Analysis of Insulating Properties of Skin (Rodent)

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Client: Dr. Caroline M. Alexander

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Overview

- Client Description
- Problem Statement
- Background
- Product Design Specification
- Preliminary Designs
  - Heating Element
  - Temperature Sensor
- Design Matrix
- Future Work
- References

Figure 1: Design team picture

Client Description

- **Dr. Caroline M. Alexander**
- Professor of Oncology
- Carbone Cancer Center
- Developmental Therapeutics
- Projects in skin modulation of metabolism

Figure 2: UW-Madison Carbone Cancer Center

Problem Statement

There is not a cost effective, accurate device to **measure the conductive heat properties** of rodent skin samples required for oncology research.

Background

- Skin is the largest organ
  - Factor in metabolic rate
- Genes control heat regulation
- Heat transfer is hard to model
  - Ignore evaporative cooling

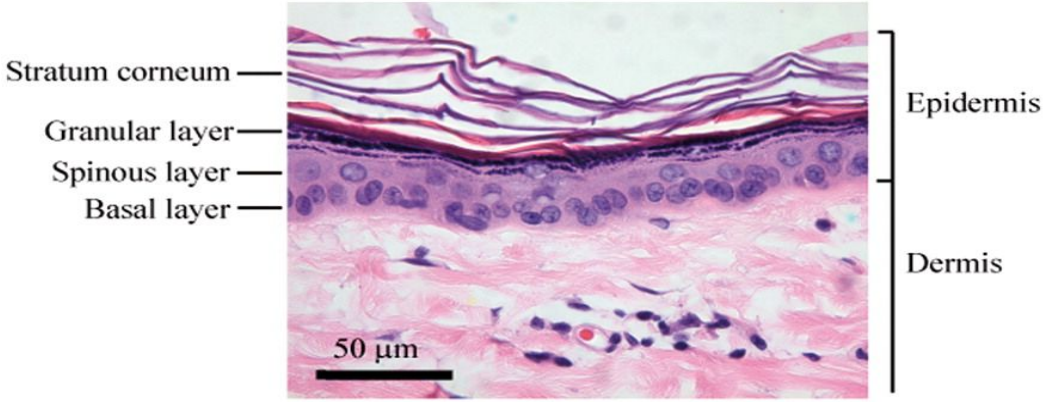


Figure 3: Scaled imaging of skin layers [1]

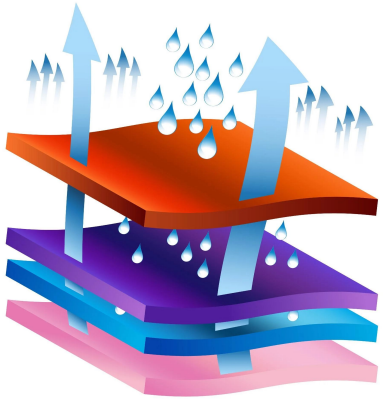


Figure 4: Illustration of evaporative cooling [2]

Competing Solutions

- Infrared Thermometer
  - Used by our client
  - Affected by evaporative cooling

Figure 5: Omega infrared camera [3]

- Thermtest MP-1
  - High precision
  - Expensive

Figure 6: Thermtest MP-1 [4]

Design Specifications

- Pulse sample with 37℃ ± 0.5℃
  - Minimum 5 Hz
- Measure heat transfer
  - Ignore evaporation cooling
  - Within 0.1℃
- Samples are 2 x 4 cm
  - 50-500 microns thick

