Sub-synchronous oscillations between FPC wind farms, VSC-HVDC links and nuclear power plants



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Scope

- Increase the knowledge and understanding of sub-synchronous oscillations (SSO) between voltage source converters (VSCs) and the mechanical masses of large synchronous generators.
- Identify and describe the different methods used for evaluating subsynchronous oscillations.
- Evaluate the suitability of the different methods for investigating SSO between large synchronous generators and voltage source converters.
- Describe the physical construction and control for the grid connected voltage source converters.
- Implement the evaluation methods on a generic test system, focusing on oscillations between a large synchronous generator and a voltage source converter.



Voltage Source Converters

- Many different topologies are used for grid connected VSCs.
- Looking at the dynamic operation of the VSCs, SSO occurs in the same time range as the lower level controls (such as AC voltage controller) and the phase locked loop (PLL).







Proposed methods for evaluation of SSO

- To evaluate if there is a risk of SSO between a VSC and a synchronous generator, the unit interference factor, UIF, can be used.
- The complex torque method gives the electrical damping seen from the generator and shows the impact of the VSC as shown in the figure.
- By measuring the impedance at subsynchronous frequencies for a VSC, the impact of different control methods can be studied.
- Time domain simulations should be used to verify the occurrence of SSO and include non-linear characteristics of the system.





Conclusions for SSO

- The risk of SSO increases if:
 - The VSC is large
 - The VSC and the synchronous generator are electrically close
 - The grid is weak
- The Unit interaction factor (UIF) is a good tool for showing the risk of SSO.
- The complex torque method is suitable for SSO evaluation for a system with a synchronous generator and a VSC.
- Frequency impedance for a VSC can give the characteristics of the VSC.
- The controller of the VSC has a large impact on the risk of SSO and also determines the possible frequencies for SSO.
- For a wind park, there can be differences between the converters that affects the results.

