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WECS based STATCOM Interconnected to GRID for Power Quality Problem Compensation

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Abstract: *The paper exhibits the power quality issue because of establishment of wind turbine with the grid. In this proposed system STATCOM is associated at a state of basic coupling with a battery energy storage system (BESS) to alleviate the power quality issues. Infusion of the breeze control into an electric network influences the power quality. The impact of the wind turbine in the grid network concerning the power quality estimations are-the dynamic power, receptive power, variety of voltage and these are measured by national/global rules. The battery energy storage is incorporated to manage the genuine power source under fluctuating wind control. The STATCOM control strategy for the grid associated WE generation system for PQ change is recreated utilizing MATLAB/SIMULINK.*

I. INTRODUCTION

The integration of wind energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, power quality problems [1]. The power quality is an essential customer focused measure and is greatly affected by the operation of a distribution and transmission network. TO have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, hydro cogeneration, etc in sustainable energy system, energy conservation and the use of renewable source are the key paradigm. Today, more than 28 000 wind generating turbines are successfully operating all over the world. In the fixed-speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. During the normal operation, wind turbine produces a continuous variable output power.

The issue of power quality is of great importance to the wind turbine [2]. 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. These power variations are mainly caused by the effect of turbulence, wind shear, and tower-shadow and of control system in the power system. Thus, the network needs to manage for such fluctuations. The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc. However the wind generator introduces disturbances into the distribution network. One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected.

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 STATCOMto achieve fast dynamic response

II. POWER QUALITY

The voltage variation issue results from the wind velocity and generator torque. The voltage variation is directly related to real and reactive power variations. The voltage variation is commonly classified as under: Voltage Sag/Voltage Dips, Voltage Swells, Short Interruptions, Long duration voltage variation

The voltage flicker issue describes dynamic variations in the network caused by wind turbine or by varying loads. Thus the power fluctuation from wind turbine occurs during continuous operation. The amplitude of voltage fluctuation depends on grid strength, network impedance [3] and phase-angle and power factor of the wind turbines. It is defined as a fluctuation of voltage in a frequency 10–35 Hz. The IEC 61400-4-15 specifies a flicker meter that can be used to measure flicker directly. The harmonic results due to the operation of power electronic converters [4]. The harmonic voltage and current should be

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limited to the acceptable level at the point of wind turbine connection to the network. To ensure the harmonic voltage within limit, each source of harmonic current can allow only a limited contribution [5], as per the IEC-61400-36 guideline. The rapid switching gives a large reduction in lower order harmonic current compared to the line commutated converter, but the output current will have high frequency current and can be easily filter-out.

The way of connecting the wind generating system into the power system highly influences the power quality. Thus the operation and its influence on power system depend on the structure of the adjoining power network [6].

The self-excitation of wind turbine generating system (WTGS) with an asynchronous generator takes place after disconnection of wind turbine generating system (WTGS) with local load. However the voltage and frequency are determined by the balancing of the system. The disadvantages of self-excitation are the safety aspect and balance between real and reactive power [7]. The risk of self-excitation arises especially when WTGS is equipped with compensating capacitor. The capacitor connected to induction generator provides reactive power compensation.

III. PROPOSED SYSTEM

The grid quality characteristics and limits are given for references that the customer and the utility grid may expect. According to Energy- Economic Law, the operator of transmission grid is responsible for the organization and operation of interconnected system. Voltage Rise, Voltage Dips Flicker Harmonics Grid Frequency

Topology for Power Quality Improvement: The STATCOM based current control voltage source inverter injects the current into the grid in such a way that the sources 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 voltages are sensed and are synchronized in generating the current command for the inverter. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC).

In this configuration, wind generations are based on constant speed topologies with pitch control turbine. The induction generator is used in the proposed scheme because of its simplicity, it does not require a separate field circuit, it can accept constant and variable loads [8] and has natural protection against short circuit. BESS-STATCOM: The battery energy storage system (BESS) is used as an energy storage element for the purpose of voltage regulation. The BESS will naturally maintain dc capacitor voltage constant and is best suited in STATCOM since it rapidly injects or absorbed reactive power to stabilize the grid system. It also controls the distribution and transmission system in a very fast rate. When power fluctuation occurs in the system, the BESS can be used to level the power fluctuation by charging and discharging operation. The battery is connected in parallel to the dc capacitor of STATCOM.

