STATCOM BASED IMPROVING GRID POWER QUALITY ON INTEGRATION OF WIND ENERGY SYSTEM

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ABSTRACT

Greening the energy sector aims at a renewable and property energy system. This method involves enhancements in energy potency, a far bigger offer of energy from renewable sources and rising power quality of generated energy from those sources. The alternative energy that has been expected to be a promising energy supply will bring new challenges once it's connected to the facility grid because of the fluctuation nature of the wind and therefore the relatively new forms of its generators. This unsteady power offer affects the most installation.
When the alternative energy is connected to an electrical grid affects the facility quality because of the non linear nature of wind energy. The installation of turbine with the grid causes power quality issues are determined by analyzing this paper methodology.
In this paper STATCOM is connected with grid at which wind turbine or solar system is connected. STATCOM is improve the power quality of the system by supplying reactive power or absorbing the reactive power during nonlinear nature of load and nonlinear nature of wind turbine. Excessive MATLAB simulation result shows the performance of the applied methodology.

Keyword: - *STATCOM, Wind energy, power quality.*

1. INTRODUCTION

Greening the energy sector aims at a renewable and property energy system. This method involves enhancements in energy potency, a far bigger offer of energy from renewable sources and rising power quality of generated energy from those sources.
India has nice potential to accelerate the employment of its invested renewable resources to power its growing economy with a secure and cheap energy offer. the govt. of Asian nation acknowledges that development of native, renewable resources is crucial to make sure that it's able to meet each its economic and environmental objectives, and it's promoted this development through policy action.
The quality of this electricity offer is obstructive India's economic process. problems like voltage fluctuation, frequency variation, spikes, black-outs, brown-outs, and different disruptions impact industrial, commercial, and residential customers. The addition of gridtied renewable power will facilitate address these problems. The gap between the demand of shoppers connected to the grid and also the offered electricity provide according by the Central Electricity Authority for 2009–2010 was virtually eighty four TWh, that is 100 percent of the entire demand. the height demand deficit was quite 15 GW, equivalent to a shortage of 16.7%. Closing this gap are essential for Asian nation to realize its growth targets, and renewable energy has the potential to enhance energy security and scale back dependence on foreign fuels and electricity whereas nisus to satisfy those goals.
As the wind generation is mechanical energy supply for space fulfill with appropriate wind speed additionally as reduction of carbonic acid gas emission, its penetration level in installation is extended to considerably employed in future [1]. The put in rated capability of wind generation reached upto forty 6,000 MW worldwide throughout 2004, and it expected to succeed in 2,00,000 MW by 2016.

India has been a pioneer within the business use of wind energy in Asia since the Nineteen Nineties. In 2009, Asian nation had the fifth largest put in wind capability globally, solely behind the u. s., China, Germany, and Spain. throughout that year, Asian nation further one,338 MW97 of wind capability for a complete put in capability of ten,925 MW. This described a 14 July annual rate and contributed three.5% to the worldwide wind market. The foremost recent information offered at the time of this writing show that India's wind capability destroyed 12,009 MW at the top of Gregorian calendar month 2010, that described seventieth of India's total renewable energy capability.99 India's sturdy domestic market has reworked the Indian wind business into a big international player. The success of the Indian wind market may be attributed to the standard of the wind resource and to government incentives, that became offered early because the international wind business began to grow. Indian company Suzlon is that the market-leader in wind generation in Asia and also the third largest manufacturer of wind turbines within the world. together with its German subsidiary RE power, Suzlon includes a world market share of 12.3% in put in new capability.

2. LITERATURE SURVEY

Table 1:- Literature review.

