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Boost PFC-Based Power Factor Enhancement in BLDC Drives

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Abstract: *Power factor correction (PFC) strategy for Brushless DC (BLDC) motor drives using a Boost converter to address the issues of low power factor and high input current harmonic distortion. While BLDC motors offer high efficiency, reliability, and compactness, their conventional drive systems-typically incorporating a diode bridge rectifier and a capacitor-fed inverter-draw non-sinusoidal currents from the AC mains, leading to degraded power quality. To overcome these limitations, a Boost PFC converter is integrated at the front end to shape the input current and regulate the DC-link voltage. BLDC motor configurations, highlighting the operational differences between inner rotor and outer rotor designs. Simulation results obtained using MATLAB/Simulink validate the effectiveness of the proposed approach, demonstrating significant improvements in power quality and motor performance. This solution is particularly well-suited for applications in industrial automation, electric vehicles, and energy-efficient appliances.*

Keywords: Brushless DC (BLDC) Motor, Power Factor Correction (PFC), Boost Converter, Power Quality, MATLAB/Simulink

I. INTRODUCTION

Brushless DC (BLDC) motors are extensively utilized in applications such as electric vehicles, robotics, HVAC systems, and consumer electronics, owing to their high efficiency, reliability, and compact construction. Despite these advantages, BLDC motor drives often suffer from poor power quality, characterized by low power factor and significant harmonic distortion. These issues can result in energy inefficiencies, increased thermal stress, and a shortened lifespan of system components.

A widely adopted approach to address these challenges is the incorporation of a **Power Factor Correction (PFC)** circuit. Among various PFC topologies, the **Boost PFC converter** stands out due to its simplicity, cost-effectiveness, and capability to substantially improve power factor while minimizing input current harmonics. This paper investigates the operational principles, implementation challenges, and performance benefits of integrating a Boost PFC converter into BLDC motor drive systems.

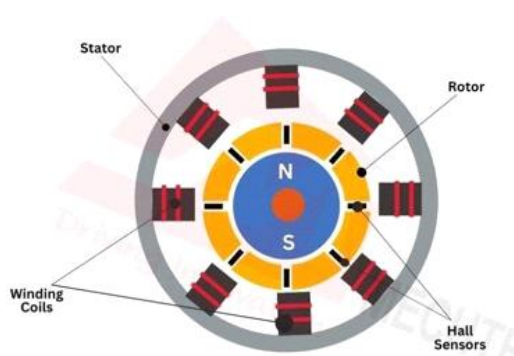

Fig-1 : BLDC Motor

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1.1 Power Quality in BLDC Drives

LDC motor drives, when directly powered from the AC mains, often exhibit poor power quality due to the non-linear nature of the rectifier and inverter stages. These switching components draw non-sinusoidal input currents, introducing significant harmonic distortion and resulting in a low power factor (PF). A reduced PF increases reactive power demand and causes higher losses in the distribution system. Moreover, such systems may fail to meet international power quality standards, which specify limits on harmonic distortion and minimum acceptable PF levels.

1.2 Boost PFC Converter

Among various power factor correction (PFC) techniques, the Boost converter has emerged as one of the most practical and widely adopted solutions for improving power quality in BLDC motor drive systems. The Boost PFC converter operates as a step-up DC-DC converter placed between the diode bridge rectifier and the DC link of the inverter. Its primary function is to shape the input current waveform to closely follow the sinusoidal shape of the input voltage, thereby achieving a near-unity power factor. By operating in continuous or discontinuous conduction mode with proper control strategies—such as average current mode or peak current mode control—the Boost converter significantly reduces total harmonic distortion (THD) at the input. It ensures that the drawn current is in phase with the input voltage and maintains a regulated DC bus voltage, which is critical for the stable operation of the downstream inverter and the BLDC motor.

