Energy Harvesting

Speaker: Ulrich Schmid, Vienna University of Technology

Energy harvesting is the principle of extracting unused energy from the environment targeting nowadays a wide range of applications such as structural health monitoring (HMS), automotive for tire pressure monitoring purposes or medical for implanted sensor systems. Especially with the progress of miniaturization and reduction of power consumption for micro- and nanomachined devices and systems, energy harvesting enables true autonomous power supply for wireless sensor systems. Despite this progress, however, it is still very challenging to recover with micromachined harvesting devices enough energy for a sensor node from the environment although a wide range of different harvesting principles, tailored materials and smart device concepts are reported in literature.

Basically this tutorial is divided into three main parts: First, a brief overview on standard MEMS related technologies are given laying the basis for the realization of the corresponding devices and systems discussed in the next two sections. Having this background, an overview on micromachined, piezoelectric harvesters is given converting vibrational to electrical energy. The performance and limitations of this type of MEMS harvesters are discussed. Finally, a health monitoring system for aircrafts targeting an autonomous wireless sensor network is introduced being regarded as advanced approach to avoid large installation efforts. In this context the energy harvesting options within an aircraft structure are evaluated, focusing on thermoelectric energy harvesting. To provide a high temperature gradient across the thermoelectric generator, a special ’phase change heat storage device’ is developed, simulated and experimentally evaluated. The successful operation of the harvesters is proven in flight tests.

About the speaker: Ulrich Schmid was born in Munich, Germany, in 1972. He started studies in physics and mathematics at the University of Kassel in 1992. In 1995, he spent 6 months at the Transport Group in the Physics Department, University of Nottingham, UK, to gain experience in wide band gap semiconductor physics. He performed his diploma work at the research laboratories of the Daimler-Benz AG (now DaimlerChrysler

AG) on the electrical characterization of silicon carbide (6H-SiC) junction field effect transistors at high temperatures. During this time, he also investigated metal-oxide-semiconductor (MOSiC) based structures, such as gate controlled diodes, MOSFETs, and integrated circuits for harsh environment applications. He finished his studies in 1998 at the University of Frankfurt/Main, Germany. In 1999, he joined the research laboratories of DaimlerChrysler AG (now EADS Deutschland GmbH) in Ottobrunn, Germany. He developed a robust flow sensor for high-pressure automotive applications and received his Ph.D. degree in 2003 from the Technische Universität München, Germany. From 2003 to 2008, he was post-doc at the Chair of Micromechanics, Microfluidics/Microactuators at Saarland University. Since October 2008, he is full professor at the Vienna University of Technology heading since 1st of January 2012 the Institute of Sensor and Actuator Systems. U. Schmid is inventor or co-inventor of 15 patents and has authored or co-authored more than 150 peer reviewed publications in conferences and journals.

Energy Harvesting for Autonomous Sensors – Basic Design Rules and Building Blocks

Speaker: Manel Gasulla, Universitat Politècnica de Catalunya

Autonomous sensors are wireless measurement systems used in multiple applications from healthcare to environmental monitoring. A large number of autonomous sensors still rely on primary batteries for their power supply. However, primary batteries present several drawbacks such as: have to be replaced when depleted, which increases the maintenance costs; may become the largest and most expensive part of the autonomous sensor; measuring their state of charge is difficult and has no optimal solution, so that system reliability asks for periodical replacement, such as in fire alarm sensors and healthcare applications; their replacement can also be unpractical or unfeasible, such as in applications with sensors implanted in human beings or animals or embedded inside building materials or structures. A proposed alternative, not exempt of challenges, is to harvest the energy from the surrounding environment or to transmit it wirelessly form a nearby point. Examples of ambient energy sources are light, thermal gradients, or vibrations whereas energy can be transmitted via antennas and inductive links.

The tutorial provides both a general overview of the basic building blocks that compose an energy harvesting system and basic design rules. Different types of energy transducers, conditioning circuits, and storage devices are introduced. As for the energy conditioning circuits, maximum power point trackers (MPPTs) have been proposed in the literature in order to maximize the energy extracted from the energy transducers, especially for solar cells. MPPTs are introduced and a novel MPPT method is presented.

About the speaker: Manel Gasulla received the Enginyer (MEng) and Doctor Enginyer (PhD) degrees in Telecommunication from the Universitat Politècnica de Catalunya (UPC, BarcelonaTech), Barcelona, in 1992 and 1999, respectively. Since 1993 he has been with the UPC, where he is an associate professor, engaged in teaching on Analog and Power Electronics and Electronic Instrumentation. In 2001-2002 he was a Visiting Postdoctoral Fellow at the Electronic Instrumentation Laboratory, Delft University of Technology, The Netherlands.

His research interests include capacitive sensors, sensor interfaces, wireless sensor networks, and energy harvesting circuits and methods for low-power autonomous sensors. He is co-author of several academic papers in international conferences and journals, five Spanish patents, one chapter of the book *“Energy Harvesting. Grundlagen und Praxis energieautarker Systeme“* (Essen: Expert-Verlag, 2007) and the book *Powering Autonomous Sensors* (Springer, 2011).