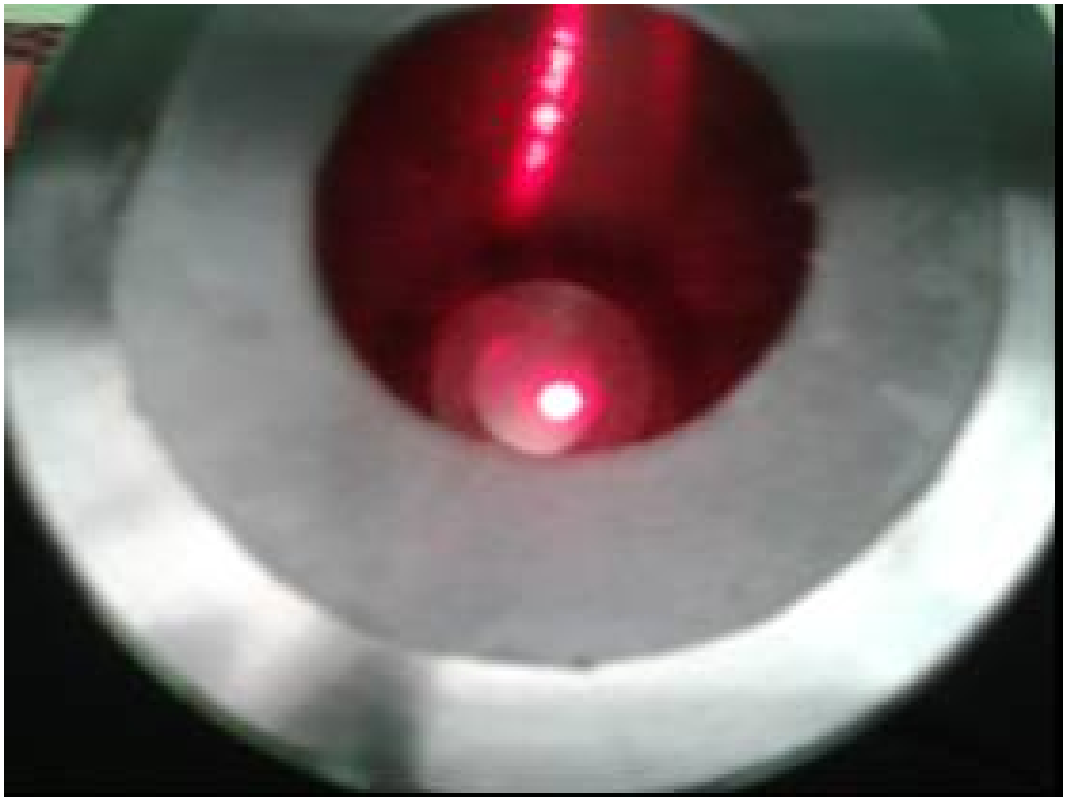
DYNAMIC CALIBRATION OF FORCE TRANSDUCERS AT CEM

Nieves Medina and Jorge Robles

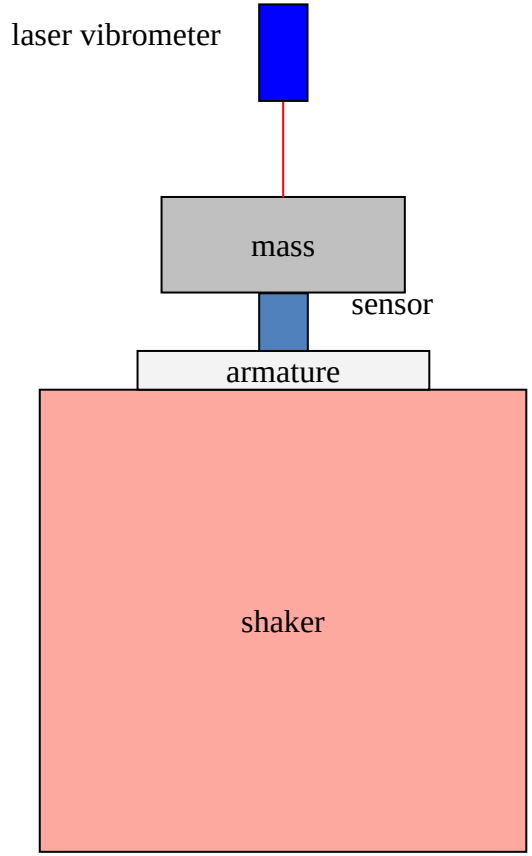
CEM CENTRO ESPAÑOL DE METROLOGÍA

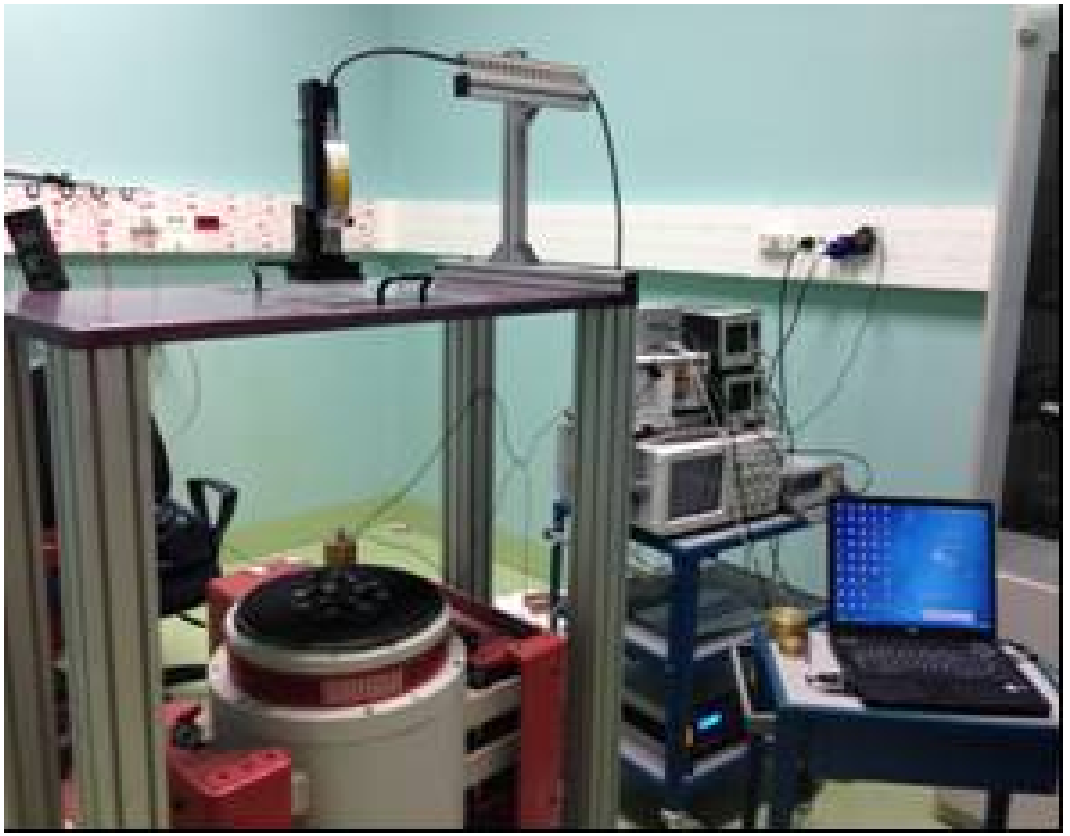
Index

- Description of the system
- Measurement model
- Influence factors
- Conclusions



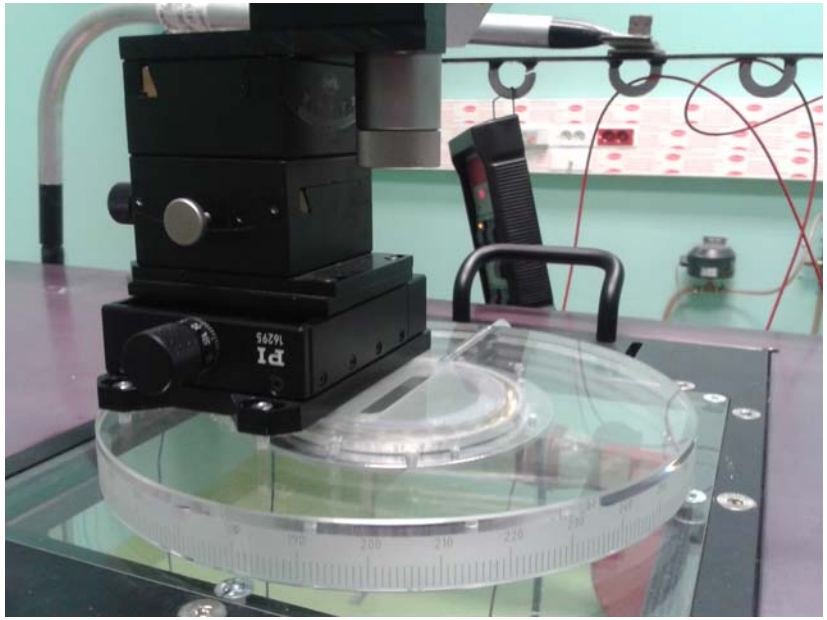
