UtahState UNIVERSITY

Mechanical & Aerospace Engineering

101.4/105! Outstanding Job

MAE 3340 *INSTRUMENTATION SYSTEMS*

Design Final Presentation

Pulse Oximeter Prototype Testing

Presenter(s): Landon Terry, Gage Salerno, Chase Halverson

MAE 3340 Lab Section: 509, Pulse Laboratories

Date, Time, Location: 01/05/2014 7:00 MDT ENGR 103

pulse Laboratories

Presentation Outline

1. Member Duties
2. Team Members and Organizational Chart
3. Background summary
4. Measurement Requirements
5. Design Requirements
6. Design Fulfillment
7. Data Acquisition and Analysis.
8. Results and Recommendations
9. Questions
10. Extra Information

Team Member Duties

Chief Engineer:

Responsibility for operation of team and workflow.

Systems Engineer:

Maintains a “big-picture” view of component functionality and integration.

Software Engineer:

Writes and maintains software for data acquisition.

Analysis Specialist:

Analyzes collected data for trends and significance.

Information Specialist:

Tracks and compiles data for deliverable items to customer.

Team Members and Organization Chart

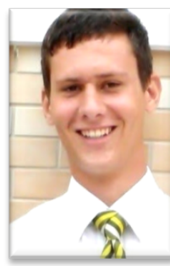
Gage Salerno: Chief Engineer

Lisa Montierth: Systems Engineer

DJ Srtingham: Software Engineer

Chase Halverson: Assembly and Analysis Specialist

Karson Halverson: Software and Testing Engineer



Jake Forsyth: Hardware and Assembly Engineer

Landon Terry: Information Specialist

Background Summary

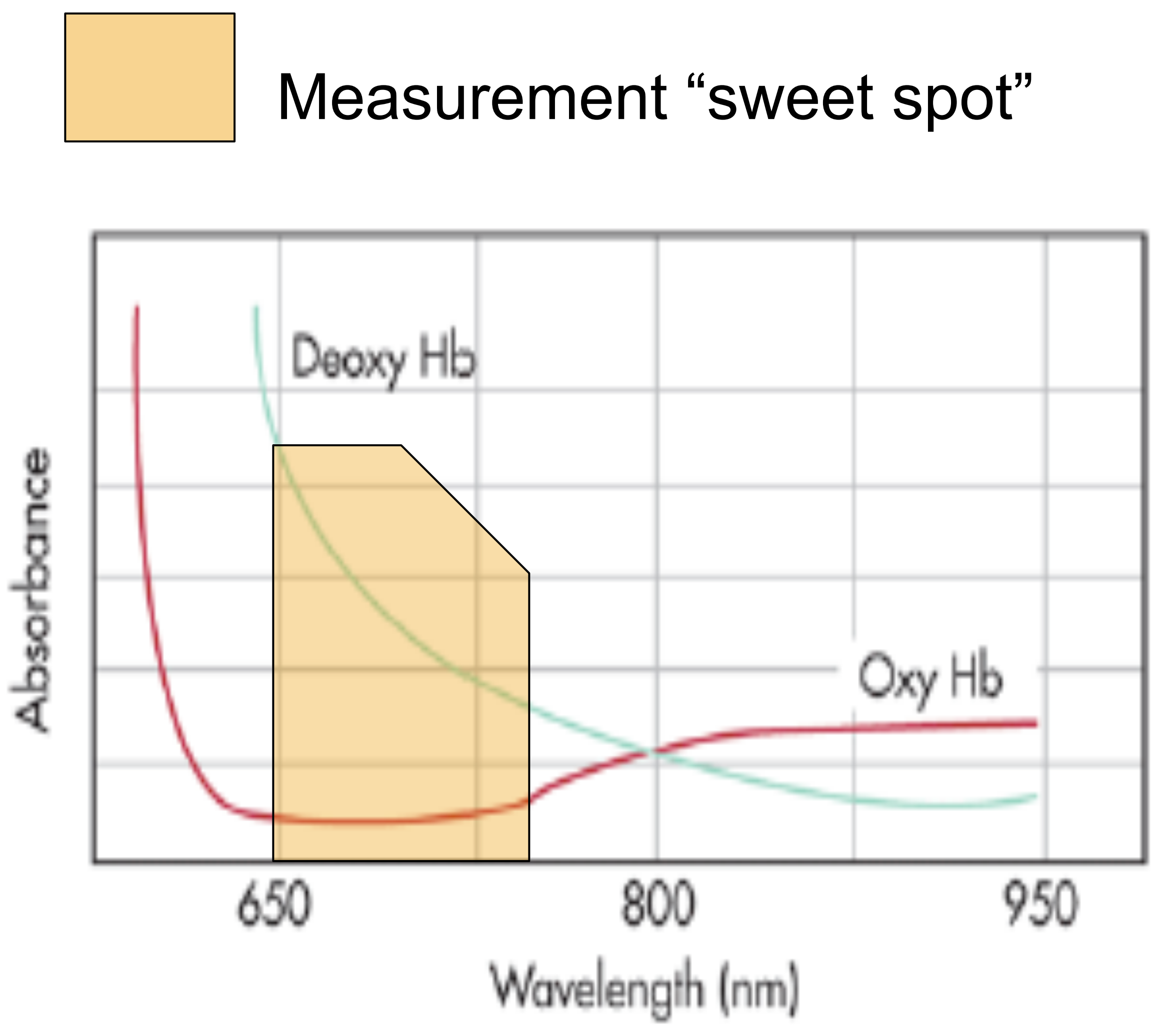
Mission statement:
Design an electrical system to measure resting and recovery heart rates.

