ELECTRIC POWER ENGINEERS

ENERGY ENGINEERING EXPERTS

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CAPACITOR SWITCHING STUDIES IN EMTP

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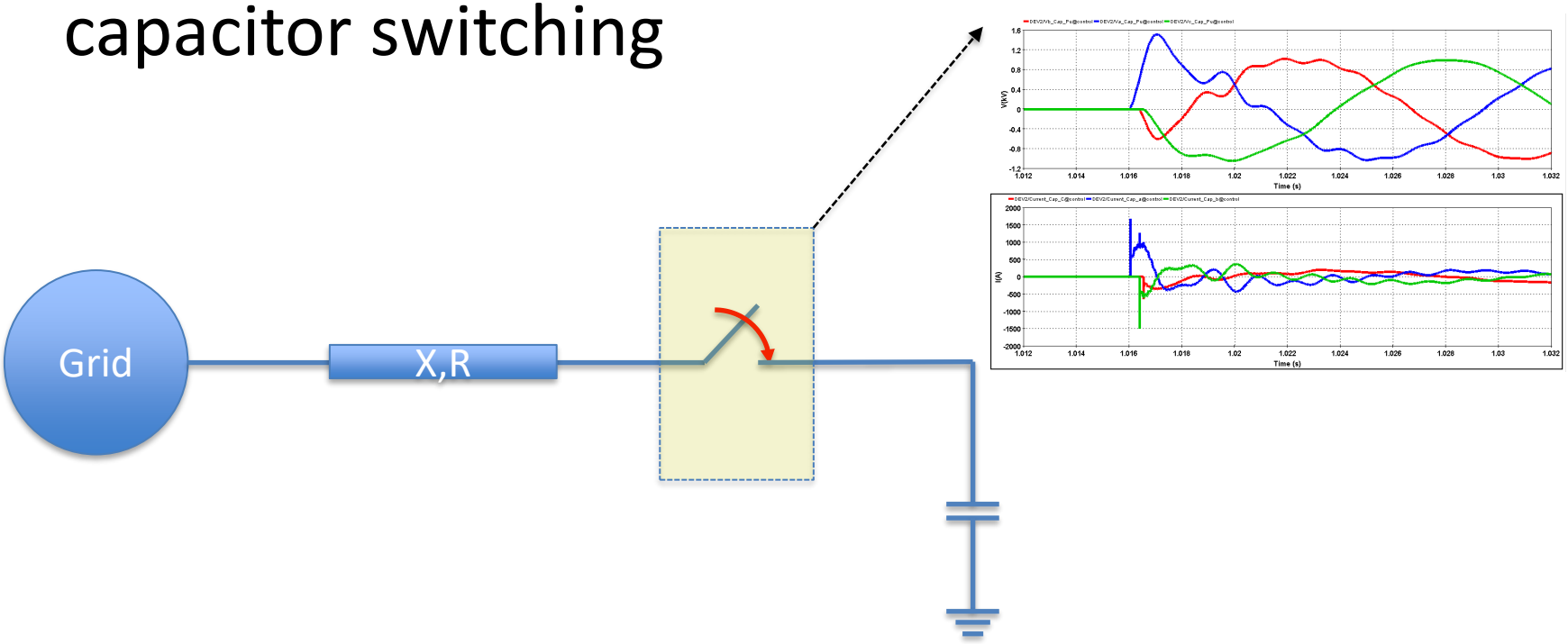
7/21/2022

WHY EMTP SOFTWARE?

- Phasor domain simulation
- Electro Magnetic Transient (EMT) simulation
- EMTP can do both!
- Conversion tool from PSSE software
- Plotting the result without loosing the frame settings
- Statistical evaluation of the results

