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ANALYSIS OF STABILITY PROBLEM IN WIND GENERATOR USING STATCOM

[1]Mr.Sandeep S.Thakur, [2]Prof.H.Murkute, [3]Prof.R.M.Bhombe

[1]PG Student, Department of Electrical Engineering, Gurunanak Institute of Engineering & Technology, Nagpur, Maharashtra, India

[2]Prof.of Electrical Engineering Department, Gurunanak Institute of Engineering & Technology, Nagpur, Maharashtra, India

[3]Asst. Prof. of EE & Head of EE, Gurunanak Institute of Engineering & Technology, Nagpur, Maharashtra, India

Abstract

This paper presents a method to enhance the stability of a grid-connected wind generator composed of a fixed-speed wind turbine generator system (WTGS) using a FACTS devices of static synchronous compensator (STATCOM). Recently, Flexible AC Transmission System (FACTS) - based devices have been used for power flow control and for damping power system oscillations. They can also be used to increase transmission line capacity; steady state voltage regulation; provide transient voltage support to prevent system collapse; and damp power oscillations. FACTS devices can be used in wind power systems to improve the transient and dynamic stability of the overall power system. Because of the asynchronous operation nature, system instability of wind farms based on FSIG is largely caused by the reactive power absorption by FSIG (Fixed Speed Induction Generator) due to the large rotor slip during fault. The Static Synchronous Compensator (STATCOM) which is from the family of FACTS devices can be used effectively in wind farms based on FSIG to provide transient voltage and to improve wind farm stability. In other words a STATCOM is an electronic generator of reactive power.

Keywords:*Introduction, STATCOM, Need of STATCOM, Wind farm, STATCOM operation*

I Introduction

With the increase in demand of power and decrease offossil fuels, mankind has been forced to search alternative sources for the generation of electricity. Wind power in spite of being stochastic in nature has proved itself as a viable solution to this problem. As the wind turbine technology is developing at a good pace, more and more wind power plants are being integrated with the conventional form of generation. With the increase in the ratio of wind generation to conventional generation, several problems related with integration of wind farms have emerged. These problems aredue to distinct properties of the generators used with the conventional form (Thermal & Hydro) of generation and wind based generation.

Doubly-Fed induction generator (DFIG) is, currently, the most employed wind generator due to its several merits. One of the advantages is the higher efficiency compared to a direct-drive wind power generation system with full-scale power converters since only about 20% of power flowing through power converter and the rest through stator without power electronics. Another advantage of a wind DFIG is the capability of decoupling control of active power and reactive power for better grid integration. However, by connecting stator windings directly to the power grid, a wind DFIG is extremely sensitive to grid faults. Moreover, wind energy is a kind of stochastic energy, implying that the output of\ Wind Farm (WF) varies in a certain range due to unstable wind characteristic. Therefore, the operating point of the power system changes from time to time when the wind power is integrated with the power system.

In this paper, a STATCOM is added to the power network toprovide dynamic voltage control for the wind farm, dynamic power flow control for the transmission lines, relieve transmission congestion and improve power oscillation damping. Simulation results show that the STATCOM devices significantly improve the performance of the wind farm and the power network during transient disturbances.

II. STATCOM

Static Synchronous Compensator is made up of a shunt transformer, a voltage source converter (VSC), a DC capacitor, a magnetic circuit, and a controller. STATCOM also known as an advanced static VAR compensator is a shunt connected FACTS device. It generates a set of balanced three phase sinusoidal voltages at the fundamental frequency, with rapidly controllable amplitude and phase angle. A typical application of a STATCOM is for voltage support. The objective of the STATCOM is to regulate the voltage at the PCC rapidly in the desired range and keep its DC link voltage constant. It can enhance the capability of the wind turbine to ride through transient disturbances in the grid. STATCOM is widely used in grid connected wind turbine for power quality improvement.

Shunt compensators are primarily used for bus voltage regulation *y*means of providing or absorbing reactive power; they are effective for damping electromechanical oscillations. Different kinds of shunt compensators are currently being used in power systems, of which the most popular ones are Static Var Compensator SVC and STATCOM. In this work, only the STATCOM, which has a more complicated topology than a SVC, is studied. The STATCOM is a FACTS controller based on voltage sourced converter VSC technology. A VSC generates a synchronous voltage of fundamental frequency and controllable magnitude and phase angle. If a VSC is shunt-connected to a system via a coupling transformer shown in fig.1 the resulting STATCOM can inject or absorb reactive power to or from the bus to which it is connected and thus regulate bus voltage magnitudes. The main advantage of a STATCOM over a SVC is its reduced size, which results from the elimination of ac capacitor banksand reactors; moreover, a STATCOM response is about 10 times faster than that of a SVC due to its turn-on and turn-off capabilities. The active and reactive power exchange between the VSC and the system in Fig. 1 are a function of the converter output voltage denoted as *Vout*, i.e.

$$P = \frac{VoutV}{X} \sin\alpha_{conv} \quad (1)$$

$$Q = \frac{V2out - VoutV\cos\alpha conv}{X} \quad (2)$$

Where $\alpha conv$is the angle between the ac system voltage V and$Vout$, and X denotes the reactance of the coupling transformer.

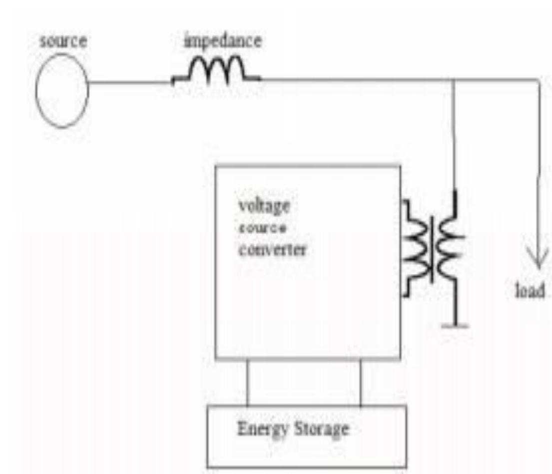


Fig. 1: Schematic Diagram of STATCOM

The negative sequence effect caused by wind turbine on gridcan be eliminated by voltage control capability of STATCOM.PI controller is used as conventional technique and comparisonis made with hybrid fuzzy logic controller. Further performanceof SVC and STATCOM is compared and STATCOM is found tobe better than SVC as it has more switching losses. SVC has thecapability to control voltage at each phase under faulty condition.But it has the disadvantage of losses which is caused due to powerswitches. This can be eliminated in case of STATCOM.

