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SAR Calculation in a Child Seven-Layer Head Model at 2.1 and 2.6 GHz

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ABSTRACT: Health and safety concerns have grown in recent years due to the increasing frequency bands and the demand for wireless communication apparatus. Electromagnetic (EM) radiation breakthrough from Radio frequency (RF) into the human head is an issue that needs to be addressed. Radiation from RF sources can cause serious biological hazards inside the human body. This study measures the average Specific Absorption Rate in a 7-year-old child's head tissues using the ANSYS HFSS software and varying the distance from the source to the antenna in order to address these issues. SAR levels of phones sold should be below certain standard limits. We have used an internal antenna of a mobile phone It's a planar inverted F-antenna (PIFA) with a connected feeding structure.

Keywords: EM radiation, Specific Absorption Rate (SAR), SevenLayer Head Model, mobile antenna

1. INTRODUCTION

Mobile communication devices have become attainable to people of all ages as a result of the advancement of technology. Particularly this intensive use of mobile phones by children raises concerns about the potentially harmful effects of electromagnetic radiation resurrected by these devices [1]. Children face particular dangers since their skulls are thinner and their growing brains are more susceptible to radiation [2]. Radiation from radio frequency (RF) electromagnetic fields causes whole-body heating, and the specific absorption rate is used to measure this effect. As a result, in its guidelines for RF safety, the International Commission on Non-Ionizing Radiation and Protection (ICNIRP) has outlined the basic limitations in terms of the SAR [3].

Based on medicinal imaging data of children, many heads or whole-body models have been developed for dosimetry purposes. Numerous scientists in the domains of dosimetry, epidemiology, and in vivo experiments have examined whether children are more vulnerable to electromagnetic fields (EMFs) generated by Handheld mobiles. Do children absorb more radiation energy into their heads from mobile phones than matures?' This issue has been a key question for dosimetry experts regarding this issue, though this question appears simple, it stays extremely fussy to answer definitively since most dosimetric etudes have compared the power suck of different individuals and the results have typically not indicated a systematic age-dependent variation in peak specific absorption rate (SAR) [4–6].

Whereas several scholars, including Gandhi, assert that children have a proportionally greater intracranial peak tissue dose because of their thinner skulls and higher water content. Additionally, the brisk rate of outgrowth and evolution of the brain and incomplete myelination make children particularly vulnerable to the influences of radiation [7]- [8].

Scaled head models representing varying ages are used to determine the level of absorption of mobile antennas inside the brain. Compared to an adult model, there were differences of 33-32% and 21-22% in 1g averaged SAR in 5 and 10-year-old scaled head models, respectively. Studies have demonstrated relatively higher SAR values in the 7-year-old child model when compared with mature female (NAOMI) and masculine (NORMAN) models under various conditions when exposed to smart meters [9].

The primary goal of this study is to investigate the EM energy absorption of a 7-year-old child's head. The ANSYS HFSS software has been used to assess the exposure to radiation at 3G and 4G LTE of mobile phones in a child's head. Where SAR is calculated at frequencies of 2.1 GHz and 2.6 GHz.

2. MODELING

In this work, a child's cape exemplar was used to characterize the electrical peculiarities of various biological tissues in a wide hesitance range, with respect to their material properties and size. This model has 7 layers that have different dielectric properties, such as permittivity, conductivity, and thickness that act as a propagation medium for radio waves. According to ICNIRP, wireless devices' radio frequency (RF) energy should be limitable to a SAR valuable 2 W/kg at 10 grams of tissue. There is a danger of serious damage if this value is exceeded.

2.1 ANTENNA MODEL

Figure 1 illustrates a planar inverted-F antenna (PIFA) with a coupled fed structure designed in HFSS to calculate the SAR. Coupled feed structures enable the antenna to exhibit broadband characteristics that support all commercial service bands. The SAR calculations were performed at two different frequencies 2.1 and 2.6 GHz by varying the distance between the child head tissues and the antenna (0 mm and 20 mm) and the power radiated by the antenna (0.125 W). Figure 2 illustrates the simulated return loss of the antenna. Figures 3 and 4 show the antenna from the top and bottom, with the system's circuit board's no-ground plane and ground plane. In the part of the antenna where there is no ground plane, there is a radiating plate located at the brim of the PCB, a feed-in, which is used to receive RF signals, and a stubby pin is used to connect the radiating plate to the PCB ground plane by means of a via whose radius is 0.3mm [10]- [11].