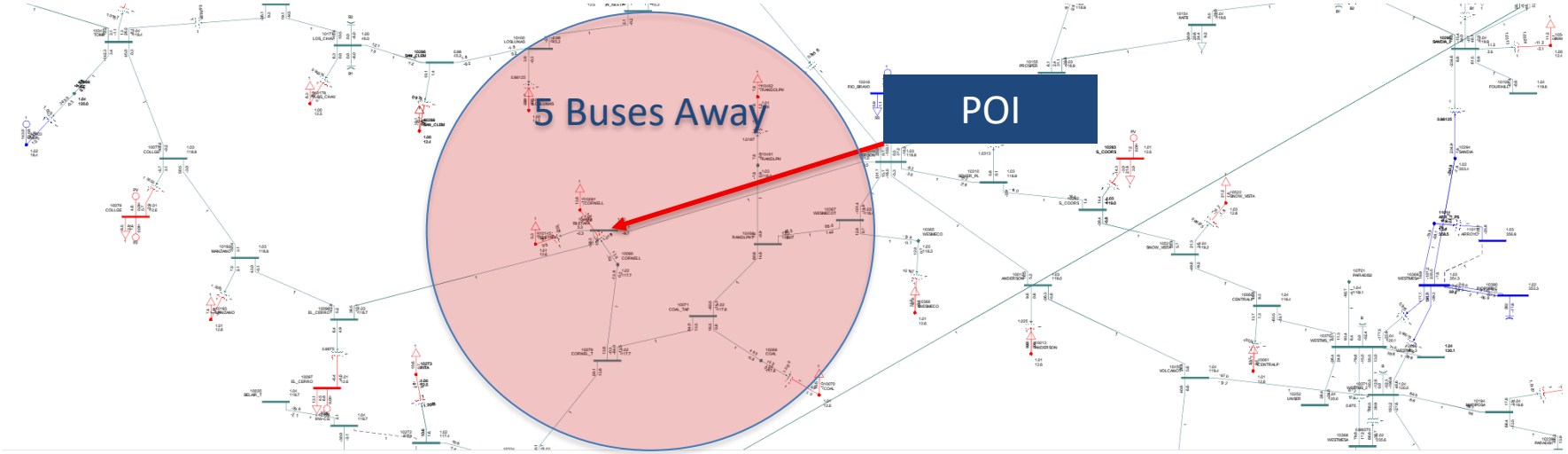
CAPACITOR SWITCHING STUDY

- The inrush current and transient voltage due to capacitor switching



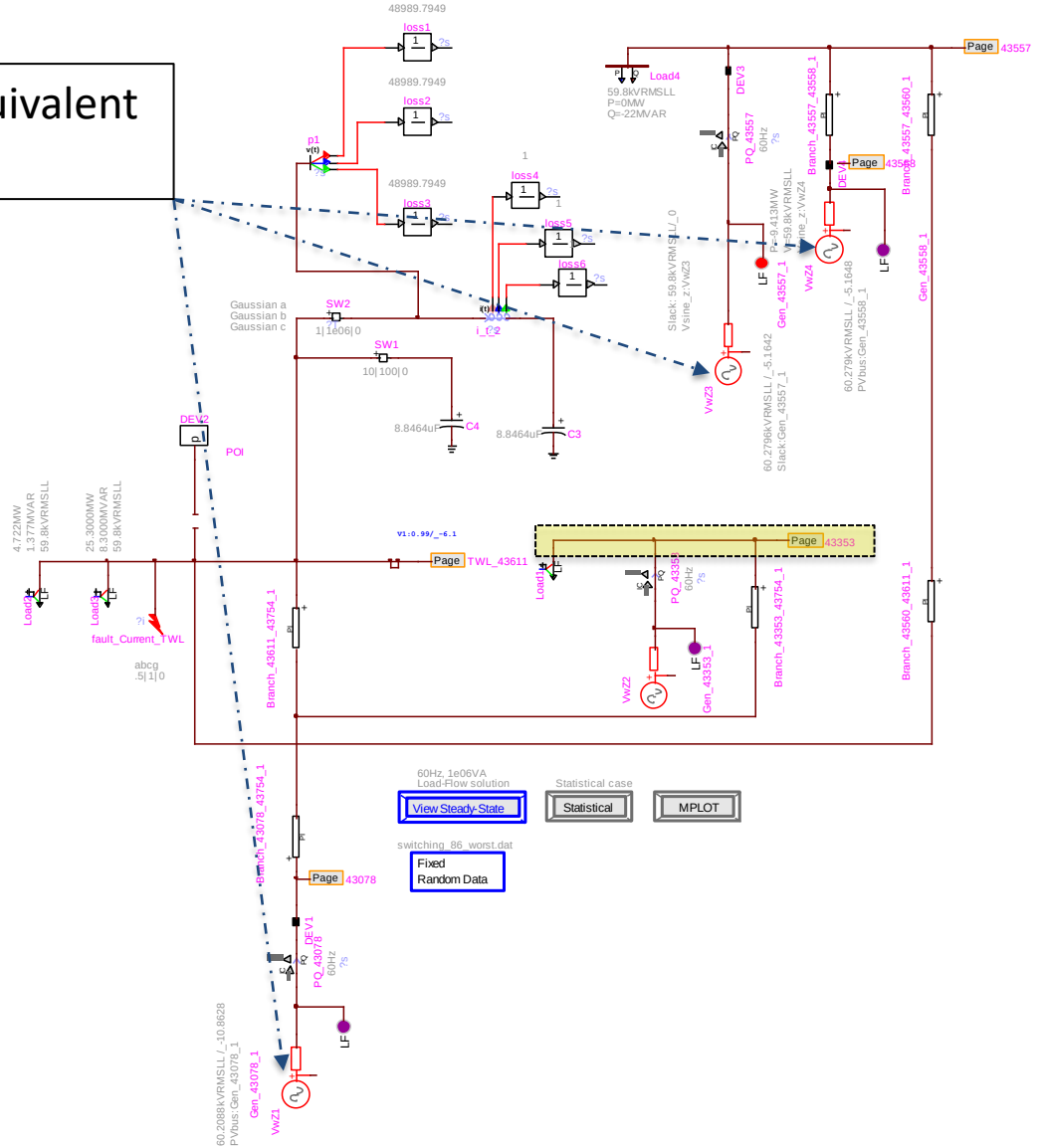
NETWORK CONVERSION

- System Conversion from PSSE
  - Requires extensive manual work but can be done with one click in EMTP software



