Accepted Manuscript

High Frequency Nano Electromagnetic Self-Powered Mass Sensor: Concept, Modelling and Analysis

Ehsan Asadi, Hassan Askari, Mir Behrad Khamesee, Amir Khajepour

PII: S0263-2241(17)30242-7
DOI: http://dx.doi.org/10.1016/j.measurement.2017.04.019
Reference: MEASUR 4700

To appear in: *Measurement*

Received Date: 24 November 2016
Revised Date: 22 March 2017
Accepted Date: 12 April 2017

Please cite this article as: E. Asadi, H. Askari, M. Behrad Khamesee, A. Khajepour, High Frequency Nano Electromagnetic Self-Powered Mass Sensor: Concept, Modelling and Analysis, *Measurement* (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.04.019

High Frequency Nano Electromagnetic Self-Powered Mass Sensor: Concept, Modelling and Analysis

Ehsan Asadi, Hassan Askari*, Mir Behrad Khamesee, Amir Khajepour

Department of Mechanical and Mechatronics Engineering, University of Waterloo, 200 University Ave. West, Waterloo, ON N2L 3G1, Canada

Abstract

This paper is allocated to the modeling and analysis of a nano plate self-powered sensor based on the electromagnetic concept. Harvesting energy directly from the environment in nano and micro scales is a promising alternative for batteries in order to provide sustainable power for minuscule devices, and powering tiny sensors. In addition, energy harvesting in high frequency can be utilized for very small mass sensing. The nano scale self-powered sensor, proposed in this paper, consists of a moving miniature permanent magnet mounted on a nanoplate, and a stationary electromagnetic coil. The vibration characteristics of the nano plate is described for cases where the plate is rested on a linear and nonlinear (Winkler) foundation. The vibration equation of the plate is discretized and solved using Galerkin approach. The electromagnetic component is modeled using analytical and finite element approaches to predict induced voltage, regenerated power and electromagnetic damping force. A good agreement is shown between the analytical and finite element models. Using the developed models, the power capacity of the nano device in linear and non linear cases is investigated under different excitations. The results indicate that the device has a primary resonance frequency of 330 MHz, and for a gap (distance between permanent magnet and coil) of 1.5 nm, the nano device is able to provide 1.7 and 2.24 mW/cm^3 for linear and nonlinear cases respectively. At a given excitation condition, the induced voltage and the generated power depends on the mass of the particle, added to nano resonator. Thus, the voltage variation due to added particle, can be used to identify the particle's mass.

Keywords: Self-powered Sensor, Electromagnetism, Nonlinear Vibrations, Nanoplate, Small Mass Sensing, Biosensor.

1. INTRODUCTION

One of the most accessible and plentiful energy sources in real world phenomena is kinetic energy due to the random vibrations in the mechanical systems. In particular, vibrations with frequencies from Hz to MHz bring the potential to obtain energy density within

*Corresponding Author