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Interfacing Wind Energy to Grid with Load Compensation by Cascaded Hybrid Multilevel Inverters (Chmli)

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Abstract: **-- Variable wind conditions necessitate the use of a variable speed wind turbine (VSWT) with a AC/DC/AC converter scheme in order to harvest the maximum power from the wind and to decouple the synchronous generator voltage and frequency from the grid voltage and frequency. In this paper, a combination of a three phase diode bridge rectifier (DBR) and a modified topology of the cascaded hybrid multilevel inverter (CHMLI) have been considered as an AC/DC/AC converter. A control strategy has been proposed for the CHMLI to achieve the objective of grid interface of a wind power system together with local load compensation. A novel fixed frequency current control method is proposed for the CHMLI based on the level shifted multi carrier PWM for achieving the required control objectives with equal and uniform switching frequency operation for better control and thermal management with the modified CHMLI. The condition of the controller gain is derived to ensure the operation of the CHMLI at the fixed frequency of the carrier. The converter current injected into the distribution grid is controlled in accordance with the wind power availability. In addition, load compensation is performed as an added facility in order to free the source currents being fed from the grid of harmonic distortion, unbalance and a low power factor even though the load may be unbalanced, non-linear and of a poor power factor. The results are validated using MATLAB simulation studies.**

I. INTRODUCTION

The proportion of distributed generation (DG) in modern electric power systems is steadily increasing in several countries. Wind generation is a renewable source and it is an important component of DG which has traditionally been used for energy conversion and is more recently being harnessed for grid support functions as well [1]. Different classes of power converters have been proposed for the integration of renewable energy resources into the distribution grid [2]. Multilevel inverters have been the preferred option for the high power applications in industrial drives for many years and more recently in wind power generation systems due to the fact that they can transfer high power using matured power semiconductor technology with reduced voltage stress on semiconductor switches, better waveforms and a lower THD. The major problems faced by wind generation systems in general are variations in available power due to varying wind speeds and variations in the frequency and voltage of the generator output when synchronous generators are used with variable speed wind turbines (VSWT). To address these problems, an AC/DC/AC system is used to decouple the generator frequency and voltage from the grid frequency and voltage. In this system the power output of the synchronous generator is first rectified to DC and then a DC-AC power converter interface with the grid with a constant voltage and frequency operation. Thus, there are two converters in use in such a scheme; a machine side converter which converts the AC to DC and a grid side converter which interfaces with the grid at an appropriate frequency and voltage. In addition, it power wind generation systems involving either a single high power wind generator or a pool of power available from a wind farm, the rating of the converter should match the maximum power transferred from the wind generation system. In this paper a three phase diode bridge rectifier (DBR) is used as a machine side converter, which is readily available in the range of the required high power ratings. However, the major problem lies with a grid side converter that requires controllable switches having large voltage and power ratings. In this paper a diode clamped multilevel inverter (CHMLI) has been considered as the grid side converter. The CHMLI is operated as a voltage source inverter (VSI) in the current control (CC) mode in order to inject a current according to the maximum available power from the wind turbine under the prevalent wind conditions. It also provides load compensation for local loads at the point of common coupling (PCC). The added duty of providing local load compensation necessitates a converter rating that is larger than the generator. Depending upon the rating of the CHMLI, it is capable of partly or fully compensating the load currents so that the source (grid) currents drawn

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are pure sinusoids, balanced and in phase with the PCC voltages.

II. LITERATURE SURVEY:

[1] Wind energy conversion systems as active filters: design and comparison of three control methods.

[2] Power ramp rate control and flicker mitigation for directly connected wind turbines.

[3] A novel type of combined multilevel converter topologies.

[4] Control schemes for equalization of capacitor voltages in neutral clamped shunt compensator.

[5]Control schemes for DC capacitor voltages equalization in diode-clamped multilevel inverter-based DSTATCOM.

III. METHODOLOGY:

3.1 Existing Proposed Control Scheme For Dcmli:

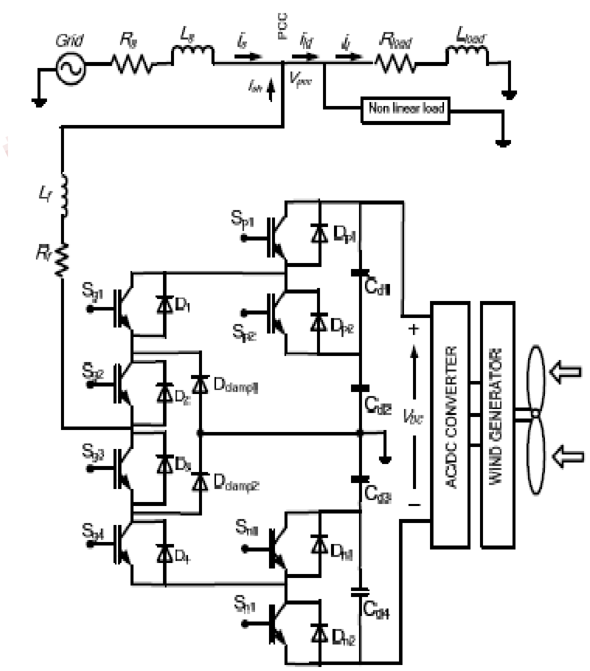

Fig 1. Block diagram (shown only for single phase) of the wind generation system connected to grid through a modified DCMLI.

