International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

To Improve the Active Power in Wind Power Generation by Using Fuzzy Logic Controller

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ABSTRACT: The output power of the present wind turbine is continuously increasing. Due to this Double fed Induction generators (DFIG) are gaining more attention especially in the field of wind power generation due to many advantages and rapid development in both power electronics and control strategies. Vector Control of doubly fed induction generator for variable speed wind power generation is used widely now days. The Control scheme used is stator flux oriented control for rotor side converter control and grid voltage vector control for grid side converter control for the control of active powers of the DFIG under variable speed operation. The scheme implemented uses Fuzzy logic controllers for the rotor side converter control to control active power and optimize the power generation from the DFIG.

Keywords: DFIG, fuzzy logic controller, active power, reactive power, wind turbine

I. INTRODUCTION

Wind energy is one of the most important and promising extra ordinary sources of renewable energy all over the world, mainly because it is considered to be non-polluting and economically viable. In terms of wind power generation technology because of numerous technical benefits the modern wind turbines always use variable speed operation which is achieved by the converter systems. These converters are typically associated with individual generators and they contribute significantly to the cost of wind turbines.

One of the most popular wind energy conversion systems includes an Induction generator with slip ring, an electronic converter and a DC link capacitor. Power electronic converter encompasses a back to back AC DC AC voltage source converter has two main parts: grid side converter (GSC) that rectifies grid voltage and rotor side converter (RSC) which feeds rotor circuit. Power converter is designed in partial scale and just about 30% of the generator rated power which makes it attractive from economical point of view. Many different structure and control algorithm can be used for control of power converter.

Using fuzzy control, we can produce controller outputs more reliable because the effect of the parameters such as noise and events due to wide range of control region and online changing of the control parameters can be considered. Moreover without the need of the detailed mathematical model of the system and just using the knowledge of the total operation and behaviour of the system, tuning of the parameter can be done more easily.

Modern variable speed wind turbines offer the possibility of controlling active and reactive power separately. However, variable speed generators need a power electronic converter interface for interconnection with the grid. There are several other advantages of using variable speed generation such as mechanical stress reduction of turbine and acoustic noise reduction. With recent developments in power electronic converters, variable speed generation looks entirely feasible and cost effective.

The main components of the proposed variable speed wind turbine electrical system consists of DFIG, whose stator winding is directly connected to the grid and rotor winding is connected to the grids through bidirectional PWM converter. The stator flux oriented vector control is adopted for rotor side converter control and the grid voltage oriented vector control is adopted for grid side Converter control. Direct and quadrature current components allow decoupled control of active and reactive power. Such an arrangement provides flexibility of operation in both synchronous and super synchronous generating modes. Quadrature rotor current is used to control the generator active power to achieve the desired rotational speed in the variable speed operation. The active power controller has to ensure power generation up to the rated value i.e., the optimum power output from the wind turbine should restricted within the range of rated value as the wind velocity increases.

However, the active power produced by the DFIG should be in tune with the optimum power obtained from the wind turbine under varying wind speed up to rated power generation. The grid side converter should keep the dc voltage almost constant which ensures the reactive power control. With the increase of the wind velocity, the increase of reference power ensures the increase of active power generation using the active power PI controller within the range of rated power, which ultimately ensures the tracking of optimum rotor speed of DFIG corresponding to a particular wind velocity.

II CIRCUIT TOPOLOGY:

Principle of Operation of Wind Energy Driven DFIG

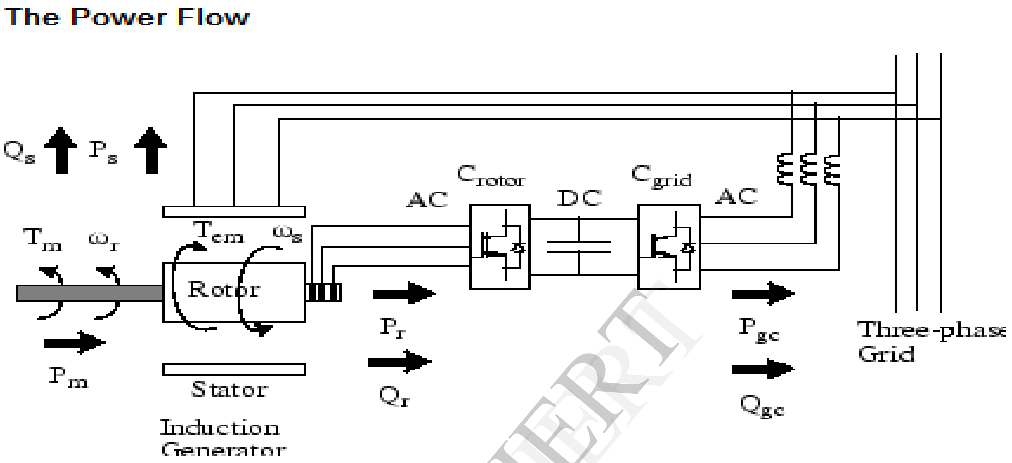

Figure 1 : Basic Configuration of DFIG wind system

In this scheme, the stator is connected to the AC mains, while the wound rotor is fed from the power electronics converter through slip rings to allow DFIG to operate at a variety of speed in response to changing wind speed. The basic concept of this scheme is to interpose a frequency converter between the variable frequency induction generator and fixed frequency grid. The DC capacitor linking stator and rotor side converter allows the storage of power from induction generator for further generation. The slip power can flow in both directions. It can flow from the supply to the rotor and from the rotor to the supply. This scheme can operate well on both sub-synchronous and super-synchronous modes of operation.

The Active and Reactive Power Equations:

The scheme makes use of the stator flux angle, which is determined dynamically; to map the stator and rotor quantities into new reference frame. It can be shown that the choice of stator flux-oriented reference frame results in a decoupled control of stator side active and reactive powers as follows: stator flux linkages expressed in the new reference frame are:

$$\lambda_{SX} = L_S I_{SX} + L_M I_{rX}$$

$$\lambda_{SY} = L_S I_{SY} + L_M I_{rY}$$

But since $\lambda_{SY} = 0$

$I_{ms} = \lambda_{sX}/ L_M$

$I_{sX} = (\lambda_{sX} - L_M I_{rX})/ L_S$

In stator flux-oriented reference frame, since, we have V_{sy}= |Vs|. Thus, $P_S = \left(\frac{3}{2}\right) * |Vs| * I_{sY}$

$Q_S = \left(\frac{3}{2}\right) * |Vs| * I_{sX}$

Therefore, substituting the above values in the equation we get….

$P_S = -\left(\frac{3}{2}\right) * |Vs| * L_m/L_s * I_{rY}$

$$Q_S = \left(\frac{3}{2}\right) * |Vs| * L_m/L_s (I_{ms} - I_{rX}) \quad (44)$$

Therefore, the d-axis component of the rotor current can be controlled to regulate the stator reactive power while the q-axis component of the rotor current can be controlled to control the stator active power and the generator speed. As a result, the control of stator active power via Iqr and stator reactive power via Idr are essentially decoupled, and so a separate decoupler is not necessary to implement field orientation control for the slip power recovery. Flux control is generally unnecessary, since it would maintain a constant level, restricted by the constant magnitude and frequency of the line voltage, while the control of the reactive power becomes possible.

Scheme of rotor side converter control using fuzzy logic controller:

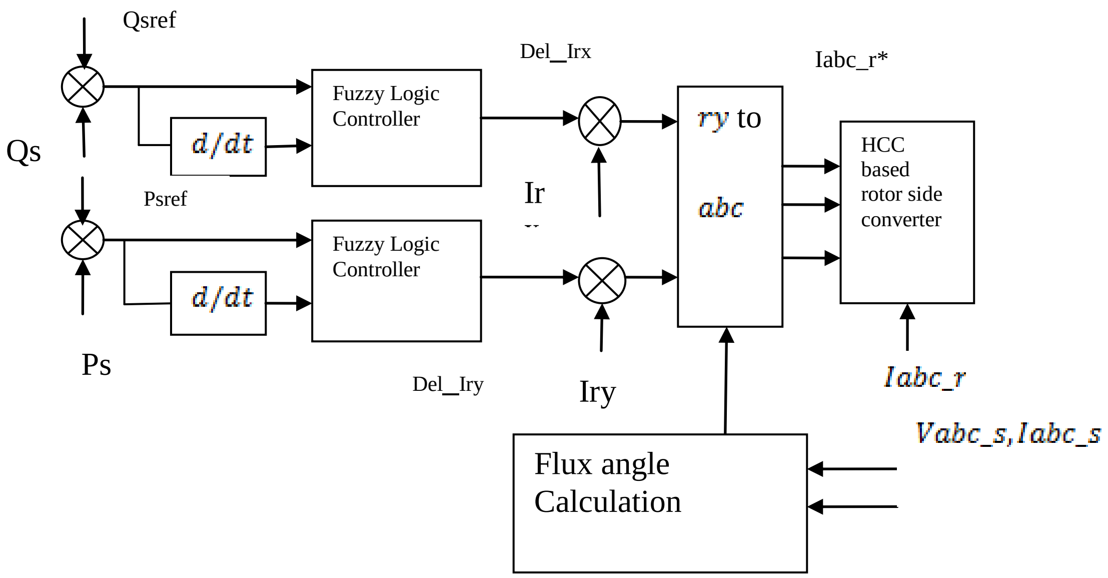

FIG: 2 Schemes Using Fuzzy Controller on the Rotor Side Converter

The fuzzy controllers used in this scheme are applied to the rotor side converter control. The main objective of the fuzzy controller is the active power control and reactive power control or the voltage control of DFIG wind turbine. Using fuzzy control, we can produce controller output more reliable.

