Stability and control of wind farms in power systems - DTU Orbit (17/11/2019)

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The Ph.D. project ‘Stability and Control of Wind Farms in Power Systems’ deals with some selected problems related to wind power in power systems. With increasing wind power penetration, wind turbines substitute the power production of conventional power plants. Therefore, wind turbines also have to take over the power system stabilisation and control tasks, that were traditionally carried out by conventional power plants. Out of the many aspects related to this problem, this project focuses on transient fault ride-through and power system stabilisation. The selection of turbine types considered in this project is limited to active-stall turbines and variable speed, variable pitch turbines with gearboxes and full-scale converter-connected synchronous generators. As a basis for the project, a study into the state of the art is conducted at the beginning of the project. Grid connection requirements that were in force, or published as drafts, at the time, and scientific literature related to the topic, are studied. The project is based on simulations of wind turbines in a power system simulations tool. Some of the models used in this project were readily available prior to the project; the development of others is part of the project. The most extensive modelling work deals with the design of the electrical part of the variable speed turbine and its controls. To simulate realistic grid operation the wind turbine models are connected to an aggregated model of the Nordic power system. For that purpose the Nordic power system model, which was available prior to the project, is extended with a realistic feeder configuration. It is commonly demanded from modern wind turbines, that they must not disconnect in case of transient faults. Therefore, controllers are designed that enable the two turbine types to ride through transient faults. With these transient fault controllers the wind turbines can stay connected to the grid, such that their generation capacity is sustained, and normal grid operation can resume, after the fault is cleared. Transient faults in the transmission system often cause power system oscillations. To further support the grid, a situation is assumed, where in future, wind turbines will be required to contribute to the damping of these power system oscillations. Power system oscillations are counteracted with a controlled injection of oscillating active power. With an active-stall turbine oscillating power injection can only be realised by controlling the pitch angle. Hence the power system stabiliser of an active-stall turbine is a pitch angle controller. Two different approaches are chosen for designing such a power system stabiliser: a conventional PID controller, and a fuzzy logic controller. For a variable speed turbine power system stabilisation is an easier task, as it varies its electrical power with power electronics. Hence, large and rapid power variations are easily possible. The negative side effect of ambitious power system stabilisation with variable speed turbines is torsional drive train oscillations. These drive train oscillations are addressed specifically, so the turbine stays stable when it performs power system stabilisation. It is concluded that the controllers designed in this project enable active-stall turbines, and variable speed turbines with full-scale converter-connected synchronous generators, to support the grid in case of transient events.

General information
Publication status: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Jauch, C.
Number of pages: 58
Publication date: 2006

Publication information
Place of publication: Roskilde
Publisher: Risø National Laboratory
ISBN (Print): 87-550-3547-7
Original language: English
(Risø-PhD; No. 24(EN)).
Keywords: Risø-PhD-24(EN), Risø-PhD-24, Risø-PhD-0024
Electronic versions:
ris_phd_24.pdf
Source: orbit
Source ID: 309635