Performance Analysis of Sliding Mode Controller fed PMSG based Wind Energy Conversion System

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Abstract — This paper proposes a Sliding Mode Controller (SMC) for a variable speed, Permanent Magnet Synchronous Generator fed Wind Energy Conversion Systems (WECS) connected to a local load. The proposed control strategy is used to reduce chattering effect and to improve THD in comparison with conventional systems. In this work a five level inverter is used. The performance of the proposed control strategy is tested by MATLAB/Simulink for a 6 kW wind turbine.

Index Terms-WECS, PMSG, Five level inverter, Sliding Mode Controller (SMC)

I. INTRODUCTION:

Renewable Energy has been considered as a substitute energy source because conventional sources like coal, nuclear are limited and causes pollution problems. Renewable Energy integration in power system raises a lot of challenges in research [1]. The schematic diagram of proposed wind energy system is shown in Fig. 1. A direct-drive multi-pole permanent magnet synchronous generator (PMSG) for variable-speed wind turbine offers better reliability and noise reduction since no slip rings and gearbox are used. So, it is supposed to be suitable for future multi megawatt offshore generator[2].

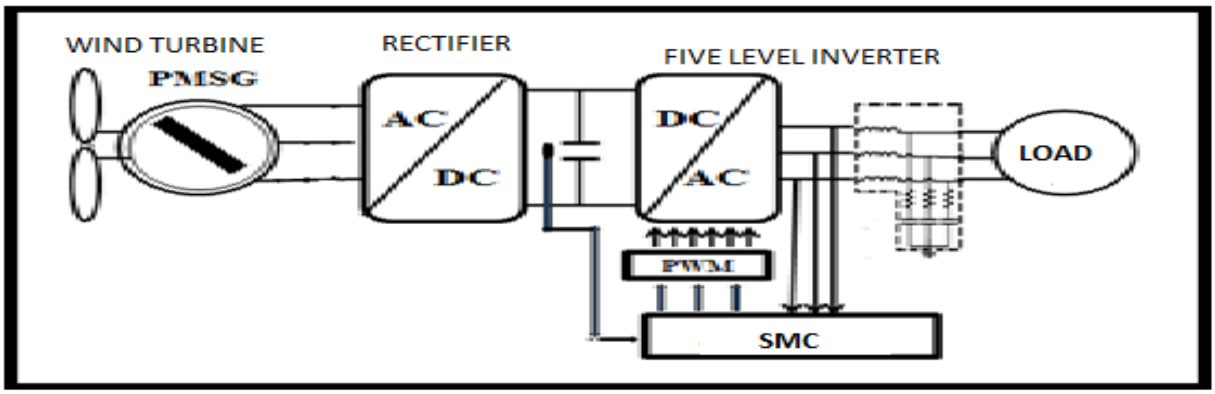

Fig. 1 Schematic Diagram of Wind Energy Conversion System

III. FIVE LEVEL INVERTER:

To reduce the Total Harmonic Distortion in the voltage and current in local load, a five level inverter is used in this work. Stepped voltage can be obtained by switching of devices in proper sequence. Variable voltage and variable frequency is possible by multilevel inverters [4]. Good power quality can be obtained by multilevel

inverters. It requires more number of switching devices and it will increases the switching losses. The number of levels in converter is defined as the number of steps generated by the converter between the output and the neutral point [7].

For multilevel inverters of this type , if the number of levels is 'm', then capacitors required are 'm-1' and switching devices per phase are 2*(m-1) [2].

If the number of levels increases the performance of inverter as well as the THD component improves. The control method used here is to produce a reference signal for pulse production which is meant to control the voltage and frequency [6].

In this work Sinusoidal PWM technique is used to produce pulses, a reference signal is produced using this control method and in this PWM for five level inverter the reference wave is to be compared with (5-1) number of level shifted carriers to produce pulse for all switches in the inverter [3].

II. SLIDING MODE CONTROL THEORY:

Sliding mode control (SMC) is a nonlinear control technique featuring significant properties of accuracy, robustness, and easy tuning and implementation [5]. The sliding mode mechanism in phase plane is shown in Fig.2.

