Modeling, Simulation and Optimization of Piezoelectric Bimorph Transducer For Broadband Vibration Energy Harvesting in Multi-Beam and Trapezoidal Approach

N. Chen[1], V. Bekekar[1]
1. Department of Engineering Technology, Middle Tennessee State University, Murfreesboro, TN, USA

Introduction: The objective of this research is to design a millimeter scale broadband energy harvester device through the use of a trapezoidal beam approach with a non-linear geometry. In this research, we use COMSOL finite element analysis software to design, simulate and analyze the voltage and power characteristics under applied mechanical vibrations of a piezoelectric cantilever beam.

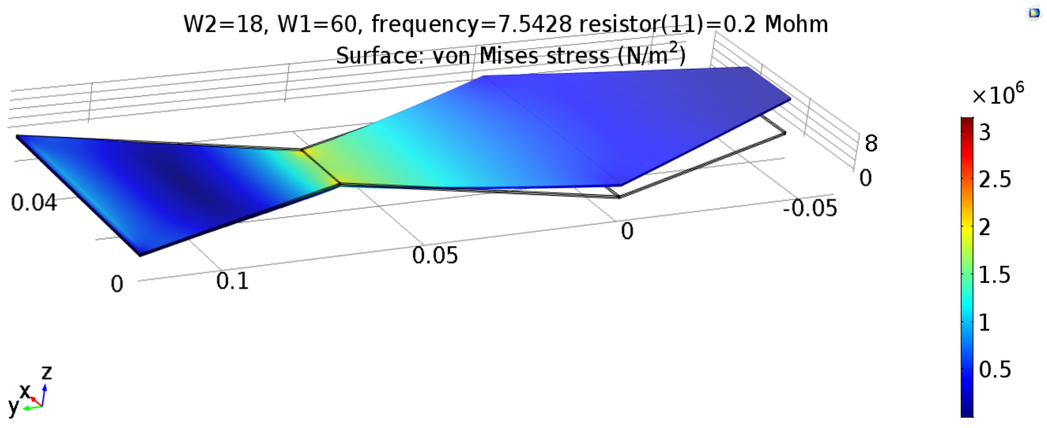

Figure 1. Trapezoidal design with fixed edge

Modeling idea: the piezoelectric ceramic composition samples have series combinations of a bimorph energy harvester design ,vibrating at the frequency near the natural frequency of the beam. We propose a new design of an optimized geometry for bimorph harvesters to capture energy at multiple frequencies. We aims to reach boarder vibration frequency response of the piezoelectric beam as well as its optimized output voltage power of the energy harvesting device by investigating fundamental frequencies ,dimensions of the beam design as well as external factors : such as optimal external resistance.

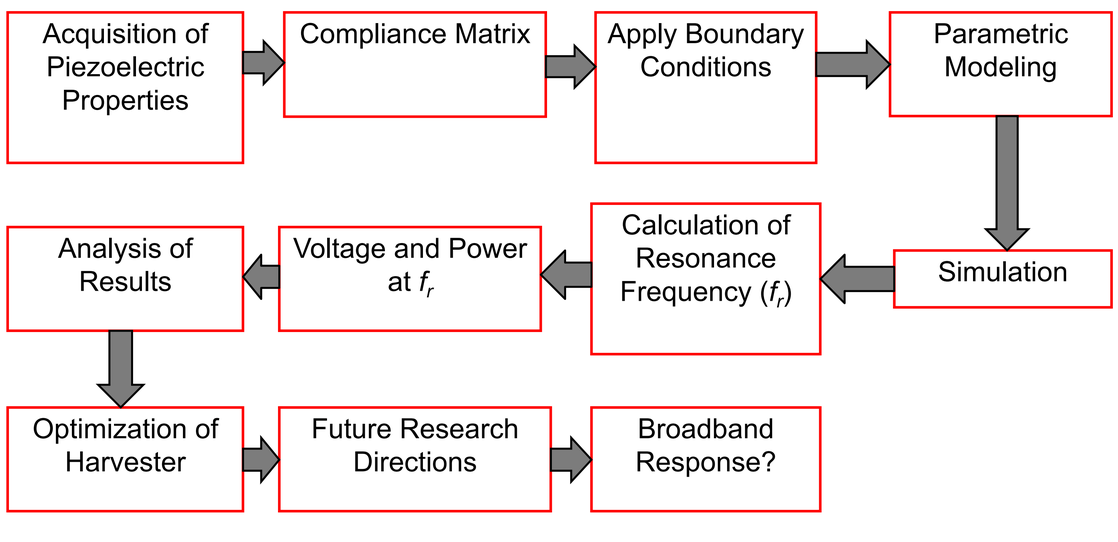

Figure 2. Optimization flow chart

Results: The vibration frequency bandwidth of the trapezoidal beam is about 40Hz, which covers 80% scanned frequency. Comparing with the previous bandwidth result in 2014, an improvement of broader band is seen.

