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Amendment of Power Quality and Dynamic Voltage of Windfarms Using Thyristor

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Abstract: In the proposed concept fully tuned inductive filtering has been implemented, to enhance power quality thyristor controlled inductive filtering can be implemented. Nonlinear loads cause significant harmonic currents with poor input power factor (PF), which create serious problems at the power supply system. Traditionally, passive filters have been used to eliminate current harmonics of the supply network. However, these devices suffer from resonance. Recently, thyristor-inductive filters (TIFs), which contain several groups of passive filters, have been used to compensate reactive power. The compensation amount of TIFs can be adjusted with the variation of load power. However, the parallel and the series resonance could occur between TIF and grid impedance a STATCOM model is also developed. Simulation studies are carried out in the Digsilent/ Powerfactory to illustrate the performance of the new grid connected wind power system. The results indicate that the new approach can not only enhance the low-voltage ride-through capability of wind turbines, but also significantly prevent harmonic components flowing into the primary (grid) winding of the new grid connected transformer.

Keywords: Inductive Filtering Method, Thyristor, Grid Connected System, Wind Farm.

I. INTRODUCTION

To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, hydro, co-generation, etc. In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. The need to integrate the renewable energy like wind energy into power system is to make it possible to minimize the environmental impact on conventional plant [1]. The integration of wind energy into existing power system presents technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network. The issue of power quality is of great importance to the wind turbine [2]. There has been an extensive growth and quick development in the exploitation of wind energy in recent years. The individual units can be of large capacity up to 2 MW, feeding into distribution network, particularly with customers connected in close proximity [3]. Today, more than 28 000 wind generating turbines are successfully operating all over the world. In the fixed-speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc [4-5].

However the wind generator introduces disturbances into the distribution network. One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected [6-7]. STATCOM can be effectively utilized to regulate voltage for one large rating motor or for a series of small induction motors starting simultaneously. Thyristor based svc loads draw large starting currents (5- 6times) of the full rated current and may affect working of sensitive loads. Thyristor based systems were initially proposed for reactive power compensation and were used for voltage flicker reduction due to arc furnace loads. However, due to disadvantages of passive devices such as large size, fixed compensation, possibility of resonance etc., the use of new compensators such as STATCOM is growing to solve power quality problems. The use of STATCOM for solving power quality problems due to voltage sags, flickers, swell etc has been suggested. The purpose of STATCOM is to provide efficient voltage regulation during short duration of thyristor based svcstarting and thus prevent large voltage dips [8-9].

II. MAIN CIRCUIT TOPOLOGY OF THE NEW GRID CONNECTED WIND POWER SYSTEM

Fig1 shows the main circuit topology of the grid connected wind power system. From this, it can be seen that it is a 50 MW wind farm composed of 25 double-fed induction generators (DFIGs), and each DFIG has a rating of 2 MW.

Each wind turbine is connected to the wind farm internal 35 kV cable network via a 2.2 MVA, 0.69/35 kV transformer. The wind farm is connected to the power grid by means of a new grid-connected transformer, which has the grid winding, the secondary winding and the filtering winding, respectively. The FT branches and STATCOM are connected to the filtering winding of the new grid-connected transformer. The point of common coupling (PCC) voltage should be regulatedeach DFIG has a rating of 2 MW. Each wind turbine is connected to the wind farm internal 35 kV cable network via a 2.2 MVA, 0.69/35 kV transformer. The wind farm is connected to the power grid by means of a new grid-connected transformer, which has the grid winding, the secondary winding and the filtering winding, respectively. The FT branches and STATCOM are connected to the filtering winding of the new grid-connected transformer. The point of common coupling (PCC) voltage should be regulated at the 110 kV.

