SAR Variation by EMI Paint Distribution on Front Case of Mobile Handsets

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Abstract

In this paper, we investigated methods to reduce SAR(Specific Absorption Rate) value with EMI(Electromagnetic Interference) paint distribution on front case of mobile handset. Simulations for several different EMI patterns were carried out. For the purpose of modeling, we used 3 dimensional CAD(Computer Aided Design) program, 'Pro-engineering'. SAR simulation was done with SEMCAD, simulation platform for electromagnetic compatibility antenna design and dosimetry. In order to distinguish the individual pieces and to enable an assignment of the different material properties, each subfile was imported separately. In simulation, folding angle was set to 142°. If we vary folding angle, different SAR value will be obtained. Among the tested EMI paint patterns, the hairpin pattern showed the best performance, i.e. the decrease efficiency of 16.5% and horizontal-direction zigzag pattern showed the decrease efficiency of 12.2% when we set the completely removed pattern as reference.

Key words: SAR(Specific Absorption Rate), EMI(Electromagnetic Interference), hairpin pattern.

1. INTRODUCTION

Mobile telephony has become one of the most successful and widely spread applications of radio communications. A majority of the population in many countries has a mobile phone, and the number of radio base stations is growing as operators strive to provide greater coverage and better quality of service. However, many people do not know exactly whether it is safe or not. Their main concerns regard the possible effects on health from radio waves that mobile handsets and base stations transmit in order to communicate with each other[1].

Possible health risk related parameter for mobile handsets is SAR(Specific Absorption Rate). Though there is no scientific evidence that there is a health hazard from radio frequency electromagnetic radiation, there have been increasing public concerns on this issue[2]. So the human exposure level to mobile handsets is strictly regulated as SAR value. SAR is defined as the rate at which radio frequency energy is absorbed by the human body when using a handset[3].

Usually, when we develop new mobile handset, we measure SAR value after all other electrical performances are passed, but not short additional period is required in most cases to meet SAR specification. That delays production of new model for not short period of time. And in most cases, after fixing the design we do not have enough choices to apply to meet SAR specification. So there is need to consider SAR at the beginning step of handset development. One of the methods to consider SAR problem at the beginning stage of new model design is a use of simulation software.

Therefore, in this paper, we investigate several EMI(Electromagnetic Interference) paint distributions on front case of mobile handset to reduce SAR value [4-7].

First, we will describe theory of SAR in chapter 2. Simulation results with applying different patterns of EMI paint on the front case of handsets are presented chapter 3. Finally, the conclusions are given in chapter 4.

2. SAR

2.1. Definition

The SAR is an indication of the amount of radiation that is absorbed into the human body(usually head) when using a handset. The SAR is calculated as the maximum energy absorbed into a unit of mass of exposed tissue. The SAR value is usually expressed in units of watts per kilogram[W/kg] in either 1g or 10g of tissue[8]. Therefore SAR is measured using the following formula.

$$SAR = \frac{\sigma|E|^2}{\rho}[W/kg] \tag{1}$$

where,

σ: conductivity of the tissue[S/m],
E : electric field strength(rms value)[V/m],
ρ : density of the tissue [kg/m^3].

If the heat diffusion and the exposure time are negligibly small, the SAR is given by [8]

$$SAR = c\frac{\Delta T}{\Delta t} \tag{2}$$

where,

c : specific heat of the phantom[J/kg·°C],
ΔT : temperature rise [°C],
Δt : heating time [s].

Equation (1) can be expressed as

$$SAR = \frac{\sigma_x}{\rho_x}|E_x|^2 + \frac{\sigma_y}{\rho_y}|E_y|^2 + \frac{\sigma_z}{\rho_z}|E_z|^2 \quad (3)$$

2.2. SAR simulation

Fig. 1 shows flow chart to compute SAR, 3D radiation pattern, E- and H-field patterns.

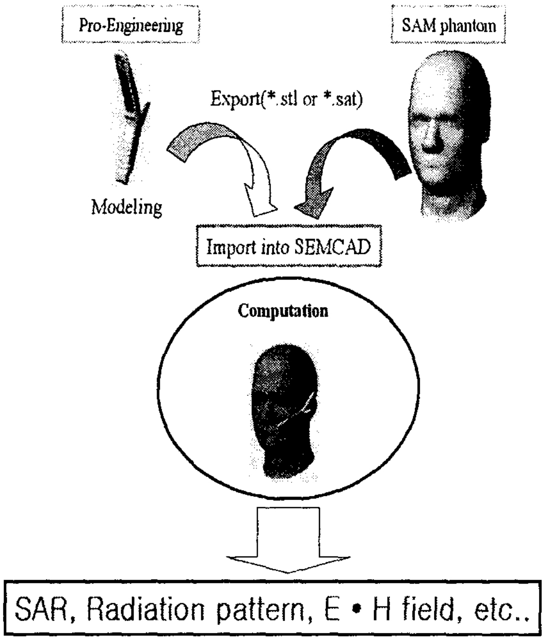


Fig. 1. Block diagram for simulation.

