Abstract of PhD Thesis on
Title: "Design and Control of Single-Stage Chargers for Light Electric Vehicles"
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The rapid growth of electric vehicles (EVs), particularly light electric vehicles (LEVs) such as electric two-wheelers and three-wheelers, has created a strong demand for high-performance battery charging solutions with enhanced functionality. While significant progress has been made in the development of high-voltage and high-power chargers, low-voltage chargers for LEVs remain relatively underexplored. Furthermore, existing charging topologies suffer from limitations including high component count, reliance on bulky electrolytic capacitors, lack of bidirectional capability, and limited integration of renewable energy sources. These challenges restrict functionality and increase dependence on grid power, which is often derived from fossil fuels.

To address these issues, this work presents the design, analysis, and development of multiple charger configurations for LEV and solar-assisted LEV (SLEV) applications, where the solar photovoltaic (PV) panel is integrated with the vehicle. The desired functionality of LEV chargers is identified from the perspectives of users, manufacturers, and power utilities. A comprehensive review of existing topologies is conducted to identify key research gaps, including the absence of single-stage bidirectional chargers with active power decoupling (APD) capability and the limited availability of multi-input chargers with reduced component count. In addition, the pros and cons of transformer-less topologies are analysed, and hence both isolated and non-isolated configurations are explored to evaluate trade-offs among additional losses, safety, and component count.

This work proposes several charger configurations featuring single-stage architecture with a focus on the reduction of component count while addressing inherent challenges such as the double-line frequency ripple in output current. An integrated active power decoupling technique is incorporated to mitigate the double-line frequency ripple in the battery current, thereby improving the battery current quality. This further benefits by enabling the use of film capacitors, resulting in an electrolytic-less topology. In addition, multi-input charger topologies are developed to enable simultaneous and independent power transfer from grid and PV sources while incorporating power factor correction (PFC) and maximum power point tracking (MPPT). Further, the feasibility of the bidirectional charging system for the LEVs is comprehensively assessed in this work. Accordingly, several bidirectional charging topologies providing grid-to-vehicle (G2V) and vehicle-to-grid (V2G) operational capability are introduced for LEV and SLEV applications, ensuring greater benefits to the LEV consumers. A bidirectional charger with an additional solar PV panel input is also presented for SLEV application with seamless mode transfer between various operational modes in both directions of power flow.

All proposed single-stage charger configurations are designed to enhance power quality performance at the supply side while fully complying with international standards under specified operating conditions. The same is analysed using steady-state and dynamic models and validated through simulation in MATLAB/Simulink and PSIM. Experimental prototypes are developed to demonstrate practical feasibility under various operating conditions. The results demonstrate improved power quality, reduced component count, and enhanced functionality compared to conventional chargers.