briefcase for critical and marginal alert display is shown below.



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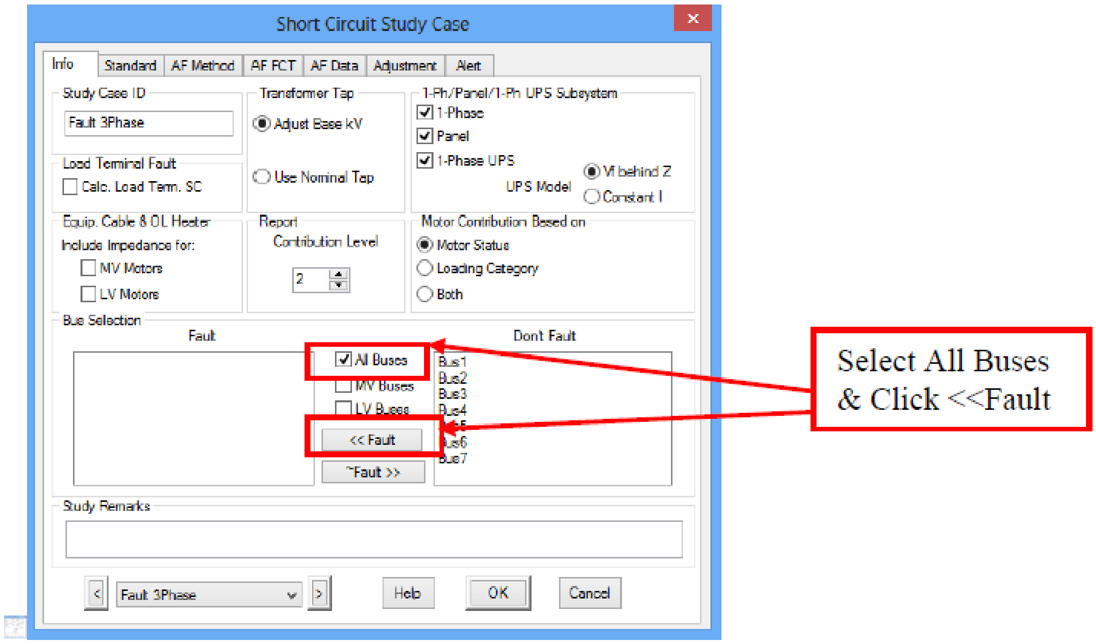
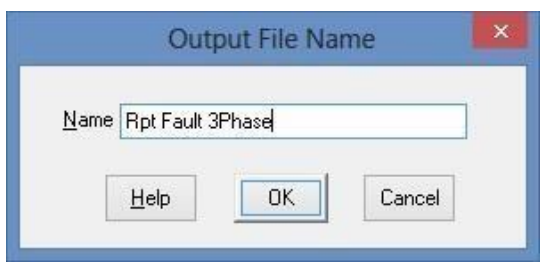
7. Select “All Buses” and Click “<<Fault” to create a fault on the selected buses.



