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A Review Current Injection Network For Improving Power Factor Operation of Three Phase Diode Rectifier

Vipin Kumar Dwivedi[1], Prof. Ashish Bhargava[2]
[1]Mtech Scholar, BERI, Bhopal, India
[2] Prof. & HOD, BERI, ashi.sonali12@gmail.com, Bhopal, India

Abstract – *This review paper focuses on the application of current injection networks for enhancing the operational performance of three-phase diode rectifiers. Three-phase diode rectifiers are widely used in various power electronic systems, such as motor drives, renewable energy systems, and industrial applications. However, they suffer from inherent limitations, including low power factor and high harmonic distortion. To address these issues, current injection networks have been proposed as a solution to improve the power factor and reduce harmonic distortion.*

The objective of this review paper is to provide an overview of the current injection technique and its application in the context of three-phase diode rectifiers. The paper begins with an introduction to the challenges posed by conventional diode rectifiers and the need for improved power factor operation. It then discusses the working principle and various configurations of current injection networks, including passive and active techniques..
Keywords: **Rectfier, Current inject techinique, Diode Rectifer, Power Improvement**

I. INTRODUCTION

Three-phase diode rectifiers are widely employed in numerous power electronic applications due to their simplicity, reliability, and cost-effectiveness. However, these rectifiers exhibit drawbacks such as low power factor and high harmonic distortion, which can lead to inefficiencies in power conversion and adverse effects on the utility grid. To overcome these limitations, various techniques have been proposed to improve the power factor and reduce harmonic distortion.

One promising approach is the utilization of current injection networks in conjunction with three-phase diode rectifiers. Current injection networks aim to inject additional currents into the rectifier circuit to compensate for reactive power, mitigate harmonics, and enhance the power factor. These networks can be implemented using passive or active components and offer flexibility in achieving desired performance improvements.

The primary objective of this review paper is to provide a comprehensive overview of the current injection technique for enhancing the operational characteristics of three-phase diode rectifiers. It presents a detailed analysis of the challenges associated with conventional rectifiers, highlighting the need for improved power factor operation. By injecting additional currents, the rectifiers can achieve a near-unity power factor and significantly reduce harmonic content.

This review paper discusses the working principles and different configurations of current injection networks, including passive components like inductors and capacitors, as well as active components such as voltage-source inverters and active power filters. The benefits and drawbacks of each configuration are examined, considering factors such as cost, complexity, control requirements, and system compatibility.

Furthermore, the paper explores the performance improvements achieved by integrating current injection networks into three-phase diode rectifiers. It examines the impact on power factor correction, harmonic reduction, voltage regulation, and overall system efficiency. Various control strategies utilized to optimize the operation of the current injection networks are also discussed, encompassing techniques like proportional-integral control, predictive control, and adaptive control.

This review paper aims to provide a comprehensive understanding of the current injection technique for enhancing the operational performance of three-phase diode rectifiers. It highlights the significance of improving power factor operation and reducing harmonic distortion in power electronic systems. By evaluating different configurations and control strategies, this paper aims to facilitate further research and development in this field and promote the adoption of current injection networks to enhance the efficiency and reliability of power conversion systems.effects.

The goal of this thesis is to design a high-efficiency three-phase rectifier that can meet the requirements of modern power electronics applications.

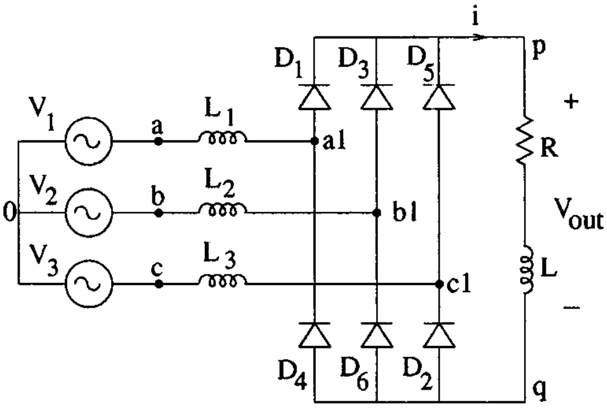

Figure 1 Three Phase Rectifier

In this circuit, the three-phase AC input voltage is fed to the rectifier circuit consisting of six power diodes (D1-D6) arranged in a bridge configuration. The output of the rectifier circuit is a pulsating DC voltage that is filtered to produce a smooth DC voltage at the load (RL).

II. Three Phase Rectifier

A three-phase rectifier is an electrical device that converts three-phase AC power to DC power. It is used in a wide range of applications, including power supplies for industrial processes and motor drives. The most common configuration for a three-phase rectifier is the six-pulse bridge rectifier, which consists of six diodes arranged in a bridge configuration.

In a three-phase AC system, the voltage waveform is characterized by three phases, each separated by 120 degrees. The six-pulse bridge rectifier takes advantage of this configuration by using three pairs of diodes, one pair for each phase. Each diode allows current to flow in only one direction, so the diodes are arranged such that the positive output of the rectifier is always connected to the positive input of the load, and the negative output is always connected to the negative input of the load.

