International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-7 Issue-4S2, December 2018

Analysis of Z-Source Matrix Converter with Different PWM Control Schemes for Wind Energy Conversion Systems

R. Bharani Kumar, A. Loganayaki

Abstract -This paper concentrates on evaluating performance of three phase z-source matrix converter (ZSM). The proposed converter is used in permanent magnet synchronous generator (PMSG) based 2.5 kW wind energy system. The proposed WES output supply frequency changes with respect to the change in wind velocity. The main objective of this ZSM 16nverter is to maintain constant frequency and constant load voltage when WES frequency changes with 16nd speed. It also reduces the power loss during low wind velocity and also due to total harmonic distortions (THD). In this work, the ZSM converter performance parameters like output voltage fi16uency, voltage magnitude, THD level are analyzed for various wind velocities and switching frequencies. The Sinusoidal pulse width modulation (SPWM), and modified carrier PWM schemes are used to control the matrix converter and results are to compare the evaluated parameters of the ZSM converter.

Keywords: z-source matrix converter (ZSM), permanent magnet synchronous generator (PMSG), total harmonic distortions (THD).

I. INTRODUCTION

In recent years, a power demand is rapidly increasing to meet new and additional electrical loads, hence energy savings has increased due to power electronic converters. It concentrates on lower cost, smaller size and higher efficiency to meet the power demand. Wind, solar and Biomass are the efficient Solution to supply power either directly to a utility grid or to an isolated load. But it requires some sort of measure is necessary to suppress the harmonic content in the power electronic converter (PEC) system. Compare with wind energy sources WES is widely used energy sources as it has longer life, reliability, simple control structure and requires lesser maintenance requirements [1, 2]. The use of conventional converters such as frequency converter and PWM voltage source power inverters are sufferes from rich lower order harmonics and poor power quality. To avoid this matrix converter is developed and implemented for variety of applications. The matrix converter provides the sinusoidal voltages and currents (both I/P and O/P) yet the higher order harmonics is minimum whereas sub-harmonics is found to be nil. Further, bi-directional energy flow capability is also found to be inherent and it has fully controllable input power factor. Matrix converter is used to convert variable frequency to constant frequency with rated voltage. There are two types of matrix converters, one is direct matrix converter and another one is indirect matrix converter.

Revised Manuscript Received on December 30, 2018.

R. Bharani Kumar, Department of Electrical and Electronics Engineering, Bannari Amman Institute of Technology Sathyamangalam, Erode, TN, India

A. Loganayaki PG Scholar/EEE, Bannari Amman Institute of Technology, Sathyamangalam, Erode, TN, India

The indirect matrix converter consists of rectifier and PWM inverter. It has the square wave output hence its voltage waveform containing rich harmonics.[3] The direct matrix converter has sinusoidal input and output waveforms, hence it has lower input and output THDs. Also the direct matrix converter requires simple control circuit hence the lower switching voltage and current stresses. However it suffers from the voltage transfer ratio, the voltage transfer ratio is only 86.6%. To overcome this limitation, this paper proposes the Z-Source direct matrix converter for regulating the frequency in wind energy conversion systems.

II. CONFIGURATION OF PROPOSED SYSTEM

The proposed system consists of 3kW wind turbine and radial flux PMG. The generated power is fed to ac-ac Z-source direct matrix converter. The frequency of the generated voltage varies with turbine speeds and it is regulated by matrix converter as shown in Figure 1. The proposed system block diagram is shown in figure 1.

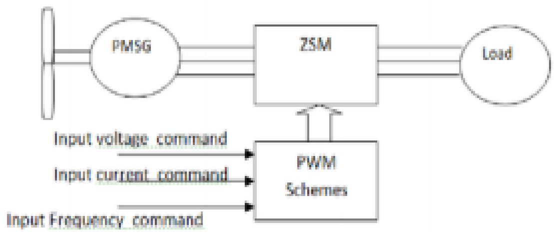

Figure 1. Z-Source Direct Ac-Ac Matrix Converter Based Wind Energy Systems

The developed turbine power is expressed in equation (1)

$$P_w = \frac{1}{2}\rho.S.V_w^3.C_p.\lambda \quad (1)$$

The Tip speed ratio is given in equation (2)

$$\lambda = \frac{\omega_m.R}{V_m} \quad (2)$$

Developed torque Tw is [9]

$$T_w = \frac{P_w}{\omega_m} = \frac{(\frac{1}{2}\rho.S.R.V_w^2.C_p.\lambda)}{\lambda} \quad (3)$$

