A Benchmark CAD Mobile Phone Model for Specific Absorption Rate Calculations

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***Abstract* — Specific Absorption Rate (SAR) calculation using a CAD (computer-aided design)-based mobile phone model is still a challenging task. Seven international laboratories participated in an interlaboratory comparison of SAR calculations using a CAD-based model of a commercially available dual-band mobile phone. Results obtained from five different electromagnetic solvers were compared. Considering the differences in the methods implemented in the solvers –either time domain or frequency domain– used for the interlaboratory comparison, overall a good agreement is observed for both the return loss and the SAR results.**

Index Terms — Dosimetry, electromagnetic modeling, numerical simulation, specific absorption rate.

I. Introduction

A standardized measurement procedure is currently enforced for the SAR (Specific Absorption Rate) compliance assessment of mobile phones [1, 2]. Although rigorous the measurement procedure proves to be time-consuming and costly –several hours are typically required for the compliance test of a triple-band mobile phone using standard dosimetric test facilities– and inappropriate during the design stage or prototyping of the mobile phone, for example. Briefly, for each operating frequency band, about 20 min. elementary SAR measurements are performed for four intended use positions –left/cheek, left/tilt, right/cheek and right/tilt– of the mobile phone placed against the SAM (Specific Anthropomorphic Mannequin) head-phantom filled with tissue equivalent liquid. Obviously a regular maintenance of the dosimetric test facility is a prerequisite to ensure meaningful measurement results.

The advent of affordable fast computers and user-friendly commercially available electromagnetic software offers interesting perspectives for numerical dosimetry. For example, the SAR calculation using a realistic phone model that can account for the typical components present in commercially available mobile phones can now be tackled in a matter of minutes using GPU (graphics processing unit) computing. The international standardization committee ICES/IEEE/TC34/SC2 is currently developing standardized procedures to approach numerical dosimetry [3, 4]. Indeed, even though the numerical simulation tools are readily available, SAR calculations using complex models are not straightforward. For example, CAD (computer-aided design)-based mobile phone models that are initially developed for mechanical engineering purposes must be carefully analyzed prior to the electromagnetic simulations [5]. Such models typically consist of a number of components other than the antenna element –battery, camera, casing, PCB (printed circuit board), display, metallic shields, etc.– that may have a considerable impact on the SAR distribution inside the SAM phantom.

To address numerical simulations using CAD-based phone models, an international interlaboratory comparison is herein undertaken using a freely available CAD model of a dual-band –900 MHz / 1800 MHz– commercial mobile phone. A previous international interlaboratory comparison using three different CAD-based mobile phone models showed some clear deviations in the SAR results [6]. Possible causes of these deviations are: CAD import incompatibilities, incorrect positioning of the mobile phones against the SAM phantom, wrong material properties being used, inappropriate mesh densities for important components, etc. In order to reduce the possible causes of error, a different approach was adopted for the current interlaboratory comparison. In order to track systematic errors such as incorrect positioning against the SAM phantom, CAD import errors (e.g. some components being incorrectly modeled), and numerical modeling errors (e.g. inappropriate mesh density for critical components), three versions of the same CAD model were provided to the participating laboratories for all the numerical simulations: (a) a basic model which consists of the antenna, the antenna support, the PCB and the casing, (b) an intermediate model which additionally included the battery, the display and the speaker, and (c) a full model which consisted of all the elements of the mobile phone. Since the CAD-model is freely available, it is proposed as a benchmark model for electromagnetic solvers employed for SAR calculations.

II. Numerical Modeling

Fig. 1 shows the main components present in the commercial mobile phone. Since the antenna is curved, the applied mesh density should be fine enough when using solvers based on the finite difference time domain (FDTD) method. The exact values of the dielectric properties of the materials are unknown. For the purpose of this international interlaboratory comparison, typical values provided in Table I are therefore used for both frequency bands. The parameters for the tissue equivalent liquid for each frequency band are provided in Table II. The 2 mm thick shell of the SAM phantom is assigned a relative permittivity of 3.7 and a conductivity of 0.0016 S/m.

