Low Frequency Human Exposure Analysis for Automotive Applications

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Hybrid and electric vehicles (HV/EV) are good alternatives to traditional internal combustion engine vehicles because of reduced exhaust and air pollution. During HV/EV system operation high-level, low-frequency electrical currents are generated. The level of electromagnetic (EM) field emission from these currents is reduced by applying such countermeasures as shielding of cables and filters in the system devices. Nevertheless, HV and EV power train systems are still considered to potentially be a source of high level EM emission.

Another aspect is related to the HV/EV battery charging methods. In order to make the charging process more user-friendly Wireless Power Transfer (WPT) system can be used. The functionality of WPT systems is based on energy transfer between two resonant coils through an air gap by the magnetic field with efficiency up to 90%. The primary coil is placed on the ground and the secondary coil is located at the vehicle underbody. According to IEC 61980-3, input power level for secondary coil varies from 3.7 kW to more than 22 kW. Because of the system functionality, a low frequency magnetic stray field occurs, which can penetrate the car body and also leak to the sides of the vehicle. As a result, both magnetic and electric fields are produced near and inside the vehicle.

Fields produced by both power train and WPT battery charging systems may affect electrical/electronic systems of the vehicle as well as penetrate the human body.

ICNIRP guidelines or national standards determine reference levels for EM fields which should not be exceeded in occupational and general public human exposure scenarios. Basic restrictions define the internal electrical field or current density which is induced into the human body.

However field strength in human body cannot be assessed by measurements. For efficient analysis of internal field levels and distribution, numerical simulations are the only possibility. Modern simulation techniques can provide internal electrical field strengths and current densities for computational human phantoms exposed to external fields. Using simulations during the vehicle development process could be a big advantage in solving EMC-problems in the early stages of the vehicle electronic systems design and to check whether the human exposure is within the given limits.

Simulation methodology considered in the current work is based on the usage of hybrid SIE and VIE computational techniques. For analysis of human exposure in industrially realistic excitation scenarios, a novel posing mechanism of a voxel-based human body model is introduced and efficiently applied. The proposed approach was applied to industrial problems such as WPT system analysis. Analysis of human exposure in relation to ICNIRP was performed to study fields induced to a human model sitting in the driver position and pedestrian standing near the car when the WPT system is in operation mode.