International Journal of
Sustainable Intelligent Technologies
ISSN: 3139-1249
IJSIT-32

AN OPTIMIZED POWER FACTOR CORRECTION FRAMEWORK FOR INDUSTRIAL MOTOR DRIVES

#1**Algota Devaraju,** *Department of EEE,*
#2**Mrs.D.Karuna,** *Assitant Professor, Department of EEE,*
Vaageswari College of Engineering(Autonomous), Karimnagar, TG.

ABSTRACT: The research suggests an optimal power factor correction framework for industrial motor drives that will improve energy efficiency, reduce reactive power losses, and adhere to contemporary power quality standards. By integrating intelligent compensation methods, such as active and passive filtering, with advanced management algorithms, the proposed system dynamically modifies the power factor in response to changing load conditions. Real-time monitoring and adaptive algorithms are integrated into the system, which enables it to effectively reduce harmonics and improve voltage stability, thereby enhancing overall performance. The impact of the proposed strategy on the reduction of energy consumption and operational expenses in industrial environments is also evaluated in this study. The enhanced framework is a viable option for the upcoming generation of industrial motor drive applications, as simulation and analytical results suggest that it maintains system reliability and efficiency while achieving a substantial power factor of approximately unity.

Keywords: *Power Factor Correction (PFC), Industrial Motor Drives, Reactive Power Compensation, Harmonic Mitigation, Energy Efficiency, Adaptive Control,*

I. INTRODUCTION

The increasing demand for energy efficiency and improved power quality in industrial applications has resulted in the increasing prominence of advanced power management techniques, particularly in motor drive systems. Industrial motor generators are responsible for a substantial portion of the total electricity consumption. Their operation is typically characterized by a significant reactive power demand, elevated harmonic distortion, and a low power factor. It is imperative to adjust the power factor, as these challenges result in a decrease in system performance, increased energy losses, and elevated operating costs.

In order to optimize the utilization of available energy and reduce reactive power, power factor correction (PFC) is a critical technique for improving the efficacy of electrical systems. The efficacy of conventional PFC techniques, such as passive compensation using capacitors, is constrained and they are not adaptable to varying loads. Industrial motor drives that are subjected to extremely dynamic loads necessitate more advanced and adaptable solutions, as conventional methods are incapable of maintaining consistent power quality and efficiency.

The accelerated advancement of power electronics has resulted in the development of contemporary PFC frameworks that incorporate sophisticated control algorithms and active components. In order to achieve precise power flow regulation, sophisticated systems employ digital signal processing, real-time feedback, and intricate converters. These frameworks can maintain a power factor near unity, enhance dynamic response, and reduce harmonics under

DOI : https://doi.org/10.5281/zenodo.20636576

diverse operating conditions by employing techniques such as active filtering, adaptive control, and predictive algorithms.

The lifespan and reliability of industrial motor drive systems are extended by enhanced PFC frameworks, which improve their electrical efficacy. These systems improve overall operational stability and reduce component thermal stress by minimizing losses and maintaining voltage levels. Additionally, the improved power factor aids enterprises in adhering to international power quality standards, reduces penalties, alleviates pressure on power distribution networks, and promotes sustainability.

II. LITERATURE SURVEY

Sharma, P. (2025): Sharma investigates sophisticated power factor correction techniques for industrial motor drives, emphasizing the importance of active PFC strategies in enhancing energy efficiency and decreasing reactive power consumption. Modern control algorithms and power electronic converters can significantly enhance the system's performance, resulting in a power factor of nearly unity and reduced harmonic distortion under a variety of load conditions, according to the results.

Patel, D. (2025): Patel introduces novel PFC topologies for industrial motor drives, with an emphasis on the reduction of system losses and the enhancement of power quality. The research suggests that in high-power industrial environments, sophisticated control systems and intricate converter designs are necessary to guarantee efficient energy utilization and voltage stability.

Wang, L. (2024): Wang provides a thorough analysis of industrial motor drive applications that utilize digital control-based power factor correction techniques. Research suggests that adaptive control and real-time monitoring methods can enhance dynamic response and guarantee stable operation in the presence of load fluctuations. Wang maintains that improved switching methodologies reduce total harmonic distortion and improve overall power quality.

