



EPRI Virtual Power System Stability and Oscillation Focused (PSSO) Forum



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Kickoff, 24 June 2026

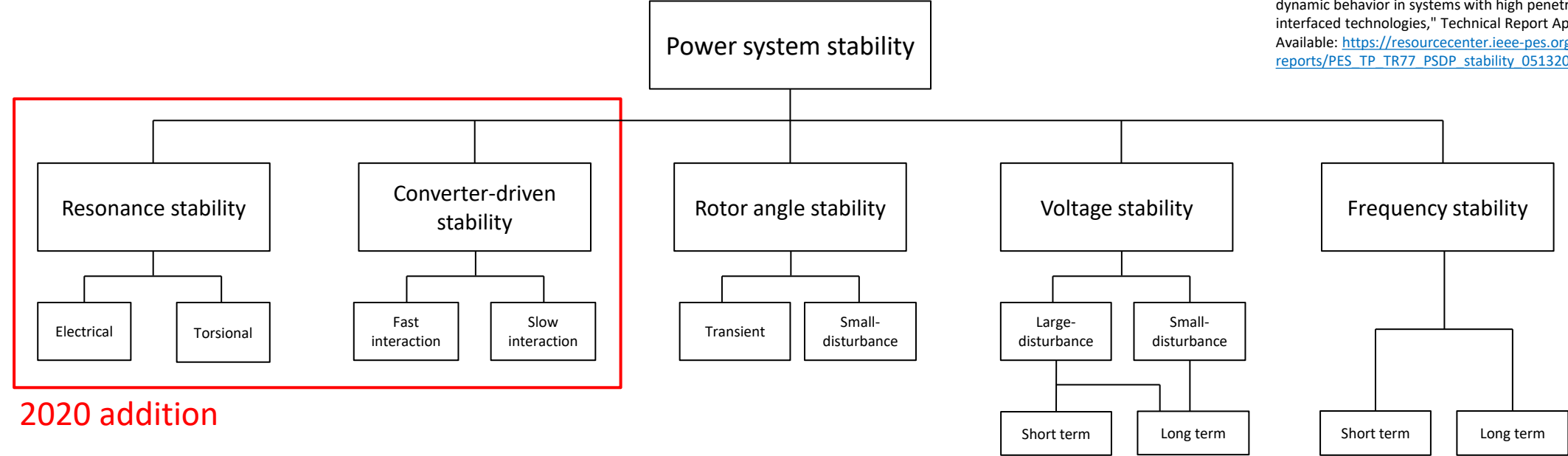
Overview

- Public forum bringing together stakeholders across the electric power system sector to engage in focused discussions on power system stability and oscillatory phenomena.
- Format
 - Fully virtual
 - One meeting every two months
 - One hour per session
 - 30-minute technical presentation
 - 30-minute open, moderated discussion
- With the presenter's permission, **all presentation materials will be made publicly accessible at no cost**, supporting broader industry learning and transparency (**link coming soon**)
- Contact **Deepak Ramasubramanian**, dramasubramanian@epri.com or **Evangelos Farantatos**, efarantatos@epri.com
- To register, contact **Kayla Poland**, kpoland@epri.com or complete the Microsoft Form located [here](#)



Classification of power system stability expanded to reflect increase in IBR

Figure from: PES-TR77, "Stability definitions and characterization of dynamic behavior in systems with high penetration of power electronic interfaced technologies," Technical Report April, 2020. [Online]. Available: https://resourcecenter.ieee-pes.org/publications/technical-reports/PES_TP_TR77_PSDP_stability_051320.html



2020 addition

Resonance stability	Torsional	➤ SSR: interactions between series compensation and torsional models of the turbine-generator mechanical shaft ➤ SSTI/DDSSO: interaction of PE controls with mechanical torsional models of turbine-generator shaft
	Electrical	SSCI: Resonance between the effective inductance of an induction generator and a series capacitor
Converter-driven stability	Slow interaction	< ~10 Hz: Examples include interactions between the control of power electronic-based devices and electromechanical dynamics of synchronous machines, synchronous machine control, or network. Low frequency oscillations due to power electronic-based device control and system strength are included in this classification.
	Fast interaction	> ~10 Hz up to kHz: Examples include interactions between the control of power electronic-based devices and the network, or other PE-based devices

Various phenomena associated with stability of power systems

Observed Solar PV Reliability Issues Are Rooted in Insufficient Unit Performance and Plant Design:

Inverter related causes

- PLL Loss of Synchronism
- AC Under- or Overvoltage
- Under- or Overfrequency
- Momentary Cessation
- Inverter AC Overcurrent
- Inverter DC Voltage

Plant controller related causes

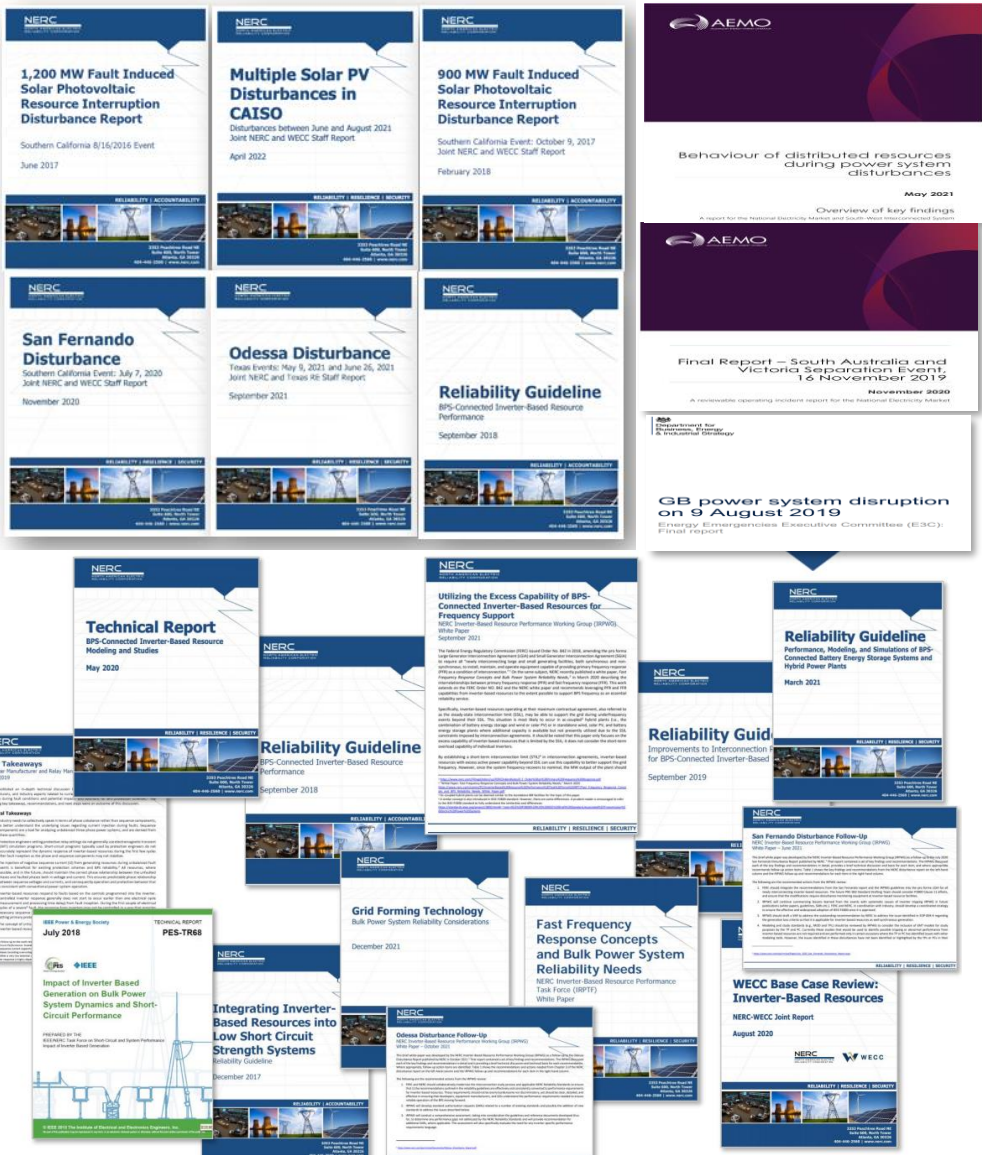
- Slow Active Power Recovery

Collector system related causes

- Feeder AC Overvoltage
- Feeder Underfrequency

NERC recommendations call for more than just guidelines:

- Improvements to NERC Reliability Standards
 - Improvements to Performance-Based Requirements
 - Performance Assessment and Mitigation
 - Ride-Through Standard In Lieu Of PRC-024-3
 - Analysis and Reporting of Inverter-Based Resource Reductions
 - Electromagnetic Transient Modeling and Studies for All Newly Interconnecting Inverter-Based Resources
- Significant Updates and Improvements to the FERC Generator Interconnection Agreements



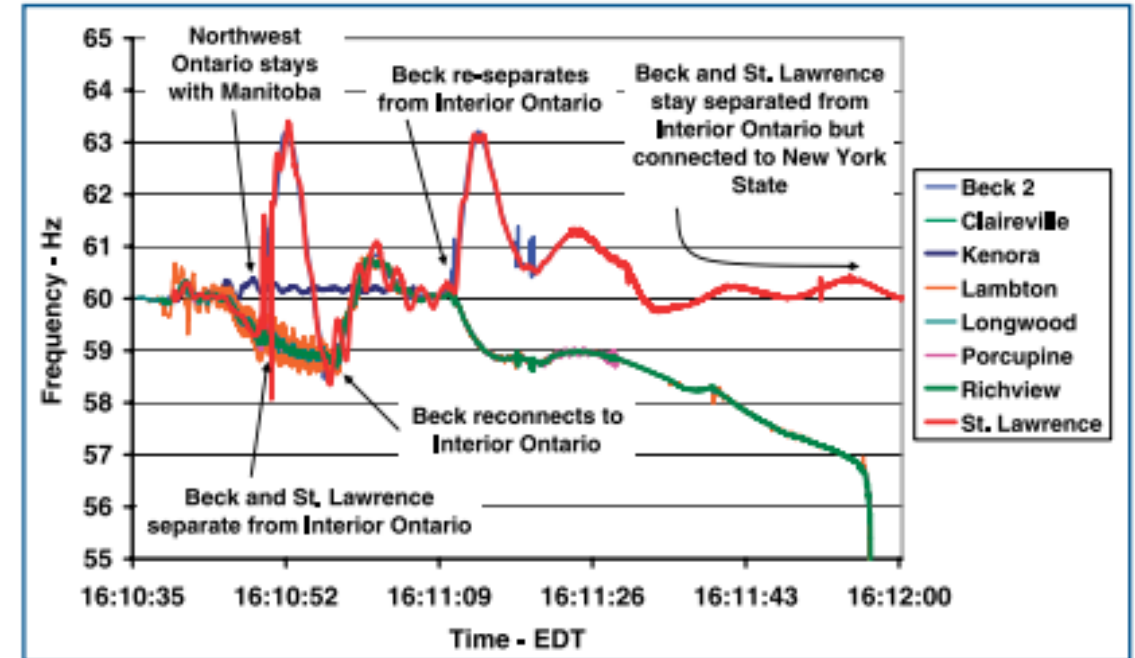
Increasing number of events occurring that appear to take the system to the edge

Events associated with power system stability (non-exhaustive)

2003 North American Blackout

- Primary driver
 - Voltage Instability / Collapse
- High load, outage of key transmission lines
- Simulation/Analysis software latent bugs

Figure 6.27. Frequency Separation Between Ontario and Western New York



https://www.nerc.com/globalassets/our-work/reports/event-reports/august_2003_blackout_final_report.pdf

2016 South Australian Blackout

- Primary driver
 - Frequency/Angular Instability
- Severe weather, loss of three major 275 kV transmission lines.
- Large loss of generation resulting in loss of synchronism between areas