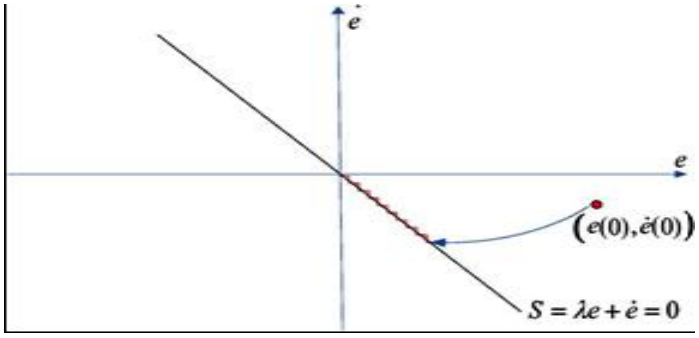

Fig.2 Sliding-mode mechanism in phase plane

V. SIMULINK MODELS AND RESULTS:

The PMSG based WECS using SMC and Five level inverter MATLAB models are shown in Fig.3,Fig.4,Fig.5.

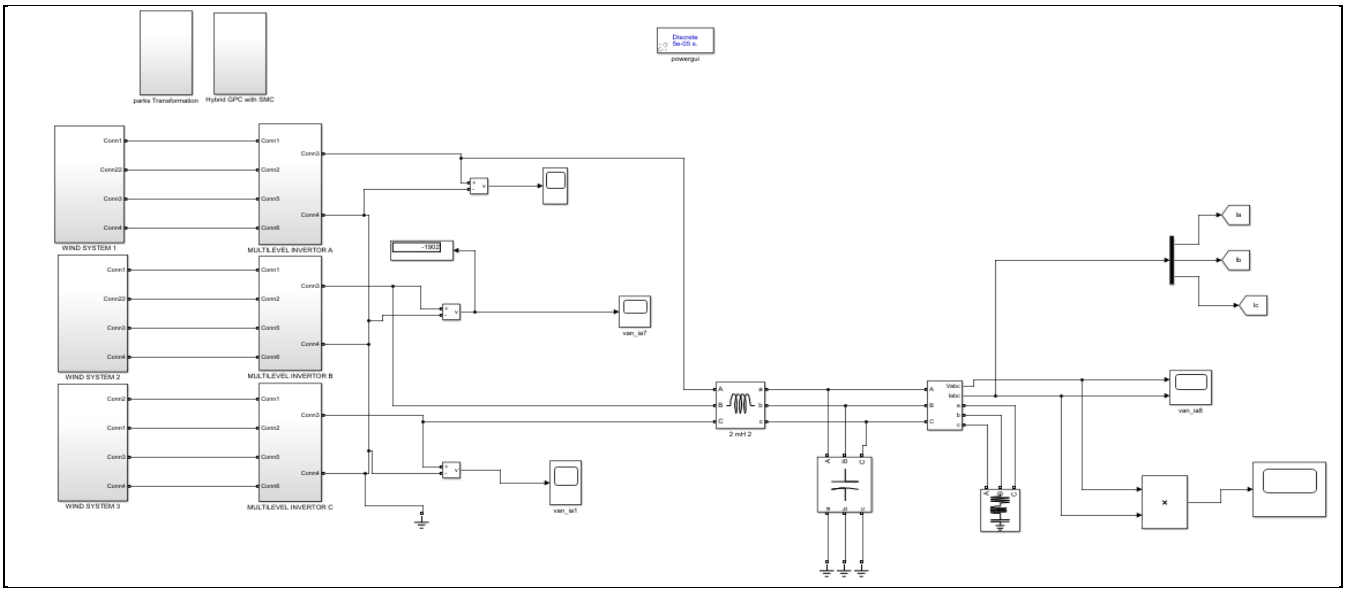

