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Modeling, Simulation & Dynamic Performance Analysis of DFIG Wind Energy Conversion System Using SVOC under Dynamic Load & Faulty Condition

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ABSTRACT:The aim of this paper is to present modelling and simulation of wind turbine driven doubly-fed induction generator. There are two pulse width modulated voltage source converters are connected back to back between the rotor terminals and utility grid via common dc link. The grid side converter itself compensates for the reactive power rather than providing an additional compensating device. Additional power is also extracted from the rotor side. The rotor side converter is used for attaining maximum power extraction and to supply required reactive power to DFIG .The grid-side converter controls the dc-link voltage and ensures the operation by making the reactive power drawn by the system from the utility to zero by using the stator voltage-oriented control technique. In this paper the performance of DFIG wind system during dynamic loading and in various fault conditions are analysed at variable wind speed. All these scenarios have been simulated with the help of the simulation program using MATLAB and its inbuilt components provided in SIMULINK library.

KEYWORDS: Doubly-Fed Induction Generator (DFIG), grid side converter (GSC), rotor side converter (RSC), stator voltage orientation scheme (SVOC).

I.INTRODUCTION

With the increase in population and industrialization, the energy demand has increased significantly. However, the conventional energy sources such as coal, oil, and gas are limited in nature. Now, there is a need for renewable energy sources for the future energy demand. The other main advantages of this renewable source are eco-friendliness and unlimited in nature. Now a days as one of the most important renewable source of energy is wind energy that is gaining interest due to its eco-friendly nature. In a few last year variable speed wind turbines with DFIG are the most applied wind turbine. The most interest for variable speed wind turbine is because of very good characteristics with modern converters and digital control systems.

This paper is about the modelling and simulation of wind driven doubly fed induction generator and converter setup that is back to back PWM with stator voltage oriented vector control. The back to back PWM converter set up consists of the Rotor Side Converter and the Grid Side Converter with intermediate DC link. The control of the DC link voltage and the grid reactive power is obtained through Voltage oriented control of GSC. Same as independent control of power from wind and reactive power of DFIG is accomplished by stator voltage oriented vector control of RSC.

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II.SYSTEM ORGANIZATION AND OPERATING PRINCIPLE

Basic configuration of the wind turbine with an induction wound rotor generator with stator winding connected directly to the grid and rotor winding connected to the three phase grid by the use of back-to-back power semiconductor converter. It consists of two pulse-width voltage converter; these converters are connected to the rotor and grid side

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with voltage pulse width modulation inverter and a common DC link. The power control system of the wind turbine is based on the theory of voltage vector control. In this theory two-axis control described in three different reference frames. The system of the wind turbine with DFIG and back-to back converter connected to the grid is shown in Fig.1 In this configuration, the generator rotor operates at a variable speed to optimize the tip-speed ratio. Therefore the generator system operates in both a sub-synchronous and super-synchronous mode, normally between +/- 30% of synchronous speed. The rotor winding is fed through a power converter, typically based on two AC/DC/IGBT based linked voltage source converter.

