IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 09, 2017 | ISSN (online): 2321-0613

Fault Analysis of Doubly Fed Induction Generator

Mr. Parmale. M. C[1] **Mr. Adapa. S. S**[2]
[1,2]Assistant Professor
[1,2]MET BKC, IOE, Nasik, India

Abstract— The DFIG based Wind Turbine system is the most popular wind energy conversion system due to its various advantages such as high operating efficiency, lower mechanical stress on the turbines and reduced power rating power electronic devices, so as there are negative impacts on the system such as grid faults in Doubly Fed Induction Generators (DFIG) based wind turbines such as stator and rotor over currents electromagnetic torque oscillations, active and reactive power fluctuations at the grid connecting points. This paper possess simulation and fault analysis of DFIG for the effectiveness of the scheme.

Key words: Doubly Fed Induction Generators (DFIG), Fault Analysis

I. INTRODUCTION

Wind is one of the most effective and promising renewable sources alternative for electrical power. It is eco-friendly. It is now considered as an actual alternative to the conventional and polluting energy sources such as oil, gas, and coal. According to World wind association, a power capacity more than 50GW were added during 2014, bringing the total wind power capacity close to 370GW [2].

Major issue concern regarding DFIG performance is of fault ride-through. Network faults introduces inherent voltage dips in the three phases connected to a generating unit. The DFIG system is highly responsive to such severe dips, inducing transient currents in the stator and rotor circuits which gives rise to high transient current which damages the power electronic devices in the converters. To protect these devices the rotor circuit is crowbarred.

II. EFFECTS OF SYMMETRICAL AND ASYMMETRICAL GRID FAULTS

The sudden voltage dips of the grid voltage results in rapid increase in the DFIG stator currents beyond the rated values. Because of the magnetic coupling between stator and rotor, a small change in magnetic flux causing induced voltages inside the rotor circuit. The magnetic flux of the DFIG is basically divided into two components. The first is the "forced flux" that rotates at the synchronous speed. It appears during the normal operation of the machine. The second is the "natural flux". It appears during voltage dips. Each component induces voltages in the rotor. The voltage induced by the forced flux is small; it may approximately zero. During gird faults, voltages are induced by the natural flux alone. The induced voltage amplitude is proportional to the depth of the grid voltage dip and type of the fault. If the depth of the voltage dip is very small and the voltage induced does not exceed the maximum voltage that the rotor converter can generate, the current remains controlled, and there is no risk on the generator. In cases of larger dips caused by symmetrical fault components, the voltage induced at rotor terminals exceeds the maximum available tension of the converter and the control of the current is lost. In this scenario, over currents appear. These currents represent a risk to DFIG. The currents will increase as the depth of the dip is bigger. This situation is transient and only occurs at the beginning (or end) of the dip, that is, when the grid voltages change abruptly.

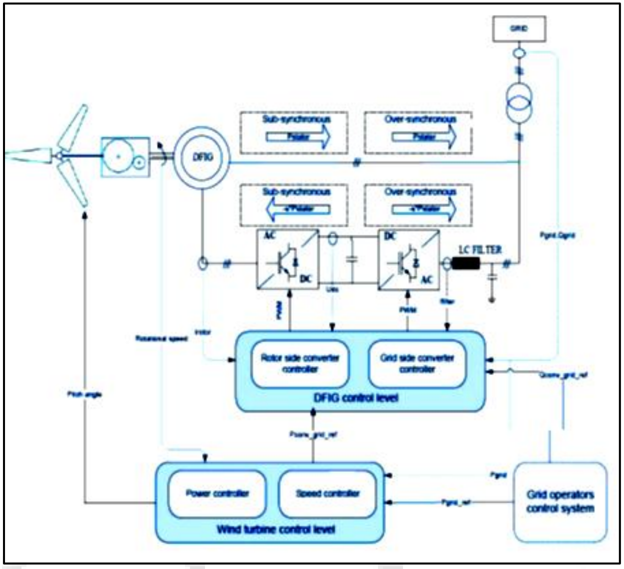

Fig. 1: DFIG Model

Simulation of a DFIG for use in a wind turbine generator was created, using simcap simulink software. The model included an electrical asynchronous machine with a bidirectional power electronic converter connected in the rotor circuit and a two-mass mechanical model to represent the wind turbine. Wind turbine without the G80's modifications for fault ride-through. The controller used gives provision for limiting high currents in the system. A rotor short-circuit 'crowbar' was simulated. A schematic of the DFIG wind turbine system is shown in figure below. A simple transmission system model was applied to the wind turbine transformer terminals. Network faults were applied as voltage dips at point 'F'. Input mechanical power was kept roughly constant during the fault scenarios. No overcurrent or rotor overspeed protection limits were applied to the model, in order that the effects of inappropriate control action could be seen. In reality, a turbine would be disconnected before it exceeded its design limits. This work is part of an ongoing project which will include the construction of a low power test facility for further validation.

