Natural Mode Description of the Transient Field Reflected by a Planar Layer of Debye Material

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Layered materials are often applied to conducting surfaces for the purpose of reducing the scattered field strength within specific frequency bands. A wideband pulse may be used to interrogate the layered structure so as to characterize the materials or determine whether the materials have degraded. If the late-time behavior of the reflected field can be expressed as a natural resonance series, then techniques such as the E-pulse method (G.J. Stenholm, et. al., *IEEE AP-S Int. Symp.*, Boston, 2001) can be used to determine whether the material properties have changed compared to baseline values determined by previous measurements.

We have shown previously (E. Rothwell, et. al., URSI North American Radio Science Meeting, San Antonio, 2002) that the transient field reflected from a conductor-backed planar layer with frequency-independent material parameters (permittivity, permeability, and conductivity) has both an early-time and a late-time component. The early-time component consists of the reflection of the incident wave from the air-slab interface. The late-time component is produced by the ensuing multiple reflections within the slab, and is a pure natural resonance series. To show this it was necessary to identify the two branch points arising in the inverse Laplace transform of the frequency-domain reflection coefficient, and to show that there is no contribution from the integral around the branch cut. In this paper we analyze the transient field reflected by a conductor-backed slab of Debye material with frequency-dependent permittivity. The Debye material gives rise to a frequency-domain reflection coefficient with two pairs of branch points. We show that there is no contribution from the integral around the two associated branch cuts, and thus the late-time scattered field is again a pure natural resonance series.

Results computed using the resonance formulation are verified by comparison to the direct inverse Fast Fourier Transform. The distribution of resonance frequencies in the complex plane and their dependence on the Debye parameters are examined.

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