

MEASUREMENT
METHODS FOR THE BROADBAND CHARACTERIZATION
OF DIELECTRIC SUBSTRATES

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The Electromagnetic Properties of Materials Project was established at the National Institute of Standards and Technology (NIST) in order to develop and evaluate measurement methods for characterizing the high-frequency electrical properties of dielectric and magnetic materials. Recently, this project has focused on evaluating techniques for measuring the relative permittivity and loss tangent of low-loss dielectric substrates such as printed-wiring boards, ceramic substrates, and other packaging materials as a function of frequency.

With the increasing interest in system performance and the advent of new applications over a wider frequency range, substrate manufacturers are developing new, high-performance substrate materials. In order to build microwave components, engineers must know the frequency-dependent electrical properties of these new materials. However, due to the many techniques available in the literature, selecting an appropriate measurement method can often be difficult.

In this presentation, we will overview four nondestructive techniques that are appropriate for measuring the relative permittivity and loss tangent of dielectric substrates over the frequency range of 1 to 60 GHz. For metal-clad substrates, we will overview the full-sheet resonance method. Next, we will discuss measurements of unclad substrates at microwave frequencies using split-cylinder and split-post resonators. Finally, we will consider the Fabry-Perot resonator for measurements of unclad substrates at millimeter frequencies. The frequency range, complexity of the theoretical model, sample geometry, orientation of the electric and magnetic fields, and overall measurement accuracy varies greatly between these four techniques. To understand the applicability of each method, we will discuss each of these variables and summarize the merits and limitations of the four measurement techniques.

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