Impedance Cardiography

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Global Collaboration

- Bi-chao Chan (Chinese name :陈必超)
- Yu Chan (Chinese name:陈宇)
- We are a multi-national engineering team!
- Zhejiang University, Biomedical Engineering Department
- Senior standing with electrical engineering background
- Advising and participating in the design process

Overview

- Impedance Cardiography Background
- Client Specifications
- Design Proposals & Matrix
- Social Considerations
- Future Work

Cardiac Output

- Cardiac Output
  - $Q = SV*HR$
    - SV = Stroke Volume, which is end diastolic minus end systolic
    - HR = Heart rate
- Cardiac Output important in diagnosis
  - Sepsis
  - Cardiomyopathy
  - Heart Failure

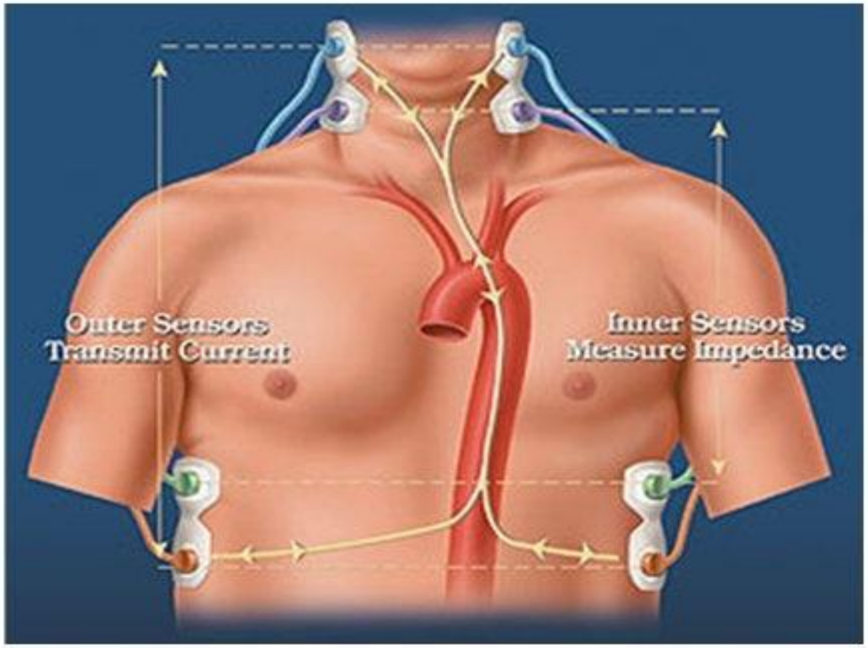
Measuring Cardiac Output

- Current methods for measuring cardiac output invasive
  - Thermodilution Catheter

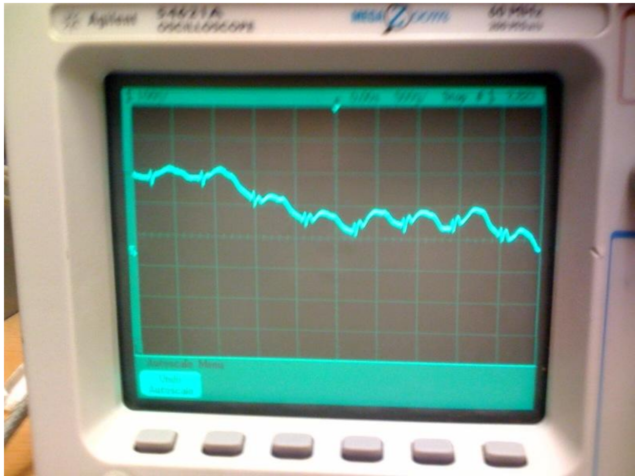
- Impedance Cardiography is the non-invasive possible solution

Impedance Cardiography

- High frequency (150 kHz) wave passed over aorta to measure impedance and track volumetric changes occurring in the cardiac cycle
- Non-invasive, painless, simple technique

