LETTER Special Issue on EMC/EMI Problems in Microwave Frequency Range

Measurement of Power Absorption by Human Model in the Vicinity of Antennas

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SUMMARY A simple method based on the pattern integration method for measuring the power absorption by human model in the vicinity of antennas is proposed. Good agreement between the measured and the numerical results is obtained conforming the validity of the present measurement method. The equipment is useful in the EMC measurement and research of the antennas for the portable telephone.

key words: *absorption of electromagnetic power, radiation efficiency, antenna, measurement, EMC*

1. Introduction

It is important to measure the power absorption by human body in the vicinity of antennas from the view point of the electromagnetic compatibility. This measurement is also required in the research and design of the antennas for the portable telephone, since these antennas are usually used near the human body and the absorption by the human body could decrease radiation efficiency of the antennas.

When the loss of the antenna conductor is neglected, one part of the input power is radiated outside and the remaining part is absorbed by the nearby human body. Therefore, if the radiated power, or radiation efficiency of the antenna can be measured, the power absorbed by the human body can be evaluated. Several methods have been proposed so far for measuring the antenna efficiency, i.e., the Wheeler cap method, the random field method and the pattern integration method. The Wheeler cap method [1], [2] is based on the assumption that the conducting sphere enclosing the antenna eliminates the radiation from the antenna while the current distribution on the antenna does not change for both cases with and without the conducting sphere. This method is convenient, but is not suitable for the antenna in the vicinity of the human body because the diameter of the cap has to be less than about 1/3 wavelength. The random field method [3] is convenient when the field around the receiving antenna is multiply-reflected or multiply-scattered field. However, it is not easy to obtain a site of the random field environment.

According to the pattern integration method, the total radiation power can be obtained by integrating the radiation power over a spherical surface completely enclosing the antenna. A measurement system using this method has been reported [4], but the human model can be hardly included, since the antenna under test is rotated in both the elevation and the azimuth directions.

In this letter, a simple method is proposed to measure the radiated power of antennas and to evaluate the absorption by the human body by using the pattern integration method. The experimental results are shown and compared with the numerical results by using the Finite Difference Time Domain (FDTD) method.

2. Experimental Setup

Figure 1 shows the structure of the experimental setup which is composed of a turntable and an arch. The arch is made of the Bakelite plate to support the probe antenna. The measured antenna and the human model is mounted on the turntable and rotated continuously in the azimuth direction. The probe antenna moves discretely in the elevation direction. The total radiated power P_r from the antenna can be calculated by

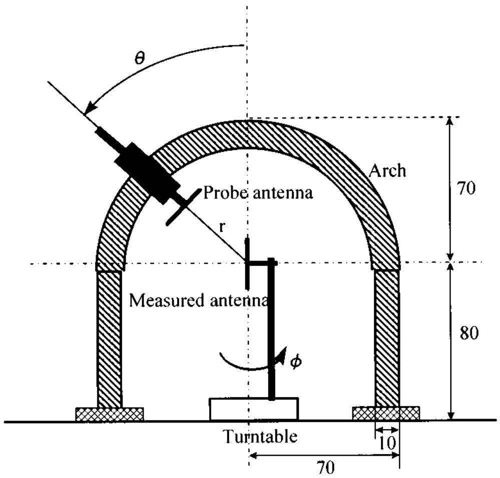

Fig. 1 Experimental setup for measuring radiation efficiency of antennas and the power absorption by the human model near the antennas. (unit: cm)

Manuscript received October 22, 1996.

Manuscript revised December 9, 1996.

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$$P_r = \frac{r^2}{A} \int_0^{2\pi} \int_0^{\pi} (P_\theta + P_\phi) \sin\theta \, d\theta d\phi \tag{1}$$

where P_θ and P_ϕ indicate the received power of the vertically and horizontally polarized components, respectively. A is the effective aperture of the probe antenna, and r is the distance between the probe antenna and the antenna. Therefore, the absorbed power P_a by the human model can be evaluated by

$$P_a = P_{in} - P_r \tag{2}$$

where P_{in} is the input power to the measured antenna. This equipment makes it possible to measure the radiation power of the antenna system including the human model since the human model can be fixed stably on the turntable which is rotated only in the azimuth direction.

The measured antenna and the probe antenna are connected to the synthesized sweeper and the spectrum analyzer, respectively. The motion of the turntable is controlled by a personal computer. The equipment is located inside the microwave anechoic chamber.

In order to confirm the validity of the measurement equipment, a pre-experiment is undertaken in which the radiated power from a half wave-length dipole antenna is measured. The geometry of the probe antenna is the same to that of the measured antenna. The two antennas have a length of 9 mm and radius of 1.1 mm, which operate at the frequency of 1.5 GHz. Figure 2 shows the ratio of measured power to the input power when the scanning step in the elevation direction $\Delta\theta$ and the distance r between the dipole antenna and the probe antenna change. The ratio is almost independent of the scanning step $\Delta\theta$ in the range from 5° to 15°. It varies slightly within a range of ±0.5 dB when the distance r changes from 30 cm to 45 cm. Thus, the high accuracy of the measuring system is confirmed.

