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WIND TURBINE VOLTAGE STABILITY USING FACTS DEVICE

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***Abstract*—Most wind turbines use induction generator in general. Series of power quality problems arises when induction generator is used in power generation. Main power quality problem is voltage fluctuation which has to be reduced. This paper discusses the mathematical model of the cascade STATCOM and single phase equivalent circuit of the cascade STATCOM. Simulation results show that this method can effectively and quickly solve the voltage stability problem of the wind farm grid voltage stability, making full use of the wind energy resources, improving economic efficiency.**

***Index Terms*— Cascade STATCOM, Asynchronous generator model, Voltage stability.**

I. INTRODUCTION

Due to the choice of the wind energy systems, power generated in the wind farm when transmitted to the grid systems series of power quality issue arise mainly the voltage stability problem. In large wind power energy systems voltage stability is important. FACTS devices are used to compensate system reactive power and hence to maintain system voltage stability, wind farms only provide active power to the grid.

Cascade static synchronous compensator as a new type is widespread concern because of the advantages of without multiple access transformers, high efficiency, scalability, and ease of modular design, moreover it responses very fast during fault conditions, it can also be able to realize the dynamic compensation. Which in turn inhibit the voltage fluctuation and flicker. Under transient condition it is able to recover the system condition by supplying the required power and thus it supports required reactive power under transient condition, accelerated system recovery in case of the failure. Harmonics which is a great problem does not occur in cascade STATCOM which compensate harmonics and thus there is no harmonic pollution on the grid thereby the efficiency get increased, the cost required to run the system is also very less and small footprint, does not occur with system resonance which is secure and reliable.

This paper use cascade STATCOM to improve wind farm grid voltage stability which in turn is used to bring back the system back to the normal condition under critical circumstances.

II. ASYNCHRONOUS GENERATOR MODEL

For asynchronous generator model rotor motion equation is given as follows:

$$-T_j \frac{d\omega_r}{dt} = T_m - T_e$$

Where: T_j is the asynchronous generator inertial time constant; ω_r is the generator speed; T_m is the input mechanical torque; T_e is the generator electromagnetic torque.

III. CASCADE STATCOM

The basic topological structure of the cascade STATCOM is the single phase full bridge converter module. Since the modules are given with alternating current supply by connecting series connection of the each module AC's side to compose each phase converter valve group in order to reduce the harmonic content of the system.

IV. HARMONICS

Sinusoidal wave having frequencies that are integer multiples of the normal system frequency is said to be harmonics. If the normal frequency is 50 Hz then the harmonics will have the frequencies that are multiples of 50 Hz.

V. POWER CIRCUIT

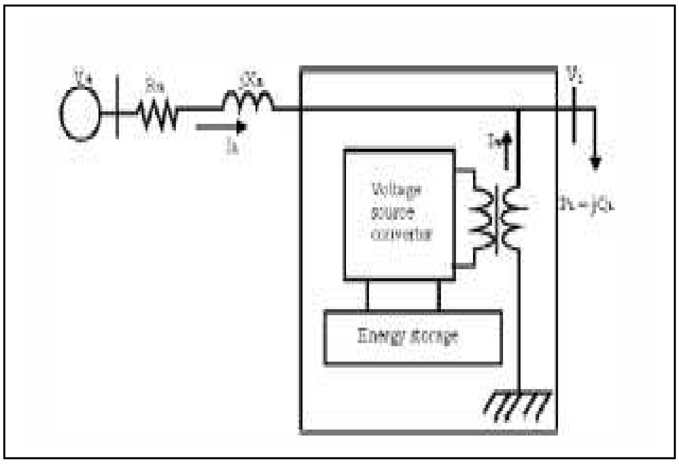

Fig. 1.Power circuit

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A STATCOM is a controlled reactive power source. It provides the desired reactive power generation and absorption entirely by means of electronic processing of the voltage and current waveforms in a voltage source converter (VSC).VSC is connected to a utility bus through magnetic coupling. Separate capacitor bank and shunt reactors are not needed for reactive power generation and absorption, thereby giving a STATCOM a compact design, or small footprint, as well as low noise. The exchange of reactive power between the converter and the ac system can be controlled by varying the amplitude of three phase output voltage,E_s of the converter .That is if the amplitude of the output voltage is increased above that of the utility bus voltage,E_t then the current flows from the converter to the ac system and the converter generates reactive power for the ac systems. If E_s is less than E_t then the current flows from the ac system to the converter and absorbs reactive power

