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RESEARCH ARTICLE

Doubly Fed Induction Generator based Wind Energy Conversion System of PI and Fuzzy Logic Controller

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ABSTRACT

The aim of this paper is the analysis of wind turbine generator configuration for a variable speed wind turbine Generator using doubly Fed induction generator. Different types of generator configurations that include DC generator, Synchronous generator, induction Generators are used for wind energy conversion system. Permanent magnet synchronous generators and doubly fed induction generators are the two most commonly used types of generators for WECS. However, in terms of energy generation in large wind farms, cost, converter size, etc., DFIG turned out to be more favorable than PMSG. This paper presents the control of Rotor side converter and stator side converter for the control of active and reactive power using two different controllers-PI controller and Fuzzy Logic Controller. Using MATLAB/SIMULINK, the full mathematical modeling of the DFIG is implemented, and the performance outcomes of both controllers are compared in terms of output power, torque, rotor and stator currents, etc.

Keywords: Doubly fed induction generator (DFIG), Voltage source converter (VSC), Wind energy conversion system (WECS), Rotor side converter (RSC), Grid side converter (GSC), PI controllers, Static compensator (STATCOM), Voltage-oriented control (VOC), Pulse width modulation (PWM).

INTRODUCTION

Due to increase in global warming and devastating contamination of the world's environment there is an increase in the use of non-conventional resources to fulfil the energy needs of the society which includes solar cells, wind turbines, hydro power and biomass etc. Numerous engineers and institutions are striving to enable the best possible use of all these alternative energy sources. One of the alternative energy sources that has been crucial to the development of civilization is wind energy. Due to a lack of technology, non-conventional energy resources were not exploited in large-scale manufacturing in previous generations. However, the technology of wind turbines has already advanced to the point that power generation is growing exponentially. Many countries like US, Spain, France, Denmark, China and India as well which considers wind energy as a serious alternate for generation of electricity. During 1980, the world's installed wind capacity was almost 13 MW .59.024 GW of wind power was in operation by the end of 2005. By the end of 2006, the total installed capacity of wind turbines has reached 74.150 GW with an annual growth of approximately 23.8%. This installed capacity increased 93.926 GW and 121.188 GW in end of 2007 and 2008 respectively with annual growth of approximately 26%. It is expected that by the end of 2012 and 2017 and as updated on 4th June 2019 the total installed wind power capacity has reached to 597 GW all over the world. Also in India, Wind power generation capacity has increased in recent years. As seen from the data of 31 March 2019 the total installed wind power capacity was 336.625 GW . The total wind farms are grown to 443 in India. Thus India has the fourth largest installed wind power capacity in the world. Wind power capacity is mainly spread across the South, West, North and East regions. There are a number of options available for the selection of wind power installation. Because of this a major focus is kept on wind power conversion systems in the current paper.

Control strategy

Rotor Side Control

The primary goal of RSC is to maximize energy extraction while maintaining separate control over reactive and active power. In a voltage-oriented reference frame, RSC is managed. Active and reactive power are controlled by direct and quadrature axis rotor currents (idr and iqr) respectively. The pulse-width modulation technique was used to build the rotor side control utilizing the equivalent steady-state circuit of the PI controller. The three phase currents are decomposed into their d and q components in this control structure. These components are compared to the reference signal, and the d and q components are obtained by transmitting the error signal through a proportional integral(PI).PWM linear feedback current control scheme

Grid side converter control

The grid side controller's main objective is to keep a constant DC-link voltage that is unaffected by the path and value of rotor energy flow. The grid side converter is powered by the revolving reference axis dq, which is aligned with the grid voltage. The line side converter control consists of d and q current references generated using the dc voltage error and the reactive power references, followed by a hysteresis current control block for generation of the gating signals. Again, for grid voltage synchronization and proper conversion to dq components, a PLL is needed. Grid side converter control for regulation of dc .Voltage and supply of reactive power .Two independent controllers—the Fuzzy Logic Controller and the PI Controller—are responsible for controlling the stator and rotor.

CONCLUSION

The Doubly Fed Induction Generator's dynamic models are examined and investigated in a variety of reference frames since control methods for standalone WECS based on DFIG require a thorough grasp of them. In order to accomplish the intended result, two control algorithms—the fuzzy logic controller and the PI controller—are used. Their transient output performance is assessed during abrupt load transients and variations in wind speed. The rotor side converter and stator side converter are controlled via the vector control technique. The control of the stator side and rotor side converters is done via vector control technology. The results show the importance of the control strategy, and both controllers were used to obtain the results. The performance of the proposed model is compared in terms of current, voltage, power Quality, Torque, Active power and Reactive Power. As a result, We can conclude that, especially at lower wind speeds, fuzzy logic controllers perform better than standard PI controllers.

