

ESSCIRC 2009 (Athens) Full-day Tutorial on

Energy Harvesting

Organizer: Prof. Dr.-Ing. Yiannos Manoli, IMTEK -University of Freiburg and HSG-IMIT

Abstract and Program

Energy harvesting (also known as power harvesting or energy scavenging) is the process by which energy is derived from external sources (e.g., solar power, thermal energy, wind energy, salinity gradients, and kinetic energy), captured, and stored. Frequently, this term is applied when speaking about small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks. (<http://www.wikipedia.org>)

The tutorial covers both the transducer concepts and devices used to convert ambient energy into electrical power and also the circuits required to drive these components at the right operating point to achieve a high efficiency. It is thus directed towards participants of both ESSDERC and ESSCIRC. The 60-minute talks are followed by 15 minutes of questions and discussions.

9:00 Introduction, Y. Manoli

In the introduction we will explore the applications and systems where energy harvesting can be applied to power autonomous devices with functions such as readout of remote sensors, observation of the environment, surveillance of buildings and industrial plants.

10:15 Break

10:45 Harvesting Generators with AC Output, D. Spreemann

Some systems convert kinetic energy from motions and vibrations by using piezoelectric, electrostatic and electromagnetic concepts. The result is an AC output power. Electrostatic or capacitive harvesting is based on the effect that vibrations separate the plates of a variable capacitor, thus converting mechanical into electrical energy. Mechanical strain on piezoelectric devices can generate electrical current or voltage and vibrating magnets moving past a coil can be used to gather electrical power.

12:00 Lunch Break

13:30 Harvesting Generators with DC Output, B. Habbe

Other concepts use electrochemical, photovoltaic or thermoelectric concepts to provide a DC energy source using fuel cells, light radiation or heat gradients. Thermoelectric generators, for example, are built up as a junction of two different materials. By connecting many devices in series a usable voltage can be achieved at the presence of thermal gradients.

14:45 Break

15:00 Adaptive Circuits for AC-Generators, D. Maurath

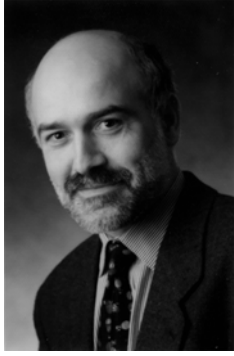
These power sources deliver low levels of usable energy, thus any system will have to seek ways to maximize the effectiveness. So diverse the energy sources are, even more wide ranging are the transduction principles that can be applied to convert the available energy to electrical power. Each one of these schemes will require a different circuit technique for achieving an optimal conversion. This adaptive control has to be intelligent enough to always find the optimum without itself requiring too large amounts of energy. Here lies a major challenge for low-power and low voltage electronics.

16:15 Adaptive Circuits for DC-Generators, M. Pollak

The last presentation covers the design and optimization of dc-dc converters for energy harvesting applications. Start-up circuits, boost converters and charge pumps are addressed. Typical applications of these modules are thermo-generators, solar cells or fuel cells. Basic knowledge is provided as well as final ASICs design from present research projects.

17:30 End

Presenter Biographies



Yiannos Manoli holds the Chair of Microelectronics at the Department of Microsystems Engineering (IMTEK), University of Freiburg, Germany. Since 2005 he additionally serves as director of the “Institute of Micromachining and Information Technology” of the “Hahn-Schickard Gesellschaft” (HSG-IMIT) in Villingen-Schwenningen. His research interests are the design of low-voltage and low-power mixed-signal CMOS circuits as well as sensor micromachining with over 200 papers published in these areas. The emphasis lies in energy harvesting and sensor read-out electronics as well as Analog-to-Digital converters. Additional research activities concentrate on motion and vibration energy transducers and on inertial sensors especially angular rate sensors or gyros. He holds a B.A. degree in Physics and Mathematics, a M.S. degree in Electrical Engineering and Computer Science from the University of California, Berkeley and the Dr.-Ing. Degree in Electrical Engineering from the Gerhard Mercator University in Duisburg, Germany.



Dirk Spreemann received the Dipl.-Ing. (FH) degree in Physical engineering from the University of Applied Sciences Ravensburg-Weingarten, in 2005. His diploma thesis focuses on resonant and non-resonant miniaturized electromagnetic vibration transducers. After studying complementary courses of Microsystems Technology at the University of Freiburg he is currently working as a Ph.D. student and scientific engineer in the “Energy autonomous systems” group at the Institute of Micromachining and Information Technology HSG-IMIT in Villingen-Schwenningen. His research interests lie in the area of micro power generation with a special focus on electromagnetic vibration conversion.



Burkhard Habbe is Vice President Business Development at Micropelt. With a degree in Mechanical Engineering from Munich’s Technical University he started as an automation engineer before shifting to technology sales and marketing in industries including Software, Consulting, Video Communication, Micro Assembly and Machine Vision. Today Burkhard Habbe drives Micropelt’s thin film thermoelectric technology to its applicable markets. Applications include energy harvesting for low power wireless sensors and data loggers, photonics micro-cooling, rapid thermal control for biochemical applications, and various thermal sensing applications.



Markus Pollak studied Electrical Engineering at the University of Erlangen/Germany and graduated with the Dipl.-Ing. degree in 2000. Since February 2001 he works at the Fraunhofer IIS, department of power efficient systems. He was working in the design of integrated circuits for RF-transceivers and power management circuits. His recent projects are concerned with DC-DC converters for energy harvesting applications and programming of microcontrollers for wireless transceivers.



Dominic Maurath received his Dipl. Ing. (FH) degree in Sensor Systems Technology from the University for Applied Science of Karlsruhe, in 2004. After studying complementary courses of Microsystems Technology at the University of Freiburg he was with the Energy Harvesting Systems Group of HSG-IMIT, Villingen-Schwenningen (Germany), between 2004 and 2007. Thereafter, he became a Ph.D. student in the Graduate School for Micro Energy Harvesting of the University of Freiburg. He is currently working on weak inversion circuit design for load matching interfaces and DC/DC converters for energy harvesting applications.