Detection of Induced and Resonance Voltage phenomenon using PMU data in real time system operation and mitigation measures

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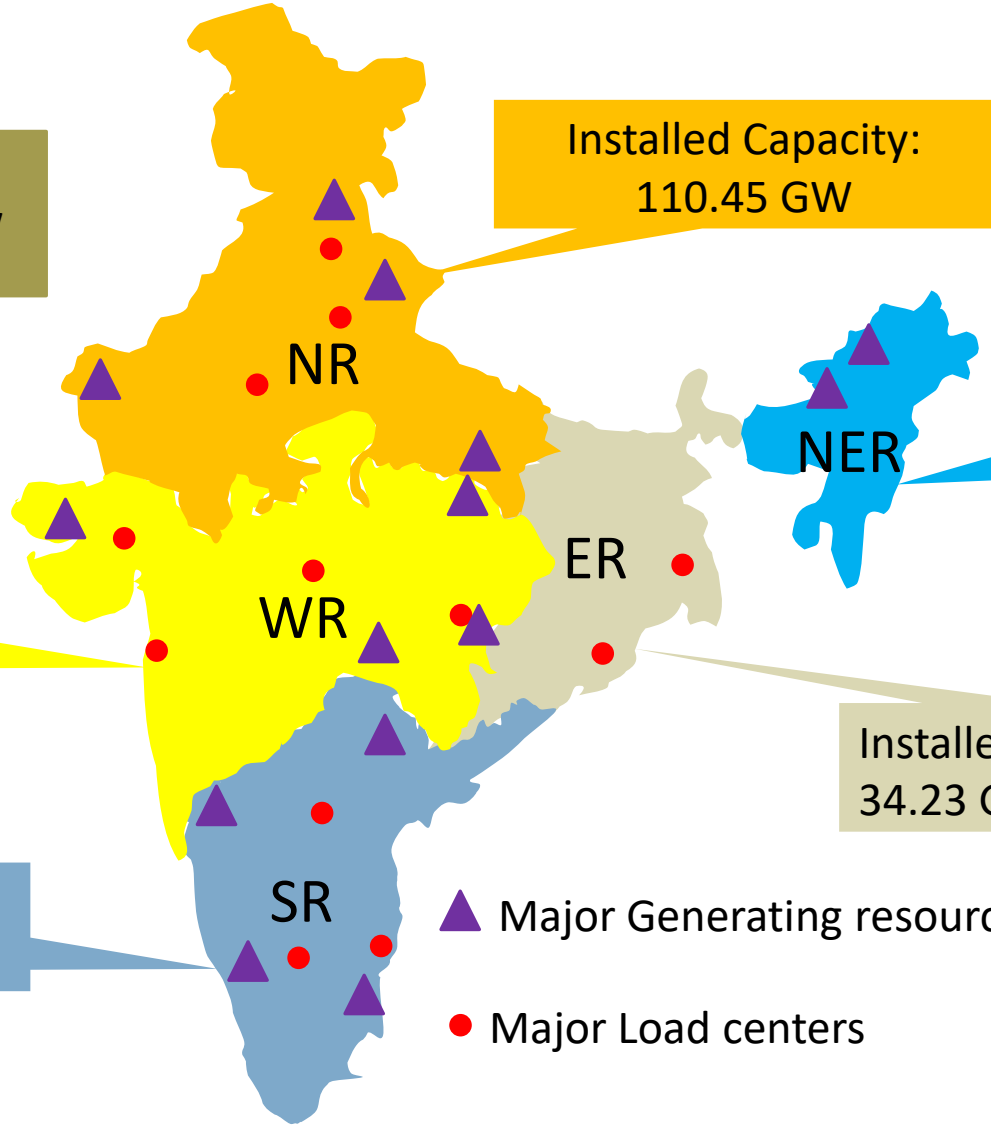
Outline

- Over view of Indian grid and URTDSM project
- Case Study: Observation of Induced and Resonance voltage phenomenon in 765 kV corridor in PMU data
- Simulation model in PSCAD
- Comparison of simulation results with PMU data
- Mitigation measures
- Comparison of simulation results with PMU data
- Summary

Overview of Indian Electricity grid:

