Journal of Innovative Research in Engineering Technology and Management Science
Volume 01, Issue 01, May 2025
www.jiretms.com

Direct Matrix Converter Based on Space Vector Modulation for Standalone Systems

Clara[1] and Mia[2]
Department of Electronic Engineering, Middlesex University, London
[1]Corresponding Author: claramsu@gmail.com

To Cite this Article
Clara and Mia, "Direct Matrix Converter Based on Space Vector Modulation for Standalone Systems", Journal of Innovative Research in Engineering Technology and Management Science, Vol. 01, Issue 01, May 2025, pp:01-05,

Abstract*: In this paper we employ the Permanent Magnet Synchronous Generator (PMSG) for standalone wind power generation because it offers high efficiency combined with minimal maintenance requirements. A direct matrix converter based on smart technology functions as the power conversion interface to create output waveforms that are sinusoidal with limited higher order harmonics while having no subharmonic components. The system removes the requirement for dc-link and all other passive equipment. By using certain switching states Space vector modulation controlled (SVM) matrix converter switching has the potential to minimize switching losses. The proposed work stands as a potential design concept for future variable speed drive technology. The suggested model for an RL load underwent evaluation through MATLAB simulation by changing the resistor and inductance values.*

Keywords*: SVM-space vector pulse modulation, wind-energy conversion system (WECS), and permanent-magnet synchronous generator (PMSG)*

I. Introduction

Wind Energy Conversion Systems stand as one of the top energy production methods in renewable energy fields including biomass alongside wind and solar and hydropower because they offer straightforward implementation. The operation of wind turbines avoids emissions produced during the production of non-replaceable thermal power and nuclear power systems [1-2]. The technology includes systems which operate independently to deliver pumping functions for irrigation water systems as well as remote power generation and grid connection capabilities. Within wind-driven generator technology there are three core categories: Fixed speed, variable speed wind turbines and induction generators. Two generator types namely DFIG and PMSG function either in fixed speed operation or variable speed operation per research conducted in [2].

A variable-speed generating system would benefit most from the implementation of PMSG technology. Direct turbine connection becomes possible because PMSG offers these enumerated benefits without needing an external excitation current and a gearbox. The device operates efficiently at low speeds while minimizing both weight and losses and costs [4]. The output voltage control of wind turbine generators using SEIG, DFIG, and PMSG has become more manageable through conventional solid-state power electronic converters consisting of voltage source inverter and impedance source inverter fed wind energy conversion system. The system consists of passive and direct-current link components. The fundamental requirement for an inverter's operational success depends on its ability to generate harmonically pure and efficient output [1].

The suitable control techniques for switch operation are selected to achieve this outcome. The control of inverter switching pulses is managed through Pulse Width Modulation Techniques (PWM) [5] that include Fixed PWM, Sinusoidal PWM and Space Vector PWM. The control approaches present distinct capabilities when compared to one another. Available technologies for high efficiency reduction with minimized harmonics guide the selection process of control techniques. The proposed matrix converter system accomplished all rectifier/dc link/inverter structural requirements and established a practical power conversion solution for motor drives and UPS and VF generators and reactive energy control applications [4].

Top features for matrix converter generation systems include bidirectional energy transfer and low-energy storage requirements together with a sinusoidal output wave for both input and output while controlling subharmonics and high-frequency harmonics. A modern alternative against traditional voltage source inverters the MC shows

enhanced performance capabilities [1]. These include the following: a power supply side unity input power factor; The matrix converter maintains a power supply side unity input power factor alongside continuous zero speed operation through switch-independent current distribution and combines these capabilities with a compact design and prolonged operational lifespan without electrolytic capacitors. This direct connection between input and output sides of the system results in limits which include a maximum voltage transfer ratio of 0.866.

