IMPEDANCE CARDIOGRAPHY

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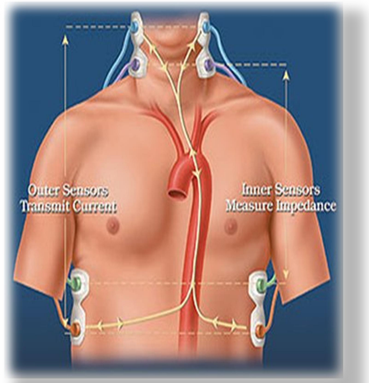
Project 14
Advisor: Professor Willis Tompkins
Client: Professor John Webster

Project Objective Statement:

The collective goal of this project is to design an accurate, reusable, and spatially specific impedance cardiograph system. This system will ensure accurate and reliable impedance readings to be taken regardless of patient position.

Problem:

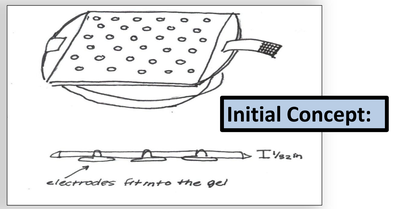
Impedance cardiography is a non-invasive procedure used to asses the state of an individuals circulation[3]. With the information attained from an impedance test, vital stats can be deduced of which includes the volume of blood flow through the aorta or cardiac output[2] . In the traditional proceedings of the test, four dual electrodes are placed on the neck and abdomen. However, it is suspected that placing the electrodes with a large separation distance results in a disturbed, untruthful output signal[1].



Client Requirements[4]:

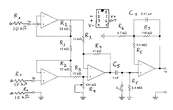
- Permit proper placement of the electrodes directly over the heart.
- Allow adjustment and modification of electrode positions in accordance with a varying ventricle placement
- Must be easy to place device onto patient and the repositioning of electrodes must be simple and straightforward
- Comfortable for the patient, allowing impedance measurements gathered through various patient positions (standing, sitting, etc)
- Device and electrodes themselves should be reusable

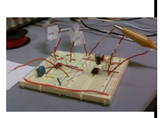
Final Design Prototype:



Amplifier:

An amplifier is a key component in evaluating the effectiveness of our prototype; it allows for the amplification and filtering of the raw signal attained from the heart, leading to a cleaner output signal from which the success of our prototype can be further assessed[4].

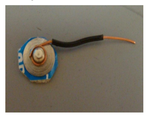




Bias Current= 11.25 nA
<< 10 µA safety limit

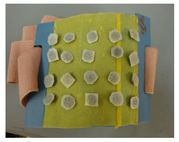
Electrode Fastening System:

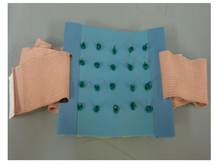
This aspect of the prototype securely fastens electrodes to the body. It is composed of a silicone rubber base, upon which Nylon plastic attached on the edges supports the silicone. A hydrophobic mesh is attached underneath to keep electrode gel from spreading and interfering with the output signal. The electrode complex size is trimmed down and wire knotted within the silicone mat. Lastly, the system is attached to the body via an elastic strap.



FINAL DESIGN FEATURES

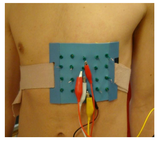
- Silicone rubber base
- Modified , extended electrode matrix
- Securing elastic strap
- Supportive plastic edges
- Hydrophobic Mesh
- Amplifying circuit

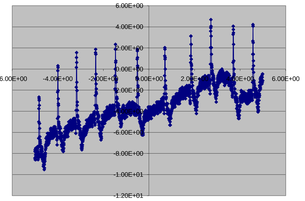




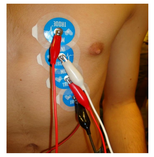
Prototype Testing:

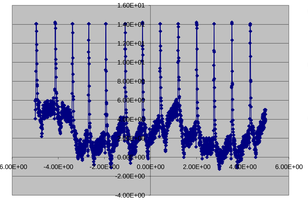
#1 Prototype Test



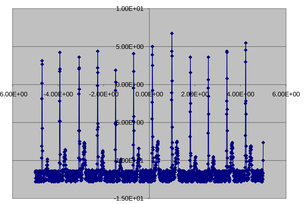


#2 Centered Electrode Method



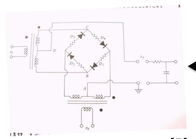


#3 Traditional Method

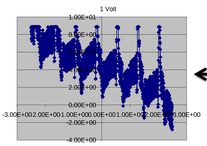


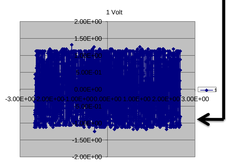
In order to determine whether or not the prototype provides a viable alternative to current impedance methods[1],[2], two controls were tested and graphed. While the first control places electrodes on the neck and lower chest in the traditional impedance method, the second control moves the electrodes directly over the heart. These tests provide a basis of comparison for our prototype to suggest whether or not it improves upon the current way of determining impedance and if the prototype is comparable to manufactured electrodes.

When compared to the traditional method, the prototype's graph demonstrates a clearer graphical display suggesting an improvement in cardiac signal. Furthermore, the prototype and centered electrode graphs share a resemblance, indicating the prototype is of similar quality.



[5]





Future Work:

- Alligator Clip support to reduce electrode movement and displacement
- Build phase sensitive demodulator to help isolate impedance signal
- De-bug amplifier
- Better determine electrode positioning with respect to the heart and incorporate heart location with electrode matrix positioning

References:

1. Babbs, Charles F. "Anterior-posterior impedance cardiography: a new approach to accurate, non-invasive monitoring of cardiac function." Department of Basic Medical Sciences and Weldon School of Biomedical Engineering, Perdue University. Submitted July 6, 2009. Pgs 1-6, 22,23.
2. Caruso, Lawernce J, MD. Et.al. "What is the Best Way to Measure Cardiac Output?". Chest. Sept. 2002, vol. 122, pgs. 771-774.
3. Van De Water, Joseph M, MD. Et al. "Impedance Cardiography: The Next Vital Sign Technology?". Chest. June 2003, vol. 123, pgs. 2028-2033.
4. Webster, John; Bezrukova, Elena. Personal Interview. September 11, 2009.
5. Webster, John G. Medical Instrumentation: Application and Design, 3rd Ed. John Wiley & Sons, Inc. 1998. pgs. 116-117.