The inputs of fuzzy controllers are error in active and reactive power and rate of change in error at any time interval. The output of the fuzzy controller is the change in the reference current that is the value added to the prior output to produce a new reference output.

III SIMULATION RESULTS:

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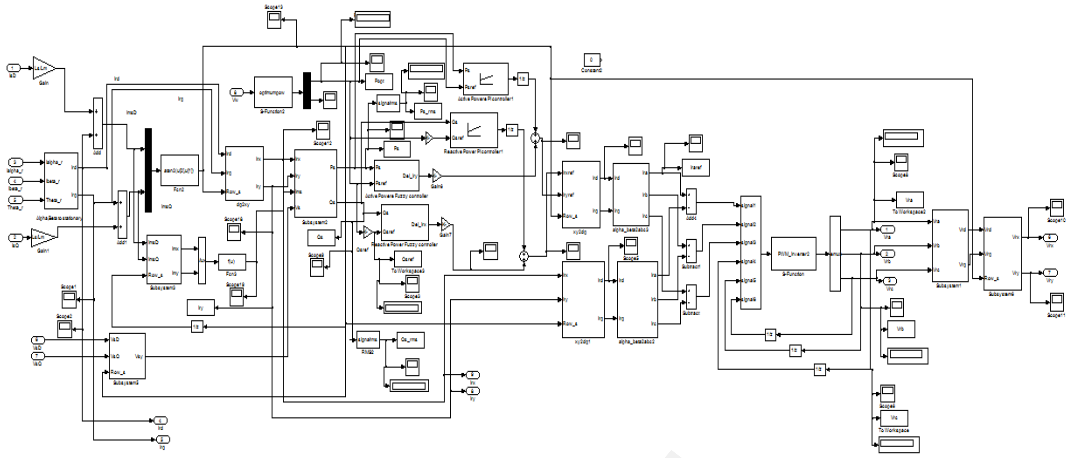

Fig:3 Modelling of Rotor side converter control with conventional PI and Fuzzy logic Controller.

Simulation results show various plots such as, the reference and actual stator active power, the actual reactive power, rotor speed w.r.t generator side.

Performance with fuzzy controller:

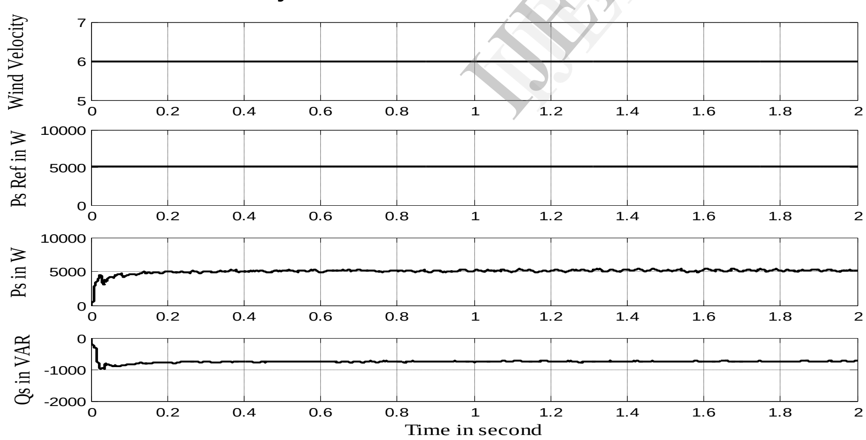

Fig:4 Active Power and Reactive Power Responses fuzzy controller.

IV CONCLUSION:

It can be observed that, with the help of additional fuzzy controller the active power generation increases and approaches the reference power more closely. The reactive power supplied to grid by the DFIG is less as compared to conventional PI controller for maintaining the same power factor at the supply end which concludes that the DFIG draws less excitation from the grid.Scope of future work is to design of fuzzy PI controllers for proposed scheme and active and reactive power control of the proposed WECS using neural network based controller.

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