III Need of STATCOM

The STATCOM basically perform the same function as the var compensators but with same advantages.The term Static synchronous Compensator is derived from its capability and operating principle, which are similar to those of operating synchronous compensators (i.e. generators), but relatively faster operation.It is a regulating device used on alternating current electricity transmission network.

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. If connect to a source of power it can also provide active AC power. It is a member of the FACTS family of device. It is inherently modular and electable. These compensators are also useable to reduce voltage fluctuations.

Wind farms are introduced in larger and larger quantities in power systems all over the world. Hence, it becomes more and more vital to be able to perform power system studies, including wind farm behavior, and it demands modeling of wind farms. This paper deals with the implementation of FACTS controller called static synchronous compensator STATCOM to improve the performance of the grid connected wind farms. The essential feature of the STATCOM is that it has the ability to absorb or inject fast the reactive power with power grid. Therefore the voltage regulation of the power grid with STATCOM FACTS device is achieved. Moreover restoring the system stability after severe disturbance is achieved by using the STATCOM. to validate the usage of STATCOM a simulated model is designed when subjected to sudden load variation. The results prove the effectiveness of the controller in restoring the system stability.

IV. Wind Farm and Electric Generator Model

In dynamic simulations, the electricity-producing wind turbine is treated as a complex electromechanical system consisting of the induction generator, the drive train system and the rotating wind turbine. Its modular diagram is given in Fig.2

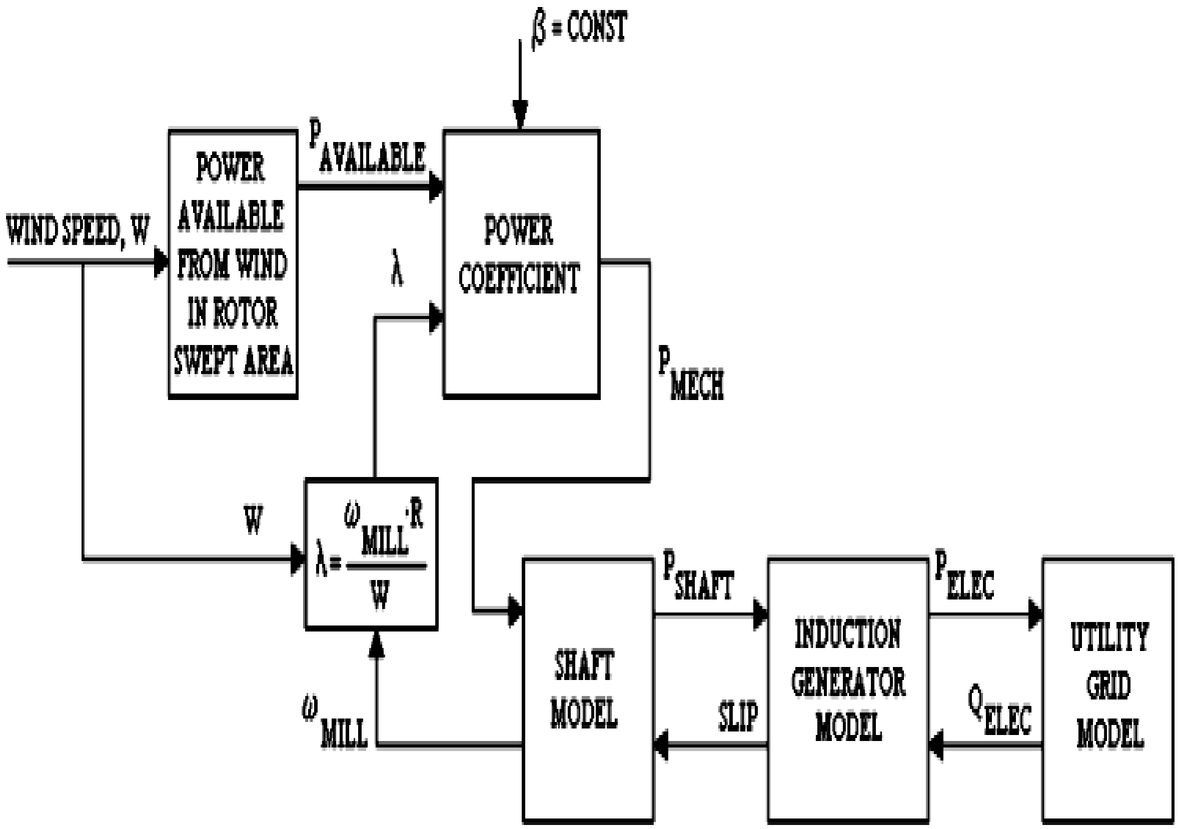


Fig. 2: Modular model of a grid-connected, stall-controlled wind turbine equipped with an induction generator

$$P_t = \frac{1}{2} \cdot \rho \cdot \pi \cdot R^2 \cdot V^3 \cdot C_p(\lambda, \beta)$$

Where Pt is the extracted power from the wind, ძ is the air density [kg/m3],R is the blade radius [m] and Cp is the power coefficient, which is a function of both tip speed ratio, λ and blade pitch angle, β [deg].In this operating mode, the wind turbine pitch control is deactivated and the pitch angle Beta ( ) is fixed at 0°. If the wind speed is above the rated value, the rotor speed can no longer be controlled within the limits by increasing the generator and/or the converter.

In this situation, the pitch control is activated to increase the wind turbine pitch angle to reduce the mechanical power extracted from the wind. The Cp-λ curves are shown in fig.2 for different values of Beta.

