Focusing effects of metallic rim-less spectacles at mobile communication frequencies on the energy absorbed in the head

Focusing effects of metallic rim-less spectacles at mobile communication frequencies on the energy absorbed in the head

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Abstract- **This paper presents simulated and measured results from a study looking at the Specific Absorption Rates (SAR) inside the head due to metallic rim-less spectacles, when the head is irradiated by a dipole source in front of the face. The study concentrates on the GSM1800, PCS1900 and UMTS 2100MHz frequency bands. Simulations were carried out using the homogeneous Specific Anthropomorphic Model (SAM) phantom and a heterogeneous head model developed from the Visible Human Project. SAR measurements were carried out using a DASY4 with the modified rear-entry Loughborough SAM head. The measurements and both sets of simulations show that the metallic crossbar can increase the peak 1g SAR inside the head by approximately 5 times in the GSM1800 uplink frequency band.**

I. Introduction

With larger screens and new applications, mobile communication equipment use in front of the face is becoming increasingly common. Since the RF radiation is incident on the face, metallic accessories about the face of particular electric size may resonate [1]. These resonant structures focus energy and may increase the SAR inside the head. In recent work, the authors have developed a modified SAM for SAR testing using a DASY4 [2] from frontal radiation sources [3]. The authors present here results from a study on the effects of metallic rim-less spectacles on the SAR when the face is illuminated by a RF source in the GSM1800, PCS1900 and UMTS frequency bands. Results for SAR were obtained first from simulation and then compared with measured values obtained using a robot driven probe and tissue simulating liquid filled phantom head.

The effects of rimmed [4] and semi-rimmed spectacles [5] on SAR have been studied previously. It was shown that children's semi-rimmed spectacles can increase the 1g SAR inside the head by approximately 5 times [6]. However, the study of changes to SAR in the head due to rim-less spectacles is novel. A photograph of a metallic rim-less spectacle is given in Fig. 1. The two lenses are held together by a metallic crossbar that horizontally traverses the nose. In this type of spectacle, there is no partial or complete metallic rim around the lens. It was hypothesized that the central metallic part, along with its associated support structure for the nose pads could resonate in the GSM1800, PCS1900 or UMTS bands.

Fig. 1 Rim-less spectacle showing metallic crossbar conecting the lenses

II. Straight Wire Results

Initially, the metallic crossbar was represented by a 2mm diameter straight wire. The 1g SAR changes inside the SAM head due to this wire were simulated with a dipole source illuminating the face in EMPIRE XCcel 5.30 [7]. Fig. 2 shows the initial positioning of the horizontal wire and dipole source relative to a modeled SAM head. The wire position relative to the tip of the nose was comparable to the crossbar location of the spectacle when placed on the face. A parametric study was conducted varying both the wire length and its horizontal separation distance from the head. The excitation dipole length and location was fixed for all simulations and the 1g SAR was calculated at 1950MHz, representing the UMTS band. The SAM head tissue was assigned a relative permittivity of 40 and a conductivity of 1.4S/m. The shell had a relative permittivity of 3.5 and was modeled as being lossless.

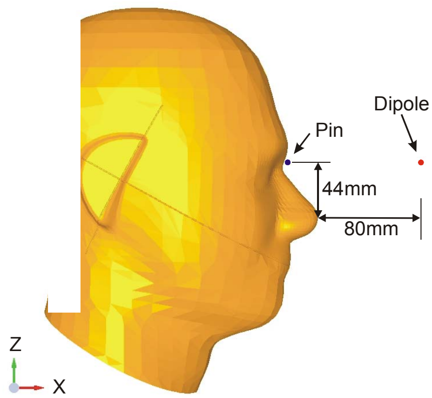


Fig. 2 Diagram showing location of dipole and initial location of wire in parametric study

The results of the parametric study are given in Fig. 3. All results were normalized to 1W accepted power. Without the wire, the maximum 1g SAR was located inside the nose and with the wire, it was located directly behind the wire. As can be seen a wire length of 0.42λ (65mm) caused the largest resonance.

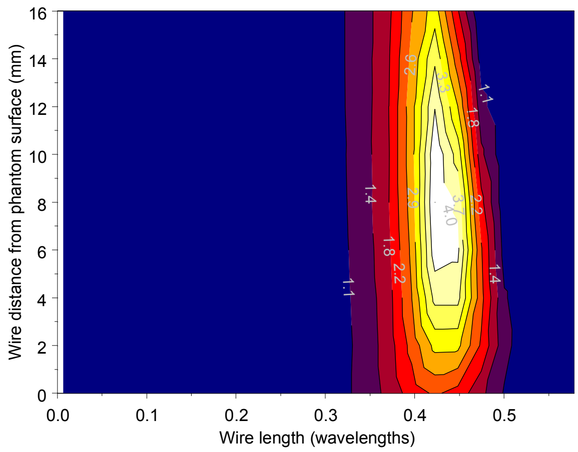
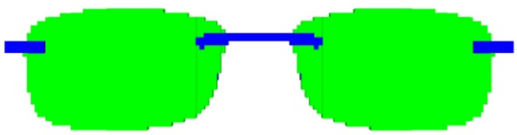


