Acquisition System for Multi-Mode Sensor Array II

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The Department of Physiology of the University of Bern and the IMT-ESPLAB of the EPFL in Neuchatel are presently developing an innovative Multi-Mode Sensor Array (MMSAII; collaborative project funded by the SNF).

The novel device is aimed at measuring the electrical activity of excitable cells at high spatial and temporal resolution. The device will permit to obtain an integrative understanding of the physiology and pathophysiology of excitable cells and is likely to find applications in drug screening studies.

Project scope

Because of the large number of integrated sensors and the high temporal resolution offered by the device, the computational needs to acquire and process the data over extended periods of time are huge and surpass the capabilities of commercially available conventional techniques.

It was the aim of this master thesis to develop an acquisition system that controls the MMSAII chip, digitizes the signals and stores the measured data. The acquisition system must handle all features offered by the MMSAII. Furthermore, special attention has to be paid on the signal quality, because the recorded signal amplitudes typically amount to 200µV – 2mV.

Results

A custom-made acquisition board was developed to interface the MMSAII. The platform is controlled by a System on Chip (SoC), implemented in a Field Programmable Gate Array (FPGA). The user can define measurement protocols and perform recordings with specifically designed software.

The system samples the sensor array at a frame rate of up to 10 kHz. It handles all features of the MMSAII, including a flexible stimulation of the cell culture with different patterns and user defined signals, as well as variable temporal and spatial recording resolutions.

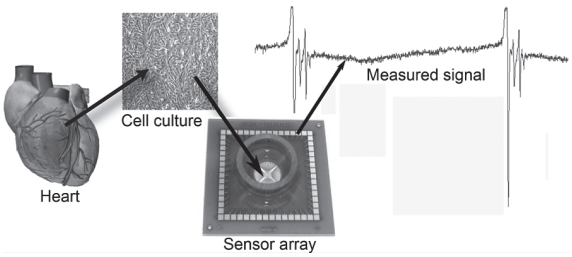
Discussion

In this master thesis, the first multi-pixel measurements with the MMSAII were performed. The experiments with the MMSAII proved that the developed system correctly records user defined subsets of sensors with an excellent signal quality. The acquisition system is now able to perform biological experiments with excitable cells.

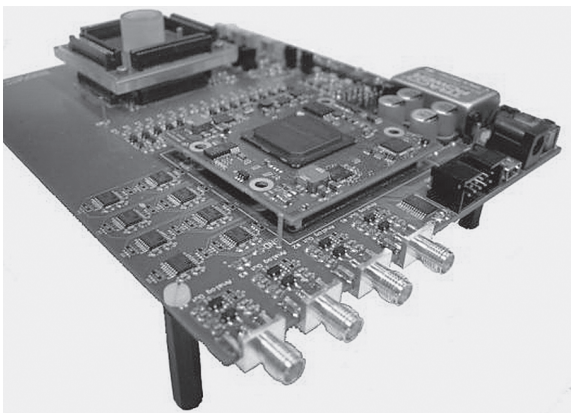
The performance of the entire platform was measured and its limits were identified. In particular, the high data rate was found to be the bottleneck for high-resolution multi-modal sensor array acquisition systems.

Implementing a fast interface to the computer and reducing the amount of data on the FPGA level are two potential solutions to improve the acquisition capabilities of the platform. A further goal is to implement an environmental control system to for example regulate the cell culture's ambient temperature.

Christian Dellenbach



The above figure shows a typical setup to perform experiments with excitable cells. A layer of heart cells is cultivated on the sensor array. The aim of the acquisition system is to record the electrical activity measured by the sensor array. Researchers are mainly interested in action potentials which, in this figure, correspond to the two peaks in the recorded signal.



Prototype of the developed acquisition platform. It consists of a base board, an Altera Cyclone IV FPGA module (in the front) and a MMSAII (in the back).