

SEPIC PFC For Three Phase IM Drive Under Normal and Abnormal Supply Voltage

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Abstract

This paper presents the design and analysis of a Single-Ended Primary Inductor Converter (SEPIC) based Power Factor Correction (PFC) circuit for a three-phase induction motor (IM) drive operating under both normal and abnormal supply voltage conditions. The proposed system aims to improve the power quality by ensuring a near-unity power factor and maintaining a regulated DC link voltage, even in the presence of voltage sags, swells, or imbalances in the input supply. The SEPIC converter topology is selected for its inherent advantages, including the ability to both step-up and step-down the input voltage, continuous input current, and reduced electromagnetic interference (EMI). A control strategy combining a Phase Locked Loop (PLL) for synchronization and a dual-loop control for voltage and current regulation is implemented to achieve dynamic stability and robust performance. Simulation results validate the effectiveness of the proposed scheme in enhancing power factor, reducing total harmonic distortion (THD), and ensuring stable operation of the IM drive under a wide range of supply conditions. This study demonstrates the feasibility of employing SEPIC PFC converters in industrial motor drive systems where supply voltage fluctuations are common.

Keywords: SEPIC Converter, Power Factor Correction (PFC), Three-Phase Induction Motor (IM) Drive, Voltage Sag and Swell, Abnormal Supply Conditions, DC Link Voltage Regulation Total Harmonic Distortion (THD), Power Quality, Phase Locked Loop (PLL), Continuous Input Current.

1. INTRODUCTION

Three-phase induction motors (IMs) are widely used in industrial and commercial applications due to their rugged construction, high efficiency, and low maintenance requirements. However, when powered through conventional rectifiers and uncontrolled converters, these drives often suffer from poor power quality, low power factor, and high total harmonic distortion (THD), especially under abnormal supply voltage conditions such as sags, swells, and imbalances. These issues not only reduce the efficiency and lifespan of the motor but also adversely affect the performance of the entire power system.

To address these challenges, Power Factor Correction (PFC) techniques are employed to improve the input power quality by ensuring sinusoidal input currents and maintaining a near-unity power factor. Among various converter topologies, the Single-Ended Primary Inductor Converter (SEPIC) offers unique advantages such as the ability to both step-up and step-down input voltage, continuous input current, and low electromagnetic interference (EMI). These features make the SEPIC converter a promising candidate for PFC applications in motor drive systems.

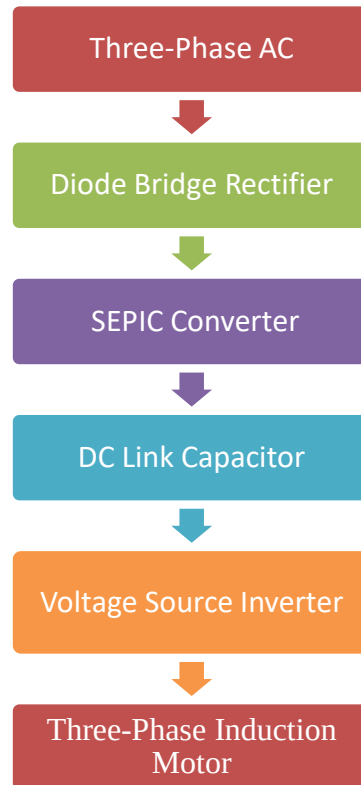
This paper investigates the implementation of a SEPIC-based PFC converter for a three-phase induction motor drive operating under both normal and abnormal supply voltage conditions. The proposed system integrates a control strategy that ensures stable DC link voltage and improved power quality, even during supply disturbances. The focus is on achieving efficient motor operation, reduced harmonic distortion, and enhanced robustness of the drive system. Simulation and experimental results are presented to validate the effectiveness of the proposed approach.

2. SYSTEM CONFIGURATION AND WORKING PRINCIPLE

The proposed system consists of a three-phase AC supply, a diode bridge rectifier, a SEPIC converter for PFC, and a voltage source inverter (VSI) feeding the three-phase induction motor. The SEPIC converter is placed between the rectifier and the DC link to regulate the voltage and correct the power factor.

