ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 3, May 2013

A Statcom-Control Scheme for Power Quality Improvement of Grid Connected Wind Energy System

B.T.RAMAKRISHNARAO*, B.ESWARARAO**, L.NARENDRA**, K.PRAVALLIKA**
* Associate.Professor, Dept.of EEE, Lendi Inst.Of Engg. & Technology, Vizianagaram, Andhra Pradesh, India
**UG Students, Dept.of EEE, Lendi Inst.Of Engg. & Technology, Vizianagaram, Andhra Pradesh, India

Abstract:* When the wind power is connected to an electric grid affects the power quality. The effects of the power quality measurements are-the active power, reactive power, variation of voltage, flicker, harmonics, and electrical behavior of switching operations. The installation of wind turbine with the grid causes power quality problems are determined by studying this paper. For this Static Compensator (STATCOM) with a battery energy storage system (BESS) at the point of common coupling to mitigate the power quality problems. The grid connected wind energy generation system for power quality improvement by using STATCOM-control scheme is simulated using SIMULINK in power system block set. This relives the main supply source from the reactive power demand of the load and the induction generator in this proposed scheme. The improvement in power quality on the grid has been presented here according to the guidelines specified in IEC-61400 standard (International Electro-technical Commission) provides some norms and measurements.

Key terms: **International Electro-technical Commission (IEC), STATCOM, Battery Energy Storage System (BESS), Total Harmonic Distortion (THD), and Point of Common Coupling (PCC).**

I. INTRODUCTION

The renewable energy resources like wind, hydro, biomass etc, are necessary to sustainable growth and social progress. So the integration of wind energy into power system is used to minimize the environmental impact on conventional plant[7]-[4].A continuous proliferation of non-linear loads is due to the intensive use of power electronics converter-based power processing units in industries and residential applications. The non-linear loads generate serious harmonic currents and reactive power to the distribution and transmission System, which results in a low power factor, leads to voltage notch and reduces the utilization of the distribution system. Traditionally, current harmonics caused by non-linear loads have been dealt with using passive filters consisting of capacitors, inductors and damping resistors. They provide simple solutions but have large size and weight; they cannot provide flexible compensation and may cause resonance problems. Nowadays, the development of power electronics and microelectronics makes it possible to consider active power filters, which can provide flexible current harmonic compensation and contribute to reactive power control and load balancing. Hence Power electronic based FACTS devices like STATCOM can be effectively utilized to improve the quality of power supplied to the customers

The increasing use of power electronic based loads (adjustable Speed drives, Switch mode power supplies, etc) to improve system efficiency and Controllability is increasing concern for harmonic distortion levels in end use facilities and on overall power system. The application of passive tuned filters creates new system resonances, which are dependent on specific system conditions. In addition, passive filters often need to be significantly overrated to account for possible harmonic absorption from power system. A number of low-power electronic based appliances such as TV sets, personal computers, and adjustable speed heat pumps generate a large amount of harmonic current in power systems even though a single low power electronic based appliance, in which a single-phase diode rectifier with a dc link capacitor is used as utility interface, produces negligible amount of harmonic current.

Three-phase diode or thyristor rectifiers and cyclo- converters for industry applications. Also generate a large amount of harmonic current. Voltage distortion or harmonics resulting from current harmonics produced by power electronic equipment has become a serious problem to be solved in many countries. Power system harmonics are not a new problem. Unlike the conventional load, the power-electronic device controls the flow of power by chopping. Flattening, or shaping the waveforms of the voltage and current. Therefore, harmonics

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 3, May 2013
are generated during the process [4]. These waveform distortions can cause problems for neighboring loads, and they tend to have an overall opposite effect on the quality of electric power. A concept that can improve the power quality is the active power filter. This type of filters can meet diverse load conditions. In addition to improve power factor, it also appears to be an attractive and viable method for reducing voltage and current harmonic distortion or other power quality problems such as flicker. The active power filter improves the system power quality by injecting equal-but opposite currents to compensate harmonic distortion and reactive power. Ideally, this active power filter should monitor and minimize voltage and went distortion of its connected load. In order to improve the drawbacks of the conventional IRP theory, a instantaneous active and reactive power theory-based the control strategy of the active power filter proposed. Also**,** for verifying the performance of this control strategy**,** computer simulations and experiment are made. From the simulation and experimental test results, it is found that proposed new instantaneous active and reactive current i_d –$I_q$theory-based three-phase shunt active power filter is to be an effective device to reduce harmonic current and THD. The objective of the electric utility is to deliver sinusoidal voltage at fairly constant throughout the system [5].

