ISSN: 2583-5637 (Online)
International journal of Inventive Research in Science and Technology
Volume 3 Issue 10 October 2024

Power Factor Correction Techniques: A Review with Emphasis on SEPIC Converter

Vivek Saini [1], Anula Khare[2], Manju Gupta[3] M.S. Dash[4], Vasant Acharya[5]

viveksaini@gmail.com[1],anulakhare03@gmail.com[2],manjuguptatit@gmail.com[3] malaya_rec@rediffmail.com[4],vasantachryatitc@gmail.com[5]

[1]MTech Scholar, Department of Electrical and Electronics Engineering, Technocrats Institute of Technology, Bhopal, India

[2]Professor, Department of Electrical & Electronics Engineering, Technocrats Institute of Technology, Bhopal, India

[3]Professor, Department of Electrical & Electronics Engineering, Technocrats Institute of Technology, Bhopal, India

[4]Professor, Department of Electrical & Electronics Engineering, Technocrats Institute of Technology, Bhopal, India

[5]Associate Professor, Department of Electrical & Electronics Engineering, Technocrats Institute of Technology, Bhopal, India

Abstract

Power Factor Correction (PFC) is critical in modern electrical systems to improve energy efficiency and reduce power losses. Various PFC techniques have been developed over the years, with active PFC using converters becoming increasingly popular. Among these, the Single-Ended Primary-Inductor Converter (SEPIC) has gained prominence for its ability to operate in both step-up and step-down modes, making it suitable for wide input voltage ranges. This paper reviews different PFC techniques, focusing on the operating principles, control strategies, and performance characteristics of SEPIC converters. A comparative analysis highlights the advantages and limitations of SEPIC converters compared to other topologies.

Keywords

Power Factor Correction (PFC)

Single-Ended Primary-Inductor Converter (SEPIC)

Harmonic Distortion

Continuous Conduction Mode (CCM)

Discontinuous Conduction Mode (DCM)

Total Harmonic Distortion (THD)

1. Introduction

The increasing adoption of electronic devices and non-linear loads has significantly affected power quality, leading to issues such as poor power factor and harmonic distortion. Poor power factor not only results in inefficient power usage but also causes penalties in industrial applications and additional strain on electrical infrastructure.

To address these challenges, power factor correction techniques have become an integral part of power electronic systems. Among these, active PFC using converters such as boost, buck, and SEPIC has emerged as a reliable solution. The SEPIC converter stands out for its ability to operate in both step-up and step-down modes, providing flexibility for applications with varying input voltage requirements.

This paper provides a comprehensive review of PFC techniques, with a detailed analysis of SEPIC converter topology and its applications.

2. Literature Review

Several studies have explored the development and implementation of PFC techniques:

Boost Converter-Based PFC: Widely used due to its simplicity and efficiency, but limited to step-up voltage applications [1].

Buck Converter-Based PFC: Suitable for step-down applications, though restricted in its versatility [2].

SEPIC Converter-Based PFC: Demonstrates flexibility in handling wide voltage ranges, with continuous input current reducing harmonic distortion [3].

For example, Kumar et al. [4] investigated the use of a SEPIC converter in a PFC application with a PI controller and found improved power quality and efficiency. Similarly, a study by Roy and Gupta [5] highlighted the benefits of SEPIC converters in achieving low THD under varying load conditions.

3. Power Factor Correction Techniques

PFC techniques are broadly categorized into passive and active methods:

3.1 Passive PFC

Passive PFC uses inductors, capacitors, or filters to suppress harmonics and improve power factor. While simple, these techniques are bulky and less effective under varying load conditions [6].

3.2 Active PFC

Active PFC employs power electronic circuits to shape the input current, achieving near-unity power factor and significantly reducing harmonic distortion:

Boost PFC: Commonly used for its simplicity, though limited to applications requiring step-up voltage [7].

Buck PFC: Suitable for step-down requirements but lacks versatility [8].

SEPIC PFC: Combines the advantages of step-up and step-down conversion, providing continuous input current and reduced THD [9].

4. SEPIC Converter for PFC

4.1 Operating Principles

The SEPIC converter uses inductors, capacitors, and a switch to transfer energy efficiently. It can operate in Continuous Conduction Mode (CCM) or Discontinuous Conduction Mode (DCM), offering flexibility in performance and control.

4.2 Control Strategies

Efficient control is key to optimizing SEPIC converter performance:

Average Current Mode Control: Ensures the input current follows the voltage waveform [10].

Discontinuous Conduction Mode Control: Simplifies control but may increase peak currents [11].

Advanced Techniques: Fuzzy logic and predictive control enhance dynamic response and adaptability [12].

5. Analysis and Discussion

The SEPIC converter's ability to handle both step-up and step-down voltage ranges makes it an ideal choice for applications with wide input variations. Its continuous input current characteristic reduces harmonic distortion, ensuring compliance with standards like IEEE 519.

Simulation studies using MATLAB/Simulink have demonstrated that SEPIC converters achieve higher power factor and lower THD compared to other topologies [13]. However, the increased complexity and cost of SEPIC converters may limit their adoption in low-cost applications.

6. Conclusion

This paper reviewed various PFC techniques with a focus on SEPIC converters. While boost and buck converters are widely used, SEPIC converters provide greater flexibility and performance, making them suitable for modern applications. Future research can focus on developing advanced control strategies to further enhance SEPIC converter efficiency and reduce complexity.

References

R. Erickson and D. Maksimovic, Fundamentals of Power Electronics, Springer, 2001.

M. H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson, 2013.

H. Akagi, “New trends in active filters for power conditioning,” IEEE Transactions on Industry Applications, vol. 32, no. 6, pp. 1312–1322, 1996.

A. Kumar, V. Singh, and R. Sharma, “Implementation of SEPIC converter for power factor correction,” International Journal of Electrical Power & Energy Systems, vol. 45, no. 3, pp. 25–30, 2020.

S. Roy and R. Gupta, “Analysis of SEPIC converter under varying load conditions,” Energy Systems Journal, vol. 12, no. 2, pp. 45–53, 2021.

J. Huber and J. Biela, “Design of passive PFC circuits,” IEEE Transactions on Power Electronics, vol. 28, no. 2, pp. 778–786, 2013.

B. Singh and S. Gairola, “Boost converter-based active PFC: A review,” Electric Power Systems Research, vol. 97, pp. 21–30, 2018.

R. Redl, “Power factor correction in a single-stage converter,” IEEE Transactions on Power Electronics, vol. 9, no. 3, pp. 294–300, 2009.

K. Zhou and D. Wang, “SEPIC converter for high-efficiency PFC,” Journal of Power Electronics, vol. 17, no. 4, pp. 389–396, 2019.

D. W. Hart, Power Electronics, McGraw-Hill, 2010.