

## **Applications of Multilevel Inverter in Grid Connected PMSG Based Wind Power Generation System**

**Lokesh Kumar<sup>1</sup> and Md Abul Hasnat<sup>2</sup>**

*<sup>1</sup>Subharti University Meerut*

*<sup>2</sup>IEEE Student Member, MNNIT Allahabad*

### **Abstract**

Wind is one of the most abundant renewable sources of energy in nature. Wind energy can be harnessed by a wind energy conversion system (WECS) composed of a wind turbine, an electric generator, a power electronic converter and the corresponding control system. The most advanced generator type is perhaps the permanent magnet synchronous generator (PMSG). As far as microgrid is concerned the loads may be unbalanced and non-linear in nature. Hence, microgrid should not inject harmonic and unbalanced currents into the grid. Harmonic currents and negative sequence currents (due to unbalance) will unnecessarily increase the line currents flowing between microgrid and grid. These problems are solved by using effective controllers with multilevel inverters. In this paper, the technology of the high voltage and high power three level converters are applied to the grid connected PMSG system. Effective MATLAB/Simulink based simulation results are presented.

**Key word:** WECS, PMSG, Voltage Source inverter, DC-DC Converter, Diode rectifier

### **1.Introduction**

The continuously increasing energy demand, along with the necessity of higher reliability requirements, are driving the modern power systems towards distributed generation (DG) as an alternative source. Wind turbines, Fuel cells (FC), Photovoltaic (PV), Batteries, etc. are nowadays the most common available DGs for generation of power mostly in peak times or in rural area. Microgrids are combinations of DGs and load. To deliver high quality and reliable power, the microgrid should appear as a single controllable unit that responds to changes in the system.

Microgrids should preferably tie to the utility grid so that any surplus energy generated within them can be channelled to the grid. Similarly, any shortfall can be replenished from the grid.

As far as microgrid is concerned the loads may be unbalanced and non-linear in nature. Hence, microgrid should not inject harmonic and unbalanced currents into the grid. Harmonic currents and negative sequence currents (due to unbalance) will unnecessarily increase the line currents flowing between microgrid and grid. Generally, harmonics increase losses in ac power lines, transformers and rotating machines. The load imbalance cause oscillatory torque leading to mechanical stress and malfunctions in sensitive equipment.

Wind is one of the most abundant renewable sources of energy in nature. Wind energy can be harnessed by a wind energy conversion system (WECS) composed of a wind turbine, an electric generator, a power electronic converter and the corresponding control system. Based on the types of components used, different WECS structures can be realized to convert the wind energy at varying wind speeds to electric power at the grid frequency. The most advanced generator type is perhaps the permanent - magnet synchronous generator (PMSG). This machine offers, compared at the same power level and machine size, the best efficiency among all types of machines with high robustness and easy maintenance due to slipring - less and exciter - less features. The inherent benefit of permanent magnet which supplies rotor flux in synchronous machines without excitation loss supports the wind power generation development. This thus results in the increasing use of PMSG. With nominal power of wind turbines has been continually growing, Direct - drive wind turbines needs higher power converters to transform variable voltage amplitude and variable frequency power to constant voltage amplitude and constant frequency power. However, The existing switch device capacity value can't satisfy the demand of large power converter. So studying high power converter topology of direct drive wind power system and its control strategy has important theoretical and engineering value.

