International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

# IMPROVEMENT IN DOUBLY FED INDUCTION GENERATOR DURING FAULT USING CROWBAR CIRCUIT

**Sidharth Bhardvas[1], Shivam Mittal[2] ,Ruby Agrawal[3]**

[1, 2]*Students, Electrical Engineering Department Greater Noida Institutes of Technology, Gr.Noida, (India)*

[3] *Assistant Professor, Electrical Engineering Department Greater Noida Institutes of Technology, Gr. Noida, (India)*

## ABSTRACT

*The performance of a 1.5 MV A wind power doublyfed induction generator (DFIG) under network fault, when the fault occurs the line voltage or current becomes 8 times to the normal rating, which can damage the converter which are connected to the rotor sideis studied in MATLAB-Simulink. The simulation network,consists of the DFIG analytical model, the detailed frequency converter model including passive crowbar protection. Simulation results show the transient behaviour of the doubly fed induction generator when a sudden voltage dip is introduced with and without the crowbar implemented.*

***Keywords: DFIG,* Grid Stability, Wind Turbine Technology, crowbar .**

## I. INTRODUCTION

Wind power has become the world's fastest growingrenewable energy source. The many benefits of the wind energy are environmental protection, economic development, diversity of the supply, rapid spread, transference and technological innovation, industrial scale electricity in network and the fact is that the wind does not pollute, it is abundant, free and unlimited.

Thereare many benefits of using DFIG over general induction generators. DFIG can operate in generator/ motor mode for all four possible operation conditions. In DFIG a speed variation of ±30% around synchronous speed can be obtained by the use of power convertor of 30% of nominal generated power. The DFIG is not necessarily to be magnetised from the power grid since it can be magnetised from rotor circuit to. The size of the convertor is not related to the total generator power but to the selected speed range and hence to the slip power.

Nowadays, there is an increasing requirement for wind farms to remain connected to the power system during faults, since the wind power lost might affect the system stability Therefore, the wind turbine behaviour during system performance and its influence in the system protection must be analyzed.The aim of this paper is to investigate and presents the transientsimulation analysis of a 1.5 MV A DFIG for wind power application under a three-phase network short circuit.

## II.DOUBLY-FED INDUCTION GENERATOR

For dynamic simulation purposes, these investigations are carried out based on well prepared Matlab simulation software's. The principle of the DFIG is that rotor windings are connected to the grid via slip rings and back-to back voltage source converter that controls both the rotor and the grid currents. Thus rotor frequency differs from the grid frequency (50 Hz). By controlling the rotor currents by means of converter it is possible to adjust the active and reactive power fed to the grid from the stator independently of the generators turning speed. The control principle used is either the two-axis current vector control or Direct Torque Control (DTC). DTC has turned out to have better stability than current vector control especially when high reactive currents are required from the generator. The doubly-fed generator rotors are typically wound with from 2 to 3 times the number of turns of the stator. This means that the rotor voltages will be higher and currents lower. Thus in the typical ± 30 % operational speed range around the synchronous speed the rated current of the converter is accordingly lower leading to a low cost of the converter. The drawback is that controlled operation outside the operational speed range is impossible because of the higher rated rotor voltage. In order to prevent high rotor voltages - and high currents resulting from these voltages - from destroying the IGBTs and diodes of the converter a protection circuit (called crowbar) is used. A doubly fed induction machine is a wound-rotor doubly-fed electric machine and has several advantages over a conventional induction machine in wind power applications. Firstly, as the rotor circuit is controlled by a power electronics converter, the induction generator is able to import and export reactive power. This has important consequences for power system stability and allows the machine to support the grid during severe voltage disturbances (low voltage ride through, LVRT). Secondly, the control of the rotor voltage and current enables the induction machine to remain synchronized with the grid while the wind turbine speed varies.