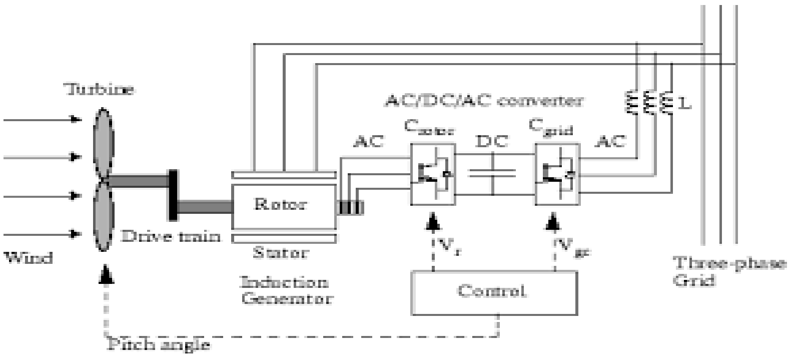

Fig1: Block diagram of DFIG wind system

III.DYNAMIC MODEL OF THE DFIG WIND ENERGY CONVERSION SYSTEM

Dynamical model of the wind turbine describes the main parts of the wind turbine drive train system and induction generator that participate in interaction of the wind turbine with electric power system.
In this wind turbine system under vector control of active and reactive power of DFIG connected to the grid the axis transformation is used that is based on reference frame theory. This transformation used on current, voltage vectors of stator and rotor from stationary reference frame into two phase rotating d-q reference frame. Stator side converter control is used to regulate the voltage across the DC link and maintain it's constant, sometime also to compensate harmonics. Voltage vector scheme is a two stage controller scheme which is achieved by voltage oriented vector control scheme by aligning the d-q axis in the direction of stator voltage. Stator or Grid converter is typically a three phase, two level voltage source converter which uses the switching device as IGBT, the main purpose of stator side converter control is done to maintain constant the DC link voltage. This has been done by implementing grid voltage oriented control scheme. In the stator voltage orientation control, the grid voltage is measured the angle, and it is detected from phase lock loop for the voltage orientation and transformation of the axis.

a. Principle of Stator Voltage Oriented Control

In DFIG wind energy systems, the stator of the generator is directly connected to the grid, and its voltage and frequency can be considered constant under the normal operating conditions. It is, therefore, convenient to use stator voltage oriented control (SVOC) for the DFIG [1]. This is in contrast to electric motor drives, where rotor- or stator-flux field oriented controls (FOC) are normally used. Fig.2 shows a space vector diagram for the DFIG with the stator voltage oriented control operating with unity power factor in super-synchronous mode. The stator voltage oriented control is achieved by aligning the d-axis of the synchronous reference frame with the stator voltage vector. The resultant d- and q-axis stator voltages are-

$v_{qs} = 0 \& v_{ds} = v_s$

Where v_s is the magnitude of $\vec{v_s}$, (also the peak value of the three-phase stator voltage).

The rotating speed of the synchronous reference frame is given by

$$\omega_s = 2\pi f_s \quad (1)$$

Where f_s is the stator frequency of the generator (also the frequency of the grid voltage). The stator voltage vector angle θ_s is referenced to the stator frame, which varies from zero to 2π when $\vec{v_s}$ rotates one revolution in space. The rotor

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rotates at speedω_r.The rotor position angle $\theta_r$is also referenced to the stator frame. The angle between the stator voltage vector and the rotor is the slip angle, defined by

$$\theta_{sl} = \theta_s - \theta_r \qquad (2)$$

The DFIG operates with unity power factor, the stator current vector $\vec{i_s}$is aligned $\vec{v_s}$ withbut with opposite direction (DFIG in generating mode). The rotor voltage and current vectors,$\vec{v_s}$ and$\vec{i_s}$, which are controlled by the converters in the rotor circuit, are also given in the diagram. The rotor voltage and current vectors can be resolved into two components along the d-qaxes$v_{dr}$and $v_{qr}$for $\vec{v_r}$ and $i_{dr}$and $i_{qr}$for$\vec{i_r}$.

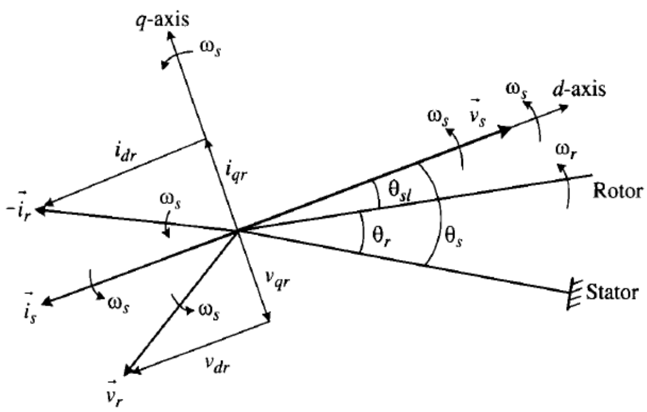

Fig.2 Space-vector diagram of DFIG with SVOC in the super-synchronous mode

These d-q axiscomponents can be controlled independently by the rotor converters. The DFIG wind energy system can be controlled by the electromagnetic torque for speed control or active power. In contrast to the other wind energy systems, the electromagnetic torque Te of the generator, the active power $P_s$and the reactive power Q_s of the stator are controlled by the rotor-side converter. Therefore, it is worthwhile to investigate the controllability of T_e,P_s , and $Q_s$by the rotor voltage and current. The investigation will also facilitate the analysis of the stator voltage oriented control. The electromagnetic torque of the generator can be expressed as

