IEEE Phoenix Senior Design Project, Spring 2011

Blood Pressure Sensor Accuracy and Precision Requirements

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Who Are We?

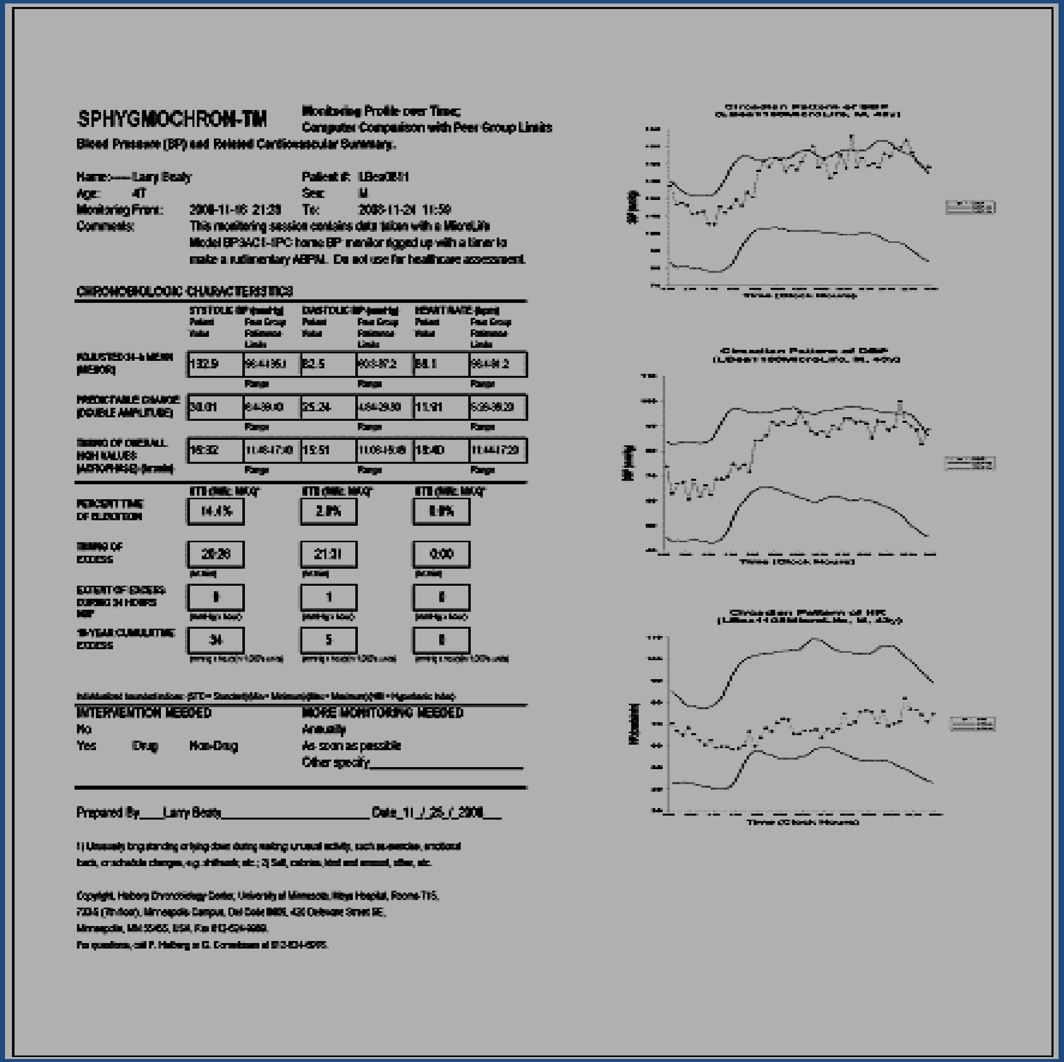
- Twin Cities IEEE Phoenix Project
  - Volunteer electrical/mechanical/software engineers
  - Our group was assembled to **productize results of research** done at the Chronobiology Lab and elsewhere
  - Open Source hardware project to **design and build a blood pressure monitor** that is inexpensive, unobtrusive, easy to use and collects a week of blood pressure measurements.

- UMN Halberg Chronobiology Lab
  - Dr. Franz Halberg, “Father of American Chronobiology”
  - Chronobiological Interpretation of Blood Pressure
    - Vascular Variability Disorders more important than hypertension
  - Our “customer”

Background

The Sphygmochron Report

Results from Continuous Monitoring



SPHYGMOCHRON-TM

Monitoring Profile over Time; Computer Comparison with Peer Group Limits

Blood Pressure (BP) and Related Cardiovascular Summary.

Name:----Larry Beaty
Patient #:
Age: 47
Sex: M
Monitoring From: 2008-11-16 21:28
To: 2008-11-24 11:59
Comments: This monitoring session contains data taken with a MicroLife Model BP3AC1-1PC home BP monitor rigged up with a timer to make a rudimentary ABPM. Do not use for healthcare assessment.

