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SPECIFIC ABSORPTION RATE ANALYSIS USING METAL ATTACHMENT

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Key words: SAR, portable telephone, metal attachment, SAR reduction

Abstract: Specific absorption rate (SAR) reduction with metal attachment is analysed in this paper. The SAR reduction technique is discussed and the effects of attaching location, distance, and size of metal on the SAR reduction are investigated. The remarkable improvement has been achieved for SAR reduction of the initial SAR value for the case of 1 gm SAR. These results suggest a guideline to choose various types of metals with the maximum SAR reducing effect for a portable telephone.

Analiza parametra SAR pri uporabi kovinske zaščite

Kjučne besede: SAR, prenosni telefon, kovinski nastavek, zmanjšanje SAR

Izvleček: V članku analiziramo vpliv kovinskega nastavka na zmanjšanje vrednosti parametra SAR. Raziščemo vpliv položaja, velikosti in razdalje le-tega na zmanjšanje SAR. Še poseben napredek smo dosegli v primeru 1gm SAR. Rezultati nam služijo kot smernica pri izbiri različnih vrst kovinskih materialov, ki najbolj vplivajo na zmanjšanje SAR pri uporabi prenosnega telefona.

1. Introduction

Mobile phone safety and human exposure to electromagnetic (EM) radiation, as well as the pertinent health effects, constitutes a matter of raised public concern, and this issue has undergoing continuous scientific investigation. Various studies on this subject exist /1–3/, most of which mainly investigate into the consequences of mobile-phone usage. Yet, devices and communication terminals operating in other frequency bands have also gained substantial interest in the last 15 years. In /4/, a ferrite sheet was adopted as protection between the antenna and the human head. A reduction of over 13% for the spatial peak SAR over 1 gm averaging was achieved. A study on the effects of attaching a ferrite sheet for SAR reduction was presented in /5/, and it was concluded that the position of shielding plays an important role in the reduction effectiveness.

In /3/, for the SAR in the human head, an effective approach is the use of a planar antenna integrated onto the back side (away from the head) of a phone model, but it brings additional design difficulties especially in achieving the required frequency bandwidth and radiation efficiency. Another approach is the use of a directional or reflecting antenna /6-8/. Such an antenna structure sacrifices the availability of signals received from all directions to the phone model. The mechanism of SAR reduction by ferrite sheet attachment was due to the suppression of surface currents on the front side of phone model /9/. However, the relationship between the maximum SAR reducing effect and the parameters such as attaching location, size and material properties of ferrite sheet remains unknown.

In /10/ a perfect electric conductor (PEC) reflector was placed between a human head and the driver of a folded loop antenna. The result showed that the radiation efficiency can be enhanced and the peak SAR value can be reduced. In /11-12/, a study on the effects of attaching conductive materials to cellular phone for SAR reduction has been presented. It is shown that the position of the shielding material is an important factor for SAR reduction effectiveness. There is a necessity to make an effort for reducing the spatial peak SAR in the design stage of ferrite sheet because the possibility of a spatial peak SAR exceeding the recommended exposure limit cannot be completely ruled out.

2. Simulation model

The simulation model which includes the handset with PIFA type of antenna and the SAM phantom head provided by CST Microwave Studio® (CST MWS) is considered in the simulation model. A complete handset model composed of the circuit board, LCD display, keypad, battery, and housing was used for simulation. The relative permittivity and conductivity of individual components were set to comply with industrial standards. In addition, definitions in /3/, /6-7/ were adopted for material parameters involved in the SAM phantom head. In order to accurately characterize the performance over a broad frequency range, dispersive models for all the dielectrics were adopted during the simulation /6/. The electrical properties of materials used for simulation are listed in Table 1. A PIFA type antenna constructed in a helical sense operating at 900 MHz for GSM application was used in the simulation model. In order to obtain a high-quality geometry approximation for such a helical structure, a predictable meshing scheme used in the FDTD method usually requires large number of hexahedrons which in turn makes it extremely challenging to get convergent results within reasonable simulation time.