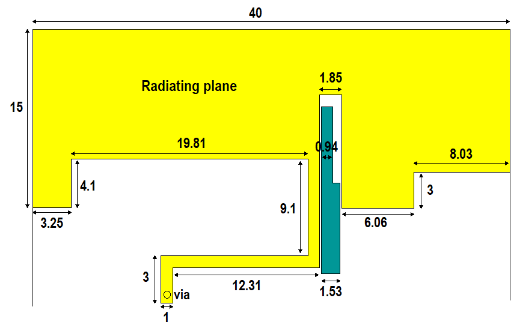


FIGURE 1. PIFA antenna geometry (in millimeters) [10]

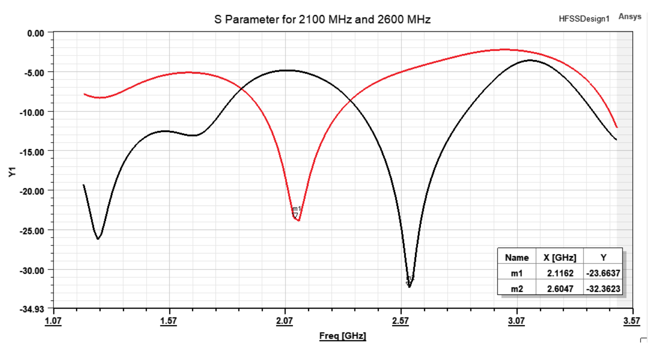


FIGURE 2. Antenna return loss simulated

2.2 HEAD MODELING

A multilayered child head model is considered in the current study. To analyze the head model, 7 layers of tissues were taken. The 7-layered model includes skin, fat, bone, Dura, cerebrospinal fluid (CSF), gray matter, and white matter as

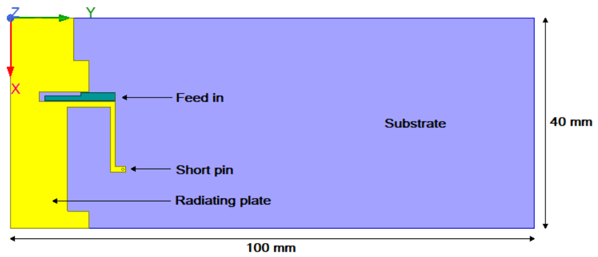


FIGURE 3. View of the antenna from the top [10]

FIGURE 4. View of the antenna from the bottom [10]

shown in figure 5 [12–14]. Listed in Table 1 are the dielectric properties of the child's head at 2.1 and 2.6 GHz as well as the thickness of his head tissue [15, 16].

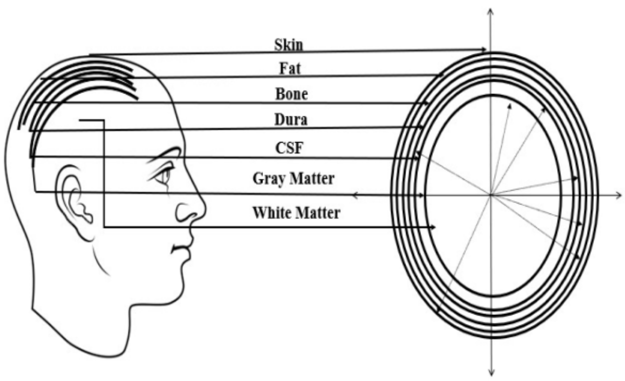
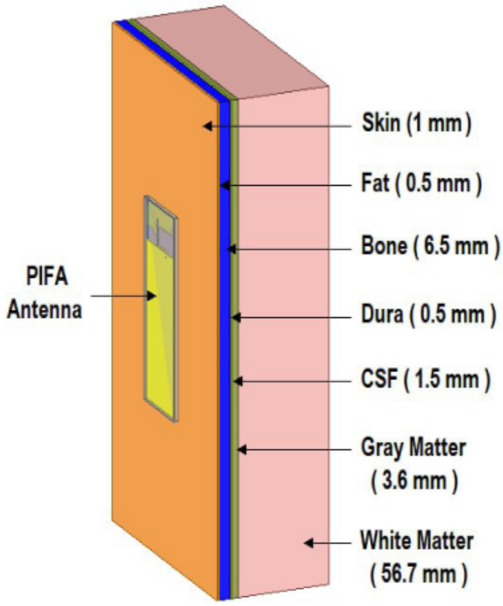


FIGURE 5. Seven-layered child head model [14]

