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Performance of the PV/Wind Hybrid System using STATCOM Connected with Power Grid

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ABSTRACT: Whenever photo voltaic and wind power production are used together, the reliability of the power grid is enhanced. But this combined hybrid system needs Controlling and Compensation, to overcome this problem, we use Static Synchronous Compensator (STATCOM) to stabilize the power supply at the grid side after many disturbances viz Voltage Sag, load changes, Distortion etc. The main advantage of STATCOM is that it has the capability to absorb or inject reactive power at faster rate. STATCOM has the ability to control the voltage dip if drastic disruption occurs. On the other hand, depending on the velocity of the wind available, wind turbine rotates and energizes an asynchronous generator for power supply to the grid. These two hybrid sources are connected together to synchronize power supply to the Grid. This thesis investigates the use of a Static Synchronous Compensator (STATCOM) along with wind farms and solar for the purpose of stabilizing the grid voltage using MATLAB/Simulink.

KEYWORDS: STATCOM, Reactive Power, Wind Turbines, PV Array, MATLAB.

I. INTRODUCTION

Renewable energy sources are not destroyed when their energy is exploited. The use of renewable energy sources requires technologies that exploit natural phenomena, such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological hydrogen production and geothermal heat. Among the above mentioned sources of energy, wind has played a vital role in the exploiting of energy. The motion of air masses produced by the irregular heating of the earth's surface by sun is called wind. Wind energy varies continuously and provides energy in sudden fragments and is not a constant source of energy [1]. In this paper, Permanent Magnet Synchronous Generator is being used because of having better performance due to higher efficiency. STATCOM is a regulating device used in the alternating current transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. It can also provide active AC power if we connect it to a source of power. It also supports if there is poor power factor and often poor voltage regulation [2]. STATCOM has many advantages which includes wind energy voltage stabilization, and harmonic filtering. In this paper, Hybrid solar/wind generating system is modeled with STATCOM to stabilize grid power supply which is being simulated in the MATLAB/Simulink Software.

II. PHOTO VOLTAIC SYSTEMS

A photovoltaic (PV) system coverts light energy into electricity and the basic device of PV System is a Photo voltaic cell. These PV cells may be combined or grouped to form PV arrays or PV panels. The voltage and current available at the terminals of a PV device may directly feed small loads such as lighting systems and dc motors [3]. Photovoltaic cells are made of several types of semiconductors using different manufacturing processes. The incidence of light on the cell generates charge carriers that originate an electric current if the cell is short circuited. Depending upon the light intensity,

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the Photovoltaic Array produces direct current. With the help of inverter or universal bridge, the dc power is being converted into ac power having phase and frequency. The equivalent circuit of PV System is shown in Fig 1.

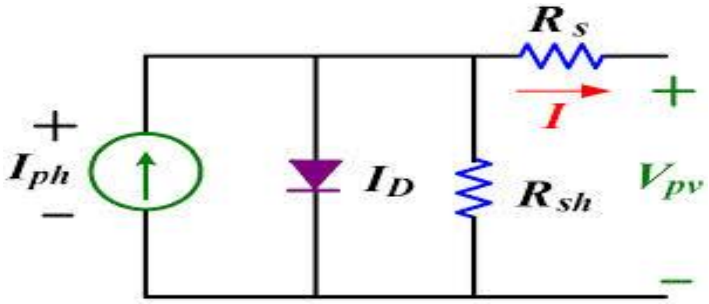

Figure 1: Equivalent circuit diagram of PV system with series and parallel Resistance

In this project, eight PV modules are used whose simulink diagram is shown in figure 2. Its electrical behavior and characteristics depends on temperature and illumination. The solar irradiance is 1000 W/m^2. The characteristic equation of PV module is given as

$$\mathbf{I = I_L - I_0 \, (e^{\,q(V + IRs)/nkT} - 1)}$$

Where
I_L = photo current, I_0 = diode saturation current, R_S = series resistance,
q = charge of electron, T = temperature, N = number of PV module.

