EVALUATION OF THE MOBILE PHONE ANTENNA ELECTROMAGNETIC FIELD THERMAL EFFECTS FOR THE NONHOMOGENEOUS CHILD MODEL BY USING COMPUTER SIMULATION

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Abstract

The thermal effects caused by exposure to the electromagnetic (EM) field emitted by the mobile phone antenna have been investigated in the presented paper. A novelty is to study matching of the mobile phone dipole antenna to the free space for the case of a non-homogenous child model with different hand positions and different distances (1mm, 10mm, 20mm) of the mobile phone (with and without hand) from the child's head model; Through computer modeling (using the Finite-Difference Time-Domain (FDTD) method) have been evaluated the EM field energy absorption power by the child model considering the hand influence (holding the mobile phone) and have been conducted a comparative analysis for hand free cases. Because the hand holding the phone absorbs most of the radiation energy emitted by the mobile phone antenna. Studied the dependence of SAR (specific absorption rate SAR-W/kg) on the conditions of matching of the mobile phone antenna with the free space. Developed recommendations for the correct use of a mobile phone to reduce the reactive field near the child head in order to reduce head SAR values. The results of the study are presented below.

1. INTRODUCTION AND PROBLEM FORMULATION

Technological progress has influenced into all areas of human life. Communications and other electrical devices are sources of radiofrequency (RF) and microwave (MW) electromagnetic (EM) radiation. The natural sources of EM field are the sun, stars and others. The human body and living organisms is adapted to the natural environment created by them. Sources of EM field are also electrical devices, the EM fields emitted by which cause "pollution" of this natural EM background. Therefore, it is very important to study the background generated by base stations and different types of EM emitters. It is also important to study the impact of the EM field on humans, living organisms in nature and the environment in various cases, which can significantly change the existing natural EM background. The influence of electromagnetic fields (EM) emitted by mobile phone antennas on human, has been studied for many years before and especially after widespread introduction and use of cellular communications technology. Since exposure to EMF increases with reduced distance between the emitting antennas and the user the efforts to minimize exposure while increasing the radiated power are one of the most important tasks to enable efficient communication systems that are at the same time complaint with international safety standard on human exposure to EM field [1]-[3].

SAR is used for evaluating the RF radiation characteristics of mobile phones to determine if they meet Federal Communications Commission (FCC) safety requirements [4]. Current safety standards, guidelines set maximum radiation levels based on the amount of energy absorbed by the human body emitted by cell phones during communication. There are concerns that exposure to EM fields emitted by cell phones can cause cancer and other potential health problems. In 2011, the World Health Organization [5] and the International Agency for Research on Cancer [6] reviewed several scientific studies and based on the results of the studies, they classified mobile phones as a possible human carcinogen, putting them in the same category as lead, gasoline engine exhaust and chloroform.

The energy absorption in the human head caused by the exposure of human to the EM field of a mobile phone antenna depends on many factors. The distance from the antenna, the power and frequency of the radiated source, and the position of the hand are also very important [7]-[10]. In addition, the type of antenna, the shape and material of the mobile "case", the location of the phone, the anatomy of the human head and the dielectric properties of the tissue significantly affect the absorption of field energy.

Existing safety standards, which have not been updated in recent decades, determine the level of radiation for cases that pose a threat to human health. On the other hand, there may be some biological effects, but they are not considered dangerous for humans [11]. Harmful effects on children are very important. They are exposed to radio-frequency radiation from an early age. Main target for radiation is their brain, the skull is much thinner than adults are, and therefore the possible negative impact on children can be more serious [11].

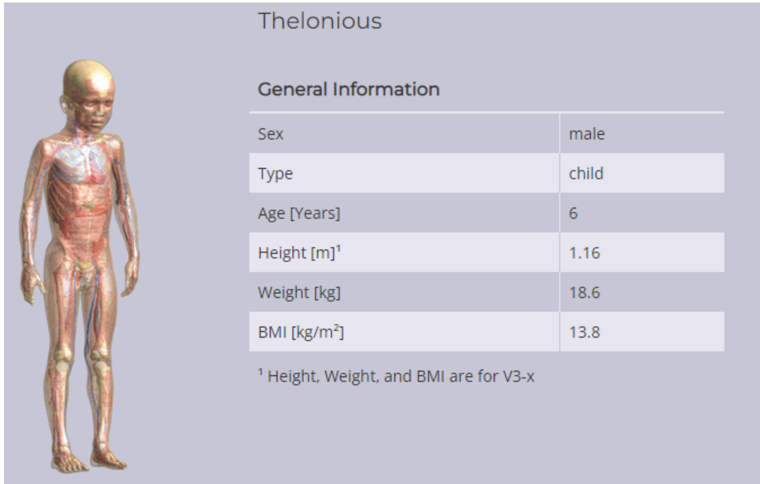
Mobile phone antennas are designed by mobile phone manufacturers so to have as low losses as possible and radiate most of the power delivered to the antenna. In this case, the antenna is well matched with free space. A quantitative characteristic is the S11 reflection coefficient, or S11 parameter. Relative positions of the user's head, hand and fingers influence on the values of the S11 parameter. Manufacturers do not consider this important factor in the process of manufacturing/testing mobile phones.

