Research Project

Electromagnetic Compatibility Issues in Automotive WPT Systems

Introduction

In recent years, wireless power transfer (WPT) systems for electric vehicle (EV) charging have become increasingly efficient and reliable, with power rates that can be compared to traditional wired chargers. One of the major limitation of this technology is due to the electromagnetic pollution they generate, both in terms of conducted emissions (CE) and radiated emissions (RE). The standard for automotive WPT system SAE J2954:2020 refers to IEC standards for what concerns conducted emissions towards AC grids, while relies on ICNIRP and IEC standards to regulate radiated emissions. EMC issues in WPT systems represent a crucial topic for their large scale industrialization, and should be deeply investigated to make WPT-EV chargers a reliable and human-friendly solution for wired systems.

CE in WPT Systems: Activities and Goals

For what concerns conducted disturbances, a realistic model for the estimation of CE towards AC or DC grids can be obtained through measurements and circuital simulations, for different loads, alignment conditions and compensation networks. A reliable model allows the mitigation of conducted disturbances to be investigated, leading to *ad hoc* design procedures for EMC filters for the specific application. In this frame, artificial intelligence (AI) can be employed for the disturbance pattern recognition. With the proper training, AI algorithms can be implemented to manage and interpret the extent and origin of the disturbance, helping the designer in defining proper mitigation strategies. Moreover, AI can be employed for the online estimation of disturbances, from which the state-of-health of the system can be monitored.

RE in WPT Systems: Activities and Goals

Radiated emissions are strongly affected by both the operating conditions and coupling-system geometry. In particular, the switching converters feeding the apparatus can make the coils currents distorted, especially in multi-coil systems and when the system operates in non perfect resonance. This leads to high frequency magnetic fields, can harm people and affect equipment in the surrounding. The impact of the generated magnetic field on human body can be assessed according to the actual standards, with a study of modern shielding techniques, both active and passive. This activity can be carried out by means of numerical simulations and experimental measurements.

Metamaterials for Electric and Magnetic Field Shielding

Among the various scenarios that involve metamaterials, the shielding of electromagnetic fields is one of the most promising. In particular, metamaterials made of 2D arrays of resonators will be studied for magnetic shielding application. In literature, only a limited number of papers analyse the near-field behaviour of metamaterials, especially when they interact with the magnetic field only. Due to the resonant behaviour of resonator arrays, they are suitable to operate at a precise frequency, for which they can exhibit positive, negative, or null magnetic permeability. With a proper design, a metamaterial can shield narrow-band magnetic fields, replacing the traditional aluminium shields, and thus saving weight and costs.

Activity Plan

Month 1

- Literature research and preliminary planning.

Months 2-4

- Circuit modeling of the typical apparatuses for automotive WPT by means of theoretical and numerical techniques;
- Definition of the neural network architecture for the prediction of conducted disturbances;

Months 5-8

- Conducted emission pattern acquisition by means of experimental measurements on automotive WPT system;
- Neural network training;
- Magnetic field exposure assessment by means of numerical simulations and experiments;

Months 9-12

- Analysis of mitigation strategies for the magnetic field shielding;
- Design and characterization of artificial electromagnetic materials, i.e. metamaterials, for automotive WPT systems.