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A Grid-Control Scheme Connected to a Wind Energy System for Improving the Power Quality

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Abstract - *The energy quality is affected by the injection of wind power into an electrical grid. The performance of the wind turbine and thus the power quality are determined on the grounds of measurements and the standards followed in accordance with the guidelines set out in the IEC-61400 standard of the International Electro technical Commission. Active power, reactive power, voltage variation, flicker, harmonics and electrical conduct of switching activity are the impact of the wind turbine in the grid system with regard to power quality measurements and are evaluated in accordance with national / international rules. Due to the assembly of wind turbine with the grid, the paper research shows the power quality issue. STATIC COMPENSATOR (STATCOM) is linked to a battery energy storage system (BESS) at a stage of common coupling to mitigate the power quality problems. Battery energy storage is incorporated under fluctuating wind power to support the true power source. Using MATLAB / SIMULINK in the power system box collection, the STATCOM control system for the grid connected wind energy generation system for improving power quality is displayed. The efficacy of the suggested system relives the primary supply origin from the charge and induction generator's partial power requirement. It was provided the creation of the system cooperation principle and the system for improving power quality standards as per the current IEC standard.*

***Key Words*: STATCOM control, STATIC COMPENSATOR, statcom, MATLAB/SIMULINK**

1. INTRODUCTION

To achieve sustainable growth and social progress, use of renewable energy resources such as wind, biomass, hydro, cogeneration, etc. is necessary to meet the energy needs. Energy conservation and the use of renewable sources are the key paradigm in the sustainable energy system. The need to incorporate renewable energy such as wind energy into power systems is to create it feasible to minimize the effect on standard plants on the environment [1]. Integrating wind energy into current power systems poses a technical challenge which needs scrutiny of voltage regulation, stabilization, issues of power quality. Power quality is a key customer-focused metric and is significantly influenced by a supply and transmission network procedure. For the wind turbine, the question of power quality is of excellent significance [2]. There has been an extensive growth and quick development in the exploitation of wind energy in recent years. Individual devices can accommodate up to 2 MW of high ability and feed into distribution networks, with clients closely connected [3]. Today, more than 28,000 wind turbines are running effectively worldwide. In the service of the fixed-speed wind turbine, all the fluctuation in the wind speed is transferred as mechanical torque changes, electrical power on the system and contributes to big voltage changes. Wind generator generates constant varying yield energy during ordinary procedure. The impact of turbulence, wind shear and tower-shadow and control system in the energy scheme are primarily triggered by these energy differences. The network must therefore handle these changes. In terms of wind generation, transmission and storage network, such as voltage sag, swells, tuckers, harmonics, etc., the power quality problems can be regarded. The wind generator, however, presents disruptions to the supply network. The induction generator linked straight to the grid system is one of the easy techniques for operating a wind generation scheme. The induction generator has intrinsic economic efficiency and robustness benefits. Generators involve magnetization electrical power. When an induction generator's produced active power is diverse owing to wind, an induction generator's absorbed reactive power and terminal voltage may be considerably impacted. To compensate for the fluctuation produced by wind turbine, a battery power storage scheme is usually needed in case of growing grid disruption. To improve the power quality that can technically manage the power level associated with commercial wind turbines; a STATCOM-based control technology has been suggested. The suggested STATCOM control system for grid-connected wind energy generation for improving power quality has goals.

- Source side unity power factor.
- Only STATCOM supports reactive energy to wind generator and load.
- Simple STATCOM bang-bang controller for quick dynamic reaction.

2. STANDARDS OF POWER QUALITY, ISSUES AND THE INTERNATIONAL GUIDELINES OF THE ELECTRO TECHNICAL COMMISSION:

The instructions for measuring the wind turbine's energy quality are given. The International Standards are created by the International Electro technical Commission (IEC) Working Group-88[15], IEC Standard 61400-21, explains the procedure for determining the features of the wind turbine's energy quality[4-10]. It specifies the standard standards.

