ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

Performance Analysis of Doubly Fed Induction Generator Coupled with Wind Turbine Using Stator Voltage Oriented Control- An Overview

V.K. Chaudhary[1] , Kuldeep Sahay[2]

M. Tech(scholar),Uttar Pradesh Technical University, Lucknow ,Uttar Pradesh, India[1]

Professor, Dept. of EE, Institute of Engineering & Technology, Lucknow, Uttar Pradesh, India[2]

ABSTRACT: This paper imparts an overview of Modelling and simulation of Doubly Fed Induction generator (DFIG) coupled with wind turbine. The developments in this field through various researches and analysis are published in latest journals. The gist of DFIG applications in wind power energy system are illustrated in this review paper. Due to various merits of DFIG over other conventional generators, DFIG is applicable for wind generations. This paper is compendium of the researches about the study of DFIG, steady state and transient analysis, its mathematical modelling, simulation, reactive power control approaches and performance analysis of DFIG coupled with wind turbine. The analysis and study of DFIG wind turbine system using SVOC is capsule here. The behaviour of DFIG wind turbine system for different faults is also overviewed in this paper.

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

I.INTRODUCTION

The booming renewable energy industry including solar, wind, tidal, small hydro geothermal is helping the world transition away from fossil fuels due to its merits over conventional energy resources. Renewable energy is sustainable, reusable and eco-friendly and clean. Although fossil fuels are continually being formed via natural processes, they are generally considered to be non-renewable resources because they take millions of years to form and the known viable reserves are being depleted much faster than new ones are being made. Therefore renewable energy is best suited for long term usage. Among the other renewable energy sources wind energy has verified to be one of the most economical one. Earlier Constant speed WECS were proposed to generate constant frequency voltages from the variable wind. However, Variable speed WECS operations can be considered advantageous, because additional energy can be collected as the wind speed increases. Variable speed WECS must use a power electronic converter. They are classified as full power handling WECS and partial power handling WECS. In full power handling WECS, the power converter is in series with the induction or synchronous generator, in order to transform the variable amplitude/frequency voltages into constant amplitude/frequency voltages and the converter must handle the full power. In a partial power handling WECS, the converter processes only a portion of the total generated power (i.e. slip power) which poses an advantage in terms of the reduced cost converter of the system and increased efficiency of the system.

II. LITRATURE REVIEW RELATED TO DFIG WIND TURBINE SYSTEM

The research scholar Aishwarya Devi R. depicts the theory of regulation of the active and reactive powers in a grid connected Doubly Fed Induction Generator (DFIG) based Wind Energy conversion System (WECS). In this paper, she conveys that a back to back PWM converter setup with stator flux oriented vector control is used to control the DFIG where back to back PWM converter set up consists of the Rotor Side Converter (RSC) and the Grid Side Converter

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

(GSC) with intermediate DC link and Decoupled control of the DC link voltage and the grid reactive power is obtained through Voltage oriented control (VOC) of grid side converter. The proposed model of the WECS is mathematically modelled in MATLAB/Simulink in this paper. Her research shows the Power regulation of a grid connected Wind energy conversion system with DFIG for varying wind speeds. Grid voltage oriented vector control is employed in the grid side converter to maintain constant DC link voltage for effective power flow and to maintain overall system power factor as unity. During change over between super synchronous and sub synchronous operations the back to back converters automatically shift between their operation as inverters and converters.

In the paper titled “Control Strategy for DFIG Wind Turbine in Variable Speed Wind Power Generation” researchers illustrates the demands of increase of power generation in the global electrical energy consumption. This paper gives the importance of doubly fed induction generator (DFIG) based wind farm. In this paper, Artificial Neural Network (ANN) control technique has been developed for Doubly Fed Induction Generator (DFIG) based wind energy generation system. This analysis instigates the dynamic performance analysis of Doubly Fed Induction Generator under various operating conditions. In this paper, PI controller and artificial neural network control techniques are used to decide the dynamic performance of the DFIG.

The aim of the paper “Doubly-Fed Induction Generator for Variable Speed Wind Energy Conversion Systems-Modelling & Simulation” is to present the complete modelling and simulation of wind turbine driven doubly-fed induction generator. The grid side converter controls the power flow between the DC bus and the AC side and allows the system to be operated in sub-synchronous and super synchronous mode of operation. The proper rotor excitation is provided by the machine side converter. The complete system is modelled and simulated in the MATLAB Simulink environment in such a way that it can be suited for modelling of all types of induction rotor reference frame using generator configurations.

