NUMERICAL ANALYSIS OF ABSORPTION MECHNISMS FOR MOBILE PHONES WITH INTEGRATED MULTIBAND ANTENNAS

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ABSTRACT

In this paper the absorption mechanism in the human tissue for mobile phones equipped with integrated antennas is analyzed by means of numerical simulations based on the FDTD (Finite Difference Time Domain) method. Singleband antennas for 900 MHz and 1800 MHz respectively are situated on realistic models of mobile phones which vary in length. The SAR (Specific Absorption Rate) in a flat-phantom filled with tissue simulating material is observed when the mobiles are situated above. It is shown that there is a strong effect of the PCB (Printed Circuit Board) of the mobile, which acts as the counterpart to the antenna module, on the SAR distribution in the phantom. The investigation shows that especially for 900 MHz the SAR generated by currents on the PCB is dominant in all configurations. Based on the above analysis an integrated multiband antenna for GSM/DCS/PCS is investigated with respect to the SAR distribution in a flat-phantom.

INTRODUCTION

The absorption of microwave energy in the human tissue generated by mobile phones has become a point of critical discussions in the public domain due to possible health risks. Whether this fear is reasonable or not is still a open point for the scientific research of biologists and will not be discussed in this paper.

There are several publications indicating that mobile phones equipped with integrated antennas provide some advantages with respect to SAR compared to traditional helical antennas [1], [2]. A simple description for this is that the antenna mounted on the back side of the mobile is shielded by the PCB towards the head. As it will be shown later on, this simple description has some drawbacks and needs to be refined. In fact there is a strong interaction of the $\lambda/4$ antenna-module with the PCB of the mobile. In [3] the antenna module and the PCB are interpreted as two resonators which couple to each other and act together as the resulting antenna. In [4] and [5] it is reported that the length of the mobile has a strong effect on the resulting impedance bandwidth of the antenna. The largest bandwidth can be reached if the dimensions of the PCB enables a $\lambda/2$ resonance on the board.

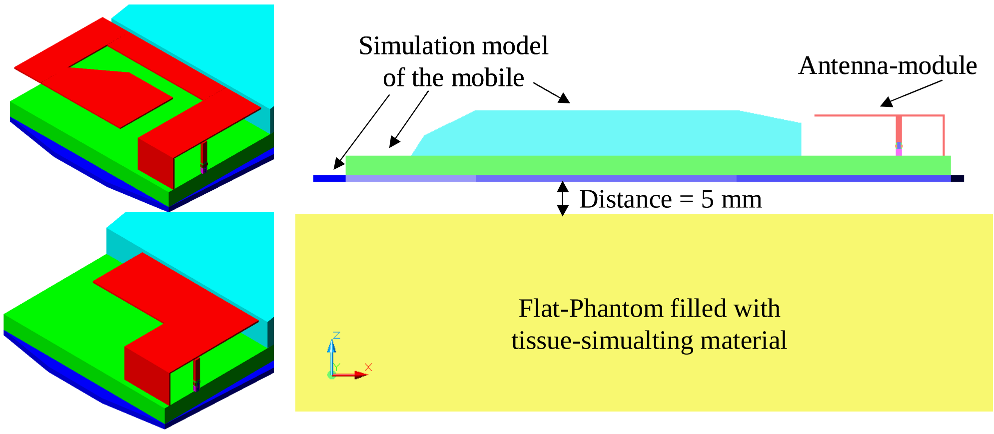
It is the aim of this paper to investigate the influence on the SAR generated by mobile phones with integrated antennas for 900 MHz and 1800 MHz with respect to different length of the mobile.

METHOD

For all numerical simulations the software EMPIRE™ is used, which is a commercial 3d-FDTD code from IMST GmbH able to deal with inhomogeneous media. Therefore the method is well suited for the simulation of SAR distributions in human tissue. A drawback of the FDTD-method with respect to antenna simulations is that the current distribution is not generated by default. Therefore the software has been extended to calculate the surface current distribution on metal objects from the prior assessed magnetic field by Faradays law.

The simulation setup consists of the models of the mobile phones including the most relevant parts such as PCB, shieldings, battery and antenna module. All parts are modelled as loss-less metallic objects. Additionally a plastic casing with a thickness of 1 mm and a relative permittivity of ε_r = 3 encloses these components. Integrated antennas for 900 MHz and 1800 MHz respectively are situated in the upper part of mobiles of different length on the RF-shielding. For both configurations the length of the mobile is varied between 80 mm and 150 mm.

