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DEVELOPMENT AND SIMPLIFIED MODEL OF DFIG WITH WIND AND SOLAR FOR EFFICIENT ENERGY IMPROVEMENT

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Abstract- *This project deals with the operation of Doubly Fed Induction Generator (DFIG) with an integrated active filter capabilities using Grid Side Converter (GSC). The main contribution of this work lies in the control of GSC for supplying harmonics in addition to its slip power transfer. The Rotor Side Converter (RSC) is used for attaining maximum power extraction and to supply required reactive power to DFIG. This Wind Energy Conversion System (WECS) works as a Static Compensator (STATCOM) for supplying harmonics even when the wind turbine is in shut down condition. Control algorithms of both GSC and RSC are presented in detail. Solar deals with the operation of efficient energy improvement. Proposed DFIG based WECS is simulated using MATLAB / Simulink. A prototype of a proposed DFIG based WECS is developed using a DSP (Digital Signal Processor). Simulated results are validated with test results of the developed DFIG for different practical conditions such as variable wind speed and unbalanced/single phase loads.*

1. INTRODUCTION

With the increase in population and industrialization, the energy demand as increased significantly. However, the conventional energy sources such as coal, oil and gas are limited in nature. Now there is a need for renewable energy sources for the future energy demand [1]. The other main advantages of this renewable source are eco-friendliness and unlimited in nature [2]. Due to the technical advancements, the cost of the wind power produced is comparable with that of conventional power plants. So the wind energy is the most preferred out of all renewable energy sources [3]. In the initial days, wind turbines have been used as fixed speed wind turbines with squirrel cage induction generator and capacitor banks. Most of the wind turbines are fixed speed because of their simplicity and low cost [4]. By observing wind turbine characteristics, one can clearly identify that for extracting maximum power, the machine should run at varying rotor speeds at different wind speeds. By using modern power electronic converters, the machine is able to run at adjustable speeds [5]. So these variable speed wind turbines are able to improve the wind energy production [6]. Out of all variable speed wind turbines, Doubly Fed Induction Generators (DFIGs) are preferred because of their low cost and higher output.

