# IMPROVEMENT OF POWER QUALITY FOR GRID CONNECTED STATCOM BASED INVERTER WITH LOCAL LOAD

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## ABSTRACT

*In this paper a novel method i.e., current-voltage controller is proposed for inverter and to improve the power quality of the grid connected system. It also enables seamless transfer of the operation mode from stand alone to grid connected or vice versa. In this the control scheme also shows the inner voltage loop and an outer current loop. This control strategy also reduces the total harmonic distortion in the local load and grid system. The proposed control strategy also used for both single phase and three phase inverters. The experimental results are done in Matlab.*

***Index Terms: STATCOM, Grid System, Power Quality, Solar Panel, THD.***

## I INTRODUCTION

We have sustainable growth and social progress, it is necessaryto meet the energy need by utilizing the renewable energy resources like wind, biomass, hydro, cogeneration,etc. In sustainable energy system, energy conservation andthe use of renewable source are the key paradigm. The needto integrate the renewable energy like wind energy into powersystem is to make it possible to minimize the environmentalimpact on conventional plant [1]. The integration of wind energyinto existing power system presents a technical challengesand that requires consideration of voltage regulation, stability,power quality problems. The power quality is an essential customer focusedmeasure and is greatly affected by the operationof a distribution and transmission network.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 solar panels introduces disturbances into the distribution network. One of the simple methods of running a solar panels system is to use the inverter system connected directly to the grid system. However; inverter system 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

Solar based 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 windGenerator and Load.

• The Dc voltage is obtained for STATCOMis generated from Solar Cells.

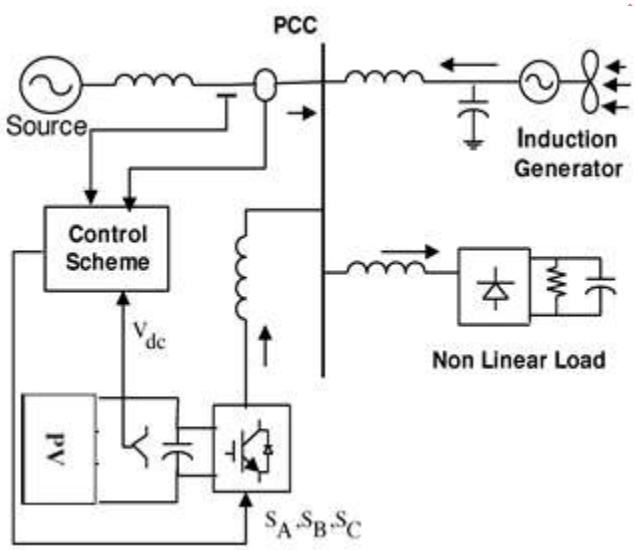



**Fig 1: Grid Connected System for Power Quality Improvement**

The Current controlled voltage source inverterbased STATOOM controller injects the current into the grid in such a way that the sourcecurrent are harmonic free and their phase-angle with respect tosource voltage has a desired value. The injected current willcancel out the reactive part and harmonic part of the load andinduction generator current, thus it improves the power factorand the power quality. To accomplish these goals, the grid voltagesare sensed and are synchronized in generating the currentcommand for the inverter. The proposed grid connectedsystem is implemented for power quality improvement at pointof common coupling (PCC), as shown in Fig. 1.The grid connected system in Fig. 1, consists of wind energygeneration system and battery energy storage system withSTATCOM. In this STATCOM controller the dc voltage is obtained by using SOLAR cells as shown in fig 1.

The shunt connected STATCOM with solar cell and battery energy storageis connected with the interface of the induction generator andnon-linear load at the PCC in the grid system. The STATCOMcompensator output is varied according to the controlledstrategy, so as to maintain the power quality norms in the gridsystem.

