International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878
Volume 2 Issue 1, January 2014

Crowbar Protection of Micro-Grid with DFIG Wind Turbine

Shilpa Mishra[1], J.N Iyer[2]

[1]Lecturer, Department of Electrical Engineering
LDRP-ITR, Gandhinagar, India

[2]Associate Professor, Department of Electrical Engineering,
L. D. College of Engineering, Gujarat Technological University
Ahmadabad, India

Abstract: ***Low Voltage Ride Through is an important aspect for wind turbine systems to fulfill grid code requirements. In case of wind turbine technologies using doubly fed induction generators (DFIG), the reaction to grid voltage disturbances is sensitive. Since the stator of a DFIG is directly connected to a grid, this sort of machine is very sensitive to grid disturbances. Grid faults cause voltage sag and over-currents and over-voltages in rotor windings, which can damage the rotor-side converter (RSC). In order to protect the RSC, a classical solution is suggested in this paper is the installation of the crowbar protection Simulations have been carried out in MATLAB SIMULINK and the results demonstrate the effectiveness of the proposed strategy.***

Keywords: DFIG, Low Voltage Ride Through (LVRT), Crowbar.

1. Introduction

The increased amount of power from decentralized, renewable energy systems, as especially wind energy systems, requires strong grid code requirements to maintain a stable and safe operation of the energy network. The grid codes cover rules considering the fault ride through behavior as well as the steady state active power and reactive power production. The actual grid codes stipulate that wind farms should contribute to power system control like frequency and voltage control to behave much as conventional power stations. A detailed review of grid code technical requirements regarding the connection of wind farms to the electrical power system is given in [1]. For operation during grid voltage faults it becomes clear that grid codes prescribe that wind turbines must stay connected to the grid and should support the grid by generating reactive power to support and restore quickly the grid voltage after the fault.

Among the various wind turbines the doubly fed induction generator (DFIG) showed in Fig. 1 are dominant due to their variable speed operation, the separately controllable active and reactive power and their partially rated power converter. But, the reaction of DFIGs to grid voltage disturbances is sensitive [4], [6] for symmetrical and unsymmetrical voltage dips, and requires additional protection for the rotor side power electronic converter.

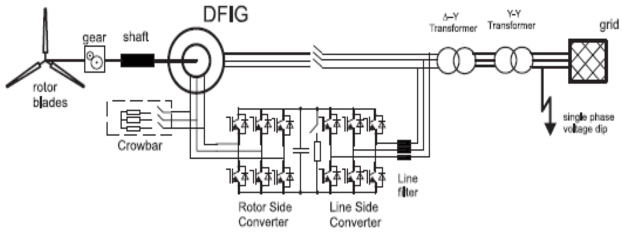

Figure 1: Schematic diagram of DFIG wind turbine system

However, because the stator of a DFIG is directly connected to the electrical grid, it is extremely sensitive to grid voltage disturbances. Voltage dips at the stator due to grid faults induce

Over-voltage in the rotor windings, resulting in over-currents of the rotor circuit, which may cause severe damage to the vulnerable rotor-side power electronic converter and large fluctuation of the dc-link voltage. Such a large rotor inrush current, dc-link overvoltage, and torque oscillations caused by grid faults are quite harmful for the DFIG-based wind turbines [2] and can lead to the destruction of converter and mechanical parts. Traditionally, once over-currents occur in rotor windings, the so-called crowbar is used to protect the rotor converter by short circuiting the rotor windings. Fig. 1 shows the block diagram of a DFIG equipped with a crowbar [6]. As can be seen, the crowbar consists of resistors, which are controlled by power electronic devices.

International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878
Volume 2 Issue 1, January 2014

2. DFIG Protection

2.1 Crowbar Protection

To protect the rotor side converter from tripping due to over-currents in the rotor circuit or overvoltage in the DC link during grid voltage dips a crowbar is installed in conventional DFIG wind turbines, which is a resistive network that is connected to the rotor windings of the DFIG. The crowbar limits the voltages and provides a safe route for the currents by bypassing the rotor by a set of resistors. When the crowbar is activated the rotor side converters pulses are disabled and the machine behaves like a squirrel cage induction machine directly coupled to the grid. The magnetization of the machine that was provided by the RSC in nominal condition is lost and the machine absorbs a large amount of reactive power from the stator and thus from the network [6].

