CONTROL USING MATRIX FOR PMSG BASED WIND ENERGY CONVERSION SYSTEM

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Abstract : This paper introducing a novel bidirectional Z-source Matrix Converter in a wind energy conversion system with a variable speed permanent magnet synchronous generator(PMSG) machine. The maximum power is extracted by using Tip Speed Ratio MPPt algorithm. Space vector modulation (SVM) technique is used for the purpose of modulation. It is designed to avoid main constraints such as poor voltage gain, need of high number of semiconductor switches, difficult modulation design. The operational principle of the ZSMC is described and its modulation strategy is explained. Simulation and experimental results are shown to verify the feasibility of the ZSMC. The effectiveness of the proposed power converter and its implementation are verified using MATLAB/Simulink simulations performed initially with a RL load and then connected to the grid.

***IndexTerms* – Control, MPPT, PMSG, WECS, Reliability.**

I. INTRODUCTION

AC/AC power converters are crucial elements in PMSG- based WECSs. First proposed converters have a back-to-back configuration; consisting of the succession of a rectifier, a passive storage component and an inverter [1, 2]. In order to eliminate the bulky storage component in the dc-stage and improve the system reliability, matrix converters emerged as a promising candidate to WECSs application [3, 4]. In fact, the exclusion of the dc-link component for energy storage in all Matrix Converter topologies decreases their dimensions and reduces the maintenance costs; two benefits highly required in WECSs. However, matrix converters present three main constraints such as their relatively complex modulation techniques, their high number of semiconductor switches and their limited voltage gain [5-7]. In order to improve the voltage gain fixed to 0.86, researcher included the Z-source concept for its voltage boosting capability in the converter topology. One of the promising solutions of AC/AC power converters suitable for PMSG-based WECSs is the new family of Z-source matrix converters with no storage component. Researchers are still interested in these topologies despite their shy industrial manufacturing [8-10]. These converters are combinations of one matrix converter topology with one Z-source network configuration. In PMSG-based WECSs, only Z-source matrix converters with unidirectional power flow are found in the scientific literature [11, 12].

The main objective of this study is to propose a new improved topology that can operate in both power directions and implement it in a PMSG-based WECS in order to highlighits performances while meeting the improvement requirements of reduced number of semiconductor switches and increased voltage gain in addition to bidirectional power flow capability.The Very Sparse Matrix Converter that has the minimum number of semi-conductor switches and still operates in two power flow directions [13] is associated to the Series Z-source network that has an improved inrush current in the Z-source inductance and also an improved Z-source capacitor voltage when compared to other Z-source network topologies [14, 15].The proposed Series Z-source Very Sparse Matrix Converte(SZS-VSMC) is implemented in a PMSG-based WECS and the overall system is simulated using Matlab Simulink Sim PowerSystems library.
This paper will be divided as follows: the proposed WECSis presented in section II, the control strategy is discussed insection III and simulations results are presented in section IV. Finally conclusions are given in section V.

II. PROPOSED SYSTEM

The main structure of the studied WECS is represented in fig. 1 and a more detailed description of the grid connected system is presented in fig.2. It consists of a wind turbine that produces a mechanical torque in terms of the wind speed and a PMSG that converts the mechanical power into electric power feeding an inductive load or the grid through the SZS-VSMC power converter. The wind turbine is directly connected to the machine that has a high-pole number and operates at low rotational speed and high mechanical torque.

The power converter is the power electronics interface that enables the system variable speed operation and the implementation of the control strategy. Its main role is to adapt the electric variables according to the grid or the load requirements. It is a full-scale ac-ac converter that decouples the generator from the grid.