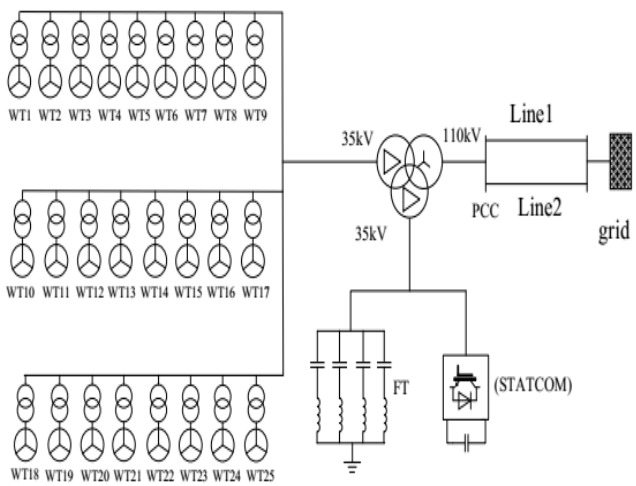

Fig.1. Main circuit topology of the grid connected wind power system.

III. HARMONIC MODEL AND EQUIVALENT CIRCUIT MODEL

To study the filtering mechanism of the inductive method, the single-phase equivalent circuit model of the new grid connected transformer is established as shown in Fig.2, in which, the VSC-based wind turbine generators can be regarded as the voltage source. The harmonic current in the grid winding, secondary winding and filtering winding are the I1n, I2n and I3n respectively. According to Fig.2, the equations of the harmonic current and voltage can be obtained: (1) Moreover, the magnetic-potential balance equation can be expressed as follows: (2) Where N1, N2, N3 are the numbers of turns of the grid winding, the secondary winding and the filtering winding respectively. Then, according to the theory of the multiwinding transformer, the voltage transfer equations can be obtained: (3) Where Z21n is the short-circuit impedance between the secondary winding and the primary winding; Z23n is the short-circuit impedance between the secondary winding and the filtering winding. They can be obtained by the transformer short-circuit test. Z2n is the equivalent impedance of the secondary winding and can be calculated by the short-circuit impedance, as shown in follows. (4) There are no harmonic current in the primary winding of the new grid connected transformer, thus we can obtain U1n≈0.

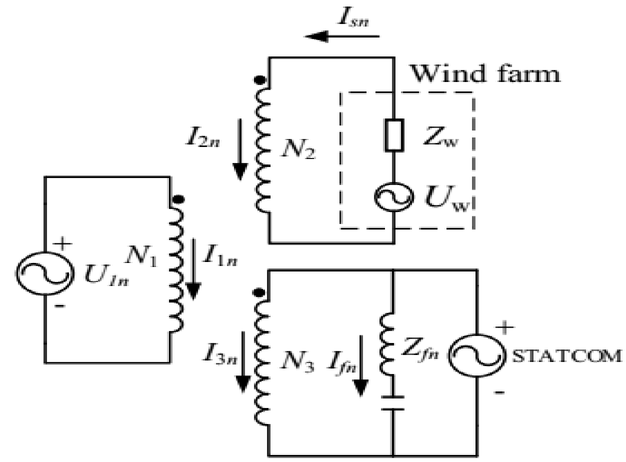

Fig.2. the single-phase equivalent-circuit model of the new grid connected transformer with FT branches.

According to the mathematic model, the current in the primary winding of the new grid connected transformer can be expressed as follows: (5) From equation (5), it can be seen that as long as the Z3n and Z fn approximately equal or equal zero, the condition of the inductive filtering method can be satisfied. Thereby, there is no or few harmonic current in the grid (primary) winding, which reveals the filtering mechanism of the new grid connected transformer and related FT branches. Moreover, the special impedance design of the new grid connected transformer can make the equivalent impedance of the filtering winding (Z3n) approximately equal zero.

IV. REACTIVE POWER COMPENSATION CHARACTERISTIC

Phasor Analysis In the new grid connected wind power system, FT branches and STATCOM can support voltage stability by compensating reactive power. According to the current distribution in the new grid connected transformer, as shown in Fig.3, we can obtain the phasor diagram of the secondary winding's voltage and current of the new grid connected transformer, as shown in Fig.4.

