Real World Vibration Energy Harvesting for Structural Health Monitoring

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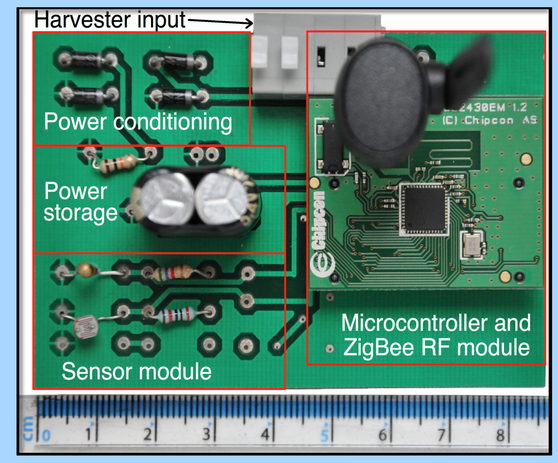
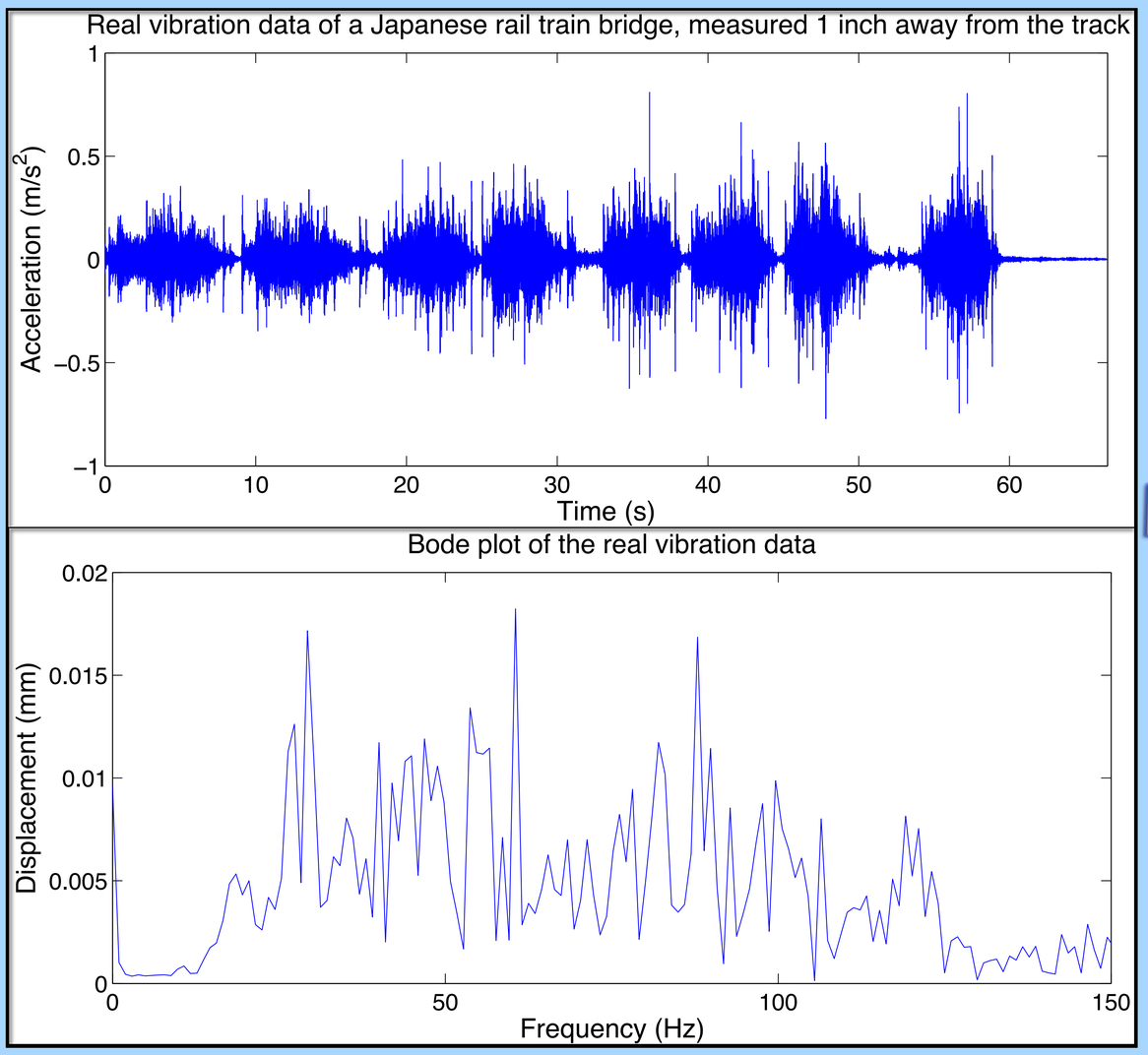
1 Background