System

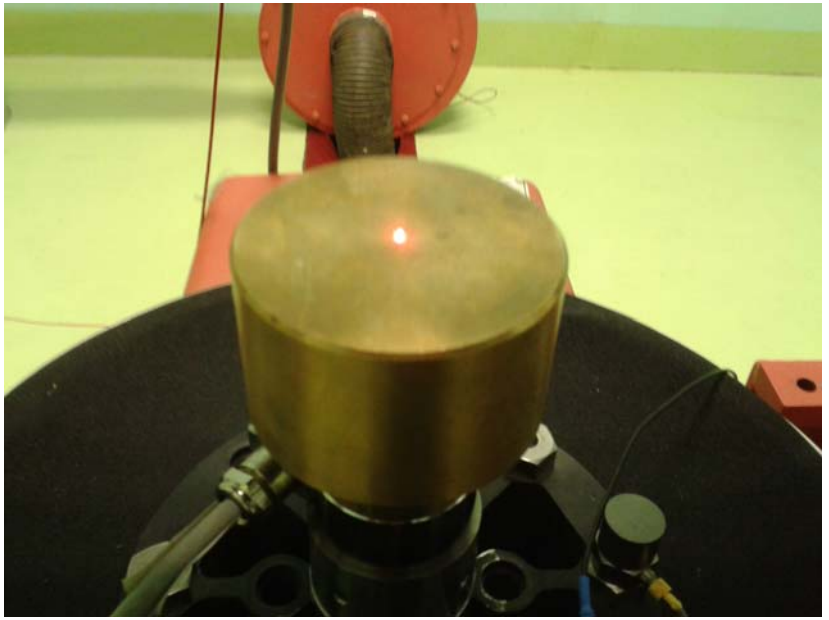




Laser vibrometer

The laser vibrometer is a modified Mach-Zehnder interferometer and it incorparates a Bragg cell (opto-acoustic modulator).





Masses

Nominal values: 350 g, 1 kg, 2 kg, 7.3 kg and 12.3 kg

Special adaptors may be required in order to attach the masses to the sensor or the sensor to the shaker.