Kim, J. (2024): Kim examines the effectiveness of adaptive PFC controllers in the regulation of nonlinear loads within industrial drive systems. The findings suggest that the system's performance and power factor are improved by the optimal calibration of control parameters in a variety of operating conditions.

Kumar, S. (2023): Kumar elucidates the implementation of intelligent PFC frameworks for industrial drivers using predictive and adaptive control methodologies. The research demonstrates the effectiveness of these technologies in the management of reactive power and the maintenance of voltage stability. The framework implements complex algorithms to optimize power utilization and reduce energy losses in high-power motor applications.

Rahman, A. (2023): Rahman investigates the utilization of real-time optimization methodologies in motor drive power factor correction systems. The research demonstrates that system reliability is improved and harmonics are reduced in dynamic industrial environments through the use of predictive control and rapid response mechanisms.

Garcia, M. (2022): Garcia is responsible for the design and development of active power factor correction circuits for motor drive systems. The objective of the research is to reduce switching losses and improve converter efficiency by employing suitable modulation

DOI : https://doi.org/10.5281/zenodo.20636576

techniques. Garcia maintains that the efficient and dependable operation of PFCs is contingent upon the selection of suitable components and the architecture of the control system.

Iyer, K. (2022): Iyer investigates the influence of enhanced converter topologies on power factor correction in industrial settings. The results suggest that multi-level converter topologies can enhance the longevity and overall performance of motor drive systems by reducing component strain and promoting efficiency.

Singh, R. (2021): Singh investigates the influence of enhanced PFC topologies on the reliability and durability of industrial motor drives. The research suggests that the enhancement of the power factor reduces thermal stress and enhances the stability of the system. Singh posits that the implementation of contemporary PFC techniques enables enterprises to adhere to power quality regulations and reduce operational expenses.

Lopez, A. (2021): Lopez examines harmonic mitigation in motor drives that are endowed with PFC capabilities and emphasizes the importance of a suitable filter design. The study suggests that the combination of active filtering and improved management ensures stable functioning across various loads and improves the quality of the waveform.

