Development of Grid Connected Induction Generator Wind Power System with STATCOM

V. Anusha[1] | Mrs. Umarani[2]

[1]PG Scholar, Department of EEE, Godavari Institute of Engineering and Technology, Rajahmundry, Andhra Pradesh, India.
[2]Assistant Professor, Department of EEE, Godavari Institute of Engineering and Technology, Rajahmundry, Andhra Pradesh, India.

ABSTRACT

Injection if wind power into an electric grid affect the power quality.The performance of the wind turbine and there by power quality are determined on the basis of measurements and the norms followed according to the guideline specified in international electro technical commission standard,IEC-61400.the influence of the wind turbine in the grid system concerning the power quality measurements are the active power, reactive power , variation of voltage, flicker,harmonics, and electrical behaviour of switching operation and these are measured according to national/international guidelines. The paper study demonstrates the power quality problems due to installation of wind turbine with the grid. In this proposed scheme STASTIC COMPENSATOR (STATCOM) is connected at appoint of common coupling with a battery energy system (BESS)to mitigate the power quality issues. The battery energy storage is integrated to sustain the real power source under fluctuating wind power. The STATCOM control scheme for the grid connected wind energy generation system for power system block set. The effectiveness of proposed scheme relives the main supply source from the reactive power demand of load and the induction generator. The development of the grid co-ordination rule and the scheme for improvement in poersuality norms as per IEC standard on the grid has been presented.

KEYWORDS: *Power Quality, Wind Energy, STATCOM, Renewable Energy.*

I. Introduction

Renewable Energy Sources are those energy sources which are not destroyed when their energy is harnessed. Human use of renewable energy requires technologies that harness natural phenomena, such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological hydrogen production and geothermal heat.

Amongst the above mentioned sources of energy there has been a lot of development in the technology for harnessing energy from the wind. Wind is the motion of air masses produced by the irregular heating of the earth's surface by sun. These differences consequently create forces that push air masses around for balancing the global temperature or, on a much smaller scale, the temperature between land and sea or between mountains. Wind energy is not a constant source of energy. It varies continuously and gives energy in sudden bursts. About 50% of the entire energy is given out in just 15% of the operating time. Wind strengths vary and thus cannot guarantee continuous power. It is best used in the context of a system that has significant reserve capacity such as hydro, or reserve load, such as a desalination plant, to mitigate the economic effects of resource variability. The power extracted from the wind can be calculated by the given formula:

P W=0.5 ρπR

The total capacity of wind power on this earth that can be harnessed is about 72 TW. There are now many thousands of wind turbines operating in various parts of the world, with utility companies having a total capacity of 59,322 MW. The power generation by wind energy was about 94.1GW in 2007 which makes up nearly 1% of the total power generated in the world. Globally, the long-term technical potential of wind energy is believed to be 5 times current global energy consumption or 40 times current electricity demand. This would require covering 12.7% of all land area with wind turbines. In the past decades, the wind power generation has experienced a very fast development. It shows the installed wind turbine capacity worldwide at the end of 2002 , although it is obvious that with such a rapid growth in some countries data of this kind become out of date very quickly. The reasons that resulted in the fast development of wind power are quite complex. Important factors include the immense potentials of wind energy on the earth, the political and economic support from the governments and the development of wind turbine technology. Power quality problems. The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network. The issue of power quality is of great importance to the wind turbine. There has been an extensive growth and quick development in the exploitation of wind energy in recent years. The individual units can be of large capacity up to 2 MW, feeding into distribution network, particularly with customers connected in close proximity. A proper control scheme in wind energy generation system is required under normal operating condition to allow the proper control over the active power production. In the event of increasing grid disturbance, a battery energy storage system for wind energy generating system is generally required to compensate the fluctuation generated by wind turbine. A STATCOM-based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial wind turbines. The proposed STATCOM control scheme for grid connected wind energy generation for power quality improvement has following objectives.