III. ROTOR CROWBAR

When energized, the rotor crowbar short-circuits the rotor windings of the manchine and effectively disconnects the converter. The crowbar was desigined as a bank of three star-connected resistors enabled by three semiconductor switches. Crowbar operation was triggered by a DC link overvoltage. Once engaged, the crowbar remained for 120ms before being switched out and remaining out of the circuit. Crowbar operation times are marked on the graphs shown with a vertical line.

IV. DYNAMIC MODEL OF A DOUBLY FED INDUCTION GENERATOR

To develop decoupled control of active and reactive power, a DFIG dynamic model is needed. The construction of a DFIG is similar to a wound rotor induction machine (IM) and comprises a three-phase stator winding and a three-phase rotor winding. Then it is fed with the help of slipring. The torque and voltage equation of the machine frame are

$$v'_{Rj} = r'_R \cdot i'_{Rj} + \frac{\partial \psi_{Rj}}{dt} \qquad j = \{1,2,3\}$$

$$T_{el} = \frac{p}{2} \cdot \sum_{j=1}^{3} i_j \cdot \frac{d\psi_j}{d\vartheta}.$$

$$v_d = \frac{2}{3} \cdot \begin{bmatrix} -v_1 \cdot \sin\vartheta - v_2 \cdot \sin\left(\vartheta - \frac{2\cdot\pi}{3}\right) \\ -v_3 \cdot \sin\left(\vartheta + \frac{2\cdot\pi}{3}\right) \end{bmatrix}$$

Network fault conditions were adopted as an effective voltage dip on the grid parameters seen by the DFIG model. The length of these dips were determined with respect to the Grid Code regulations for England & Wales, specified by National Grid Transco. The severeness of the fault is strongly dependent upon the associated network. The majority of faults on the 220kV system are single phase-earth due to the steel tower construction, hence the need to look at unbalance results shown here include 1) a three-phase balanced fault arising at 40% retained voltage, 2) a close-up three-phase balanced fault to earth, resulting in voltage dip to 0% on all phases and (iii) a local single-phase unbalanced fault to earth. The faults were each initiated at 3.0 seconds to allow the simulation to reach prefault steady state operation. Earth faults endured for 150ms and the 50% depression for 690ms. These are the longest voltage dips that must be accommodated to comply with Grid Code requirements. The rates of voltage fall and recovery were extrapolated from measured data. The near zero earth fault voltages were assumed large enough to permit an angle measurement for the vector controller

V. EXPERIMENTAL RESULTS

Readings were taken on a wind turbine system having a doubly fed cycle generator produced by, Germany. The rated power is 1.5MW, and the rated speed is nr=1,850 rpm. Typical results are illustrated in the top trace shows variation of wind speed as a function of time (elapsed time 0-650 s). Shows generator speed Up to the time instant *t*=200 s, the pitch control is not very active because maximum power is not reached. Hence, the main controller seeks to maximize output power according to the maximum efficiency curve shown in Fig.2 beyond 340 s, we can see wind speed going up to approximately 25 m/s. Fig shows that the wind turbine controller now limits the torque command at 90%. The actual output power delivered to the grid is shown in fig and matches the command value perfectly.

VI. SIMULATION RESULTS

Detailed system simulation were performed to evaluate the performance DFIG. The below figure shows line current, rotor current and o/p analyze system response and tune feedback parameter an active power step response is simulated shows the response when the decoupling network is in active, the machine is controlled using the basic steady-state voltage model based on contrl onslip. System performance depends on speed due to the coupling between *d* and *q axis* variables. Fig. shows system response when decoupling is performed according the Detailed system simulation were performed to evaluate the performance of the vector controlled DFIG. The below figure shows line current, rotor current and o/p active power

