Simultaneous Exposure of workers to EMF Radiated by a Three Band Base Station Antenna

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INTRODUCTION

Occupational exposure of maintenance workers in close proximity to transmitting base station antennas has been the focus of many studies [1][2][3]. However, most of these studies investigate exposure at a single frequency and do not consider the possibility of simultaneous exposure to several transmitting frequencies at the same time. By using numerical FDTD simulations, we have evaluated the combined EMF exposure of an anatomical human model positioned in front of a 3 band panel base station antenna, with simultaneous exposure at frequencies of 900, 1800 and 2100 MHz.

MATERIALS AND METHODS

We used the FDTD software SEMCAD X by Schmid & Partner engineering for the numerical simulations. First, we built a detailed model of the base station antenna. The antenna in question was a double cross polarized KATHREIN 742 265 (16 dBi gain, 10°vertical beamwidth at GSM and 18 dBi gain, 5°vertical beamwidth from 1700 to 2180 MHz) directional antenna. To validate the antenna model, we compared the far-field pattern, gain, horizontal and vertical beam widths with the data in the manufacturer's datasheet and good agreement was obtained. The human model used was an adult male from the Virtual Family [4](Duke). To keep the computation time reasonably short, the maximum voxel size in the human model was limited to 5 mm. The model was positioned facing the antenna at different distances – from 15 to 50 cm away from the rear metal reflector of the antenna.

Separate simulations were performed for each of the 3 frequencies at each location. Results normalized to 1 W radiated power and spatial peak SAR were extracted for each frequency. In order to be able to straightforwardly add the SAR contribution from each frequency we had to use exactly the same computational grid in all three cases.

To evaluate simultaneous exposure, formula (1) from the ICNIRP guidelines was used:

$$\sum_{i=100\,kHz}^{10\,GHz} \frac{SAR_i}{SAR_L} \geq 1 \qquad (1)$$

Where SAR_i is SAR caused by exposure at frequency i and SAR_L is the basic restriction for that frequency. This formula can be used for both whole-body and partial SAR. A power of 30 W for each of the carrier frequencies was chosen to represent a realistic exposure scenario.

RESULTS

Figure 1 shows a cross-section of the model and the SAR distribution. The highest SAR values were found in the head and chest regions. Locations of the spatial peak SAR can vary with frequency – the highest SAR value is located at the red square in each part of figure 1. Table 1 shows the values of SAR at the frequencies studied.

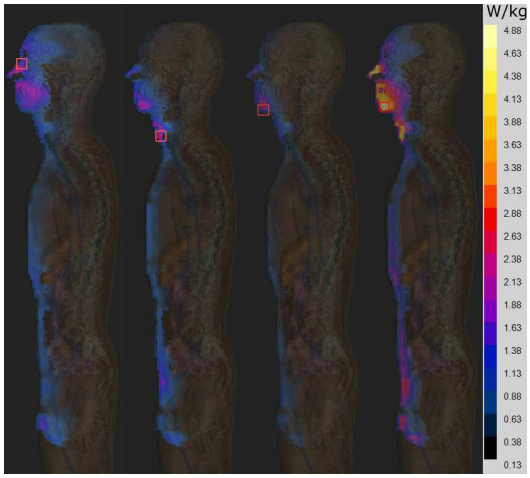

Figure 1: Spatial peak SAR at 30 cm distance from the antennas. From left to right: 900 MHz, 1800MHz, 2100 MHz and combined exposure.

	distance	15 cm	30 cm	45 cm
900 MHz	Spatial peak	4,75 W/kg	2,88 W/kg	1,36 W/kg
	Whole-body	0,22 W/kg	0,17 W/kg	0,12 W/kg
1800 MHz	Spatial peak	6,09 W/kg	2,06 W/kg	1,66 W/kg
	Whole-body	0,17 W/kg	0,13 W/kg	0,07 W/kg
2100 MHz	Spatial peak	7,65 W/kg	2,36 W/kg	1,11 W/kg
	Whole-body	0,16 W/kg	0,05 W/kg	0,04 W/kg
Combined	Spatial peak	14,79 W/kg	5,47 W/kg	3,22 W/kg
	Whole-body	0,55 W/kg	0,35 W/kg	0,22 W/kg

Table 1: Spatial peak and whole body SAR values at different frequencies vs. distance from antenna

CONCLUSIONS

The results show that when considering simultaneous exposure to multiple frequencies, the whole-body SAR basic restriction presents a stricter limit than spatial peak SAR, as the latter generally does not have peaks at the same position each frequency. Therefore, the whole body SAR value will reach the basic restriction at a greater distance than spatial peak SAR. In our exposure scenario none of the separate frequencies exceeded the basic restrictions, even at the shortest distance investigated. In the case of combined exposure whole-body SAR exceeds the basic restriction at approximately 26 centimetres and spatial peak SAR at the distance of 22 centimetres.

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