Free Space Characterization of Conductor-Backed Absorbing Materials Using an Aperture Screen

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ABSTRACT

Absorbing materials are often adhered to conducting surfaces for the purpose of controlling the electromagnetic field scattered by objects. Many of these materials have both electric and magnetic properties, and these properties may degrade with time, thereby decreasing the effectiveness of the coatings. Because of this, it is important to accurately assess the health of the coatings by interrogating them with an electromagnetic wave and analyzing the interaction of the wave with the coating materials. Ideally, the permeability and permittivity of the coatings would be measured and compared to baseline values. Since these measurements must be done in the field, the materials cannot be removed from the underlying conducting surfaces.

One convenient way to measure the permittivity and permeability of coatings is to illuminate a coated surface using an antenna placed at a certain standoff distance from the coated object. Standoff techniques do not involve physical contact with the coatings and thus reduce the possibility of damaging the coating during the measurement process. Because both complex permeability and complex permittivity are desired, two sufficiently different measurements of the complex reflected field are required. Previous studies have shown that varying the polarization or incidence angle of the interrogating field does not provide enough variation on the reflected field for robust measurements of the material parameters. These studies have also shown that applying a material layer in front of the coating does not alter the information about the coating available from measurements of the reflected field, and is thus ineffective.

In the technique proposed here, one measurement is made by illuminating the coated surface with a plane wave and a second measurement is made by illuminating the coated surface with a conducting screen containing an aperture placed immediately on top. This approach has proven effective with a waveguide contact probe, and the purpose here is to assess its viability as a free-space technique. The specific case of a narrow rectangular aperture is emphasized due to its simplicity of analysis compared to other aperture shapes. The constitutive parameters are extracted by comparing the measured reflected field in the presence of the aperture to the reflected field obtained from a numerical model that has been developed. The model is based on plane wave excitation of an infinite layered medium with the reflected field found by numerically solving a magnetic field integral equation. The numerical
solution is validated by using a radiation problem with a line source placed in the aperture. Error analysis is used to compare the efficacy of the proposed aperture method to that of the two-thickness method (which, although effective, cannot be applied in the field). Calibration of the approach is also considered and measured results are described.