Team 1817:Electrical plug, connector, and receptacle temperature sensor (Hubbell)

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Personnel and collaborators

- Personnel:
  - Jim Lin (EE)
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  - Kyle Mullins (EE)
  - Robert Townsend (CE)
- Faculty Advisor:
  - Necmi Biyikli
- Company Contact:
  - John Brower

Outline

- Company Information
- Task
- Goals
- Timeline
- Research
  - Background
  - IR
  - RTD
- Possible Solutions
- Prototyping
- Next Steps

Company Background

- Hubbell Incorporated
  - Shelton, CT
  - Produce plugs, connectors, and receptacles
  - Cover a range of rated voltages up to 600 VAC

Fig. 1 : Hubbell L1430P Hubbell, Twist Lock Plug, 30Amp

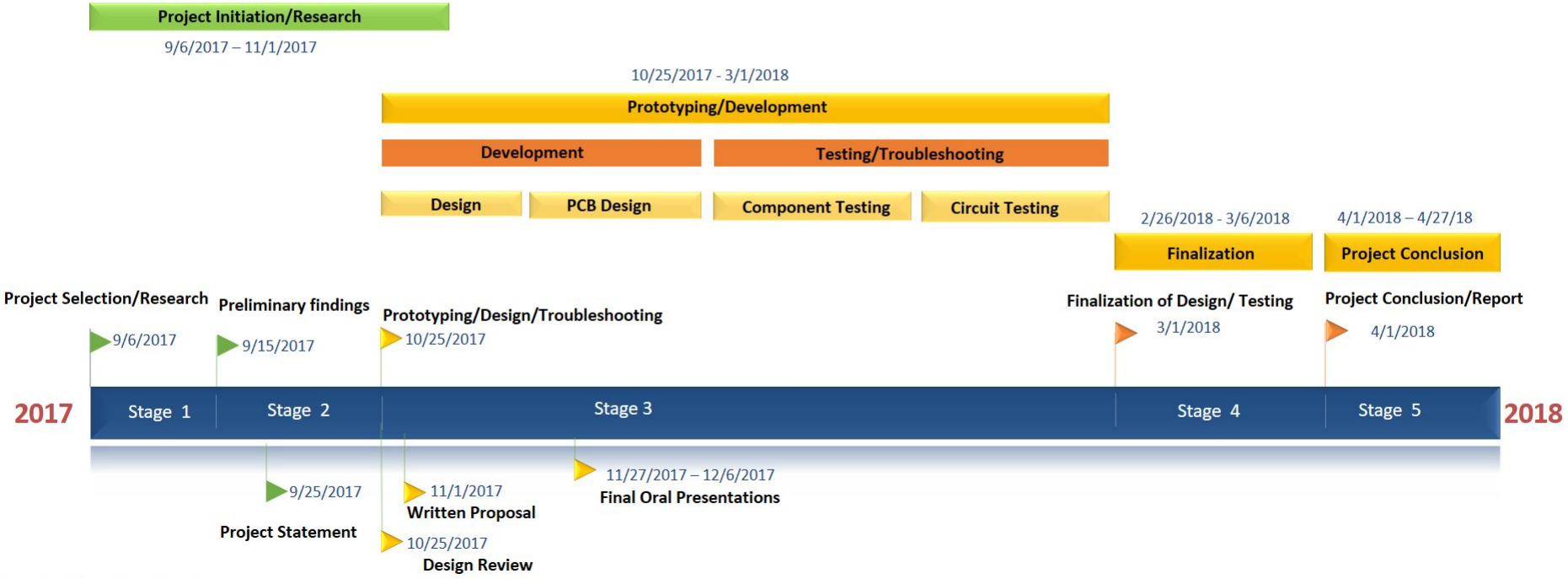
The Purpose

- Research existing temperature sensing technologies
  - Method of measurement
  - Contact vs. non contact
  - Temperature range
  - Accuracy
  - Associated problems
- Look to utilize existing technology to improve performance