Sr.No.	Author & year	Methodology	Claim by author
1.	Kyung soo Kook, Yilu Liu & Stan ACTITTY 2006	The simulation model for the Energy Storage System (ESS) connected to the wind farm is implemented using the Power System Simulator	ESS improve the power stability of system.
2.	Yuvaraj Dr.S.N.Deepa & 2011	FACTS device STATCOM is connected at a point of common coupling with a battery energy storage system (BESS) to reduce the power quality problems. The battery energy storage system is integrated to support the real power source under fluctuating wind power	The feasibility and practicability of the approach for the applications considered.
3.	D.Shobha Rani, Md Asif & 2013	Performance of the system with BESS under load variations and Fault ride through capability of the svc light was analyzed.	It maintains the source voltage and current in-phase and support the reactive power demand for the wind generator and load at PCC in the grid system and it has fault ride through capability, thus it gives an opportunity to enhance the utilization factor of transmission line.
4.	M. Anbarasi, K. Pandia Rajan, K.Karthikeyan & 2015	It is made to predict the reactive power burden of the wind farm based on conventional fixed speed induction generator during wind variation and fault condition.	The proposed system is efficient way mitigate the reactive power in transmission line.
5.	D. Vinothini, S. Rathinamala & 2015	This method improves the power quality of grid using STATCOM for solar power system.	This technique maintains the source voltage and current in phase and support the reactive power demand for the load.
6.	A.Srinivasa Rao, B.Kanaka Rao & 2015	This method introduce cascaded two-level inverter-based multilevel STATCOM for high-power applications.	The effectiveness of the proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator.
7.	Arindam	In this article various technology reviewed for	This was only review of different

	Chakrabortty, Shravana K. Musunuri & 2012	improve the power quality of power system when wind turbine synchronized.	technologies.

3. IMPROVING GRID POWER QUALITY ON INTEGRATION OF WIND ENERGY SYSTEM

This [1] system illustrates a possible solution to mitigate these integration issues of the wind power by application of the energy storage to the wind farm in power systems focusing on its short-duration perspective. The simulation model for the Energy Storage System (ESS) connected to the wind farm is implemented using the Power System Simulator for Engineering(PSS/E) which is one of the most widely used program for the power system analysis in US. Employing a sample power system, the control effect of the ESS for mitigating the wind generation related power quality issues by suppressing the power flow fluctuation of the wind farm, and improving power system stability is validated.

The system [2] clearly shows the existence of power quality problem due to installation of wind turbines with the grid. In this proposed scheme a FACTS device {STATIC COMPENSATOR (STATCOM)} is connected at a point of common coupling with a battery energy storage system (BESS) to reduce the power quality problems. The battery energy storage system is integrated to support the real power source under fluctuating wind power.

This system present the FACTS device (STATCOM) -based control scheme for power quality improvement in grid connected wind generating system and with nonlinear load. The power quality issues and its consequences on the consumer and electric utility are presented. The integrated wind generation and FACTS device with BESS have shown the outstanding performance. Thus the proposed scheme in the grid connected system fulfills the power quality norms as per the IEC standard 61400-21.

The system [3] proposes a scheme based on FACTS device called SVC light which is connected at a Point of Common Coupling. Performance of the system with BESS under load variations and Fault ride through capability of the svc light is also analysed. This control scheme for the grid connected wind energy generation system is to improve the power quality.

SVC Lightts is a STATCOM type of device, based on VSC (Voltage Source Converter) technology and equipped with IGBTs (Insulated Gate Bipolar Transistor) as semiconductors.

Power quality issues [5] are harmonics, voltage sag, voltage swell, voltage fluctuation and waveform distortion. To overcome power quality issue STATCOM based voltage source inverter is used to reduce harmonics content of the load current at the point of common coupling. By injecting the current into grid can achive pure sinusoidal waveform with the fundamental frequency of 50 Hz. Therefore system life time has been increased and these system is implementd in hardware.

STATCOM is connected at the point of common coupling to reduce the power qulity issues. it has capability to cancel out the harmonics part of the load current. It maintain the source voltage and current in phase and support the reactive power demand for the load at PCC in the grid system and enhance the utilization factor of transmission line.

The control scheme [6] 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 algorithm needs the measurements of several variables such as three-phase source current isabc, DC voltage Vdc, inverter current isabc with the help of sensor. The current control block, receives an input of reference current isabc* and actual current isabc are subtracted so as to activate the operation of STATCOM in current control mode.

