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# Power Quality Improvement in Wind Grid Energy System using STATCOM With BESS -Control Scheme

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**ABSTRACT:** The grid connected wind energy generation system for power quality improvement by using STATCOM-control scheme is simulated using MATLAB When the wind power is connected to an electric grid affects the power quality. The effects of connecting wind turbine in grid system covers power quality areas are the active power, reactive power, and variation of voltage, harmonics and electrical behavior of switching operations. The installation of wind system with the grid introduces the power quality problems which can be determined by studying this paper. By using the Static Compensator (STATCOM) with a battery energy storage system (BESS) at the point of common coupling to improve the power quality of the grid. The battery energy storage used to maintain real power from varying wind power. At low power demand hours The generated power can be stored in the batteries. The combination of battery storage with wind energy generation system will stabilize the grid system by absorbing or injecting reactive power and enable the real power flow required by the load. This relives the main supply source from the reactive power demand of the load and the induction generator in this proposed scheme.

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

## 1 INTRODUCTION

The renewable energy resources like wind, hydro, biomass etc are necessary to growth and social progress. So the integration of wind energy into power system is used to minimize the environmental impact on conventional plant. 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. Current harmonics due to non-linear loads have been dealt with using passive filters consist of inductor, capacitor and resistors (damping resisters). They provide simple solution but having 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 increase in use of power electronic based loads (adjustable Speed drives, SMPS, etc) to improve system efficiency and Controllability is increasing concern for harmonic distortion levels in end use facilities and on overall power system. The use of passive tuned filters generates new system resonances, depending on specific system conditions. In addition, passive filters also significantly overrated to account for possible harmonic absorption from power system. Various low-power based electronic appliances such like TV sets, personal computers, and adjustable speed heat pumps generates a large amount of harmonic current in power systems even though a single low power electronic appliance, consist of single-phase diode rectifier with a dc link capacitor is as utility interface, produces negligible amount of harmonic current.

A concept that can improve the power quality is the active power filters. This type of filters can meet diverse load conditions. In addition improve the power factor, as well as appears to be an attractive and viable method for reducing voltage and current harmonic distortion and other power quality problems such as flicker. Thus 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 distortion of connected load. Wind energy generating system is to use the induction generator connected directly to the grid system. The induction generator has advantages of cost effectiveness and robustness. However; the induction generators needs reactive power for magnetization. When the generated active power of an induction generator is varied due to variation of wind, absorbs reactive power and terminal voltage of an induction generator can be 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. On increasing of grid disturbance, battery energy storage (BESS) system for wind energy generating system is generally required to compensate the fluctuation generated by wind turbine. A STATCOM based control methodology has been proposed for improving the power quality which can technically manages the power level associates with the commercial wind turbines.

## 2 POWER QUALITY ISSUES

Perfect power quality means that the voltage is continuous and sinusoidal having constant amplitude and frequency. Power quality can be expressed in terms of physical characteristics and properties of electricity. It is mostly described in terms of voltage, frequency and interruptions.

### 2.1 GRID SIDE POWER QUALITY ISSUES

The power quality problems in the grid side that affect the WEG (Wind Electric Generator) are mainly concerned with the quality of voltage that is being supplied by the utility.

### 2.2 VOLTAGE VARIATIONS

Voltage variation has implications on both real and reactive power associated with wind farms. A decreased voltage condition increases the current through the generator, making line losses to increase. Decreasing voltage also affects the power factor as the capacitive VAR generated out of the installed capacitor decrease as voltage decreases.

### 2.3 FREQUENCY VARIATIONS

The variation in frequency affects the power generation in Wind Energy Generator (WEG) to a large extent changing the aerodynamic efficiency. Frequency changes lead to imperfect tip speed ratios and reduced efficiencies. These leads to decrease the energy capture and output power of wind turbines.

### 2.4 VOLTAGE UNBALANCE

Voltage unbalance is caused due to large unbalanced non-linear loads. The unbalance in voltage causes negative sequence currents to flow in induction machines, causing overheating.

### 2.5 GENERATION OF CURRENT HARMONICS

Current harmonics are generated due to starting of induction generators during motoring mode. This causes distortion in the line voltage and affects all the consumers connected to the line.

### 2.6 INJECTION OF FLUCTUATING POWER

Power in wind is varied by nature and is checked by annual, monthly, daily and hourly variations. This results in generation and supply of a power that is fluctuating and leading to operational problems.