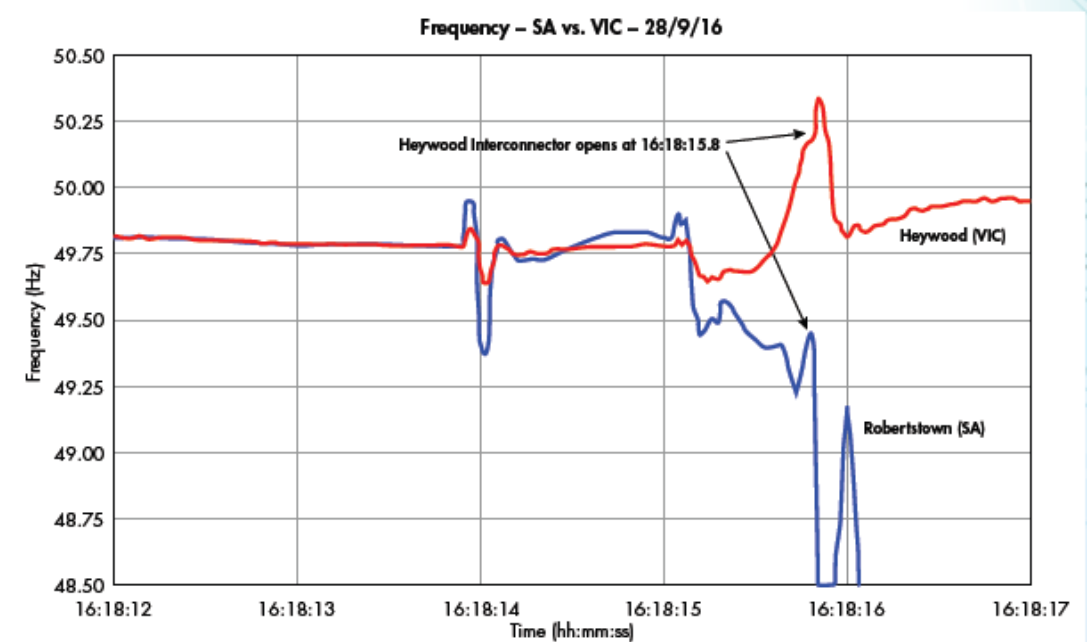


Figure 2. Frequency in the SA and Victoria systems before and after the disconnection of the Heywood Interconnector.
[Source: AEMO- UPDATE REPORT – BLACK SYSTEM EVENT IN SOUTH AUSTRALIA ON 28 SEPTEMBER 2016]

<https://www.epri.com/research/products/000000003002009882>

2025 Wyoming, South Dakota Blackout

- Primary driver
 - Voltage Instability/collapse
- Cascading outage of dozens of transmission lines
- loss of more than 1 GW of load and 4.5 GW of generation .

