Analysis of SAR (Specific Absorption Rate) Layered Spherical Human Head Model

Deepesh Kumar Singh[1]
[1]M.Tech Student
[1]Department of Microwave Engineering
[1]SRMS CET, Bareilly, India

Abstract— As the use of wireless communication devices increases by the people. The effect of electromagnetic effect gets increased in surrounding environment causes more harmful effect to the humans. This paper is asses the mobile phone radiation effect on human head. SAR on different layer of human head is calculated using HFSS simulating software. Layers of human head consist of different tissue. Human head modeled as single, and three layered spherical head model. In Hand held device PIFA antenna is used.

Key words: Planner inverted-F antenna (PIFA), High frequency structural simulator (HFSS), Specific absorption rate (SAR)

I. INTRODUCTION

As the mobile phone technologies grow up faster, the number of people using mobile headsets is increasing. Headsets are easier to use for several people even a child or an adult. Exposure to the radiation pattern of a mobile headset seems to be safer than mobile handsets. With the rapid increase in technology, the world without communication is unimaginable. So, mobile phone handset devices act like another hand to human society. Every product has its own advantages as well as disadvantages. We never thought of biological ill effects due to mobile phones a wireless communication device used by various age groups. The abundant usage of handsets has kindled some interest in few scientist and researchers regarding the ill effects due to Electro Magnetic radiation emitted by mobile phone antenna. Mobile phone nearer to head, the emitted EM radiation gets coupled to human head tissues, which might alter the basic biological function of cells. Even, we can sense the temperature increment in outer case of handset as well as ear, where handsets are pressed while talking for longer hours [2]. The consequences of excessive heating in the body vary from temporary disturbances in cell functions to permanent destruction of tissues.

Radiation exposure from mobile phone is non-uniform; limits can be précised in terms of Specific Absorption Rate (SAR) with an averaging mass of 1 g and 10 g of tissue in the shape of cube.

II. MEASUREMENT OF EM FIELD ABSORPTION

The SAR as a quantity for EM measurement at radiofrequency spectrum is defined as

SAR- The specific absorption rate (SAR) is used to quantify the energy absorbed in tissues at radiofrequency spectrum, which is expressed in units of watts per kilogram [5]. SAR is defined as the ratio of the absorbed power to the absorbing mass. The total power absorbed in the human body is

$$P_{abs} = \int_v \frac{1}{2}\sigma|E|^2 dv \qquad (1)$$

Where σ(S/m) is conductivity of tissue, E (V/m) is the electric field intensity and V is the volume of the biological tissue. SAR is also defined as

$$SAR = \left(\frac{\sigma}{2\rho}\right)E^2 \qquad (2)$$

Where ρ(kg/m ^{3}) is mass density of the tissue. SAR is preferred as low as possible to minimize the biological effect.

III. PHANTOMS

The exact measurement of SAR and EM field in the human body are not possible: so the phantoms have been designed to model the human body at normal body temperatures. They have many shapes, such as spherical and human-like bodies. The liquids or gels as materials to tissues are placed in phantoms and exposure source is situated near them [10]. One robot arm will then measure the E or H field by a probe placed at various locations near the model. A computer processor calculates the SAR.

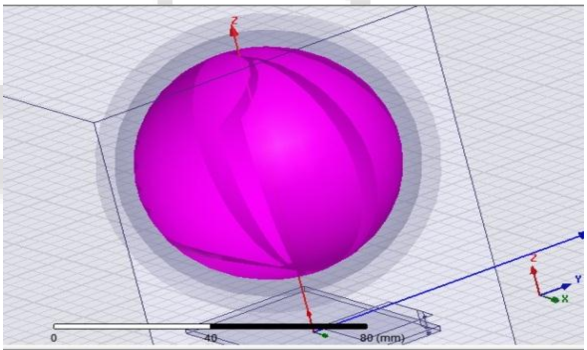

Fig. 1: three layer human head mzodel

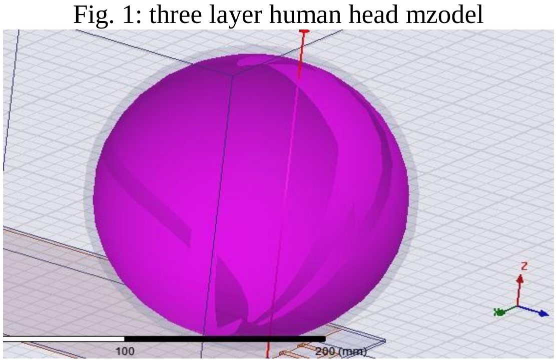

Fig. 2: single layer human head model

IV. MODELING

HFSS (High frequency structural simulator) is used for SAR modeling, this model contains three parts

A. Antenna Designing (Excitation):

PIFA antenna is the most used antenna in wireless communication devices. Here PIFA is designed on HFSS at

1.8 GHz. The following equation is used to calculate the resonant frequency of PIFA

$$fo = \frac{c}{4(W_p + L_p)} \qquad (3)$$

Where c is the speed of light, L_p and W_P are the length and width of the PIFA, f_0 is the resonant frequency.