Installed Capacity: 395.60 GW
Highest demand met: 200.57 GW



Installed Capacity: 110.45 GW

Installed Capacity: 4.93 GW

Installed Capacity: 127.94 GW

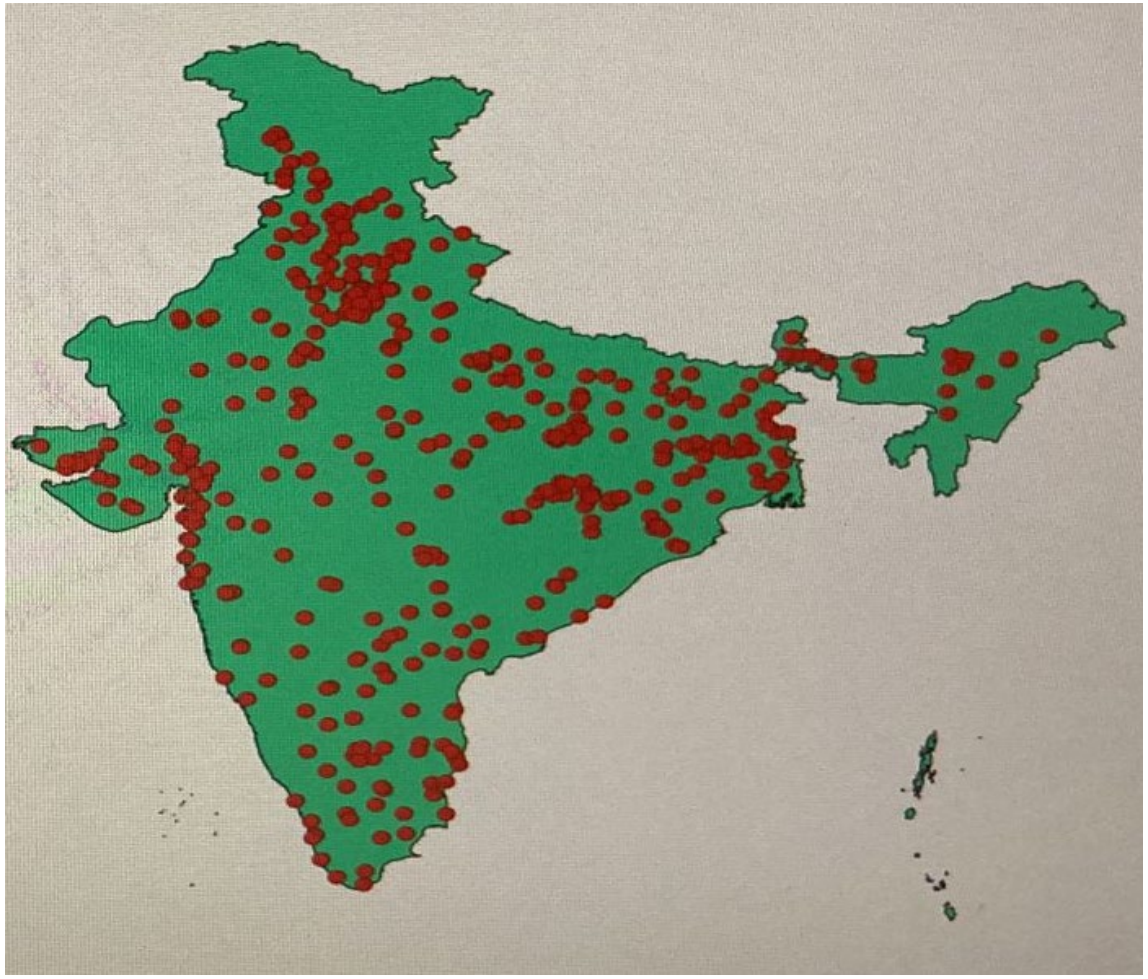
Installed Capacity: 34.23 GW

Installed Capacity: 117.95 GW

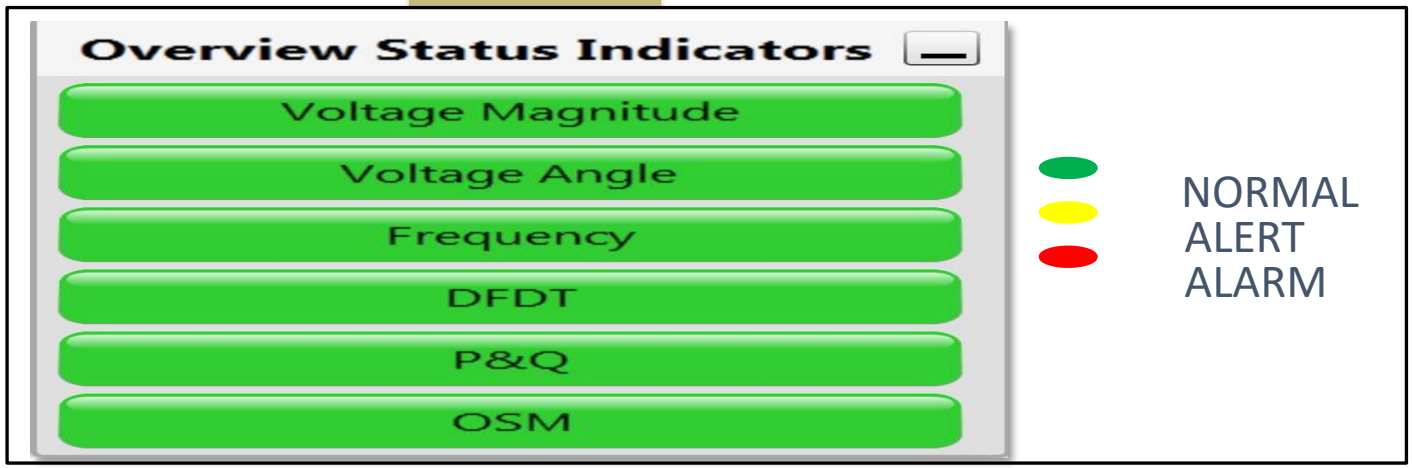
Source: Installed capacity report of CEA

Utilization of PMU data in real time system operation:

PMU locations in India



Alarms



Angle difference

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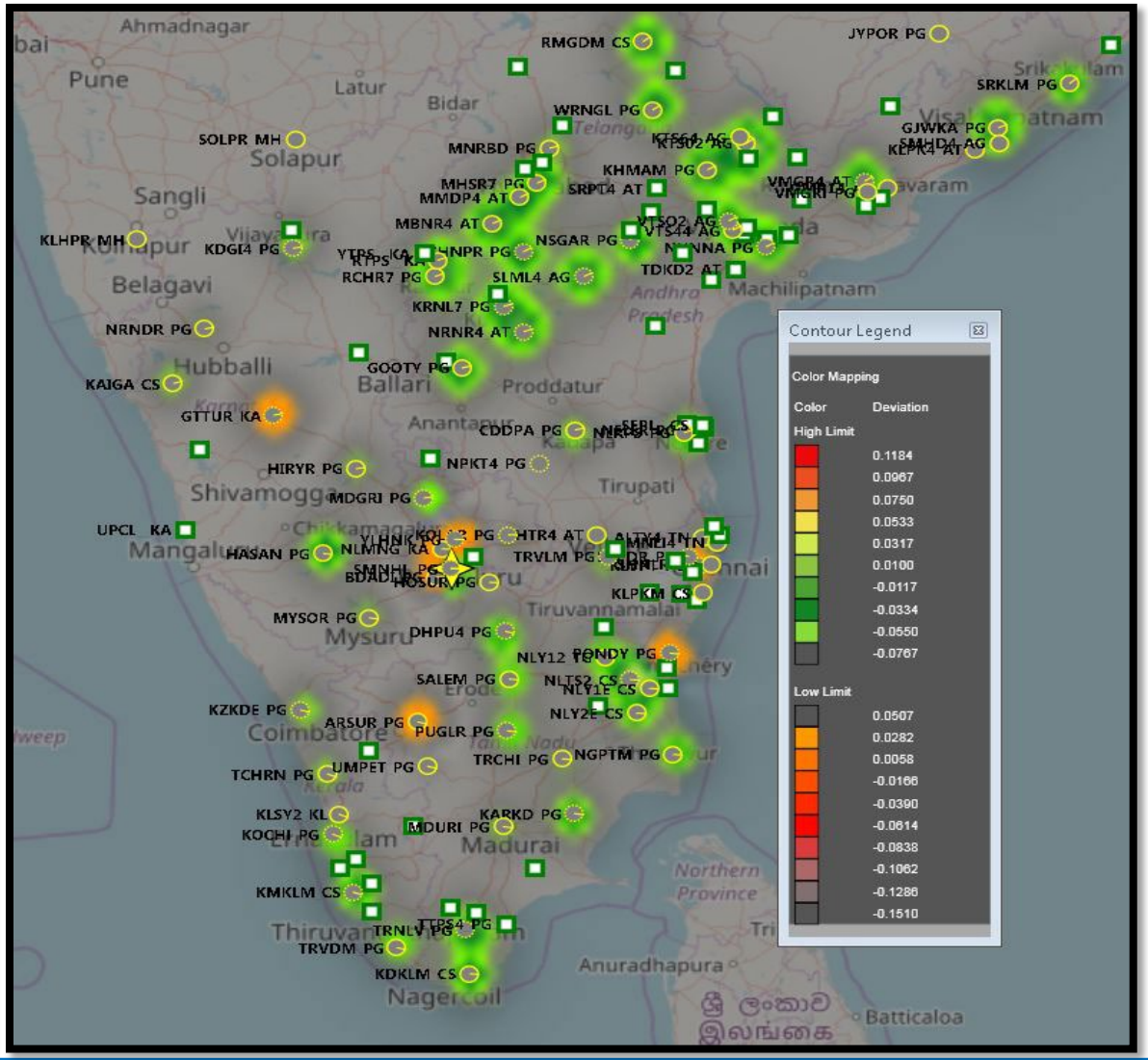
Geographical view

