Modelling of the Clamping Fixture of a Piezoelectric Cantilever-type Energy Harvesting Device

T. Hoang[1,2], G. Poulin-Vittrant[2], G. Ferin[1], F. Levassort[2], C. Bantignies[1], A. Nguyen-Dinh[1], M. Bavencoffe[2]

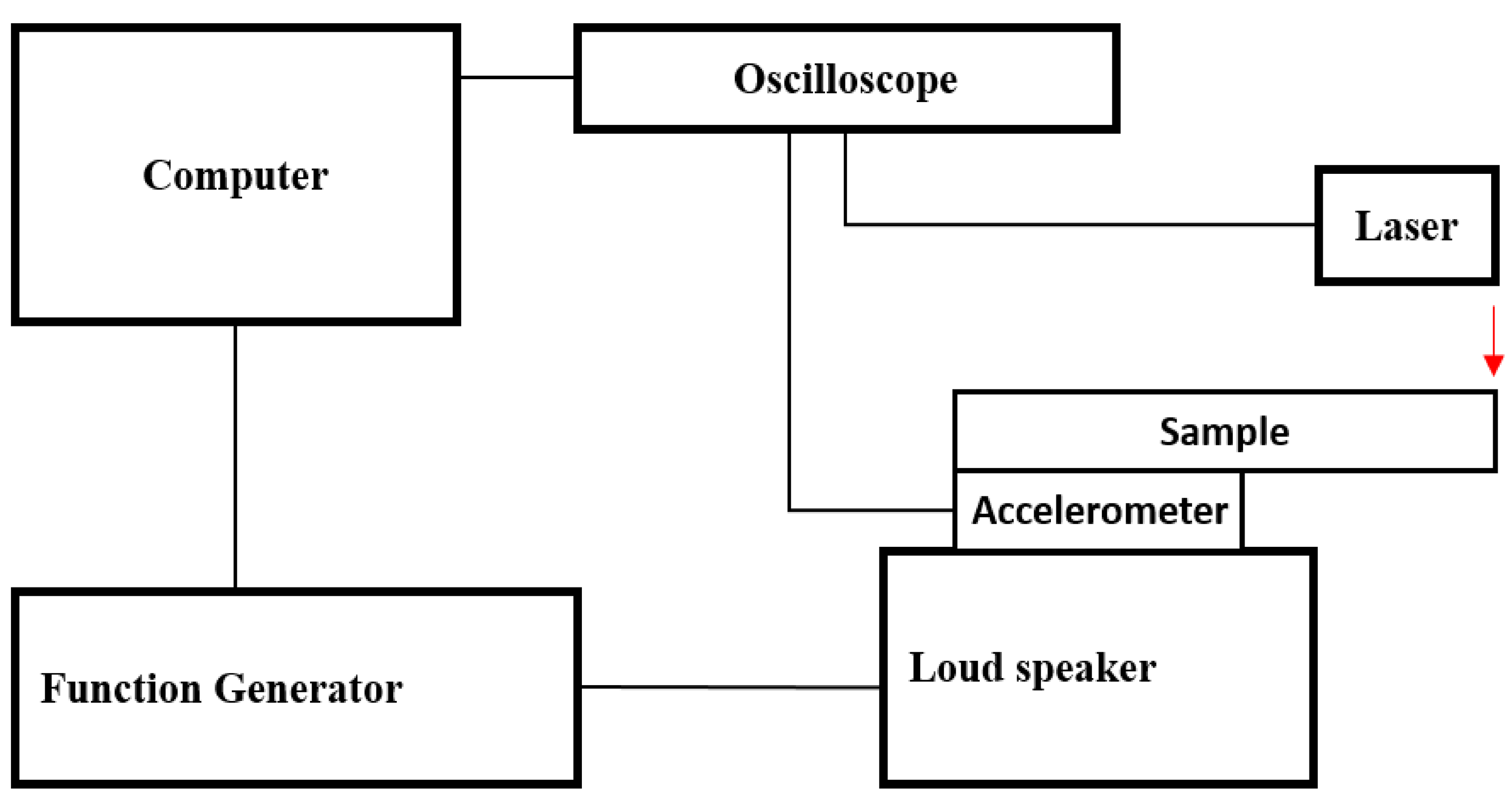
[1] Advanced Research dept., VERMON S.A., Tours, France