## **2. System description and control**

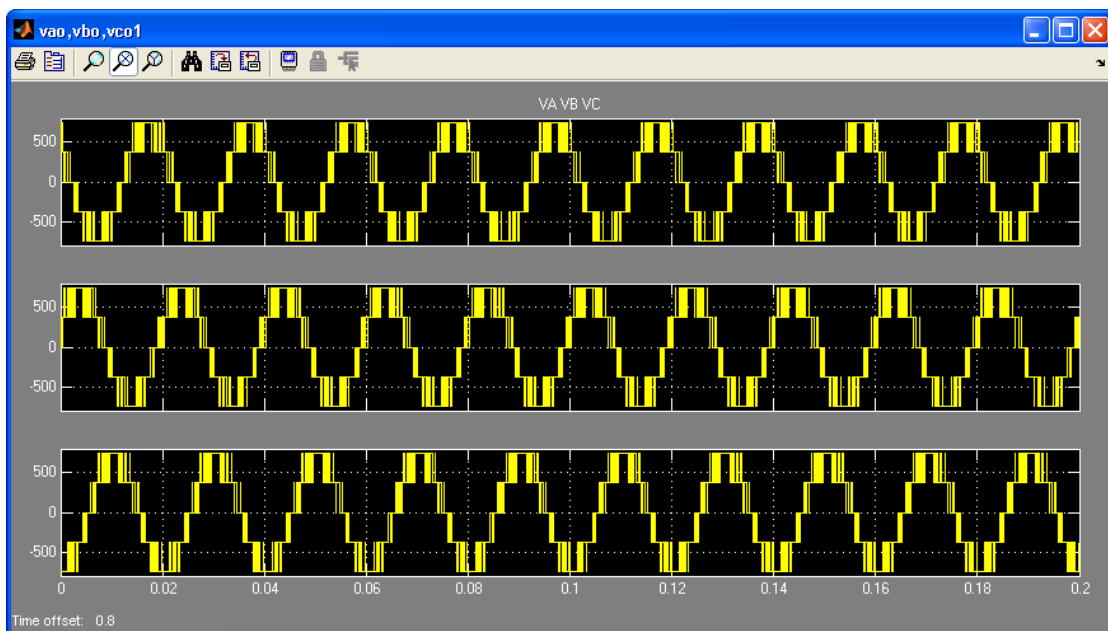
The technology of the high voltage and high power three level converters are applied to the system of direct drive wind power, and the converter structure is the dual three level with back - to - back structure. The generation - side converter guarantees the point tracking of the maximum power and the smooth operating of the generator through the double - loop control scheme of the maximum ratio of torque to current. The grid - side converter adopts the vector control of grid voltage orientation, realizing the decoupling control of the active and reactive power. Meanwhile, the constant DC power can be ensured and the working state of the converter can be maintained in a unity power factor state. The system as shown in Fig. 1 and control diagram as shown in Fig. 2.



Multilevel converters control output frequency and voltage including the phase angle providing a fast response and autonomous control. This paper adopts double three level back - to - back converter structure, that is to say, generator side and grid side converter adopt Neutral - point - clamped (NPC) three level topology. The maximum power tracking and generator stable operation can be realized by using the space voltage vector pulse width modulation and combining with double closed loop control. In this system, the design of a complete analytical model of the converters is very useful to easily develop a control strategy corresponding to a specific application of the multilevel converter.

### 3.Results and Discussions

The simulation results show that the use of the dual three level converter not only realizes the dynamic control of the system but also ensures the high quality of the electricity delivered to the grid. Output 3-phase line to line voltage of Grid side converter (before filter) as shown in Fig. 3. From Fig. 3, because of using 3-level inverter, the line to line voltages are having 5 levels.



**Fig. 3:** Line to Line voltage before filter

Now consider steep changes in wind speed from 12 to 9 and 9 to 12. During this time, wind generation decrease and again it increases. The corresponding PMSG currents are shown in Fig. 4. During these changes, proposed controller maintained dc-link voltage at its reference value as shown in Fig. 5. During this time our three level inverter is transferring generated power to grid and it as soon in Fig. 6. Our controller can maintain zero reactive power.