CHRONOBIOLOGIC CHARACTERISTICS

	SYSTOLIC BP (mmHg) Patient Value	Peer Group Reference Limits	DIASTOLIC BP (mmHg) Patient Value	Peer Group Reference Limits	HEART RATE (bpm) Patient Value	Peer Group Reference Limits
PREDICTABLE CHANGE (DOUBLE AMPLITUDE)	30.01		25.24		11.91	
TIMING OF OVERALL HIGH VALUES	16:32		15:51		15:40	
PERCENT TIME OF ELEVATION	14.4%		2.8%			
TIMING OF EXCESS	20:28		21:31		0:00	
EXTENT OF EXCESS DURING 24 HOURS			1			
10-YEAR CUMULATIVE EXCESS	34		5			

INTERVENTION NEEDED
No
Yes Drug Non-Drug

MORE MONITORING NEEDED
Annually
As soon as possible
Other specify

Prepared By____Larry Beaty

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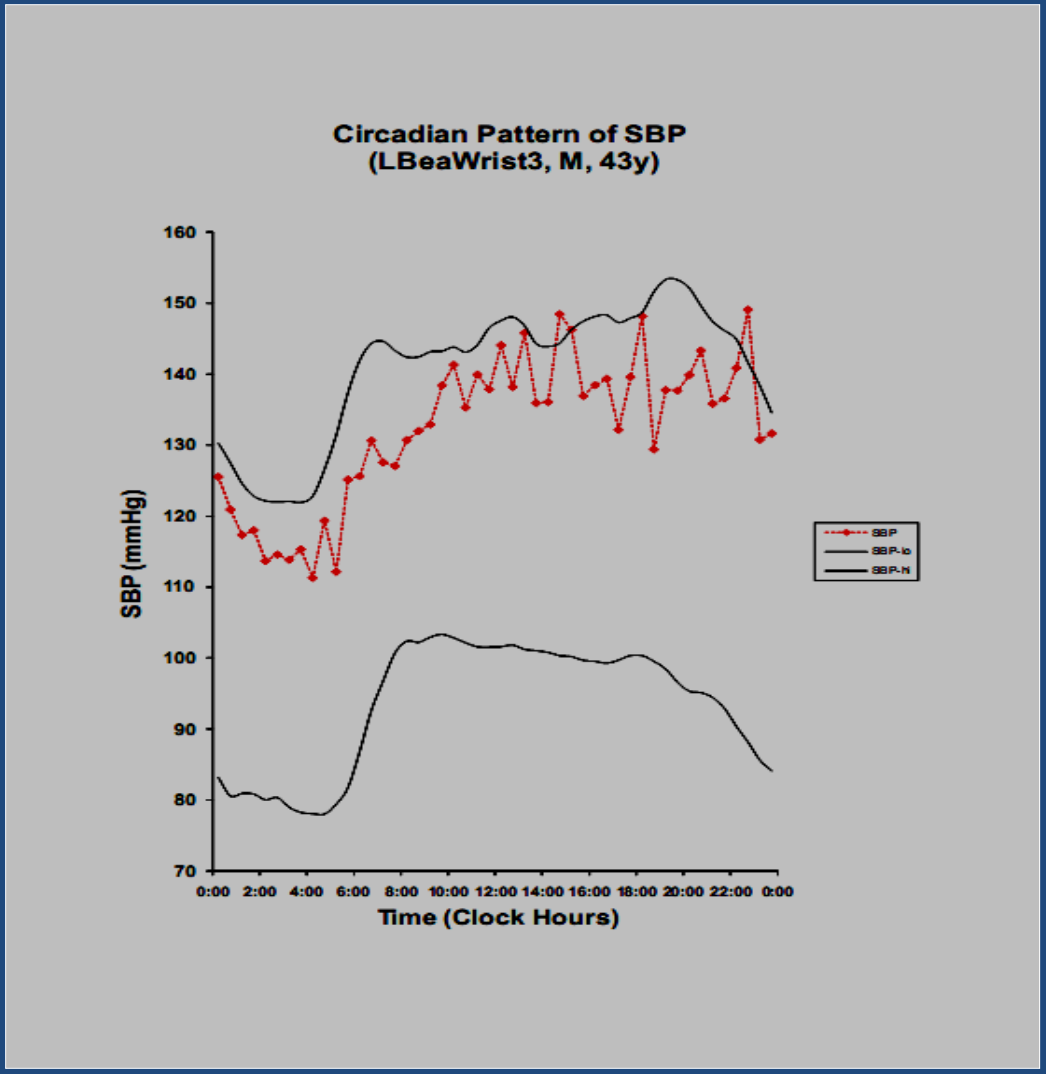
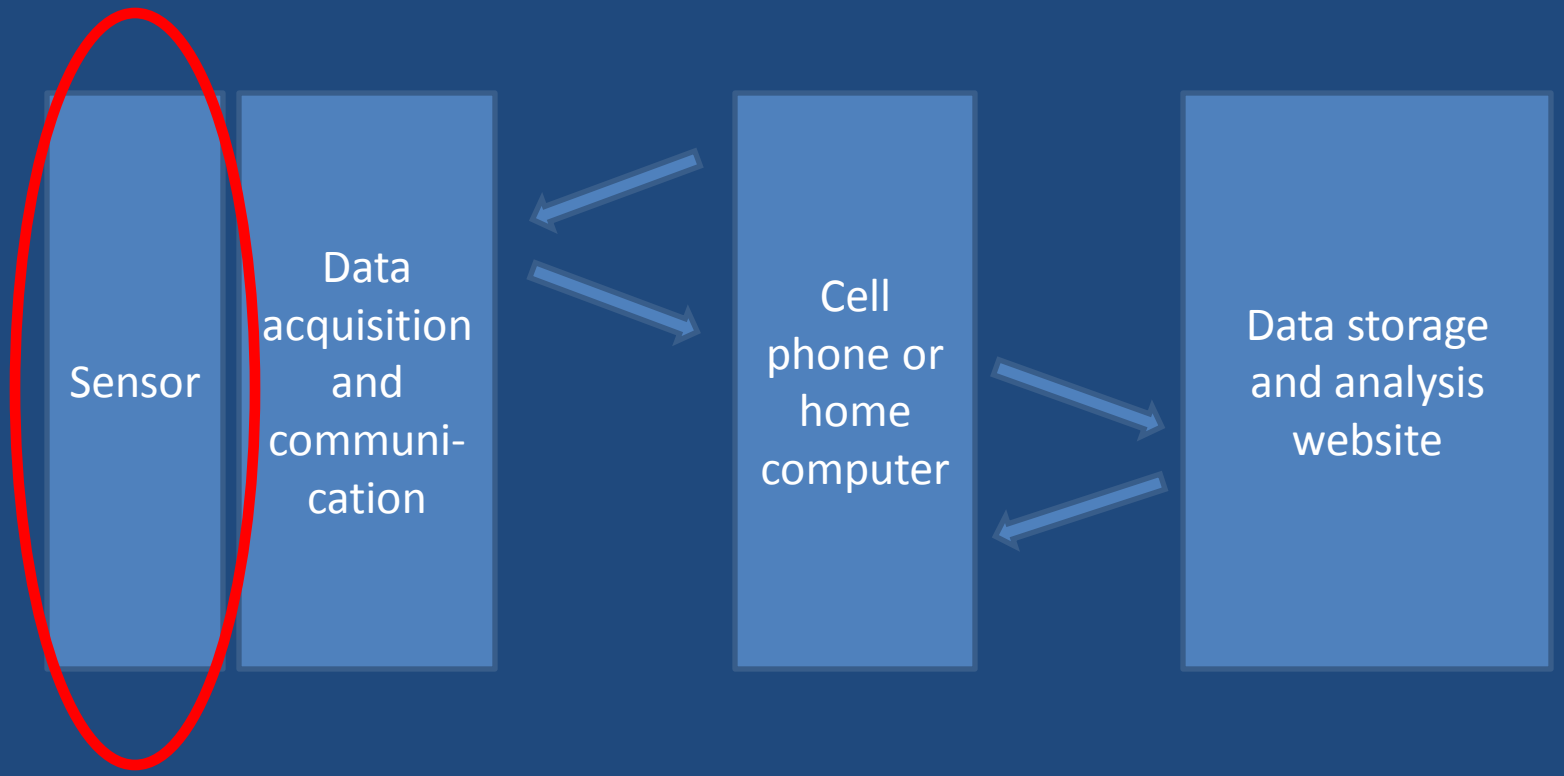


Where the student project fits in

- Over-Simplified Block Diagram of the System



What is Pulse Transit Time (PTT)?

- The heart beats every 1 second or so
- It takes a couple of hundred milliseconds for a pulse to travel (transit) from the heart to extremities
- The pulse's **velocity is related to blood pressure** (and other things such as compliance of the artery)
- Also called Pulse Wave Velocity (PWV)

- In theory, you **put two pulse sensors along an artery, calculate the transit time** (velocity), then **derive the blood pressure**.