8. To study different faults for the selected buses, click “60909” & give name for Output File Name as shown below.



9. Results of Three phase faults will be displayed as shown below.

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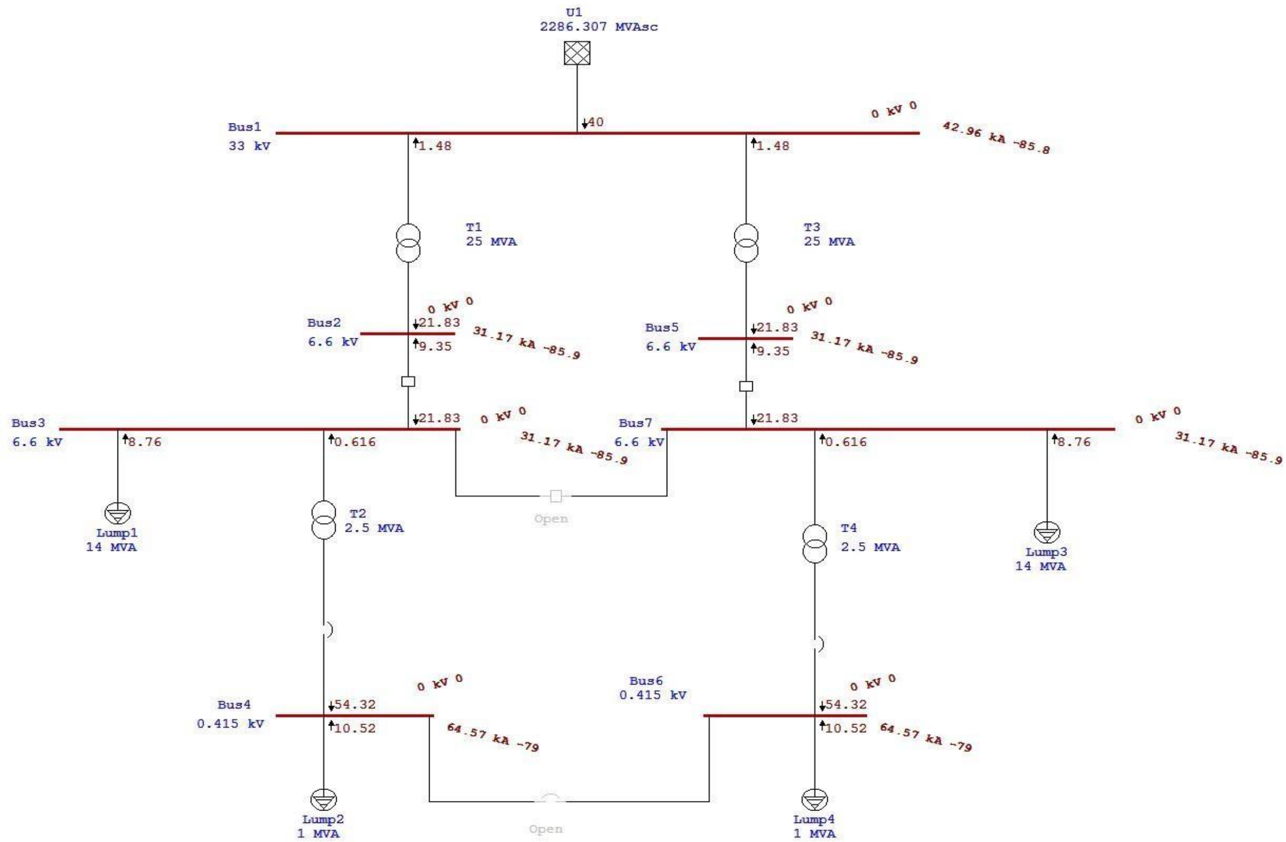

10. Go to Display Options to change the type of fault on the selected buses as shown below.

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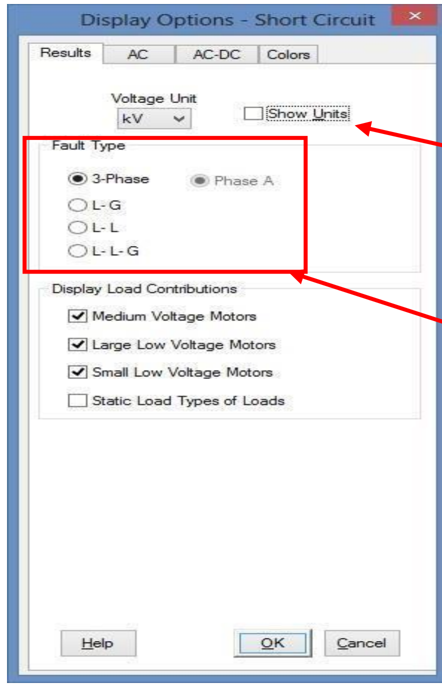

Check Show Units for displaying units in OLV.

Change the Type of Fault & click OK for displaying fault currents of a specific fault on OLV.

11. ETAP results shows the total bus fault currents, individual contributions of each branch and also the contributions of the dynamically modelled load as shown below for three phase fault.