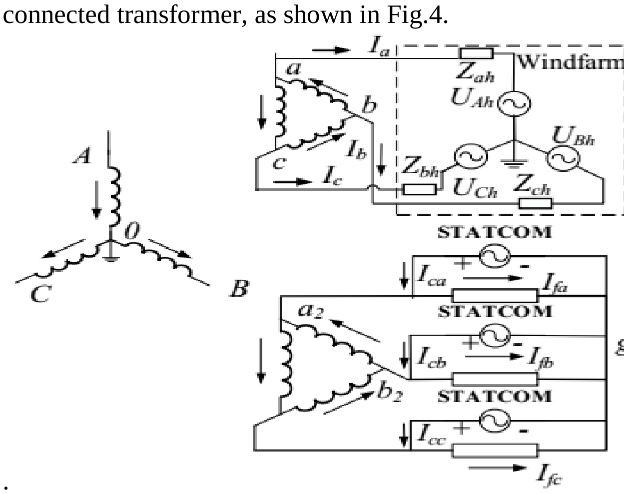

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Fig. 3. The current distribution of the new grid connected transformer.

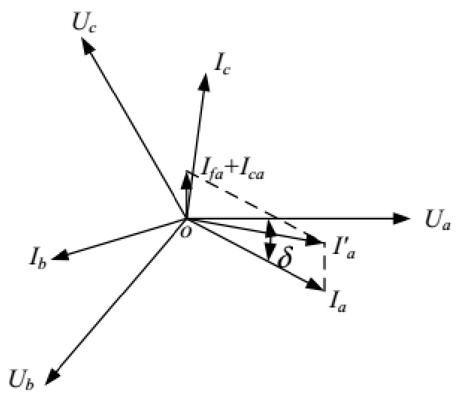

Fig.4 Phasor diagram of the voltage and current of the secondary winding.

Taking the A-phase winding in Fig.4 as an example, assume the secondary winding current Ia lags the phase of the secondary winding voltage Ua by δ. Since the impedance of the FT branches is capacitive for the fundamental, when we carry out the FT branches and STATCOM, the phase current of the FT branches will lead 90º to the secondary winding voltage Ua. In addition, the currents Ica that the STATCOM injected lags the phase of the secondary winding voltage UA by 90º, also. Thus, we can obtain that the angle of the loadside I′ a (with the inductive filtering method and STATCOM) lags the secondary winding voltage Ua is smaller than δ. Hence, it is known that the FT branches and STACOM have reactive power compensation ability in the secondary winding, which means the FT branches and STATCOM can improve the power quality of the wind farms. The system of home meter reading is composed of control terminal in distance, GPRS module and user metering module. Shown in Figure 2.

B. Control Scheme of STATCOM

The STATCOM and its controller are shown in Fig.5. It connects the filtering winding and can improve transient stability of power grid (Vac).

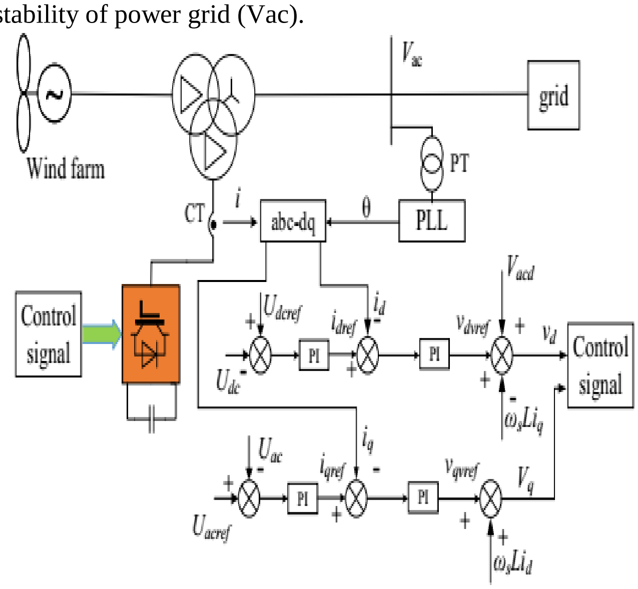

Fig.5. Schematic diagram of STATCOM controller.

