Wind Turbine Imbalance Fault Detection Using Current Signals

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Introduction

❖ The penetration of wind power has increased greatly over the last decade in the United States and across the world;

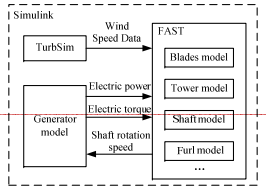
❖ Online condition monitoring and fault detection is an effective means of not only increasing the reliability but also reducing the costs associated with operation and maintenance of wind turbine generators (WTGs);

❖ This work investigates the method for wind turbine imbalance fault detection by using the WTG stator current signals.

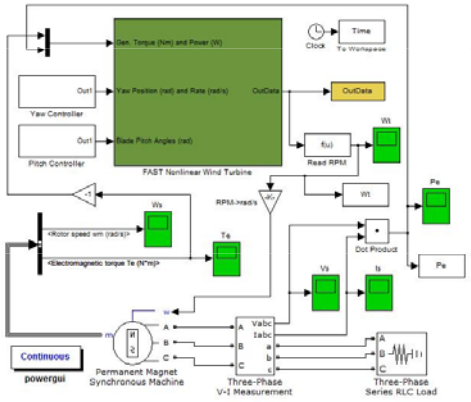
WTG Model and Simulation Platform

❖ The dynamical model of a 10-kW WTG system is developed in a combined environment of TurbSim, FAST, and Simulink;

❖ FAST simulates the dynamics of the turbine; Simulink simulates the dynamics of the generator and other electrical components; TurbSim generates time series of variable wind speeds for the simulations in FAST;



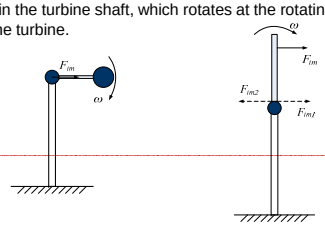
The structure of the model WTG system in simulation environment



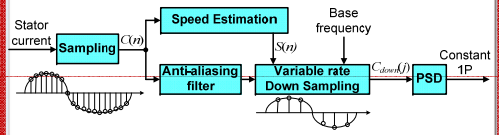
The model WTG in FAST/Simulink environment

Fault Characteristic Frequency Extraction

❖ When an imbalance faults occurs, an additional force, F_{im}, will be applied in the turbine shaft, which rotates at the rotating speed (i.e., 1P) of the turbine.



❖ A 1P-invariant power spectrum density (PSD) method is developed to extract the fault characteristic frequency at 1P



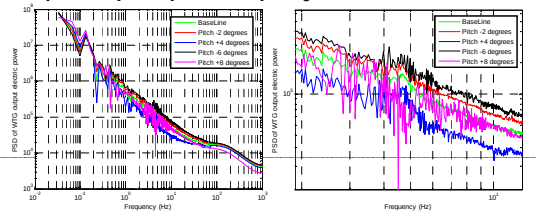
Conclusion

❖ The PSD results show that the excitations of the WTG electrical power signals become more significantly at 1P when the degree of the imbalance faults becomes higher.

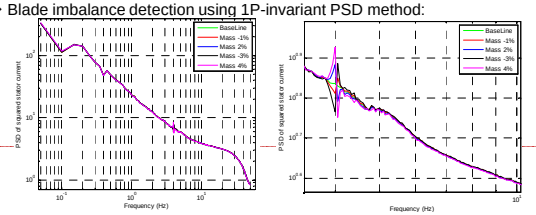
❖ By using the proposed 1P-invariant PSD method, the imbalance faults of the wind turbine can not only be discovered but also be quantified and evaluated by the location and degree of the excitation in the stator current PSD of the wind generator.

Simulation Results

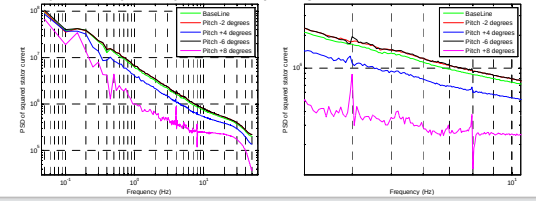
❖Aerodynamic asymmetry detection by using standard PSD method:



❖ Blade imbalance detection using 1P-invariant PSD method:



❖ Aerodynamic asymmetry detection by using 1P-invariant PSD method:



Experimental Results

❖Blade imbalance detection by using 1P-invariant PSD method: