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Effect of transient flux compensation control on fault ride through of doubly fed induction generator wind turbine

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Abstract. The fault ride through (FRT) of doubly fed induction generator (DFIG) is studied in this paper. Two different FRT strategies are compared. First strategy uses only active crowbar to protect the turbine and the second strategy uses transient flux compensation in addition to the crowbar. Simulations are carried out using Matlab/Simulink. The aim of the study is to reveal how the transient flux compensation improves the operation of DFIG during a fault. If the transient flux is removed the DFIG is controllable during a fault and the reactive power injection to the grid can be maximized. This is an important aspect since the latest grid codes insist that wind turbines should be able to inject reactive power during a fault in order to support the depressed grid voltage. Thus, this paper proposes that after a fault it is reasonable to use the current capacity of rotor side converter to remove the transient flux. This leads to better performance of wind turbine, improved power quality and maximized voltage support.

Key words

DFIG (doubly fed induction generator), FRT (fault ride through), voltage dip, transient flux

1. Introduction

The global warming, air pollution and the shortfall of fossil energy sources have increased the interest towards the generation of electrical energy from renewable energy sources. Thus, the number of wind turbines installed to the grid has grown dramatically in recent years. According to the World Wind Energy Association (WWEA), the global wind power capacity had increased to 159.2 GW by the end of 2009.[1] Hence, the penetration of wind generation has increased in many areas to a significant level. In such areas, power system operators have created grid codes which demand the wind turbines to be able to endure deep voltage dips in order to ensure power system stability. Grid codes include specifications that determine the requirements for the operation of generation units during disturbances. These specifications are known as the fault ride through (FRT) requirements.

As an example, E.ON Nezt grid codes regarding symmetrical faults are illustrated in Figs. 1a and 1b. [2] The wind turbines are not allowed to disconnect from the grid if the grid voltage is over the red line in Fig. 1a. In addition, the wind turbines should be able to inject reactive power to the grid in order to support the grid voltage. It can be seen in Fig. 1b that wind turbines should inject a nominal value of reactive current if the voltage is lower than 50% of the nominal value. [2]

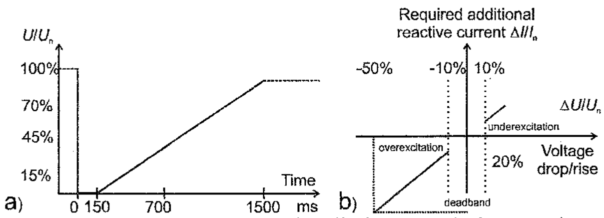

Fig. 1. a) Wind turbine operation limit curve during a voltage dip. b) Voltage support of wind turbine during a fault. [2]

The use of doubly-fed induction generators (DFIG) in variable speed wind turbines has been popular since the size and costs of the needed power electronic components are smaller compared to full power converter design. This fact leads also to smaller losses. However, the behaviour of the DFIG concept during grid voltage dip is problematic since the induction generator generates high voltages and currents to the rotor side as a result of the dip.

A. Behaviour of DFIG during symmetrical voltage dip

The amplitude of the rotating magnetic flux of DFIG is proportional to the stator voltage. A voltage dip in stator terminals decreases the amplitude of the rotating flux of the generator instantaneously. However, the total flux cannot change instantaneously. The difference between total flux and rotating flux is called a transient flux or a natural flux as defined by Lopez *et al.* [3]. The transient flux is not rotating and it appears only if there is a sudden step in the stator voltage. In addition, the transient flux gets its maximum value at the beginning of the voltage step.