Optimization of the Spatial Peak Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices

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Abstract— This paper is intended to show how to optimize a simple phantom, which is commonly used to calibrate Specific Absorption Rate test equipment, using the Ansoft HFSS Design Environment, which uses Finite element method to optimize the phantom under test. This paper, presents the dipole antenna with intact bandwidth. Proposed dipole can work as simple antenna and is loaded with spherical bowl which encloses another spherical shaped structure, which has the relative permittivity same as brain fluid, in order to determine the Specific Absorption Rate in the Human Head due to this dipole. The proposed phantom is operated in UHF band and the SAR distribution shows the possibility of distribution of Microwave energy into Human Head.

Key words: SAR, PEC, Phantom

I. Introduction

On the basis of various experimental studies on animals and humans, the external thermal load to create a 1^0 C temperature rise over about 15 minutes is about 4 W/kg or 4 mW/g. For partial body exposures, the presence of blood circulation can reduce the temperature increase. In particular, the limbs and head, which are the most likely to receive higher exposure, require around 10 W/kg to generate this rise. From a medical point of view, a 1ºC rise is not a severe event at all. This can easily be achieved by internal energy expenditure occasioned by gentle jogging. When considering this, scientists use the specific absorption rate (SAR) to learn how much of the radiation is absorbed by human tissue. The specific absorption rate (SAR) is a measurement used for determining the amount of radiation absorbed by human tissue when exposed to a radio frequency (RF) electromagnetic field. What's referred to as the SAR value is a common property used for measuring absorbed energy, and this value is calculated as:

$$SAR = p / \rho = \sigma \mid E \mid^2 / \rho \qquad (1)$$

Where P is the power absorbed in the tissue in W; ρ is the mass density in kg/ m3, σ is the electrical conductivity in S/m, and |E| is the rms magnitude of the electric field strength vector in V/ m.

To smooth out the fluctuation in SAR measurement, SAR is usually averaged over a small sample volume (typically 1 g or 10 g of tissue). It would be too gross to use real tissues in SAR measurements, so various tissue-simulating liquids are introduced. The dielectric properties of different human tissues can vary over quite a wide range. To simplify the test procedure, usually only two human parts, head and body, are considered in SAR measurements. As the dielectric properties of head or body are close enough at adjacent frequency bands and a ±5% tolerance from the target value is allowed according to most standards, a single simulating liquid might be used when measuring adjacent bands, such as 850MHz and 900MHz bands, or 1800MHz and 1900MHz bands. As the dielectric properties are variables of temperature, the ambient temperature and also the tissue-simulating liquid temperature need to be well controlled within a certain range. According to equation (1), only electrical field is required when measuring a device. The human head geometry is the same geometry (SAM Phantom) provided by IEEE from their standard specification of SAR value measurements. The original geometry was imported into COMSOL Multi-physics. In addition, the model samples some material parameters with a volumetric interpolation function that estimates the variation of tissue type inside the head.

II. Design Configuration

Depicted in Figure 1, the dipole antenna is printed on a perfect electric conductor (PEC) substrate with $\varepsilon_{r=l,}$ which is an idealized material exhibiting infinite electrical conductivity or with zero resistivity. This concept is a useful model when electrical resistance is negligible compared to other effects. The length of half dipole is 83.5 mm with radius 1.8 mm, which indicates the total length of full dipole is 167.0 mm with diameter 3.6mm and gap between the two dipoles is taken 1mm.

