"THEORETICAL APPROACH OF DFIG SYSTEM WITH HARMONICS & DISTORTION"

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Abstract-*Wind power generation based on the doubly-fed induction generator has gained increasing popularity due to several advantages, including smaller converters rating around 30% of the generator rating, variable speed and four quadrants active and reactive power operation capabilities, lower converter cost, and power losses compared with the fixed-speed induction generators or synchronous generators with full-sized converters. This paper presents the theoretical approach of DIFG system with doubly-fed induction generator (DFIG)-based wind-power generation system.*

Keywords: **doubly-fed induction generator, reactive power, fixed speed induction generators.**

1.INTRODUCTION

With the increased penetration of wind energy into power grids all over the World, more and more large-scale wind turbines and wind power plants have been installed in rural areas or offshore where the grids are generally quite weak. The operation and control of such remote wind turbines under
non-ideal voltage conditions, including severe voltage sags, network unbalance, and harmonic voltage distortions, have attracted more and more attention [1–14]. With many excellent merits such as low rating converter capacity, variable speed constant frequency operation and independent power regulation capability, wind turbines based on doubly-fed induction generators (DFIGs) have become one of the mainstream types of variable speed wind turbine in recent years. Unlike wind generators with the full-sized grid-connected converters (such as permanent magnet synchronous generators), DFIG is very sensitive to aforementioned grid disturbances as its stator is directly connected to the grid and the rating of the back-to-back converter is limited.

2. RELATED WORK

Marouane El Azzaoui et. al.[1] proposed the backstepping control of Double-Fed Induction Generator (DFIG) and integrated with wind power system. The proposed algorithm combines the nonlinear Backstepping approach and the field orientation applied to control the DFIG. In a first step, this technique is applied to the side converter rotor (RSC), to control the electromagnetic torque and reactive power, and secondly, it is applied to the grid side converter (GSC) to control the power exchanged with the grid and regulate the DC bus voltage. Author presents the simulations results and performances of system in terms of set point tracking, stability, and robustness with respect to sudden changes in wind speed.

Jayasankar V N et. al [2] proposed the Hybrid Wind-Solar system and show the simulated results in MATLAB. Author used the DC-DC converter and grid interfacing for grid interconnection of Renewable System. Inverter is controlled in such a way that it act as a grid interfacing unit as well as a shunt active filter. Non linear loads are connected at point of common coupling. Various Renewable Energy generation conditions with unbalanced and distorted grid conditions are simulated and found that system works well for different conditions. Thus grid interfacing inverter with additional functionality of shunt active power filter can be utilized in distribution systems for cost effective distributed generation with power quality improvement features.

Rojan Bhattarai et. al. [3] investigating the state feedback control strategy for Doubly Fed Induction Generator (DFIGs). Bu using the state feedback control technique author designs both the rotor side converter and grid side converter control of DFIG. Author also presents the comparison between the traditional PI based vector control (VC) of DFIG with the proposed system. It has been shown that this methodology helps in easier controller design for DFIG, exhibits competitive performance in terms of low interaction between power and voltage control and provides better system damping. The simulation results for a system connected to a grid through a transmission line have been presented and the capabilities of the proposed controller are discussed.

Peng Kou et. al. [4] proposed the stochastic model predictive control (SMPC) technique for the DFIG wind turbine system. In this techniques author takes into account the uncertainties in wind speed forecasts. Using wind speed predictive distributions, the forecasted wind speeds are modeled as Gaussian disturbances. Using probabilistic constraints, the uncertainties in these disturbances are incorporated into the SMPC problem formulation. By converting the probabilistic constraints into deterministic constraints, the formulated stochastic programming problem is recast as a convex quadratic optimization problem, which can be solved very efficiently. In this way, author computed control actions and handles the uncertainties associated with the wind speed forecasts, thus ensuring the optimal operation of DFIG.

Rahmat Suryana et. al. [5] presents the experimental investigation of network frequency stability controlled by wind power plants with doubly fed induction generators without supporting from other conventional power plants in the laboratory scale. In this paper author used the combination of kinetic energy and pitch control methods and implemented by many wind turbines in a wind farm and coordinated by a wind farm control center. Using this method gives all advantages and overcome all the drawbacks of previous methods. The active pitch control can support long period frequency control, and the kinetic energy control can support fast action of frequency control. Therefore, the combination method provides fast action and long period support of network frequency controlled by wind power plants.

Jiefeng Hu et. al. [6] proposed the novel control strategy of doubly fed induction generators (DFIGs) under unbalanced grid voltage conditions. Author used a model predictive direct power control (MPDPC) method and power compensation techniques. In MPDPC, the appropriate voltage vector is selected according to an optimization cost function; hence the instantaneous active and reactive powers are regulated directly in the stator stationary reference frame without the requirement of coordinate transformation, PI regulators, switching table, or PWM modulators. In addition, the behavior of the DFIG under unbalanced grid voltage is investigated. Next, a power compensation scheme without the need of extracting negative stator current sequence is developed. By combining the proposed MPDPC strategy and the power compensation technique, distorted currents injected into the power grid by the DFIGs can be removed effectively.