VI. MULTILEVEL VSC BASED STATCOM

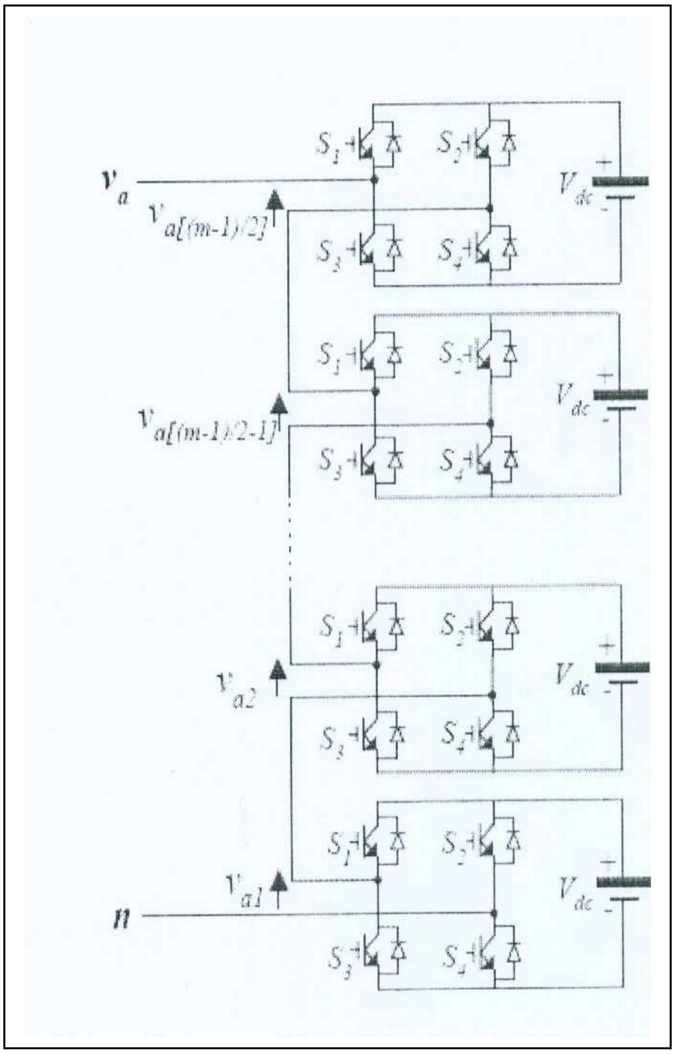


Fig2. Multilevel VSC based STATCOM

The harmonic contamination of the power system network can be reduced by employing multilevel VSC configuration. Multilevel converters usually synthesize a staircase type voltage waveform .Because of its structure that is by increasing the number of switches it reduces harmonic distortion. In three level VSI the switches are turned ON and OFF to generate a 15 step ac output voltage over one fundamental cycle. In general n-level VSI would produce $(2^{n+1}$-1) step ac output voltage.

VII. STATCOM STRUCTURE AND VOLTAGE CURRENT CHARACTERISTICS

The STATCOM has a characteristic similar to the synchronous condenser, but as an electronic device it has no inertia and is superior to the synchronous condenser in several ways, such as better dynamics, a lower investment cost and lower operating and maintenance costs.

