Mohmoud Mossa

Modeling, Analysis and Enhancement of the performance of a Wind Driven DFIG During steady state and transient conditions

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ABSTRACT

Wind electrical power systems are recently getting lot of attention, because they are cost competitive, environmental clean and safe renewable power source, as compared with fossil fuel and nuclear power generation. A special type of induction generator, called a doubly fed induction generator (DFIG), is used extensively for high-power wind applications. They are used more and more in wind turbine applications due to ease controllability, high energy efficiency and improved power quality.

This research aims to develop a method of a field orientation scheme for control both the active and reactive powers of a DFIG driven by a wind turbine. The proposed control system consists of a wind turbine that drives a DFIG connected to the utility grid through AC-DC-AC link. The main control objective is to regulate the dc link voltage for operation at maximum available wind power. This is achieved by controlling the d^e and q^e axes components of voltages and currents for both rotor side and line side converters using PI controllers. The complete dynamic model of the proposed system is described in detail. Computer simulations have been carried out in order to validate the effectiveness of the proposed system during the variation of wind speed. The results prove that, better overall performances are achieved, quick recover from wind speed disturbances in addition to good tracking ability.

Generally, any abnormalities associated with grid asymmetrical faults are going to affect the system performance considerably. During grid faults, unbalanced currents cause negative effects like overheating problems and mechanical stress due to high torque pulsations that can damage the rotor shaft, gearbox or blade assembly. Therefore, the dynamic model of the DFIG, driven by a wind turbine during grid faults has been analyzed and developed using the method of symmetrical components. The dynamic performance of the DFIG during unbalanced grid conditions is analyzed and described in detail using digital simulations.

A novel fault ride-through (FRT) capability is proposed (i.e. the ability of the power system to remain connected to the grid during faults) with suitable control strategy in this research. In this scheme, the input mechanical energy of the wind turbine during grid

faults is stored and utilized at the moment of fault clearance, instead of being dissipated in the resistors of the crowbar circuit as in the existing FRT schemes. Consequently, torque balance between the electrical and mechanical quantities is achieved and hence the rotor speed deviation and electromagnetic torque fluctuations are reduced. This results in a reduction of reactive power requirement and rapid reestablishment of terminal voltage on fault clearance.

Extensive simulation study has been carried out employing MATLAB/SIMULINK software to validate the effectiveness of the proposed system during grid faults. The results demonstrate that the potential capabilities of the proposed scheme in enhancing the performance of DFIG based wind farms to fault ride-through are excellent.

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