NETWORK CONVERSION

Modeled as an equivalent Thevenin sources



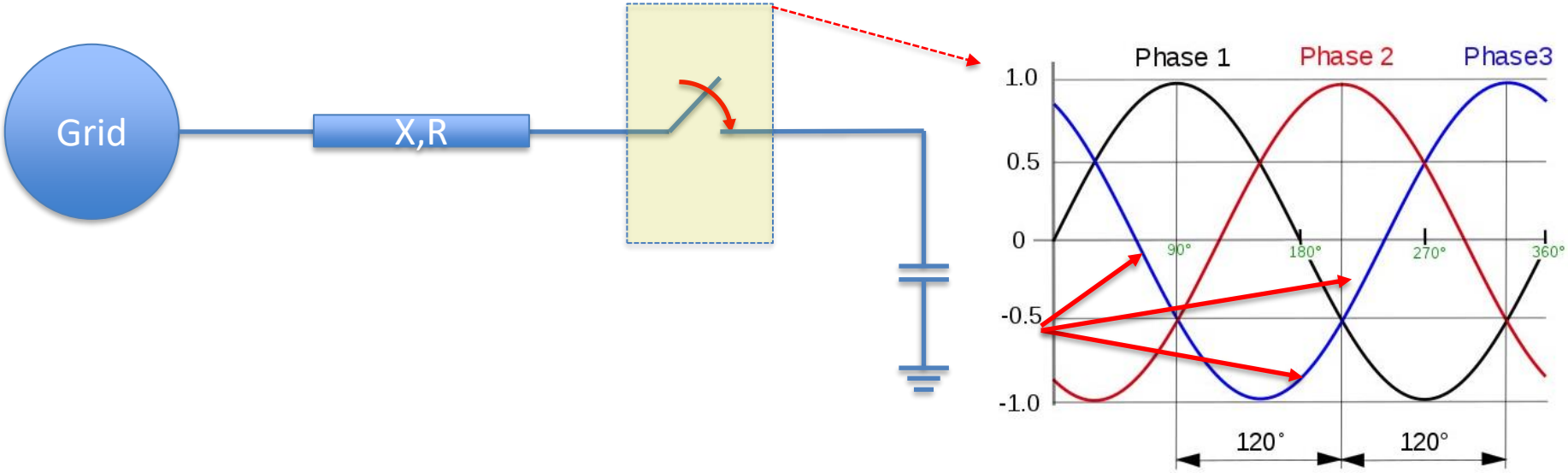
NETWORK CONVERSION

- Benchmarking Load flow and Short circuit
  - The error of less than 2% achieved for all the buses

Buses	V(EMTP)	V(PSSE)	Error	Isc (EMTP)	Isc (PSSE)	Error
4166	1.023	1.024	0.0978%	12.32	12.43	0.89%
4167	1.023	1.021	0.1955%	11.87	11.73	1.17%
4178	1.018	1.019	0.0982%	13.34	13.2	1.04%
4039	1.022	1.021	0.0978%	12.14	12.3	1.31%
4038	1.021	1.021	0.0%	12.14	12	1.15%