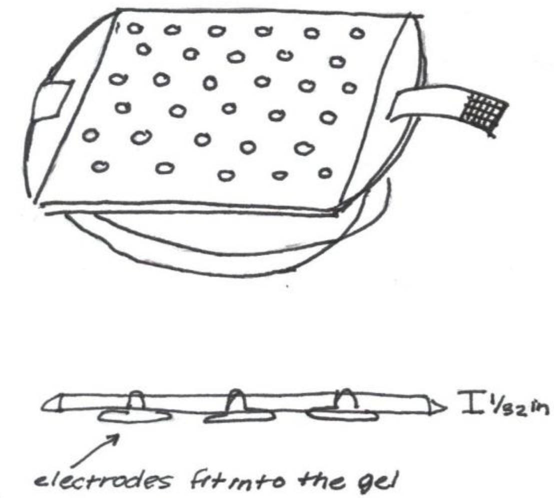


Impedancecardiography.com



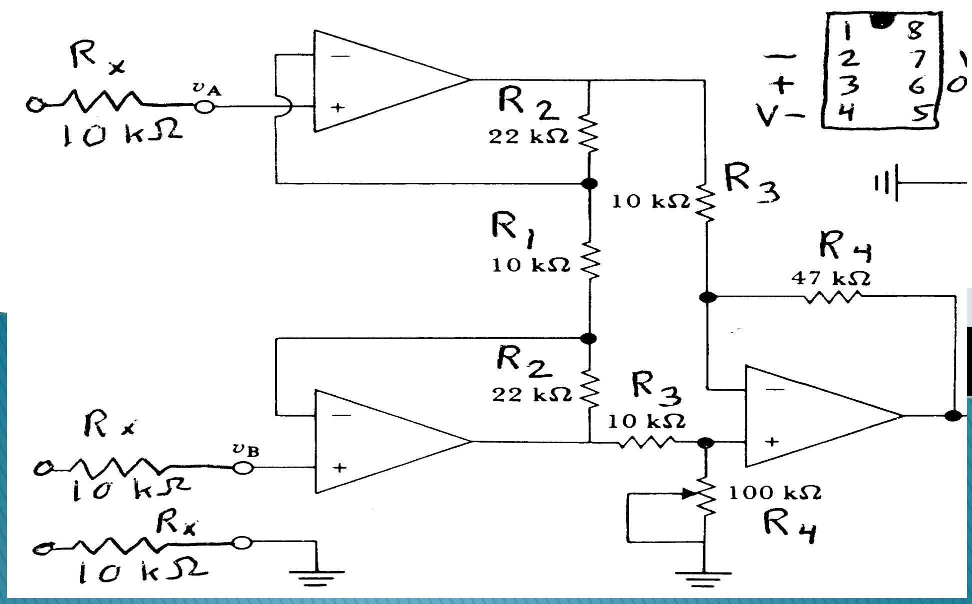
Client Specifications

- Electrodes over the heart
- Reusable electrodes
- Easy to use
- Clear impedance signal
  - Without EKG interference
- Determine best position of electrodes



Amplifier Only

- ECG amplifier to amplify signals from the heart.
- Ratio of output to input voltage is the gain
- Sensitivity = 0.1 — 6 mv