A VSI is capable of operating in either voltage or current control mode. If one is used in current control mode it can also compensate the load currents so that the source currents are sinusoidal, balanced and have the specified phase angle with respect to the PCC voltage, which improves the power factor at the PCC, irrespective of unbalancing, a low power factor and harmonic distortion of the load currents. The dc link of the VSI is fed from the output of the uncontrolled diode bridge rectifier connected to the synchronous generator. Fig. 1 shows the proposed wind generation system interfaced with the grid through a modified DCMLI [3]. It is assumed that the load is reactive, which deteriorates the power factor and has harmonic components due to the presence of nonlinear loads and/or may be unbalanced. The output terminal voltage of the synchronous generator usually has a variable magnitude and frequency due to wind speed variations. However, in the present case the terminal voltage is held constant due to the excitation controller which keeps the dc link voltage constant over the normal speed and load range. The VSI is required to inject current according to the available wind power and provide the required compensation at the PCC. As the power levels of individual wind turbines increase and cross into the multi-megawatt range, the converter technology also needs to be improved to handle the increased thermal stress. It is becoming increasingly clear that the current practice of having low voltage two level converters and then stepping up the voltage in order to interface with medium voltage (MV) grids will not suffice. MV inverters are fast emerging alternatives and have been around in drives applications for several years. Instead of using several devices in series and parallel to handle the increased voltage and current stress, multi level converters offer the advantages of reductions in voltage stress, THD and current stress at medium voltage for the same power. For medium voltage distribution systems, it is desired that multi-level inverters (MLI) be used as grid side converters since they offer the promise of interfacing wind energy conversion systems (WECS) directly to the grid without the bulky and costly transformers which are being placed at the tower bases in current designs. As pointed out earlier in this paper, because of its advantages over the other topologies for wind energy conversion systems (WECS), a DCMLI has been used in this paper for grid connection of the wind turbine generator. The DCMLI injects current in such a way that the harmonics and reactive power component of the current are supplied by the shunt connected DCMLI thus relieving the grid of the need to supply these components. As a result the grid current drawn is sinusoidal and balanced and in phase with the PCC voltage. In low wind conditions the main ac source, i.e., the grid, supplies the bulk of the power required by the load and a small part of the load power may be supplied by the wind turbine. When the wind power availability is good the operating strategy is to inject as much of the wind power as possible to the PCC, so that all or a major component of the load is supplied by wind power and the import from the grid is reduced. Thus, the DCMLI controls the power flow according to the wind power availability so as to inject the maximum amount of power into the PCC. During times when the load is more than the capacity of the wind generator, the load can be shared by both the turbine and the main source (grid).

3.2 Proposed Control Scheme For Chmli:

A n-level DCMLI helps in reducing the device voltage stress by a factor of 2/(n-1) times the required net DC link voltage. The total number of semiconductor switches required per phase is 2(n-1). However, the total number of clamping diodes is 2 for a 5 level modified CHMLI compared with the 12 diodes required per phase for a conventional CHMLI [3]. The use of level shifted unipolar PWM results in the harmonic spectrum of the output voltage to lie at the carrier frequency and the sidebands are shifted from this center in multiples of the fundamental frequency. The switching harmonics amplitude is also reduced by a factor of 1/(n-1) in the output voltage. The ripples are thus reduced to a great extent and smooth modulation is possible at a fixed switching frequency. For a n-level CHMLI, (n-1) carriers are required.

The carrier frequency used in this paper is 5.0 kHz. Hence, on average each switch operates at 5.0 kHz/(n-1) = 1.25 kHz for n = 5. The tools will be using for results and validations MATLAB-SIMULINK Software.

IV. CONCLUSION:

A Cascaded Hybrid multilevel inverter is well suited for the current control of a CHMLI used as the grid interface of a higher power rated wind energy conversion system, since it has only a single dc source. The proposed fixed switching frequency control leads to an equal and uniform distribution of the switching stress among the various switches. It is shown that following the proposed gain calculation method ensures the operation of the CHMLI at the fixed frequency of the carrier. With the multicarrier level shifted current control, the net switching frequency increases and the ripple magnitude is reduced leading to a higher feed forward gain and hence better control characteristics. It is shown through simulation results that the available wind power can be controlled to feed the load real power with the balance real power being supplied from the grid. In addition to real power injection, the objective of load compensation is also achieved leading to a balanced, distortion free, and unity power factor source current. The voltages across the capacitors of the CHMLI remain balanced under all conditions with the proposed control method.

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