The STATCOM is a three-phase voltage source inverter having the capacitance on its DC link and connected at the point of common coupling. The STATCOM injects a compensating current of variable magnitude and frequency component at the bus of common coupling.

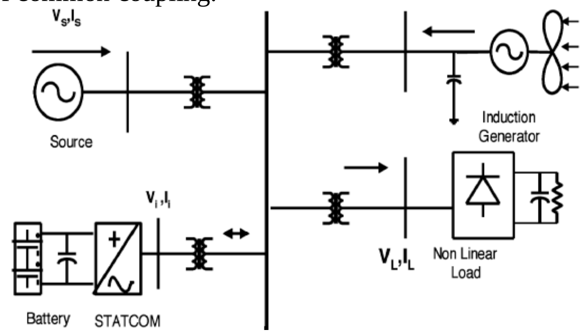

Figure 1: Grid connected system for power quality improvement

The shunt connected STATCOM with battery energy storage is connected with the interface of the induction generator and non-linear load at the PCC in the grid system. The STATCOM compensator output is varied according to the controlled strategy, so as to maintain the power quality norms in the grid system. The current control strategy is included in the control scheme that defines the functional operation of the STATCOM compensator in the power system. A single STATCOM using insulated gate bipolar transistor is proposed to have a reactive power support, to the induction generator and to the nonlinear load in the grid system.

IV. CONTROL SCHEME

The control scheme approach is based on injecting the currents into the grid using “bang-bang controller.” The controller uses a hysteresis current controlled technique. Using such technique, the controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for STATCOM operation. The proposed control scheme is simulated using SIMULINK in power system block set. The system performance of proposed system under dynamic condition is also presented.

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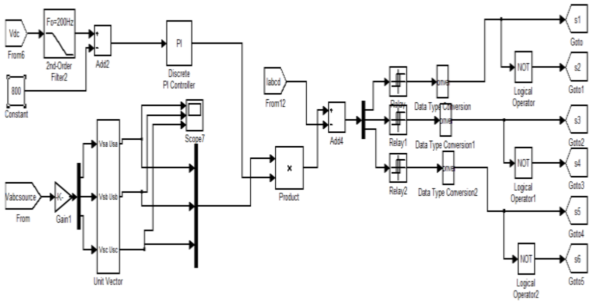

Figure 2: control Strategy

The three phase injected current into the grid from STATCOM will cancel out the distortion caused by the nonlinear load and wind generator. The IGBT based three- phase inverter is connected to grid through the transformer. The generation of switching signals from reference current is simulated within hysteresis band of 0.08. The choice of narrow hysteresis band switching in the system improves the current quality. The choice of the current band depends on the operatingvoltage and the interfacing transformer impedance. The compensated current for the nonlinear load and demanded reactive power is provided by the inverter. The real power transfer from the batteries is also supported by the controller of this inverter.

It is observed that the source current on the grid is affected due to the effects ofnonlinear load and wind generator, thus purity ofwaveform may be lost on both sides in the system.The inverter output voltage under STATCOM operationwith load variation. This shows that the unity powerfactor is maintained for the source power when theSTATCOM is in operation. The current waveformbefore and after the STATCOM operation is analyzed, The Fourier analysis of this waveform is expressed andthe THD of this source current at PCC withoutSTATCOM is 4.71%. The power quality improvement is observed at point of common coupling, when the controller is in ON condition.
The STATCOM is placed in the operation at 0.7 s and source current waveform is shown. The above tests with proposed scheme has not only power quality improvement feature but it also has sustain capability to support the load with the energy storage through the batteries.

V. SIMULATION RESULTS

The wind energy generating system is connected with gridhaving the nonlinear load. The performance of the system ismeasured by switching the STATCOM at time s in thesystem and how the STATCOM responds to the step changecommand for increase in additional load at 1.0 s is shownin the simulation. When STATCOM controller is made ON, without change in any other load condition parameters, it startsto mitigate for reactive demand as well as harmonic current.The dynamic performance is also carried out by step change ina load, when applied at 1.0 s. This additional demand is fulfillby STATCOM compensator. Thus, STATCOM can regulate theavailable real power from source.