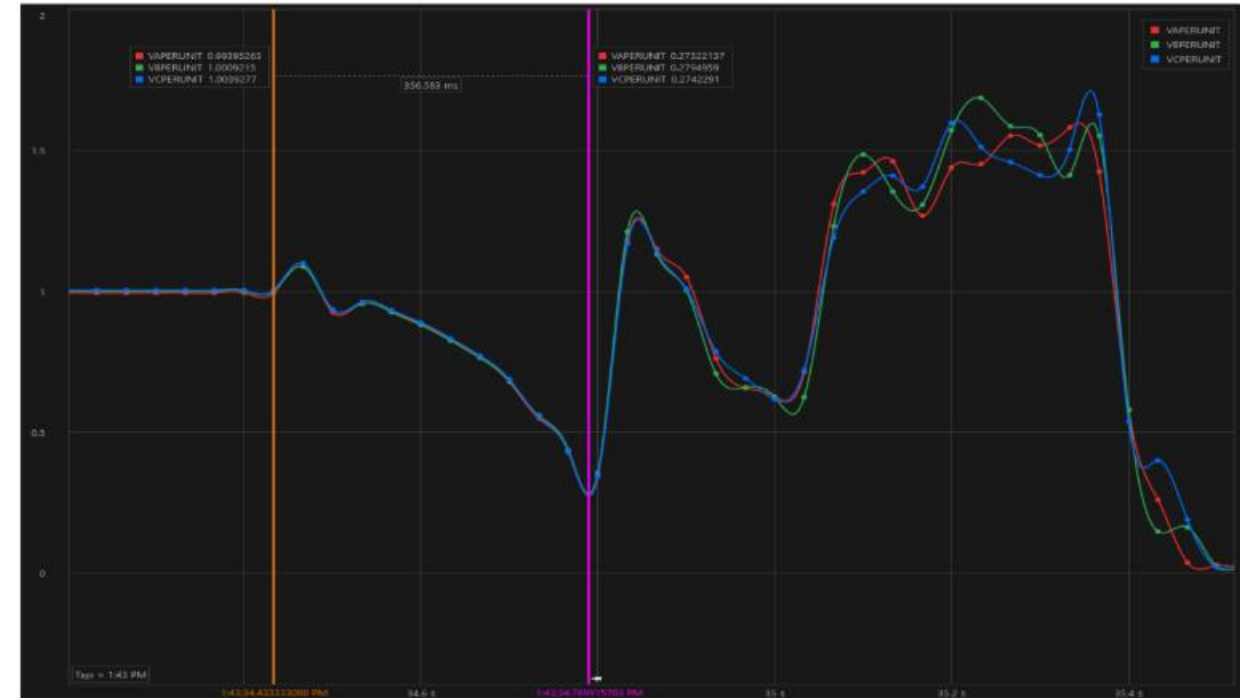


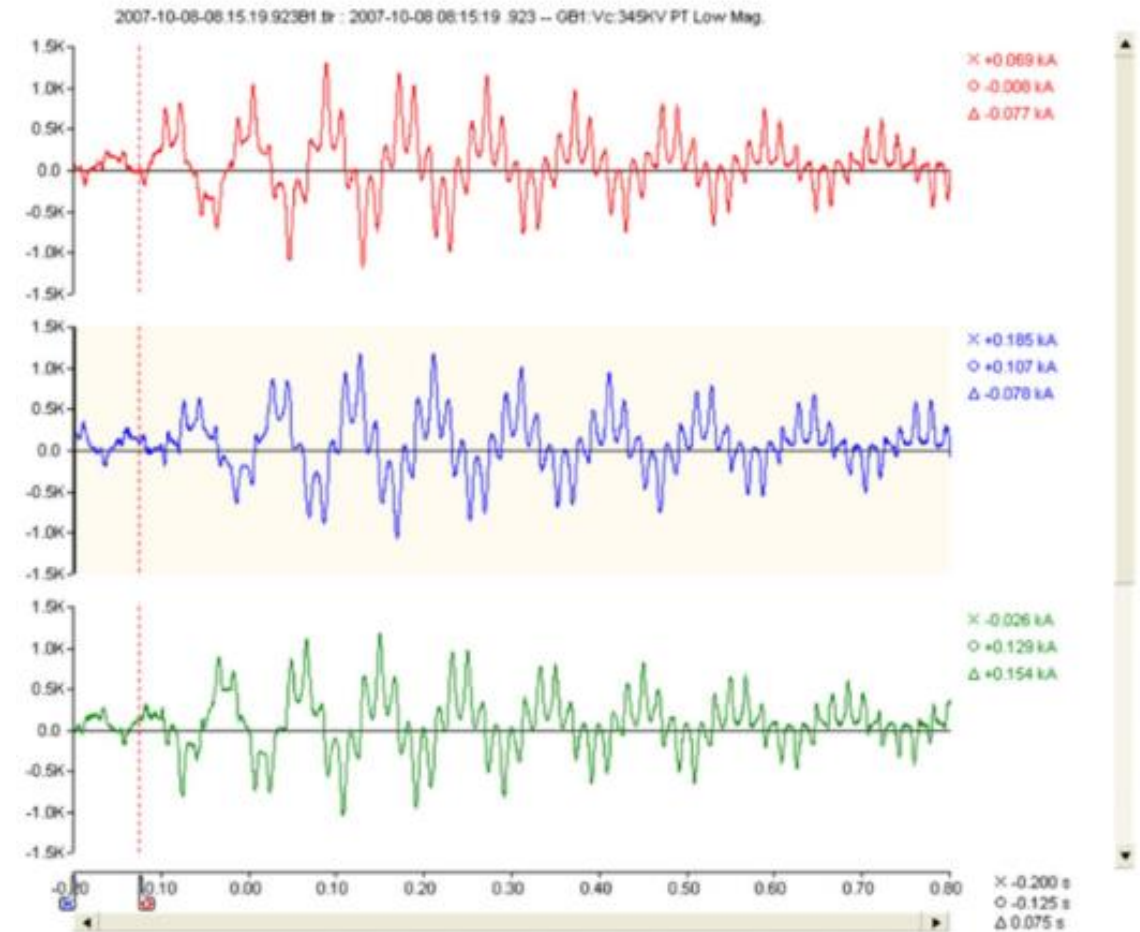
Figure 3: Aeolus 500 kV bus volts (orange marks the time of Aeolus–Clover line opening; magenta marks the time of Aeolus–Anticline tripping).

