Characterisation of UWB antennas by their spatio-temporal transfer function based on FDTD simulations

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As any other complex rf-system that has to be brought to the market within a short development process, the design of UWB systems requires numerical simulations in an early stage where no prototypes are yet available and different implementations have to be tested. For UWB systems, the demands for the antenna are not limited to large bandwidths only. Other quality criteria, like low ringing and gain stability over the frequency range, are often requested [1] and are of course affected by the specific implementation of the antenna in the user environment.

In this paper a concept for the efficient characterisation of UWB antennas based on an FDTD calculation using EMPIRE™ software in combination with signal processing techniques is presented. It is the basic idea to consider the antenna as a LTI (Linear Time-Invariant) system completely characterized by its spatio-temporal transfer function [1, 2]. In order to assess the transmit transfer function it is sufficient to perform the EM simulation of the antenna only in a small nearfield region if the farfield characteristics is calculated by a nearfield-to-farfield-transformation. Using Lorentz' principle of reciprocity, the receive transfer function is calculated from the prior assessed transmit transfer function. Based on the transfer functions all other quality measures can be calculated [1]. In particular it is possible to predict the antenna performance in a realistic user environment by a numerical simulation.

In order to proof the above approach, the transmission between two identical biconical antennas is calculated by two methods. For the first method both antennas are modeled in the computational domain. While the first antenna is excited by a Gaussian pulse (1 GHz ≤ f ≤ 20 GHz) the second is positioned in a distance of 50 cm and receives the field radiated by the first antenna. This allows the calculation of the transmission in terms of s_{21}. For the second method only the farfield characteristics of one antenna is calculated by a FDTD simulation. The transmit and receive transfer functions of the antenna are determined using the above approach [2]. Therefore the transmission between two virtual antennas can be calculated by equation 1.

$$s_{21}(\omega) = \left.\frac{b_2}{a_1}\right|_{a_2=0} = \vec{A}_1\left(\hat{\vec{k}}_{12},\omega\right)\cdot\vec{h}_2\left(\hat{\vec{k}}_{12},\omega\right)\frac{e^{-jk_0 d}}{d} \qquad (1)$$

In equation 1 A_1 is the transmit transfer function of the transmit antenna and h_2 is the receive transfer function of the receive antenna assuming that the antennas are separated by the distance d. The comparison of the results from both methods in Fig. 2 shows a good agreement thus proves the implemented method and allows the calculation of all quality measures of interest based on the transfer function of the antenna.

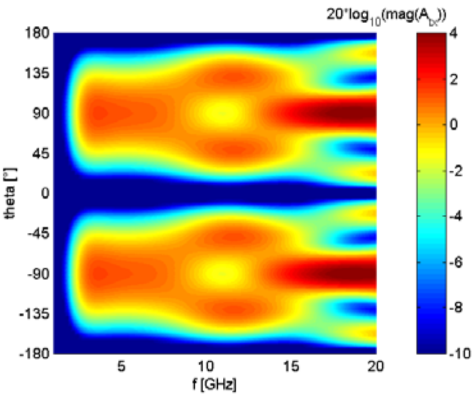

Fig. 1: TX transfer function of the biconical antenna in the E-Plane.

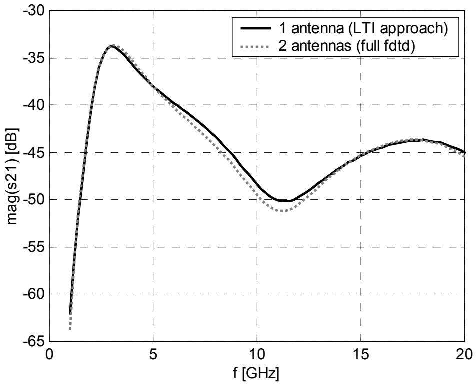

Fig. 2: Transmission between two biconical antennas positioned at 50 cm distance. Presented approach vs. full analysis.

[1] W. SÖRGEL, CH. WALDSCHMIDT, W. WIESBECK: Transient response of Vivaldi antenna and logarithmic periodical dipole array for ultra wideband communication. In: *AP-S – International Symposium on Antennas and Propagation*, Proc. on CDROM, Columbus (Ohio) USA, 2003

[2] J. KUNISCH, J. PAMP: UWB radio channel modeling considerations. In: Proc. Of ICEAA'03, Turin, Sep. 2003