• Unity power factor at the source side.
• Reactive power support only from STATCOM to wind Generator and Load.
• Simple bang-bang controller for STATCOM to achieve fast dynamic response.

II. SCIG Wind Power System

The schematics of the SCIG system including the wind turbine, pitch control, and reactive power compensator. The entire system includes three stages for delivering the energy from wind turbine to the power grid. The first one is wind farm stage which handles with low voltage, the second is distribution stage which has medium voltage, and the third is grid transmission stage which has high voltage. The three-phase transformers take care of the interface between stages.

As mentioned, nominal power Pn SCIG is considered as active power reference to regulate the pitch angle while *V*dis and Idis denote the distribution line-to-line voltage and phase current, and they are monitored to favour the reactive power compensation for distribution line. This fairly straightforward technique was first used since it is simple and has rugged construction, reliable operation, and low cost. However, the fixed-speed essential and potential voltage instability problems severely limit the operations of wind turbine. Since SCIG is of fixed-speed generator, for a particular wind speed, the output active power is fixed as well. Thus, with the increase of wind speed, so does the output power until the nominal power is reached. The wind speed at this moment is called nominal wind speed.

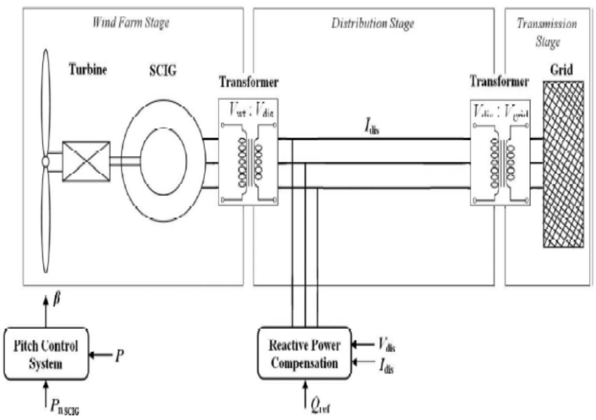

Fig. 1 SCIG wind power system

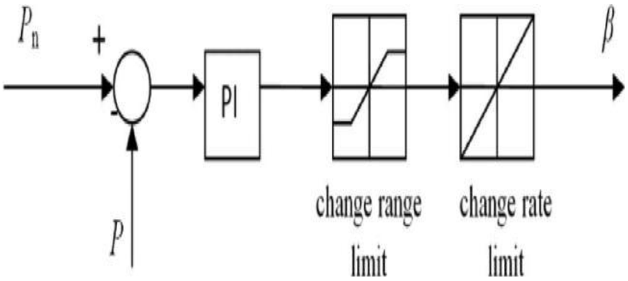

Fig. 2 Pitch angle control

A proportional integral (PI) controller is used to control the blade pitch angle in order to limit the electric output power to the nominal mechanical power. The pitch angle is kept constant at zero degree when the measured electric output power is under its nominal value. When it increases above its nominal value the PI controller increases the pitch angle to bring back the measured power to its nominal value.

III. DFIG Wind Power System

The dynamic slip control is employed to fulfil the variable-speed operation in wind turbine system, in which the rotor windings are connected to variable resistor and control the slip by the varied resistance [1],[3]. This type of system can achieve limited variations of generator speed, but external reactive power source is still necessary, to completely remove the reactive power compensation and to control both active and reactive power independently, DFIG wind power system is one of most popular methods in wind energy applications [1], [3],[7]. In particular, the stator-side converter control involving an *RL* series choke is proposed. Both controlling of rotor- and stator-side converter voltages end up with a current regulation part and a cross-coupling part. The wind turbine driving DFIG wind power system consists of a wound-rotor induction generator and an ac/dc/ac insulated gate bipolar transistor (IGBT)-based pulse width-modulated (PWM) converter (back-to-back converter with capacitor dc link), as shown in Fig. 3. In this configuration, the back-to-back converter consists of two parts: the stator-/grid-side converter and the rotor-side converter. Both are voltage source converters using IGBTs, while a capacitor between two converters acts as a dc voltage source.