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2. BLOCK DIAGRAM

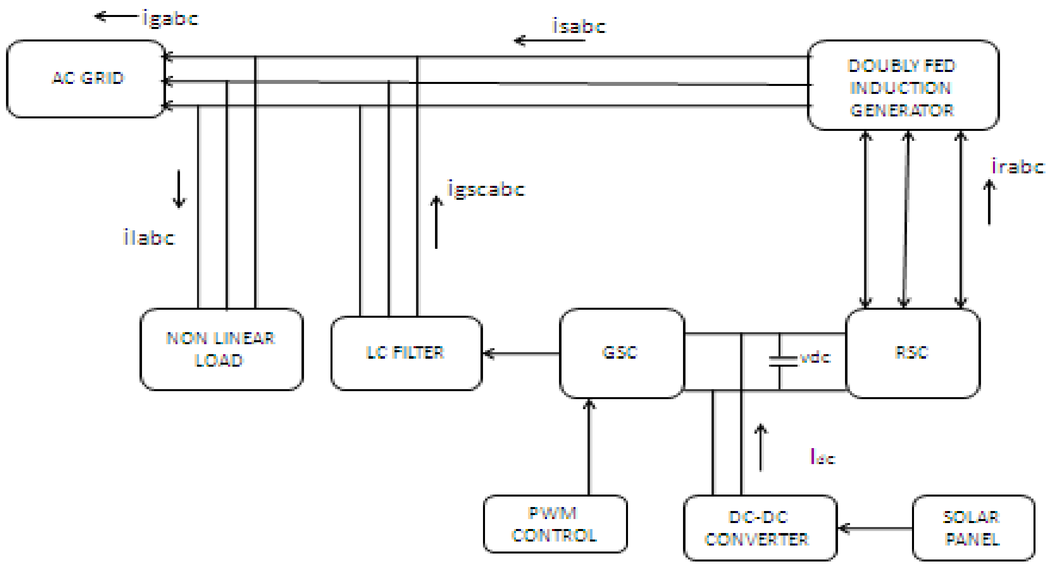

Fig 1.Block diagram

This project deals with the operation of Doubly Fed Induction Generator (DFIG) with an integrated active filter capabilities using Grid Side Converter (GSC). The main contribution of this work lies in the control of GSC for supplying harmonics in addition to its slip power transfer. The Rotor Side Converter (RSC) is used for attaining maximum power extraction and to supply required reactive power to DFIG. This Wind Energy Conversion System (WECS) works as a Static Compensator (STATCOM) for supplying harmonics even when the wind turbine is in shut down condition. Control algorithms of both GSC and RSC are presented in detail. Proposed DFIG based WECS is simulated using MATLAB / Simulink. A prototype of a proposed DFIG based WECS is developed using a DSP (Digital Signal Processor). Simulated results are validated with test results of the developed DFIG for different practical conditions such as variable wind speed and unbalanced/single phase loads. This Wind Energy Conversion System (WECS) works as a Static Compensator (STATCOM) for supplying harmonics even when the wind turbine is in shut down condition. Control algorithms of both GSC and RSC are presented in detail. Proposed DFIG based WECS is simulated using MATLAB / Simulink. A prototype of a proposed DFIG based WECS is developed using a DSP (Digital Signal Processor). Simulated results are validated with test results of the developed DFIG for different practical conditions such as variable wind speed and unbalanced/single phase loads. The main purpose of RSC is to extract maximum power with independent control of active and reactive powers. Here, the RSC is controlled in voltage oriented reference frame. So the active and reactive powers are controlled by controlling direct and quadrature axis rotor currents (idr and iqr) respectively. Direct axis reference rotor current is selected such that maximum power is extracted for a particular wind speed. This can be achieved by running the DFIG at a rotor speed for a particular wind speed.

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3. MODULE DESCRIPTION

A. DOUBLY FED INDUCTION GENERATOR

An induction generator is composed by a stator and a rotor. In the case of a DFIG, both stator and rotor have three sinusoidal distributed windings, corresponding to three phases, displaced by 120_. The three phases are called a, b and c.

The stator has p pairs of poles. The rotor is connected to the grid through converters. A three-winding transformer gives different voltage levels for stator and rotor side. When the machine produces energy, only a small part of the generated power flows from the rotor to the grid. The converters can then be chosen in accordance with this small rotor power. This means smaller converters compared to fully rated converters and this allows decreasing the costs.

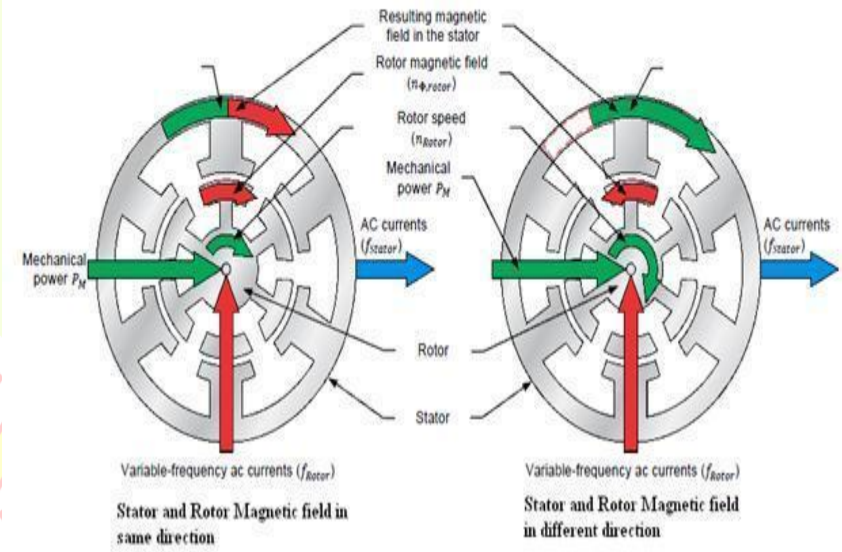

Fig.2.DFIG Stator and Rotor Magnetic field

DFIG for Double Fed Induction Generator, a generating principle widely used in wind turbines. It is based on an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with brushes for access to the rotor windings. It is possible to avoid the multiphase slip ring assembly (see brushless doubly fed electric machines), but there are problems with efficiency, cost and size. The principle of the DFIG is that rotor windings are connected to the grid via slip rings and back-to-back voltage source converter that controls both the rotor and the grid currents.

Thus rotor frequency can freely differ from the grid frequency (50 or 60 Hz). By using the converter to control the rotor currents, it is possible to adjust the active and reactive power fed to the grid from the stator independently of the generator's turning speed.