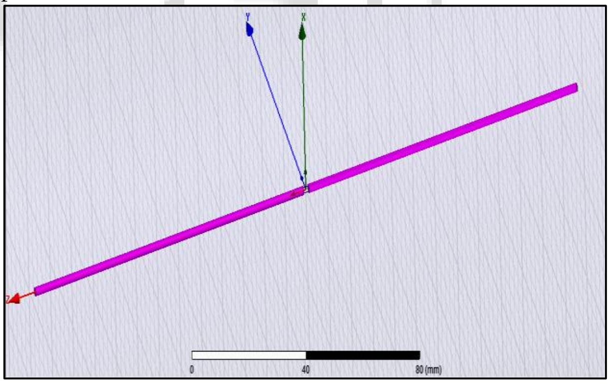

Fig. 1: Full Length Dipole Antenna

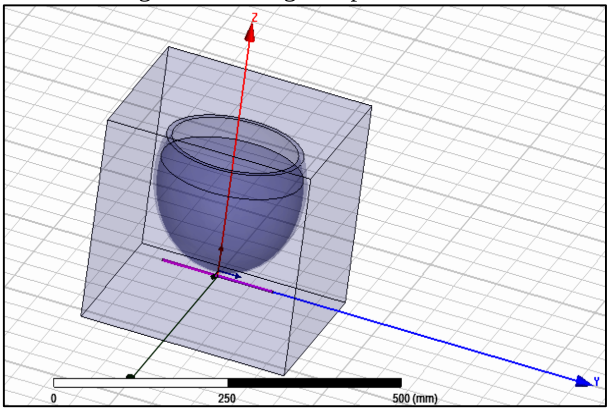

Fig. 2: Spherical Bowl

The design consists of spherical shape (bowl), with inner radius equal to 106.5 mm, thickness of 5mm and opening of 170 mm with relative permittivity of 4.6. The bowl encloses the another spherical shaped structure with relative permittivity of 42.9, σ= 0.9, and $\rho=1g/cm^3$, which is same as brain fluid, in order to determine the effect of microwave energy radiating from dipole on the human brain. The Figure 2, below depicts the structure of spherical bowl. This also includes the inner bowl which contains the brain fluid.

The design also consists of SAR line of 129 mm, in order to made physical connection between dipole and inner bowl containing brain fluid.

III. RESULTS & DISCUSSIONS

The design comes out with the various simulation results. The analysis of proposed phantom is done using the simulation performed on Ansys HFSS EM simulator at the frequency of 835Mhz. Figure 3 depicts the simulated Average SAR, Local SAR in terms of volts per unit distance (V/m) and magnitude of Electric field at designed frequency (835Mhz) for ϕ=0.

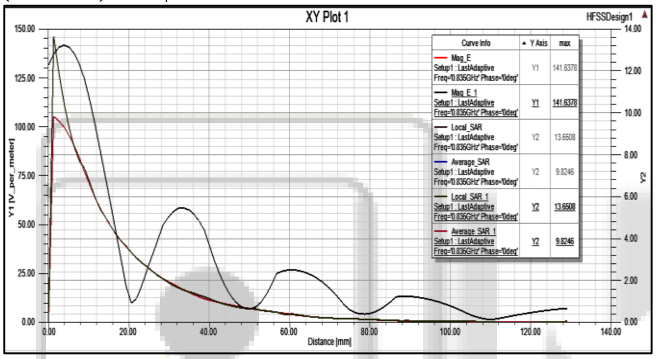

Fig. 3: Local SAR, Average SAR and Magnitude of E.

From the Figure 3 shown above it is clear that, the maximum magnitude of Electric field is 141.637 volts. The Local SAR has maximum value of 13.65 v/m and Average SAR has maximum value of 9.82 v/m. Thus, there is a considerable absorption per unit distance.

Figure 4 shown below, depicts SAR distribution in Brain fluid after conducting optimization for frequency value of 835 MHz. The magnitudes values are set for the dipole antenna and the phase values are set to zero. The result of optimum SAR distribution is show in Figure 5 for frequency value of 835 MHz, accordingly. The figures show that the SAR distribution is directed towards the brain fluid location.

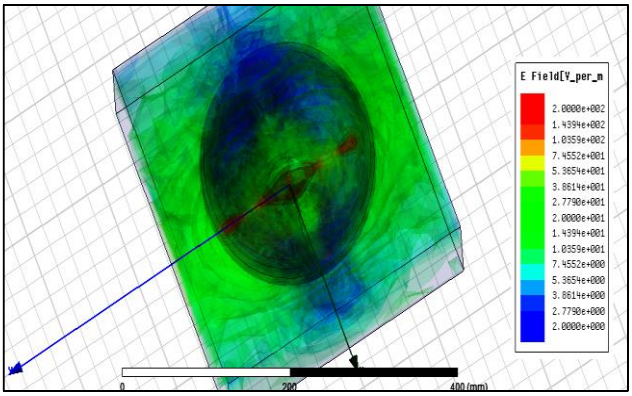

Fig. 4: SAR distribution in Brain fluid after conducting optimization for frequency value of 835 MHz at ϕ=0.

