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Optimized Control Techniques For Synchronous Reluctance Motors in Electric Vehicle Applications

J Gowrishankar[1], Chinnapapa Ajay [2], Madhan Teruvai[3], Chandragiri Pravallika[4], Chinthapudi Chenchu Krishnaiah[5], Kogila Gopi[6]

Professor, Department of EEE, Siddharth Institute of Engineering & Technology, Puttur, AP, India[1]

UG Student, Department of EEE, Siddharth Institute of Engineering & Technology, Puttur, AP, India[23456]

sietkrnd@gmail.com[1], 19016ee003@gmail.com[2], Madhanteruvai@gmail.com[3], pravallikareddy9988@gmail.com[4], rockchenchu3@gmail.com[5], kogilagopi883@gmail.com[6].

Abstract: *This project explores the development and optimization of control strategies for a Synchronous Reluctance Motor (SynRM) drive in electric vehicle (EV) applications. A bidirectional DC/DC converter is implemented as an interface between the battery and motor drive, ensuring a well-regulated and boostable DC-link voltage for enhanced performance across a wide speed range. Additionally, the converter facilitates efficient regenerative braking, improving overall energy efficiency by recovering energy back to the battery. The proposed SynRM drive incorporates robust current PWM switching control to mitigate slotting effects, along with a model reference-based speed control strategy. An Adaptive Commutation Scheme (ACS) is introduced to optimize commutation timing, thereby minimizing motor losses. Furthermore, enhanced control techniques such as back-EMF cancellation and tracking error compensation are integrated into the feedback loop to ensure smooth operation and improved torque response. A Proportional-Integral (PI) controller is implemented within a closed-loop control system to regulate motor speed and torque based on real-time sensor feedback. This approach improves accuracy, enhances system robustness against varying load conditions, and optimizes energy efficiency, thereby extending battery range. The proposed control strategies contribute to reliable and efficient EV propulsion, ensuring superior motor performance while maximizing energy utilization.*

Keywords: Synchronous Reluctance Motor (SynRM), Electric Vehicle (EV), Bidirectional DC/DC Converter, Regenerative Braking, PWM Switching Control, Adaptive Commutation Scheme (ACS), Back-EMF Cancellation, Model Reference-Based Speed Control, Proportional-Integral (PI) Controller, Closed-Loop Control, Energy Efficiency, Torque Optimization, DC-Link Voltage Regulation