## II GRID SYNCHRONIZATION

In three-phase balance system, the RMS voltage source amplitude is calculated at the sampling frequency from the sourcephase voltage (Vsa, Vsb, Vsc) and is expressed, as sample templateVsm, sampled peak voltage

$$V_{sm} = \left\{\frac{2}{3}(V_{sa}^2 + V_{sb}^2 + V_{sc}^2)\right\}^{1/2}.$$

The unit vectors implement the important function in the grid connection for the synchronization for STATCOM. This method is simple, robust and favorable as compared with other methods.

## III WIND TURBINE

The wind turbine captures the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to anelectrical generator. The equation describes the mechanicalpower captured from wind by a wind turbine [4] can beformulated as:

$$P_m = 0.5\rho A C_p v^3$$

The theoretical maximum value of the power coefficient is 0.59. It is dependent on two variables, the tip speed ratio (TSR) and the pitch angle. The pitch angle refers to the angle in which the turbine blades are aligned with respect to its longitudinal axis. *TSR* is defined as the linear speed of the rotor to the wind speed.

Fig.2 shows a typical "CVs. λ" curve for a wind turbine.In practical designs, the maximum achievable ranges Pfrom 0.4 to 0.5 for high speed turbines and 0.2 to 0.4 for slowspeed turbines. Fig.2 shows that has its maximum value ($C_{pmax}$) at λopt. Which results in optimum efficiency andmaximum power is captured from wind by the turbine.

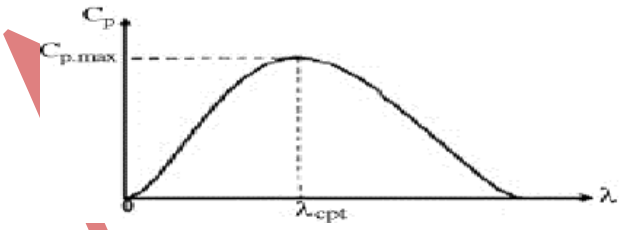


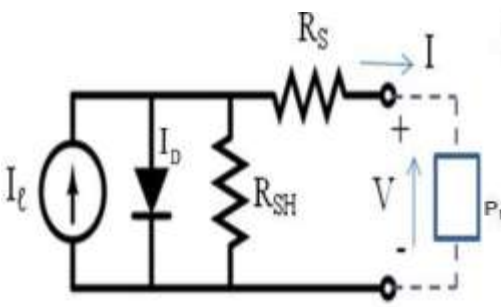

**Fig 2: Power Coefficient Vs Tip Speed Ratio**

## IV SOLAR CELL

A solar cell is the most fundamental component of a photovoltaic (PV) system. The PV array is constructed bymany series or parallel connected solar cells to obtainrequired current, voltage and high power [8]. Each Solar cellis similar to a diode with a p-n junction formed bysemiconductor material. When the junction absorbs light, itcan produce currents by the photovoltaic effect. The outputpower characteristic curves for the PV array at an insolationare shown in Fig. 3. It can be seen that a maximum powerpoint exists on each output power characteristic curve. TheFig: 4 shows the (I-V) and (P-V) characteristics of the PVarray at different solar intensities. The equivalent circuit of asolar cell is the current source in parallel with a diode of aforward bias. The output terminals of the circuit areconnected to the load. The current equation of the solar cell isgiven by:

$$I = I_{ph} - I_D - I_{sh}$$
$$I = I_{ph} - I_0[\exp(\frac{q V_D}{nkT})] - \frac{V_D}{R_{SH}}$$

The power output of a solar cell is given byP = V * I



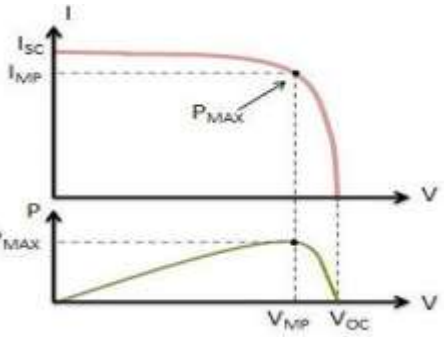




**Fig 3: Equivalent circuit of PV Module** **Fig 4: Output characteristics of PV Array**

## V CONTROL SCHEME

The control scheme approach is based on injecting the currentsinto the grid using "bang-bang controller." The controlleruses a hysteresis current controlled technique. Using such technique,the controller keeps the control system variable betweenboundaries of hysteresis area and gives correct switching signalsfor STATCOM operation. The control system scheme for generating the switching signalsto the STATCOM is shown in Fig. 5.