During mobile telephone communication, the antenna, the user's hand and head are mainly involved in the formation of radiation. A reactive EM field is often created near the human head. Therefore, the aim of the presented research is to study in detail how different hand configuration and different distances between the child head and the phone affect the mobile phone antenna parameter value (S11 coefficient).

The goal of the study is to determine the correlation between the matching parameter of the phone antenna (S11) and the EM field energy (SAR) absorbed by human tissues for 2100 MHz frequency, considering that smartphones automatically increase the radiation power to achieve a reliable connection in case of weak signal to the base station.

2. MATERIALS AND METHOD

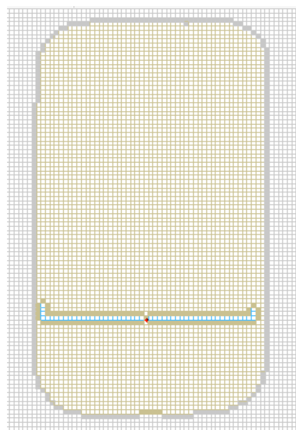
Research was conducted through computer modeling. The numerical simulations were carried out using the FDTDLab software package developed at TSU [7]-[10]. The FDTDLab program is based on the Finite-Difference Time-Domain (FDTD) method, which is a discretization of Maxwell's equations. A discrete grid, each cell of which is 1mm, is considered for the calculation area. A three-dimensional inhomogeneous discrete model of the child (Thelonious) from the "virtual population" (IT‛‛IS Foundation) [12] with 1mm discretization was used for numerical calculations Figure 1, Figure 2.



Sex	male
Type	child
Age [Years]	6
Height [m][1]	1.16
Weight [kg]	18.6
BMI [kg/m²]	13.8

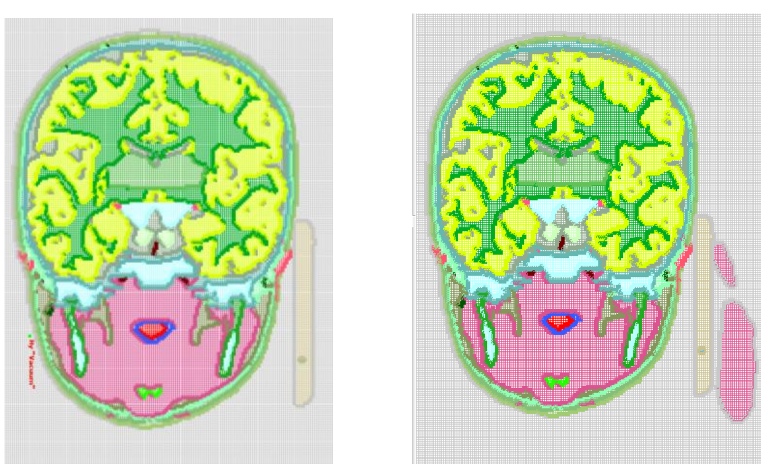
[1] Height, Weight, and BMI are for V3-x

a)



b)

Figure 1. a) Physical data of the child model ([Thelonious]()). b) Mobile phone discrete model with dipole antenna.



a)   b)

Figure 2. Child discrete head models with the mobile phone: a) without hand, b) with hand.

Frequency-dependent tissue parameters were used from the known database [13], a sinusoidal waveform of 2100 MHz frequency will be used for simulations.

The dipole length for the selected frequency (2100 MHz) was selected so the S11 coefficient to be the lowest as possible. In this case, the best antenna matching to open space was obtained. The length of the dipole antenna was 0.52 mm.

One hand position was prepared for the child's model (because the child's hand is approximately the size of a mobile phone). The mobile phone and the hand were placed at distances of 1mm, 10mm and 20mm from the child head model.

3. RESULTS AND DISCUSSIONS

On Figure 3 it is shown frequency characteristics for a considered mobile phone dipole antenna for the selected frequency.