Contour displays



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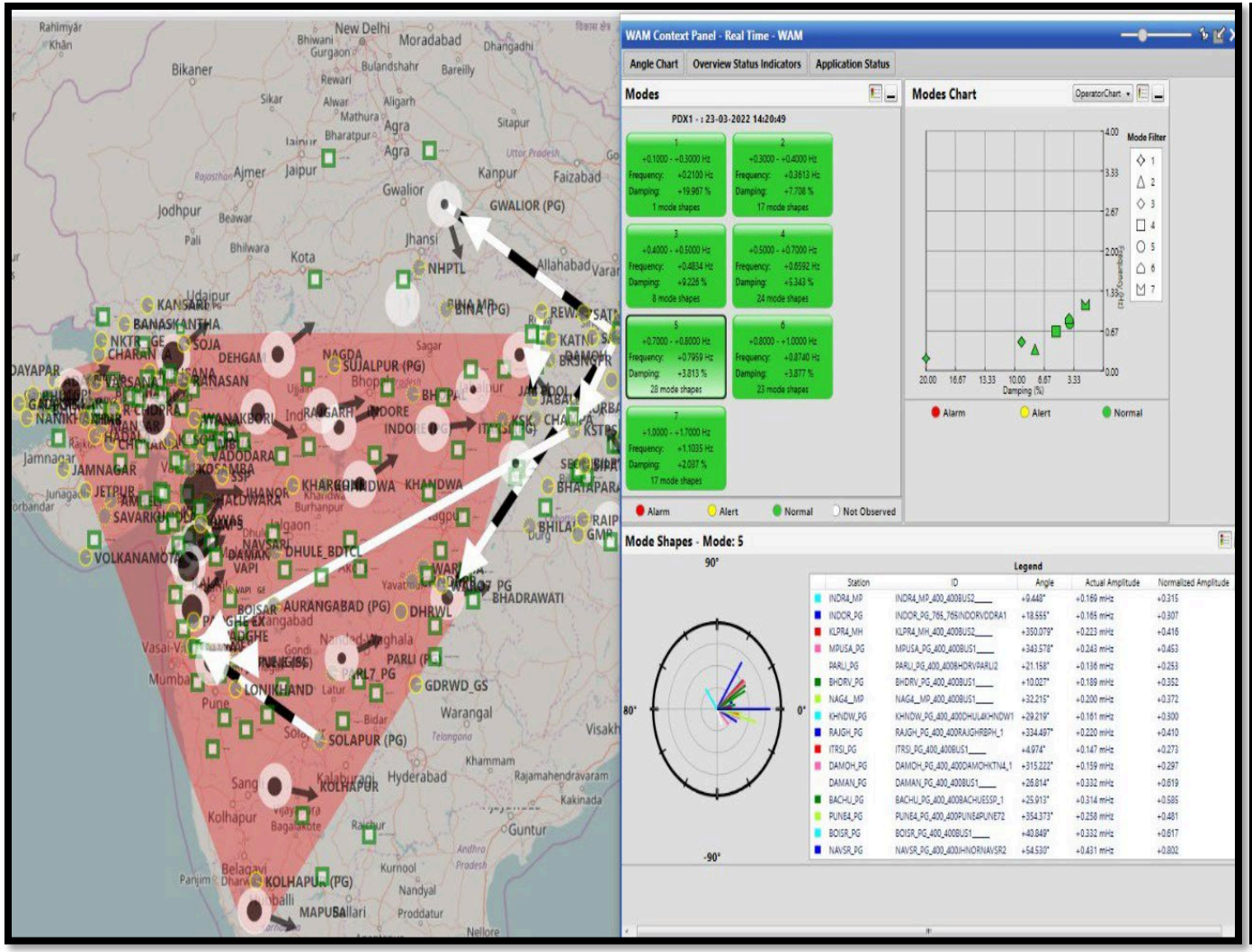
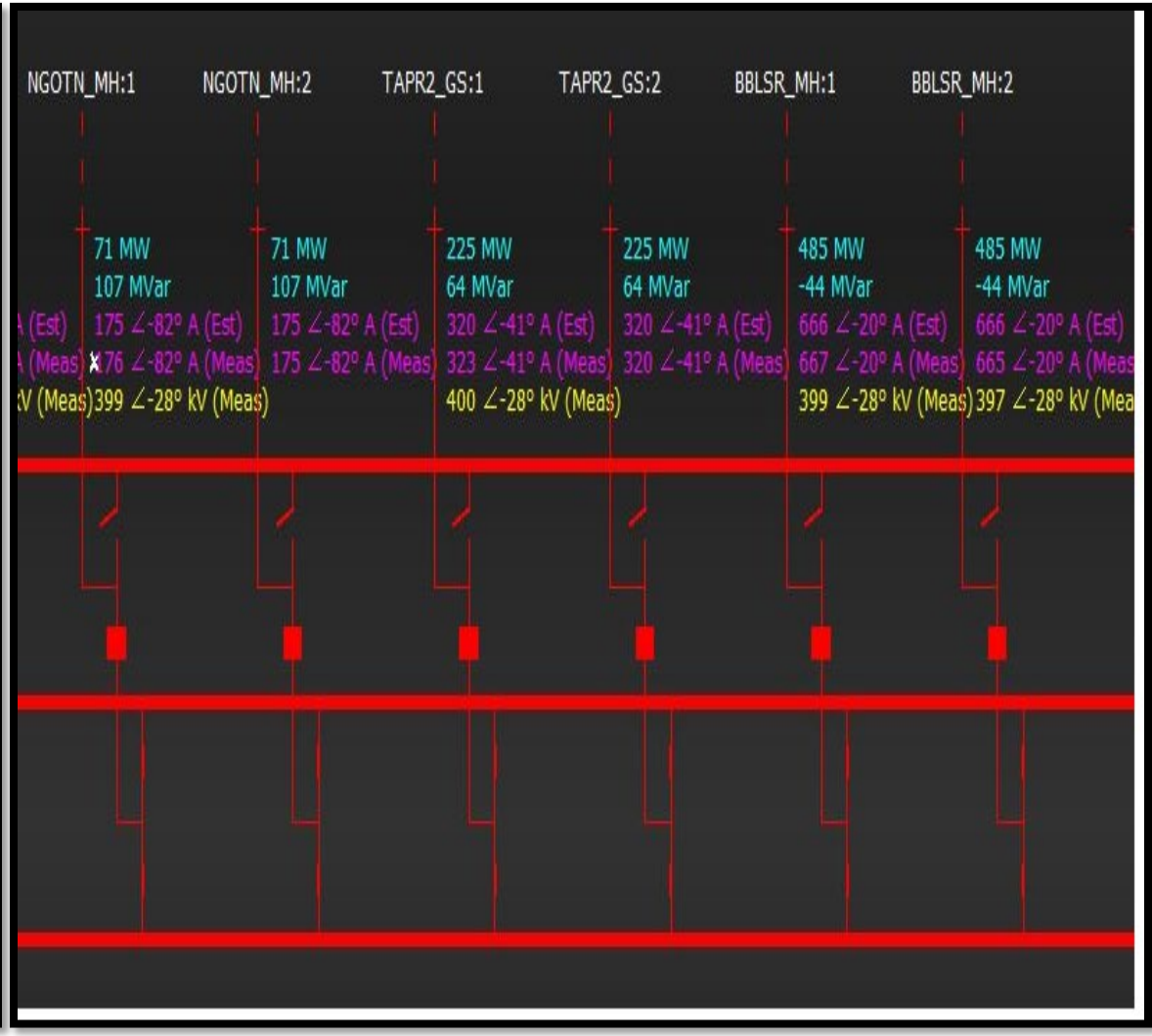
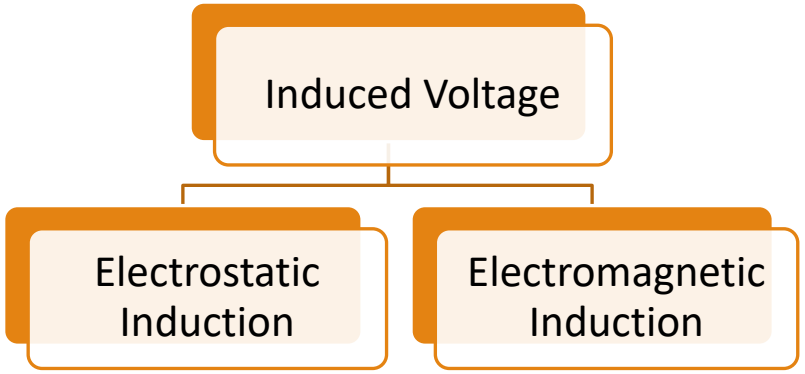
Oscillatory Stability Management (OSM)