4. PROPOSED METHODOLOGY

4.1. STATCOM

A [7] STATCOM could be a controlled reactive-power supply. It provides the specified reactive-power generation and absorption entirely by means that of electronic process of the voltage and current waveforms in a VSC. A STATCOM principle diagram is shown in Figure 2.

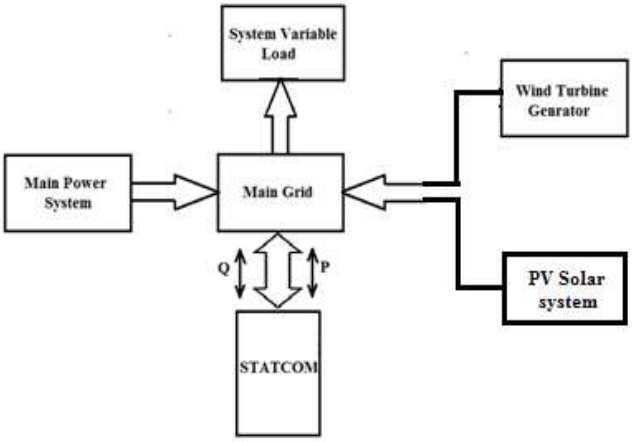

Fig 1:- Proposed approach block diagram

The VSC is connected to a utility bus through shunt electrical device. vacation is that the bus voltage. Iac is STATCOM injected current. Vout is that the VSC output voltage. Vdc and Idc square measure the DC electrical device aspect voltage and current. AN IGBT with back to back diode denotes the three arm IGBT bridge.

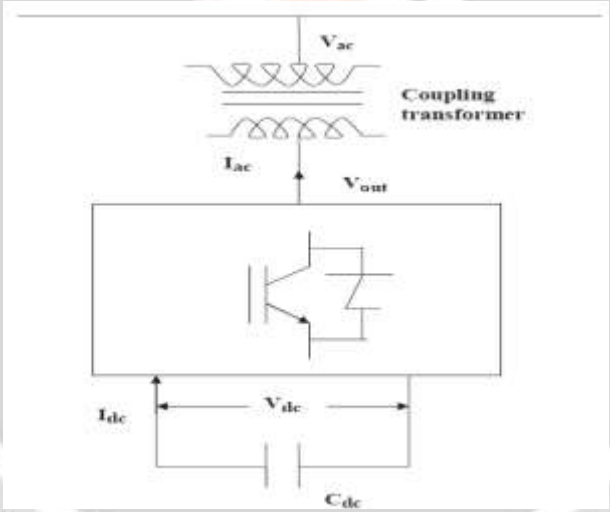

Fig 2:- A functional model of STATCOM

Top three IGBTs area unit referred to as as positive cluster and bottom three IGBTs area unit referred to as as negative cluster IGBTs. The electrical converter operation takes place, once IGBTs conduct and convertor operation takes place, once diodes conduct. Figure three shows the conception of STATCOM power exchange.

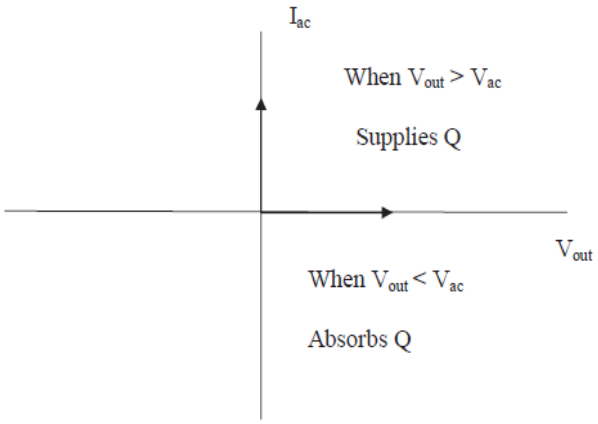

Fig.3:- STATCOM power exchange

STATCOM is seen as an adjustable voltage source behind a reactance. It means that the capacitor banks and shunt reactors are not needed for reactive-power generation and absorption, thereby it gives the STATCOM, a compact design. The equivalent circuit of the block diagram of VSC based STATCOM is shown in Figure 4.

