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FDTD Computation of SAR Distributions in Human Head for Mobile Phones

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Abstract:***The influence of radio frequency (RF) field orientation on specific absorption rate (SAR) in a human head is investigated in this paper. The amount of temperature raised in Human Head due to Mobile Phone usage with different frequency range is analyzed using a versatile electromagnetic field simulator based upon the Finite-Difference Time-Domain method (FDTD).The harmful effects of recent unbranded mobile phone is compared with the Branded Mobile Phones. This paper investigates the harmful effects of both Branded and Unbranded Mobile Phones for various frequency range and the result shows that the usage of Unbranded Mobile Phone will cause greater damage to brain cells when compared with Branded Mobile Phones.***

Keywords***:*** **Specific Absorption Rate (SAR), Mobile Phone, Finite-Difference Time Domain(FDTD).**

I. INTRODUCTION

The extensive use of cellular communicationdevices is accompanied by public concerns aboutpossible harmful effects on human health as a result ofexposure to electromagnetic (EM) radiation from thesedevices. Because of this, considerable effort has goneinto improving the capabilities of computer simulationsfor quantifying the EM absorption from such devices.Computer modeling and simulation can providevaluable information involving various aspects of EMproblems. The finite difference time domain(FDTD) method [1-2] is considered to be one of themost accurate and simple for implementing numerical methods when solving EM problems. Further, the human head is one of the most sensitive organs for EM radiation. Thus, research on the SAR calculations in the head for EM radiation has been Carried out extensively [3 – 5]. Inaccordance withrapid development of the computer, anatomically based models of human heads can be incorporated into EM simulators.

Different EM simulator based on the extensive research, both experimental and theoretical, various national and international standards and guidelines have been established for safe levels of EM exposure at different frequencies. A generally accepted dosimetric measure of EM exposure is the specific absorption rate (SAR), which is defined as the power absorbed per unit mass of tissue [W/Kg], and can be determined at any voxel in the computational space by

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

where E is the amplitude of electric field (V/m), σ is the conductivity (S/m), and ρ is the mass density of thetissue.

In this paper, we present a finite-difference time- domain (FDTD) calculation of the specific absorption rate (SAR) in two-dimensional human head model at GSM 920 MHz, 835MHz and 1.900GHz radiation. The head model is exposed to an incident plane wave. The FDTD code is implemented using the EMPIRE XCcel Software. Simulation results indicate that the SAR value is minimum for GSM 835MHz when compared with other GSM frequency range.

II. METHOD OF ANALYSIS

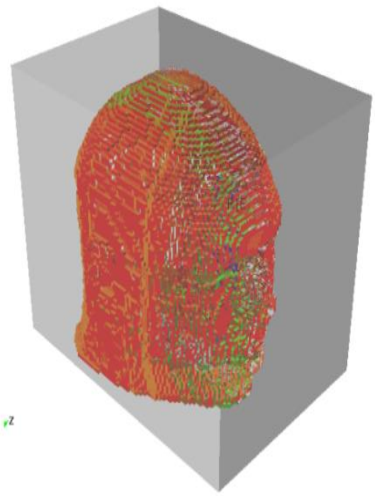
In this section, the FDTD method is used to investigate the interaction between the human headmodel (comprised of 10 tissues) and incident planewave source. Radiofrequency radiation from cell phone and cordless phone exposure has been linked in more than one dozenstudies to increased risk for brain tumors and/or acoustic neuromas (a tumor in the brain on a nerve related to our hearing).