III. MODELLING OF WIND TURBINE PM GENERATOR

The suggested radial flux PMG is modeled by using rotor reference frame and its equations are described below.[4]

$$V_L = K_v\omega_e \sin(\omega_e.t)$$
(4)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$\omega_e = \omega_m \cdot \left(\frac{N_p}{2}\right) \quad (5)$$

Title	Parameters	Value & unit
General	1. Cut in wind speed 2. Cut out wind speed 3. rated wind speed	3m/s 16m/s 8m/s
Generator	4. rated power output 5. Type 6. Voltage 7.Revolutions 8. frequencies	2.5 kW Permanent Magnet 400V 145 to 410 rpm 50Hz
Wind Turbine	9. No. of Blades 10. Diameter 11.Material 12. Max. speed	3 3 m Fiber glass 410 rpm

Table 1 Proposed Pmsg System Parameters

IV. Z-SOURCE DIRECT AC-AC MATRIX CONVERTER

To overcome the drawbacks of direct matrix converter, a diagonal shape Z-Source network is connected across the input ac source. The Z-network contains of three inductors and three capacitors. The power circuit consists of nine bidirectional IGBT switches as shown in figure 2. The frequency of the generated voltage in wind generator system is varying with wind velocity and it is requalified by suitable selection of PWM scheme for direct matrix converter.[7,8].

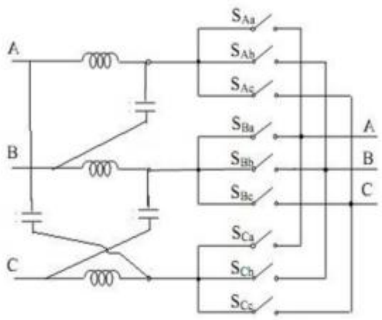

Fig 2Topology Of Z-Source Matrix Converter

V. PWM SCHEMES FOR Z-SOURCE DIRECT AC-AC MATRIX CONVERTER

The PWM schemes are used to control the conversion period of each switch in matrix converter. The proposed matrix converter consists of nine bidirectional switches. Each switch converts for a period of 120 degree.[5]

The input and output harmonic levels and power transfer are controlled by selecting the suitable PWM scheme. In this situation to select a suitable PWM scheme for matrix converter two PWM matrices and their results are compared. The PWM schemes are,[6]

1. Sinusoidal PWM scheme
2. Modulation carrier PWM scheme

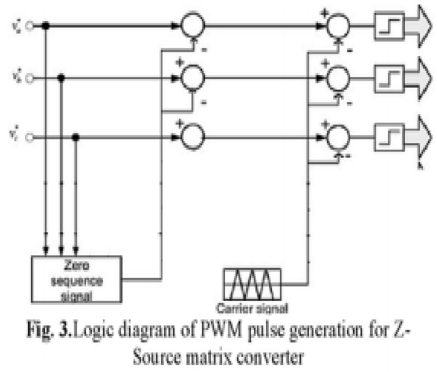

Fig 3 Logic Diagram Of PWM Pulse Generation For Z-Source Matrix Converter

A. *Sinusoidal PWM scheme*

In Sinusoidal PWM scheme, a sine wave is used as a reference waveform. The sinusoidal waveform is to be taken from the PWM terminals and it is compared with reference voltages and then it is feed to control circuit. The control circuit provides the PWM pulses to the matrix converter.

B. *Modulation carrier PWM scheme*

The carrier signal is modulated as per the required frequency and it is super imposed with reference waveforms. After that it is feed to control circuit, the control circuit provides PWM signals for matrix converter.

VI. RESULTS AND DISCUSSIONS

The proposed wind energy conversion systems with Z source matrix converter is simulated in MATLAB/SIMULINK environment as shown in Fig 4. The simulated model is verified for different input and output conditions. Fig.5 and 6 show the generated voltages for different wind velocities. Due to control systems the Z source matrix converter produces the constant voltages of 415 volts with 50Hz frequency across theload as given in Fig. 7. Fig.8 shows the load current waveforms. From Figs.9 and 10 it is noted that the matrix converter having lesser THD in both current and voltage waveforms.

