Experimental Near-Field Method for Validating Simulation Antenna Models

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***Abstract*—Experimental validation of numerical antenna models are performed to verify the model accuracy before their use in larger scale simulations. Model validation is usually performed by comparing to measurements of the antenna or device under test. This verification is highly recommended in RF exposure simulations where the antenna model is employed as source within larger models (encompassing vehicles, human body, pavement, etc.). In exposure simulation, the model verification is required in terms of electric and magnitude fields in the near field (NF) region of the model. NF measurements at distances required for model verification in RF exposure scenarios are difficult and therefore with limited accuracy. The inverse source or equivalent current/source method (EQC) is a post processing technique. It determine equivalent electric and magnetic currents on a volume enclosing the antenna from measured near-field or far-field data. From the currents very accurate near fields on an arbitrary 3D surface can be determined.**

In this paper, we report the preliminary findings on using the EQC method combined with traditional near-field or far-field antenna measurements in the validation of numerical antenna models in RF exposure scenarios. An UHF monopole antenna working at 380-520 MHz is investigated using noise-free simulated data. The final validation of the method based on the measurement of the UHF Monopole antenna is on-going.

I. Introduction

Reference full wave numerical antenna models are widely used in Computational Electromagnetic (CEM) scenarios for evaluating and controlling items such as pattern distortion, inter-antenna coupling, near-field susceptibility and so on. Due to accuracy requirements of the full-wave models, their validation is an important step, with particular reference to the near field region. The model validation is performed here by comparison of the full wave simulated NF of the antenna model with experimental data in the same domain.

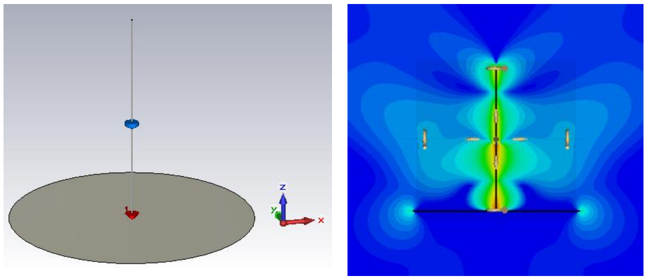
The main advantage of this approach is the possibility of using the experimental NF data to reconstruct the field in an arbitrary region or 3D set of points, starting from different NF scan geometries (sphere, cylinder, plane) or even Far Field (FF) data. The measured field is expanded using equivalent currents on a surface conformal to the antenna and the NF is subsequently derived in the same domain of the full wave simulation for comparison, for example a set of points along a line at a certain distance from the antenna.

The equivalent source representation of the measured antennas has initially been developed as an efficient diagnostics and echo reduction tool in general antenna measurement scenarios as described in [1-4].

II. Results

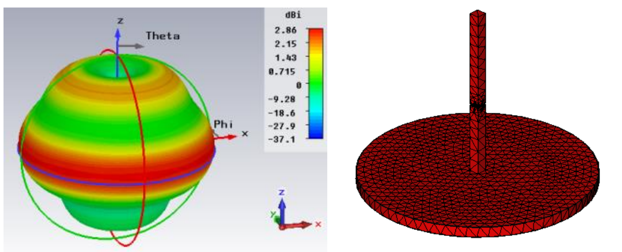
The accuracy and effectiveness of the proposed method are illustrated by an example, using the data free of the noise introduced by experimental measurements. The antenna model is a UHF monopole working at 380-520 MHz shown in Fig. 1. It features an inductive loading coil in the mid section of the antenna, placed on a 1000 mm diameter circular ground plane.

FF radiation pattern is simulated using the FDTD [5] numerical method in order to generate an input data for the NF reconstruction method. Such simulation based input data have been initially used to investigate the method capabilities without including the effects of measurement noise. As a first step, the simulated FF is processed by the EQC method to calculate the electric (J) and magnetic (M) equivalent currents on a surface conformal to the antenna using INSIGHT [3], as shown in Fig 2 and Fig 3. Then the E and H fields along the line at a 200 mm distance from the antenna axis have been calculated from the J and M currents. The test points are equally distributed on the line with 100 mm spacing.



