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MONITRING AND CONTROLLING THE VOLTAGE AND FREQUENCY IN PERMANENT MAGNET SYNCRONOUS GENERATOR USING SPARSE MATRIX CONVERTER

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Abstract

Owing to the drastic exploitation of non-renewable resources such as fossil fuel impart to the increase in need of power generation through renewable energy resources. So, power extraction from wind at an enormous quantity became a well perceived industry. The most commonly used generators in wind energy are Doubly Fed Induction Generator (DFIG) and Permanent Magnet Synchronous Generator (PMSG). In this proposed system, variable-speed wind power generation system using PMSG. In PMSG, required voltage induced is not enough to synchronize with the system at low wind speed. Also the variation in the wind speed makes the system more oscillatory. In order to make the system stable, Sparse Matrix Converter (SMC) is introduced. The practical application of variable speed large capacity generation system using Pulse Width Modulation (PWM) converter. Because, it can utilize the vector control and realize torque control. In this study, the voltage and the frequency of the system are taken into consideration. Results show the consistency of the proposed structure to control voltage and frequency when integrated to PMSG wind turbine based on Sparse Matrix Converter.

***Key Words*:**doubly fed induction generators (DFIGs), permanent magnet synchronous generators (PMSGs), Sparse Matrix Converter (SMC), Pulse Width Modulation (PWM).

1 Introduction

Wind energy will play a major role to meet the future energy target worldwide to minimize the dependency on fossil fuel and to reduce the adverse impact of climate change. Wind energy is the fastest growing generation technology among the renewable energy sources. Over the last decade, power generation by wind is drastically increased because the wind energy capacity is abundant and wind is an important competitor entrant to the traditional sources of energy. As the wind penetration increases, the structure and the dynamics of the power system network will change significantly over the coming decades. The replacement of traditional synchronous generators with power electronics converter based synchronous generators due to the intermittent nature of wind power. It will introduce special challenges in grid interconnections and bi-directional power control, high voltage fault ride through, satisfy grid code, system security, reliability and protection. The wind generator system using PMSG and diode bridge rectifier can constitute the low-cost converter. Most of distributed energy resources now use inverter, rectifier or other power electronics structures. Therefore the stability of these power systems and its analysis are complicated than before. By using the converter, torque control of PMSG cannot be carried out and thus the windmill speed control is difficult. Ultimately during the low wind speed, the induced voltage required for the system synchronization or interconnection is not obtained. Recently, the system using PMSG and diode rectifier which realized the windmill speed control and system interconnection is not reported. This paper proposes the controlling strategy of voltage and frequency by using the Sparse Matrix converters. The whole system including the wind turbine emulator, main circuit, power system and sparse matrix controllers are tested to verify the proposed system. In the experimental results, it is shown that the proposed system has the sufficient performances as variable speed wind power generation systems.However, in many papers, dc link capacitor considers as a disadvantage, which is heavy and bulky, increases the cost and decreases the overall lifetime of the system. Instead of back to back rectifier- inverter topology, Sparse matrix converters modeled in this study. The main advantages of using sparse matrix converter are inherent bidirectional power flow, sinusoidal input and output waveforms with moderate switching frequency, possibility of compact design. Sparse matrix converters are modified configurations from indirect matrix converter that used in this study. Compared with traditional converter, it has many advantages such as regeneration capacity, operation with unity power factor, sinusoidal input and output.

2 BLOCK DIAGRAM DESCRIPTION

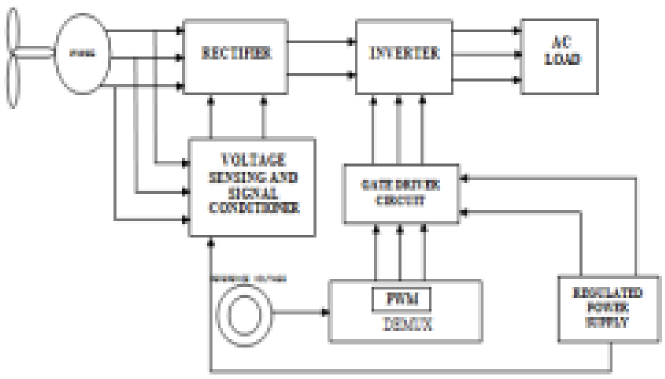

Figure 1 Block Diagram

A. Wind Power

Wind power converts the kinetic energy of the wind blade which is caused by the flow of air into electrical power with the help of wind turbines. To produce large quantity of electricity, a group of wind turbines are connected to the high voltage electric power transmission network in the same location is known as wind farm. In China, Gansu wind farm is the largest wind farm in the world with the capacity of about 6000MW. The cost of erection and installation of wind power may be high but it has no fuel cost and also it does not require much cost in running and maintenance when compared to other conventional power plant.On comparing with the environmental impacts of fossil fuels, wind power is relatively minor and it is more eco-friendly.

