A Comparison of One-Tier and Two-Tier Stripline Calibration Techniques for Applications in Electromagnetic Material Characterization Measurements

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Electromagnetic material characterization is the process of determining the permittivity and permeability of a sample. A stripline field applicator can be utilized to facilitate measurement of these constitutive parameters, especially since it is an inherently broadband device that supports a relatively uniform TEM field distribution, has a larger cross-sectional area than a 7 mm coaxial sample holder, can be clamped (thus eliminating the effects of gaps) and has an easily-machinable sample geometry. A critical part of the material characterization process is achieving an accurate calibration. The goal of this paper is to present and compare two types of frequency-domain stripline calibration schemes, referred to here as one-tier and two-tier techniques, and the resulting effect that these techniques have on measurement accuracy.

The overall objective of the above material measurement process is to experimentally obtain the sample scattering parameters using a network analyzer and compare them with their theoretical expressions, that is

$$S_{11}^{thy}(\omega, \varepsilon_r, \mu_r) - S_{11}^{exp}(\omega) = 0$$
$$S_{21}^{thy}(\omega, \varepsilon_r, \mu_r) - S_{21}^{exp}(\omega) = 0$$

These coupled equations can be solved for ε_r and μ_r in closed form using the well-known Nicolson-Ross-Wier procedure. However, the front and back sample planes are not immediately accessible for the measurement of S_{11}^{exp} and S_{21}^{exp}, therefore an initial stripline calibration must be performed. In the two-tier calibration scheme, the network analyzer is first calibrated to the end of the network analyzer 7mm cables using the internal network analyzer cal kit and associated 7mm calibration standards. During the secondary stage, specialized stripline standards are utilized to remove the effects of the stripline transition regions. In comparison, the one-tier calibration involves immediate calibration of both the cables and stripline device in one stage. Consequently, the one-tier calibration scheme requires fewer measurements and subsequently leads to enhanced accuracy.

The permittivity and permeability of various samples will be determined and a comparison will be made using both calibration schemes. Details of the stripline calibration techniques and corresponding measurement procedure will be presented and discussed.

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