Journal of Engineering Technology and Sciences
Volume 02, Issue 05, May 2025 *ISSN: 3048-913X*
www.jets.org.in *DOI:10.63590/jets.2025.v02.i05.pp07-12*

Indirect Z-source Matrix Converter with PSO-PI Controller for Induction Motor Speed Control under Different Break Conditions

K. Ramesh
Department of Electrical Engineering, Aditya University, Kakinada
Corresponding Author: rameshkeee@gmail.com

To Cite this Article
Ramesh, "Indirect Z-source Matrix Converter with PSO-PI Controller for Induction Motor Speed Control under Different Break Conditions", Journal of Engineering Technology and Sciences, Vol. 02, Issue 05, May 2025, pp:07-12, DOI: http://doi.org/10.63590/jets.2025.v02.i05.pp07-12
Submitted: 14-02-2025 *Accepted: 18-04-2025* *Published: 05-05-2025*

***Abstract**: More industries select induction motors for their industrial applications because these motors provide both cost and operational simplicity compared to direct current devices. A z-source matrix converter operating indirectly controls the speed of three-phase induction motors. Flux control technique maintains a V/f ratio at the same time it regulates slippage. The research evaluates different braking approaches for the motor by studying their impact on flux variation together with reference velocity. The suggested system received its desired response parameters from PSO Algorithm through PI controller coefficient determination. The suggested system implementation using corresponding converter data matched to an induction machine operated through MATLAB software in SIMULINK. The proposed system together with the indirect Z source matrix converter shows fast performance in generating suitable torque and velocity.*

***Keywords**: Induction motor, converter, particle swarm optimization (PSO), method, and indirect Z-source matrix*

I. Introduction

The Matrix Converter has garnered significant attention among power converter families due to its direct power conversion (AC/AC) capability. Venturini introduced this type of converter in 1980 [1], and Venturini and Alesina [2] conducted a detailed analysis of it in 1989. In recent years, matrix converters have gained a lot of attention as a desirable alternative to traditional indirect power converters because of their many benefits, including sinusoidal input-output current, the ability to regulate input power factor per load, the lack of bulky reactive power conserving elements, their monolithic and simple design, and their excellent recovery capabilities [3-6].

II. Z - Source Indirect Matrix Converter

The use of a z-source converter enables matrix converters to address their basic limitation involving low voltage transfer ratio. In 2008 Zhong and Song introduced the z-source matrix converter principles by presenting two versions of direct and indirect converters [10]. When operating a matrix converter to provide power to an induction motor the bi-directional switches permit two-way current movement.

The control system offers four operational areas for velocity-torque regulation [11]. The control methods for induction motor speed control using the matrix converter include field orientated control with Venturini pulses and modulation at less than 0.866 voltage transfer ratio and converter signal harmonics along with direct vector control and vector space control using modulation technique [12] [13]. The methods create computation errors when speeds are slow due to sluggish parameter modifications [15].

The depicted Figure (2) illustrates the suggested induction motor speed control system. A closed-loop system performs a reference velocity comparison against the motor velocity signal to deliver the proportional-integral controller the velocity error signal. The slippage velocity regulator produces (w)sl velocity output through applying controller output signals.

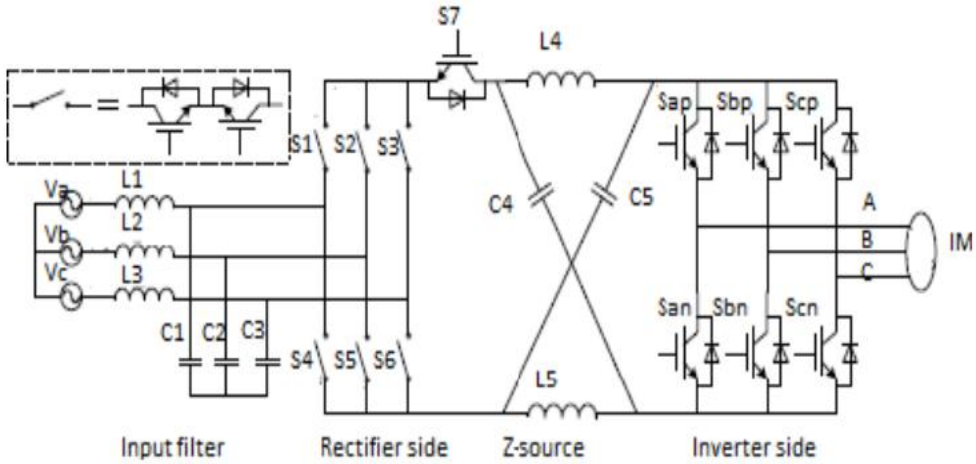


Fig 1: Z - Source Indirect Matrix Converter

After performing calculations, the system obtains details about the motor frequency operation as well as output voltage conversion and Wms and first harmonic frequency values. The flux control block determines the required voltage for the motor application by utilizing (Wms). The modulation index controls converter output voltage at Block 1 when operating in this state under conditions where V is lower than the maximum output voltage without z-source impedance.

