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Power Quality Improvement for Grid Connected Wind Energy System by Using STATCOM Control Scheme

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Abstract

Injection of the wind power into an electric grid affects the power quality. The performance of the wind turbine and thereby 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 behavior of switching operation and these are measured according to international guidelines. The paper study demonstrates the power quality problem due to installation of wind turbine with the grid. In this proposed scheme Static Compensator (STATCOM) is connected at a point of common coupling with a battery energy storage 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 quality improvement is simulated using MATLAB/SIMULINK in power system block set. The effectiveness of the proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator. The development of the grid co-ordination rule and the scheme for improvement in power quality norms as per IEC-standard on the grid has been presented.

Keywords: International electro-technical commission (IEC),power quality, wind generating system (WGS).

1. Introduction

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. The need to integrate the renewable energy like wind energy into power system is to make it possible to minimize the environmental impact on conventional plant [1]. The integration of wind energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, 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 [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 [3]. Today, more than 28 000 wind generating turbine is 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. 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 canbe 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. 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 achieves fast dynamic response. The paper is organized as fallows. The Section II introduces the power quality standards, issues and its consequences of wind turbine. The Section III introduces the grid coordination rule for grid quality limits. The Section IV describes the topology for power quality improvement. The Sections V, VI, VII describes the control.

The power quality of power supply of an ideal power system means to supply electric energy with perfect sinusoidal waveform at a constant frequency of a specified voltage with least amount of disturbances. Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of usage. The various power quality problems are voltage sag, very short interruptions, long interruptions, voltage spike, voltage swell, harmonic distortions, voltage fluctuations, voltage unbalance etc. This causes the malfunction of equipments namely microprocessor based control system, programmable logic controller; adjustable speed drives, flickering of light and screen. It leads to tripping of contractors, tripping of protection devices, stoppage of sensitive equipment like personal computer, programmable logic control system and may stop the process. Even can damage of sensitive equipment also degrade the power quality in the grid? The solutions for this are Flywheels, static capacitors, DVR, DSTATCOM, UPFCetc. [6]

A STATCOM consists of a two-level Voltage Source Converter (VSC), a DC energy storage device connected in shunt to the distribution network through the coupling transformer. The VSC converts the DC voltage across the storage device into a set of three-phase AC output voltages. These voltages are in phase and coupled with the AC system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the STATCOM output voltages allows effective control of active and reactive power exchanges

2. Simulation

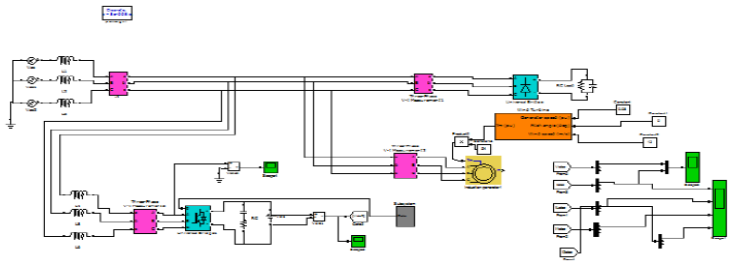

Figure 1: Simulink Block of Grid Connected Wind Energy System for Power Quality Improvement by Using STATCOM

Between the STATCOM and the AC system. Such configuration allows the device to absorb or generate controllable active and reactive power [1]. The battery energy storage system (BESS) is used as an energy storage element for the purpose of voltage regulation and this maintains dc capacitor voltage constant. And STATCOM is useful to inject reactive power to stabilize the grid system. It also controls the distribution and transmission system in a very fast. When power fluctuation occurs in the system, the BESS can be used to level the power fluctuation by charging and discharging operation [1]. The shunt connected STATCOM with battery energy storage system is connected to the induction generator and non-linear load at the PCC in the grid system. The STATCOM compensator output is varied to maintain the power quality as norms in the grid system by using hysteresis current controller. 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 [3]. The control scheme approach is based on injecting the currents into the grid using “hysteresis current controller.” Using this technique, the hysteresis current controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for STATCOM operation. The control algorithm needs the measurements of several variables such as three-phase source current (iabc), DC voltage (Vdc), inverter current (iabc). The current control block, receives an input of reference current (i*abc) and actual current (iabc) are subtracted so as to activate the operation of STATCOM in current control mode. The control system scheme for generating the switching signals to the STATCOM is presented below. The RMS voltage source amplitude is calculated at the sampling frequency from the source phase voltage (Va, Vb, Vc) for the three phase balanced system. And this can be expressed as *Vm*, sampled peak voltage, is in below equation.