## 3 POWER QUALITY IMPROVEMENT TOPOLOGY

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 reaches a desired value. The injected current cancel out the reactive and harmonic part of the load and induction generator current, thus it improves power factor and power quality of system. To accomplish these goals, the grid voltages are sensed and are synchronized in generating the current command for the inverter. The grid connected system is implemented for power quality improvement at point of common coupling (PCC), as The grid connected system shown in Fig. 1, consists of wind energy generation system and battery energy storage system with STATCOM. *Wind Energy Generating System* The wind generating system (WEGS) consists of turbine, induction generator, interfacing transformer, and rectifier to get dc bus voltage. For constant dc bus voltage, the power flow is represented with constant dc bus current. In this configuration, wind generations are based on constant speed topologies with pitch control turbine. The induction generator because of its simplicity, does not require any separate field circuit, and can be connected with constant and variable loads. The available power of wind energy system is presented by equation:

$$P_{wind} = \frac{1}{2} \rho \text{ A } V_{wind} \tag{1}$$

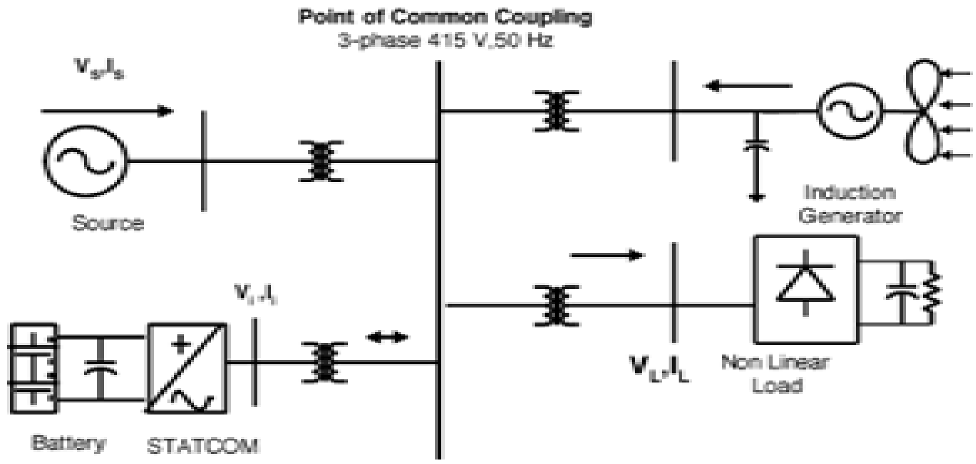


***Fig. 1. Grid connected system for power quality improvement***

Where ρ (kg/m) is the air density and A (m) is the area swept out by turbine blade, is the wind speed in meter/s. It is not possible to extract all kinetic energy of wind, thus it extract a fraction of wind power, called wind turbine power coefficient *Cp* , and it is given by the equation:

$$P_{mech} = C_p P_{wind} \tag{2}$$

Where *Cp* (power coefficient), depends on the type and operating condition of wind turbine. This coefficient also express as a function of tip speed ratio and pitch angle. The mechanical power produce by wind turbine is given as:

$$P_{mech} = \frac{1}{2} \rho \prod R^2 V^3_{wind} C_p \tag{3}$$

Where R is the radius of the blade (m).

### 3.1 BESS-STATCOM

The STATCOM (or Static Synchronous compensator) 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 system. In general it is solid state switching converter device 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. Basically, 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 subsequent ac system voltage through leakage reactance. For the voltage regulation in STATCOM, the battery energy storage system (BESS) is used as an energy storage element. The BESS naturally maintains dc capacitor voltage constant and it is best for STATCOM since it rapidly injects or absorbs reactive power to stabilize the grid system. It also controls the power fluctuations occurs distribution and transmission system with very fast response by charging and discharging of DC link capacitor. 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.

A STATCOM can improve power-system performance in following areas:

- The dynamic voltage control in electrical (Transmission and Distribution) system;
- The transient stability;
- The voltage flicker control; and
- It also controls real power flow in line when it is needed.

### 3.2 ADVANTAGES OF STATCOM

- It occupies small area by replacing the large passive banks and circuit elements with compact converters.
- Reduces site work and time.
- Its response is very fast.

