

Capability Limits of Doubly Fed Induction Generator Wind Turbines

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Ph.D. Thesis

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Abstract

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The research investigates mainly the capability of Doubly Fed Induction Generator (DFIG) wind turbines to meet the grid code requirements with special emphasis on stability. A complete modelling of the DFIG was carried out for this purpose for both transient and steady state analysis. A controller was designed with a novel technique for tracking the rotor angle.

The performance of the DFIG with battery as an energy storage device connected to the DC link was investigated. A method was formulated using the wind data for the derivation of battery capacity that should be used. Eigen value analysis was undertaken to determine the influence of connecting battery at the DC link and a comparison was made with the DFIG model with capacitor connected at the DC link. Since having a battery as an energy storage device connected to the DC link had many advantages this was chosen for the final DFIG model with the controller

A laboratory set up of a prototype DFIG was done similar to the derived model with a battery connected to the DC link. Tests were carried out using the control techniques

derived during the modeling. The methods developed for tracking the rotor angle for rotor current injection were tested. Adjustments were made where necessary during testing and a final controller model was validated experimentally. The behavior of the DFIG output with rotor current injection were checked and investigated.

Then using the model of the DFIG with the developed controller, dynamic behaviour of the DFIG with and without energy storage was investigated. A comparison for response to wind fluctuations and fault ride through operation was compared for DFIG with battery and DFIG with Capacitor connected to DC link

Using the derived and validated DFIG model and the controller, an investigation was carried out on capability limits of the DFIG, when operating within the specified speed range taking in to consideration the limitations on the rotor power, stator current and the stability. It was investigated on how the stability could be improved by selecting wound rotor induction machine with different machine parameters and reactive power exchange with the power system. A capability chart of the DFIG was prepared using an iteration method. A small signal model of the DFIG wind farm, connected with the power system, was used for the stability studies with Eigen value analysis.

Finally, a case study was carried out to find the feasibility of connecting a DFIG based wind farm with energy storage at Puttalam area in Sri Lanka. Dynamic studies were carried out and the performance was compared with a DFIG wind farm with and without energy storage. The impact on the present power system for wind fluctuations and fault ride through operation was investigated.