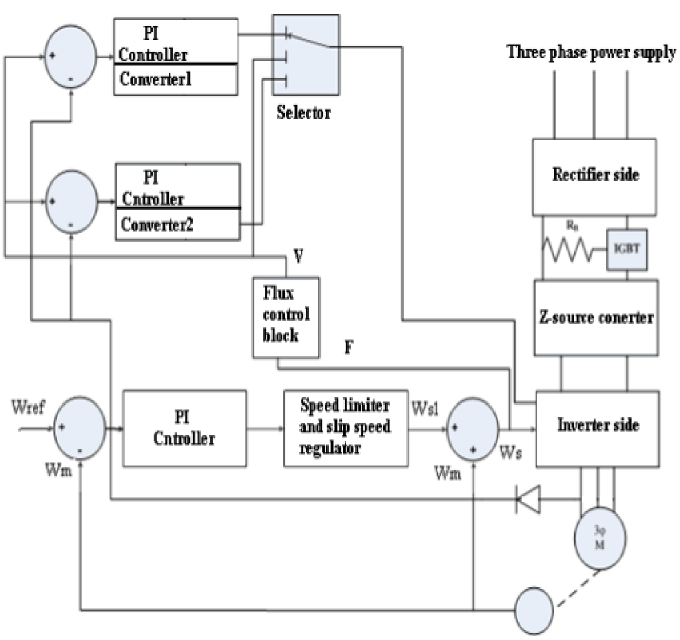


Fig 2: The Proposed System

Kennedy and Eberhart developed PSO, a revolutionary population-based optimization technique, in 1995 to stimulate fish schools and bird flocks [13]. It makes use of several particles that make up a swarm. The swarm's knowledge of the specified searching space is updated continually. A position array and a velocity array are involved in each swarm particle. One potential remedy for the issue is the position array.

III. Attainment of Break State

Whenever a system undergoes velocity command signal alterations below its working motor speed the motor will operate as a generator due to negative slippage. The induction motor gains inverted current direction that diverts power from entering the z-source converter through the reverse parallel diodes of the matrix converter inverter stage in order to charge converter capacitors. The capacitors develop excessive voltage when the energy output exceeds proper utilization because it threatens the semi-conducting components [15]. A resistance combined with Figure 3 presents one method to discharge capacitors to waste energy through heat loss during dynamic breaks. The rectifier section uses bi-directional switches as another technology solution. Keeping power flow switches active enables the network to obtain power supply for this purpose. The operating generator creates source power delivery beyond absorption capacity that may lead to capacitor explosion within the z-source converter.

The best approach to reach break state is by combining these two previously discussed methods. Seeing the described converter in a new way demonstrates that its dynamic break procedure offers the system economic advantages. The z-source converter achieves cheaper circuit costs and lower energy waste by employing capacitors as dynamic break capacitors and making use of rectifier part switches to return power to the network.

