

## **Abstract of Ph.D. Thesis**

# **“Control of Position Sensorless PMBLDC Motor Drive for Solar-PV Assisted Light Electric Vehicles”**

**Mr. Biswajit Saha (2019EEZ8344), Research Scholar**

The rapid urbanization and industrialization of modern society have led to a significant rise in energy consumption and environmental pollution, primarily due to the extensive use of fossil fuel-powered transportation. To address the growing concerns over climate change, greenhouse gas emissions, and the depletion of non-renewable energy resources, the global automotive industry is undergoing a paradigm shift toward Electric Vehicles (EVs). Range anxiety” is a major obstacle to the rapid adoption of EVs, and drivers' fear about being stranded with insufficient range to reach the destination.

However, the adoption of EVs, particularly in the category of Light Electric Vehicles (LEVs) such as e-rickshaws, scooters, and small delivery vehicles, is often constrained by limited battery range, long charging times, and insufficient charging infrastructure. To overcome these limitations, integrating Solar Photovoltaic (PV) systems with EVs has emerged as a promising solution. Solar-PV-assisted EVs can harness clean, renewable energy directly from the sun to charge their batteries, thus reducing reliance on grid electricity and enabling energy autonomy, especially in remote or off-grid areas. This makes the system not only more sustainable but also economically attractive in regions with abundant sunlight.

The heart of any EV lies in its electric drivetrain, and among various motor technologies available, the Permanent Magnet Brushless DC (PMBLDC) motor stands out as an ideal choice for LEVs. PMBLDC motors are known for their high efficiency, compact size, low maintenance, and excellent torque-speed characteristics. These features make them particularly well-suited for the frequent start-stop cycles and variable load conditions typical in urban driving environments.

Despite their advantages, conventional PMBLDC motor drives rely on position sensors like Hall-Effect sensors to detect rotor position for proper commutation. These sensors increase system cost, reduce reliability (especially under harsh environmental conditions), and add to mechanical complexity. To address these challenges, position sensorless control techniques have been developed. By estimating rotor position from the motor's back Electromotive Force (back-EMF), these methods eliminate the need for physical sensors, enhancing system robustness and reducing costs.

This research presents the analysis, design, and control of various configurations of solar photovoltaic (PV)-assisted brushless DC (BLDC) motor drives with advanced motor control algorithms for light electric vehicles (LEVs). Comprehensive modelling and control of BLDC motor drives are performed with an emphasis on automotive applications, incorporating regenerative braking strategies to alleviate range anxiety by enhancing energy recovery during deceleration. Dual-stage solar-PV assisted BLDC motor drives are investigated, employing multiple DC–DC converter topologies with maximum power point tracking (MPPT) control, and their performance is compared through simulation and experimental validation. In parallel, single-stage solar-PV assisted drive configurations are developed to eliminate intermediate DC–DC converters, thereby reducing system cost and complexity. A position sensorless control scheme is implemented using advanced observer-based estimation techniques to accurately determine rotor position and speed with minimal offset and delay, eliminating the need for Hall-effect sensors. Furthermore, an ultra-low-speed sensorless starting method and a wide-speed range control scheme are proposed to improve startup performance and ensure smooth operation across the entire automotive speed spectrum. To address inherent torque pulsations, a novel torque ripple mitigation strategy is integrated within the sensorless control framework, providing an efficient and complete drive solution for EV applications. Multiple DC–DC converter designs are developed, and a detailed comparative performance analysis is conducted using both simulation and hardware implementation results. The proposed integrated approach—combining renewable energy integration, advanced control strategies, and optimized power electronics—offers a cost-effective, efficient, and reliable solar-PV assisted BLDC motor drive solution tailored for next-generation light electric vehicles.