Three dimensional CAD(Computer Aided Design) program, 'Pro-engineering' was used for modeling handset. And modeled handset was imported into SEMCAD, simulation platform for electromagnetic compatibility antenna design and dosimetry to compute SAR value. In order to distinguish the individual pieces and to enable an assignment of the different material properties, each subfile was imported separately.

3. MODELING AND SIMULATION

3.1. Modeling of handset

Fig. 2 depicts modeling of handset. Each parts of handset are ①antenna, ②antenna cover, ③front case, ④rear case, ⑤lower case, ⑥upper case, ⑦battery case, ⑧ ground of PCB, ⑨ dielectric of PCB, ⑩ antenna bushing, ⑪key pad, ⑫glass, ⑬front case EMI paint, ⑭rear case EMI paint.

Especially, PCB(Printed Circuit Board) structure consists of 1 dielectric and 2 PEC(perfect electric conductor) layers as well as interconnecting vias. As shown in Fig. 2(b), in order to achieve proper excitation, a source region is modeled which exactly resembles handset. Also, to achieve an electric separation between antenna and PCB, a small region of the upper PCB ground layer was isolated from its main part by introducing an air gap of 1mm thick. Consequently, the source was placed between the resulting PEC island-like plate and the remaining ground layer.

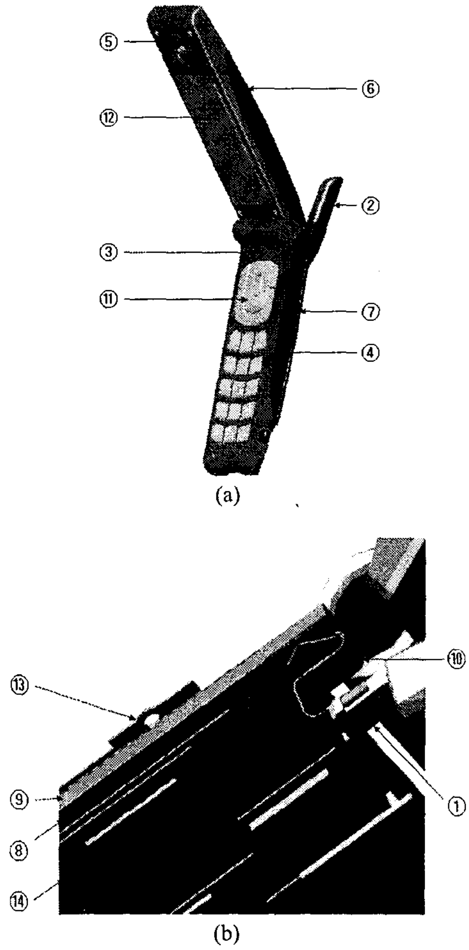


Fig. 2. Modeling of handset.
(a) Whole view, (b) Inner view.

Table 1 shows dielectric components with material parameters which are used in SEMCAD. Except dielectric, all metallic parts are set to PEC.

Table 1 Electrical characteristic of main dielectric parts of modeled handset

part	ε_r	σ [s/m]
Antenna cover	2.5	3E-3
PCB dielectric	4.5	7E-2
LCD glass	4.5	1E-2
Housing	3.5	2E-2
Keypad	3.5	2E-2

Fig. 3 shows EMI paint on front case for simulation.

Fig. 4 shows touch point between phantom and handset. Folding angle is set to 142°. If we vary folding angle, different SAR value will be obtained. When folding angle is set to 142°, phantom is in touch with handset at one point, ear point in our simulation.

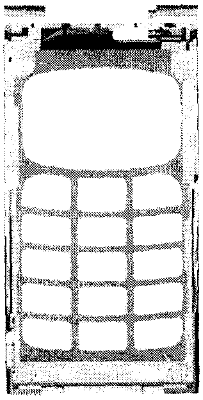


Fig. 3. EMI paint on front case.

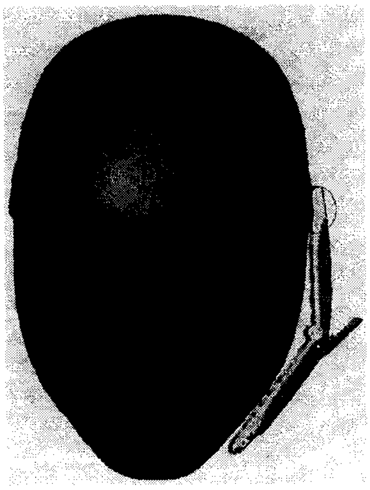


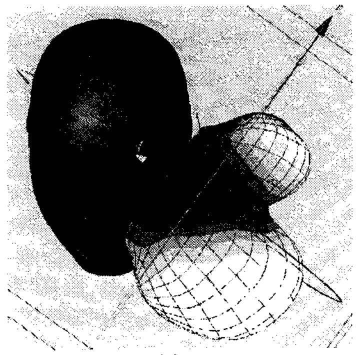
Fig. 4. Touch point with folding angle of 142°.