3. Results

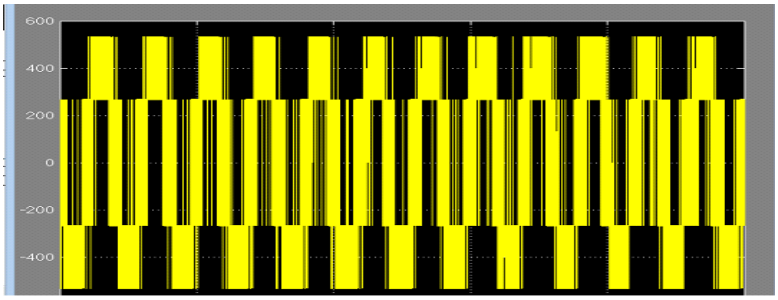

Figure 3 : STATCOM output voltage

The source voltage on the grid is affected due to the effects of non-linear load and wind generator, thus purity of wave form may be lost on both sides in the system. This dynamic load does affect the inverter output voltage. Above is the injected statcom output voltage useful to mitigate the problems occurring in the power quality of non-linear load and wind generator.

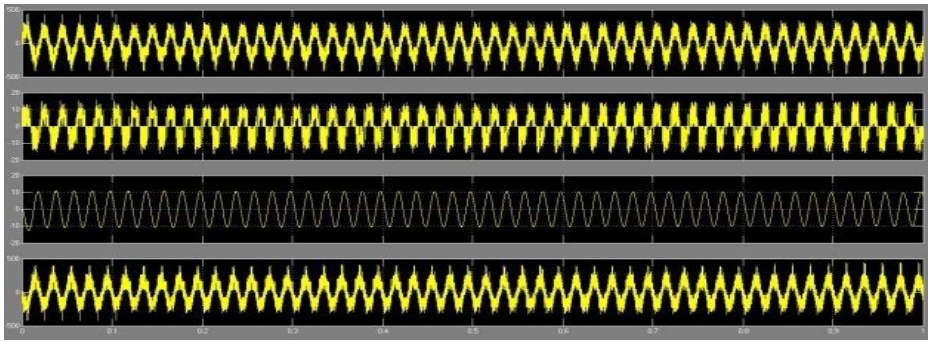

Figure 4 : (a) Source current (b) Load current (c) Wind generator current (d) Inverter injected current

The above source current, load current, wind generator current contains more total harmonic distortions because of a continuous variation of non-linear load and wind generating system. So in the above STATCOM injected current is useful to mitigate the harmonics in the source and load currents

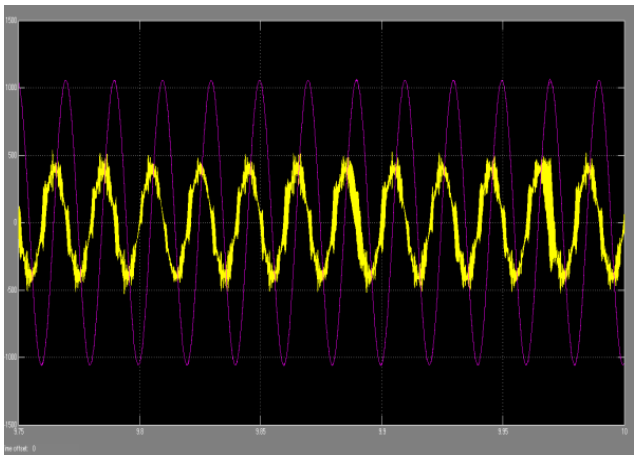

Figure 5: Supply voltage and current at PCC without STATCOM

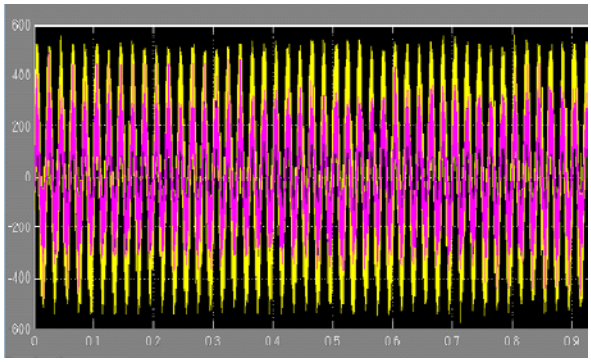

Figure 6: Supply voltage and current at PCC with STATCOM

In the above supply voltage and current at PCC without STATCOM shows current leading the voltage, this affects the performance of the system. By using the STATCOM current and voltage are in-phase. This shows that the nearer unity power factor is maintained for the source power when the STATCOM is in operation

4. Conclusion

This paper presents the grid connected wind energy system for power quality improvement by using STATCOM. The power quality problems, its consequences and their mitigation techniques are presented here. In this proposed scheme to eliminate the harmonic content of the load current the STATCOM-BESS control system is used. So that power quality is maintained at the point of common coupling. And hysteresis current control scheme in the STATCOM is used for the fast dynamic response. It also maintains voltage and current in phase. That means unity power factor is maintained at the source end.

5. References

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