Methodology:
Two devices were prototyped: one with a photo resistive sensor and one with a photo generative sensor.

Implementation:
A team of undergraduate USU students designed and built the devices through the MAE Instrumentation class.

Measurement Requirements

Measurement “sweet spot”



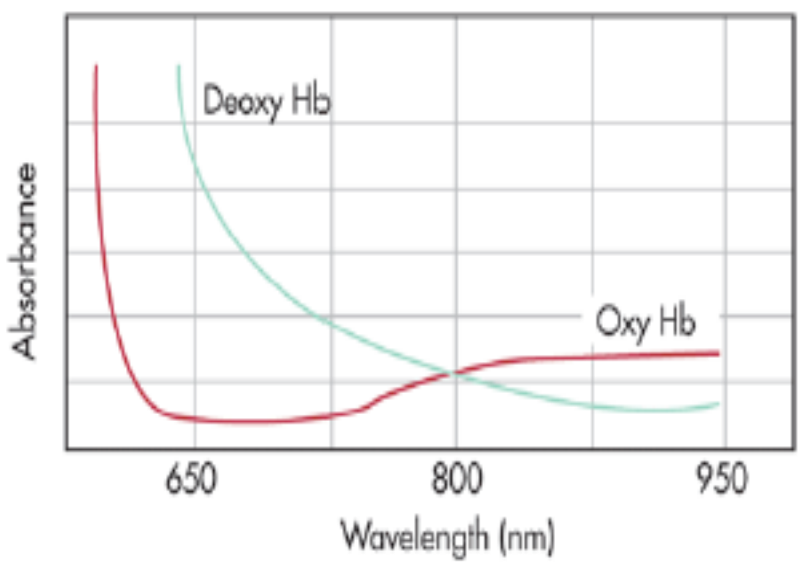
Design of Systems:

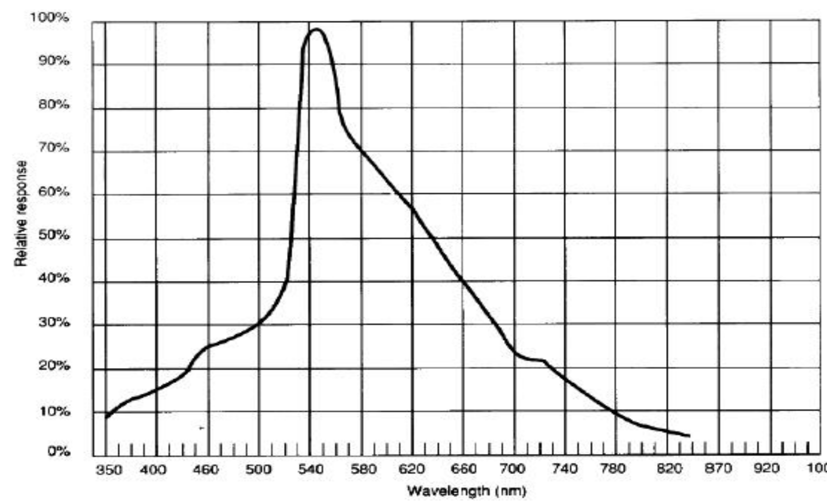
Gage Salerno

Design Requirements: Photo Resistor

Photo Resistor Design requirements:

- Sensitivity
- Peak wavelength
- Circuit design

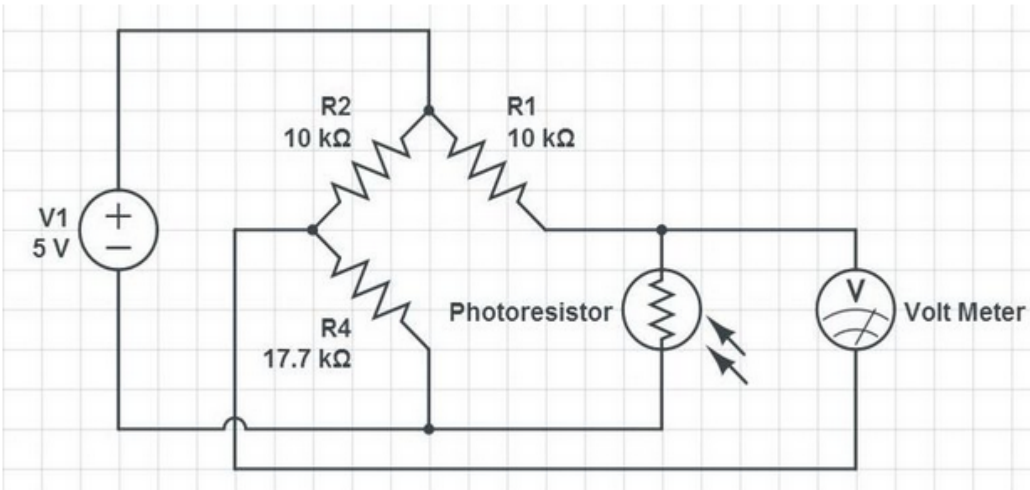




Design Fulfillment: Photo Resistor

Photo Resistor Parts and Components:

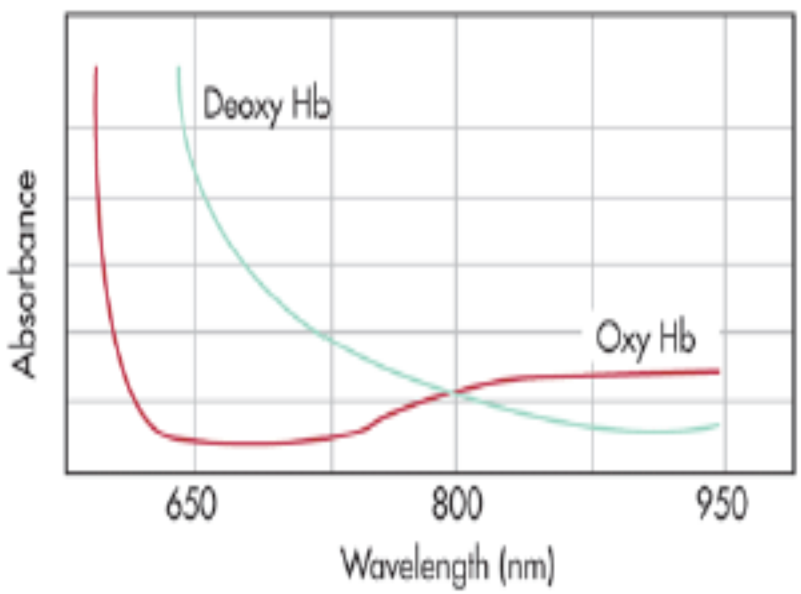
- Design of bridge
- Resistors for bridge
- Pre-analysis

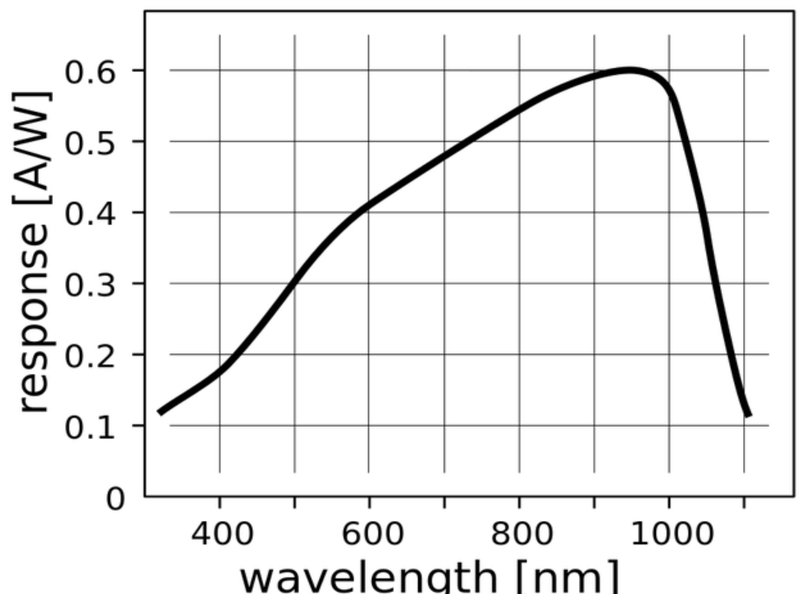


Design Requirements: Photo Generative

Photo Resistor Design requirements:

- Sensitivity
- Peak wavelength
- Circuit design

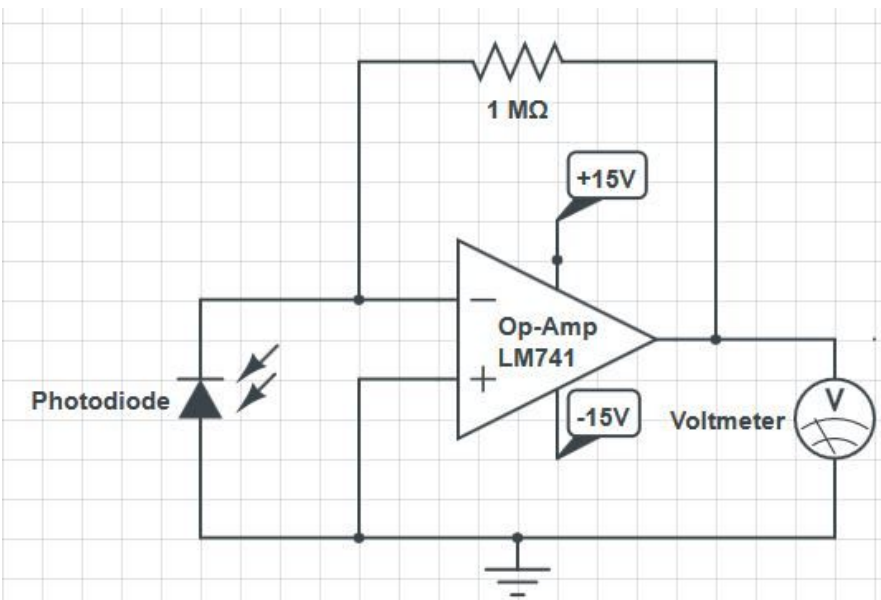




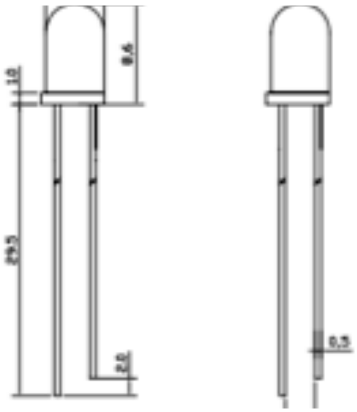
Design Fulfillment: Photo Generative

Photo Resistor Parts and Components:

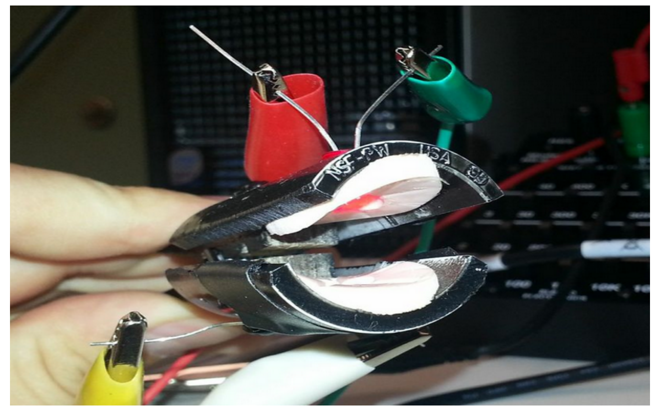
- Diode
- OpAmp
- Resistor Value



Parts and Components



LED



Pulse Oximeter

Photo Diode

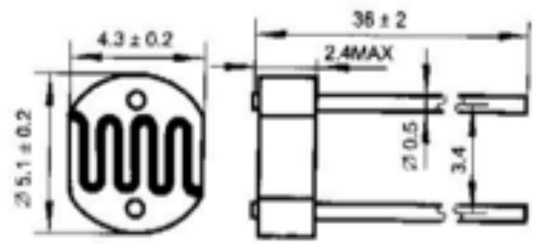


Photo Resistive Cell

Assessment of Design

Photo resistive Sensitivity issues

Sensor Isolation

LED externally powered

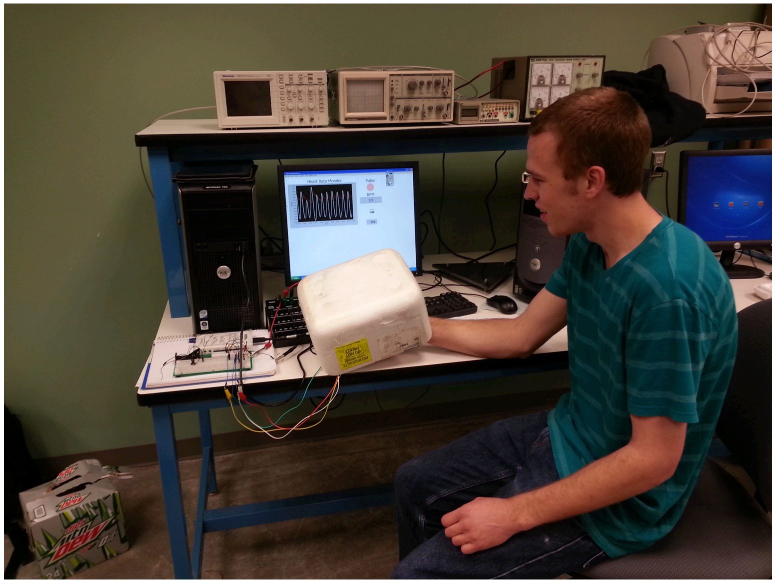
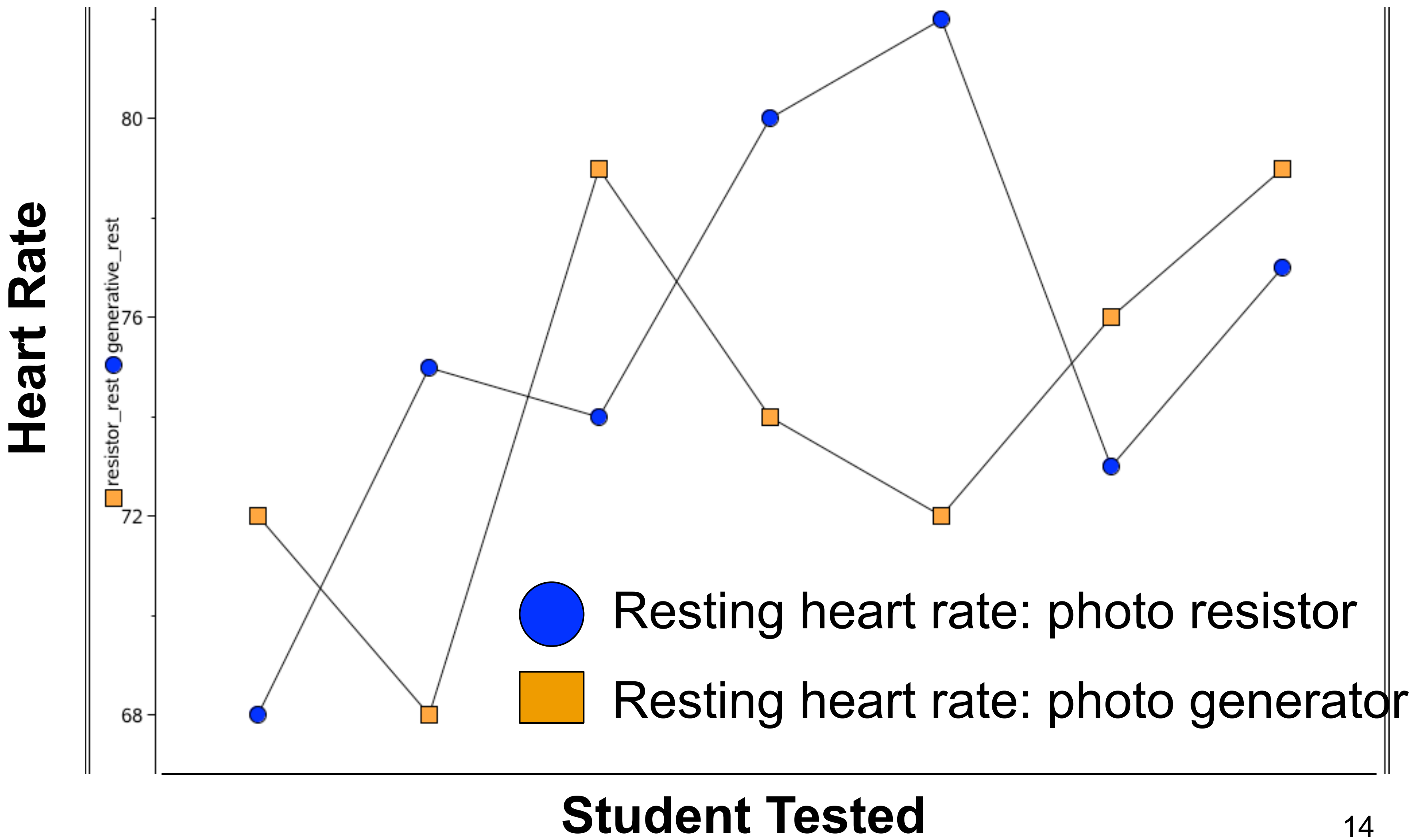