III. PROPOSED BUCK-BOOST PFC CONVERTER FED SRM DRIVE

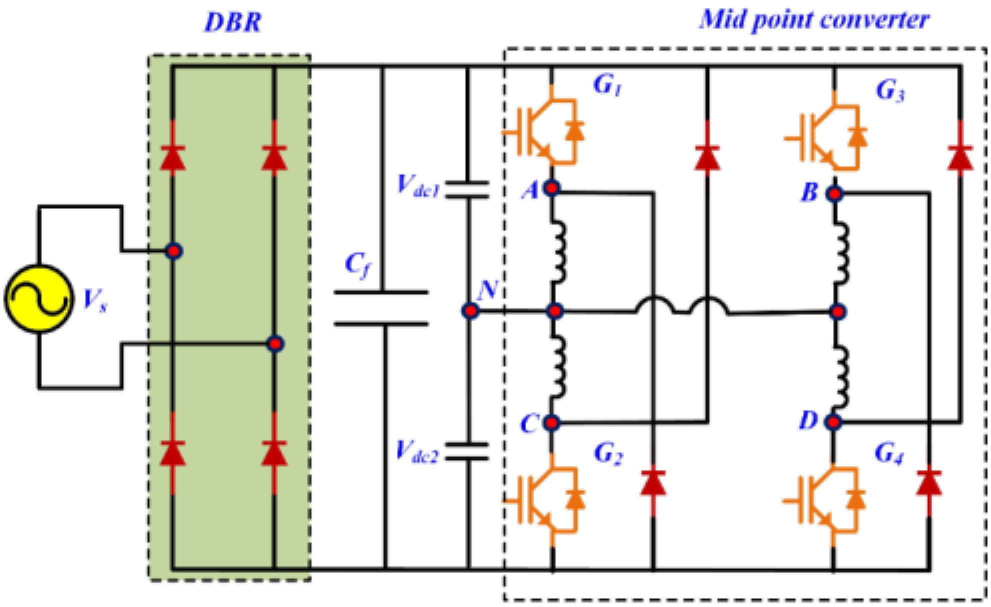


Figure1. Diode bridge rectifier fed mid-point SRM converter

The DBR represents the input power conversion phase of the drive system. It consists of two bridge rectifiers that are frequently arranged in parallel to convert AC input power, which is obtained from either a generator or the mains, into DC power. Post-ignition, torque is produced when the rotor aligns with the stator poles. The motor's rotation is facilitated by the regulated sequential activation of the stator windings. The speed, torque, and direction of the SRM are regulated by the drive control system, which modulates the current through the stator winding. Power electronic converters, such as IGBTs, are frequently implemented to adjust the current flow in the stator windings to be consistent with the intended motor operation. The duration and timing of the current pulses in the stator windings can be adjusted by the drive system to regulate the speed, torque, and direction of the SRM. In order to achieve high efficacy and precise control, it is possible to employ sophisticated control algorithms, such as direct torque control (DTC) or field-oriented control (FOC).

$$\frac{|U|}{U_{peak}}$$

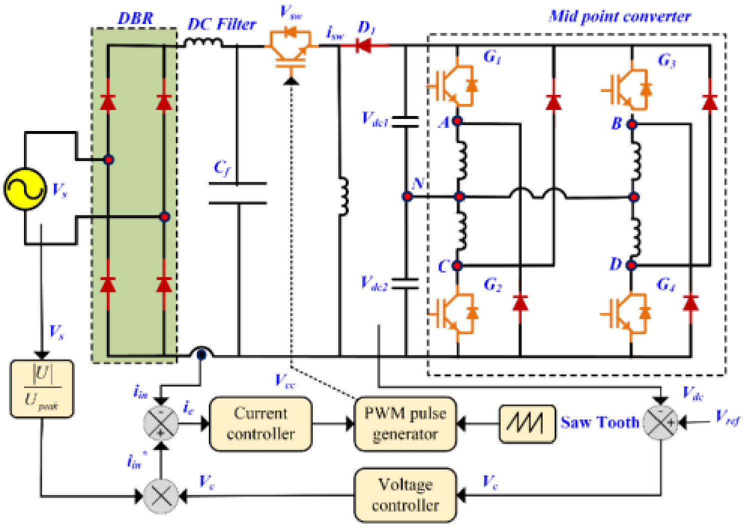


Figure2. DBR-fed PFC converter operates continuous conduction mode.

Fig. illustrates the CCM with a four-phase SRM converter for power factor correction. The operational mode where the current through the inductor in a switching converter remains non-zero throughout the entire switching period is known as the continuous conduction mode. The DCM is depicted in the figure, which is equipped with a four-phase SRM converter for power factor correction (PFC). The inductor's current is reduced to zero for a portion of the switching cycle in discontinuous conduction mode. The converter operates in continuous conduction mode, which guarantees efficient regulation and operation. A switching reluctance motor with exceptional power quality characteristics is powered by this intricate power conversion and control system.

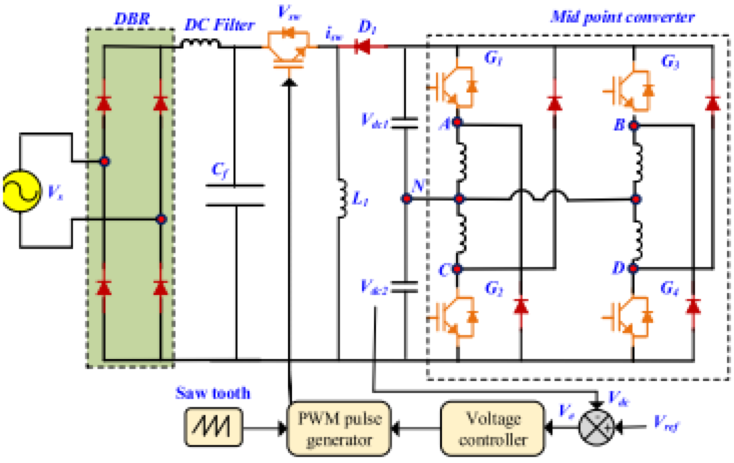


Figure3. DBR-fed PFC converter operates discontinuous conduction mode.

