Proc. of Int. Conf. on Computer Electronics Electrical Mechanical and Civil

Power Quality Improvement of Grid Connected Photovolatic System using Statcom Controler

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***Abstract*—The main aim of this paper is to enhance the power quality of grid interconnected system with photovoltaic cell under some unbalanced conditions with non-linear load. The photovoltaic system plays a key role in the present scenario as compared with other Renewable energy systems. And STATCOM controller one of the device in FACTS family is proposed in this paper for improving the power quality in a grid interfaced solar system. The STATCOM control technique is designed using model control theory to contribute the effective damping characteristics. The system performance is verified under two cases i.e. with statcom and without statcom controller. These experimental setup is simulated using Matlab/Simulink.**

***Index Terms*— Photovoltaic cell, Statcom Controller, Power Quality.**

I. INTRODUCTION

With increase in quality and quantity of loads, as a result of increase in population, power system operation is subjected to a number of challenges. The high utilization of non-conventional energy source, as one of the resource for distribution of energy, given rise to problems like low-frequency oscillations, poor voltage regulation and other related power quality problems. Therefore, the power electronic based forced commutated converters are preferred in distribution systems for maintainece of system stability, reliability and quality of power as the point of common coupling [1].

With expansion in the interest for Electricity because of expansion in populace and industrialization, the Generation of power was truly a test now a day. In the event that we need to expand the power produced in the customary path i.e., by method for non-renewable vitality sources like coal, diesel, normal gasses and comparative fossil energizes, the contamination builds which debases the Environment and human way of life [2]. The frequent occurrence of power quality problems in a system is mainly voltage and current variations and these problems occurs due to usage of non-linear loads. In case of grid interfaced photovoltaic system it is difficult to identify these power quality problems. If these PQ problems occurs continuously in a system causes loss of production, damage of equipment. Therefore, the power electronic based forced commutated converters are preferred in distribution systems for maintainece of system stability, reliability and quality of power as the point of common coupling.

A shunt device is a compensating device i.e. which is connected between the grid connected point called as PCC and the ground. Shunt device either can absorb or generate the reactive power for controlling the magnitude of voltage at point of common coupling. STATCOM can be effectively utilized to improve power

Grenze ID: 02.CEMC.2015.1.16

quality of the system. Figure 1 shows the schematic construction of the proposed grid interfaced system. The main parts present in this grid interfaced system are Renewable Energy System, Statcom Controller, Hysteresis Controller and three phase Non-Linear loads. This paper proposes a concept of photovoltaic system based renewable energy system. Maximum power point tracker is a high efficiency Dc to Dc converter that presents an optimal electrical load to solar panel or array produces a voltage suitable for the load.

The paper is arranged as follows: chapter I describes the importance of grid interfaced system and its main components. Extensive experimental setup and its results are discussed in Section II and finally, Section III concludes the paper.

A. Grid Interconnection of Photo Voltaic System

Recently grid connected photovoltaic 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 photovoltaic module to the grid by just keeping the dc link voltage which is to be maintained constant. 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 PV system that is connected to a grid first stage is the boosting stage and the second stage is DC-AC converter. 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 PV system and grid separately.

