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FUTURE NETWORKS: 5G AND BEYOND

RF-EMF exposure assessment in the new incoming 5G indoor exposure scenarios

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Abstract

In the next years the development of the incoming 5G networks will drastically change the level of exposure of the population to RF-EMF. For this reason, there is a need to promptly conduct an adequate exposure assessment. In the present work a specific case of a user exposure scenario is evaluated, where the user is placed in a room where a 5G access point is located. More in details, the exposure of two 8x8 multi-element antenna planar arrays are examined in an indoor environment and correctly modelled at 3.7 GHz and 27 GHz. The user exposure assessment will be conducted using the FDTD solver implemented in Sim4Life platform. In specific, the user will be described by the head of Ella model from the Virtual Family, who will be placed at a distance of 50 cm from the antenna array, simulating two different worst cases of exposure scenario. The quantities that will be analyzed for determining the exposure levels are the specific absorption rate (SAR) and the transmitted power density (S_{tr}), as indicated in the basic restrictions of the ICNIRP guidelines.

1 Introduction

The next incoming generation of 5G mobile networks will be implemented to provide new services and utilities to all the population. Among them, the most innovative aspects will regard the automotive, health and industry sectors. The 5G networks will in fact develop the concept of future smart societies, smart cities and smart homes characterized by the idea of Internet of Things devices' connections [1, 2]. To support these high-performing applications the new networks will have to provide transmissions with a significant data rate increase w.r.t. the actual 4G networks and very low latency, thus new technologies will be necessary to satisfy these unprecedented demands. In particular, one of key 5G technologies outlined in the last Releases of the standardization group 3GPP (3rd Generation Partnership Program) is the use of millimeter (mm)–Wave MIMO (Multiple-Input-Multiple Output) links, requiring the deployment of multi-element antenna arrays operating at these frequencies never used before for mobile applications. In Italy, the first new licensed frequency ranges are 3.6 – 3.8 GHz and 26.5 – 27.5 GHz [3]. The use of these higher frequencies, suffering of very high path loss, will require the use of smaller cells and consequently an increment of the number of base stations (BS), and also the use of directive antennas able to focus the radiation in highly directional beams, i.e. antenna array with a great number of antenna elements. Such technology in 5G networks will be adopted not only at the outdoor BSs (positioned on the roof of high building) but also at radio units at lower height (e.g. on top of traffic lights) for the coverage in urban areas and in indoor scenario. In fact, only the intensive use of new frequencies and multi-element array antennas with high beamforming capability to countermeasure the increased path loss while reducing the interference, will be able to improve the performance in connectivity as foreseen for 5G new applications [4].
However, all these innovations will also drastically change the exposure conditions of a user to the RF-EMF and for this reason it became evident the need of conduction promptly an exposure assessment to these new 5G networks. Consequently, the present work will focus specifically to an example of exposure assessment of a user in downlink scenario at an indoor environment, simulating the presence in the room of a 5G access point. The details of the chosen scenario and of the work are described in the following paragraph.

2 Materials and Methods

In this preliminary work two different examples of indoor planar 8x8 antennas arrays were modelled and tested to simulate the presence of a 5G access point in the room. The selected working frequency for the two antennas arrays was one at 3.7 GHz and one at 27 GHz, which represent the frequencies of the first frequencies ranges that will be implemented in 5G Italy networks. Each of the 64 elements of antennas arrays was modelled as a simple patch antenna, whose dimensions and proprieties were chosen according to literature [5]. The spacing between the elements was set equal to $\lambda/2$ for both the arrays. To evaluate the exposure levels, it was considered the worst-case exposure levels, where all the elements of the array have a phase shift of 0°, resulting in a central frontal beam perpendicular to the plan of the array. The user was simulated with the model Ella from the Virtual Family and her head was placed at the center height of the antennas array, at a distance of 50 cm. Three different configurations will be examined for both the antennas arrays, one where the user is in front of the antennas array one where the user is placed from the side and the last where the back of the user head is in front of the antenna arrays, as it can be seen from Fig.1.

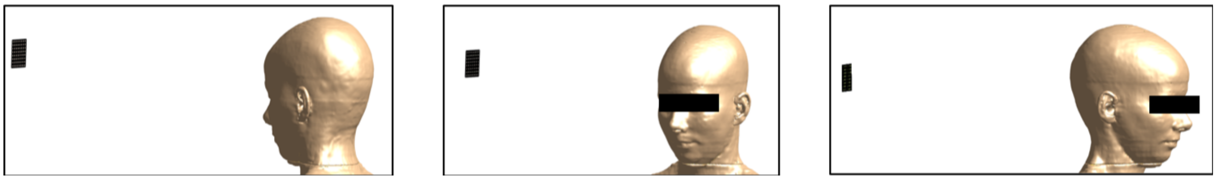

Figure 1: Scheme of the three different user's configurations that will be analysed for each antennas array. Note that in this figure is represented the antenna array dimensions at 27 GHz.

