Power Quality Improvement In Grid Connected Wind Energy System Supplying Nonlinear Load Using statcom

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Abstract *- The wind energy generation, utilization and its grid penetration in electrical grid are increasing worldwide as the fossils that we are using are almost on the verge of extinction. Moreover the domestic , industrial, commercial loads used nowadays are generally nonlinear in nature and thus affect the power quality. The objective of this paper is to analyze modern techniques used for mitigation of power quality issues that arise in grid connected wind energy system supplying a nonlinear load. STATCOM is used as a FACT device to mitigate these power quality issues. Sinusoidal pulse width modulation (SPWM) control strategy is used for generating switching signals for STATCOM. Multilevel inverter (MLI) is used as a voltage source inverter as it offers number of advantages compared to the conventional two level inverter. In this paper, an investigation on a fixed speed wind turbine squirrel cage induction generators connected to the grid that is supplying a nonlinear load in combination with a STATCOM is analyzed by simulation results.*

Keywords: *Cascade H bridge multilevel inverter, Grid , IG, SPWM , STATCOM.*

1. INTRODUCTION

The size of wind power plants has increased significantly since last three decades and it should grow even more. The need to integrate the renewable energy like wind energy into power system is to make it possible to minimize the environmental impact of conventional plant . The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network. This has brought new challenges to power system engineers, especially in the power quality field. Number of power quality issues arise on interconnection of wind generation system with grid that is already supplying a nonlinear load such as harmonic distortion, reactive power. One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. 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. A STATCOM based control technology has been proposed for improving the power quality which can technically manage the power level associates with the commercial wind turbines.

2. GRID CONNECTED WIND ENERGY GENERATION

Fig.1 shows grid connected wind generation. The induction generator is used as a wind generation in the proposed scheme because of its simplicity. The

available power of wind energy system is given by equation (1)

$$P_{mech} = \frac{1}{2}\rho A V^3_{wind} \qquad (1)$$

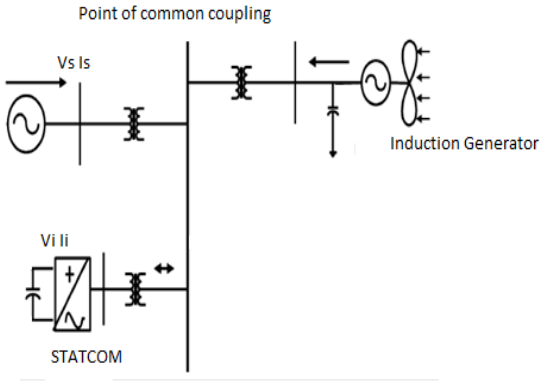

Fig.1 Grid connected wind energy system for power quality improvement

The STATCOM injects compensating current into the grid that will cancel out the reactive part and harmonic part of the load and induction generator current and thus improves the power factor and the power quality.

3. STATCOM

The Static Synchronous Compensator (STATCOM) is a shunt connected reactive compensation equipment which is capable of generating and/or absorbing reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system. The STATCOM basically consists of a step-down transformer with a leakage reactance, a three-phase GTO or IGBT voltage source inverter (VSI), and a DC capacitor.

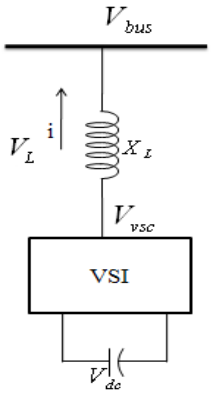

Fig.2 Static Synchronous Compensator

The current controlled voltage source inverter based STATCOM injects the current into the grid in such a way that the source current (grid current) are harmonic free and they are in phase-angle with respect to source voltage. The injected current will cancel out the reactive part and harmonic part of the induction generator current and load current, thus it improves the power quality.

4. SINUSOIDAL PULSE WIDTH MODULATION

Sinusoidal Pulse Width Modulation (SPWM) is most widely used PWM technique it can directly control the inverter output voltage. In SPWM technique a a sequence of voltage pulses can be generated by comparing the sinusoidal waves with the triangular wave. The carrier triangular wave is usually a high frequency (in several KHz) wave. Depending on whether the signal amplitude is larger or smaller than the carrier waveform, either the positive or negative dc bus voltage is applied at the output.When the modulating signal is a sinusoidal of amplitude Am, and the amplitude of the triangular carrier is Ac, the ratio m=Am/Ac is known as the modulation index. Controlling the modulation index controls the amplitude of the applied output voltage. With a sufficiently high carrier frequency, the high frequency components do not propagate significantly in the ac network (or

load) due the presence of the inductive elements. However, a higher carrier frequency does result in a larger number of switching per cycle and hence in an increased power loss.

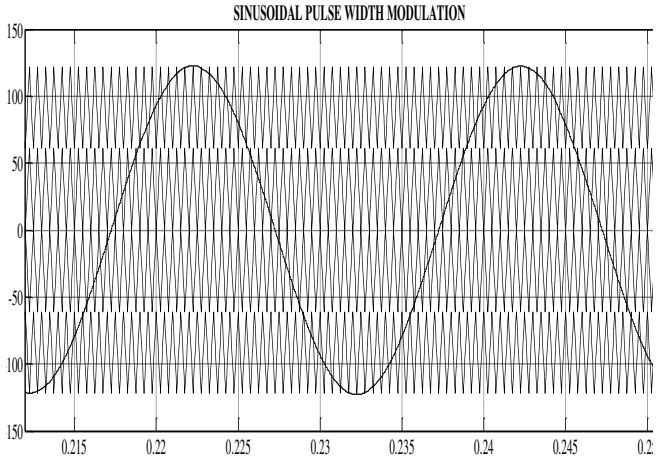

Fig. 3 Sinusoidal Pulse Width Modulation

5. CASCADE H BRIDGE MULTILEVEL INVERTER

Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The most common MLI topologies classified into three types are Diode clamped MLI (DC-MLI), flying capacitor MLI (FC-MLI), and cascaded H-Bridge MLI (CHB-MLI). Among the three types of multilevel inverters, the cascade inverter has the least components for a given number of levels. Cascade multilevel inverters consists of a series of H-bridge cells to synthesize a desired voltage from several separate DC sources (SDCSs) which may be obtained from batteries or fuel cells.

