Experimental SAR Evaluation with a New Extrapolation Function for MHz-Band Wireless Power Transfer Systems

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Recently, wireless power transfer (WPT) technology has received much interest from industries due to its application in charging wirelessly electric vehicles, home electronic appliances, and so on. WPT systems enhance ubiquitous mobility of electronic devices since ones do not need to connect a power cable to them. Meanwhile, WPT systems increase public concerns about their biological hazards due to exposures from their strong electromagnetic (EM) fields in the proximity. Hence, it is necessary to evaluate the human exposure level to ensure that WPT systems comply with national regulations and the international safety guidelines.

Evaluations of EM exposures due to WPT systems can be performed by measurement of specific absorption rate (SAR) or induced electric field inside a tissue-equivalent liquid phantom with an SAR probe. Measurements allow us to use actual WPT systems as an EM source and real exposure situations can be fully considered. However, accurate SAR measurement at a location close to the phantom boundary, where SAR peaks are usually found, is difficult because of the boundary effect [1]. Therefore, it is necessary to estimate the SAR by extrapolation of the measured data. In this paper, we propose a new expression for extrapolation of the induced E-field inside the phantom as follows.

$$E(x) = \frac{A}{(x+B)^2}\exp(-\alpha_0 x), \tag{1}$$

where A and B are fitting parameters determined by a curve fitting method, x denotes the distance from the phantom boundary, and α_0 is an attenuation factor calculated by permittivity and conductivity of the liquid phantom. A and B are derived by a nonlinear regression method using the Levenberg-Marquardt algorithm. Eq. (1) includes two physical terms considering the decay characteristics of reactive near-fields of WPT systems and the decay characteristics due to medium loss expressed by the exponential term.

An SAR measurement system shown in Fig. 1 has been constructed. A glass-made water tank filled with a 0.04 mol/L NaCl solution is used to simulate a human-body trunk. Size of the tank is 90 cm × 30 cm × 30 cm. Two types of WPT systems; i.e., flat-spiral and solenoid types, are fabricated and used as an EM source for exposures. Fig. 2 shows orientation of the WPT system and an SAR distribution measured at 2.5 cm far from the phantom boundary for the fabricated flat-spiral-type WPT system with an input power of 1 W in the coronal orientation at 7.4 MHz. It was indicated that measurement results are in good agreement with that obtained from a numerical simulation using method of moments, demonstrating validity of our system. Peak 10g-average SARs (SAR_{10g}) determined by extrapolation using measured E-field data were found to be 0.060 mW/kg and 0.098 mW/kg for the solenoid and flat-spiral WPT systems, respectively. Difference in the SAR_{10g} from MoM results were less than 13%, proving the validity of the new extrapolation function.

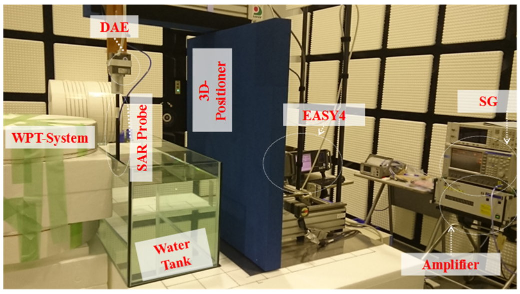

Fig. 1 Constructed SAR measurement system

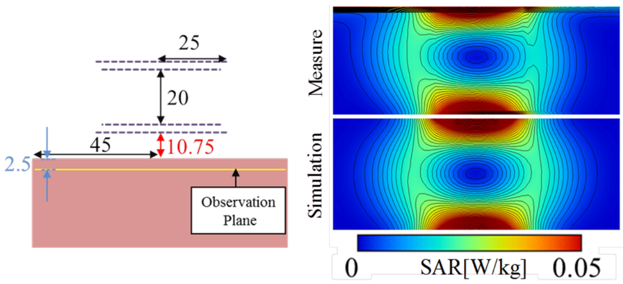

Fig. 2 SAR distribution measured at 2.5 cm from the boundary

Acknowledgement This study was supported by the Ministry of Internal Affairs and Communications, Japan.
[1] K. Pokovic, “Advanced electromagnetic probes for near-field evaluations,” Dissertation of Doctor of Technical Science, Swiss Federal Institute of Technology, Zurich, 1999.