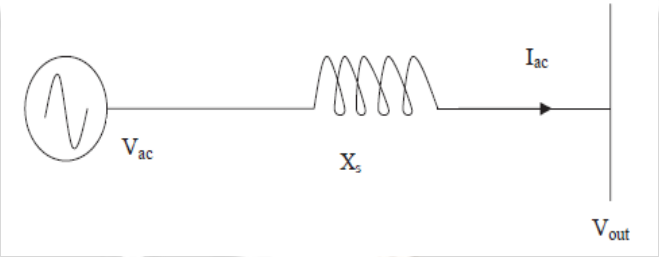

Fig.4:- Equivalent circuit of the STATCOM.

4.2 WIND TURBINE

Wind turbine components 1-Foundation, 2-Connection to the electric grid, 3-Tower, 4-Access ladder, 5-Wind orientation control (Yaw control), 6-Nacelle, 7-Generator, 8-Anemometer, 9-Electric or Mechanical Brake, 10-Gearbox, 11-Rotor blade, 12-Blade pitch control, 13-Rotor hub.

Wind turbine [4] design is the process of defining the form and specifications of a wind turbine to extract energy from the wind. A wind turbine installation consists of the necessary systems needed to capture the wind's energy, point the turbine into the wind, convert mechanical rotation into electrical power, and other systems to start, stop, and control the turbine.

In 1919 the physicist Albert Betz showed that for a hypothetical ideal wind-energy extraction machine, the fundamental laws of conservation of mass and energy allowed no more than 16/27 (59.3%) of the kinetic energy of the wind to be captured. This Betz' law limit can be approached by modern turbine designs which may reach 70 to 80% of this theoretical limit.

In addition to aerodynamic design of the blades, design of a complete wind power system must also address design of the hub, controls, generator, supporting structure and foundation. Further design questions arise when integrating wind turbines into electrical power grids.

4.3. PV Solar Cell

In PV panels solar cells are the basic components and it is made of silicon. A solar cell is generally a p-n junction which is made of silicon. It is made up of two different layers when a

smaller quantity of impurity atoms added to it. A PV system convert's sunlight in to electricity and the PV cell is basic device of the photovoltaic system. No of Cells are combined and grouped to form PV panels or modules. No of PV Panels can be grouped to form large photovoltaic arrays. The solar arrays are the combination of number of cells connected in series or in parallel or the combination of a group of panels.

Day by day conventional source of energy are diminishing fast, with rise in cost. Again the large use of conventional fissile fuels which are the primary source of energy causes the savior environmental pollution. Due to the possible solution to the environmental problem renewable energy offers a promising alternative source. Also renewable energy supply power to the remote communities where main electrical grid is absent. Photovoltaic generation system has many merits such as less maintenance, noise free and pollution free so it's becoming increasingly important as a renewable source. Solar panel is used in PV system to convert sunlight into electricity and provide energy to the consumer or feed power to the grid.

There are many stages are used in grid connected PV system like PV array, DC to DC converter, DC to AC converter. In this paper a model is developed through converting common circuit equation of solar cell in to simplified form including the effects of changing solar irradiation and changing temperature. In this paper a control approach for interfacing the PV array with DC-DC converter.

The power injected into the grid from the PV panel through two stages. In first stage in order to enhance the DC voltage level of PV panel the PV array is connected to the DC-DC converter. And MPPT is used to track the maximum power point in order to achieve the maximum power point. In second stage through grid connected inverter control dc power is converted into ac power. Also this control control the current and power injected from the grid.