B. WIND ENERGY CONVERSION SYSTEM

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Wind Energy Conversion System covers the technological progress of wind energy conversion systems, along with potential future trends. It includes recently developed wind energy conversion systems such as multi-converter operation of variable-speed wind generators, lightning protection schemes, voltage flicker mitigation and prediction schemes for advanced control of wind generators. Modelling and control strategies of variable speed wind generators are discussed, together with the frequency converter topologies suitable for grid integration. Wind Energy Conversion System also describes offshore farm technologies including multi-terminal topology and space-based wind observation schemes, as well as both AC and DC based wind farm topologies. The stability and reliability of wind farms are discussed, and grid integration issues are examined in the context of the most recent industry guidelines. Wind power smoothing, one of the big challenges for transmission system operators, is a particular focus. Fault ride through and frequency fluctuation mitigation using energy storage options are also covered. Efficiency analyses are presented for different types of commercially available wind turbine generator systems, large scale wind generators using superconducting material, and the integration of offshore wind and marine current farms. Each chapter is written by a leader in the wind energy arena, making Wind Energy Conversion System a valuable reference for researchers and students of wind energy.

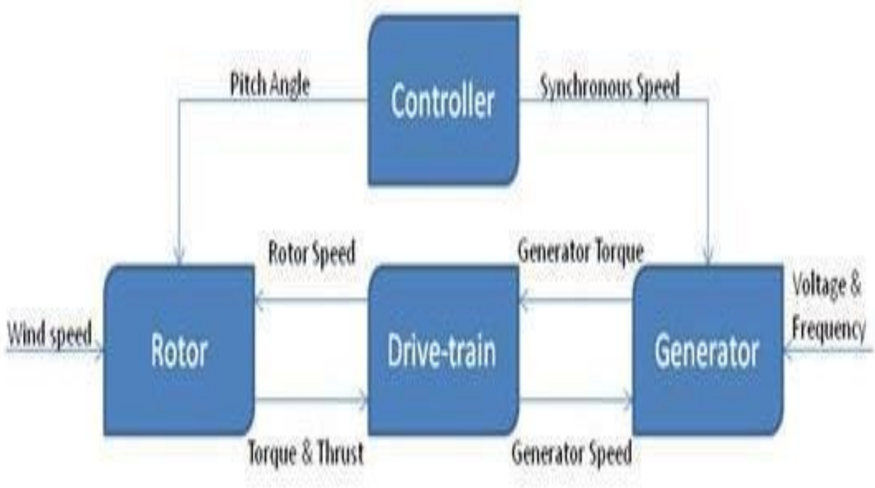

Fig 3.wind energy conversion

C. NON LINEAR LOAD

A nonlinear load in a power system is characterized by the introduction of a switching action and consequently current interruptions. This behaviour provides current with different components that are multiples of the fundamental frequency of the system. These components are called harmonics. The amplitude and phase angle of a harmonic is dependent on the circuit and on the load it drives. For a fundamental power frequency of 60 Hz, the 2nd harmonic is 120 Hz, the 3rd harmonic is 180 Hz, and so on. The harmonic currents flow toward the power source through the path of least impedance. Some examples of nonlinear loads that can generate harmonic currents are computers, fax machines, printers, PLCs, refrigerators, TVs and electronic lighting ballasts. Personal computers constitute nonlinear loads since they incorporate switched-mode power supplies. The PC current is mainly dominated by the third and fifth harmonic components. Current harmonics deteriorate the power factor of the system, what is the ratio between the average power of a certain load and the average power calculated for a pure resistive load with equal voltage amplitude.