II. BLOCK DIAGRAM

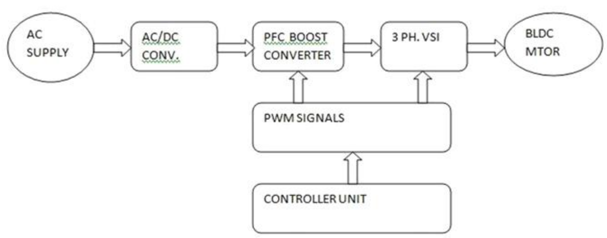

Fig-2 : Block Diagram

power factor correction (PFC) based BLDC motor drive system using a Boost converter. The system begins with an AC power supply, which is first converted to DC using an AC/DC converter, typically implemented as a diode bridge rectifier. This rectified DC voltage is unregulated and contains significant ripple, which is unsuitable for direct use by the inverter. To address this, a Boost PFC converter is employed. This converter serves two key purposes: it boosts and regulates the DC-link voltage and shapes the input current to follow the input voltage waveform, thereby improving the power factor and reducing total harmonic distortion (THD). The Boost converter operates under the control of a controller unit, which generates pulse width modulation (PWM) signals to regulate its switching behaviour.

In addition to controlling the Boost converter, the controller also generates PWM signals to operate the three-phase voltage source inverter (VSI), which converts the regulated DC voltage into three-phase AC signals required by the BLDC motor. The VSI is responsible for the electronic commutation of the motor, ensuring proper sequencing of phases for efficient and smooth motor operation. Overall, this architecture provides a robust solution for driving BLDC motors with improved power quality and reduced energy losses.

III. METHODOLOGY

The proposed BLDC motor drive system is structured into four primary stages. The first stage is the AC input source, which supplies a standard sinusoidal voltage at 50 Hz and serves as the initial power source for the system. This AC voltage is then fed into a bridge rectifier, which converts it into a pulsating DC signal. Although this rectified output provides the necessary DC form, it lacks regulation and introduces harmonic distortion into the system. To address these issues, the third stage incorporates a Boost Power Factor Correction (PFC) converter, which performs two essential functions: it regulates and boosts the DC-link voltage to the desired level and simultaneously shapes the input

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current to be sinusoidal and in phase with the supply voltage. This significantly enhances the power factor and reduces total harmonic distortion (THD), ensuring compliance with power quality standards. Finally, the regulated DC voltage is fed into a three-phase Voltage Source Inverter (VSI), which converts it into the appropriate three-phase AC signals required to drive the Brushless DC (BLDC) motor efficiently. Each stage in the system plays a critical role in ensuring stable operation, improved efficiency, and enhanced power quality.

3.1 Circuit Diagram

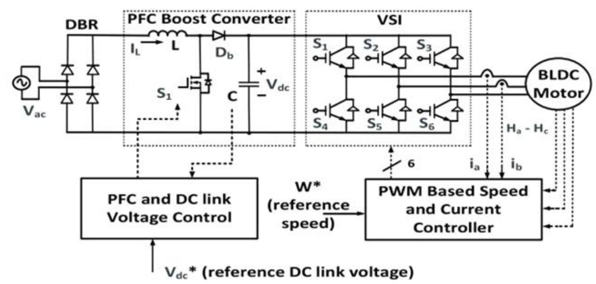

Fig-3 : Circuit Diagram

BLDC motor drive system includes a diode bridge rectifier (DBR), a Boost PFC converter, a voltage source inverter (VSI), and a control unit. The AC supply is first rectified to DC, which is then regulated by the Boost PFC converter to improve power factor and reduce harmonic distortion. The PFC controller maintains a constant DC-link voltage, while the VSI converts this voltage into three-phase AC to drive the BLDC motor. A PWM-based speed and current controller adjusts inverter switching based on reference speed and rotor position, ensuring efficient and stable motor operation with enhanced power quality.