5. SIMULATION MODEL

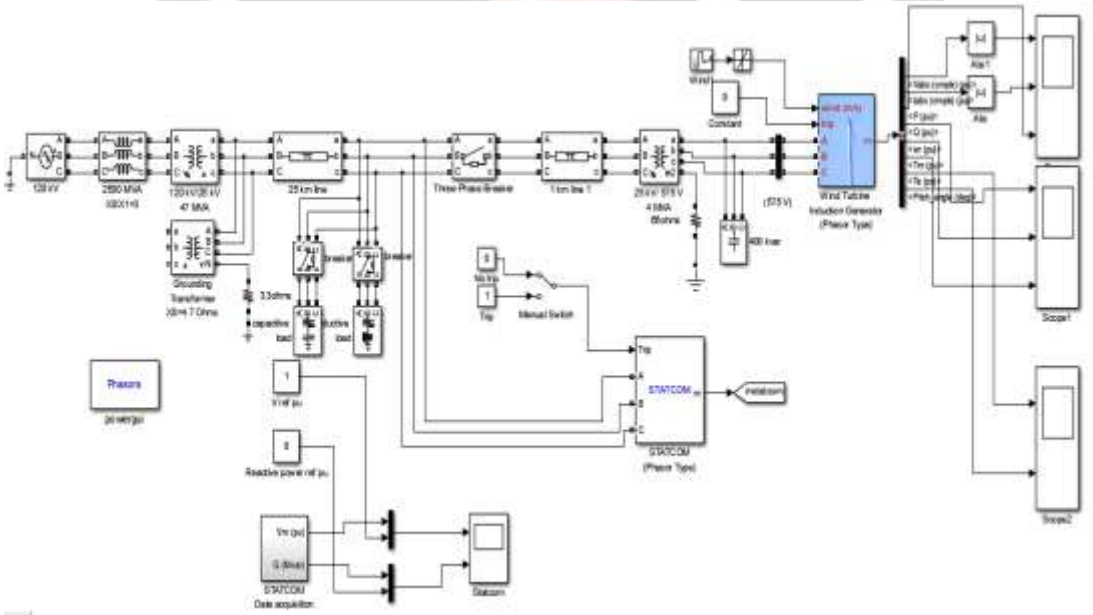

Fig.5:- Matlab simulation model for STATCOM based improving grid power quality on integration of wind energy system

A wind park consisting of 2 one.5-MW wind turbines is connected to a 25-kV distribution system exports power to a 120-kV grid through a 25-km 25-kV feeder. The 9-MW wind park is simulated by 3 pairs of one.5 MW wind-turbines. Wind turbines use squirrel-cage induction generators (IG). The stator coil winding is connected on to the sixty Hertz grid and also the rotor is driven by a variable-pitch turbine. The pitch angle is controlled so as to limit the generator output power at its value for winds exceptional the nominal speed (9 m/s). so as to come up with power the immunoglobulin speed should be slightly on top of the synchronous speed. Speed varies more or less between one atomic number 94 at no load and one.005 atomic number 94 at full load.

Reactive power absorbed by the IGs is part paid by capacitance banks connected at every turbine low voltage bus (400 kvar for every combine of one.5 MW turbine). the remainder of reactive power needed to take care of the 25-kV voltage at bus B25 near one atomic number 94 is provided by a 3-Mvar STATCOM with a third droop setting.

Variable load area unit connected with main grid through 3 section breaker within which inductive load of 3000Mvar connected with system between four to five second of total simulation time whereas electrical

phenomenon load of 3000Mvar connected in system between half dozen to seven second of total simulation time of model. This behavior of load act as non linear or variable load of system. Total simulation time is ten second.
The wind speed applied to rotary engine is controlled by the "Wind 1" block. Initially, wind speed is ready at eleven m/s, then beginning at t=2s for "Wind rotary engine ", wind speed is rammed to five m/s in four seconds. once more wind speed is 6m/s at five seconds so finally wind speed amendment to nine m/s at 8second and continue up to total simulation time. This shows the nonlinear behavior of alternative energy in turbine system.
In that simulation model turbine generator connected to grid at two second time with the assistance of 3 section breaker.

