Fraunhofer

PORTUGAL

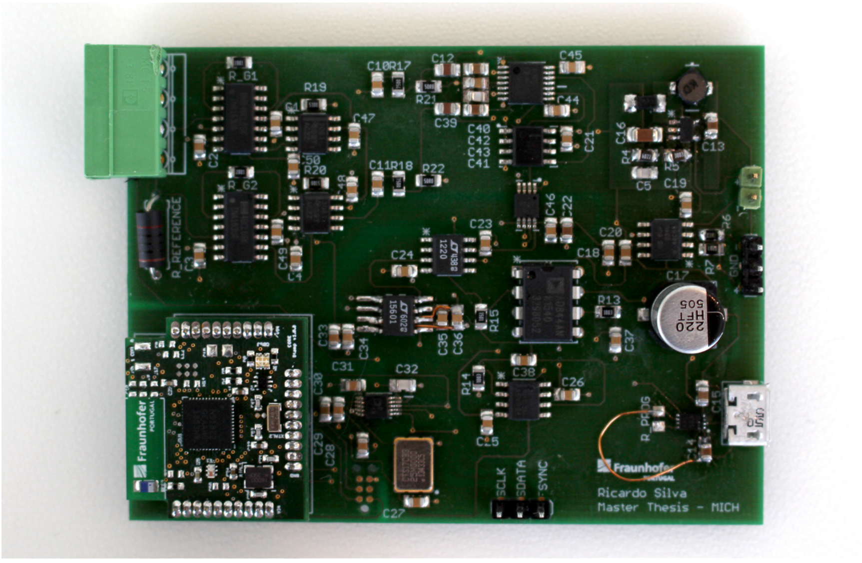

Fig1. Bioimpedance Spectroscopy device used in this project.

MEDICARE

MEASURING IMPEDANCE IN CONGESTIVE FAILURE PATIENTS

MEDICARE proposes the development of a low-cost and mobile Bioimpedance Spectroscopy system to diagnose pulmonary edema in congestive failure patients.

Motivation

A Bioimpedance Spectroscopy device was already developed in the past by Fraunhofer which allowed the measurement of impedance magnitude and phase in the frequency range between 20 kHz and 1 MHz. This system has a Bluetooth module to connect the system to a smartphone in order to transmit the measured data.

This system was not calibrated and validated. Thus, the main objective of this project is to perform its calibration and electrical validation.

For analysis of data of impedance measurements, it is usually used the Cole model to approximate the tissue electrical behaviour. The Cole parameters are the following: R_0 the resistance for low frequencies; R_∞ the resistance for high frequencies; α a dimensionless number that characterizes the Cole dispersion; and τ a time constant characteristic. They can be extracted using curve fitting methods and different approaches of the Cole model.
Methods and models for extraction of these parameters were studied in order to implement the best one for the Android OS.

Approach

Non Linear Least Squares (NLLS), Robust Least Squares (RLS) and Least

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Conclusions

All methods and models for Cole parameter extraction studied shown to be accurate, with exception of reactance against frequency model.

Use of Oscilloscope as ground truth has some limitations due to the amount of fluctuations in measured values of magnitude and phase.

System validation has to be improved since errors of the extracted Cole parameters are significant high in relation to standard values and some other studies found in Literature.

Future Work

Use of another ground truth for calibration.

Validate the measurement system.

Implement another methods and models for extraction of parameters.

Study variation of Cole parameter inside a group of Healthy subjects.

Study variation of Cole parameter within healthy and sick subjects.

Improve Android Application to be more user friendly.

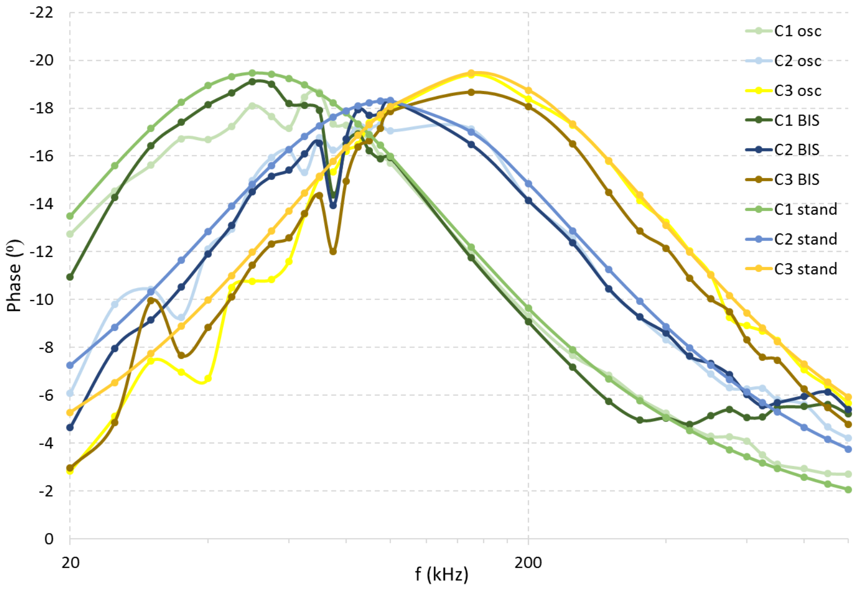

Fig2. Comparison between phase results of oscilloscope and BIS system and standard values.

Absolute Deviation (LAD) curve fitting methods were used in combination with Cole plot, impedance, reactance and resistance models in order to study the method with the best relation between accuracy and processing power required. With this purpose, the relative error of each extracted parameter as well as time and iterations spent for each fitting process were analysed and compared.

For the calibration procedure, the three-reference circuit calibration method was adopted which uses the oscilloscope measurements of three RC circuits with known parameters. System Validation was performed measuring other three RC circuits.

Results

From the previous analysis we concluded that the best method to implement in Android OS was NLLS combined with the resistance model.

Regarding calibration, it was observed some fluctuations in the Oscilloscope results. The average errors in phase are 0.65 degrees and the magnitude average relative error 4.06% in relation to standard expected values.

After calibration, the oscilloscope results and BIS system results show fluctuations in measured values of phase and magnitude. These fluctuations are reflected in a deviation of BIS system results when compared with standard values. Also, an average phase error of 0.87° is observed between oscilloscope and BIS system results. Regarding magnitude results the relative error is 2.8%.

The extracted value for the Cole parameters have shown relative errors around 10% for estimation of R_0, R_∞ and τ and around 1% for α.

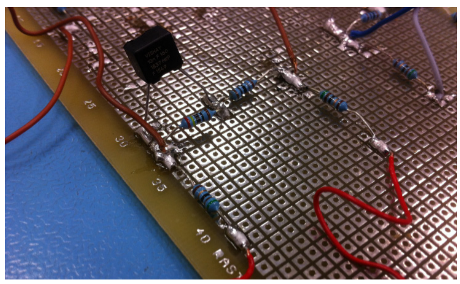

Fig3. Example of RC circuit used in the validation and calibration of the system.