Reliability Analysis of AC-DC and DC-DC Converter Stages in Level-1 Electric Vehicle Chargers

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Abstract

This study presents a reliability evaluation frame work for Level-1 EV charger converter topologies, utilizing the MIL-HDBK-217 reliability prediction methodology. The frame work evaluates three prevalent AC–DC power factor correction (PFC) topologies: conventional boost, bridgeless boost, and interleaved boost, alongside three isolated DC–DC converter configurations: conventional flyback, isolated half-bridge LLC resonant, and phase-shifted full-bridge center-tapped (PSFB CT) converters. Component failure rates are determined using MIL-HDBK-217 models for semiconductor devices, capacitors, magnetic components, and auxiliary elements. Converter-level reliability is examined using a series reliability structure, which facilitates the calculation of total failure rates and mean time between failures (MTBF). The results indicate that capacitors are the primary contributors to overall system failure rates and that reducing electrical stress enhances reliability performance. This framework offers a clear, practical way to evaluate and choose the most reliable converter designs for home EV charging.

Keywords

Electric Vehicle Charger, Reliability Analysis, MIL-HDBK-217F, MTBF, Level-1 Charging, PFC Converter, Flyback Converter, LLC Resonant Converter, PSFB Converter, Power Electronics Reliability.