Shaker

Frecuency: 5 Hz to 2400 Hz
Acceleration: 600 m/s^2

Auxiliary accelerometer

B&K 8305

Data acquisition system

NI PXI 1033 module with a
4462 card (24 bits, 204.8 kS/s)

- Programmed in Labview

- Sampling: each signal separately with 40kS/s

- Excitation frequency directly detected by the software

AIM: avoid harmonic distortion and noise

Sine approximation method

$$a(t_i) = A\cos(2\pi f t_i) - B\sin(2\pi f t_i) + C$$

Up to 3rd harmonic

$$\begin{aligned} a(t_i) = {} & A_0\cos(2\pi f t_i) - B_0\sin(2\pi f t_i) + C + \\ & + A_1\cos(4\pi f t_i) - B_1\sin(4\pi f t_i) + \\ & + A_2\cos(6\pi f t_i) - B_2\sin(6\pi f t_i) + \\ & + A_3\cos(8\pi f t_i) - B_3\sin(8\pi f t_i) \end{aligned}$$

Amplitude and phase

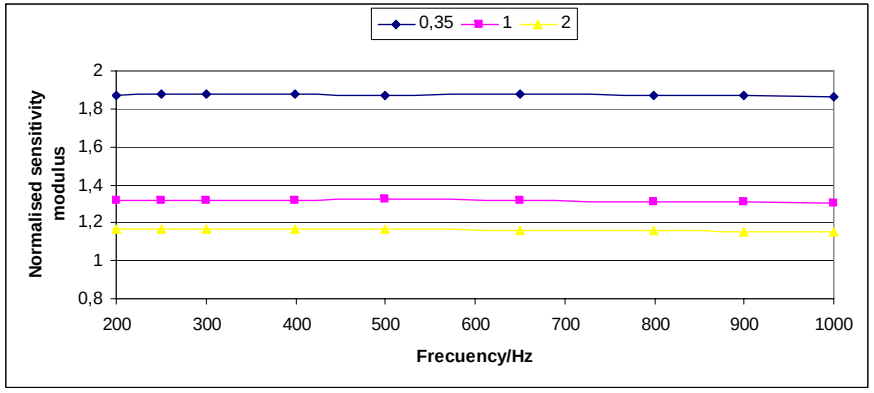
$$\hat{a} = \sqrt{(A_0)^2 + (B_0)^2}$$

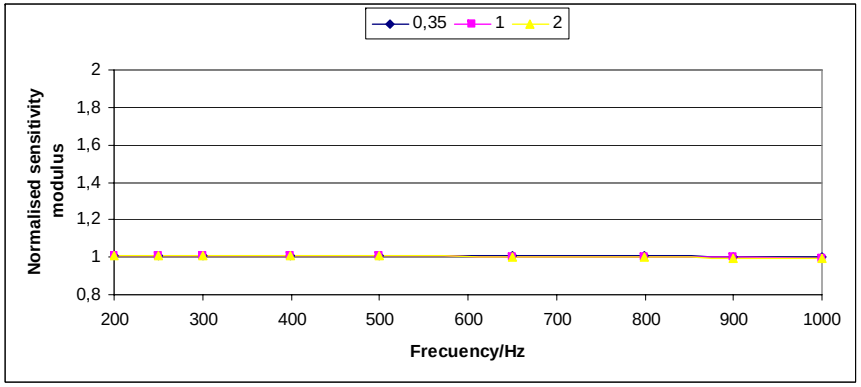
$$a_\varphi = \arctan\left(\frac{A_0}{B_0}\right)$$

