Electromagnetic Emissions from Wireless Power Transfer System

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Abstract — **In this paper, the measurement and analysis of the electromagnetic radiated emissions from the wireless power transfer system is reported. The aim is to evaluate the level of the electromagnetic field produced by the magnetic resonance wireless power transfer system. Due to the advances of the wireless power transfer technology, it becomes feasible to apply the wireless power transfer in the electric vehicles charging. Among the existent wireless power transfer technologies, the magnetic resonant coupling is proven to be the most suitable for this task. Because of strong electromagnetic field generated by wireless power transfer system the electromagnetic compatibility has become an important issue.**

Keywords: Wireless power transfer, electromagnetic emissions, electromagnetic field measurement.

I. INTRODUCTION

The Wireless power transfer (WPT) is a relatively new technology, which is developing dynamically last decade. At present the WPT technology is widely used in industrial and consumer electronic devices in the area of low power and in the high power applications, namely an intelligent machining systems, robots, forklift trucks. The wireless power transfer technologies become to be applied to the electric transportation system ensuring safe and convenient charging of electric vehicles (EV) battery [1].

Essentially, all methods could be divided into two groups depending on physical phenomena of the electromagnetic fields (EMF) propagation: near field and far field. The near field methods are associated with induction and allow energy to be transmitted wirelessly over relatively short distances, usually much less than 1 meter. Far field is associated with radiation comprising lasers, microwave and radio wave transmissions and allows long-range energy transfer.

Among the methods of near field can be named the inductive coupling, the capacitive coupling and the resonant inductive coupling. Between the near field methods the best results was obtained by the researchers of the Massachusetts Institute of Technology (MIT) The MIT team demonstrated that a resonant magnetic coupling can be used to transfer energy wirelessly over a mid-range distance of 2 meters between the transmitter and receiver [2].

Among the existent WPT technologies, the magnetic resonant coupling is proven to be the most suitable for the EV charging [1,2]. For effective and safe power transfer, the transmitter needs to recognize the receiver and check that the coupling is correct [3]. An important and essential step is to combine the energy transfer with bidirectional data transmission. The data, such as EV identification, frequency, the required power values, payment data are some examples of the information that need to be transmitted between the transmitter and several receivers.

The mutual communication between the transmitter and the receiver is extremely important, especially when high intensity electromagnetic fields produced by WPT system will cause highly undesirable influence. Thus the electromagnetic compatibility has become an important issue [4]. Moreover, is important to estimate the possible impact of the WPT electromagnetic emissions on the environment, human health and biological objects.

In this paper a study related with measured and analyzed electromagnetic radiated emissions from the wireless power transfer system operating at kHz frequency range is presented.

This paper is organized as follows. Section 2 presents the Radiation Safety Standards and Organizations. Section 3 presents the modeling of the WPT System. Section 4 presents the experimental part. Finally, concluding remarks are given in Section 5.

II. RADIATION STANDARDS

Several guidelines and references have been published by various international organizations which developed the radio frequencies (RF) safety standards for electronic equipment and human being.

Between the most respected standardization organizations and international experts involved in formulating radiation safety standards can be named the International Commission on Non-Ionizing Radiation (ICNIRP). It is an independent organization, which provides scientific advice and guidance on the health and environmental effects of non-ionizing radiation (NIR) to protect people and the environment from detrimental NIR exposure. The ICNIRP Guidelines for public and occupational exposure [5] is shown in Figure 1.

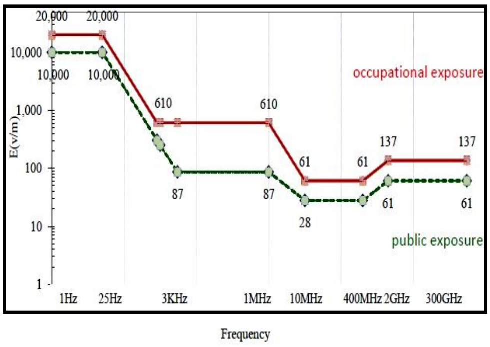

Fig. 1. ICNIRP (1998) reference levels for occupational and general public exposure [5].

III. MODELING

The WPT system is represented by the equivalent circuit consisting on a two coils, where V_S is the AC power source, R_1, L_1 and C_1 are respectively the primary parasitic resistor, inductance and resonant capacitor, L_M is the mutual inductance between the primary and the secondary, R_2, L_2 and C_2 are respectively the secondary parasitic resistor, inductance and resonant capacitor, R_L is the load resistance.

The power transfer efficiency is given by:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{R_L \omega^2 L_M{}^2}{R_2' (R_1' R_2' + \omega^2 L_M{}^2) \cos\varphi} \qquad (1)$$

IV. EXPERIMENTAL PART

The analysis was aimed at the measurement of the electromagnetic radiation caused by WPT system operating at kHz frequency range for EV battery charging. To determine the level of external electromagnetic radiation for different frequencies was used a measuring instrument Narda SRM- 3000 Selective Radiation Meter and an antenna for the 100 kHz÷3 GHz frequency domain.

The amplitudes of main harmonics generated by WPT system operating at 142 kHz frequency at different distances of measurement and Pout = 800 W are shown in Fig. 2. As expected the practical values of the electric field is a function of the distance to the measuring antenna from the WPT system.

In the Figure 1, which shows the ICNIRP Guidelines for public and occupational exposure, it can be observed that for frequency range of 3 kHz – 1 MHz the level reference for general public exposure is E = 87 V/m. The maximum value of the electromagnetic emission produced by studied WPT system is E = 40 V/m, what is significantly less than the reference level. It is important to mention that this maximum value was obtained for a very short distance (4 cm), and that value decreases very rapidly with the distance.

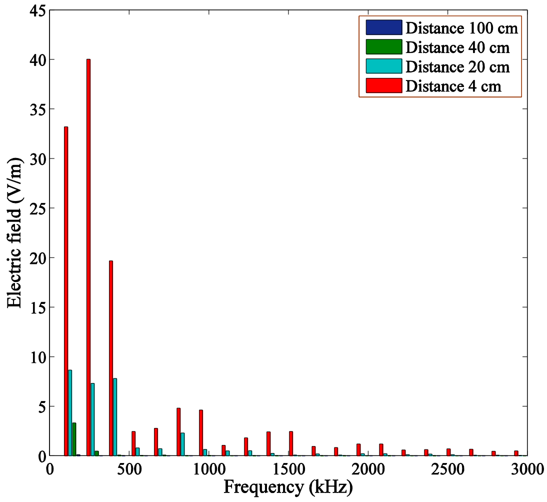

Fig. 2. Electric field generated by WPT system at 142 kHz frequency at different distances of measurement.

IV. CONCLUSION

The objective of this paper is to characterize the electromagnetic field levels emitted at different distances by the WPT system operating at 142 kHz frequency range. The measured levels were compared to the ICNIRP reference [5]. The comparison of the results obtained from the several tests with the reference level of the ICNIRP guideline shown that all of the results presented a value bellow of the required by that guideline.

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