3.2 Mode of Operation

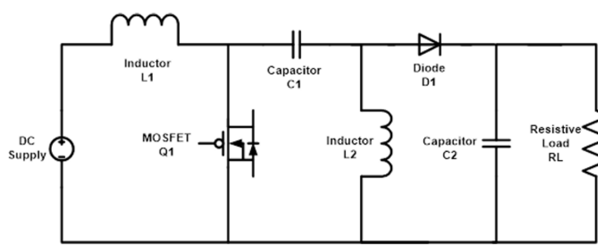

Fig-4 : the conventional sepic converter operation of sepic converter consists of two-part when MOSFET is ON and when MOSFET is OFF

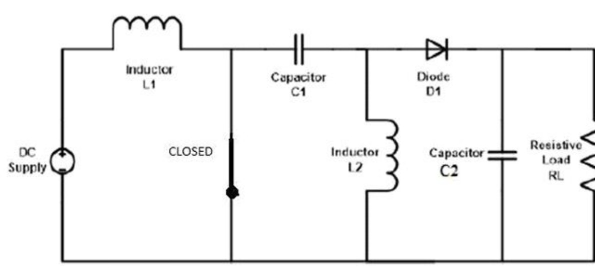

Fig-5 : Mode 1 Operation

The MOSFET is turned ON, causing the inductor to store energy.
The diode is reverse biased, and the capacitor supplies the load.

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$$\Delta I_{L,ON} = \frac{V_{in} \cdot t_{on}}{L}$$

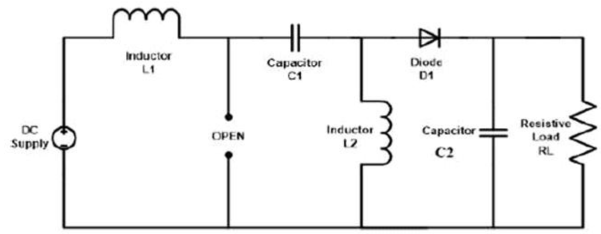


Fig-6 : Mode 2 Operation

The MOSFET is turned OFF, and the inductor releases energy through the diode.
Both the capacitor and inductor provide current to the load, boosting the output voltage.

$$\Delta I_{L,OFF} = \frac{(V_{out} - V_{in}) \cdot t_{off}}{L}$$

IV. SIMULATION AND RESULT

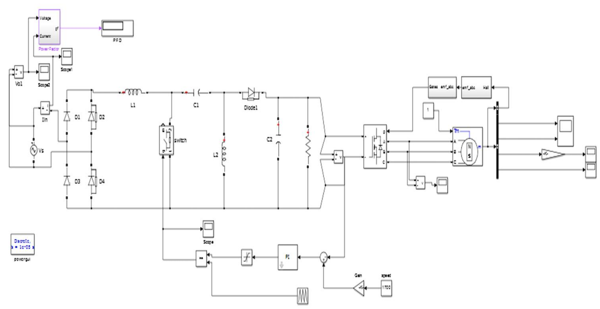
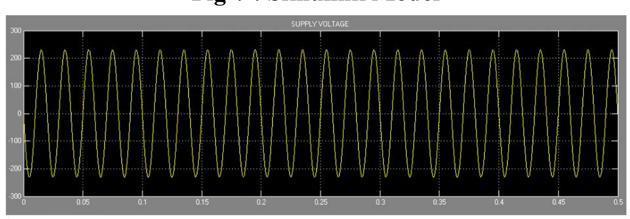
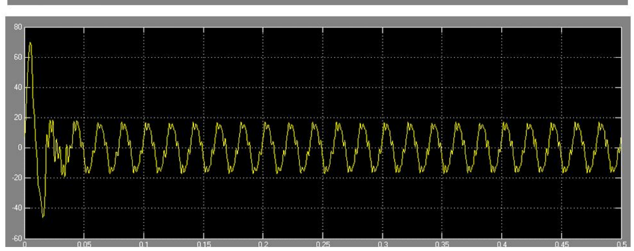
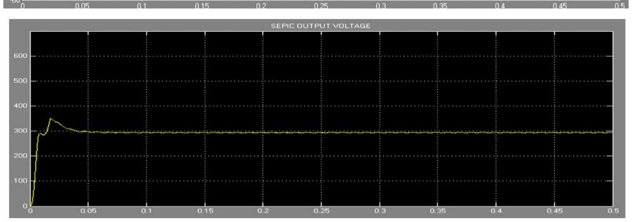


