Small Signal Stability Analysis of Wind Turbines

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Abstract. Nowadays, the fast growth of wind power on electricity grids, has been declared as an important issue on wind energy industry. Today a penetration of 20% in Europe is feasible.

As is widely known, basically wind turbines are manufactured for two conditions: Constant Speed or Variable Speed. In this way, the Constant Speed Wind Turbines (CSWT), are built with Squirrel Cage Induction Generators (SCIG) and the Variable Speed are built with Doubly Fed Induction Generators (DFIG) or synchronous machines.

This work researches the Small Signal Stability, using the most common turbine generators, the Squirrel Cage Induction Generators and the Doubly Fed Induction Generators.

That dynamic operation of wind turbines makes important to design, model and simulate their behavior prior to install them. By this way, one of the main studies realized is stability study that professionals, researchers and specialists are developing constantly due to the fast growth of the wind turbine industry.

It is important to remark that this report will not be dedicated to power quality issues or the study and explanation of the physical or aerodynamic issues caused by the wind. It is presented the eigenvalues analysis of these wind turbines near 2MW and an application on wind farms using an open source toolbox.

The power system models in this project were all built using SIMULINK and the specialized Power Systems Analysis Toolbox, PSAT a software application developed for MATLAB, which performs both the numerical simulation and linearized eigenstructure analysis. Roots positions and its values as they appear on this plot show if system is stable or not. The full eigenvalues report shows results in matrix and also participation factors are presented.

So far, basically two main small disturbance stability problems have been widely discussed and by that, are still clearly and widely accepted such as rotor angle stability and voltage stability. Small signal stability is defined as the capability of a power system to return to a stable operating point or to the original steady, after the occurrence of a disturbance that leads to an incremental change in one or more of the state variables of the power system.

Here will be confirmed what theory says. The electromechanical modes generated for small signal stability studies occur in the frequency range of 0.1 to 2 Hz. Interarea oscillations, are typically in the frequency range of 0.1 to 1 Hz. The interarea modes are usually complex and associated with groups of machines swinging to other groups across a transmission line. The higher frequency electromechanical modes defined as local modes are in the order of 1 to 2 Hz, typically involve one or two generators swinging against the rest of the power system.

With those two basics machines were realized two studies. First of all, an Small Signal Stability Analysis of a SCIG then a DFIG connected to infinite bus. With last results, two analysis of a wind farm are carried out, one powered by 3 Squirrel Cage Induction Generator and another powered by 3 Doubly Fed Induction Generators

Some interesting and novel results were found for modeling and simulation that shows the advantage of the method used.

This analysis shows that the wind turbines have a great influence on the small signal power system stability. Frequencies values determined that two possible oscillation modes are represented, interarea and local.

It was confirmed, that wind resource variability seems not to creates power system instabilities when it has Squirrel Cage or Doubly-Fed Induction generators aggregated on a small grid under certain conditions simulated here.