In the research paper titled “Control of Doubly Fed Induction Generator Based Wind Energy Conversion System” the main objective of the grid side converter is to maintain dc-link voltage constant for necessary action. For this issue, the reference current generation control technique is approached. The PWM converter is current regulated with the generation of reference current is being used to regulate the DC link voltage for balanced supply condition by using p-q theory is also used to regulate the reactive power. Since VAR compensation is a major problem in WECS. Capacitors banks are to be added in parallel to the machine which leads to many problems such as over voltages etc. In this paper, 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 machine-side converter controls the rotor speed by using the v/f control technique while 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 voltage-oriented control technique. The grid-side current is controlled by using reference current generation in p-q theory

The paper Doubly Fed Induction Generator for Wind Energy Conversion System with Integrated Active Filter capabilities proposed by N.K Swami Naidu and Bhim Singh deals with the operation of doubly fed induction generator (DFIG) with integrated active filter capabilities using grid side converter (GSC). The main contribution of this work lies in the control of grid side converter for supplying harmonics in addition to its slip power transfer. The rotor side converter (RSC) is used for attaining maximum power extraction and to supply required reactive power to Doubly Fed Induction Generator.

The impact of wind power plant with doubly fed induction generator on the power systems presented that Wind Power Plant (WPP) has been experiencing a rapid development in a global scale. The size of wind turbines and wind power plants are increasing quickly; a large amount of wind power is integrated into the power system. As the wind power penetration into the grid increases quickly, the influence of wind turbines on the dynamic stability is becoming more and more important. This paper studies the effect of wind power plants with double fed induction generator (DFIG) on the electric power system operation. The important characteristics such as: Voltage quality, grid voltage stability, active and reactive loss of a DFIG at different fault conditions studied. The simulation results Cleary show the effect of wind power plants on the grid voltage stability and power quality of electric power system.

Study of Fault Current Characteristics of the DFIG Considering Dynamic Response of the Rotor Side Converter illustrates that during non severe fault conditions, the crowbar protection is not activated and the rotor windings of a doubly fed induction generator (DFIG) are still excited by the ac/dc/ac converter. In these cases, the dynamic response of a rotor-side converter (RSC) has a large influence on the fault current characteristics of the DFIG. In this paper, an analysis method for the fault current characteristics of the DFIG under non severe fault conditions is proposed. The fault characteristics of the stator current are studied and the analytical expressions of the stator fault current are

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

represented. The proposed analysis method is applicable for the study of fault current characteristics of DFIG with different control strategies for low-voltage ride through. The research results are helpful to the construction of adequate relaying protection for the power grid with penetration of DFIGs.

III. WIND ENERGY CONVERSION SYSTEM

Wind turbines use a doubly-fed induction generator (DFIG) consisting of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 50 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. The optimum turbine speed producing maximum mechanical energy for a given wind speed is proportional to the wind speed. Another advantage of the DFIG technology is the ability for power electronic converters to generate or absorb reactive power, thus eliminating the need for installing capacitor banks as in the case of squirrel-cage induction generator.

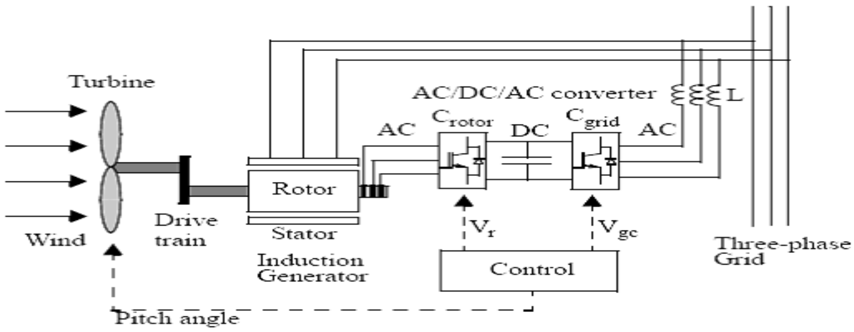

Fig.1 Basic diagram of Doubly fed induction generator with converters

Where V_r and V_{gc} are the rotor voltage and grid side voltage respectively. The AC/DC/AC converter is basically a PWM converter which uses sinusoidal PWM technique to reduce the harmonics preset in the wind turbine driven DFIG system. Here C-rotor is rotor side converter and C-grid is grid side converter. To control the speed of wind turbine gear boxes or electronic control can be used.

