DOCTORAL CANDIDATE: CUONG PHU LE

DEGREE: Philosophiae Doctor

FACULTY: Faculty of Mathematics and Natural Sciences

DEPARTMENT: Department of Informatics

AREA OF EXPERTISE: Micro and Nano Systems Technology

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DISSERTATION TITLE: *Transducer configurations for MEMS electrostatic energy harvesters*

Vibration-based energy harvesting is a smart method for electrical energy generation from the mechanical energy of ambient motion. The technique has valuable applications in wireless communications in self-powering sensors and actuators. Inconvenient use of batteries for low-power electronic systems can therefore be eliminated. Conventional energy harvesters face a limitation of generated power when the mechanical excitation is sufficiently strong due to their restricted volume.

A device concept utilizing internal impact was proposed to overcome this limitation. Additional electrostatic transducers acting as end-stops are integrated to harvest extra power when a proof mass in the harvester is excited to its maximum displacement amplitude. Microlectromechanical systems (MEMS) devices were fabricated using a standard silicon micromachining process. Benefits of the transducing end-stops have improved the harvester effectiveness and its efficiency under sinusoidal and broadband excitations. The achieved output power is up to about six times higher than that of a reference harvester that was designed and measured under the same conditions.

Finally, there is a challenge for small-scale harvesters to scavenge mechanical energy from high-amplitude vibrations that are frequently distributed in the low-frequency range. To be adaptive for low-frequency operation, a capacitive transducer is investigated to achieve a wide tuning range for the centre frequency downwards to low values. The concept is here to control the effective device stiffness by a useful combination of hardening and electromechanical softening springs. A record tunability of 162.2% has been achieved for the investigated prototype. This tuning capability is applicable to MEMS electrostatic energy harvesters in low-frequency applications, e.g. structural health monitoring or human wearable sensors and implantable systems.