Heating Element Designs

- **Wall Power Design**
- Beefcake relay for 120 V

- Arduino microcontroller
  - Thermistor circuit
  - Switch for on/off control

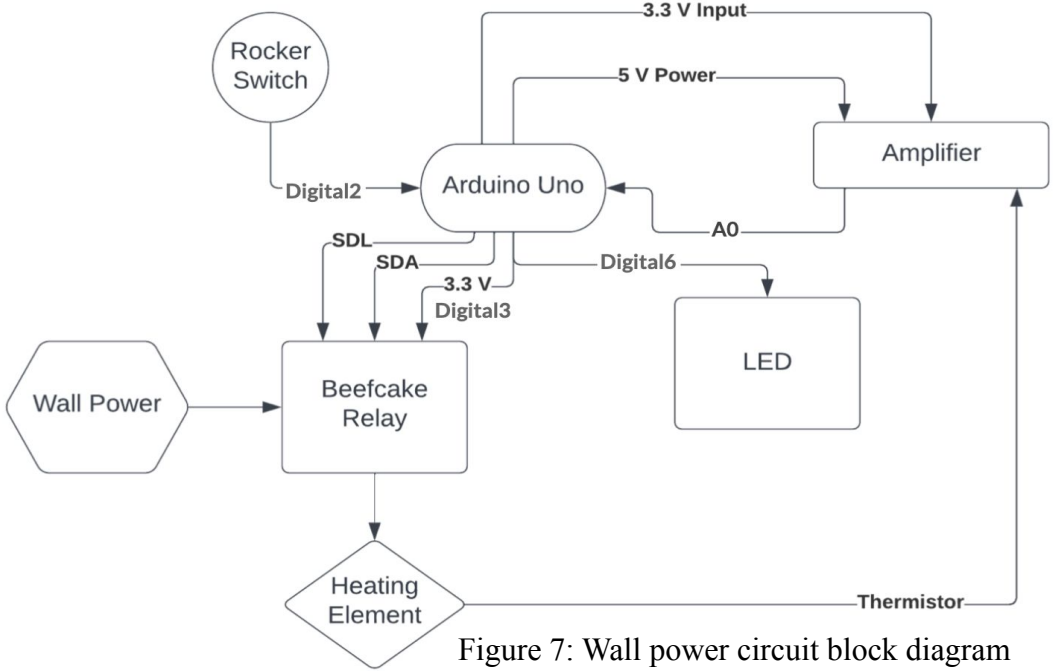


Figure 7: Wall power circuit block diagram

Heating Element Designs

- **Battery Power Design**
- 12 V DC Adapter

- Arduino microcontroller
  - Thermistor circuit
  - Switch for on/off control

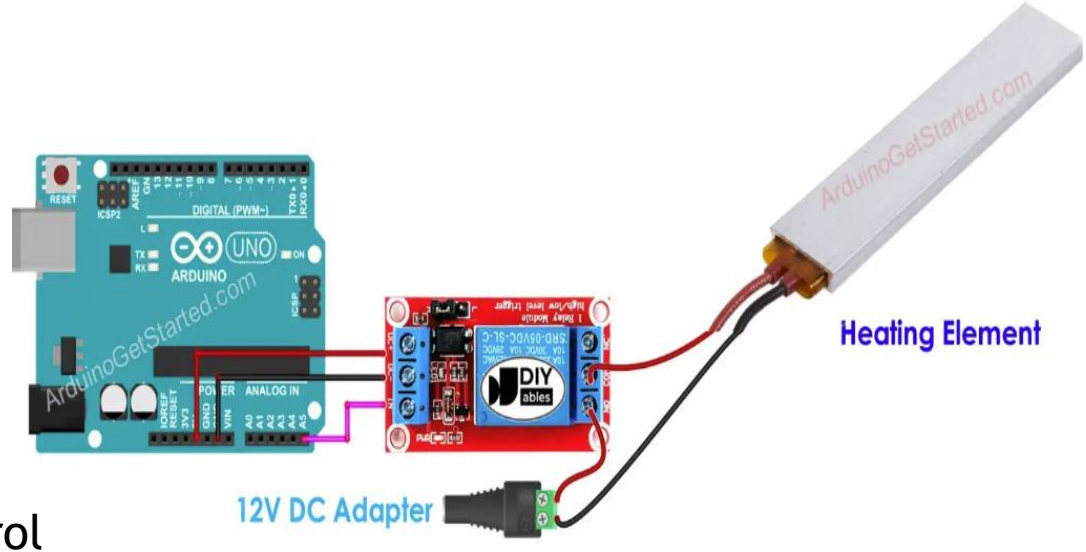


Figure 8: Battery power Fritzing diagram [5]

Temperature Sensor Designs

- **Thermistor Design**
- Thermistor temperature sensor
- Non-inverting amplifier
  - Gain = 1 + R_T / R3
- Calibration

Figure 9: Flat NTC thermistor [6]

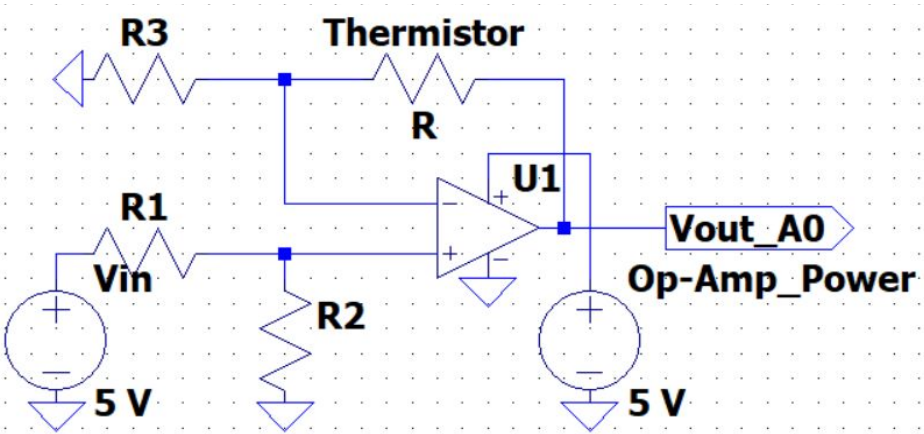


Figure 10: Thermistor circuit LTSpice schematic

Temperature Sensor Designs

- **Thermocouple Design**
- Require LT 1025
- Require filter(s)

