EFFECT OF SIZE OF HUMAN HEAD ON ELECTROMAGNETIC FIELDS ABSORPTION

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ABSTRACT – In this paper the effect of size of subject under exposure on SAR, E-Field strength and H-Field strength are simulated. The head model of a normal human (IEC 66209 standard) as an adult are simulated. Also a dipole antenna as an exposure source is simulated. On the next step to evaluate the effect of size, the size of head is reduced to \( \frac{1}{2} \). Also to validate the results the simulations are done at two frequencies i.e. 835 and 1900MHz. These two frequencies are for mobile telecommunication as a useable but with probable hazardous effect for human body technology. The simulations are done by HFSS.

Key words: children, human head, IEC66209, frequency

INTRODUCTION

With the growth of use of portable devices in mobile telecommunication such as cell phones with portable antenna, the interactions between such devices become an important subject. Many experiments and studies the entire world has been done to dedicate these probable effects [1]. The biological effects have been described by many scientists the entire world. Human body has dielectric properties which vary with frequency [2]. For more information references [3-6] can be seen. Also the EM (Electromagnetic) fields are useful for medical applications and play an important role in medical treatments such as hyperthermia to treat cancers. Many parameters affect the value of EM absorption in human tissues. Such as frequencies, exposure sources and tissue sizes[7-8].

In the real world the experiment on human body with the electromagnetic source exposure is not possible due to probable biological effects. Because of it the standards company model the human body and exposure sources to evaluate and simulate the interaction between human body and exposure sources [9].

Specific Absorption Rate

The specific absorption rate is defined

\[
SAR = \frac{\sigma_E}{2\rho} |E|^2 = \frac{c}{\rho} \frac{dT}{dt}
\]

(1)

Where \( E \) is the induced electric field vector, \( c \) is the specific heat capacity, \( \sigma_E \) is electric conductivity, \( \rho \) is the mass density of the tissue and \( \frac{dT}{dt} \) is temperature increase in the tissue. The unit of SAR is Watt per Kilogram [10].

The SAR value depends on frequency, exposure source, geometry of tissue and etc. Dielectric properties of tissues are \( \varepsilon, \mu \) and \( \sigma \). Because of these properties EM fields can interact with human body.

For example the dielectric properties of skin have been shown in Fig 1 and 2 [11].

Models and simulations

In this part an antenna and a human head model has been introduced. The properties of model are according to references [10], [12]. The models for human head simulations are various. For example spherical, cubic, etc. we used from spherical model with sizes in IEC66209[10]. In real systems there are a shell with low loss as a human body model (phantoms). The equivalent human body material (in liquid or jell) put in it and a dipole antenna as an exposor source situates in for example 5mm (according to IEC66209) of it. Then a electric or magnetic probe measures the E or H field strenth and finally with equation 1 the SAR is calculated. Figure 1 shows the model.
Figure 3-a-adult head and dipole antenna model

Figure 3-b-child head and dipole antenna model

The human head equivalent material properties and dipole antenna length are in Table 1 and Table 2.

Table 1. the properties of human head model

<table>
<thead>
<tr>
<th></th>
<th>835MHz</th>
<th>1900MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head matter</td>
<td>41.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Shell</td>
<td>4.6</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. the dipole characteristics (power=1 watt)

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Length (mm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>161</td>
<td>3.6</td>
</tr>
<tr>
<td>1450</td>
<td>89.1</td>
<td>3.6</td>
</tr>
</tbody>
</table>

RESULTS

Figure 4 to 9 show the E and H field and SAR simulations in human head model as an adult and \( \frac{1}{2} \) human head model as a child at 835MHz.
Fig 7. E-field strength in child head at 835MHz

Fig 8. H-field strength in child head at 835MHz

Fig 9. SAR in child head at 835MHz

Fig 10. E-field strength in adult head at 1900MHz

Fig 11. H-field strength in adult head at 1900MHz

Fig 12. SAR in adult head at 1900MHz

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To validate the results the simulations repeat for higher frequency i.e. 1900MHz. Figure 10 to 15 show the E and H and SAR simulations in human head model as an adult and \( \frac{1}{2} \) human head model as a child at 1900MHz.

**RESULTS**

Table 3. Comparison between absorption in adult and child head due to exposure to dipole antenna

<table>
<thead>
<tr>
<th></th>
<th>Adult 835MHz</th>
<th>Adult 1900MHz</th>
<th>Child 835MHz</th>
<th>Child 1900MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>22.8</td>
<td>85.7</td>
<td>23.7</td>
<td>95.4</td>
</tr>
<tr>
<td>E-field</td>
<td>159</td>
<td>325</td>
<td>156</td>
<td>339</td>
</tr>
<tr>
<td>H-field</td>
<td>3.89</td>
<td>5.57</td>
<td>3.92</td>
<td>6.16</td>
</tr>
</tbody>
</table>

All of the simulations have done to compare the EM absorption in human head of adult and children. The summery of the result has been shown in Table 3. As it can be seen all of the values for the adult and child both at 835 and 1900MHz show that in the same conditions, the absorption of E and H field strength and SAR in children’s head is larger than adults (about 2 times). So the children need more protection against the EM fields because their bodily tissues specially brain are growing. Also by the increasing in frequency the effects have been increased.

The other subject is real conditions. This model is a commercial model in standard but cannot show the good model of human head because the head includes many tissues with various \( \varepsilon \) and \( \sigma \). So the better model should design to better and accurate results.

**REFERENCES**


[9] International Standard IEC 62209-1, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices human models, Instrumentation, and procedures-Part1: procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz), IEC publication, 2005.