3.2. Radiation pattern simulation

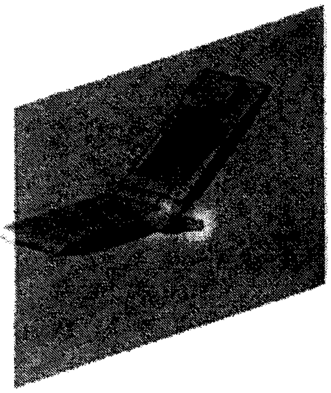
We simulated mobile handset to get 3D, E- and H-field radiation patterns by using SEMCAD. Fig. 5 shows the simulation results for radiation patterns. Radiation pattern is disturbed by phantom. Fig. 5(b), (c) show E- and H-field patterns without phantom.

3.3. Applying different patterns of EMI paint

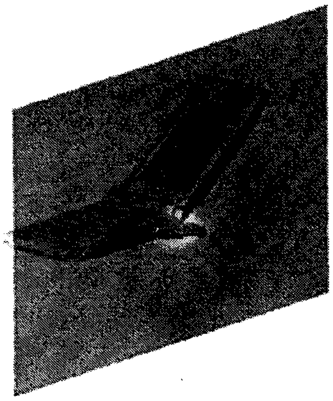
EMI paint is widely used on the purpose of electromagnetic shielding in handset. Usually, EMI paint acts role that increases SAR. But, it is very difficult to remove EMI paint perfectly, because of radio sensitivity and static electricity [4]. We investigated SAR variation with different EMI paint patterns applied on the front case of handset. Fig. 6 shows several EMI paint patterns investigated.



(a)



(b)



(c)

Fig. 5. Radiation pattern of handset.
(a) 3D Radiation pattern,
(b) E-field, (c) H-field.

To compare the performance, we define 'decrease efficiency(D)', as equation (4).

$$D\,(\%) = \frac{R - E}{R} \times 100\,(\%) \tag{4}$$

where,

D : decrease efficiency[%],
R : reference SAR[W/kg],
E : each case of SAR[W/kg].

Table 2 shows simulation results for each case of Fig. 6 When we compute 'decrease efficiency(D)', completely removed case is set as reference.

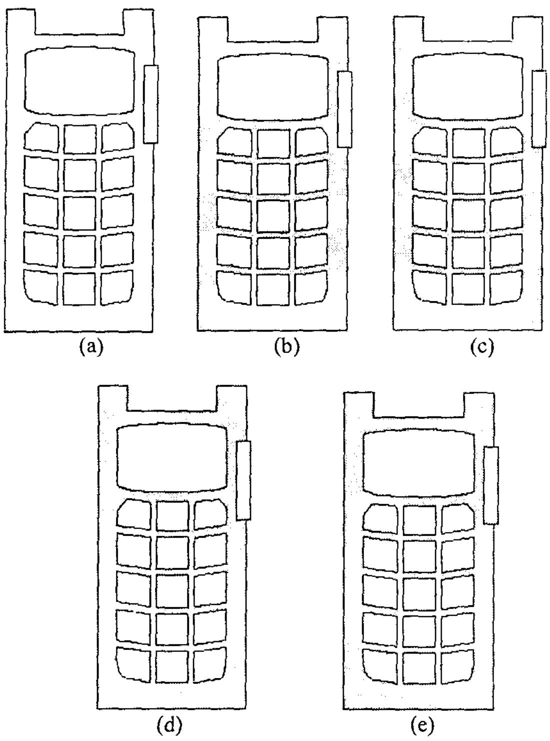


Fig. 6. EMI paint patterns.
(a) Completely removed,
(b) Horizontal-direction zigzag pattern,
(c) Inverse horizontal-direction zigzag pattern,
(d) Hairpin pattern,
(e) Inverse hairpin pattern.

Table 2 Comparison of SAR values for each case of Fig. 6

Figure	1g averaged SAR[W/Kg]	D(%)
(a) Completely removed	1.76580	0
(b) Horizontal-direction zigzag pattern	1.55036	12.2
(c) Inverse horizontal-direction zigzag pattern	1.65418	6.3
(d) Hairpin pattern	1.47415	16.5
(e) Inverse hairpin pattern	1.65186	6.5

We can see from the table that different pattern gives different SAR value. Among the investigated patterns, the hairpin pattern showed the best performance, i.e. the decrease efficiency of 16.5% and horizontal-direction zigzag pattern showed the decrease efficiency of 12.2%. Simulations for SAR were done at the frequency of 1770MHz.

4. CONCLUSION

We investigated SAR variation with applying different patterns of EMI paint on the front case of handset with simulations.

In simulation, folding angle was set to 142°. If we vary folding angle, different SAR value will be obtained because the distance between an antenna and a phantom is changed and radiation property is also changed. So changing folding can be one method of solution for SAR problem.

Among the tested EMI paint patterns, the hairpin pattern showed the best performance of the decrease efficiency of 16.5%. And horizontal-direction zigzag pattern showed the decrease efficiency of 12.2% when we set the completely removed pattern as reference. We can confirm that some EMI paint patterns decreases SAR value by simulation results.

Recently, SAR is of great interest, and can be a major fact to choose specific handset model. We expect that our approach to solve SAR problem can be some kind of solution.

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