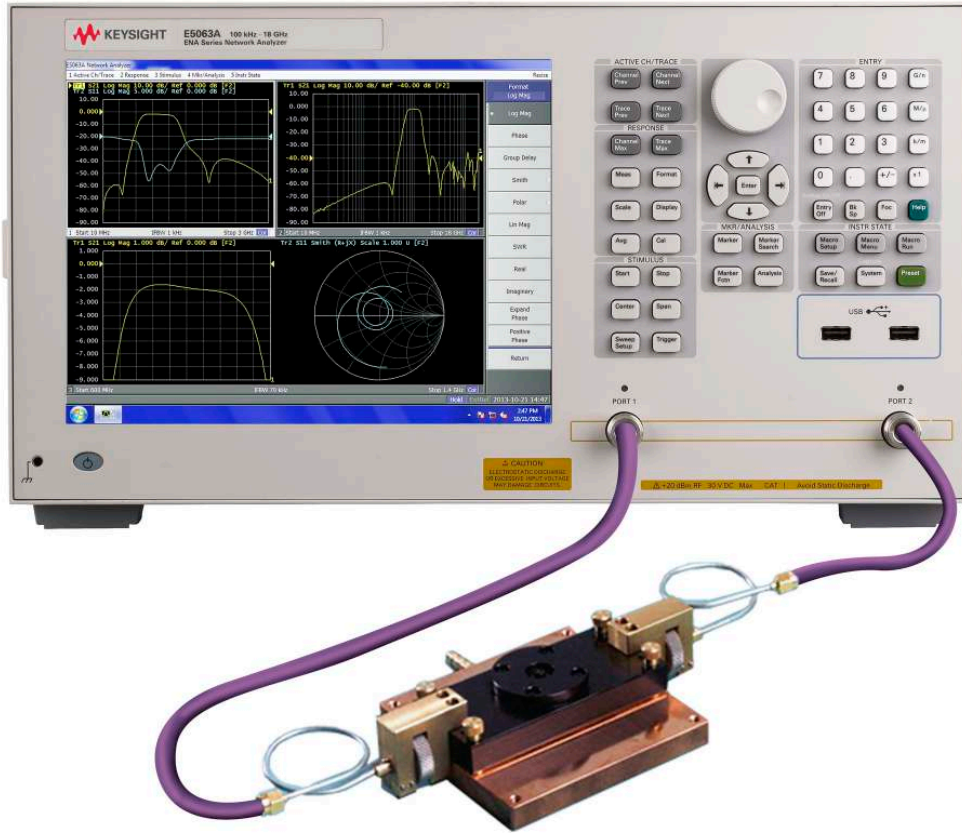


Keysight Technologies

Materials Measurement: PCB Materials

Application Brief



Overview

The dielectric properties measurement such as relative permittivity (dielectric constant: Dk) and dielectric loss tangent (dissipation factor: Df) is essential for the development and quality assurance of PCB materials. Traditionally, the dielectric properties of PCB materials for commercial use have been tested at relatively low frequencies such as 1 MHz and 1 GHz. The required measurement frequencies are being increased in line with the trend to higher data transfer speeds for mobile handsets, PCs and tablet devices. For example, PCB materials for wireless communication devices are tested at frequency points between 1 GHz and 10 GHz frequency range.