$$T_e = \frac{3P}{2}\left(i_{qs}\lambda_{ds} - i_{ds}\lambda_{qs}\right) \qquad (3)$$

whereλ_{ds} and λ_{qs} are the d-q-axis stator flux linkages, given by

$$\begin{cases}\lambda_{ds} = L_s i_{ds} + L_m i_{dr} \\ \lambda_{qs} = L_s i_{qs} + L_m i_{qr}\end{cases} \qquad (4)$$

from which the d-q axis stator currents are calculated to be

$$\begin{cases}i_{ds} = \frac{\lambda_{ds} - L_m i_{dr}}{L_s} \\ i_{qs} = \frac{\lambda_{qs} - L_m i_{qr}}{L_s}\end{cases} \qquad (5)$$

Substituting Equation (5) into (3)

$$T_e = \frac{3PL_m}{2L_s}\left(-i_{qr}\lambda_{ds} + i_{dr}\lambda_{qs}\right) \qquad (6)$$

From the induction generator model the stator voltage vector for the steady-state operation of the generator is

$$\vec{v_s} = R_s\vec{i_s} + j\omega_s\vec{\lambda_s} \qquad (7)$$

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the representation in d-q axis is

$$(v_{ds}+jv_{qs}) = R_s(i_{ds}+ji_{qs}) + j\omega_s(\lambda_{ds}+j\lambda_{qs}) \quad (8)$$

from which the d-q axis stator flux linkages are

$$\begin{cases}\lambda_{ds} = \frac{v_{ds}-R_s i_{ds}}{\omega_s}\\ \lambda_{qs} = \frac{v_{qs}-R_s i_{qs}}{\omega_s}\end{cases} \quad (9)$$

Substituting Equation (9) into (6)

$$T_e = \frac{3PL_m}{2\omega_s L_s}\left(-i_{qr}(v_{qs}-R_s i_{qs}) - i_{dr}(v_{ds}-R_s i_{ds})\right) \quad (10)$$

$$T_e = \frac{3PL_m}{2\omega_s L_s}\left(-i_{qr}v_{qs} + R_s i_{qs} i_{qr} + R_s i_{ds} i_{dr} - i_{dr} v_{ds}\right) \quad (11)$$

With $v_{qs} = 0$ for the stator voltage orientation control, the torque equation can be simplified to

$$T_e = \frac{3PL_m}{2\omega_s L_s}(R_s i_{qs} i_{qr} + R_s i_{ds} i_{dr} - i_{dr} v_{ds}) \quad (12)$$

Ignoring the stator resistance from the above equation that the electromagnetic torque is a function of d-axis rotor current and stator voltage. The stator active and reactive power can be calculated by

$$\begin{cases}P_s = \frac{3}{2}(v_{ds}i_{ds} + v_{qs}i_{qs})\\ Q_s = \frac{3}{2}(v_{qs}i_{ds} - v_{ds}i_{qs})\end{cases} \quad (13)$$

Using the stator voltage oriented control($v_{qs} = 0$) the above equation can be simplified to

$$\begin{cases}P_s = \frac{3}{2}v_{ds}i_{ds}\\ Q_s = -\frac{3}{2}v_{ds}i_{qs}\end{cases} \quad \text{For } v_{qs} = 0 \quad (14)$$

Substituting the value of current in above equation,

$$\begin{cases}P_s = \frac{3}{2}v_{ds}\left[\frac{\lambda_{ds}-L_m i_{dr}}{L_s}\right]\\ Q_s = -\frac{3}{2}v_{ds}\left[\frac{\lambda_{qs}-L_m i_{qr}}{L_s}\right]\end{cases} \quad (15)$$