Below shown Figure 6 depicts the 2D radiation pattern of the phantom antenna under test at the designed frequency of 835 MHz for Φ=0 and Φ=90 degrees. It can be seen that the proposed antenna has a nearly Omni-directional radiation pattern in the H-plane and a dipole-like radiation pattern in the E-plane.

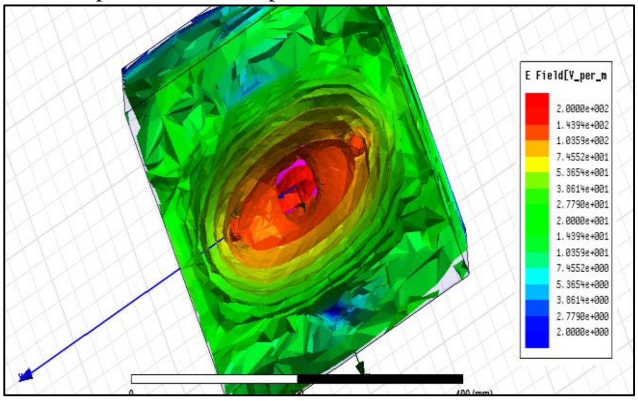

Fig. 5: The result of optimum SAR distribution for frequency value of 835 MHz at ϕ=0.

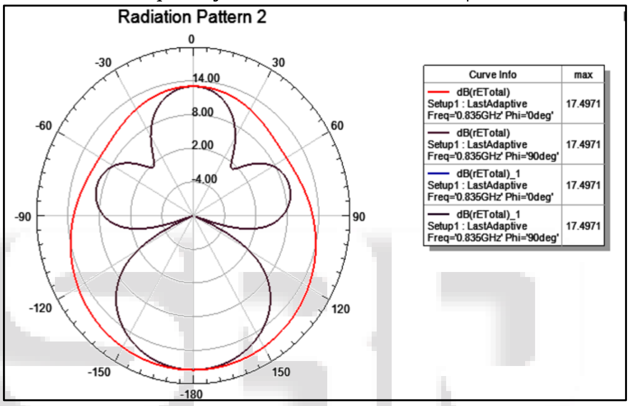

Fig. 6: Simulated radiation pattern of the dipole antenna for Φ=0 and Φ= 90 degrees at 835 MHz.

The figure 6 shown above also depicts that the device under test have maximum gain of 17.49 db at 835 MHz for Φ=0 and Φ= 90 degrees.

Figure 7 shown below depicts the 3D gain plot of the antenna under test.

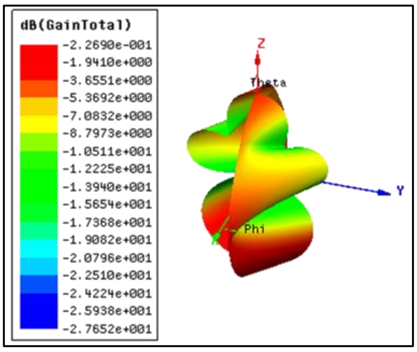

Fig. 7: Simulated 3d gain plot of the device under test Φ=0 and Φ= 90 degrees at 835MHz.

It can be seen that there are various irregularities in the 3d gain plot, which is due to the absorption of Microwave energy in the human head radiated from dipole antenna under test.

IV. CONCLUSION

In this paper, we proposed the simple dipole antenna design used to optimize the SAR in Human Head due to wireless communication devices. The possible exception would be the Local SAR above the feedpoint. This is likely due to the use of 50 Ὠ lumped gap sources as an approximation to the balun feed for the dipoles. The specific energy absorption rate (SAR) distribution is investigated inside phantom model. The objective is set to find the optimum amplitude and phase of a dipole antenna. Element to maximize SAR value and enhance the localization of the microwave energy inside the brain location. Simulation has been conducted at relatively low frequency value of 835MHz.

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