Goal and Requirements

- Miniaturization/Optimization design project
- Small temperature sensing system
  - Two or more sensors
  - 1 inch x 1 inch component density
  - Temperature range: -20°C to 80°C
  - Minimum Accuracy: ±1°C
  - Onboard Microcontroller for data interpretation
- Stay within a Budget of $6 - $8 USD

Timeline


Project Initiation/Research
9/6/2017 – 11/1/2017
10/25/2017 - 3/1/2018
Prototyping/Development
Development
Testing/Troubleshooting
Design
PCB Design
Component Testing
Circuit Testing
2/26/2018 - 3/6/2018
Finalization
4/1/2018 – 4/27/18
Project Conclusion
Project Selection/Research
9/6/2017
Preliminary findings
9/15/2017
Prototyping/Design/Troubleshooting
10/25/2017
Finalization of Design/ Testing
3/1/2018
Project Conclusion/Report
4/1/2018
2017
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
2018
9/25/2017
Project Statement
11/1/2017
Written Proposal
10/25/2017
Design Review
11/27/2017 – 12/6/2017
Final Oral Presentations

Research

- Examine existing temperature sensing technologies
  - Find the mechanism of measurement
  - Infrared, resistance temperature detectors, and semiconductor devices
- Compare
  - Accuracy
  - Effective range
  - Measurement type

Project Materials

- Multiple temperature sensors
- Required supplementary components for each sensor
- Microcontroller Unit
- Temperature display device

Possible Solutions

- Based on research, optimal technologies include:

  1. Resistance Temperature Detectors

  2. Infrared devices

Resistance Temperature Detectors (RTD)

- Correlates resistance value to temperature value

$$R = R_o(1 + \alpha(T - T_{ref}))$$

- Close proximity/contact
- Typical Operating Range of -60℃ to over 600℃
- High Accuracy (many are below (+/- 1℃)
- Two Basic Styles: Wire-wound and Thin Film

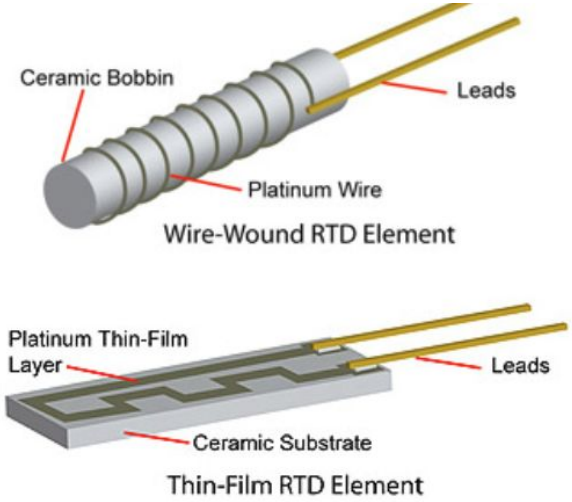


Figure 2. RTD Styles

RTD Background

- Common composition materials: Copper, Nickel, and Platinum
- Three types of RTD configurations: 2-wire, 3-wire, and 4-wire
- Voltage potential in wheatstone bridge
- **Provides repeatability, stability, and are the most accurate temperature sensors**

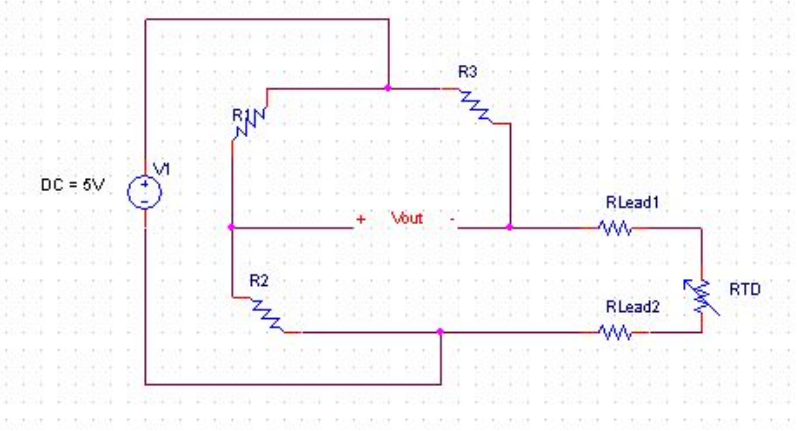
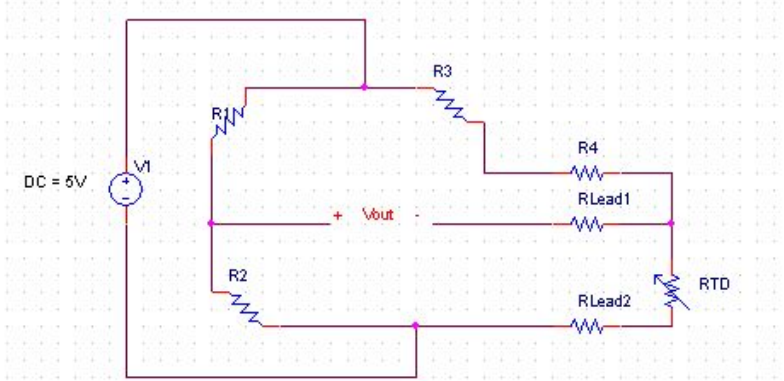