Linear state estimation

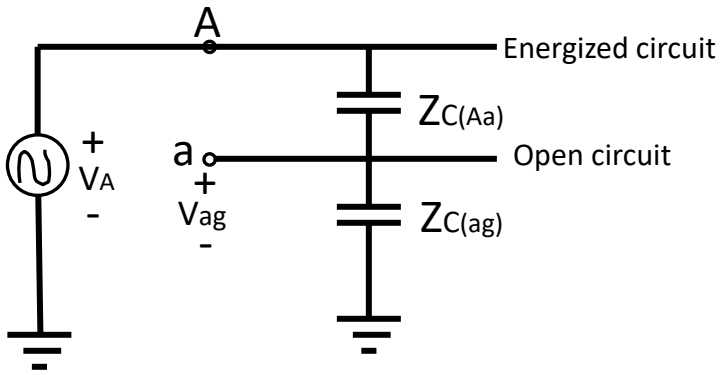


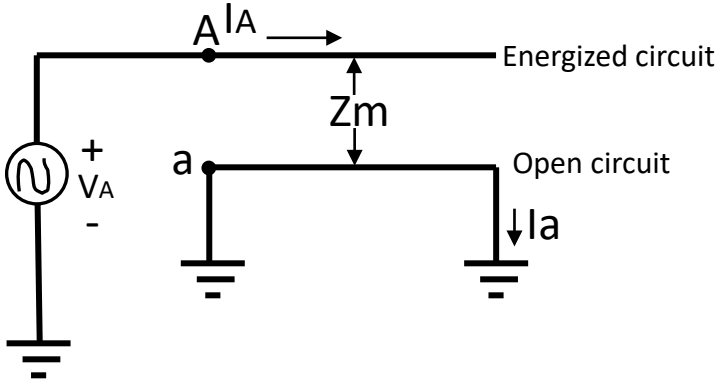
Induced and Resonance Voltage:

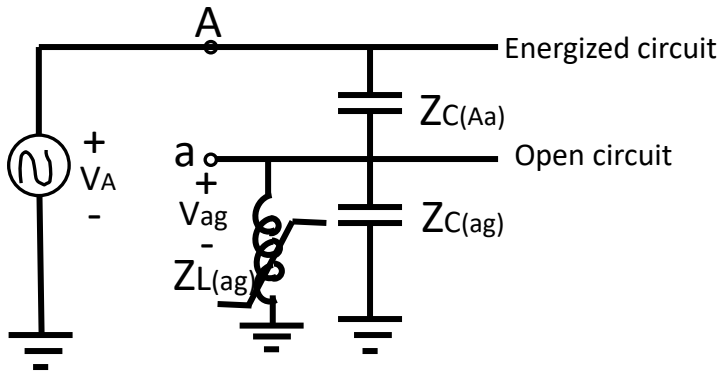


Resonance Voltage

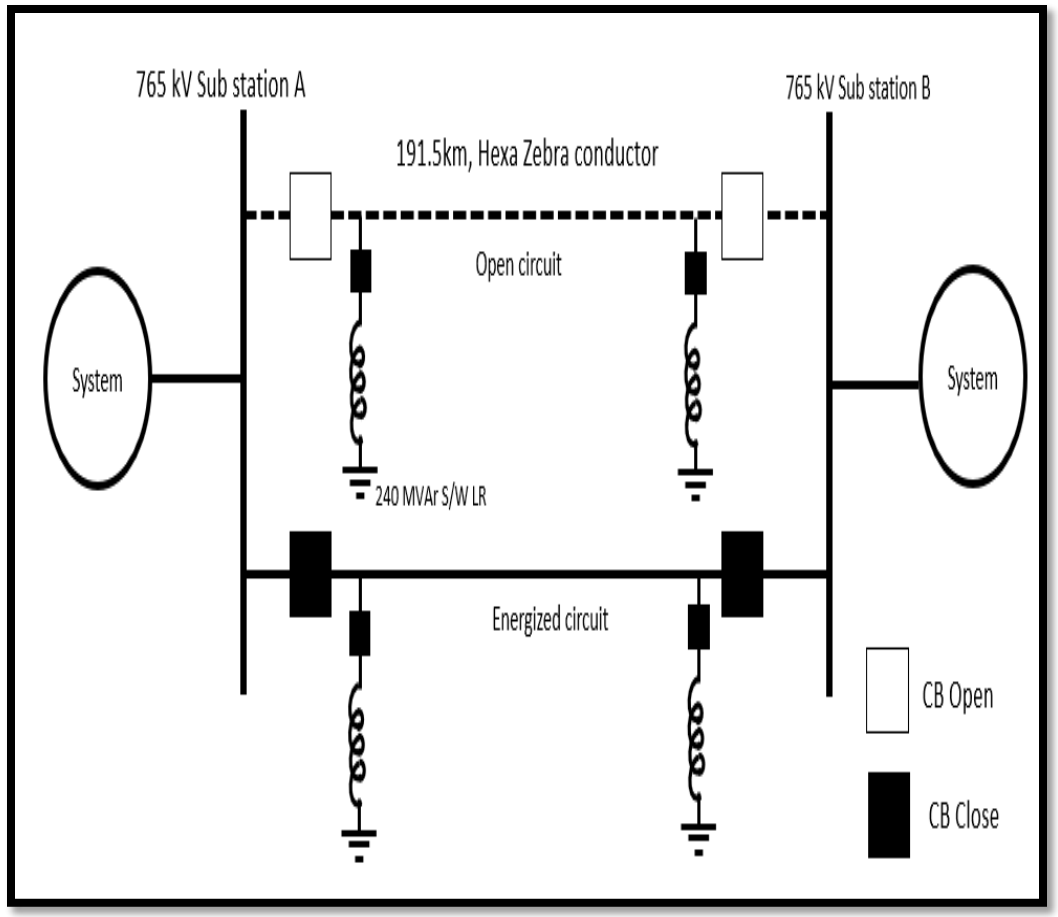
The Ferroresonance is a type of resonance involving a capacitance in series with a nonlinear inductance. The ferroresonance oscillations can be periodic, quasi periodic or chaotic.





