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JAČINA ELEKTRIČNOG POLJA I JAČINA MAGNETNOG POLJA MOBILNIH TELEFONA U PREDELU GLAVE

ELECTRIC FIELD STRENGHT AND MAGNETIC FIELD STRENGHT OF MOBILE PHONES IN THE HUMAN HEAD REGION

Radoje Jevtić, Jovan Ničković, *Elektrotehnička škola "Nikola Tesla", Niš*

Sadržaj - *Povećano izlaganje elektromagnetnom zračenju emitovanom od strane mobilnih telefona predstavlja predmet mnogo različitih istraživanja u proteklih nekoliko godina, pa se postavlja logično pitanje rizika po zdravlje korisnika mobilnih telefona. Iz tog razloga, neophodno je izmeriti jačinu električnog polja i jačinu magnetnog polja I uporediti dobijene vrednosti sa vrednostima koje su propisane odgovarajućim standardima. Zbog nemogućnosti merenja jačine električnog polja i jačine magnetnog polja unutar ljudskog tela, razvijeni su mnogi programi koji mogu izračunati pomenute veličine i prikazati njihovu raspodelu unutar ljudskog tela. Ovaj rad prikazuje rezultate za jačinu električnog polja i jačinu magnetnog polja za deset različitih tipova mobilnih telefona dobijene pomoću odgovarajućeg mernog instrumenta i rezultate simulacije u programu HFSS 10 dobijene na petoslojnom simulacionom modelu ljudske glave originalno razvijenom od strane autora kao i njihovo upoređivanje.*

Ključne Reči: Elektromagnetno zračenje, Model glave, Mobilni telefoni, Simulacija

Abstract - *The increaseing exposure of electromagnetic radiation which is emited by mobile phones presents the object of many different exploriatoons in the past several years, so there is a logic question of healthy risk to the users of mobile phones. For that reason, it is necessary to measure the electric field strength and magnetic field strength and to compare measured values with the values which are formed by appropriate standards. Becouse of the disability of measuring electric field strenght and magnetic field strength inside of the human body, many different programs which can calculate listed dimensions and show their distribution inside of the human body are developed. This work gives the results applied on ten different mobile phones of electric field strenght and magnetic field strength which are attained by appropriate measure instrument and the results of simulation in program HFSS 10 on five layer structure simulation model of human head originally developed by authors, and comparing each other.*

Key Words: Electromagnetic radiation, Human head model, Mobile phones , Simulation

1. INTRODUCTION

Many different science sources are climing that there are more than two billions users of mobile phones, so that the present world could not be imagined without mobile telephony. According to the Nokia corporation, five billions of users will be conected with mobile phones at the end of 2015 using new 4G LTE (Long Term Evolution) technology. The dimensions of mobile phones at present are smaller, but functions and possibilities of mobile phones are greater then at past several years. The mobile phone became a multirole complex device, capable to make much easier now present work and life. Many mobile operaters are providing a great number of services such as low cost, net telephoning, post paid, pre paid and similar, that grows the using of mobile phones. By the time for using the mobile phone, users are exposed to electromagnetic radiation in dependance of durration of call, location and frequency. Becouse of that reason, it is neccesary to have values of electric field strength and magnetic field strength for the time using the mobile phones which can be compared with values formed by standards and valuate the possible risk on human`s health. The measuring of named values around the human body is not a problem and with the proper measure instrument it can be realized , but the measuring inside the human body is. For that purpose, there are many simulation programs that were developed and that can be used. They enable simulation of electric field strength and magnetic field strenght and their distribution inside the human simulation model, using the finite model method as mathematical algoritm for the calculation of electromagnetic field and their components. The results of the simulation and the results of measurement can be comperd according to the valid standards and according to each other. This work have used the HFSS 10, program for simulation of electromagnetic field in the different multilayer structures.

2. THE RESEARCH

According to the research which was done in Niš in 2009. on population of 2000 mobile phone users from all society spheres, which includes profesors, doctors, pupils, students, workers, police officers and many other mobile phone users at the age of 15 to 70, the next results for model of mobile phones and users in Niš, the duration of one call, the duration of all calls in one day and the number of sent messages were discovered and shown in the next figures. Data about the duration of one call, the duration of all calls in one day and the number of sent messages were processed according to the realized traffic. The mobile phones chosen for measuring were Nokia 2600, Nokia 6151, Samsung SGH E-620, Samsung D520, Siemens C45, Siemens M55, Motorola V3, Motorola W218, Sony Ericsson W660i and Sony Ericsson W610i.

