

SAR EVALUATION IN A GTEM CELL FOR IN VITRO DOSIMETRY

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Abstract: The Specific Absorption Rate (SAR) of in vitro biological samples exposed in a GTEM cell is evaluated by means of numerical and experimental techniques based on the electric field and the temperature measurements.

I. INTRODUCTION

In spite of the considerable amount of published data, a large number of in vitro investigations are aimed at achieving a correlation between mobile-phone usage and possible biological effects. However, in many cases, electromagnetic (e.m.) field studies suffer from inconsistencies between different laboratories, owing to the often raised inability in rigorously replicating the experiment conditions.

Therefore, the design of in vitro laboratory arrangements and consequent evaluation, interpretation and correlation of biological data with the observed physical mechanisms is a rather crucial task.

The exposure system, chosen to meet the in vitro experiment requirements, is a suitably designed GTEM cell. In particular, accurate and repeatable measures can be performed in the GTEM cell for frequencies up to a few GHz. Moreover, the e.m. field obtainable inside the GTEM cell is characterized by a well-defined orientation, uniformity and controllable intensity [1-2].

II. GTEM CELL DOSIMETRY

II.1 SAR evaluation

Aiming at the evaluation of the exposure conditions during the dosimetric experiments,

a combined technique involving experimental and numerical electric field data has been used for indirectly assessing the SAR of the sample under test. By applying this procedure, the correspondence between the simulated and measured E-field values has been employed to evaluate the SAR pertaining to the biological sample.

On this purpose, a full-scale numerical model of the realized GTEM cell has been developed by CST MW Studio. In order to assess the exposure conditions during the dosimetric experiment, the E-field has been evaluated in nine points around the sample position both numerically (by CST) and experimentally (by means of an innovative optical probe [3]).

$SAR_m=1$ W/kg, averaged over the sample volume has been achieved for input power $P_{in}=0.78$ W, at $f=1.8$ GHz.

The same exposure condition during the experiment (i.e. unchanged values of the incident E-field strength and the mean SAR) has been obtained for an input power slightly higher than that used for the CST simulation. Under the above circumstances, $SAR_m=1$ W/kg is achieved at 1.8 GHz for $P_{in}=1.5$ W.

II.2 SAR validation

SAR of the exposed biological sample can be indirectly estimated by measuring the induced temperature variation. In particular, the actual overall temperature variation, as a function of time t , results from a balance between heat gain and loss in the biological sample.

A valuable method for the SAR assessment is based on the analysis of the temperature

values measured in consecutive heating and cooling time intervals [4]. On this purpose, the temperature T is expressed as a function of time t as follows:

$$T(t) = \begin{cases} T_0 & 0 \leq t \leq t_0 \\ T_0 + \frac{A}{k} (1 - e^{-k(t-t_0)}) & t_0 \leq t \leq t_0 + \tau \\ T_0 + \Delta T_{on} e^{-k(t-t_0-\tau)} & t \geq t_0 + \tau \end{cases} \quad (1)$$

where T_0 is the initial temperature corresponding to the thermodynamic equilibrium reached before the e.m. irradiation for $0 \leq t \leq t_0$, whereas $\Delta T_{on} = T(t_0 + \tau) - T(t_0)$ is the temperature increase due to the electromagnetic irradiation during the power-on interval, $t_0 \leq t \leq t_0 + \tau$. The unknown parameters k , A , and ΔT_{on} of eq.1 are identified from the measured temperature data by linear regression analysis. The average SAR is calculated as follows:

$$SAR = c A = c \frac{k \Delta T_{on}}{1 - e^{-k\tau}} \quad (2)$$

where c is the sample specific heat capacity. In order to assess the SAR of the exposed biological sample and validate the results obtained from simulation, the aforesaid heating-cooling curve analysis has been applied.

Fig.1 shows the GTEM cell temperature measurement setup scheme. The signal generator and the amplifier are linked to the GTEM cell and a personal computer, via GPIB interface, different electromagnetic exposure conditions being allowed. An optical temperature control probe is inserted in the biological sample during the exposure and is connected, through the GTEM cell side door aperture, to its remote unit by an optical fibre. The temperature is recorded during the experiment by the computer connected to the remote unit via RS232.

Fig.2 reports the temperature variation in consecutive power-on and off intervals. By analysing the measured data (dots), the fitting curve (solid curve) is recovered by eq.1.

Therefore, by eq. 2, a SAR=1.1 W/kg is obtained for $P_{in}=1.5$ W.

III. CONCLUSION

A numerical and experimental procedure for

the assessment of the SAR of a biological sample exposed in a GTEM cell has been proposed. A good agreement between numerical (SAR=1 W/kg) and experimental (SAR=1.1 W/kg) results has been achieved for an input power $P_{in}=1.5$ W.

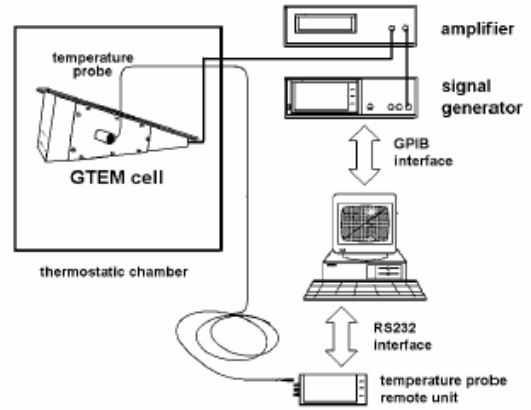


Fig.1 – Temperature measurement setup.

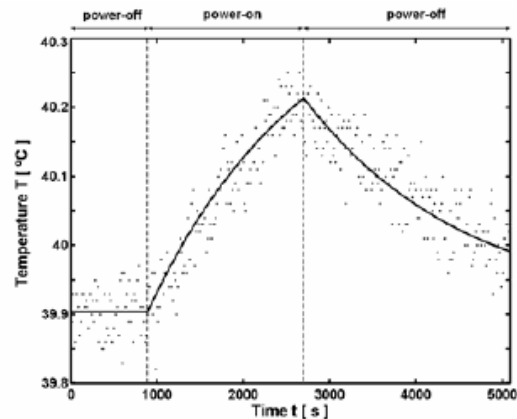


Fig.2 – Biological sample temperature vs time: measured values (dots) and fitting curve (solid curve).

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