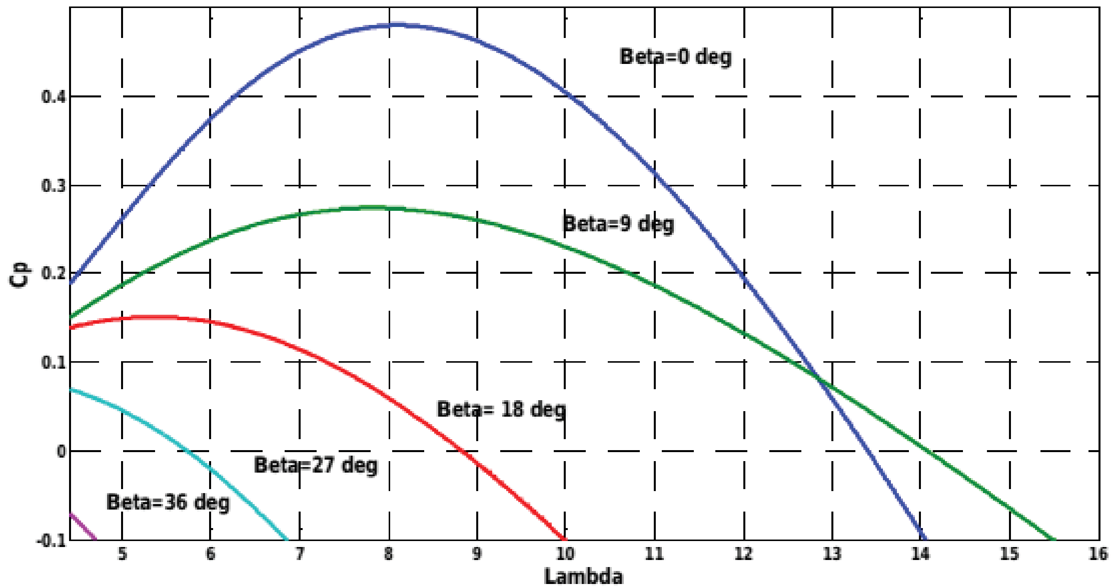


Fig.3: CP-β Curves for Different Pitch Angles.

In order to generate power the induction speed must be slightly above the synchronous speed but the speed variation is typically so small that the WTIG is considered to be affixed speed wind generator.

The basic schematic arrangement of a Doubly Fed Induction Generator (DFIG) coupled to a wind turbine as shown in fig.4.

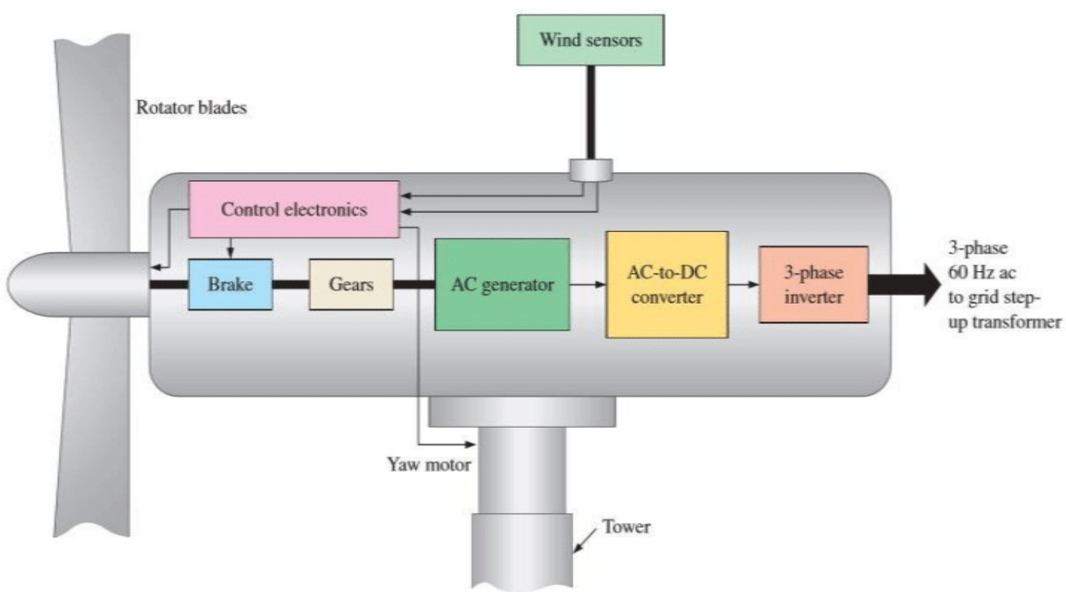


Fig.4: Wind Turbine and Induction Generator

V STATCOM Operation

1. STATCOM Operation under Normal Condition

Fig.5 and Fig.6show the power system with STATCOM operation in Var regulation mode, with *iq*reference is equal to 1, under normal system conditions. The STATCOM 48-pulse voltage waveform is verified in Fig.5. The VSC phase currents in Fig.6 are within 1550A (1 pu.) without any system disturbances.

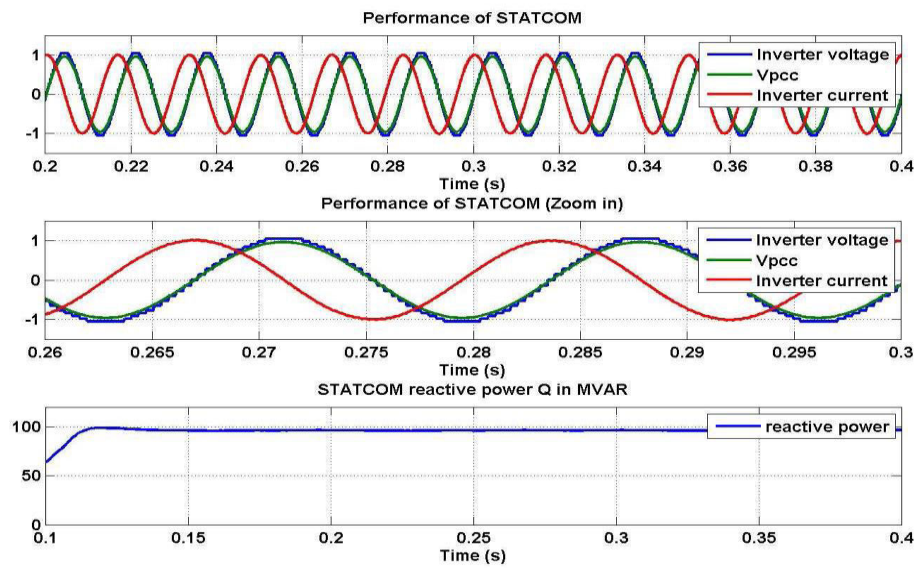


Fig.5: STATCOM operation in Var regulation mode under normal system condition (a) Bus voltage, STATCOM primary 48-pulse voltage, STATCOM primary injected current, (b) STATCOM reactive power Q in MVAR