Activities in the sensor project

- Understand and **describe** the supplied pulse model, and derive expected transit times and accuracy.
- Develop **requirements** and an **error budget** for a sensor system to record the shape of individual pulses at two locations on the body to determine adequate blood pressure readings.
- **Design, build,** and **test** a *non-invasive* sensor system to record pulse waveforms at two locations on the body (e.g. forearm and wrist).
- Publish a final **report** that will be posted on the Phoenix Project website. (Can be the same as your class report.)
- Additional “stretch goals” available

Sensor Technologies to choose from

- Piezoelectric
- Infrared optoelectronic
- Acoustic (sound/microphone)
- Impedence Plethysmography
- Your ideas???
  - Anything that can detect a pulse might be viable
  - Only one good sensor idea is needed for your project

Resources

- We work in the IEEE student lab (Keller Hall, 2-110)
- In-the-lab or on-Skype meetings on Saturdays 10:00 to 1:00
- We have worked with students before
- Equipment in our lab on campus
- Academic papers (or do your own searches)
- Previous student projects

Examples of previous projects

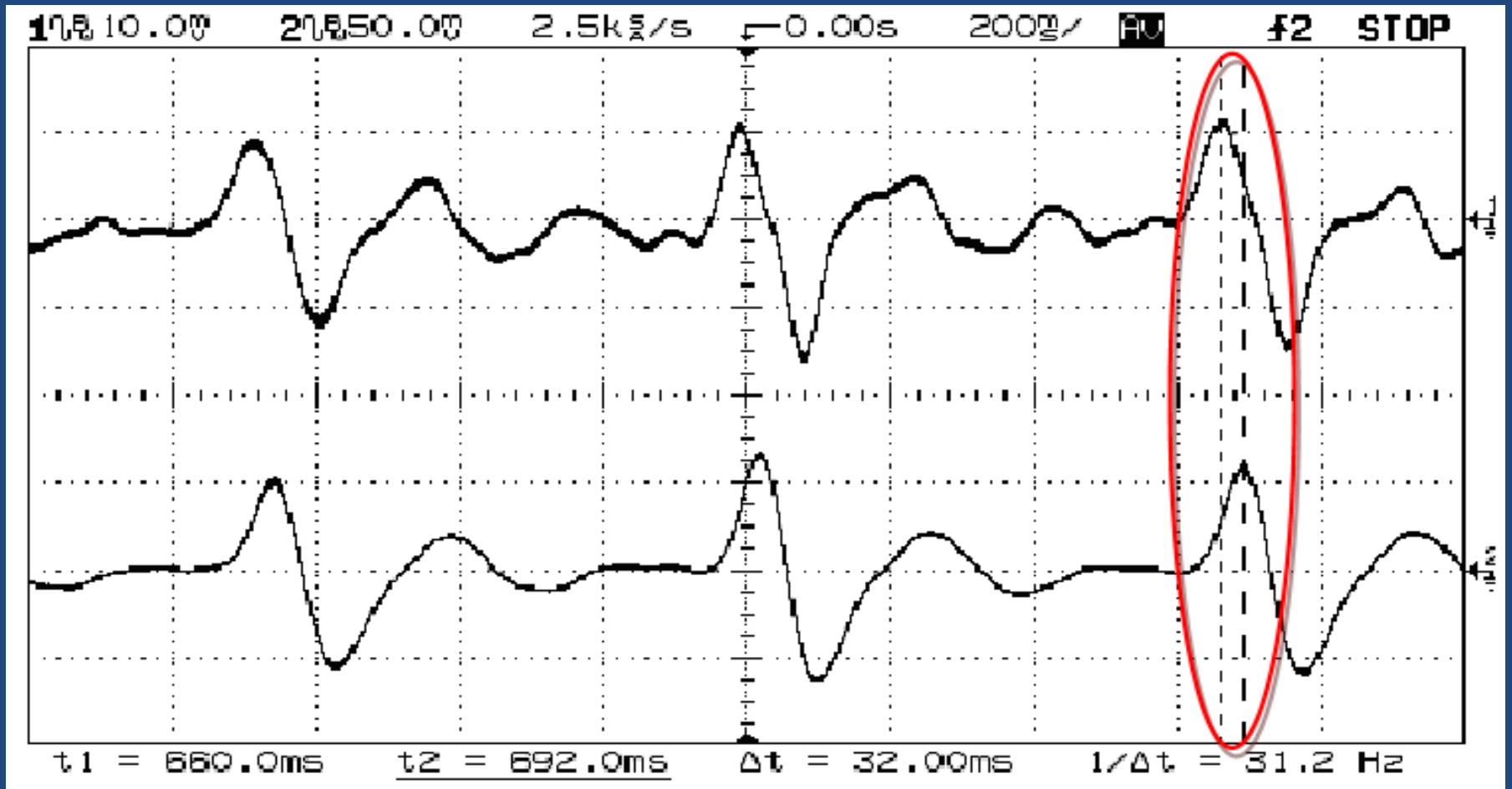


Fig 1. An example of pulse propagation delay between forearm and wrist

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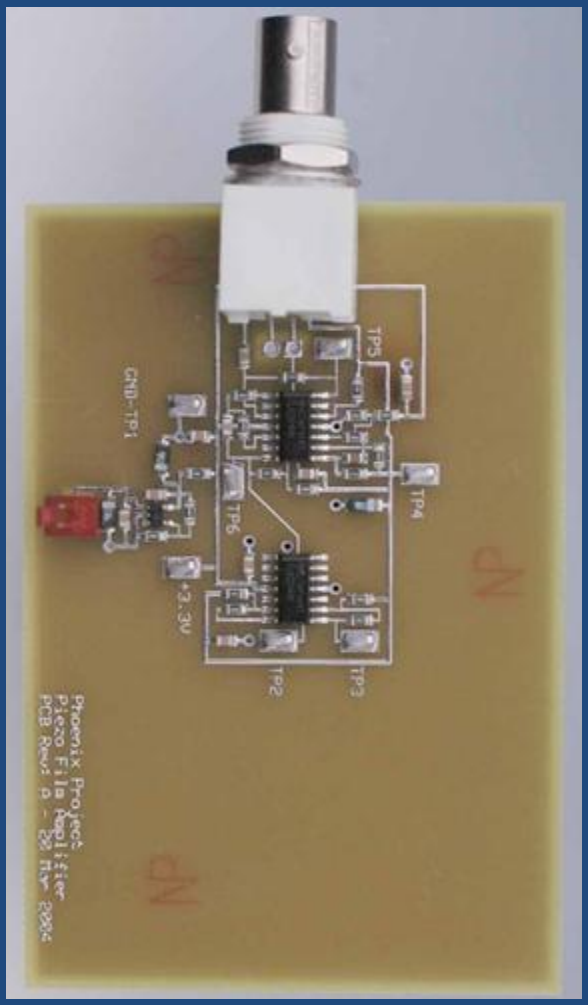

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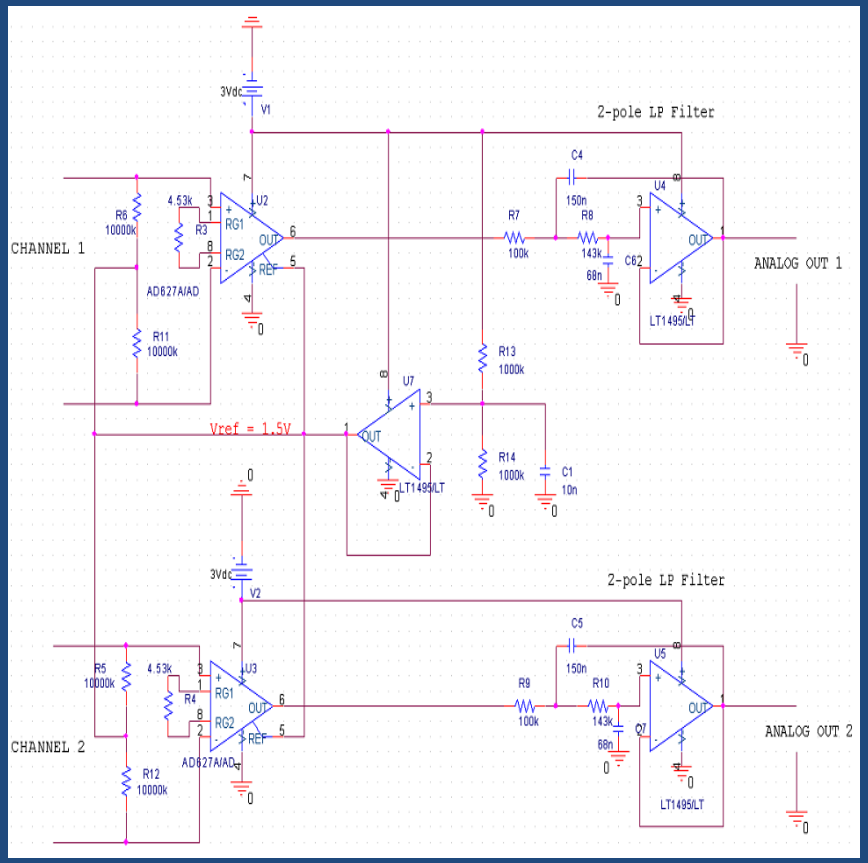

