Green Function Formulation for Bi-Layered Uniaxial Parallel-Plate Waveguide

Adam L. Brooks*, Michael J. Havrilla
Air Force Institute of Technology, WPAFB, OH 45433 USA

A renewed interest in the use of anisotropic materials in electromagnetic applications has made it increasingly important to develop non-destructive evaluation methods for those materials in their installed configuration. These techniques are critical for manufacturing verification, material longevity studies, damage assessment, and maintenance. In many applications, these materials are permanently affixed onto conducting bodies to reduce unwanted reflections. This makes it impossible to collect S_{21} or S_{12} transmission measurements as used in many techniques based on the well-known Nicolson-Ross-Weir algorithm. It also makes it impractical to reorient the sample to collect orthogonal measurements aligned with the optical axes of the anisotropic material. The goal of this research is to develop a two-reflection coefficient measurement method for extracting constitutive parameters from non-destructive interrogation of a conductor backed uniaxial material using a flanged rectangular waveguide probe.

The two reflection coefficients may be experimentally obtained in the following manner. First, the flanged rectangular waveguide probe is placed directly onto the conductor backed unknown uniaxial material and the corresponding reflection coefficient is measured via a network analyzer. The second reflection coefficient measurement involves placing a known uniaxial material between the flanged probe and the unknown uniaxial layer. Note, by placing the probe onto the unknown conductor backed material, a single or bi-layer parallel plate region is formed. Expressions for the theoretical reflection coefficients are found via a Green function development using a scalar potential formulation. Subsequent comparison of the experimental and theoretical reflection coefficients via nonlinear least square optimization leads to the extracted material properties of the unknown uniaxial layer. The details of the bi-layer Green function development, as well the corresponding complex plane analysis, are expounded. The simplicity and physical insight gained through the use of the scalar potential formulation is discussed. Future research efforts are also provided.

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