From which

$$\begin{cases}i_{dr} = -\frac{2L_s}{3v_{ds}L_m}P_s + \frac{1}{L_m}\lambda_{ds}\\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m}Q_s + \frac{1}{L_m}\lambda_{qs}\end{cases} \quad (16)$$

Substituting the stator flux linkages from Equation (9) into (16)

$$\begin{cases}i_{dr} = -\frac{2L_s}{3v_{ds}L_m}P_s + \frac{v_{qs}-R_s i_{qs}}{\omega_s L_m} = -\frac{2L_s}{3v_{ds}L_m}P_s - \frac{R_s}{\omega_s L_m}i_{qs}\\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m}Q_s + \frac{v_{qs}-R_s i_{qs}}{\omega_s L_m} = -\frac{2L_s}{3v_{ds}L_m}Q_s - \frac{R_s}{\omega_s L_m}i_{qs} - \frac{v_{ds}}{\omega_s L_m}\end{cases} \quad (17)$$

For $v_{qs} = 0$

Neglecting the stator resistance R_s, we have

$$\begin{cases}i_{dr} = -\frac{2L_s}{3v_{ds}L_m}P_s\\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m}Q_s - \frac{v_{ds}}{\omega_s L_m}\end{cases} \quad (18)$$

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The above equations indicate that for a given stator voltage, the stator active power P_s and reactive power Q_s can be controlled by the *d-q-axis* rotor currents.

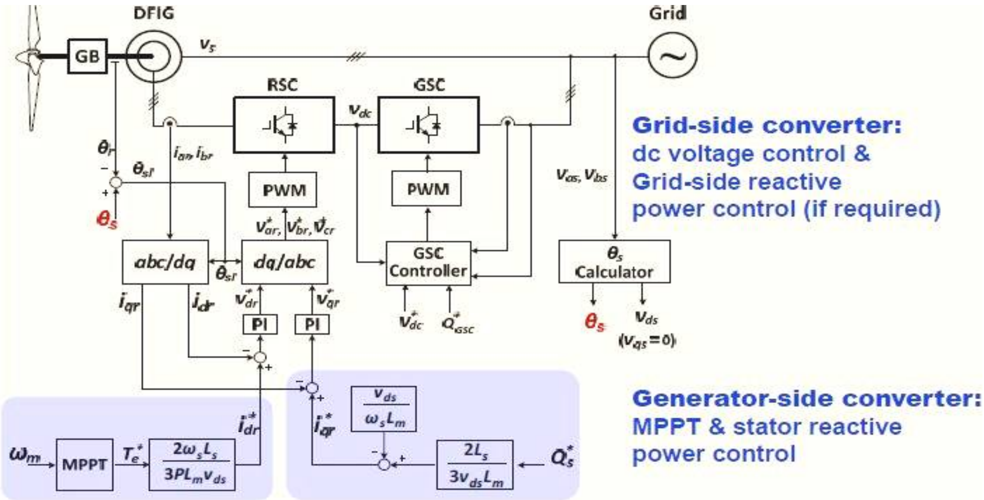

Fig3 Block diagram of a DFIG wind energy system with stator voltage oriented control

b. DC Link Voltage Selection

The dc-link voltage must be greater than twice the peak of maximum phase voltage. The dc link voltage selection depends on both rotor voltage and stator voltage. While considering from the rotor side, the rotor voltage is slip times the stator voltage. In DFIG used stator to rotor turns ratio as 2:1. Normally, the DFIG operating slip is ±0.3. So, the rotor voltage is always less than the grid voltage. So, the dc-link voltage only depends on grid voltage. While considering the grid side line voltage (V_{ab}) is 575V. Therefore, the dc-link voltage is estimated as

$$V_{dc} \geq \frac{2\sqrt{2}}{\sqrt{3} * m} V_{ab}$$

Where V_{ab} is the line voltage at the grid. Maximum modulation index is selected as 1 for linear range. The value of dc-link voltage (V_{dc}) is estimated at 1000 V. Hence, it is selected as 1000 V.

c. Converter Rating

In DFIG normally, the operating speed range is 0.7 to 1.3 pu. Therefore, the maximum slip (S_{max}) is 0.3. For making unity power factor at the stator side, reactive power is needed from the rotor side. The maximum rotor active power is (S_{max} ×*P*). The power rating of the DFIG is 1.5 MW. Therefore, the maximum rotor active power P_{rmax} is 0.45 MW (0.3 ×*1*. 5 MW = 0.45 MW).