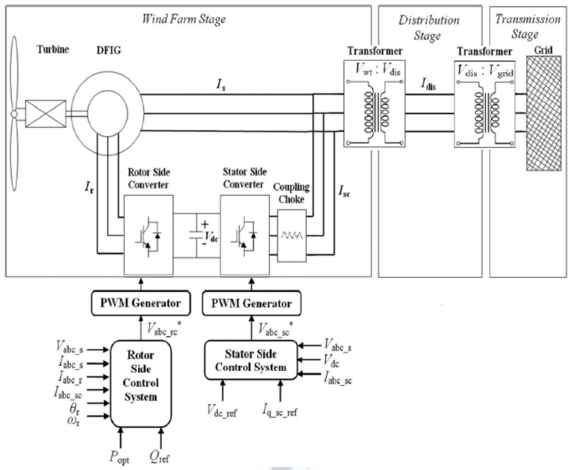

Fig. 3 Wind turbine–doubly fed Induction generator system configuration

IV. SEF-DFIG Wind Power System

In SEF-DFIG wind power system is same as that of DFIG wind power system but the stator of the machine is connected with a direct power grid and the controlling of rotor directly connected to inverter without any eternal power source. This is known as single external feeding of DFIG uses an additional grid power converter to regulate the rotor power; but in SEF-DFIG, the external source of a grid power is only connected to the stator windings. Due to this feature, the rotor-side inverter can be integrated on the rotor without any slip ring.

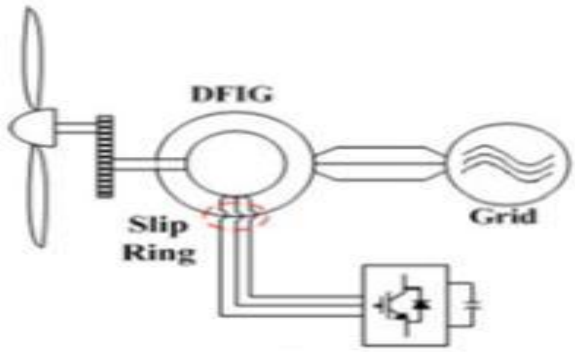

Fig. 4 Block diagram of SEF-DFIG.

V. Grid Connection Requirement

While renewable energy systems are capable of powering houses and small businesses without any connection to the electricity grid, many people prefer the advantages that grid-connection offers. A grid-connected system allows you to power your home or small business with renewable energy during those periods (daily as well as seasonally) when the sun is shining, the water is running, or the wind is blowing. Any excess electricity you produce is fed back into the grid. When renewable resources are unavailable, electricity from the grid supplies your needs, eliminating the expense of electricity storage devices like batteries. In addition, power providers (i.e., electric utilities) in most states allow net metering, an arrangement where the excess electricity generated by grid-connected renewable energy systems "turns back" your electricity meter as it is fed back into the grid. If you use more electricity than your system feeds into the grid during a given month, you pay your power provider only for the difference between what you used and what you produced

Harmonics Problems:

"Harmonics" means a component with a frequency that is an integer multiple (where n is the order of harmonic) of the fundamental frequency; the first harmonic is the fundamental frequency (50 or 60 Hz). The second harmonic is the component with frequency two times the fundamental (100 0r 120 Hz) and so on. The utilization of electrical power mainly depends up on supply of power with controllable frequencies and voltages, where as its generation and transmission takes place at nominally constant levels. So to convert nominal frequency to variable frequency power electronics circuitry (non-linear loads) is needed, which distorts the voltage and current waveforms. Therefore, the main source of harmonics in the power systems is the non linear loads. The total harmonic distortion (THD), of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Harmonic distortion is caused by the introduction of waveforms at frequencies in multiplies of the fundamental i.e. 3rd harmonic is three multiplied by the fundamental frequency (150Hz). THD is a measurement of the sum value of the waveform that is distorted. The THD is a very useful quantity for many applications. It is the most commonly used harmonic index. However, it has the limitation that, it is not a good indicator of voltage stress within a capacitor because that is related to the peak value of voltage waveform.