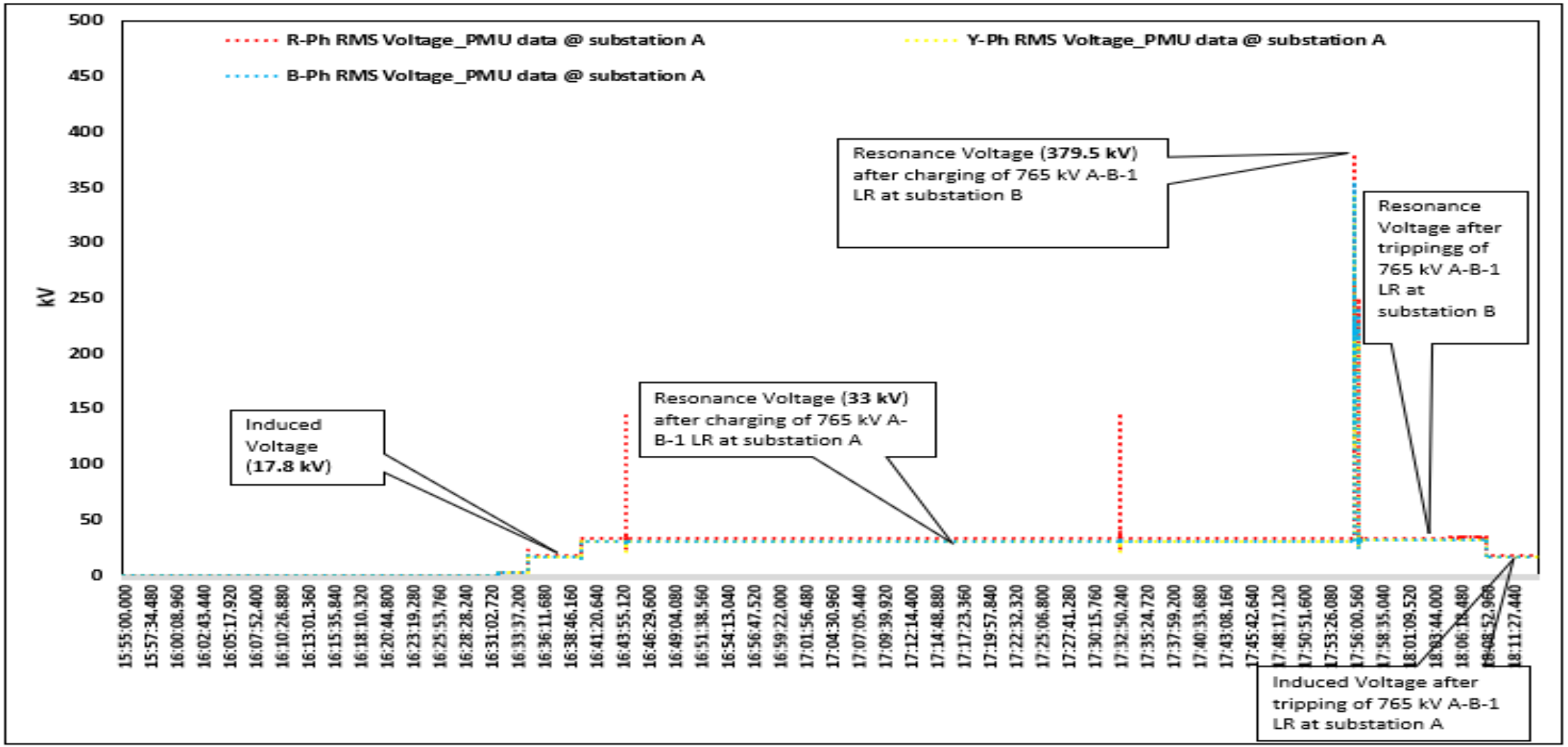


Case Study: Induced and Resonance voltage phenomenon in 765 kV corridor



- 765 kV double circuit between A and B: 191.5km, Hexa Zebra conductor
- 240 MVAr switchable line reactor (SLR) at both ends
- 94.5% of reactive power compensation
- Planned for generation evacuation and system strengthening scheme
- First time charging of circuit-2 was facilitated after compliance of First Time Charging (FTC) procedure and after conducting of steady state studies in real time depend on system conditions and ckt charged with SLR at both ends
- Grid code was issued for first time charging of ckt-1

Induced and Resonance Voltage observation in PMU installed at Substation A:



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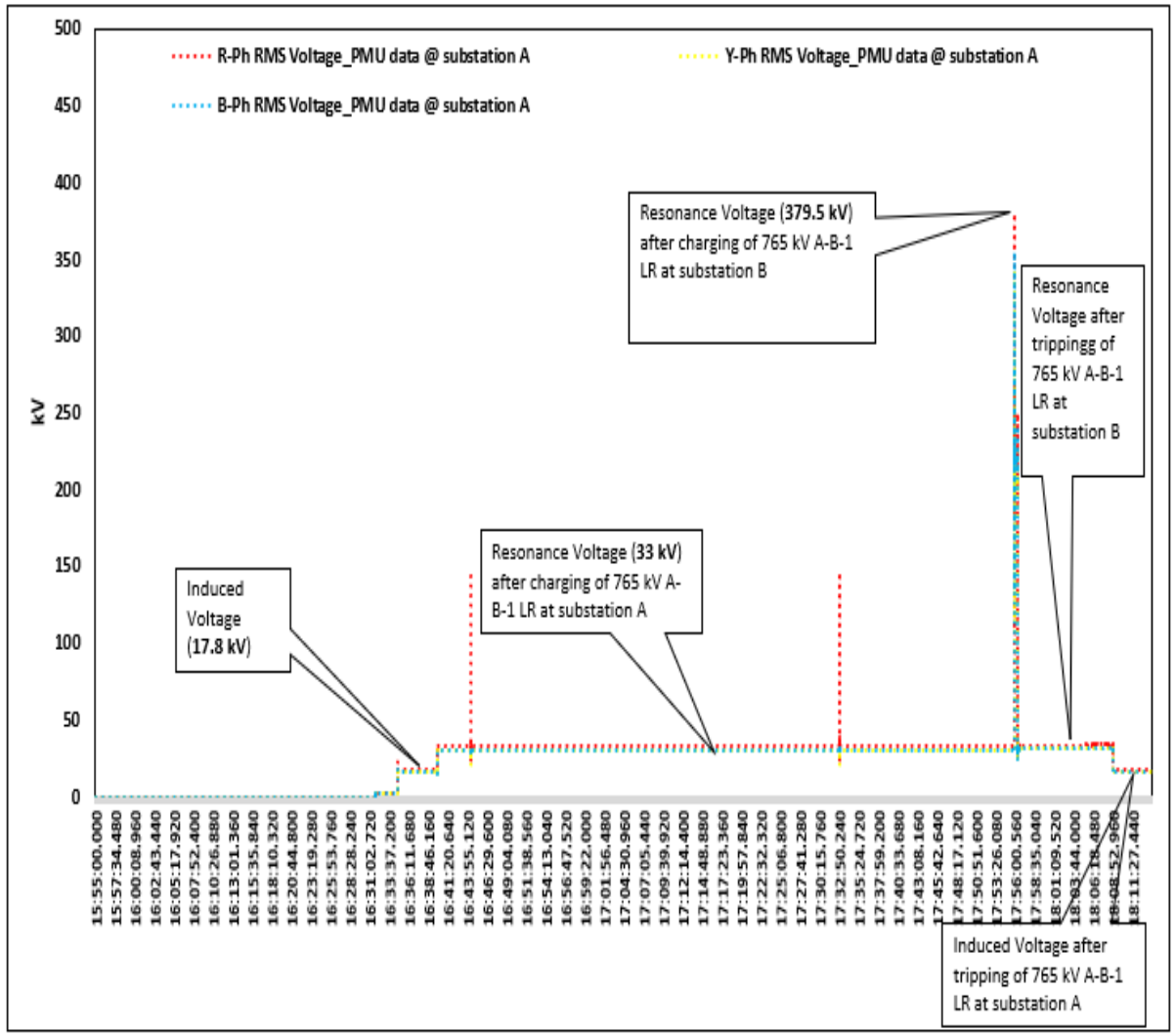
S No	Number of phases opened in circuit 1	Description	Maximum voltage observed in PMU of substation A (kV)
1	3	Induced voltage (without LR at both ends)	17.8
2	3	Resonance Voltage (With 240 MVAr LR at substation A)	33
3	3	Resonance Voltage (With 240 MVAr LR at substation A and B)	379.5

