# Electromagnetic Scattering From Arbitrarily Shaped Three-Dimensional Chiral Objects Using The Finite Difference Frequency Domain Method

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There has been an increasing interest in recent years in artificial chiral materials in the microwave range. Electromagnetic propagation in chiral medium differs from the behavior of simpler, isotropic materials in several ways (I. V. Lindell, A. H. Sihvola, S. A. Tretyakov, and A. J. Viitanen, *Electromagnetic Waves in Chiral and Bi-isotropic Media*. Boston and London: Artech House, 1994). A linearly polarized wave propagating in a chiral medium undergoes a rotation of its polarization. Therefore chiral material has been proposed for many applications due to its unique electromagnetic property. Among them are antennas and arrays, antenna radomes, microstrip substrates and waveguides.

The analysis of chiral materials has been an important topic in computational electromagnetics. Numerical analysis of chiral materials has been carried out using a variety of numerical methods, such as the moment method (MoM), the finite-difference time-domain (FDTD) method, boundary value solutions (BVS) and so forth. In this paper, the finite difference frequency domain (FDFD) method has been used and its advantages have been discussed.

The FDFD formulation has been developed for the analysis of electromagnetic scattering from arbitrary configuration and composition of three-dimensional (3D) chiral objects. The termination of the computational domain is based on the perfectly matched layer (PML) approach developed by Berenger. The validity of the formulation for scattering problems has been confirmed by comparing the numerical results to exact and other numerical solutions. It is found that the proposed FDFD method shows excellent agreement. The effects of chirality on the scattered fields are also investigated. It is shown that adding chirality to the scatterer material causes significant changes to the co-polarized and cross-polarized field components. These changes can be tailored to produce a desired radiation pattern.