Photo Generative Results

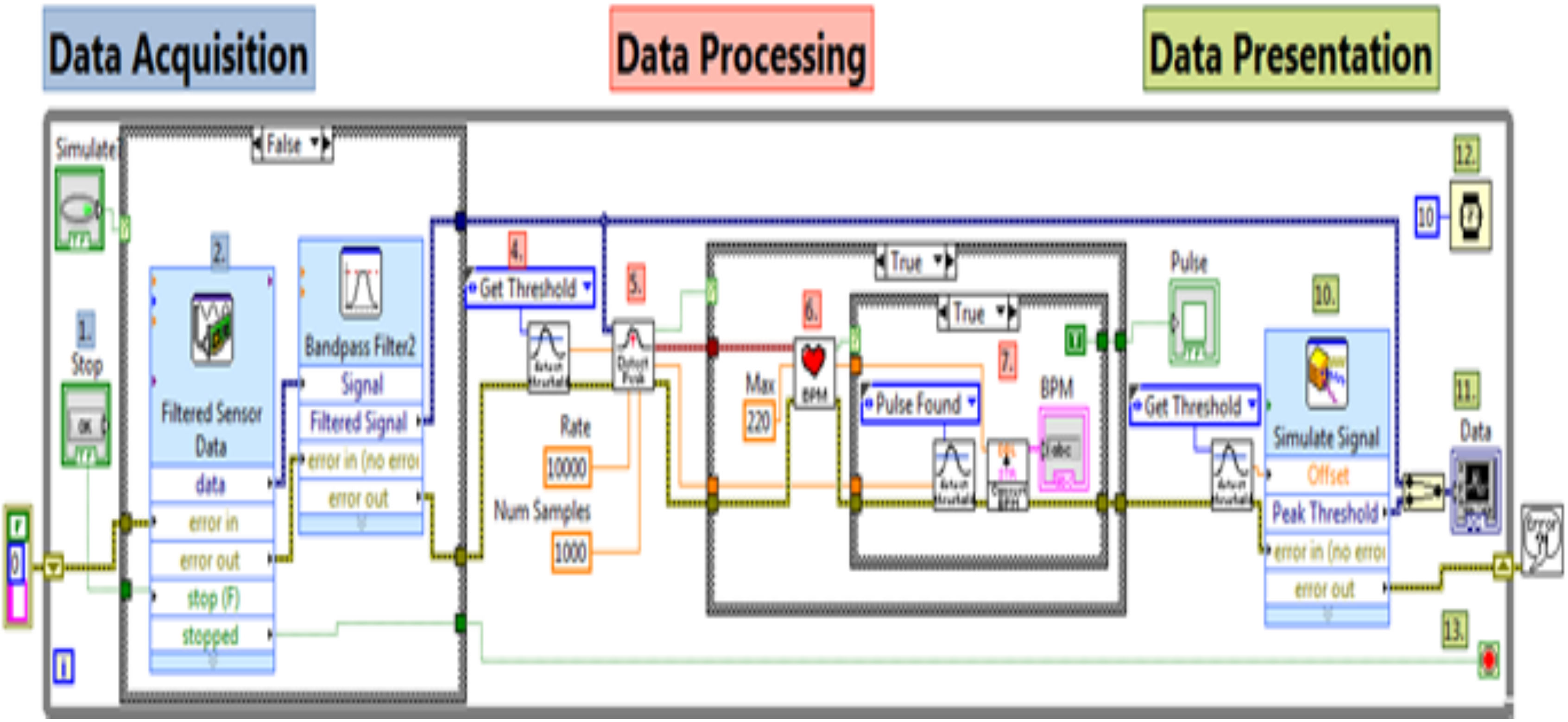
Issues

Resolution

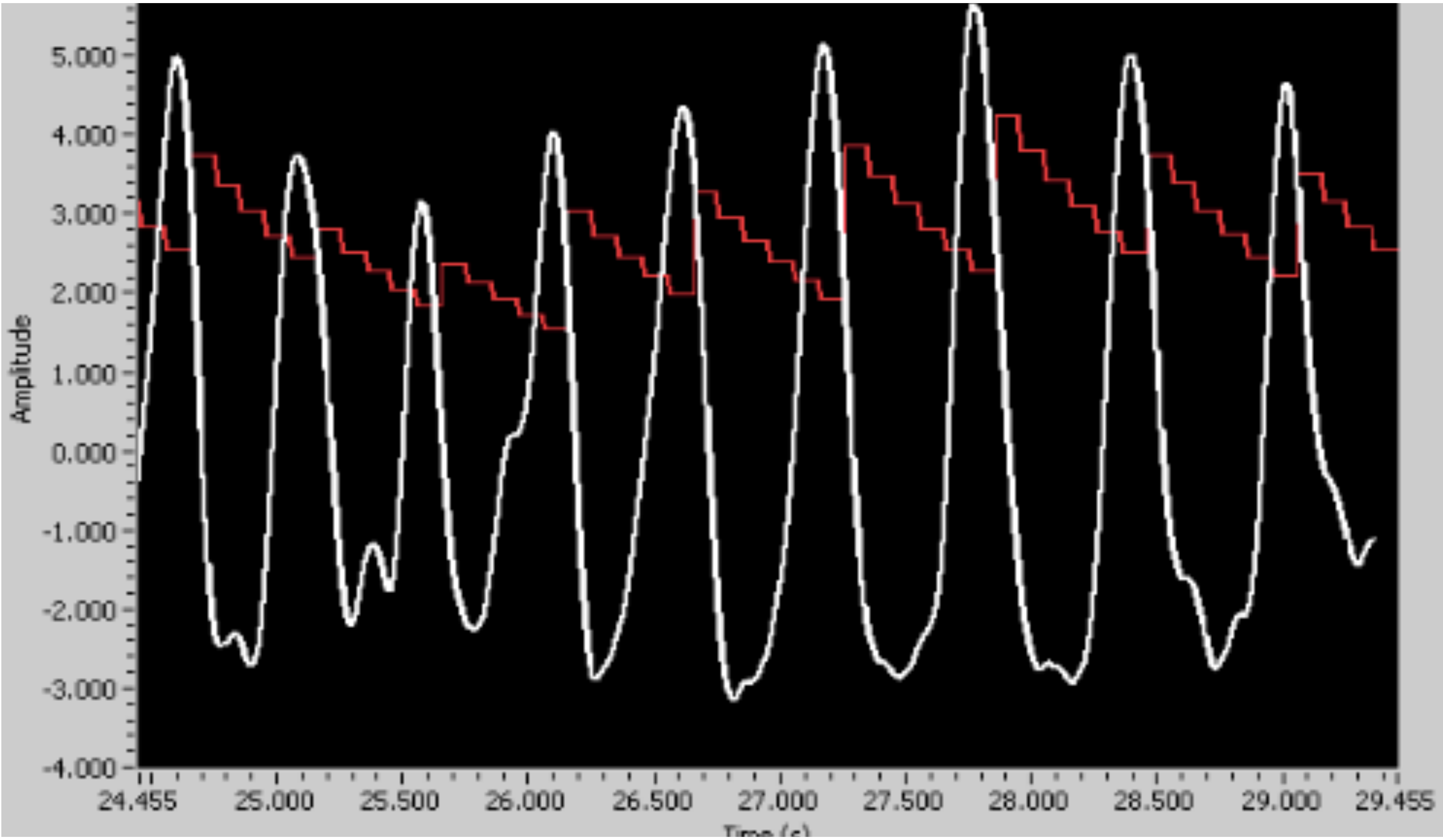
Example Test Results



Software Flowchart



Software Example Test



Statistical Results Analysis:

Chase Halverson

Data Acquisition and Analysis

Student t distribution analysis was used due to small sample set

Confidence Interval

$$\bar{x} - t_{c/2,\nu} \cdot \frac{S_x}{\sqrt{n}} \le \mu_x \le \bar{x} + t_{c/2,\nu} \cdot \frac{S_x}{\sqrt{n}}$$

t test: Degrees of freedom

$$\nu = \frac{\left[\left(S_1^2/n_1\right) + \left(S_2^2/n_2\right)\right]^2}{\frac{\left(S_1^2/n_1\right)^2}{n_1 - 1} + \frac{\left(S_2^2/n_2\right)^2}{n_2 - 1}}$$

t test: Distribution value

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(S_1^2/n_1\right) + \left(S_2^2/n_2\right)}}$$

Data Results: Photo Generative (resting heart rate)

Confidence Interval

$71.272 \leq \mu x \leq 79.870$

Student t test

v=Degrees of Freedom (calculated)	6.150751704
Round Degrees of Freedom Down	6
Confidence Interval (percent)	95
t value at 0.95/2 and v=6	2.446
Calculated t	1.453820777

Table 9: t-Test Comparison Results for Photo Generative (Resting Heart Rate)

Summary and Conclusion

Lessons Learned:

Data collection issues and solutions

Software issues

Assessment of Design:

Final recommendation: Photo generative sensor system

More accurate

Assessment of test results:

Statistical significance

Results compared to national data

Questions??

Appendix B: References and Citations

1. Millikan G. A. (1942). "The oximeter: an instrument for measuring continuously oxygen-saturation of arterial blood in man". *Rev. Sci. Instrum* 13(10): 434- 444. doi:10.1063/1.1769941.

2. Torres, D., "Build A Wrist Heart-Rate Monitor Using An Ultra-Low-Power MCU," Electronic Design, http://electronicdesign.com/digital-ics/build-wrist-heart-rate- monitor-uultra-low-power-mcu, [Retrieved 22 April 2014].

3. Harden, Scott W. "Single Wavelength Pulse Oximeter." *SWHardencom*. N.p., 06 Dec. 2012. Web. 22 Apr. 2014. <http://www.swharden.com/blog/2012-12-06-single- wavelength-pulse-oximeter/>.