Pinghua Xiong et. al [7] proposed the novel algorithm sort of nonlinear backstepping and combining with direct power control (DPC) to wind turbine driven doubly fed induction generator (DFIG) under normal and especially harmonic grid voltage. Firstly, the power control objectives are analyzed and designed under normal and harmonic grid voltage for the purpose of harmonic stator current suppression; secondly, a unified mathematic model of DFIG under normal and harmonic grid voltage is founded, exploring its power model in detail; finally, the backstepping algorithm is implemented and the backstepping-based direct power control (BS-DPC) algorithm of DFIG is developed under normal and harmonic grid voltage. Author shows the comparative simulation results between vector control (VC) with resonant controller, look-up table DPC (LUT-DPC) and BS-DPC under normal grid voltage with proposed BS-DPC realizes the decoupling control of active and reactive power of DFIG, with better dynamic performance than VC, as well as with better steady performance than LUT-DPC.

3. GENERAL MODEL OF DFIG SYSTEM

A General block diagram DFIG system shows a laboratory prototype of DFIG system as shown in Fig 1, in which the DFIG is driven by a squirrel cage induction machine as the wind turbine. The induction machine is driven by a general converter. The rotor side converter of DFIG is connected with a dc power supply. A controllable three-phase power grid is set up to simulate the practical harmonic power grid. The control strategy is implemented on the Controller, and the driver for IGBT. [1]

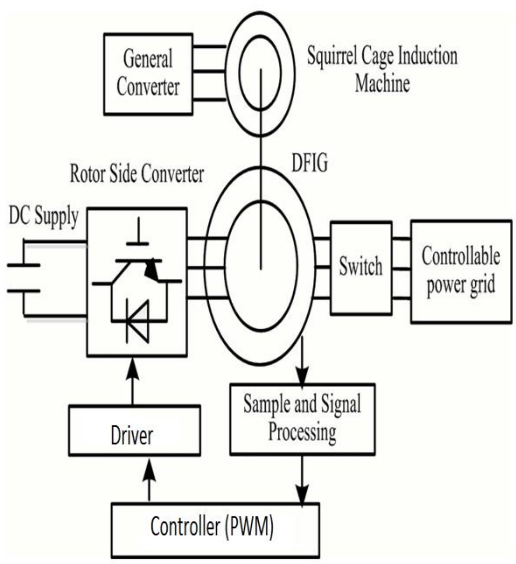

Fig 1: General Block Diagram DFIG System

In this DPC control strategy for DFIG system under the distorted grid voltage. First, the grid voltage phase is obtained through phase lock loop (PLL) proposed in the rotor position and speed are achieved by the output of an encoder. The stator active and reactive powers can be calculated by sampling three-phase stator voltage and current. The stator active and reactive power control error, which is the input of the PI regulator, can be calculated according to the actual signal and reference signal. The output of the PI regulator, together with the compensation back electromagnetic force, would be sent to the SVPWM to generate the IGBT switching signals to full the control target. The control target in this is chosen as smooth stator output active and reactive power [1].

4. DOUBLY FED INDUCTION GENERATOR

Doubly fed electrical generators are similar to AC electrical generators, but have additional features which allow them to run at speeds slightly above or below their natural synchronous speed. Doubly fed electric machines are electric motors or electric generators where both the field magnet windings and armature windings are separately connected to equipment outside the machine. By feeding adjustable frequency AC power to the field windings, the magnetic field can be made to rotate, allowing variation in motor or generator speed. This is useful for large variable speed wind turbines, because wind speed can change suddenly. When a gust of wind hits a wind turbine, the blades try to speed up, but a synchronous generator is locked to the speed of the power grid and cannot speed up. So large forces are developed in the hub, gearbox, and generator as the power grid pushes back. This causes wear and damage to the mechanism. If the turbine is allowed to speed up immediately when hit by a wind gust, the stresses are lower and the power from the wind gust is converted to useful electricity.

5. HARMONICS AND DISTORTION

Harmonics are the odd integral multiples of fundamental frequency resulting in the distortion of supply waveform due to interference by superposition. Harmonic order or harmonic number is a reference to the frequency of the harmonic component e.g. 3rd order harmonic component refers to a harmonic component having frequency 3 times that of fundamental i.e. for a 50 Hz supply 3rd order component is of 3x50=150Hz.Generally the sum of even harmonics is less than 1% of fundamental component thus they are not considered also 3rd, 5th and 7th order harmonics constitute about 97% of harmonic.

6. PULSE WIDTH MODULATION (PWM)

Being one of the most widely implemented modulation techniques, PWM is based on width of the pulse generated with respect to the control signal information. In electrical voltage regulation, the control signal is often a sinusoidal wave. There are several methods which is commonly applied in PWM modulation such as carrier based PWM, space vector modulation (SVM) and random PWM.

7. CONCLUSION

Enhancement of stability or stabilization of wind energy conversion system is important in real time operation. Power system controllers are receiving a wide interest since many technical studies have proven their effects on damping system oscillations and stability enhancement. In order to improve the damping of electromechanical oscillations when necessary, such systems should be designed to allow proper processing of stabilization signals, usually derived from the machine rotor-speed or electrical power. This paper presents the theoretical approach of DIFG system with doubly-fed induction generator (DFIG)-based wind-power generation system

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