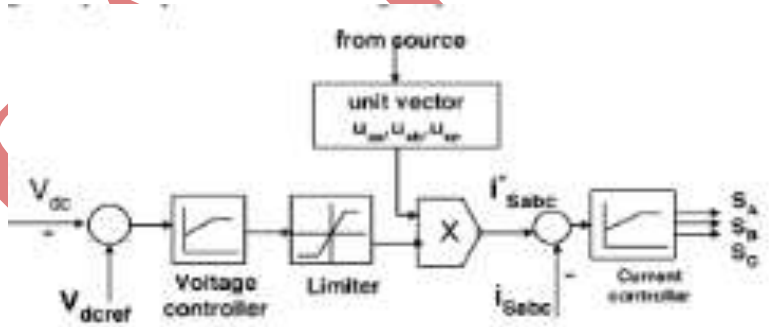



**Fig 5: Control Diagram**

## VI SIMULATION DIAGRAM AND RESULTS

The proposed control scheme is simulated using SIMULINK in power system block set.The main block diagram of the systemoperational scheme is shown in Fig. 1.The simulation is done based on the fig 1, as shown in figure 6 and the obtained power quality is shown below.

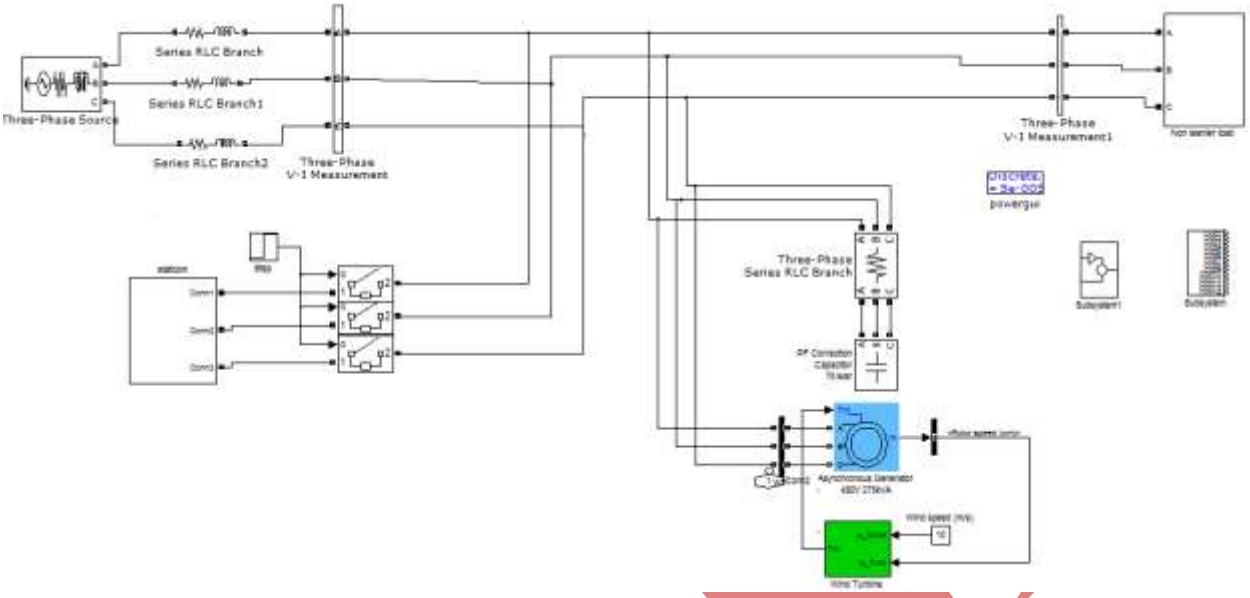



**Fig 6: Simulation Diagram for Grid Connected System**

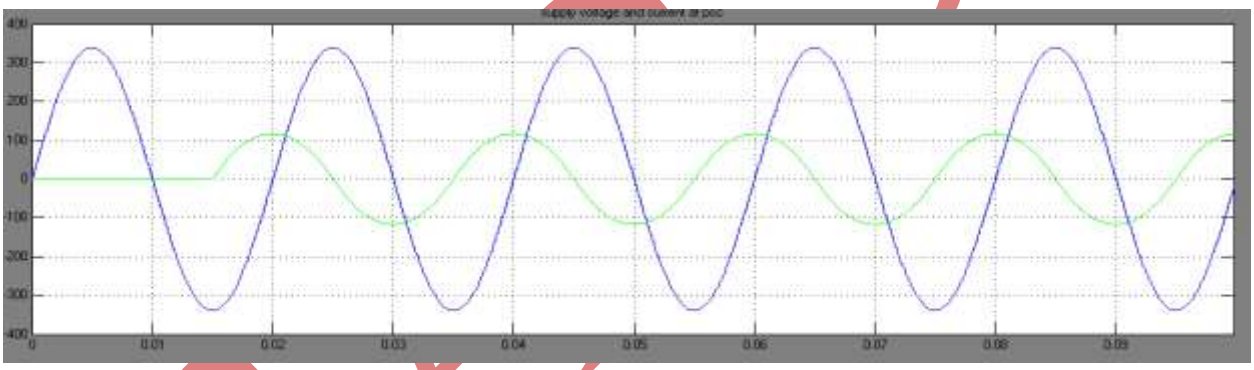


**Fig 7: Supply Voltage and Current at PCC**

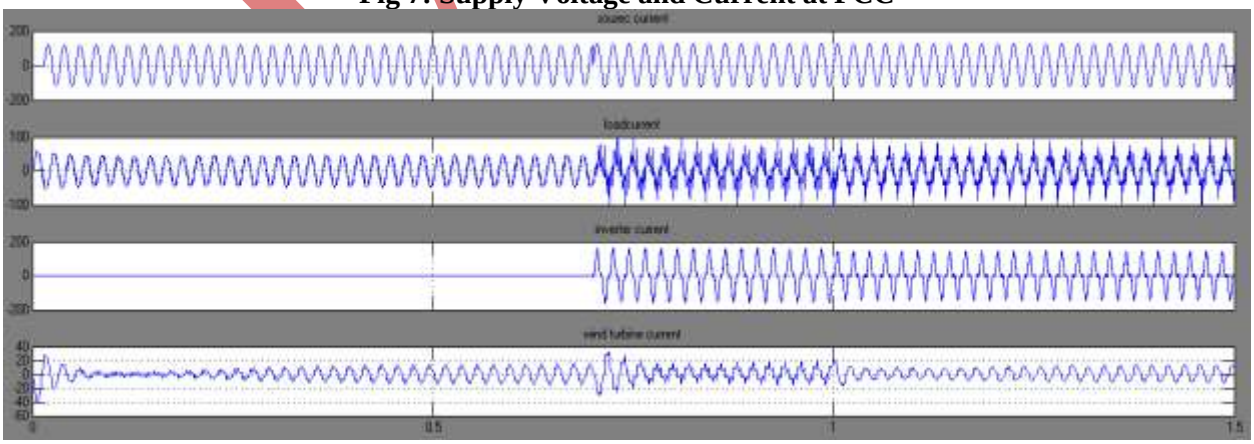



**Fig 8: simulation result (a) Source Current. (b) Load Current. (c) Inverter Injected Current. (d) Wind generator (Induction generator) current.**

