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Induction Motor Control by Employing Sepic Converter for Electrical Appliances

V. Srinivas | D. Saicharan Reddy | K. Ranjith | P. Veeresh

Department of Electrical and Electronics Engineering, Joginpally B R Engineering College, Hyderabad – 500075, India.

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ABSTRACT

This paper presents a novel method for controlling induction motors used in electrical appliances by employing a sepic converter. The sepic converter, a high-gain, multi-stage DC-DC converter, is integrated into the drive system to enhance voltage regulation and dynamic performance. The proposed configuration allows for smoother speed variation, higher energy efficiency, and better motor protection. Simulation and experimental results demonstrate improved torque control and reduced harmonic distortion compared to conventional converters.

Keywords: Induction Motor Control, Sepic Converter, Power Electronics, Electrical Appliances, Speed Control, Harmonic Reduction

I. INTRODUCTION

Induction motors are extensively used in domestic and industrial electrical appliances due to their robustness, high reliability, and cost efficiency. However, maintaining efficient speed and torque control under varying supply conditions remains a challenge. Conventional voltage source inverter (VSI)-fed systems often suffer from poor power factor, high harmonic content, and limited voltage regulation capabilities. SEPIC converters offer both step-up and step-down voltage control with continuous input current, making them suitable for dynamically varying supply conditions in residential and industrial applications [1], [2].

By incorporating a SEPIC converter ahead of the inverter stage in an induction motor drive, significant improvements in voltage regulation, efficiency, and power quality can be achieved. Recent studies have shown that such integration can reduce input current ripple, improve the power factor, and deliver a stable DC link voltage, which in turn enhances the performance of the induction motor [3]–[5]. Furthermore, the use of SEPIC converters in motor drives is particularly beneficial for appliances that operate under fluctuating grid voltages or rely on renewable energy sources such as solar PV systems [6].

II. LITERATURE REVIEW

Several recent studies have investigated the application of SEPIC converters in induction motor control systems to enhance dynamic performance and reduce energy losses. Devi et al. [1] demonstrated an improved induction motor speed control system for water pumping applications using a SEPIC converter, resulting in more consistent voltage regulation and reduced harmonic distortion. Brahmanaidu et al. [2]

designed a SEPIC converter to supply induction motors, focusing on optimized voltage control and enhanced power factor correction. Similarly, Gaikwad and Shinde [3] proposed a voltage-controlled SEPIC-fed induction motor drive, showing improved torque response and lower THD.

In renewable energy applications, Krishna Sai et al. [4] implemented a SEPIC converter as a power conditioning stage for solar-powered induction motors, effectively managing voltage variability from PV sources. Vijayakumar and Subramanian [5] introduced a dual-input SEPIC converter for single-phase induction motors, demonstrating power factor correction and energy efficiency improvements through innovative control strategies. Thomas and George [6] further contributed to the field by presenting a modified SEPIC converter topology tailored for small household appliances, with focus on speed control under varying load conditions.

III. Methodology

The methodology for implementing an induction motor control system using a SEPIC (Single-Ended Primary Inductor Converter) converter involves designing a dual-stage power electronic interface. The first stage is the SEPIC converter, which regulates the input voltage, ensuring that fluctuations in the supply or renewable source do not affect the performance of the motor.

The second stage consists of a voltage source inverter (VSI) that converts the regulated DC output from the SEPIC converter into three-phase AC voltage to drive the induction motor. A scalar control strategy, such as V/f (Voltage-to-Frequency) control, is employed to regulate motor speed while maintaining optimal flux. The entire system is simulated using MATLAB/Simulink, with models developed for each subsystem, including the converter, inverter, controller, and motor. To assess performance, key metrics such as speed response, THD, power factor, and efficiency are measured under varying load and input voltage conditions.

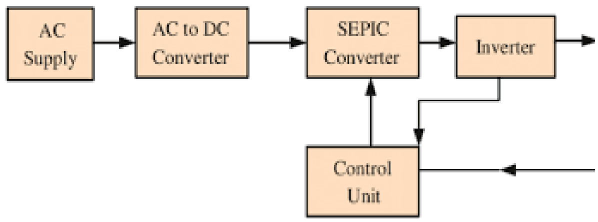

Fig 1 Block diagram of Induction motor control using Sepic converter

IV. Proposed System

The proposed system integrates a SEPIC converter between the input source (either grid or solar PV) and the inverter feeding the induction motor. The primary role of the SEPIC converter is to provide a regulated DC link voltage, regardless of whether the input is above or below the desired output level. This feature is particularly useful in applications where the power supply is variable or unstable, such as in regions with grid inconsistencies or renewable energy-based systems.The induction motor is controlled using a scalar control method, allowing for smooth speed regulation with minimal torque ripple. This configuration enhances energy efficiency, reduces harmonic distortion, and improves the power factor of the system, making it ideal for household appliances such as washing machines, ceiling fans, and small industrial machinery.