Operating Principle of DFIG

The stator is directly connected to the AC mains, whilst the wound rotor is fed from the Power Electronics Converter via slip rings to allow DIFG to operate at a variety of speeds in response to changing wind speed. Indeed, the basic concept is to interpose a frequency converter between the variable frequency induction generator and fixed frequency grid. The DC capacitor linking stator- and rotor-side converters allows the storage of power from induction generator for further generation. To achieve full control of grid current, the DC-link voltage must be boosted to a level 18 higher than the amplitude of grid line-to-line voltage. The slip power can flow in both directions, i.e. to the rotor from the supply and from supply to the rotor and hence the speed of the machine can be controlled from either rotor- or stator-side converter in both super and sub-synchronous speed ranges. As a result, the machine can be controlled as a generator or a motor in both super and sub-synchronous operating modes realizing four operating modes.
Below the synchronous speed in the motoring mode and above the synchronous speed in the generating mode, rotor-side converter operates as a rectifier and stator-side converter as an inverter, where slip power is returned to the stator. Below the synchronous speed in the generating mode and above the synchronous speed in the motoring mode, rotor-side converter operates as an inverter and stator side converter as a rectifier, where slip power is supplied to the rotor. At the synchronous speed, slip power is taken from supply to excite the rotor windings and in this case machine behaves as a synchronous machine.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

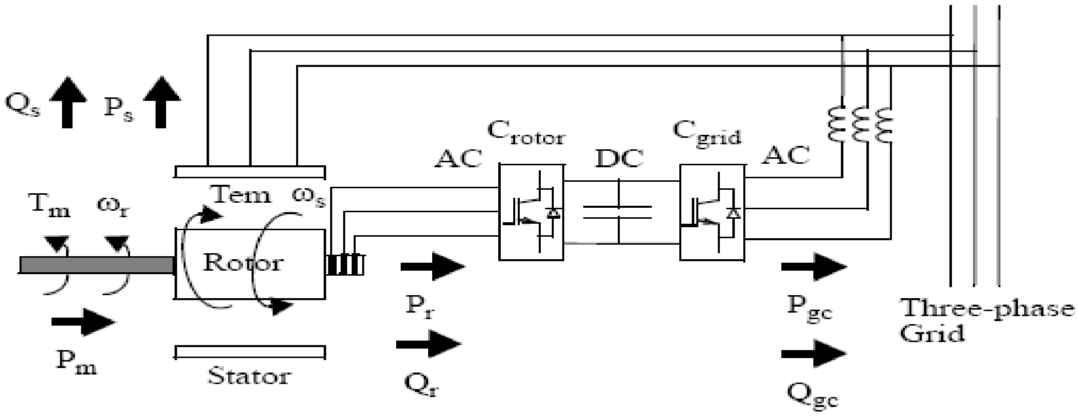

Fig.2 Power flow diagram of DFIG

The mechanical power and the stator electric power output are computed as follows:

$$P_r = T_m * \omega_r \quad (3.1)$$
$$P_s = T_{em} * \omega_s \quad (3.2)$$

For a loss less generator the mechanical equation is:

$$J\frac{d\omega_r}{dt} = T_m - T_{em} \quad (3.3)$$

In steady-state at fixed speed for a loss less generator

$$T_m = T_{em} \text{ and } P_m = P_s + P_r \quad (3.4)$$

And It follows that:

$$P_r = P_m - P_s \ \& \ T_m\omega_r - T_{em}\omega_s = -sP_s \quad (3.5)$$

Where, $s = (\omega_s - \omega_r)/\omega_s$ is defined as the slip of the generator

Generally the absolute value of slip is much lower than 1 and, consequently, Pr is only a fraction of Ps. Since Tm is positive for power generation and since ω_s is positive and constant for a constant frequency grid voltage, the sign of Pr is a function of the slip sign. Pr is positive for negative slip (speed greater than synchronous speed) and it is negative for positive slip (speed lower than synchronous speed). For super-synchronous speed operation, Pr is transmitted to DC bus capacitor and tends to raise the DC voltage. For sub-synchronous speed operation, Pr is taken out of DC bus capacitor and tends to decrease the DC voltage. C-grid is used to generate or absorb the power P_{gc} in order to keep the DC voltage constant. In steady-state for a lossless AC/DC/AC converter P_{gc} is equal to Pr and the speed of the wind turbine is determined by the power Pr absorbed or generated by C-rotor.
The phase-sequence of the AC voltage generated by C-rotor is positive for sub-synchronous speed and negative for super-synchronous speed. The frequency of this voltage is equal to the product of the grid frequency and the absolute value of the slip. C-rotor and C-grid have the capability for generating or absorbing reactive power and could be used to control the reactive power or the voltage at the grid terminals.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