A STATCOM is built with Thyristors with turn-off capability like GTO or today IGCT or with more and more IGBTs. The static line between the current limitations has a certain steepness determining the control characteristic for the voltage. The advantage of a STATCOM is that the reactive power provision is independent from the actual voltage on the connection point. This can be seen in the diagram for the maximum currents being independent of the voltage in comparison to the SVC. This means, that even during most severe contingencies, the STATCOM keeps its full capability. In the distributed energy sector the usage of Voltage Source Converters for grid interconnection is common practice today. The next step in STATCOM development is the combination with energy storages on the DC-side. The performance for power quality and balanced network operation can be improved much more with the combination of active and reactive power.

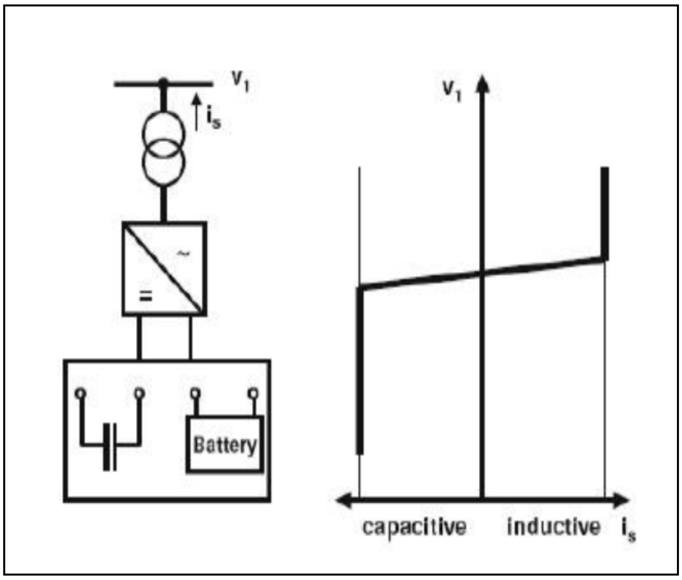


Fig.3. STATCOM V/I characteristics

VIII. MAIN CIRCUIT OF CASCADE STATCOM

Main circuit of the cascade STATCOM is shown below in which u_{sa}, u_{sb}, u_{sc} be the STATCOM voltage and u_{ca}, u_{cb}, u_{cc} be the output voltage, reactance is L and the resistance is R.

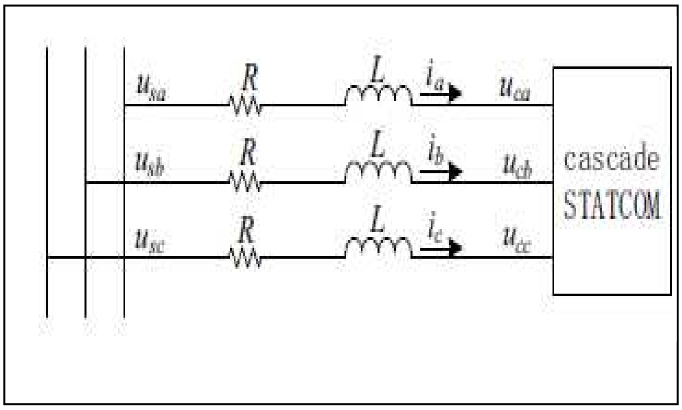


Fig.4.cascade STATCOM

In order to more effectively control the power, so that the reactive current having a better response characteristic, and requires the use of the Park transformation. DC side circuit equation can be derived based on the DC and AC side power balance, which can be obtained based on the cascade STATCOM mathematical model of the instantaneous power:

$$\frac{d}{dt}\begin{bmatrix} i_d \\ i_q \\ u_{dc} \end{bmatrix} = \begin{bmatrix} -\frac{R}{L} & \omega & -\frac{\sqrt{3}K}{\sqrt{2}L}\sin\delta \\ -\omega & -\frac{R}{L} & -\frac{\sqrt{3}K}{\sqrt{2}L}\cos\delta \\ \frac{\sqrt{3}K}{\sqrt{2}C}\sin\delta & \frac{\sqrt{3}K}{\sqrt{2}C}\cos\delta & 0 \end{bmatrix} \begin{bmatrix} i_d \\ i_q \\ u_{dc} \end{bmatrix} + \frac{1}{L}\begin{bmatrix} 0 \\ \sqrt{3}u_s \\ 0 \end{bmatrix}$$

Where:

K is the cascade STATCOM gain ratio; δ is cascade STATCOM output voltage and synchronizing signal sampling point the angle of the system voltage, ω is the rotational angular frequency of the d-q coordinate system, the same system voltage angular frequency; us is the instantaneous voltage effective value, u_{dc} is the sum of DC capacitor voltage .