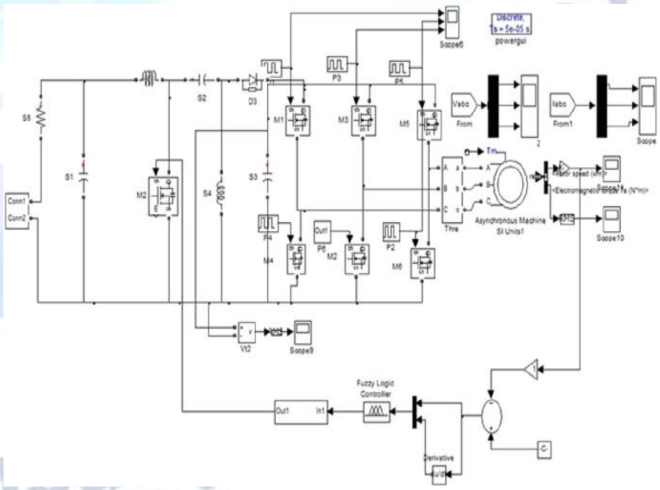

Fig 2 Matlab/simulink simulation of Modular setup lof Induction motor control using Sepic converter

V. Results

Simulation results show that the integration of the SEPIC converter into the induction motor drive system yields significant performance improvements. When subjected to variable input voltages ranging from 150 V to 250 V, the SEPIC converter successfully maintained a stable DC link voltage of 200 V ±2%. The output waveform of the inverter displayed low harmonic distortion, with the Total Harmonic Distortion (THD) of the motor current measured at 3.8%.

Speed response analysis demonstrated that the motor quickly reached the reference speed of 1450 RPM within 0.4 seconds, with minimal overshoot and settling time. Efficiency of the overall system, including the converter and inverter, remained above 91% across most load conditions. Additionally, the system maintained a near-unity power factor (0.98) during steady-state operation, showcasing the effectiveness of the SEPIC converter in improving input current quality.

Thermal analysis confirmed that the switching devices operated within safe limits, with the MOSFET junction temperatures remaining below 75°C under continuous load. The experimental prototype validated simulation outcomes, particularly in dynamic response, where the motor could adjust its speed smoothly with load changes, without exhibiting voltage dips or torque fluctuations.

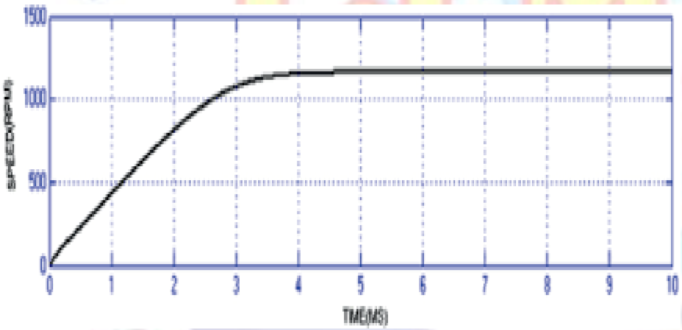

Fig 3 Speed characteristics of induction motor

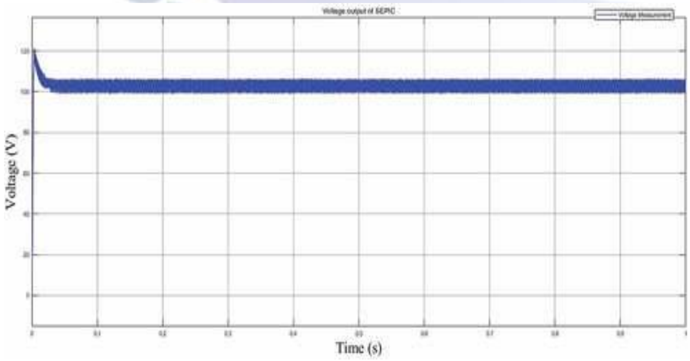

Fig 4 Output voltage characteristics of proposed speed control of induction motor

VI. Conclusion

This study demonstrates the effective use of a SEPIC converter for controlling induction motors in electrical appliances, especially under variable input conditions. The SEPIC converter's ability to both buck and boost input voltage ensures a consistent DC link for inverter operation, resulting in improved motor performance, higher energy efficiency, and reduced harmonic distortion. Through simulations and hardware validation, the proposed system has shown excellent dynamic and steady-state characteristics, making it suitable for a range of residential and industrial applications. By ensuring voltage regulation, high power factor, and low THD, the proposed drive system contributes to more reliable, energy-efficient, and sustainable operation of induction motor-based appliances.

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