IV. 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.

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. This is in contrast to electric motor drives, where rotor- or stator-flux field oriented controls (FOC) are normally used. Fig.3 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-

$$v_{qs} = 0 \;\&\; v_{ds} = v_s \qquad (4.1)$$

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

$$\omega_s = 2\pi f_s \qquad (4.2)$$

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 rotates at speed ω_r. The rotor position angle θ_r is also referenced to the stator frame. The angle between the stator voltage vector and the rotor is the slip angle, defined by

$$\theta_{sl} = \theta_s - \theta_r \qquad (4.3)$$

The DFIG operates with unity power factor, the stator current vector $\vec{i_s}$ is aligned $\vec{v_s}$ with but 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-q axes v_{dr} and v_{qr} for $\vec{v_r}$ and i_{dr} and i_{qr} for $\vec{i_r}$.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

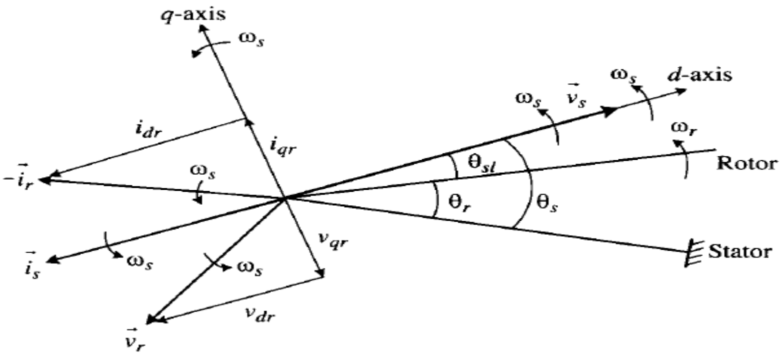

Fig.3 Space-vector diagram of DFIG with SVOC in the super-synchronous mode

These d-q axis components 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

$$T_e = \frac{3P}{2}\left(i_{qs}\lambda_{ds} - i_{ds}\lambda_{qs}\right) \qquad (4.4)$$

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

$$\begin{cases}\lambda_{ds} = L_s i_{ds} + L_m i_{dr}\\ \lambda_{qs} = L_s i_{qs} + L_m i_{qr}\end{cases} \qquad (4.5)$$

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

$$\begin{cases}i_{ds} = \frac{\lambda_{ds} - L_m i_{dr}}{L_s}\\ i_{qs} = \frac{\lambda_{qs} - L_m i_{qr}}{L_s}\end{cases} \qquad (4.6)$$

Substituting Equation (4.6) into (4.4)

$$T_e = \frac{3PL_m}{2L_s}\left(-i_{qr}\lambda_{ds} + i_{dr}\lambda_{qs}\right) \qquad (4.7)$$

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

$$\vec{v_s} = R_s\vec{i_s} + j\omega_s\vec{\lambda_s} \qquad (4.8)$$

the representation in d-q axis is

$$\left(v_{ds} + jv_{qs}\right) = R_s\left(i_{ds} + ji_{qs}\right) + j\omega_s\left(\lambda_{ds} + j\lambda_{qs}\right) \qquad (4.9)$$

from which the d-q axis stator flux linkages are

$$\begin{cases}\lambda_{ds} = \frac{v_{qs} - R_s i_{qs}}{\omega_s}\\ \lambda_{ds} = \frac{v_{qs} - R_s i_{qs}}{\omega_s}\end{cases} \qquad (4.10)$$

substituting Equation (4.10) into (4.7)

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

$$T_e = \frac{3PL_m}{2\omega_s L_s}\left(-i_{qr}\left(v_{qs} - R_s i_{qs}\right) - i_{dr}\left(v_{ds} - R_s i_{ds}\right)\right) \qquad (4.11)$$

$$T_e = \frac{3PL_m}{2\omega_s L_s}\left(-i_{qr}v_{qs} + R_s i_{qs} i_{qr} + R_s i_{ds} i_{dr} - i_{dr} v_{ds}\right) \qquad (4.12)$$