B. Proposed converter (SPARSE MATRIX converter)

Sparse Matrix Converteris one of the AC to AC convertor. It was invented by Prof. Johann W.Kolar in the year 2001. It avoids multi-step commutation procedure and offers reduced complexity modulation scheme because of less number of components and low realization effort.These are the difference between the conventional converter and Sparse Matrix converter.

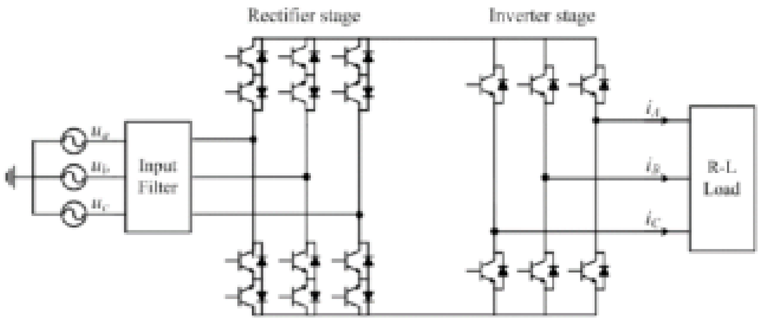

Figure 2 Proposed Converter

Figure 2 shows a simple circuit diagram of a SPARSE MATRIX converter, consisting of 18 Transistors and 18 Diodes. Compared to the direct matrix converterthis topology provides identical functionality, but with a reduced number of power switches and the option of employing an improved zero DC-link current commutation scheme, which provides lower control complexity and higher safety and reliability.

C. Rectifier stage control

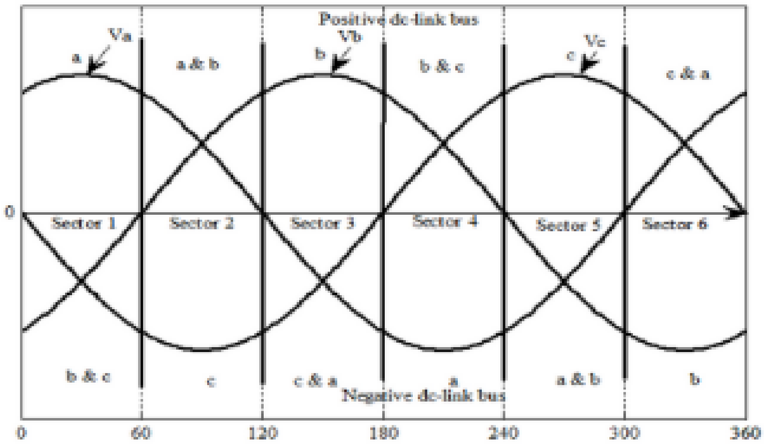

Figure 3 Modulation strategy of Rectifier stage.

Figure 3 shows the modulation strategy of the rectifier stage in the SMC. According to the phase angle with the difference of 60 degree, one complete cycle is divided into six sectors. Consider three phase voltage waveform. Each phase is denoted by a, b and c. In the region of 0 degree to 60 degree, a phase is in positive cycle while b and c are in negative cycle. So M2, M6 are in ON state and remaining switches in the rectifier stage are in OFF state. Similarly, the sector switches accordingly.

D. Inverter stage control

The pulse signals generated by PWM techniques are the switching signals to the inverter stage. The required pulse is generated by PWM sampling technique at the rate of 10 micro-second. In sampling, the difference between the reference and actual valve is taken into consideration. If the valve is positive, then it will be in ON state otherwise in OFF state.

3 WORKING OF BLOCK DIAGRAM

In this proposed system, Permanent Magnet Synchronous Generator (PMSG) is used as generator which is connected to the wind turbine. The voltage from the generator is sensed and processed by the voltage sensing and signal conditioner block. The conditioned output is fed as input to the rectifier. This rectifier section has six switches. The switching operation is based on three phase voltage waveform and divided into nine mode of switching states. Here, the ac voltage is converted into dc. Filter is used to reduce the distortion in the rectifier output. The reference voltage from the grid is fed into inverter controller circuit in which Pulse Width Modulation technique is used to convert desired pulsing signal. This pulse signal is given as input to the inverter through Gate Driver Circuit.

