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RESULTS OF THE MEASURING AND SIMULATION OF THE ELECTROMAGNETIC FIELD OF MOBILE PHONES IN THE HUMAN HEAD REGION

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Abstract. *The rapid growth of the mobile phone industry has lead to increasing exposure to electromagnetic radiation which is emitted by mobile phones, so there is a logic question of the health risk to users of mobile phones. For that purpose, much of the research in this field has involved the applying of many measurements of electric field strength, magnetic field strength and the SAR (the specific absorption rate) and their comparison with the values which are formed by appropriate standards. Because of disability of measuring electric field strength, magnetic field strength and SAR inside of the involvement of the human body, many programs have been developed which can calculate the listed dimensions and show their distribution inside of the human body. For success calculation, it is necessary to construct an appropriate simulation model, set up appropriate frequency and area of the electromagnetic field. This paper gives the results of a simulation involving the head region – the inside and outside of a human head for three different types of mobile phones as well as the results of measurements made using instrument outside of the human head. The program which we used for the simulation was the HFSS 10.*

Key Words: *Electromagnetic radiation, Head model, Mobile phone model, Simulation*

1. INTRODUCTION

It is a well known fact that there are more than two billion users of mobile phones, so the world of today could not be imagined without the mobile phone industry. According to Nokia, five billion users will be connected by means of mobile phones at the end of 2015 using 4G LTE (Long Term Evolution) technology. During the time spent using mobile phone, the users are exposed to radiation. It is necessary to have the values of electric field strength, magnetic field strength and SAR values for the time spent using a mobile phone which can be compared with the values formed by standards and evaluate the possible risk for human health. The measuring of the aforementioned values around the hu-

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man body is not a problem, but the measuring inside the human body is. For that purpose, there are many simulation programs that can be used. They enable measuring the electric field strength, magnetic field strength, SAR and their distribution inside the human simulation model, using the finite model method as a mathematical algorithm for the calculation of the electromagnetic fields and their components. In this paper we have used the HFSS 10 program for simulation of electromagnetic fields [6].

2. THE RESEARCH

Based on the research which was done in Niš in 2008 and 2009 on a population of 500 mobile phone users from all social spheres, the following results for the model of mobile phones and users in Niš, the duration of one call, the duration of all the calls in one day and the number of mobile phones by user were noted and shown in the following tables [6]:

Table 1. Models of mobile phones and users in Niš

Manufacture	Nokia	Samsung	Motorola	SonyEricsson	Siemens	Panasonic	Rest
Number of users	318	72	63	25	11	9	2

Table 2. The duration of one call

Duration of one call	to 5 min.	to 10 min.	to 20 min.	to 45 min.	over 60 min.
Number of users	235	87	112	64	2

Table 3. The duration of all the calls in one day

Duration of all calls in one day	to 5 min.	to 10 min.	to 20 min.	to 30 min.	to 40 min.	to 50 min.	to 60 min.	over 60 min.
Number of users	37	109	147	89	56	27	12	23

Table 4. The number of mobile phones by user

Number of phones	one	two	three and more
Number of users	156	290	54

Based on the research results, the following models of mobile phones were chosen: Nokia 2600, Samsung SGH-E620, Motorola V3 and used for the measurement and simulation.

3. THE RESULTS OF THE MEASURING

The measuring of the electric field strength and magnetic field strength of the aforementioned models of mobile phones was done with the Spectran HF 6080, an instrument for measuring electromagnetic fields [1]. The measuring was done for the five-minute call, around the instrument at a distance of 2 mm-22 mm in steps of 5 mm, with an angle of 0°, 45°, 90°, 135° and 180° in a horizontal plane, with a frequency of 835MHz [6].