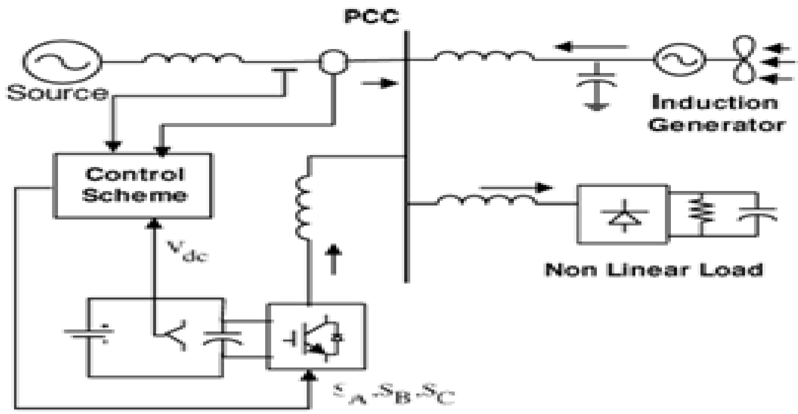


*Fig. 2. System operational scheme in grid system*

## 4 CONTROL SCHEME OF SYSTEM

The control scheme of **Grid Connected Wind Energy System** approach is based on injecting the current into the grid using hysteresis band using hysteresis band. Using such techniques controller keeps the control system variables between the boundaries of hysteresis area and thus gives correct switching signals. The control algorithm needs the measurements of several variables such as three-phase source current $i_{sabc}$, DC voltage $V_{dc}$, inverter current $i_{iabc}$ with the use of sensor. The current control block, receives an input of reference current $i^*_{sabc}$ and actual $i_{sabc}$ current are subtracted so as to activate the operation of STATCOM in current control mode Hence; the inverter maintains the continuous power for the critical load.

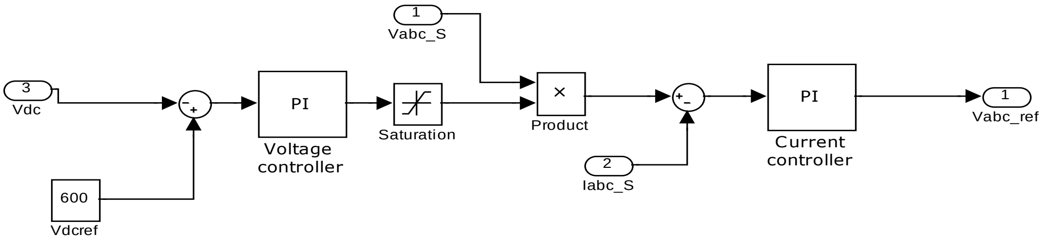


***Fig. 3. Control system scheme***

### 4.1 HYSTERESIS BASED CURRENT CONTROLLER

Current control based hysteresis controller is used in this scheme. The reference current is generated as in and the actual current is detected by current sensors that are subtracted for obtaining current errors for a hysteresis based controller. ON/OFF pulse signals for IGBT switches of inverter are derived from hysteresis current controller. When the measured current is higher than the generated reference current, it is necessary to get negative inverter output voltage so that corresponding switches are commutated. Thus output voltages are decreased so that the output current reaches the reference current. Also, if the measured current is less than the reference current, positive inverter output voltage are obtained by commutating particular switch Thus output current increases to the reference current. Hence, the output current will be within a band around the reference one. The switching function SA for phase 'a' is expressed as follows:

$$i_{sa} > (i*_{sa} + HB) then\, S_A^+ = 0 \quad (4)$$

$$i_{sa} < (i*_{sa} - HB) then\, S_A^+ = 1 \quad (5)$$

Where HB is a hysteresis current-band, similarly the switching function SB, SC can be derived for phases ''b'' and ''c,'' respectively [9]. The current control mode of inverter injects the current into the grid in such a way that the source currents are harmonic free and their phase-angles are in phase with respect to source voltage. The reactive and harmonic part of load side is cancel out by the injected current at shunt part. Thus, overall it reduces harmonic content and improves the source current quality at the PCC. As soon as battery energy system is fully charged with the help of micro-wind generator, the power transfers take place [4]. The source voltage is sensed and synchronized in generating the desired reference current command for the inverter operation.