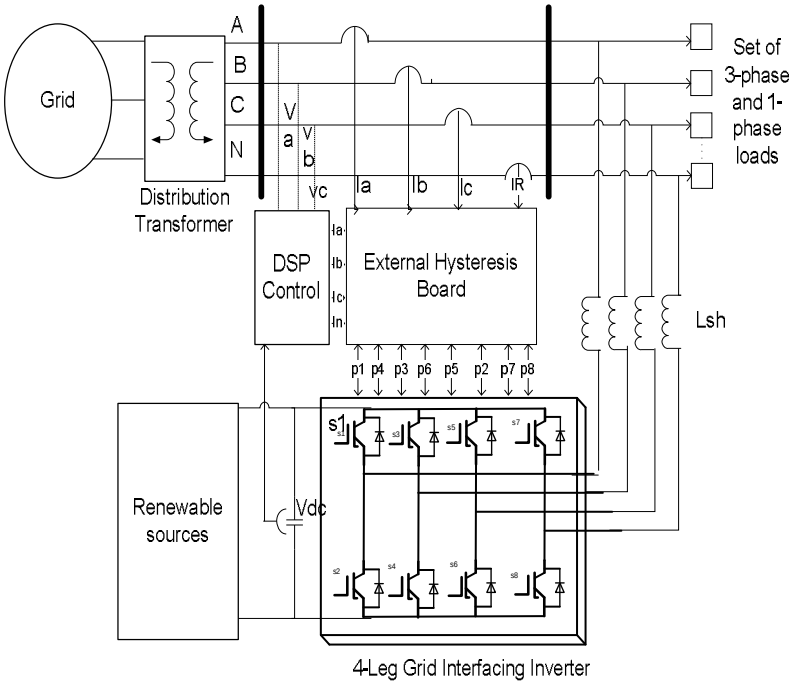

Figure 1. Schematic diagram of the proposed grid connected photovoltaic system

B. Solar Panel

Solar cell is a p-n junction fabricated semiconductor. The radiation from the sun is directly converted into electrical power (or) energy by using photovoltaic effect. The Solar Cell model is shown in Figure-2.

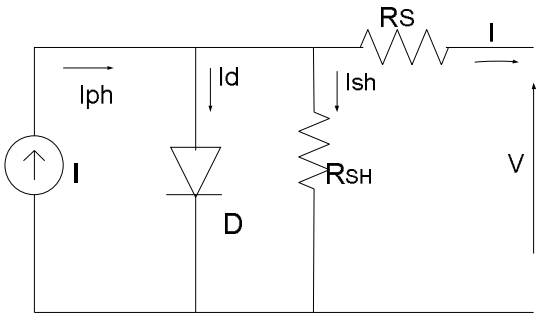

Figure 2. Basic Solar Cell Model

By exposing to the solar radiation on the photons the energy greater than the band-gap energy of the semiconductor are absorbed and some electron holes appear which are proportional to the radiation utilized. Under the influence of the internal electric fields, these carriers are move apart and created a photo current which is directly equal to solar isolation.

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The V-I equation of solar cell is

$$I= [IPH – IS [exp\ q(v + IRs) / kTCA – 1] – [(V+IRs)/RSH]] \quad (1)$$

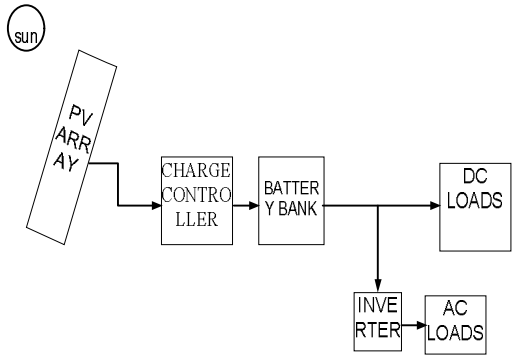

Figure 3. Schematic Diagram for PV System

Stand alone and grid connected are types of main system configurations. The standalone PV system operates normally and supplies power to a given load. During the night time and failure of sunlight these system supply power to the load by a storage units like battery banks. These types of systems are also called autonomous systems due to their independent supply.

C. Maximum Power Point Tracking Technique:

The output of PV varies with respect to the weather condition which means solar radiation and temperature. So to make the PV output constant different techniques are available. In that perturb & observe (P and O) algorithm is mostly used. The P&O algorithm is implemented easily and it is shown in Figure-6.

The P and O algorithm produce a constant power at all period without considering weather conditions and variety of PV array. The operation of this P and O maximum power point tracking technique is explained with the help of flowchart as shown in figure 4. It calculates periodically by changing the array output voltage and calculating the PV obtained output with that of the previous perturbation (calculated) value. If the value is ascending the perturbation will continue in the next cycle, otherwise the (perturbation) calculation of value will continue in reverse direction. This means that the array terminal voltage is perturbed every MPPT cycle. When P&O is reached it will oscillate around it.