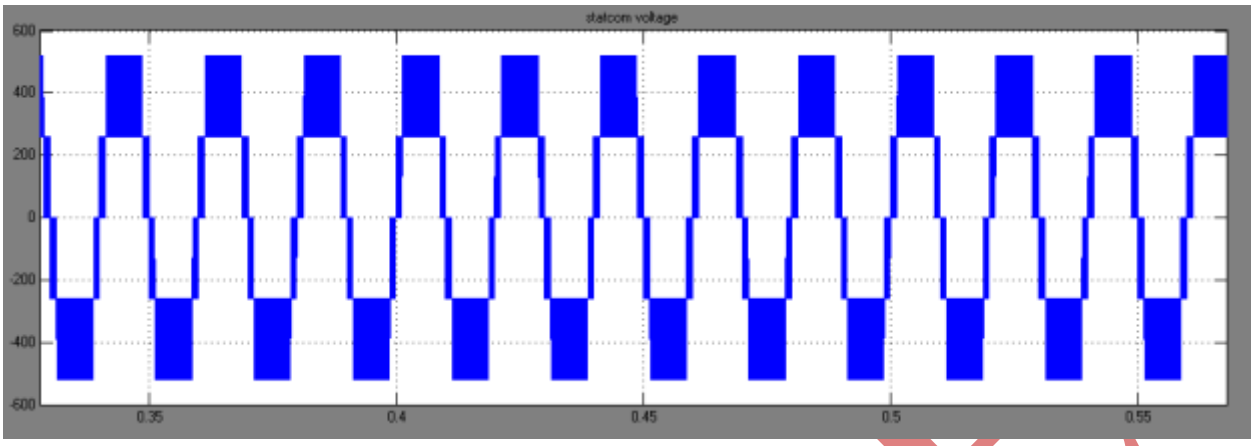



**Fig 9: STATCOM Voltage**

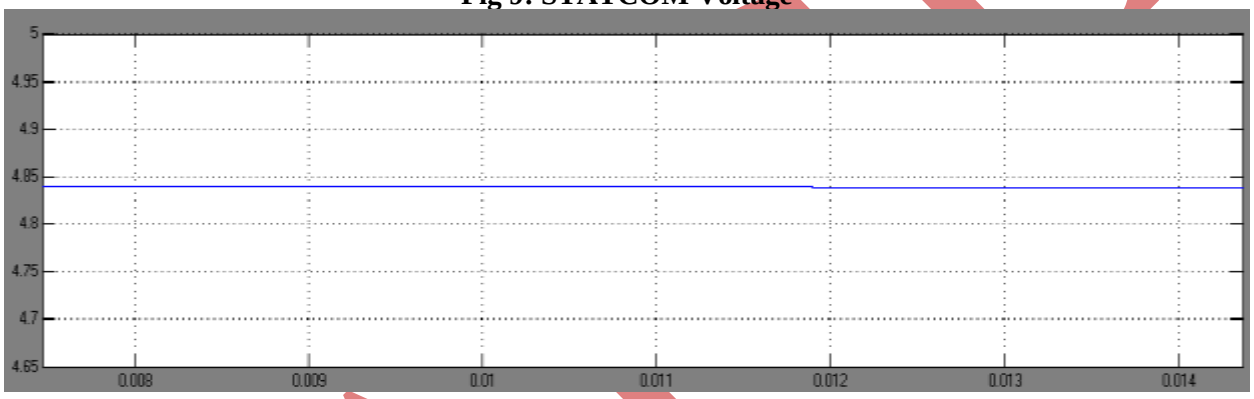



**Fig 10: PV Voltage**

## VII CONCLUSION

The paper presents the STATCOMbased control scheme forpower quality improvement in grid connected wind generatingsystem along with PV Cell and with non-linear load. The power quality issues andits consequences on the consumer and electric utility are presented.The operation of the control system developed for theSTATCOM-PV in MATLAB/SIMULINK for maintainingthe power quality is simulated. It has a capability to cancel outthe harmonic parts of the load current. It maintains the sourcevoltage and current in-phase and support the reactive powerdemand for the wind generator and load at PCC in the gridsystem, thus it gives an opportunity to enhance the utilizationfactor of transmission line. The integrated wind generationand STATCOM with PV have shown the outstanding performance.

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