Fig. 3 1g SAR inside SAM head at 1950MHz when size and length of wire were varied

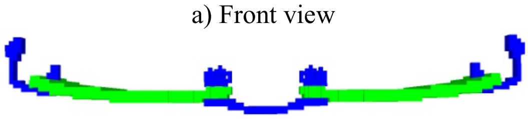
For a resonant wire, all separation distances caused an increase in the SAR, but the optimum separation distance for maximum 1g SAR was 6mm. At optimum length and location, the 1g SAR inside the head increased by approximately 6 times from 0.73W/kg to 4.42W/kg. We expect these results to represent the worst case scenario.

III. Simulated Spectacle Model

Following the parametric study, the wire was replaced with a model created by digitizing the spectacle shown in Fig. 1. The spectacle and a ruler were scanned on a flat-bed scanner along three orthogonal angles and the resulting images were descritised into 1mm squares. The information was then combined to form the 3D 1mm resolution model. The lenses were designated as CR-39 plastic with a relative permittivity of 2.24 and a loss of 0.001. The metallic sections were classed as perfect metallic conductors. The front and top views of the model are given in Fig. 4.



a) Front view



b) Top view

Fig. 4 Front and top views of digitized metallic rim-less spectacle

As can be seen the metallic support structure for the nose pads were included in the model along with the hinges for the arms. The metallic arms were not simulated in the model because their inclusion had little effect on the 1g SAR but added to the complexity. It can also be argued that similar rim-less spectacles could have plastic arms.

The position of the spectacle on the SAM head model is shown in Fig. 5. The inside surface of the metallic crossbar is 7mm from the surface of the SAM shell. As with the previous simulation, the horizontal separation distance from the tip of the nose to the dipole was 80mm. Its vertical distance from the tip of the nose was increased 45mm so that it was aligned with the crossbar of the spectacle. The nose, eye, eyebrow and the lower forehead regions were meshed with a 1mm resolution whilst the remainder of the head had a 2mm resolution.

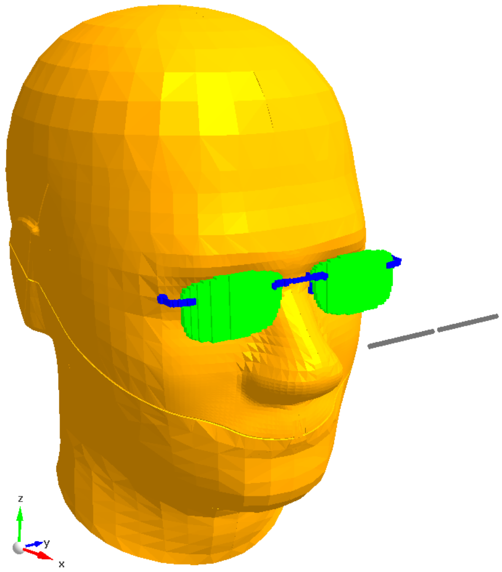


Fig. 5 Simulation model showing SAM head, spectacle and dipole source

IV. SAM Head Spectacle Results

Simulation results over a broad frequency range covering GSM1800, PCS1900 and UMTS indicated that the spectacle's strongest focusing effect was in the GSM 1800 uplink band.

These simulated results are given in Fig. 6. Using the DASY4 and the Loughborough SAM head, the 1g SAR due to the spectacle was measured in the frequency band 1710MHz to 1830MHz. The narrow measured frequency band was due to the limited frequency calibration of the electric field measurement probe. Nevertheless, the presented results indicate an increase in the 1g SAR due to the focusing effect of the spectacle. At 1710MHz, in the measurement, the 1g SAR increased by ~5.2 times from 0.87 to 4.56W/kg and in the simulation, the 1g SAR increased by ~5.0 times from 0.70 to 3.52 W/kg. There is also an increase in the 1g SAR in the PCS1900 uplink band of 1850MHz to 1910MHz. Both simulated and measured results show good agreement. We rationalize that small errors in agreement may be due to the discretisation and positional inaccuracy of the spectacle model. Extensive simulations have shown that due to the curvature of the crossbar and supporting structure around the nose (see Fig. 4), the phantom has a large dielectric loading effect on the spectacles. Therefore, the electrical lengths of spectacle components are dependent on their positions relative to the phantom surface. For example, simulations have shown that modifications in spectacle position can increase focusing in the PCS1900 band.