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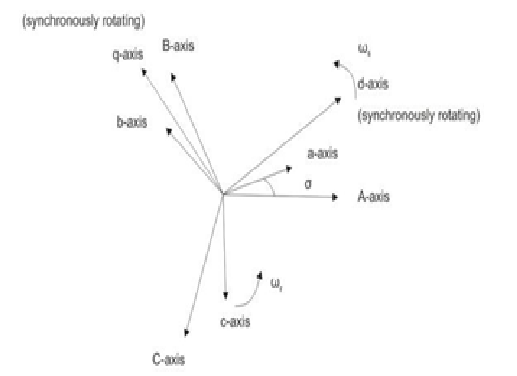

Fig:1 Reference system used in DFIG d-axis equivalent circuit of WRIM

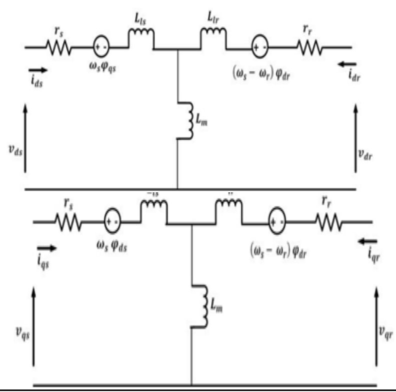

Fig :5 q-axis equivalent circuit of WRIM

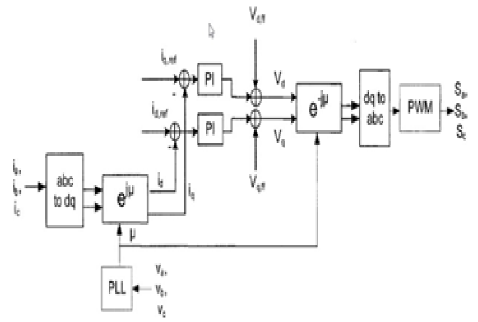

Fig :4 PWM linear feedback current control scheme

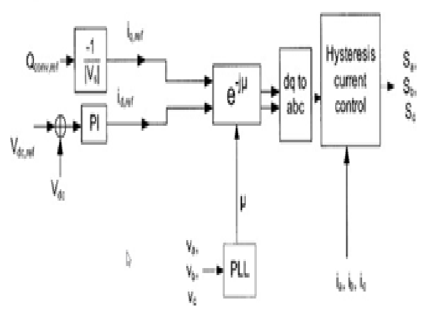

Fig :5 Grid side converter control for regulation of dc Voltage and supply of reactive power

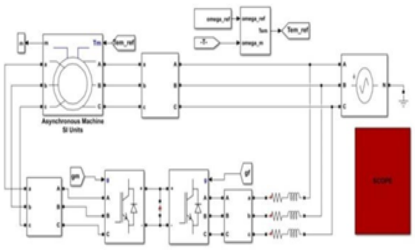

Fig :6 Simulink diagram of doubly fed induction generator

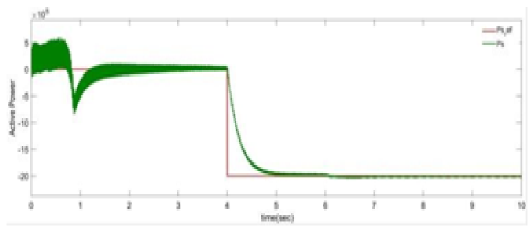

Fig :7 Active power of stator using PI Controller

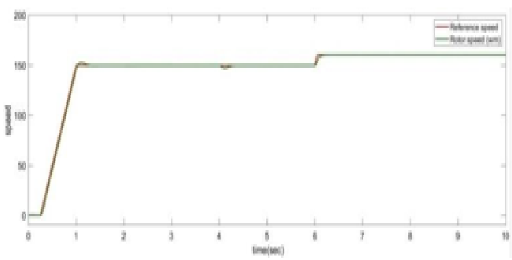

Fig :8 Rotor speed tracking using fuzzy logic controller

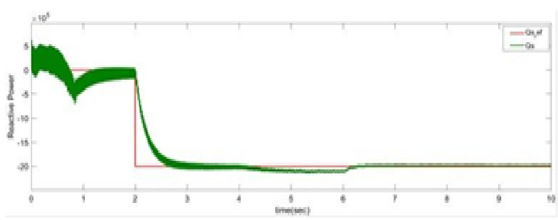

Fig :9 Reactive power of stator using PI controller