Combined Power Harvesting from AC and DC Sources

Adam Wickenheiser*[a], Ephrahim Garcia[a]

[a]Sibley School of Mechanical and Aerospace Engineering, Cornell University Laboratory for Intelligent Machine Systems, Ithaca, New York 14853

ABSTRACT

There are a number of approaches to power harvesting that are under-exploited in many applications germane to sensing and communication. Power can usually be obtained from numerous sources – such as solar, thermal, vibrational, and electromagnetic energy – using a variety of transduction methods. However, in general a power harvesting system and its associated electronics interface are designed only to exploit a single energy source. This research presents the development of innovative ways of gathering power and addressing the design issues in providing a unified energy source from disparate power harvesting approaches, specifically alternating and direct current methods. These power sources are integrated into a single source to be utilized for sensing and communication. Several circuit designs are offered to improve the combined energy harvesting performance over that of the individual harvesters. The transient dynamics of charging a storage capacitor are presented for the individual and combined power sources. Complications arising from backwards electromechanical and mutual coupling are discussed.

Keywords: power harvesting, piezoelectric, thermoelectric

1. INTRODUCTION

Typically, the lifespan of wireless sensors and communications nodes is limited by size or weight constraints placed on its battery or other energy storage device. The prospect of harvesting readily available, ambient energy provides a potential solution to this limitation that does not require maintenance or replacement of the system [1]. Consequently, the field of harvesting ambient energy for powering wireless electronics has seen much growth in research and development in the last decade. The predominant sources considered in the literature include thermoelectric, vibration, and electromagnetic [2-3].

Despite the plethora of studies regarding modeling, implementation, and optimization of energy harvesters (see [2-5] for review papers), relatively few researchers have considered combining multiple sources of energy. Indeed, many wireless systems operate in environments in which multiple sources of energy exist. Providing multiple pathways of energy transduction results in the possibility of increased average power transferred to the system from the environment and less blackout time in which no power is transferred. This improvement can consequently enable higher power applications or increased duty cycle of any attached devices. Researchers have considered a number of methods to increase harvesting performance for small scale systems. MacCurdy et al. [6] consider a piezoelectric cantilever power harvester in which the added tip mass is replaced with a magnet and utilized for electromagnetic transduction through a solenoid. Reissman et al. [7] discuss several design considerations for a miniature, multi-source energy harvesting system for powering implanted devices on insects. Lhermet et al. [8] have designed an integrated power management circuit for charging a micro-battery from radio frequency and thermoelectric power.

This paper presents an overview of some of the considerations salient to designing a multi-source power harvesting system. The architecture of such a system is depicted in Fig. 1. The AC sources are rectified for charging a storage unit (capacitor or battery). An impedance matching or power management step can also be added between the transducers and the storage unit to regulate the voltage (and, therefore, the effective impedance) of the storage device through

* amw30@cornell.edu; phone 1 607 255-5457; fax 1 607 255-1222

Active and Passive Smart Structures and Integrated Systems 2009, edited by Mehdi Ahmadian, Mehrdad N. Ghasemi-Nejhad, Proc. of SPIE Vol. 7288, 728816 · © 2009 SPIE · CCC code: 0277-786X/09/$18 · doi: 10.1117/12.817305