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

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Outline

- Background
- Project Statement
- Specifications
- Research
- Design Options
- Testing
- Timeline
- Future Steps

Hubbell

- Founded in 1888 by Harvey Hubbell and incorporated in 1905 in CT
- Patented the pull chain light socket in 1896
- Patented the first US power plug and socket in 1904
- Ranked in the top 25 public Connecticut companies by size
- Still headquartered in Shelton, CT

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

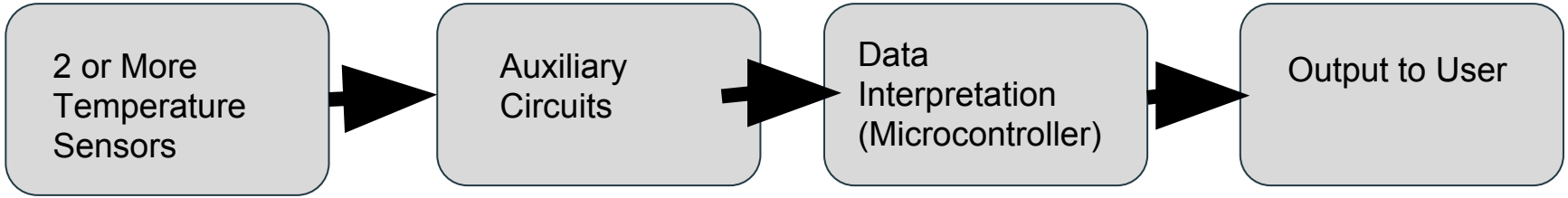
Project Statement

- The Task:
  - Research existing temperature sensing technologies
    - Accuracy
    - Temperature Range
    - Method
    - Problems
  - Look to utilize existing technology in miniaturization/optimization

Specifications/ Constraints

- 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
  - Final design cost $6-8

Setup


2 or More Temperature Sensors
Auxiliary Circuits
Data Interpretation (Microcontroller)
Output to User

Research

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

Possible Solutions

Based on our research, the two optimal technologies are:

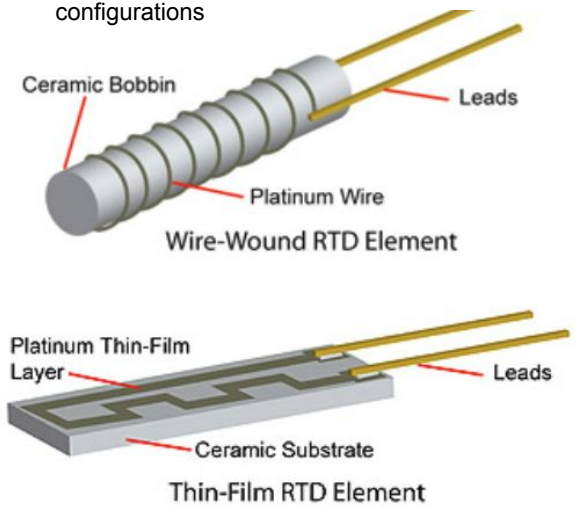
- Resistance temperature detectors (RTDs)
- Infrared devices (IR)

RTD

- Correlates resistance value to temperature value
- Close proximity/contact
- Typical Operating Range of -60℃ to over 600℃
- High Accuracy **(many are below (+/- 1℃)**
- Common composition materials:

  Copper, Nickel, and Platinum
- Two Basic Styles: Wire-wound and Thin Film

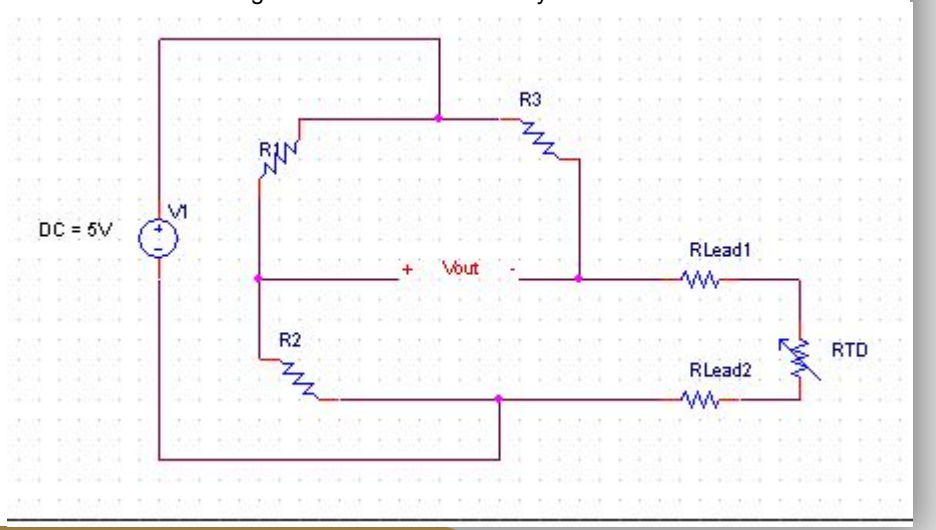
Figure 2: Wire-wound and thin-film RTD configurations



RTD

- Three types of RTD configurations: 2-wire, 3-wire, and 4-wire
- Requires minimal supplemental circuits
- **Provides repeatability, stability, and are extremely accurate temperature sensors**

Figure 3: 2-wire RTD auxiliary circuit



Infrared

- Long wave infrared: 8 micrometers to 15 micrometers
- **Non-Contact**
- Possible Components: IR Thermopile
  - Seebeck Effect
  - Produces small voltage based off temperature difference
  - Requires: output voltage amplification and ambient temperature

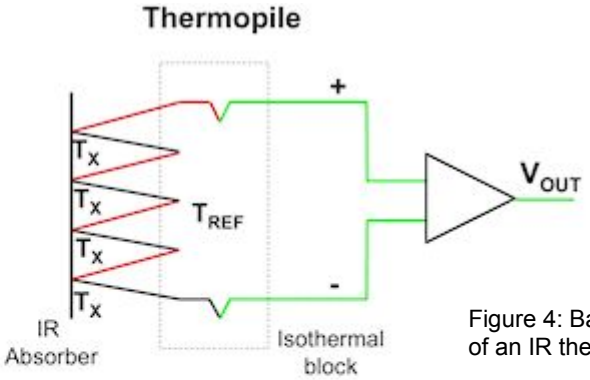


Figure 4: Basic design of an IR thermopile

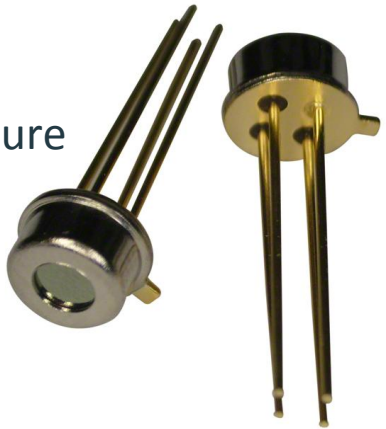
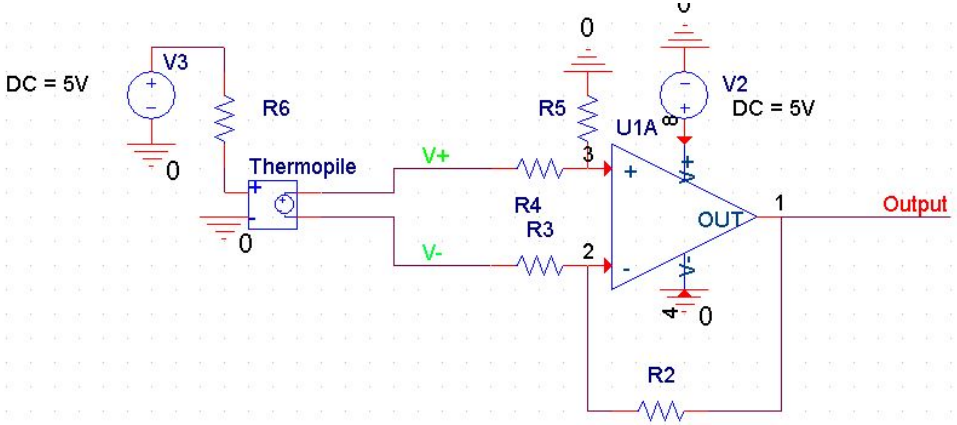


