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 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 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 STATCOMs generated from Solar Cells.

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

The Current controlled voltage source inverter based STATCOM controller 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 has a desired value. The injected current will cancel out the reactive part and harmonic part of the load and induction generator current, thus it improves the power factor and the power quality. To accomplish these goals, the grid voltages are sensed and are synchronized in generating the current command for the inverter. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC), as shown in Fig. 1. The grid connected system in Fig. 1, consists of wind energy generation system and battery energy storage system with STATCOM. 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 storage is connected with the interface of the induction generator and non-linear load at the PCC in the grid system. The STATCOM compensator output is varied according to the controlled strategy, so as to maintain the power quality norms in the grid system.

**II GRID SYNCHRONIZATION**

In three-phase balance system, the RMS voltage source amplitude is calculated at the sampling frequency from the source phase voltage (Vsa, Vsb, Vsc) and is expressed, as sample template Vsm, sampled peak voltage.
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 an electrical generator. The equation describes the mechanical power captured from wind by a wind turbine [4] can be formulated as:

\[ P_m = 0.5 \rho AC_p V^3 \]

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. \( \lambda \)” curve for a wind turbine. In practical designs, the maximum achievable ranges \( P \) from 0.4 to 0.5 for high speed turbines and 0.2 to 0.4 for slow speed turbines. Fig. 2 shows that has its maximum value \( (C_{p, \text{max}}) \) at \( \lambda_{\text{opt}} \). Which results in optimum efficiency and maximum power is captured from wind by the turbine.

![Fig 2: Power Coefficient Vs Tip Speed Ratio](image)

### IV SOLAR CELL

A solar cell is the most fundamental component of a photovoltaic (PV) system. The PV array is constructed by many series or parallel connected solar cells to obtain required current, voltage and high power [8]. Each Solar cell is similar to a diode with a p-n junction formed by semiconductor material. When the junction absorbs light, it can produce currents by the photovoltaic effect. The output power characteristic curves for the PV array at an insolation are shown in Fig. 3. It can be seen that a maximum power point exists on each output power characteristic curve. The Fig. 4 shows the (I-V) and (P-V) characteristics of the PV array at different solar intensities. The equivalent circuit of a solar cell is the current source in parallel with a diode of a forward bias. The output terminals of the circuit are connected to the load. The current equation of the solar cell is given by:
The power output of a solar cell is given by:

\[ P = V \times I \]

V CONTROL SCHEME

The control scheme approach is based on injecting the currents into the grid using “bang-bang controller.” The controller uses a hysteresis current controlled technique. Using such technique, the controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for STATCOM operation.

The control system scheme for generating the switching signals to the STATCOM is shown in Fig. 5.

VI SIMULATION DIAGRAM AND RESULTS

The proposed control scheme is simulated using SIMULINK in power system block set. The main block diagram of the system operational 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.
VII CONCLUSION

The paper presents the STATCOM-based control scheme for power quality improvement in grid-connected wind generating system along with PV Cell and with non-linear load. The power quality issues and its consequences on the consumer and electric utility are presented. The operation of the control system developed for the STATCOM-PV in MATLAB/SIMULINK for maintaining the power quality is simulated. It has a capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in-phase and supports the reactive power demand for the wind generator and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. The integrated wind generation and STATCOM with PV have shown the outstanding performance.

REFERENCE


