Abstract of Ph.D. Thesis

"Power Quality Improvement in Battery Chargers of Light Electric Vehicles"

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The objective of this work is the design and development of improved power quality based converters with improved efficiency and high power density for power factor correction at the front end of the conventional charger of light EVs. These converters are designed for low cost EVs such as E-rickshaw battery, either in two stage or single stage configurations. A diode bridge rectifier (DBR) is the basic circuit to convert available AC mains voltage into DC voltage for charging, which leaves behind many harmonics in the input side current owing to its nonlinear behavior resulting in poor power quality indices e.g. voltage distortion, high THD in source current, low PF, low DPF (Displacement Factor) and high CF (Crest Factor). For the conventional EV chargers with DBR and capacitor filter, the line current has high current THD in the order of 50-60% at rated battery current and a poor power factor (PF) in the range of 0.8-0.85. Hence, single phase PFC converters are used to improve the power quality of EV battery charger at AC mains. Several topologies of single phase EV chargers with front-end PFC are reported in the literature, which are divided into five classes namely non-isolated PFC converters-based charger, bridgeless non-isolated PFC converters-based charger, isolated PFC converters based charger, bridgeless isolated PFC converters based charger and interleaved PFC converters based chargers. All these configurations has different advantages such as high efficiency, high power density, reduced semiconductor stress, low charge current ripple and low cost. The size and cost of the charger are significantly affected by the control technique used for PFC converter. This work aims at the design of PFC converter in discontinuous conduction mode (DCM), which employs the voltage feedback based control with single voltage sensor to be used for inherent PFC and output voltage regulation. However, a constant current-constant voltage based charging method is used to control the battery current at rated line and loading conditions. For two stage battery charger configuration, a flyback converter is used to regulate the charge current through the battery. Many charger configurations with front-end single phase buck-boost PFC converters are designed and developed in this work to exhibit the improved PQ based operation in two stage EV chargers. Some overlooked features of bridged and bridgeless PFC converters, such as Cuk, Zeta, SEPIC, CSC and Landsman converter, with or without isolation, are discussed for single phase EV chargers. Moreover, many new and improved versions of bridged or bridgeless configuration such as Cuk, SEPIC, Luo and Zeta converters are presented along with interleaved configuration of PFC Cuk, Luo and Landsman converters. The improved circuit performance and unity PF based charging performance of these EV battery chargers are assessed in MATLAB/Simulink based environment using a developed model. The obtained results are seen to be corroborated with the experimental validation of the hardware prototype, for all the configurations. The performance of PFC converters-based chargers is evaluated at steady state as well as during dynamic condition for rated line voltage and loading conditions. Various input and output side quantities, device stresses as well as the voltage and current through different components are recorded as per the design and selection parameter. The improved power quality indices are observed as per the international regulations such as the IEC 61000-3-2 standard throughout the charging duration.