The output power from PV system can be obtained from this equation,

$$\mathbf{Ppv\,(t) = Ins\,(t) * A*Eff(pv)}$$

Where
Ins (t) = insolation data at time t (kw/ m^2), A = area of single PV panel (m^2),
Eff(pv) = overall efficiency of the PV panels and dc/dc converters.

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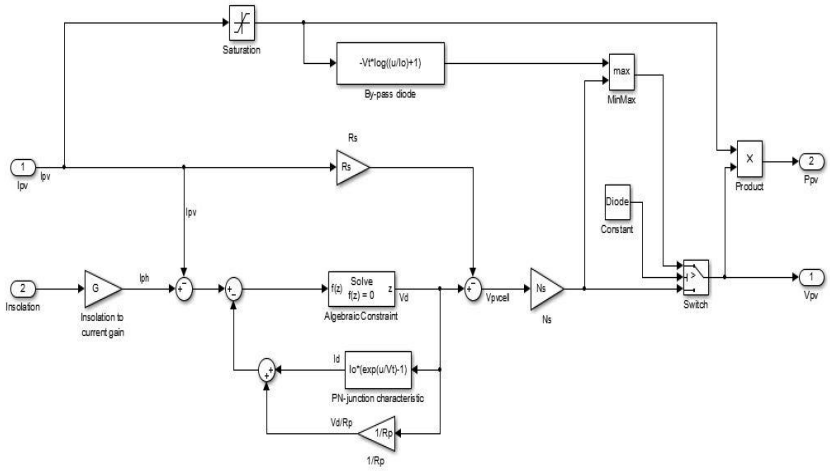
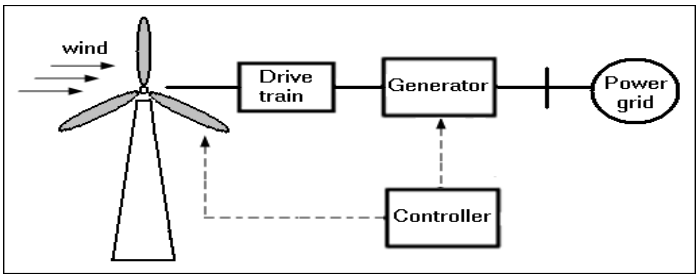


Figure 2: Simulink of Photovoltaic System

III. WIND ENERGY SYSTEM

A wind turbine captures the kinetic energy from rotor having many blades and converting into electrical energy. This process can be done using the energy from wind to run a windmill, which in turn drives a generator to produce electricity [4]. The windmill in this case is usually called a wind turbine. This turbine transforms the wind energy to mechanical energy, which in a generator is converted to electrical power. An integration of wind generator, wind turbine, aero generators is known as a wind energy conversion system [5]. Wind turbines can be divided into two basic types based on the axis about which the turbine rotates. Those turbines which rotate in horizontal axis are very common than vertical axis rotation. The components of wind energy system are shown in figure.

Figure 3:



Components of wind energy system

The output power equation of wind turbine is given by

$$P_m=C_p(\beta,\lambda)\ \rho A/\ 2(V_w)^3$$

Where Pm = Turbine mechanical output power C_p= Performance coefficient of turbine

