International Journal of Trend in Innovative Research (IJTIIR)
Available Online @ www.ijtiir.com | ISSN: 2582-0354

Simulation, Modeling and Control of a Doubly Fed Induction Generator Base Wind Turbine System-A Review

[1]Sawood Alam, [2]Pramod Kumar Rathore
[1]Student, RKDF College of Engineering Bhopal (MP), sawood.alam08@gmail.com
[2]Assistant Professor, RKDF College of Engineering Bhopal (MP), pkrathore23@gmail.com

Abstract-- This paper describes the simulation and control technique for a dual-feed induction generator grid (DFIG) dependent wind energy conversion device. Control methods for the grid side (GSC) and the rotor side converters (RSC) in the DFIG rotor circuit are presented; Along with the statistical simulation of the configuration used. Second, we have built models for the various elements of the DFIG conversion chain and maximum power point tracking (MPPT) control strategy. In addition, the vector-oriented stator flux technique of the decoupled regulation of the electromagnetic torque (active) and the reactive power is built to investigate the impact of direct Idr and quadrature Iqr rotor currents on actual power stator and Qs reactive power and Or reactive power rotor. The simulation results of the 3MW wind device are finally displayed in the MATLAB/Simulink environment. The findings of the simulation are described and analyzed at the conclusion of this article.

Keywords: *Wind turbine, doubly fed induction generator, Back-to-Back Converter, vector control*

I. INTRODUCTION

Wind power generation has significantly increased during the last years[1]; it is one of the most important and promising sources of renewable energy all the world, mainly because it is considered to be nonpolluting and economically viable. At the same time, there has been a rapid development of wind turbine technology [2] Nowadays, the market for variable speed wind turbines is oriented to the design of high power wind generation systems (1 MW and more). For such applications, doubly fed induction generators have great interests since they are able to generate a controllable high power thanks to reduced rated power converters in comparison with other wind generator technologies for the same power [3,4]. Currently, wind variable speed system based on a doubly fed induction generator (DFIG) is most commonly used in wind farms due at its many advantages [5]. This paper deals with the modeling and control of the doubly fed induction generator based wind conversion system. For this, three-control strategies are considered, MPPT control, control of Rotor Side Converter (RSC) and the control of Grid Side Converter (GSC). The GSC ensures the regulation of the DC voltage to the desired value, while the RSC controls the torque active and reactive powers injected by the DFIG to the grid.

II. MODELING AND WIND CONVERSION SYSTEM DESCRIPTION

A simplified diagram of the power system based on wind power generation is illustrated in figure 1. It consists of a wind turbine, a gearbox, a DFIG, and back-to-back converters composed of two voltage-source inverters linked through a DC capacitor this configuration is also referred to as the Scherbius topology. The stator circuit is directly connected to the network, the rotor-side converter (RSC) is connected to rotor windings via slip rings and brushes, the Grid-side converter (GSC) is connected to the network through a harmonic filter. The Rotor-Side Converter (RSC) and the generator stator active and reactive powers are controlled in a decoupled manner such that the MPPT operation can be obtained while maintaining unity, lagging, or leading power factor at the grid. While the Grid-side inverter (GSC) regulates the active power flow between rotor and mains supply maintaining a constant DC link voltage and line-side power factor. Both VSCs are capable of supporting bidirectional power flow. This capability is used to operate the DFIG in both the hyper-synchronous mode where power flows from the rotor to the grid, and the hypo-synchronous mode where the power flows from the grid to the rotor.

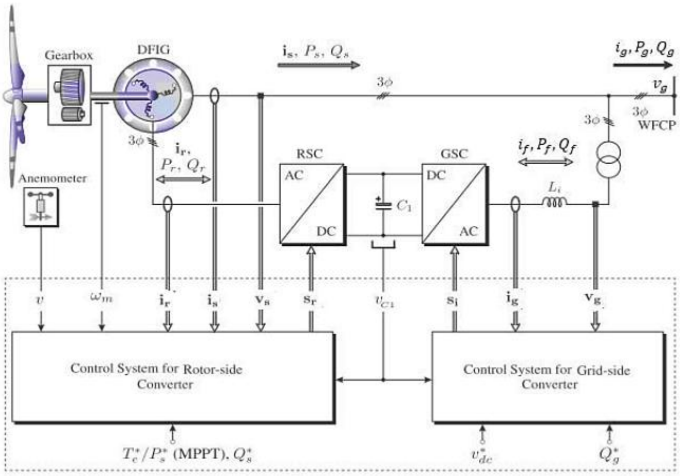

Figure 1: Block diagram of the digital control scheme for BTB VSC-based DFIG WECS.

The wind energy conversion system (WECS) can be divided into three interacting main subsystem, which will be separately modeled:

- Aerodynamic Sub-system.
- Mechanical Sub-system.
- Electrical Sub-system.

