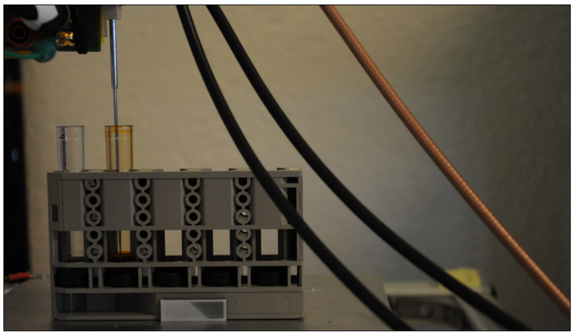
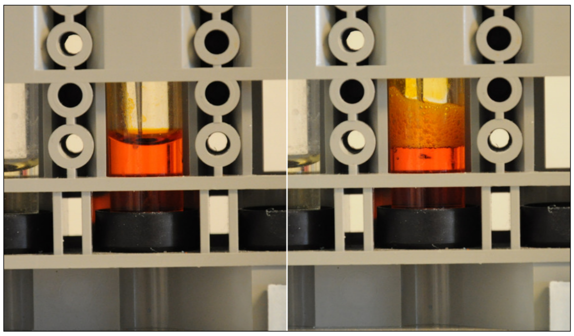

Nikolas
Gerber

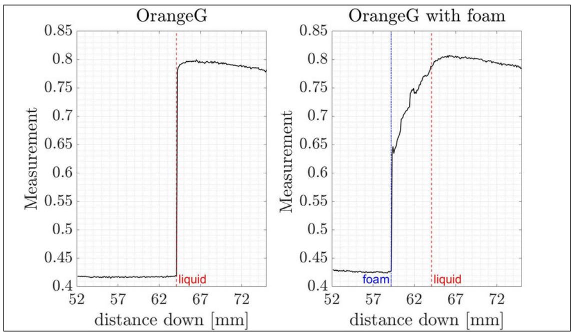

Alexandra
Kerstin
Désirée
Hug

Graduate Candidates	Nikolas Gerber, Alexandra Kerstin Désirée Hug
Examiners	Prof. Dr. Heinz Mathis, Nicola Ramagnano
Co-Examiner	Stefan Hänggi, VBS / armasuisse, Bern, BE
Subject Area	Wireless Communications
Project Partner	Roche Diagnostics, Rotkreuz, ZG

Frequency-Domain Liquid Level Detection for In-Vitro Diagnostics


OrangeG measurement setup with a steel needle and two sample tubes
Own presentment


OrangeG with and without foam
Own presentment



Measurement results for OrangeG with and without foam
Own presentment

Introduction: Liquid Level Detection(LLD) for In-Vitro Diagnostics is used to detect the position of the liquid surface in a sample tube. This information then enables precise positioning of the needle tip relative to the liquid's surface. LLD can be achieved via the means of optical, acoustic or electrical signals, typically measured in the time domain. This thesis focuses on a novel approach whereby electric signals applied to the steel needle are measured in the frequency domain.

Three typical challenges of Liquid Level Detection are:

- Some liquids produce foam, when they are shaken or filled into the tube. This foam could then be mistaken for the actual surface of the liquid.
- The needle acts as a monopole antenna. Thus, noise and unwanted signals can be picked up, which interfere with the measurements.
- The entire measurement process needs to be fast, as the needle is typically moved at high speeds.

While the first two challenges are more relaxed with frequency-domain methods, they are typically more computationally demanding.
Nevertheless, it is expected that this challenge can be solved with the computing power available in modern microprocessors.

Approach: In order to understand the significance of relevant parameters, a physical model of the needle and the fluid in the tube is created in the frequency domain. The required modelling data is obtained by measurements with an LCR meter and a vector network analyzer (VNA).

A measurement system is designed that is capable of estimating these model parameters. By tracking the changes of the parameters, both the liquid level as well as the presence of foam can be detected.

The designed hardware consists of a dedicated RF front end and a subsequent processing unit which are placed in close proximity to the needle. To allow many such needles to be operated in a tight row configuration, each measurement system needs to be small in size and cost efficient.

Conclusion: The extraction of the physical model has been successful and the realized frequency-domain LLD system is able to reliably detect the liquid surface even if foam is present.

The designed hardware complies with budget and space restrictions.
Currently, the signal processing is carried out offline, but it is possible to upgrade the design to real-time liquid level detection.

HSR
HOCHSCHULE FÜR TECHNIK
RAPPERSWIL

FHO Fachhochschule Ostschweiz