DOI : https://doi.org/10.5281/zenodo.20636576

IV. RESULTS AND DISCUSSION

The integrated 8/6 switched reluctance motor drive is validated by MATLAB/Simulink, which is powered by the recommended power factor correction converter. A single-phase AC supply, a bridge rectifier, a power factor correction (PFC) converter circuit, a midpoint converter that powers an 8/6 switched reluctance motor (SRM) drive, and a load comprise the proposed power supply. The input is connected to the filter circuit to reduce harmonic distortion. The sensor that determines the rotor's position activates and deactivates the converter switches. The MATLAB model operates with a sampling interval of one microsecond. The experimental data from the prototype hardware and a MATLAB/Simulink model were employed to simulate the DBR-fed SRM motor at varying speeds.

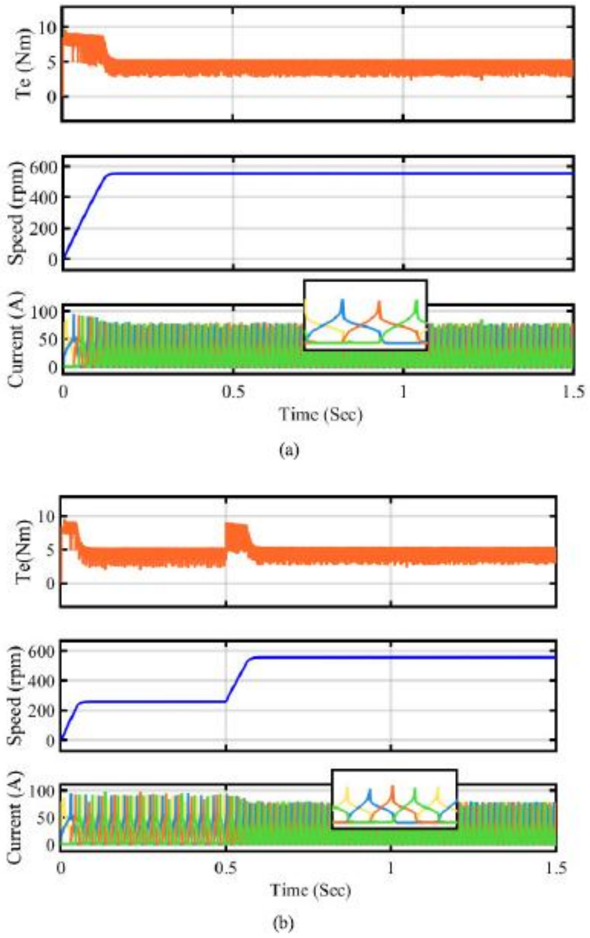
Simulation Results

The current performance, torque, and pace are depicted in Figure 6. The steady-state speed is denoted by 600 rpm, while the acceleration phase is represented by the range of 300 to 600 rpm. The image illustrates the current input to the drive, the torque of 5 Nm, and the current in each of the four phases. The quantitative evaluations of stator current total harmonic distortion (THD), speed, and torque ripple for various management strategies across a range of operating velocities and a load of 1.8 Nm are depicted in Figure 6. The evaluations are obtained by adjusting the sample rate during protracted tests while maintaining a consistent average switching frequency of approximately 8.5 kHz. The dynamic response to sudden motion variations and high load torque was investigated in the simulation. Figure 7 illustrates the steady-state speed at 500 rpm, the acceleration of the speed from 500 to 800 rpm, and a load torque of 4 Nm that is applied over a one-second period.

Experimental Validation

The SRM drive's hardware implementation is rated at 2.2 kW. In conjunction with the 8/6 SRM, the DC generator functions as a burden. All input phase currents and voltages across the capacitors are monitored by the voltage and current sensors. The Hall effect sensor, converter pulses, and converter switches are produced by the WAVECT (WEC300) controller. The signal conditioning circuit receives signals from the voltage and current sensors. The rotor's position is determined by the optical encoder, which generates pulses for the four valves. The hardware configuration of 8/6 SRM drives with the load linked to the PFC converter is depicted in Figure 8. Sensors, encoders, controllers, and an interface system constitute the hardware configuration.

DOI : https://doi.org/10.5281/zenodo.20636576



(a)

(b)

Figure4. Steady states driving conditions (a) 600 rpm (b) 300 to 600 rpm.