6. SIMULATION RESULT

6.1. STATCOM RESULT

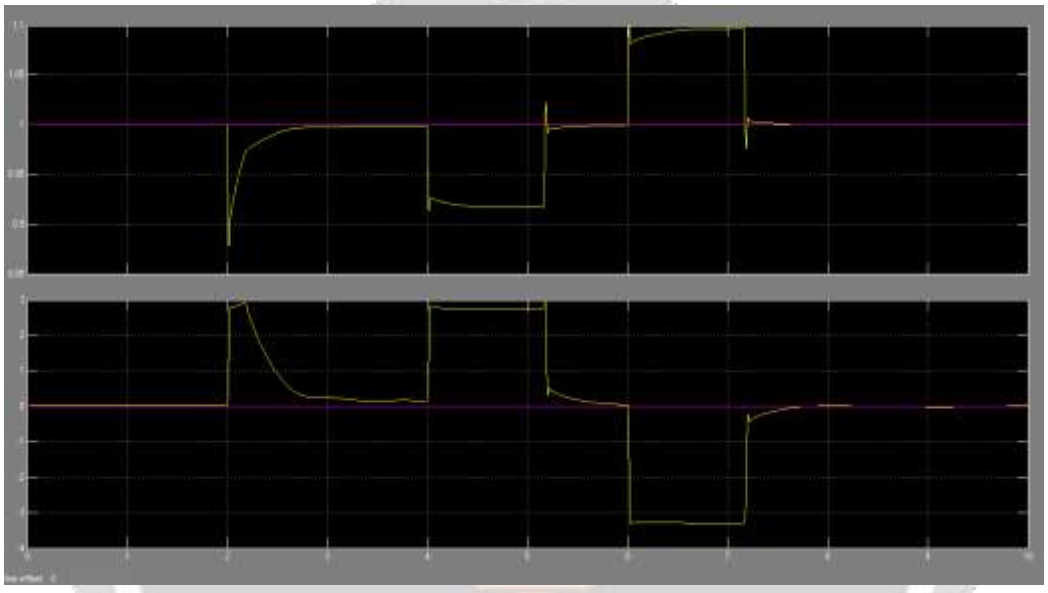

Fig.6:- STATCOM act as voltage regulator corrected grid voltage and generated and absorbing reactive power

Above figure 6 and 7 shows that, When the simulation model run, at 2 second time wind turbine connected with main grid through three phase breaker. The wind speed applied to turbine is controlled by the "Wind 1" block. Initially, wind speed is set at 11 m/s, then starting at t=2s for "Wind turbine ", wind speed is rammed to 5 m/s in 4 seconds. Again wind speed is 6m/s at 5 seconds and then finally wind speed change to 9 m/s at 8second and continue up to total simulation time. This shows the nonlinear behavior of wind generation in wind turbine system.
At 2 second when wind turbine connected with grid system voltage get reduced but at that time STATCOM generate 3 pu reactive power and supply reactive power to grid for voltage improvement upto reference voltage that is 1 pu.
At 4 second simulation time inductive load of 3000mVar connected in grid through breaker and closed at 5 second. During this period, due to inductive load grid voltage get drop upto -0.93 pu but STATCOM generate the +2.97 pu reactive power for improve the grid voltage of 1 pu.
At 6 second again capacitive load of 3000Mvar are connected with grid and disconnect at 7 second. During this period, due capacitive load grid voltage becomes rises upto +1.1 pu but STATCOM absorbing the reactive power of -3.2 pu for maintaining grid voltage as reference voltage that is 1 pu.