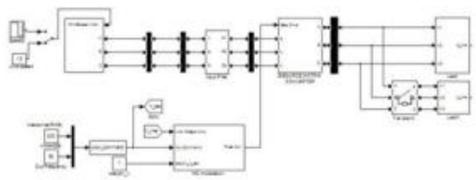

Fig.4 Proposed System-Simulation Model

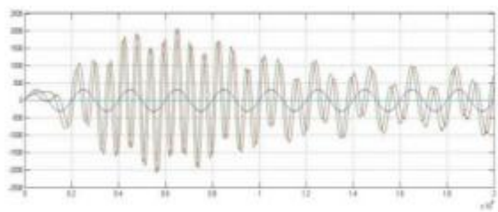

Fig 5. WES Voltage Waveform Under Variation Of Wind Velocity

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

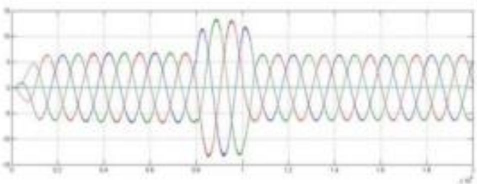

Fig 6. WES Voltage Waveform Under Variation Of WindVelocity

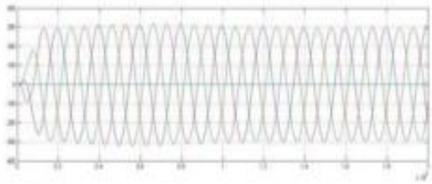

Fig 7 Terminal Voltages- Z Source Matrix Converter

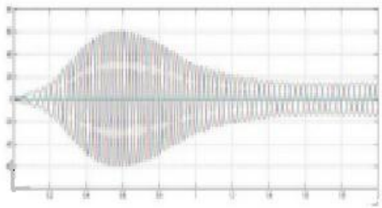

Fig 8 Load Current Of Z-Source Matrix Converter

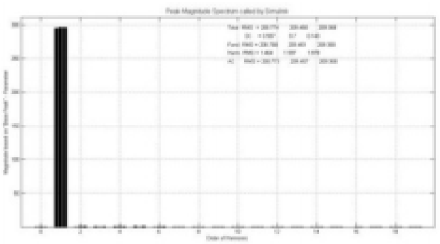

Fig 9 Voltage THD Spectrum

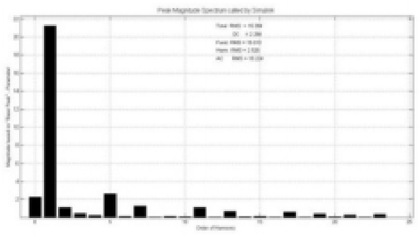

Fig 10 Current THD spectrum

VII. CONCLUSION

The matrix converter with wind turbine driven PMSG is modeled and simulated. The model is simulated with varies input and output conditions. The Z-Source matrix converter is controlled by using SPWM and modified carrier PWM schemes are used and the results of the matrix converter provides constant voltage and frequency with irregularity of PMSG voltages. Also the Z-Source matrix converter having lesser value of THD both in voltages and current.

REFERENCES

1. T. Shanker and R. K. Singh, "Wind energy conversion system: A review," 2012 Students Conference on Engineering and Systems, Allahabad, Uttar Pradesh, 2012, pp. 1-6. doi: 10.1109/SCES.2012.6199044.
2. N. Ramesh Babu, P. Arulmozhivarman, "Wind Energy Conversion Systems – A Technical Review", Journal of Engineering Science and Technology, Vol. 8, No. 4, pp. 493 – 507, 2013.
3. Thiringer.T.; "Power Quality Measurements Performed on a Low-Voltage Grid Equipped with Two Wind Turbines", Energy Conversions, IEEE Transactions on, Vol.11, Issue 3, September 1996,Pages :601-606.
4. M. Venturini, "A New Sine Wave in Conversion Technique Which Eliminates Reactive Elements," in Proceedings of Powercon 7, pp. E3/1-E3/15, 1980.
5. M. Kazerani, Dynamic Matrix Converter Theory Development and Application, Ph.D. thesis, Department of Electrical Eng., McGill University, Canada, 1995.
6. H. Nikkhajoei, A. Tabesh, and R. Iravani, "Dynamic model of a matrix converter for controller design and system studies", IEEE Trans. on Power Delivery, Vol. 21, Issue 2, Apr. 2006, pp.744 - 754.
7. P.W. Wheeler, J. Rodriguez, J. C. Clare, L. Empringham, A. Weinstein, "Matrix converters: a technology review, "IEEE Trans. on Industrial Electronics vol. 49, Issue 2, pp. 276 – 288 April 2002.
8. Bharani Kumar, Ramasamy., Nirmal Kumar, A. and Maheswari "Modeling and Simulation of Wind Turbine Driven Axial type PM generator with Z Source Inverter", Australian Journal of Electrical and Electronics Engineering, Vol.9 No.1, pp.27-41, 2012.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication