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Conversion of Atmospheric Variations into Electric Power – Design and Analysis of an Electric Power Generator System

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10 Abstract

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11 Given its abundant availability, ambient thermal energy harvesting has the potential to power standalone 12 microelectronic systems. The challenge in efficiently harvesting temperature and pressure variations is the low thermal 13 to electric conversion ability of current harvesters. Most thermal harvesters require high temperature gradients. This 14 paper presents the design, analysis, and implementation of an energy harvesting system that effectively harnesses 15 naturally occurring temperature variations using ethyl chloride filled mechanical bellows. A mechanical drivetrain 16 scales the bellows displacement and a coil spring stores the potential energy. This energy is periodically released and 17 converted into useable electric power by a DC generator. A series of mathematical models are developed and 18 accompanying numerical analyses completed on the harvester system. For a low frequency sinusoidal temperature 19 cycle of ±1°C about 22°C, 9.6 mW of electrical power was produced using a 1.5V micro DC generator for a 24 hour 20 harvesting period. The power generation capacity of the proposed harvester is sufficient to indefinitely operate low 21 power sensors and microelectronics in environments with small temperature gradients.

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Keywords: atmospheric variations; thermal energy harvesting; energy storage.

25 1. Introduction

The process of harnessing or "capturing" energy from ambient sources that are natural or artificial, and 26 27 converting it to useable electric power is referred to as energy harvesting. Strict environmental regulations 28 and rising interest in power capability of electronic devices, wireless sensor networks and autonomous 29 devices have created a rising market for energy harvesting technologies. Currently, mass manufactured 30 energy harvesting devices are targeted to run a range of low-power and mid-power electronic equipment. 31 Energy harvesting allows implementation of self-sustaining, portable smart devices that have increased life 32 and minimal maintenance requirements [1]. These energy harvesters can facilitate the use of smart 33 computers, low power sensors [2] and LED lighting systems in remote regions throughout the world with minimal battery storage requirements. Ideally energy harvesters are compact, miniature systems that can be 34 35 integrated into devices without significant structure or space requirements. Advanced material 36 technologies, micro-manufacturing and three dimensional (3D) printing have enabled the development of 37 micro components that satisfy functional requirements, at lower costs. Energy storage techniques have also 38 received considerable attention in offering dense power capacities for uninterrupted power when coupled 39 with energy harvesting systems.

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