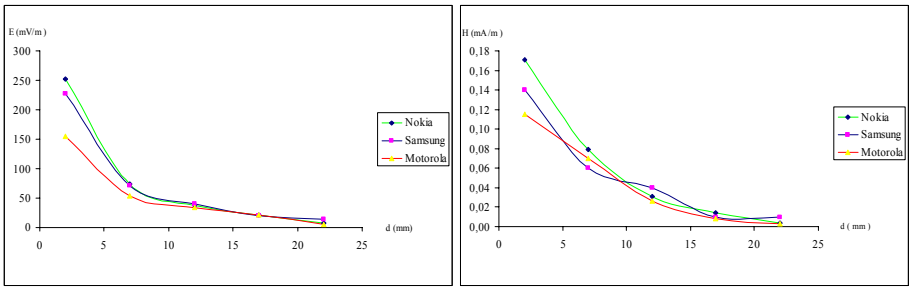

Fig. 1. Dependence of electric field strength (left) and magnetic field strength (right) on distance for all three models of mobile phones

4. THE SIMULATION MODEL

The simulation was done in the HFSS 10 program, an interactive software package for calculating the electromagnetic behavior of a structure. The software includes post-processing commands for analyzing this behavior in detail. Using the HFSS, the basic electromagnetic field quantities and, for open boundary problems, the near and far radiated fields, characteristic port impedances and propagation constants, the eigenmodes or resonances of a structure and many other parameters can be calculated. First, it is necessary to construct a simulation model of a human head, which is presented as a five-layer structure which consist of skin, fat, muscle, skull bones and brain. Every layer has its own electric, magnetic and conductive properties, and it is modeled based on an appropriate geometry model, so that the entire structure is presented as an ellipsoid model, whose dimensions are 19,08x18,2x20,8 cm^3. Also, eye and ear holes were modeled. The entire ellipsoid model was placed into an air box.

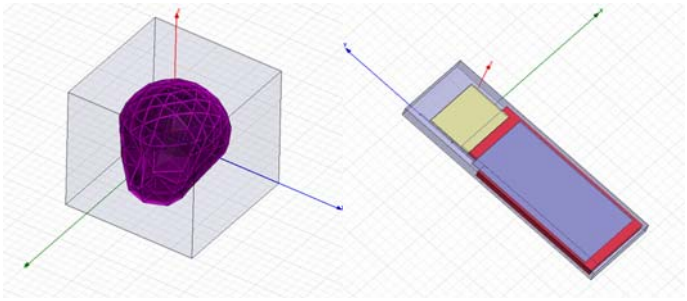

Fig. 2. Representation of a five-layer 3D structure (left) and the phone model (right) in HFSS 10

Then, it is necessary to construct the simulation model of the phone. Each phone is modeled according to the manual specification [8,9,10], where the antenna is modeled as a Hertz dipole. After that step, it is necessary to set up the solution properties as frequency (835 MHz), boundaries, calculation steps etc. Before the start of the simulation, it is preferable to validate the simulation, that is, check the parameters and conditions of the simulation. After that step, the simulation can start. Depending on the complexity of a structure and solution conditions, the simulation can last several hours [2].

5. THE RESULTS OF THE SIMULATION

The results of the simulation can be shown graphically and numerically and contain a wide group of values that can be presented: electric field strength, magnetic field strength, SAR (local and average), Poynting's vector, surface and volume loss densities.

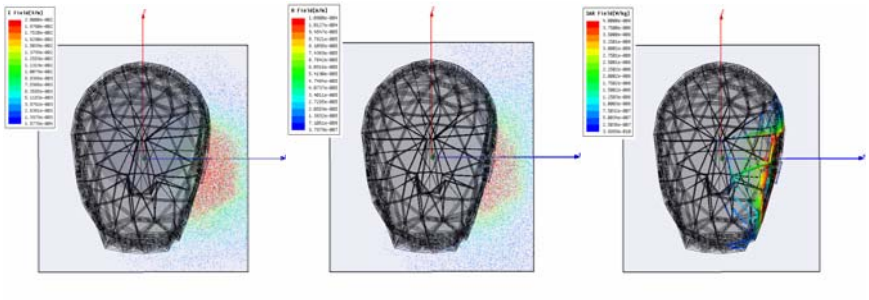

Fig. 3. The graphic representation of a simulation results for electric field strength (left), magnetic field strength (middle) and SAR (right)

