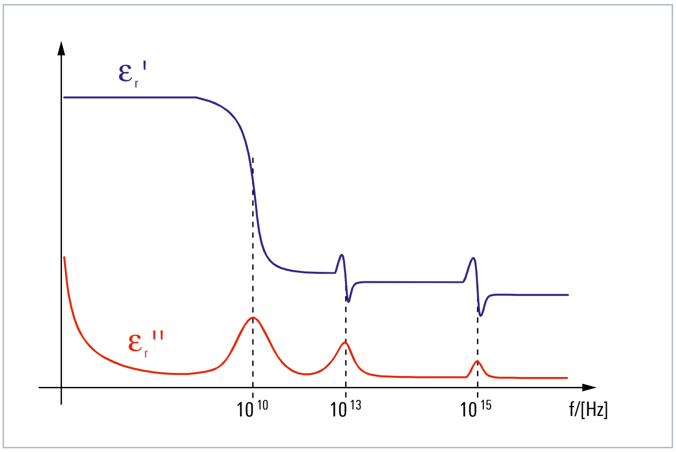
RF characterization of solid materials
Application

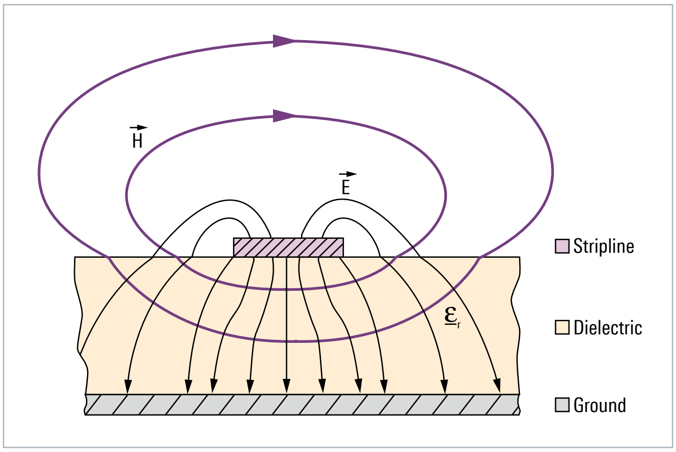
Dielectric constants such as permittivity, permeability or loss tangent can be determined easily with R&S®ZVA/ZVB/ZVT one-box solutions



The complex permittivity (ε_r', ε_r'') describes the frequency-dependent behavior of materials in the RF and microwave range.

Your task

Measurements of complex dielectric properties of materials are becoming more and more important. Particularly for applications such as designing printed RF circuits or developing absorbing materials, accurate measurements of permittivity and permeability are essential.



Different propagation velocities in the air and inside the printed board material impact the RF circuits.

The behavior of material used for a printed board is normally described by its dielectric constant. The dielectric constant shows that the propagation velocity of electromagnetic fields inside the dielectric material differs significantly from the propagation velocity through the air. To minimize dispersion effects, this behavior needs to be taken into account during the development phase of printed RF circuits.

Another typical application for solid material measurements is the characterization of absorber materials. Such materials are commonly used in anechoic chambers. Special coating materials are also used on building facades, for example in and around an airport, to minimize unwanted radar reflections. The information about the energy losses within the absorber material is of interest, and is expressed by ε_r'' of the complex dielectric constant or the loss tangent.

T&M solution

The R&S®ZVA/ZVB/ZVT vector network analyzers offer a material characterization routine that not only handles data acquisition, but also automates the calculation of the complex permittivity, permeability, loss tangent and conductivity of the material under test. Two different measurement methods are supported in order to cover the individual test requirements.

The transmission/reflection (T/R) method is applied to determine the complex permittivity and the complex permeability using a coaxial or a waveguide transmission line. For the resonator method, a split-post dielectric resonator (SPDR) is used to define the permittivity and the loss tangent of the material under test.

T/R method

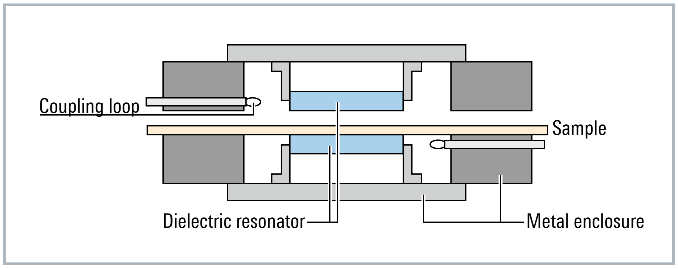
The T/R method is based on the Nicholson-Ross-Weir algorithm. The complex permittivity **and** the complex permeability are calculated from the S_{21}- and S_{11}-parameters, which are obtained by performing transmission and reflection measurements with the R&S®ZVA/ZVB/ZVT.

The material to be tested must be placed either in a coaxial air line or in a section of a waveguide depending on the frequency required. Measurements in the range from 300 kHz to 67 GHz are performed with an R&S®ZVA/ZVB/ZVT. By using additional R&S®ZVA-Zx converters, the frequency range can be extended up to 325 GHz. The measurement results are graphically displayed in traces as well as recorded in a table. This data can be read out to an external PC.

The advantage of using a coaxial air line is that measurements over a wide frequency range from several kHz up to the microwave range are possible. The advantage of waveguides is the simple preparation of the test samples.

Resonator method

The resonator method is used to measure the permittivity and dielectric loss tangent of laminar dielectrics at a fixed frequency. Different resonators between 1 GHz and 20 GHz are available. The complex permittivity is calculated on the basis of the measured resonance of the resonator, with and without the sample, and the sample thickness.



Schematic of the SPDR.

The resonator is connected to the R&S®ZVA/ZVB/ZVT through the coupling loops. For the measurement, the flat sample is inserted through one of the open sides of the SPDR. The bandpass search function of the network analyzer supports automatic measurement of both the resonance frequency and the Q-factor – in just one step.

Besides being easy to use, the advantage of the resonator method is its high measurement accuracy. The uncertainty predominantly arises from determining the actual thickness of the test sample. In addition, the SPDR is suited for very thin and low-loss test samples.

Conclusion

The described test setups from Rohde & Schwarz offer a convenient and flexible solution that allows you to determine the material constants of your solid materials with high precision and in line with your needs.

Setups for material measurement tests using the R&S®ZVA/ZVB/ZVT

The clear layout of the user interface of the R&S®ZVA/ZVB/ZVT vector network analyzers facilitates the determination of important material constants of solid materials based on the T/R method (top) or the resonator method using an SPDR (bottom).

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