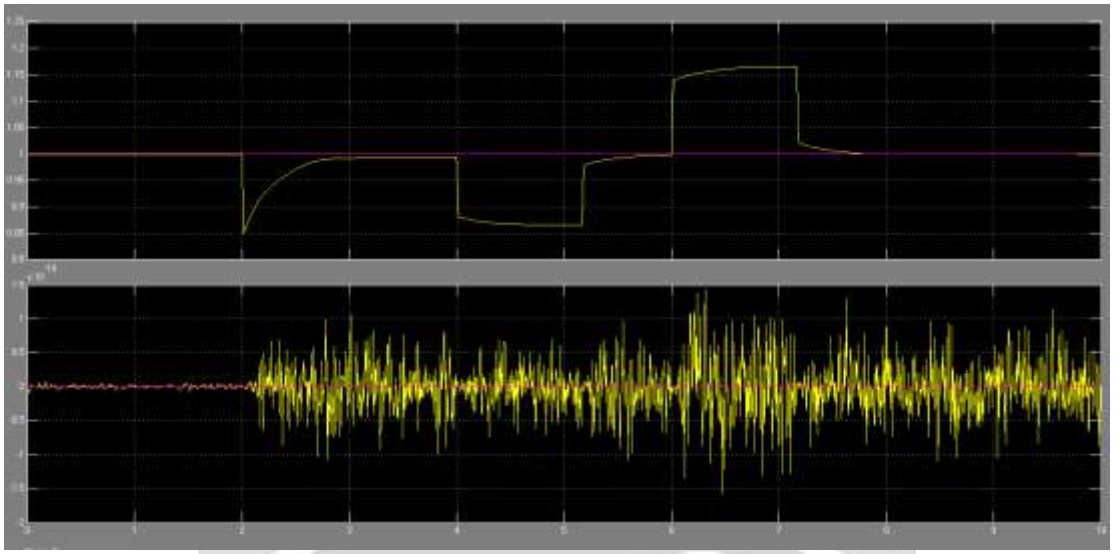

Fig.7:- STATCOM act as reactive power compensator for voltage profile improvement corrected grid voltage and generated and absorbing reactive power

6.2. WIND TURBINE RESULT

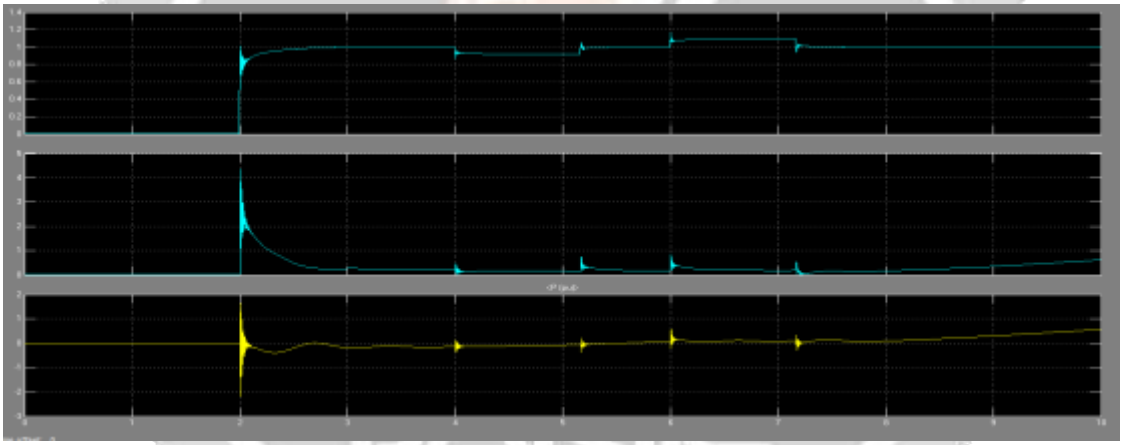

Fig.8:- Phasor voltages, Phasor currents Ia, Ib, Ic in pu and output power in pu respectively of wind turbine.

