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Performance Analysis of Microelectromechanical Systems-Based Piezoelectric Energy Harvester

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Abstract : Microscale energy harvesters can be used to convert ambient mechanical vibrations to electrical energy. Such devices have great applications in low powered electronics in remote environments like powering wireless sensor nodes of Internet of Things, lightings on highways or in ships, etc. In this paper, a Microelectromechanical systems (MEMS) based energy harvester has been modeled using Analytical and Finite Element Method (FEM). The device consists of a microcantilever with a proof mass attached to its free end and a Polyvinylidene Fluoride (PVDF) piezoelectric thin film deposited on the surface of microcantilever in a unimorph or bimorph configuration. For the analytical method, the energy harvester was modeled as an equivalent electrical system in SIMULINK. The Finite element model was developed and analyzed using the commercial package COMSOL Multiphysics. The modal analysis was performed first to find the fundamental natural frequency and its variation with geometrical parameters of the system. Then the harmonic analysis was performed to find the input mechanical power, output electrical voltage, and power for a range of excitation frequencies and base acceleration values. The variation of output power with load resistance, PVDF film thickness, and damping values was also found out. The results from FEM were then validated with that of the analytical model. Finally, the performance of the device was optimized with respect to various electro-mechanical parameters. For a unimorph configuration consisting of single crystal silicon microcantilever of dimensions 8mm×2mm×80µm and proof mass of 9.32 mg with optimal values of the thickness of PVDF film and load resistance as 225 µm and 20 MΩ respectively, the maximum electrical power generated for base excitation of 0.2g at 630 Hz is 0.9 µW.

Keywords : bimorph, energy harvester, FEM, harmonic analysis, MEMS, PVDF, unimorph
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