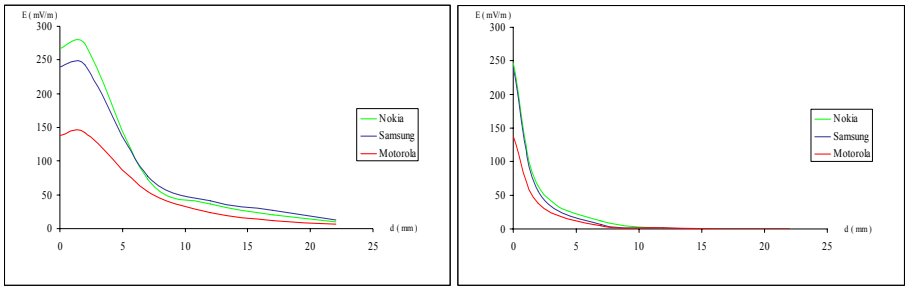

Fig. 4. The simulation results for electric field strength outside (left) and inside (right) the head model for all three models of mobile phones

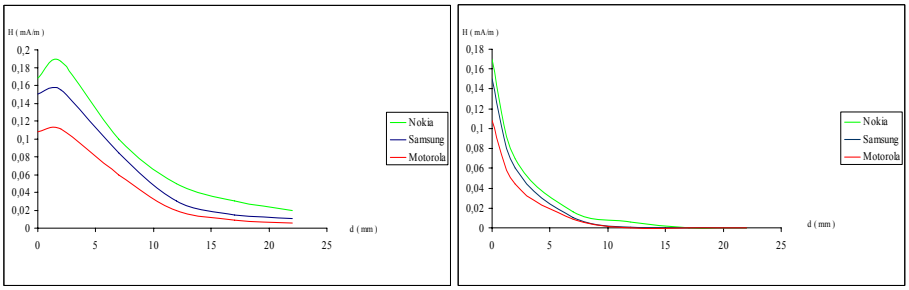

Fig. 5. The simulation results for magnetic field strength outside (left) and inside (right) the head model for all three models of mobile phones

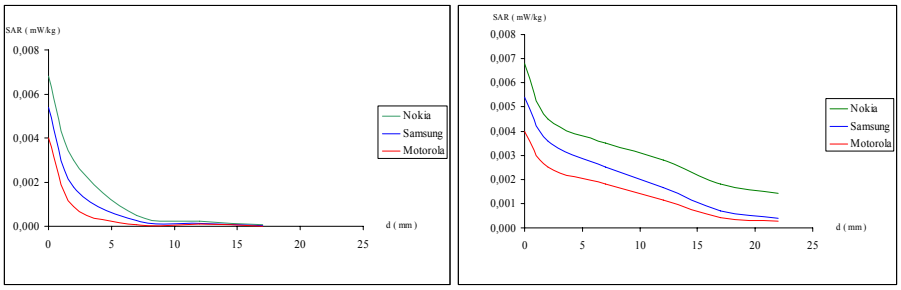

Fig. 6. The simulation results for SAR inside (left) the head model and at a different distance from head model (right) for all three models of mobile phones

6. The Comparative Presentation of Measuring and Simulation Results

Based on the presented data, it is possible to show a comparative presentation of the measuring and simulation results for electric field strength and magnetic field strength outside the head model. The measuring results are slightly different from the simulation results, but this was expected based on the different calculating terms. The measuring values are marked with different colors, with the letter M behind the phone's name, while the simulation values are marked only with the phone names, (Fig.7). Also, it is possible to compare the measuring and simulation results with the appropriate standards (CNRIP, JUS, IEEE).