IEC 61400-21: Wind turbine generation scheme, part-21. Measurement and evaluation of energy quality characteristics of grid-connected wind turbine.

IEC 61400-13: wind turbine— measurement of energy conduct.

IEC 61400-3-7: emission limit assessment for load fluctuation

IEC 61400-12: performance of wind turbines.

The wind turbine electrical information sheet offers the basis for the utility evaluation of a grid connection [11-13].

3. CIRCUIT DIAGRAM FOR PROPOSED SYSTEM

Figure 1 shows the block diagram of proposed system.

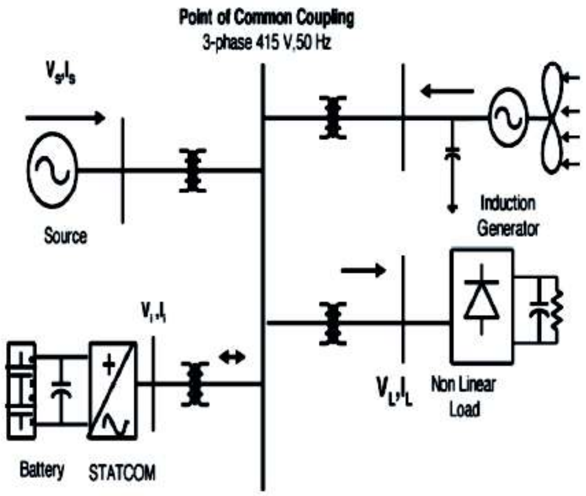

Fig-1: Block diagram of proposed System

Figure2 ahows the screen shot of the simulated proposed system.

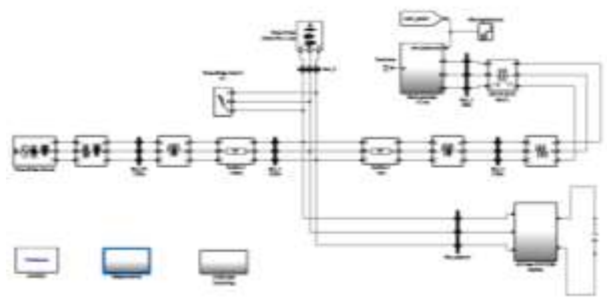

Fig - 2: Matlab file of simulated system

4. VARIATION OF VOLTAGE

The problem of voltage variation outcomes from the wind speed and torque of the generator. The variation in voltage is directly linked to differences in real and reactive power. The variation in voltage is usually categorized as below:

- Voltage Sag/Voltage Dips.
- Voltage Swells.
- Short Interruptions.
- Long duration voltage variation.

The problem of voltage flicker depicts dynamic network differences induced by wind turbine or variable loads. Thus the wind turbine energy fluctuation takes place during ongoing operation. The voltage fluctuation amplitude relies on the wind turbines, grid strength, network impedance[14], phase angle and power factor. It is described as a voltage fluctuation in a 10–35 Hz frequency. The IEC 61400-4-15 sets a flicker meter for direct measurement of flicker.

5. HARMONICS

Harmonic outcomes owing to electronic energy converter operation[15]. The harmonic voltage and current at the point of wind turbine attachment to the network should be restricted to the appropriate rate. Each source of harmonic current can only allow a limited contribution[16], as per the IEC-61400-36 guideline, to guarantee harmonic voltage within the limit. Rapid switching provides a big decrease of harmonic current in reduced order compared to the line switched converter, but the output current will have high frequency current and can readily be filtered out.

6. WIND TURBINE LOCATION IN THE ENERGY SCHEME

The way the wind producing system is connected to the energy scheme greatly affects the quality of the power. Thus the operation and its energy system impact depends on the adjacent energy network structure[17].

