Numerical assessment of the induced SAR within humans due to EM radiations from Smart Meters

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Summary

Absorption of electromagnetic waves emitted by smart meters has been investigated by using numerical models representing a sample of the population: namely, a 23-year old female (NAOMI), a 34-year old male (NORMAN) and a 7-year old child (Eartha). Absorption within each of the models has been assessed at two different frequencies representing the ZigBee (2450MHz) and general purpose telemetry (868MHz) band. Frequency-dependent and age-dependent tissue properties have been taken into consideration within each model. The Specific Energy Absorption Rate (SAR) induced inside each heterogeneous voxel model has been calculated with 1W input power, fed to an optimised antenna similar to that used in commercial devices. Preliminary results of the 2450MHz source depict that whole body SAR values are well under the limits specified by ICNIRP guidelines.

Introduction

The use of smart meters for transmitting utility readings has become widely available during the past few years [1-5]. Smart meters use radiofrequency (RF) signals for communication through a home area network (HAN) as well as a wide area network (WAN). People in proximity to smart meter devices are exposed to the RF signals and will absorb a fraction of the transmitted energy in their bodies.

The objective of this study is to quantify the absorption of energy in the human body arising from the exposure to the RF signals emitted by smart meters and compare the resulting Specific Energy Absorption Rates (SARs) with international exposure guidelines (ICNIRP) [6].

Material and methods

Given the transmission characteristics of smart meters expected to be rolled out in UK homes, the study focuses on two HAN operational frequencies, namely, 868MHz and 2450MHz. The entire numerical domain, including optimised antennas and the various human models, were modelled by using a Finite Integral Technique (FIT) [10] solver, which is equivalent to the Finite Difference Time Domain (FDTD) method. Both operational frequencies have been considered to assess the electromagnetic (EM) absorption within numerical models representing a sample of the population: namely: a 23-year old female (NAOMI [7]), a 34-year old male (NORMAN [7]) and a 7-year old child (Eartha [8, 9]). These models were adapted from peer-reviewed voxel anatomical structures derived from 3D MRI scans and contained heterogeneous internal tissues [7, 8]. The dielectric properties for each of the included tissue types were represented by frequency dispersive and age-dependent properties [15, 16]. The computation domain was discretised with a maximum mesh resolution of 1.49 mm at 2450MHz, and up to 2 mm at 868MHz. The EM wave distributions, the whole-body averaged SAR (WBSAR), and the 10g peak SARs induced within the human models have been assessed under different exposure scenarios. The models were positioned in standing or sleeping positions and exposed in realistic near field scenarios where the smart meter antenna was placed at a prescribed height and with possible nearest and realistic exposure distances. They were also exposed in scenarios representing larger distances where far-field conditions would apply.

The impact of the age-dependent dielectric properties on the EM interaction with animals has been investigated previously in [11, 14, 15]. It is commonly accepted that the measured dispersive tissue properties from animals of different ages broadly follow similar trends to humans and therefore the tissues can be mapped across accordingly [7, 12, 13]. The different tissues in NORMAN and NAOMI, were assigned dielectric properties based on the database of Gabriel et al (1997) [13]. In the case of the child model, age related dielectric properties were considered from data reported in [15]. Interpolation equations were used to estimate dielectric properties of 20kg pigs corresponding to a 7-year old human child. The dimensions for the voxel models were chosen to accommodate the required high-resolution anatomy of the model and the FIT/FDTD numerical stability criteria.

Results and discussion

A total of 24 exposure scenarios have been considered in the study. Here we present the results for a scenario in which the smart meter was positioned at 1m height and 15cm away from the models, while exposed to 2450MHz Continuous Waves (CW). The calculated WBSAR and peak SAR at 2450MHz were respectively 0.9 mW/kg and 45.1 mW/kg for the NAOMI model, and 1.9 mW/kg and 64.4 mW/kg for the child model. These SAR values have been normalised to an antenna output power of 1W, which is ten times higher than the typical 100mW power expected from devices during transmission. The peak SAR distributions resulting from these exposure conditions are shown in Figure 1 and are clearly very much below the ICNIRP general public restriction of 2 W/kg in the head and trunk. The WBSAR of NAOMI, NORMAN and the child were found to be around 1%, 1% and 2% of ICNIRP general public WBSAR restriction respectively. Similar WBSAR values were obtained at 868MHz but are not reported here. These preliminary results suggest that WBSAR and 10g-peak SAR values from smart meters are much less than the restriction values in the ICNIRP guidelines, even with 10-fold over-estimation of the transmitted power, and using continuous wave exposure conditions that do not take into account the short operational duty cycles that will occur in practice.

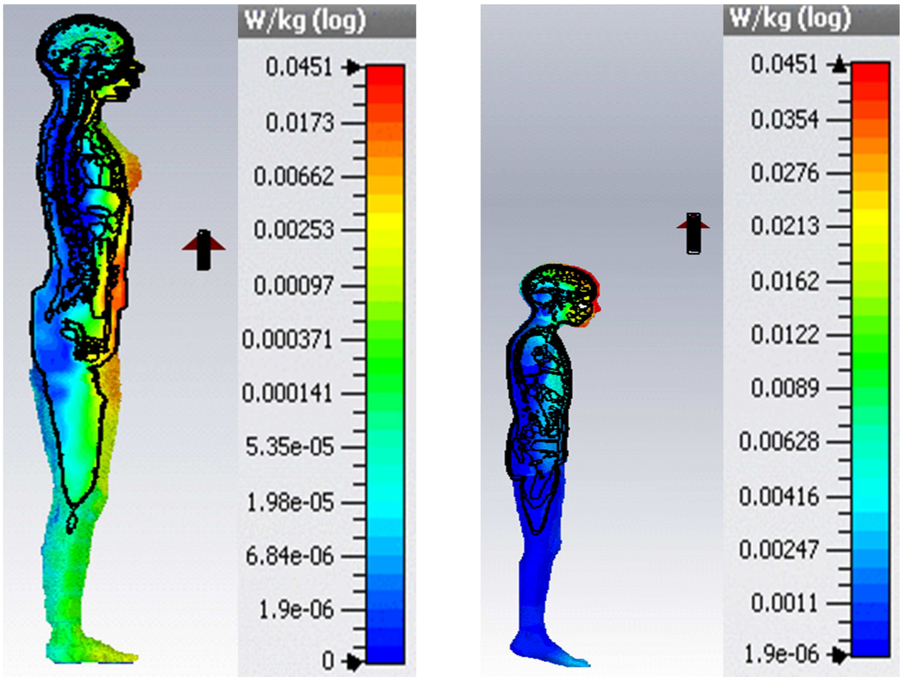

Figure 1: SAR distributions per W of output power in NAOMI and Eartha due to 2450MHz exposure from smart meter signals, when standing in front of the meter under grounded conditions

Conclusion

SAR values have been calculated in adult male and female voxel phantoms and a 7-year old child under various scenarios involving exposure to 2450MHz signals from a smart meter. Under pessimistic conditions involving over-estimation of the transmitted power and assuming continuous transmission, the results showed exposures were well within the basic restrictions specified by ICNIRP.

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