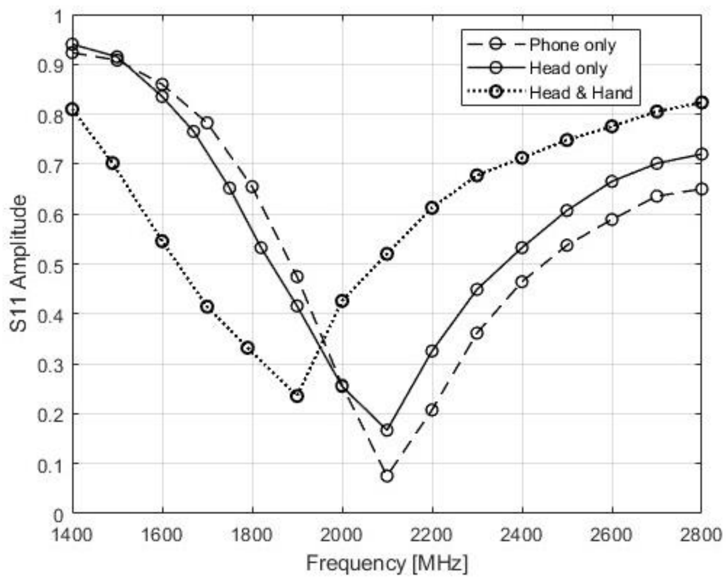
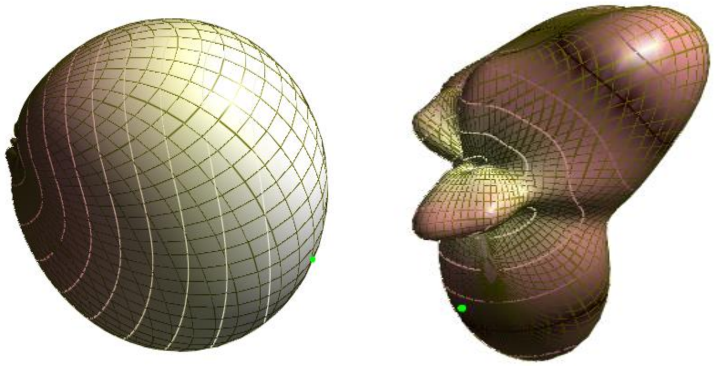


Figure 3. Mobile phone dipole antenna frequency characteristics.

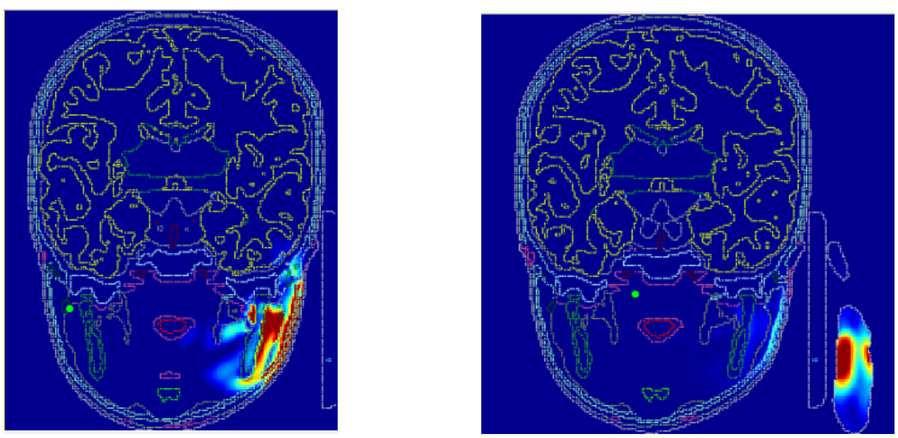
As the numerical experiments show, the values of the S11 coefficient increase due to the influence of the hand. In some cases, the head, hand reduce the S11 coefficient, this means that the antenna is well matched to the free space, not at the considered frequency, but at shifted frequencies. It also depends on the modeling scenarios.



a) b)

Figure 4. 3D radiation patterns for the mobile antenna at 2100 MHz: a) head model only, b) head with hand

Three-dimensional radiation patterns of a mobile phone antenna without head and with hand are shown in Figure 4. The obtained results show that when the presence of hand and head is considered, the radiation pattern and re-radiation power in the far zone are changed;



a) b)

Figure 5. SAR distribution inside the child head-hand models at 2100 MHz: a) head without hand, b) head and hand

Peak SAR location is observed inside the hand when the antenna is covered by the hand. Child hand absorbs a big part of the EM field energy and therefore, SAR peak values in the head tissues are reduced. It can be well seen from Figure 5.