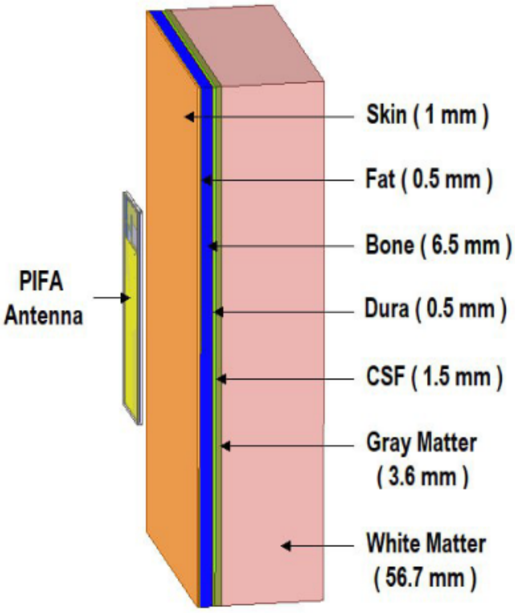
3. RESULTS AND DISCUSSION

With the layers of the child's head, we simulated the PIFA antenna with ANSYS HFSS. For both frequencies 2.1 and 2.6 GHz, the antenna is placed in two dimensions from the head layers at 0 cm and 2 cm. The simulated head layers are shown in Figure 6 (a) with the antenna at 0 cm, and Figure 6 (b) with the antenna at 2 cm.

Table 2 presents a comparison between the simulated SAR (W/kg) over a volume of 10 grams of tissue at 2.1 and 2.6 GHz over two different head-to-antenna distances and the ICNRP safety limit (2W/kg). In skin tissue only at 2.1 GHz and in skin and fat tissues only at 2.6 GHz, If there is no separation between the head and the antenna, the SAR value exceeds the guideline limit (2 W/kg). SAR values never exceed the safety guideline if the distance Paine the head and antenna is 2 cm in all child head tissues. In addition, all layers of the head exhibit increased SAR values as frequency increases.



(a) The distance is 0 cm



(b) The distance is 2 cm

FIGURE 6. The simulated 7 layers child's head at two frequencies and two distances (a) 0 cm and (b) 2 cm

Table 1. Dielectric properties of the 7-year-old child's head tissues at 2.1 and 2.6 GHz

Head Tissue	2.1 GHz		2.6 GHz		Mass Density	Tissue Thickness (mm)
	Conductivity (S/m)	Relative Permittivity	Conductivity (S/m)	Relative Permittivity	(kg/m3)	
Skin	1.351	39.62	1.589	39.05	1125	1
Fat	0.102	6.01	0.124	5.95	916	0.5
Skull	0.360	12.63	0.458	12.32	1990	6.5
Dura	1.509	43.61	1.808	42.97	1050	0.5
CSF	3.166	67.09	3.620	66.38	1007	1.5
Gray Matter	1.573	49.51	1.914	48.66	1038	3.6
White Matter	1.046	36.6	1.291	35.99	1038	56.7

Table 2. SAR10g for child's head tissues at different antenna distances and different frequencies

SAR10g (W/kg) at for the child's head layers					
Tissue name	2.1 GHz		2.6 GHz		(ICNIRP) safety
	0 cm	2 cm	0 cm	2 cm	limit of SAR (W/kg)
Skin	11.5	0.24	20.2	0.28	2
Fat	1.76	0.020	2.17	0.026	2
Skull	1.17	0.033	1.46	0.0466	2
Dura	0.33	0.042	0.41	0.0468	2
CSF	0.62	0.087	0.72	0.091	2
Gray Matter	0.28	0.044	0.31	0.048	2
White Matter	0.14	0.029	0.16	0.031	2

4. CONCLUSION

An investigation of the effects of RF waves radiated from a cellular phone antenna on the head of a 7-year-old child was conducted at 2.1 and 2.6 GHz frequency at 0.125 W at 0 cm and 2 cm distance from the antenna to the head. The distribution of SAR was evaluated using a seven-layer head model. In head tissues, if there is nope separation between the head and the antenna, SAR values are high in the skin only at 2.1 GHz, measuring 11.5 W/kg, and in the skin and fat tissues at 2.6 GHz, measuring 20.2 W/kg and 2.17 W/kg respectively. A distance of 2 cm between the head and antenna at both frequencies causes the SAR values to decrease and not exceed the safety limits in all layers of the child's head.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

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