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Influence of metallic spectacle frame on SAR in the head of a mobile phone user

***Abstract**. This paper describes an approach to investigate the influence of glasses on SAR (Specific Absorption Rate) value in two-layer human head model with mobile phone operating at dual band frequencies such as 900 and 1800 MHz. The applied antenna is dual-patch antenna without housing. The human head model is homogenous head with skin layer, stimulated with tissue equivalent material. The SAR of human head has been calculated. Further specific parameters related to SAR such as overall values, 1 gram and 10 gram are computed. The spectacle frame is varied and results are compared.*

Streszczenie.** W niniejszym artykule przedstawiono analizy interesującego aspektu SAR – wpływ okularów z całkowicie metalowymi oprawkami na wartość SAR w modelu dwuwarstwowym głowy użytkownika telefonu komórkowego. Skupiono się na zbadaniu wartości SAR od telefonu komórkowego z anteną dwupasmową pracującą na częstotliwościach sieci 900MHz i 1800MHz. Wykazano, że otoczenie, jakim są okulary zmieniają wartość absorbowanej energii w przedstawionym modelu głowy.(**Wpływ metalowych ramek okularów na wartość SAR w głowie użytkownika telefonu komórkowego)

Keywords: SAR, human head, mobile phone, spectacle frame, GSM900, GSM1800
Słowa kluczowe: SAR, głowa, telefon komórkowy, okulary, GSM900, GSM1800

Introduction

In recent years, the number of mobile phone users has been increased rapidly. Cellular phones came into wide use in our social life. Everyone using a mobile phone is subjected to the electromagnetic field (EMF). It is considered, that the part of the electromagnetic wave radiated from mobile phone is absorbed into the human body. Unlimited electromagnetic energy can cause a serious health problems, thus SAR has been proposed by standard organizations to set the limit values [1-2]. International Commission on Non-Ionizing Radiation Pattern (ICNIRP) specifies that the ratio limit should be at or below 2 W/kg, while American National Standard of Institute (ANSI) set the limit value to 1.6 W/kg over a volume of 1 g of tissue. Specific abortion rate (SAR) is the most significant variable quantifying EMF interaction with human body. SAR is a unit of measurement for the amount of RF energy absorbed by tissue when exposed to electromagnetic field. Equation value of SAR is described by formula below:

$$SAR = \frac{\sigma \times |E|^2}{\rho} \quad (1)$$

Where: σ - conductivity of tissue (S/m), E- root mean square (RMS) value of the electric field strength inside the tissue (V/m), ρ - density of the tissue (kg/m^3).

Assessments of the maximum local SAR are important, when the part of body is exposed to electromagnetic radiation, thereby the estimation of SAR distribution in human head during the use of a mobile phone has become important for users. The EMF influence on living organisms is also used for therapeutic effects, for instance hyperthermia [3]. The SAR distributions in a human head exposed on RF field from mobile phone have been studied by many researchers [4-5]. In his work [6], Trzaska years ago drew attention to the problem of the possible resonance phenomena in the case of using handheld TRx by users with eyeglasses. SAR variation versus the separation distance between the antenna and user head for a dual band (PIFA) antenna was analyzed in [7]. Comparison of SAR induced in a child-sized head and an adult head using a dual-band mobile phone was proposed in [8]. Wearing glasses during calling is very popular, just like incongruity spectacle frames. It leads to the change of SAR value in human head. SAR experiments with real human bodies are strictly restricted and hazardous; thereby it's worth to perform electromagnetic modeling, because it may provide similar result to real human bodies experiments.

In this paper a SAR study with human glasses has been performed using dual-band Planar Inverted-F antenna (PIFA) operating at 900 MHz and 1800 MHz. Appearance of absorption RF energy from mobile phone is observed especially in human head.. Presented the spectacle frame size influence to SAR value in human head depending on both bands.

Head and Antenna Model

Nowadays special software for 3D EM simulation is commonly used. CST Microwave Studio^{TM} is one of many commercial tools available on the market**.** It provides the possibility to import 3D CAD models, and also fast and accurate analysis of a high frequency devices, such as antennas, which are the key elements of physical layer of every wireless network. Traditionally used external antennas such as monopoles and helical antennas increase the size of the device, also external antennas are not easy to shield. In consequences it can radiate more power in the direction of the head. External miniaturized antenna, such as patch antenna is widely used in mobile applications, since it has more advantages than the traditional antennas [9].