Below fig. 2 shows the typical arrangement of crowbar protection of DFIG fault response in MATLAB. The system resembles the dump resistor protection model. The difference lies in the protection block.

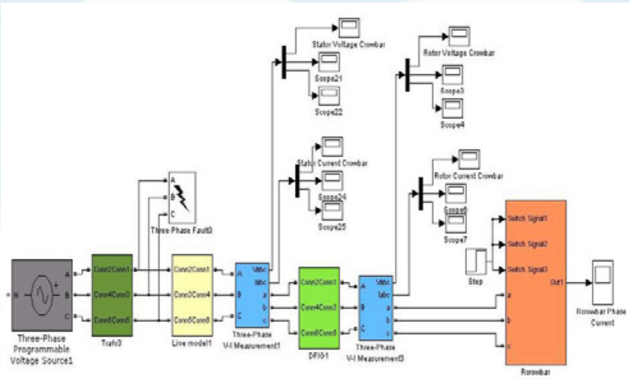

Figure 2: MATLAB Simulation of Crowbar Protection

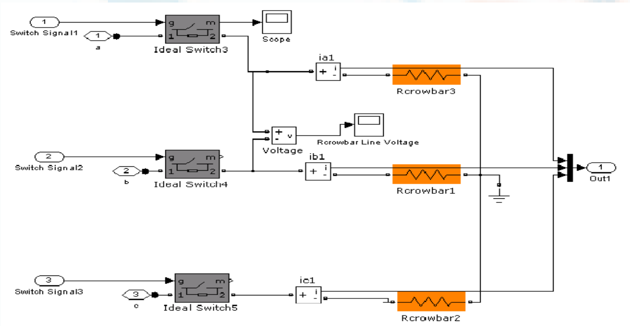

Figure 3: crowbar resistor subsystem at $R_{crowbar}$ = 0.1 ohms

3. Simulation Results and Discussion

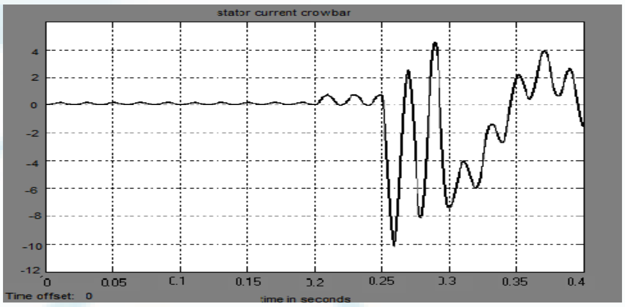

Figure 3.1: Simulation result for stator current with crowbar protection

The effects on the stator voltage and current are shown in Figure 3.1. The protection response may be viewed during the second half of the fault. This applies to all fault modeling simulations in this report. The stator current increases when the additional resistors are connected while the voltage is decreases.