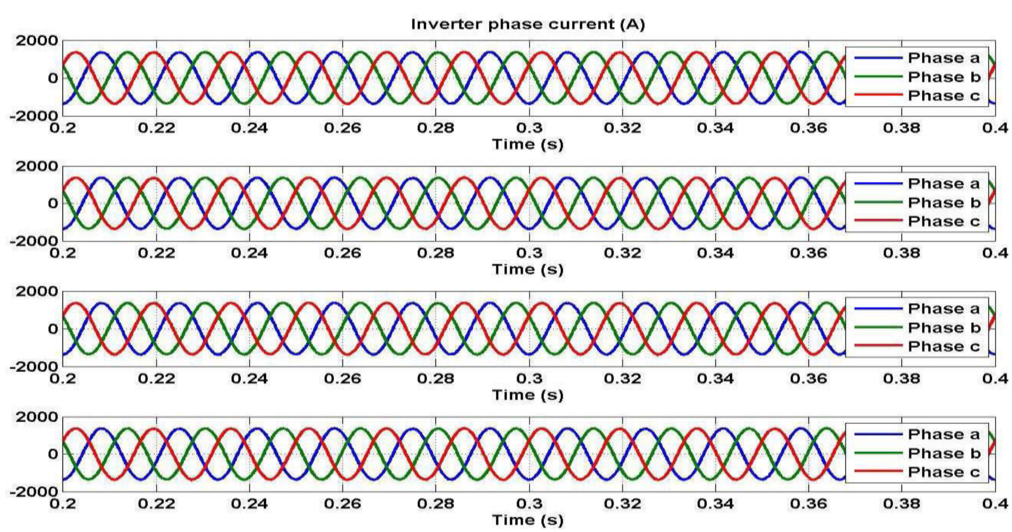


Fig.6: Four VSC phase currentsunder normal system operations

2. STATCOM Operation under Single-line to Ground Fault

Fig.7 and Fig.8show the STATCOM operation in Var regulation mode under 6- cycle single-line to ground fault at bus 2. There is sag on AC bus voltage and accordingly, at the output voltage of converter due to the fault. Fig.7 shows that the VSC currents exceed 3000A (twice that of nominal 1550A peak in Fig.8), and will result in over current and trip to protect the VSC devices in a practical system.

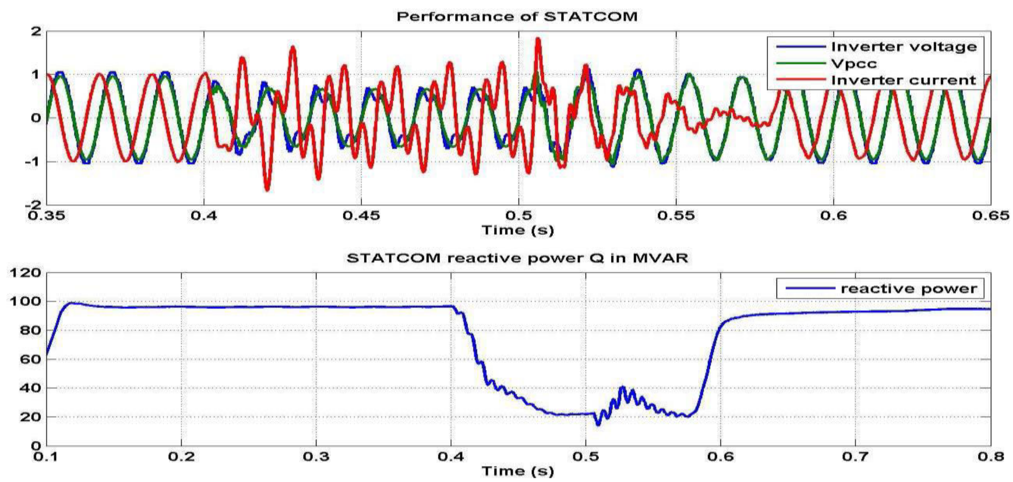


Fig.7: STATCOM operation in Var regulation mode under single-line to ground fault condition (a) Bus voltage, STATCOM primary 48-pulse voltage, STATCOM primary injected current, (b) STATCOM reactive power Q in MVAR

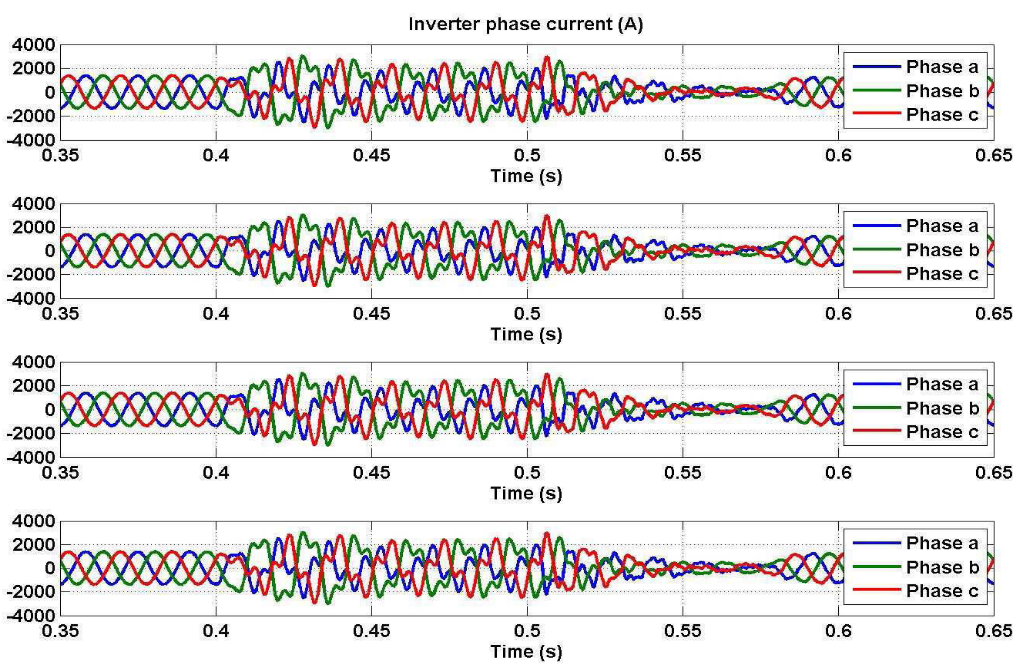


Fig.8: Four VSC phase currents under single-line to ground fault condition

3. STATCOM Operation under line-line fault

Fig.9 and Fig.10 show the ATATCOM operation in Var regulation mode under 6- cycle line-line fault at bus 2. Fig.8 shows that the VSC current, the peak value of which is 4 pu., is much higher than that under normal condition.