A. EMPIRE XCcel Software:

EMPIRE XCcel^{TM} is an established and versatile electromagnetic field simulator based upon the Finite-Difference Time-Domain Method (FDTD). At the IMST GmbH, this powerful method has been applied to build an Electromagnetic fieldsimulator for the analysis of Packages, Interconnects, Radiators, waveguide Elements (EMPIRE XCcel^{TM}) and EMCproblems.The exact knowledge of electromagnetic fields and the propagation of waves is a prerequisite for the design of radio frequency (RF) elements. In former times, RF design tasks were based on measurement and simple models, leading to time and costs consuming design procedures. Today, affordable computer hard- and software have established and simulation programs can accurately predict the electromagnetic behavior of new products. So, field simulators have become a new standard for RF calculations.Unlike the Finite Element Method, which has long been established in computing electromagnetic fields, the FDTD method had its breakthrough in the late 80's when extensive research and development lead to a number of improvements in applying advanced boundary conditions, e.g. free space or waveguides, and, therefore, reducing significantly the area of simulation. Today, its applicability covers the whole area of three-dimensional (3D) field simulations for RF designer. Originally intended to analyze planar passive structures, the EMPIRE XCcel^{TM} simulator was continuously extended to capture more and more high frequency applications. It has proven its functionality in numerous comparisons with measurements and was successfully applied in many different microwave component designs. The method is based on the most efficient algorithm known which is very accurate and simplification is hardly necessary since it solves the discretized Maxwell's equations directly.For the exposure of human bodies with electromagnetic field, body models can be included into the Ganymede GUI. Body model data or SAM phantom data can be obtained using CAD.

B. Voxel Model :

For the modification of existing body models a voxel editor is available as shown in Fig.1. Here, parts of the model can be separated, moved or rotated to transform e.g. a standing



body. FIG:

Mass Density and dielectric properties of the Head tissues at 900MHz given in tabul;ar column 1.

Tabulation 1.

TISSUE	ρ [Kg/m³]	εr	σ [S/m]
Skin	1010	41.4	0.87
Muscle	1040	55.0	0.94
Bone	1810	21.0	0.32
Blood	1060	61.4	1.54
Fat	920	11.3	0.11
Cartilage	1100	40.8	0.81
Grey Matter	1040	54.7	1.19
White Matter	1040	35.7	0.61
Humor	1010	74.1	1.97
Lens	1100	51.3	0.89
Sclera/ Cornea	1170	52.1	1.22
Cerebellum	1040	49.6	1.03
Hypophysis	1040	49.6	1.03
CSF	1010	74.0	2.12
Parotid	1040	49.6	1.03
Tongue	1040	57.0	0.80

III. RESULTSAND DISCUSSION

The SAR distribution in the head at 800MHz, 835 MHz and 1900 MHz is measured using EMPIRE XCcel Software tool and the results are analysed. The SAR value for different frequency range is as shown below.

