- Short technical notes

Portable Dielectric Measurement Kit

Dielectric Materials have many applications ranging from microwave components and subsystems to industrial and manufacturing processes. The precise knowledge of the dielectric properties of these materials is very important for industrial as well as scientific microwave applications success.

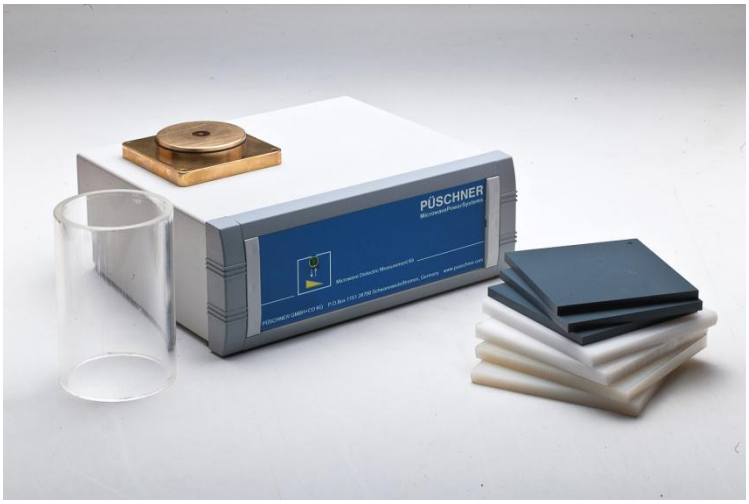

Fig. 1. The Portable Dielectric Measurement Kit (PDMK) with the container for measurement of liquids and powders

The Portable Dielectric Measurement Kit (PDMK) is a new instrument designed to determine the complex permittivity for a wide range of solid, semi-solid, granular and liquid materials around the ISM frequency of 2.45 GHz. Unlike other instruments, it performs automatically all the necessary control functions, generation and analysis of microwave signals, data processing, dielectric calculation, storage and display of results. The PDMK is able to measure low, moderate and high loss dielectric materials with the same set-up.

Measurement Principle

The dielectric measurement probe has been designed as an open-endend coaxial resonator probe (see Figs. 1 and 2) where the microwave signals interact with the material.

When the material is touching the open resonator, electromagnetic fields fringe into the material under test (DUT) and change due to the dielectric properties of the sample, affecting the signal reflected back to the resonator. From these reflection measurements, the resonant frequency and quality factor are determined and related with the dielectric properties by using an in-house developed numerical procedure.

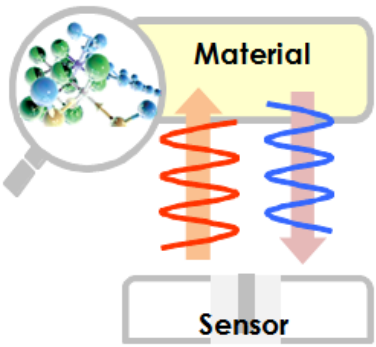

Fig 2. Sensor tip with microwaves interacting dielectric material.

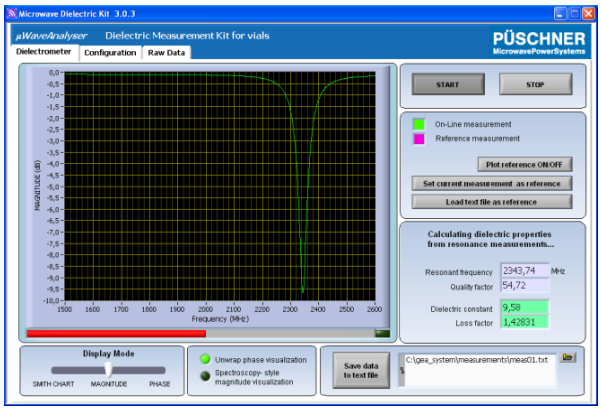

Fig 3. Labview-based Control Panel

A Labview-based software has been developed to perform automatically all the necessary functions with a user-friendly interface. Fig. 3 shows a screenshot of the main labview control panel with resonant response, typical of a measurement of the device.

Despite of the equipment is specially designed for solid materials, liquid or powder materials can also be measured by using a sealed container to keep the material in contact with the sensor tip. Polymers, wood, food, powders, liquids, etc. are materials that can be measured by the PDMK.

Dielectric properties are composed by two independent measured parameters (dielectric constant -ε'- and loss factor -ε''-) which can also be related with other physical parameters (i.e., moisture, curing, density, chemical reaction, ageing, etc.)

Technical Specifications

- Frequency range: 1.5GHz to 2.6GHz (nominal, limited by MUT properties)
- Dielectric constant: ε′<100, Loss factor: 0.001<ε″<10 (more than four orders of magnitude)
- Accuracy: about 1% in dielectric constant and 2-5 % in the loss factor (depending on the range)
- Microwave power level: 0 dBm
- Communication with PC: USB link
- Operating Temperature: 10-50 °C
- Required OS: Windows XP/Vista/7

The following table shows some measurements of common materials. Comparisons with other measurement methods or published data are also included.

Material	ε'_r	ε''_r	ε'_r (References)	ε''_r (References)	References
PTFE	2.049	0.0006	2.050	0.0006	[1]
PVC	2.898	0.0227	2.919	0.0229	[2]
Nylon	3.092	0.0474	3.082	0.0440	[2]
Acetal	2.977	0.1239	2.968	0.1290	[2]
Crosslinked Polyestirene	2.532	0.0018	2.540	0.0017	[3]
Water	76.782	5.8634	77.594	5.3608	[4]
Methanol	24.461	11.9626	25.738	12.7004	[5]
Dimethil Sulphoxide	44.529	8.6168	45.222	8.1670	[5]
2-Propanol	3.852	3.1081	3.967	2.9999	[5]

[1] “Measurement of dielectric material properties”, Application Note, Rodhe&Schwartz.
[2] F. L. Penaranda-Foix et al. (2010). Passive Microwave Components and Antennas, Ed. INTECH
[3] Krupka et al (1998) *Meas. Sci. Technol*. 9 1751
[4] A. P. Gregory et al., National Physics Laboratory Report MAT 23, 2009.
[5] D.V. Blackham (1997) *IEEE Trans. On Intrum. And Meas*., Vol. 46, No.5.