Analysis of Human Exposure due to Wireless Power Transfer in 100-200 kHz Range

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***Abstract*—Wireless power transfer seems to be a convenient way of charging of mobile phones and other mobile devices, especially in cars. The analysis of human exposure to incident electromagnetic fields generated by such devices is presented in this paper. Critical distances for general public exposure referent levels are calculated.**

Keywords—wireless power transfer; mobile devices; electromagnetic field; human exposure

I. Introduction

Wireless power transfer (WPT) based on inductive coupling is utilized in modern cars. In 2009 Wireless Power Consortium released the first worldwide standard for mobile devices up to 5 W which is called "Qi" [1]. This standard defines basic designs of power transmitter. Operating frequencies of such devices are in the range from 110 kHz to 205 kHz. At this frequencies electromagnetic field can be assumed to be quasistatic for situations where distances between field source and observation point is far less then ~230 m, as can be seen from:

$$\frac{c_0}{2\pi f} = \frac{3\cdot 10^8}{2\pi\cdot 205\cdot 10^3} = 232.7 \text{ m} \qquad (1)$$

Therefore, humans in car are in near-field zone of WPT device and consequently it is important to identify possible health risks.

The ICNIRP (International Committee on Non-Ionising Radiation Protection) issued guidelines [2] for electromagnetic field reference levels for human exposure. According to it, the recommended maximum allowed magnetic flux density for general public exposure for frequencies of 110 kHz and 205 kHz is 6.25 μT and 4.49 μT, respectively. Furthermore, referent limits for public exposure in each country are prescribed by national legislatives, which are usually more strict than ICNIRP recommendations. For example, prescribed magnetic flux density limits in Croatia at these frequencies are 2.5 μT and 1.8 μT.

This paper presents analysis of electromagnetic field distribution for typical WPT device arrangement according to "Qi" standards [1]. Critical distances from WPT charger, according to ICNIRP guidelines and Croatian legislative, are determined as well.

II. Model

Power transmitter and the power receiver of WPT device both have 10 turns and one layer. The primary coil of power transmitter is made from no.20 AWG type 2 litz wire of radius 0.81 mm (consisting of 105 strands of no.40 AWG litz wire). The secondary coil of power receiver consists of litz wire having 24 strands of no. 40 AWG (0.08 mm diameter). The shielding, both for the transmitter and receiver, extends 2 mm beyond the outer diameter of the coils, has a thickness of 0.5 mm and is placed 1.0 mm apart from the primary/secondary coil. The shielding is made from the low-loss soft magnetic material and has a dual purpose. It enhances the magnetic flux through the coils and thus improves the transmitted power factor and at the same time it shields the surrounding environment reducing the electromagnetic compatibility effects. The neodymium magnet serves for accurate positioning of the power receiver by the user [3]. The design explained and shown in Fig.1 fully complies with the Wireless Power Consortium design guidelines [1].

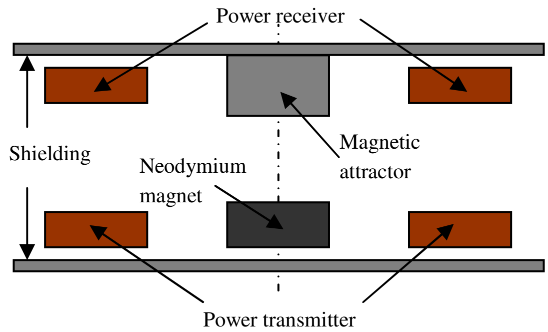

Fig. 1 Power transmitter and power receiver cross section

The above mentioned design was modeled in *Infolytica Magnet 7.4* software package in 3D (Power receiver was scaled by a factor 0.8), as shown in Fig.2, and calculation was done for two limit frequencies, 110 kHz and 205 kHz.

The modeled Power receiver induced 5 V and 1 A at the secondary coil terminals, according to common specifications for wireless chargers. Simulated current flowing through the primary coil of the power transmitter needed to obtain such magnetic field was set at 3.02 A for 110 kHz and 2.42 A for 205 kHz.

