Constitutive Parameters Extraction in Cylindrical Structures

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One of the most popular methods for extracting the constitutive parameters of an isotropic material planar slab is the S parameter method. This is a well known procedure described in the literature (D.R. Smith, S. Schultz, P. Markos, C.M. Soukoulis, Phys. Rev. B 65, 195104, 2002 and X. Chen, T. M. Grzegorczyk, B.-I.Wu, J. Pacheco, J. A. Kong, Phys. Rev. E. 70.1, 016608, 2004). This method encounters a problem of ambiguity in the evaluation of the pairs of ε_r and μ_r, which can be solved by varying the width of the material slab. This method is unable to evaluate the constitutive parameters of a cylindrical 2D structure.

We propose a method for extracting the constitutive parameters of an isotropic, lossless, cylindrical, 2D dielectric structure using a bistatic RCS measurement procedure. The parameters ε_r and μ_r are unknowns for the mentioned structure. Initially, we measure the bistatic RCS of the structure. Then, we calculate analytically the bistatic RCS of the structure for different pairs of ε_r and μ_r. A search procedure is launched to evaluate the electrical parameters that best fit the actual RCS of the cylindrical structure. A fast algorithm based on an interpolation technique is used for the RCS calculation. Using the bistatic RCS at different angles, we show that it is possible to solve the ambiguity problem and get a unique set of constitutive parameters, without a need to change the frequency or the width of the material.

The proposed method can be used also for calculating constitutive parameters of 2D cylindrical metamaterials structures. Metamaterials are periodic structures, usually made of conductors and dielectrics. These structures have a very interesting and unusual properties, such as $\varepsilon_r<0$ and $\mu_r<0$ or $0<\varepsilon_r<1$ and $0<\mu_r<1$ (A. Alu, N. Engheta, ", IEEE Trans. on Antennas and Propagation, Vol. 58, 328 – 339, 2010). Using metamaterials, it is possible to design a planar lens with an ideal focal point, electromagnetic cloaking ,etc. Metamaterials can be analyzed using the unit cell concept. The geometry of the unit cell and the periodicity determine the effective material properties as a function of frequency. There are many works describing how to extract the constitutive parameters of planar, bulk, metamaterial structures, but if the structure is non-planar these techniques are not accurate due to the curvature of the structure. In our presentation, we will show how it is possible to extract the constitutive parameters of a 2D metamaterial cylindrical shell, in case that the unit cell is much smaller than the wavelength.

All simulations were performed using CST Microwave Studio commercial software in the frequency domain.