The design of interfacing inductors between GSC and PCC depends upon allowable GSC current limit dc-link voltage, and switching frequency of GSC. Maximum possible GSC line currents are used for the calculation. Maximum line current depends upon the maximum power and the line voltage at GSC. The maximum possible power in the GSC is the slip power. In this case, the slip power is 1.5 MW. Line voltage (V_L) at the GSC is 575 V (the machine is connected in delta mode). So, the line current is obtained as

I_{gsc} = 1.5 MW/ (√ 3 ×575) = 1506.13 A.

Considering the peak ripple current as 25% of rated GSC current, the inductor value is calculated as

$$L_f = \frac{\sqrt{3} m V_{dc}}{12 a f_m \Delta i_{gsc}}$$

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Vol. 6, Issue 6, June 2017

IV.MODELLING AND SIMULATION

The ratings of VSCs and dc-link voltage are very much important for the successful operation of wind energy conversion system. Fig.4 Simulink diagram of DFIG wind energy conversion system at variable wind speed. Figure shows DFIG wind model simulation in MATLAB/ SIMULINK. The three phase programmable source is generating power at 120 kV, which has stepped down to 25 kV by the step down two winding transformer and then transmitted by the 30 km transmission line for stepping down the voltage level to the 575 V at the point of common coupling between the grid and the DFIG wind energy conversion systems. The DFIG wind energy conversion system is generating power of 1.5 MW. In this, the wind turbine uses a doubly-fed induction generator (DFIG), which consists of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The dc voltage is applied to IGBT/ Diode of two level inverter. The pulse width modulation technique has been used in this inverter, in order to achieve higher accuracy , the carrier frequency or switching frequency is 1620 Hz, discrete sample time is micro sec, Ts =5microsec. The stator side is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the converter. The DFIG wind system allows extracting maximum energy from the wind for low wind speeds to optimize the turbine speed, while minimized mechanical stresses on the turbine during the gusts of wind. Wind speed is variable type and the range of wind speed is 12m/s to15m/s.

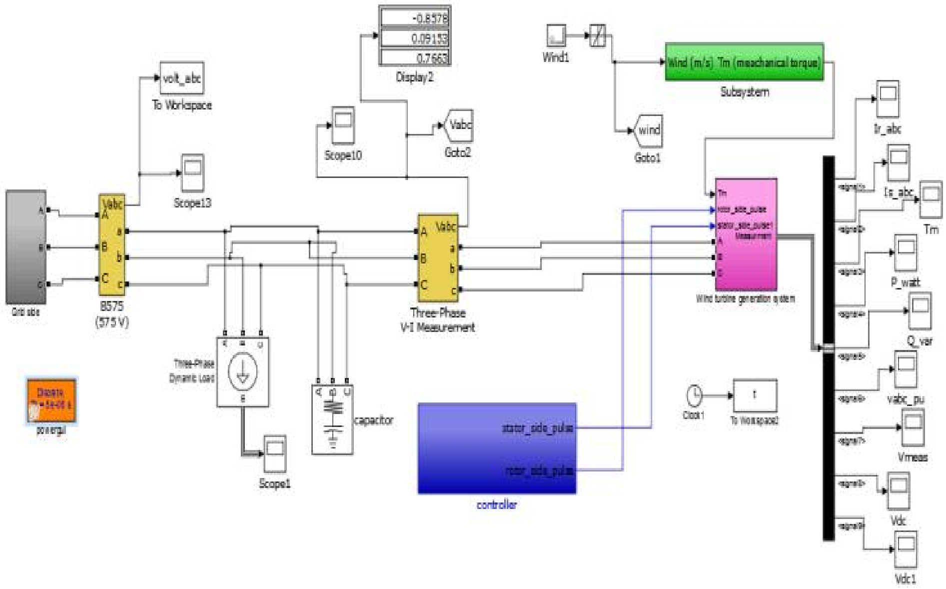

Fig.4 Simulink Diagram of DFIG wind generation system under dynamic load.