4 SIMULATION RESULT

Proposed simulation diagram for controlling frequency and voltage in PMSG by using SMC and the simulation result for the proposed method is analyzed with the MATLAB software. Simulation is analyzed for proposed method. The AC signal from the PMSG whose voltage and frequency is variable since the wind turbine rotates with respect to variable speed of the wind and this is fed as the input to the rectifier stage of the Sparse Matrix Converter. Inverter switching pulse is generated by the Pulse Width Modulation method by employing the sampling technique which is clearly explained in the working chapter. This modulated pulse is given as input to the inverter stage of the Sparse Matrix Converter. Three Phase Output Voltage and Current The output voltage and current to the proposed system is as shown in the following fig. 4.

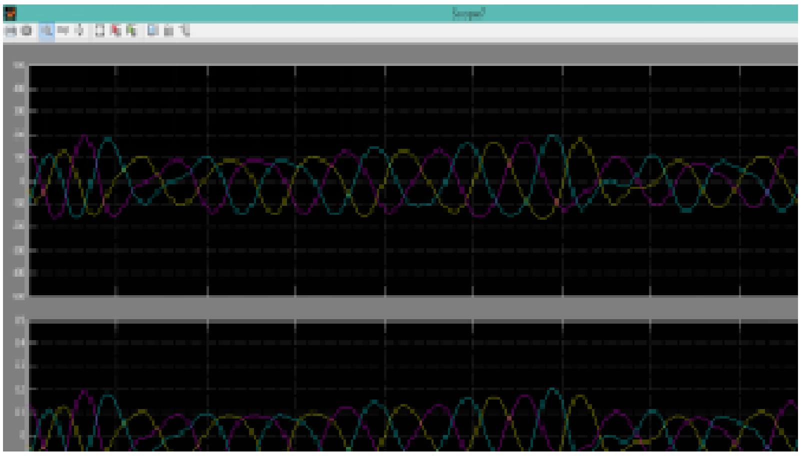

Figure 4 Three Phase Output Voltage and current

5 CONCLUSION

The aim of this study was to show the consistency of the proposed structure to control voltage and frequency when integrated to PMSG wind turbine based on Sparse Matrix Converter. With the changes in the wind speed, the generator output voltage and frequency is maintained constant with the implementation of SMC and also generated harmonics are considerably reduced when compared to existing model.

References

[1] BahmanKhaki, Mohammad Iman Bahari, S. EbrahimAfjei.DFIG Wind Turbines with Very Sparse and SparseMatrix Converters to control frequency. 8th Power Electronics, Drive Systems Technologies Conference, Feb. 2017.

[2] Mohamed Aner, Edwin Nowicki, David Wood. Employing a Very Sparse Matrix Converter for Improved Dynamics of Grid-Connected Variable Speed Small Wind Turbines.

[3] L. Huber, D. Borojevic. Space vector modulated three-phase to three phase matrix converter with input power factor correction. IEEE Transactions on Industry Applications, Nov. 1995.

[4] D. Casadei , G. Serra , A. Tani , L. Zarr. Matrix converter modulation strategies: a new general approach based on space-vector representation of the switch state. IEEE Transactions on Industrial Electronics, Apr. 2002.

[5] A. Alesina; M. G. B. Venturini. Analysis and design of optimum amplitude nine-switch direct AC-AC converters. IEEE Transactions on Power Electronics.

[6] Prasad, V.H. Analysis and Comparison of Space Vector ModulationSchemes For Three-Leg and Four-leg Voltage Source Inverters. Master Thesis, Electrical Engineering, Virginia Tech, May 15, 1997.

[7] K. B. Larsen, A. H. Jorgensen, L. Helle, F. Blaabjerg. Analysis ofsymmetrical pulse width modulation strategies for matrix converters. Power Electronics Specialists Conference, IEEE, 2002.

[8] Javier Vadillo , J. M. Echeverria , Miguel Martinez-Iturralde, Luis Fontan. Modeling and simulation of indirect space vector modulated matrix converter using MATLAB/Simulink. International Journal of Electronics by Taylor Francis, Jun 2009.

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