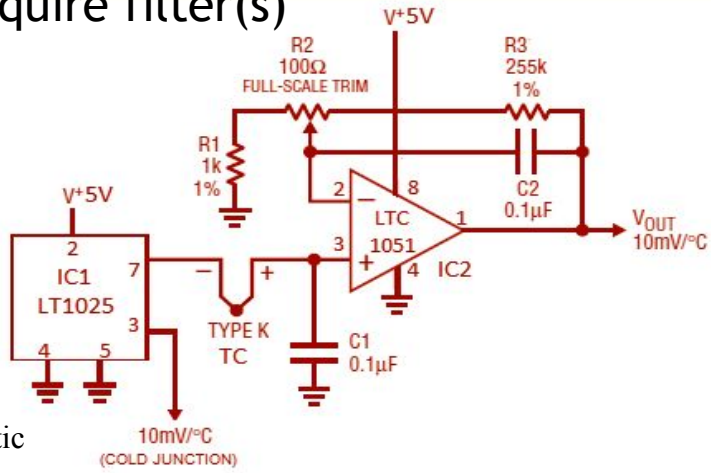


Figure 11: Thermocouple circuit schematic

- **Thermopile Design**
- Thermocouples in series
- High temperature range

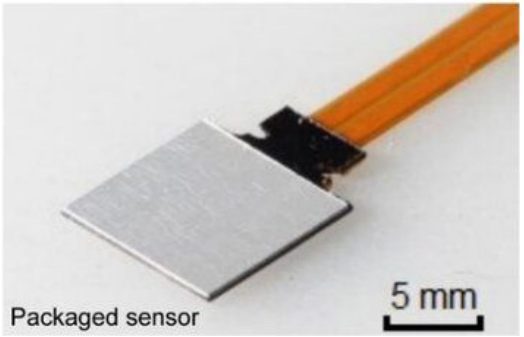


Figure 12: Flat thermopile sensor [7]

Heating Element Design Criteria

- Safety
- Accuracy
- Ergonomics
- Cost
- Ease of Fabrication

Heating Element Design Matrix

Design Categories (Weight)	Wall Power Heating Element 		Battery Power Heating Element 	
Safety (30)	2/5	12	4/5	24
Accuracy (25)	4/5	20	3/5	15
Ergonomics (20)	3/5	12	3/5	12
Cost (15)	4/5	12	1/5	3
Ease of Fabrication (10)	4/5	8	2/5	4
Total (100)	**64**		**58**	

Table 1: Heating Element Design Matrix, with ranking of each design

Temperature Sensor Design Criteria

- Accuracy
- Ease of Fabrication
- Cost
- Size
- Safety

Temperature Sensor Design Matrix

Design Categories (Weight)	Thermistor Temperature Sensor 		Thermocouple Temperature Sensor 		Thermopile Temperature Sensor 	
Accuracy (35)	4/5	28	5/5	35	1/5	7
Ease of Fabrication (20)	4/5	16	3/5	12	2/5	8
Cost (20)	4/5	16	3/5	12	2/5	8
Size (15)	5/5	15	4/5	12	3/5	9
Safety (10)	4/5	8	3/5	6	3/5	6
Total (100)	**83**		**77**		**38**	

Table 2: Temperature Sensor Design Matrix, with ranking of each design

Materials and Testing

- Conductive materials
- Thermistor calibration curve
- Temperature testing
- Heating element testing

