Geometric Optimization of Piezoelectric Energy Harvesting System

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Abstract

Introduction: Piezoelectric energy harvesting systems are able to provide a clean source of energy by transforming mechanical vibrations into electrical charges that can be used to operate ultra-low power devices. However, innovative technical approaches need to be developed in order to increase the efficiency of piezo-harvesters, as the percentage of output power in comparison to the input mechanical vibrations is considerably low. The aim of this study is to optimize the harvested energy by investigating different geometrical structures for a unimorph piezoelectric cantilever. This will be achieved by connecting a previously optimized cantilever in a two-element and a three-element array to increase energy conversion efficiency (Figure 1). The elements of the array have the same geometrical structure. Use of COMSOL Multiphysics: The analysis was made on Lead Zirconate Titanate (PZT-5H) in COMSOL, using the Piezoelectric Devices interface. The model has two different material layers, the top layer is the piezoelectric material, and the bottom layer is made of steel. A parametric study was conducted to optimize the design by varying the element-spacing of adjacent elements in the array. The models were then excited at their resonance frequencies and results were compared to that of a single element. Results: The overall stored energy for the two-element array and the three-element array was much more than that of the single element. This is a result of a significant increase in the open circuit voltage and charge measurements (Figure 2). Conclusion: Results of this study proves that geometrical optimization of a piezoelectric device connected in an array configuration can greatly affect its performance and increase its efficiency. The results are based on the condition that the device was excited at its resonance frequency and that the element spacing between the cantilevers was optimized for maximum output.

Reference

[1] M. Guizzetti, V. Ferrari, D. Marioli and T. Zawada, "Thickness Optimization of a Piezoelectric Converter for Energy Harvesting", Proceedings of the COMSOL Conference 2009 Milan.

Figures used in the abstract

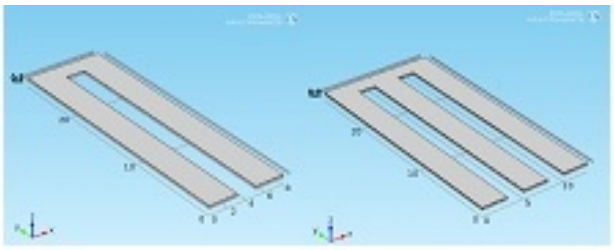

Figure 1: Geometric setup for the array configurations.

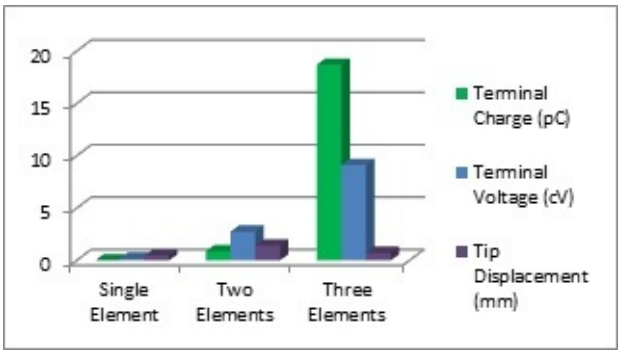

Figure 2: Comparing results for a single cantilever and an array of two and three elements.