The SEPIC converter uses an inductor, capacitor, and coupled switch mechanism to regulate the voltage. By controlling the duty cycle of the switching device, the converter can either step-up or step-down the input voltage, making it highly adaptable to varying supply conditions. This adaptability is critical during voltage sags or swells.

3.BLOCK DIAGRAM



4. Control Strategy

To ensure effective PFC and voltage regulation, a dual-loop control strategy is implemented:

- **Outer Voltage Loop:** Maintains the DC link voltage at a constant reference value.
- **Inner Current Loop:** Ensures the input current follows a sinusoidal reference, in phase with the supply voltage.

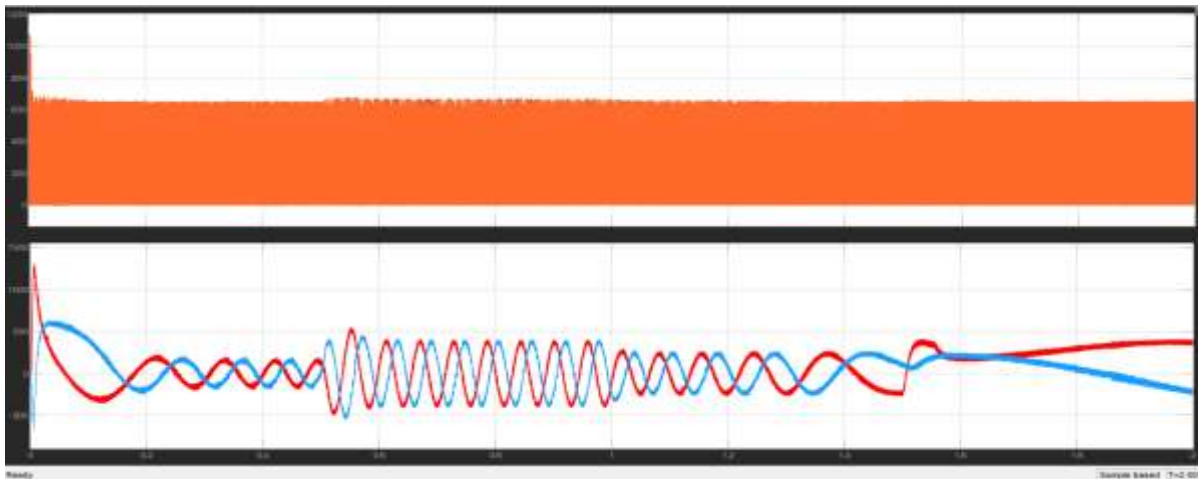
A Phase Locked Loop (PLL) is used to synchronize the reference signal with the input supply. The control system is implemented using digital signal processing for real-time adjustment of the SEPIC converter's switching.

5.Design of SEPIC Converter for PFC

Design Specifications

Parameter	Value
• Input Voltage (AC)	: 230 V RMS (Line to Neutral), 50 Hz
• Rectified DC Input	: ~325 V peak
• Output Voltage (DC Link)	: 400 V (regulated)
• Output Power	: 1.5 kW
• Switching Frequency (fs)	: 50 kHz

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UNBALANCED VOLTAGE AND CURRENT

7. Conclusion

The SEPIC-based PFC converter proves to be a robust and efficient solution for three-phase induction motor drives, especially in environments with frequent voltage disturbances. The proposed system enhances power quality, ensures continuous and stable motor operation, and meets the standards for harmonic distortion. Future work can focus on hardware implementation and real-time testing under industrial conditions. The SEPIC-based Power Factor Correction (PFC) converter proves to be a robust and efficient solution for three-phase induction motor (IM) drives, particularly in industrial environments prone to frequent voltage disturbances.

8. Future Work

Future developments can explore the following directions:

- **Hardware prototyping and real-time testing** to validate the system's performance under practical industrial operating conditions.
- Implementation of **advanced control algorithms** such as fuzzy logic, model predictive control (MPC), or neural network-based control for enhanced adaptability and efficiency.
- **Integration with renewable energy systems**, such as solar or wind power, to support sustainable motor drive applications.
- Development of a **compact PCB design** for space-constrained applications and integration into commercial motor drive packages.

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