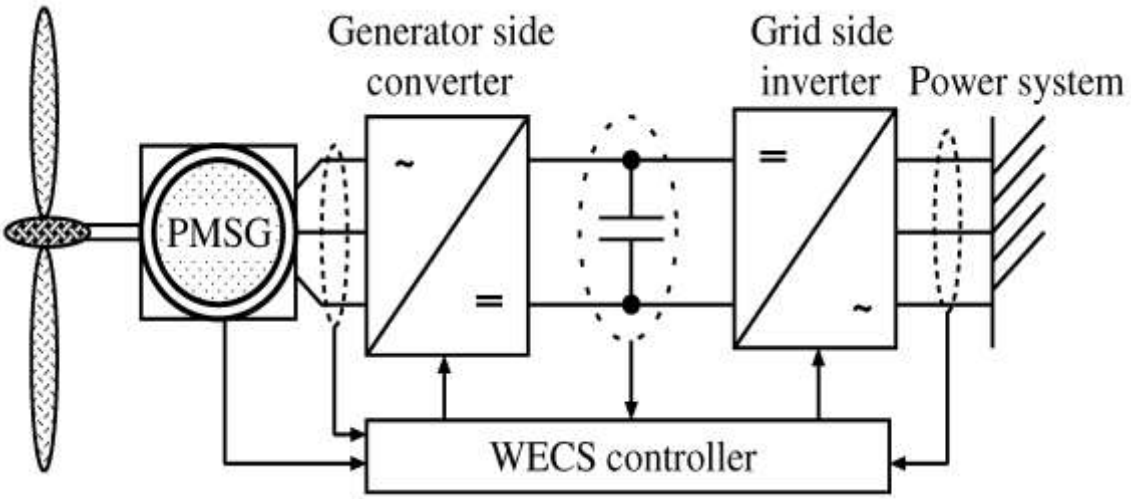

Fig.1.Basic structure of WECS

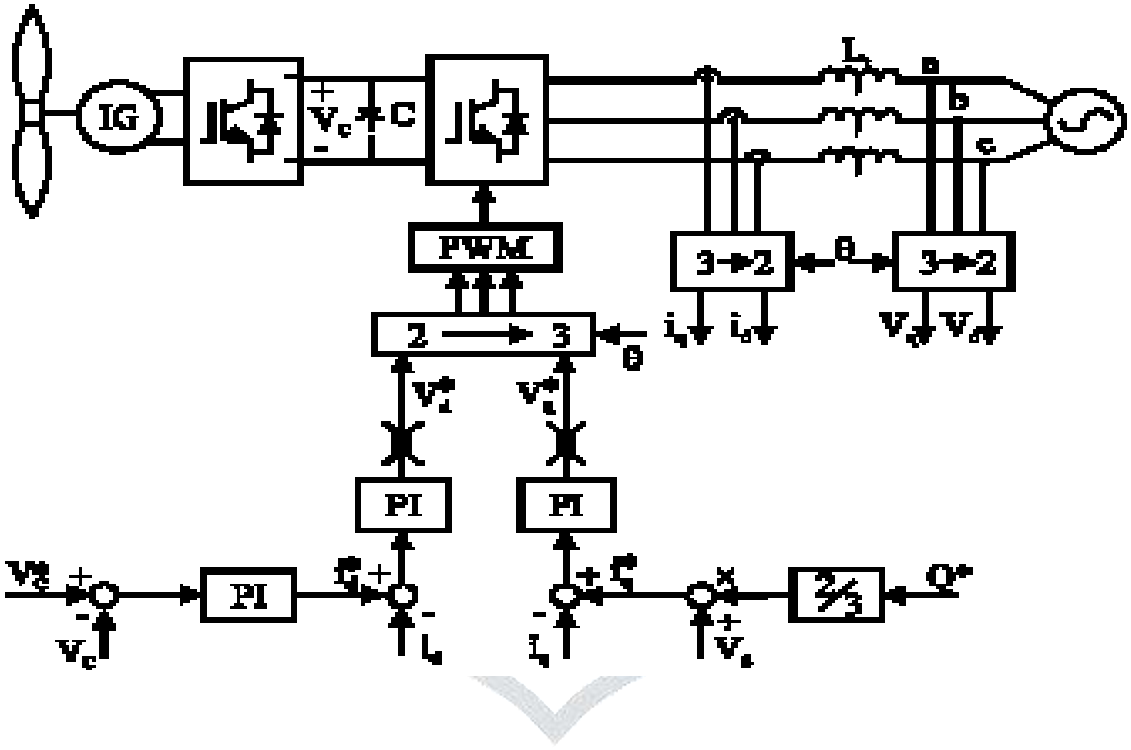

Fig.2.Structure of WECS connected with grid

The topology of the Series Z-source Very Sparse Matrix converter is also presented in fig.1 and fig.2. It is an arrangement of the Very Sparse Matrix converter and the series Z-source concept that boosts the dc-voltage by varying the rate of change of the inductors current. The series Z-source network was proven effective with the Ultra Sparse Matrix converter [14]. While keeping the same boosting ratio as that of the traditional cascaded Z-source, it overcomes its main constraints by limiting the evident inrush current in the inductors due to resonance phenomenon at start-up and reducing the capacitors voltage; decreasing the cost and volume of the capacitors. A power switch S1 is inserted between the two inductors in order to ensure the possibility that the current can flow backward giving an additional feature for the proposed topology.

