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Original Article

The Study of Biological Effect of EM Radiation by Antenna at Different Position of Human Model

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ABSTRACT

This paper presents an approach to modeling of field penetration and gives contribution to understanding the real effects of the fields and the sensitivity of human model to electromagnetic radiation generated by mobile antenna. When a human body is exposed to the electromagnetic radiation, because human body contain 70% of liquid, and it contain more liquid near of head, heart, abdomen (near of Thai). It is similar to that of cooking in the Microwave oven. The finite difference time domain (FDTD) method is widely used as a computational tool to simulate the electromagnetic wave propagation in biological tissues. The FDTD method has been used for calculating SAR (specific absorption rate) values on human model by varying the EM radiation at frequency 1.47 GHz. Electromagnetic field effect showing at different position of the human model.

Introduction

In recent years, the use of wireless communication devices that are used in close proximity to the human body has been increasing. The public has lately attached importance to the risk of electromagnetic (EM) radiation and the telecommunication industry has lately realized the needs to test its devices for the compliance with the safety limits. As we know, specific absorption rate [1] is one of important characteristics used to evaluate the EM energy absorbed by human body.

In order to satisfy the safety limits, we need to develop accurate and effective FDTD methods to predict the EM effects on human body and guide the product design. Obviously, it is popular that simulation methods are better choice because of their high efficiency.

The SAR in the human body affected by EM wave from the cellular phones has been widely investigated [2], because the cellular phones are used in the vicinity of the human head. However, the SAR of using the commercial wireless terminal has not been investigated so much. The EM waves of these devices penetrate to the deep region of the human body because the wavelength of the EM waves of the device operating in VHF band are longer than those of a cellular phone operating in the GHz band. Therefore, it is necessary to evaluate the SAR of the human body. SAR is defined as -

$$SAR = \sigma \frac{E^2}{\rho}$$

Where σ and ρ are the conductivity and density of the human body tissues respectively and E is the electric

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field in the tissues. The unit of SAR is watt per kilogram (W/Kg).

In this work, numerical method was used to compute the magnetic and electric fields of monopole antenna. The finite-element method was used because is flexibility to deal with complex geometries. Images of the magnetic and electric fields were then formed and used to calculate the SAR (specific absorption rate). Numerical results showed a good agreement with data reported in the literature.

Description of Geometry

Using software XFDTD 7.3.0.4 [7] the geometry of anatomical human model has been imported. The width, depth and height of the anatomical human model are 118mm, 70mm and 378 mm respectively. In order to keep the computational accuracy and reliability of the model as high as possible, a high resolution of 5mm × 5mm × 5mm for the anatomical human model was used in our investigation. Each voxel was color coded and assigned a tissue type. The tissue types and mass density values (Kg/m^3) used in the man models are shown in Table 1. The permittivity value assigned to a tissue type was calculated based on frequency. These permittivity values were obtained from the four-term Cole–Cole fits published by Gabriel [4]–[7].Which is simulated at 1.47 GHz.

Table 1. Tissue Types and Mass Density (Kg/m^3) Values Used in the Human Model

Tissue	Mass Density (Kg/M^3)
Bile	928
Bladder	1086
Blood	1050
Blood Vessel	1102
Body Fluid	1050
Bone(Cancellous)	1178
Bone(Cortical)	1908
Bone Marrow	1029
Brain(White Matter)	1041
Brain(Grey Matter)	1045
Brain(cerebellum)	1045
cartilage	1100
Cerebral Spinal Fluid	1007
Eye(Cornea)	1051
Eye(Lens)	1076
Eye(Sclera)	1032
Eye(Vitreous humor)	1005
Fat	911
Gall Bladder	1071
Gland	1028
Heart	1081
Intestine(Large)	1088
Intestine(Small)	1030
Kidney	1066
Ligament	1142
Liver	1079
Lung(inner)	394
Lung(outer)	1050
Lymph	1035
Mucous Membrane	1102
Muscle	1090
Nail(Finger and Toe)	1908
Nerve (Spine)	1075
Pancreas	1087
Skin/Dermis	1109
Spleen	1089
Stomach	1088
Testicles	1082
Tooth	2180

The monopole antenna geometry is created with a simple Box and wire body antenna. The Box dimensions width, length and height are 60mm, 15mm and 50mm respectively and the length of antenna is 50mm. Monopole antenna is assigned electric and magnetic properties as a perfect electric conductor & free space respectively. SAR sensors have been added for collecting the values of 1g and 10g average SAR data. Geometry of human model in close proximity with monopole antenna at different places [3] as shown in Figure 1.

Figure 1. Geometry of human model with monopole antenna

Methodology

FDTD solves Maxwell's equations in the time domain. This means that the calculation of the electromagnetic field values progresses at discrete steps in time. One benefit of the time domain approach is that it gives broadband output from a single execution of the program; however, the main reason for using the FDTD approach is the excellent scaling performance of the method as the problem size grows. As the number of unknowns increases, the FDTD approach quickly outpaces other methods in efficiency.