<https://www.wecc.org/wecc-document/28226>

Events associated with power system oscillation (non-exhaustive)

2007 Minnesota

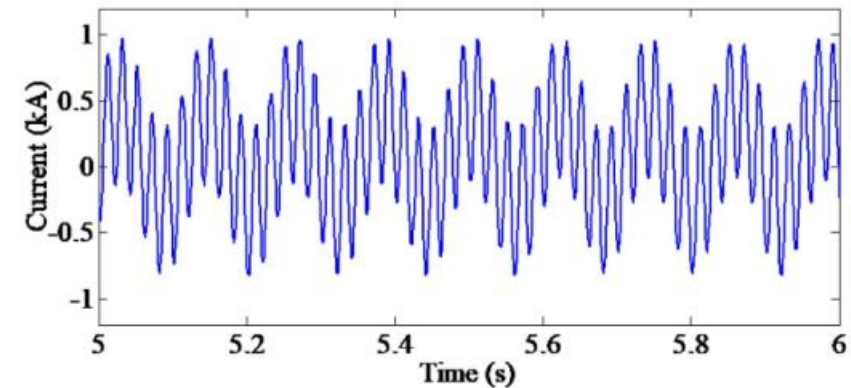
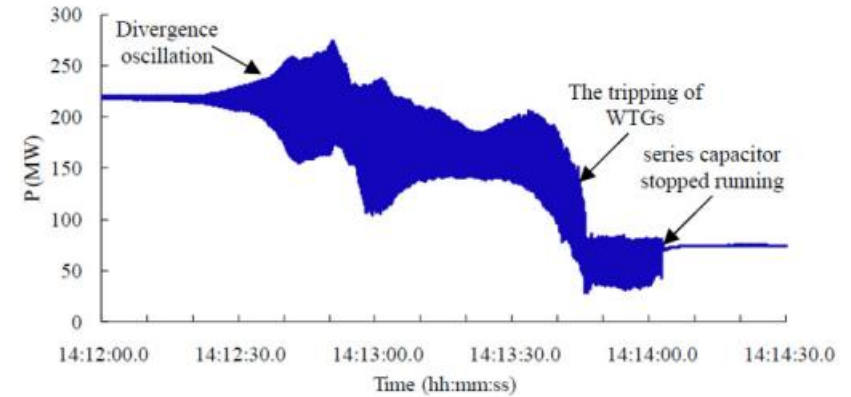
- Primary driver
 - Series compensation
- Wind plant and combustion turbine generator units placed in a radial connection with a series capacitor