SAR value for 1g of tissue at 800MHz is shown in Fig 2

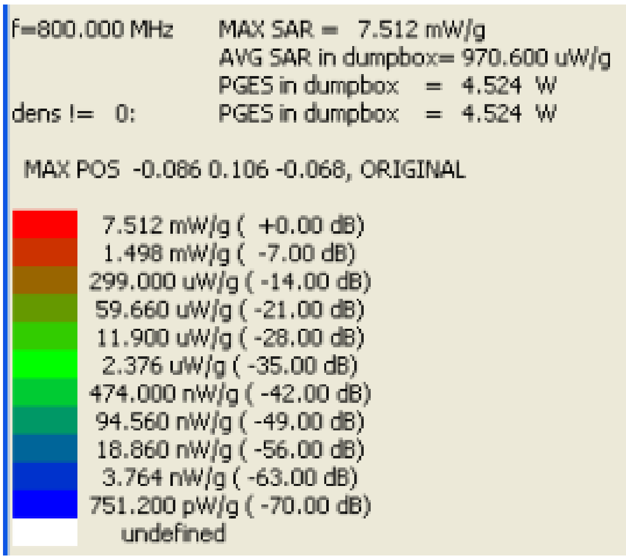


Fig 2.SAR value for 10g of tissue at 800MHz is shown Fig 3

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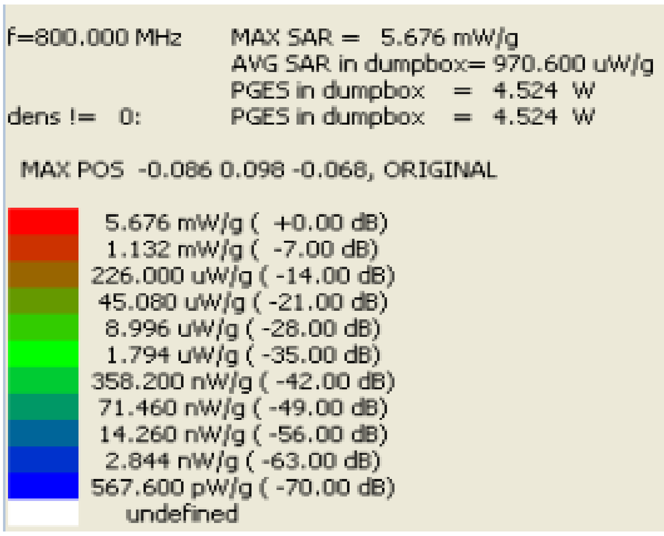
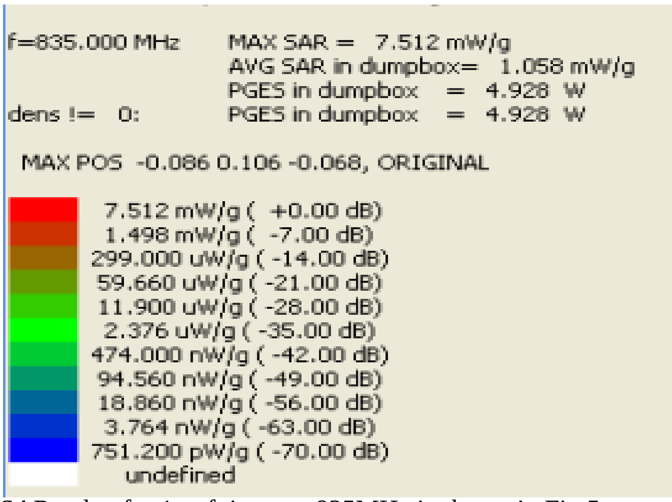


Fig 3.SAR value for 1g of tissue at 835MHz is shownFig 4.



SAR value for 1g of tissue at 835MHz is shown in Fig 5.

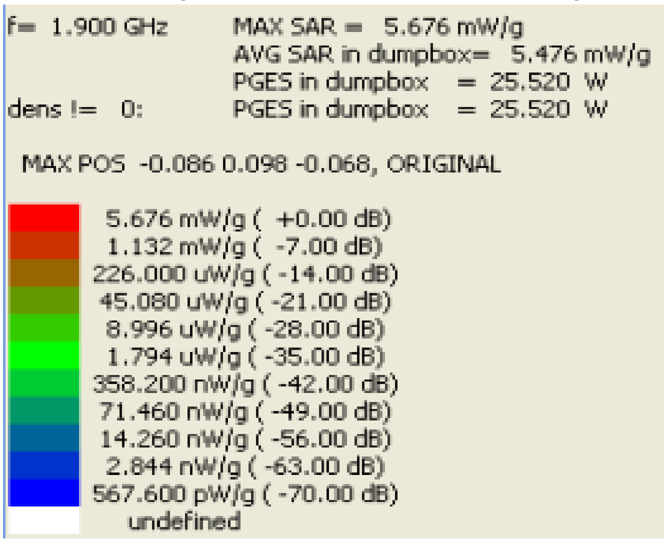


Fig 5. : SAR value for 1g of tissue at 1900MHz shownFig 6.

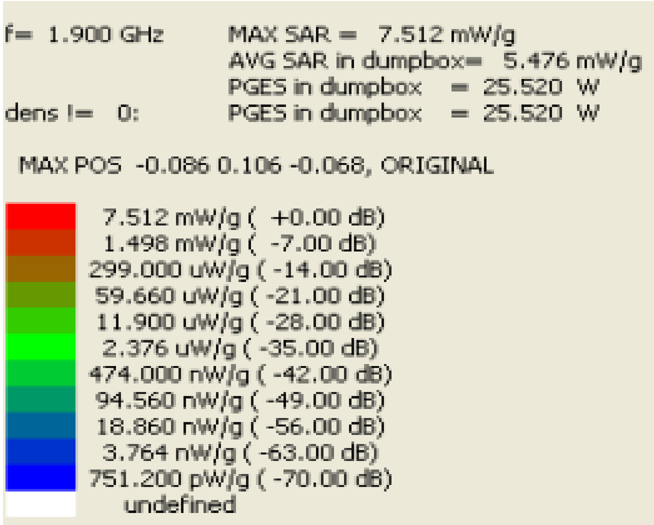
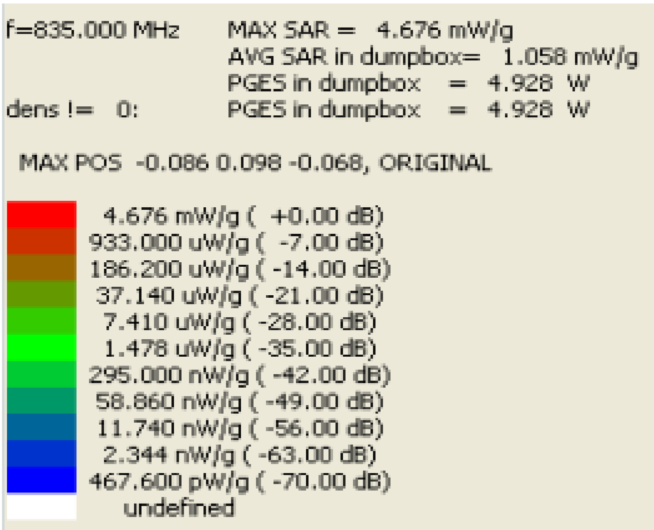


