Development of a Low-Power Digital Transceiver Prototype for Leadless Multi-Chamber Pacemaker Synchronization

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Introduction

Research from the University of Bern [1] shows that conductive intracardiac communication (CIC) is well-suited for leadless cardiac pacemaker (LLPM) systems. This thesis wants to achieve a combined digital and analog prototype for demonstrating a LLPM communication system. LLPM have shown good feasibility, safety and efficacy with favourable complication profiles compared to conventional pacemaker. However, only single-chamber systems are available at the moment. A single-chamber system can only cover a small percentage of pacemaker implantations. A dual-chamber or even multisite LLPM system is wanted. Therefore the need for a communication system between one or more LLPM.

Methods

A new transceiver prototype board was developed to test a bi-directional CIC between two LLPMs. The board combines a transmitter and an earlier developed receiver circuit. Additional control systems for test automation were added. This printed circuit board (PCB) will be connected to a field programmable gate array (FPGA) board. Several digital logic modules were implemented for the FPGA board. The over the heart tissue transmitted signals will be manchester encoded. A primary task was to evaluate different manchester encoder circuits.

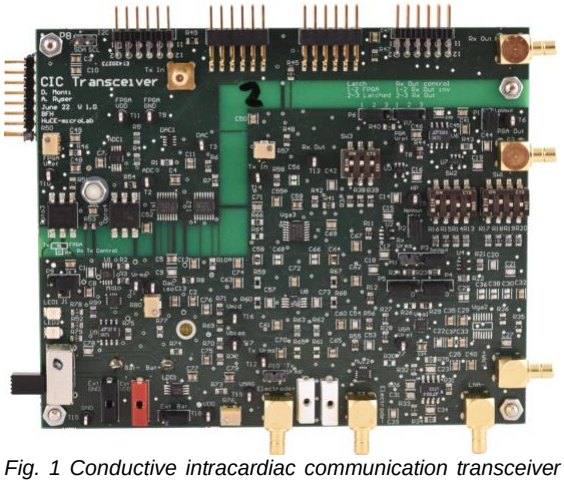

Fig. 1 Conductive intracardiac communication transceiver board

Results

The results include analog characteristic measurements of the transceiver board and bit error rate measurements of the communication system. The bit error rate measurements are used to evaluate two different manchester encoders. The measurements were conducted with a resistance network and with a porcine heart. A clock mismatch between the receiver and transmitter system was also tested.

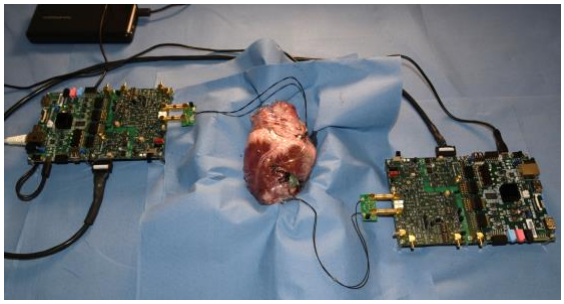

Fig. 2 Conductive intracardiac communication test setup with a procine heart

Discussion

The measured analog characteristics of the transceiver PCB showed the expected behaviour. The bit error rate measurements showed that both tested manchester encoder systems demonstrated a reliable manchester signal encoding. The I/Q modulator-based encoder was superior in comparison to the edge transition-based encoder. The measurements lead to a fixation of the transmission frequency of 100kHz. A suitable communication strategy was found.

References

[1] Adrian Ryser et al. “Modulation Scheme Analysis for Low-Power Leadless Pacemaker Synchronization Based on Conductive Intracardiac Communication”. In: IEEE Transactions on Biomedical Circuits and Systems 16.3 (2022), pp. 419–429. doi:https://doi.org/10.1109/TBCAS.2022.3178444