Seminar:
"Emerging Topics in IEEE Circuits and Systems"

Sponsored by the IEEE CASS outreach activity:
"Inter- and Cross-disciplinary Topics in Circuits and Systems Community"

Thursday, 29 October 2015

Aula Beta, Building 24
Politecnico di Milano, DEIB
Via Golgi 40, Milan, Italy

14:30–14:40	Opening: the IEEE CASS vision
14:40–15:10	Inertial Energy Harvesting in MEMS: Some Recent Trends
15:20–15:50	Phase and amplitude noise in oscillators, and potential application to energy harvesting
16:00–16:30	Thin-film Piezo for next wave of MEMS actuators
16:40–17:00	Discussion

Participation is free of charge

Inertial Energy Harvesting in MEMS: Some Recent Trends

Raffaele Ardito
Politecnico di Milano

Abstract: The application of piezoelectric materials is continuously increasing, with different possible uses of both "direct" (conversion of mechanical into electric energy) and "indirect" effect. The latter is applied for actuating purposes, e.g. in the case of micropumps; "direct" effect is now widely used for energy harvesting. In recent times, the concept of energy harvesting has been applied to MEMS devices, with similar functioning principles: an additional broadening of applications can be forecast in the next future, with the immediate corollary of a fundamental need for improved computational tools. The talk will be focused on the fundamentals of inertial energy harvesting, for possible application at the MEMS scale. After a short presentation of the state-of-the-art, some details will be provided on computational techniques, which can be used to predict the actual behavior of MEMS device and to carry out the optimization process on the basis of Design of Experiments (DOE) procedures. Finally, some specific provisions for improving the harvester performances will be discussed.

Raffaele Ardito is associate professor of Structural Mechanics at the Politecnico di Milano. He graduated in 2000 (cum laude) at the Politecnico di Milano in Civil Engineering. Between 2001 and 2004 he has been Ph.D. student in Structural Engineering (Politecnico di Milano); he received the Ph.D. degree, cum laude, in 2004. Since 2004 to 2006 he has been research fellow at the National Institute for Nuclear Physics, joining an international research group with focus on solid mechanics in cryogenic conditions. In 2007, he was back in the Politecnico di Milano and he started working on the topic of multi-physics simulations for Micro-Electro-Mechanical Systems (MEMS). He spent, in 2008 and 2010, two periods of research at the Research Laboratory of Electronics, Massachusetts Institute of Technology, as visiting scientist. He is co-inventor of two patents and co-author of more than 80 publications on structural mechanics and numerical methods; among them, 30 publications are papers on International Journals. In 2000, he got the Maddalena prize for the best Master Thesis in Civil Engineering and Architecture. In 2009 he has been awarded the "Young researcher" grant from the Dept. of Structural Engineering, Politecnico di Milano. His scientific interests are theoretical and computational aspects of multi-physics behavior of MEMS.

Phase and amplitude noise in oscillators, and potential application to energy harvesting

Michele Bonnin
Politecnico di Torino

Abstract: Energy harvesting promises to be a disruptive technology, making self-powered devices available for a large number of applications. Many of the devices proposed for energy harvesting are based on oscillators that collect the energy from random vibrations. It has been shown that in certain situation nonlinear oscillators may outperform their linear counterparts. In this talk we present a mathematical framework to study the dynamical behavior of nonlinear oscillators subject to perturbations modelled by white Gaussian noise. The method is based on the idea to describe the oscillator's dynamics in terms of amplitude and phase variables, that are the ideal framework for evaluating energy harvesting performances. Making use of the theory of stochastic differential equations and Itô calculus, a rigorous set of equations for the phase and the amplitude of oscillators of any order is derived. It will be shown that the noise influences not only the amplitude of the oscillations, but also the expected frequency. Using Floquet theory, it will be shown that a partial decoupling between the phase and the amplitude dynamics can be obtained, and how reduced order models can be derived. Potential applications to energy harvesting and stochastic resonance will be discussed.

Michele Bonnin received the Laurea degree in Physics from the University of Turin, Italy, and the Ph.D. degree in Electronic and Communication Engineering from the Politecnico di Torino, Italy, in 2003 and 2007, respectively. From 2007 to 2011 he was research associate with the Department of Electronics of Politecnico di Torino. In 2011 he joined the Department of Electronics and Telecommunications of Politecnico di Torino as Assistant Professor. His research interests include the theory of dynamical systems, both quantum and classical, and its application to circuits and systems. He is author or coauthor of more than 60 papers published on international journals and international conference proceedings. Michele Bonnin was the recipient of the 2004 Best Paper of the Year Award by the International Journal of Circuit Theory and Applications. He was the conference secretary for the 3th International Workshop on Cellular Nanoscale Networks and their Applications and for the 3rd Symposium on Memristor.

Thin-film Piezo for next wave of MEMS actuators

Dino Faralli
STMicroelectronics

Abstract: A growing number of applications is pushing the development of smart-systems which integrates MEMS sensors and actuators, with an increased demand of new ways to interface the system versus man and ambient. New enabling technologies are required to be available in manufacturing lines to allow for prototyping and production of such devices. A pilot line for integration of piezoelectric thin-films into MEMS devices has been recently installed in the STMicroelectronics Fab in Agrate Brianza. A summary of the technology module and characterization of the piezo materials will be shown, together with an overview of the products under development.

Dino Faralli received the Laurea degree in Physics in 1996 and PhD degree in Theoretical Physics in 2000 from the University of Perugia, Italy. He is currently working as MEMS technology development team leader, responsible for development of MEMS technologies and products, with focus on piezo-electric materials, within the AMS group of STMicroelectronics, based in Agrate Brianza, Italy. He has 15 years experience in technology development from the concept phase, to industrialization and manufacturing. He worked on development of several technologies which reached product maturity and manufacturing phase e.g. High Voltage and Smart Power BCD, BCD 200V on SOI, Pressure sensors, Accelerometers, Probe storage devices, Thermal and Piezoelectric Inkjet print-heads. He holds 16 patent applications and scientific publications in the semiconductor technology field.