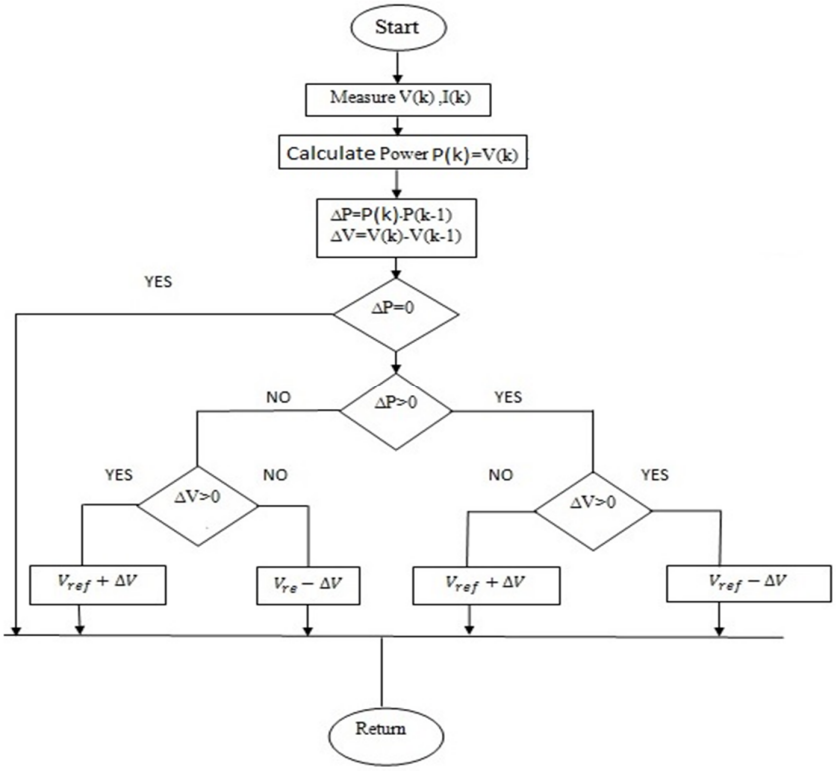

Figure 4. MPPT processing technique

II. STATCOM CONTROLLER

A STATCOM is a one of the compensated device which is obtained from the FACTS family and is a combination of power electronic converter along with reactor. Mostly, the converter is constructed by the use of fully controlled devices such as GTO, IGBT or MOSFET. The main purpose of this STATCOM converter control technique is used to compensate the deviations in power system for improving power quality. In this paper grid interfaced wind turbine based STATCOM control scheme is proposed for improving the reliability of electrical power.

The Dc voltage obtained for STATCOM is generated from Solar Cells. The schematic diagram of Static compensator is given in figure 5. 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.

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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. The control scheme used here is shown in the Figure 6.

$$V_{sm} = \{2/3(V^2_{sa}+V^2_{sb}+V^2_{sc})^{1/2}\} \quad (2)$$

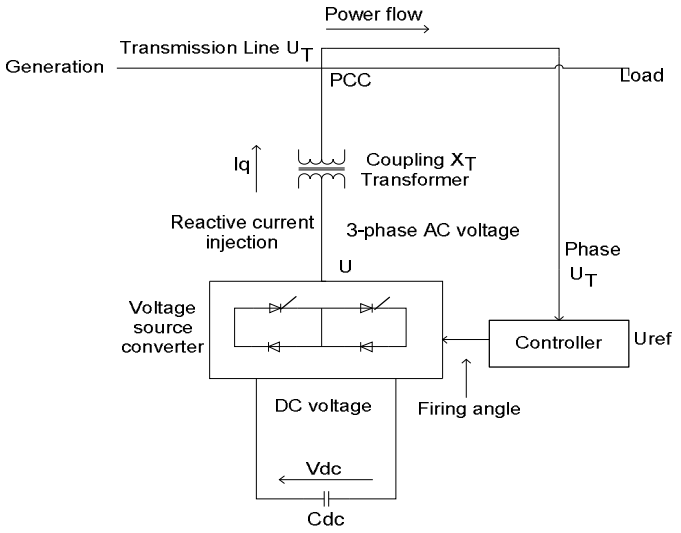

Figure 5. Block Diagram for Static Compensator

The in-phase unit vectors are obtained from AC source phase voltage and the RMS value of unit vector U_{sa}, U_{sb}, U_{sc} as shown in Eqn. 3;

$$U_{sa} = \frac{V_{sa}}{V_{sm}} U_{sb} = \frac{V_{sb}}{V_{sm}} U_{sc} = \frac{V_{sc}}{V_{sm}} \tag{3}$$

