Authonomous Spintronics Sensor and Power Harvesting System

Proposers

Ricardo Ferreira (ricardo.ferreira@inl.int, INL)

Rita Macedo (scardoso@inesc-mn.pt , INESC-MN/IST)

Paulo Freitas (ricardo.ferreira@inl.int, INL/INESC-MN/IST)

Introduction

Fully autonomous sensors capable to harvest energy from the environment where they are inserted and use that power to acquire and transmit meaningful information are a key building block of large IoT networks. Such sensors don't require a dedicated infrastructure since they are completely unplugged both for powering and data transmission purposes and they don't rely on batteries, meaning that the network can be kept with minimum logistics and maintenance costs. Such networks are suitable both for monitoring large infrastructures distributed over a large geographical area (e.g. : power networks and highway networks) as well as more compact systems where the almost indefinite operation of the data acquisition is a key advantage (e.g. : sensors operating within the human body do monitor biological functions or parameters from biomedical devices and prosthesis). Demonstrating the hability to use a spintronics sensor and a spintronics zero-threshold rectifier within the same autonomous sensing system is the objective of this PhD proposal.

Project outline/goal

In the past year, a zero-threshold energy harvesting device was demonstrated at INL. Such a device can effectively generate a DC current from an RF current, without being limited by the minimum voltage thresholds of conventional rectification solutions, making it particular useful for the rectification of low power signals that can be harvested from the environment. Furthermore, the rectification device is not of a resonant-type, i.e., it operates over a very large frequency window. While the advantages of this new device are obvious, the physical mechanisms behind its operation are not yet fully understood and the device is far from being optimized. The PhD candidate working on this project will make a quantitative model of the system which will be used to optimize the harvesting efficiency. Once such optimization has been done, an authonomous sensing system will be demonstrated. Such a system will integrate : an antenna to collect electromagnetic radiation in the frequency range usable by the rectifier, the zero-threshold rectifier, an capacitor which will be charged by the antenna and rectifier, a low power CMOS circuit which will be feed by the capacitor and a magnetoresistive sensor that will be used to collect data. This demonstrator will be used to gauge the performance of the system and evaluate this solution for more practical applications.

Partner 1 – INESC-MN

INESC-MN has a large experience in the production of magnetoresistive sensors. The PhD candidate will develop the magnetoresistive sensors needed for the final sytem at INESC-MN.

Partner 2 – INL

INL demonstrated the zero-threshold rectification function on a 100-nm MTJ nanopillar with a free layer close to the transition from in-plane magnetization to out-of-plane magnetization. Such device exhibits a very unusual linear resistance dependency with respect to the bias current. This is a key feature enabling the rectictification function, but the physical origin is not completely understood. The PhD candidate working on this project will have to model this system, design and conduct the experiments required to explain this behavior and optimize the system towards higher efficiencies. The modeling predicitions will have to be matched by electrical measurements performed at wafer level on real nanofabricated devices.

System Integration – INL and INESC-MN

Once the wafer level functionalities of the sensor and rectifier are demonstrated and characterized, a system level integration of the devices will be performed. To this end, the PhD candidate will have to interface the sensor and rectifier together with an antenna and CMOS taking care of the system control and data transmission. A demonstration setup enabling the measurement of the systems efficiency and benchmarking with other potential solutions will have to be implemented.

Student profile

Profile sought: hard working and persistent student with an Engineering Physics background and experience in cleanroom Micro/Nanofabrication, programming, modeling and data acquisition circuit design.