DESIGN AND SIMULATION OF PIEZOELECTRIC ENERGY HARVESTER

A THESIS

submitted by

ANURUDDH KUMAR

for the award of the degree

of

MASTER OF SCIENCE

(by Research)

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Declaration by the Research Scholar

This is to certify that the thesis entitled "**Design and Simulation of 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 research work carried out by me under the supervision of **Dr. Rajeev Kumar** and **Dr. Vishal Singh Chauhan**. 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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Date:

Thesis Certificate

This is to certify that the thesis entitled "**Design and Simulation of Piezoelectric Energy Harvester**", submitted by "Anuruddh Kumar" to the Indian Institute of Technology, Mandi for the award of the degree of Master of Science by Research is a bonafide record of research work carried out by him under our supervision. 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

The continuous reduction in power consumption of wireless sensing electronics has led to immense research interest in vibration energy harvesting technique for self-powered devices. Currently most vibration-based energy harvester are designed as linear resonator that only work efficiently with limited band-width near their resonator frequencies. Unfortunately in the vast majority of practical scenarios, ambient vibrations are frequency varying or totally random with energy distributed over a wide frequency range. Hence, increasing the bandwidth of vibration energy harvesters has become one of the most critical issues before these harvesters can be widely deployed in practice.

In this thesis an array of piezoelectric energy harvesters has been designed and analyzed to obtain maximum mean energy density at wide frequency range. Electromechanical behavior of piezoelectric energy harvester (PEH) has been modeled using finite element method. Modeling is based on first order shear deformation theory (FSDT) and linear piezoelectric theory. Finite element model of PEH has been validated with existing result in the literature. Optimum value of designed parameters are determined using genetic algorithm.

Compressive investigation has been performed among single piezoelectric energy harvester (SPEH), array of double piezoelectric energy harvester (DPEH) and array of triple piezoelectric energy harvester (TPEH). The numerical results predict that the mean energy /power density of SPEH 9% and 13% more than DPEH and TPEH respectively. However the power is maximum in case of TPEH at wide frequency range. Frequency

range of TPEH, DPEH and SPEH have been as 91-109 Hz, 91.5-109 Hz and 95.5-104 Hz respectively.

To demonstrate practical application, energy harvesting from the flow of exhaust of chimney has been investigated by an array of piezoelectric energy harvesters. Investigated predict minimum power of 2 W and mean power density 0.17 W/cm^3 can be obtained over a wide range of frequency under the given conditions. The performance of different piezoelectric materials is also investigated for piezoelectric energy harvester. A set of Lead-based and Lead-free piezoelectric materials have been chosen for investigation of performance in energy harvesting application. The mean power density of PZT (lead-based piezoelectric material) is only 3.2% higher than that of KNLNTS (lead-free piezoelectric material). Thus KNLNTS (lead-free piezoelectric material) is potential candidates for piezoelectric energy harvesting application.

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