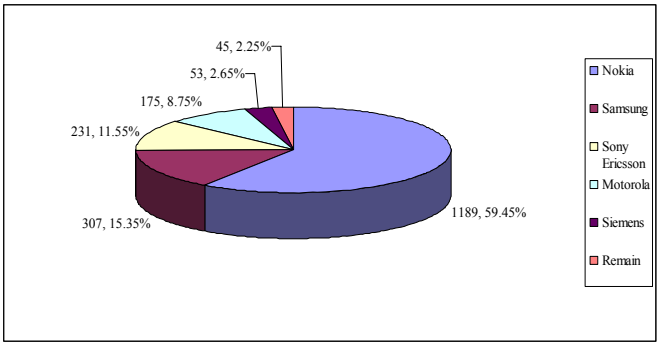


Figure 1. Models of mobile phones and users in Niš

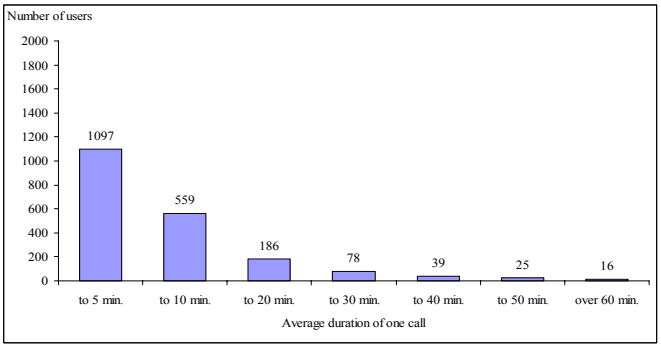


Figure 2. The average duration of one call

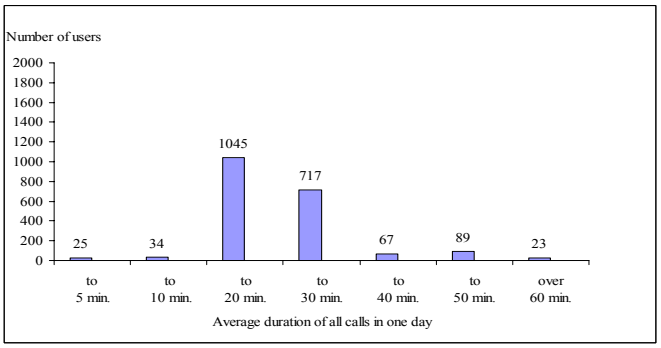


Figure 3. The duration of all calls in one day

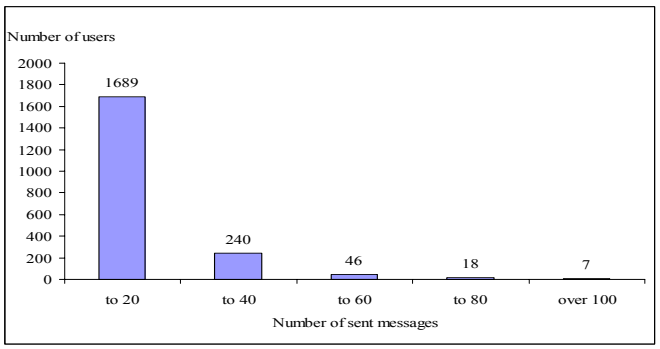


Figure 4. The number of sent messages

3. THE RESULTS OF MEASURING

The measuring of electric field strength and magnetic field strenght of named models of mobile phones was done with Spectran HF 6080, the instrument designed for measuring of high frequency electromagnetic field. The measuring was done for the time of the call duration of 5 minutes, from the top of the measuring instrument`s antenna in the distance of 2 mm-22 mm and in steps of 5 mm, in horizontal plane, along by the axis of the antenna of measuring instrument. The front panel of the phone was turned to the top of the antenna of the measuring instrument, according to the manual [1]. The measuring was done in laboratory and laboratory conditions – temperature, pressure and humidity. The measuring frequency was 900 MHz and it was stipulated by the instrument. The conversation was simulated by two music players near the phones. The results of measuring are shown in the next figures.