Fig-7 : Simulink Model







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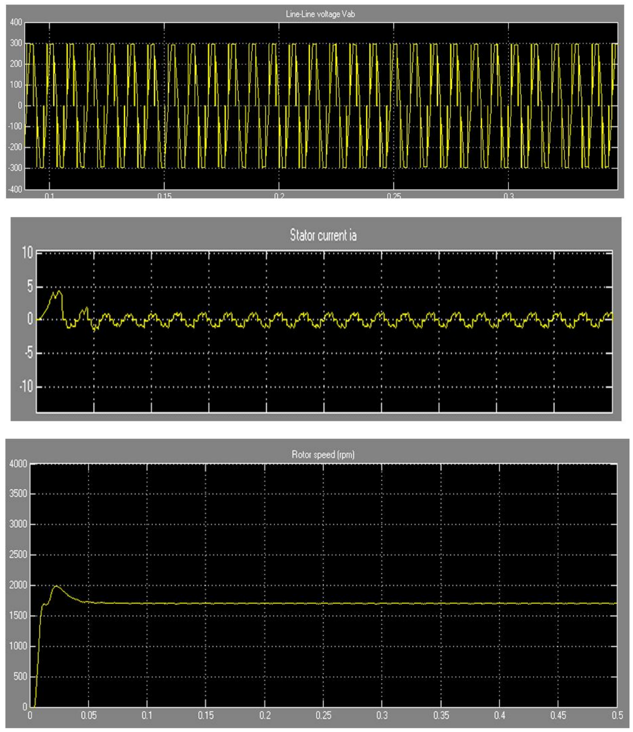

Fig-8 : Simulated Results

The model consists of an AC supply, bridge rectifier, Boost PFC converter, voltage source inverter, and BLDC motor. The Boost PFC stage shapes the input current to improve power factor and regulate the DC link voltage, while the inverter drives the motor with controlled three-phase signals. Measurement blocks capture voltage, current, speed, and torque for performance evaluation.

V. APPLICATIONS

- Electric Vehicles (EVs): Ensures efficient motor operation and compliance with grid power quality standards.
- HVAC Systems: Improves energy efficiency in compressors, fans, and air conditioning units.
- Industrial Automation: Provides reliable and precise control for motors in pumps, conveyors, and robotics.
- Consumer Electronics: Enhances performance and reduces noise in appliances such as washing machines and refrigerators.
- Renewable Energy Systems: Regulates DC bus voltage and improves PF in solar PV and fuel cell–based drives.

VI. CONCLUSIONS

In this project, a BLDC motor drive with a Boost PFC converter was designed and simulated to overcome common power quality issues. The integration of the PFC stage helped achieve a higher power factor, reduced harmonic distortion, and maintained a steady DC link voltage, all of which contributed to smoother and more efficient motor operation. The MATLAB/Simulink results clearly demonstrated these improvements, showing that the proposed system can be a practical solution for a wide range of applications, from household appliances to industrial and commercial drives.

REFERENCES

[1]. Singh, B., & Bist, V. (2015). "Power Quality Improvement in BLDC Motor Drive Using Isolated and Non-Isolated PFC Converters." Published in the International Journal of Engineering, Science, and Technology.

[2]. Kulkarni, R., & Pathak, R. (2021). "Analysis of PFC Converter for BLDC Motor Drive Using MATLAB/Simulink." Published in the International Research Journal of Engineering and Technology (IRJET), focusing on practical implementation and optimization of Boost PFC converters for BLDC motors.

[3]. ARPN Journal of Engineering and Applied Sciences (2017). "Control of PFC Converters for BLDC Motor Drives." This research elaborates on PFC converter configurations, performance metrics, and applications in real-world scenarios.

[4]. Khan, I., & Gupta, P. (2017). "Efficiency Optimization in PFC Converters for BLDC Motors." This study explores advanced PFC strategies with a focus on low THD and high power factor for industrial applications.

[5]. Patel, A., & Sharma, N. (2020). "Hybrid PFC Topologies for Motor Drives." This research discusses the potential of hybrid and modular PFC configurations for broader application and increased efficiency