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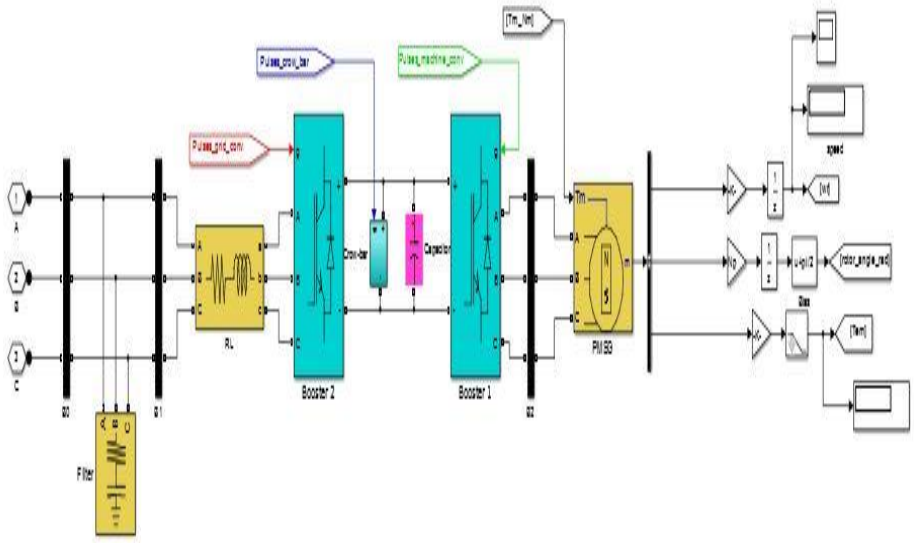
ρ= Air density (Kg/m^3), λ= speed ratio, A= swept area of turbine, β= blade pitch angle
V_w= wind speed (m/s)

For better performance and efficiency, Permanent Magnet Synchronous Generator is being used. The Simulink model of wind Turbine is shown in figure 4.

Figure 5: Simulink of wind energy system using PMSG



IV. STATCOM DESCRIPTION

The shunt connected reactive-power compensation device called STATCOM that is capable of generating or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. STATCOM has the ability to improve the steady state and transient stability systems. Static Var Compensator is considered as solid state switching converter because it has the capability of injecting or absorbing real and reactive power at its output terminals. It consists of Voltage source Inverter (VSI), DC Capacitor, Signal Generation, Coupling Transformer and Control Circuit. The STATCOM consists voltage source converter from a given input of dc voltage produces a set of three phase AC output voltages, each in phase with and coupled to the corresponding ac system voltage through leakage reactance [5]. The STATCOM will operate as capacitive mode if the output voltage will be greater than ac output voltage and Vice-Versa. The Simulink model of STATCOM is shown in figure 6.

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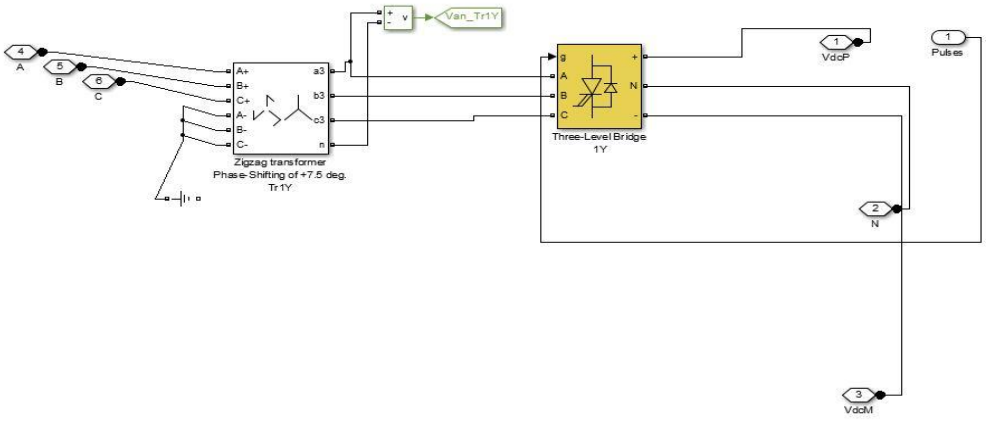

Figure 6: Simulink model of STATCOM 500KV, 1000MVA

The STATCOM is a 3-Phase voltage source inverter having the capacitance on its DC link and connected at the point of common coupling and then The STATCOM injects a compensating current of variable magnitude and frequency component at the bus of common coupling. The simulink model of STATCOM Controller is also shown in figure 7.