CASE STUDY 1: When Dynamic Load is applied

Under dynamic loading conditions, it is analysed that grid side voltage of DFIG system has variation between 0.05 to 0.14 sec, in Fig. 5 and besides this duration it is almost constant and equal to 0.8pu.

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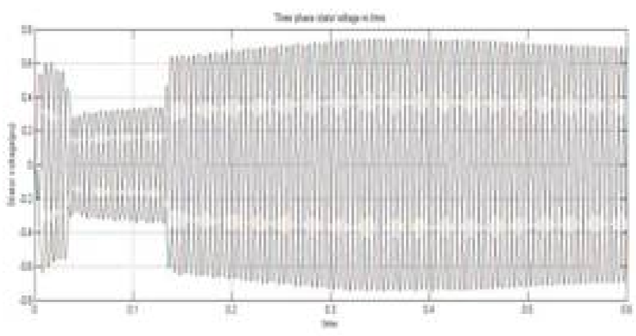
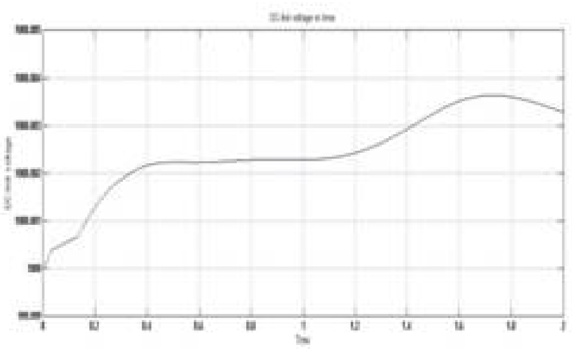

Fig.5 and 6: Stator voltage Vs. Time, Dc-link Voltage Vs. time

The active power of the DFIG wind system under variable wind speed, we obtained that power varies around required value of 0.4MW in Fig. 7 the electromechanical torque in Fig. 8 under the dynamic load is pulsating but at the starting point it fluctuates. Fig. 6 shows the DC-link voltage almost constant during the simulation.

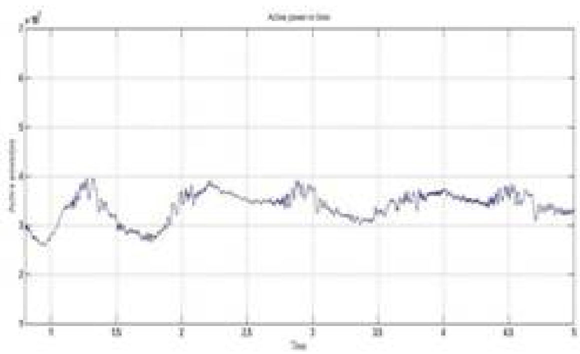
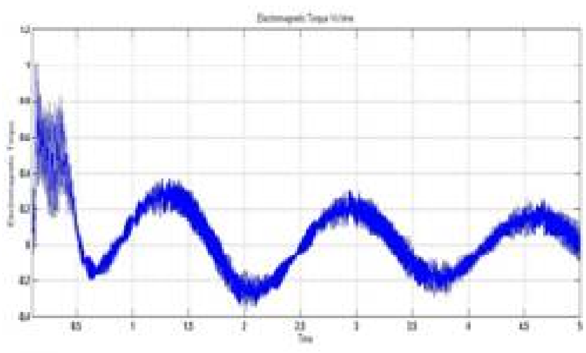

Fig.7&8: Rotor active power Vs. Time, Electromagnetic torque Vs. time

CASE STUDY 2:When fault occur at grid

When the most severe fault two phase to ground, that is unsymmetrical fault applied at grid side from 0.9 sec to 1.1sec. The results are presented at below from Fig.9 to Fig.12. In Fig.9 and Fig.10 shows the dc link voltage and stator side voltage, when fault occur from 0.9 sec the dc link voltage drastically increase its value when fault is clear after 1.1sec it will maintain its constant value. In stator voltage two phase value will down between the fault.