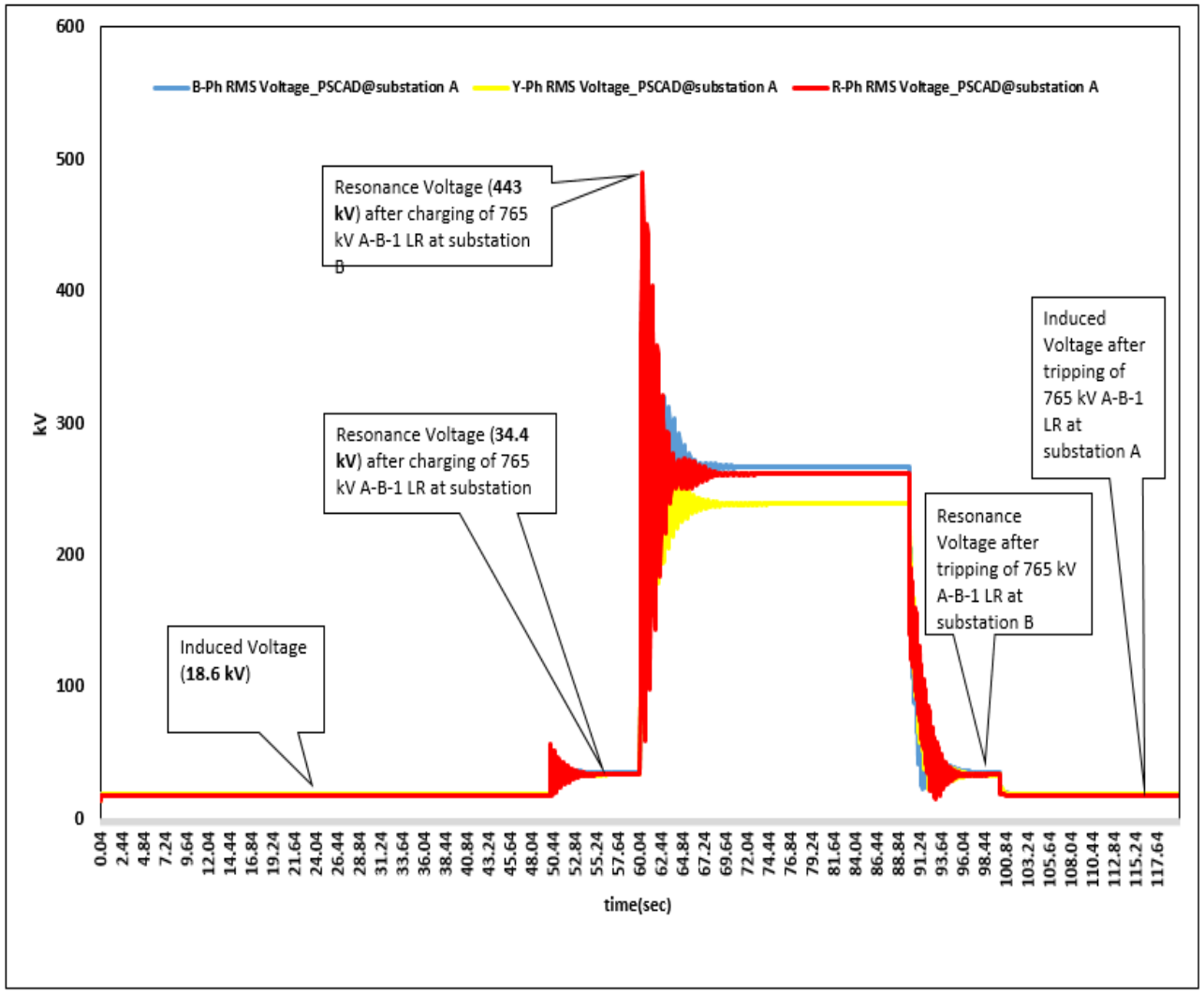
Simulation Model:

- Electromagnetic Transient (EMT) study in PSCAD with following details
  - ❑ **Details collected from Transmission licensee:**
  - ✓ Transmission Tower details
  - ✓ Transposition details
  - ✓ Line reactor and Neutral Grounding Reactor (NGR) details

  - ❑ Thevenin voltage sources at Station A and B were modelled to accurately represent the fault current contribution from the remote system

Comparison of Simulation results with PMU data:





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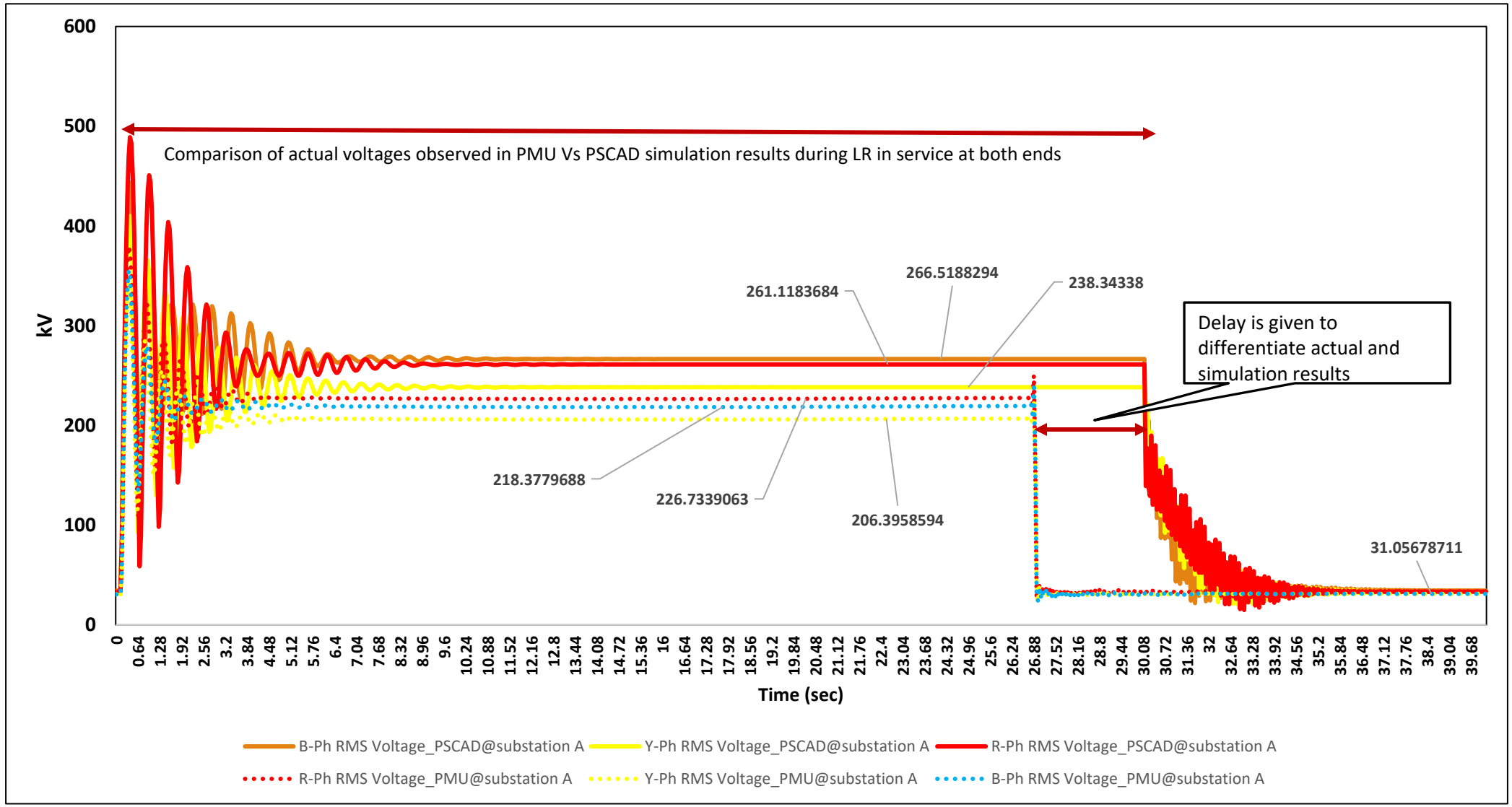
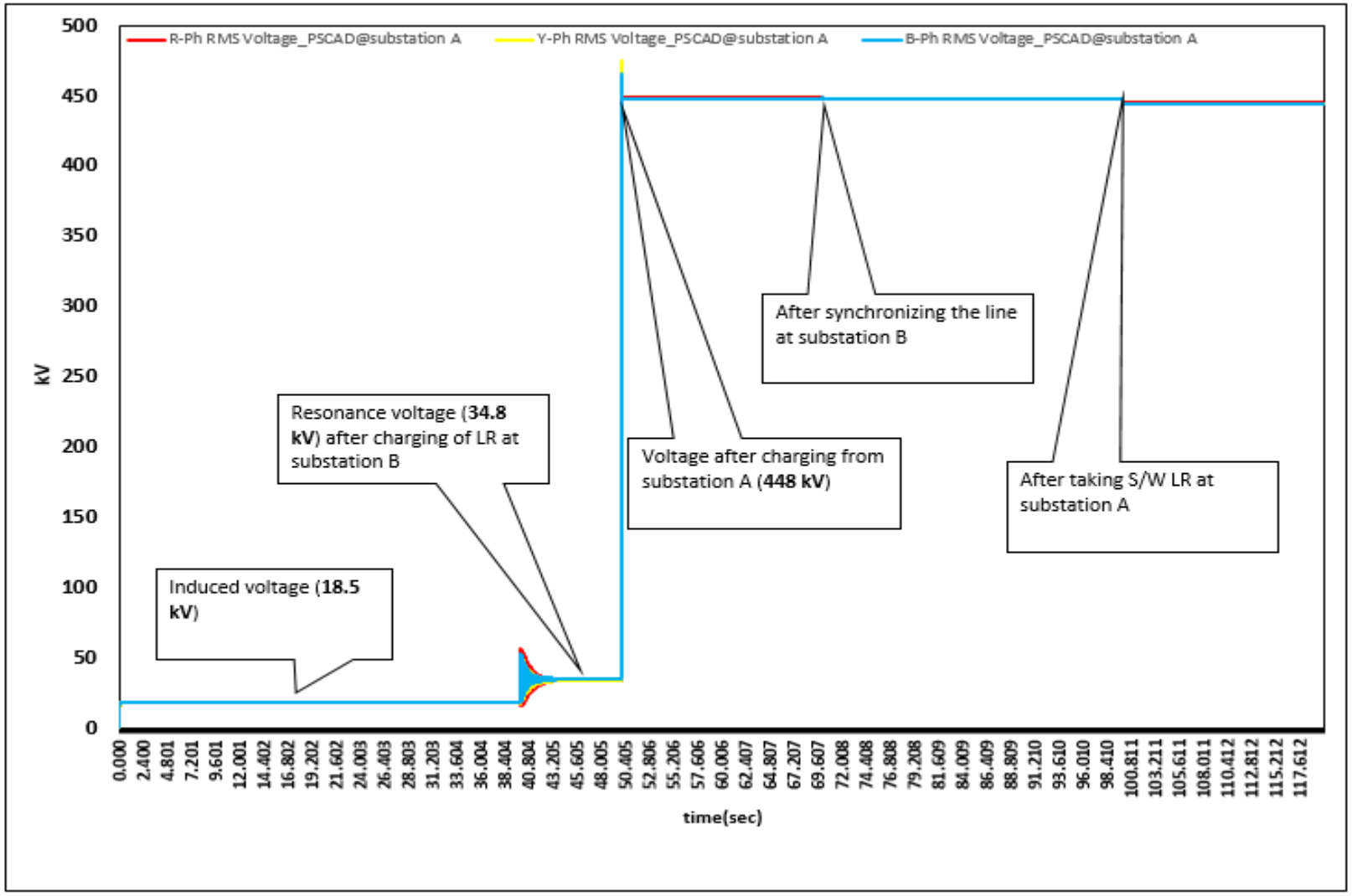
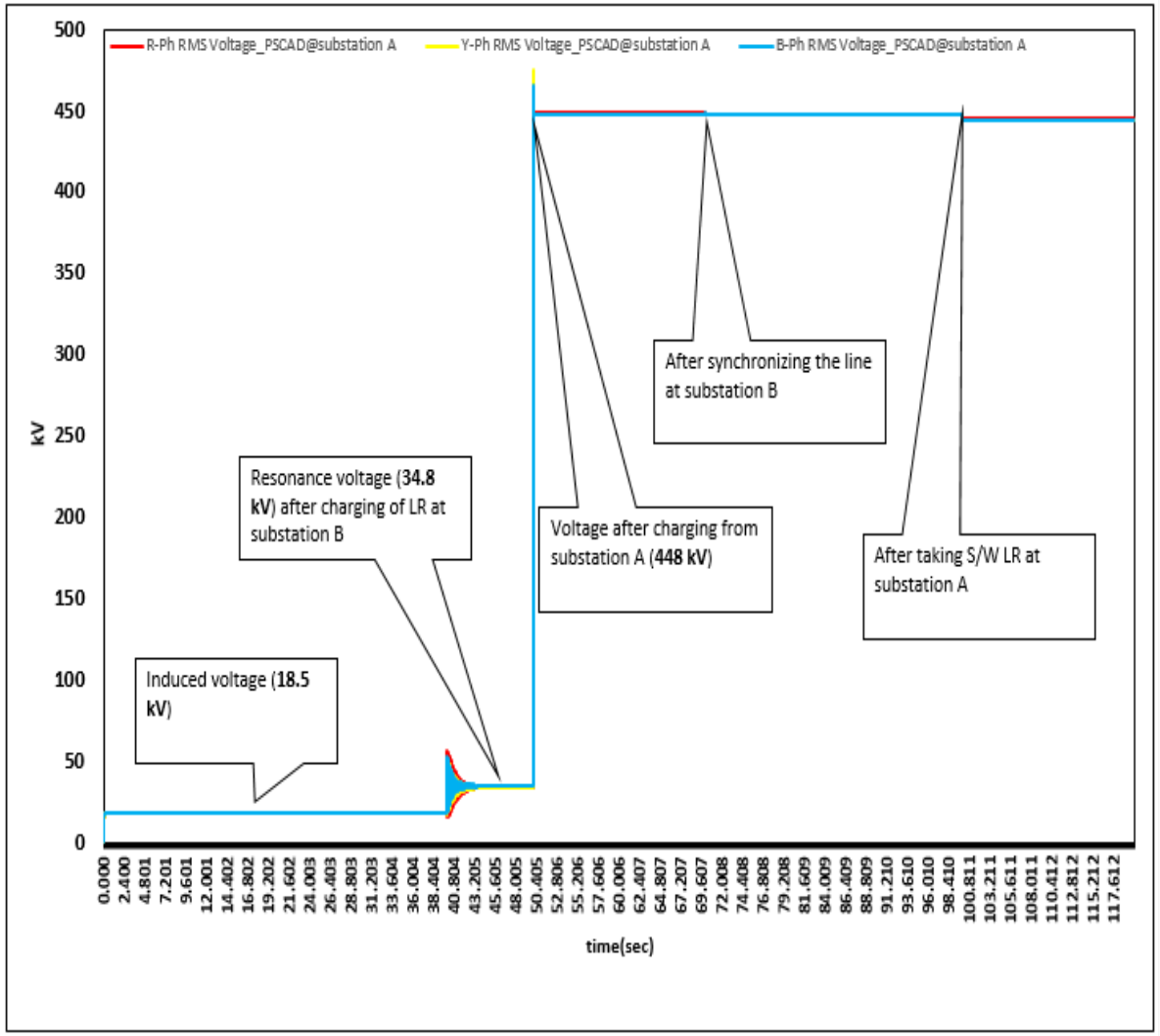

