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Speed Control of 3-Phase Induction Motor by Employing Boost Converter

Shivangi Sahu | S. Shresta Vagdevi | Koneti Preethi | G. Naveen

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

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ABSTRACT

This paper proposes an efficient speed control strategy for a 3-phase induction motor using a boost converter. Induction motors are widely used in industries due to their robustness and cost-efficiency. However, conventional speed control methods lack dynamic response and energy efficiency. In this research, a DC-DC boost converter regulates the input to a voltage source inverter which controls the motor. The proposed method improves speed response and ensures better handling of load disturbances. Simulation and hardware results validate the effectiveness of the proposed approach.

Keywords: Induction Motor, Boost Converter, Speed Control, Inverter, Power Electronics, DC-DC Converter

I.INTRODUCTION

Induction motors are extensively utilized in industrial applications due to their robustness, reliability, and cost-effectiveness. Controlling the speed of these motors is crucial for enhancing system performance and energy efficiency. One effective method for speed control involves adjusting the input frequency supplied to the motor, typically achieved through the use of inverters..

Traditional inverter configurations often face challenges related to inrush currents and input voltage harmonics, which can adversely affect the performance and longevity of induction motors. To address these issues, integrating power electronic converters, such as boost converters, has been proposed. Boost converters can regulate the DC voltage supplied to the inverter, thereby mitigating inrush currents and reducing harmonic distortions. Implementing control strategies, like Proportional-Integral (PI) controllers optimized through algorithms such as Particle Swarm Optimization (PSO), can further enhance the performance of boost converters, leading to improved overall system efficiency and stability [1].

II.LITERATURE REVIEW

The control of induction motor speed using power electronic converters has been a subject of extensive research. Various studies have explored the integration of boost converters with inverters to achieve desired performance outcomes. For instance, Caceres and Barbi [2] introduced a new structure of single-phase boost converters capable of generating AC voltage at the output, providing a foundation for subsequent developments in inverter design. Amarapur and Doddappa [3] proposed a novel control method based on bandwidth modulation for the startup and speed control of induction motors, offering a simplified approach for calculating harmonic currents and optimizing PWM switching patterns to minimize harmonic losses. Further advancements include the application of fuzzy-PI controllers for speed control in induction motors, as studied by Arulmozhiyal et al. [4], demonstrating improved dynamic response and reduced steady-state error. Mohit et al. [5] focused on the design and control of highly efficient boost converters, emphasizing the importance of converter efficiency in overall system performance. Additionally, research by Sreekumar and Agarwal [6], Prudente et al. [7], Seeman and Sanders [8], and Zhenyu and Prodic [9] has contributed to the development of advanced control methods in boost rectifiers, addressing issues related to power quality and converter stability.

III. METHODOLOGY

The system initiates with rectification of the AC supply to DC. A boost converter then steps up this voltage based on the speed demand. The output feeds a 3-phase inverter that drives the induction motor. Speed feedback is obtained using an optical encoder and compared to a reference value. A PWM-controlled duty cycle regulates the boost converter output to match the speed demand. The entire setup is modeled in MATLAB/Simulink, and a prototype is implemented using an Arduino controller and MOSFET-based circuitry.

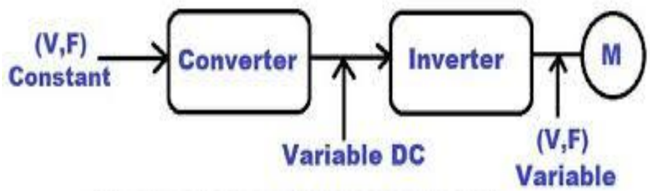

Fig. 1 Block diagram of proposed system

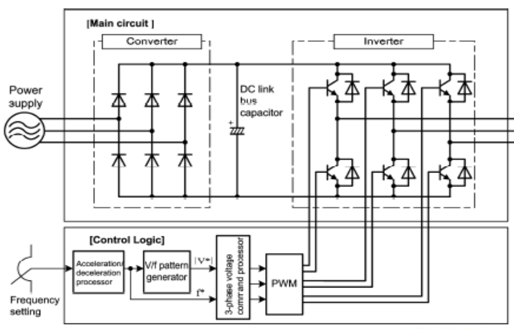

Fig. 2 Architecture of proposed control scheme of Three phase induction motor

IV. PROPOSED SYSTEM

The proposed configuration utilizes a three-phase boost converter controlled by a Proportional-Integral (PI) controller to manage the speed of an induction motor. The converter increases the input DC voltage and supplies it to a three-phase inverter, which drives the motor. The PI controller ensures the DC-link voltage remains stable, supporting consistent motor performance. This setup effectively limits inrush current, reduces voltage ripple, and enhances power quality. Simulations conducted in MATLAB/Simulink confirm that the system achieves reliable voltage control, accurate speed regulation, and lower harmonic distortion, even when operating under dynamic load variations

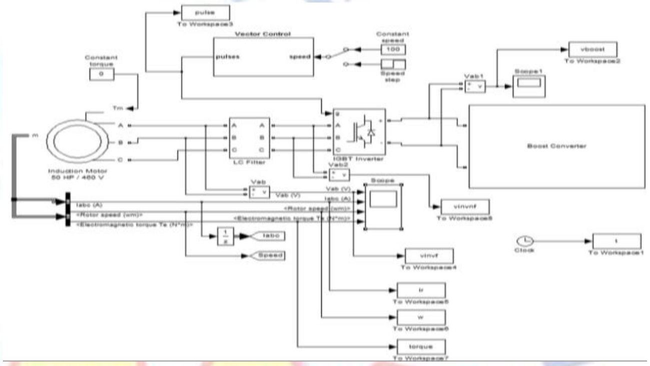

Fig 3 Simulated model of the proposed system under study in MATLAB software

V. RESULTS

The effectiveness of the proposed control strategy—employing a three-phase boost converter with a Proportional-Integral (PI) controller—was demonstrated through simulations conducted in MATLAB/Simulink. The system was able to consistently regulate the DC-link voltage at approximately 350 V under different load conditions, ensuring stable and efficient operation of the induction motor and its associated inverter. The induction motor exhibited a well-regulated speed response with smooth acceleration, minimal overshoot, and fast settling time. Overall, the results validate that the three-phase boost converter combined with a PI controller offers precise voltage and speed regulation, robust disturbance rejection, and superior power quality, making it suitable for applications where reliable and efficient motor control is essential.

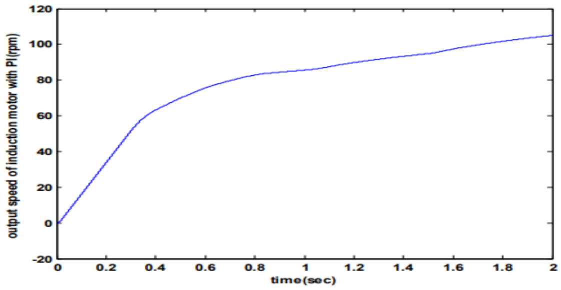

Fig 4 Output speed of induction motor with PI (rpm)

VI. CONCLUSION

This paper introduces a reliable method for controlling the speed of a three-phase induction motor by employing a three-phase boost converter paired with a Proportional-Integral (PI) controller.. Additionally, the design curbs inrush current and voltage instability, contributing to higher efficiency and operational dependability. Overall, the proposed approach offers a cost-effective and efficient solution for applications requiring consistent and robust motor control

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