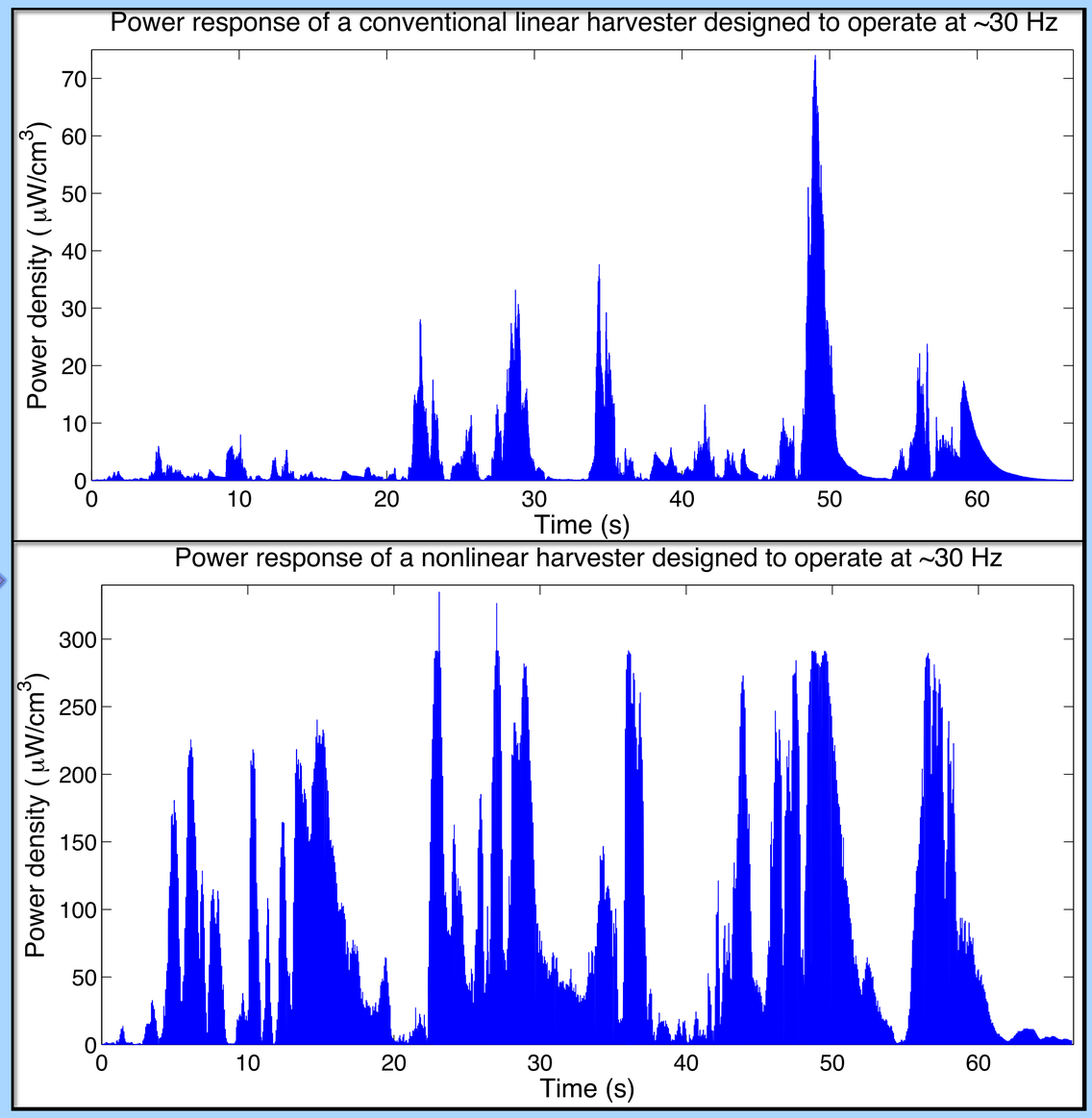
- Real world vibration is wideband in nature but conventional linear harvesters are designed for a specific frequency.
- Design modeling typically use a simple sinusoidal source instead of real data.
- Aim: employ mechanical amplification and nonlinear vibration (broader frequency response) harvesters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

2 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.

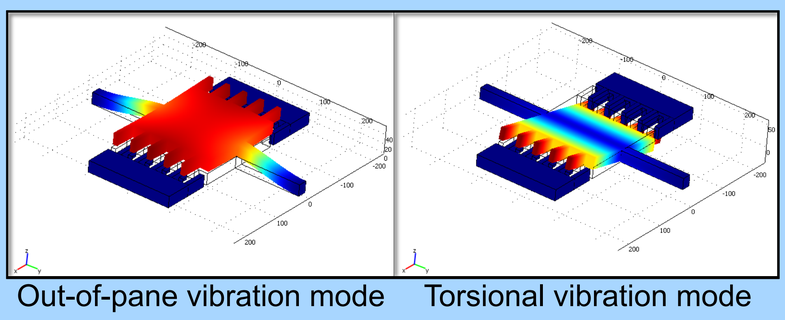






3 MEMS design strategies

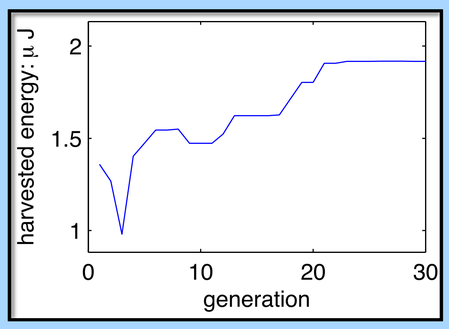
- Additional initial spring mechanism for lower 1st mode frequency (10^2's Hz) and mechanical amplification.
- Nonlinear vibrational designs to access broader frequency bandwidth.
- Multiple axial vibration and out-of-plane motion to enable large capacitance change without displacement limit and compact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



Out-of-pane vibration mode Torsional vibration mode

4 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.



5 Conclusion

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

6 Future work

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

7 References

1. Wong *et al.* (2009) MEMS for Energy Harvesting, PowerMEMS 2009 (poster).
2. Ye *et al.* (2009), Optimisation of a piezoelectric system for energy harvesting, IEEE IUS, pp. 759-762.
3. Jia *et al.* (2012), TBA *Sens. Actuator A*, (in review)

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