In order to investigate the mechanisms relevant for absorption without the influence of the anatomic shape and the inhomogeneous tissue distribution of a realistic phantom of the human head, a flat-phantom filled with homogeneous tissue simulating material is used. The material parameters for 900 MHz are: $\varepsilon_r = 42.5$ and $\sigma = 0.86\ \Omega^{-1}\mathrm{m}^{-1}$ and for 1800 MHz: $\varepsilon_r = 41$ and $\sigma = 1.69\ \Omega^{-1}\mathrm{m}^{-1}$. The mobiles are placed with a distance of 5 mm to the surface of the flat-phantom as it can be seen in Fig. 1.



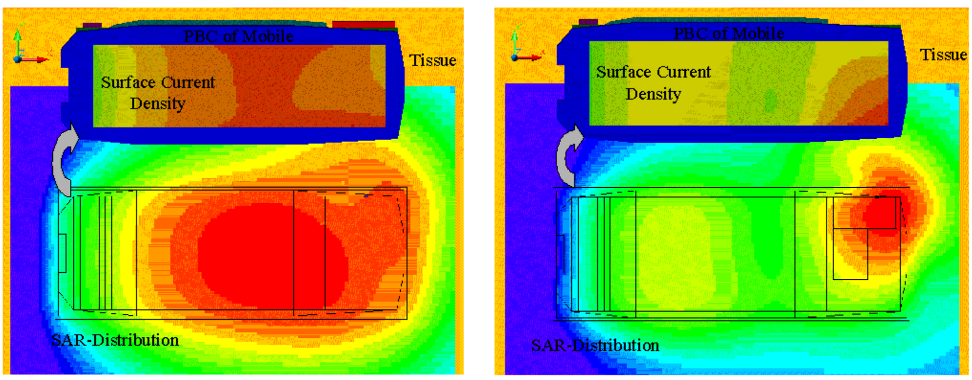
a)Antenna models.

b) Simulation setup with a flat phantom.

Fig. 1: Mobile placed in 5 mm distance above a flat-phantom.

The SAR distribution in the flat-phantom is calculated for all configurations. Additionally the distribution of the surface current density on the front-side of the PCB (opposite side to the antenna) is calculated.

RESULTS

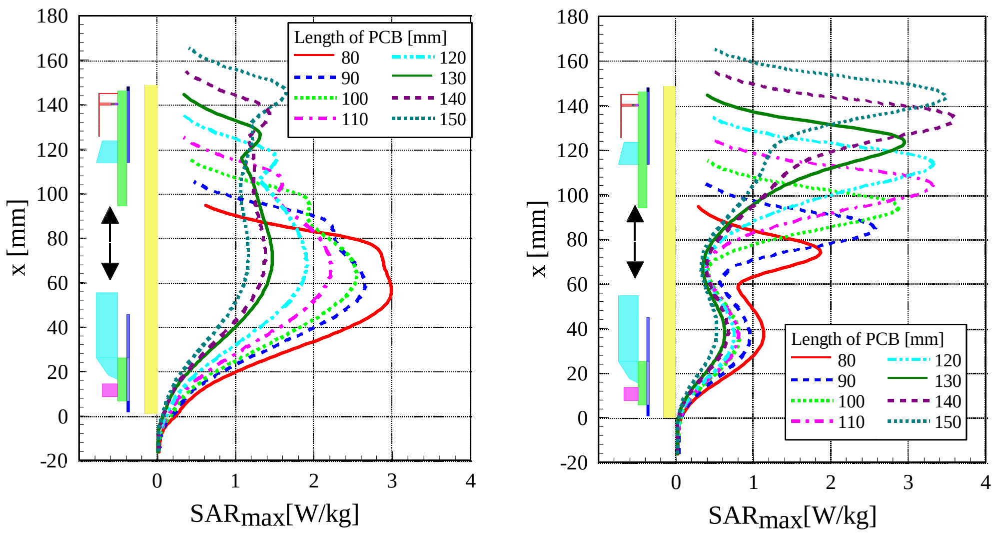


a) f = 900 MHz.

b) f = 1800 MHz

Fig. 2: Relation of the Surface Current Distribution on the PCB and the SAR induced in the flat-phantom: Length of mobile 110 mm.