III. PROPOSED CONTROL STRATEGY

The main structure of the studied WECS is represented in fig. 1 and a more detailed description of the grid connected system is presented in fig.3. It consists of a wind turbine that produces a mechanical torque in terms of the wind speed and a PMSG that converts the mechanical power into electric power feeding an inductive load or the grid through the SZS-VSMC power converter. The wind turbine is directly connected to the machine that has a high-pole number and operates at low rotational speed and high mechanical torque.

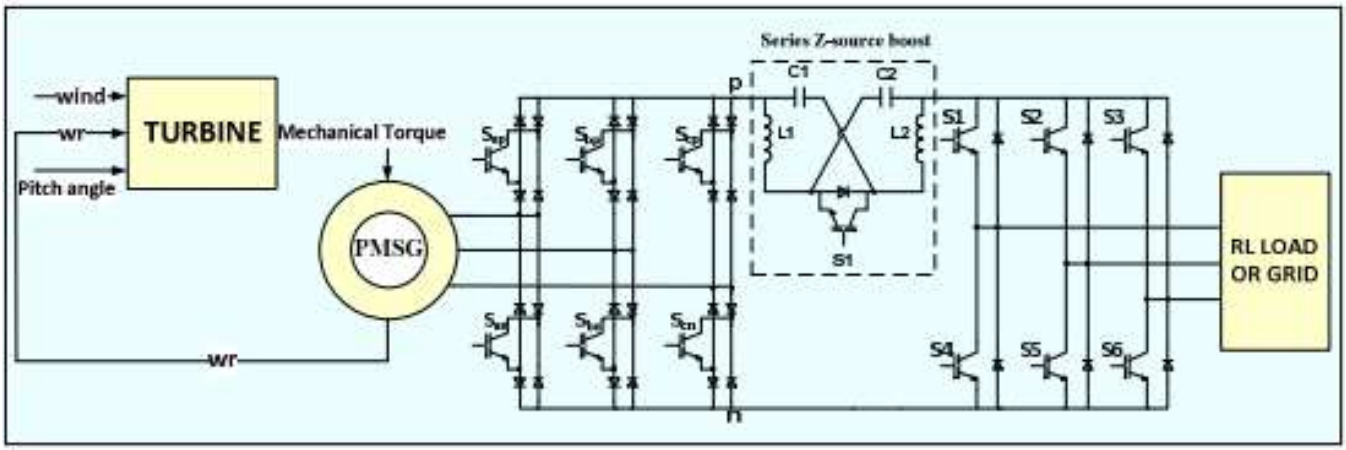

Fig. 3. Matrix based PMSG-WECS

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IV. RESULTS

Matlab based software simulations are carried out using the Simulink platform and suitable results were shown .