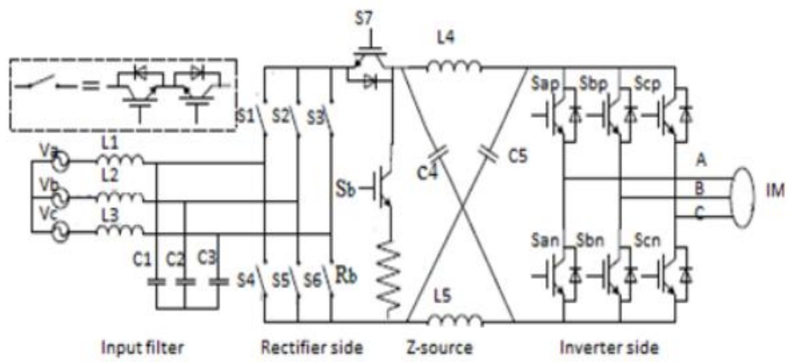


Fig 3: Attainment of break state

IV. Simulation Results

The following are the simulation results

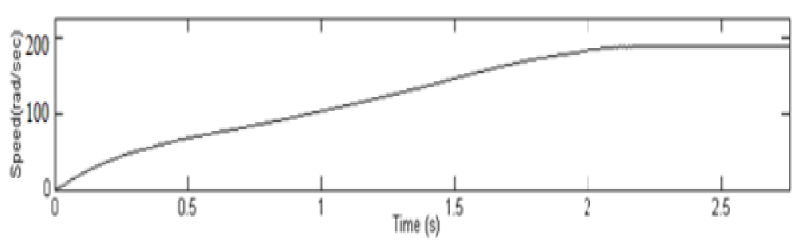
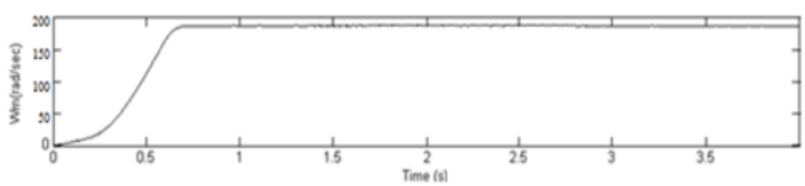


Fig 4: Motor start up state with PI controller



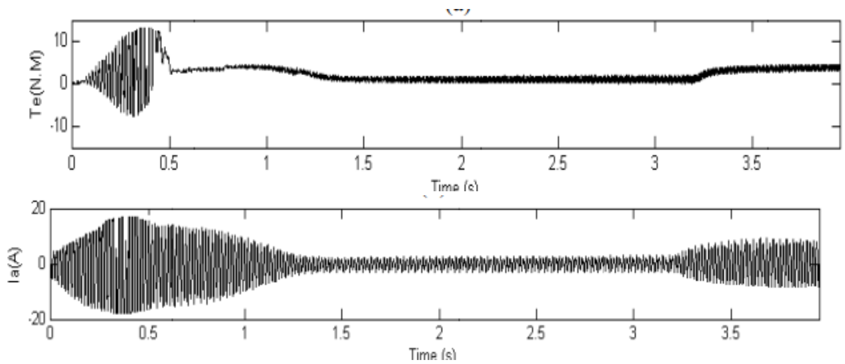


Fig 5: Start up condition

Figure 6 shows the motor's electric torque, velocity, three-phase current, and line voltage for each change in load torque independently.

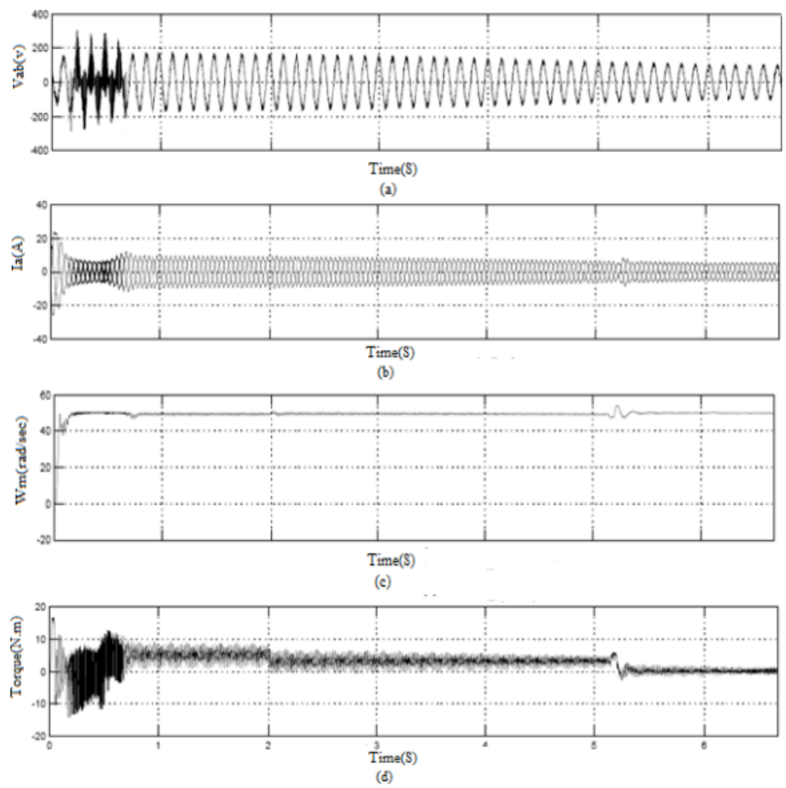


Fig 6: System parameter response to load torque changes a) line voltage b) three-phase motor current c) motor velocity d) electromagnetic torque

The velocity that is induced into the system is indicated by the command signal in Figure (7). Figures (7-9) display the respective outcomes of adjusting the motor settings and converter.