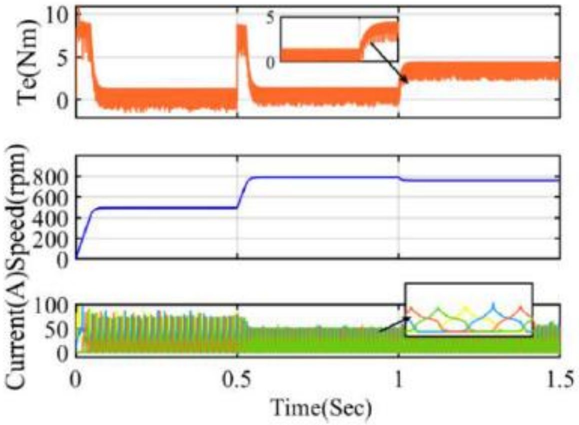


Figure5. Dynamic driving conditions speed from 500 to 800 rpm and high load torque response.

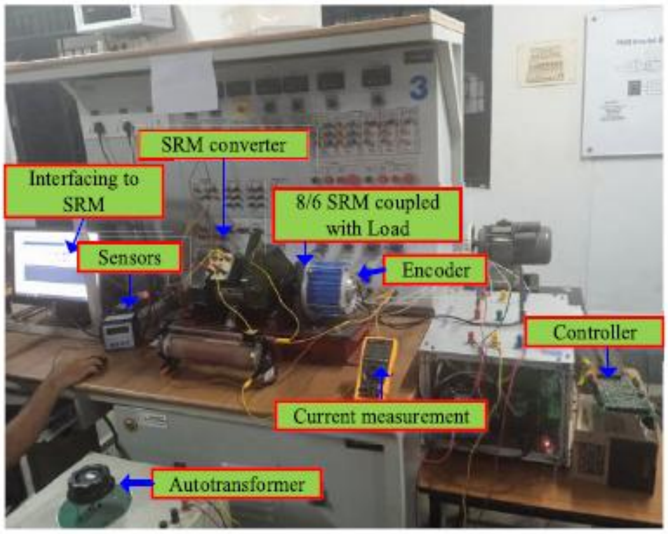


Figure6. Experimental hardware setup.

Fig. illustrates the steady-state performance of the experimental hardware arrangement, including the driving current, all four phase currents, DC link voltage, and steady-state speed of 600 rpm. The steady-state speed is 600 rpm, the motor phase current is 50 A, and the DC link voltage is maintained at 120 V.

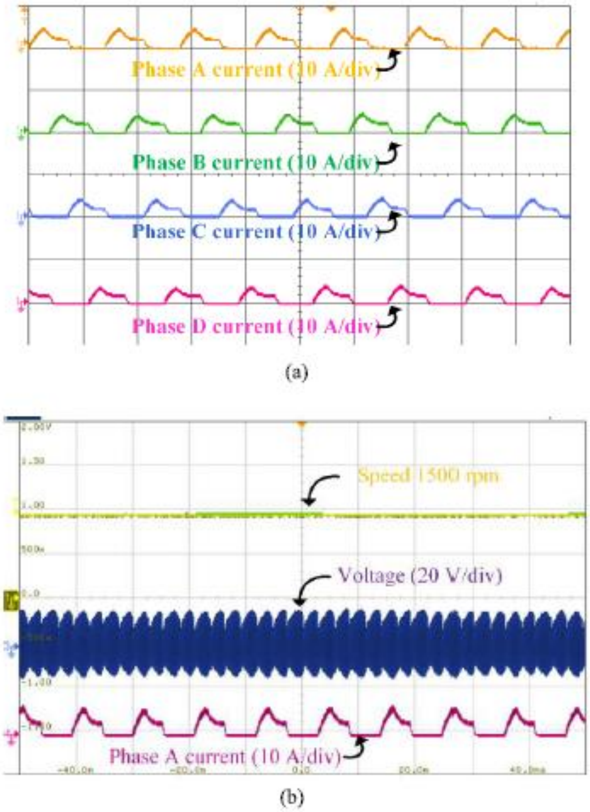
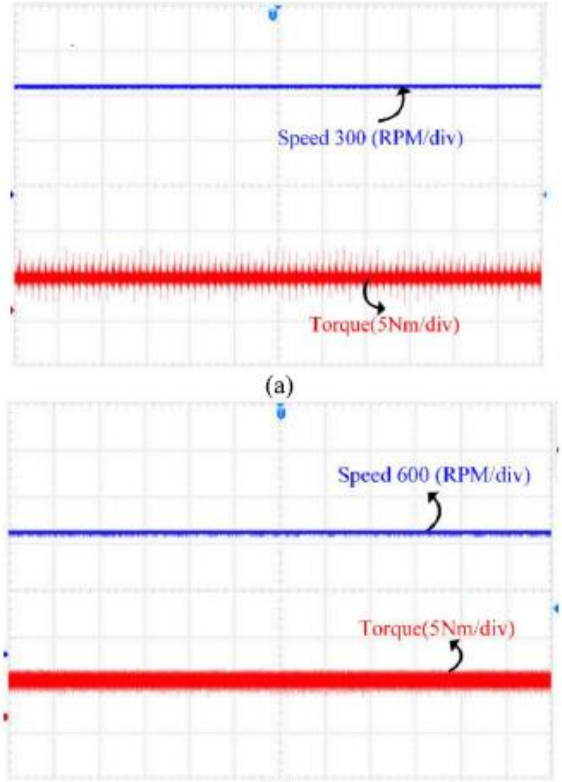