A. Aerodynamic Model

The aerodynamic model represents the power extraction of the rotor, calculating the mechanical torque as a function of the air flow on the blades. The wind speed can be considered as the averaged incident wind speed on the swept area by the blades with the aim of evaluating the average torque in the low speed axle. The torque generated by the rotor is defined by the following expression [6]:

$$T_a = \frac{1}{2.w_t} . C_p(\lambda, \beta).\rho.S.V^3$$

Where represents the wind turbine power conversion efficiency. It is a function of the tip-speed ratio, as well as the blade pitch angle in a pitch-controlled wind turbine. Is defined as the ratio between the tangential speed of the blade tip and the wind speed.

Modeling of mechanical Sub-system the mechanical system of a DFIG wind turbine is modeled in some literature as a lumped a two-mass Stiffness of the shaft connecting the DFIG rotor mass to the turbine mass [8] as shown in Figure 2

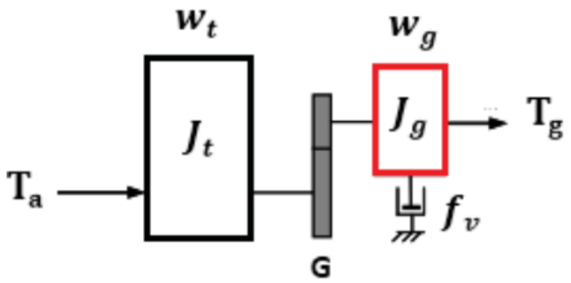

Figure 2: Mechanical system of a DFIG wind turbine.

The power transmission train is constituted by the blades linked to the hub, coupled to the slow shaft, which is linked to the gearbox, which multiplies the rotational speed of the fast shaft connected to the generator. Torque and shaft speed of generator side, are given by:

$$T_g = \frac{T_t}{G}$$

$$w_g = G.w_c$$

$$1 = \frac{1_t}{G^2} + 1_g$$

C. Modeling of the electrical Sub-system

C.1. Model of DFIG:

The mathematical model of the DFIG, which will later be simplified in this paper, is presented here, considering the generator's variables in the d,q synchronous reference frame. The equations for the stator and rotor windings can be written as:

$$\begin{cases} V_{ds} = R_s t_{ds} - w_s \varphi_{qs} + \dfrac{d\varphi d_s}{dt} \\ V_{qs} = R_s t_{ds} + w_s \varphi_{qs} + \dfrac{d\varphi d_s}{dt} \end{cases}$$

$$\begin{cases} V_{dr} = R_r t_{dr} - w_r \varphi_{qr} + \dfrac{d\varphi d_r}{dt} \\ V_{qr} = R_r t_{dr} + w_r \varphi_{qr} + \dfrac{d\varphi d_r}{dt} \end{cases}$$

The d–q synchronous reference frame equations of the stator flux and rotor may be written also as:

$$\begin{cases} \varphi_{ds} = L_s t_{ds} + M t_{dr} \\ \varphi_{qs} = L_s t_{qs} + M t_{qr} \end{cases}$$

$$\begin{cases} \varphi_{dr} = L_r t_{dr} + M t_{ds} \\ \varphi_{qr} = L_r t_{qr} + M t_{qs} \end{cases}$$

C.2.Average model of back to back converter

Generally, back-to-back converter is modelled using detailed model that use switching device in simulation. When this converter is connected to a complex circuit, especially system with high frequency switching, the time that needed to run the simulation will be very long. It makes the simulation become inflexible. Concerning the situation, average model of back-to back converter is proposed to generate flexible simulation for many different types of condition. Average model is faster than detailed model in simulation because it is not performing switching operation [8]. The voltage and current value of both grid side converter and rotor side converter in the d,q synchronous reference frame.

C.3. Grid Side System (RL Filter Model)

The description of the grid is very simple, represented by a resistance, an inductance and a voltage source, for each phase. The electric equations of the filter (R_f , L_f) connected to the grid in the synchronous d–q frame are given bellow:

$$\begin{bmatrix} \theta_d \\ \theta_q \end{bmatrix} = L \frac{d}{dt} \begin{bmatrix} t_{fd} \\ t_{fq} \end{bmatrix} + \begin{bmatrix} R & -w_s L_f \\ w_s L_f & R \end{bmatrix} \begin{bmatrix} t_{df} \\ t_{qf} \end{bmatrix} + \begin{bmatrix} v_{fd} \\ v_{fq} \end{bmatrix}$$

C.4. DC-Link Model

The RSC and GSC are connected through a DClink in a back-to-back topology. The power balance between the DC- link and the inverters' output is carried out. Thus, in order to obtain the current in the DC-link capacitor.