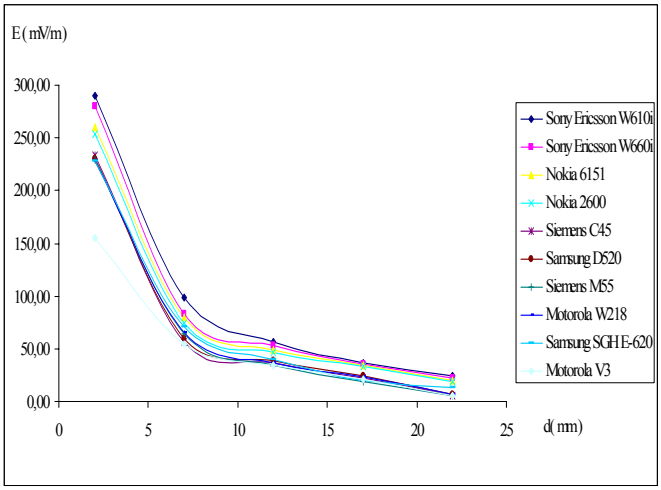


Figure 5. Dependence of electric field strength from distance for all ten models of mobile phones as a result of measuring

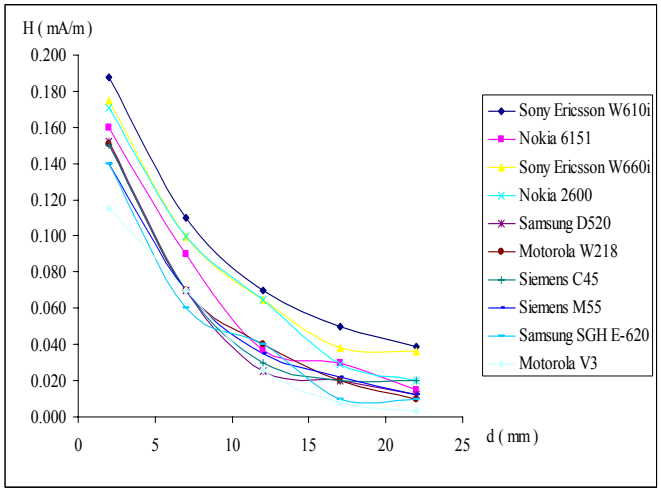


Figure 6. Dependence of magnetic field strength from distance for all ten models of mobile phones as a result of measuring

4. THE SIMULATION AND SIMULATION MODEL

The simulation was done in HFSS 10, an interactive software package for calculating the electromagnetic behavior of a multilayer structures. The software includes post-processing commands for analyzing this behavior in detail. Using HFSS, basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields; characteristic port impedances and propagation constants; the eigenmodes or resonances of a structure and many other parameters can be computed. [2].

First, it is necessary to construct a simulation model of a human head, which is presented as five layer structure which consist of skin, fat, muscle, skull bones and brain [3]. Every layer has its own electric, magnetic and conductive properties, and it is modeld by appropriate real geometry human head model, so that hole structure is presented as elipsoid model, which dimensions are 19,08x18,2x20,8 cm^3. Skin, fat and muscle layers have its own thickness of 2mm, skull has thickness of 4mm and brain has average radius of 8,7 cm. Also, there were eyes and ear hole modeled; eye hole as a sphere which diameter is 25 mm and ear hole as cone which radius is 4mm and height 22mm. The hole ellipsoid model is placed into an air box. [4].

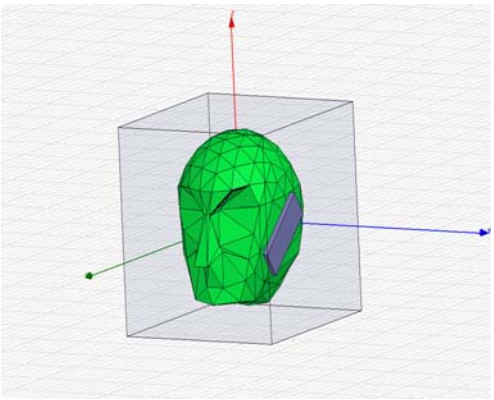


Figure 7. Five layer 3D simulation structure in HFSS 10

After that, it is necessary to construct the simulation model of the phones. Each phone is modeled according to the manual specification [5], [6], [7], [8], [9], [10], [11], [12], [13], [14] where the antennas were modeled as Hertz dipole. After that step, it is necessary to set up the solution properties as frequency, boundaries, calculation steps etc. Before the start of the simulation, it is preferable to validate the simulation, where the check of the parameters and conditions of the simulation are done. After that step, the simulation can start. Depending of complicacy of a structure and solution conditions, the simulation can last several hours . The results of the simulation can be shown graphicly and numericly.

