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

Minnakuri Venkateswara Rao
Pushpa Seshadri
Pradeep Kumar Sanodiya
Priyam Jain
Saibal Ghosh
Srinivas Chituri
Vishal Puppala
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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: 127.94 GW

Installed Capacity: 117.95 GW

Installed Capacity: 110.45 GW

Installed Capacity: 34.23 GW

Installed Capacity: 4.93 GW

Source: Installed capacity report of CEA
Utilization of PMU data in real time system operation:

PMU locations in India

Alarms

Angle difference
Contd..

Geographical view

Contour displays
Oscillatory Stability Management (OSM)

Linear state estimation
Induced and Resonance Voltage:

**Induced Voltage**

- Electrostatic Induction
- Electromagnetic Induction

**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.

![Diagram of induced and resonance voltage](image_url)

Session # 14, 04:30-04:50 pm Power System Operation Corporation Limited, India
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:

- **Induced Voltage (17.8 kV)**
- **Resonance Voltage (379.5 kV) after charging of 765 kV A-B-1 LR at Substation B**
- **Resonance Voltage after tripping of 765 kV A-B-1 LR at Substation B**
- **Induced Voltage after tripping of 765 kV A-B-1 LR at Substation A**
<table>
<thead>
<tr>
<th>S No</th>
<th>Number of phases opened in circuit 1</th>
<th>Description</th>
<th>Maximum voltage observed in PMU of substation A (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>Induced voltage (without LR at both ends)</td>
<td>17.8</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Resonance Voltage (With 240 MVAR LR at substation A)</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Resonance Voltage (With 240 MVAR LR at substation A and B)</td>
<td>379.5</td>
</tr>
</tbody>
</table>
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:

- Resonance Voltage (177.3 kV) after charging of 765 kV A-B-1 LR at substation B
- Resonance Voltage after tripping of 765 kV A-B-1 LR at substation B
- Resonance Voltage (53 kV) after charging of 765 kV A-B-1 LR at substation A
- Induced Voltage (17.8 kV)
- Induced Voltage after tripping of 765 kV A-B-1 LR at substation A
- Resonance Voltage (443 kV) after charging of 765 kV A-B-1 LR at substation A
- Induced Voltage after tripping of 765 kV A-B-1 LR at substation A
Contd..

Comparison of actual voltages observed in PMU Vs PSCAD simulation results during LR in service at both ends

Delay is given to differentiate actual and simulation results.
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:

- Resonance voltage (34.8 kV) after charging of LR at substation B
- Voltage after charging from substation A (448 kV)
- After synchronizing the line at substation B
- Induced voltage (18.5 kV)

- Induced Voltage (16.67 kV)
- Voltage after charging from substation A (453.7 kV)
- After taking 5/5 LR at substation A

- Resonance Voltage (31.64 kV) after charging of LR at substation B
- After synchronizing the line at substation B
- After taking 5/5 LR at substation A
Summary:

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


Thank You

Email: venkyminnakuri@posoco.in
POSOCO, India