7. WIND TURBINE GENERATING SYSTEM SELF EXCITATION

Wind turbine generating system (WTGS) self-excitation with an asynchronous generator occurs after the wind turbine generating system (WTGS) is disconnected with local load. In particular, the risk of self-excitation arises when WTGS is equipped with capacitor compensation. The capacitor connected to the generator of induction provides compensation for reactive power. However, the system balance determines the voltage and frequency. Figure3 shows the wind turbine system with self excitation. The safety aspect and balance between real and reactive power are the disadvantages of self-excitation [5].

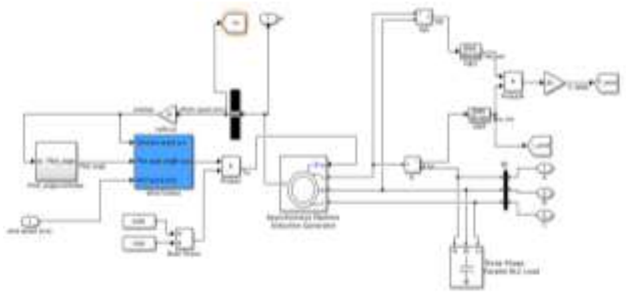

Fig -3: Wind turbine system with self excitation

8. GRID COORDINATION RULE

Grid quality features and boundaries are provided for references that the client and utility grid might expect. The transmission grid operator is liable for the organisation and operation of the interconnected scheme, according to Energy-Economic Law.

- *Voltage Rise*
- *Voltage Dips*
- *Flicker*
- *Harmonics*
- *Grid Frequency*

9. POWER QUALITY IMPROVEMENT TOPOLOGY

The present voltage source inverter based on STATCOM injects the current into the grid in such a manner that the source current is harmonic-free and has a required value in its phase angle with regard to the source voltage. The injected current will cancel the reactive portion and the harmonic portion of the current generator load and induction, thus enhancing the power factor and the quality of the power[18]. The grid voltages are felt and synchronized when producing the present inverter command to achieve these objectives. The suggested grid-connected system is introduced at the point of common coupling (PCC) to improve energy performance.

10. WIND ENERGY GENERATING SYSTEM

Wind generations are based in this setup on steady topologies of velocity with turbine pitch control. Because of its simplicity, the induction generator is used in the suggested system, it does not require a distinct field circuit, it can accept steady and variable loads[17] and it has natural short circuit protection.

11. STATCOM

For voltage regulation purposes, the battery energy storage system (BESS) is used as an energy storage element. Naturally, the BESS will retain continuous dc capacitor voltage and is best suited for STATCOM as it quickly injects or absorbs reactive energy to stabilize the grid system. It also controls a very quick pace of the distribution and transmission system. By charging and discharging procedure, the BESS can be used to level the energy fluctuation when energy fluctuation happens in the scheme. The battery is linked to the STATCOM dc condenser in parallel has capacity on its DC connection and linked to the common coupling point. The figure4 shows the statcom used in this system. The STATCOM injects a variable magnitude and frequency element compensating current into the popular coupling bus.

12. SYSTEM OPERATION

At the PCC in the grid system, the shunt linked STATCOM with battery power storage is linked to the induction generator interface and non-linear load. According to the controlled strategy, the STATCOM compensator output is varied to maintain the power quality standards in the grid system. In the control scheme which describes the functional activity of the STATCOM compensator in the energy system, the present control approach is included. A single STATCOM using a bipolar insulated door transistor is suggested to assist the reactive power, the induction generator and the grid system's nonlinear load.

13. CONTROL SCHEME

The control system method is based on the use of "bang-bang controller" to inject the electrons into the grid. A regulated hysteresis present method is used by the controller. Using such method, the controller maintains the control system variable between hysteresis zone limits and provides right STATCOM operation switching signals. Figure 4 shows the control scheme for statcom. 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.

