

A Review of Power Control Strategies for DFIG based Wind Energy Conversion System

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Abstract - Wind energy conversion system is becoming very popular now a days and the application of wound rotor induction machine is widely spread in wind energy generating stations because of its adaptability for variable speed wind turbines through which maximum possible extraction of wind energy is possible. Also among all the induction generator configurations for wind power systems the use of Doubly Fed Induction Generator (DFIG) configuration with back to back pulse width modulated voltage source converters (VSC) is one of the best topologies available and it is suitable for both grid connected systems as well as stand-alone systems. In this paper, a brief review of all the control strategies for both stator side converter and rotor side converter are discussed in stator flux oriented reference frame and results are compared on the basis of cost, efficiency, power consumption and harmonics.

Key Words: 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).

1. 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. There are many engineers and several institutes working for making the optimal utilization of all these non-conventional energy sources. Wind energy is one of the alternative forms of energy that has played an important role in the history of civilization. In earlier generation, non-conventional energy resources were not used in large scale production due to lack of technology. But now wind turbine technology has emerged out with an exponential growth in the generation of power. The wind power has its own importance because of the various advancements and improved performance in several Wind Energy Conversion Systems (WECS). Most of the global energy is being increasingly generated by modern wind power systems. Germany is among the biggest wind power markets. The total wind farms are grown to 443 in India. There are a number of options available for the selection of wind power installation. DFIG consist of a two voltage source back to back converter connected to stator

and grid side respectively. The basic working of DFIG is based on the fact that stator side converter is used to control the output voltage in direct voltage control manner and the rotor side converter is current controlled where the power imbalance of the system is nullified using dc link voltage controller which modifies the quadrature axis rotor current reference value according to the changes in the wind speed as well as the load. There are various control strategies for DFIG. Although the converter used in the below works are extremely similar, great differences lie within the control strategy and complexity and therefore a brief review of DFIG with different types of intermediate converter is discussed below:

1.2 DFIG with Static Kramer Drive and SCR converter:

In this paper, the control of RSC and GSC is done in such a way so that GSC is controlled for supplying harmonics in addition to slip power transfer and RSC is used to extract maximum power and supply reactive power to grid. The proposed model uses WECS as a STATCOM for compensating harmonics during variable wind speed conditions and also during variation in the load. STATIC KRAMER DRIVE AND SCR CONVERTER METHOD are the two proposed methodology described.

1.2.1(i)STATIC KRAMER DRIVE: It consist of a diode rectifier on Rotor side and on Stator side, line commutated inverter is implemented. This converter combination provides a sliding mode control which converts the dynamics of non linear system to slide by using discontinuous control signal. Thus, providing control of stator active and reactive power at reduced switching frequency.

Disadvantage: This method is applicable only under super-synchronous speed.

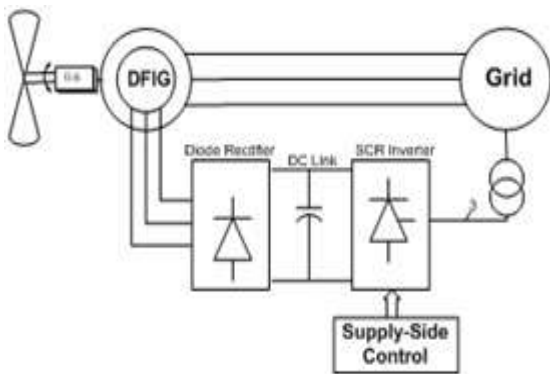


Fig1: DFIG with Static Kramer Drive.

1.2.2(ii) SCR CONVERTER METHODS: The limited application of Kramer drive to operate in super synchronous mode is mitigated by the use of SCR converter which provide a wide range of power control at both sub and super synchronous speed .But this approach also have some disadvantage of firing control and commutation with RSC and harmonic distortion to grid, created by supply side thyristor converter[1].