High-Low Pass Filters

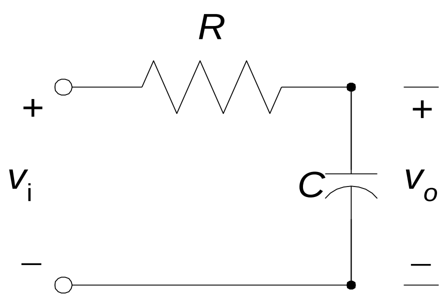


Figure 1 – Low pass filter

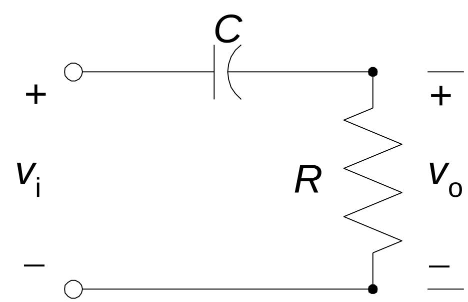


Figure 2 – High Pass Filter

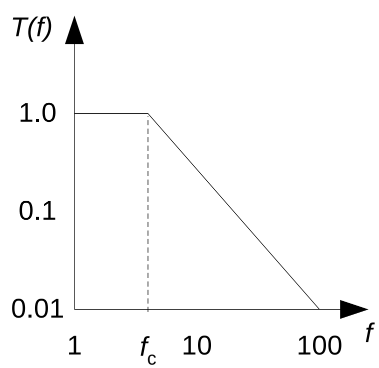


Figure 3 – T(ω) frequency response of a low pass filter

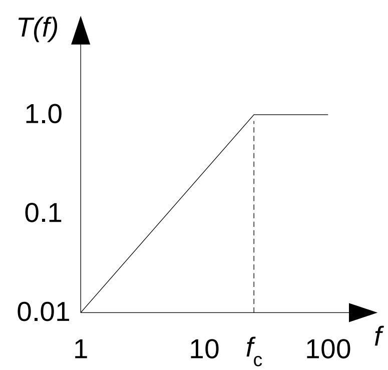
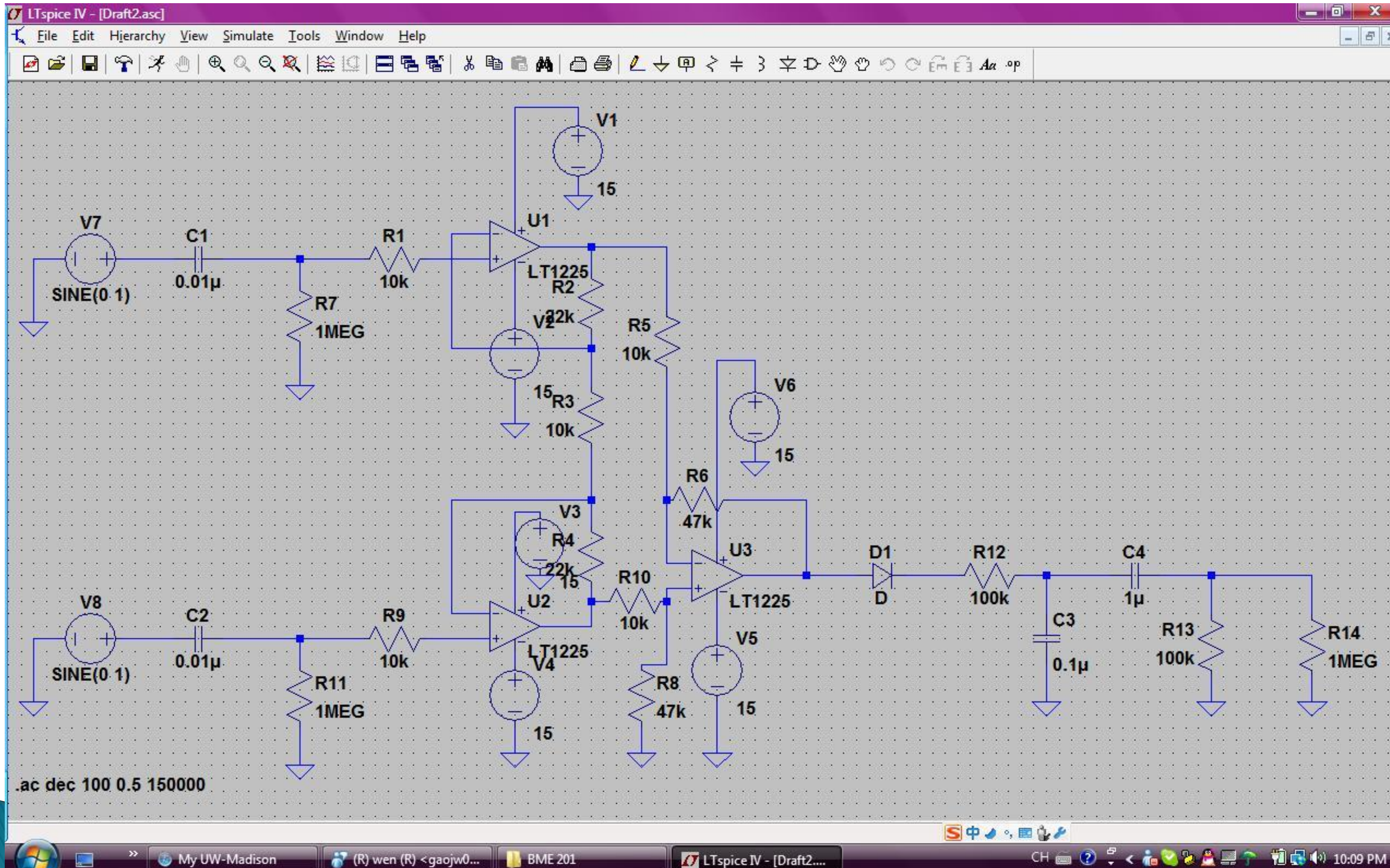


Figure 4 – T(ω) frequency response of a high pass filter

Our Amplifier



Demodulator

- Demodulation: Extracting desired information from carrier wave
- Demodulator: Demodulate signals
- Our design: 0.5Hz–20Hz frequencies modulated with 150kHz signals
- Goals: Extracting the envelop and get rid the "carried" noise
- Possible demodulator design:

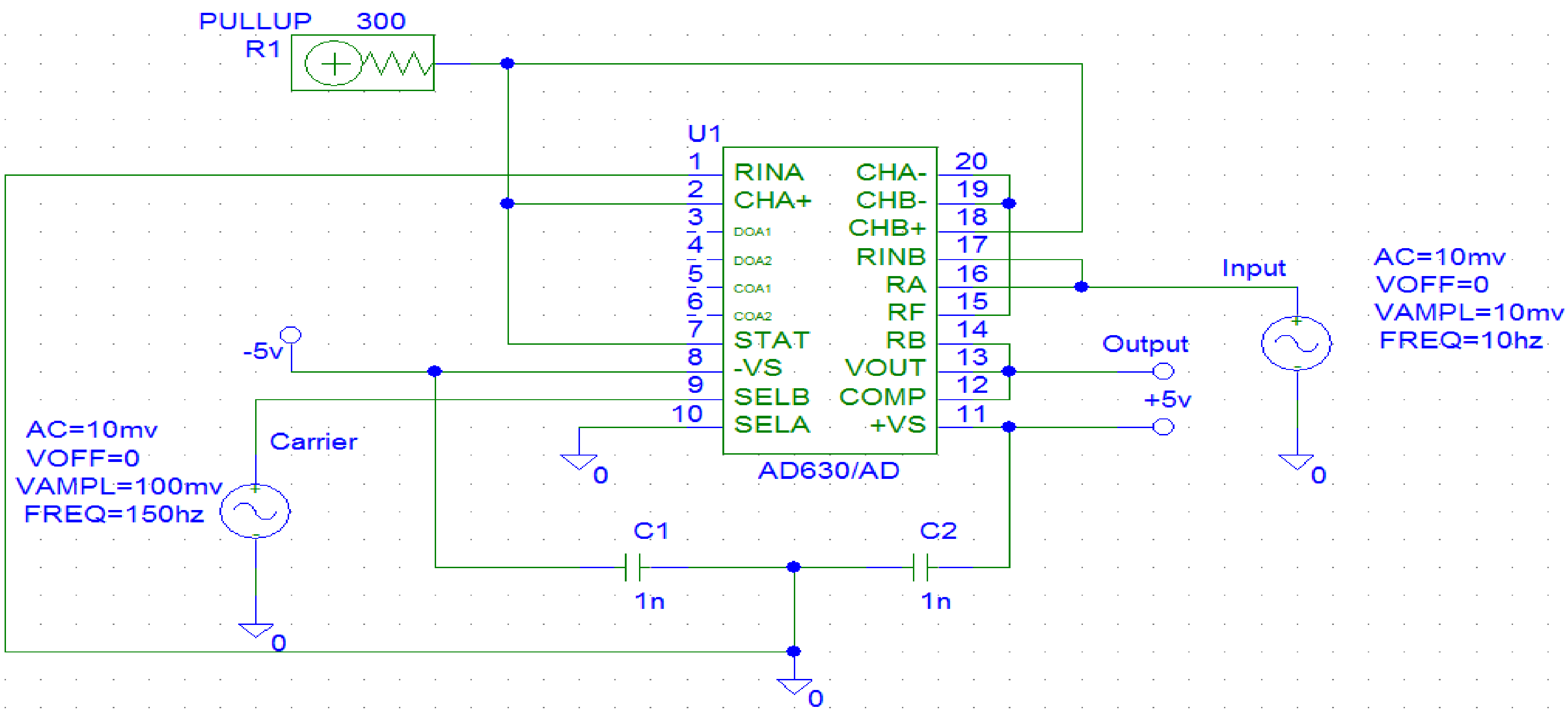


Figure – The schematic for demodulator designed by our international colleague Bi-Chao Chan. The carrier signal is filtered after demodulation. The actual signal is been transmitted and amplified for final display.

Design Matrix

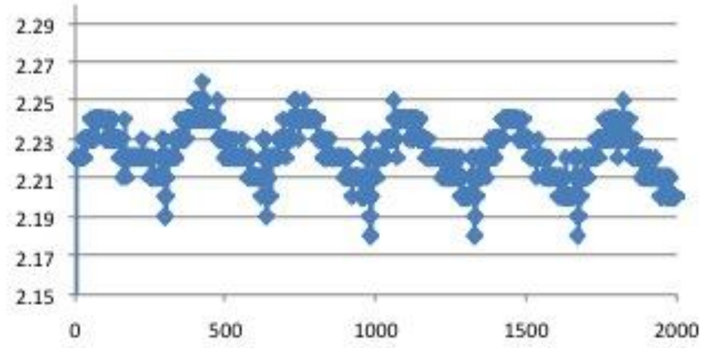
	Ease of Use (10)	Effectiveness (30)	Ease of Manufacture (10)	Accuracy (20)	Size (10)	Total (80)
Passive Filter *	9	24	9	18	9	69
Phase Sensitive Demodulator	8	28	7	18	4	65
Filter-less	10	8	10	8	9	45

Perspectives and Ethics

- Requires personal interactions
  - Operator–patient relationship
- Safety considerations
  - Electrical components
  - Electrode components

Future Work

- Obtain clean impedance signal
- Interpret the signal



- Build demodulator (if needed)
- Determining best position for electrodes

Reference

- Mitchell, G. F. (2009). Clinical achievements of impedance analysis. *Medical & Biological Engineering & Computing, 47*(2), 153-163.

- O'Rourke, M. F. (1982). Vascular impedance in studies of arterial and cardiac function. *Physiological Reviews, 62*(2), 570-623.

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Acknowledgments

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Questions?