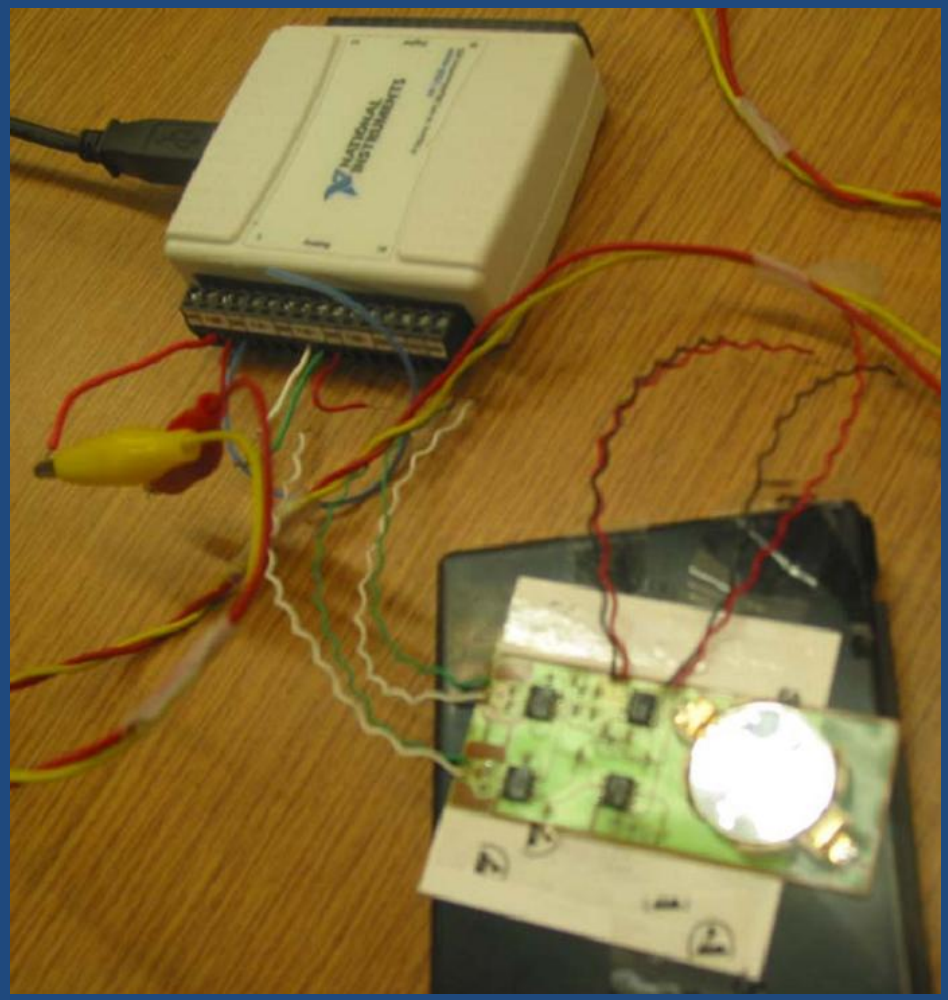

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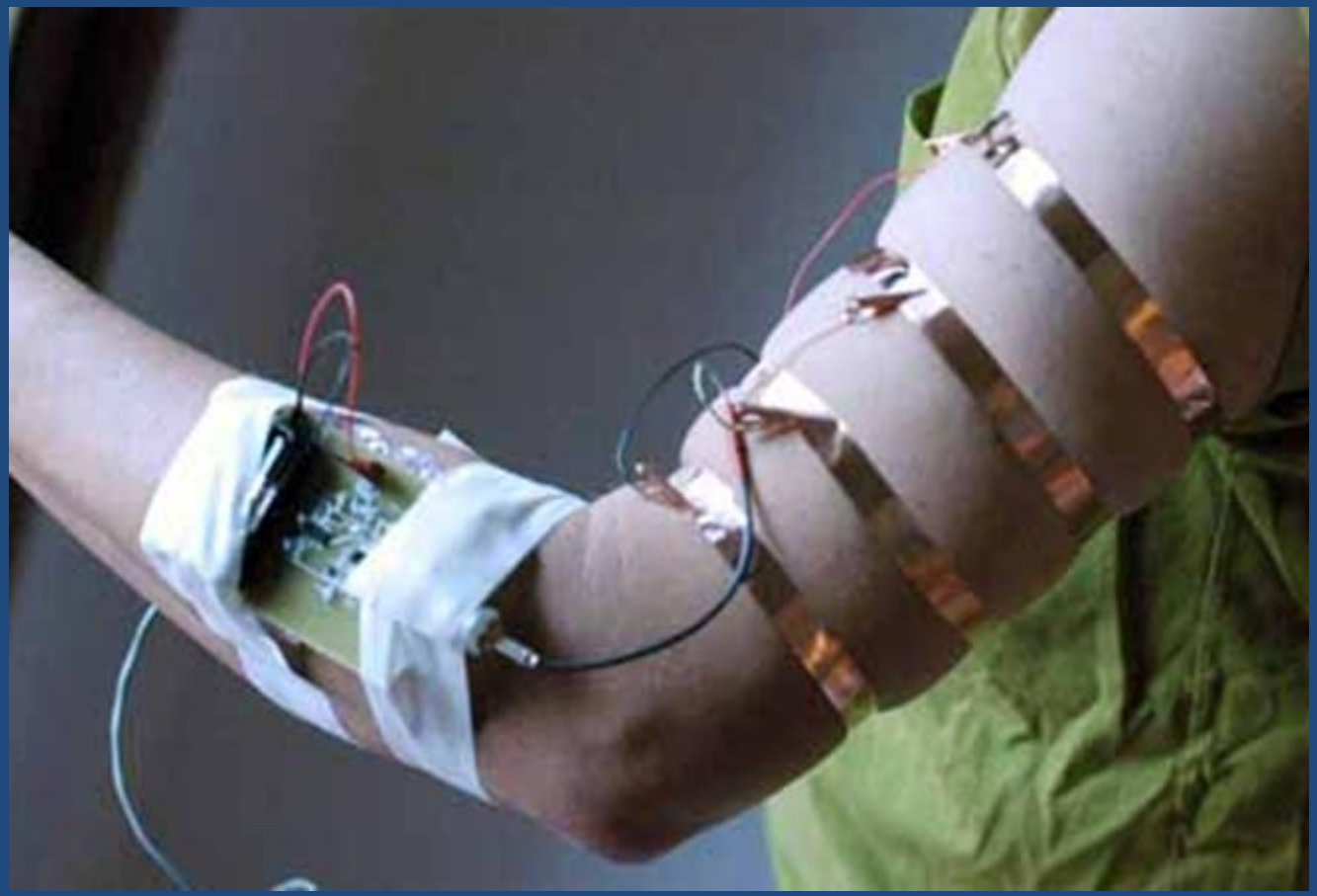