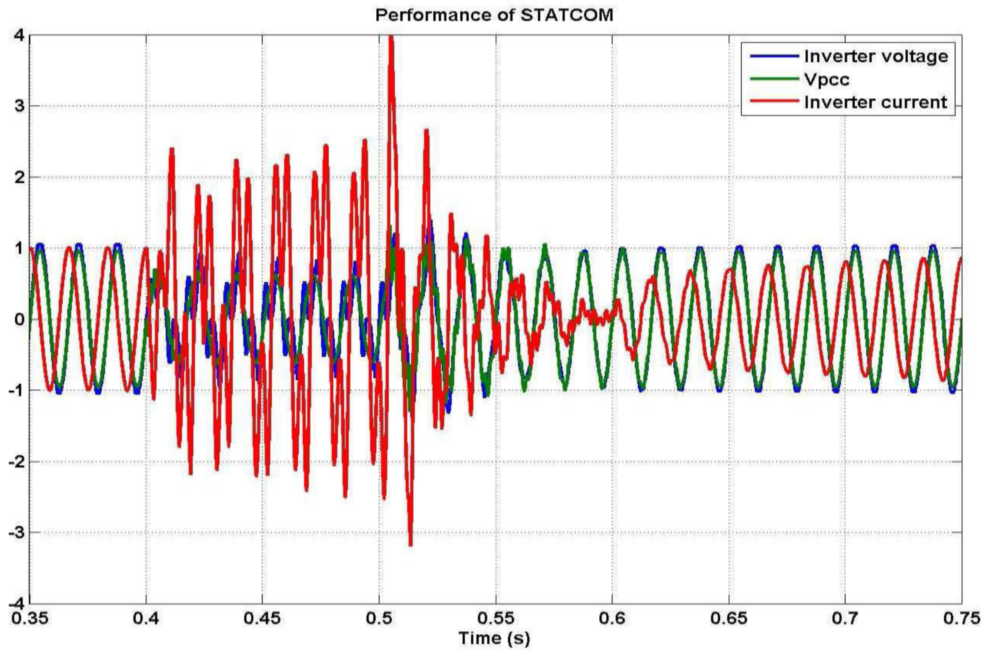


Fig.9: STATCOM operation in Var regulation mode under line-line fault: Bus voltage,STATCOM primary 48-pulse voltage, STATCOM primary injected current