Due to computational cost for the 27 GHz frequency, the simulation domain will be limited to the region where the head of the model is present, not considering the rest of the body. The simulations will be conducted using the Sim4Life platform, where the FDTD solver is implemented. The tissues dielectric proprieties of the Ella model were chosen according to literature [6, 7]. For the boundaries of the simulations, it was applied an absorbing condition with perfectly matched layer (PML) and at last each single element of the two arrays was excited by a gaussian signal centred in the two chosen frequencies normalized for a total of 100 mW input power. Data on specific absorption rate (SAR) and transmitted power density (S_{tr}), as suggested from the ICNIRP guidelines [8], will be analyzed for the exposure assessment.

3 Results

In the present paragraph are reported only some preliminary results about the complete analysis that will be conducted for the three different configurations for the indoor planar 8x8 antennas array at 3.7 GHz and at 27 GHz.

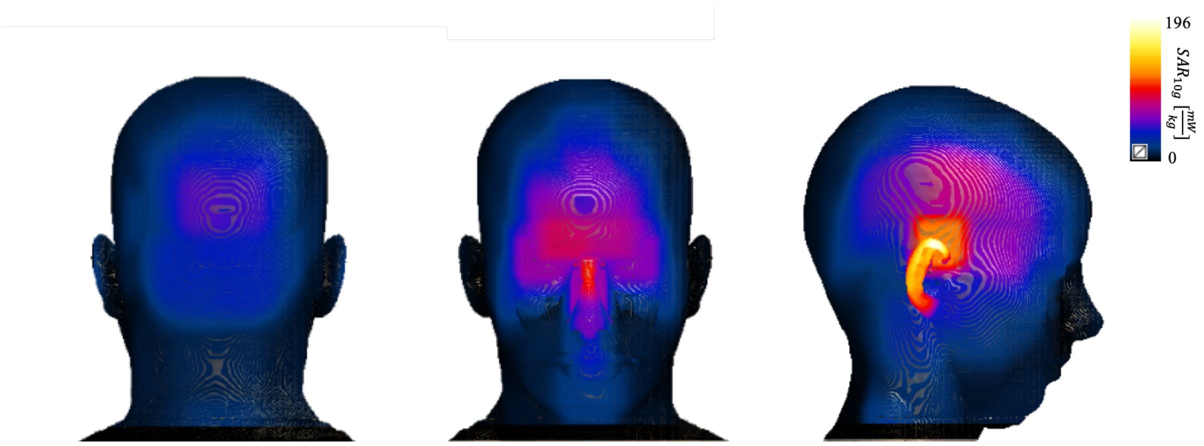

Figure 2: Distribution of SAR_{10g} induced on the head skin model by the 8x8 planar antenna array at 3.7 GHz with a total of100 mW input power. At the left for the posterior configuration, in the middle for the frontal one and at the right for the lateral one.

In Fig.2 it is in fact illustrated the SAR, averaged on 10 g of skin tissue (SAR_{10g}), for the three different configurations obtained from the exposure to the 8x8 planar antenna array at 3.7 GHz with an input power of 100 mW. As it can be seen for the figure, the configuration that caused the highest values of exposure is the lateral one, principally in the ear skin area, with a peak of SAR_{10g} equal to 196 mW/kg, well below the ICNIRP limit of 2 W/kg for the average head and torso exposure. The peak SAR_{10g} for the frontal configuration is a bit lower and equal to 104 mW/kg, whereas the lowest values of exposure are obtained for the posterior configuration, where the highest value of SAR_{10g} is equal to 51 mW/kg, almost a quarter of the peak value of the frontal configuration. The next work steps will involve a detailed analysis to assess the exposure levels on different tissues in the head model. The same analysis will be replied also for the configurations with the 8x8 array antenna at 27 GHz.

4 Conclusion

The presented work will mainly focus on some downlink exposure cases in indoor environment, characterizing a single user exposure levels changes that will occur with the introduction of the multi-element antennas array with beamforming capability in the mm-wave frequency range. The exposure assessment will be evaluated principally based on ICNIRP guidelines.

Future works will also involve the use of stochastic methods and machine learning [9, 10] approaches combining with deterministic dosimetry to face the high variability of scenarios that will characterize the 5G networks.

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