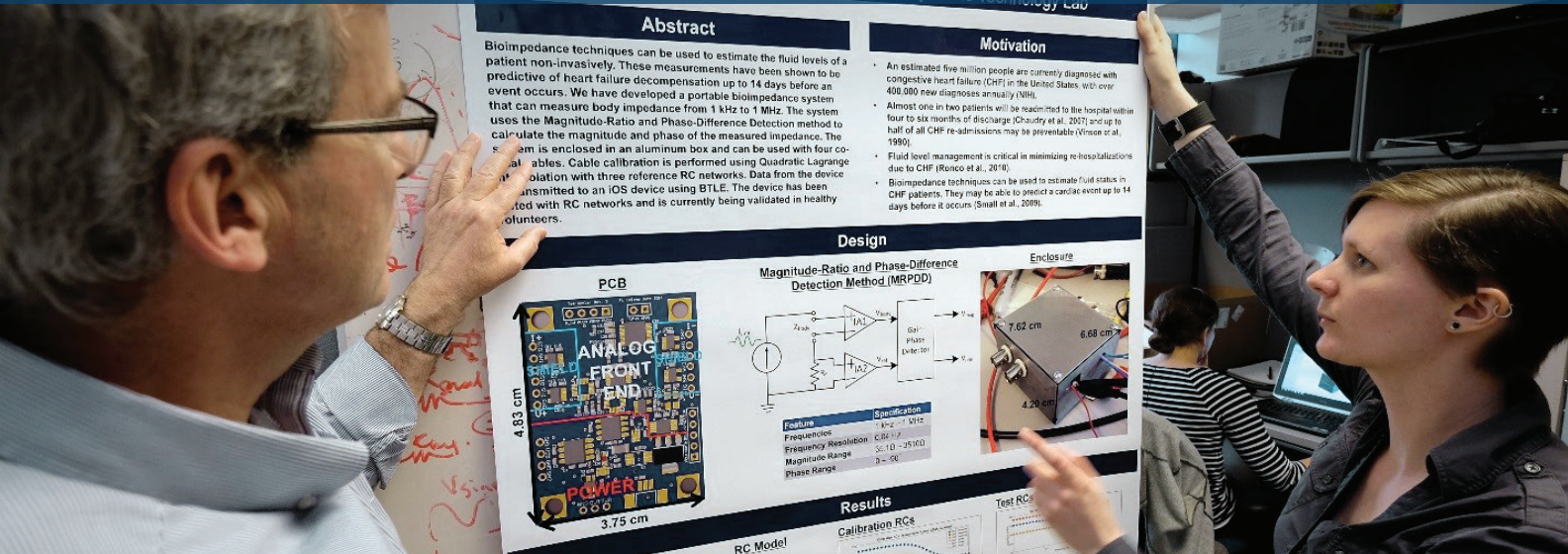


M.K. Delano and
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A PORTABLE BIOIMPEDANCE SPECTROSCOPY MEASUREMENT SYSTEM FOR CONGESTIVE HEART FAILURE (CHF) MANAGEMENT

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Abstract

Bioimpedance techniques can be used to estimate the fluid levels of a patient non-invasively. These measurements have been shown to be predictive of heart failure decompensation up to 14 days before an event occurs. We have developed a portable bioimpedance system that can measure body impedance from 1 kHz to 1 MHz. The system uses the Magnitude-Ratio and Phase-Difference Detection method to calculate the magnitude and phase of the measured impedance. The system is enclosed in an aluminum box and can be used with four coaxial cables. Cable calibration is performed using Quadratic Lagrange interpolation with three reference RC networks. Data from the device is transmitted to an iOS device using BTLE. The device has been characterized with RC networks and is currently being validated in healthy volunteers.

Motivation

- An estimated five million people are currently diagnosed with congestive heart failure (CHF) in the United States, with over 400,000 new diagnoses annually (NIH).
- Almost one in two patients will be readmitted to the hospital within four to six months of discharge (Chauly et al., 2007) and up to half of all CHF re-admissions may be preventable (Vince et al., 1990).
- Fluid level management is critical in minimizing re-hospitalizations due to CHF (Russo et al., 2016).
- Bioimpedance techniques can be used to estimate fluid status in CHF patients. They may be able to predict a cardiac event up to 14 days before it occurs (Small et al., 2009).

Design

PCB

4.83 cm
3.75 cm

Magnitude-Ratio and Phase-Difference Detection Method (MRPDD)

Enclosure

7.62 cm
6.68 cm
4.20 cm

Feature	Specification
Frequency	1 kHz - 1 MHz
Frequency Resolution	0.01 Hz
Magnitude Range	$\pm 10^{-3} \text{ to } 10^3 \text{ Ohms}$
Phase Range	0 - 360

Results

RC Model
Calibration RCs
Test RCs

An estimated five million people are currently diagnosed with congestive heart failure (CHF) in the United States, with over 400,000 new diagnoses annually. Almost one in two patients will be readmitted to the hospital within four to six months of discharge. Up to 50% of these early readmissions may be prevented if symptoms are recognized early enough. Bioimpedance measurements have been shown to be predictive of heart failure decompensation up to 14 days before an event occurs. We have developed a portable bioimpedance system that can measure body impedance from 1 kHz to 1 MHz. The system uses the magnitude ratio and phase difference detection method to calculate the magnitude and phase of the measured impedance (see Figure 1). The system is enclosed in an aluminum box (see Figure 2) and can be used with four coaxial cables to reduce the impact of stray capacitances. The device has been characterized with RC networks and is being tested with healthy volunteers.

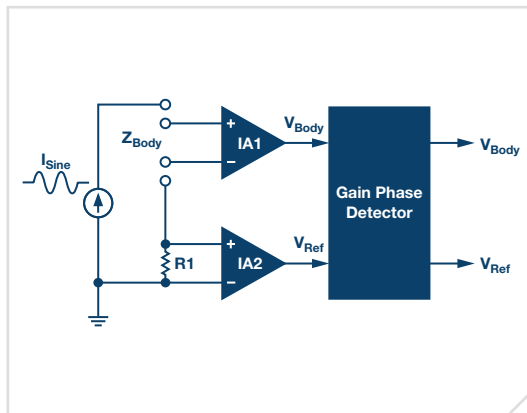


Figure 1: A schematic overview of the magnitude ratio and phase difference detection method. A fixed sinusoidal current is driven through the body and a sense resistance. The voltage is amplified and measured by a gain phase detector chip (AD8302).

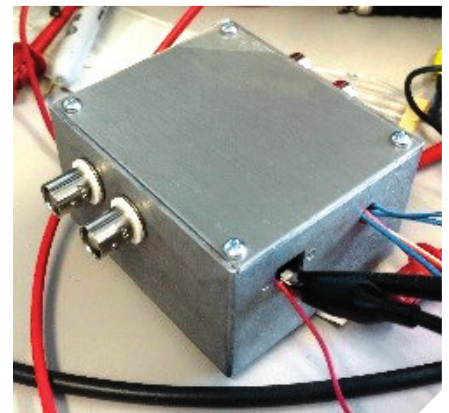


Figure 2: The portable bioimpedance spectroscopy measurement system inside the enclosure.

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