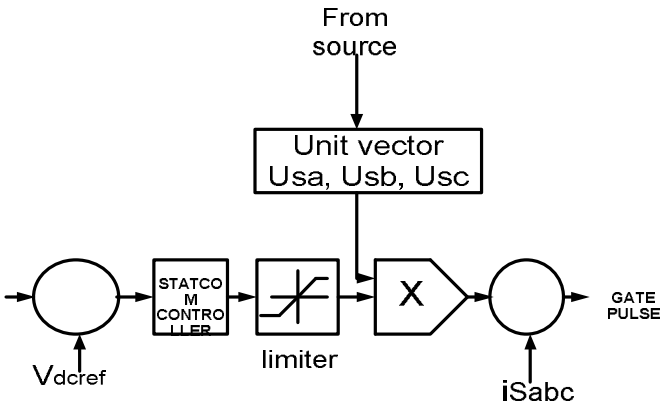

Figure 6. Control Diagram

III. 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 7.

In figure 8 the wave form (a) shows the output for source current after compensation, (b) waveform for load current, (c) waveform for the injected current without converter and finally the waveform (d) shows the result for current from wind turbine. Figure 9 shows its total harmonic distortion waveform.

In figure 10 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 11 shows the total harmonic distortion of proposed system with Statcom controller.