## 5 STATCOM—PERFORMANCE UNDER LOAD

The Grid Connected Wind Energy System is connected having the nonlinear load. The functioning of the system is measured by switching the STATCOM at time t= 0.3 s in the system. When STATCOM controller is turn ON, without change in load condition parameters, it starts to extenuate for reactive demand as well as harmonic current. This additional demand is fulfill by STATCOM compensator when the load in variation. Thus, STATCOM can regulate the available real power from source.  The DC link voltage regulates the source current in the grid system, which maintained constant across the capacitor. The current through the dc link capacitor indicating the charging and discharging operation.

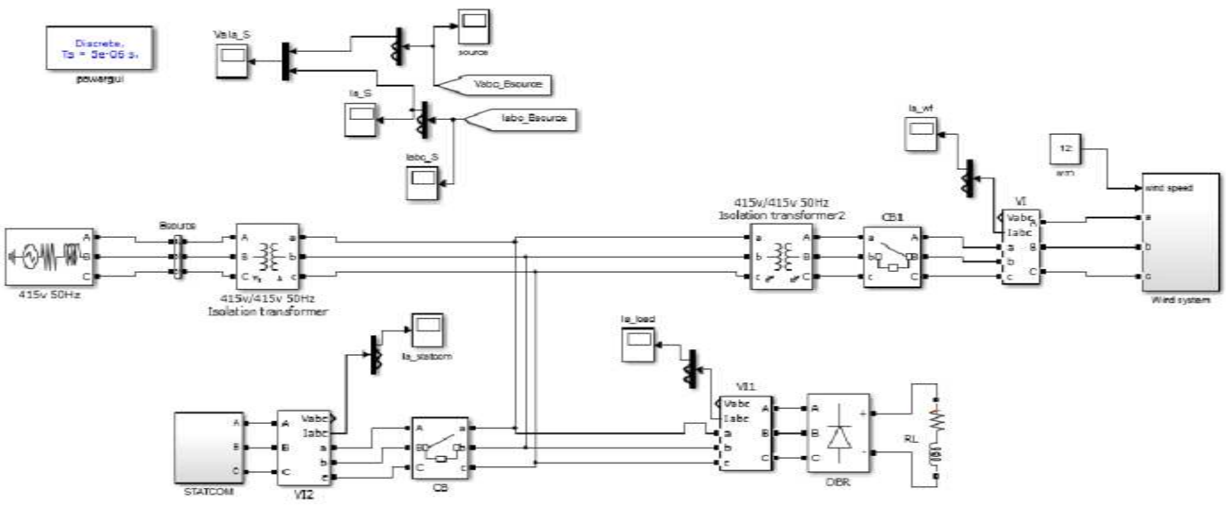


*Fig. 4. Matlab Dig Of Grid Connected Wind Energy System using STATCOM*

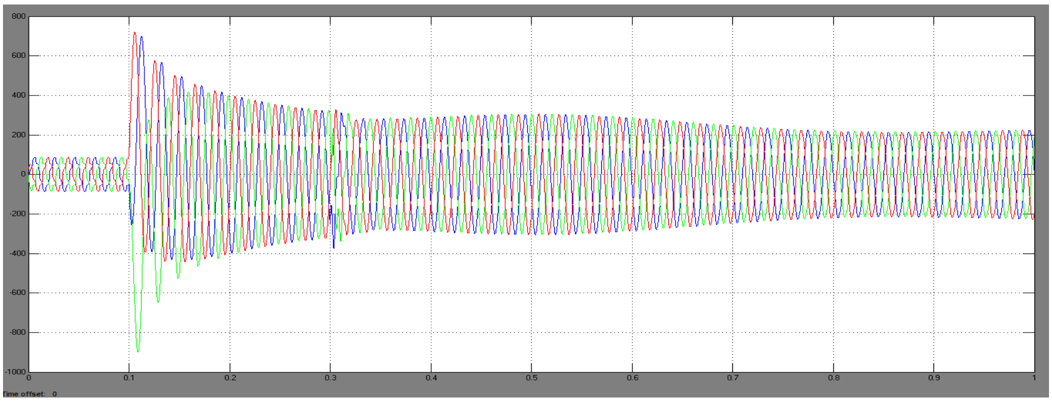


*Fig. 5. Output wavefome of source current*

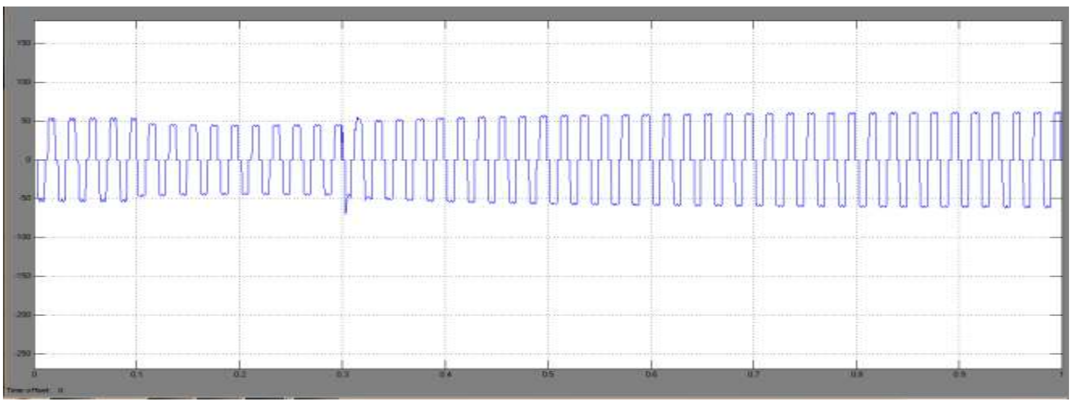

*Fig. 6. Output wavefome of load current*

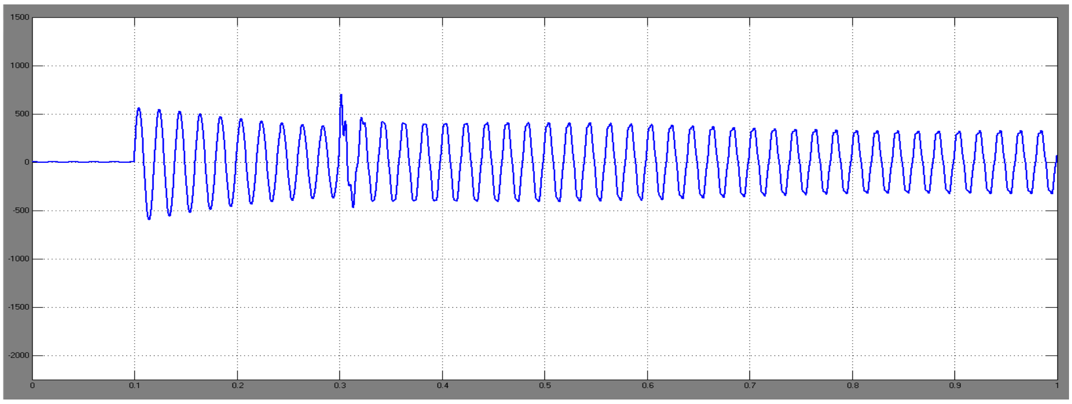

*Fig. 7. Output waveform of wind current*

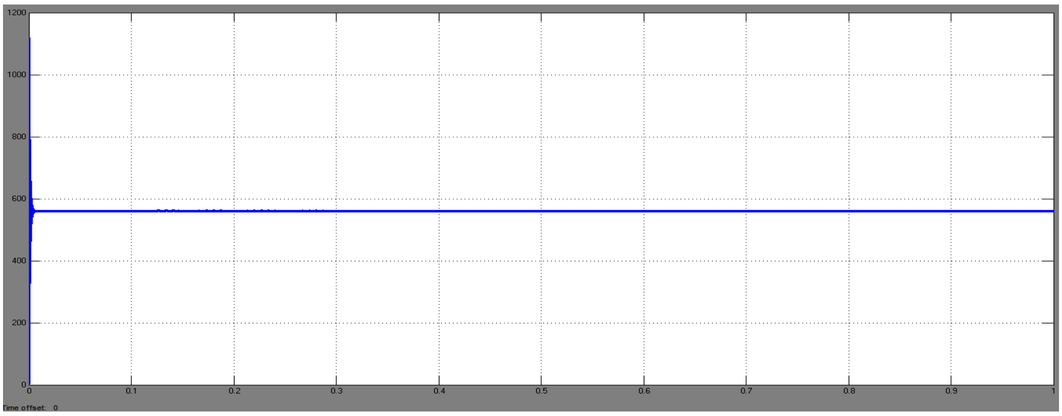

*Fig. 8. Output wavefome of DC link voltage*

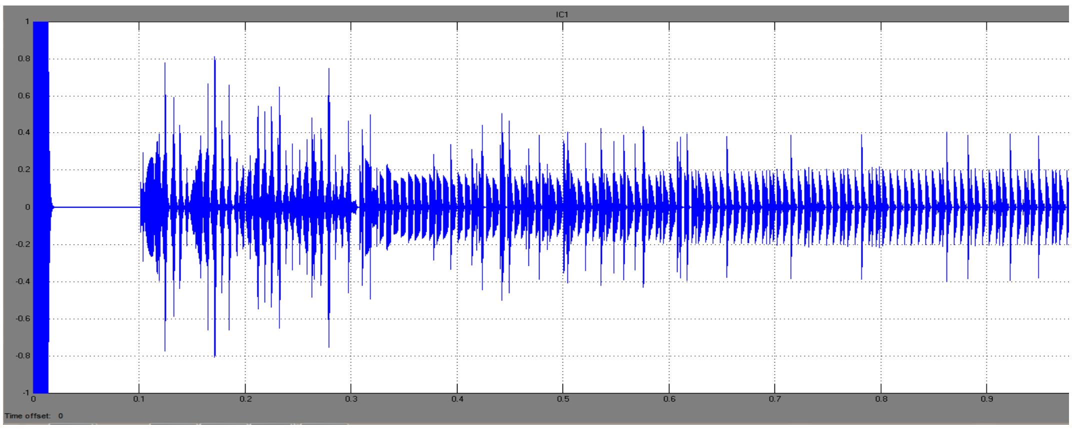