With its modularity and flexibility, the CMI shows superiority in high-power applications, especially shunt and series connected FACTS controllers. The CMI synthesizes its output nearly sinusoidal voltage waveforms by combining many isolated voltage levels. By adding more H-bridge converters, the amount of VAR can simply increased without redesign the power stage. In cascade H bridge inverter the H bridges are cascaded in every phase. With increase in H bridges in a phase the output waveform tends to be more sinusoidal. In N level topology (N-1)/2 identical bridges are used in every phase. Therefore five level topology consist of two identical H bridges in each phase. There must be separate DC source for the DC bus of every individual H bridge.

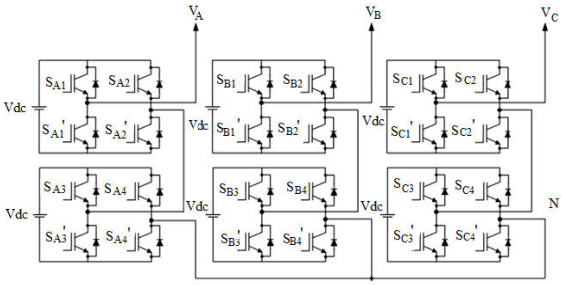

Fig. 4 Five level cascade H bridge inverter

Table 6.3 Switching States of Five level Cascaded Multilevel Inverter

Output (Vo)	S_{A1}	S_{A1}'	S_{A2}	S_{A2}'	S_{A3}	S_{A3}'	S_{A4}	S_{A4}'
+2Vdc	1	0	0	1	1	0	0	1
+Vdc	1	0	0	1	0	0	0	0
0	0	1	0	1	0	1	0	1
-Vdc	0	1	1	0	0	0	0	0
-2Vdc	0	1	1	0	0	1	1	0

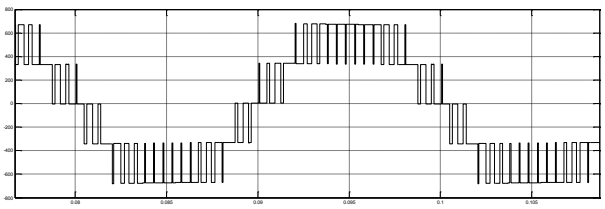

Fig.5 STATCOM output voltage for five level CHB inverter

6. SIMULATION RESULTS :-

A 415 volt system is connected to 3.35 KVA ,415 volt Induction Generator and is supplying a nonlinear load of 25 KW.The simulation results are observed after connecting statcom to the system.

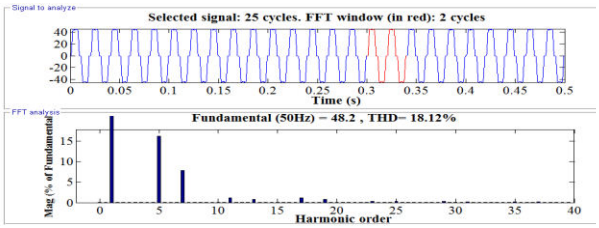

Fig.6 Simulation result of grid current THD without statcom

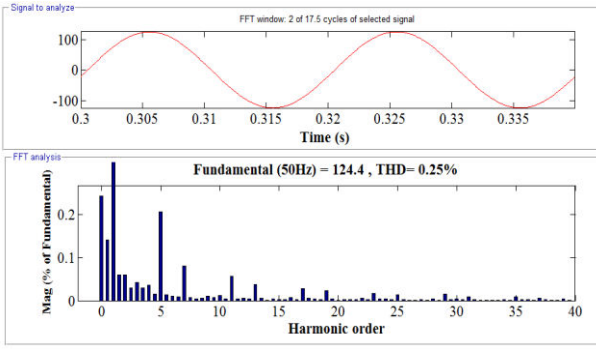

Fig.7 Simulation result of grid current THD using five level CHB inverter statcom

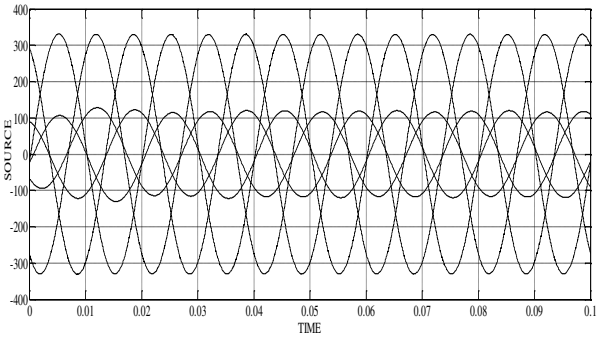

Fig.8 Source current and voltage on connection of five level CHB inverter statcom

7. CONCLUSION

In this paper a multilevel inverter based statcom control scheme is developed in MATLAB/ SIMULINK. It has a capability to cancel out the harmonic parts of the load current as well as support the reactive power demand for the wind generator and load in the grid system and thus supply source gets relieved. Also connection of statcom to grid connected system maintains source voltage and current in-phase. Thus connection of statcom results in improvement of power quality.

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