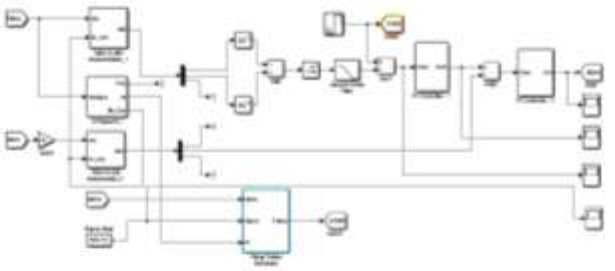

Fig-4: Control scheme for statcom

14. CURRENT CONTROL-VOLTAGE SOURCE INVERTER OPERATION

STATCOM's three-phase injected current into the grid will eliminate the distortion induced by the wind and nonlinear load generator. The transformer connects the IGBT-based three-phase inverter to the grid. The generation of reference present switching signals is simulated within the 0.08 hysteresis band. Choosing the scheme to switch the tight hysteresis band increases the present performance. The switching frequency control signal within the working band. The present band selection relies on the working voltage and the impedance of the interfacing transformer. The inverter provides the compensated current for the nonlinear load and the required reactive power. The controller of this inverter also supports the actual energy transfer from the batteries.

15. POWER QUALITY IMPROVEMENT:

It is noted that the source present on the grid is influenced by the impacts of nonlinear load and wind turbine, which means that both sides of the scheme may lose the purity of the waveform. Under STATCOM operation, the inverter output voltage with load variability. This demonstrates that when the STATCOM is in service, the unity energy factor is preserved for the source power. The present waveform is evaluated before and after the procedure of STATCOM. This waveform's Fourier Analysis is displayed and the THD of this source current at PCC without STATCOM is 4.71%. The improvement in power quality is noted when the controller is in ON condition at the stage of popular coupling.

The STATCOM is set at 0.7s in the procedure and the present source waveform is displayed. Not only does the above testing with the suggested system have power quality improvement function, but it also has sustainability capacity to help the load through the batteries with energy storage.

16. RESULTS

The below figure shows the voltage, current, active and reactive powers at bus1.

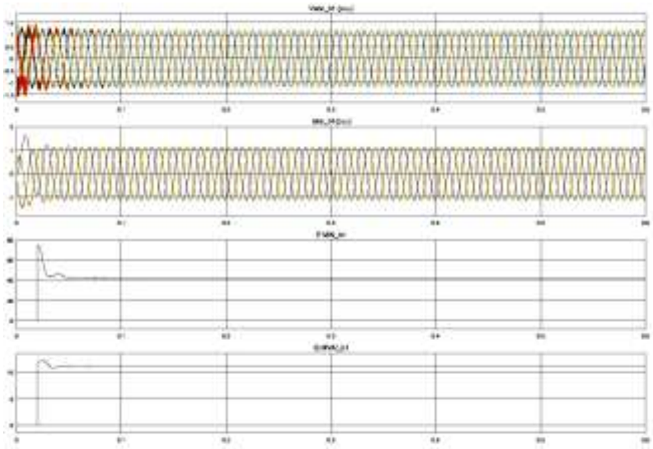

Fig-5: Voltage, current, active and reactive powers at bus1

The below figure shows the voltage, current, active and reactive powers at bus2.

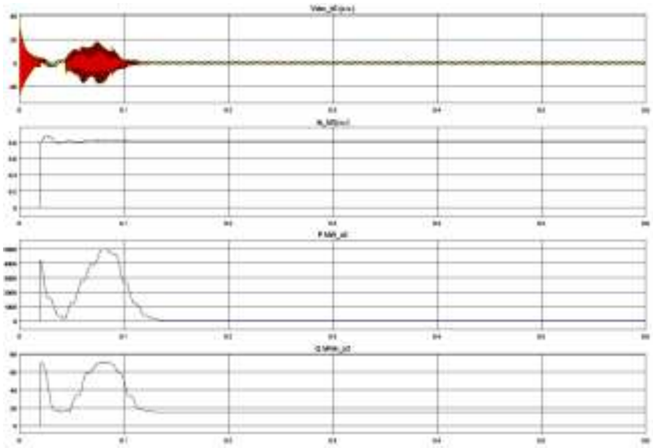

Fig-6: Voltage, current, active and reactive powers at bus2

The below figure shows the voltage, current, active and reactive powers at bus3.