Figure 5:Amphenol Advanced Sensors ZTP-135SR-Thermopile Sensor

Infrared

- IR 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
  - **Accurate, fast, and non-contact method of measurement**

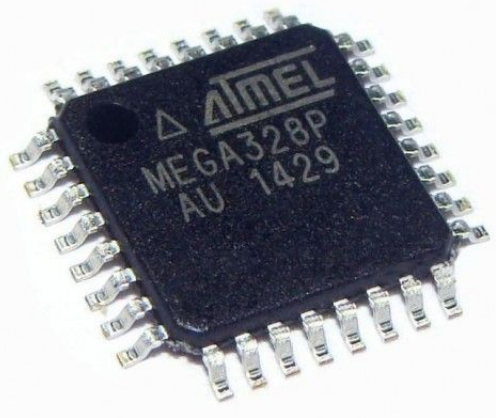
Figure 6: IR thermopile test circuit



Microcontroller

- Requires multiple inputs from sensor array
- Small Size
- Atmega328P
  - **23** General purpose I/O connections
  - Offered on a development board (Testing)
  - Offered as a **standalone chip**
  - Operates within temperature sensing range
  - Onboard ADC
  - Includes Interrupt functions

Figure 7: Atmel Atmega328p surface mount package



Microcontroller

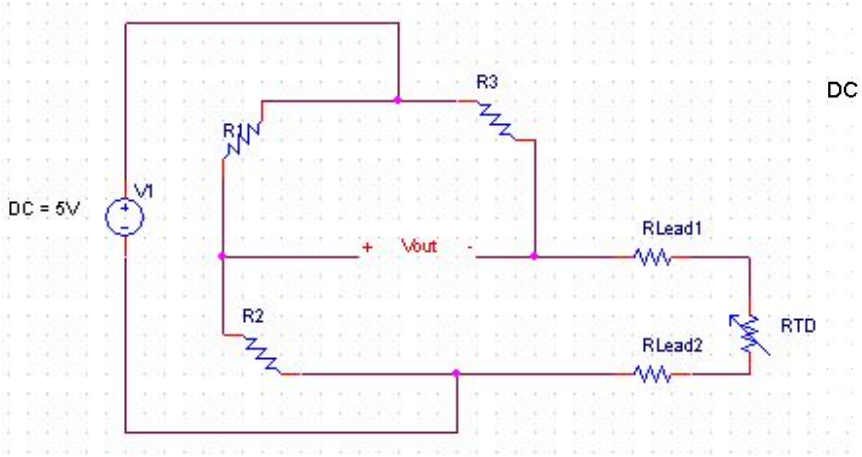
- Atmel Studio
  - Test program written in C
  - UART interface
  - Displays as much data as possible
    - Raw input
    - Converted temperatures
    - Temperature range exceeded notifications
  - Multiple sensors handled at once

Figure 8: IDE used for producing the test code

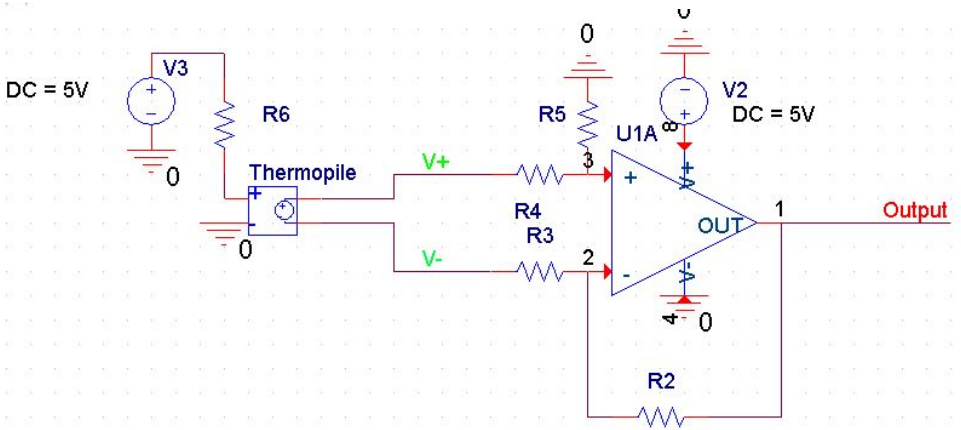
Testing

- Build auxiliary circuits on a breadboard
  - Compare components in the IR and RTD ranges
  - Different package sizes and manufacturers
  - Compare IR and RTD circuits at the same time
  - Utilize UART connection for output temperature
- Compare the temperature measurements of different materials
  - Copper, Brass, Aluminum
  - Range of temperatures from -20°C to 80°C and temperatures outside the range
- Look at adjustment to be made for improvement