Fig. 3: 2-wire Circuit

Fig. 4: 3-wire Circuit



Infrared (IR)

- The long wave infrared spectrum
  - Includes wavelengths of 8 micometers to 15 micrometers
  - Stefan-Boltzmann Law
    - $P=\varepsilon\sigma A(T-Tc)^4$
- **Non-contact**
- Thermal imaging

IR background

- Thermopiles are composed of multiple thermocouples
  - Thermocouples are made of 2 wires made of different metals
  - 2 Conductors form an electrical junction in Thermocouples
- Must be configured / adjusted for measuring material

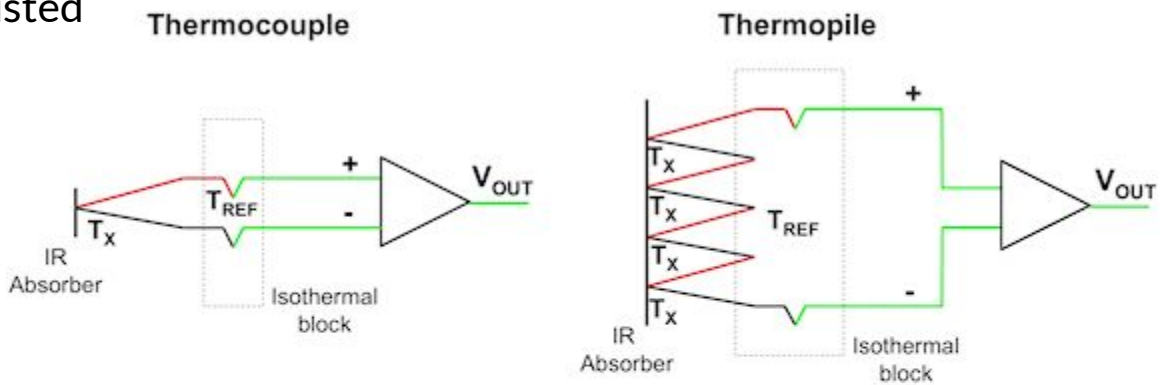


Fig. 5: Thermocouple vs. thermopile

Thermopiles

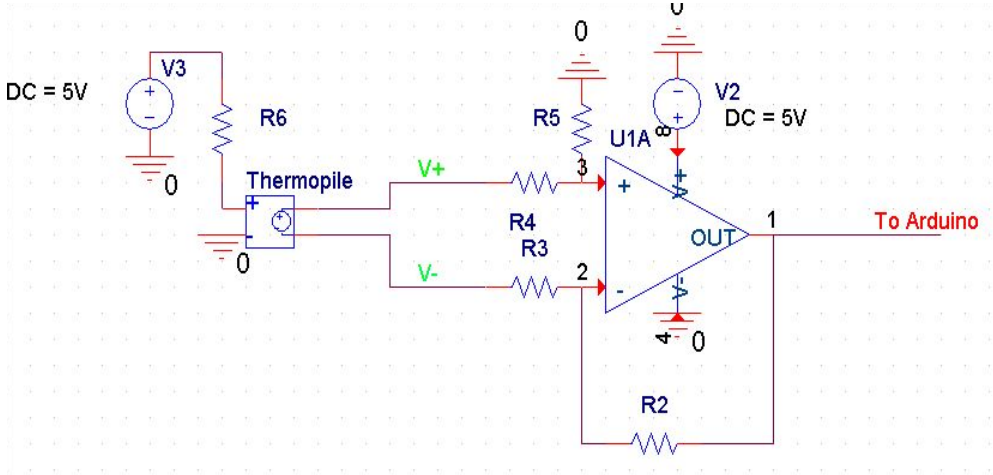
- Typical Operating Range of -20°C to 100°C
- Typical accuracy: ±0.5°C to ±1°C
- Temperature causes a small voltage output
- Emissivity of surface affects the readings
- Ambient temperature: RTD

