Master Thesis Presentation

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Title:	Leadless Cardiac Multi-Site Pacemaker System
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Leadless Cardiac Multi-Site Pacemaker System

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Introduction

Conventional cardiac pacemakers have leads that deliver the electrical impulses to the heart to stimulate it. These leads are prone to failure e.g. due to mechanical wear. To overcome this problem, leadless pacemakers have been introduced. However, these devices are not able to perform multi-chamber pacing. Multi-chamber pacing could be enabled by implanting several leadless pacemakers that communicate wirelessly to synchronize. The goal of this thesis was to develop prototypes of pacemaker modules that can perform cardiac pacing and bidirectional wireless communication.

Materials and Methods

As communication method, galvanic coupled intra body communication (IBC) was used. The hardware is based on a microcontroller development board (ST Microelectronics nucleo) in conjunction with the developed analog electronics. The data is pulse position modulated and directly applied to the heart tissue by needle electrodes. The software was written using Keil's Real Time Operating System CMSIS. Communication reliability between two modules was tested on porcine heart tissue.

Results

Prototype modules which allow pacing and bidirectional communication using IBC were developed (Figure 1). The data is pulse position modulated with adjustable frequency in the range between 100 kHz and 5 MHz. To allow the analog to digital converter to detect the high frequency pulses, an envelope detector was introduced in the input stage (Figure 2). The modules feature different use cases which can be accessed over a built-in user interface. Preliminary tests on cardiac tissue allowed to verify the functionality of the prototype. Two devices were able to communicate over the tissue with needle electrodes with a channel attenuation of 60 dB. Reliability tests were performed at several frequencies sending 5 Byte of data in continuous mode (4000 data packets). At a communication frequency of 200kHz, 74.3% of the sent packets could be demodulated correctly by the receiver module.

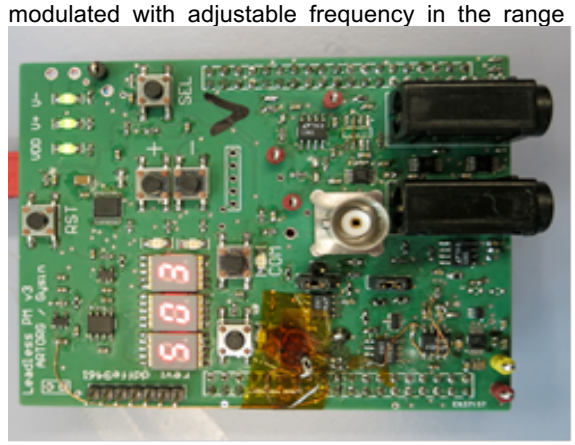

Figure 1 Developed prototype modules

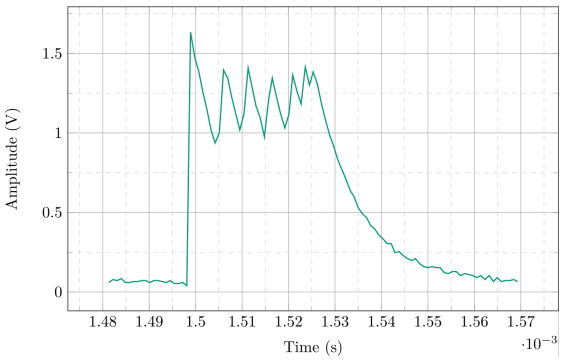

Figure 2 Received data pulses, measured at the output of the envelope detector

Discussion

Two functional leadless pacemaker modules using IBC were developed. The modules can be used for testing in-vitro and in-vivo. However, some parts of the analog hardware need to be modified to achieve a higher communication reliability.

References

Seyedi et. al, A Survey on Intrabody Communications for Body Area Network Applications, *IEEE Trans Biomed Eng*, 2013

Acknowledgements

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