

Adaptable, High Performance Energy Harvesters

Can Energy Harvesting Deliver Enough Power for Automotive Electronics?

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Abstract—Energy harvesting has become a very popular research topic over the last 12 years, but has only made an industrial impact in a few areas, noticeably in process plant monitoring, including the water and petrochemical processing industries. Like most technologies, greater adoption needs to be realized if performance is to increase and cost to decrease. Batteries cost only tens of pence per Wh, and whilst harvesters can in theory generate very large amount of energy over a long enough period of operation, a typical harvester can require a capital expenditure of tens to hundreds of pounds, making them unattractive in many applications. The automotive sector is a potential area in which harvesters could provide useful functionality and gain from economies of scale, if they can be made reliable enough with a high enough power density and work well in a wide enough variety of scenarios. Recent work on increasing the power density of energy harvesters has focused on improving the power electronic interface, tuning the resonant frequency of motion-driven harvesters and reducing the power consumption of the load electronics.

Keywords—energy harvesting; adaptive systems; power density

I. INTRODUCTION

Although widely regarded as a highly useful concept, energy harvesters have to date only made a limited industrial impact. In order to broaden this impact and enable a host of new applications the devices must achieve higher performance in real situations. For motion-driven harvesters, one of the key issues is therefore adaptability of the resonant frequency to track the dominant frequency in the input spectrum over time. In addition, the system must contain a high efficiency power processor capable of extracting maximum power from the transducer and transferring it to a storage element with minimal loss. In this panel session, I will cover the recent work that has been done towards achieving these goals, concentrating on an EPSRC funded project "Holistic Energy harvesting" in which expertise in low power digital design, MEMS, power electronics and multi-domain simulation was brought together.

II. HOLISTIC APPROACH

In order to achieve an efficient and high performance energy harvesting system, several subsystems - harvesting transducer, power processor, energy storage and computational element - must be designed in a complimentary and optimal way. A key issue with many existing motion-driven harvesters is that the vast majority have been designed to work at fixed frequency. However, in most applications, including automotive ones, this is not realistic. Several techniques have been proposed to

broaden bandwidth, including using reactive loads synthesized by a power converter [1], and by mechanical means by modifying the spring. Recently, a new low-power method of changing the resonant frequency has been demonstrated [2] where a magnetic potential well is used to add a spring-like effect in parallel with the physical harvester spring and this has been shown to decrease the necessary power consumption for tuning by around 30% with appropriately shaped pole pieces. Harvester damping can be controlled via a suitably controlled rectifier interface [3]. The computational load on the system is responsible for two primary aspects of system operation: performing its intended processing task (perhaps looking at the frequency content of sampled data) and also the low power control tasks of the generator, such as calculating a demand resonant frequency and the use of power aware digital load circuits can increase the robustness of the system when energy is scarce [4]. All of this work is brought together through a common simulation tool interface [5] and the advances demonstrated in this project bring harvesters closer to real applications, such as those in the automotive sector.

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