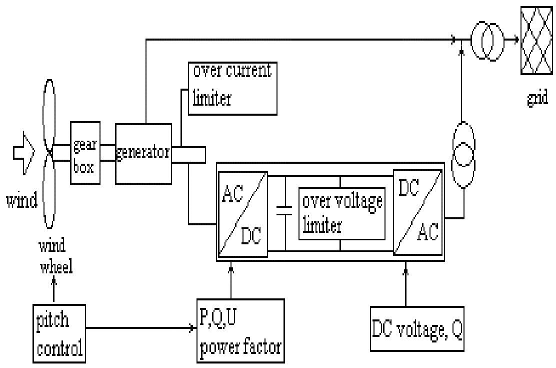


**Figure 1.The block diagram of protection measure for FRT of DFIG WT.**

## III. CROWBAR

The Sim Power Systems DFIG model does not include a crowbar protection. This has therefore been added, with some simplifications. The crowbar is made up of a symmetric three phase y-connected resistance. It is connected to the rotor

through a controllable breaker. This is not the real case (in reality, the crowbar may be made up of one resistance fed through a switched rectifier bridge), but it may be sufficient for us to assess the overall impact of a crowbar protection on the LVRT. The breaker is normally open, but it is closed short circuiting the rotor

International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

through the resistance if either the rotor current or the DC-link capacitor voltage become too high. At the same time the switching of the RSC is stopped. The value of the crowbar resistance is chosen according to as 20 times the rotor resistance. The choice of the crowbar resistance is important because, as we will see, it determines how much reactive power the DFIG will draw while the crowbar is inserted.

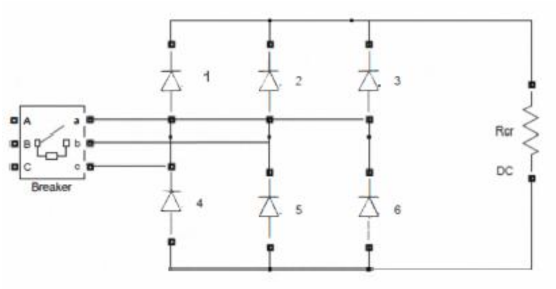


**Figure 2. Crowbar scheme**

## IV.RESULTS FROM DFIGSIMULATIONS WITH FAULT AND WITHOUT CROWBAR

At the fault instant, the voltage at the DFIG generator terminal drop and it leads to a corresponding decrease of the stator and rotor flux in the generator. This results in reductionin the active power. As the stator flux decreases, the magnetization that has been stored in the magnetic field is released. Immediately after fault, the generator starts to absorb reactive power for its magnetization from the power system as shown below. When the voltage in poverty the networkside converter is no longer able to transfer power to the rotor side converter therefore received the additional power will be borne by the capacitor voltage, which generates a rapid increase in the dc voltage converter.