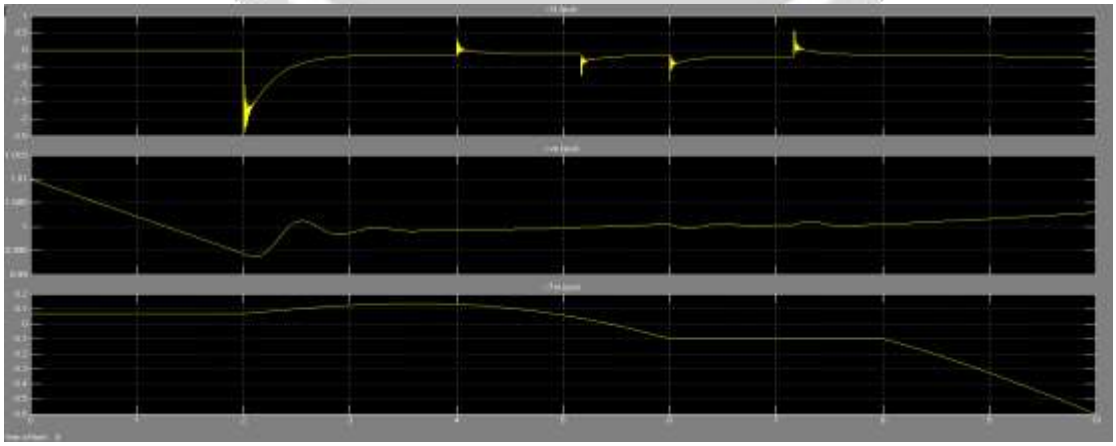

Fig.9:- output reactive power in pu, Generator rotor speed (pu) and Mechanical torque applied to the generator in pu respectively for wind turbine.

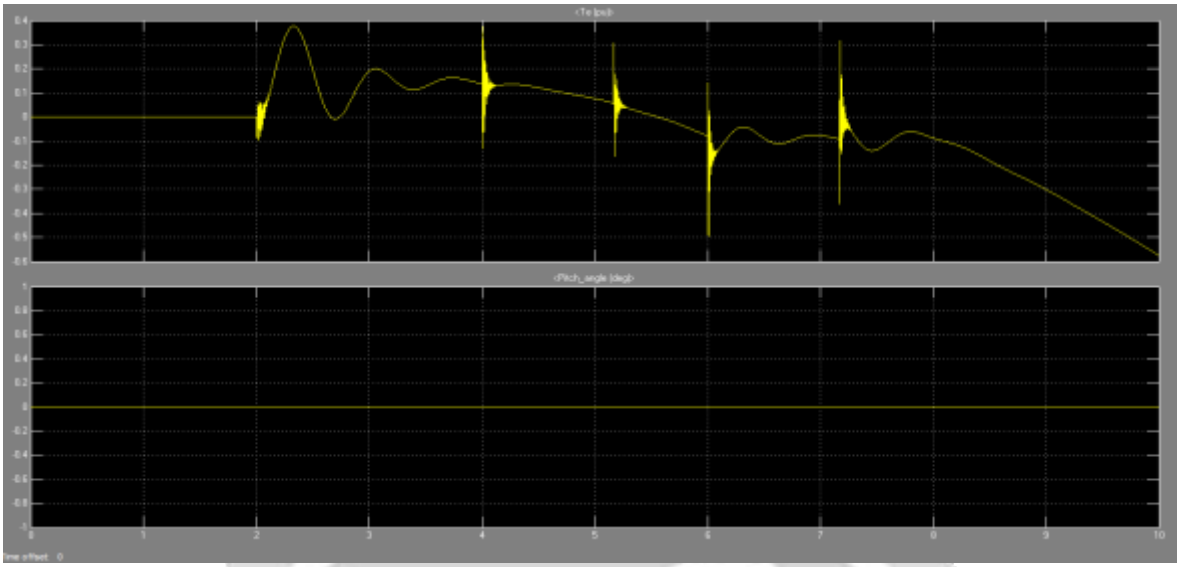

Fig.10 :- Electromagnetic torque in pu and Blade pitch angle in degrees respectively for wind turbine.

7. CONCLUSION

This paper is an effort to present technique used for improve the power qulity of system when wind turbine connected with power system grid.The importance and technical significance of BESS with STATCOM is elaborated here. Advantages of using BESS in connection to STATCOM in the power system for minimizing the transient dynamics of the power system. It has been observed that the STATCOM-battery combination can be very effective in compensating generator rotor angle oscillations and thus well suited for improving transient stability and the dynamic behavior of the power system.

STATCOM is suitable for improving the power quality of the grid when the wind turbine or wind farm connected with grid. Also non-uniform nature of load disturb the quality of voltage at grid. This power quality also improve by STATCOM by absorbing and generating reactive power using Voltage Source Convertor using DC link that is battery system.

8. FUTURE SCOPE

This work extends for creating hybrid power system which consist of solar, wind and tidal energy resources. In that system STATCOM play important role for improving the power quality with renewable energy resources use.

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