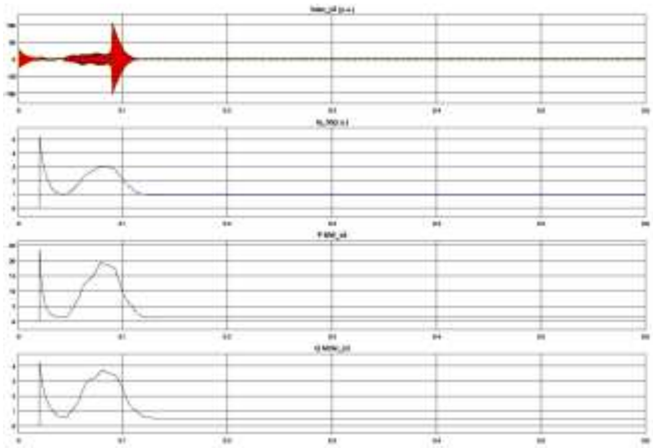

Fig-7: Voltage, current, active and reactive powers at bus3

The below figure shows the voltage, current, active and reactive powers at Wind generator.

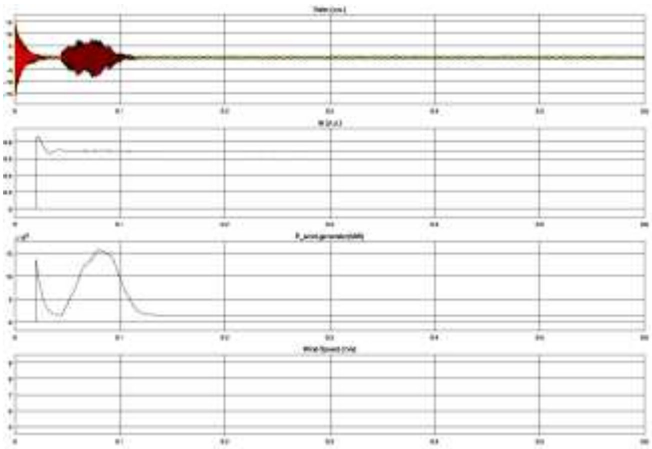

Fig-8: Voltage, current, active and reactive powers at wind generator

The below figure shows the voltage, current, active and reactive powers at Statcom.

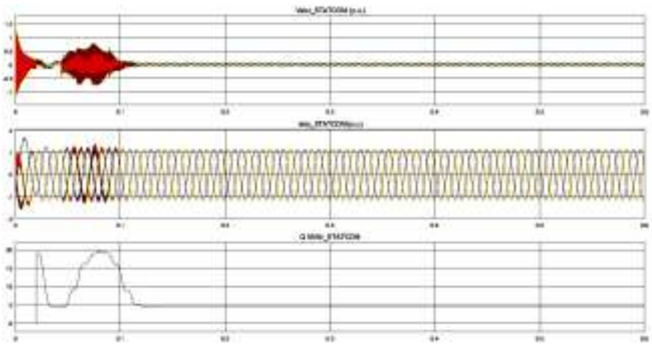

Fig-10: Volatge, current and rective powers at STATCOM

17. CONCLUSIONS

The article introduces the STATCOM-based control system for improving power quality in grid-connected wind generation and non-linear loading systems. Power quality problems are described and their implications for consumer and electrical utility. It simulates the activity of the control system created for the MATLAB / SIMULINK STATCOM-BESS to maintain the power quality. It has the ability to cancel the load current's harmonic components. It retains in-phase source voltage and current and supports reactive power supply in the grid system for the wind generator and load at PCC, thus providing an chance to improve the transmission line usage factor.

The excellent performance was demonstrated by the embedded wind generation and STATCOM with BESS. Thus, the suggested scheme in the grid-connected system meets the IEC standard 61400-21 [19-23] energy quality standards.

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