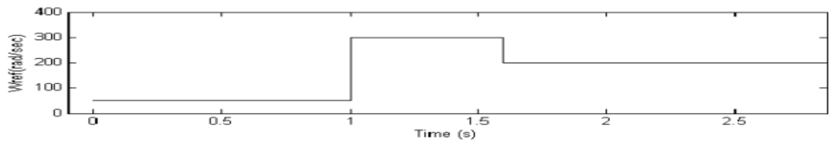


Fig 7: Command signal induced to the system

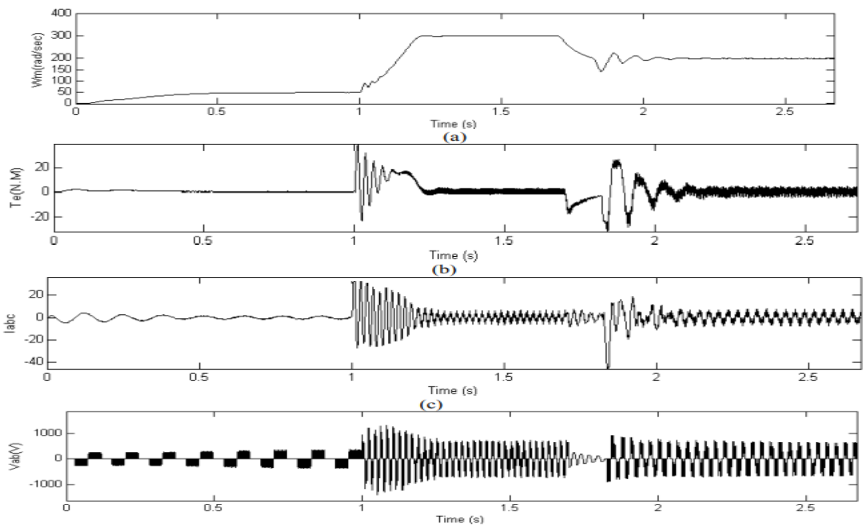


Fig 8: Parameter changes compared to command signal changes at resistive break state a) velocity b) torque c) single-phase current of the motor d) output voltage of matrix converter

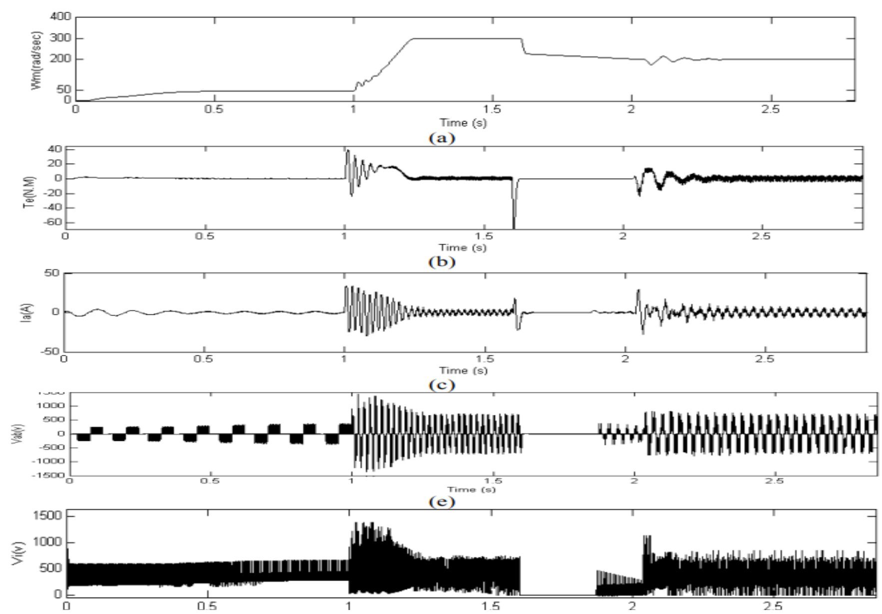


Fig 9: Parameter changes compared to command signal changes at generator’s break state a) velocity b) torque c) single-phase current of the motor d) output voltage of matrix converter e) output voltage of Z source converter.

V. Conclusion

The research evaluates the simulation approach for z-source indirect matrix converters when used to control induction motor speeds. The obtained results from the simulation were compared to PI results to determine feature improvements. An increase in the matrix converter's voltage transfer ratio became possible due to implementing z-source converter properties. Research has found that the converter possesses natural characteristics which can function as break states thereby allowing further circuits to disappear after conducting investigations on different break techniques. The provided system allows voltage fluctuations through different management frequencies by using shoot-through coefficients with modulation index controls thus reducing switch losses and stress in the converter. PSO Algorithm functions as an optimization method to configure system elements based on PI controller count. The findings validate that this method delivers superior reactions in comparison to conventional PI controllers[15].

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