FDTD has also been identified as the preferred method for performing electromagnetic simulations for biological effects from wireless devices. Researchers have shown the FDTD method to be the most efficient approach in providing accurate results of the field penetration into biological tissues.

FDTD Basics

In the FDTD approach, both space and time are divided into discrete segments. Space is segmented into box-shaped cells, which are small compared to the wavelength. The electric fields are centered on the edges of the box and the magnetic fields are centered on the faces as shown in Fig 2. This orientation of the fields is known as the Yee cell, and is the basis for FDTD.

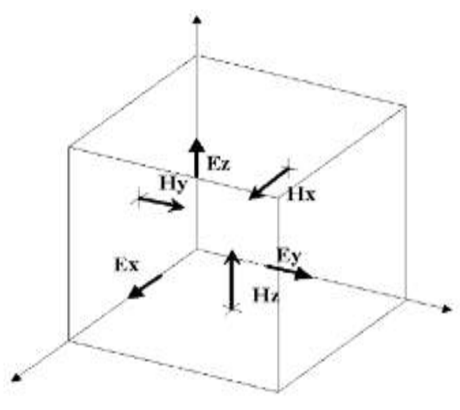

Figure 2. The Yee cell with labelled field components

Time is quantized into small steps where each step represents the time required for the field to travel from one cell to the next. We refer to this as the "timestep". Given the offset in space of the magnetic fields from the electric fields, the values of the field with respect to time are also offset. The electric and magnetic fields are updated using a leapfrog scheme where the electric fields and then the magnetic are computed at each step in time.

When many FDTD cells are combined together to form a three-dimensional volume, the result is an FDTD grid. Each FDTD cell will overlap edges and faces with its neighbours, so by convention each cell will have three electric fields that begin at a common node associated with it. The electric fields at the other nine edges of the FDTD cell will belong to other, adjacent cells. Each cell will also have three magnetic fields originating on the faces of the cell adjacent to the common node of the electric fields, as shown in Figure 2.

Results

In this paper we present the depth of penetration of radiation and its effect on biological tissue. In essence the amount of electromagnetic power absorbed by biological tissues for various exposure conditions and types of emitting sources, utilizing a detailed model of the human body with monopole antenna at different positions of body.

Monopole antenna has maximum Gain is -0.0884dbi, Directivity is -1.9699dbi, S_{11} is -34.415db, VSWR is 1.039 and impedance is 51.938+ 0.07023j ohms.

SAR Distribution at body

SAR values have been measured by changing the position of antenna in human body and keeping it at head, heart, and thai. Table 2 shows the values of SAR of the proposed antenna position in human model at frequency 1.47 GHz. As shown in the Table 2 the maximum SAR value is 0.04745 W/Kg at near of head and lowest SAR value is 0.01103 W/Kg at near of heart.

Table2. Simulated results of SAR

Body Part	Avg. SAR (w/kg)	Max SAR (w/kg)	SAR 10g (w/kg)	SAR 1g (w/kg)
Head	$1.175e^{-05}$	0.04745	0.01483	0.03008
Heart	$9.173e^{-06}$	0.01103	0.00444	0.00627
Thai	$1.295e^{-05}$	0.02820	0.00810	0.01590

Field Distribution

Apart from the Specific Absorption Rate, period of exposure to radiation is an extremely important parameter while assessing the effects on biological tissue. Correlation between the amount of radiation versus model of head, heart and thai is a complex phenomena, addressed in simulation models. Electric field radiation around the human model due to monopole antenna is showing in different colour in Figure 3. Red color region showing maximum electric field and violet color region showing minimum electric field due to antenna. Electric field values are 61.33v/m, 47.14v/m and 40.01v/m at head, heart and thai respectively.