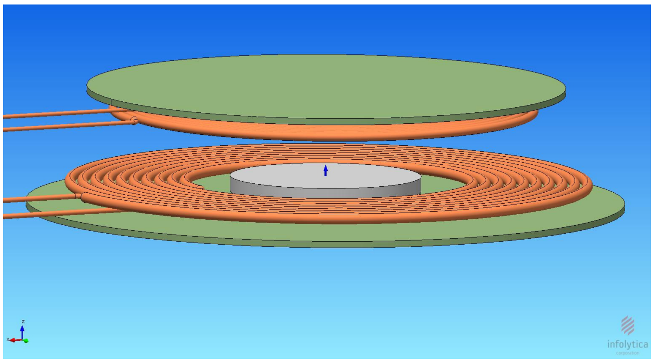

Fig. 2 Power transmitter and power receiver model

III. RESULTS

The transmitted power factor was around 45%. The distribution of magnitude of magnetic flux density phasor can be seen in Fig. 3.

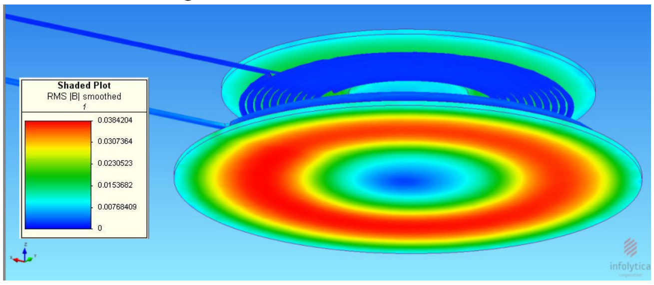

Fig. 3 Calculated magnetic flux density at 110 kHz

Magnetic flux density distributions at 205 kHz in the vicinity of WPT charger and the lines with ICNIRP referent level (4.49 μT) at the plane of the power transmitter and 2.5 cm above are shown in Fig. 4.

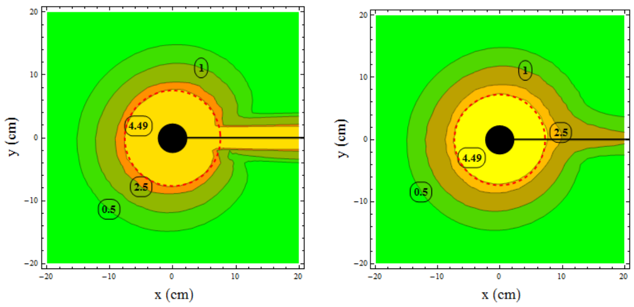

Fig. 4 Magnetic flux density distribution in μT at 205 kHz in the plane of power transmitter (left) and 2.5 cm above (right)

Critical volume with magnetic flux density greater than INCIRP referent value at 205 kHz is visible in Fig. 5.

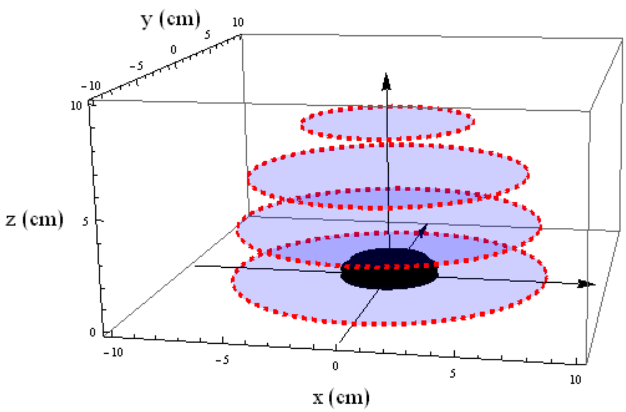

Fig. 5 Critical volume at 205 kHz

Based on critical volume calculations made for two limit frequencies, critical distances from WPT charger according to ICNIRP guidelines and Croatian legislative were determined and are presented in Table I.

TABLE I. CRITICAL DISTANCES FROM WPT CHARGER

	Critical distances (cm)	
	110 kHz	**205 kHz**
ICNIRP	8.7	8.6
Croatian	11.9	11.8

IV. CONCLUSION

As can be seen in Fig.4-5 and Table I, while using the wireless charger, greater electromagnetic fields then recommended/prescribed are achieved in the vicinity of the device.

Therefore, health risk exists and special care should be taken while using such devices especially in restricted spaces (cars).

Final paper will focus on analysis of couple of standard power receivers that can typically be found in mobile devices such as mobile phones, cameras, tablets, etc. The emphasis will be put on non-ideal positioning of charged devices and its influence on electromagnetic field distribution and critical distances.

REFERENCES

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