Figure7. Steady states driving conditions SRM four (a) Phase currents
(b) Speed at 600 rpm.

DOI : https://doi.org/10.5281/zenodo.20636576



(a)

(b)

Figure8. Steady states driving conditions speed at 300 rpm and 600 rpm.

V. CONCLUSION

In order to improve the quality of input power, reduce harmonic distortion, and increase the overall efficacy of industrial motor drive systems, this study suggests an optimal power factor correction (PFC) technique. By integrating sophisticated control algorithms with resilient converter topologies, the proposed technology achieves a near-unity power factor under dynamic load conditions and reduces switching losses and electromagnetic interference. Additionally, the framework enhances the durability and reliability of the system by reducing stress on electrical components and facilitating voltage management. In summary, the proposed optimize PFC system is a cost-effective and viable solution for modern industrial motor driving applications, energy efficiency standards, and sustainable power consumption.

REFERENCES

[1] P. Sharma, “Optimized power factor correction frameworks for industrial motor drives using active PFC techniques,” IEEE Trans. Ind. Appl., vol. 61, no. 2, pp. 1450–1459, 2025.
[2] D. Patel, “Advanced PFC topologies for industrial motor drives to improve power quality and efficiency,” IEEE Trans. Power Electron., vol. 40, no. 4, pp. 3220–3229, 2025.
[3] L. Wang, “Digital control-based power factor correction strategies in industrial motor drive applications,” IEEE Trans. Ind. Electron., vol. 71, no. 7, pp. 6785–6794, 2024.
[4] J. Kim, “Adaptive power factor correction controllers for nonlinear industrial drive systems,” IEEE Trans. Energy Convers., vol. 39, no. 1, pp. 210–218, 2024.

[5] S. Kumar, “Intelligent PFC frameworks using predictive and adaptive control methods for industrial drives,” IET Power Electron., vol. 16, no. 5, pp. 1320–1328, 2023.
[6] A. Rahman, “Real-time optimization techniques in PFC systems for industrial motor drives,” IEEE Trans. Sustain. Energy, vol. 14, no. 4, pp. 1890–1899, 2023.
[7] M. Garcia, “Design and optimization of active power factor correction circuits in motor drive systems,” IEEE Trans. Power Electron., vol. 37, no. 9, pp. 10210–10218, 2022.
[8] K. Iyer, “Impact of advanced converter configurations on power factor correction in industrial applications,” IEEE Trans. Ind. Appl., vol. 58, no. 6, pp. 7205–7213, 2022.
[9] R. Singh, “Impact of optimized PFC frameworks on reliability and lifespan of industrial motor drives,” IEEE Trans. Ind. Electron., vol. 68, no. 11, pp. 11020–11028, 2021.
[10] A. Lopez, “Harmonic mitigation techniques in PFC-enabled motor drives using active filtering methods,” IET Power Electron., vol. 14, no. 3, pp. 540–548, 2021.

DOI : https://doi.org/10.5281/zenodo.20636576