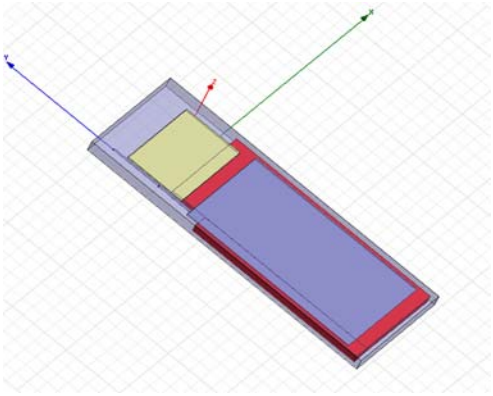
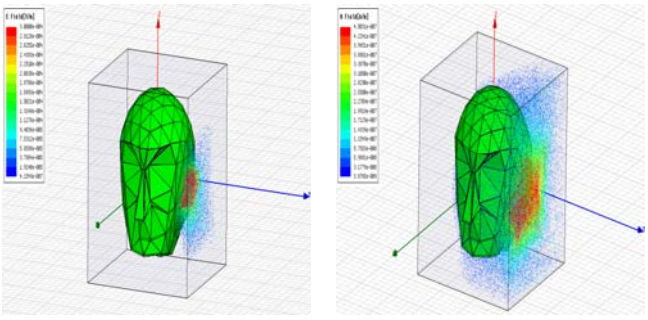


Figure 8. The example of modeled phone in HFSS 10

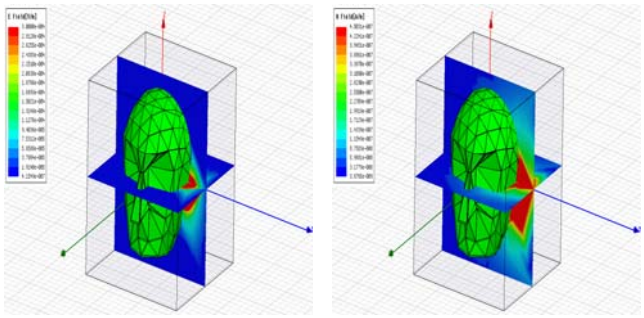
5. THE RESULTS OF THE SIMULATION

The results of the simulation were done for electric field strenght and magnetic field strenght outside and inside the head model becouse the measuring with the instrument inside the head was not possible.



a) **b)**

Figure 9. The graphic representation in volume of a simulation results for electric field strength (a) and magnetic field strenght (b)



a) **b)**

Figure 10. The graphic representation in XY and YZ planes of a simulation results for electric field strength (a) and magnetic field strenght (b)

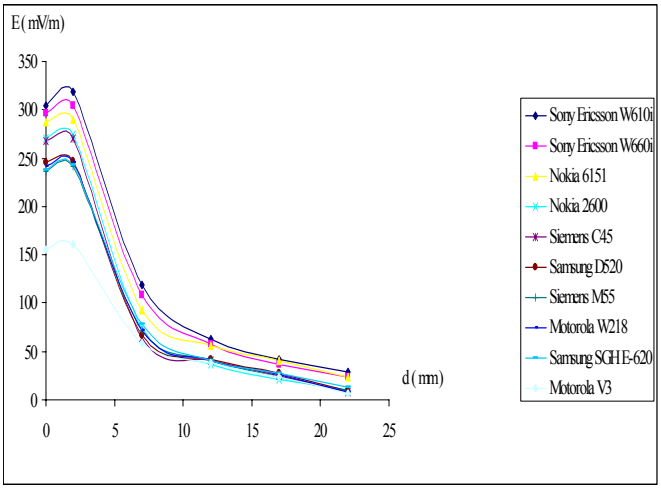


Figure 11. The simulation results for electric field strength outside of the head model for all ten models of mobile phones

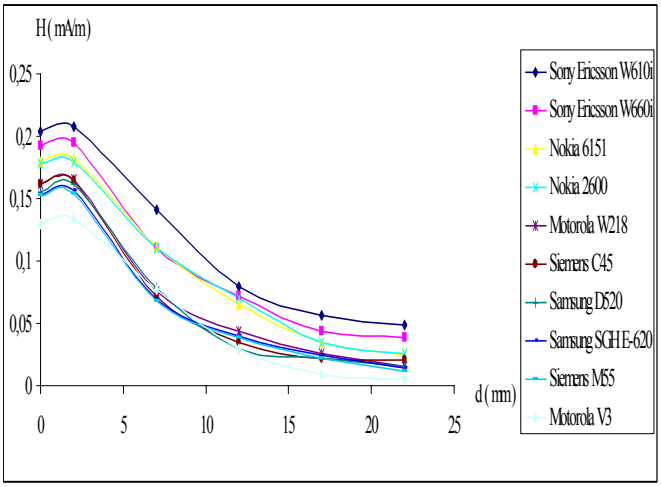


Figure 12. The simulation results for magnetic field strength outside of the head model for all ten models of mobile phones

