A laser pistonphone designed for absolute calibration of infrasound sensors from 10 mHz up to 20 Hz

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Sharing is encouraged

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The metrological traceability:

This project aims to establish in the infrasound frequency range the first link in the chain of traceability from the definition of acoustic pascal.

The laser pistonphone : General principle

The infrasound sensor to be calibrated is exposed to a calculable sound pressure produced in a coupler by a piston.

The pressure sensitivity of the infrasound sensor is determined from its output voltage and the applied sound pressure.

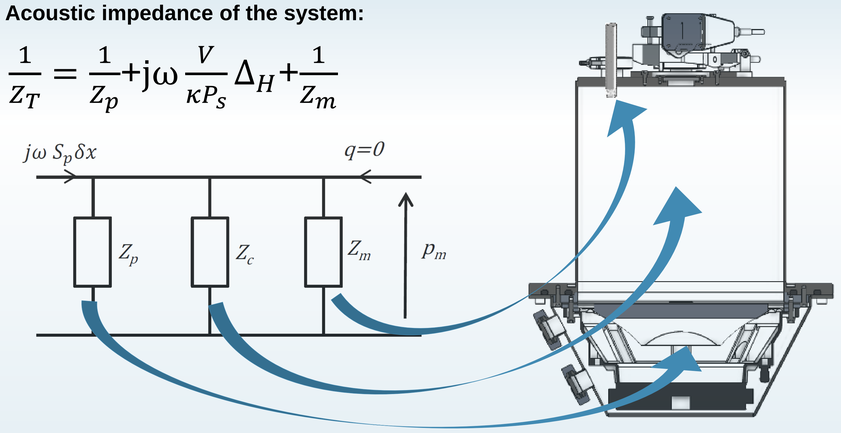
$$M_P = \frac{U_m}{P_c}$$

The sound pressure is calculated from the acoustic impedance of the coupler and the measurement of the volume velocity of the piston.

$$P_c = Z_T \int_S v_p ds \quad \text{If rigid piston} \quad P_c = Z_T j\omega S \delta_z$$

Acoustic impedance of the system:

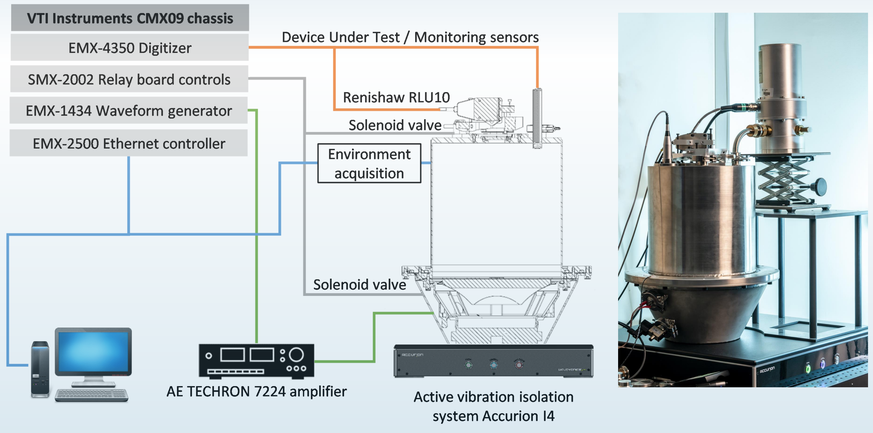
$$\frac{1}{Z_T} = \frac{1}{Z_p} + \mathrm{j}\omega \frac{V}{\kappa P_s} \Delta_H + \frac{1}{Z_m}$$



The sound pressure is assumed to be uniform in the coupler (valid for $\lambda \gg \sqrt[3]{V}$, i.e. frequencies < 20 Hz).

The influence of the heat conduction losses in the cavity is taken into account through the correction factor Δ_H. See Vincent et al. Acoustic transfer admittance of cylindrical cavities in infrasonic frequency range. Metrologia 56 (1), 2018.

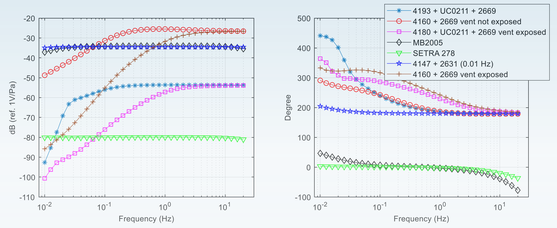
Synoptic diagram



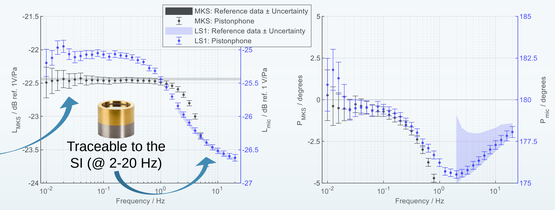
Design features:

- Frequency range: 0,01 Hz – 20 Hz
- Amplitude up to 50 Pa
- Interferometer 633 nm
- Static pressure equalization (through solenoids)
- Rigid and flat membrane
- Cylinder Ø=(300 ± 1) mm
- Height (300 ± 0.5) mm
- Calibration of microphones, microbarometers, barometers, manometers.

Example of calibrations and metrological performance



Traceable to the SI (@DC)



Equivalence of calibration are demonstrated through method comparisons:

- High frequencies: LS1 microphone (reciprocity calibration) traceable to the SI (2 Hz – 20 Hz)
- Low frequencies: Differential capacitance manometer (MKS Baratron Type 616A) traceable to the SI (DC)

Uncertainties: Example for a microphone B&K Type 4160

Frequency (Hz)	0.010	0.016	0.03	0.06	0.13	0.25	0.50	1 – 8	16	20
Amplitude: Expanded uncertainty in dB (k=2)	0.16	0.12	0.09	0.06	0.05	0.04	0.04	0.03	0.04	0.04
Phase: Expanded uncertainty in degree (k=2)	2.06	1.28	0.70	0.43	0.32	0.27	0.25	0.24	0.30	0.33

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