[2] GREMAN UMR 7347, Université de Tours, CNRS, INSA Centre Val de Loire, Blois, France

OUTLINE

- **Motivation**: to design efficient energy harvesting devices dedicated to low frequency (<30Hz) biomedical applications and industrial applications (<50Hz)
- **Aim**: to get a 3D Finite Element (FE) predictive model of a piezoelectric bimorph cantilever beam manufactured using thinned-bulk piezoelectric materials
- **Means**: functional characterization using a dedicated vibration test bench and modelling by FE method

EXPERIMENTAL METHOD



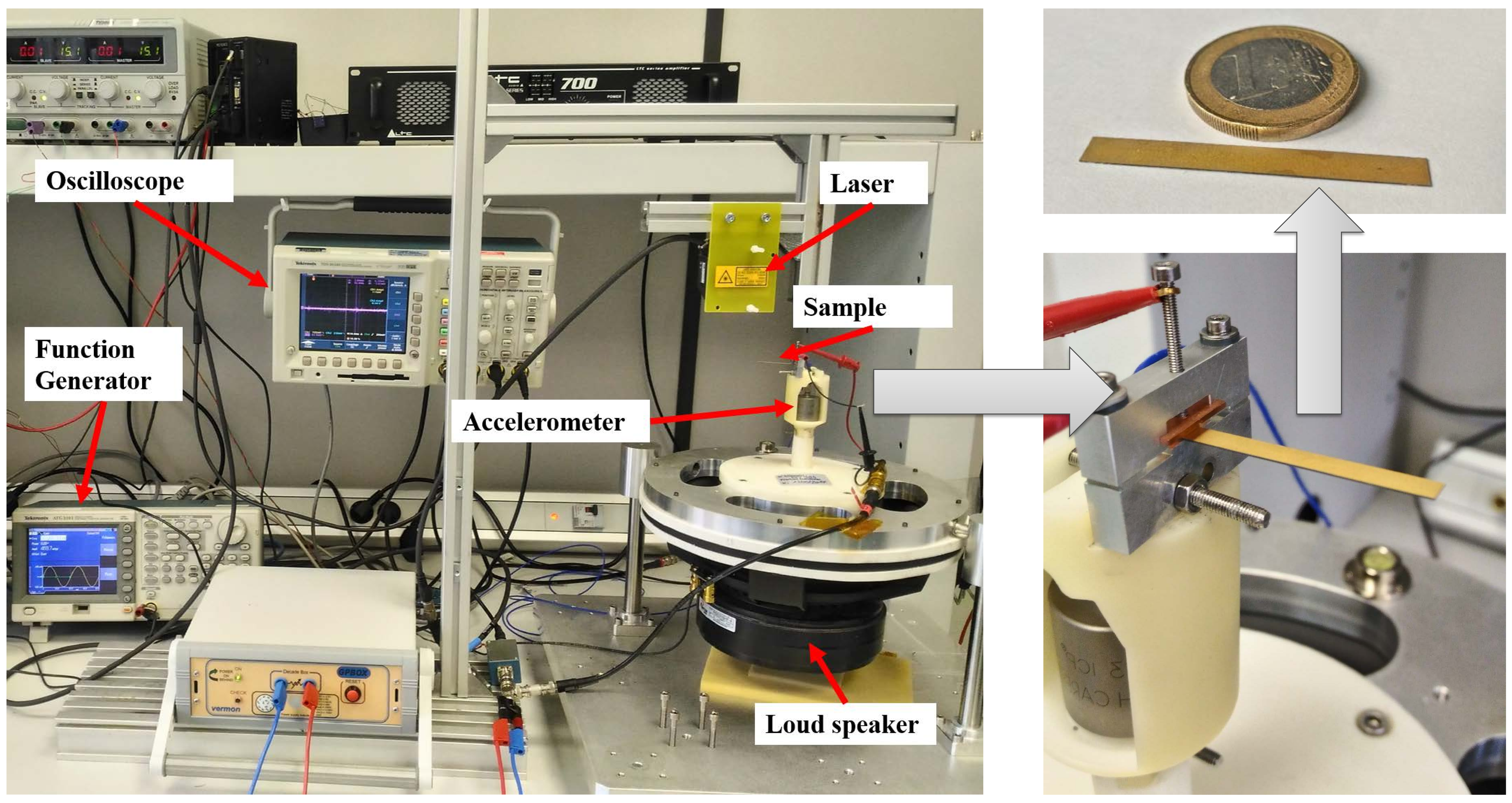


Figure 1. The vibration characterization test bench – detail of the PZT sample

MODELLING APPROACH

- With COMSOL Multiphysics® FEA software
  - 3D geometry modelling in vibration
  - Using the Piezoelectric Devices interface of the Structural Mechanics Module
  - Ideal clamped-free boundary condition is applied at the device's ends
  - Frequency Domain study performed
- As a discrepancy between simulation and measurement results is observed (Figure 2):
  - Different ways of modelling the clamping fixture of the beam are considered, from the ideal clamped-free boundary condition up to the 3D FEM model of the fixing system imported from the CAD CAM integrated software TOPSOLID by using the CAD import Module.
  - Modal Analysis is performed to determine the first mode of resonance and to compare with the measurement results (Table 1).

