IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 1, August 2025

Impact Factor: 7.67

A Review of DC Motor Drive Systems Powered by Three-Phase Full-Control Bridge Converters

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Abstract: *Motor speed control is essential in various industrial and domestic applications, where efficient techniques enhance performance, reduce energy consumption, and minimize harmonic distortions. This literature review examines recent advancements in controlling DC, induction, and brushless DC (BLDC) motors using converters such as full-bridge cycloconverters, phase-shifted full-bridge converters, and thyristor rectifiers. Key studies focus on transfer function-based estimation, PID controllers, voltage control methods, and harmonic analysis. The review highlights the shift toward digital and predictive controls for improved dynamic response and reduced total harmonic distortion (THD). Findings indicate that converter-based strategies offer flexibility in speed regulation, though challenges like parametric variations and load changes persist.*

Keywords: BLDC motor, DC motor, Full-bridge converter, Induction motor, Motor speed control, PID control, Phase-shifted converter

I. INTRODUCTION

Bidirectional Electric motors are fundamental to modern machinery, powering everything from household appliances to industrial equipment. Among them, DC motors provide precise torque control, induction motors offer robustness and low maintenance, and BLDC motors deliver high efficiency with minimal mechanical wear. However, achieving variable speed operation while maintaining efficiency and power quality remains a key challenge. Traditional methods, such as varying pole numbers or armature resistance, are often inefficient or impractical under dynamic conditions.

Converter-based approaches have emerged as viable solutions, enabling frequency or voltage modulation to adjust motor speed. Cycloconverters, for instance, directly convert AC frequencies without intermediate DC links, while full-bridge converters facilitate zero-voltage switching for reduced losses. Recent research emphasizes integrating digital controls, like PID and predictive algorithms, to handle nonlinearities and disturbances. This review synthesizes nine key studies on these techniques, exploring their applications to single-phase, three-phase induction, DC, and BLDC motors. It assesses methodologies for speed estimation, torque control, and harmonic mitigation, providing insights into their strengths and limitations [2-5].

II. STATE OF THE ART

The literature on motor speed control reveals a focus on converter topologies and control algorithms to achieve stable operation across varying loads and speeds.

Yahia et al. investigated speed and torque estimation for a separately excited DC motor (SEDCM) using transfer function characteristics [1]. A three-phase bridge-controlled rectifier regulates the motor speed, with a neural network-PI controller determining thyristor firing angles. The approach estimates speed from converter output voltage and current, tested under steady-state and dynamic conditions via MATLAB/Simulink. Results show fast response and alignment between estimated and actual values, making it suitable for sensorless applications.

For three-phase induction motors, Hartono et al. proposed a universal bridge with PID control [2]. The system uses pulse-width modulation (PWM) in a voltage source inverter to vary voltage and frequency. Open-loop and closed-loop simulations in MATLAB/Simulink demonstrate good dynamic response, with the PID stabilizing DC-link voltage and enabling precise speed adjustment.

Ramkumar et al. explored voltage-controlled speed regulation for three-phase AC induction motors [3]. Employing a PIC16F877A microcontroller and PWM in a three-phase inverter bridge, the method reverses rotation via relays and switches. It achieves bidirectional control with simple on/off mechanisms, reducing costs by eliminating extra windings or gears, though limited to discrete speed steps.

An early work by Doradla and Mandal examined a three-phase AC-to-DC power transistor converter for DC motor drives [4]. Using equal pulse-width modulation (EPWM) with 18 pulses per half-cycle, the study evaluates external performance under constant torque. Experimental verification confirms good agreement with theory, and inductance-capacitance filters mitigate harmonic effects, highlighting transistor-based simplification for variable DC supplies.

Amadi et al. analyzed DC motor speed control via a three-phase bridge thyristor rectifier [5]. Armature voltage control adjusts speed, with MATLAB/Simulink modeling a 5HP separately excited motor. Varying firing angles (30° to 120°) yields speeds from 4350 rpm to near zero, with reduced ripple and effective torque response, validating thyristors for flexible control.

Garg and Sharma focused on THD in three-phase fully controlled converters [6]. The study quantifies distortion as the ratio of harmonic RMS to fundamental components, emphasizing impacts on grid quality and motor heating.

Valle et al. presented digital control for variable-speed low-inductance BLDC motors [7]. Treating the voltage source inverter as a full-bridge enables unipolar switching at 100 kHz, using a deadbeat controller for three-phase currents without back-EMF compensation. Stability analysis shows zero steady-state error and robust transients, with IP control ensuring precise speed regulation.

Kang et al. studied control for input-series output-parallel (ISOP) phase-shifted full-bridge converters using a virtual DC motor model [8]. The strategy optimizes power sharing and voltage balance, analyzed via MATLAB/Simulink for industrial power systems.