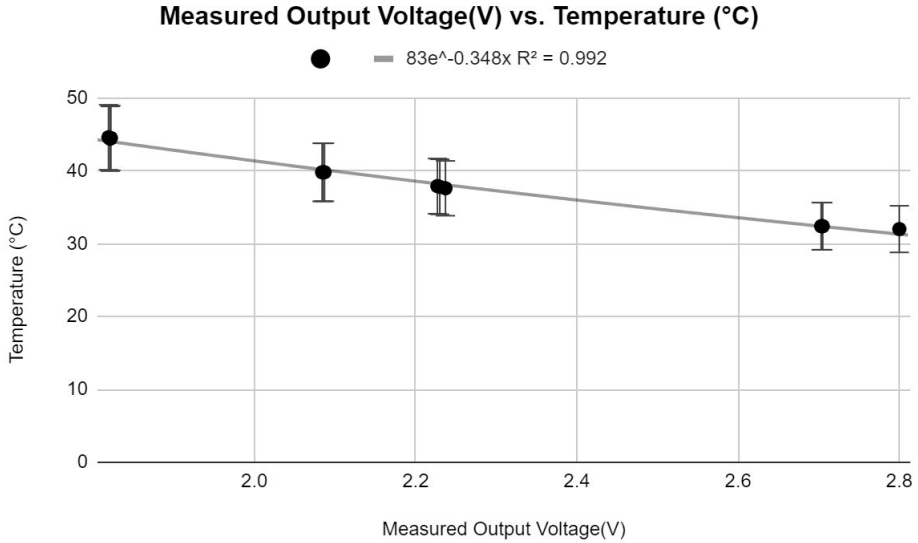
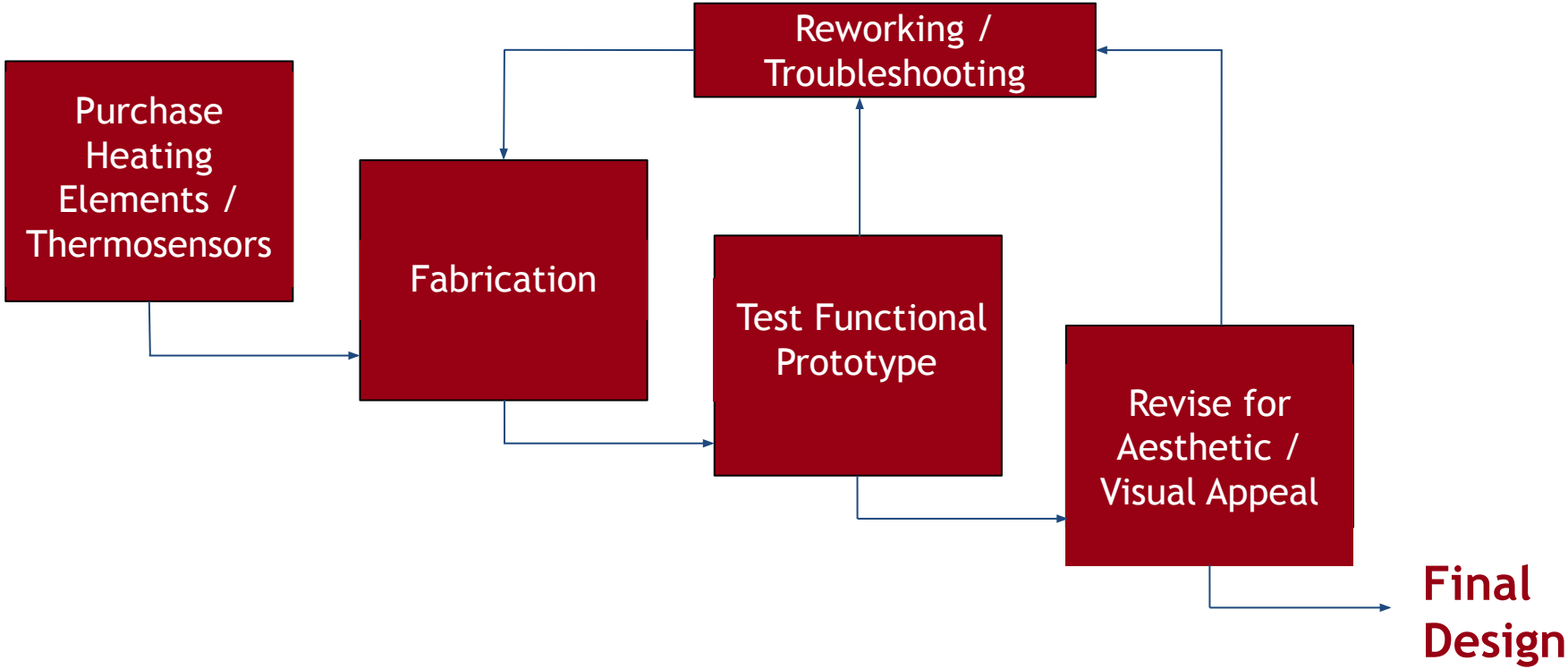


Figure 13: Thermistor circuit calibration curve

Future Plans



What we've learned

- Continued client communication and questions
- Look for variability
- Team communication and planning is key

Acknowledgments

Thank You!

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Prof. Justin Williams
Dr. Caroline M. Alexander

References

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