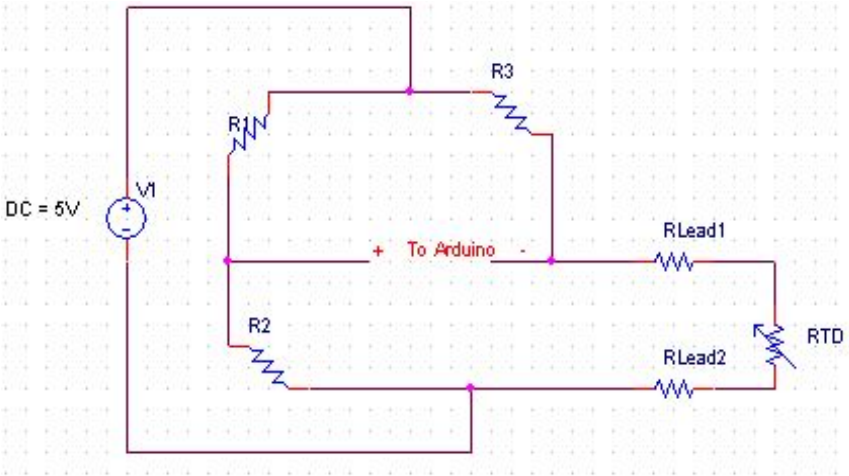
Figure 6:Amphenol Advanced Sensors ZTP-135SR-Thermopile Sensor

Comparison

	RTD	IR (Thermopile)
Benefits	Minimal external circuits, Highly accurate	Non-contact measurement
Drawbacks	Contact or close proximity to object required	Reflective surfaces, cold junction, and ambient temperature must be known

Prototyping





$$V_{Out} = \frac{R2}{R3} * ((V^+) - (V^-))$$

$$V_{OutRTD} = V_3 * (\frac{R_{RTD}}{R_{RTD} + R_6})$$

$$Vout = V_1 * (\left(\frac{R_x}{R_x + R_3}\right) - \left(\frac{R_2}{R_2 + R_1}\right))$$

$$R_x = R_{RTD} + 2R_{Lead}$$

Summary

- Optimal options are IR and RTD
- Small temperature sensing system
  - Two or more sensors
  - 1 inch x 1 inch component density
  - Temperature range: -20°C to 80°C
  - Minimum Accuracy: ±1°C
  - Onboard Microcontroller for data interpretation

Next Step

- Prototyping
  - Establish microcontroller information / Code for testing
    - C Code
    - UART based testing
  - Circuit Design
  - Testing with commercially available components

Future Steps

- Deciding Sensor
- Components
- PCB Design
- Development/Troubleshooting

Questions?

Works Cited

- “Figure 1”, http://logonoid.com/images/hubbell-logo.png , Accessed: 23, October 2017
- “Figure 2”, http://www.sensortips.com/temperature/designing-with-rtd-temperature-sensors/, Accessed: 22, October 2017
- Karaki, Habib. “Figure 2”, 27 February 2014, http://www.sensorsmag.com/components/demystifying-thermopile-ir-temp-sensors , Accessed: 23 October 2017
- “Figure 6”, https://www.digikey.com/product-detail/en/amphenol-advanced-sensors/ZTP-135SR/235-1330-ND/3974095 Accessed: 23 October 2017