



Master Thesis Project

Design and Optimization of Piezoelectric Microenergy Generators for Internet of Things application

Background:

As microsystems shrink and become increasingly integrated, they have ever-increasing power demands. The vision is to have an entirely Internet of Things (IoT)-based sensing platform having a self-sustaining source of energy, for example incorporating an energy harvester and an energy storage unit on a single chip. Vibration-based energy harvesters are suitable candidates for an on-chip harvesting system as its transduction requirements can be procured by the vibrations present in the surroundings such as engines, railway lines and moving vehicles. A disadvantage of these harvesters is their narrow bandwidth of harvestable frequencies (when working at resonance). For the micro-scale harvesters (our case), the bandwidth broadening solutions cannot be easily scaled down. Moreover, the manufacturing process is complicated and expensive. Thus, we require optimized models for micro-energy harvesters that enable prediction of their energy and power outputs.

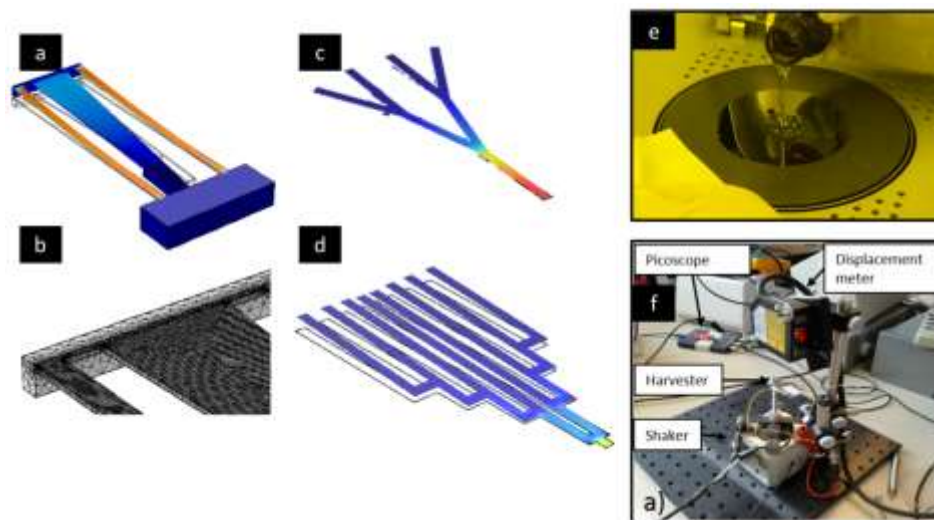


Figure 1: (a) M-shaped energy harvester for improved stress distribution, (b) Finite Element discretization of the M-shaped design (c, d) Fractal shaped design for <100 Hz resonant frequency (e) Fabrication in MC2 cleanroom, (f) Test setup at RI.SE Smart hardware.

Purpose and Project Description:

The objective of this thesis is to design, optimize and analyze two-degree-of-freedom (2DOF) coupled microcantilevers, M-shaped and Fractal devices. This will include:

- Derive a 2D Finite Element (FE) model that enables prediction of 3dB bandwidth, energy and power outputs at different vibrational frequencies and accelerations.
- Analyze the structure using multi-objective optimization with respect to several objectives such as bandwidth and energy output.
- Conceptually describe the effects of different parameter (e.g. length, width, thickness,

proof mass volume) have on final output.

- Experimental characterization and analysis at RISE Smart hardware and comparison with numerical results.

The FE code should be able to model the effects from the acceleration from the surroundings, influence of stress induced on the side-beams of the cantilever on the 3dB bandwidth, influence of material effects such as damping, etc. Recommended FE program is COMSOL Multiphysics, but others may also be used.

The project is suitable for 1-2 students from MPAME, MPPDE, MPSYS, MPSEB and master programs linked to MC2 or Engineering Physics.

Student Background:

This project is suitable for students who are interested in computational mechanics and the Finite Element Method. Students with strong interest and good experiences in programming are encouraged to apply. They will have an interaction with the microfabrication facility at MC2 Chalmers and be provided with experimental support from RISE-Smart Hardware.

***Remark:** This project could be preferably performed with another master project (Fabrication of micro-energy harvester, MC2) as a collaboration between master and PhD students from different departments.*

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About:

RISE Smart Hardware:

RISE Smart Hardware is a Swedish research institute within electronics, optics and communication technologies. As one of Europe's top research institutes, we provide cutting edge resources and knowledge within electronics, optics and communication technologies. We have the facilities and lab resources to offer advanced R&D as well as small scale production and prototyping. Our mission is to find new ICT-solutions for existing and future demands, creating sustainable growth in industry and society.

MC2:

The Department of Microtechnology and Nanoscience – MC2 – is a unique research department in the areas of micro- and nanotechnology, housing more than 200 researchers and PhD students. We focus our research on the areas of future nano- and quantum electronics, photonics, bio- and nanosystems.

References: A micromachined coupled-cantilever for piezoelectric energy harvesters

(<https://www.mdpi.com/2072-666X/9/5/252>)

Bandwidth Improvement of a Piezoelectric Micro Energy Harvester

(<https://odr.chalmers.se/handle/20.500.12380/301205>)