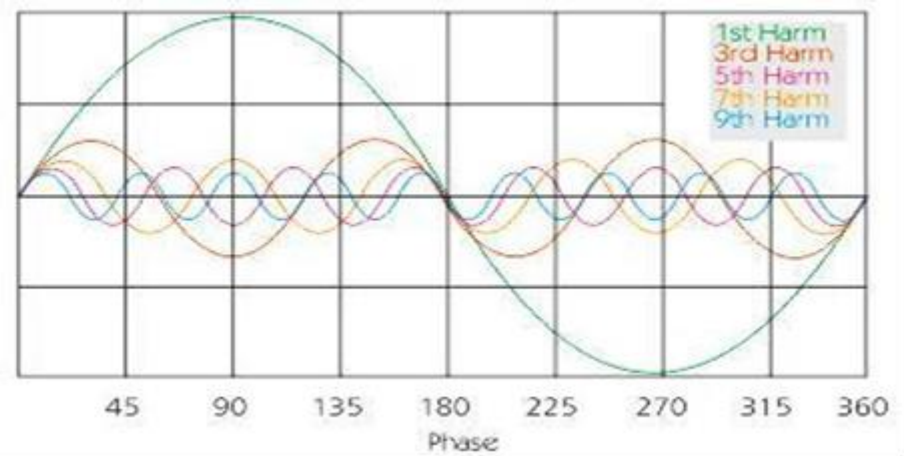

Fig.4.Non-Linear Load

D. POWER QUALITY

Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of usage. Sensitive power electronic equipment and non-linear loads are widely used in industrial, commercial and domestic applications leading to distortion in voltage and current waveforms. With ongoing regulatory, policy and structural changes in the Indian electricity industry, following the Electricity Act 2003, the issue of PQ is poised to become a figure-of-merit amongst the competing distribution utilities. Improvement of PQ has a positive impact on sustained profitability of the distribution utility on the one hand and customer satisfaction on the other. The main objective of the course is to enhance the knowledge of the participants in the emerging area of power quality and several key issues related to its modeling, assessment and mitigation. The course will provide a platform to an in-depth discussion on the various challenges and their possible remedies with respect to maintaining power quality in electricity sector, which will benefit participants from academic and R & D institutions, professional engineers from utilities, industries and policy maker.

E. SOLAR ENERGY

Solar power is energy from the sun that is converted into thermal or electrical energy. solar energy is the cleanest and most abundant renewable energy source available and the U.S has some of the richest solar resources in the world. Modern technology can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use.
Solar energy is a flexible energy technology: solar power plants can be built as distributed generation (located at or near the point of use)or as a central-station, utility-scale solar power plant(similar to traditional power plant).
It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the way they capture and distribute solar

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energy or convert it into solar power. Here dc to dc converter is used to boost the power value.

4. RESULT ANALYSIS

In figure 6, 7, 8 and 9 shows the simulation diagram and graph of the RSC and GSC converter. In the graph results shows the exact output waves of the converter. The simulation and experimental results confirm to verify the feasibility of the proposed converter. The simulation and output waveform s are done by MATLAB software.