VI. Power Quality Improvement

The PQ issue is defined as "any occurrence manifested in voltage, current, or frequency deviations that results in failure, damage, upset, or misoperation of end-use equipment." Today, most of the power quality issues are related to the power electronics equipment which is used in commercial, domestic and industrial application. The applications of power electronics equipment for resident al purposes-TVs, PCs, Refrigerator etc. For business purposes-copiers, printers etc. For industrial purposes-PLCs (Programmable logic controller), ASDs (Adjustable speed drive), rectifiers, inverters etc. Today almost all electrical equipment is based on power electronics which causes harmonics, interharmonics, notches and neutral currents. Transformers, motors, cables, interrupters, and capacitors (resonance) are some of the equipment which is affected by harmonics. Notches are produced mainly because of the converters, and they basically affect the electronic control devices. Neutral currents are produced in that equipment which uses switched-mode power supplies, such as printers, photocopiers, PCs, and any triplets' generator. Neutral current affects the neutral conductor temperature and transformer capability. Inter-harmonics are generated because of cycloconverters, static frequency converters, arching devices and induction motors. The presence of harmonics in the power lines results in greater power losses in distribution, and cause problem by interfering in communication systems and, sometime cause operation failures of electronic equipment, which are more and more critical because it consists of microelectronic control systems, which work under very low energy levels. Because of these problems, the power quality issues delivered to the end consumers are of great concern. International standards concerning electrical power quality impose that electrical equipments should have limitation on the injection of harmonics in the system within a specified limit which has been satisfied by the international standards. Meanwhile, it is very important to solve the problems of harmonics caused by that equipment which is already installed. The STATCOM based current control voltage source inverter injects the current into the grid in such a way that the source current are harmonic free and their phase-angle with respect to source voltage has a desired value. The injected current will cancel out the Reactive part and harmonic part of the load and induction generator current, thus it improves the power factor and the power quality. To accomplish these goals, the grid volt-ages are sensed and are synchronized in generating the cur-rent command for the inverter. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC), as shown in Fig. 4.1. The grid connected system in Fig. 4.1, consists of wind energy generation system and battery energy storage system with STATCOM.

The timing problem between pulsed latches is solved using more than one non-overlap not on time pulsed clock indicators rather than a single pulsed clock sign. A small range of the pulsed clock indicators is utilized by grouping the latches to numerous sub shifter registers and the usage of extra transient garage latches. The implementation results of proposed and traditional architectures based totally on Xilinx FPGA Spartan XC3S200 are summarized.

STATCOM:

The STATCOM (or SSC) is a shunt-connected reactive-power compensation device that is capable of generating and/ or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. In general it is solid state switching converter which is capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source at its input terminals. Specifically, the STATCOM considered in this is a voltage-source converter from a given input of dc voltage produces a set of 3-phase ac-output voltages, each in phase with and coupled to the corresponding ac system voltage through leakage reactance. The dc voltage is provided by an energy-storage capacitor. A STATCOM can improve power-system performance in such areas as the following:

1. The dynamic voltage control in Transmission and distribution systems;
2. The power-oscillation damping in power transmission systems;
3. The transient stability;
4. The voltage flicker control; and
5. It also controls real power in line when it is needed.

Advantages

1. It occupies small areas.
2. It replaces the large passive banks and circuit elements by compact converters.
3. Reduces site work and time.
4. Its response is very fast.