*Fig. 9. Output wavefome of current across capaciter*

## 6 CONCLUSION

In this paper we present the STATCOM based control scheme for power quality improvement in wind generating system on integration to the grid and with nonlinear load. The power quality issues and its effects on the consumer end and electric utility are shown. The operation of the control system developed for the STATCOM in MATLAB/SIMULINK for maintaining the power quality is to be simulated. It has potentiality to cancel out the harmonic parts of the load end current. It maintains the source voltage and current in-phase and support the reactive power during demand for the wind generator and load at PCC in the wind grid system, thus it enhance the utilization factor of transmission line also. The integrated wind generation and FACTS device with BESS have shown with the outstanding performance. Thus the proposed scheme in the wind grid connected system fulfils the power quality norms as per the IEC standard 61400-21.

## REFERENCES


[1] Sharad W. Mohod, and Mohan V. Aware.: 'A STATCOM-Control Scheme for Grid Connected Wind Energy System for Power Quality Improvement'. IEEE, VOL. 4, pp. 346-352, September 2010.

[2] Fu. S. Pai and S.-I. Hung, "Design and operation of power converter for micro turbine powered distributed generator with capacity expansion capability," IEEE Trans. Energy Conv., vol. 3, no. 1, pp. 110–116, Mar. 2008.

[3] J. Zeng, C. Yu, Q. Qi, and Z. Yan, "A novel hysteresis current control for active power filter with constant frequency,"Elect. Power Syst. Res., vol. 68, pp. 75–82, 2004.

[4] M. I. Milands, E. R. Cadavai, and F. B. Gonzalez, "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.

[5] S. W. Mohod and M. V. Aware, "Power quality issues & its mitiga- tion technique in wind energy conversion," in Proc. of IEEE Int. Conf. Quality Power & Harmonic, Wollongong, Australia, 2008.

[6] K.R.Sujal, .Jacob RagJend, "Power Quality Improvement in Grid Connected Wind Energy System Using STATCOM," 2012 International Conference on Computing, Electronics and Electrical Technologies [ICCEET] ., pp. 259-266.

[7] S. Sirisukprasert, A. Q. Huang, J. S. Lai "Modeling, analysis and control of cascaded-multilevel converter-based STATCOM," IEEE PES general meeting, vol. 4, pp. 2561 - 2568, July 2003

[8] J. J. Gutierrez, J. Ruiz, L. Leturiondo, and A. Lazkano, —Flicker measurement system for wind turbine certification, IEEE Trans. In strum. Meas., vol. 58, no. 2, pp. 375–382, Feb. 2009