II. OBJECTIVES OF THE PROJECT

The grid connected wind energy generation system for power quality improvement by using STATCOM has the following objectives.

- To maintains power factor as unity at the source end.
- To meet the reactive power to wind generator and non-linear load.
- To provides hysteresis current controller for STATCOM to achieve fast dynamic response.

III. POWER QUALITY PROBLEMS, ITS CONSEQUENCES AND THEIR MITIGATION TECHNIQUES

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 is Flywheels, static capacitors, DVR, DSTATCOM, UPFC etc.[6]

IV. SIMULATION

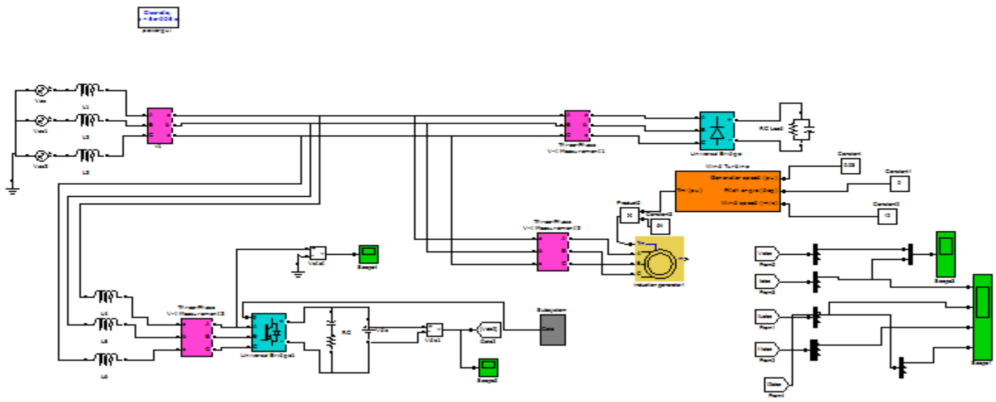

Fig 1 Simulink Block of Grid Connected Wind Energy System for Power Quality Improvement by Using STATCOM

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

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 3, May 2013

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.

$$V_m = \{\frac{2}{3}(V_a^2 + V_b^2 + V^2)\}^{1/2} \quad \ldots\ldots 4.1$$

The in-phase unit vectors are obtained from AC source phase voltage and the RMS value of unit vectors are shown below as

$$u_a = \frac{Va}{Vm}\ ;\ u_b = \frac{Vb}{Vm}\ ;\ u_c = \frac{Vc}{Vm} \quad \ldots\ldots 4.2$$

The in-phase generated reference currents are derived using in-phase unit voltage template as represented below

$$i^*_a = I.u_a;\ i^*_b = I.u_b;\ i^*_c = I.u_c \quad \ldots\ldots 4.3$$

Where I is proportional to magnitude of filtered source voltage for respective phases. This ensures that the source current is controlled to be sinusoidal. The unit vectors implement the important function in the grid connection for the synchronization for STATCOM .

The reference current is generated as in equation below and actual current are detected by current sensors and are subtracted for obtaining a current error for a hysteresis based current controller. Thus the ON/OFF switching signals for IGBT of STATCOM are derived from hysteresis controller. The switching function SA for phase ‘a’ is expressed as

When $i_a < (i^*_a - HB)$, SA = 0

When $i_a > (i^*_b - HB)$, SA = 1

Where HB is a hysteresis current-band, similarly the switching function SB , SC can be derived for phases b and c respectively[2].

V. V.RESULTS

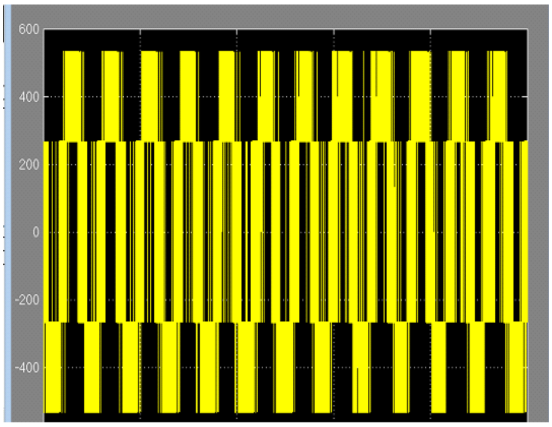

Fig 2 STATCOM output voltage

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.