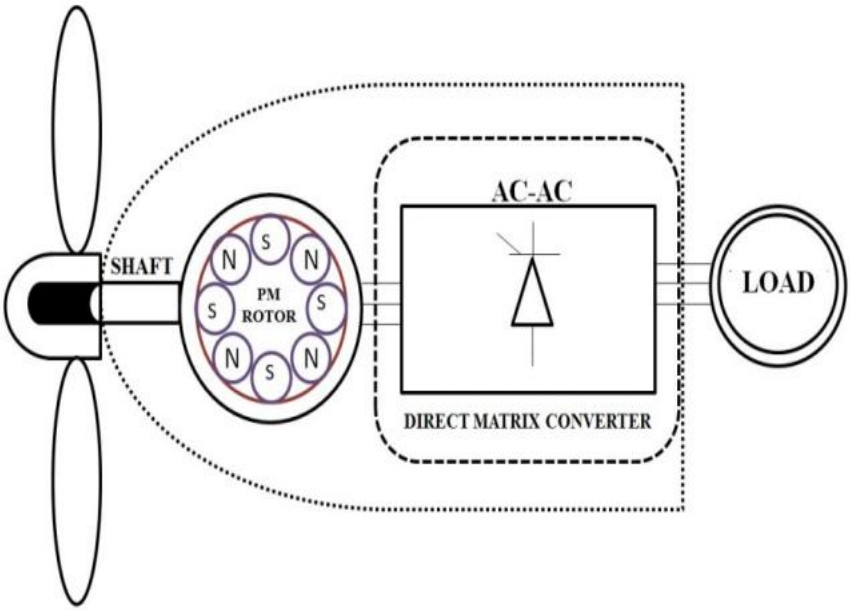

Fig 1: Circuit Diagram of the Proposed Method

II. Matrix Converter Directly

The direct matrix converter shown in Figure 2 represents a direct AC-AC converter system that brings multiple advantages compared to traditional inverters. This device features an intrinsic dual-directional power flow capability which generates waveforms with sinusoidal signals while maintaining low harmonic content and eliminating sub-harmonic frequencies and enables comprehensive input power factor management. The device's minimal energy storage requirement eliminates the necessity of employing large energy-storing capacitors and frequency converters. The nine bidirectional switches enable any combination between any output phase and any input phase.

The nine bidirectional switches enable the matrix converter to serve various possible combinations of switching states. Some of these possible solutions fail to deliver practical benefits. Two essential rules govern the choice of matrix converter switching states regardless of control method implementation: the converter is powered by a voltage source and typically feeds an inductive load; As a voltage-source converter operating on inductive loads the device needs to maintain open input phases and avoid stopping output currents. Actual application demands each output phase to utilize only one single bi-directional switch at any particular moment [1-2].

The 27 distinct output switching possibilities exist in three-phase to three-phase matrix converters because of this limitation. The matrix converter design requires direct output generation from input voltages and currents because it contains no energy storage components between its input and output sides. The main advantage of matrix converters includes their ability to modify power factor characteristics at the input. An input filter operates as a channel between the matrix converter and AC mains for blocking unwanted harmonic currents [3].

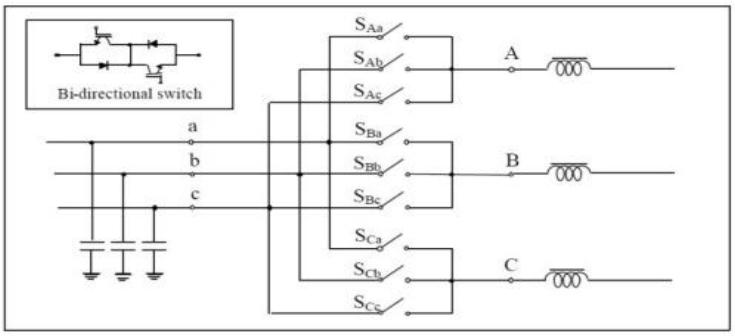

Fig 2: Direct matrix converter

III. SVM for Direct Matrix Converter

The method uses controlled lengths of legitimate three-phase null states from a matrix converter to develop necessary sinusoidal output voltages combined with inverter output control through space vector modulation. The representation of all functional switching states in a matrix converter takes place through voltage space vectors. Implementation of the SVM method requires selecting switching vectors plus calculating vector on-time values as its two essential sequential steps. The three-phase matrix converter includes 27 distinct switch combinations that result in 27 voltage vectors available for selection. The 27 possible switch combinations of matrix converters divide into three distinct groups. There are three different vector types including zero vectors and stationary vectors and synchronously spinning vectors.