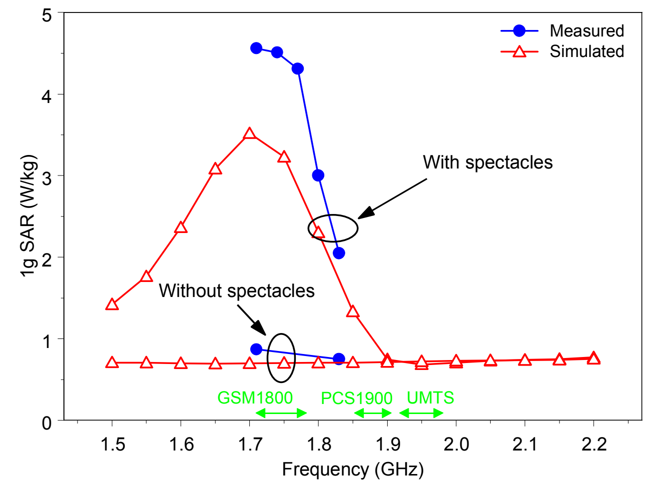


Fig. 6 Measured and simulated results with and without the spectacle on the SAM head

V. Heterogeneous Head Simulated Results

Simulations have also been conducted using a heterogeneous head model developed by the Brooks Air Force Base (www.brooks.af.mil) from the Visible Human Project data. This has 26 different tissue types including internal air.

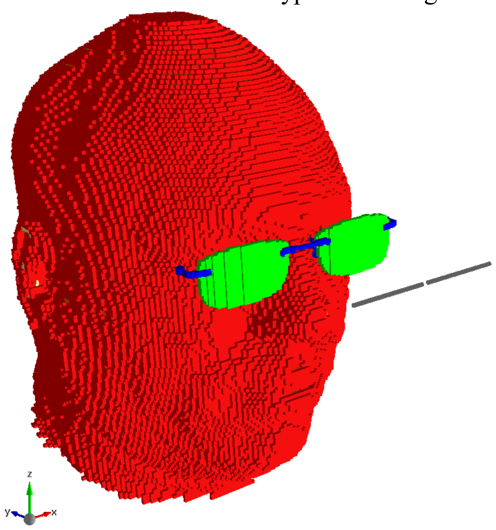


Fig. 7 Simulation model showing the Heterogeneous Brooks head, spectacle and dipole source

The previously used spectacle was positioned on the head model and a 75mm long resonant dipole was placed at a horizontal distance of 80mm from the tip of the nose. Its vertical height from the tip of the nose was 44mm. The location of the spectacle relative to the dipole was modified because of the shape of the face. The metallic crossbar of the spectacle was located 40mm vertically from the tip of the nose so as to make its position realistic with regard to the location of the eyes. The simulation setup is shown in Fig. 7.

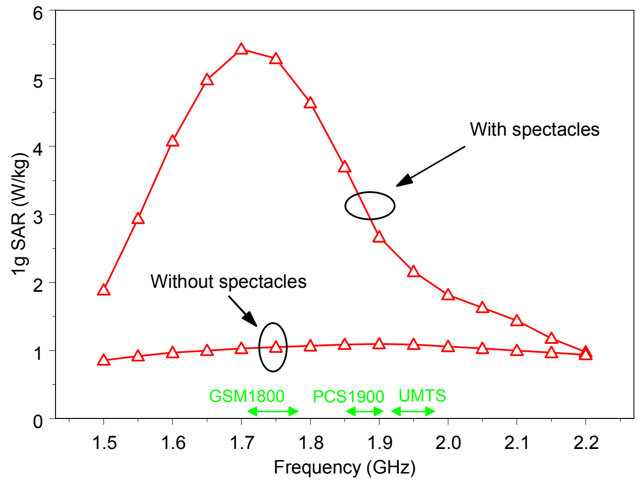


Fig. 8 Simulated 1g SAR results inside the Brooks head with and without the spectacle

Fig. 8 shows the simulated 1g SAR results inside the Brooks head with and without the spectacle. The largest increase was observed at 1700MHz; the 1g SAR increased from 1.03W/kg to 5.43W/kg, an increase of more than 5 times. The increase also seems to extend into the PCS1900 and UMTS frequency bands. The simulations indicated that the 1g SAR is extremely sensitive to the positioning of the spectacles relative to the face.

VI. Conclusions

This study has investigated through simulations and measurements the focusing effects of a rim-less spectacle on the 1g SAR inside the head. At certain frequencies rim-less spectacles may redistribute energy in the head and increase the 1g SAR. At GSM1800 uplink frequencies, the metal crossbar was shown to increase the 1g SAR inside the head by more than 5 times in both the SAM phantom and the heterogeneous Brooks head. However, when considering the 1/8th duty-cycle and the separation distance of the handset from the face, this increase is unlikely to exceed recommended safety levels. Nevertheless, these results may be of interest to engineers working with RF radiation.

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