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STATCOM based Control Scheme for Power Quality Improvement in Grid-Connected wind Energy System with Non-Linear Load

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Abstract: Generally, the non-conventional energy sources are being extensively used in case of power electronic converter based distribution systems. This paper mainly focuses on the wind energy system integrating with grid connected system and also improvement of power quality features. The wind energy power plant is modelled based on associated equations. For improving this power quality problems, this paper proposes the concepts of shunt converter controllers. This paper also proposes the concepts of PQ-theory based Static Compensator. And also the results are compared for this cases. Thus with such a control, a balanced load currents are obtained even in the presence of non-linear load. The experimental setup is done in Matlab and verified the simulation results.

***Index Terms—SVC, distributed generated system (DG), distribution system, and renewable energy*.**

1 .INTRODUCTION

Generally, with increase in the power demand due to increase in population, utilization, the Generation of power was really a challenge now a day. Due to high utilization of non-conventional energy sources [1] as a one of the distribution energy source, may causes the stability problems such as voltage regulation and other power quality problems. Therefore, the power electronic based forced commutated converters are preferred in distribution system for maintaining the system stability, reliable performance and efficient work and also improving the quality of power at coupling junction point.

The current distortions in non-linear load may result same distortions in the system voltages and in some cases also shows the serious effect on power system. Generally, the problems in power system are more complicated and also have difficult to identify the problem when we integrate the wind energy system with grid connection [2]. If this problems continuous, it's mainly causes the damage of system and also reduces the system efficiency. By controlling the system parameters such as magnitude of voltage, transmission impedance and load angle then we maintain the power flow.

The power flow controlling device is a device which is used for varying and controlling the system parameters [3].

A shunt device is a compensating device i.e. which is connected between the grid connected point called as PCC and the ground [4]. Shunt device either can absorb or generate the reactive power for controlling the magnitude of voltage at point of common coupling. The reactive power compensation is also one of the applications of shunt converter devices [5].

Figure 1 shows the basic diagram for the shunt connected inverter based grid connected system[6].

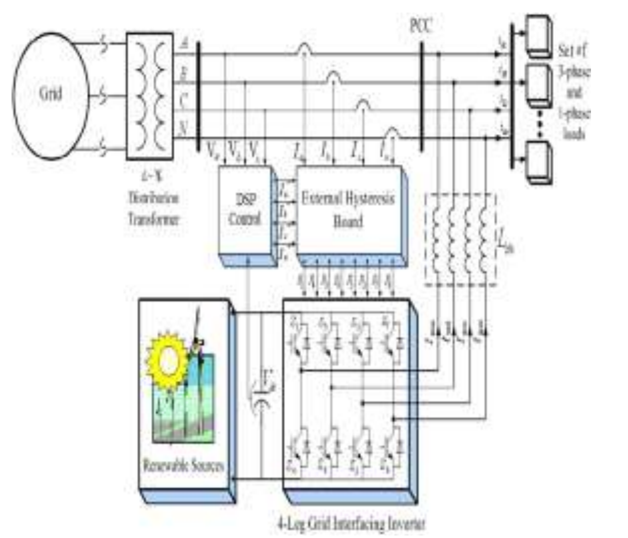

Fig 1: Diagram for Proposed System.

2. Grid Interconnection of Wind Energy System

Recently grid connected wind system have been spreading in residential areas and in industrial areas. So we have to find a suitable MPPT technique that gives a better power output when connected is to find out. For a grid connected system there are certain factors that have been considered such that DC-AC conversion with highest output power quality with the proper design of filters System main controlling factors like MPPT. Grid interface inverters which transfers the energy from the wind energy generation system to the grid by maintaining constant of dc link voltage. For a grid connected system the utility network mainly demands for better power quality and power output. In the case of voltage fluctuations control of grid parameters is very difficult. So for a wind system that is connected to a grid first stage is the boosting stage and the second stage is DC-AC converter [7]. An output filter is usually employed which reduces the ripple components due to switching problems. The problem associated with the grid connected system is that the dc link voltage that must be oscillates between the two levels which depends on the operating climatic conditions (ambient temperature & irradiance) in which inverter which acts us a power controller between the dc link and the utility. Dc link is generally used to isolate between the grid side and the inverter side so that we can control both wind system and grid separately. All the available power that can be extracted from the wind system is transferred through the grid [8]-[9].

2.1 Wind Energy System:

The generation of electrical power is obtained mainly in two ways i.e one is conventional source and other is non- conventional energy sources. The generation of electricity using non-renewable resources such as coal, natural gas, oil and so on, shows great impact on the environment by production of pollution from their general gases. Hence, by considering all these conditions the generation of electricity is obtained from the renewable energy sources.