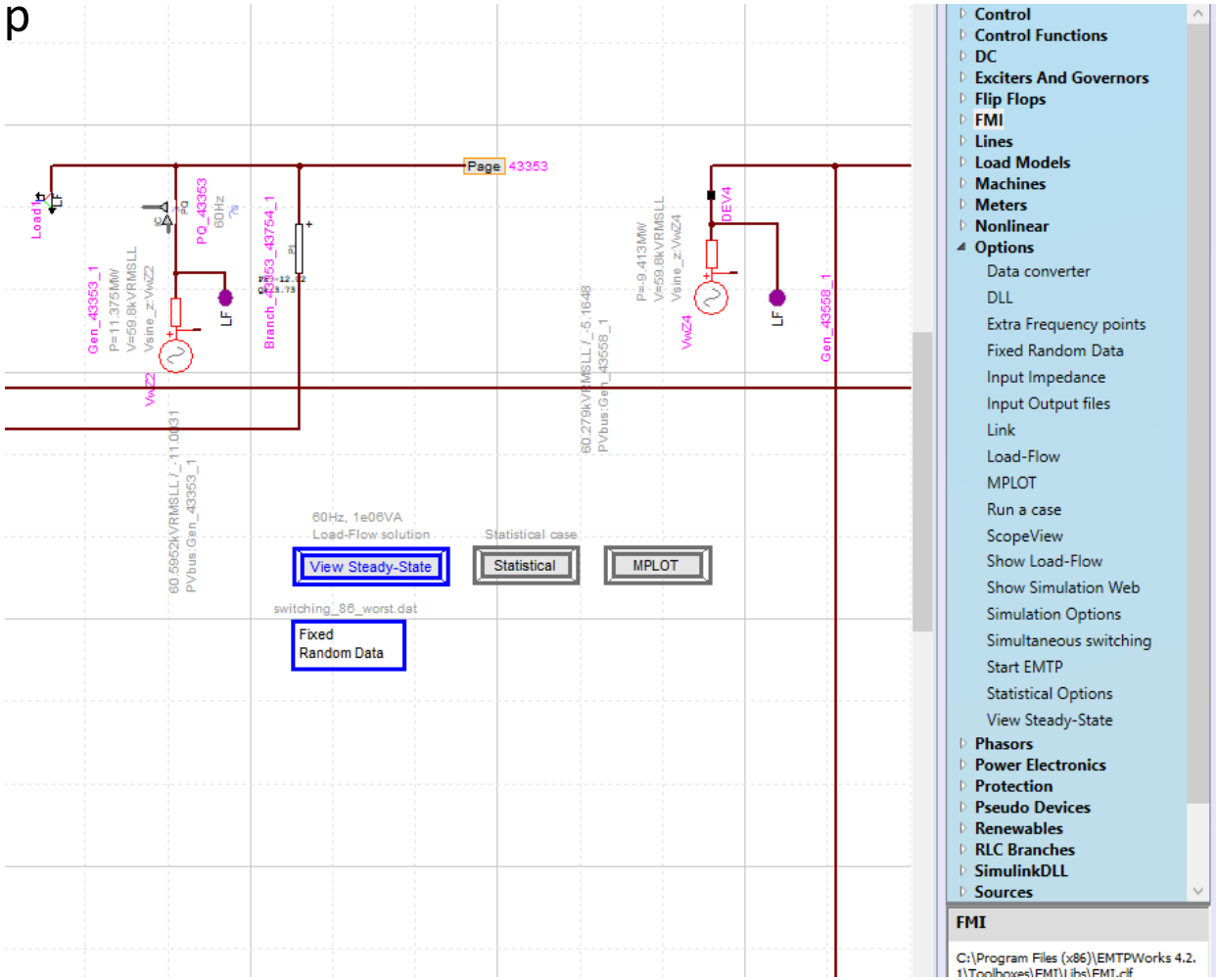
PERFORMING THE STUDY

The study must be performed on various breaker closing point (1-360 degree). At least 100 points of wave to be considered