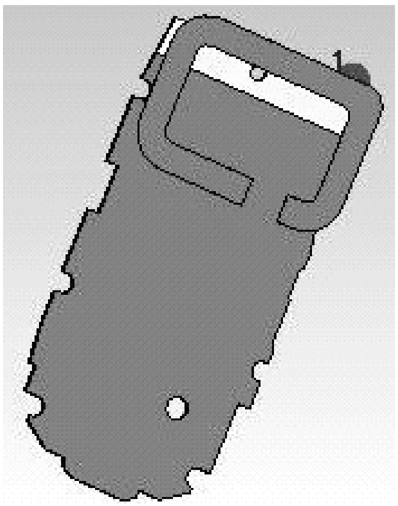


Figure 2. Planar Inverted-F antenna used in simulation

Currently, most of antennas used in mobile phones are the multi-band patch antenna, such as Planar Inverted-F Antenna (PIFA), widely used in portable devices, since it has a directional pattern, small size, low profile, built-in structure, hence it can be fitted in mobile phone housing. For presented analysis mobile phone (Fig. 2) and male human head model (Fig. 3) have been taken from CST MWS Studio examples. This homogenous, anthropomorphic SAM Phantom EN 50361 model consist of two layers – first is the skin and second is the interior of the head. Table 1 shows the parameters of the layers.

Table 1. Parameters of tissues

Human head	Relative permittivity	Conductance [S/m]	Density [kg/m^3]
Exterior (skin)	5	0,12	1000
Interior	42	0,99	1100

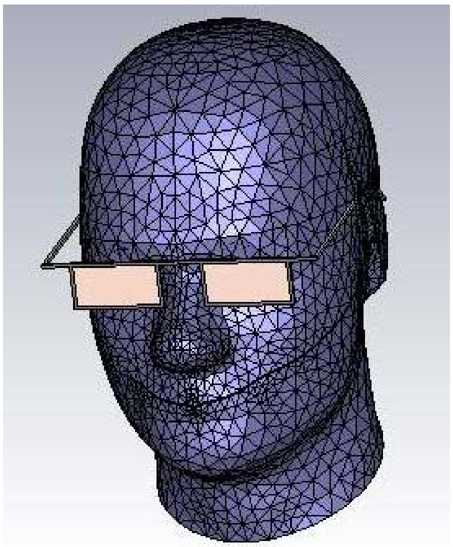


Figure 3. Homogenous head model with eyeglasses

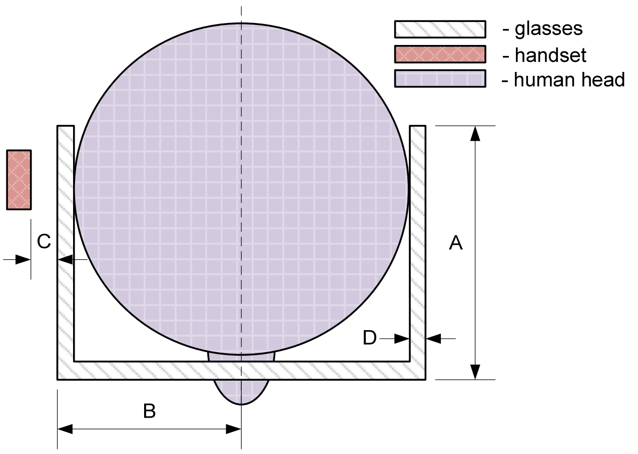


Figure 4. Spectacle frame in used model temples (A) and lenses(B)

Fig 4 shows the dimensions of the spectacle frame. Dimension B range is from 81 to 84 mm and dimension A range is from 106 mm to 115 mm. There are 40 different combinations in each simulation. For each step maximum SAR value has been calculated. While B is increasing dimension C is decreasing, it permits to have constant dimension between cell phone and human head model. Dimension D is the width of spectacle frame.

Analysis and results

The maximum and minimum SAR value in each 40 steps of human head model with and without the glasses is shown in Table 2**.** For both frequencies, the microwave peak power is set to 0,125 W.

Table 2. Maximum and minimum SAR values with and without glasses

Human head model	900 MHz				1800 MHz			
	SAR 10g		SAR 1G		SAR 10g		SAR 1g	
	Max	Min	Max	Min	Max	Min	Max	Min
Without glasses	0,57		0,85		0,79		1,24	
With glasses	0,97	0,78	1,42	1,17	1,33	1,16	2,12	1,9
SAR increase [%]	67,74	38,22	71,18	36,92	67,65	46,19	70,69	53,32

In presented model maximum SAR value in the human head depends on the glasses location on the human head model. Table 2 shows that the maximum SAR value can increase up to 71 % for 900 MHz with the spectacle frame comparing to the same model without glasses. Minimum increase of the SAR value with the glasses is 37 %. Figures 6-9 shows the SAR value for different variants of the simulation. Each of them shows, how SAR value averaged over 1 g or 10 g for both bands is changing depending on temples size and it's possible to observe the resonance. For 1800MHz band resonance appeared for temples length A=109 mm and at 900MHz for A=110mm

Table 3. Relative value between maximum and minimum value of SAR with the glasses.