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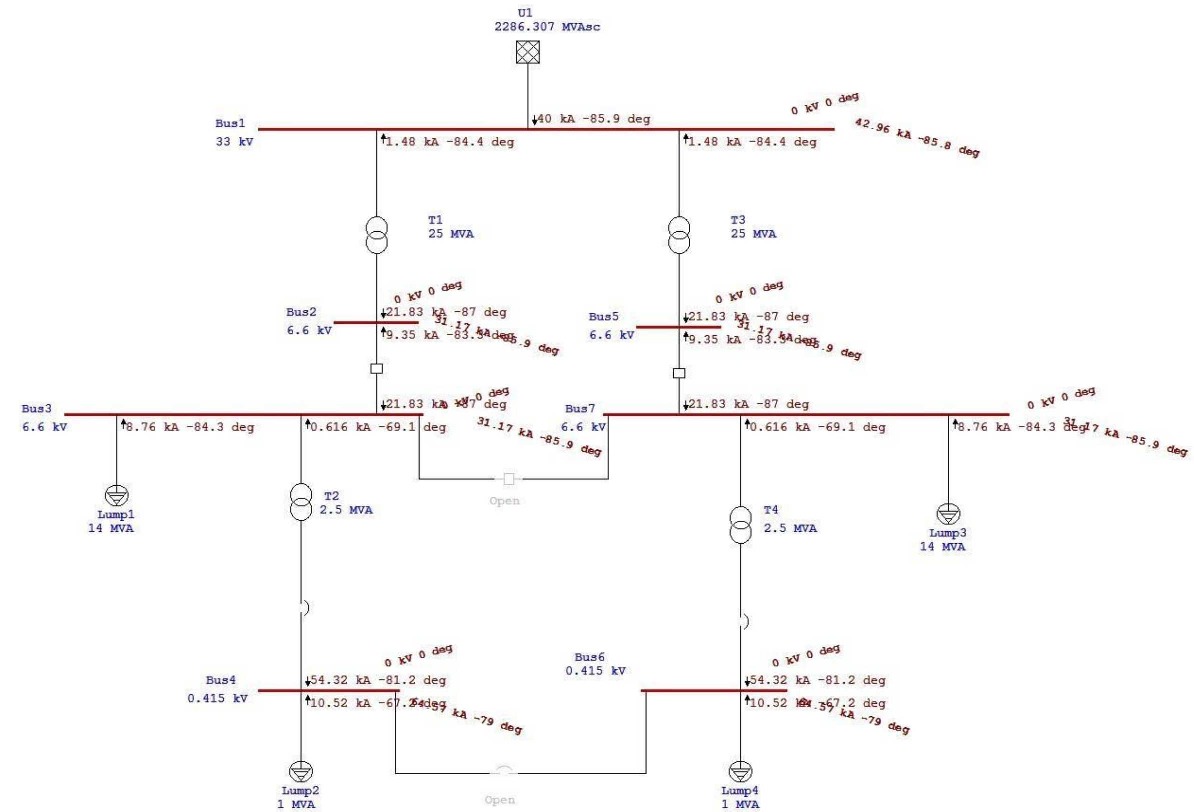
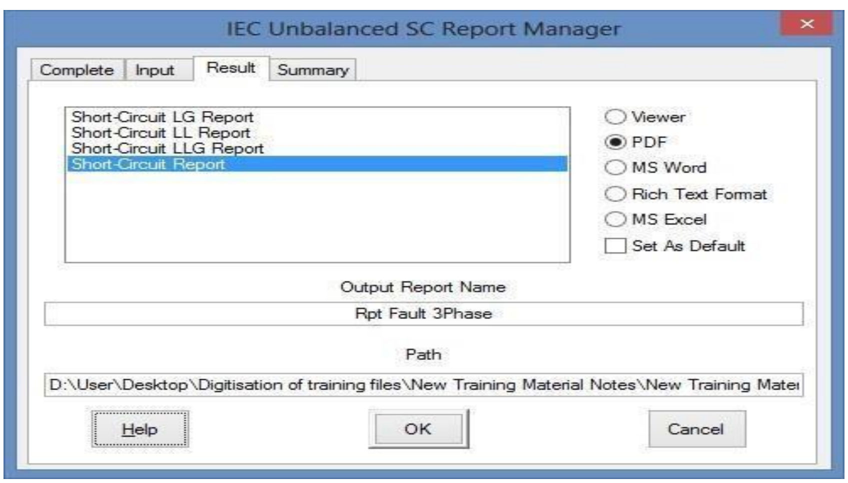