PERFORMING THE STUDY

EMTP Options Tap



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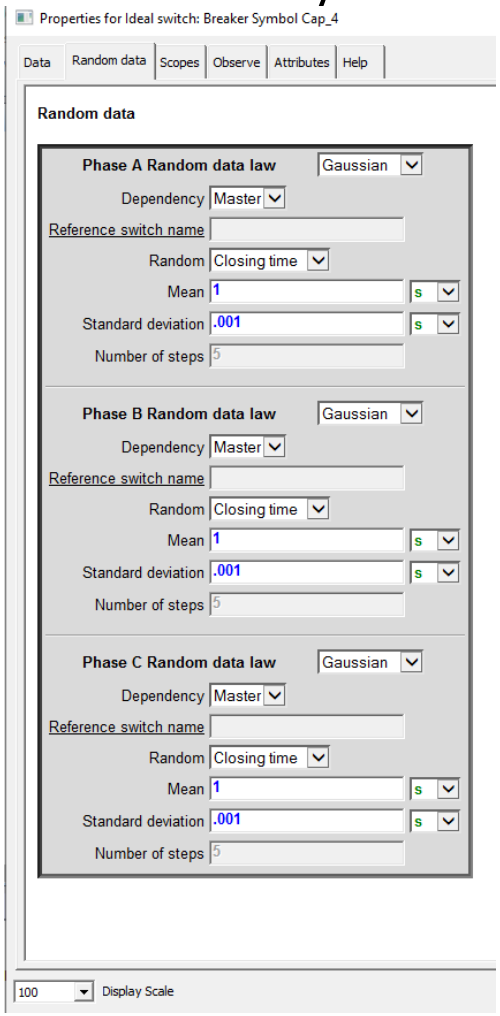
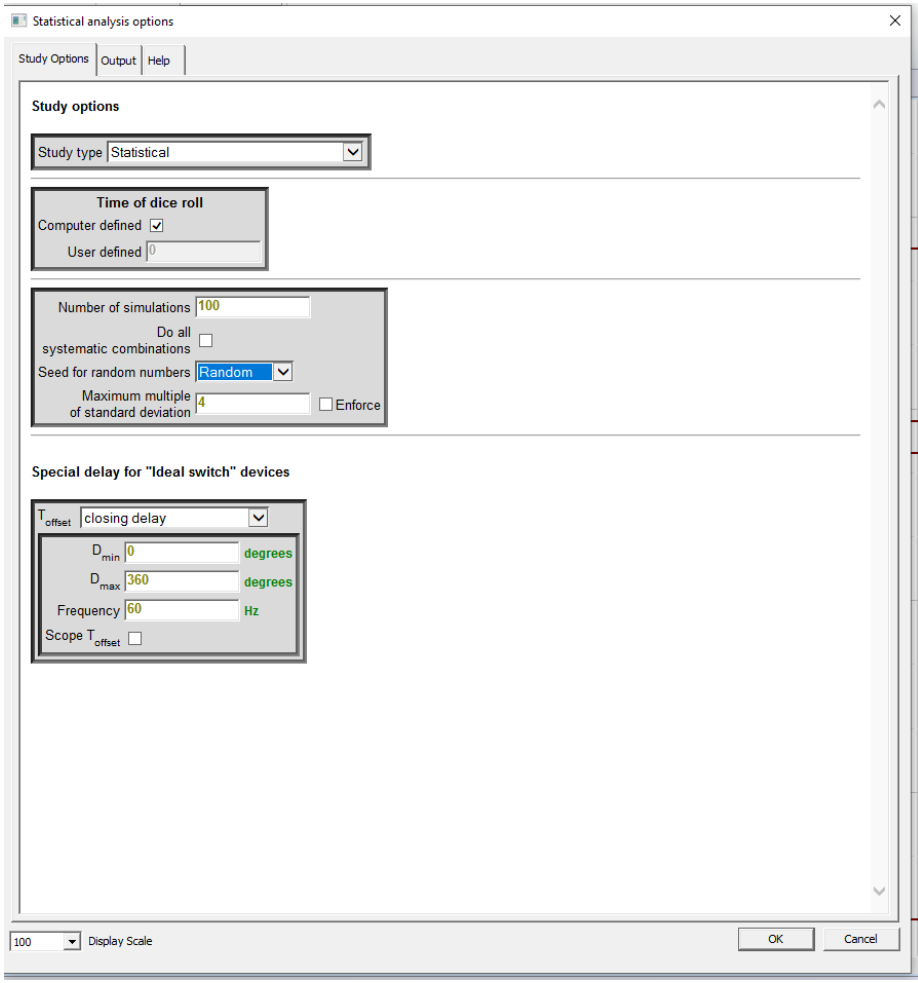
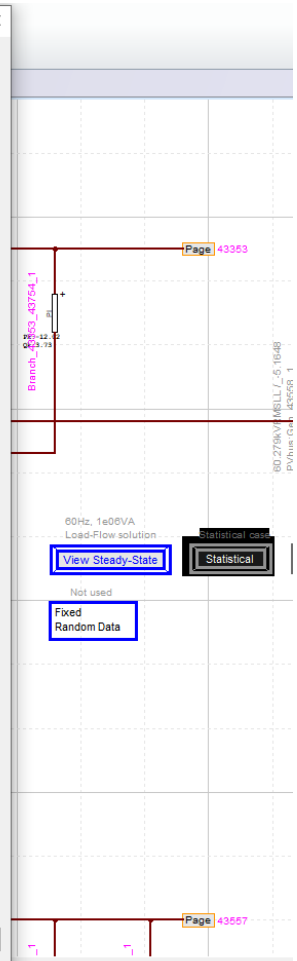
PERFORMING THE STUDY

Statistical analysis







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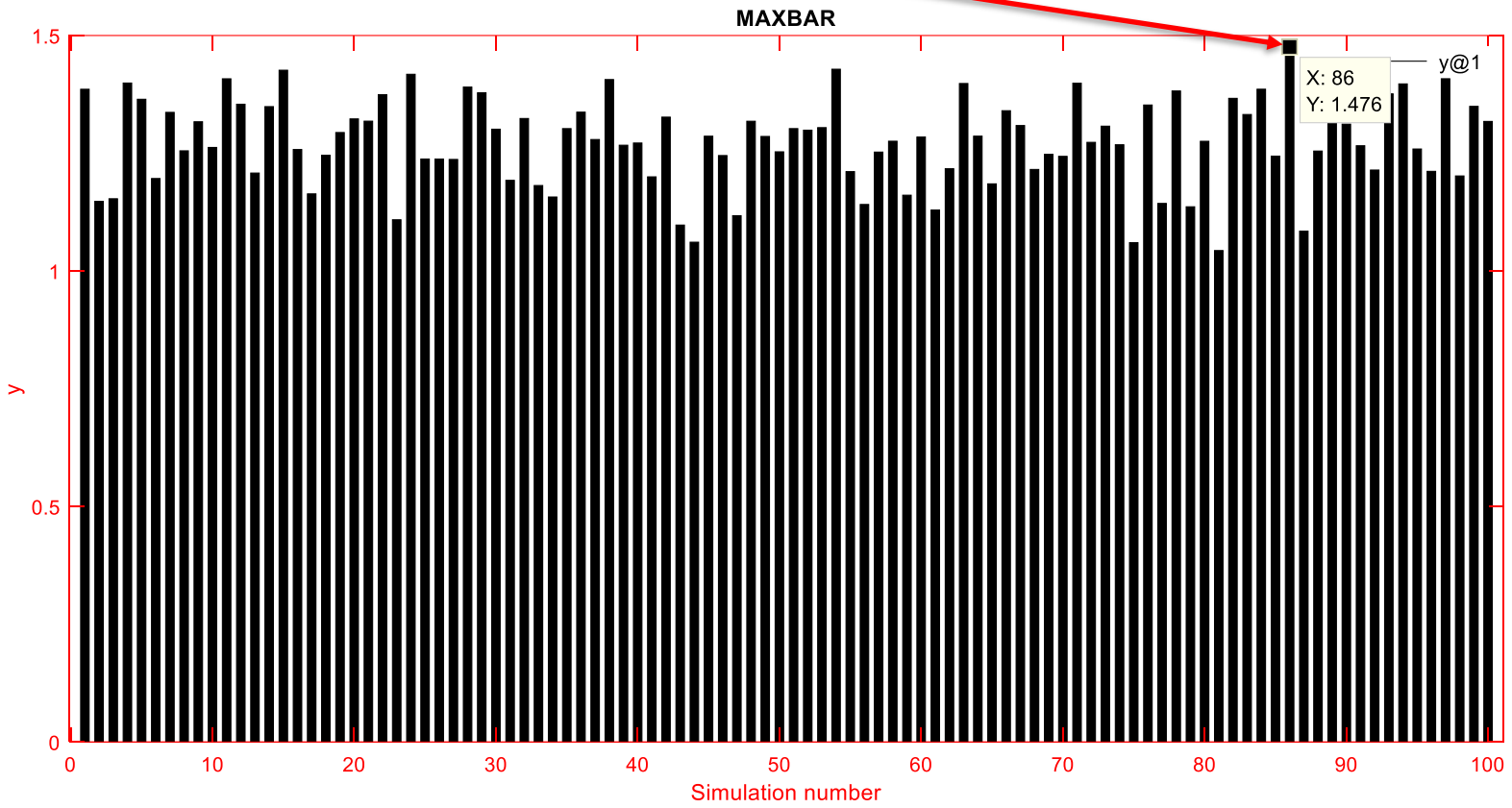
PERFORMING THE STUDY