		1800MHz 10G avg [%]	1800MHz, 1G avg [%]	900MHz, 10G avg [%]	900MHz, 1G avg [%]
B	81	9,08	11,08	17,52	16,33
	82	10,63	4,57	16,64	11,06
	83	10,70	7,39	16,26	11,39
	84	10,05	5,49	14,11	9,24

Table 3 shows the percentage change of the SAR value depended on frame dimension . Result show differences from 5 % to 17 % between maximum and minimum value of SAR .

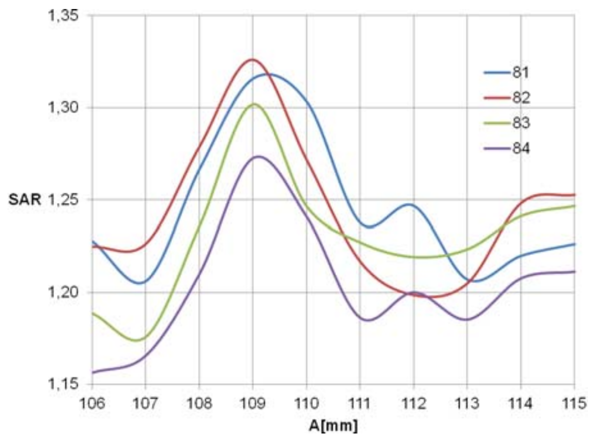
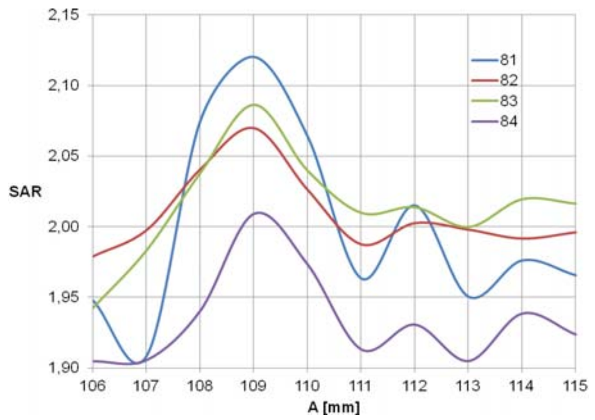


Figure 6. Maximum of SAR value for each B step as a function of temples length (1800MHz, 10G SAR averaged)



,Figure 7. Maximum of SAR value for each B step as a function of temples length (1800MHz, 1G SAR averaged)

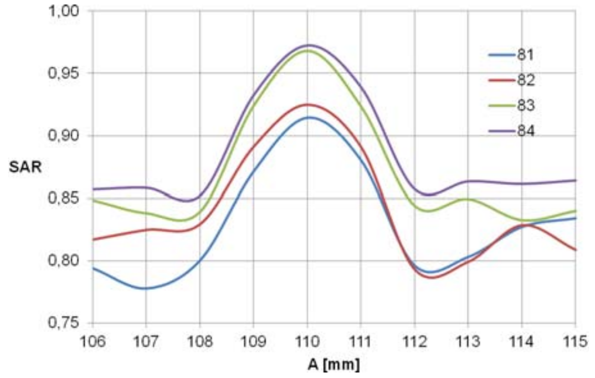


Figure 8. Maximum of SAR value for each B step as a function of temples length (900MHz, 10G SAR averaged) l tu.

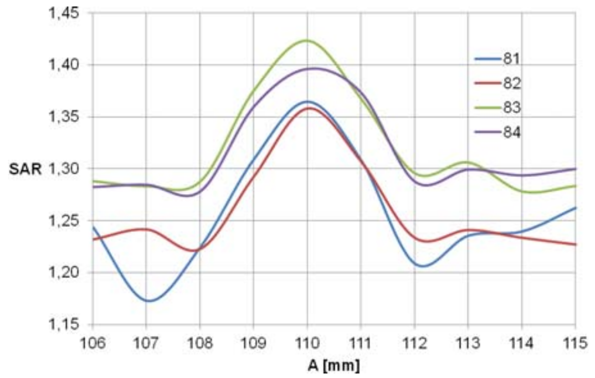


Figure 9. Maximum of SAR value for each B step as a function of temples length (900MHz, 1G SAR averaged)

Conclusion

A case study of metallic frame influence on the SAR value in human head model was presented. Result showed that the maximum SAR value in human head model depends on the spectacle frame shape and dimensions Spectacle frame can cause SAR increase up to 70% in relation to human head model without spectacle frame. It have been proved that the spectacle frame cause the resonance for two different temples dimensions, 109 mm for 1800MHz and 110 mm for 900MHz. SAR distributions have been calculated using FITD method by means CST Microwave Studio. Human model was exposed to the EMF radiated from dual-band antenna commonly used in mobile phones .

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