Fig 6.: SAR value for 10g of tissue at 1900MHz is shown in Fig 7.



source frequency is reduced. The resultant value is tabulated in tabular column 1

Tabulation 2

S.No	Frequency	SAR value	
		1g Average	10g Average
1	800MHz	0.9 W/Kg	0.97 W/Kg
2	835MHz	1.05 W/Kg	1.058 W/Kg
3	920MHz	1.28 W/Kg	1.32 W/Kg
4	1900MHz	5.4 W/Kg	5.47 W/Kg

The result shows that increase in frequency range will cause increase in SAR value. These results are only for Mobile Phone having FCC Certificate.

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IV. MOBILE PHONE TYPES

Mobile Phones manufacturing companies produce different Mobile Phone types and Models with different SAR value, off course SAR value depends upon the proper designing of the Mobile Phones. Poor designing of Mobile Phones leads to high radiations, so it is necessary to design a perfect Mobile Phone with low SAR value.

Tabulation 3.

Mobile Brand	Model Number	SAR value
Nokia	1100	0.67
Nokia	2600	0.80
Nokia	8210	1.00
Nokia	8810	1.14
Sony Ericsson	2200	1.39
Sony Ericsson	Z1010	1.41
Sony Ericsson	P802	0.64
Motorola	C200	0.78
Motorola	C300	0.95
Motorola	L2	1.33
Motorola	L7	0.95

The tabular column 3 shows the different SAR value for different Mobile Phone Brand and Model number.The SAR value is different for each type of Mobile Phone model,this is because SAR valuedepends upon the size of the antenna,location of the antenna and size of the Mobile Phone.The basic design procedure of unbranded Mobile Phones are not acceptable, because theradiation level is over the limit.

V. SURVEY

I prepared a list of questions regarding Mobile Phones and took a survey from different peoples. The result shows that, peoples using unbranded Mobile Phones are affected more as compared with branded Mobile Phone users. Even, many of my friends are interested in buying this unbranded Mobile Phones.One of my friend using this unbranded Mobile Phone have come across so many health problems like headache, heating sensation in the ear, irritating sensation to eyes.The main specialty of this unbranded Mobile Phone is, low cost with all special features like MP3, MP4, BLUETOOTH, TV, CAMERA. The audio output is very high as compared with other Mobile Phones.The presence of speaker near the Camera may cause high radiation and it will affect the Mobile Phone usersdirectly.The unbranded Mobile Phones have so many drawbacks, but peoples are not aware of these drawbacks and everyone is willing to buy these unbranded Mobile Phones.

The Mobile Phone used by friend is shown in Fig 8.

The fig 9 shows, a one Rupee coin is stick with the unbranded Mobile Phone exactly behind the screen due to the presence of speaker in that location.

Fig 9.

So it is necessary to consider the design procedure to get the low SAR value type mobile Phones.

VI. CONCLUSION

i. The amount of temperature raised in Human Head will be decreased with selected mobile brands.

ii. A versatile electromagnetic field simulator based upon the Finite-Difference Time-Domain method (FDTD) will make the temperature which causes the harmful rays.

iii. The result shows that, peoples using unbranded Mobile Phones are affected more as compared with branded Mobile Phone users.

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