Fig. 2 shows the distribution of the SAR on the surface of the flat-phantom when it is irradiated by a mobile which is 110 mm in length. Additionally the distribution of the surface current density on the PBC is displayed. To visualize the surface current distribution on the side of the PCB which is orientated towards the phantom and the SAR on the flat-phantom simultaneously, the mobile is turned around in Fig. 2. For 900 MHz two maximums can be found in the SAR distribution. The first maximum occurs near the shorting edge of the antenna above and the second maximum can be found near the mid part of the mobile above. Comparing the SAR with the distribution of the surface current density on the PCB of the mobile we can find a certain relation. Especially at the mid part of the board there is a maximum of the current density which is due to the coupling of the λ/4-antenna module with the PCB. For 1800 MHz we can observe that the coupling of the antenna module to the PCB is smaller. The largest current density occurs near the shorting edge of the antenna and therefore the maximum SAR appears according to these currents.



a) f = 900 MHz.

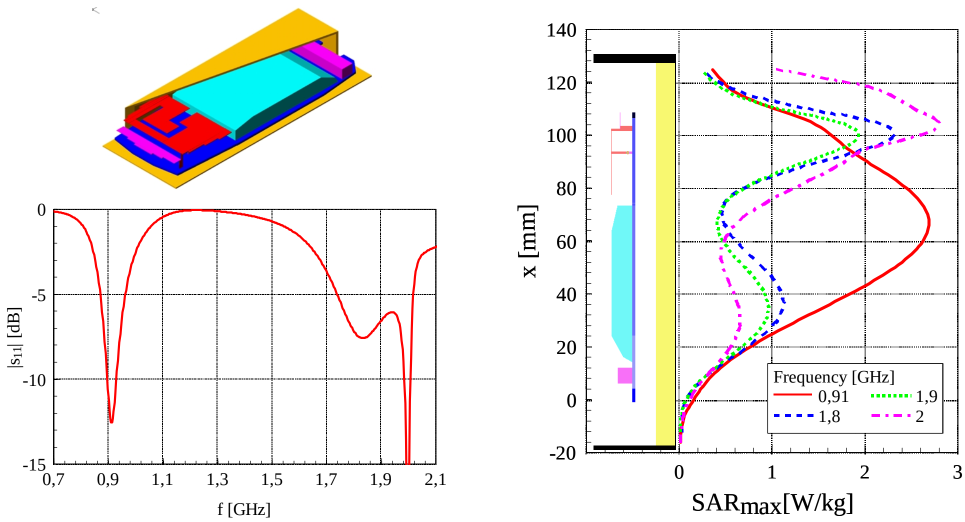
b) f = 1800 MHz.

Fig. 3: Maximum SAR in planes of x = constant in the flat-phantom.

Performing the same analysed for all configurations according to varying length of the mobile, we can observe from Fig. 3 that for 900 MHz the maximum SAR is generated by currents on the PCB in all configurations. The ratio of the maximums differs with respect to the length of the mobile. The lowest SAR maximum is reached for a configuration of 130 mm. In accordance to the investigation in [5] at this length the PCB provides a λ/2 resonance at the frequency of operation. Additionally [5] shows that at this length the largest bandwidth can be reached. For 1800 MHz the influence of the PCB acting as the counterpart to the antenna is less dominant. It can be observed that the maximum SAR is generated by currents near the shorting edge of the antenna-module.

As an example of a realistic multiband antenna configuration an integrated tripleband antenna for the standards GSM/DCS/PCS is investigated on the same aspects. The antenna consists of a double resonant folded patch with a parasitic element providing a broadband matching in the upper frequency range. The antenna is matched to the desired frequencies via a common feeding point. A detailed description of the antenna can be found in [5].

It can be observed from Fig. 4 that for the GSM mode the maximum SAR is due to currents on the PCB of the mobile while the maximums at DCS and PCS occur due to currents near the shorting edge of the antenna. This is in consistence to the above basic investigations.



a) Integrated tripleband antenna. b) Maximum SAR in a flat-phantom.

Fig. 4: An integrated tripleband antenna for GSM/DCS/PCS.

CONCLUSION

The mechanism generating SAR from mobile phones equipped with integrated antennas has been analysed for the 900 MHz and the 1800 MHz frequency band respectively. It has been shown that especially for 900 MHz the interaction of the integrated antenna with the PCB of the mobile plays a dominate role. Therefore the maximum SAR is generated by currents on the PCB in this configuration. A variation of the length of the mobile shows that the amount of this effect differs. The lowest SAR is reached if the PCB enables a $\lambda/2$ resonance at the frequency of operation. Additionally at this length the largest bandwidth can be reached. For 1800 MHz this effect is less dominant. The maximum SAR occurs due to currents near the shorting edge of the antenna in all configurations.

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