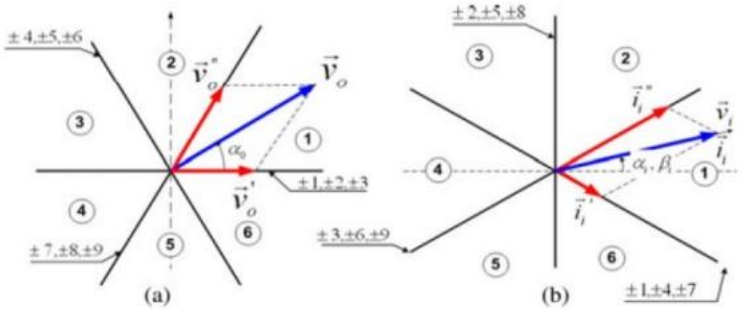

Fig 3: (a) Output line-to-neutral voltage vector. (b) Input line current vector

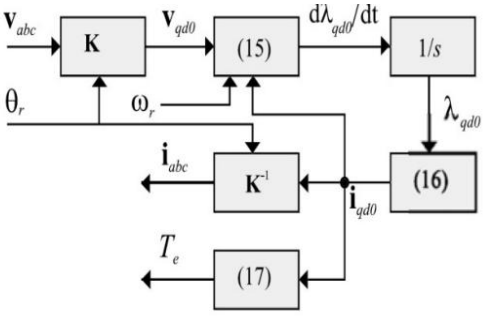

Fig 4: Diagram of simulation model

IV. Simulation and Results

The control systems based on space vector modulation for PMSG-fed resistive and inductive loads operate through AC-to-AC matrix converters and their MATLAB/Simulink model implementations are shown in Figure 5. When PMSG serves as a power source the modelling approach is implemented [2]. The model design implementation used equations from (9) through (20) under a 12 m/s wind speed condition. The PMSG Simulink model appears in figures 6 and 7.