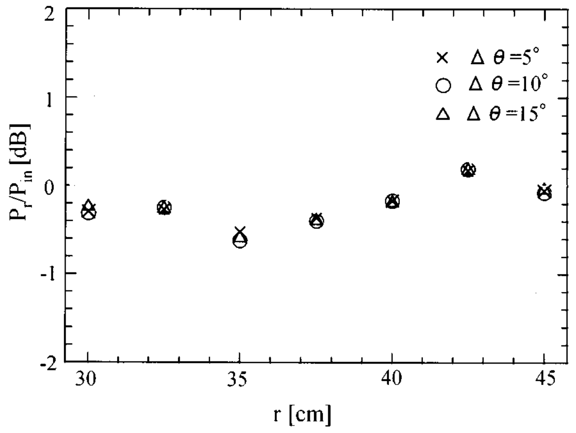

Fig. 2 The ratio of radiated power P_r to the input power P_{in} when the scanning step $\Delta\theta$ in elevation direction and the distance r between the dipole antenna and the probe antenna change.

3. Experimental Results

The power absorption by the human model is measured. Figure 3 shows the human model which is a plastic container filled with saline water in the vicinity of the half wave-length dipole antenna.

The measurement is performed at the frequency of 1.5 GHz. A numerical analysis is also performed for the same model by using the FDTD method [5], [6]. In the FDTD analysis, size of the cube cell is 5 mm × 5 mm × 5 mm and 200 × 200 × 200 cells are used. The time step is 9.4 ps, and 3000 time steps are adopted. The ab-

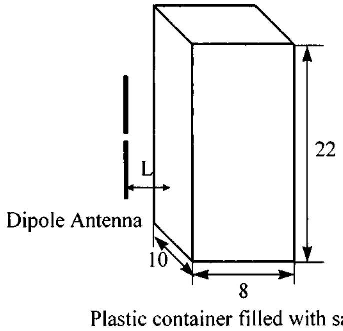

Fig. 3 Geometry of dipole antenna in the vicinity of rectangular plastic container filled with saline water. (unit: cm)

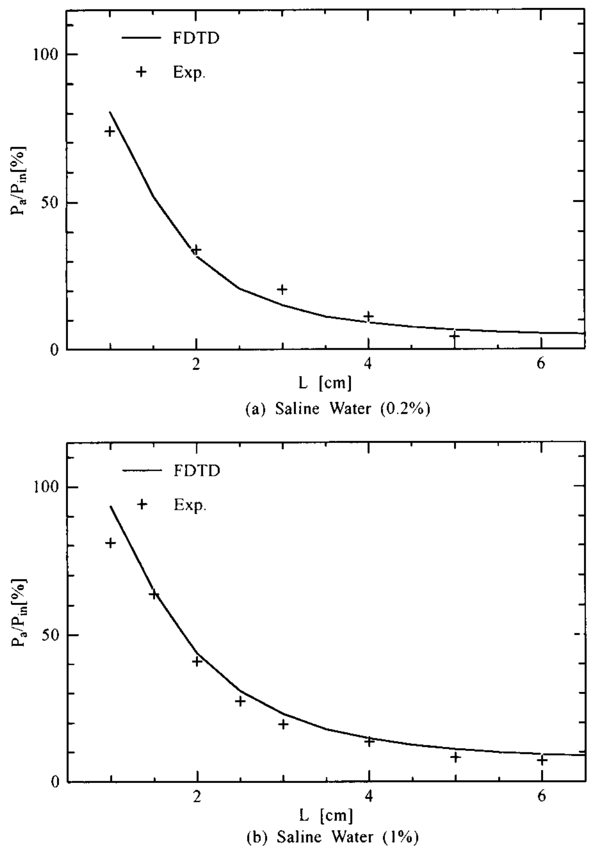

Fig. 4 Ratio of the absorbed power to the input power with different density of saline water.

sorbing boundary condition of the Mur's second order approximation is applied.

Figure 4 shows the results of experiment and the numerical analysis in the case of 0.2% and 1% saline water, corresponding to $\varepsilon_r = 82$, $\sigma = 0.32$ S/m and $\varepsilon_r = 76$, $\sigma = 1.5$ S/m [7], respectively. These parameters are used in the FDTD analysis. Experimental data agree quite well with the results of the numerical analysis except that the distance between the dipole and the container is very small because a small error of the distance could cause a large error of the radiation efficiency in this region.

4. Conclusion

A simple experimental system based on the pattern integration method has been developed, which can be used to measure the radiated power of the antennas in the vicinity of a human model and the power absorption by the human model. Good agreement between the measured and the numerical results has been obtained conforming the validity of the present measurement method. This equipment can be useful for the EMC measurement and the research of the antennas for the portable telephone.

Acknowledgement

This research is partly supported by the Central Research Laboratory, Hitachi, Ltd.

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