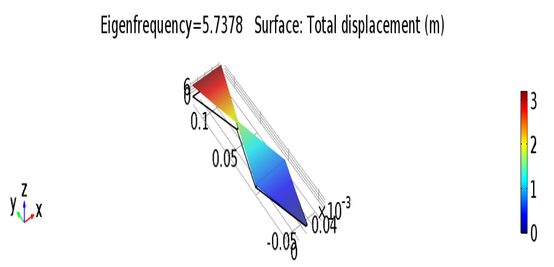

Figure 3. Another design

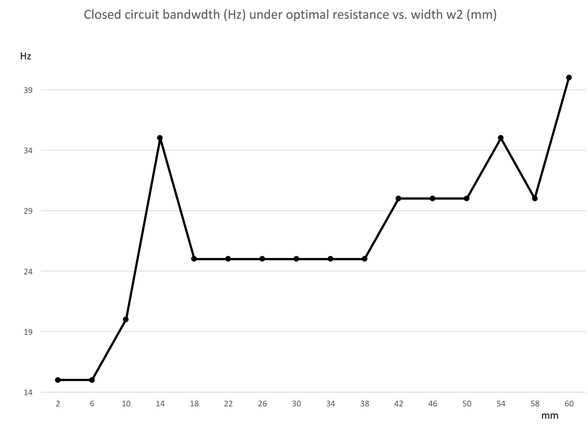

Figure 4. Bandwidth vs. width

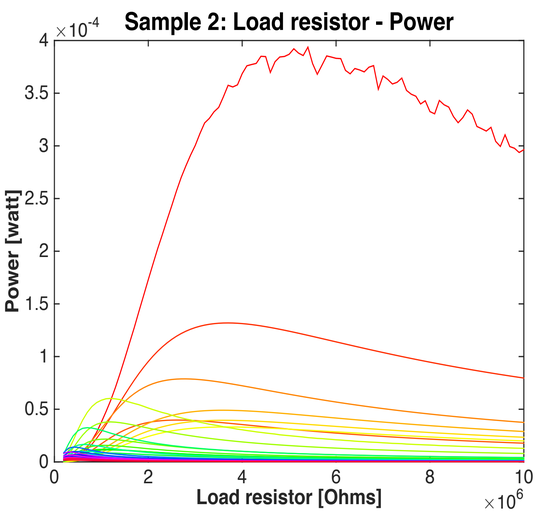

Figure 5. Power vs. R

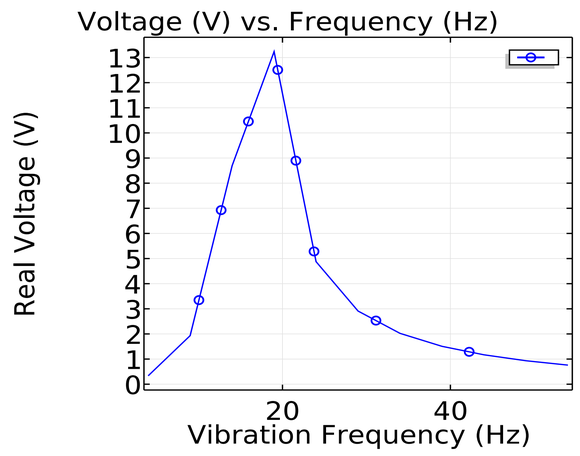

Figure 6. Voltage vs. frequency

Conclusions: The vibration frequency bandwidth of the beam is about 40Hz , covers 80% scanned frequency. Maximum apparent power 2.5 mW. Maximum power and broadband frequency band responses of a trapezoidal piezoelectric beam of design can be simultaneously achieved by increasing the central width of the beam W_2 to the maximum of 60mm in the study.

References:

1. Priya, Shashank. et al. ,Energy Harvesting Technologies. Springer, 2006 p93
2. Moheimani, S.O. Reza. et al. ,Piezoelectric Transducers for Vibration Control and Damping. London: Springer,2006, p16, p21