Uniaxial Depolarizing Dyad Artifact Removal via Spectral Domain Analysis

Michael J. Havrilla*
Air Force Institute of Technology, 2950 Hobson Way, WPAFB, OH 45434, USA

Vector potentials are frequently utilized in the electromagnetic analysis of problems involving simple (i.e., linear, homogeneous, and isotropic) media. In recent decades, various scalar and vector potential formulations have been investigated for the analysis of anisotropic and bianisotropic media. This interest has been greatly influenced by the significant developments in material fabrication capability and the phenomena associated with complex media. Uniaxial anisotropic media are particularly interesting from an application viewpoint due to the relative ease of manufacturing this type of material.

The goals of this paper are to first briefly review a scalar potential formulation for a magnetically and electrically uniaxial anisotropic medium. Next, expected and unexpected depolarizing dyad contributions are identified in the scalar potential development. It is discussed, from a physical viewpoint, why the unexpected depolarizing dyad should not exist. Based on this insight, the final goal is to demonstrate via two alternative methods that the unexpected depolarizing dyad is actually removable, thus leading to a physically and mathematically consistent theory.

The first method to demonstrate the removal of the unexpected uniaxial depolarizing dyad is a Green's function spatial domain analysis. It is shown that the field recovery process is related to the scalar potentials via spatial derivatives. Through proper handling of the source point singularity, it is rigorously demonstrated that an additional contribution that appears through careful application of Leibnitz's rule exactly cancels the unexpected depolarizing dyad term. The second method to demonstrate the removal of the unexpected uniaxial depolarizing dyad is a Green's function spectral domain analysis. It is shown here via Fourier transformation that a spectral domain term encountered in the complex-plane analysis appears which again exactly cancels the unexpected depolarizing dyad, leading to mathematical and physical consistency. A comparison of the advantages of the two techniques is provided.

* The views expressed in this article are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.