The STATCOM regulate voltage of the grid winding of the new grid connected transformer by controlling the reactive power injected into or absorbed from the power grid. In the Fig.5, an outer regulation loop contains an ac voltage regulator and a dc voltage regulator, while an inner regulation loop contains a current regulator. The control signal of STATCOM (e.g. Vd, Vq) can be obtained by the regulator loop and they are usually used by the PWM module to generate the pulse signals to drive IGBT of the STATCOM. The objective of the STATCOM is primarily to keep the ac voltage constant. During the normal conditions, the grid voltage is stability and the reactive power flow from or to STATCOM is approximately zero. When the grid is under fault conditions, The STATCOM will inject amount of reactive power for the system instantly. Hence, this voltage control strategy reacts immediately to a sudden voltage variation and is well-suitable for fault condition operation in the grid connected wind power system.

V. STATIC VAR COMPENSATOR

A static VAR compensator is a set of electrical devices for providing fast-acting reactive power on high voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor, and harmonics and stabilizing the system. Unlike a synchronous condenser which is a rotating electrical machine, a static VAR compensator has no significant moving parts (other than internal switchgear). Prior to the invention of the SVC, power factor compensation was the preserve of large rotating machines such as synchronous condensers or switched capacitor banks. The SVC is an automated impedance matching device, designed tobring the system closer to unity power factor. SVCs are used in two main situations: Connected to the power system, to regulate the• transmission voltage ("Transmission SVC") Connected near large industrial loads, to improve power• quality ("Industrial SVC")bring the system closer to unity power factor. SVCs are used in two main situations: Connected to the power system, to regulate the• transmission voltage ("Transmission SVC")Connected near large industrial loads, to improve power• quality ("Industrial SVC").

In transmission applications, the SVC is used to regulate the grid voltage. If the power system's reactive load is capacitive (leading), the SVC will use reactors to consume VARs from the system, lowering the system voltage. Under inductive (lagging) conditions, the capacitor banks are automatically switched in, thus providing a higher system voltage. By connecting the thyristor-controlled reactor, which is continuously variable, along with a capacitor bank step, the net result is continuously variable leading or lagging power. In industrial applications, SVCs are typically placed near high and rapidly varying loads, such as arc furnaces, where they can smooth flicker voltage. Thyristor Controlled Reactor: In an electric power transmission system a tcr is a• reactance connected in series with a bidirectional thyristor valve The thyristor valve is phase controlled, which allows the• valve of delivered reactive power to be adjusted to meet varying system conditions. Thyristor controlled reactor can be used for limiting• voltage rises on highly loaded transmission lines. In parallel with series connected reactance and thyristor• valve there may also be a capacitor bank, which may be permanently connected or which may be mechanical or thyristor switching. This combination is called a static var compensator. Thyistor Switched Capacitor: A thyristor switched capacitor is a type of equipment• used for compensating reactive power in electrical power system It consists of a power capacitor connected in series with a• bidirectional thyristor valve and usually a current limiting inductor. The thyristor switched capacitor is an important• component of a svc where it is often used in conjunction with a thyristor controlled reactor.

VI. MATLAB/SIMULATION RESULTS

Simulation results of this paper is as shown in bellow Figs.6 to 15.

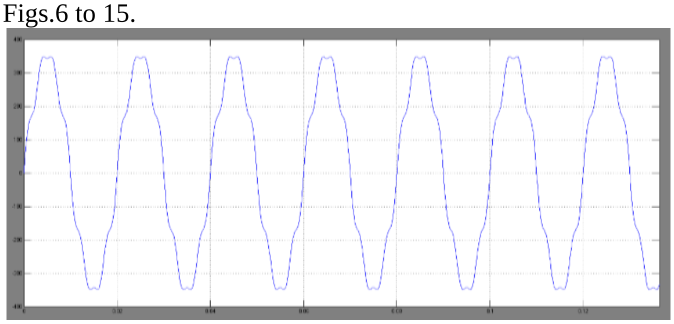

Fig.6. Current in the grid winding of the new grid-connected transformer without inductive filtering method.