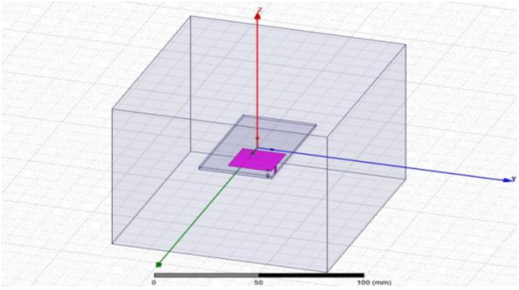

Fig. 3: PIFA design in HFSS at 1.8 GHz

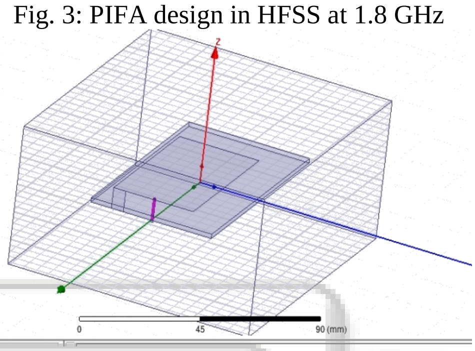

Fig. 4: PIFA design in HFSS at .9 GHz

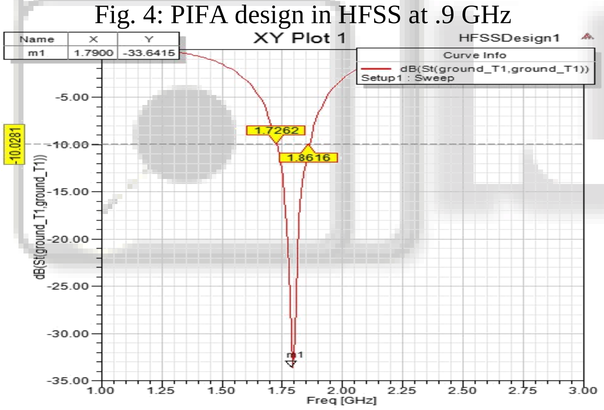

Fig. 5: Return loss of PIFA antenna

B. *SAR Analysis:*

There are two types of SAR Field Overlay plots available in HFSS [1];

1) *Local SAR:*

When calculating the local SAR, HFSS uses the equation (2) to calculate the SAR at each mesh point on an overlay plot. HFSS interpolates the values between the mesh points across the plot.

2) *Average SAR:*

When plotting the average SAR, for each mesh point on the plot, HFSS reports the SAR averaged over a volume that surrounds that point. The volume is determined by the settings for the material's mass density and mass of the material surrounding each mesh point set in the Specific Absorption Rate Setting dialog box. The volume will not cross object boundaries.

3) *The Standards of SAR:*

- European: 2 w/kg, averaged over a volume of 10 grams of tissue
- American: 1.6 w/kg, averaged over a volume of 1 grams of tissue

C. *SAR on Head Model:*

In order to evaluate the near-field exposure produced by wireless handsets, phantom models simulating the human head have been used. To reduce measurement variations, a phantom model with a standardized size and shape has been defined in this recommended practice, as well as specific parameters for the tissue-equivalent liquids. SAR can be achieved by choosing suitable tissue dielectric parameters, which provide some overestimation when used in a homogeneous phantom. Heterogeneous head models with multiple tissues, including skin, skull, muscle, brain, and eyes are difficult to construct. Moreover, measurements are often limited to specific regions of the phantom because of restrictions imposed by the bony structure.

Because of the available commercial systems, the common models for SAR measurements are a thin bowl (5 thickness shell with 4.6 relative permittivity) containing fully the head (brain) tissue equivalent materials.