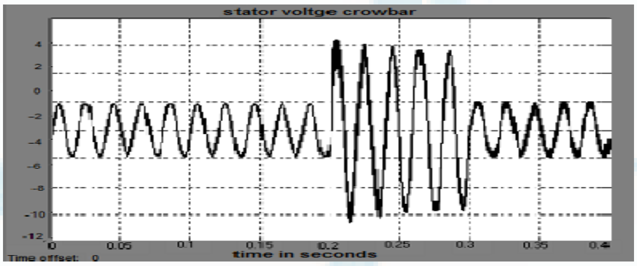

Figure 3.2: Simulation result for stator voltage with crowbar protection

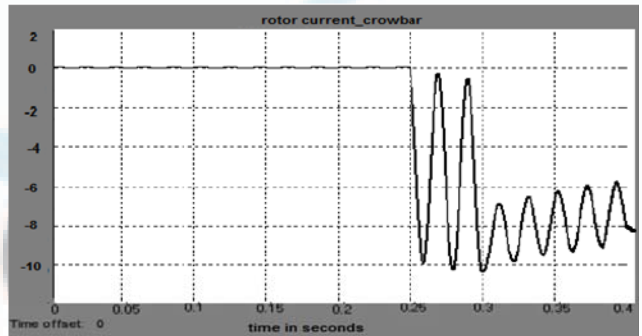

Figure 3.3: Simulation result for rotor current with crowbar protection

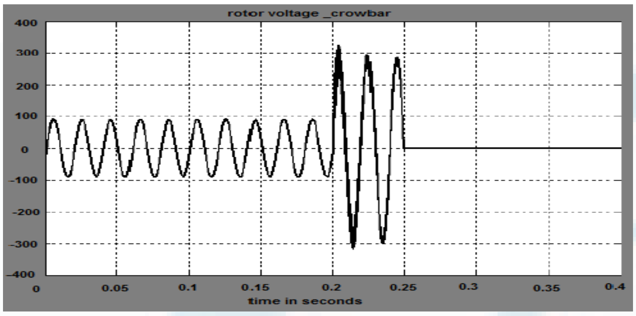

Figure 3.4: Simulation result for rotor voltage with crowbar protection

Since the fault was applied between 0.2 and 0.3 seconds by setting the fault block to generates a short circuit between all 3 phases [3], [4]. The protection was switched on at 0.25 seconds by applying a signal to the crowbar resistor switch.

One may observe that after connecting the protection, the voltage is greatly reduced. However, residual voltage may still be seen until the fault subsides at 0.3s. The crowbar protection is employed to attenuate severe faults. The excess energy of the rotor (from high currents due to fault) is to be dissipated in the resistors.

4. Conclusion

To protect the Rotor side converter during grid faults, the classical solution of installation crowbar protection for Micro-grids with DFIG wind turbines demonstrate the effectiveness of the proposed strategy. The crowbar protection is attenuates severe faults and the excess energy of the rotor dissipates in the resistors.

References

[1] S. Chaudhary, S.P Chaudhary and P. Crossely, “Microgrid and Active Distribution Networks”, IET Renewable Energy Series 6, 2009
[2] Sheng Hu, Xinchun Lin, Yong Kang, and Xudong Zou, “An Improved Low-Voltage Ride-Through Control Strategy of Doubly Fed Induction Generator During Grid Faults”, IEEE transactions on power electronics, vol. 26, no. 12, december 2011, pp 3653-3665.
[3] Erlich, H. Wrede, and C. Feltes, Dynamic Behavior of DFIG-Based Wind Turbines during Grid Faults, 1-4244-0844-X/07, 2007 IEEE, pp 1195-1200.
[4] F. Katiraei, M. R. Iravani, P. W. Lehn, “Micro-Grid Autonomous Operation During and Subsequent to Islanding Process”, IEEE transactions on power delivery, vol. 20, no. 1, Paper no. TPWRD- 00103-2003, pp.248-256, January 2005
[5] F. D. Kanellos, A. I. Tsouchnikas, N. D. Hatziargyriou, Micro-Grid Simulation during Grid-Connected and Islanded Modes of Operation, Presented at the International Conference on Power Systems Transients (IPST‟05) in Montreal Canada, June 19-23, 2005 Paper No. IPST05 – 113
[6] Jes´us L´opez, Pablo Sanchis, Xavier Roboam, & Luis Marroyo, “Dynamic Behavior of the Doubly Fed Induction Generator During Three phase Voltage Dips” IEEE transactions on energy conversion, vol. 22, no. 3, pp 709-717, September 2007
[7] Omar Badrana, Emad Abdulhadi, Rustum Mamlook, “Evaluation of parameters affecting wind turbine power generation”.
[8] Dr. Gary L. Johnson “Wind Energy Systems” November 21, 2001, vol I.
[9] K. L. Shi,T. F. Chan, Y. K. Wong and S. L. Ho, Modeling and Simulation of Direct Self-Control Systems,Vol. 19, No. 4, pp. 646-654, 2003, 0949-149, Tempus Publications.

Author Profile

Ms. Shilpa Mishra received the B.E. and M.E. degrees in Electrical Engineering from Gujarat University and Gujarat technological university in 2009 and 2013, respectively. She worked as a design engineer for 1 year and currently she is working as a Lecturer in department of Electrical Engineering at LDRP-ITR, Gandhinagar, India.

Prof, J.N Iyer received the B.E. and M.E. degrees in Electrical Engineering from L.D College of Engineering in 1993 and 2002, respectively. Currently she is working as an Associate Professor, department of Electrical Engineering at L.D College of Engineering, Ahmedabad, India.