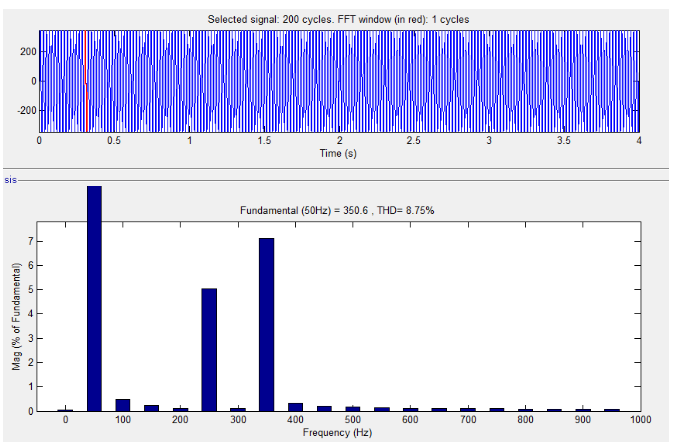

Fig.7. FFT results on the current waveform in the without filter.

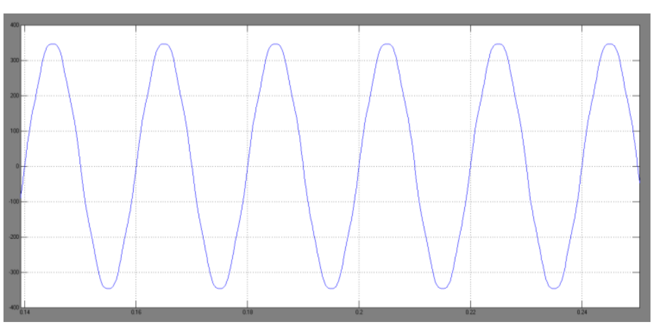

Fig.8. Current in the grid winding of the new grid-connected transformer with inductive filtering method.

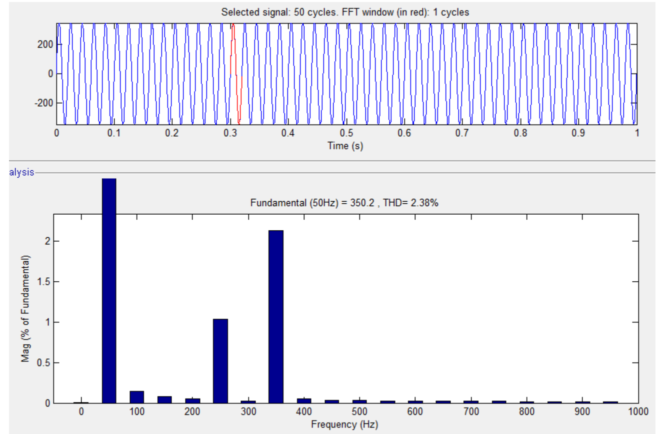

Fig.9. FFT results on the current waveform in the with filter.

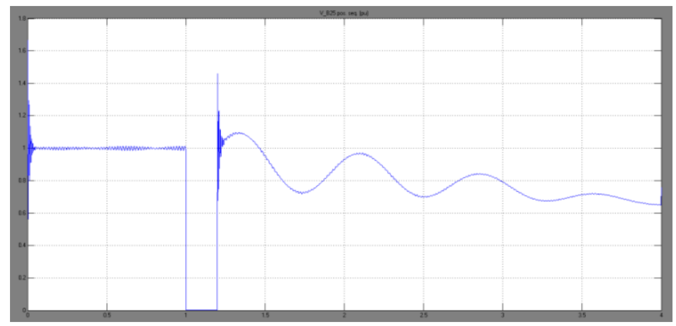

Fig. 10. Magnitudes of the voltage at the PCC without STATCOM.