12. To view the short circuit report, go to Report Manager in Short Circuit Toolbar and Click on Result & select Short-Circuit Report as shown below. Select the type of file format to view it.



13. Sizing of HV and LV switchgear can be done from short circuit results obtained from 3-Phase Device Duty (IEC 60909) in Short Circuit toolbar.

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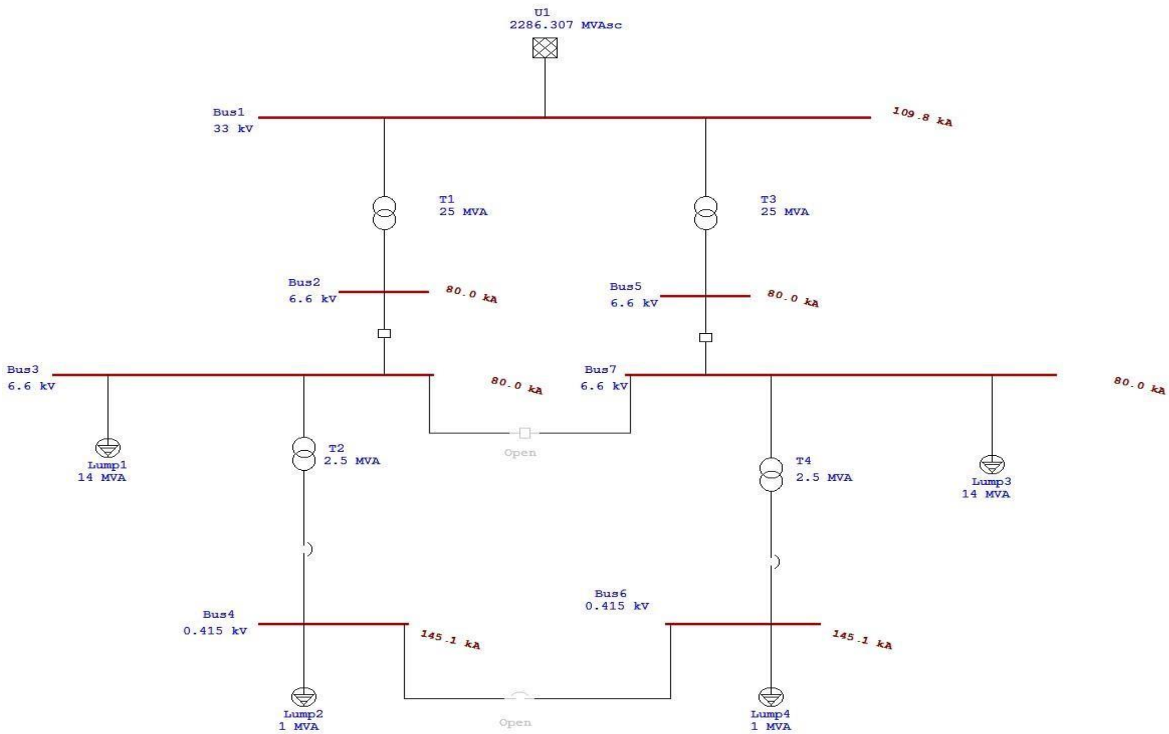
14. Run 3-Phase device duty calculation and check Peak Short Circuit Results as shown below.



15. Proceed to Alert View in short circuit toolbar for list of alerts for inadequate sizes of breakers.