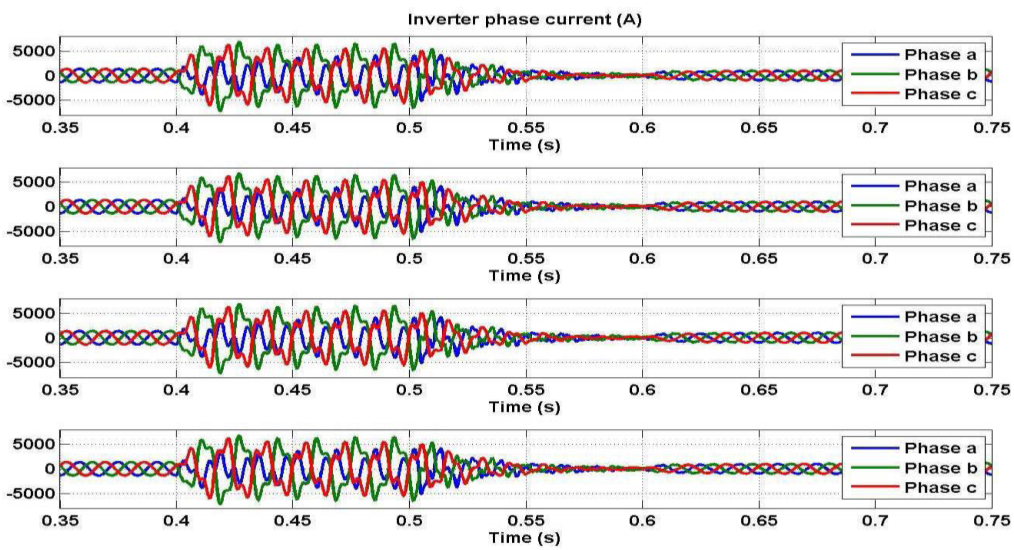


Fig.10: Four VSC phase currents under line-line fault

VI. Matlab/Simulink Results

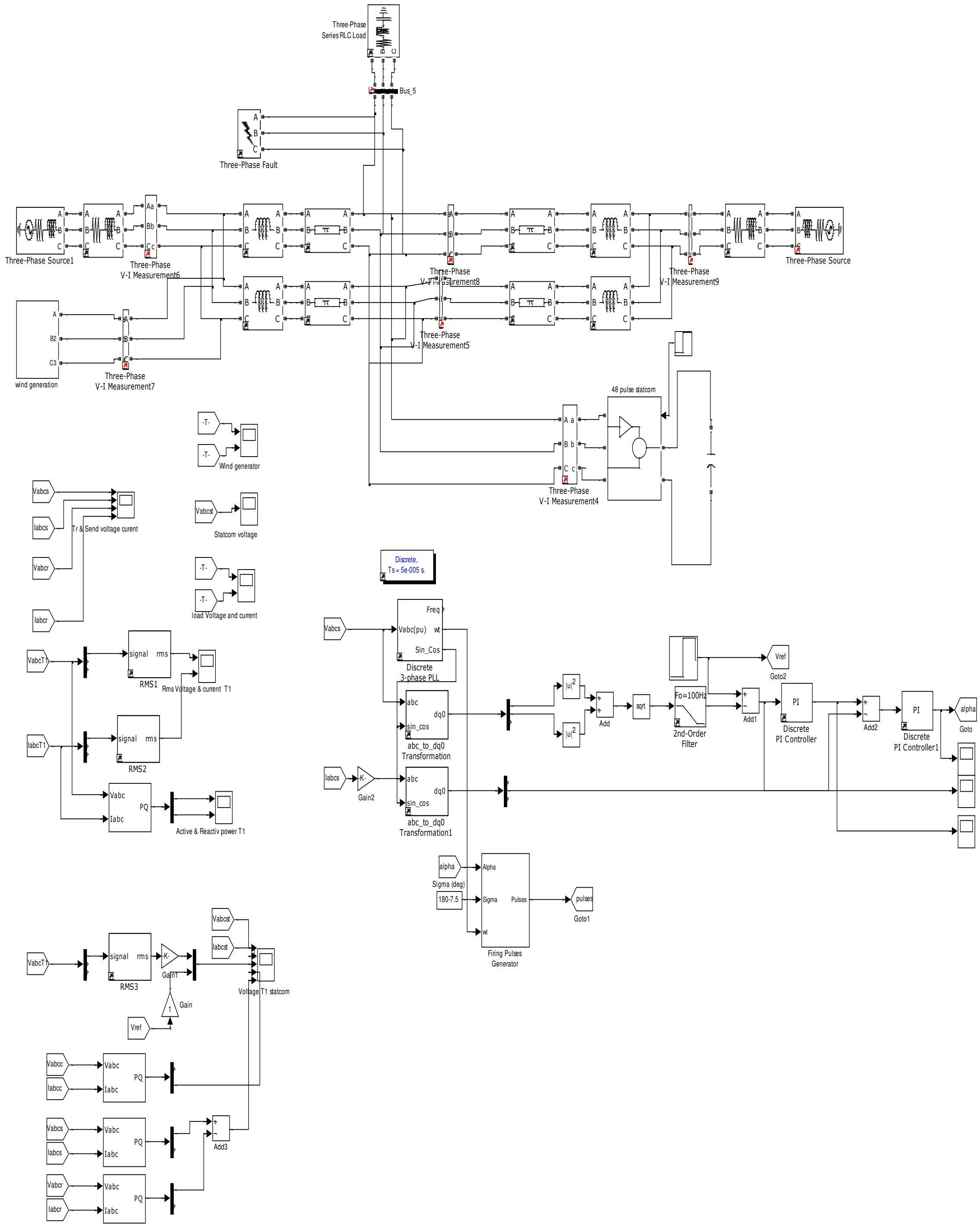
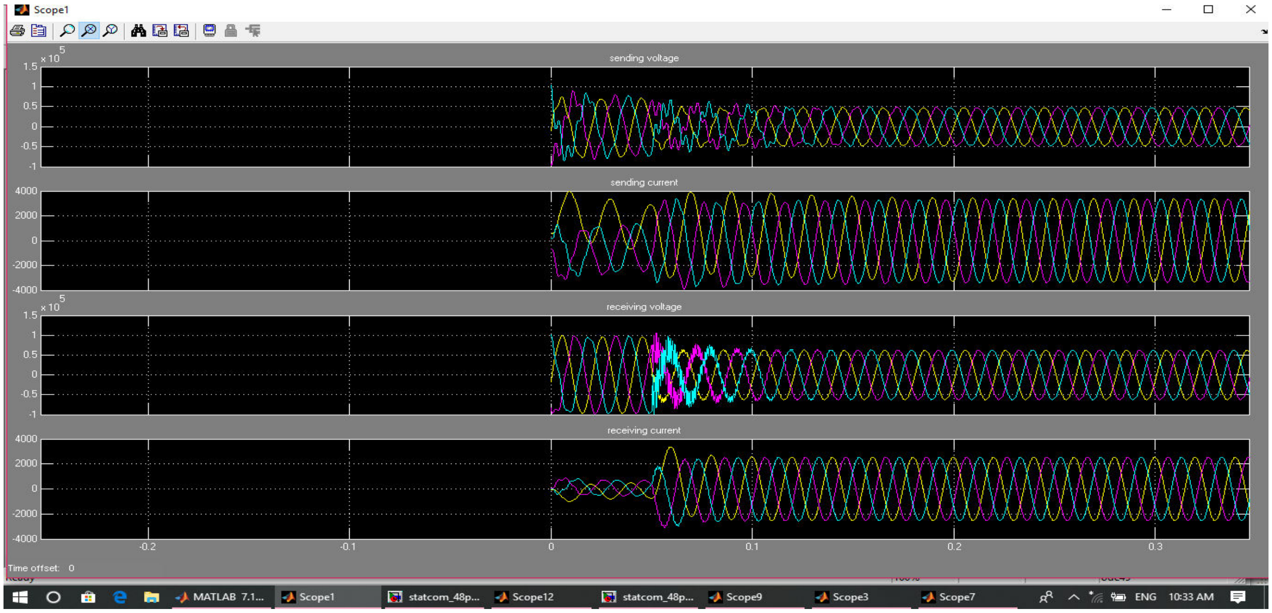


