NUMERICAL AND EXPERIMENTAL STUDY OF BISTABLE PIEZOELECTRIC ENERGY HARVESTER

A Thesis

Submitted

By

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Declaration by the Research Scholar

This is to certify that the thesis titled "**Numerical and Experimental study of Bistable Piezoelectric Energy Harvester**" submitted by me, to the Indian Institute of Technology Mandi for the award of the degree of **Master of Science (by research)**, is a bonafide record of the research work carried out by me in the School of Engineering, Indian Institute of Technology Mandi, under the supervision of Dr. Mohammad Talha and Dr. Rajeev Kumar. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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Thesis Certificate

This is to certify that the thesis titled "**Numerical and Experimental Study of Bistable Piezoelectric Energy Harvester**" submitted by **Vishrut Shah**, to the Indian Institute of Technology Mandi for the award of the degree of **Master of Science (by research)**, is a bonafide record of the research work done by him under our supervision in the School of Engineering, Indian Institute of Technology Mandi. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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ABSTRACT

Enormous research is going on to reduce the size of portable electronic appliances and the use of self-contained power source is required to make more powerful and lightweight electronic devices without traditional batteries. Moreover for remote applications of the electronic devices it is very challenging as well as uneconomical to replace traditional batteries from the electronic systems. Piezoelectric energy harvester (PEH) may be used to power the small electronic devices but the major limitation of a PEH is generation of sufficient amount of energy essential for the autonomous operation of the portable electronics over the wide range of environmental vibration frequencies.

Energy harvesters based on piezoelectric effect have attracted great research interest as the energy conversion efficiencies of piezoelectric materials are higher than those of electrostatic or electromagnetic materials. But linear PEH scavenge limited amount of power just near the resonance frequencies that rendered the linear PEHs useless in practical environmental vibration conditions.

To overcome such complications, a Bistable Piezoelectric Energy Harvester has been proposed. To harvest the energy over the wide frequency range of environmental vibrations nonlinearity is introduced in the stiffness by mean of two neodymium magnets. The harvester has been modeled using Finite Element Method and validated with experimental study. The experimental results suggests that the efficiency of the bistable PEH is almost twice than that of its linear counterpart. The power reported in case of bistable system is 100% higher than the cantilever-type energy harvester and also significant over the wide frequency range.

The performance of various piezoelectric materials in bistable configuration is also studied. The numerical simulation demonstrates that lead-free piezoelectric material family $K_{0.5}Na_{0.5}NbO_3$-$LiSbO_3$ (KNN-LS) exhibits better performance than the conventional lead-based piezoelectric

material lead zirconate titanate (PZT). ZnO based nanogenerator is also studied. The complexity in the problem arises due to the existence of semiconducting properties along with the piezoelectric properties in ZnO nanowires. The developed model provides fairly accurate results when compared with the literature.

Keywords: Piezoelectric energy harvesting, Finite Element Method, Lead free Materials, Vibration, ZnO nanowire.

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