Basically, out of all renewable energy sources the wind turbine plays an important role for generating electricity. And also from economical point of view the wind turbine has low maintainece cost because it needs no fuel so that it is pollution free. Mostly, in present world 50-60 percent [13] of energy is generated from wind turbine as compared with all other renewable energy sources.

The wind turbine converters wind energy to electrical energy and the generator mechanical shaft power is obtained by the following expression:

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

The typical layout of wind power generation as shown below.

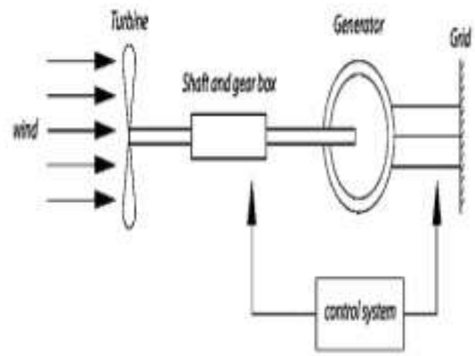

Fig.2 basic schematic diagram of wind turbine

And the coefficient of power also plays a key role for wind system and the basic minimum value of power coefficient is 0.5. The power coefficient is obtained by the ratio of tip speed ratio to pitch angle. The pitch angle is the angle to which the blades of turbine is arranged based on their longitude axis and changing of wind direction. The tip speed ration is defined as ratio of linear speed of the rotor to the wind speed.

Fig.3 shows a typical waveform for coefficient of power with respect to the tip speed ratio. The maximum achievable range of TSR is from 0.4 to 0.5 for turbine with high speed and from 0.2 t0 0.4 for turbine with low speed [14].

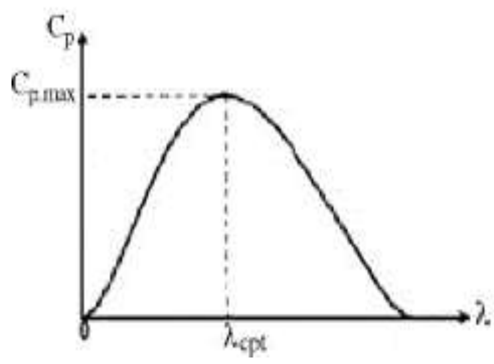

Fig 3: Power coefficient Vs Tip Speed Ratio

3. STATCOM and Its Control Technique:

A STATCOM is built with Thyristors with turn-off capability like GTO or today IGCT or with more and more IGBTs.A STATCOM based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial photo voltaic system. The proposed Solar based STATCOM control scheme for grid connected photo voltaic 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.

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

A STATCOM is a controlled reactive-power source. The STATCOM is connected to the power system at a PCC (point of common coupling), through a step-up coupling transformer, where the voltage-quality problem is a concern [10]. It provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external reactors or capacitor banks. Using the controller, the VSC and the coupling transformer, the STATCOM operation is illustrated in Figure 4.

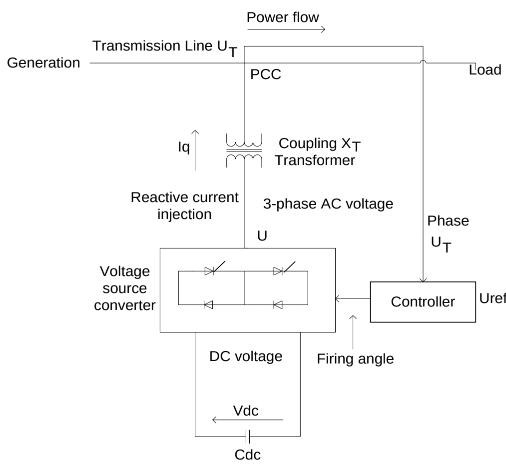

Figure 4: Basic Block Diagram for Static Compensator

The utilization of different types of electrical loads in three phase system, produces an unbalances in current, which causes the unreliable power. Thereby for maintaining the electrical reliability the statcom controller plays a key role. In this statcom control technique, the reference voltage and dc link capacitor voltages are compared and the result obtained from this is converted to two phase coordinators called as orthogonal vectors.

The STATCOM acts either as a source or a sink of reactive power. It provides voltage support by injecting or by absorbing reactive power at the point of common coupling without any large external reactors or capacitor banks. Here we use a PID controller with STATCOM for damping enhancement. The PID controller is designed using the Model Control Theory. The mathematical modelling of the controller is given in [10]. The control scheme used here is shown in the Figure 5.