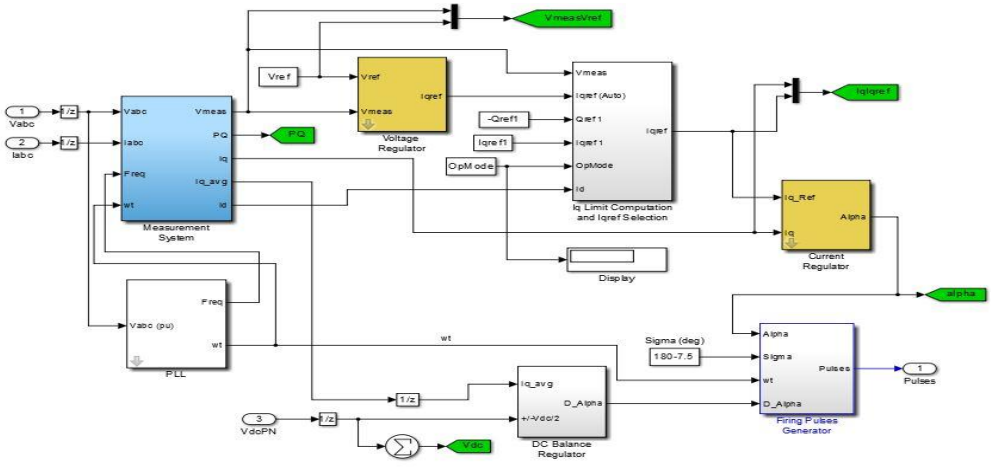

Figure 7: Simulink model of STATCOM Controller

Figure 8 shows the complete model of PV/Wind hybrid generating system connected with grid.

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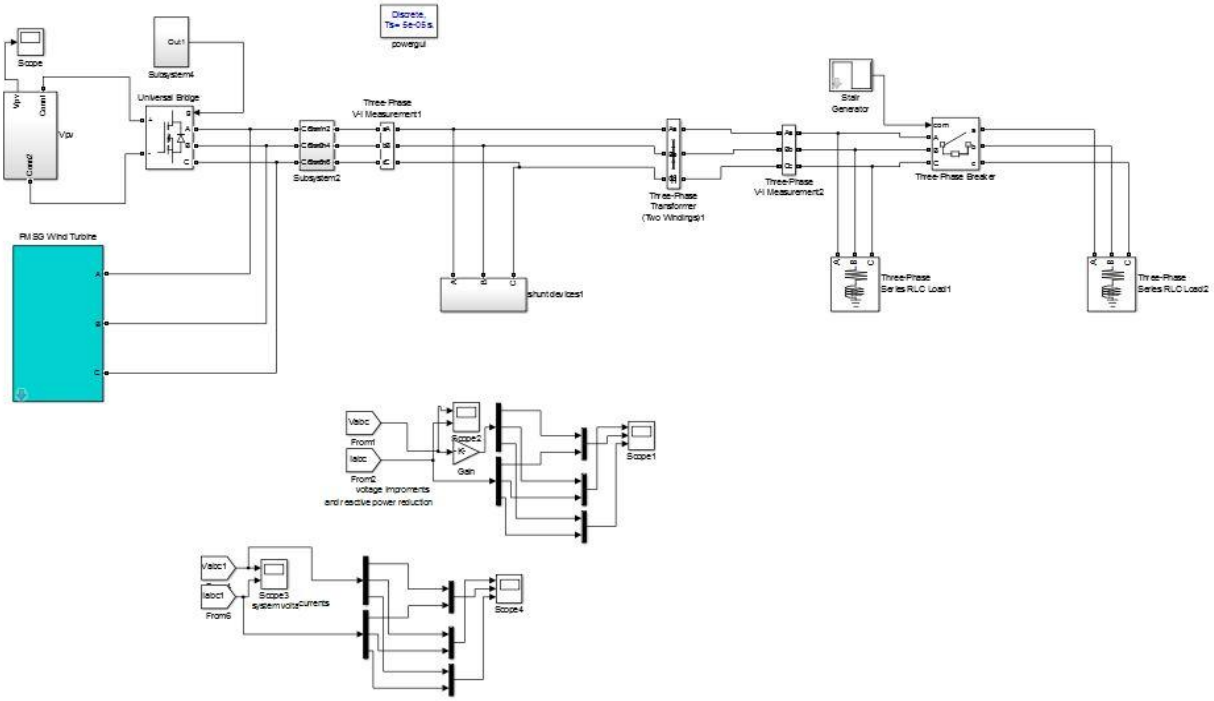

Figure 9: Simulink Model of PV/wind hybrid system connected with Grid.