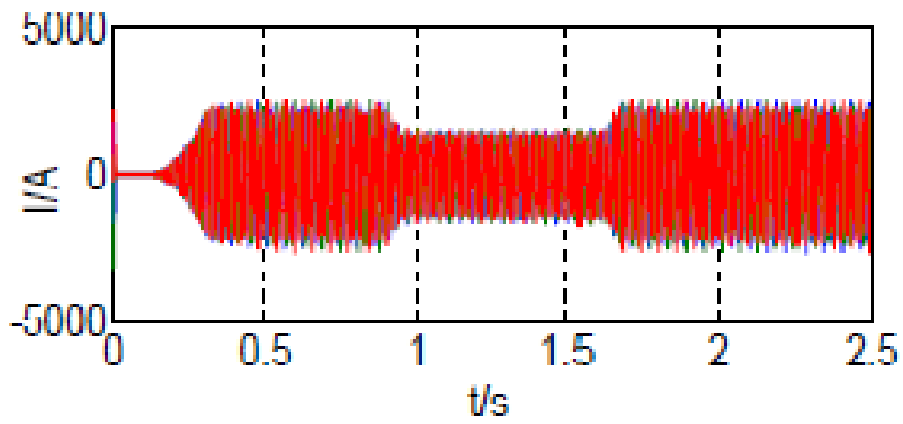


Fig. 4: PMSG output currents

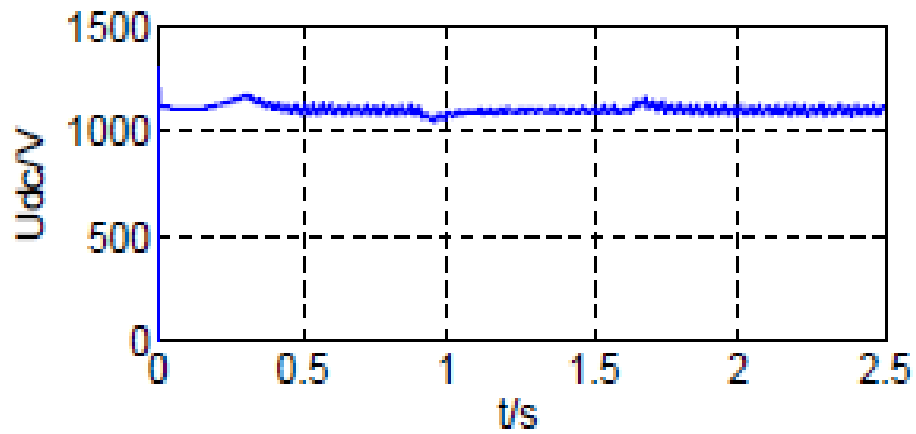


Fig. 5: Dc-link voltage

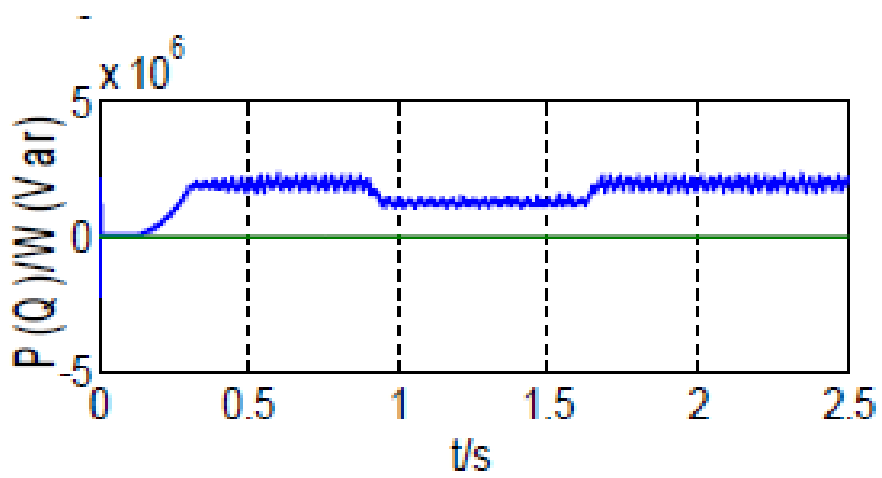


Fig. 6: Real and Reactive power transferred to grid via three level inverter.

## 5. Conclusions

Using Three - level NPC Converter, the whole system decreasing output harmonic effectively while improving power capacity of whole equipment, and reducing the voltage stress of switch and the equivalent switching frequency.

Simulations show that generator - side can realize the maximum wind power tracking, and makes the generator operate stably and efficiently by using double closed loop control based on maximum ratio of torque to current. The grid - side converter adopts the vector control of grid voltage orientation, realizing the decoupling control of the active and reactive power. while feed - in grid high quality electrical energy, it also improves the utilization of the whole system.

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