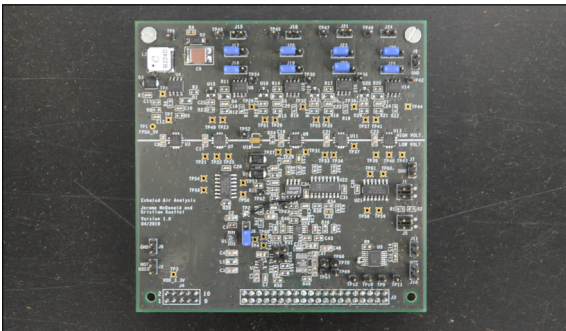| Graduate Candidates	Kristian Küttel, Jérôme McDonald
Examiner	Prof. Guido Keel
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Subject Area	Sensorics
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Exhaled Air Analysis

Flow Rate and Molar Mass Measurement of Exhaled Air by Ultrasound
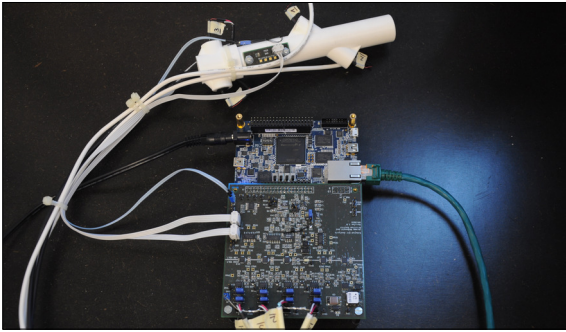
The entire system in operation
Own presentment

Objective: The objective was to develop a prototype, that is capable of measuring the flow rate and molar mass of a fluid. The main requirement hereby is contactless measurement to prevent contamination of the equipment. The system will serve as a basis for further research and result in the next version of ECO MEDICS' pulmonary function testing system. Thus hard- and software had to be developed, focusing on a high level of precision and speed of measurement. Furthermore, the system has to be easily adaptable to different approaches.

Approach: Four individual ultrasound transducers were employed to measure the time of flight. The acquired data was then used to calculate the flow speed and the absolute speed of sound. An exact value for the speed of sound is needed to calibrate the flow measurement and to calculate the molar mass. Moreover, the temperature, humidity and ambient pressure within the system are measured to determine the molar mass.
To generically use various transducers and sensors, different common interfaces were implemented and multiple assembly variants conceived. Finally, a four layer layout was designed for optimal low noise measurement.

Conclusion: The resulting system is a highly customisable and functional prototype. The hardware can be used and easily adapted to manage a variety of sensors. The board is controlled by a FPGA and can be configured intuitively by the main software running in MATLAB. Ultimately, the received measurements are processed and visualized by the MATLAB software.
The system meets all requirements and can be further optimised to reach the necessary precision.

The Exhaled Air Analysis board
Own presentment

The GUI in operation
Own presentment