4. "Lambert-Beer Law." *Lambert Beer Law*. N.p., n.d. Web. 22 Apr. 2014. <http://www.optek.com/Lambert_Beer_Law.asp>.

5. Nshimiyimana, M. "Summer Internship 2012 Physical Computing with Arduino." *Arduino Projects*. N.p., n.d. Web. 22 Apr. 2014. <http://arthur.sewanee.edu/marcen0/HTML5T/arduino/>.

6. "Light Dependent Resistors - LDR." *Light Dependent Resistors - LDR*. N.p., n.d. Web. 22 Apr. 2014. <http://www.mcuexamples.com/sensors/Sensors-Light-Dependent- Resistors.php>.

7. Ekelof, S. "The Genesis of the Wheatstone Bridge". Published in "Engineering Science . and Education Journal", Vol. 10, No. 1, February 2001, pages 37–40.

8. Brooker, G, *Introduction to Sensors for Ranging and Imaging*, ScitTech Publishing, 2009 ISBN 9781891121746 page 87

9. "Build Your Own Heart Rate Monitor, Part 1 of 4: Overview." - *National Instruments*. National Instruments, 22 Aug. 2012. Web. 22 Apr. 2014. <http://www.ni.com/white-paper/14248/en/>.

10. Whitmore, S. Ph.D., (2014). "Lab 5 Programming Template." Web. 25 Apr. 2014. . <http://www.neng.usu.edu/classes/mae/3340/MAE3340_web_main.html>.

11. Ostchega, Y. "Resting Pulse Rate Reference Data for Children, Adolescents, and Adults: United States, 1999-2008." National Health Statistics Report, 24 Aug 2011. <http://www.neng.usu.edu/classes/mae/3340/Project/nhsr041.pdf>. [Retrieved 22 April 2014]

12. Watanabe, J. "Heart Rate Recovery Immediately After Treadmill Exercise…" American Heart Association, 2001. <http://www.neng.usu.edu/classes/mae/3340/Project/Active_Heart_Rate_Survey. pdf>.

Heart rate data: Photo Resistor

Name	Resting (BPM)	(BPM)
Gage Salerno	72	140
Karson Halverson	68	160
Chase Halverson	79	160
Lisa Montierth	74	160
Jacob Forsyth	72	163
Landon Terry	76	160
David Stringham	79	170
Mean	74.28571429	159
Standard Deviation	4.029652	9.146948489
Number of Samples	7	7

Heart rate data: Photo Generative

Name	Resting (BPM)	(BPM)
Gage Salerno	68	128
Karson Halverson	75	130
Chase Halverson	74	130
Lisa Montierth	80	140
Jacob Forsyth	82	132
Landon Terry	73	136
David Stringham	77	135
Mean	75.57142857	133
Standard Deviation	4.649628761	4.203173404
Number of Samples	7	7

Results and Discussion

National values for heart rate:

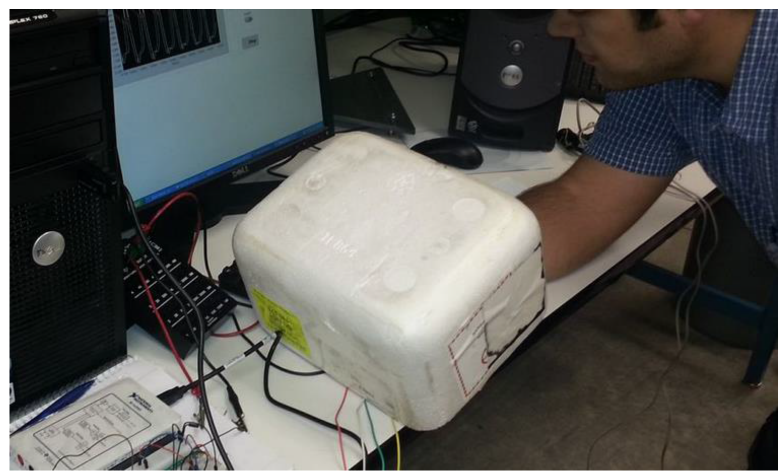
Mean (BPM)	154
Standard Deviation	20
Number of Samples	4633

Table 4: National Data for Average Active Heart Rate [12]

Concept of Operations

Construction of device:
- PVC pipe
- Clothespins
- foam

Data capture:
- Shielding Techniques
- Noise reduction
- Capture of data



Data Results: Photo Resistor (resting heart rate)

Confidence Interval

$70.561 \leq \mu x \leq 78.011$

Example: Student t test

v=Degrees of Freedom (calculated)	6.208703128
Round Degrees of Freedom Down	6
Confidence Level (percent)	95
t value at 0.95/2 and v=6	2.446
Calculated t	0.836976967

Table 5: t-Test Comparison Results for Photo Resistor (Resting Heart Rate)