Unipolar Amplifier Design for True Bipolar Long-term ECG Leads

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A novel unipolar amplifier to measure biopotentials on the human body has been investigated. An evaluation board containing the circuit was developed. The measurements made with the board are compared to those measured simultaneously with a fully differential ECG monitoring device.

Introduction

Today, long-term ECG recordings are done with Holter monitoring devices. Cables are used to connect the electrodes to the monitoring device. The aim of this thesis is to investigate a novel unipolar amplifier circuit, found in literature, for its capability to measure long-term ECG signals. In particular it shall be investigated if this circuit is capable to measure ECG signals at specific positions using two electrodes in close vicinity to each other. This reduces the amount of wires needed to measure biopotential differences.

Materials and Methods

An evaluation board is developed to measure biopotentials (Fig.1). The sensing electrode is connected to the non-inverting input of an instrumental amplifier and a low-pass filtered copy of it to the inverting input. With the result that the signal present at the electrode is high-pass filtered and amplified. Measurements done with the evaluation board are compared to simultaneously measured, fully differential ECG signals derived with a conventional, monitoring device (BioRadio 150). Additionally, the influence of the placement of the grounding electrode is investigated.

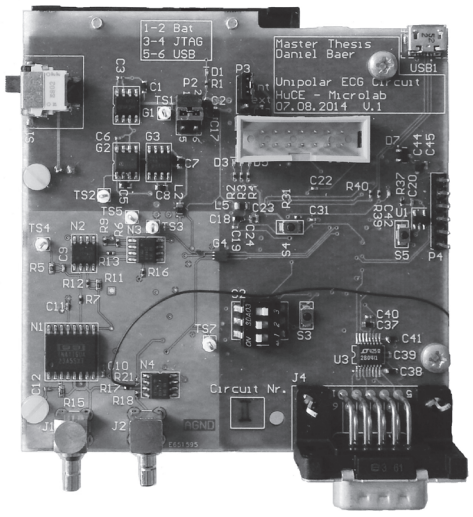

Fig. 1: Evaluation board containing the unipolar analog front-end and a microcontroller.

Results

The results derived with the evaluation board confirm that leads I, II and III can be reproduced with this circuit and they closely match the ECG measured with a standard recorder (Fig.2). The correlation coefficient was 0.95 or higher. However, potentials are highly dependent on the positioning of the grounding electrode.

Discussion

Independent unipolar measurements cannot be conducted with this circuit if both, sensing and grounding electrode, are positioned in close vicinity to each other. They lie on the same iso-potential line of the electric field, which is created by the electric activity of the heart. The physical principles governing measurements including electrodes also apply to this circuit.
Two-electrode circuits still hold advantages as no grounding electrode must be connected to the leg. Measurements indicate that there are locations on the human arm where a potential difference can be measured, with the electrode distance still close enough to be integrated into a single measurement unit.

References

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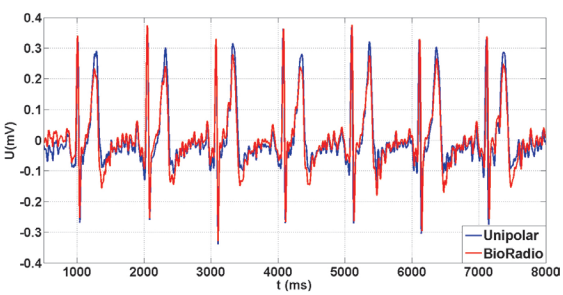

Fig. 2: Comparison of lead I between unipolar (blue) and standard differential circuit (red).

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