V. SIMULATION AND RESULTS

The PV/Wind hybrid system with power grid connected has been implemented with statcom in the Simulink/Matlab as shown in figure. The PV system is connected with universal bridge which converts DC into AC supply. The PMSG used in the Wind energy system provides AC power supply. These combined power supplies are fed to power grid which is not stabilized and is contains harmonics. To overcome this problem, we use 100KV, 1000MVA STATCOM to stabilize and balance the power supply to the grid side. The various waveforms are shown below.

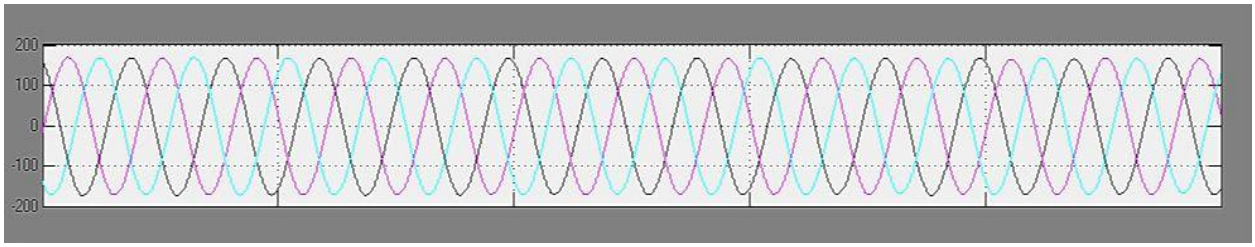

Figure 10: Voltage without using STATCOM

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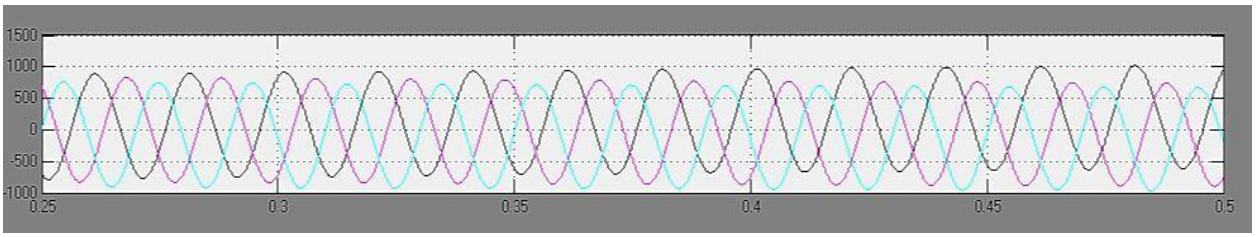

Figure 11: Current without using STATCOM

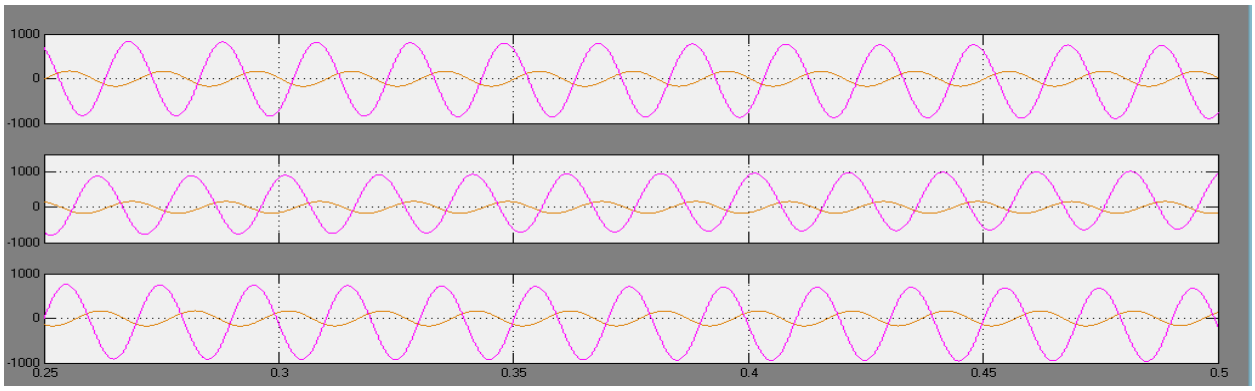

Figure 12: Due to poor power factor and low voltage regulation, the phase difference between voltage and current is large which results large amount of current will be drawn from load side.

