HAND INFLUENCE ON THE MOBILE PHONE ANTENNAS' MATCHING TO THE FREE SPACE

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Abstract

The goal of the research is to study the thermal effects caused by the electromagnetic (EM) field emitted by the mobile phone antenna. A novelty of the study is the Hand Influence consideration on the Mobile Phone Antennas' matching to the free space.

Inhomogeneous human model with different positions of the hand (fingers) and at different distances (1 mm, 10 mm, 20 mm) from the human head to the headset are studied;

The mobile phone antenna matching study to free space was carried out using the Finite-Difference Time-Domain (FDTD) method.

3700 [MHz] standard communication frequency was selected for numerical simulations.

1. INTRODUCTION

Mobile phones have recently become an integral part of our lives. Naturally, interest arose in their impact on human health. Electromagnetic fields (EMF) emitted from mobile phone antennas interact with the human head and other parts of the body, which in some cases can affect human health. Exposure to these electromagnetic fields is inversely proportional to the distance between the head and the mobile phone. But during communication, in most cases, the mobile phone antenna is in close proximity to the sensitive tissues of the human head. Therefore, the study of possible side effects associated with it is very relevant and important today.

As it is known, the energy absorption of EMF in tissues is characterized by the SAR coefficient (specific absorption coefficient [W / kg]), which is determined by the power absorbed by the unit of mass of the tissue. SAR is the only safety criterion for assessing the effects of this radiation on humans. Its thresholds are set by the Federal Communications Commission (FCC) in the USA and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in Europe [1]. Existing studies have shown that the interaction between an EM field and a biological object depends on the characteristics of the emitter [2]: its frequency, its location, and its orientation toward the object; On the shape of the emitted wave and the amplitude value of the EM field; As well as the ability of the biological body to absorb and accumulate energy [3].

Many publications show that absorption of radiated energy (SAR) depends on mobile phones and antenna types [4-5], its positions, and radiated power from the mobile phones [6]. The radiation nature and EM fields behaviour depends on complex human body geometry [8], user's hand positions, other objects' existence around the user; where the user is located, in an enclosed or semi-enclosed space. But it's impossible to thoroughly quantitatively consider all these details.

Modern smartphones have AGC (Automatic Gain Control) and automatically increase the radiation power to establish a good connection in case the signal from the base station is weakened. The reactive field around the antenna increases. Because the reactive field area is larger than a cell phone with a hand, it covers all nearby objects with the ear, head, and hand. The result will be a large absorption at high reactive fields, which can be dangerous for humans' health [9].

The negative effects associated with these impacts are cumulative nature and may apear in the future. Of particular note are the harmful effects on children. They are exposed to RF radiation from an early age. The brain is the "main target organ" for this EM radiation. The nervous system of children and the brain are still unformed, the tissue composition is relatively different (contains a relatively large amount of water, which has a permeability, the children's skull is much thinner, more permeable to this radiation than adults and therefore the negative impact in children can be more serious [8].

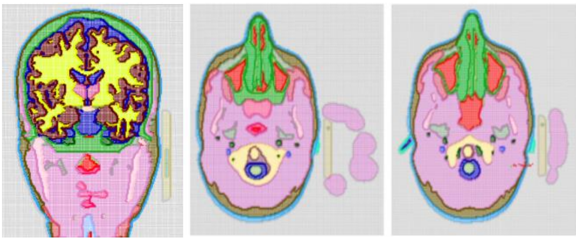
The goal of the proposed research is to investigate: how the hand and fingers different positions affects on the phone radiation parameter (S11 coefficient), which discribes antenna matching to the free space.

2. METHODOLOGY

Since, the real experiments on human is not permitted, we will investigate scheduled tasks, by means of computer modelling. The Finite-Difference Time-Domain (FDTD) method [6], [9] will be used for numerical simulations. FDTD is the most suitable numerical method for computational analysis of complex-shaped and inhomogeneous objects like the human body. It gives us ability to use realistic nonhomogeneous human model in our research. However, the disadvantage of FDTD method is that we can't estimate the calculation error. Numerical experiments will be carried out using the EM and thermal solver of the proprietary FDTD based program package "FDTDLab", developed at TSU (Laboratory of Applied Electrodynamics of the Tbilisi State University). The woman computer head model, named "Ella", a 3D model with 1 mm discretization from "Virtual Population" (IT'IS Foundation) will be used for EM exposure simulations. Different hand configurations in holding the mobile phone (with different types of antennas) will be created by us (for example, phone held by fingers and phone held and covered by the palm) [9]. The considered head model consists of 47 types of tissues with different dielectric properties. For simplicity, the hand model will be filled with muscle material.

Frequency-dependent tissue parameters will be used from the known database (https://itis.swiss/virtualpopulation/tissueproperties/database/database-summary/) A sinusoidal waveform of 3700 MHz frequency will be used for simulations.

For the human head model, two hand positions were prepared: When the mobile phone is held with fingers tip (**hand 1**), and when the mobile phone is held tightly with hand, touches the hand palm (**hand 2**), **Figure 1.**



a) b) c)

Figure 1. Woman discrete model: (a) without hand, (b) with hand position 1, (c) with hand position 2. at 3700 MHz

The mobile phone dimensions were (L × W × H) 5 × 0.8 × 9 [cm], with the dipole antenna embedded. The phone case permittivity was ε = 2.