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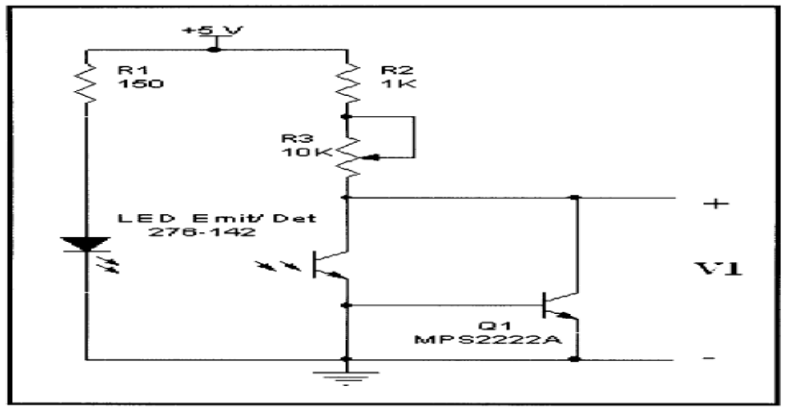
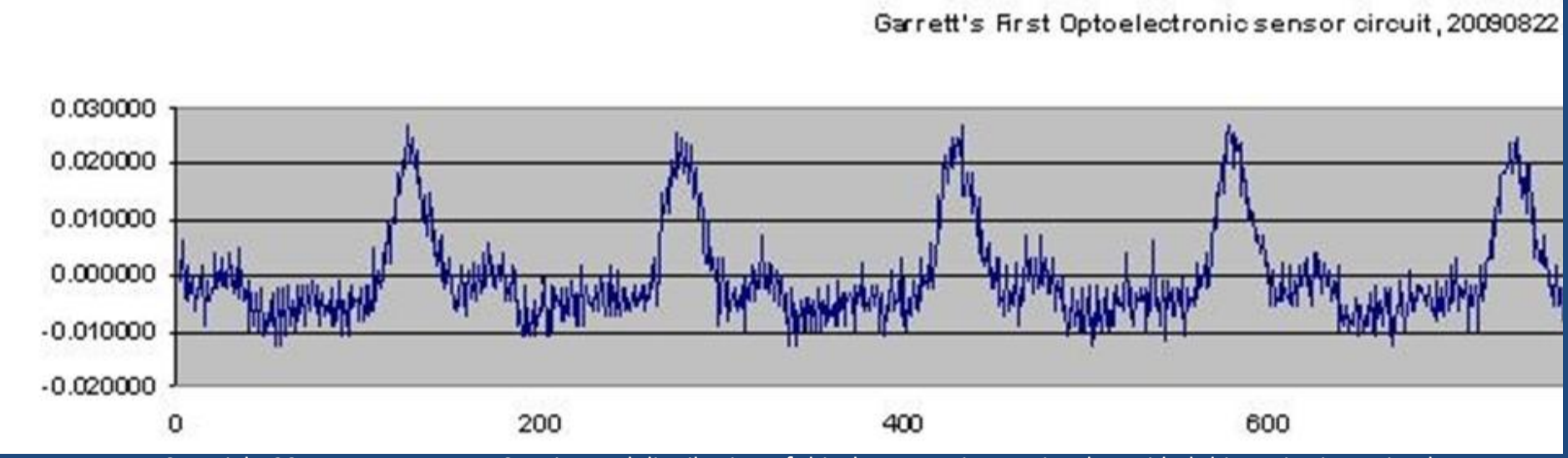


Figure 2: Heartbeat transducer circuit with output V1.

