Human Exposure Analysis to EMFs from Ground Assembly of a WPT System during the Vehicle's Non-Attendance

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Human Exposure Analysis to EMFs from Ground Assembly of a WPT System during the Vehicle's Non-attendance

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***Abstract*—This paper presents assessment analysis for the human exposure to electromagnetic fields from the ground assembly (GA) of the wireless power transfer (WPT) before alignment, while the vehicle does not exist over the pad. A 25 kW WPT system from Momentum Dynamics is analyzed using finite-element software during the low power alignment operation. The same system is installed at the National Renewable Energy Laboratory (NREL) and tested at the same conditions. Good agreement is observed between the results. In addition, both results comply with standard exposure limits.**

***Index Terms*— Electric Vehicles (EV), Electromagnetic Fields (EMF), Human Exposure, Low Power Excitation (LPE), WPT.**

I. Introduction

Wireless Power Transfer (WPT) systems are designed to provide power efficiently from a stationary primary source to one or more movable secondary loads over relatively large air gap by magnetic induction. Because of safety, reliability and being automatic, the WPT technology is considered ideal for frequent short-duration and automated electric vehicle (EV) charging. Nevertheless, the high-frequency (HF) strong electromagnetic fields (EMFs) from WPT system may have the possibility to present safety concerns for humans and living organisms if they are not controlled to meet the safety regulations. Several studies have investigated this issue based on either numerical analysis for the system, or/and experimental tests for prototypes [1]. All these studies investigated the exposure to the EMFs while the system is operating at full power with the two pads are fully or partially aligned. However, the existence of the charging pad in the ground outdoor may present human exposure issues during the vehicle's non-attendance. Since, typically in these system, as the vehicle approaches the charging pad, the vehicle and the primary station start to communicate through radio-frequency link. At the same time, the primary station injects a HF low power excitation (LPE) through the primary pad to allow the vehicle system to detect accuracy of alignment. This HF LPE produces EMFs over and around the pad, while the vehicle is not present. These EMFs need to be tested and regulated to comply with the standards for human exposure. Therefore, this paper presents an assessment analysis for the EMFs due to the ground pad of a 25-kW WPT system installed in NREL's shuttle. The analyses are conducted during the LPE operation and the vehicle's non-attendance.

II. Proposed EMFs Assessment Procedure

Computational model for the primary pad of a 25-kW WPT system is built and analyzed using the finite element analysis software JMAG. The model is analyzed with HF LPE operation. The magnetic field distribution for the primary pad only with 2 A coil current is depicted in Fig. 1. Moreover, the actual system installed at NREL' campus was tested. The vehicle was parked near the charging pad to allow the LPE initiation. Measurements for electric and magnetic fields right over the pad are conducted along X, Y and Z axes, as indicated in Fig. 2. The tests are performed using a low frequency isotropic field probe-analyzer (EHP-50D, Narda), 5 Hz-100 kHz bandwidth, which is connected to a PC by a fiber optic cable for probe setting and data acquisition. The measured and simulated EMFs are compared with the reference limits defined by ICNIRP2010 guidelines [2], to ensure the compatibility with human exposure standard limits.

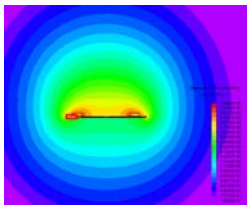

Fig. 1: B distribution for ground pad.

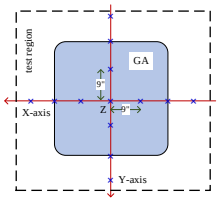

Fig. 2: EMFs test points.

III. Results and Conclusion

The EMFs from the ground pad are measured with a 19 kHz, 2 A primary current. The FFT distribution of the measured magnetic field at the center of the primary pad with 6.25" height is depicted in Fig. 3. In addition, the maximum RMS values for the magnetic field (Max. B_{rms}) along y-axis are measured and compared with the simulated values in Fig. 4. Good correlation can be noticed between the simulation and experimental data. In addition, both the measured and simulated EMFs are within the ICNIRP2010 standard limits for general public and occupational.

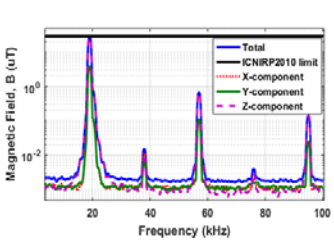

Fig. 3: Measured FFT for B at the center of the primary pad.

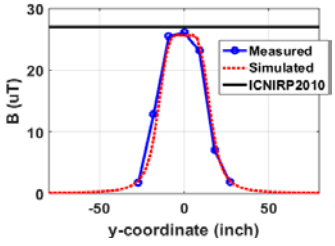

Fig. 4: Measured and simulated Max. B_{rms} along y-axis at 6.25" height.

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