Study Committee C4

Power System Technical Performance

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Stability with Synchronous Condensers for Power Export from Inverter Dominant Generation Regions

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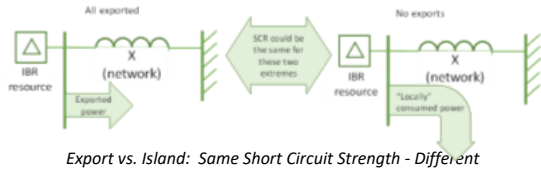
Motivation

- North America grids challenged to transmit massive amounts of inverter-based resources (IBR), i.e. wind and solar power from remote areas across many hundreds of miles/km of EHV AC transmission lines to load centers
- Many solutions. This study focused on use of embedded synchronous condensers to enhance stability



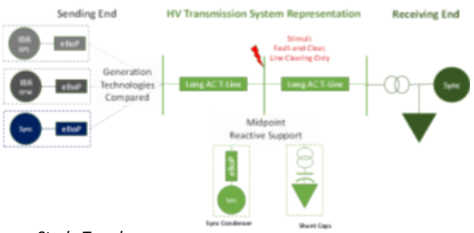
Export vs. Island: Same Short Circuit Strength - Different Problem

Method / Approach

- Synchronous generation vs. Grid-following IBR vs. Grid-forming IBRs
- Time simulations using proprietary detailed EMT supplied by original equipment manufactures
- Tests of system dynamics and determination of illustrative stability limits

Experimental Setup & Test Results

- Full 3 phase, EMT representation

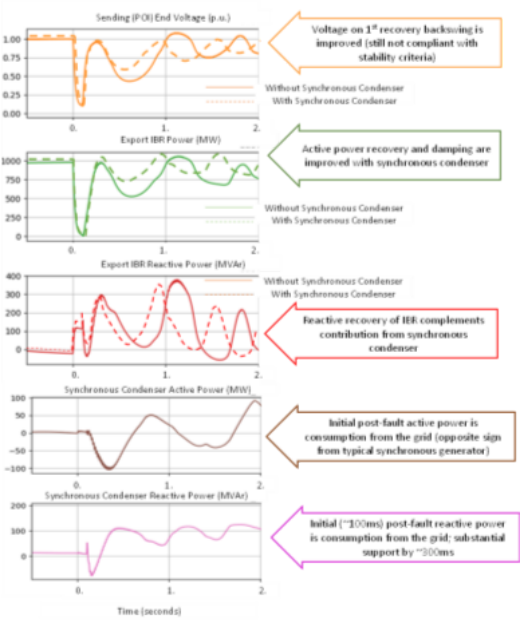


Study Topology

- Interaction of synchronous condensers with inverter-based generation

Discussion

- With condensers, "conventional" electro-mechanical oscillations are to be expected.
- Oscillations driven by reactive power and voltage
- Not the same genesis as with synchronous machine oscillatory interaction
- Adverse interaction with grid-following inverters were observed to be much more acute and complex than with grid-forming inverters



Conclusion

- Synchronous condensers may have the best efficacy in supporting high power transfer levels when located towards the electrical middle of the exporting system, rather than being co-located with the exporting IBRs.
- Oscillatory behavior for a highly stressed exporting system can, but does not necessarily, result in complex interaction between the IBRs and the synchronous condensers.
- System engineers need to be cautious regarding the causality and mitigation of observed oscillations, as they may have different genesis than the more familiar electromechanical swings associated with all synchronous machine systems.
- Controls of the IBRs have a profound effect on the stability of the IBR-dominant system and of the condensers.
- The grid-forming inverter controls used in this study performed substantially better than the grid-following controls.
- This work is insufficient to determine whether the differences are purely due to controls or due to intrinsic differences between the two inverter approaches.