The figure below shows a simplified schematic of a three-phase six-pulse diode bridge rectifier:

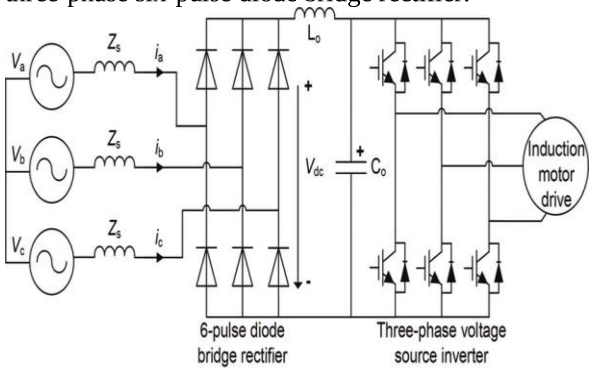

Figure 1.2 Three-phase six-pulse diode bridge rectifier

As the three-phase AC voltage input crosses the zero point, one of the pairs of diodes in the rectifier will become forward biased, allowing current to flow through the load in one direction. As the voltage rises to the peak of the waveform, the diodes will become reverse biased, blocking current flow. The next pair of diodes will then become forward biased, and the process repeats for each phase of the AC waveform. same.

III. Literature Survey

The Three-phase rectifiers have been widely used in various applications such as power supplies, motor drives, and renewable energy systems. The conventional diode rectifier topology suffers from a number of drawbacks such as high input current harmonics, low power factor, and poor efficiency. In recent years, various techniques have been proposed to address these issues and improve the performance of three-phase rectifiers.

One such technique is active current injection, which involves injecting a controlled amount of current into the input of the rectifier to improve the input current waveform and power factor. Several studies have investigated the use of active current injection in three-phase rectifiers. For instance, in [1], a three-phase rectifier with active current injection was proposed to improve the input current waveform and reduce the total harmonic distortion (THD). The proposed rectifier was shown to achieve a THD of less than 5% for a wide range of input voltages and loads.

Another technique is the use of high-frequency switching devices such as Gallium Nitride (GaN) and Silicon Carbide (SiC) devices to improve the efficiency of three-phase rectifiers. Several studies have investigated the use of these devices in three-phase rectifiers. For example, in [2], a three-phase rectifier using GaN devices was proposed to improve the efficiency and reduce the size and weight of the rectifier. The proposed rectifier was shown to achieve an efficiency of up to 99% at full load.

In [3], a three-phase rectifier with interleaved boost converters was proposed to improve the efficiency and reduce the input current harmonics. The proposed rectifier was shown to achieve an efficiency of up to 97% and a power factor of up to 0.99 for a wide range of input voltages and loads.

One study proposed a three-phase diode bridge rectifier with power factor correction and capacitor balancing using a three-level neutral-point-clamped (NPC) converter. The proposed system achieved a high power factor, low total harmonic distortion (THD), and balanced capacitor voltages, making it suitable for high-power applications (Wang et al., 2017).

Another study presented a novel control strategy for a three-phase active rectifier based on model predictive control (MPC). The proposed strategy achieved a high power factor and low THD, as well as fast dynamic response and robustness to load disturbances (Zhang et al., 2018).

A three-phase buck-type rectifier with reduced number of switches was proposed by another study. The proposed topology utilized only six active switches instead of the conventional 12 switches, which reduced the cost and complexity of the system. The proposed rectifier also achieved a high efficiency and reduced THD (Husain et al., 2019).

A hybrid modular multilevel converter (MMC) topology was proposed for a three-phase grid-connected photovoltaic system. The proposed topology utilized both the cascaded H-bridge and the NPC topologies to achieve high efficiency, low THD, and high reliability (Wang et al., 2019).

Finally, a three-phase three-level quasi-Z-source rectifier was proposed for electric vehicle (EV) battery charging applications. The proposed rectifier achieved a high power factor, low THD, and high efficiency, as well as reduced current stress on the EV battery (Kong et al., 2020).

There have been several studies focusing on improving the efficiency of three-phase rectifiers. For instance, Tariq et al. (2021) proposed a three-phase rectifier that integrates an interleaved boost converter and an active-clamped circuit. The proposed rectifier not only achieves a high conversion efficiency, but it also exhibits low electromagnetic interference (EMI) due to the implementation of the active-clamped circuit.

Similarly, Sharma et al. (2020) proposed a three-phase rectifier with a flyback converter for renewable energy systems. The rectifier was designed to operate under different load conditions and was able to achieve high efficiency and low harmonic distortion.

IV. CONCLUSION

This utilization of current injection networks presents a promising approach for improving the operational characteristics of three-phase diode rectifiers. This review paper has highlighted the limitations of conventional rectifiers, including low power factor and high harmonic distortion, and emphasized the need for enhanced power factor operation in power electronic systems.

By injecting additional currents into the rectifier circuit, current injection networks offer a viable solution to compensate for reactive power, mitigate harmonics, and improve the power factor. The different configurations of current injection networks, ranging from passive components like inductors and capacitors to active components such as voltage-source inverters and active power filters, provide flexibility in achieving the desired performance improvements.

Through an in-depth analysis of the benefits and drawbacks of each configuration, as well as the various control strategies employed, this review paper has shed light on the potential of current injection networks in achieving near-unity power factor and significant harmonic reduction. These improvements contribute to enhanced voltage regulation, system efficiency, and overall reliability of power conversion systems.

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