Ph.D. in Information Technology: Thesis Defense

July 21st, 2021

online by Teams at 10.00

Alireza MESRI GENDESHMIN – XXXII Cycle

Mixed-Signal Electronics for Optogenetic Experiments and Cell Monitoring

Supervisor: Prof. **Giorgio Ferrari**

Abstract:

Neurodegenerative diseases occur as the result of progressive loss of structure, function, or even death of neurons. Training4CRM project, funded by the European Union Horizon 2020 Programme, is a highly cross disciplinary project and focuses on bridging the existing gaps within cell-based regenerative medicine for the treatment of neurodegenerative disorders (e.g. Parkinson's disease, Huntington's disease, and epilepsy) by joint training and education of 15 Ph.D. students, in 6 European countries.

In this Ph.D. thesis, which is a part of the Training4CRM project, a platform based on commercial off-the-shelf components is proposed to perform optical stimulation and electrochemical measurements on optogenetically modified dopaminergic cells. The system can be powered by small batteries and remotely controlled using the Bluetooth standard. Thus, it is compatible with a mounting on the head of freely moving rats for in-vivo optogenetic experiments.

Moreover, a novel technique is proposed to perform simultaneous multi-frequency impedance measurements on cells. The proposed technique is based on a double demodulation of the measured signals, the first in the analog domain and the second in the digital domain. Square wave excitation and demodulation signals are used to allow a compact and low-power implementation. A set of rules are introduced for selecting the frequencies of excitation and demodulation signals. The proposed technique was implemented and experimentally verified in an integrated circuit in 180 nm TSMC CMOS technology. The chip dissipates only 6 mW, including the analog-to-digital conversion of the signal, and operates up to a frequency of 15 MHz. The proposed chip is also able to perform amperometry and cyclic voltammetry measurements simultaneously with multi-frequency impedance measurements, allowing detailed electrochemical characterizations of the sample under test.

PhD Committee

Prof. **Marco Sampietro**, DEIB
Prof. **Gian-Franco Dalla Betta**, Universita' di Trento
Prof. **Arto Heiskanen**, Technical University of Denmark