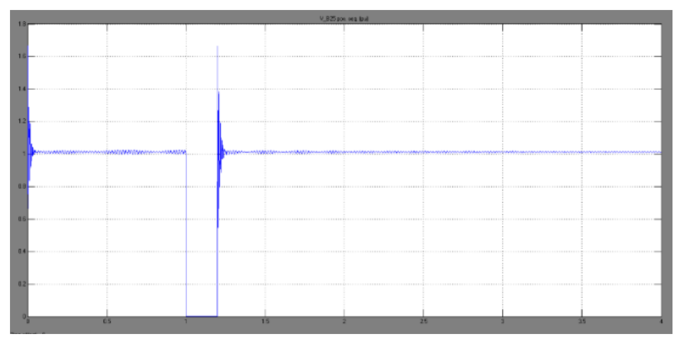

Fig. 11. Magnitudes of the voltage at the PCC with STATCOM.

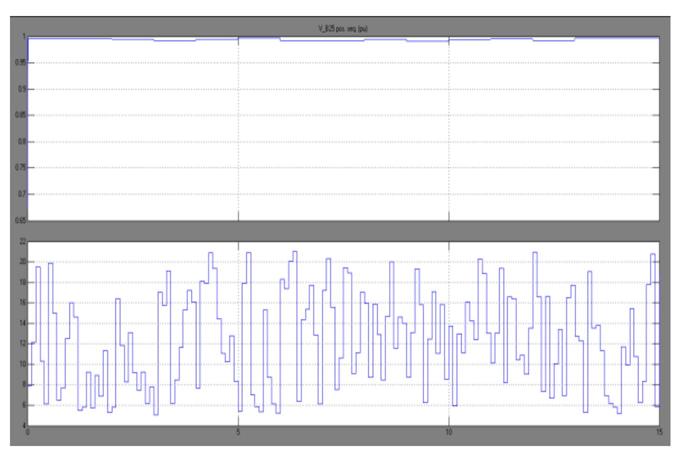

Fig. 12. Wind speed vs. time for the wind farm.

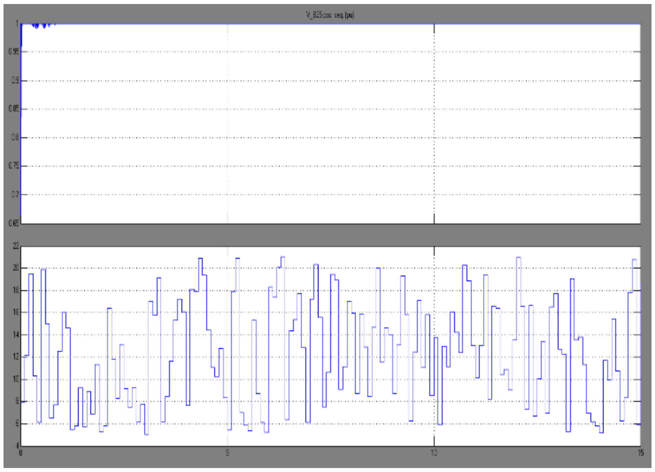

Fig. 13. Magnitudes of the voltage at the PCC.

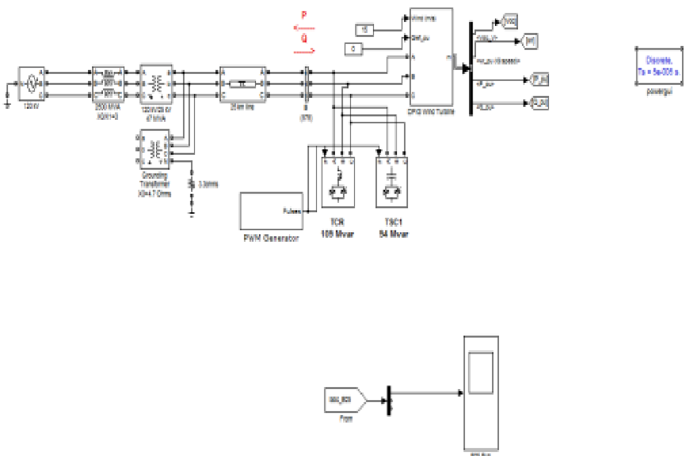

Fig.14.Matlab/Simulation model of Main circuit topology with thyristor svc.