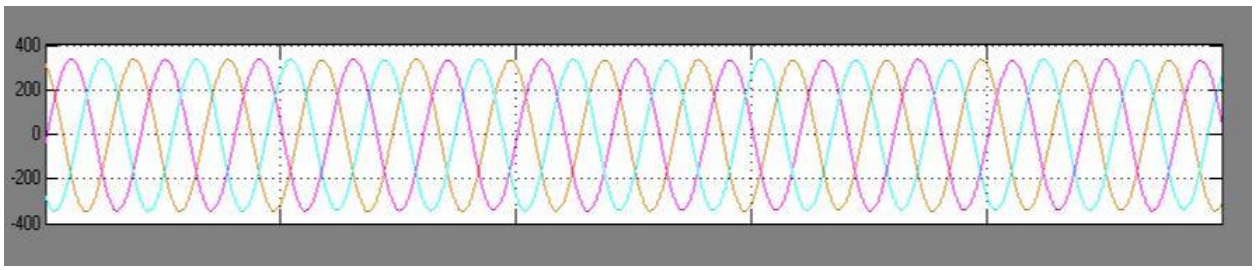

Figure 13: Voltage after using STATCOM

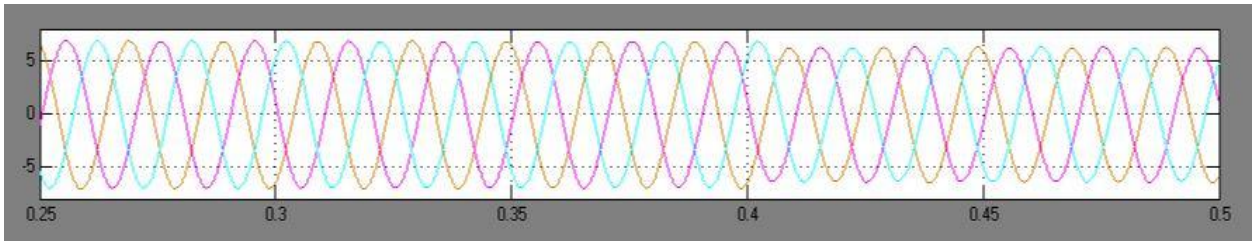

Figure 14: Current after using STATCOM

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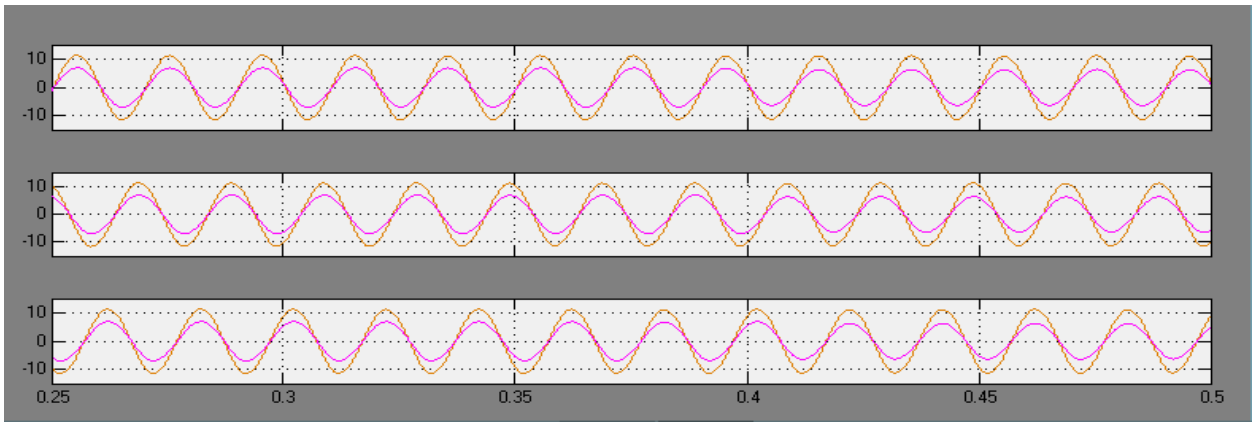

