Real World Vibration Energy Harvesting for Structural Health Monitoring

Background

• Real world vibration is wideband in nature but conventional linear harvesters are designed for a specific frequency.
• Design modeling typically use a simple sinusoidal source instead of real data.
• Aim: employ mechanical amplification and nonlinear vibration (broader frequency response) harvesters that are tailor designed for application specific real vibrational structures.

MEMS design strategies

• Additional initial spring mechanism for lower 1st mode frequency (10^-2 Hz) and mechanical amplification.
• Nonlinear vibrational designs to access broader frequency bandwidth.
• Multiple axial vibration and out-of-plane motion to enable large capacitance change without displacement limit and compact spacing of comb fingers. Therefore, higher power density.

Integrated system designed for real vibration

• Novel nonlinear harvester design with mechanical amplification mechanism (undergoing patent filing.)
• Novel nonlinear harvester offers around 5 times more calculated peak power (graphs below) than linear harvester (experimentally validated).
• Optimised design with broader frequency response to extract maximum energy from real vibration.
• Full system integration with wireless sensor motes.

Genetic algorithm

A genetic algorithm with numerical simulations that considers the effects of each parameter of the real vibrational source in order to yield an optimal power and frequency response after n generations of a roulette wheel selection and evolution process.

Conclusion

Numerically and experimentally shown performance enhancements of novel nonlinear harvester over linear harvester (*5 peak power & *3 wider frequency).

Future work

• Nonlinear and broadband mechanisms,
• Low frequency MEMS designs,
• System level integration of harvester and wireless sensor.

References