E5063A network analyzer with 85071E Option 300 software

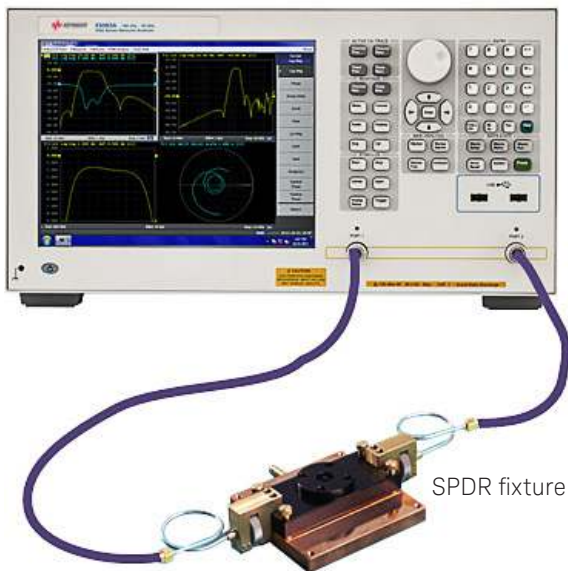


Figure 1. Typical system configuration with SPDR

Problem

PCB materials require low dielectric loss tangent to keep low transmission loss of digital signals. So, measurement systems are required to measure dielectric properties accurately against low loss materials (Df is around 10^{-3}). Because the values of dielectric properties are frequency dependent in general, users need to measure dielectric properties at several frequency points to evaluate the quality of the PCB material.

Solution

The resonant cavity method provides high accuracy in the measurement at specific resonant frequency points. You can measure Dk and Df at multiple frequency points with high-order resonant frequencies or using plural resonant cavities. For example, the method with Split Post Dielectric Resonators (SPDR) is one of the easiest and highest accuracy methods for measuring complex permittivity and loss tangent of low loss and thin sheet materials¹. It can provide a convenient, accurate, and nondestructive measurement of a substrate and printed circuit board. The SPDR fixtures can be purchased in single frequencies from 1 to 22 GHz from QWED or through Keysight Special Handling Engineering. Keysight offers a complete solution that includes the 85071E Option 300 software and an Keysight vector network analyzer^{1,2}.

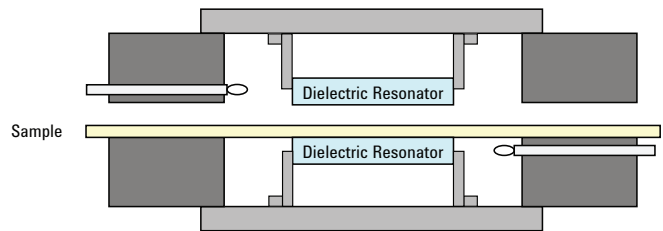
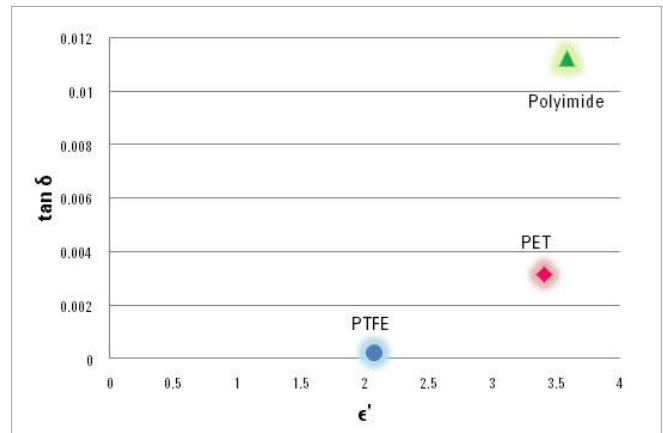


Figure 2. Structure of Split Post Dielectric Resonator (SPDR)



If you need to measure dielectric properties with very wide frequency ranges for preliminary investigation, the transmission line method can be used². A trade off of the transmission line method is that the measurement accuracy is reduced for very low loss materials⁷. One recommendation would be the combination of the resonant cavity method and the transmission line method. You can get broad frequency range results with the transmission line method first, then use a resonant cavity to acquire more precise results for frequency points of interest.

Conclusion

The resonant cavity method is gaining in popularity as a response to the growing measurement needs at higher frequencies for PCB materials measurements. The transmission line method can complement the resonant cavity method with its availability for a wide frequency range measurement. For more information, applications notes and white papers are available under references.

The following table shows the typical frequency ranges depending on measurement methods.

Methods	Typical frequency range
Parallel plate	Up to 1 GHz
Transmission line	100 MHz to 110 GHz
Resonant cavity	1 GHz to 40 GHz

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8. *Solutions for Measuring Permittivity and Permeability with LCR Meters and Impedance Analyzers*, Application note, Literature number 5980-2862EN

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