Testing Circuits

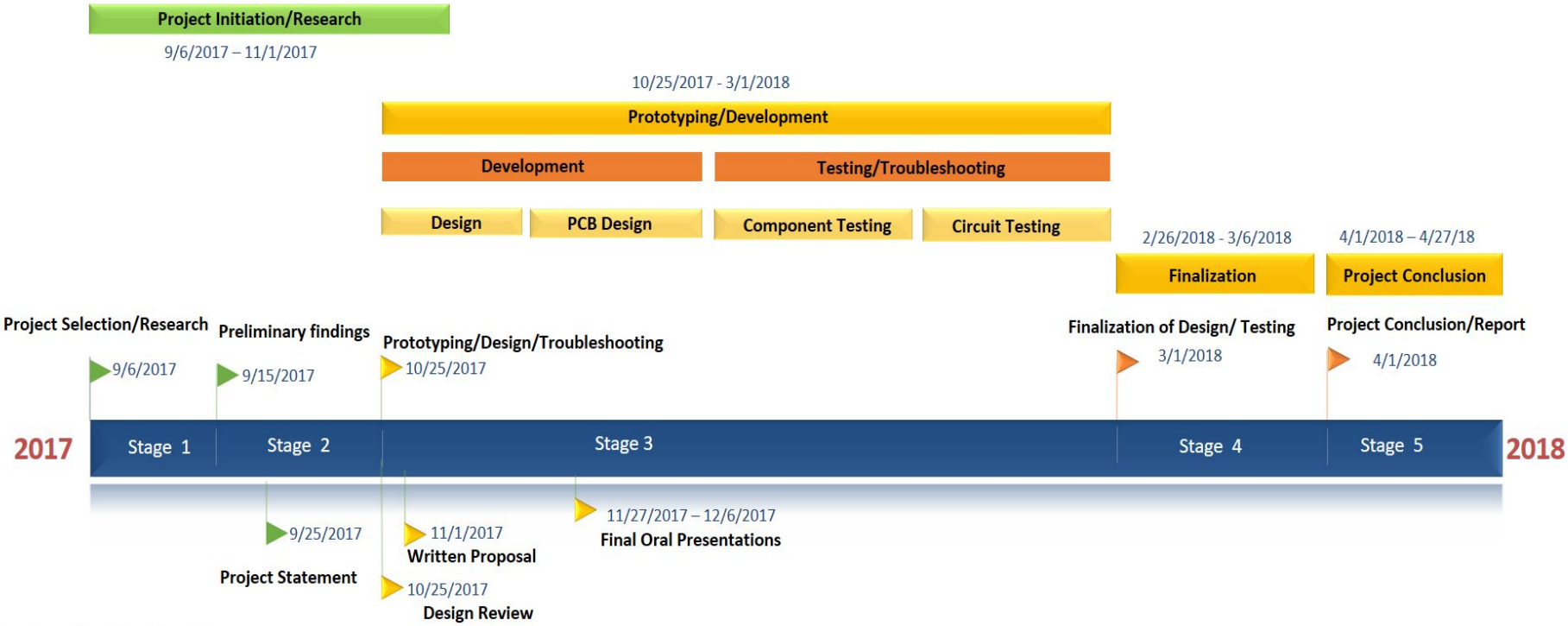


RTD



IR

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

Next Steps

- Continued testing
- PCB design
- What can be improved?
  - Sensors
  - Auxiliary components
  - Size

Questions?

Works cited

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- “Figure 8” http://www.atmel.com/webdoc/atmelstudio/ Accessed: 22 November 2017