Brindha et al. focused speed control for single and three-phase induction motors with a full-bridge cycloconverter [9]. Frequency variation (f to f/5) via thyristor triggering achieves step-wise adjustment, overcoming pole-changing limitations. Simulations confirm economical, reliable operation without resizing the motor.

III. SYSTEM METHODOLOGY

This review presents a focused analytical approach to evaluate DC motor speed control using three-phase fully controlled bridge converters. The methodology examines converter topologies utilizing thyristors or IGBTs, incorporating modulation techniques such as phase-angle control and pulse-width modulation (PWM). Control strategies are divided into classical PID tuning, transfer function-based speed estimation and advanced digital methods like deadbeat and IP control. MATLAB/Simulink is used extensively to simulate dynamic behavior, analyze total harmonic distortion (THD), and assess system stability under varying load and operating conditions. Mathematical modeling includes armature voltage equations, converter output characteristics, and speed-torque relationships to support performance evaluation. Key metrics such as speed regulation accuracy, transient response, ripple minimization, and harmonic suppression are extracted to compare control effectiveness. This structured approach facilitates a comprehensive understanding of converter-driven motor control systems, highlighting their efficiency, adaptability, and practical implementation potential [4-8].

IV. CONCLUSION

The reviewed studies underscore converter-based techniques as effective for motor speed control, with cycloconverters and full-bridge designs enabling frequency/voltage modulation for induction and DC motors. Modern control techniques such as PID tuning and predictive algorithms have shown improved responsiveness and effective harmonic suppression, particularly in brushless DC motor systems. However, parametric uncertainties and load variations pose ongoing challenges. Future research could integrate AI for adaptive tuning, broadening applications in renewables and EVs. Overall, these advancements promote energy-efficient, reliable motor drives.

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REFERENCES

[1]. Yahia, T., Antar, R., & Saleh, A. (2023). DC Motor Speed/Torque Estimation and Control Based on Transfer Function Characteristics. 2023 International Conference on Engineering, Science and Advanced Technology (ICESAT), 156-161. https://doi.org/10.1109/ICESAT58213.2023.10347312.

[2]. Hartono, H., Sudjoko, R., & Iswahyudi, P. (2019). Speed Control of Three Phase Induction Motor Using Universal Bridge and PID Controller. Journal of Physics: Conference Series, 1381. https://doi.org/10.1088/1742-6596/1381/1/012053.

[3]. Ramkumar, S., Amudha, A., Emayavaramban, G., Balachander, K., Elangovan, N., Eswaran, K., Manickam, R., Premnath, R., & Bharath, T. (2022). Three Phase AC Induction Voltage Controlled Motor Speed Control. 2022 International Conference on Electronics and Renewable Systems (ICEARS), 427-435. https://doi.org/10.1109/ICEARS53579.2022.9751827.

[4]. Doradla, S., & Mandal, S. (1987). A Three-Phase AC-to-DC Power Transistor Converter-Controlled DC Motor Drive. IEEE Transactions on Industry Applications, IA-23, 848-854. https://doi.org/10.1109/TIA.1987.4504994.

[5]. Amadi, H. N., Aguiyi, N. W., &Uwho, K. O. (2024). Performance of a Direct Current Motor Speed Control using a Three-Phase Bridge Thyristor Rectifier. International Journal of Technology and Engineering Studies, 10, 1-8.

[6]. Garg, A., & Sharma, A. (2024). Analysis of Total Harmonic Distortion (THD) in Three-Phase Fully Controlled Converters. International Research Journal of Modernization in Engineering Technology and Science, 6(9), 61550.

[7]. Valle, R., De Almeida, P., Fogli, G., Ferreira, A., & Barbosa, P. (2020). Simple and Effective Digital Control of a Variable-Speed Low Inductance BLDC Motor Drive. IEEE Access, 8, 13240-13250. https://doi.org/10.1109/ACCESS.2020.2966437.

[8]. Kang, W., Xie, G., & Zhang, L. (2023). Study on the Control Strategy of Input-Series Output-Parallel Phase-Shifted Full Bridge Converter Based on Virtual DC Motor. 2023 IEEE/IAS Industrial and Commercial Power System Asia (I&CPS Asia), 1053-1058. https://doi.org/10.1109/ICPSAsia58343.2023.10295040.

[9]. Brindha, B., Porselvi, T., & Ilayaraja, R. (2018). Speed Control of Single and Three Phase Induction Motor Using Full Bridge Cycloconverter. 2018 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS), 318-327. https://doi.org/10.1109/ICPECTS.2018.8521626.