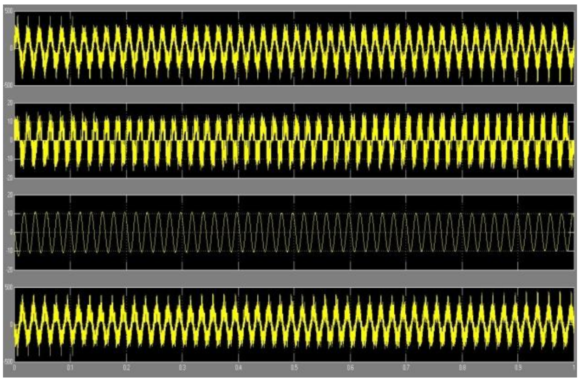

Fig 3 (a) Source current (b) Load current (c) Wind generator current (d) Inverter injected current

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.

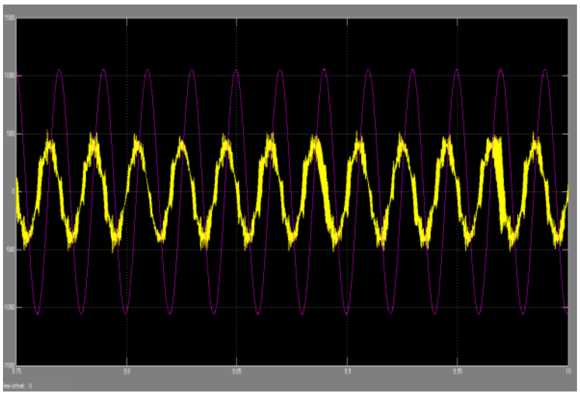

Fig 4Supply voltage and current at PCC without STATCOM

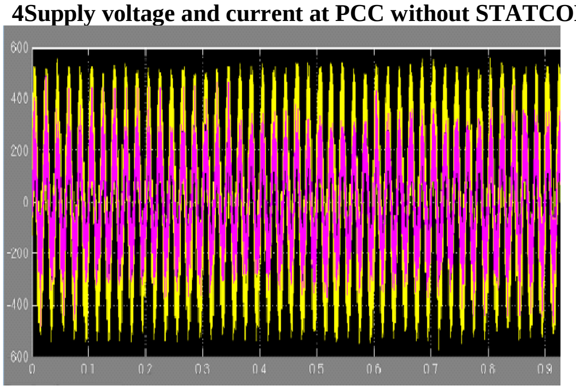

Fig 5. Supply voltage and current at PCC with STATCOM

In the above supply voltage and current at PCC without STATCOM shows current leading the voltage, this effects 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.

VI. 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.

REFERENCES

[1] Han. A,Huang. Q,Baran. M, Bhattacharya. S and Litzenberger. W, "STATCOM impact study on the integration of a large wind farm into a weak loop power system," IEEE Trans. Energy Conv., vol. 23, no. 1, pp. 226–232, Mar. 2008.

[2] Heier. S, Grid Integration of Wind Energy Conversions. Hoboken, NJ: Wiley, pp. 256–259, 2007.

[3] Kinjo. T and Senjyu. T, "Output leveling of renewable energy by electric double layer capacitor applied for energy storage system," IEEE Trans. Energy Conv., vol. 21, no. 1, Mar. 2006.

[4] Manel. J, "Power electronic system for grid integration of renewable energy source: A survey," IEEE Trans. Ind. Electronics, Carrasco vol. 53, no. 4, pp. 1002–1014, 2006.

[5] Milands. M. I, Cadavai. E. R, and Gonzalez. F. B, "Comparison of control strategies for shunt active power filters in three phase four wire system," IEEE Trans. Power Electron., vol. 22, no. 1, pp. 229–236, Jan. 2007.

[6] Mohod. S. W and Aware. M. V, "Power quality issues &it's mitigation technique in wind energy conversion," in Proc. of IEEE Int. Conf. Quality Power & Harmonic, Wollongong..

[7] Sannino. A, "Global power systems for sustainable development," in IEEE General Meeting, Denver, CO, Jun.2004.

AUTHOR BIOGRAPHY

* B.T.Ramakrishna Rao Completed M.Tech from JNTU Hyderabad. Presently working as Associate professor in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India. His areas of interests are Power system stability and Electrical machines. He published many papers in various reputated national and international journals and conferences.

**B.Eswararao graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.

**L.Narendra graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.

**K.Pravallika graduate in electrical and electronics engineering, LENDI institute of Eng. & Tech., Andhra Pradesh, India.