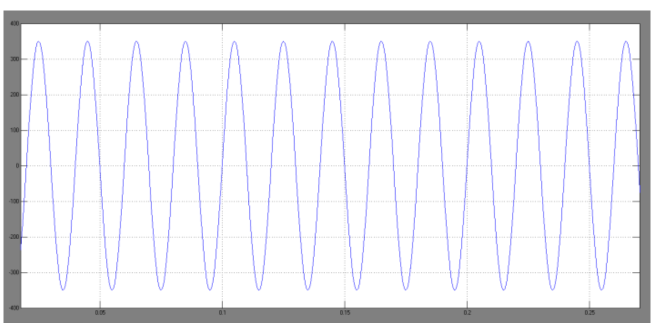

Fig.15.phase to phase voltage of inverter.

VII. CONCLUSION

A model of three phase source feeding motor loads has been developed using Simulink tool of standard MATLAB software. To proposed with thyristor svc extent of voltage dip with and without STATCOM controller. This dip is very large and it may affect the functioning of other sensitive equipment connected at PCC Model of STATCOM system applied in shunt configuration has been developed The STATCOM control utilizes two PI controllers for regulating DC link voltage and also the ac terminal voltage at PCC. The simulation results indicate that the new approach not only can significantly improve the filtering performance, but also effectively reduced the level of voltage fluctuation when the wind speed varies in a large range. Moreover, the new approach can successfully reestablished the PCC voltage in case of the grid fault, and therefore, enhanced the low-voltage ride through capability of the wind farm.

VIII. REFERENCES

[1] D. Dhungana and R. Karki, "Data constrained adequacy assessment for wind resource planning," IEEE Trans. Sustrain. Energy.,Vol 6, no. 1, pp: 219-227, Jan. 2015. [2] A. Haque, M. Nehrir and P. Mandal, "A hybrid intelligent model for deterministic and quantile regression approach for probability wind power forecasting" IEEE Trans. Power Syst.,Vol 29, no. 4, pp: 1663-1672, Jul. 2014. [3] M. Zugno, P. Pinson and H. Madsen, "Impact of wind power generation on european cross-border power flows," IEEE Trans. Power Syst.,Vol 28, no. 4, pp: 3566-3575, Nov. 2013. [4] L. Shun, Q. Hu and W. Lee, "A survey of harmonic emissions of a commercially operated wind farm," IEEE Trans. Ind. Appl.,Vol 48, no. 3, pp: 1115-1123, May. 2012. [5] C. Li, P. Zhan, J. Wen, M. Yao, N. Li and W. Lee "Offshore wind farm integration and frequency support control utilizing hybrid multi terminal HVDC transmission," IEEE Trans. Ind. Appl.,Vol 50, no. 4, pp: 2788-2797, Jul/Aug. 2014. [6] S. W. Mohod and M. Aware "A STATCOM-control scheme for grid connected wind energy system for power quality improvement," IEEE Trans. Syst. Journal.,Vol 4, no. 3, pp: 346-352, Sep. 2010. [7] W. Li and D. Truong, "Dynamic stability improvement of four parallel-operated PMSG-based offshore wind turbine generators fed to a power system using a STATCOM," IEEE Trans. Power. Del.,Vol 28, no. 1, pp: 111-118, Jun. 2013.

[8] K. Hasan, K. Rauma, A. Luna, J. Candela and P. Rodríguez, "Harmonic compensation analysis in offshore wind power plant using hybrid filters," IEEE Trans. Ind. Appl.,Vol 50, no. 3, pp: 2050-2060, May/Jun. 2014. [9] Y. Li, L. Luo, C. Rehtanz, D. Yang, S. Rüberg and F. Liu, "Harmonic transfer characteristics of a new HVDC system based on an inductive filtering method," IEEE Trans. Power. Elect.,Vol 27, no. 5, pp: 2273-2282, May. 2012.

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