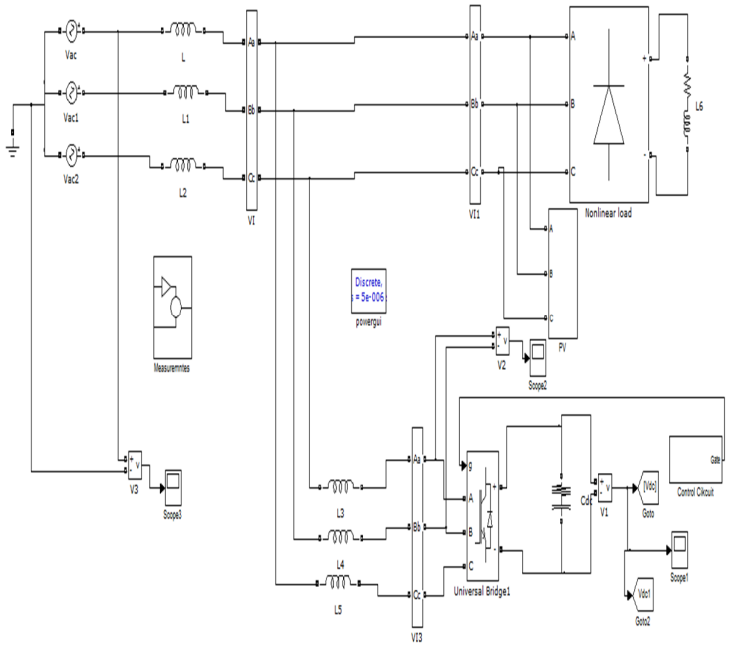

Figure 7. Simulation Diagram of Proposed Grid Connected System

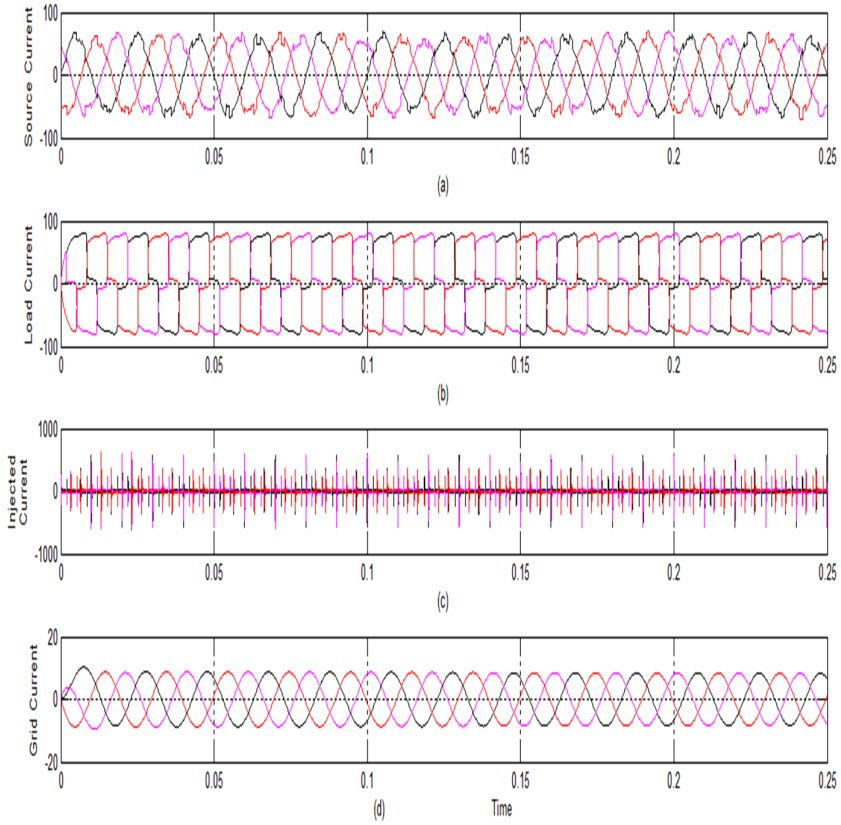

Figure 8: Results for Wind Energy System without STATCOM

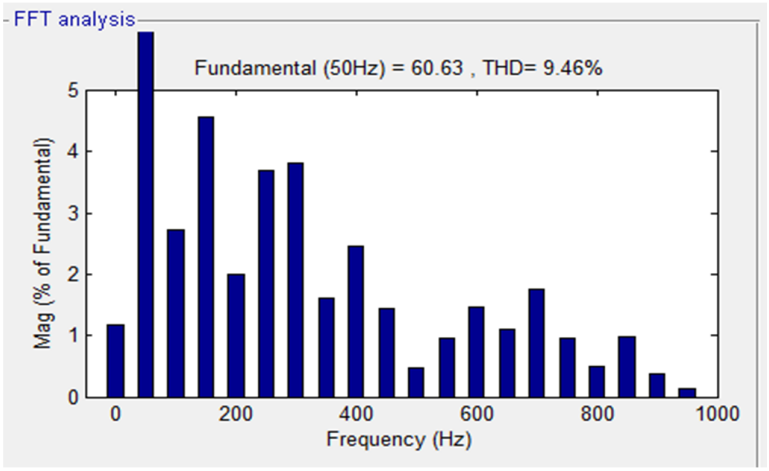

Figure 9. FFT analysis for Source current

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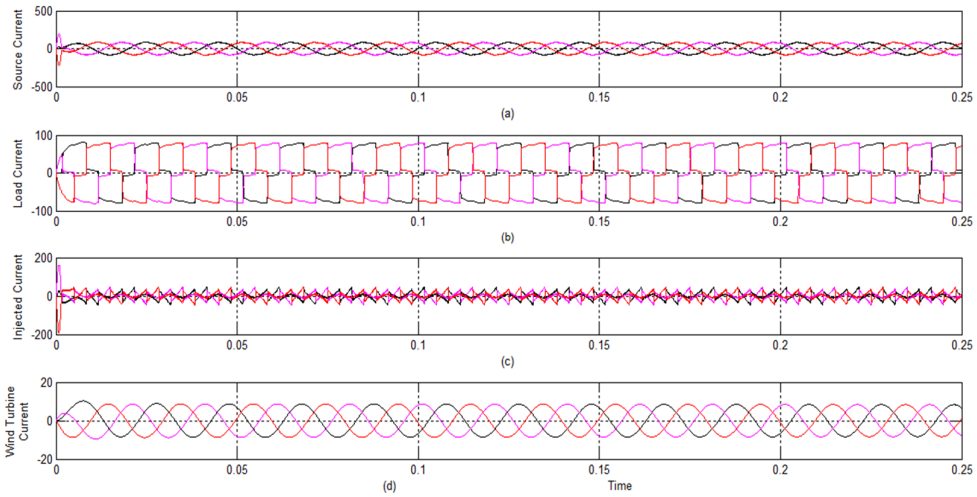