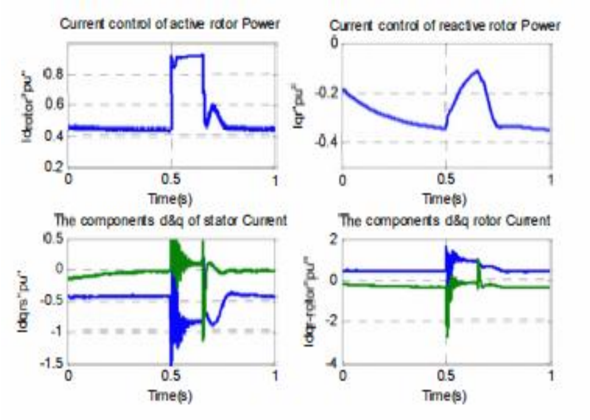


**Figure 3. The active and reactive current and (d,q) current components**

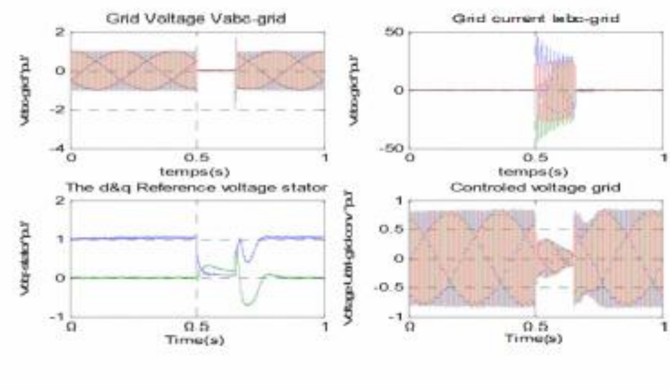


**Figure 4. The three phase voltage and current**

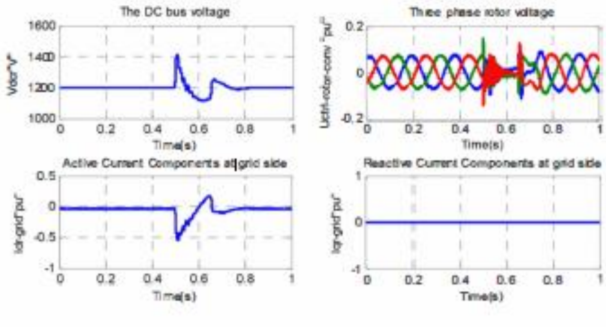


**Figure 5. The DC voltage three phase rotor and (d,q) current components at the grid**

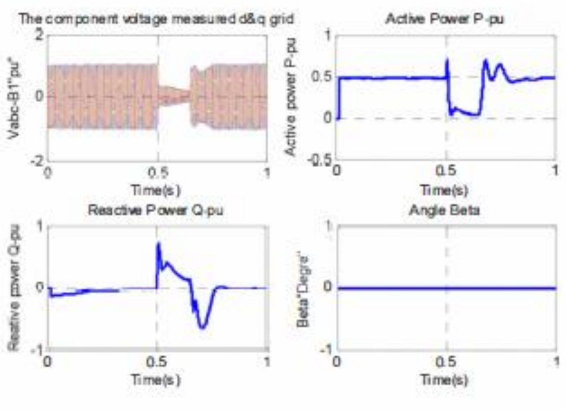


**Figure 6. The active and reactive power**

## V.RESULTS FROM DFIG SIMULATIONS WITH FAULT AND WITH CROWBAR

The simulation of the LVRT of a DFIG wind farm has beenperformed using the described crowbar protection. The resultsare shown below. Before the fault, the DFIG wind farm was insteady state with almost no reactivepower. When the faultoccurs,the crowbar protection is triggered, protecting the RSCwhich stops switching. The rotor current in the crowbar and therotor windings decays and the DC link voltage increasesslightly while the crowbar is connected. Notice that thecrowbar disconnects and the RSC starts switching while the fault is still active, at about 70 ms after the fault. This isimportant since it allows the DFIG to feed reactive power(about 0.3 pu) into the network, increasing the voltage. This ofcourse may have a positive

International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE
ISSN 2321 - 2055

effect for the voltage stability of thesystem. The rotor current in the DFIG windings decreases, while the RSC current (I_rot) is zero when thecrowbar is active. The RSC voltage is then the voltage over thecrowbar. The DC-link capacitor voltage does not increasemuch just after the fault. However, its increase is very high (2pu) when the fault is disconnected at 650 ms, even though thecrowbar is correctly reinserted to limit the RSC current. Thisincrease, as can be seen, is due to the fact that the DFIGabsorbs active power just after the fault is disconnected. Thisclearly indicates the need for a chopper to be connected acrossthe DC-link capacitor to limit its voltage. Finally notice thatwhen the fault is disconnected, the DFIG absorbs reactivepower, thus decreasing the voltage in the network. This is dueto the fact that, being the crowbar still connected for a longtime (because of the high DC-link voltage), the DFIG isactually a FSIG accelerating and thus drawing lot of R=0.146.

