Study of Resonance Issues in Wind Farms

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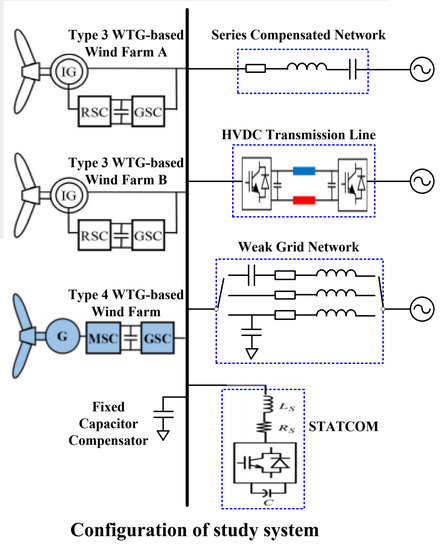
BACKGROUND

With respect to the nature and human beings, the renewable-based wind power generation has gained an increasing popularity in the past years, leading to a large quantity of operational and under-construction wind farms (WFs) around the world. However, the large-scale integration WFs in the existing transmission and distribution networks has brought some issues. Among them, low-frequency oscillations, sub-synchronous resonance (SSR) oscillations and high-frequency resonance (HFR) oscillations have been observed in WFs and caused serious damage to WFs. Therefore, investigations of various resonance issues in WFs are quite crucial.

AIMS AND OBJECTIVES

Investigation and Mitigation of Resonance issues in WFs



Configuration of study system

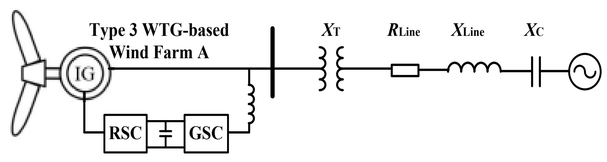
- Time-/frequency-domain study model
  WFs: WTG types, control schemes, operations, etc.
  Transmission systems, FACTS controllers, etc.
- Resonance between different types of WFs and the series compensated network
- Resonance between different types of WFs and the HVDC transmission line
- SSR and HFR Oscillations in weak grid network
- Resonance Mitigation using FACTS controllers, e.g. static synchronous compensator (STATCOM)
- Coordinated control strategies of WFs, HVDC transmission and STATCOM systems

RESULTS

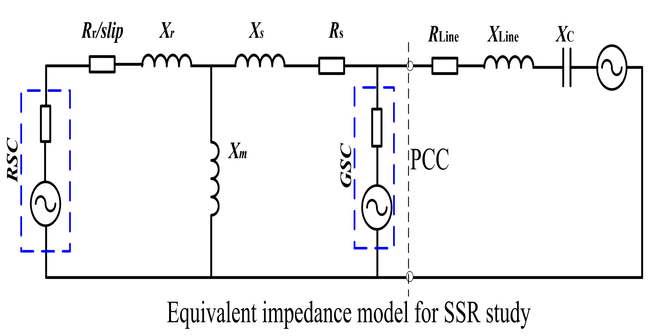
SSR Oscillations between Type 3 WTG-based WF and Series Compensated Network

1) Study Object: Type 3 WTG & Series Compensated Network

- The SSR study model is built based on IEEE First Benchmark Study Model, replacing synchronous generator with Type 3 WTG.
- Due to the power converters in the rotor circuit, Type 3 WTG is actually the most vulnerable type to the SSR incidents.



SSR study model



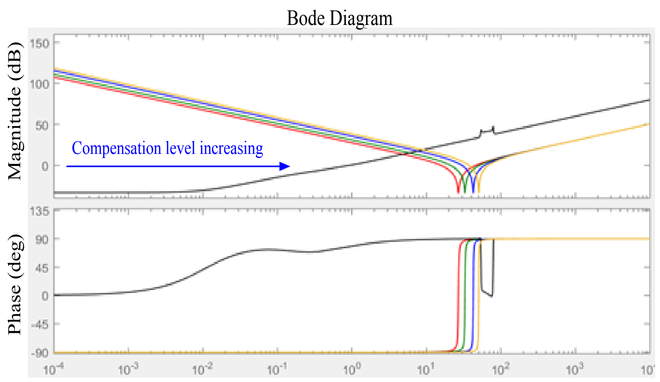
Equivalent impedance model for SSR study

2) Study Objectives

- Investigating the influence of some factors.
- Observing the SSR phenomena in the circuit.