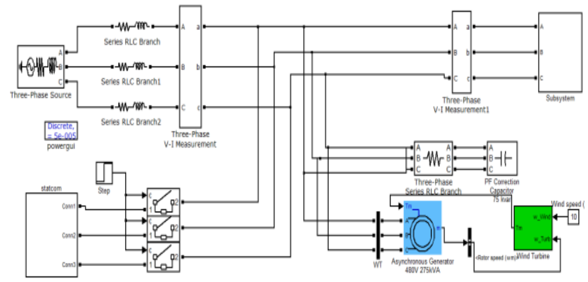

Figure 3: Simulation design of proposed network

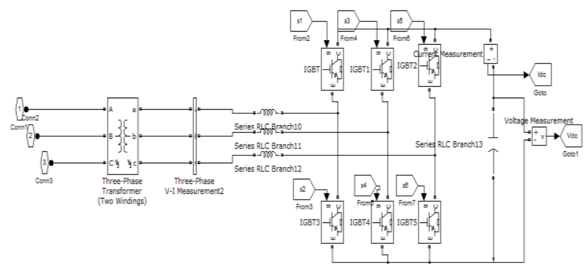

Figure 4: STATCOM circuit

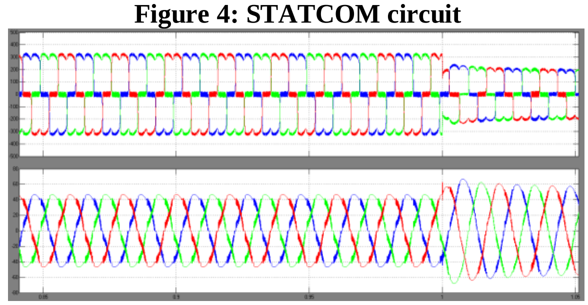

Figure 5: load voltage and load current

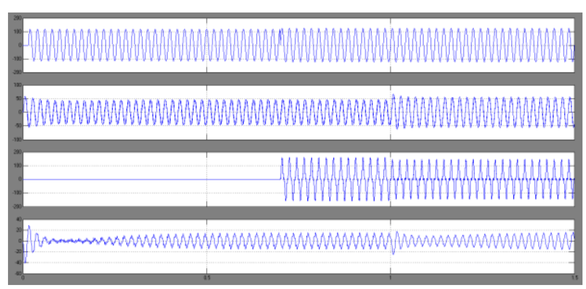

Figure 6: source, load, statcom and wind generator currents

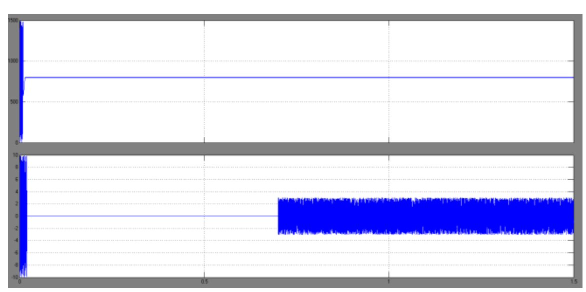

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Figure 7: DC link voltage and current

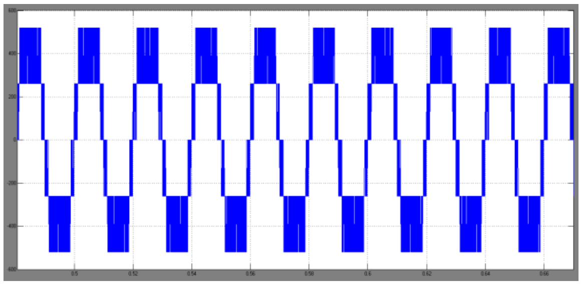

Figure 8: STATCOM voltage

VI. CONCLUSION

The paper introduces the STATCOM-based control plot for power quality compensation in network associated wind energy system and with nonlinear load. The power quality issues and its results on the customer and electric utility are introduced. The operation of the control framework created for the STATCOM-BESS in MATLAB/Simulink for keeping up the power quality is reproduced. It has an ability to counter balance the consonant parts of the load current. It keeps up the source voltage and current in-stage and support the reactive power interest for the wind generator and load at PCC in the grid system, along these lines it gives a chance to improve the use factor of transmission line.

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