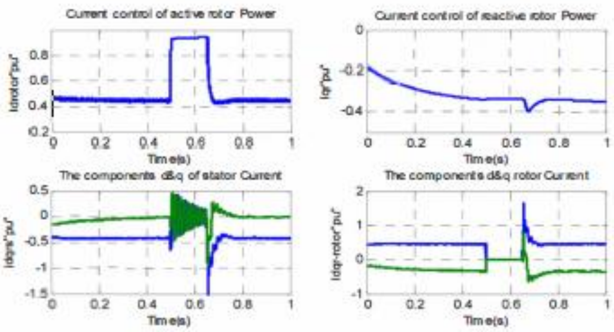


**Figure 7. The active and reactive current and (d,q) current components**

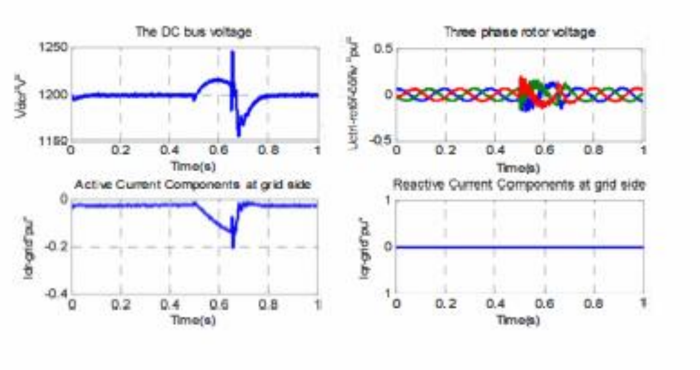


**Figure 8. The DC voltage three phase rotor and (d,q) current components atthe grid**

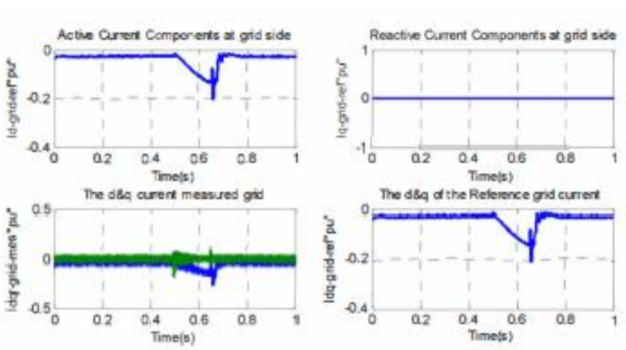


**Figure 9. The active and reactive current and (d,q) current components**

International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

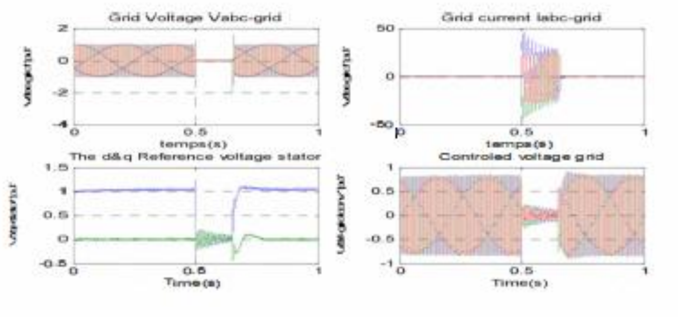


**Figure 10. The three phase voltage and current**

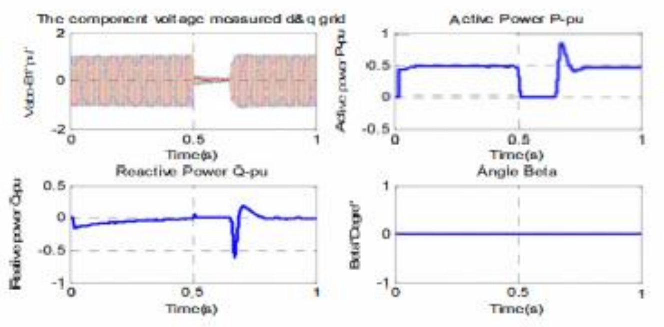


**Figure 11. The active and reactive power**

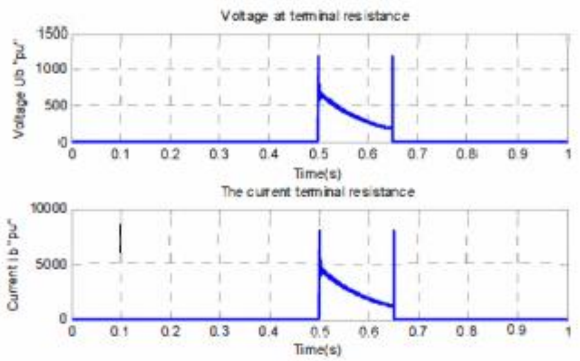


**Figure 12. The current to the terminal of the resistance of the crowbar**

## VI.EXPERIMENTAL SETUP

The 9MW wind farm is connected to a 25 kV network, viaa 66 KV/440V transformer. The transformer is rated 12 MV A. A resistive load of 500kw is connected at the wind farm. A high pass capacitor filter is used, the DFIG wind farm is connected to the 120 kV network through a 30 km 66 kV line and a 120/125 kV transformer.

## VII.CONCLUSIONS

The crowbar protectinavoides high rotor currents, high stator current and improvement in DC link voltage. During fault when crowbar is active the doubly fed induction generator act as a squirrel cage generator which consumes large amount of reactive power that's why we have to choose a proper resistance for crowbar circuit. So that it consumes less amount of reactive power and protects the circuit. Simulation results show the transient behaviour of the doubly fed induction generator with and without the crowbar implemented when a sudden voltage dip is introduced.

## REFERENCES


[1] J B. Ekanayake, L. Holdsworth, X G. Wu, N. Jenkins, "DynamicModeling of Doubly Fed Induction Generator Wind Turbines," IEEE Transaction on Power Systems, Vol. 18. No. 2, May 2003, pp. 803 - 809.