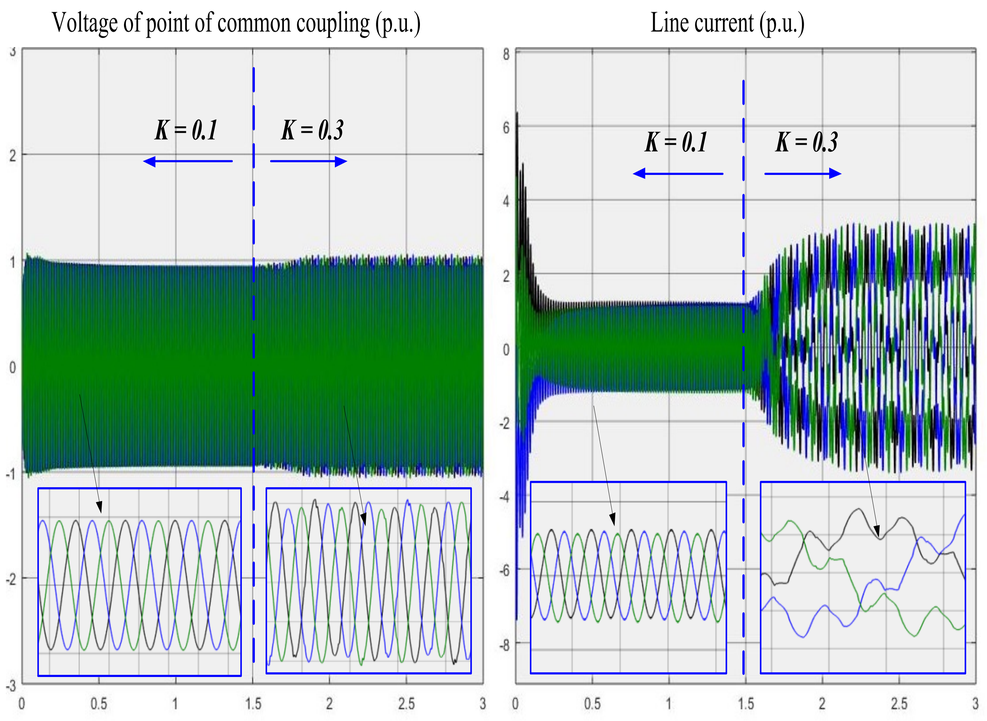
3) Analysis Methods

- Impedance Model-based Analysis.
- Time-Domain Simulations.



Bode diagrams under different compensation levels

Conclusion of Simulation Results	
Important Factors	**SSR damping performance**
Compensation level (*K*)	Negative
Wind speed	Positive
Control gain in RSC inner current loop	Negative



Time domain simulation results under different compensation levels

FUTURE DIRECTIONS

Enhancing the Damping of Wind Farms

1) Mitigation Method for Low-frequency / SSR / HFR Oscillations

- Employing FACTS controllers, e.g. STATCOM / Active use of power converters in WTGs.

2) Coordinated Control Scheme

- WF system: WTG type / control method, WF superior control strategy.
- HVDC transmission system: onshore / offshore station structures, control method.
- FACTS controller system: power rating, control method.

PARTNERS

We are developing collaboration with

Aalborg University

Tsinghua University

University of Calgary

FES PROJECT OVERVIEW

T14-P02

Increasing wind power development in Alberta will lead to significant challenges to the Alberta electrical grid in terms of frequency control, short circuit level, interactions with surrounding systems such as HVDCs. In addition, from WF's perspective, it is important that the Wind Turbine Generators (WTGs) are working properly without early failure. For a large wind farm with hundreds of WTGs, the Operation and Maintenance (O&M) costs account for about 25% of the cost of wind power, while maintenance costs plus revenue loss due to downtime represents roughly 15% of the total cost of energy, and there is great cost reduction potential by enhancing the reliability of wind power generation system. This project will deal with both the grid operation and WF operation issues.

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