Effect of Presence of Human Body on Antenna Gain

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Abstract

This paper focuses on the interaction between two types of antenna (Slot Coupled Patch Antenna and Probe Feed Patch Antenna) and human head model at 835MHz. Real experiments on human body and electromagnetic fields is not possible because of it the HFSS software has been used to simulate the head model and antenna as an exposure source. The simulation results (calculated in SAR and E field strength parameters) show that the electromagnetic fields can be absorbed in human tissues. Regular papers have been done in this way. In this paper it is shown that the human tissues can decrease the gain of antenna as an interaction.

Keywords: Antenna Gain, Biological Effects, HFSS Software, Human Head Model, Probe Feed Patch Antenna, Slot Coupled Patch Antenna

1. Introduction

Many researchers all of the world work on EMFs (Electromagnetic Fields) and their applications¹². The effects are various and divide into thermal and nonthermal and also these effects depend on many parameters such as exposure source, geometry of human tissues, frequency of fields and etc. Human tissues have electrical properties³ and because of it the electromagnetic fields can interact with them in three forms: absorption, reflection or transmission. The various mechanisms have been introduced for these interactions by many researchers. If electromagnetic passes from human tissue, it can be converted to heat and damage the body because the temperature has been rise⁴,⁵.

2. High Frequency Electromagnetic Fields

Human body has various tissues with various dielectric properties. Also the electrical properties on different frequencies have different values, so the biological effects on various frequencies are different⁶. The mechanisms are heating and induce electric and magnetic currents. Eye damage is including cornea injury, cataract and retina, lens and iris effects⁷–¹⁰.

Skin damages are including (increase the temperature of the skin and burning, deep burns, heat exhaustion and heat stroke)¹¹.

Blood-Brain Barrier (BBB)¹²–¹⁴, RF Haring (effect on hearing)¹⁵, Behavioral effects including loss, sleep disorders and insomnia, decrease in REM sleep, slowed motor skills and reaction time in school children, impaired nervous system activity, loss of concentration and “fuzzy thinking”, spatial disorientation, change in the brain’s electrical activity¹⁴–¹⁶, decreased immune function, increased heart rate, increased blood pressure, DNA damage (genetic damage) and changes in DNA repair capacity, cell proliferation and cancer¹⁴,¹⁷–¹⁹.

3. Discussion

The human head model and antenna in the commercial systems are modeled. Usually the phantoms are human
Body shaped shells with low $\varepsilon$ and losses. The materials with the same human body characteristic (the same $\varepsilon$, $\sigma$, $\mu$) have been placed in the phantoms and situated near the antenna as an exposure source. Then the SAR and E-field strength values are calculated to show that if the exposure device is standard or not. (SAR is a unit for calculate the value of EM absorption in tissues. This parameter express in terms of (Watt/Kg)). The most important parameters in SAR calculations are field strength, frequency, exposure environment and etc2.

The experiment with human body is not possible because it is dangerous for human body so in the engineering fields the antenna and human body should simulate. In this article the HFSS software is used.

The human head as the most important part of body next to cell phone are modeled. Also the probe feed patch antenna, slot coupled patch antenna and dipole antenna as an exposure sources are simulated. All of the simulations are in 835MHz because it is a useable frequency in mobile telecommunication systems.

The human head model i.e. phantom that is including three layers (Skin, Skull, Brain) and a shell around them. All of these tissues have different electrical properties including permittivity and conductivity. Both of these properties are varying with frequency. The electrical characteristics of human head are in Table 1.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>$\varepsilon_r$</th>
<th>$\sigma$</th>
<th>Thickness of tissues (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skull</td>
<td>17.40</td>
<td>0.25</td>
<td>105.1</td>
</tr>
<tr>
<td>Skin</td>
<td>35.40</td>
<td>0.63</td>
<td>106.5</td>
</tr>
<tr>
<td>Brain</td>
<td>45.26</td>
<td>0.92</td>
<td>98.3</td>
</tr>
<tr>
<td>Shell</td>
<td>4.6</td>
<td>0</td>
<td>111.5</td>
</tr>
</tbody>
</table>

4. Simulations

In this part a three layer human head model according to Table 1 has been simulated that shown in Figure 1.

To complete the model, two antennas have been simulated; Probe feed patch antenna and slot coupled patch antenna that has been shown in Figure 2 and 3. All of the antenna structure characteristics are in reference 20 and 21.

All of the simulations have been done at 835MHz and by HFSS software.

5. Results

Because of dielectric properties of human tissues, it can be interact with electromagnetic fields. Due to it, in the first step the E-field strength has been calculated to show the level of absorption of EM field in human head model. In the commercial model the human head are situated
next to the antenna to test. In this section this model has
been simulated with two antennas. The results for SAR
and E-strength have been shown in Figures 4-13.

5.1 Slot Coupled Patch Antenna (Figures 4–8)

Figure 4. The E-field strength in brain layer.

Figure 5. The E-field strength in skull layer.

Figure 6. The E-field strength in skin layer.

Figure 7. The average SAR.

Figure 8. The local SAR.

5.2 Probe Feed Patch Antenna (Figures 9–13)

Figure 9. The E-field strength in brain layer.
Figure 10. The E-field strength in skull layer.

Figure 11. The E-field strength in skin layer

Figure 12. The average SAR.

5.3 Antenna Gain

When the word interaction is used, the action is done in both ways. While an antenna affect on tissues, the tissues affect antenna parameters. For example in this paper antenna gain has been evaluated for two types of antenna and the results have been shown in Figures 14-17.
5.3.2 Probe Feed Patch Antenna (Figures 16,17)

Figure 16. Antenna gain in presence of head.

Figure 17. Antenna gain without head.

6. Conclusion

In this paper the value of effect of EM has been simulated and described. The paper has been considered that human tissues are interacted with EM and their relationship is in both way, i.e. antenna and human head affects on each other. For example gain of antenna is changing with or without presence of head. The results show that the presence of head reduces the gain of antenna (both antenna).

SAR and E-strength field have been shown in presence of both antennas. The results show that maximum value (red color) for these models happen where the antenna is normal toward to the human model. (In the HFSS software the colors show the amplitude and strength of parameters).

Also there is some problem with these kinds of simulations in real conditions. In real condition the materials of human phantoms are in jell or liquid and it is not possible to simulate three layers easily, so more study have to done.

7. References

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