Measurement model

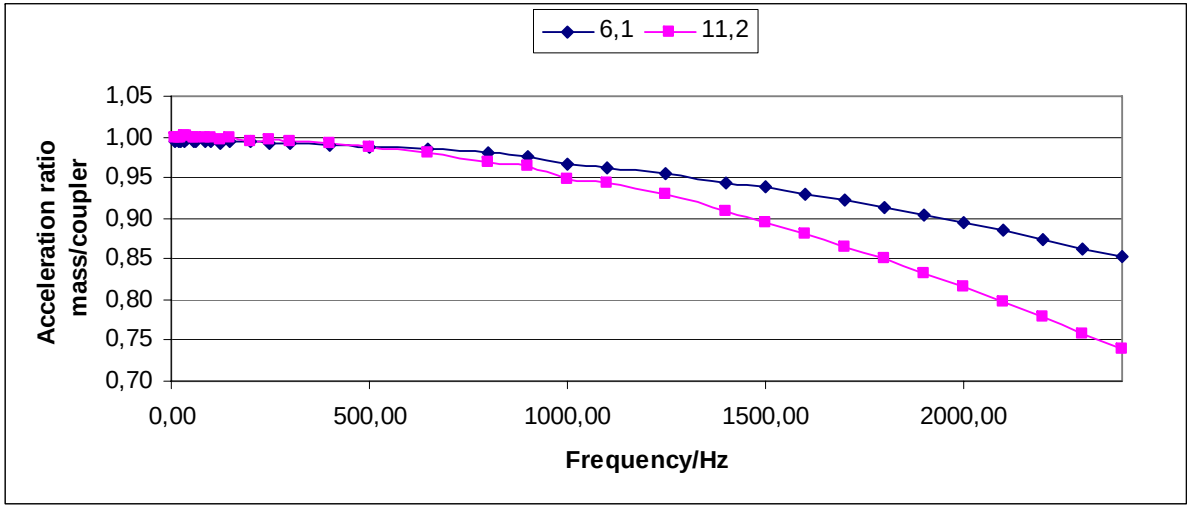
$$S = \frac{U/V}{(m + m_i) \cdot a}$$

$$S = |S| \cdot e^{i\varphi}$$

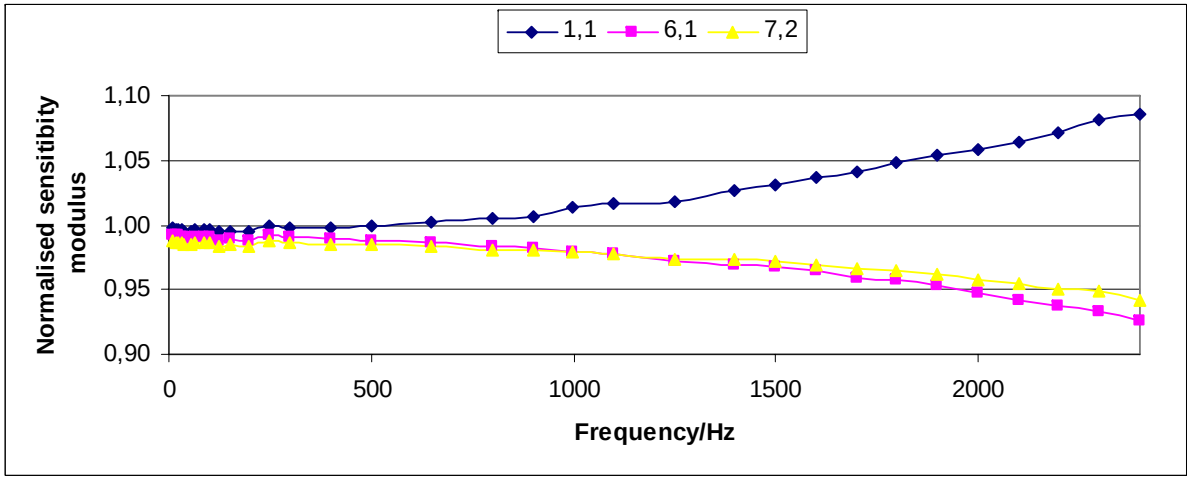




m_i = 315 g

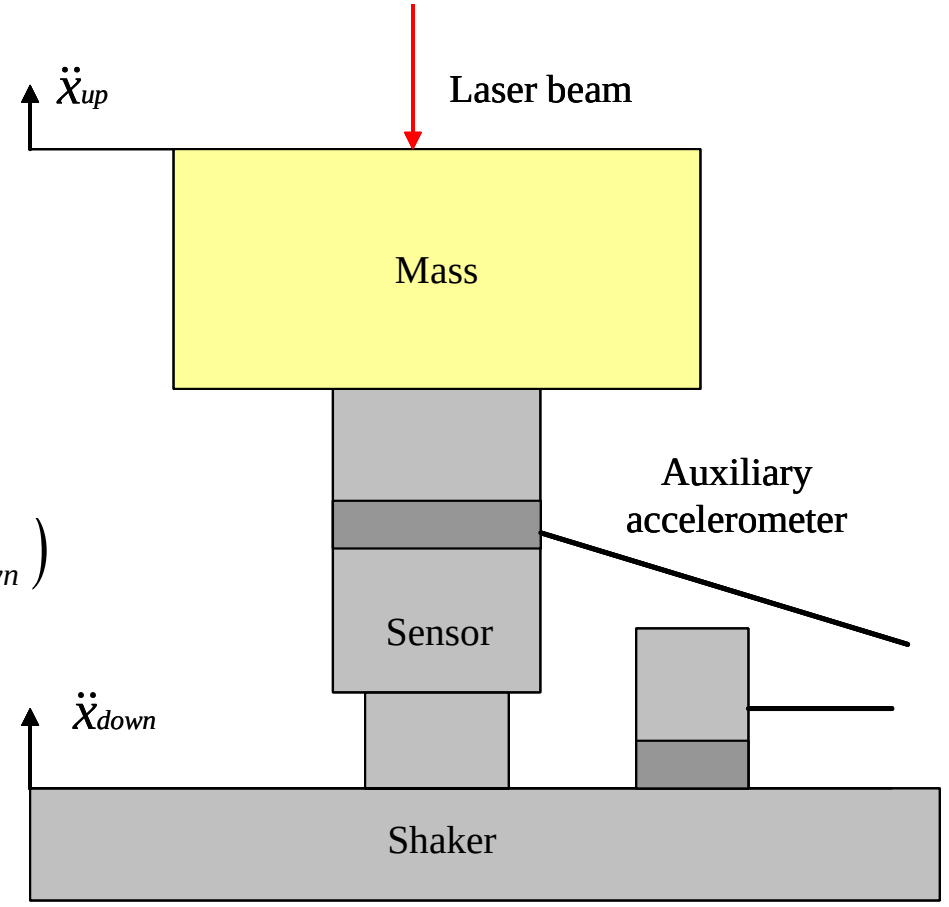


$$S = \frac{m_1 + m_2}{\frac{m_1 + m_s}{S_1} + \frac{m_2}{S_2}}$$

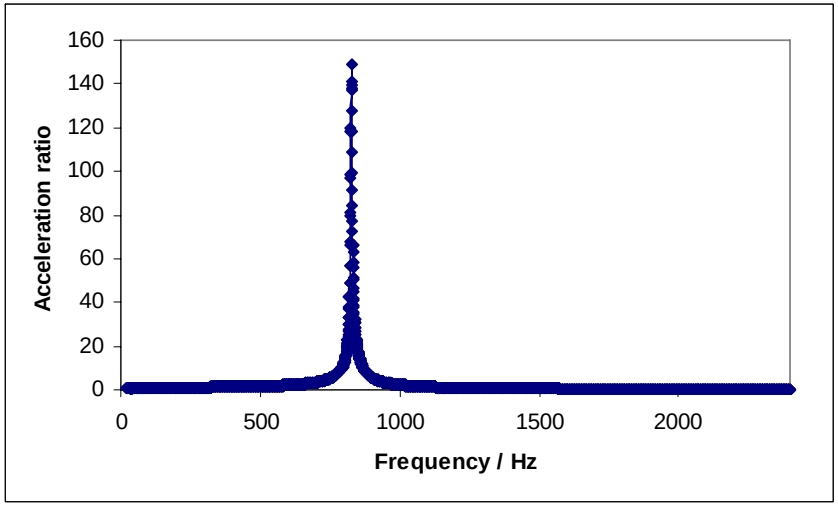


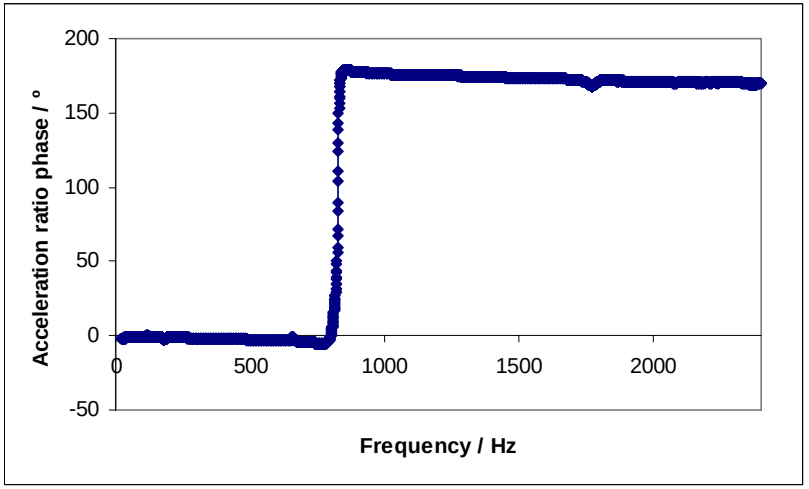
Mechanical resonator

$$m \cdot \ddot{x}_{up} = -k \cdot \left(x_{up} - x_{down}\right) - b \cdot \left(\dot{x}_{up} - \dot{x}_{down}\right)$$



$$\frac{a_{up}}{a_{down}} = \frac{k + ib\omega}{k + ib\omega - m\omega^2}$$





Influence factors

Type B

Uncertainty contribution	Contribution to the sensitivity modulus	Contribution to the sensitivity phase
Data acquisition system	0.05 %	2×10^{-5} º/frequency
Laser vibrometer	0.1 %	0.25 º
Conditioning amplifier	0.05 %	0.25 º
Sensor temperature	< 0.06%	-
Loading mass	0.01%	-