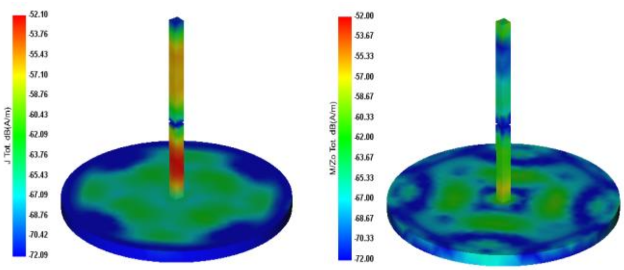
(a) (b)

Fig. 1. (a) UHF monopole working at 380-520 MHz; (b) Simulated NF radiation pattern, XZ plane, at 380MHz, 60dB dynamic range.



(a) (b)

Fig. 2. (a) Simulated Far Field at 380MHz; (b) Triangularly meshed recontructing geomentry.



(a) (b)

Fig. 3. (a) J, electric currents, (b) M, magnetic at 380MHz, 30dB dynamic range.

Comparison in terms of E field amplitudes between the NF FDTD simulated data and those obtained from processing based on the J and M equivalent currents is shown in Fig 4 at 380 MHz and at 532 MHz. The differences between the near fields can be expressed as an Equivalent Error Level according to Eq. (1).

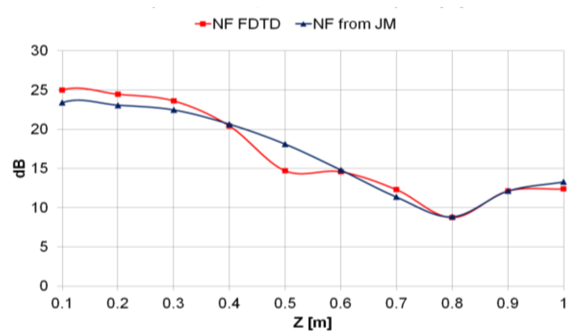
$$e_i(\theta,\phi)=\left|\frac{E(\theta,\phi)-\tilde{E}(\theta,\phi)}{E(\theta,\phi)}\right|\cdot\frac{\left|\tilde{E}(\theta,\phi)\right|}{\left|\tilde{E}(\theta,\phi)\right|_{MAX}} \qquad (1)$$

where

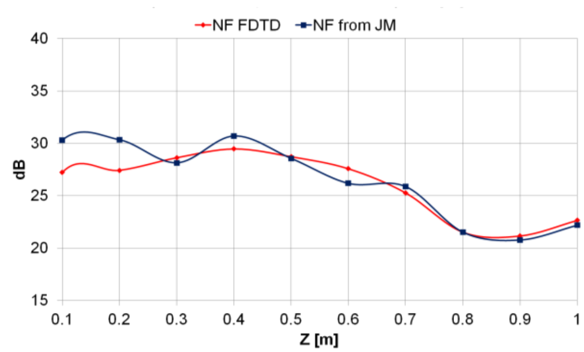
$\tilde{E}(\theta,\phi)$ is the reconstructed pattern,

$E(\theta,\phi)$ is the reference pattern.

Errors levels are -21.8dB @ 380MHz and -21.0 dB @ 532MHz. These are acceptable values, considering the close distance to the antenna and are in agreement with the findings in [2]. However, the maximum deviation between the two methods is high at a few specific distances reaching +1.6dB / -3dB @ 380MHz and +3.1dB / -1.4dB @ 532MHz. The preliminary investigation based on noise free simulated data is encouraging and confirm that the EQC method can be used efficiently in validating computational antenna models for RF exposure scenarios. A further validation of the method based on NF measurements data is on-going.



(a)



(b)

Fig. 4. Comparison of total electric field magnitude, simulated by FDTD method (NF FDTD) and calculated from the J and M equivalent currents (NF from JM) in the NF, line parallel to z axis, 200 mm from the antenna axis at equally distributed test points with 100 mm spacing (a) 380MHz; (b) 532MHz.

References

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