IX. MAIN CIRCUIT

In this case generator of 110kv,mutual inductance,three phase transformer,transmission line with desierd frequency and length,three phase parrel RLC load,wind turbine generating wind power by the rotation of the wind blades at particular speed,STATCOM.etc are taken into consideration.

Since both generator and wind turbine is taken into account both generates power and transmits to the transmission line and the FACTS device specially STATCOM is introduced so that particular pulse is allowed,in this case harmonics is reduced and the system efficiency is increased,by increasing the number of switches the harmonics can be reduced but the switching cost gets increased and here in this case the number of switches are reduced and kept under control,fault is being introduced and the system performance is considered.

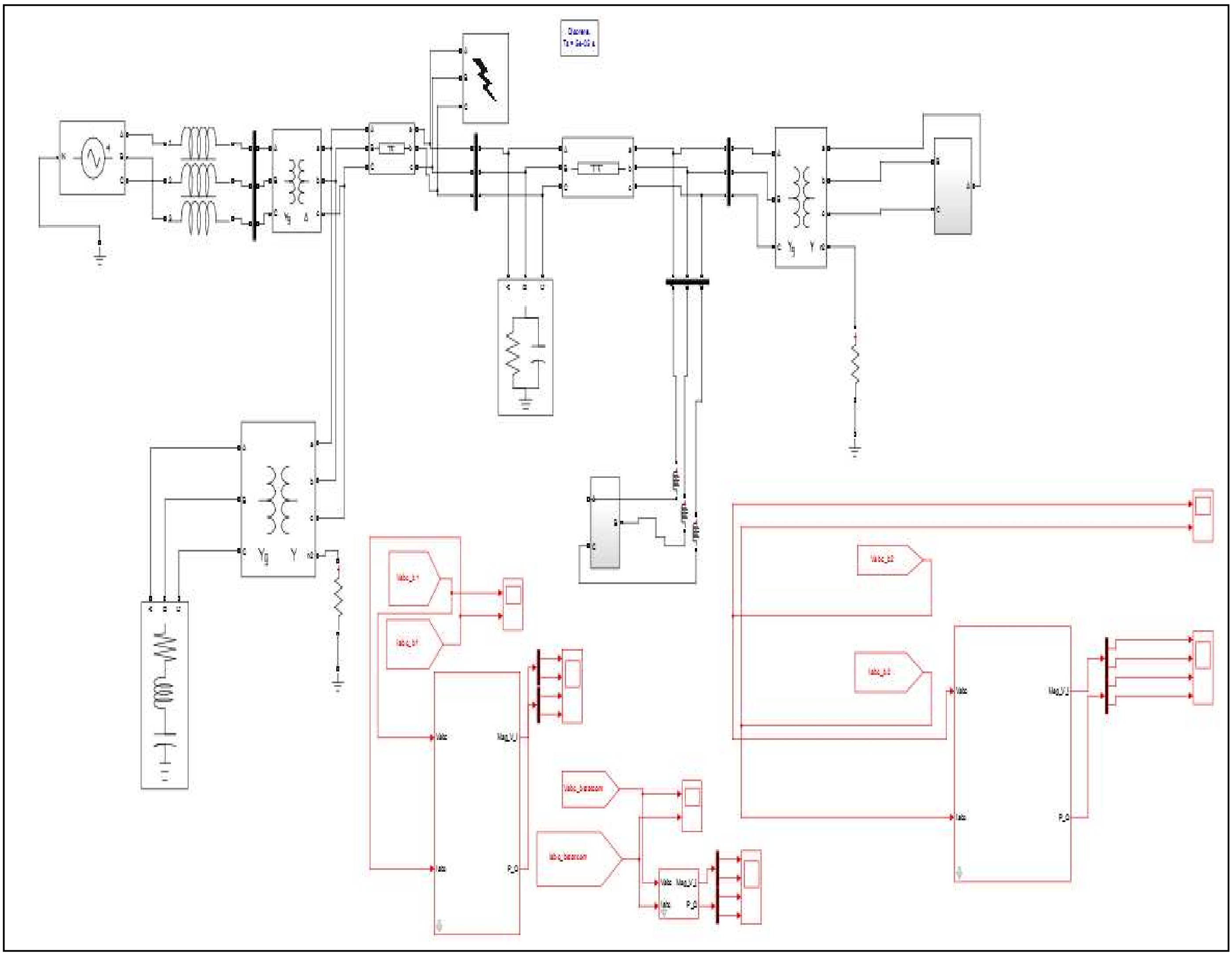
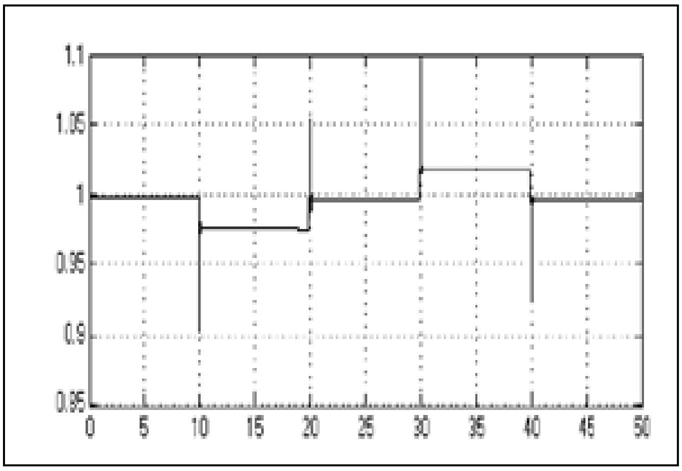