The first attempt to record a pulse wave from a lab member's finger looks like the following:



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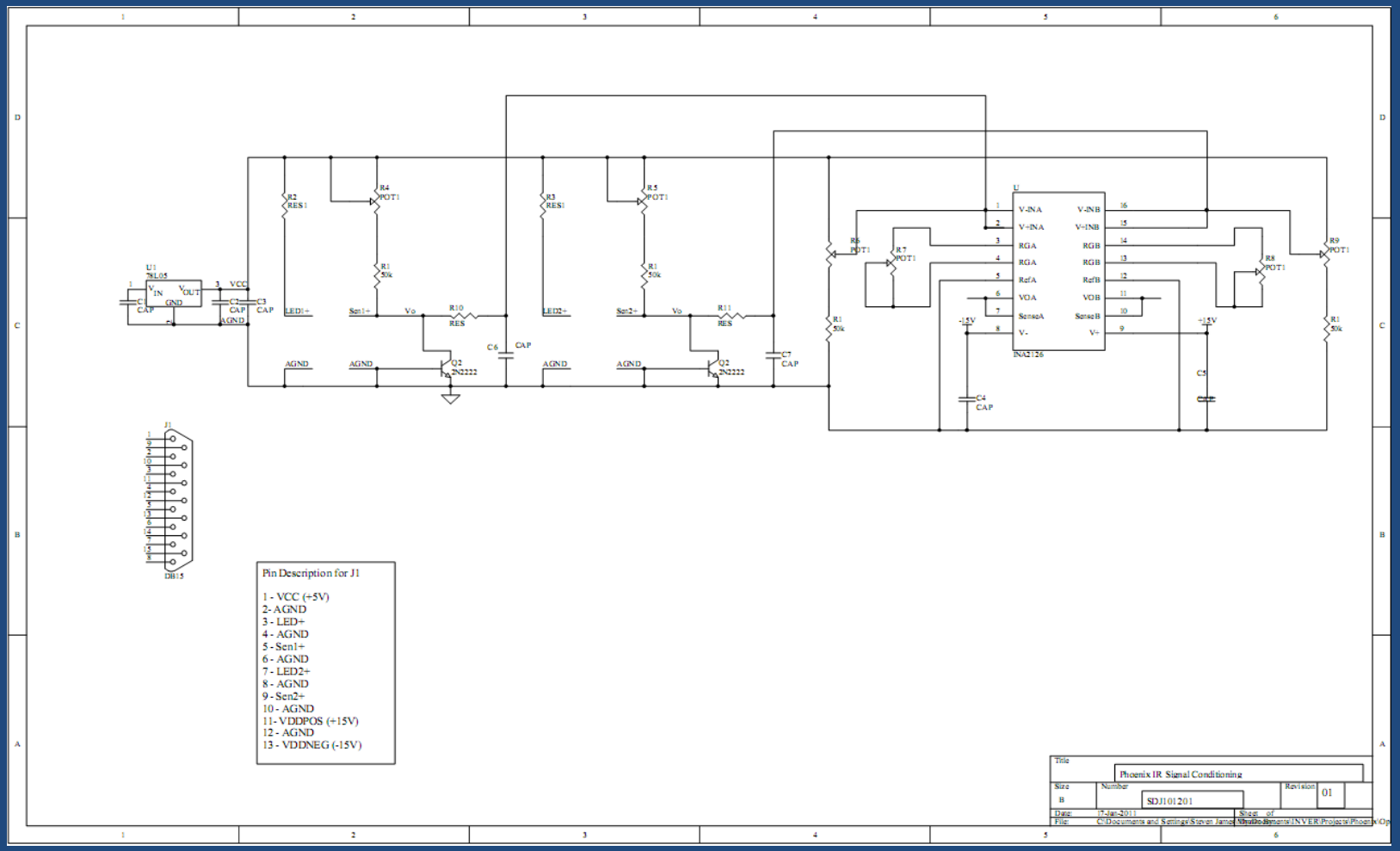

Conclusion

- We are looking to extend the R&D we've done so far, and then productize something from the ongoing research; the student projects are an important part of that.
- Dr. Halberg expects this to change healthcare in a major way for all 7 billion people on the planet by preventing and diagnosing diseases we can't detect today.

- Would you like to say that you got an "A" for doing your part on an open source healthcare-related project that went from visualization in the academic world to R&D and then to production?
  - Companies like to hire people who can say stuff like that!