Statistical analysis/Worst Case



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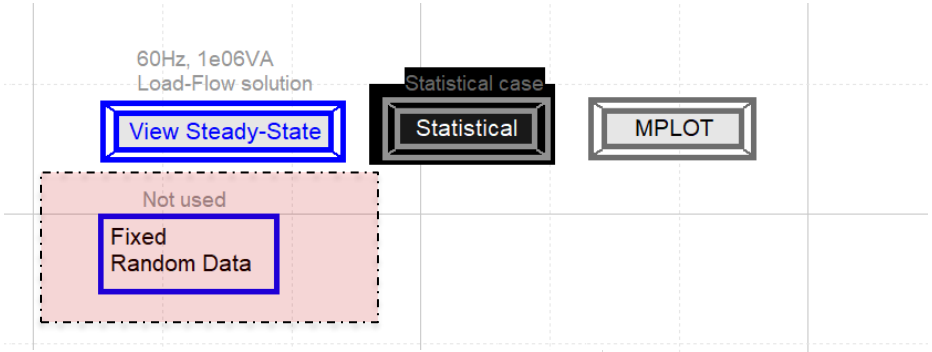
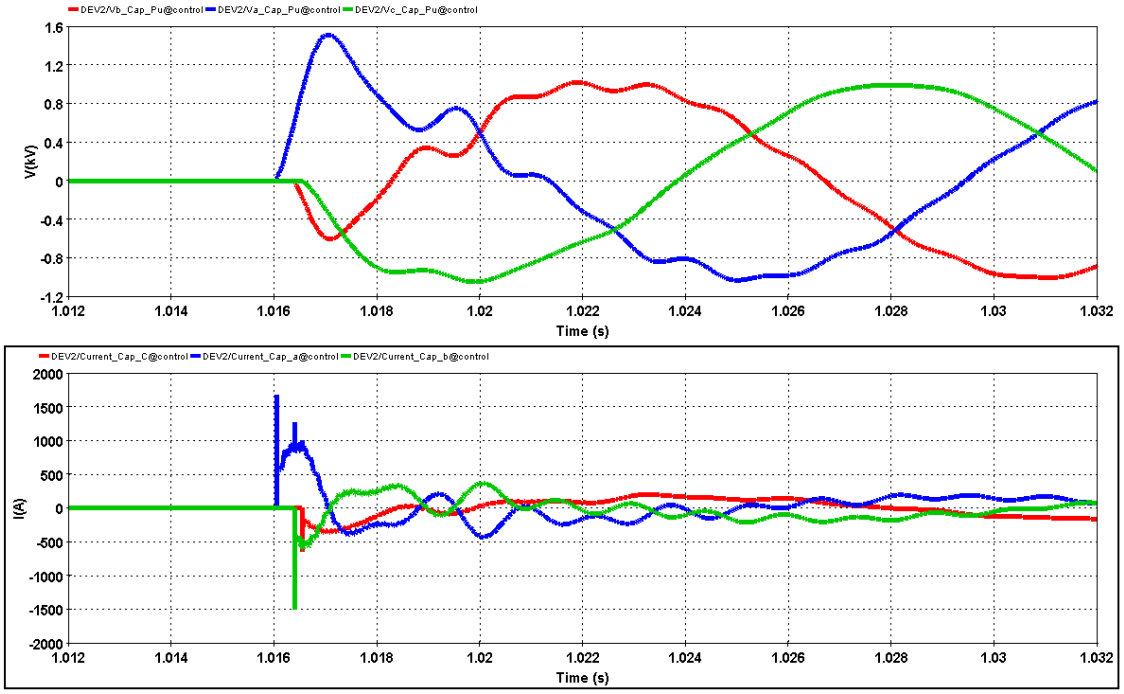
PERFORMING THE STUDY

