Abstract

This thesis presents the critical aspects of reliability and performance enhancement concerning the integration of electric vehicles (EVs) into the power grid. With the rapid growth of EV adoption, their interaction with the grid becomes increasingly important for ensuring efficient operation and stability. The research delves into methodologies and strategies to improve the reliability of grid-integrated EV systems while enhancing their performance. Key focus areas include robustness against grid fluctuations, optimizing charging infrastructure, controlling application in power electronics converters, and managing energy flows between vehicles and the grid. By addressing these challenges, the thesis aims to contribute to developing sustainable and resilient electric mobility solutions.

This research presents an event-triggered control designed for a boost converter's LPV (linear parameter varying) framework, incorporating a suitable triggering criterion. The controller's design, which depends on the duty ratio, improves voltage regulation performance. The stability of the closed-loop system employing the boost converter and parameter-dependent controller is confirmed.

This thesis also introduces a sliding mode control (SMC) methodology for bidirectional DC-DC power converters employed in Battery Electric Vehicle (BEV) chargers. The aim is to precisely track the desired current and output voltage in grid-to-vehicle (G2V) and vehicle-to-grid (V2G) modes. BEV chargers play a crucial role in facilitating two-way power exchange between the grid and the vehicle, yet effective power flow control presents challenges. SMC offers a practical solution by capitalizing on the advantages of DC-DC converters and simplifying hardware implementation compared to traditional Pulse Width Modulation (PWM) techniques. The proposed methodology integrates an integral-proportional controller for output voltage regulation and a sliding-mode controller for regulating the inner current loop. Stability analysis is conducted for both step-up and step-down operation modes, and simulation results validate the effectiveness of the proposed controller in both G2V and V2G applications.

This thesis presents a novel interleaved buck-boost topology featuring reduced switches designed for application in AC-DC and DC-DC conversion systems. The proposed AC-DC buck-boost converter exhibits effective Power Factor Correction (PFC) operation across a wide input voltage range, utilizing a single-sensor controller, thus making it advantageous for battery charging technologies. This work provides a tabular comparison evaluation of the proposed converter alongside simulation results and discusses its merits. The thesis also includes a comprehensive evaluation of discontinuous Conduction Mode (DCM) inductors and considerations for selecting filter capacitors. Moreover, critical conduction parameters necessary for DCM operation are determined through simulation. Validated at 1 kW, the proposed operation demonstrates an efficiency of 96% and a power factor of 0.9992, rendering it a suitable choice for EV battery charging. Furthermore, in addition to conventional G2V applications, the proposed on-board charger can serve as a universal converter for Vehicle-to-Vehicle (V2V) and Station-to-Vehicle (S2V) applications due to its compact size and reduced cost. The final section of this thesis addresses possible methodologies to enhance system efficiency, reduce cost, and achieve a reduced, less complicated design by minimizing the number of power conversion stages.