Fig.3 Simulink model of overall system

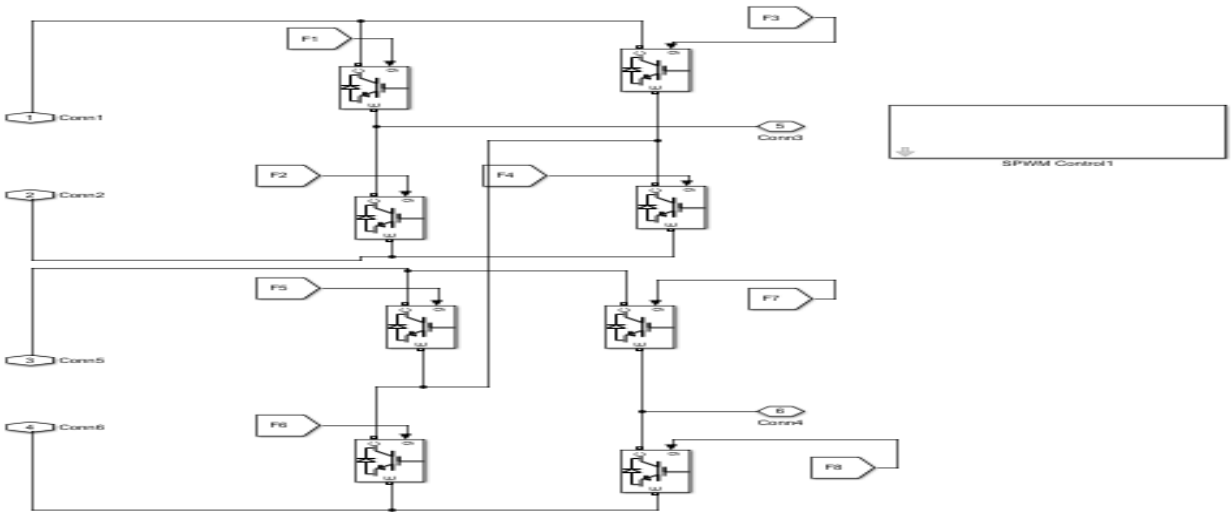

Fig. 4 Simulink model of Five level inverter

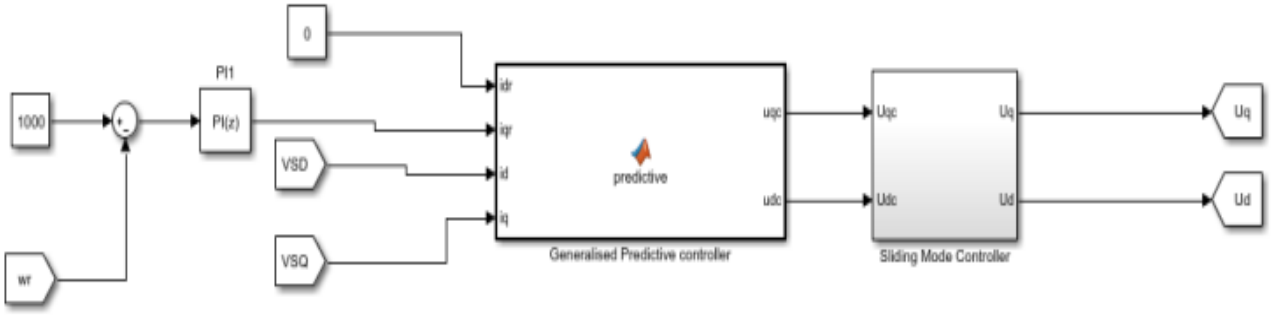

Fig.5 Simulink model of Hybrid GPC with SMC

The obtained wave forms are shown in below Figures namely Fig.6, Fig.7, Fig.8.