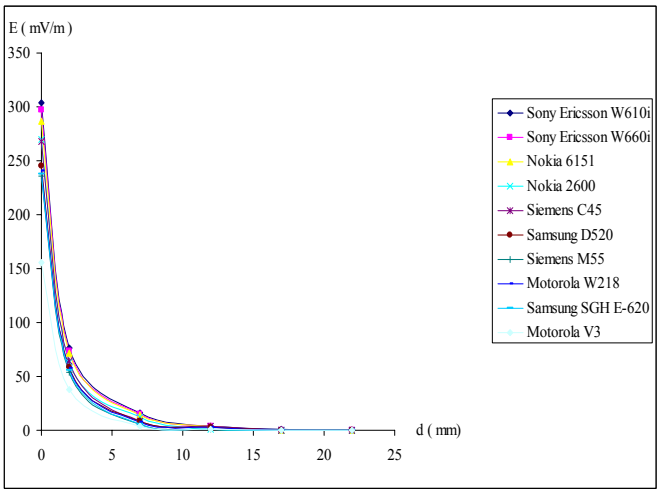


Figure 13. The simulation results for electric field strength inside of the head model for all ten models of mobile phones

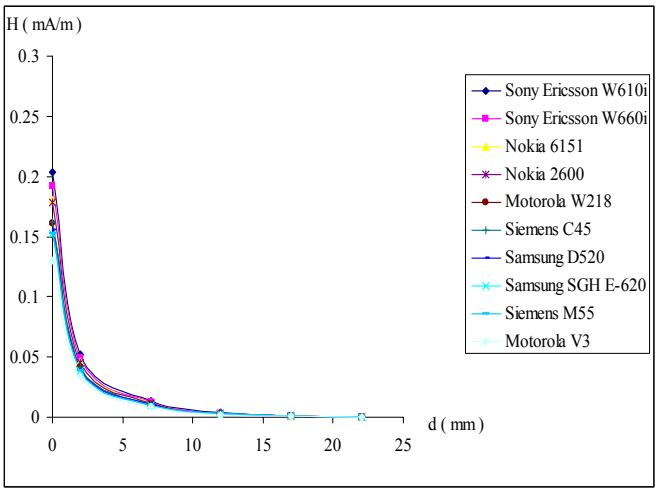


Figure 14. The simulation results for magnetic field strength inside of the head model for all ten models of mobile phones

6. THE COMPARATIVE ANALYSIS OF MEASURING AND SIMULATION RESULTS

According to all exposed, it can be concluded that the measuring results are slightly different from the simulation results, which can be seen in figures 5, 6, 11 and 12, which was expected according to the different calculating terms and tehnical difficulties and all of them are under the values that are regulared by appropriate standards, what can be seen comparing the results in named figures and values in table 1.

Also, it is possible to compare the measuring and simulation results with valid appropriate standards (ICNRIP, JUS,IEEE) [15]. The example of ICNIRP standard was shown in the next table.

Table 1. ICNRIP electric field strength and magnetic field strength proper values

f (MHz)	E (V/m)	H (A/m)
10-400	28	0.073
	61	0.160
400-2000	$1.375\sqrt{f}$	$0.0037\sqrt{f}$
	$3.000\sqrt{f}$	$0.0080\sqrt{f}$
2000-300000	61	0.160
	137	0.360

7. CONCLUSION

Comparing the measuring and simulation results with results in similar projects and resalts based on available literature [16], [17] it can be concluded that the results of measuring and simulations in this paper are in accordiance with the results of practical and simulation experiments. Also, it can be concluded that the results of measuring for the duration of 5 minutes and simulation are under the limits regulared by the appropriate standards what prove that the conversation by mobile phones should be short, precise and explicit. Of course, it is very important to mentione that the mobile phones radiation is the least where the reception of signal is the best, which indicates that mobile phones should be used outdoor as much as possible.

The using of programs for simulation of electromagnetic field in multilayer is a good, safe, relative accurate and regular way for measuring electromagnetic field components and presentation of their distribution through the volume of analyzed object (in this case the human head), or through each of its layers particulary.

This work can be a good base for a several problems of great importance that should be researched, such as electromagnetic field of mobile phones at frequency of 1800 MHz, thermal and nonthermal effects of mobile phones, the influence of mobile phones on brain and brain`s frequencies, using of mobile phones at basic and middle school children etc.

8. REFERENCES

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