A micro Electrical Impedance Tomography System for Vessel Studies

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Introduction
Electrical Impedance Tomography (EIT) is an imaging modality, based on measurement and reconstruction of spatial impedance distributions inside an object under test [1-4]. Current injection and the voltage measurements are done via electrodes, placed around an object under test. Based on measured voltages in combination with the known currents the spatial impedance distribution can be reconstructed [1, 3, 5]. Due to the fact, that the spatial resolution is mainly determined by the number of independent measurements the position of the current injection has to be rotated around the object under test to obtain all possible transfer impedances [5]. This work presents a multi-frequency EIT system for micro-vessel studies. The system is based on an embedded System on Chip (SoC) Field Programmable Gate Array (FPGA) architecture. The developed system can be divided into three blocks: micro-EIT vessel, embedded data acquisition hardware, and a host PC. Figure 1 shows the basic system architecture of the developed system.

![System architecture – Micro EIT system](image)

Methods
The objects under test are placed in the micro-EIT vessel. The vessel is filled with a conducting medium to ensure a proper connection to the surrounding electrodes. The vessel itself has a diameter of 20 mm and consists of an electrical insulating material. It is equipped with 32 electrodes with a diameter of 2 mm each. To allow measurements at different heights the EIT system can be cascaded with up to three other systems. Figure 2 shows a principle drawing with four interconnected EIT systems.

![Structure of the micro EIT-system baseboard](image)

Hardware Description
The hardware of the developed micro-EIT system is based on a centralized SoC FPGA architecture. The FPGA (LFX2P2 from Lattice Semiconductor) is in charge for controlling data acquisition, preprocessing and transmission in real-time. To ensure the complete usage of the full scale input voltage range of the ADC a Programmable Gain Amplifier (PGA, ADB250 from Analog Devices) is used for adaptive signal amplification. The first stage of the PGA consists of an instrumentation amplifier with very high input impedance to ensure signal integrity. The excitation signal and its frequency are adjustable in a frequency range of 10 kHz to 250 kHz. To allow fast measurements, in addition to conventional sinusoidal excitation signals also linear chirps or any other signal-overlay can be used. The advantage of linear chirps is a minimization of the data acquisition time within broadband impedance measurements [6].

![Assembled prototype of the developed embedded EIT system PC](image)

Conclusion
We have developed a multi-frequency EIT system of micro-vessel studies. The developed EIT system allows multi-dimensional spectroscopic measurements of the containments of a small vessel. The containments can be analyzed over time and frequency to allow an accurate electrical characterization with a spatial resolution in real-time.

The collected information can be used for a broad range of applications in life sciences, industrial settings or in chemistry.

References
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