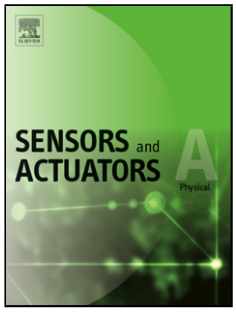

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Independent nonlinearity tuning of planar spring via geometrical design for wideband vibration energy harvesting

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Highlights:

1. Nonlinearity tuning can be realized through sophisticated geometrical design.
2. Nonlinear stiffness coefficient can be designed independently.
3. Both simulation and experiment validate the tuning method.
4. Working bandwidth of the output voltage can be tuned from 37Hz to as wide as 75Hz.
5. The tuning method is compatible with MEMS batch fabrication process.

Abstract

This paper reports a novel nonlinearity tuning method through sophisticated geometrical design for wideband energy harvesting application. By carefully controlling the thickness to length ratio of the planar spring beams, the nonlinear stiffness coefficient can be intentionally and precisely adjusted, while the linear stiffness coefficient can be kept unchanged. Thanks to the different effects on the linear and nonlinear parts, both the resonant frequency of the linear part and the bandwidth range of nonlinear vibration can be designed separately. As a proof of concept, MEMS-based electromagnetic vibrational energy harvesters employing the independent nonlinearity tuning method have been designed and fabricated. Both simulation and experiment were conducted to validate our method. At the acceleration of 0.5g, the micro-fabricated device is able to tune the operating bandwidth of the output voltage from 37Hz to as wide as 75Hz. This design can easily tune the length and thickness of the spring beams without changing the volume of the whole energy harvester device, which is compatible with MEMS batch fabrication process.

Key words: Electromagnetic energy harvesting; Nonlinearity tuning; Geometrical design; Planar spring; Micromachining; MEMS

1. Introduction

Recently the rapid development of internet of things (IoT) has led to growing demand of wireless sensors. Power source may become the main obstacle that hinders their low-cost and large-scale application. Vibration energy harvesters, which are capable of converting ambient kinetic energy into electrical energy, have attracted much attention due to their potential as alternatives to traditional electrochemical batteries [1, 2]. Typical vibration energy