Extension and Validation of the Equivalent Sources Helical Antenna Modeling with the FDTD Code

Gianluca Lazzi, Q.S. Yu, and Om P. Gandhi
Department of Electrical Engineering, University of Utah
50 S CENTRAL CAMPUS DR RM 3280, SALT LAKE CITY UT 84112-9206, USA
Ph: (801) 581-6941, Fax: (801) 581-5281, e-mail:lazzi@ee.utah.edu

1   Introduction

The Finite-Difference Time-Domain method (FDTD) is currently the most used numerical techniques for dosimetry of wireless devices. A concern is that the structurally complex antennas might not be modeled accurately. Specifically, helical antennas are often used and these are incompatible with rectangular grid FDTD without resorting to staircase approximation of the antenna geometry. We have introduced therefore in a previous publication [1] a new method to model small diameter normal mode helical antenna with the FDTD code for cellular telephone applications. This approach, that uses equivalent electric and magnetic sources to model the helix, has however not been previously tested for cases where the diameter of the helix may be more than two times the grid size. In this paper, we present a modified weighted equivalent source method and its experimental validation for these larger diameter helical antennas. The test case presented in this paper has been suggested by the IEEE Standards Coordinating Committe SCC-34 as a benchmark test to validate the modeling capabilities of the FDTD code for helical structures.

2   Geometry of the Test Case

The geometry of the proposed test case is shown in Fig.1. The glass sphere has a thickness of 5 mm, and radius 11 cm. The glass has a relative dielectric constant of 4, and the sphere is filled with a material of relative dielectric constant 42.8 and conductivity 1.125 S/m. The helical dipole has a length of 52.5 mm and a pitch of 2.45 mm, with a diameter of 7.82 mm. The specific absorption rate, or SAR, was required for three distances (d=0, 5, and 25 mm) between the helical dipole and the outer edge of the sphere. The test case is illustrated in Fig.1.

3   Modeling of the Helical Dipole

To model the proposed helical dipole it has been necessary to modify the formulation presented in [1]. In fact, to accurately model the lossy sphere, the FDTD grid resolution of 2.5

mm has been chosen. Being a near field problem, the helical dipole needs to be represented with a size close to the physical size of the antenna. The whole helical dipole of length 52.5 mm has been modeled, therefore, by using a stack of 21 layers, each of which are made of a 3×3 array of cells containing equivalent electric and magnetic sources. After calculating the relative weights of electric and magnetic sources according to the equations given in [1], the electric and magnetic field values have been split in each cross-sectional plane according to the scheme in Fig. 2.

4   Results

The FDTD-computed SAR has been compared with the SAR measured by using the University of Utah experimental SAR system described in [2]. We have compared experimental and numerical peak SARs, peak 1g SARs, and the SAR along the z-axis (Fig.1). The results have been normalized to a total radiated power of 0.5 W. Experimental and numerical values are fairly close, with a somewhat larger difference for the largest distance between the sphere and the helix, probably due to errors in the normalization caused by the very poor matching of the experimental helical dipole. Table I summarizes the SAR results, and Fig.3 shows the agreement between experimental and numerical data for the SAR along the z-axis of the sphere.

Acknowledgement

References

[1] G. Lazzi and O.P. Gandhi, "On Modeling and Personal Dosimetry of Cellular Telephone Helical Antennas with the FDTD Code," *IEEE Transactions on Antennas and Propagation*, Vol. 45, pp. 525-530, 1997.

[2] Q.S. Yu, O.P. Gandhi, M. Aronsson, and D. Wu, "An Automated SAR Measurement System for Compliance Testing of Personal Wireless Devices," sumitted to *IEEE Transactions on Electromagnetic Compatibility*.
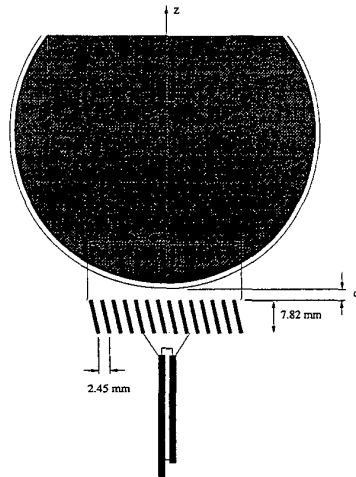
Figure 1: The geometry used for the exposure of the glass sphere filled with a lossy ($\epsilon_r = 42.8$, $\sigma = 1.125$ S/m.) material to a helix dipole.
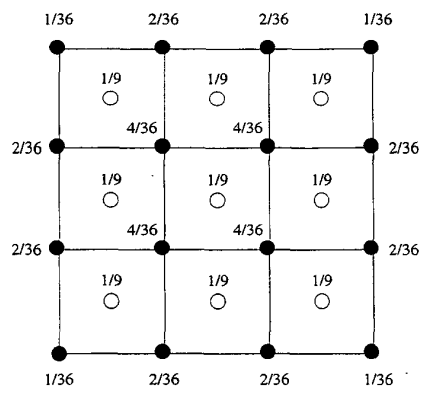

Figure 2: Relative weights of the equivalent sources for each cross-sectional plane used to model the helix.
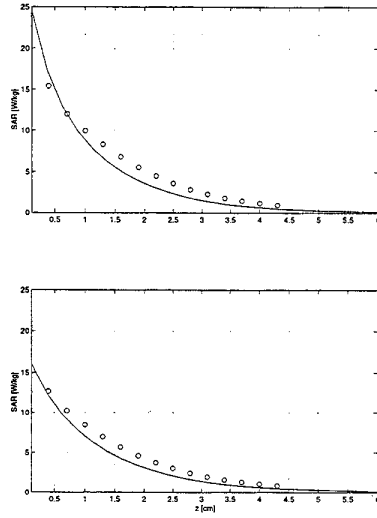
Figure 3: The FDTD-Computed and measured SAR distributions for the helical dipole at a distance d of 0 mm (top) and 5 mm (bottom) from the sphere. Continuous line: FDTD data; Circles: Measured data.

Table 1: The FDTD-Computed and Measured SAR Values for the Sphere at Four Different Distances d from the Helical Dipole. Frequency = 835 MHz, Radiated Power = 0.5 W

Distance d (mm)	Power Reflected %	Peak SAR (W/kg) - FDTD -	Peak SAR (W/kg) - Measured -	1-g Av. SAR (W/kg) - FDTD -	1 g Av. SAR (W/kg) - Measured -
0	86.5	24.60	23.42	16.00	14.81
5	60.5	16.06	17.19	11.15	11.05
25	36.4	3.21	4.81	2.46	3.47