Newsletter No. 32
December 2013

Micro piezoelectric vibration energy harvesters and its interfacing circuits

Introduction

This article presents a micro-piezoelectric energy harvesting (MPEH) system which was designed to obtain electrical energy by converting vibrational energy within the environment. The withdrawn energy from 0.5 g accelerating vibration is able to illuminate a low power consuming LED with human visibility. The MPEH system creates a green, consistent self-power source for wireless sensor nodes which takes critical role in the machine to machine (M2M) network.

Recently, as the VLSI technology progressed rapidly to ULSI, and even to GLSI, the power consumption of electronic device has reduced as its size shrinks for consumer products. On the other hand, the energy crisis has proceeded as was predicted. This indicates that, as the suppressed power requirements of micro-watts have met the powering abilities of MPEH systems, the device size should also be compatible or other words in the scale of less than $1cm^2$. With all the merits required, we devote into developing the micro-piezoelectric harvesting systems which can provide tens of micro-watts. Using the interfacing circuits to collect power, we will be able to provide WSN nodes working at duty cycle modes. Therefore our work focuses on the transducer (MPEH) design and the interfacing circuit design, which dominates the energy efficiency of the overall system.

The power harvesting device was firstly designed and fabricated. A paperclip size, d_{31} piezoelectric cantilever energy harvester was presented, with the maximum output 200W under 1.5g.

Monthly Events

- 2013 Open House is held on December 8, 2013. The detailed event information is on our center web page: http://ccc.ntu.edu.tw/index.php/ch/event/152
- Vice President of Intel Labs and Director of Integrated Computing Research, Dr. Vida Ilderem visits NTU for delivering a talk on “Internet of Things: Making It all Work” on December 11, 2013.
- Dr. Mate Boban, a research scientist of NEC Laboratories Europe, gives a talk on “Vehicle-to-Vehicle Channel Modeling for Large-Scale Simulation” on December 27, 2013.

Our group had also measured environmental vibration source, and installed the energy harvester system in the air conditioner vent to obtain power. Recently, in the late 2013, two journal papers presenting the power generating devices were accepted by Smart Material and Structures and Journal of Micro-mechanics and Micro-engineering, entitled "Piezoelectric micro energy harvesters based on stainless-steel substrates," and "Fabrication of PZT MEMS energy harvester based on silicon and stainless steel substrates utilizing an aerosol deposition method". This honor has proved our hard work on the design of energy harvesting devices.

As far as the interfacing circuit is concerned, synchronized switching harvesting on inductance (SSHI) technique was used. The SSHI is powerful for enhancing the efficiency when the coupling effect of the power harvesting device is low. The bottleneck of the SSHI was the switch control. That is, previously, the switch requires external powering, which takes often more than what could be harvested. Then, with the help of the inventing team of SSHI in France, a self-powered design was proposed. Despite the loss of the switch, from our experimental results, the self-powered switch was able to enhance power outputs up to three times in comparison to classical regulating circuits.

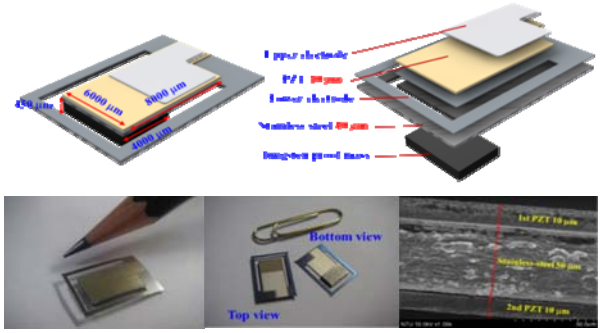

Figure 1: Paper clip sized energy harvesting device

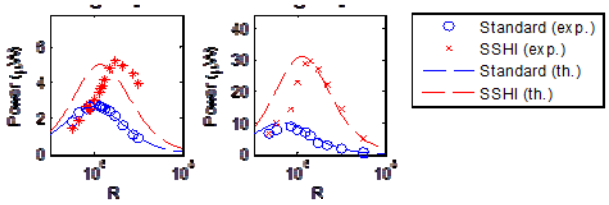

Figure 2: Power enhancing experiment with k^2Q_M = 0.17 and 0.39

In overall system performance, around 90 μ w can be harvested and stored. The energy harvested from the environment was fond to be able to illuminate a 1026LED in a duty cycle of more than 25%. It proved that the power harvested was sufficient for other devices. And it is our goal to continue to strive to progress, and ultimately integrate with wireless sensor nodes.

Intel-NTU
Connected Context Computing Center

BL-7C, Barry Lam Hall,
1 Roosevelt Road, Sec. 4
National Taiwan University
Taipei, 10617 Taiwan
Tel: +886-2-3366-1467

http://ccc.ntu.edu.tw

About the Author

Wen Jong Wu, Associate Professor,

Department of Engineering Science and Ocean Engineering, National Taiwan University;

SIGARG PI, Intel-NTU Connected Context Computing Center

Acknowledgments

This work was jointly supported by National Science Council, National Taiwan University and Intel Corporation under Grants NSC101-2911-I-002-001 and NTU101R7501-1.