Table 1: Electrical properties of materials used for simulation

Phone Materials	ε_r	σ (S/m)
Circuit Board	4.4	0.05
Housing Plastic	2.5	0.005
LCD Display	3.0	0.02
Rubber	2.5	0.005
SAM Phantom Head		
Shell	3.7	0.0016
Liquid @ 900MHz	40	1.42

3. Numerical techniques

CST Microwave Studio with the finite integral time-domain technique (FITD), was used as the main simulation instrument. A non-uniform meshing scheme was adopted so that the major computation endeavor was dedicated to regions along the inhomogeneous boundaries for fast and perfect analysis. The minimum and maximum mesh sizes were 0.3 mm and 1.0 mm, respectively. A total of 2,097,152 mesh cells were generated for the complete model, and the simulation time was 1163 seconds (including mesh generation) for each run RAM on an Intel Core ™ 2 Duo E 8400 3.0 GHz CPU with 4 GB system.

The analysis workflow started from the design of the antenna with complete handset model in free space. The antenna was designed such that the $S11$ response was less than -10 dB over the frequency band of interest. The SAM phantom head was then included for SAR calculation using the standard definition as /4/

$$SAR = \frac{\sigma}{2\rho} E^2$$

where E is the induced electric field (V/m), ρ is the density of the tissue (kg/m^3), and σ is the conductivity of the tissue (S/m). The resultant SAR values averaged over 1 gm and 10 gm of tissue in the head were denoted as SAR 1 gm and SAR 10 gm, respectively. These values were used as a benchmark to appraise the effectiveness in peak SAR reduction.

Result and Discussion:

A metal sheet covering the human body is utilized to reducing the EM absorption in this section. A compact size of metal sheet is considered in this reasearch. A numerical calculation has been done for investigating the possibility of using a metal sheet with a small size to reduce the EM absorption. The metal sheet was modeled as an infinitely thin perfect conductor with the same sizes as the metal sheets. The efficiency ξ was still used to evaluate the effect on the reduction of EM absorption. The calculated results for efficiency ξ are shown in Table-1, Table-2, and Table-3 for Category-1, Category-2, and Category-3 respectively. Table-3, for Category-3, is the largest size among the three types and thus the largest reflection effect is expected. It should be noticed that the values of efficiency ξ are negative for both at 900 MHz and 1800 MHz. Especially, at 1800 MHz, the absorbed power is increased by 15.8%. Table-1 implies that a metal sheet with small size cannot reduce the SAR in the human head. For the Category-1, and Category-2, the efficiency is shown in the Table-1 and Table-2.

Table 1: Effect of metal sheet on sar reduction (Category-1: 3X4 cm metal size positioned in top of mobile phone)

ξ [%]		
	900 MHz	1800 MHz
Peak SAR gm for head	-4.8	-13.2
Peak SAR 1gm for brain	-5.3	-14.3
Average SAR for eyeball	-2.13	-0.62
Average SAR for head	-2.21	-6.9
P_{abs} by head	-2.21	-6.9

Table 2: Effect of metal sheet on sar reductioN (Category-2: 3X4 cm metal size positioned at the edge of mobile phone)

ξ [%]		
	900 MHz	1800 MHz
Peak SAR gm for head	-4.9	-13.4
Peak SAR 1gm for brain	-5.1	-14.9
Average SAR for eyeball	-3.34	-0.6
Average SAR for head	-2.71	-6.8
P_{abs} by head	-2.71	-6.8

This is due to the strong EM field that is induced in the neighbor of the edges of the metal sheet which is small compared to the head. The head is exposed to the strong EM field and thus absorbs more EM energy. However, for

Table 3: Effect of metal sheet on sar reduction (Category-3 : 6X4 cm metal size at the top of mobile phone)

ξ [%]		
	900 MHz	1800 MHz
Peak SAR gm for head	-8.7	-24.3
Peak SAR 1gm for brain	-10.2	-23.8
Average SAR for eyeball	-7.4	-0.98
Average SAR for head	-3.6	-15.8
P_{abs} by head	-3.6	-15.8

a metal sheet, no strong EM field is induced in its neighbor because of its ability to absorb EM energy and transform it into heat.

5. Conclusions

The EM interaction between an antenna and the human head with metal sheet has been discussed in this paper. Utilizing metal in the phone model a SAR value is reduced for 10 gm and for SAR 1 gm. Based on the 3-D FDTD method with lossy-Drude model, it is found that for the both cases peak SAR 1 gm and SAR 10 gm of the head can be reduced by placing metals between the antenna and the human head.

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