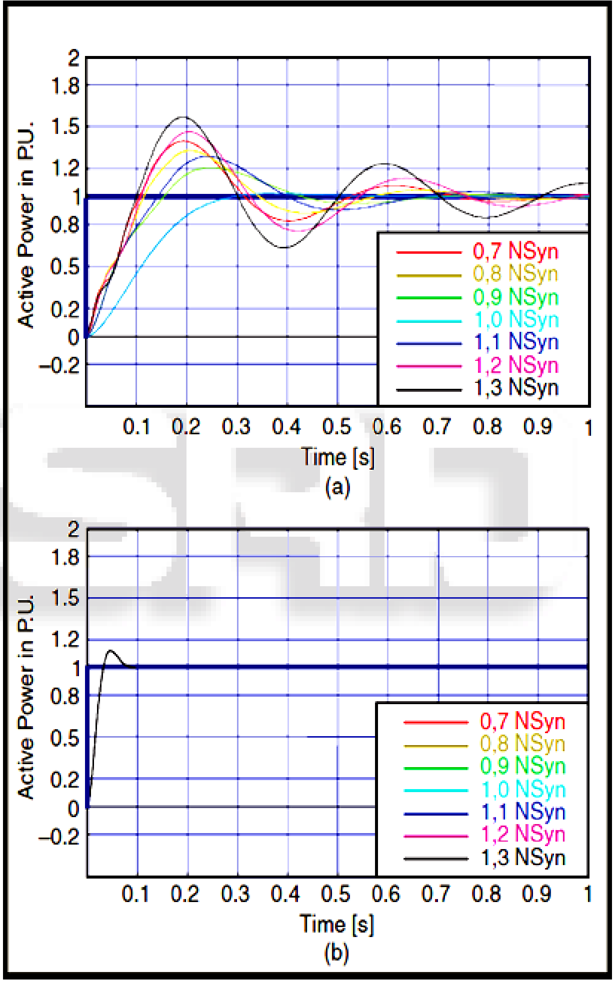

Fig. 2: Transient active power step response of DFIG. (a) Response without decoupling at different speeds. (b) Response with decoupling.

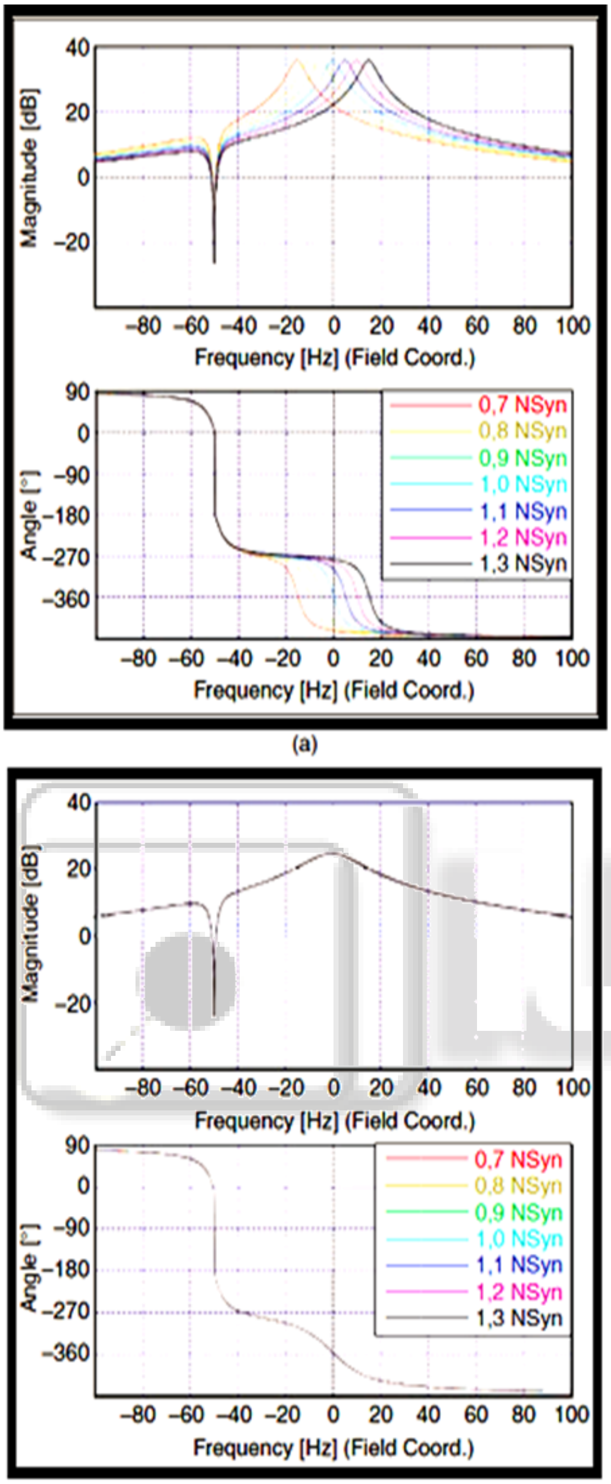

Fig. 3: Bode diagram of the rotor voltage to stator current IS/VR admittance.
(a) Admittance IS/VR Bode plots without decoupling.
(b) Admittance IS/VR Bode plots with decoupling.

