Analysis of thin-wire antennas in the presence of double negative metamaterials with a hybrid FDTD-MoMTD technique

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The radiation properties of antennas are seen to undergo great changes when they are in the presence of materials. In previous works (A. R. Bretones, et a, IEEE Microw. Guided Wave Lett., 8, 281-283, 1998), a hybrid FDTD-MoMTD tool has been successfully employed to address problems involving arbitrarily oriented thin-wire antennas in front of inhomogeneous media (successfully employed in the simulation of breast tumor detection, ground-penetrating radar, etc.). The hybridization technique subdivides the total problem into two subproblems, each treated by the most appropriate method. The subproblems are interconnected by Huygens' principle, which, when using the FDTD method, allows us to replace the antenna by a set of equivalent sources.

Double negative metamaterials (DNGMTM) with simultaneously negative electric permittivity and magnetic permeability are becoming a topic of increasing research. Their theoretical properties, explored more than 30 years ago by Veselago (V. G.Veselago, Sov. Phys. Uspekhi 10, pp. 509-514, 1968), have recently begun to be experimentally tested (R. W. Ziolkowski and A. D. Kipple, IEEE Trans. Antennas and Prop., 51, pp. 2626-2640, 2003). The Finite Difference Time Domain (FDTD) method is a powerful tool that can be modified to analyze DNGMTM (M.W. Feise et al IEEE Trans. Antennas and Prop., 52, pp. 2955-2962, 2004), but cannot accurately handle arbitrarily oriented thin-wire structures.

In this work, we extend the FDTD-MoMTD hybrid method in order to treat the novel DNGMTM and thus simulate the behavior of thin-wire antennas in the presence of these materials. Several models of thin-wire antennas (dipoles, pre-fractal, etc.) are simulated, to show how the antenna parameters are affected (resonance frequency, input impedance, gain, directivity, etc.).