

- Short technical notes

Dielectric Kit for Vials

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. Dielectric Kit for Vials (DKV) in two formats (standard vials of 1ml and 8 ml)

The Dielectric Kit for Vials (DKV) is a new instrument designed to determine the complex permittivity (dielectric constant and loss factor) of a wide range of liquid, granular or powdered materials around the ISM frequency of 2.45 GHz.

The equipment is a complete solution which includes all necessary components to perform the generation, separation, control and analysis of microwave signals, calculation of dielectric properties and display of results. Calibration or adjustments with reference liquids is not necessary, and measurement of sample dielectric properties is simple, fast and convenient. Although other available instruments, the dielectric kit for vials is able to measure low, moderate and high loss dielectric materials with the same set-up.

Two versions of the Dielectric Kit for Vials have been designed depending on the sample volume to measure. Standard quartz or polypropylene vials of of 1mL or 8 mL are employed as sample holders.

Despite of this equipment is specially designed for liquid, granular or powdered materials. Solid materials might be measured if machined in rod shape with the inner vial dimensions. Pharmaceutical powders, nanopowder, food, liquids, etc. are materials that can be measured by the DKV.

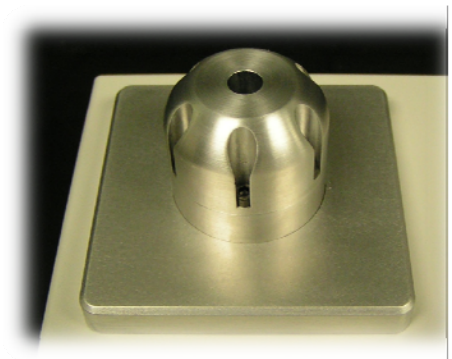


Fig 2. Top of the Microwave Sensor

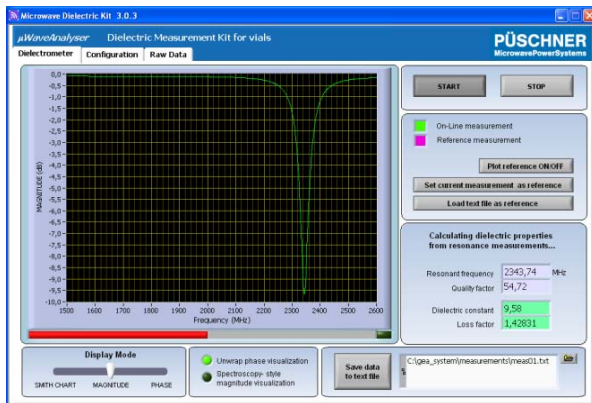


Fig 3. Labview-based Control Panel

Operation Principle

The dielectric probe is an aluminium resonator where the microwave signals interact with the material. Vials containing the material under test are introduced in the resonator through a hole at the top of the probe. After sample insertion, the resonant frequency and quality factor of the resonator is shifted. From the measurement of the shifted response, the complex permittivity of the sample is calculated by using the electromagnetic model of the structure by a numerical procedure.

The Vials Dielectric Kit is fully controlled by a Labview-based software, which has been developed to perform all the necessary functions with a user-friendly interface.

Technical Specifications

- Frequency range: 1.5GHz to 2.6GHz (nominal, limited by MUT properties)
- Dielectric constant: $\epsilon' < 100$, Loss factor: $0.001 < \epsilon'' < 10$
- Accuracy: about 1% in dielectric constant and 2-5 % in the loss factor (depending on the range)
- Microwave output: 0 dBm
- Communication with PC: USB (Speed of communication: 115 kbits/sec)
- Operating Temperature: 22-50 °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	Dielectric Constant	Loss Factor	Diel. Constant (Published)	Loss Factor (Published)	References
Water	77.79	7.371	77.83	6.789	[1]
Methanol	24.68	13.653	24.96	14.188	[1]
Dimethyl Sulphoxide	45.51	8.790	45.02	8.966	[1]
2-Propanol	3.80	2.909	3.89	2.724	[1]
Quartz sand	2.49	0.003	2.27	0.012	[2*]
Granular Paraffin	1.71	0.001	1.77	0.011	[2*]
Powdered Milk	2.06	0.072	2.12	0.068	[2]
SiC	8.57	1.289	8.49	1.335	[2]
Perlite	2.68	0.018	2.73	0.011	[2]

[1] A. P. Gregory, R.N. Clarke, National Physics Lab. Report MAT 23, 2009.

[2] Measurements with Agilent coaxial probe HP-85070B. (*Not suitable for low losses materials)