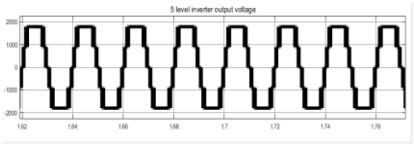

Fig.6 Five Level Inverter output Phase Voltage when load is not connected

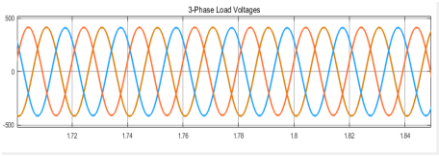

Fig.7 Load output L_L 3- Phase Voltages

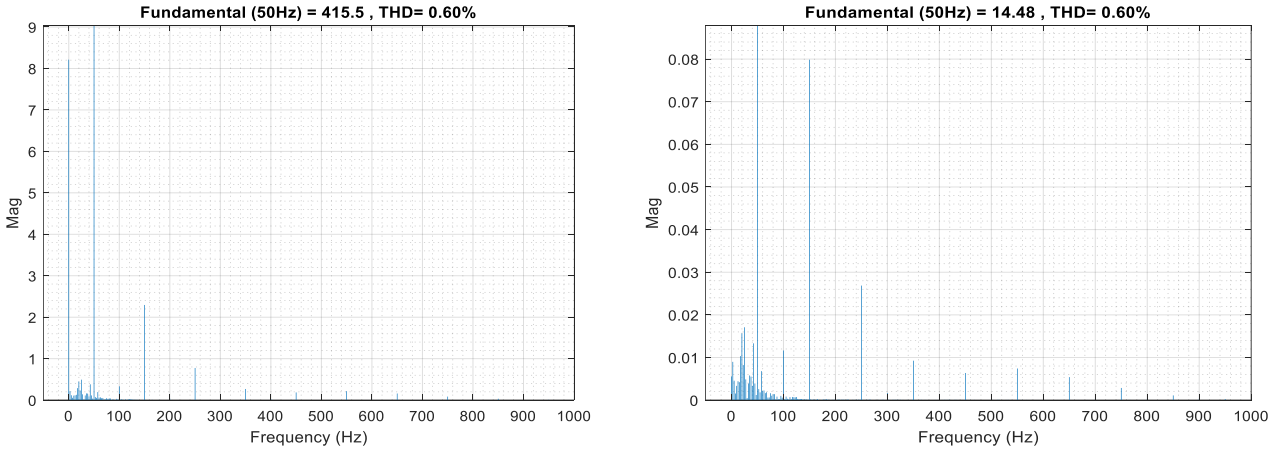

Fig.8 Total Harmonic Distortion of Load Output Voltage and Current respectively

Total Harmonic Distortion in the load voltage = 0.62 %

Total Harmonic Distortion in the load Current = 0.6%

Fundamental Voltage= 414.5 V

Fundamental Current-14.48 A

VI. CONCLUSION

From the above results it is understood that the THD level for an isolated load was analyzed for a five level inverter based SMC in a PMSG fed WEC system. It is noted that the THD values are less compared to many conventional systems. This system provides a good power quality supply.

REFERENCES:

[1] A. G. Sanchez, M. G. Molina, and A. R. Lede, 'Dynamic model of wind energy conversion systems with PMSG-based variable-speed wind turbines for power system studies', International journal of hydrogen energy, vol. 37, no. 13, pp. 10064–10069, 2012.
[2] Y. Ming, L. Gengyin, Z. Jiancheng, Z. Weiran, and X. Yifeng, 'Modeling and control strategies of directly driven wind turbine with permanent magnet synchronous generator', POWER SYSTEM TECHNOLOGY-BEIJING-, vol. 31, no. 15, p. 61, 2007.
[3] A. Rolan, A. Luna, G. Vazquez, D. Aguilar, and G. Azevedo, 'Modeling of a variable speed wind turbine with a permanent magnet synchronous generator', in Industrial Electronics, 2009. ISIE 2009. IEEE International Symposium on, 2009, pp. 734–739.
[4] A. D. Hansen and G. Michalke, 'Modelling and control of variable-speed multi-pole permanent magnet synchronous generator wind turbine', Wind Energy, vol. 11, no. 5, pp. 537–554, 2008.
[5] S. M. Mozayan, M. Saad, H. Vahedi, H. Fortin-Blanchette, and M. Soltani, 'Sliding mode control of PMSG wind turbine based on enhanced exponential reaching law', IEEE Transactions on Industrial Electronics, vol. 63, no. 10, pp. 6148–6159, 2016.
[6] Leon M. Tolbert, Fang Zheng Peng and Thomas G. abetler," Multilevel PWM Methods at Low Modulation Indices," IEEE Transactions on Power Electronics, Vol.15, No. 4, July 2000