VII. Simulation & Results

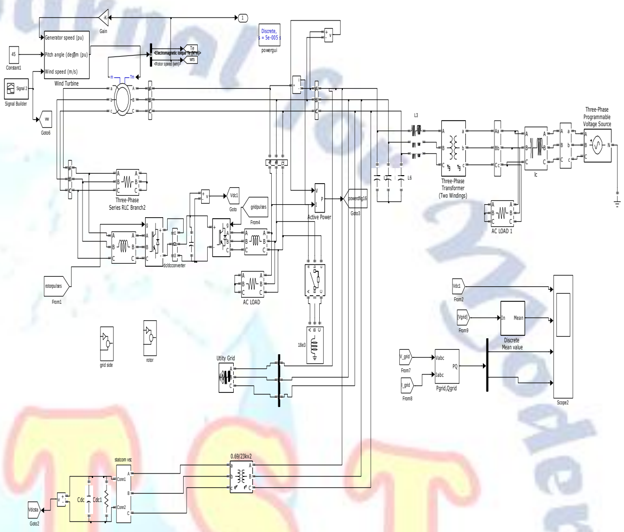

Fig 5:Simulation diagram of Grid connected Wind Energy System with STATCOM

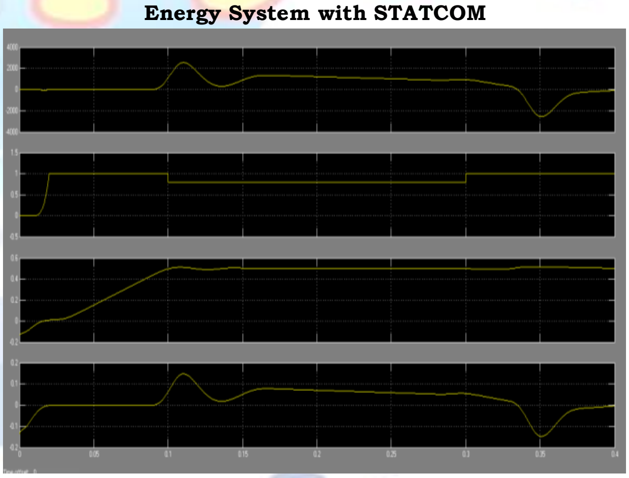

Fig 6(a) Vdc Voltage, (b) Grid Voltage mean value, (c) Active Power (d) Reactive Power.

VIII. Conclusion and Future Scope

With the penetration of wind energy in power systems it is always necessary to maintain the constant active power of the grid. With wind energy connected to the grid it is difficult to maintain constant power as the wind energy varies continuously with wind speed and makes it difficult to connect to the grid as it affects the total grid power. The development of power electronic devices like AC/DC/AC converters it is possible to use a Doubly-Fed Induction Generator (DFIG) with Energy storage system (ESS) to maintain constant power to the total wind farm and makes it feasible to interconnect the wind farm to the grid.

In the present work, the design of a wind farm is done using 15 DFIG's each producing 3.6MW power. The proposed control strategies for controlling the rotor and grid side converters are also described. The simulation is done with a 120kv grid which supplies a constant power of 36MW which is connected to the wind farm. Simulation results are observed for the power supplied by the wind farm with and without ESS, here observation has been made that without ESS the total power generated by wind farm has high variations compared to the wind farm with ESS where we can observe a constant active power is obtained. With step changes in power at the grid, the power tracking performance of the wind farm generates active power by the wind farm dynamically by tracking the power demand with good precision. This power tracking capability cannot be achieved without using the ESSs or the proposed control scheme. The proposed system and control schemes provides a promising solution to help achieve high levels of penetration of wind power into electric power grids

Future Scope

By the proposed system and schemes the control of Reactive power in the wind farm, with few modifications in the control scheme can also be obtained so that in case of system sags or swells and during faults the wind farm should be able to supply or consume the reactive power and maintain the system voltage. So, as futures work the reactive power control can also be done.

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