Design and Analysis of a Three-DOF Piezoelectric Vibration Energy Harvester

R. T. P. Reddy[1], X. Xiong[2], J. Hu[3]

[1]University of Bridgeport, Bridgeport, CT, USA
[2]Department of Electrical and Computer Engineering, University of Bridgeport, Bridgeport, CT, USA
[3]Department of Mechanical Engineering, University of Bridgeport, Bridgeport, CT, USA

Abstract

Introduction:

Vibration energy harvester can convert mechanical vibration energy into electrical energy and store it in battery for later use. It can create clean renewable energy from vibration movements such as walking, jumping, running, etc. This can convert energy previously wasted into useful energy for charging portable electronic devices, wireless sensors. If such devices are widely used, it can generate a large amount of green energy and help protect the environment. Most MEMS energy harvesters are designed to harvest energy from one direction only. In this research, a novel MEMS piezoelectric vibration energy harvester with three-DOF (degree-of-freedom) responses is proposed. The device consists of a H-shape central silicon mass suspended by two sets of T-shape beams from both sides. The four sets of folded beams are fixed in both sides along the mass to vibrate along X direction. The two sets of straight beams allow the mass to vibrate along both Y and Z directions. Piezoelectric material is pre-deposited along the surfaces of the beams. It can convert the vibration energy of beams into electric voltage, which is passed through a rectifying circuit to charge a battery. The device can harvest vibration energy along all three axes, resulting more effective energy harvesting outcome. It is designed and simulated in COMSOL Multiphysics® software. The proposed MEMS energy harvester can be attached to shoes, tires or other vibrating surfaces to harvest energy from movement of walking, running, driving for clean energy generation.

Use of COMSOL Multiphysics:
COMSOL software is used to simulate the designed MEMS piezoelectric vibration energy harvester. Piezoelectric material is used in the simulation to show how the energy can be harvested and stored by the device. The harvested energy can be used to recharge battery for portable electronics. It offers a convenient and efficient way to harvest energy due to walking, running and other everyday activities of human being.

Results:
COMSOL software is used for the design and simulation of the MEMS piezoelectric vibration

energy harvester. The simulation results reveal how much energy can be harvested and stored by the proposed energy harvester. The device can be widely used inside shoes, underground and in other places with frequent shaking/vibration to harvest energy previously was wasted.

Conclusion:

In this research, the design and simulation of a vibration energy harvester with three degree-of-freedom responses is proposed. The device can convert mechanical vibration energy into electrical energy and store it in battery for later use. It can create clean renewable energy from vibration movements such as walking, jumping, running, etc. This can convert energy previously wasted into useful energy for charging portable electronic devices, wireless sensors. If such devices are widely used, it can generate a large amount of green energy and help protect the environment. The function of the energy harvest is simulated and verified by COMSOL software.