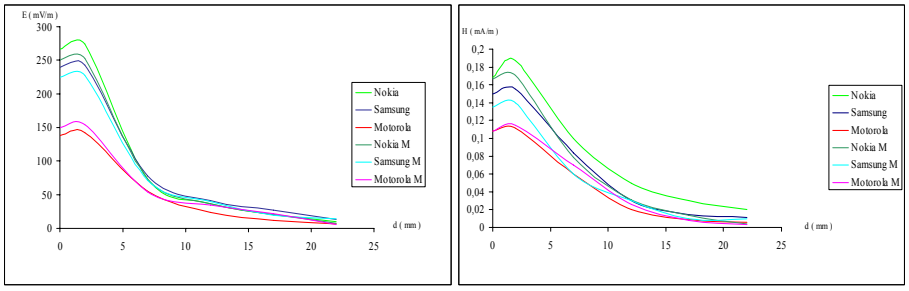

Fig. 7. The comparative presentation of the measuring and simulation results of electric field strength (left) and magnetic field strength (right) outside the head model for all three models of mobile phones

7. Conclusion

Comparing the measuring and simulation results with the results in similar projects and the results based on the available literature, it can be concluded that the results of the measuring and the simulations in this paper are in accordance with the results of the practical and simulation experiments. Also, it can be concluded that the results of the measuring and simulation are within the limits regulated by the appropriate standards [5,7],

which is of great importance for human health. The use of programs for the simulation of electromagnetic fields is a good, safe, relatively accurate and standard way for measuring electromagnetic field components and presenting their distribution through the volume of the analyze object (in this case the head), or through each of its layers individually.

REFERENCES

1. AAronia AG, *Spectran manual*, 2005.
2. Ansoft, *HFSS manual issue*, 2003.
3. Gandhi, O.P., Lazzi, G., Furse, C.M., *Electromagnetic absorption in the human head and neck for mobile telephones at 835 and 1900 MHz*, IEEE Trans. Microwave Theory Tech., 1996.
4. Hartsgrowe, G., Kraszewski, A., Surowiec, A., *Simulated Biological Materials for Electromagnetic Radiation Absorption Studies*, Bioelctromag.,vol 8, 1987.
5. *IEEE Standard for Safty Levels With Respect to Human Exposure to Raduo Frequency Electromagnetic Fields 3KHz to 300 GHz*, ASNSI/IEEE Standard C95.1, New York, 1999.
6. Jevtić, R. B., *Raspodela elektromagnetnog polja frekvencija mobilnih komunikacija u čoveku*, magistarska teza, 2009., unpublished.
7. *Jugoslovenski standard sa obaveznom primenom, Radio komunikacije, Radio frekvencijska zračenja. Maksimalni nivoi izlaganja koji se odnose na ljude*, JUS N.No.206, 1990.
8. Motorola, *Let's start Motorola V3 manual*, 2005.
9. Nokia, *Nokia 2600 manual*, 2007.
10. Samsung, Samsung SGH-E620 manual, 2006.

REZULTATI MERENJA I SIMULACIJE ELEKTROMAGNETNOG POLJA MOBILNIH TELEFONA U REGIONU LJUDSKE GLAVE

Radoje Jevtić, Jovan Ničković

Sve veća upotreba mobilnih telefona dovodi do povećanog izlaganja elektromagnetnom zračenju koje mobilni telefoni emituju, pa se logično postavlja pitanje rizika po zdravlje korisnika mobilnih telefona. Za tu svrhu, vrše se mnoga merenja jačine električnog polja, jačine magnetnog polja i SAR-a (specifična stopa apsorpcije) i upoređivanje pomenutih veličina sa vrednostima koje su propisane odgovarajućim standardima. Zbog nemogućnosti merenja jačine električnog polja, jačine magnetnog polja i SAR-a unutar ljudskog tela, razvijeni su mnogi programi koji mogu proračunati pomenute veličine i prikazati njihovu raspodelu unutar ljudskog tela. Za uspešan proračun neophodno je konstruisati odgovarajući simulacioni model, postaviti odgovarajuću frekvenciju i delokrug elektromagnetnog polja. Rad daje rezultate simulacije u regionu glave - unutar i van glave čoveka za tri različita tipa mobilnih telefona kao i rezultate merenja pomoću mernog instrumenta van glave. Program koji je korišćen za simulaciju je HFSS 10.

Ključne reči: *elektromagnetno zračenje, model glave, model mobilnog telefona, simulacija*