USING NETWORK ANALYZERS TO MEASURE FLUIDS, GELS AND SOLIDS

Measure the dielectric characteristics of various material types

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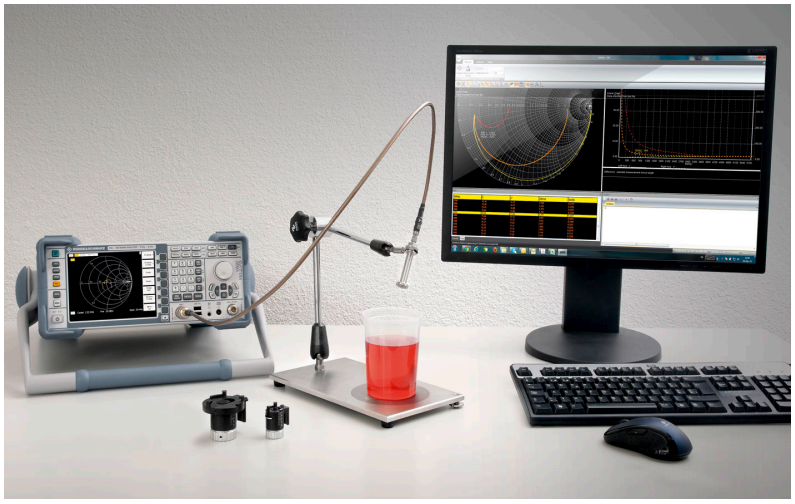
Rohde & Schwarz vector network analyzers are not just for analyzing electronic circuits. Together with a measurement kit from the Swiss company SPEAG, they can also measure the dielectric characteristics of numerous types of materials. There are many different application areas, such as electronics and medicine and the chemical and food industries.

WANTED: COMPLEX PERMITTIVITY

In many industrial applications, it is necessary to determine the dielectric characteristics, for example the specific absorption rate (SAR), of fluids, gels or solids in order to determine the influence of cellular network signals on the human body. The gel-like substances used to simulate the human body must exhibit specific characteristics.

A suitable measurement setup consists of an R&S®ZVL, R&S®ZNC or R&S®ZNB and a dielectric assessment kit (DAK) from the Swiss company SPEAG (see figure). This material measurement kit contains one or more measurement probes, a fixture for the cable connected to the network analyzer, a calibration block (short) and the control and evaluation software. The analyzer provides the measurement data necessary to calculate the properties of the dielectric material, e.g. complex permittivity (ε', ε'', σ, tan δ).



Measurement setup with the R&S®ZVL network analyzer and the SPEAG DAK material measurement kit

HIGH-QUALITY MEASUREMENT PROBES – CRUCIAL FOR MEASUREMENT QUALITY

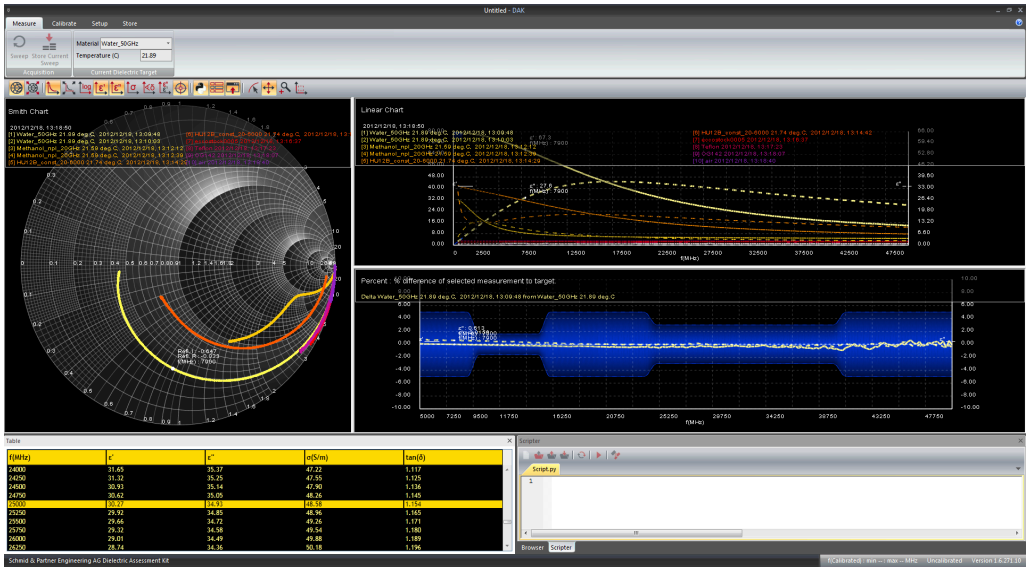
In addition to a phase-stabile network analyzer, the measurement probes – in particular their material and geometry – are crucial for high-quality material measurements on fluids and gels. The corrosion-resistant probes from SPEAG with their smooth surfaces are easy to clean. This prevents build-up of fluid residue that could lead to incorrect measurement results. Thanks to their sophisticated characteristics, the probes ensure good measurement reproducibility. Probes are available for the frequency ranges from 10 MHz to 3 GHz, 200 MHz to 20 GHz and 5 GHz to 50 GHz. All of the probes have been characterized by the manufacturer for frequency and for numerous dielectric materials. Solids can be measured nondestructively if the material under test is sufficiently large and thick so that reflections do not appear at the edges. In the near future, it will also be possible to characterize thin materials such as printed circuit boards.

CALIBRATION – DIFFERENT THAN NORMAL

In order to calibrate the measurement setup, one-port error correction is performed using the open, short and match (OSM) calibration standards. The open is created using dry probes that have not been submerged in the fluid. The short is created using a copper plate that is placed in a calibration block and tightened against the probe contact surface with set screws in order to obtain the best possible termination of the probe. The match is created by immersing the probe in a fluid with known properties that are stored in software, for instance in water and ethanol or in a gel.

MEASUREMENT RESULTS IN DIAGRAMS AND TABLES

The control and evaluation software controls the network analyzer and configures all necessary measurement parameters. The raw data measured by the analyzer can be optionally visualized in a Smith chart or in linear or logarithmic form. Results can also be compared against stored reference curves for various materials. Threshold bands and measurement uncertainty ranges facilitate evaluation of results. Tabular display of the measurement data is supplemented by graphical representations.



Comparison of measurement results for various materials

ADVANTAGES OF MEASUREMENTS WITH PROBES

Compared to other methods, e.g. the waveguide and resonator methods, the use of measurement probes has the advantage that it allows characterization of fluids and gels. The characteristics of solids can also be determined without needing to cut the material to waveguide size or to make the material match the dimensions of the resonator. Finally, the same measurement system can be used to characterize a large number of different materials – a broad application area for Rohde&Schwarz vector network analyzers.

Rohde&Schwarz
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