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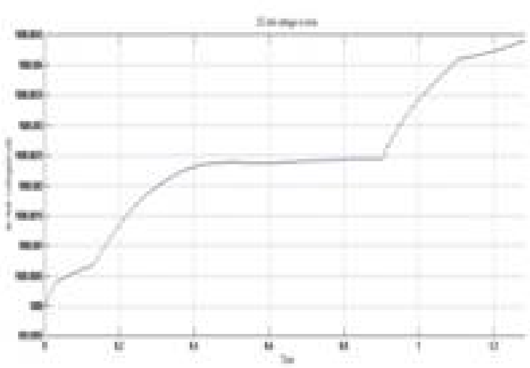


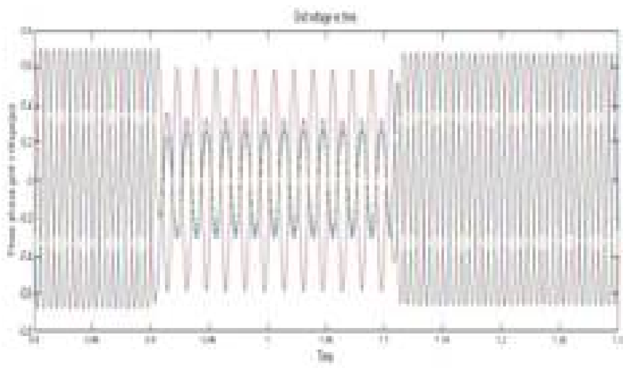
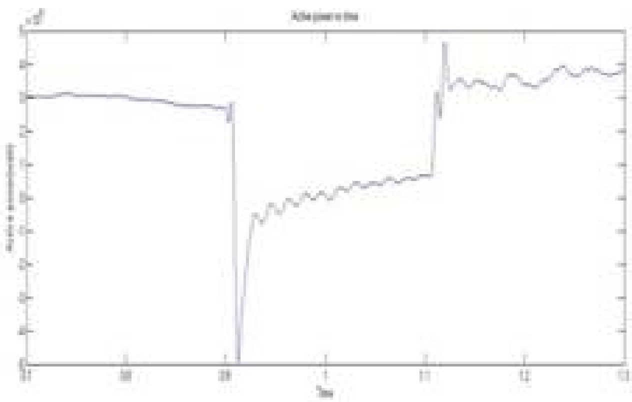


Fig.9& 10: DC-link voltage at fault condition, Grid side voltage at fault condition

Fig.11 and Fig.12 shows the electromagnetic torque and rotor active power, it will shows when fault occur the system has been very distorted and the electromagnetic torque and active power will go to the negative value and very much oscillating.



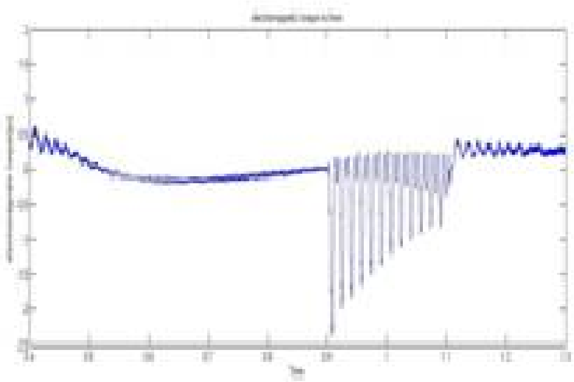


Fig.11 &12: Active power, Electromagnetic torque at fault condition

V.CONCLUSION

The modelling and simulation of DFIG wind system and control technique SVOC is used for maximum energy extraction and grid synchronisation reference frame and conditions. The simulation is performed for variable speed turbine conditions on DFIG integrated with grid under MATLAB/SIMULINK.