The numerical simulations were performed by seven international laboratories using six different commercially available electromagnetic solvers: (1) EMPIRE based on the FDTD method from IMST, (2) EMPro based on the FDTD method from Agilent, (3) HFSS based on the finite element method (FEM) from Ansoft, (4) Microwave Studio based on the finite integral technique (FIT) from CST, (5) Microstripes based on the transmission line matrix (TLM) method from CST, and (6) XFDTD from Remcom. Some laboratories were available to perform the numerical simulations using two different solvers, thereby yielding a total of 9 different laboratory results. The SAR calculations were performed for the right/cheek and right/tilt positions of the mobile phone against the SAM phantom at 890 MHz and 1750 MHz.

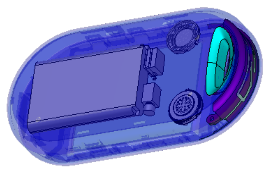

Fig. 1. CAD-based model of the commercially available mobile phone used for the international interlaboratory comparison.

TABLE I
DIELECTRIC PROPERTIES OF THE DIFFERENT COMPONENTS OF THE MOBILE PHONE

Component	Relative permittivity	Conductivity [S/m]
Antenna	1.00	PEC (perfect electrical conductor)
Antenna support	2.33	0.01
Battery	1.00	PEC
Battery Connectors	1.00	PEC
Casing	3.00	0.01
LCD (liquid crystal display)	4.80	0.01
PCB (printed circuit board)	1.00	PEC
Receiver	1.00	PEC
Speaker	1.00	PEC
Speaker Connectors	1.00	PEC
Vibrator	1.00	PEC

TABLE II
DIELECTRIC PROPERTIES OF THE TISSUE EQUIVALENT LIQUID

Parameters at given frequency		Tissue Equivalent Liquid
890 MHz	Relative permittivity	41.5
	Conductivity [S/m]	0.97
	Mass density [kg / m^3]	1000
1750 MHz	Relative permittivity	40.0
	Conductivity [S/m]	1.40
	Mass density [kg / m^3]	1000

III. RESULTS

Fig. 2 shows the result of the interlaboratory comparison of the return loss of the full CAD model. Overall a good agreement is observed taking into account the different solvers employed. Similar results are observed for the basic and intermediate CAD models.

The normalized peak 10 g average SAR values obtained by the different laboratories at 890 MHz and 1750 MHz for the full CAD model are shown in Fig. 3. The maximum deviations are 10 % and 20 % at 890 MHz and 1750 MHz, respectively.

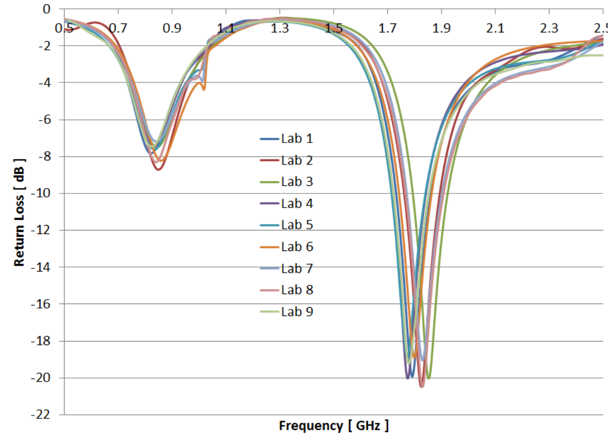

Fig. 2. Interlaboratory comparison of the return loss.

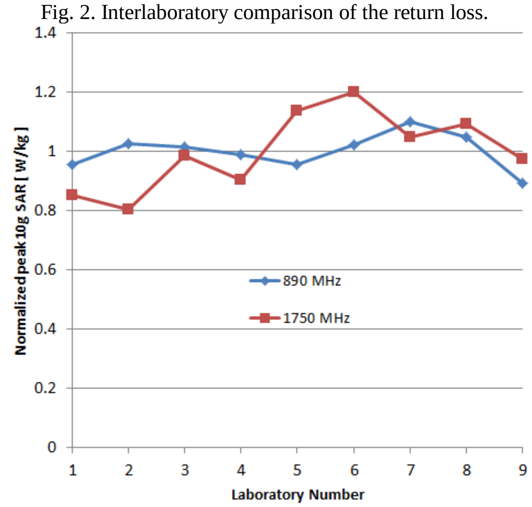

Fig. 3. Interlaboratory comparison of the normalized SAR calculated at 890 MHz and 1750 MHz.

IV. REFERENCES

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