

A Novel Crowbar Protection Technique for DFIG Wind Farm during Fault Ride Through

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Abstract- This paper proposes a terminal crowbar protection technique for Doubly Fed Induction Generators (DFIG) to protect the rotor converter and enhance network stability during grid disturbances. Simulation test using MATLAB-Simulink toolbox is implemented on a 9 MW wind farm exports its power to 120 KV grid. The simulation is performed using different values of crowbar resistances. The variations of rotor current, rotor speed, DC-link voltage, active power and reactive power of the wind farm are investigated. Also, a comparison between the conventional crowbar and the proposed crowbar protection techniques is investigated.

Index Terms- DFIG, Conventional Crowbar, Terminal Crowbar, Rotor Current, Active Power, Reactive Power, Short Circuit.

I. INTRODUCTION

Wind energy is one of the fastest growing industries at present and it will continue to grow worldwide, as many countries have plans for future development. The increased penetration of wind energy into power system over the last decade generates new challenges for the power system operators, who have to ensure a reliable and safe grid operation. The use of doubly fed induction machines in modern variable-speed wind turbines has increased rapidly. This development has been driven by the cost reduction as well as the low-loss generation of Insulated Gate Bipolar Transistors (IGBT) [1-3]. According to new grid code requirements, wind turbines must remain connected to the grid during grid disturbances. Moreover, they must also contribute to voltage support during and after grid faults. The crowbar protection system is essential to avoid the disconnection of the doubly fed induction wind generators from the network during faults. The insertion of the crowbar in the rotor circuits for a short period of time enables a more efficient terminal voltage control. As a general rule, the activation and the deactivation of the crowbar system is based only on the DC-link voltage level of the back-to-back converters. However, wind power plants based on the DFIG are very sensitive to grid disturbances, especially to voltage dips. When faults occur and cause voltage dips, subsequently the current flowing through the power converter may be very high over-current. During this situation, it is common to block the converter to avoid any risk of damage, and then to disconnect the generator from the grid [4-7]. Therefore DFIG requires a crowbar protection system disconnects the converter

in order to protect it, turning the DFIG generator into a squirrel cage induction generator. The crowbar may comprise of a set of thyristors that will short-circuit the rotor windings when triggered and thereby limit the rotor voltage and provide an additional path for the rotor current. Different values of the crowbar resistances result in a different behavior. Using this technology, the DFIG can stay connected to the grid and resume operation as soon as possible. Several researches have dealt with different crowbar strategies for Low Voltage Ride Through LVRT improvement. The value of crowbar resistance should be chosen carefully. There are two requirements that give an upper and a lower limit to the crowbar resistance. It should be high enough to limit the short circuit rotor current and it should be low enough to avoid too high voltage in the rotor circuit. Also, the optimal crowbar resistance is constrained by the machine rating (MVA rating), rotor current transient and DC-link transient following crowbar deactivation [8-15]. This paper proposes a terminal crowbar resistor connected at the terminal of the DFIG. With the proposed protection techniques, the rotor converter of DFIG is not blocked. Several dynamic simulations are carried out for different terminal crowbar resistance values in case of 150 ms three-phase fault at wind farm terminals. Also, a comparison between the behaviors of DFIG wind farm during three-phase fault with conventional crowbar protection and with proposed crowbar protection is investigated.

II. DFIG SYSTEM MODEL AND CONTROL

The DFIG control and its performance in normal operation have already been discussed in a variety of publications [16-19]. The behavior of DFIG control system during disturbance will be discussed in this section. The DFIG wind turbines utilize a wound rotor induction generator, where the rotor windings are fed through back to back variable frequency, voltage source converter. Figure 1 shows a schematic diagram of the DFIG wind turbines connected grid with conventional crowbar protection. The Rotor Side Converter (RSC) is connected to the Grid Side Converter (GSC) using a DC link. During grid disturbances, due to the magnetic coupling between the stator and the rotor a high rotor current transient is excited. Hence, to avoid damage to the converter, the RSC is short circuited using a resistor bank, which is commonly known as the crowbar protection. The crowbar effectively decouples the back to back converter unit from the wound rotor induction generator, and enables the DFIG to operate as an induction generator [20].

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