V. RESULTS

In this section the results of human head model in one and three layer and antenna model both dipole and PIFA are shown

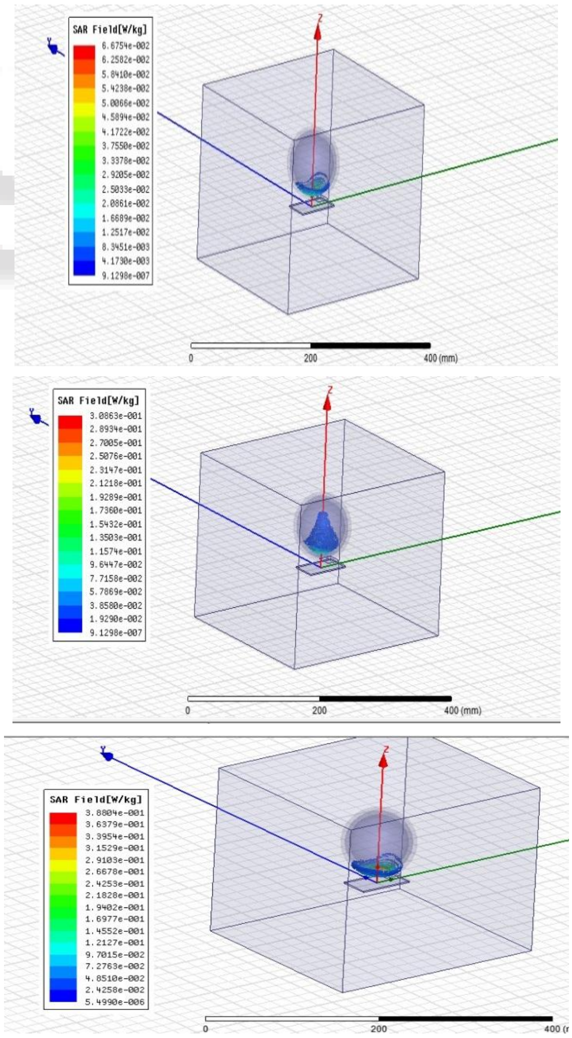

Fig. 5: SAR on 3 layered spherical model, with different tissue bone, brain and skin

Max SAR (W/Kg)	**Layer**	**Conductivity (S/m)**	**Local SAR (W/Kg)**	**Average SAR (W/Kg)**	**Mass density (Kg/m^3)**
One layer + PIFA at 900 MHz	Shell	0	0	0	1050
	Head equivalent model	0.9	1.1572×10^{-1}	7.5595×10^{-2}	1050
Three layer + PIFA at 1.8 GHz	Skin	0.9	3.8804×10^{-1}	3.0863×10^{-1}	1080
	Bone	0.	6.6754×10^{-2}	3.8766×10^{-2}	1810
	Brain	1.5	3.0863×10^{-1}	1.8462×10^{-1}	1050

Table 1: SAR of Two Models

VI. CONCLUSION

The simulation is done at 900 MHz and 1.8 GHz because it widely used in mobile communication systems. The resulting data shows that when human head tissue is exposed to EM field which is generated by PIFA antenna. The field penetrates in all the human head tissues. The SAR and E-field strength depends on tissue material properties (conductivity, permittivity, permeability).

By increasing conductivity, SAR increases too. The layered human head model is easy to maser and simulate. Single layer human head model is not reliable, because it does not show a good and real model of human head. So as the number of layers increases means as we consider more tissue result gets better and better.

VII. ACKNOWLEDGMENT

My Special thanks go to Mr. Sovan Mohanty, Mr. Hardesh Kumar Singh faculty members of Electronics and Communication department.

REFERENCES

[1] Modeling the specific absorption rate distribution of a Smartphone, Application Brief by Desmond Tan
[2] Balamurugan Rajagopal and Lalithambika Rajsekaran “SAR assessment on three layered spherical human head model irradiated by mobile phone antenna” human– centric computing and information sciences2014, Springer
[3] Recommended Practice for Determining the Peak Spatial-average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, IEEE Standard 1528-2003
[4] IEEE C95.1-2005, IEEE standards for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz," Institute of Electrical and Electronics Engineers, New York, NY, 2005
[5] Asma lak, Homayoon Oraizi “Evaluation of SAR distribution in six-layer human head model” International journal of antenna and propagation volume 2013,article id 580872
[6] Christopoulou, M., S. Koulouridis, and K. S. Nikita, \Parametric study of power absorption patterns induced in adult and child head models by small helical antennas," Progress In Electromagnetics Research, PIER 94, 49,67, 2009
[7] W. Joseph and L. Martens, “Safety factor for determination of occupational electromagnetic exposure in phantom model,” Electron. Letter, vol. 39,no. 23, pp. 1663–4, Nov. 2003.
[8] Antenna Theory: Analysis and Design, 3rd Edition by Constantine A. Balanis, wile India publication
[9] Broadband planar antennas Design and application, John Wiley & Sons, Ltd by “Zhi Ning Chen and Michael Y.W Chia, 2006
[10] RF/Microwave Interaction with biological tissues, IEEE PRESS, A John Wiley & Sons, INC, Publication by Andre Vander Vorst, Arye Rosen, Youji Kotsuka,2006