Vsm={2/3(V2sa+V2sb+V2sc)1/2}……………..(a)

The in-phase unit vectors are obtained from AC source phase voltage and the RMS value of unit vector Usa, Usb, Usc as shown in (b)

$$Usa = \frac{Vsa}{Vsm} Usb = \frac{Vsb}{Vsm} Usc = \frac{Vsc}{Vsm}$$……….(b)

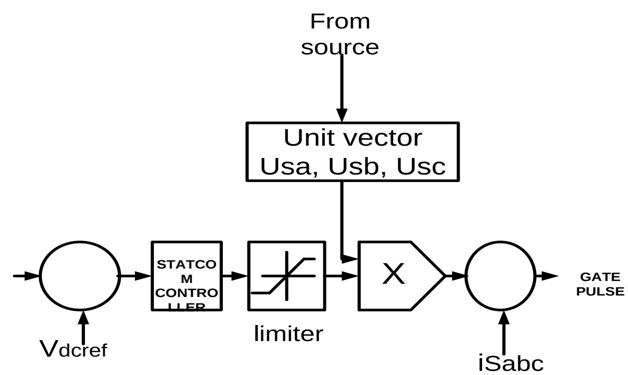

Figure 5: Control Diagram

4. SIMULATION STUDY:

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 Figure. 1. The simulation diagram of the proposed PV cell based grid interfaced system using Statcom is as shown in figure 6.

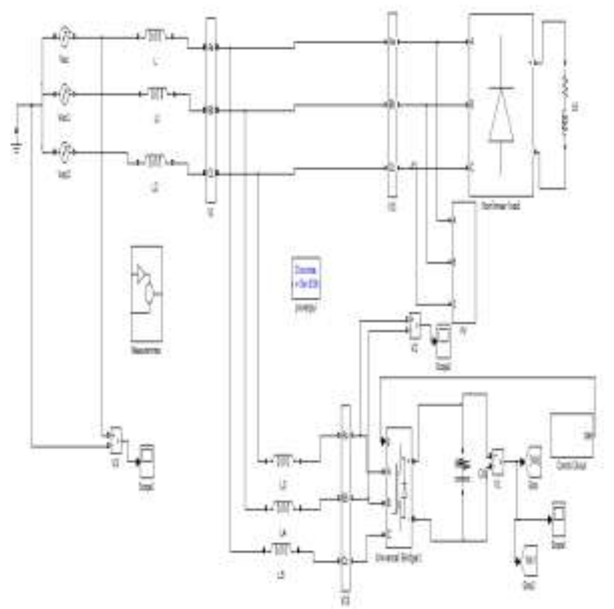

Figure 6: Simulation Diagram of Proposed Grid Connected System

In figure 7 the wave form (a) shows the output for source current after compensation, (b) waveform for load current, (c) waveform for the injected current by the Statcom converter and finally the waveform (d) shows the result for current from wind turbine. Figure 8 shows the total harmonic distortion of proposed system with Statcom controller

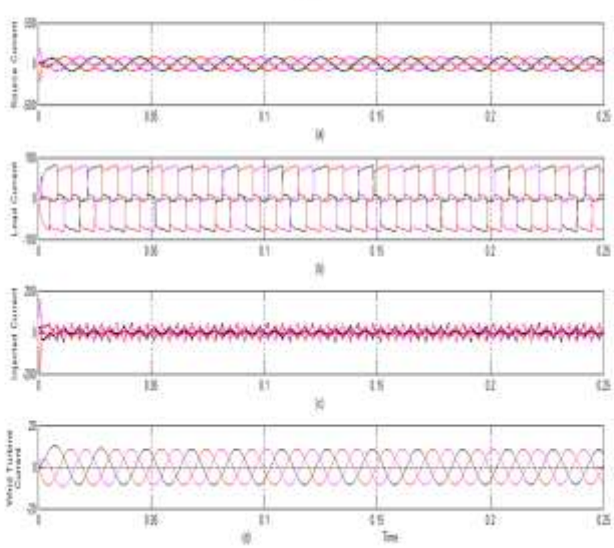

Figure 7: simulation result for current.

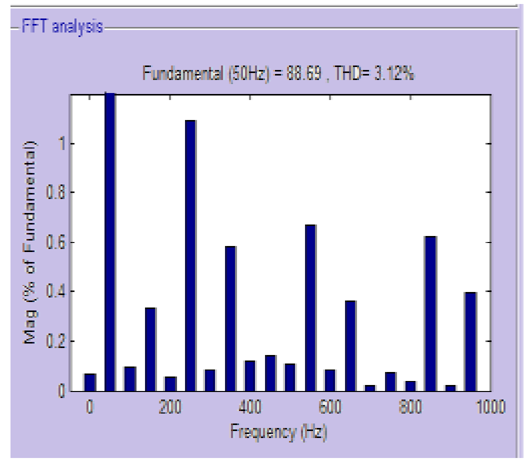

Figure 8: FFT analysis for Source current.

CONCLUSION

The paper presents the STATCOM based control scheme for power quality improvement in grid connected wind energy system linked 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 support the reactive power demand for the solar panel and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. The integrated grid and STATCOM with PV have shown the outstanding performance.

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