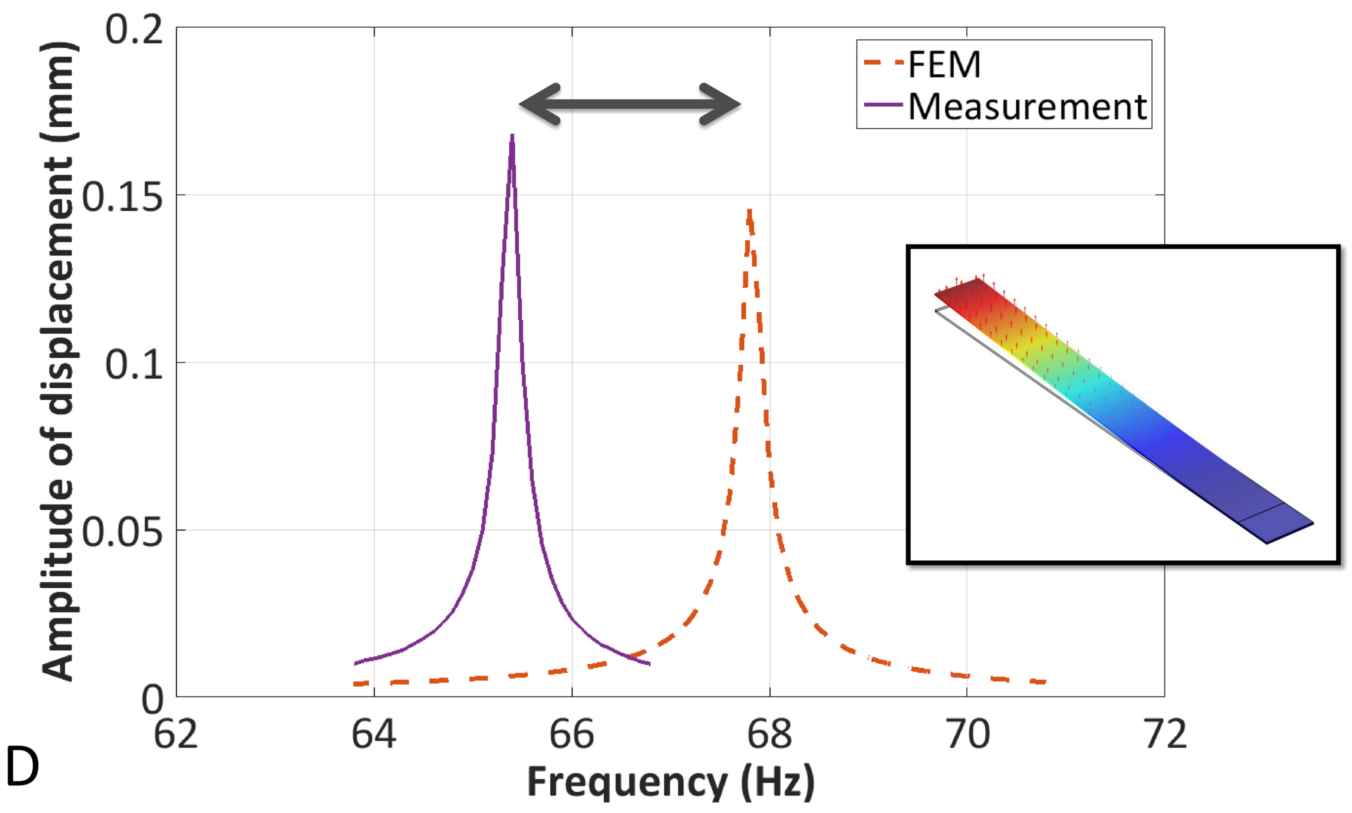
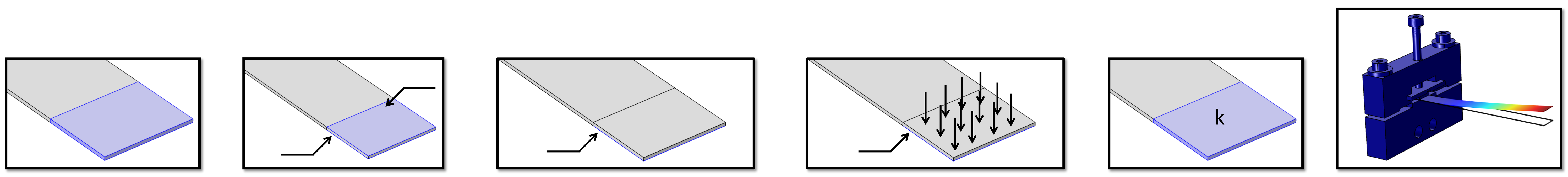


Figure 2. Comparison between simulation and measurement results



	Measurement	Fixed Constraint in domain		Fixed Constraint on two surfaces		Fixed Constraint on bottom surface		Fixed constraint on bottom surface + top surface load 2.10⁷N/m²		**Spring k=7,3.10⁶N/m in domain**		3D FEM model of the real fixing system	
	f (Hz)	f (Hz)	Δ(%)	f (Hz)	Δ(%)	f (Hz)	Δ(%)	f (Hz)	Δ(%)	**f (Hz)**	**Δ(%)**	f (Hz)	Δ(%)
First mode of vibration	65,4	68,07	4,08	68,06	4,07	67,90	3,81	67,92	3,85	**65,40**	**0,00**	67,966	3,92

Table 1. Comparison between simulation and measurement results for different clamping fixture of the beam

CONCLUSION

- ☑ Simulation and comparison of different ways of modelling the clamping fixture of a piezoelectric cantilever-type energy harvesting device.
- ☑ Successful comparison of the modelling and the experiment for predicting the first resonance mode of piezoelectric samples (discrepancy < 5% with all the fixture models).
- ☑ Use of a functional design tool: clamping fixture modelled by a spring in domain with adapted stiffness (discrepancy < 1%).

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