<https://ieeexplore.ieee.org/document/9740416>

2012 – 2013 North China

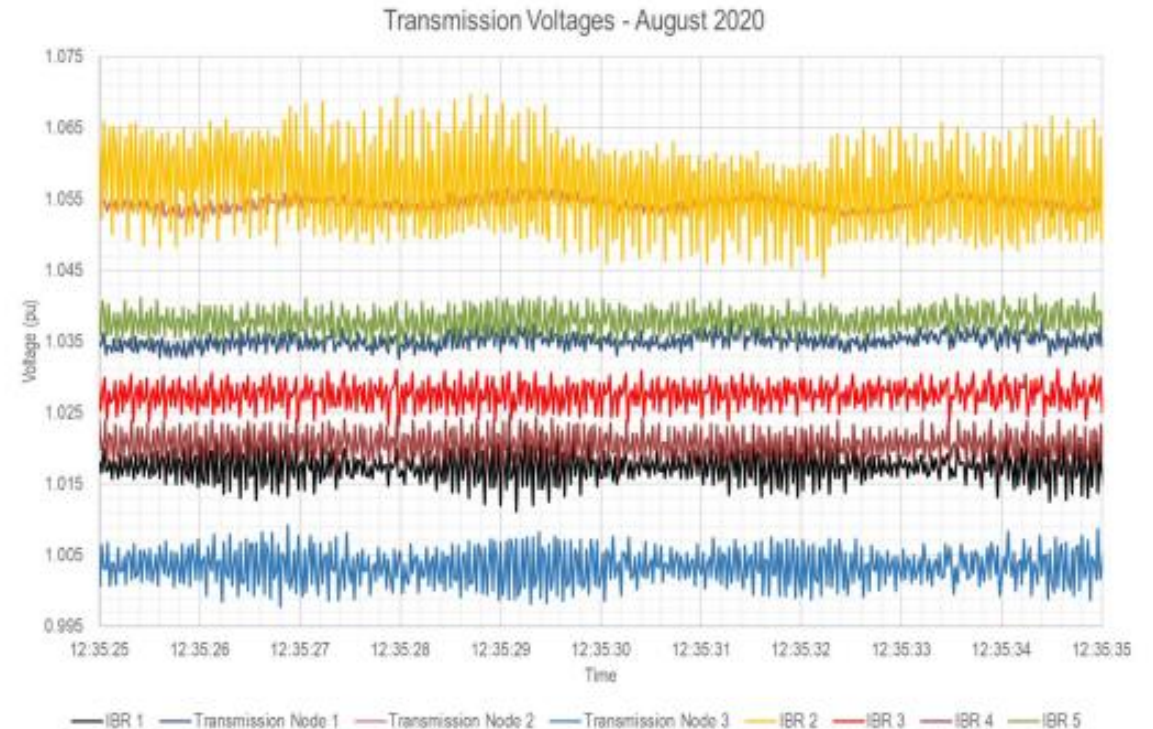
- Primary driver
 - Series compensation
- Wind plants interacting with multiple series capacitors
- If any one of the series capacitors is bypassed, oscillation is not present



<https://ieeexplore.ieee.org/document/9740416>

2020 Australia

- Primary driver
 - Weak grids and IBR controls
- Multiple IBR plants in an area interacting with each other
- Different versions of control and OEMs



<https://ieeexplore.ieee.org/document/9740416>

Topics relevant for this forum

Notions of stability and oscillations

- Is there a need to change existing classifications of stability
- Example:
 - Many regions have reports oscillations in the range of 0.1Hz to 3Hz
 - Classically, such modes tagged as inter-area or local modes
 - There is however an emerging trend to classify these oscillations as SSO

What changes need to be brought about in planning criteria?

- There is a need to improve interoperability of various devices
- This may require controller design criteria that promote the notion of 'do-no-harm' on the network
- Are such controller designs possible and to what extent can guarantees of stability be provided?

Do we have the requisite software tools and methods?

- Tools (commercial and research grade) for both frequency domain evaluation and Eigen value evaluation exist and are available.
- Challenges that remain (non-exhaustive):
 - Handling multiple operating points in an efficient manner
 - Data sharing rules/requirements between OEM and TP/PC
 - With whom does the burden lie?
 - Using blackbox models
 - Time domain to frequency domain?
 - Linearized state space?
 - Interpreting results
 - Identification of participation in mode and assigning responsibility of mitigation

Will deployment of AGS/GFM hide issues present in the network?

- IBR control architectures such as AGS/GFM can bring about an improvement in damping, if designed and tuned well.
- However, many historical stability events have been due to either inadvertent settings, or design flaws.
- Will the presence of devices that provide improved damping serve to hide the present issues (sweeping it under the rug)?

New types of instabilities and interactions

- What new forms of instabilities would arise in our power system, especially with changing nature of generation & load?
- How to evaluate, screen, and consider impacts on stability due to large loads?
- For large loads, can power system side mitigation be applied for all instabilities or will there need to be mitigation in consumption profiles?

As an industry, how can we do more to:

- Improve design and planning to reduce occurrence of such events?
- Improve visibility and detection of events?
- Improve deployment of mitigation measures?
- What will be improvements needed in model validation?
- Role played by newer technology (source, network, load side)
- And many more...

Bring your ideas, thoughts, and experiences to the forum

Next PSSO Forum meeting...

- Tentatively in August 2026
- Meeting agenda will be finalized closer to the date
- Technical presentation:
 - Summary and lessons learned from EPRI's member-oriented oscillations management in operations workshop

Reach out to Deepak or Evangelos if you are interested in presenting at a future meeting of the PSSO Forum



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