# Esophageal ECG Recorder: Low-Power Hardware

Supervisors: Prof. Dr. Josef Götte and Prof. Dr. Marcel Jacomet
Institutions: HuCE-microlab, Bern University of Applied Sciences; ARTORG cardiovascular Engineering, University of Bern
Examiners: Prof. Dr. Josef Götte and Prof. Dr. Rolf Vogel



Heart rhythm disorders (arrhythmias) can lead to fatal outcomes, e.g. sudden cardiac death or cerebral apoplexy. The surface electrocardiogram (ECG) using skin electrodes attached to the chest wall and the limbs is the clinical gold-standard to detect and to characterize arrhythmias. However, many patients suffer only from short-lasting, rarely occurring episodes, and therefore require long-term ECG recordings to establish the diagnosis. This is where the idea of the E2corder builds upon.

The probability to detect short-lasting, rarely occurring (paroxysmal) arrhythmias increases with the recording duration. Regrettably, surface ECGs suffer from two important limitations. First is the limited sensitivity for the electrical activity of the atria, which is crucial for modern treatment strategies. Second is the limited suitability for clinical long-term studies, which is related to electro-mechanical contact problems of the skin electrodes and their potential to harm the skin. As a promising alternative, ECG signals are captured from the esophageal mucosa. These signals offer detailed information on atrial activity, and the esophagus allows long-term instrumentation with excellent electromechanical contact.

## Methods

The goal of this thesis has been to research and to design ultra low-power front-ends which interfere as little as possible with the sub-millivolt input signals. The signals must be conditioned in a manner that they are ready for further processing. Off-the-shelf components solutions (discrete circuits) and integrated circuits were designed and simulated. The discrete circuits were built on a PCB and measured.

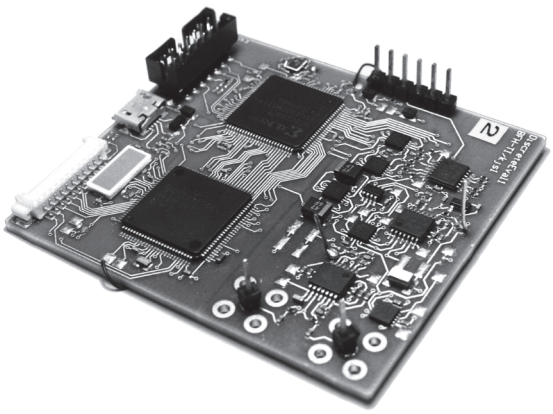
## Results and Discussion

In comparison with the existing first prototype, the new discrete version consumes less then 10% power, which corresponds to a current of 12µA at a supply voltage of 1.8V. Measurements on the discrete evaluation board lead to the conclusion that the used circuit fulfills all requirements concerning frequency and phase response, sufficient low noise characteristic and a high common mode rejection ratio.

In order to further reduce power consumption and especially to reduce area needs, an integrated implementation has been designed, which can be realized in an ASIC (Application Specific Integrated Circuit). Using the Nagaraj technique in the simulation of switched capacitor circuits, the challenges of large time constants (more than one second) and the associated large capacitor areas can be overcome. Large time constants are given by the low-frequency spectral characteristic of ECG signals. Frequency and phase response proved that this applied approach is well-suited. Supply currents in the sub micro-ampere are attainable.

Silvan Kojic

Esophageal ECG recording by a catheter



Discrete Evaluation Board