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Reference SAR values for system validation using body material

Introduction

SAR measurements are performed by scanning an electric field probe in a liquid simulant representing the dielectric parameters of the body. These measurements are sensitive to the choice of dielectric parameters and to environmental conditions (such as temperature and background RF noise). It is therefore important to conduct a performance check of the measurement system on a regular basis to verify that the system is operating properly. The standard method of checking the measurement system is to measure the SAR induced in a flat phantom by a dipole antenna (as specified in [1]) and compare the results with reference values.

Reference SAR values currently exist for head simulating liquids [1]. However, there are no known reference values for the body parameters defined in [2]. The purpose of this document is to establish reference SAR values for these body parameters.

Method

The reference values in [1] for head parameters were determined from numerical simulations and validated with experimental measurements. Therefore, the same approach is used here. SEMCAD, a commercial software package based on the Finite-Difference Time-Domain method, is employed to compute the 1-gram and 10-gram averaged SAR. The approach is first to compute the reference values for head parameters and validate them against those in [1]. Once validated, the same setup is used with body parameters. Measurements are then used to compare against the final numerical values.

Simulations were run for two frequencies: 835 MHz and 1900 MHz. For each frequency, the simulation uses a flat phantom and a dipole antenna. The flat phantom consists of a block of dielectric material representing the liquid with the proper dielectric parameters. No outer shell is modeled, since it will have negligible effect on the results. The dielectric parameters are those specified in [1] for head parameters and [2] for body parameters. The flat phantom and the dipoles conform to the specifications listed in Tables 1 and 2.

The FDTD grid uses 2nd order Mur boundaries with at least 10 cells from the model to each boundary. A fine mesh is used, with a maximum grid dimension of less than $\lambda/10$ in the medium. The source impedance is 50 ohms.

Description	**IEEE P1528 Specification (mm)**	**Dimension in FDTD model (mm)**
Dipole		
- length	161	161
- diameter	2 – 4	3.6
- gap	0.5 – 3	1
- distance to phantom	15	15
Flat phantom		
- length	≥ 269	270
- width	≥ 216	220
- height	≥ 150	150

Table 1: Specifications and dimensions of the model at 835 MHz.

Description	IEEE P1528 Specification (mm)	Dimension in FDTD model (mm)
Dipole		
- length	68	68
- diameter	2 – 4	3.6
- gap	0.5 – 3	1
- distance to phantom	10	10
Flat phantom		
- length	≥ 118	120
- width	≥ 95	100
- height	≥ 150	150

Table 2: Specifications and dimensions of the model at 1900 MHz.

Results

The computed results are shown for 835 MHz and 1900 MHz in Table 3 and 4, respectively. The left column gives the results for head parameters. The return loss is provided to show that the reflected power is low. SAR results are normalized to 1 W of forward power. These parameters are all within 3.5% of the reference values in [1]. Thus, the method is deemed to be valid. In the right column are the results for body parameters using the same setup. Note that the return loss at 1900 MHz using body parameters is slightly above –20 dB. This was also noted in the measurements, and it is due to the incorrect choice of dipole length in [1]. This issue is currently being investigated by IEEE Standards Coordinating Committee 34. Nonetheless, the return loss is still very low and has negligible effect on the reference SAR values.

Computed Parameter	Results for head parameters [1]	Results for body parameters [2]
S_{11} (dB)	-38.6	-25.9
SAR 1g / 10g (W/kg)	9.81 / 6.36	9.90 / 6.46

Table 3: Computed results for 835 MHz.

Computed Parameter	Results for head parameters [1]	Results for body parameters [2]
S_{11} (dB)	-20.4	-17.2
SAR 1g / 10g (W/kg)	40.60 / 20.84	40.50 / 20.89

Table 4: Computed results for 1900 MHz.

Measurements were also conducted using body parameters. Measurements were performed according to [2]. Table 5 shows the measured SAR values and the deviation between measured values and reference values. The deviation is less than the required 10% [1]. Thus the reference values are deemed to be valid.

Frequency (MHz)	SAR 1g / 10g (W/kg)	Deviation (%)
835	9.92 / 6.50	0.20 / 0.62
1900	42.62 / 22.26	5.23 / 6.56

Table 5: Measured SAR results using body parameters for 835 and 1900 MHz.

It was also observed that minor changes to the model (FDTD cell size, flat phantom dimensions) did not significantly change the computed results. Therefore, the model and the method are robust.

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References

[1] IEEE, “Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques,” Std 1528-200X, Draft 6.5 – August 20, 2001.

[2] FCC OET Bulletin 65, Supplement C, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields: Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions,” June, 2001.