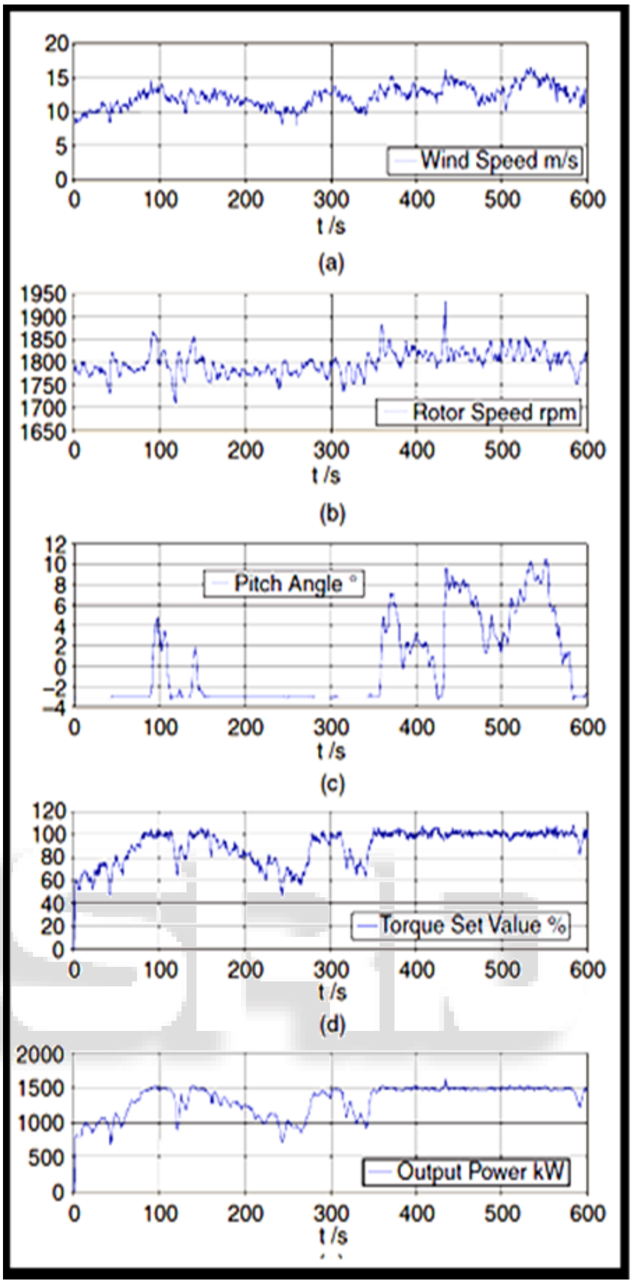

Fig. 4: Recorded waveforms on a 1.5 MW DFIG system. (a) Wind speed. (b) DFIG rotor speed. (c) Pitch angle of turbine blades. (d) DFIG controller output power command. (e) DFIG measured output power.

VII. CONCLUSION

This paper proposes a new and efficient strategy for fault analysis of the DFIG wind turbine. This strategy enables the DFIG to continue the electricity production, and absorb the excessive energy by increasing the generator rotor speed temporarily when a fault occurs. This method also introduces a compensation item to the grid side controller in order to suppress the DC-link over-voltage during the faults. The simulation results show that the proposed control strategy is able for the effectively suppression of the transients in the rotor circuit current. Compared with the conventional protection, the DFIG Wind Turbine installed with this control strategy gives a better transient behavior in event of short term fault.

REFERENCES

[1] A. Hansen and G. Michalke, “Fault ride-through capability of DFIG wind turbines,” Renew. Energy, vol. 32, no. 9, pp. 1594–1610, Jul. 2007.

[2] Erlich, J. Kretschmann, J. Fortmann, S. Mueller-Engelhardt, and H. Wrede, “Modeling of wind turbines based on doubly-fed induction generators for power system stability studies,” IEEE Trans. PowerSyst., vol. 22, no. 3, pp. 909–919, Aug. 2007.

[3] P S Bhimra “Generalized theory of electrical machine”.Mc-Graw Hill.

[4] H.A.Toliyat ,T.A. Lipo ,”Transient Stator ,Rotor Bar and End rings Fault” IEEE Transactions On Energy Conversion, Vol. 10, 1995, pp.241-247.

[5] G. G Yen , K Lin ,”Wavelet Packets Feature Extraction for Vibration Monitoring “IEEE Transactions on Industrial Electronics 2000.

[6] DONG Mingchui , CHEANG Takson , SEKAR Booma Devi†, CHAN Sileong “Fuzzy-Expert Diagnostics for Detecting and Locating Internal Faults inThree Phase Induction Motors” TSINGHUA SCIENCE AND TECHNOLOGY ISSN1007- 021413/18pp817-822 Volume 13, Number 6, December 2008.

IJSRD