Abstract

This thesis aims to assess the effect of wind energy on power system stability and quality. Main power quality issues of wind power with a small-scale integration and for large-scale integration to the utility grid are discussed. A dynamic wind turbine model for power quality assessment of wind turbines is presented. Then an aggregate wind farm model for power quality and stability analysis from large wind farms is presented. The aggregate wind farm model exhibits the smoothing of the relative power fluctuation from a wind farm compared to a single wind turbine. Finally, applications of the aggregate wind farm model to the power systems are presented. The power quality and stability characteristics influenced by large-scale wind power are illustrated first with an assumed power system configuration and then for a wind farm site. MATLAB/SIMULINK and PSCAD/EMTDC software are used for the simulation of the developed models.

In this project, emphasis has been given to appropriate modeling of the wind acting on wind farms. It is named as wind speed model. The wind speed model for a single wind turbine includes turbulence and tower shadow effects of wind. The rotational sampling turbulence due to the rotation of the blades has also been included. In the aggregated wind farm model, the wind speed model at the park scale includes the spatial coherence between different wind turbines. Here the wind speed model is applied to a constant rotational speed wind turbine/farm, but the model is suitable to variable speed wind turbine/farm as well.

The cases presented here illustrate the influences of the wind power on the power system quality and stability. The flicker and frequency deviations are the main power quality parameters presented. The power system stability concentrates on the voltage stability and on the power system oscillations.

In the case studies, voltage and the frequency variations were smaller than expected from the large-scale wind power integration. This is perhaps due to the low spatial correlation of the wind speed. The voltage quality analysed in a wind farm site about 30km away from the grid showed very small voltage variations. The frequency variation was also small.
Concerning the stability analysis, the study showed that large-scale wind power modifies the voltage stability of the power system and can cause power oscillations. It is showed here that the reactive power from the wind farms is the key factor on the voltage stability problem. During continuous operation, the distributed wind power variations did not give any problems to the power system stability concerning the power oscillations.

In the simulation part the wind turbine models are used with normal and faulty condition of the wind farm. The wind turbines are equipped with their relay models, which can trip these decentralized units at abnormal operation in the power system. The large wind alarm is assigned to the Indian specifications for connection of large wind farms to transmission power networks. The power supply from wind turbines corresponds to 50% of power consumption in the grid. Investigations are carried out for a number of cases during visits to Satara wind farm (M.S.). The wind farm is considered with fixed-speed, active stall controlled wind turbines equipped with induction generators.

The results are presented in graphical form and discussed for quality and stability of the system. Satisfactory results are obtained from the research.