Type A

- Harmonics and noise

- Repeatability

- Transverse acceleration and rocking motion

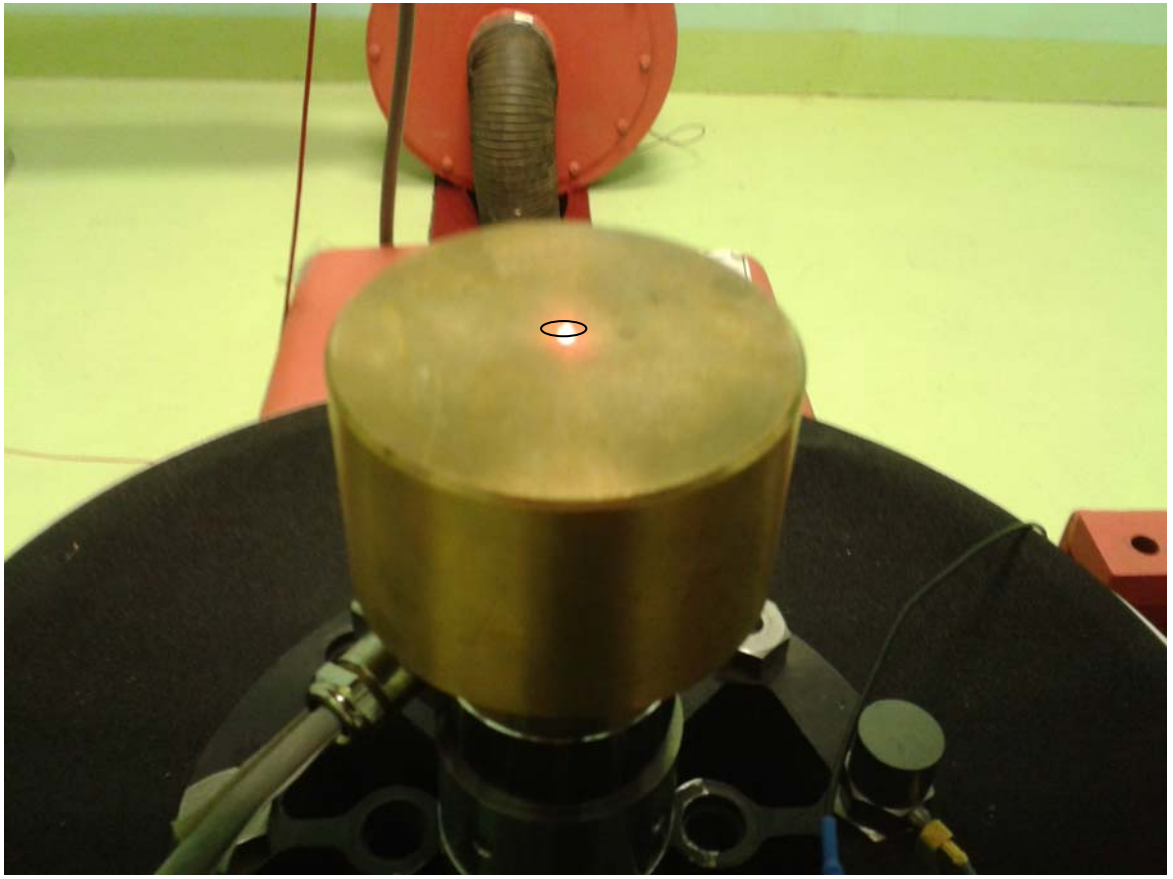
- Reproducibility of mounting

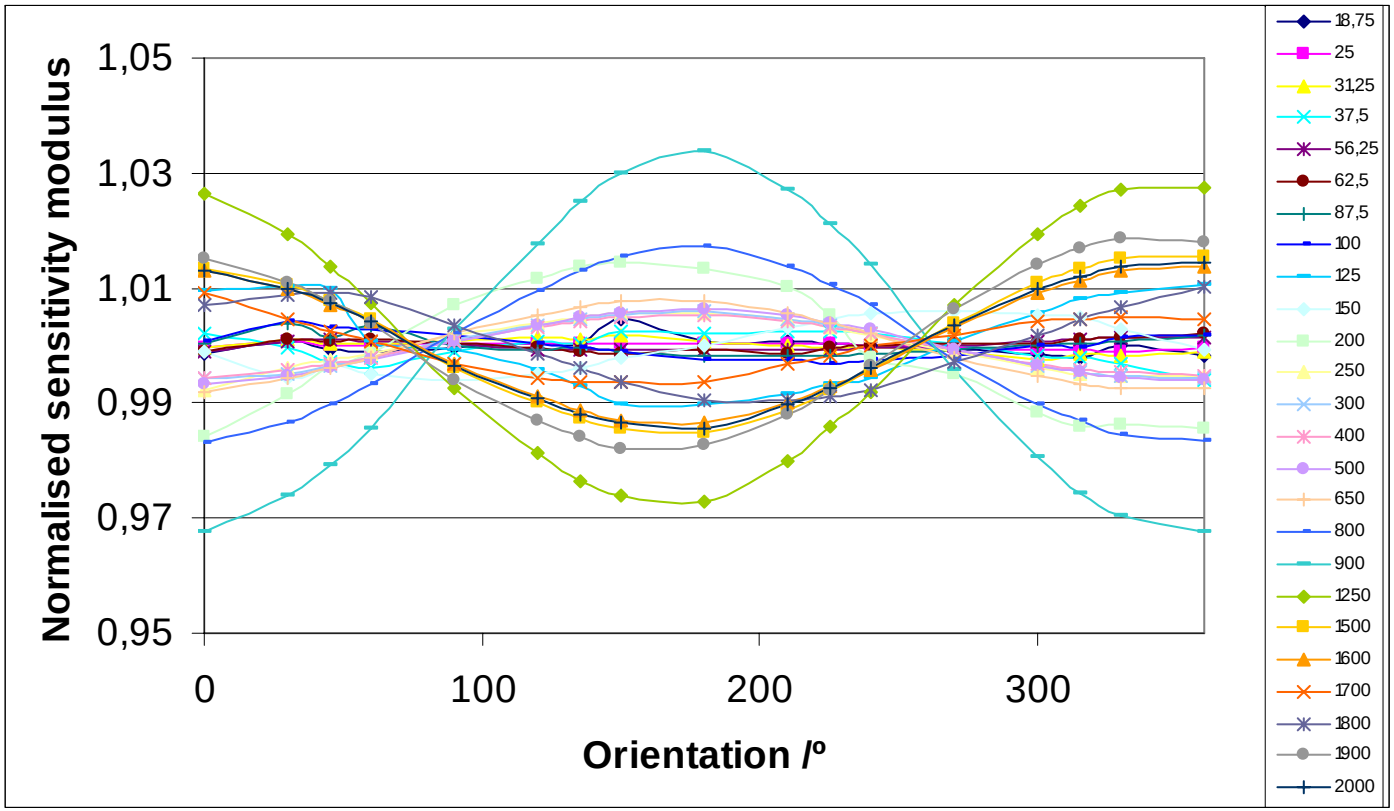
Harmonics and noise - Sine approximation method (40kS)

