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Doubly Fed Induction Generator and Conventional Synchronous Generator Based Power Plants: Operation during Grid Fault

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Abstract. The use of doubly fed induction generator in wind power plants has result in new necessities to maintain a reliable operation of the network. The tendency of the grid codes is to require the ability from the wind power plant to keep connected during and after grid disturbance, similarly to the synchronous generators requirements. This paper analyse the behaviour of a wind power plant equipped with doubly fed induction generators connected to a transmission system during grid fault and compare its performance with a conventional synchronous generator based power plant. The results have shown that the conventional synchronous generator has much more effective injection of reactive power during grid fault and, by consequence, the terminal voltage is kept in higher levels.

Key words.

wind power plant, doubly fed induction generator, transient stability, power system stability.

1. Introduction

The use of doubly fed induction generator (DFIG) has increased in the last 15 years [1]. The fast growing of wind power penetration in Europe and, more recently, in USA and China has changed the way that the Transmission System Operators (TSO's) administrates then power systems. In general, the fault tolerance of wind turbine generators tends to be equal to the conventional synchronous generator pushed by more restrictive grid codes [2]. They should not disconnect from the grid and they should contribute to the voltage regulation during and after faults. However, this is a task which depends on the specific characteristics of a certain power systems.

The conventional concept of synchronous generator (SG) is directly connected to the power system via a power transformer and the control of terminal voltage (or power factor) is by the field excitation. The rotor windings of the DFIG-based wind turbines are connected with the use of two back-to-back converters, while the stator windings are connected directly to the network via a power transformer. The control of terminal voltage (or power factor) by the DFIG is performed by the two back-to-back converters. The rotor side converter (RSC) and also the grid side converter (GSC) can inject reactive power simultaneously. The investigation presented in this paper compares the performance of both power plants in order to better understand the positive and negative impacts on the stability and on the voltage regulation in a scenario accomplished to the new grid code requirements.

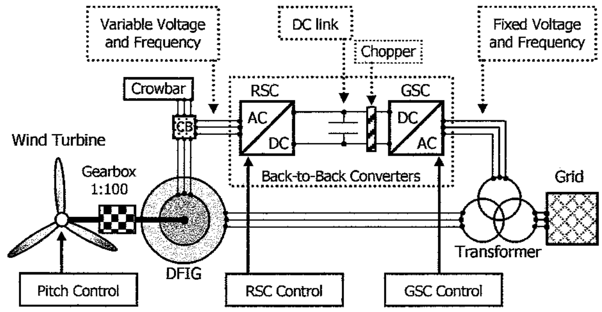

Fig. 1 Doubly fed induction generator (DFIG).

The dynamic models are developed using the *Matlab/Simulink* toolbox called *SimPowerSystems*. The phasor analysis was chosen as it is a common strategy for transient stability studies.

The paper sections are organized as follows. Section II discusses the aerodynamic model of the wind turbine. Section III describes the DFIG model. The test system is shown in Section IV. The comparative responses between the SG and the DFIG during grid faults are presented in Section V. The conclusions are discussed in Section VI.

2. Aerodynamic Model of the Wind Turbine

The aerodynamic model of the power capture from the wind is implemented using the well-know equation [3]:

$$P_m = \frac{1}{2} A \rho V^3 C_P(\lambda, \beta) \qquad (1)$$

where A is the turbine rotor area, ρ is the density of the air, V is the wind speed, C_p is the performance coefficient, β is the blade pitch angle, $\lambda = \omega R/V$ is the tip speed ratio, R is the radius of the rotor and ω is the angular speed of the blades.

3. Doubly Fed Induction Generator (DFIG)

This model comprises the electric generator and the converter controllers involved in the technologies. The power electronics are considered ideal, in this case the voltage reference signals determined by the controller is