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Design, modeling, and frequency domain analysis with parametric variation for fixed-guided vibrational piezoelectric energy harvesters

Namrata Saxena [a b e], Varshali Sharma [c], Ritu Sharma [a], Kamlesh Kumar Sharma [a], Sudha Gupta [d]

[a] Department of Electronics & Communication Engineering, Malaviya National Institute of Technology, Jaipur 302017, India
[b] Department of Electronics and Communication Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur 302017, India
[c] Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[d] Solid State Physics laboratory, DRDO, New Delhi 110054, India
[e] MEMS & Microsensors Group CSIR-CEERI, Pilani, Rajasthan 333031, India

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Abstract

The aim of the presented work is to design, model, and analyze the fixed-guided two-beam (FG2B) & fixed-guided four-beam (FG4B) piezoelectric energy harvesters, especially for ambient mechanical energy harvesting applications. Two and four rectangular beams are connected at the middle of the square-shaped seismic-mass in these configurations. The performance of the energy harvesters is analyzed using eigen-mode analysis and frequency domain analysis. To determine the resonance frequency of the energy harvesters the eigen-mode analysis is performed. The frequency domain analysis is coupled with parametric sweep analysis to analyze the effect of variation in input acceleration from 1g to 5g $(g = 9.8 m/s^2)$ on von Mises stress, displacement, electric potential, and output electric power. The main aim of the energy harvester is to generate electric power from the ambient mechanical vibrations. The reported FG2B and FG4B energy harvester produce an optimum electric output power of 0.55μW and 0.25μW at the maximum load resistance of 0.52MΩ and 0.2MΩ, respectively, with the electric potential of 0.8V and 0.32V respectively. Hence, the proposed energy harvesters generate higher electric potential and output power at a higher resistive load range with less device volume than the work reported in the literature. The designed energy harvesters resonate at around 550 Hz and 770 Hz for FG2B and FG4B respectively, which is in the low-frequency range and hence can be efficiently utilized for low-frequency energy harvesting applications with better electrical output power.

Keywords

Electric potential; Electric output power; Fixed-guided beam (FGB); Frequency Domain Analysis; Piezoelectric energy harvester (PEH); Vibrational Piezoelectric energy harvester (V-PEH); Von Mises stress

1. Introduction