III. CONTROL OF THE DFIG BASED WIND CONVERSION SYSTEM

The dynamic model of the DFIG and controller design for the two converter stages are discussed in detail in this Section. The rotor side converter directly controls the active and reactive power flow from the stator of the DFIG to the grid. This is achieved by controlling the magnitude, frequency, and phase angle of the three-phase currents injected into the rotor by the duty ratio (PWM) control of the voltage source converter. The specific control objectives of the rotor side converter are:

A. Maximum power extraction

The control system of DFIG wind turbine assures the variable speed operation that maximizes the output power for a wide range of wind speeds. The power extracted from the wind is maximized when the rotor speed is such that the power coefficient is optimal. Therefore, we must set the tip speed ratio on its optimal value, so that turbine blade can capture the maximum of the wind power.

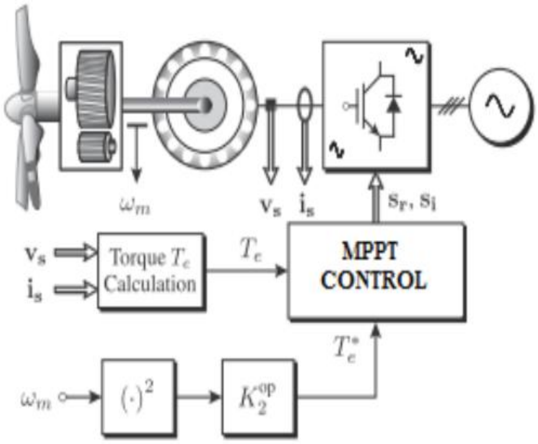

Figure 3: optimum torque control

B. Vector Control of the Active and Reactive Powers

Vector control allows to separately controlling the active and reactive power flow between utility grid and wind generator and the grid and defines the machine magnetization level through the rotor circuit. For this, we apply vector control, also known order by the direction of flow. We choose d,q reference linked to the rotating field, figure 4

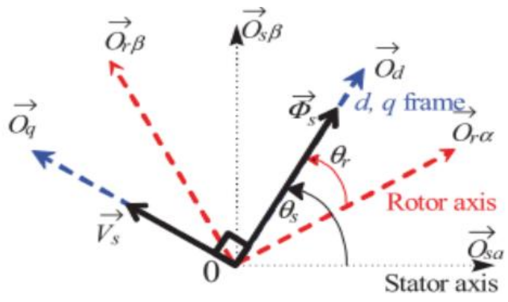

Figure 4: Orientation of d and q

CONCLUSION

In this article, we designed the two major interactive subsystems of the Wind Energy Conversion Method (WECS). The cascaded control algorithm has been correctly developed. Second, the achievement of the highest power performance of the WECS was ensured by integrating the MPPT technology with the WECS. The way to regulation. A decoupled d, q regulation for both GSC and RSC is implemented. For the GSC control algorithm, the q-component of the filter current is used for the DC voltage regulation and the d-component is used for the reactive power regulation. In comparison, for the RSC control algorithm, the q-component of the rotor current is used to control the active power pumped by the DFIG into the grid while the d-component is used to control the reactive power. The GSC and the RSC. According to this model, the control algorithm Simulation is given in the MATLAB/Simulink programmed To examine the relevance of the report. We note that the simulation results indicate that the active and reactive control forces of the stator provide reasonable output. The power management technique is therefore well suited to this kind of framework.

References

[1] Integrating Wind Developing Europe's Power Market for the Large-scale Integration of Wind Power, Mar. 2009.

[2] D. J. Leith and W. E. Leithead, «Appropriate realization of gain-scheduled controllers with application to wind turbine regulation» Int. J. Contr. vol. 65, no. 2, pp. 223–248, 1996.

[3] S. Muller, M. Deicke, R. W Doncker, «Doubly-Fed Induction Generators Systems for Wind Turbines», IEEE Industry Applications Magazine, May-June 2000.

[4] Thierno Lamarana Sow, «Nonlinear control of the wind turbine at DFIG for a participation to the regulating of the frequency of the network» Doct. Thesis, Superior technology school, Quebec, Jan. 2012.

[5] W. Hofmann, F. Okafor, «Doubly-Fed Full-Controlled Induction Wind Generator for Optimal Power Utilization» in Proceeding of IEEE International Conference on Power Engineering and Drive Systems, 2001, vol. 1, pp. 355 – 361.

[6] Doubly Fed Induction Machine: Modeling and Control for Wind Energy Generation. Gonzalo Abad, Jesus Lôpez, Miguel Rodriguez, Luis Marroyo, Grzegorz Iwanski. October 2011, Wiley-IEEE Press.

[7] S. El Aimani, B. François, F. Minne et B. Robyns, «Comparison analysis of control structures for variable wind speed turbine» chez Proceedings of CESA, Lille, France, Juillet 2003.

[8] Akhmatov V., Nielsen A.H. and Pedersen J.K. Variable-speed wind turbines with multi-pole synchronous permanent magnet generators. Part I: Modelling in dynamic simulation tools. Wind Engineering, 27, 531–548. (2003).