

# Measurement of Dielectric Material Properties

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## 1 Introduction

Material measurement is integral when developing solutions in the millimeter-wave (mmWave) frequency range, it can provide the electrical or magnetic characteristics of the materials, which proved useful in many research and development fields. PCB, antenna, material science, microwave circuit design, biological research, and automotive engineers along with metrology and research institutes must characterize various materials to better understand their effects on electromagnetic wave propagation to achieve more expected designs, or to test manufacturing processes to control product quality, etc. Similar questions from different applications create a continual demand to accurately measure dielectric and magnetic properties of materials.

As of today, the industry mostly uses vector network analyzer, impedance analyzer and LCR meter and other instruments and algorithm software, combined with various professional fixtures, to achieve accurate measurement of material electrical permittivity and magnetic permeability through various methods. Each method has its application field, which depends on several factors: frequency range, expected values of  $\epsilon_r$  and  $\mu_r$ , required measurement accuracy, material properties (i.e. homogeneous, isotropic), material form (i.e. liquid, powder, solid, sheet), sample size restrictions, destructive or nondestructive, contacting or non-contacting, temperature and cost.

The application note describes the transmission line method to measure material dielectric properties using a vector network analyzer, methods for converting the S parameters to dielectric properties, and through the real case study shows the wide applicability of VNA as a characterization tool of high-frequency materials and the SIGLENT material test solution. Note that the conversion methods discussed is only suitable for solid material measurement.

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### **North American Headquarters**

SIGLENT Technologies NA  
6557 Cochran Rd Solon, Ohio 44139  
Tel: 440-398-5800  
Toll Free: 877-515-5551  
Fax: 440-399-1211  
[info@siglent.com](mailto:info@siglent.com)  
[www.siglentamerica.com/](http://www.siglentamerica.com/)

### **European Sales Offices**

SIGLENT TECHNOLOGIES GERMANY GmbH  
Staetzlinger Str. 70  
86165 Augsburg, Germany  
Tel: +49(0)-821-666 0 111 0  
Fax: +49(0)-821-666 0 111 22  
[info-eu@siglent.com](mailto:info-eu@siglent.com)  
[www.siglenteu.com](http://www.siglenteu.com)

### **Asian Headquarters**

SIGLENT TECHNOLOGIES CO., LTD.  
Blog No.4 & No.5, Antongda Industrial Zone,  
3rd Liuxian Road, Bao'an District,  
Shenzhen, 518101, China.  
Tel: + 86 755 3661 5186  
Fax: + 86 755 3359 1582  
[sales@siglent.com](mailto:sales@siglent.com)  
[www.siglent.com/ens](http://www.siglent.com/ens)