Figure 10. simulation result for current

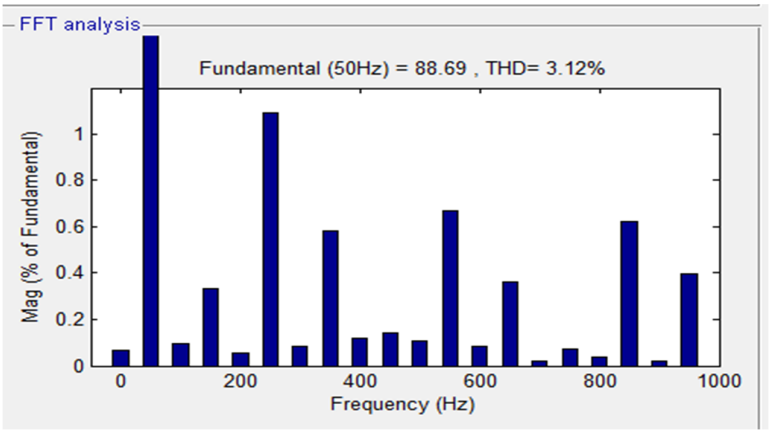

Figure 11. FFT analysis for Source current

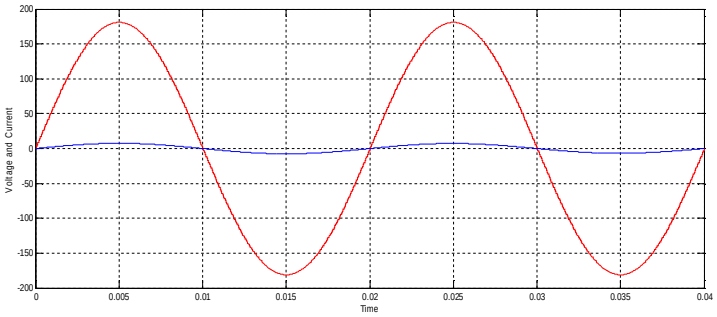

Figure 12. Simulation Result for Utility Grid Voltage and Current for UPF

Figure 12 shows the simulation result of utility grid voltage and current waveforms shows unity power factor conditions.

IV. CONCLUSION

The paper presents a novel concept of integration of STATCOM with grid inter faced wind energy system for power quality improvement. The shunt devices proposed in this paper, mainly concentrate on reduction of harmonics in currents, and improvement of power factor by the reduction of reactive power demand from the PV system and the load at point of common coupling. Thus, the integration of FACTS devices maintains the desired power quality requirements. The operation of STATCOM and its control strategies are experimentally verified using MATLAB/SIMULINK. From this results we conclude that the STATCOM provides better harmonic compensation as compared with other custom power devices.

REFERENCE

[1] Wang F, Duarte J L, and Hendrix M A M; (2010), "*Pliant active and reactive power control for grid-interactive converters under unbalanced voltage dips"*, IEEE Transactions on Power Electronics, **(26);** (2011), "*Grid-Interfacing Converter Systems with Enhanced Voltage Quality for Microgrid Application Concept and Implementation"*, IEEE, **26**.

[2] Huang A Q, Baran M, Bhattacharya S, 2008, "*STATCOM importance on the integration of a PV into a weak loop power system"*, IEEE Transcations Energy Conversion, **(23 (1)**, 226–232; 2008, "*STATCOM impact study on the integration of a large wind farm into a weak loop power system*, IEEE Transcations Energy Conversion", (23 (1), 226–232.

[3] Qing-Chang Zhong, Senior Member, 2013, "*Cascaded Current–Voltage Control to Improve the Power Quality for a Grid-Connected Inverter With a Local Load"*, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, (**60**), (**4**).

[4] Oliveria, S.E.M., 1994. "*Synchronizing and damping torque coefficients and power system steady state stability as affected by static var compensators*", IEEE Transactions on Power Systems, 9(1): 109-116.

[5] Manel J, 2006, "*Power electronic system for grid integration of renewable energy source: A survey*" IEEE Transcations Industrial Electronics, (**53**), (**4**), 1002–1014.

[6] Tsili M and Papathanassiou S, 2009, "*A review of grid code technology requirements for wind turbine*" Proceeding IET Renewable power generation, (**3**), 308–332.

[7] Hamad, A.E., 1986. "Analysis of Power System Stability Enhancement by Static VAR Compensators", IEEE Transactions on Power Systems, 1(4): 222-227.

[8] Gutierrez J J, Ruiz J, Leturiondo L, and Lazkano A, 2009, "*Flicker measurement system for wind turbine certification*" IEEE Transcations Instrumentation Measurements, (58), (2), 375–382.