

Micro-solenoid Electromagnetic Power Harvesting for Vibrating Systems

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ABSTRACT

The field of renewable energy has recently taken a surge with the advent of power harvesting systems. Much of the work previously done has focused primarily on dipole materials such as piezoelectric generators due to their high energy density. Exploring other vibration conversion techniques, electromagnetism has been theorized to be highly viable as well. In fact, in the presence of strong magnetic fields, its energy density can exceed that of piezoelectric systems. The key aspects to its usefulness lie in maximizing the rate of change of magnetic flux and thus maximizing the electric potential from the electromotive force. The specifics of this research include the descriptions of the electromagnetic theory, fabrication, and performance of a micro-electromagnetic power harvester with a vibration energy source. In addition, an empirical analysis of the influence of the micro-coil's geometry on the performance of the MEMS power harvester is given.

Keywords: Power harvesting, energy harvesting, electromagnetism, electromagnetic induction, MEMS, solenoid, in-plane spiral, geometric effects

1. INTRODUCTION

Vibration source energy harvesters can be typically broken down into one of three main types, piezoelectric, electromagnetic, or electrostatic generators. Each has been shown to be a viable option for the powering of micro-devices, with researchers citing varying electrical output performances and fabrication difficulty levels. In evaluating their work, researchers have documented varying metrics in which to compare these different mechanical to electrical energy converters, see [1-4], but still to this day, a clear standard for comparison has yet to be chosen. From a pure energy density comparison, many researchers [5-6] have predominantly investigated piezoelectric systems, claiming practical energy densities to be 3-4 times higher than that of electromagnetic or electrostatic [1]. Along that same principle, investigators have developed a wealth of theory describing the physics of how these piezoelectric harvesters convert mechanical to electrical energy and how best to optimize that transferred energy into electrical storage via power harvesting circuitry, see references [7-13]. Many researchers do admit though that given low vibration energy sources [1,3,14], and the limited efficiencies [1,5-6], that many of these devices are typically only useful for low power applications. Since classic low power applications are normally found within MEMS driven devices, a MEMS-based power harvester would be an ideal candidate for a power source in an integrated MEMS system.

While there has been some work in scaling and fabrication of MEMS-based piezoelectric harvesters, the implementation using standard CMOS techniques has not been easy [15-16]. Difficulties in fabrication arise from the piezoelectric materials with high electromechanical coupling coefficients having lead present. Selection of other piezoelectric materials without lead for CMOS fabricated devices exhibit lower coupling coefficients, thus negating the energy density advantage that was the previous motivation in choosing piezoelectric over electromagnetic or electrostatic

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