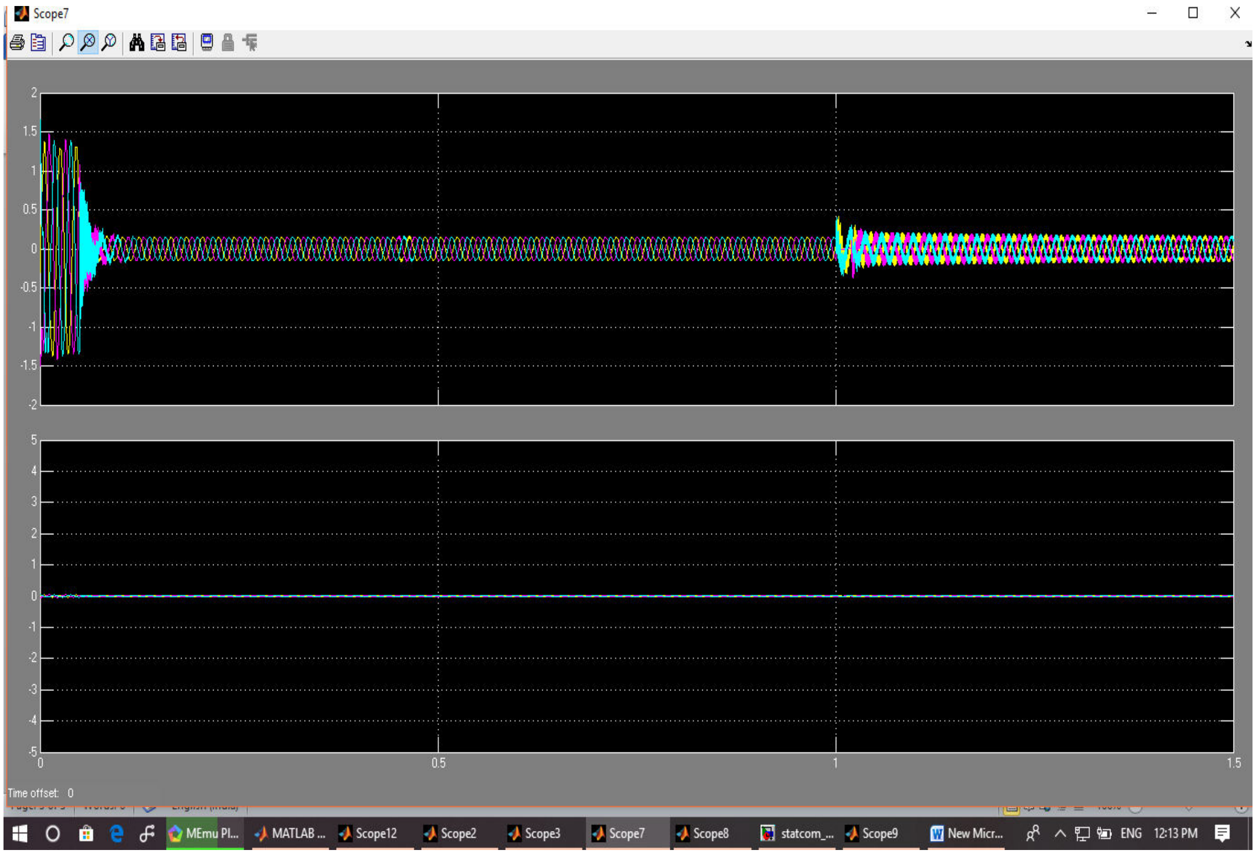
Fig. 11: Matlab/Simulink Model of Proposed Circuit WithSTATCOM