[2] J G. Slootweg, H. Polinder, W L.Kling, "Dynamic Modeling of a Wind Turbine with Doubly Fed Induction Generator " Proc. of 200 1 IEEE Power Engineering Society Summer Meeting, Vol. I, pp. 644 - 649.

[3] L. Holdsworth, X G. Wu; 1. B. Ekanayake, N. Jenkins: "Comparison of fixed speed and doubly-fed induction wind turbines during power system disturbances" lEE Proceedings - Generation, Transmission and Distribution, Volume: ISO, Issue: 3, 13 May 2003, pp. 343 - 352.

[4] A Tapia, G. Tapia, J.X Ostolaza, J. R. Saenz: "Modeling and control of a wind turbine driven doubly fed induction generator" IEEE Transactions on Energy Conversion, Volume: 18, Issue: 2, June 2003, pp. 194 - 204.

[5] R. Koessler, S Pillutla, L. Trinh, D. Dickmander: "Integration of large wind farms into utility grids (Part I - Modeling of DFlG)", Proc. Of 2003 IEEE PES General Meeting.

[6] M. H. J Bollen, M. Martins, G. Olguin, "Voltage dips at the terminals of wind-power installations," presented at the Nordic Wind Power Conference 2004, 1-2 March 2004, Chalmers University of Technology, Goteborg, Sweden.

[7] F. Runcos, R. Carlson, A M. Oliveira, P Kuo-Peng, N. Sadowski, "Performance Analysis of a Brushless Double Fed Cage Induction Generator," presented at the Nordic Wind Power Conference 2004, 1-2. March 2004, Chalmers University of Technology, GOteborg, Sweden.

[8] J Niiranen, "Voltage Dip Ride Through of Doubly-fed Generator Equipped with Active Crowbar, " presented at the Nordic Wind Power Conference 2004, 1-2 March 2004, Chalmers University of Technology, Goteborg, Sweden.

[9] MATLAB SimPowerSystems User's Guide, Version 4.6 (R2008a), http://www.mathworks.com/access/helpdesk/help/toolbox/physmod/powersysl

[10] A khmatov V., "Induction Generators for Wind Power", Multi-Science Publishing Company, Ltd., 2005.

[11] EOLE Program 2010, "http://www.edfcom",2010.