Specific-absorption-rate variation study applying a set of diverse human body models

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INTRODUCTION

Exposure to EM (electromagnetic) radiation causes absorption of EM power to biological tissues. The amount of absorption is usually measured via Specific Absorption Rate (SAR) [W/kg]. Limits have been set up for acceptable SAR doses and reference levels by e.g. ICNIRP (International Commission on Non-Ionizing Radiation Protection). If a reference level is exceeded in an exposure setup (e.g. human near a base-station antenna), it is necessary to check the SAR values, i.e., do they exceed the basic limits. Measurement of SAR inside living humans is impossible, at least nowadays. Thus, in practice, SAR values are often estimated via modeling.

Currently, an international exposure assessment standard IEC 62232 is under development. This standard will include measurement and computation protocols of RF fields and SAR. The standard, based on latest research and experience, also requires that full uncertainty budget of a SAR assessment can be determined. In this work, data is created which helps creating an uncertainty budget of SAR assessment. To be more specific, in the ongoing project, several physical parameters of planewave exposure setup are varied as the SAR values are computed. Information is obtained on how the SAR values depend on the human body size and type, field polarisation, wave incoming angle, and frequency. The ongoing project is part of the MMF-GSMA Dosimetry Program Phase II (MMF: Mobile Manufacturers Forum, GSMA: GSM Association).

METHODS

The involved human body models are anatomically realistic voxel models. Tissue types are specified via tissue density ϱ, conductivity σ and permittivity ϵ. Electrical parameters σ and ϵ are frequency dependent. SAR computation is based on Finite-Difference Time-Domain (FDTD) method: a parallel FDTD code is run at selected point frequencies to obtain necessary field values inside the body which are further processed to obtain electromagnetic power loss inside the tissues. Power loss is then averaged over mass to obtain the required SAR values, for example, the whole-body-averaged SAR (WBASAR). Other important SAR data are 1g-averaged SAR and 10g-averaged SAR distributions, max(1g-SAR), max(10g-SAR), and locations of SAR maxima in the body. Actually, SAR maxima are separately computed for head/trunk region and for the limbs.

The parallel FDTD solver is run in CSC's HP supercluster "Murska" (parallel batch jobs). Power loss and SAR computation codes are run as serial batch jobs. The manipulation and preparation of the human body models for FDTD-SAR computation, as well as the creation of input files and batch-script files, is done using Matlab (user interface). The computation and user interface codes have been developed in TKK. CSC has helped in the FDTD code optimisation.

EXAMPLE RESULTS

Actually, all the SAR key figures are required at 300, 450, 900, 2100, 3500 and 5000 MHz, for horisontal and vertical polarisation. The number of required incoming angles (Fig.1) depends on the model. As an example, Fig. 2 shows some WBASAR results at 2100 MHz for vertical polarisation.

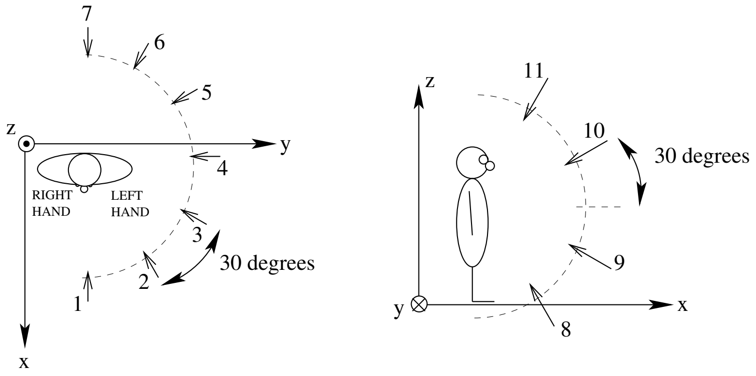

Figure 1: Plane wave incoming angles in horisontal and vertical plane.

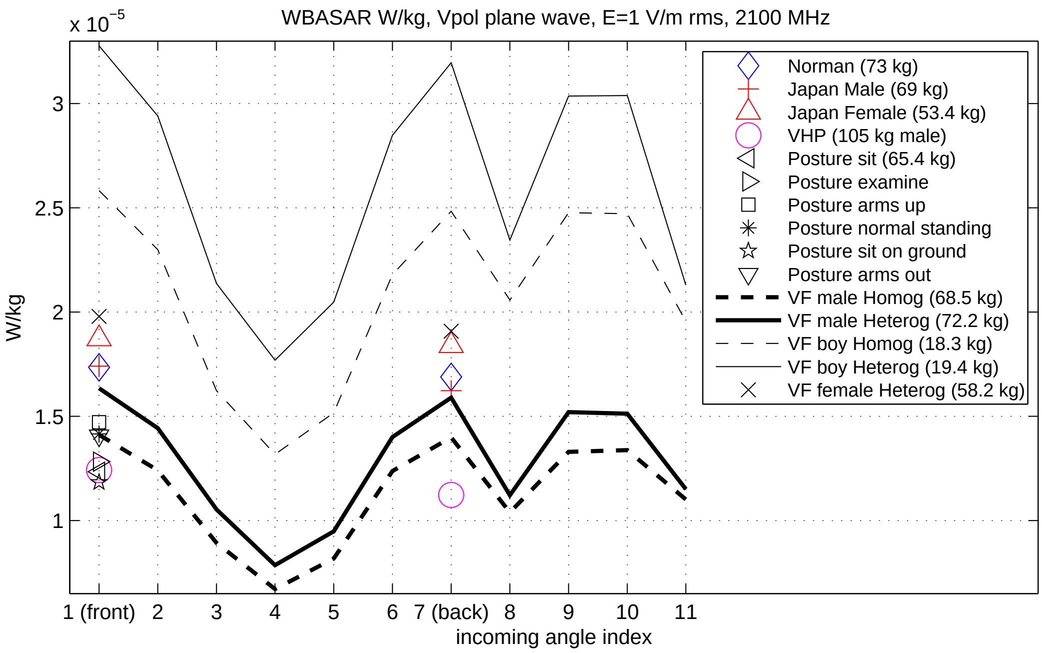

Figure 2: Example WBASAR results

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