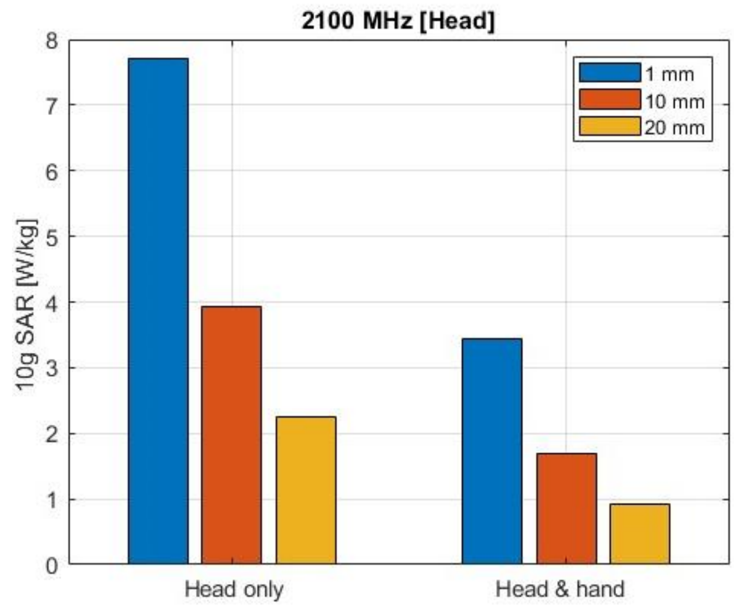


Figure 6. 10g SAR peak values for the child head model at 2100 MHz frequency.

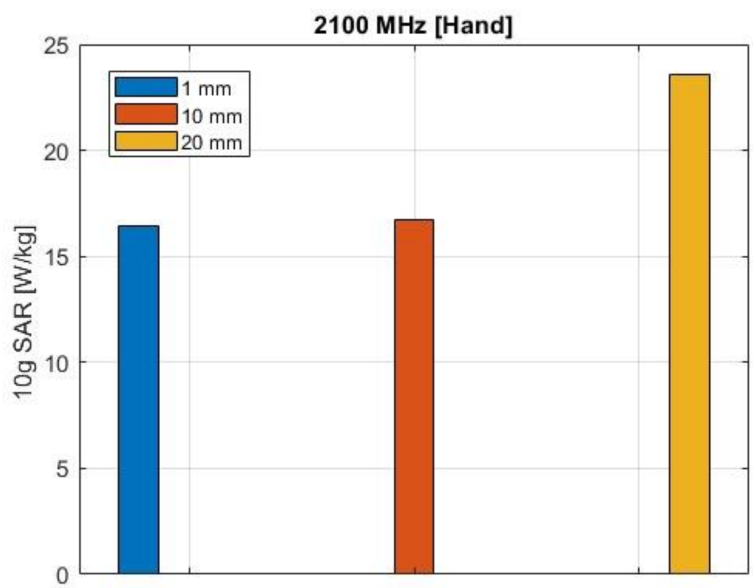


Figure 7. 10g SAR peak values for the child hand model at 2100 MHz frequency.

Due to the inverse dependence of the EM field on the square of the distance, the 10g SAR values are also inversely proportional to the distance between the mobile phone and child head. The 10g SAR value decreases when the distance between the child head model and the mobile phone is big. The peak SAR values in head tissues are reduced when the presence of the hand is taken into account (Figure 6 and Figure 7).

On Figure 8, dependence of SAR peak values on the matching conditions (S11 coefficient) is presented. SAR values are normalized to the value of the phone's EM field in free space. The first point on each graph corresponds to the value of SAR on the head without the hand, the second with the hand.

From the obtained results we can assume that bad matching is the reason for the increasing in peak SAR values in the child head and hand models. The hand, which holds the communication device, absorbs part of the radiated energy; therefore, to restore a good connection with the base station the total radiated power of the mobile phone increases. As a result, we obtain increased peak SAR values in the child head model.

4. CONCLUSION

The influence of a child's hand holding a mobile phone on the process of EM exposure was investigated in this paper. The research results showed that the presence of a hand changed the peak SAR values in the child's head model. The SAR values in the head model including the hand are lower than without the hand. Also, resultant SAR values reduce by increasing distance from the EM source to the child head.

It is clear that the selection of a model parameters affects the obtained results. The hand with which we hold the communication device absorbs part of the radiated energy; therefore, to establish a good connection with the base station, as already mentioned, the total radiated power of the mobile phone increases. As a result, the SAR peak increased values in the child head model are obtained.

It should be noted that the technological progress of communication devices is very fast, which makes it difficult to make general conclusions. For this reason, these problems are still relevant today and require further research.

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