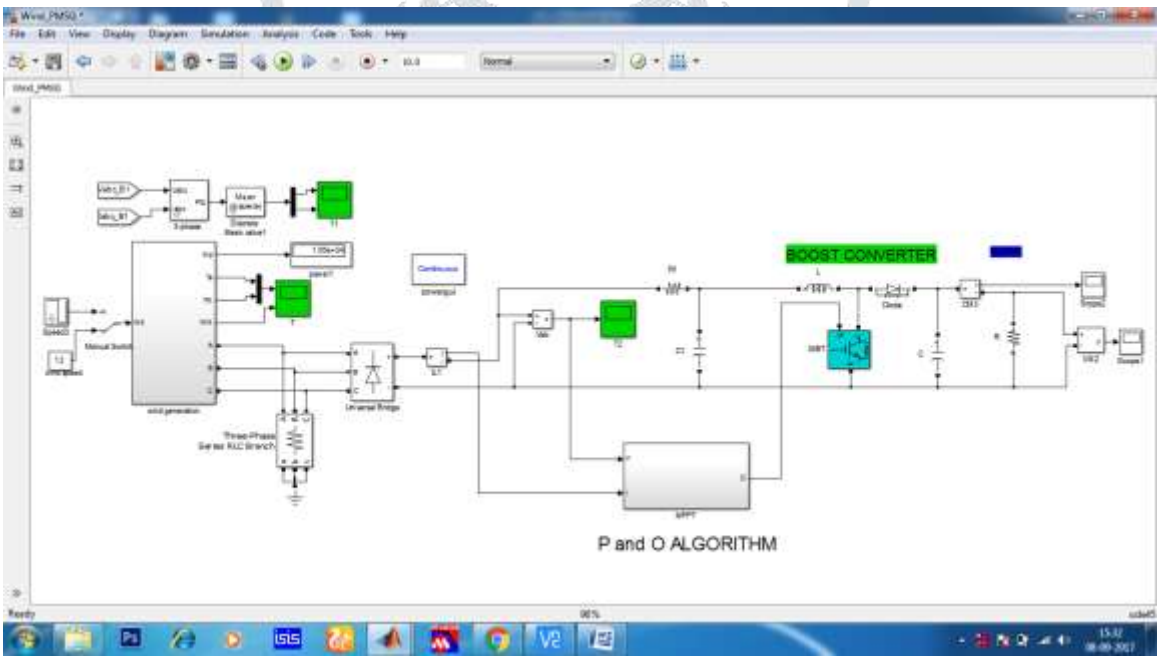

Fig. 4. Simulink PMSG-WECS

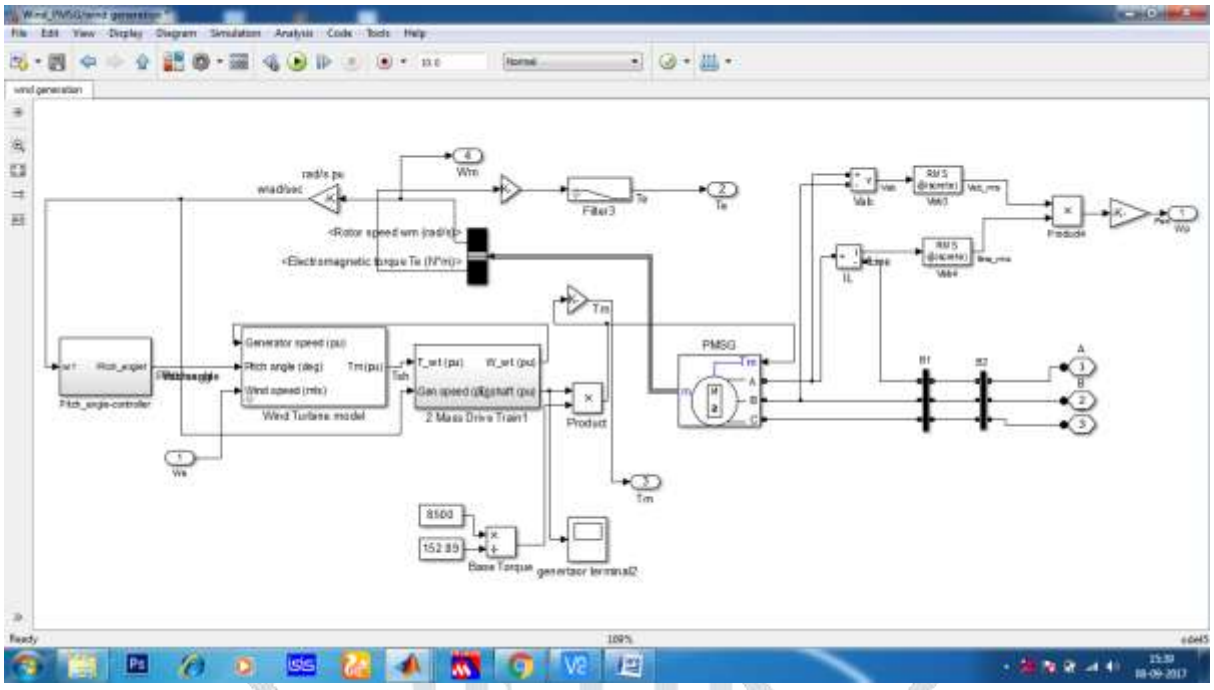

Fig. 5. Simulink Matrix control

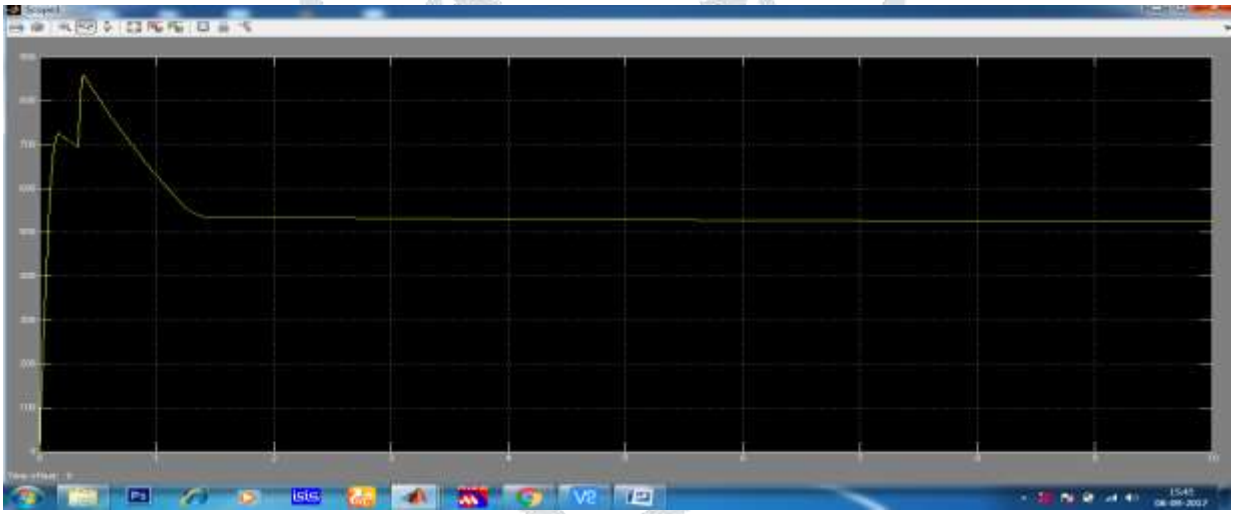

Fig. 6. Voltage wave

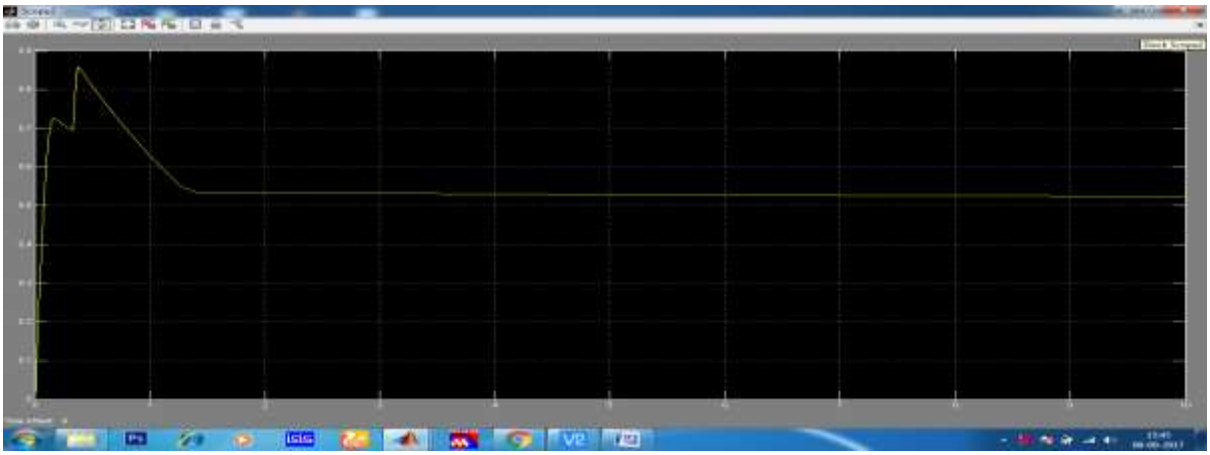

Fig. 7. Current wave

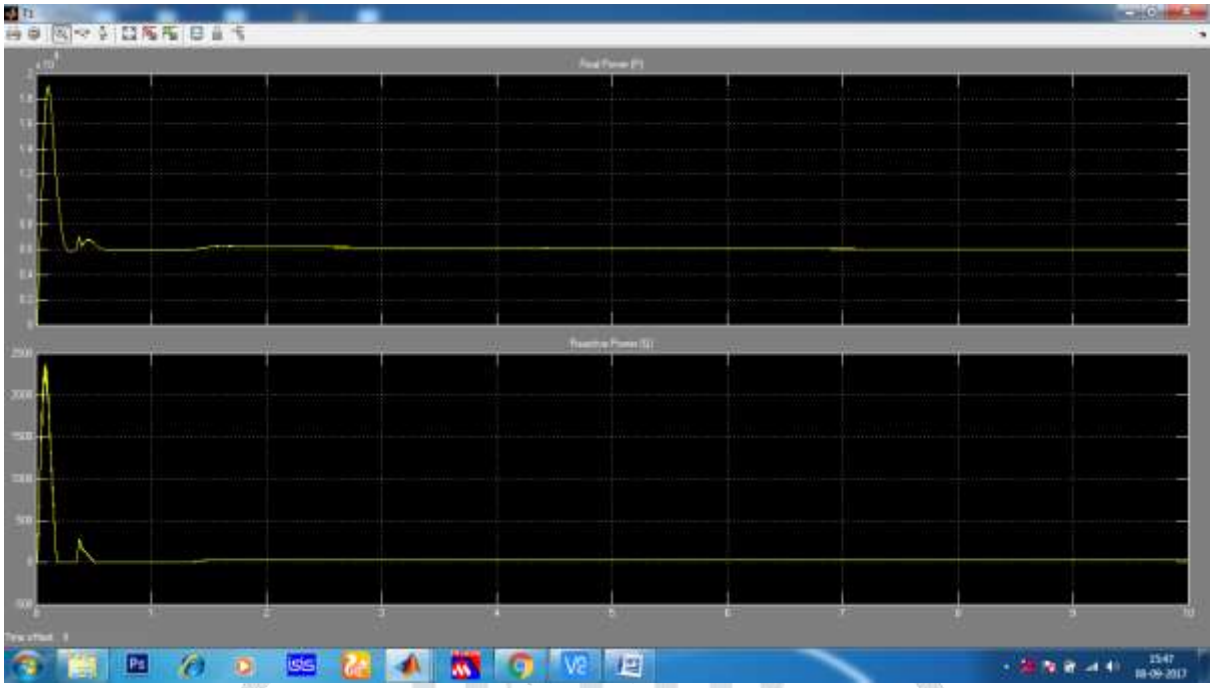

