Technical University of Denmark

Popular science summary of the PhD thesis

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Title of the PhD thesis	Voltage Stability in RES based power systems
PhD school/Department	Department of Electrical Engineering

Science summary

* Please give a short popular summary in Danish or English (approximately half a page) suited for the publication of the title, main content, results and innovations of the PhD thesis also including prospective utilizations hereof. The summary should be written for the general public interested in science and technology:

This thesis concerns the further development of existing voltage stability assessment methods for real-time operation. Modern power systems are transitioning towards minimal dependency of fossil-fuel based power production by replacing them with renewable energy sources, such as solar and wind based generation. With the larger share of renewable energy sources, the power production will be sensitive to prevailing weather conditions, which can cause fluctuations in the system operating points. This can complicate the process of planning production and consumption schemes several hours in advance, which is based on offline analysis and this approach will be insufficient in ensuring secure and stable operation of the power system. This introduces the need for methods that are able to assess system stability and security in real-time. This PhD work is part of the research project Security Assessment of Renewable Power Systems (SARP), which pursues the forward development of methods capable of real-time monitoring of system security and stability margins.

The weakness of existing method for voltage stability assessment using Thevenin equivalents was identified and a new improved approach was proposed that overcomes the limitations. The traditonal approach detects voltage instability based on the Thevenin impedance matching criteria. The improved approach takes into account how load changes are reflected in the Thevenin voltages. The new proposed approach is able to determine the point of maximum deliverable power to a load to and detect voltage instability well before the traditional Thevenin based method.

Type IV wind turbines with full scale power converters were investigated. With regards to long-term voltage stability, it is of interest to determine the behaviour of the grid-side converter when reaching its current limitation and how it affects system stability and security boundaries. A simple test system was used and dynamic simulations were performed. A new stability boundary was discovered when the current limitation of the grid-side converter is reached and the type IV wind turbines prioritize active power injection. The new stability boundary appears as a straight line in the injection impedance plane and represents the aperiodic small signal stability boundary of the wind turbines. Through dynamics simulations it was shown that current-limited wind turbines are very sensitive to system changes and the lack of inertia causes the wind turbines to instantly lose synchronism, when the stability boundary is crossed due to the fast acting power converters.

To validate the improved voltage stability assessment method, a system representing the Swedish grid was used. Dynamic simlations were performed, where the system operating conditions are highly stressed. The test cases show that the improved method is able to detect voltage instability well before the traditional approach of determining the point of maximum deliverable power to the load with Thevenin impedance matching. In both cases the tap-changing mechanism of the \ac{OLTC}-transformers was the driving force leading to voltage instability. This eventually lead to several generators losing synchronism and a collapse of system voltages.

Please email the summary to the PhD secretary at the department