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

$$T_e = \frac{3PL_m}{2\omega_s L_s}\left(R_s i_{qs} i_{qr} + R_s i_{ds} i_{dr} - i_{dr} v_{ds}\right) \qquad (4.13)$$

While ignoring the stator resistance from the above equation, the electromagnetic torque becomes function of d-axis rotor current and stator voltage. The stator active and reactive power can be calculated by

$$\begin{cases} P_s = \frac{3}{2}\left(v_{ds} i_{ds} + v_{qs} i_{qs}\right) \\ Q_s = \frac{3}{2}\left(v_{qs} i_{ds} - v_{qs} i_{qs}\right) \end{cases} \qquad (4.14)$$

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

$$\begin{cases} P_s = \frac{3}{2} v_{ds} i_{ds} \\ Q_s = -\frac{3}{2} v_{ds} i_{qs} \end{cases} \text{for } v_{qs} = 0 \qquad (4.15)$$

Substituting the value of current in above equation,

$$\begin{cases} P_s = \frac{3}{2} v_{ds}\left[\frac{\lambda_{ds} - L_m i_{dr}}{L_s}\right] \\ Q_s = -\frac{3}{2} v_{ds}\left[\frac{\lambda_{qs} - L_m i_{qr}}{L_s}\right] \end{cases} \qquad (4.16)$$

From which

$$\begin{cases} i_{dr} = -\frac{2L_s}{3v_{ds}L_m} P_s + \frac{1}{L_m}\lambda_{ds} \\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m} Q_s + \frac{1}{L_m}\lambda_{qs} \end{cases} \qquad (4.17)$$

Substituting the stator flux linkages from Equation (4.10) into (4.17)

$$\begin{cases} i_{dr} = -\frac{2L_s}{3v_{ds}L_m} P_s + \frac{v_{qs} - R_s i_{qs}}{\omega_s L_m} = -\frac{2L_s}{3v_{ds}L_m} P_s - \frac{R_s}{\omega_s L_m} i_{qs} \\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m} Q_s + \frac{v_{qs} - R_s i_{qs}}{\omega_s L_m} = -\frac{2L_s}{3v_{ds}L_m} Q_s - \frac{R_s}{\omega_s L_m} i_{qs} - \frac{v_{ds}}{\omega_s L_m} \end{cases} \text{for } v_{qs} = 0 \qquad (4.18)$$

Neglecting the stator resistance R_s, we have

$$\begin{cases} i_{dr} = -\frac{2L_s}{3v_{ds}L_m} P_s \\ i_{qr} = -\frac{2L_s}{3v_{ds}L_m} Q_s - \frac{v_{ds}}{\omega_s L_m} \end{cases} \qquad (4.19)$$

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.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

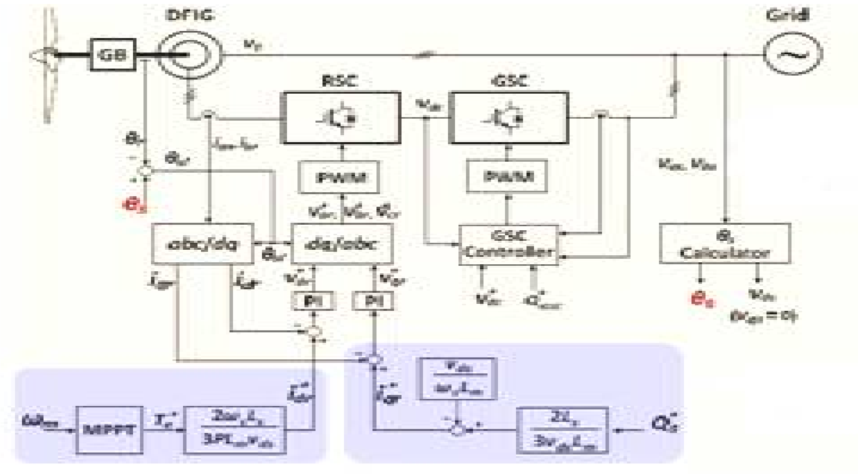

Fig.4 Block diagram of a DFIG wind energy system with stator voltage oriented control

Depending on the speed of the rotor, there are two modes of operation in the doubly fed induction generator wind energy conversion system, that is the super-synchronous mode and sub-synchronous mode. In the super-synchronous mode, the generator operates above the synchronous speed and in sub-synchronous mode; the generator operates below the synchronous speed. In the super-synchronous operation mode, the mechanical power delivered from the shaft to the grid through both stator and rotor circuit. For sub-synchronous operation, the rotor receives the power from the grid and both mechanical power and rotor power are delivered to the grid through the stator. The stator power is the sum of mechanical power and rotor power but it will not exceed its power rating since in sub-synchronous mode the mechanical power from the generator shaft is lower than that in the super-synchronous mode.

VI.CONCLUSION

This review paper is to analyze a DFIG based wind energy power system and control technique for maximum energy extraction and grid synchronization under stator voltage orientation reference frame and conditions. A rotor-side converter control design has been presented which is the key to work conducted in this paper. The performance assessment of the controller designed has been carried out by analyzing its real/reactive power control in stator-voltage oriented frame, and analyzing its effectiveness in speed control, and the ability of the controller in facilitating effective synchronization with the power grid.

REFERENCES

[1] Babypriya, B., Anita,R., "Modelling ,simulation and analysis of doubly fed induction generator (DFIG) for wind turbines" , journal of electrical engineering, vol. 60, no. 2, 2009.

[2] Muller, S., Deicke, M., Doncker, R.W.D., " Doubly fed induction generator system for wind turbines'', IEEE industry application magazine, may-june, 2002.

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

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

[5] Cortajarena,J.A., Marcos. J.D.,Alvarez. P., Vicandi. V.J., Alkorta. P.,'' Start up and control of a DFIG wind turbine test rig'', IEEE, 2011

[6] Bin Wu,Yongqiang, Navid Zargari, Samir Kouro, "Power Conversion And Control Of Wind Energy System," IEEE Press, A John wiley & sons, inc., Publication

[7] Bhim Singh, "Performance of Wind Energy Conversion System using a Doubly Fed Induction Generator for Maximum Power Point Tracking," 2010 IEEE transaction paper.

[8] S.Muller, M.Deicke&Rik W,DeDoncker, "Doubly Fed Induction Generator Systems for Wind Turbines, "IEEE Industry Applications Magazine, vol. 8, no.3, May/June 2002.

[9] Seung-Ho Song, Shin-il Kang, Nyeon-Kun Hahm "Implementation and Control of Grid Connected AC-DC-AC Power Converter for Variable Speed Wind Energy Conversion System," IEEE Trans. On Power systems, vol. 1, no. 1, pp. 154–158, 2003.

[10]S. Engelhardt, I. Erlich, C. Feltes, J. Kretschmann, F. Shewarega, "Reactive Power Capability of Wind Turbines Based on Doubly Fed Induction Generator", IEEE Trans. on Energy Conversion, vol. 26, no. 1, pp. 364-372, March 2011.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

[11] Xiangping Kong, Zhe Zhang, Xianggen Yin, Member, IEEE, and Minghao Wen, "Study of Fault Current Characteristics of the DFIG Considering Dynamic Response of the RSC" IEEE transactions on energy conversion, vol. 29, no. 2, June 2014.

[12] 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.

[13]S. Müller, M. Deicke, and R. W. de Doncker, "Doubly Fed Induction Generator Systems for Wind Turbines," IEEE Industry Applications Magazine, Vol. 8, No. 3, 26-33, 2002.

[14]Heng Nian, *Member,* IEEE, and Yipeng Song, "Direct Power Control of Doubly Fed Induction Generator Under Distorted Grid Voltage," IEEE transactions on power electronics, vol. 29, no. 2, february 2014.

BIOGRAPHY

Virendra Kumar Chaudhary is a M. Tech Scholar in the Department of Electrical Engineering, SRMS College of Engineering & Technology, Bareilly. He received his B.Tech degree in Electrical Engineering from KNIT, Sultanpur, India, in 2001.He has total 07 years of teaching experience in the Dept. of Technical Education, Uttar Pradesh. His research area of interest includes renewable energy resources and hybrid system.

Kuldeep Sahay, Ph.D. is associated with Institute of Engineering & Technology, Lucknow since 1996, where, he is presently Professor in the Department of Electrical Engineering, An Autonomous Constituent College of Dr. A.P.J. Abdul Kalam Technical University, Lucknow. He has authored numbers of research paper in National and International Journal having good citation and published a book. His research interests are in the area of Mathematical Modelling of Energy Storage System, Integration of Renewable Energy System with Grid. Prof. Sahay for his overall contribution in research and academics has been awarded "Shiksha Rattan Puraskar" and "Rashtriya Gaurav Award" by India International Friendship Society, New Delhi in 2011