Scope 1

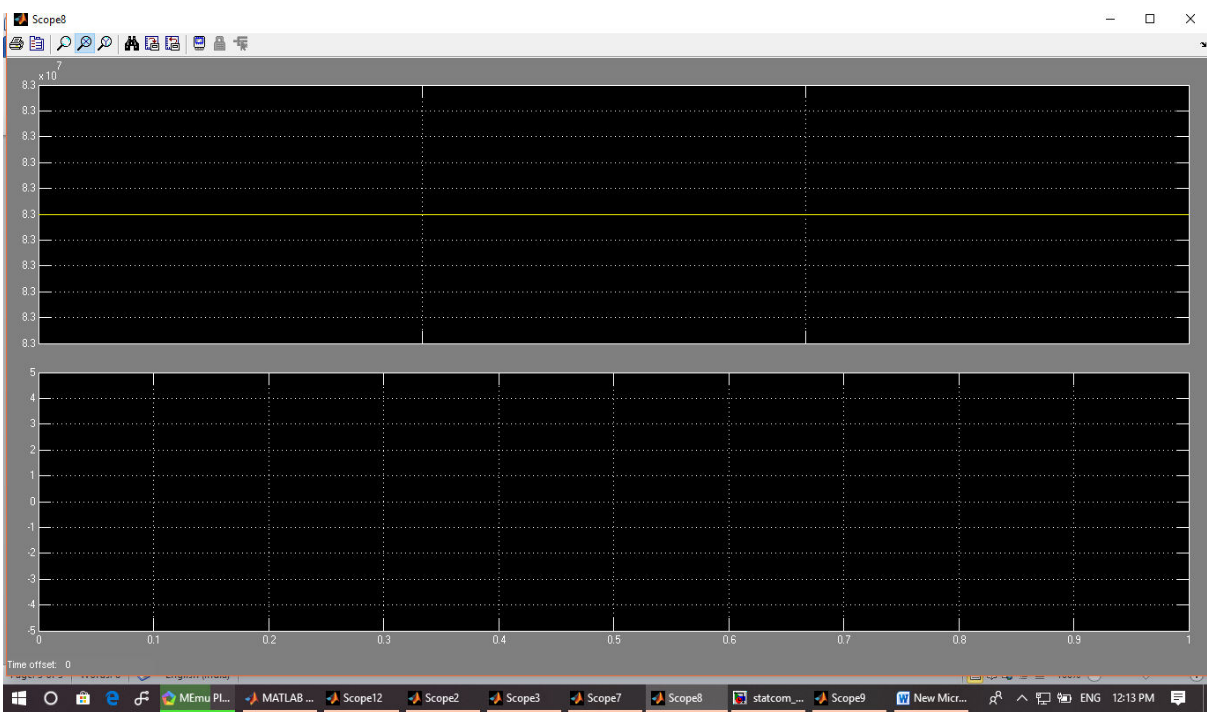


Scope 3

Scope 7



Scope 8



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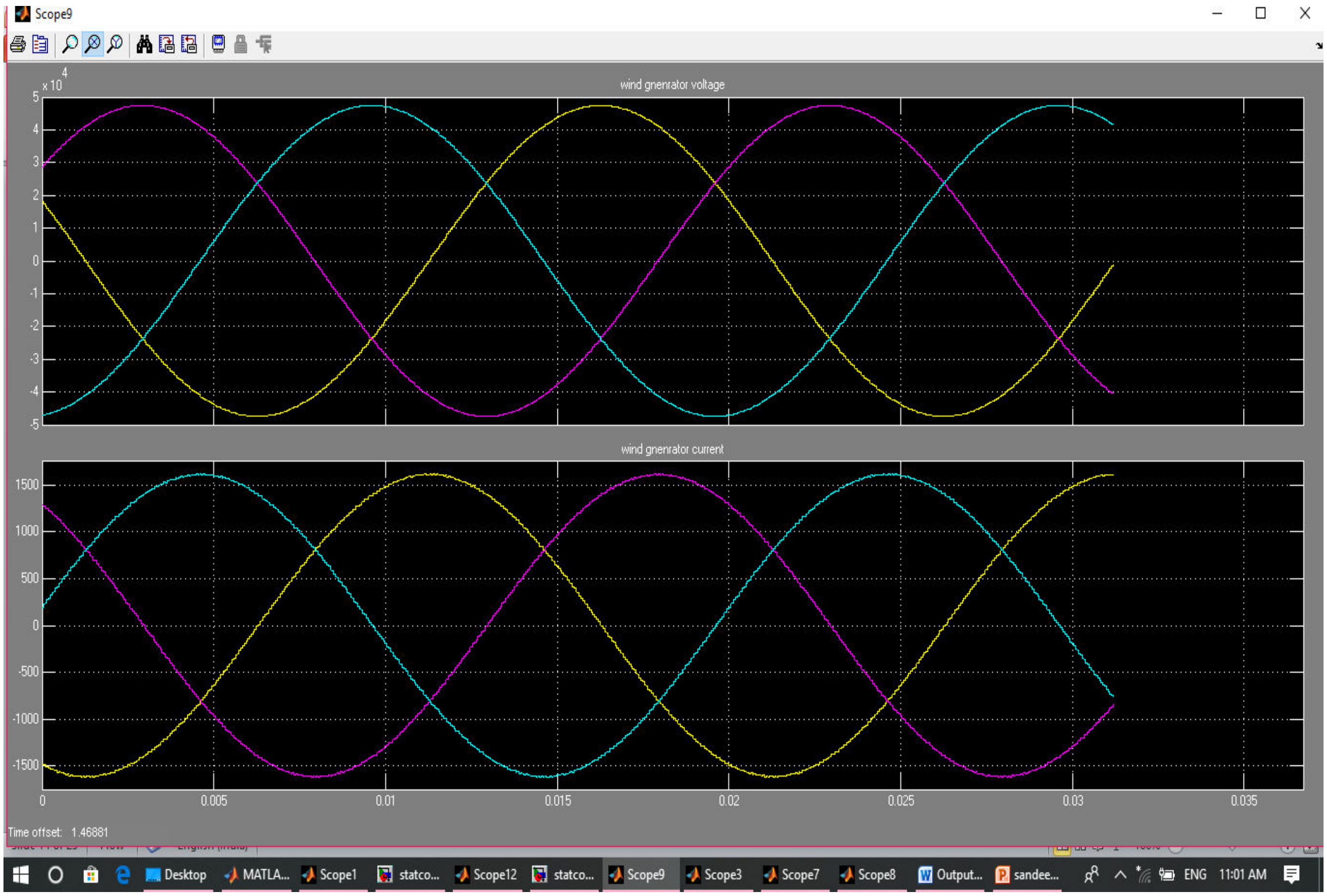
Scope 9



VII. Conclusion

The detailed results of fault(**LG**) without STATCOM and Fault with STATCOM has been noted and analyzed in Simulation with proper justification.

In view of that, From Fig. 11 wind generator bus measurement without STATCOM Waveform of fault during 1.0sec to 1.02 sec during observes waveform. When after the fault clearing then about voltage unstable during 1.1 sec then voltage is stable. When the STATCOM connect with grid and obtain measurement of wind generator Scope1 & Scope2. Then System voltage unstable about 1.028sec then system voltage is stable.

So justify when system including with STATCOM then Transient voltage stability is improve.

VIII. References

[1] "Issues of Connecting Wind Farms into Power Systems'' Z. Chen, Senior Member, IEEE, IEEE/PES

Transmission and Distribution Conference & Exhibition China 2005

[2] "Analysis of Stability Problem in Wind Generator Using STATCOM and SDBR'' Silaparasetti V Kumar, R. Bhargav, T.SrinivasaRao IJEAR Vol. 6, Issue 1, Jan - June 2016

[3] Voltage Stability in Power Network when connected Wind Farm Generators by P. N. Boonchiam Member, IEEE, PEDS2009

[4] "Comparison of SVC and STATCOM impacts on wind farm stability connected to power system'' M. Sedighizadeh, A. Rezazadeh, M. Parayandeh International Journal of Engineering and Applied Sciences (IJEAS)Vol.2, Issue 2(2010)13-22

[5] Wind Integration: International Experience, WP2: Review of Grid Codes, October 2011.

[6] M. Tsili, S. Papathanassiou,"A review of grid code technical requirements for wind farms," Renewable Power Generation, IET, Vol. 3, No. 3, pp. 308–332, Sept. 2009.

[7] M. Sedighizadeh, M. M. Hosseini,"INVESTIGATION AND COMPARISON OF USING SVC, STATCOM AND DBR's IMPACT ON WIND FARM INTEGRATION, International Journal of Engineering and Applied Sciences (IJEAS),Vol. 2, Issue 4, pp. 38-54, 2010

[8] Paulo Fischer de Toledo, HailianXie,"TOPIC 7: WIND FARM IN WEAK GRIDS COMPENSATED WITH STATCOM", KTH, Kungl Tekniska Högskolan, EME department Teknikringen 33-35, Stockholm, Sweden.

[9] M. Jahangir Hossain, Hemanshu R. Pota, Valeri A. Ugrinovskii, Rodrigo A. Ramos,"Simultaneous STATCOM and Pitch Angle Control for Improved LVRT Capability of Fixed-Speed Wind Turbines", IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, Vol. 1, No. 3, October 2010.

[10] X.P. Zhang, C. Rehtanz, B. Pal, "Flexible AC Transmission Systems: Modeling and Control", Springer Verlag Berlin Heidelberg 2006.

[11] O. Noureldeen,"Characteristics of Fixed Speed Wind Turbines Interconnected Grid during Wind Speed Variations", 13th Middle East power systems conference MEPCON, 2009 Assuit University, Egypt, December 20-23, 2009.

[12] F.G.R. de campos, A.A. Jr. penteado,"WindEnergygenerationSimulation with asynchronous generator connected to ENERSUL distribution System", IEEE/PESTransmissionand Distribution conference and Exposition, Latin America, pp. 149-154, 2004.