Repeatability - 10 measurements

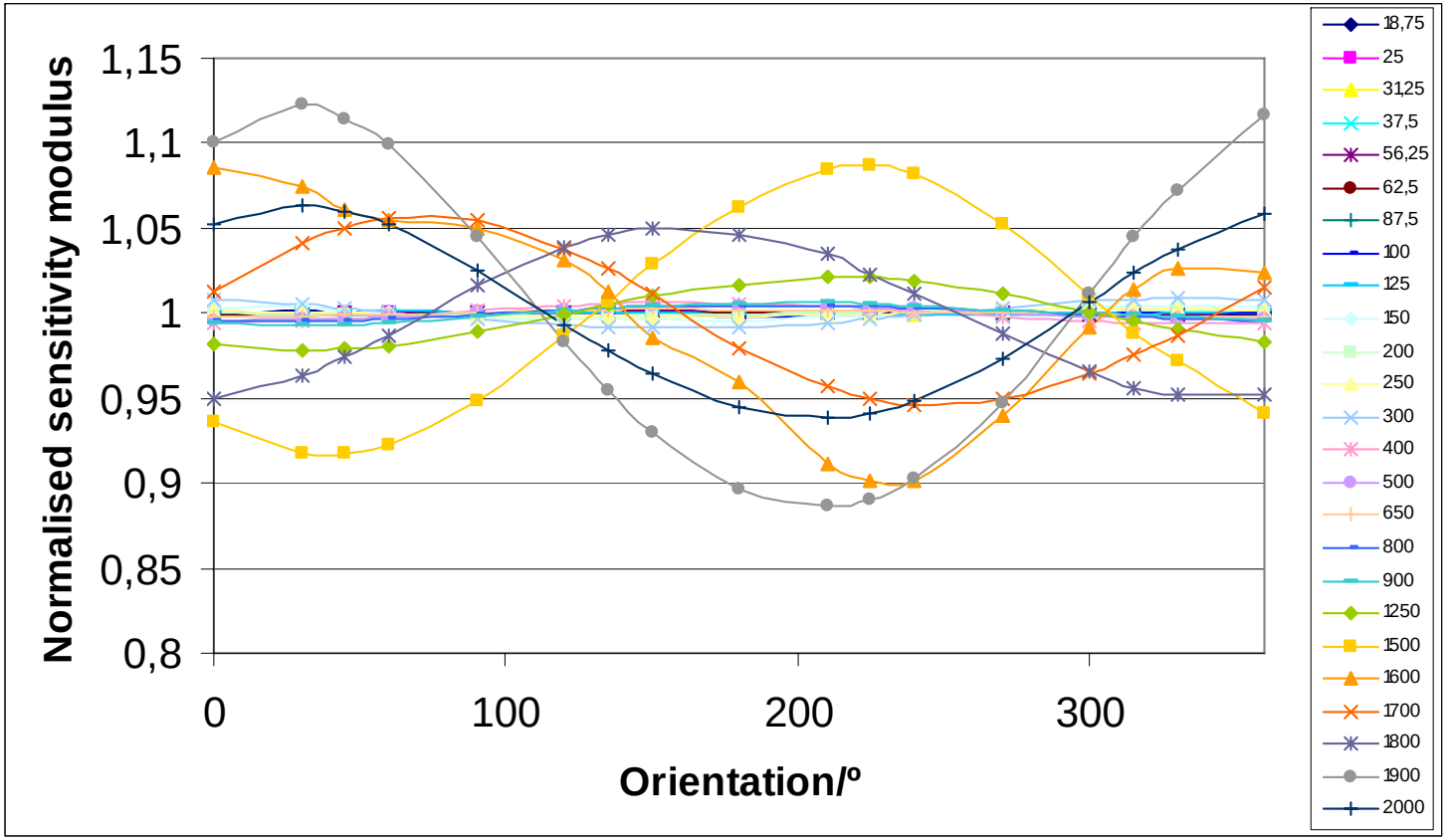
} NEGLIGIBLE

Transverse acceleration and rocking motion

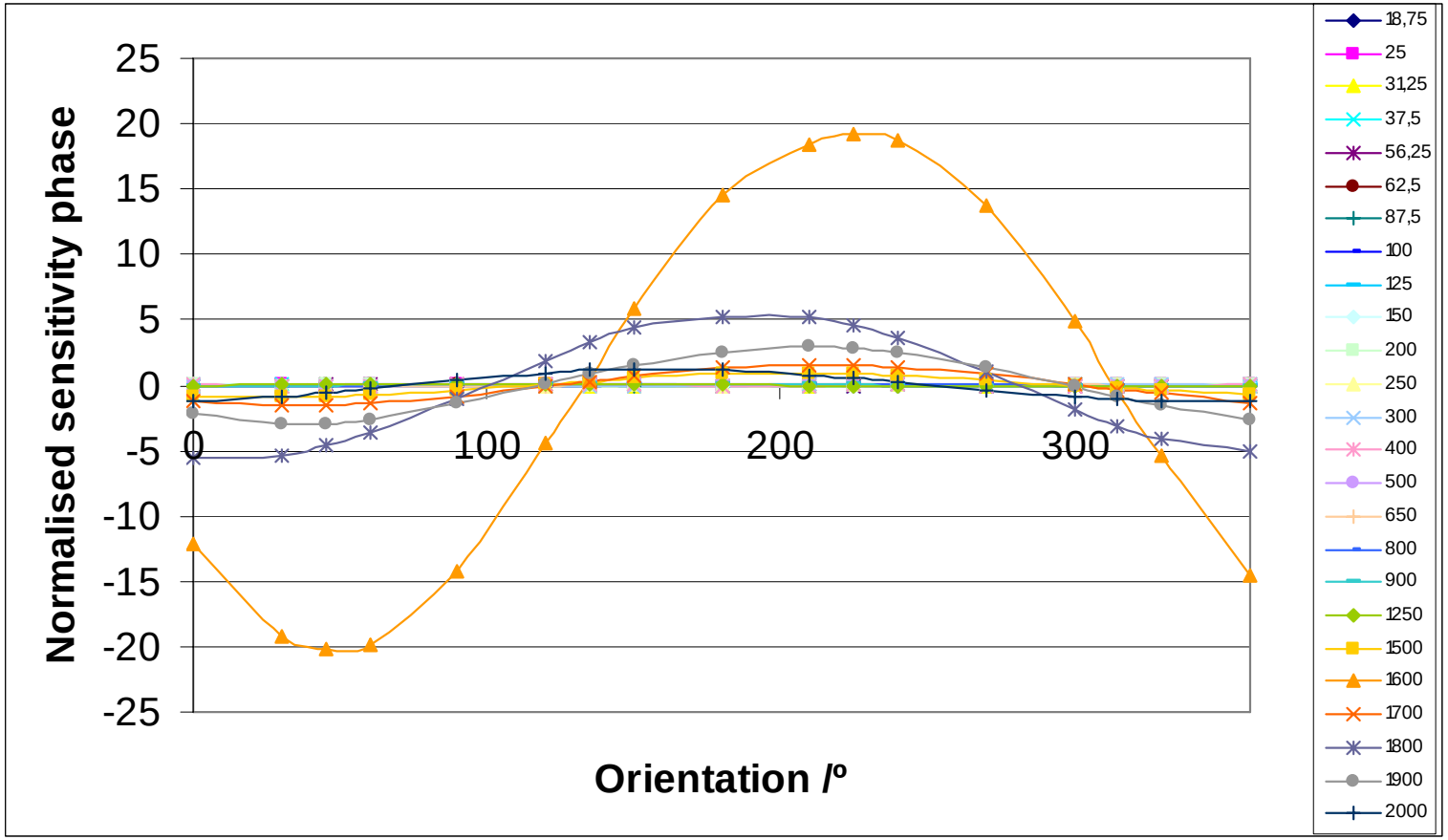




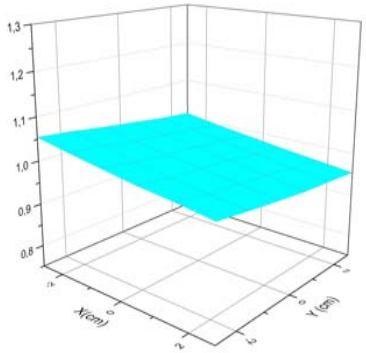
Load = 7.2 kg, radius =1 cm



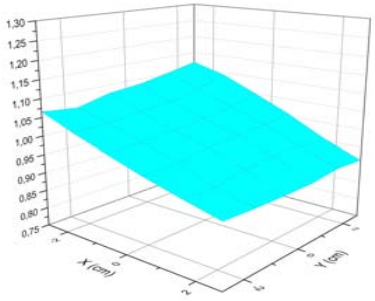
Load = 2 kg, radius =1.7 cm



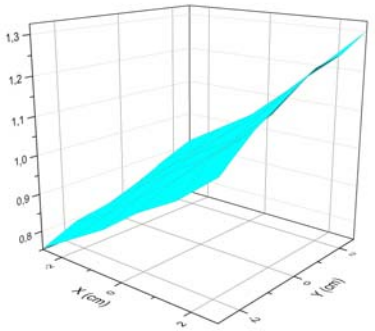
Load = 2 kg, radius =1.7 cm



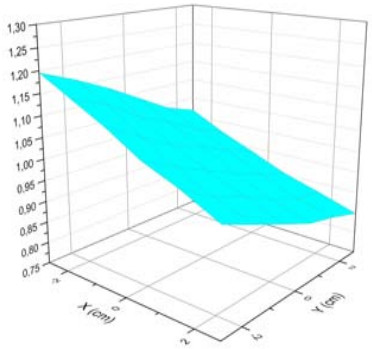
1.25 kHz



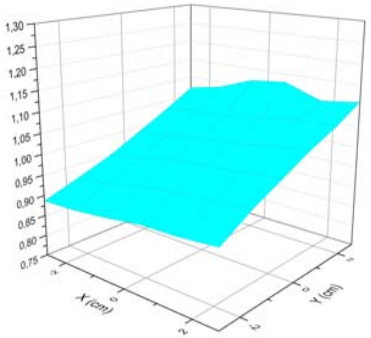
1.8 kHz



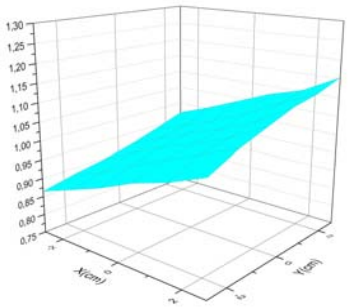
1.9 kHz



1.5 kHz

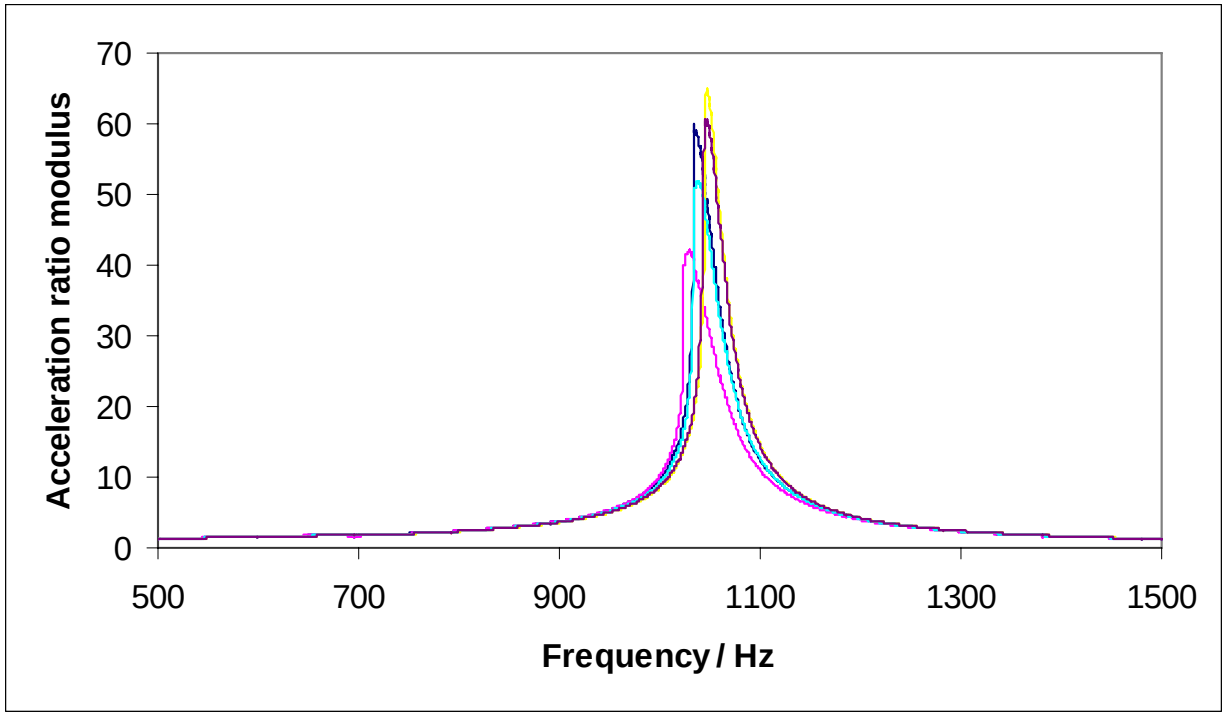


1.7 kHz



2 kHz

Reproducibility of mounting



Special care has to be taken to ensure that the contact between pieces is made by means of flat surfaces.
The torque which is applied to connect the different parts is also under careful control.

Conclusions

- Primary standard for dynamic forces

- Main influence: rocking motion

- Best uncertainty
  - 0,5 % → 3 %
  - 1 º

This work is part of the EMRP project
“Traceble dynamic measurement of mechanical quantities”

Thank you very much for your atention

Nieves Medina Telf. + 34 91 807 47 89 Email: mnmedina@cem.minetur.es