In this research paper, we have studied about DFIG and its working for dynamic load applied at grid side and examines the conditions of the system at fault conditions. For regulation of dc link voltage, we also employed SVOC method. During the research, it is analysed that when input voltage to the voltage source inverter changes; it could not maintain the dc link voltage at constant value. It is seen by analysis that SVOC scheme has the merits of providing effective synchronisation of DFIG with power grid.

Under dynamic loading conditions, it is analysed that grid side voltage of DFIG system has variation between 0.05 to 0.14 sec, and besides this duration it is almost constant and equal to 0.8pu. This variation has occurred due to synchronisation with the grid. The active power of the DFIG wind system under variable wind speed, we obtained that power varies around required value of 0.4MW. The electromechanical torque under the dynamic load is pulsating but at the starting point it fluctuates. While developed torque (Tm) is constant.

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REFERENCES

[1] E. Toledo, L. Aromataris, G. Tarnow ski, M. Oliveira, O. Perrone5, H. Reversat "Voltage Control in Wind Power Generation Using Doubly Fed Induction Generators" Energy Study Centre to Development (CEED), National University of Misiones (UNaM) Oberá, Misiones, Argentina.

[2] Bhim Singh and N. K. Swami Naidu, "Doubly Fed Induction Generator for Wind Energy Conversion System with Integrated Active Filter capabilities" IEEE Transactions On Automatic Control, Vol. 54, No. 7, July 2015.

[3]A.A.Hassan1, A.M. El-Sawy1, O.M.Kamel **"**Direct Torque Control of a Doubly fed Induction Generator Driven By a Variable Speed Wind Turbine" Journal of Engineering Sciences, Assiut University, Vol. 41 No1 pp.199-216 - January 2013.

[4] Ankit Gupta, S.N.Singh, Dheeraj K. Khatod, "Modelling and Simulation of Doubly Fed Induction Generator Coupled with Wind Turbine –An Overview", JEC&AS, Vol. 2, No.8, Aug. 2013.

[5] Rakesh Sharma, Kuldeep Sahay, Sateyndra Singh, "Effects of Varying Load on DC- Link Voltage in DFIG Based Wind Energy Conversion System," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 5, May 2014.

[6]NaliniTelu, K. Veeresham, RohiniTelu "Design, Simulation and Control of A Doubly Fed Induction Generator" International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue 3, May-Jun 2012.

[7]Resham R. Wandile, Sandeep V. Karemore, and Rakesh G. Shriwastawa **"**Direct active and reactive power control of DFIG for wind energy generation" International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control EngineeringVol. 3, Issue 5, May 2015.

[8]Rakesh Sharma, Kuldeep Sahay, Satyendra Singh, "Modeling and simulation of Fixed and Variable Speed of DFIG Wind System", International Journal of Recent Development in Engineering and Technology, volume 2, Issue 5, May 2014

[9] Arifujjaman,Md., Iqbal,M.T., Quaicoe, J.E,''Vector control of a DFIG based wind turbine'', Journal of Electrical and Electronics Engineering, Vol-9, Number-2, Year-2009.

[10] Muller, S., Deicke, M., Doncker, R.W.D., " Doubly fed induction generator system for wind turbines'', IEEE Industry Application Magazine, May-June, 2002.

[11] LiyanQu, Wei Qiao, ''Constant Power Control of DFIG Wind Turbines WithSuper capacitor Energy Storage", IEEE Transaction On Industrial.

[12] Shaheen, S.A, Hasanien, M., Badr, M.A., "Study On Doubly-Fed Induction Generator Control", MPECON'10,December 19-21,2010, ID 251

[13] Leban, K.,'' Doubly fed induction generator fault simulation'', Institute of Energy Technology Aalborg 2009.

[14]Ajay Kushwaha1, Inderpreet Singh, "Literature review paper on doubly fed induction generator wind turbine technology" International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463,Vol. 2 Issue 9, September-2013.

[15] Rakesh Sharma, Mariya Alvi, "DIFG for wind energy generation using stator voltage orientation control-A Review", International Journal of Scientific Research in Science Engineering and Technology (IJSRSET).Print ISSN:2395-1990,Online ISSN:2394-4099,VOLUME 2,Issue 1 ,pp490-496, Jan-Feb-2016.

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