Fig. 8. Real and reactive power

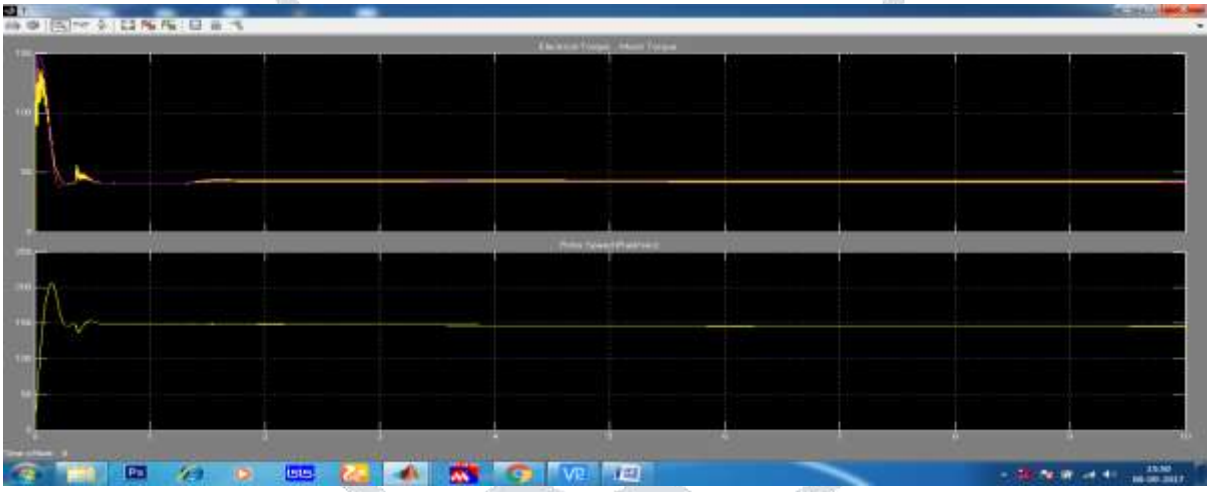

Fig. 9. Torque

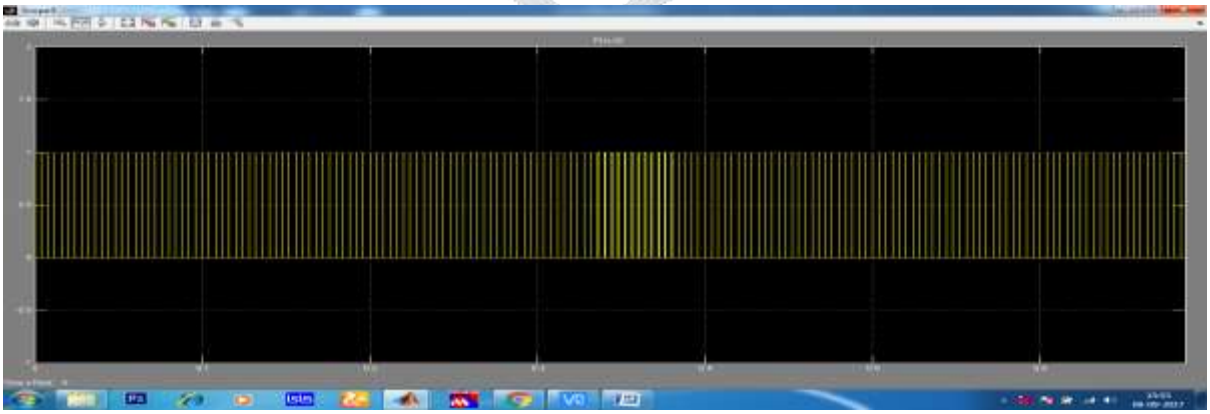

Fig. 10. Matrix control gate pulse

V. CONCLUSION

Matlab mockup results of the the proposed SZS-VSMC is a promising solution for PMSG based WECSs whether applied with an inductive load or connected to the grid. It was concluded that the proposed matrix converter is able to provide a frequency response similar to the load voltage reference when the WECS is feeding an inductive load or similar to the grid frequency detected by the PLL when the WECS is connected to the grid without compromising the quality of the output current that has a Total Harmonic Distortion lower than 5 %. Therefore, the resulting WECS is more efficient since the power losses in the machine are reduced and is more reliable due to the absence of the gearbox and the storage component in the matrix converter.