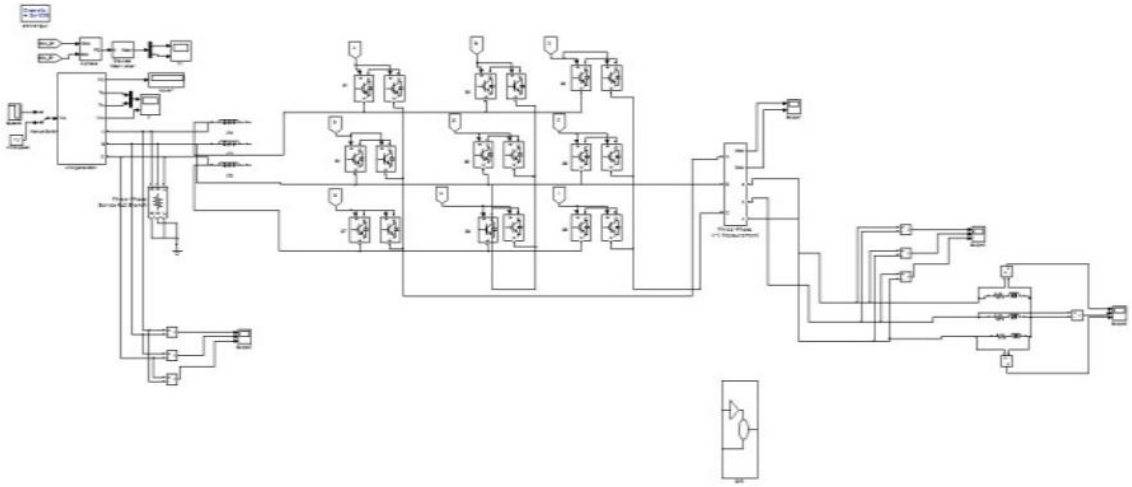

Fig 5: Simulink Model of the SVM Controlled PMSG

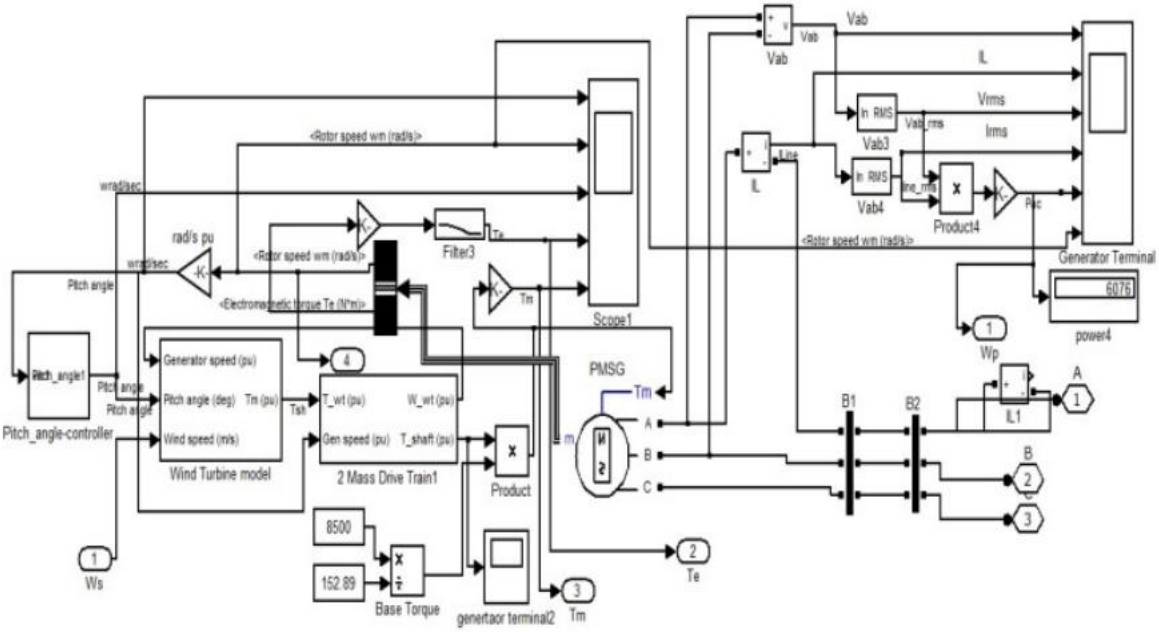

Fig 6: Simulink model of PMSG

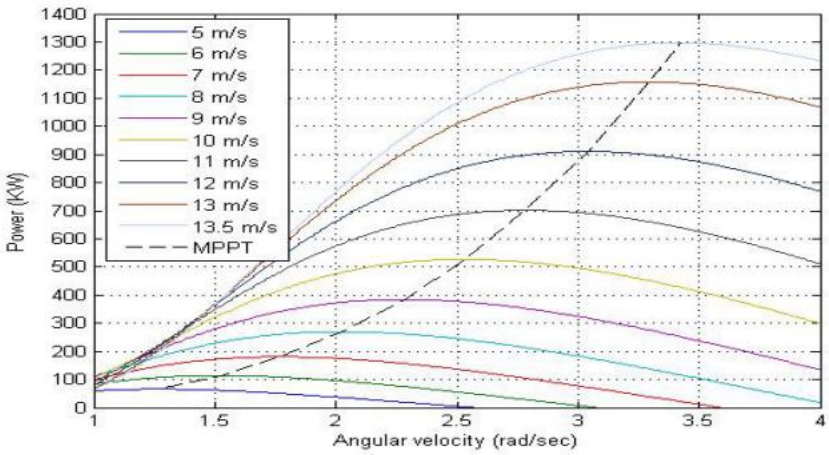

Fig 7: Characteristics of the wind turbine

V. Conclusion

The research demonstrated space vector modulation techniques used to analyze comparative effects between various resistances and inductances. The addition of energy storage components to the RL load becomes unnecessary whenever PMSG operates with a direct AC-AC matrix converter [1-2]. Among all PWM techniques SVPWM demonstrates superior performance. The PMSG modelling requires 12 m/s as its minimum wind velocity for analysis. Matrix converters replace traditional DC-links to achieve high efficiency alongside low-cost operation. Future research efforts will expand extensively to develop modelling techniques for variable speed drives based on agricultural motors alongside water pumping mechanisms.

References

[1] Chie Lee and Yadav Kumar. "An Matrix Converter using Array System in Power Electronics in Communication Systems". Springer Conference in Hindustan University, Chennai, VOL. 2, NO. 3, March 2009

[2] Saritha, Srikanth, Subhakar and Sunitha, "A Process control system in Industrial Applications using Thyristors in power electronics for PMSG",". Elsevier 2011. China, 7 – 9, January 2012.

[3] Niharika, Lakshman Reddy and Shanchie, "A Novel of MIMO concepts in wireless relay networks in Space Time and Space Frequency in achieve diversity", " IEEE Conference Proceedings on Innovative Research in Communication Systems (IRCS), International Conference. vol. 2, pp. 67 – 75, January. 2010

[4] Johe Diesel, Shang Chee and Cooper Lee, "Standalone Grid system for On and OFF modes Using Renewable energy sources using PMMC Technology', "Springer Proceedings on Green Energy on World environmental Day", IEEE conference proceedings held at Madras University, on the 20tt Century. pp.10-19, 2020

[5] F Max Savio, M Sasi Kumar. "An Effective Control Technique for an Impedance Source Inverter Based Wind Energy System". 2012 IEEE International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM-2012)

[6] Sasikumar M and Chenthur Pandian S. "Characteristics Study of ZSI For PMSG Based Wind Energy Conversion Systems". Journal of Electrical Engineering (JEE). ISSN: 1582-4594.