WIRELESS POWER TRANSFER SYSTEM FOR ELECTRIC AUTONOMOUS VEHICLES BATTERY CHARGING

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Electric vehicles (EVs) are key pillar in the energy transition towards decarbonization, and EVs integrated with renewables play a crucial role for significantly reducing this share of greenhouse gases emissions. However, high purchase price, uncertainty about battery life, long charging times, inadequate charging infrastructure, limited autonomy and range anxiety are the main obstacles that slow down the spread of EVs. New socio-economic models based on shared mobility, where the owned vehicle is replaced by transportation services and resources shared between multiple users, aim to reduce the overall costs for transportation, as well as to reduce traffic congestion and land used for parking in large urban areas. On the other hand, Wireless Power Transfer (WPT) technologies provide revolutionary opportunities to solve, or at least mitigate, several critical issues related to the EVs battery charging and to the limited EVs driving range. As a matter of fact, the charging of the on-board battery by means of a wired connection between car and charging station is a critical aspect of the current EVs technology, as it is completely manual and exposes the user to the risk of electric shock in the event of poor or damaged insulation. Charging stations based on static WPT eliminate the risk of direct contact between the user and the high voltage components of the charging system, increasing safety. Moreover, the wireless charging process can be easily automated: current Advanced Driver Assistance Systems (ADAS) installed on cars can be used to find the optimal position of the vehicle for the charging process, either as a support for the driver or integrated into autonomous driving systems. In addition, dynamic WPT allow energy to be transferred to the vehicle when it is in motion, increasing the driving range. Among various WPT methods, Resonant Inductive Power Transfer (RIPT) [1] is the most suitable for EVs, both for static and dynamic applications. It is based on the magnetic coupling of two coils, the transmitting coil on the ground and the receiving coil on the underbody of the EV, resulting in a coreless transformer.

The aim of this research is the study and the optimization of the components of a contactless battery charger for EVs, as well as the most challenging task of the design of the whole RIPT system and its integration onboard the vehicle. Several aspects and technical peculiarities of this technology have to be addressed simultaneously. The large air gap and the possible misalignment between pads require specific strategies to facilitate energy transfer [2]-[4]. The shape and components of the pads are designed to maximize the amount of magnetic flux linked by the two coils. Active or passive shielding layers are then added to confine stray fields and to comply with the ElectroMagnetic Field (EMF) safety standards: by driving auxiliary coils out of phase to generate counteracting fields around the pad region [5], [6]. The analysis and optimization of the coreless transformer makes extensive use of Finite Element (FE) models, with different levels of detail and accuracy. In addition, compensation networks consisting of energy storage elements, namely capacitors and inductors, are introduced to resonate with the inductance of the pads and to improve power transmission [7]-[8]. The optimization of the system is of paramount importance to increase system efficiency while reducing cost and size, as well as to ensure safe and reliable operation.

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