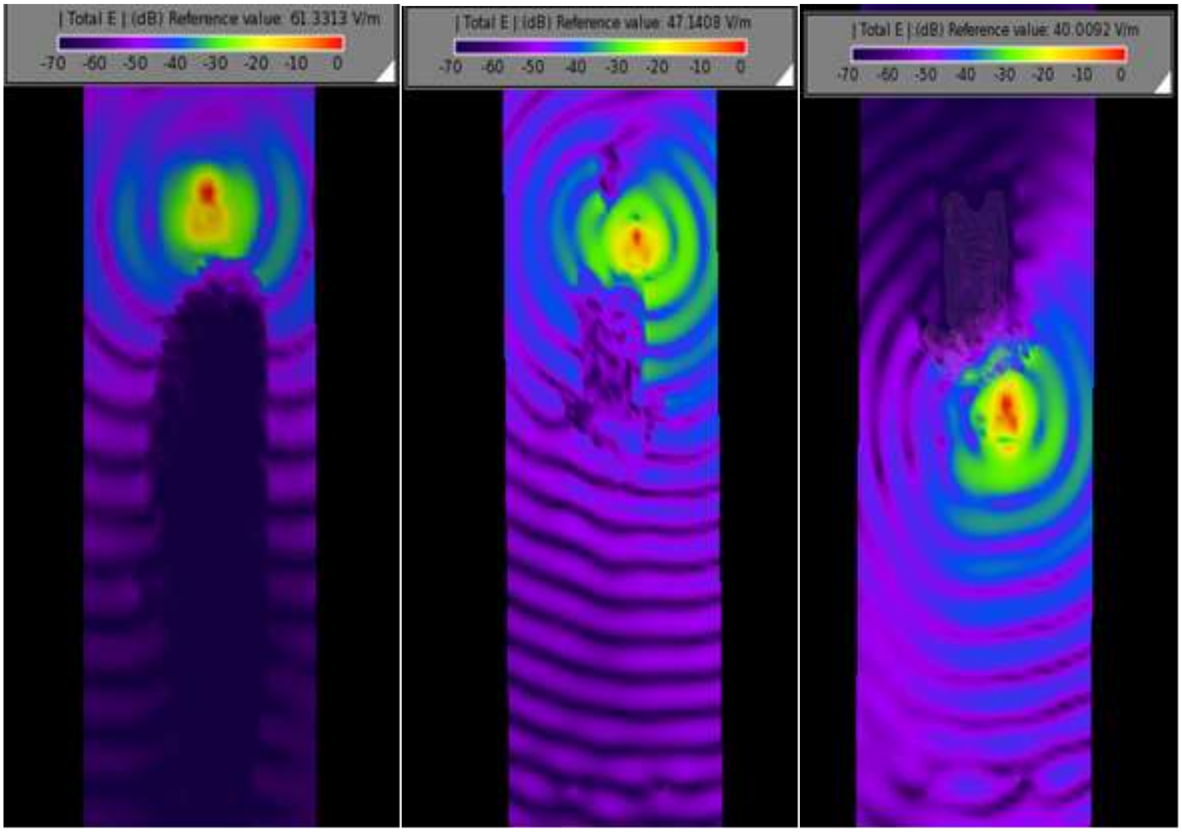

Figure 3. Radiation pattern for head, heart and thai respectively

Figure 4 shows polar graph between electric field strength and angle (θ), where angle varies from 0° to 180°. Graph for Electric field strength vs. Angle in Figure 4 (a), (b) and (c) are for head, heart, and thai respectively. Electric field strength is maximum for heart with the value 0.089027 v/m and minimum for thai with the value 0.012499 v/m.

(a) (b) (c)

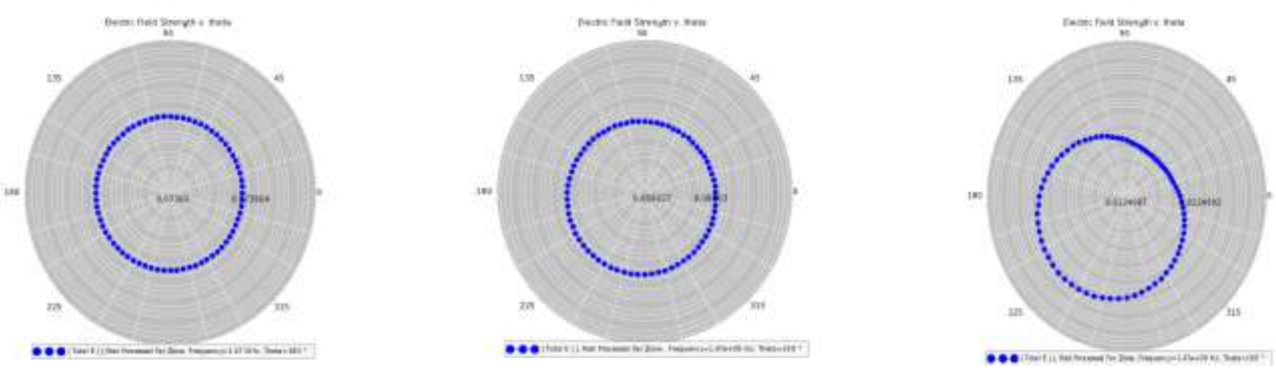

Figure 4. Electric field strength vs. Angle

Conclusion

In this work SAR distribution, field distribution and peak SAR averaged over 10g and 1g tissue of model. Using XFDTD software is evaluated. It is concluded that SAR values is maximum at head which indicates more absorption of EM radiation and minimum at heart which indicates less absorption of EM radiation as compare to head and thai. Also it is been observed that Electric field penetration is maximum at head in rest of all positions of antenna at frequency 1.47 GHz. Finally the conclusion is that SAR and Electric field is maximum near to head, which is harmful for our health. i.e. we should try to keep the cell phone away as much as possible from the head, and avoid talking more by cell phone.

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XFDTD software from Remcom, www.remcom.com

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