REFERENCES

[1] F. Blaabjerg, M.Liserre, K. Ma, "Power Electronics Converters for Wind Turbines Systems", IEEE Trans. Ind. Appl., vol. 48, NO. 2, pp. 708-719, April 2012.
[**2]** Z. Chen, J. M. Guerrero, F. Blaabjerg, "A Review of the State of the Art of Power Electronics for Wind Turbines", IEEE Trans. Power Electron., vol. 24, NO. 8, pp. 1859-1875, August 2009.
[3] C. Nasr El-Khoury, H. Kanaan, I. Mougharbel, K. Al-Haddad, "A Review of Matrix Converters Applied to PMSG Based Wind Energy Conversion Systems", in Proc. IEEE IECON'13, Vienna, Nov. 2013.
[4] J. Wang, B. Wu, D. Xu and N. R. Zargari, "Multimodular matrix converters with sinusoidal input and output waveforms", IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 17-26, January 2012.
[5] M. Y. Lee, P. Wheeler, C. Klumpner, "Space-Vector Modulated Multilevel Matrix Converter", IEEE Trans. Ind. Electron., vol. 57, No. 10, October 2010.
[6] L. Empringham, J. W. Kolar, J.Rodriguez, P. Wheeler, J. Clare, "Technological Issues and Industrial Application of Matrix Converters A Review", IEEE Trans. Ind. Electron., vol. 60, No. 10, October 2013.
[7] P. Wheeler, « Matrix converters: a technology review », IEEE Trans. Ind. Electron., vol. 49, no. 2, pp. 276-288, April 2002.
[8] B. Ge, Q. Lei, W. Qian, F. Z. Peng, "A Family of Z-Source Matrix Converters", IEEE Trans. Ind. Electron., vol. 59, No. 1, January 2012.
[9] O. Elleban, H. Abu-Rub and S. Bayhan, "Z-Source Matrix Converter: An Overview", IEEE Trans. Power Electron., August 2015.
[10] S. Liu, B. Ge, X. Jiang, H. Abu-Rub, F. Z. Peng, "Comparative Evaluation of Three Z-Source Quasi-Z-Source Indirect Matrix Converters", IEEE Trans. Ind. Electron., August 2014.
[11] M. Aner, E. Nowicki and D. Wood, "Employing a very sparse matrix converter for improved dynamics of grid-connected variable speed small wind turbines", in Proc. IEEE Power and Energy Conference, Illinois, February 2012.
[12] E. Karaman, M. Farasat and A. M. Trzynadlowski, "A 3ï-3ï quasi zsource matrix converter for residential wind energy systems", in Proc. IEEE Energy Conversion Congress and Exposition (ECCE), Sept. 2012.
[13] J.W. Kolar, F. Schafmeister, S. Round and H. Ertl, "Novel three-phase AC-DC-AC sparse matrix converter" IEEE Trans. Power Electron., vol. 22, no. 5, pp. 1649-1661, September 2007.
[14] E. Karaman, M. Farasat, A. M. Trzynadlowski, "A Comparative Study of Series and Cascaded Z-Source Matrix Converters", IEEE Trans. Ind. Electron., vol. 61, No. 10, October 2014.
[**15]** C. Nasr El-Khoury, H. Kanaan, I. Mougharbel, K. Al-Haddad, "A comparative study of four bidirectional Sparse Matrix Converter topologies proposed for Wind Power Application", in Proc. IEEE Int. Conf. on Industrial Technology (ICIT), Seville, March 2015.