Figure 15: With STATCOM, the power factor is high, resulting the improved phase difference between voltage and current.

VI. CONCLUSION

The modeling of hybrid PV and wind for power system generation is done and analyzed with MATLAB/SIMULINK. The power quality is being improved using STATCOM. The reactive power is being maintained by STATCOM and controls the bus voltage as well. The un-stabilized and unbalanced power supply is being improved and enhanced with the help of STATCOM which is shown in various waveforms.

REFERENCES

1. Champa Nandi, A. K. Chakraborty, "Wind Power Plants with VSC Based STATCOM in PSCAD/EMTDC Environment''2012.
2. Beatriz Arenal Redondo, Javier Ibiricu,Ion Etxeberria-Otadui, UnaiViscarret, Izaskun Zamakona,"Improved STATCOM Operation Under Transient Disturbances for Wind Power Applications", 2007.
3. Krishnarayalu M S, Prasanthi N.L, Rajiv K. Varma,"Photovoltaic Solar Plant STATCOM During Dark Periods In A Distribution Network", IEEE Trans, vol.1, no. 9, November 2012.
4. E.E. Iheonu, F.O. A. Akingbade, M. Ocholi Wind Resources Variations over selected sites in the West African sub-region. Nigerian J. Renewable Energy, 10, 43-47(2002).
5. Francisco Diaz Gonzalez1, Marcela Martnez-Rojas (2011) "Strategies for Reactive Power Control in Wind Farms with STATCOM" IREC Catalonia Institute for Energy Research.
6. Pierre Giroux, Gilbert Sybille, Hoang Le-Huy "[1] pierre Giroux, Gilbert Sybille, Hoang Le-Huy "modeling and simulation of distribution STATCOM using Simulink power system blockset"IECON'01: the 27th annual conference of the IEEE industrial electronics society
7. G.sundar ,S.Ramareddy,"digital simulation of DSTATCOM for voltage"IECON'01: the 27th annual conference of the IEEE industrial electronics society.
8. Power Quality Improvement for Hybrid Wind, Solar and Diesel Generator Energy Systems, Using DStatcom, S.UmaMaheswari, G.Vijaya Gowri, IJAEEE, ISSN: 2319-1112 /V3N1: 36-46
9. Sandeep kaur, G S kochar, D S mahal, Sunita Goyal " power quality improvement using distributed static synchronous compensator" international conference on electrical power and energy system
10. Power Quality Improvement of Standalone Hybrid Solar-Wind Power Generation System using FACTS Devices, S.Angalaeswari, M.G.Thejeswar, R.Santhana Poongodi, W.Valeed Basha, .Sasikumar, IJAEEE,Vol. 3,Issue 3,March 2014.
11. A Statcom-Control Scheme for Grid Connected Hybrid Wind-Solar Energy System to Improve Power Quality Boopathi.R, Vijayakumar.G, INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY(IJESRT),Vol. 3(1) 1,January 2014.
12. Simulating Solar and Wind Based Hybrid Systems Synchronized and Segmented for Grid Connectivity, Md. Sifat Ferdous Chowdhury and Mohammad Abdul Mannan,IJMSE, Vol.5, No. 8, August 2014.
13. Simulation and Analysis of Wind Energy and Photo Voltaic Hybrid System, R. Valarmathi, S. Palaniswami, N. Devarajan, International Journal of Soft Computing and Engineering (IJSCE) ,ISSN: 2231-2307, Volume-2, Issue-2, May 2012.