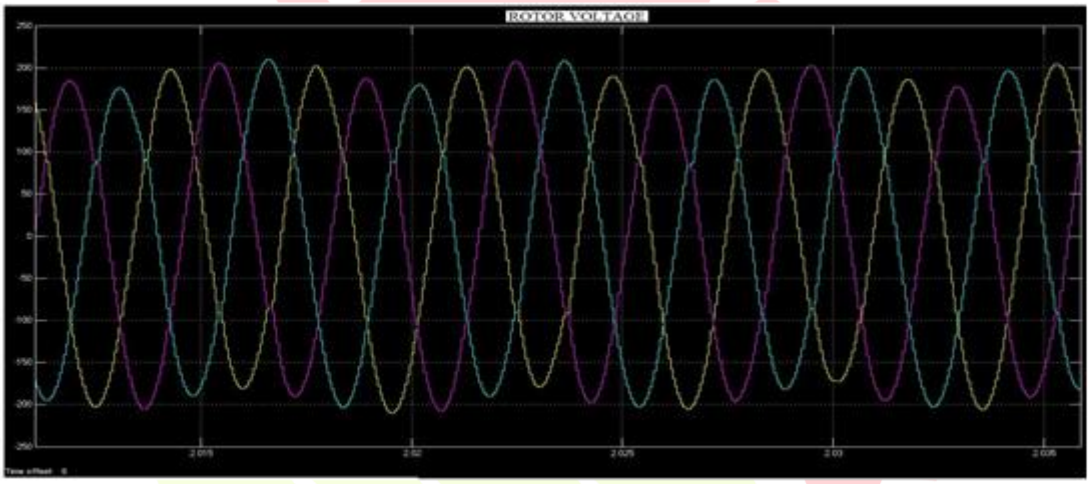

Fig5.simulation graph

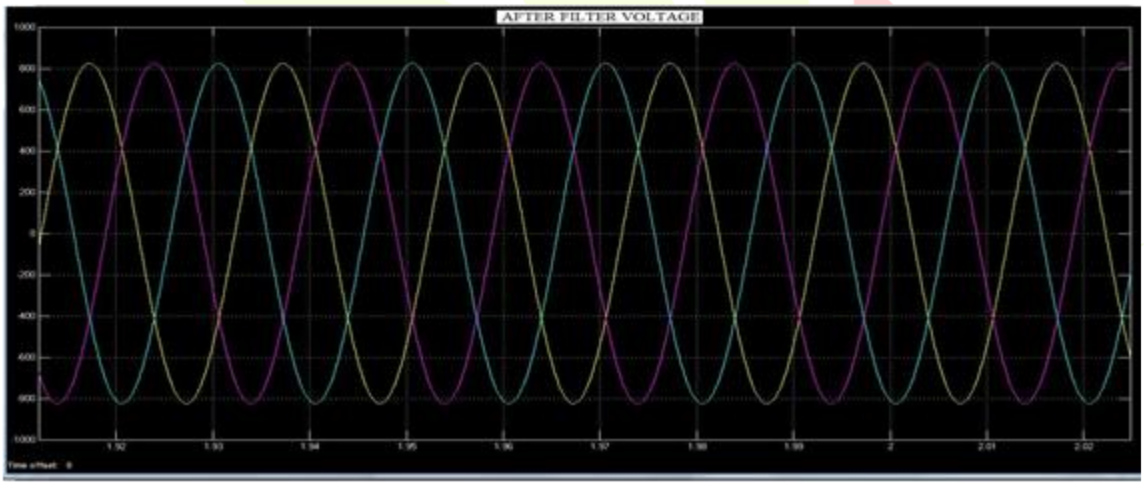

Fig 6.simulationgraph

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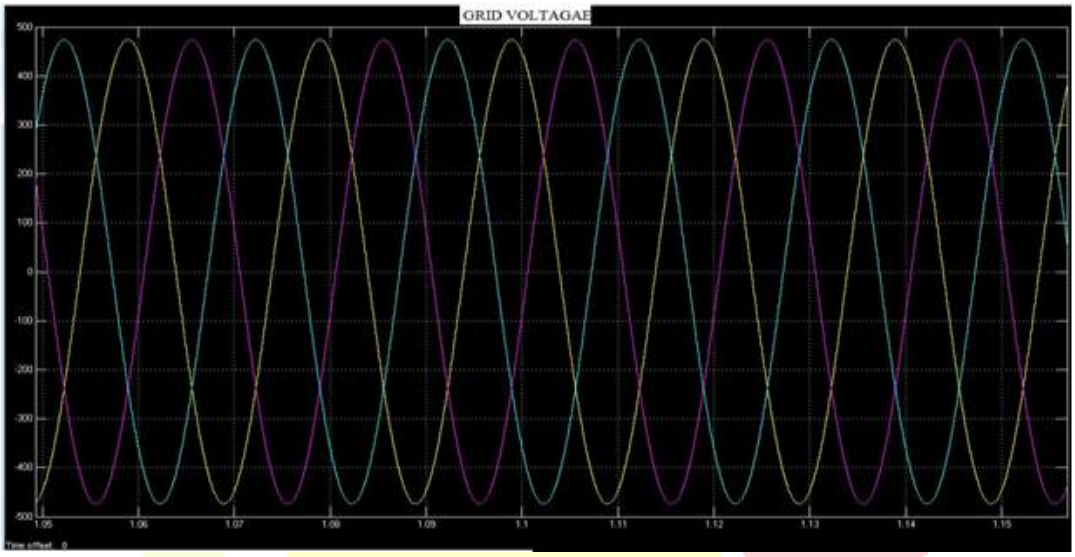

Fig 7.simulationgraph

5. CONCLUSION

The DFIG system costs more than fixed-speed induction generators without converters. However, the performance and controllability are excellent in comparison with fixed speed induction generator systems; they capture more wind energy, they exhibit a higher reliability gear system, and high-quality power supplied to the grid. The decoupled control of both active and reactive powers has been achieved by RSC control. The proposed DFIG has also been verified at wind turbine stalling condition for compensating harmonics and reactive power of local loads. This proposed DFIG based WECS with an integrated active filter has been simulated using MATLAB/Simulink environment and simulated results are verified with test results of developed prototype of this WECS. Steady state performance of proposed DFIG has been demonstrated for a wind speed. Dynamic performance of this proposed GSC control algorithm has also been verified for the variation in the wind speeds and for local nonlinear load.

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