Statistical analysis/Worst Case





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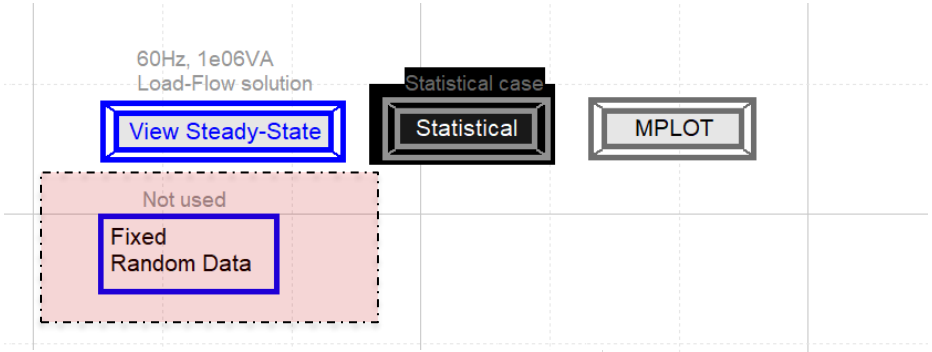
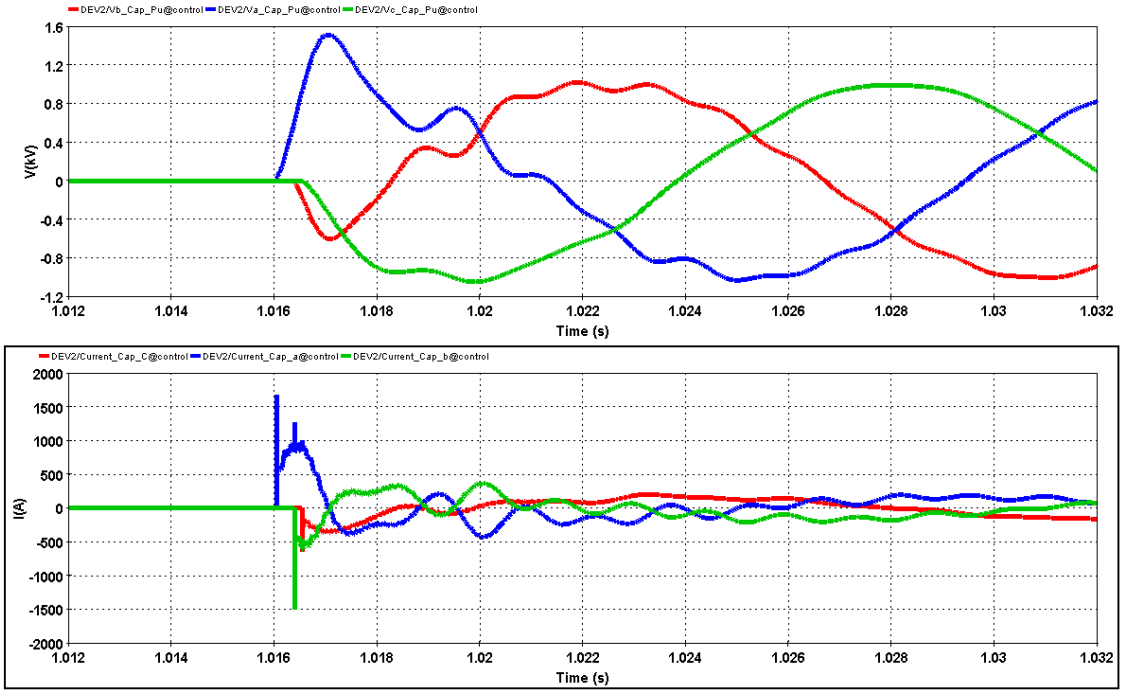
1

