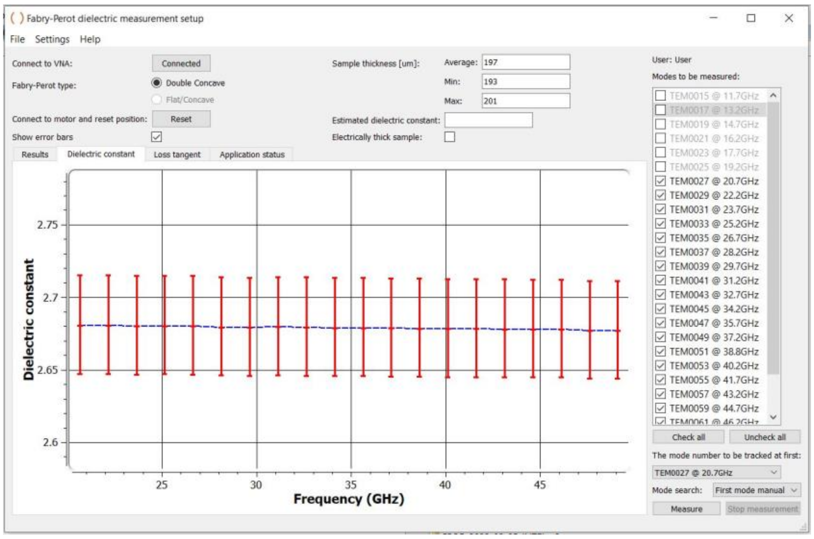
FABRY-PEROT OPEN RESONATOR
20-110 GHz

QWED offers a novel type of a **Fabry-Perot open resonator** (FPOR) with Gaussian mirrors for automated broadband and precise resonant measurements of electromagnetic properties of low-loss dielectric sheets in the **20-110 GHz** frequency range. The FPOR system is equipped with a specialized **software** controlling the measurement process and extracting complex permittivity of the material under test from the measured frequency and quality factor.

The whole measurement setup consists of a computer, where the aforementioned control software is installed, connected to the FPOR and to measurement equipment (either VNA or **scalar Q-Meter**). The FPOR operates at consecutive $TEM_{0,0,q}$ Gaussian odd modes spaced every **1.5 GHz**.

Due to a sophisticated adaptive algorithm implemented in the control software dedicated to precise and robust tracking of the modes during the measurement, total measurement time usually does not exceed **10 minutes** in the 20-50 GHz range.

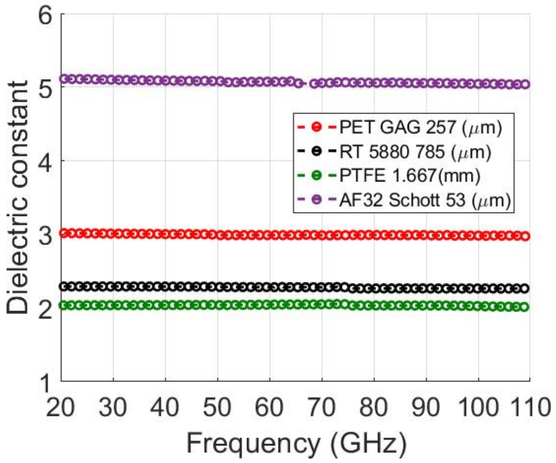
Fabry-Perot Open Resonator

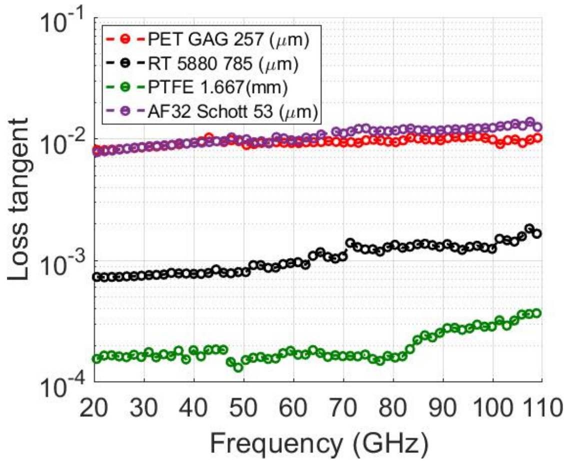


Measurement results (PVC, t = 197 µm)

The system allows measuring samples with the following properties:

1. **dielectric constant**: *ε'* = 1 … 15 (accuracy: $\Delta\varepsilon'/\varepsilon' < 0.5\%$)
2. **loss tangent**: $\tan\delta > 10^{-4}$ (accuracy: $\Delta\tan\delta/\tan\delta < 2\%$),
   and for $\tan\delta < 10^{-4}$ only dielectric constant can be measured.
3. **thickness**: 1µm – 3mm
4. **diameter**: 75mm < *d* < 150mm (recommended *d* = 100mm)





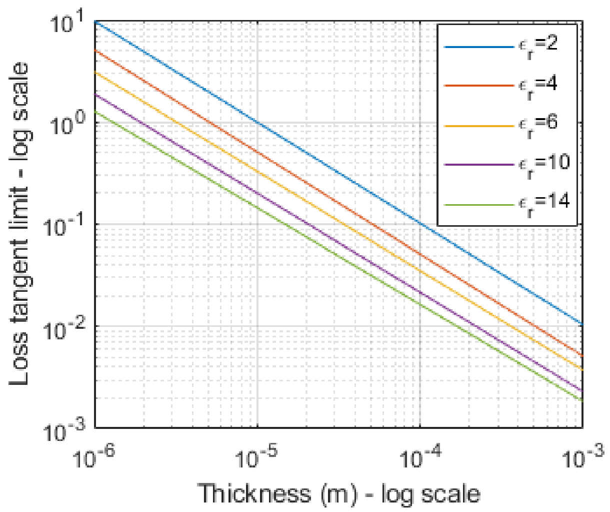
Exemplary measurement results

Fabry-Perot Open Resonator 20-110 GHz

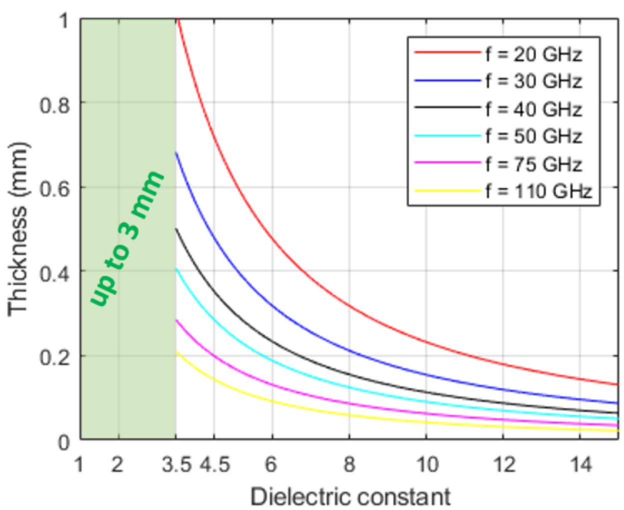
Parameters of a Fabry-Perot Open Resonator (FPOR)

Accuracy/uncertainty	**Method (accuracy):** $\Delta\varepsilon_r/\varepsilon_r = \pm 0.5\%$ for $\varepsilon_r = 1 \ldots 15$ $\Delta\tan\delta/\tan\delta = \pm 2\%$ for $\tan\delta \le 2\%$ **Measurement (uncertainty):** $\Delta\varepsilon_r/\varepsilon_r \approx -(\varepsilon_r - 1)\,\delta t$ $\Delta\tan\delta/\tan\delta \approx 2(\sigma_t + \sigma_0) / (Q_0 - Q_t)$ when $Q_0 \approx Q_t$ (low-loss case) $\Delta\tan\delta/\tan\delta \approx 2\,(Q_0 / Q_t)\,\sigma_t / (Q_0 - Q_t)$ when $Q_0 >> Q_t$ (high-loss case) δt – sample thickness relative uncertainty Q_0 (Q_t) – Q-factor of the resonator without (with) the sample σ_0 (σ_t) – uncertainty of the Q-factor of the resonator without (with) the sample Example: $\sigma_0 = \sigma_t = 500$, $Q_0 = 200{,}000$, $Q_t = 100{,}000$ → $\Delta\tan\delta/\tan\delta = \pm 2\%$
Operational frequency range	20-110 GHz The upper frequency depends on the network analyzer, so it is usually one of the following: 50 GHz, 67 GHz or 110 GHz.
Operational temperature range	Room temperature
Additional equipment needed to perform measurement	1. PC computer 2. Vector Network Analyser (e.g. Keysight, N5245A) OR scalar Q-Meter 3. LAN cable OR National Instruments 488.2 GPIB controller
Measurement procedure	The whole measurement is automated and controlled via dedicated software installed on a PC computer. At first, resonant frequencies and Q-factors of $TEM_{0,0,q}$ odd modes of the empty resonator are measured. Afterwards, sample is inserted onto the holder and all the modes of interest are adaptively sought for and the changed resonant frequencies and Q-factors are measured in order to extract dielectric constant and loss tangent by comparing the results with a look-up table computed with a dedicated FPOR electromagnetic model.

Limitations



Estimated upper limit of the **loss tangent** of the sample that can be measured with the FPOR



Estimated upper limit of the **thickness** of the sample that can be measured with the FPOR

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