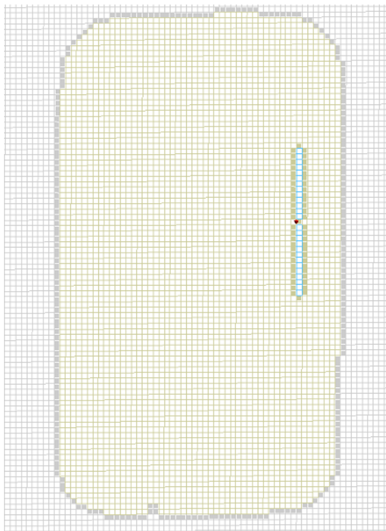


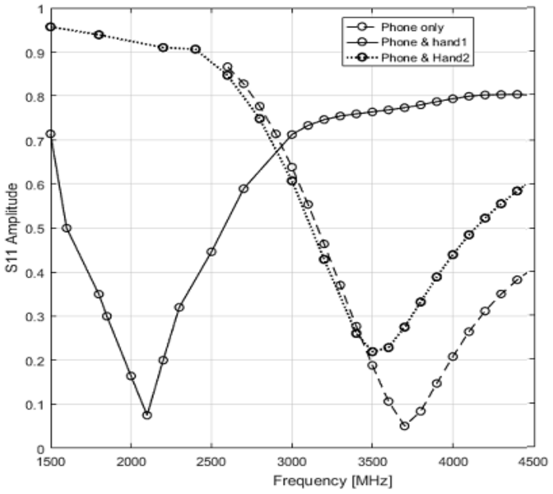
Figure 2. Mobile phone model with Dipole antenna.

The dipole length for the selected frequencies (3700 MHz) was selected so the S11 coefficient to be the lowest possible. In this case, the best antenna matching to open space was obtained. The length of the dipole antenna was 0.26 mm while the minimal S11 was 0.08 **Figure 2.**

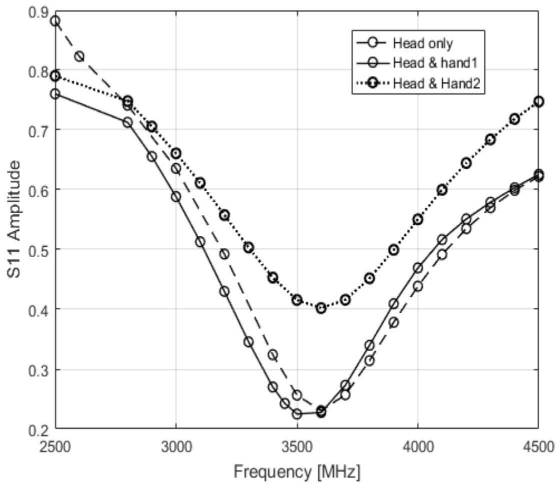
3. RESULTS OF NUMERICAL SIMULATIONS AND DISCUSSIONS

We studied frequency characteristics for a considered dipole antenna at the considered frequency, as it is shown in **Figure 3.**

In both cases of numerical experiments hand considerations increase the S11 coefficient. In some cases, the head, hand, or fingers different positions reduce the S11 coefficient (this means that the antenna is well matched but at the shifted frequencies).



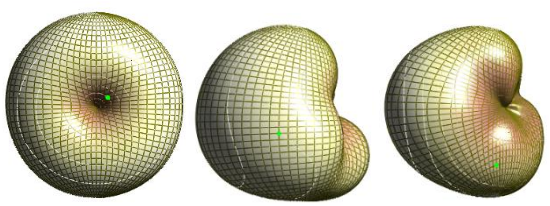
a)



b)

Figure 3. Dipole antenna frequency characteristics:
a) head without hand, b) head with hand 1, and hand 2.

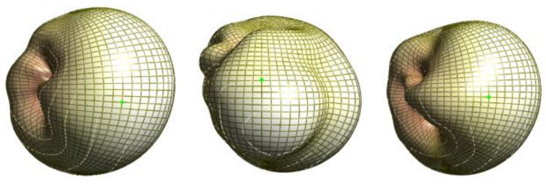
When mobile phone antenna is hold with a hand fingures (hand 1) bad matching is observed (with and without head consideration) compared to the case when the mobile phone is covered with a hand palm (hand 2) **Figure 3.**



a) b) c)

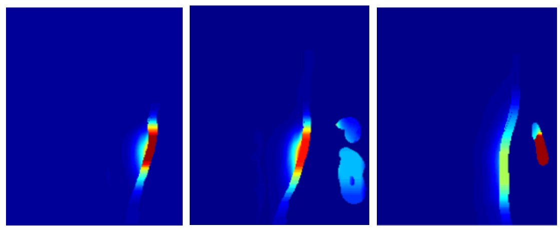
Figure 4. 3D radiation patterns for the mobile antenna without a head model at 3700 MHz:
a) only phone, b) phone+hand 1, c) phone+hand 2.

The 3D radiation patterns for the mobile antenna without a head and with different hand configurations are shown in **Figure 4, 5.** It is well seen that the radiation patterns for the fixed-gain depended on the modeling scenarios.



a) b) c)

Figure 5. 3D radiation patterns for the mobile antenna with a head model at 3700 MHz: a) phone+only head,
b) phone+head and hand 1, c) phone+head and hand 2



a) b) c)

Figure 6. SAR distribution inside the human head-hand models at 3700 MHz: a) head without a hand, b) head and hand 1, c) head and hand 2

Point SAR distribution inside the head-hand models is illustrated in **Figure 6.** When the hand is considered, peak SAR locations were observed inside the hand. Because hand absorbs a big part of the EMF energy and therefore, SAR peak values in the head tissues are reduced.

4. CONCLUSION

In the present study, we investigated the impact of hand and head on mobile phone antenna matching conditions. The obtained results showed that hand consideration changes the antenna matching to the free space significantly.

The results of the research will be of great importance to each of us, and it will have a potential impact on the relevant industry and the wider community.

Research is not complited. The problems raised in the proposed paper are most significant and need further researches.

5. ACKNOWLEDGMENTS

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