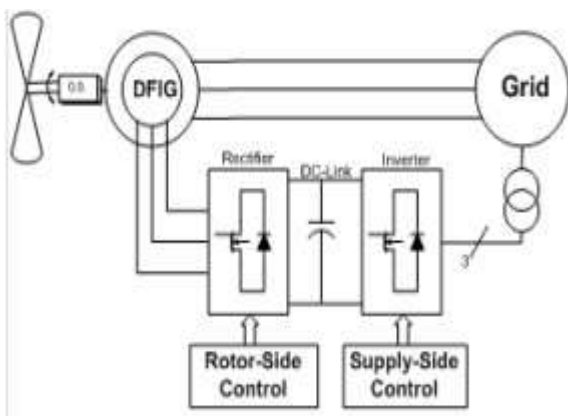


Fig2: DFIG with Back- to Back Converter

2. DFIG with Active Filter Capabilities: During power control and power transfer to the grid , the use of converters and the non-linear load connected to the grid may generate harmonics which affect the generation of power .This proposed paper presents a DFIG based WECS working as a STATCOM in which GSC is used to supply harmonics in addition to slip power transfer and RSC is used for maximum power extraction and to supply required reactive power to DFIG at different variable speed and loads. The RSC is controlled in voltage oriented reference frame and so the active and reactive powers are controlled by controlling d & q-axis rotor currents. A-DSTATCOM (Distribution Static Compensator) coupled with fly-wheel energy storage system is used at the wind farm for mitigating harmonics and frequency disturbances. The tuning of PI controllers used in both RSC and GSC is achieved by Ziegler Nicholas method. The harmonics supplied by GSC to make the grid currents sinusoidal and balanced is achieved by an indirect current control where fundamental frequency current are converted

into DC and all other harmonics are converted into non -DC quantities. In this proposed DFIG, the reactive power for the induction machine has been supplied from the RSC and the load reactive power has been supplied from the GSC. The decoupled control of both active and reactive powers is achieved by RSC control. The proposed DFIG has also been verified at wind turbine installing condition for compensating harmonics and reactive power of local loads. [2]

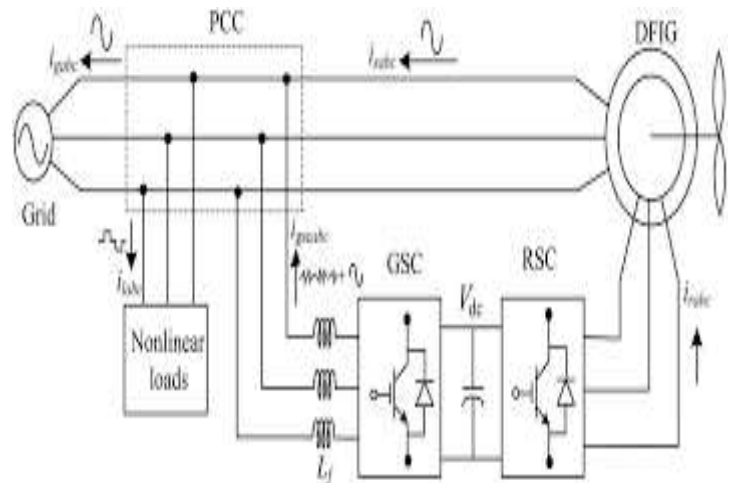


Fig3: DFIG Model for Harmonic analysis

3. DFIG Based on Power Transfer Matrix: To avoid the dependency of power on d-q reference frame for the controller operation, this proposed paper presents a power transfer matrix that uses instantaneous real/ reactive power as system state variables. The controller used here used 6 compensators for capturing the maximum wind power and supplying the required reactive power to DFIG and also providing protection against fault .Vector control scheme in a stator field oriented frame of reference is presented which directly controls the machine flux and Torque by selecting suitable voltage vectors. The multivariable control system is designed using sequential loop closing technique which capture maximum wind power and injects required reactive power to system via GSC .It consist of two loops: (a)inner loop where the control of reactive power requirement of grid and machine is done.(b)Outer control loop: where Rotor speed and dc-link voltage is regulated. Also ,fault ride through algorithms like active crowbar, series dynamic restorer etc is suggested to provide additional protection during fault condition .During transient, an extra feedback loop which will sense only the magnitude of current has been mentioned. This approach improves robustness of system and also provides simplicity to control the variables during unbalanced condition.

4. DFIG with PI Controller: In [5],the performance of PI controller for the control of active and reactive power in DFIG is simulated by keeping the wind turbine pitch control deactivated .It uses a vector control to independently control active and reactive power exchange between the stator of generator and grid with classical PI controllers. The power P_s and Q_s are independently controlled by using a PI controller .The PI controller used to control DFIG as generator is simple

characteristics of wind energy system over a wide range of operating wind speed,, the fuzzy Logic controller provides a smooth active power and better power regulation and performance.

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