PERFORMING THE STUDY

Statistical analysis/Worst Case





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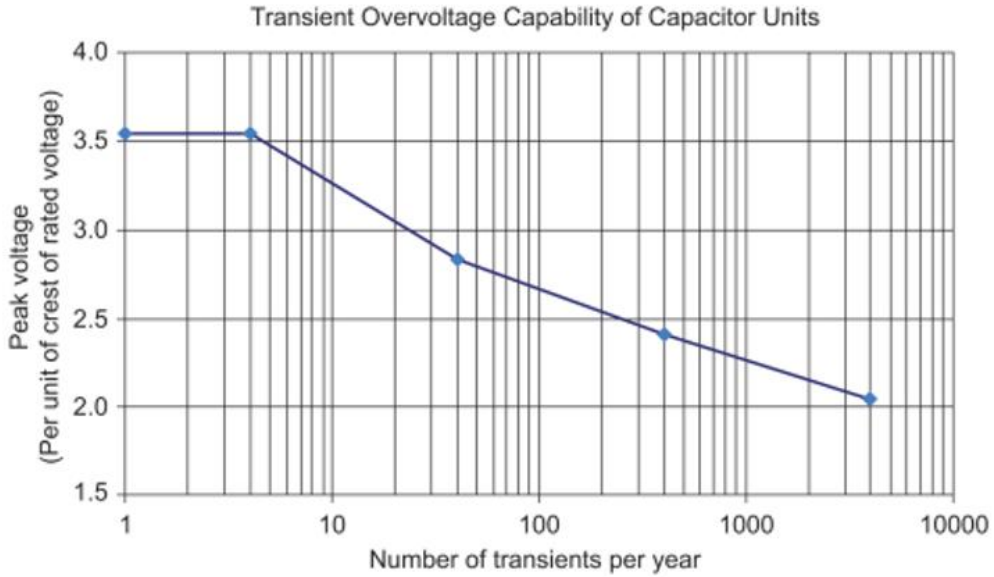
EVALUATION OF THE RESULTS



NOTE—This curve is based on straight line segments between the following points on semi-log coordinates: (1.0, $5/\sqrt{2}$), (4.0, $5/\sqrt{2}$), (40, $4/\sqrt{2}$), (400, $3.4/\sqrt{2}$), and (4000, $2.9/\sqrt{2}$).

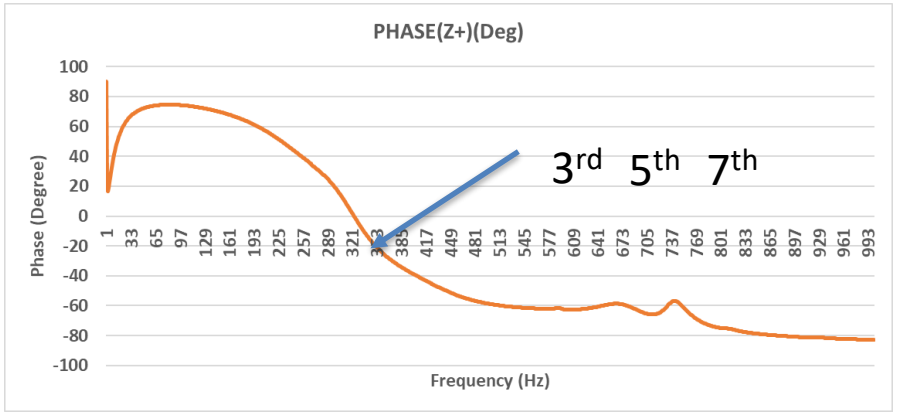
IEEE C37.06, the product of the peak magnitude and the maximum frequency of the outrush current must be limited to values less than 20 kA·kHz

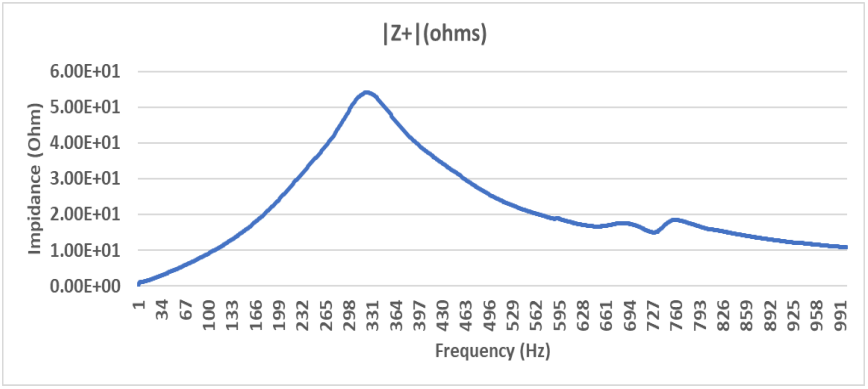
MITIGATION METHODS

- Staged capacitor switching
- Special operation criteria
- Current Limiting reactor
- Point of Wave (POW) devices

FREQUENCY SCAN OF THE SYSTEM

- Frequency scan analysis at the POI
- The conversion of the system to 5-10 buses away
- Indicates if the addition of cap bank will result in harmonic or transformer switching





SUMMARY OF THE EXPERIENCE WITH EMTP SOFTWARE

- Powerful conversion tool with high accuracy
- Generates an acceptable SLD after conversion
- Easy process to generate a sub-systems
- Powerful plotting tool (can be used as a benchmarking tool with other software)
- Accurate power flow tool
- Relatively fast simulation time
- Useful tools for Statistical evaluation and post data processing

QUESTIONS

Ref: https://stock.adobe.com/ro/search/images?k=any+questions