Comparison of actual voltages observed in PMU Vs PSCAD simulation results during LR in service at both ends
261.1183684
266.5188294
238.34338
Delay is given to differentiate actual and simulation results
218.3779688
226.7339063
206.3958594
31.05678711
kV
Time (sec)
B-Ph RMS Voltage_PSCAD@substation A
Y-Ph RMS Voltage_PSCAD@substation A
R-Ph RMS Voltage_PSCAD@substation A
R-Ph RMS Voltage_PMU@substation A
Y-Ph RMS Voltage_PMU@substation A
B-Ph RMS Voltage_PMU@substation A

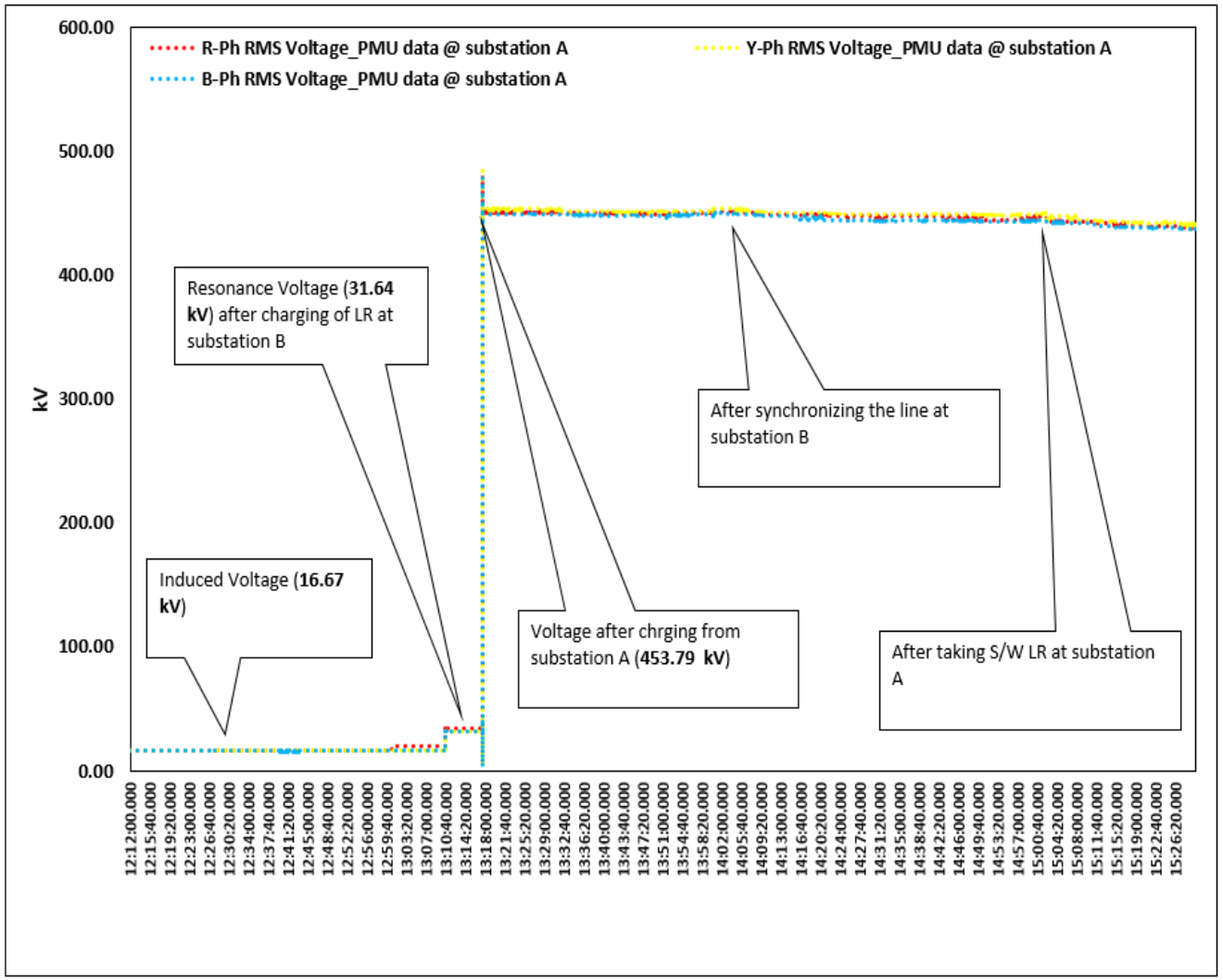
Mitigation measures:



Charge the line with LR at only one end in service to reduce the percentage compensation and control the high induced plus resonance voltage phenomenon. After successful charging of line, another end LR to be taken into service

Comparison of simulation results with PMU data:





Summary:

- Utilization of Synchrophasor measurements for detection of Induced and Resonance voltage phenomena during real time system operation
- Evaluation of mitigation measures

References:

1. A. J. F. Keri, A. Jain D. Kidd, A. S. Mehraban, “Resonances, Safety And Parallel Transmission Lines”, CIGRE US National Committee, 2012 Grid of the Future Symposium

2. R. Horton, K. Wallace, “Induced Voltage and Current in Parallel Transmission Lines: Causes and Concern,” IEEE Trans. on Power Delivery, Vol. 23, Oct. 2008

Thank You

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