Fig.5. Main circuit

When the wind farm running in the rated conditions, studding wind speed is 14m/s the grid voltage fluctuations of the wind farm after adding cascade STATCOM. Grid voltage from 1.00pu fell to 0.90pu and restored to 1.00pu , By 1.00pu rise to 1.10pu, then restored to 1.00pu Analyzing 110kV bus bar, 25kv bus bar and wind farm export terminal voltage 600V bus voltage response curve.



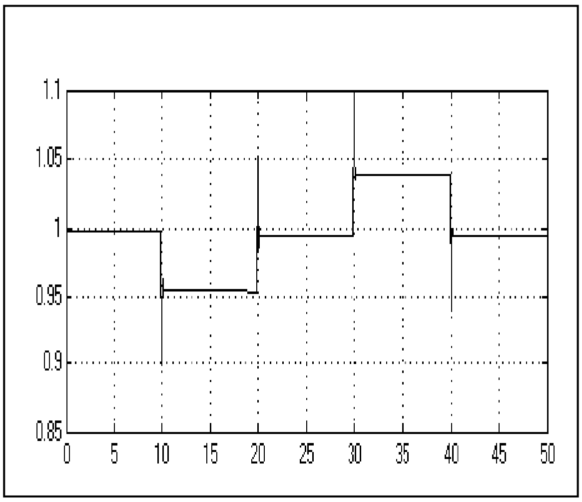


Fig.6. A 25kv bus voltage waveform

X. WIND TURBINE:

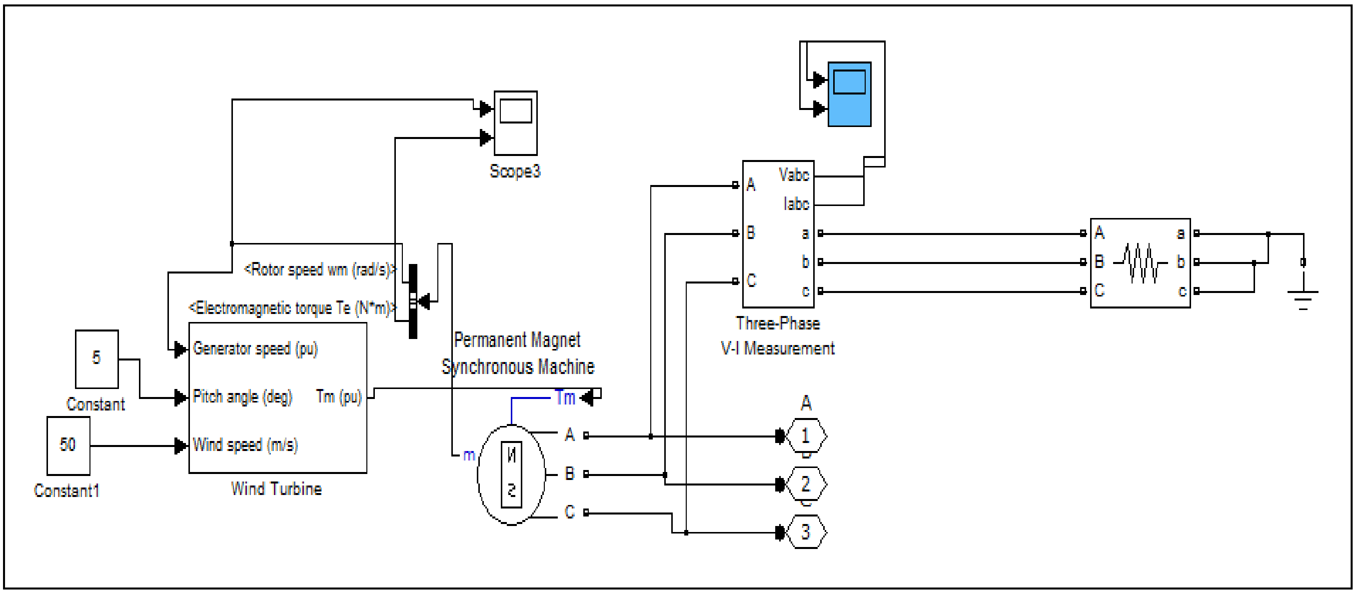


Fig7. Wind Turbine

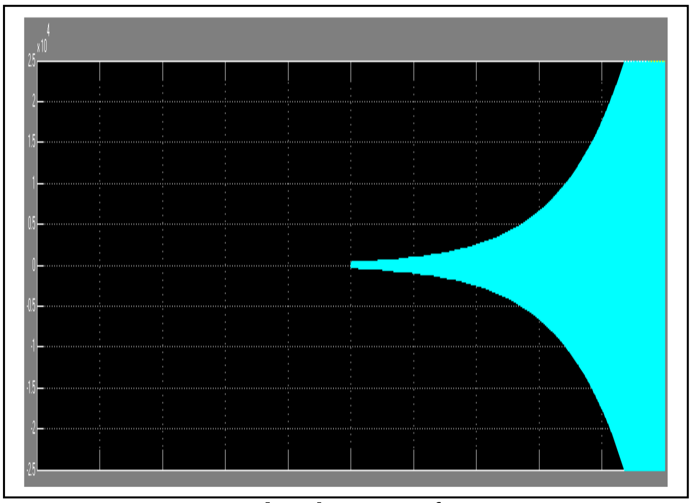


Fig8. Wind Turbine Waveform

XI. CONCLUSION

This paper established the cascade STATCOM containing wind power system with infinite grid model. The simulation results show that, cascade STATCOM plays a very significant role in maintaining wind power generation system voltage stability, due to its fast response characteristics, can meet the wind power industry low voltage ride-through capability of wind power quality requirements, will become the preferred device of wind power system reactive power compensation in the future.

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