UMassAmherst

Midway Design Review

Solar Winds - Team 6

December 7th, 2018

Faculty Advisor: Stephen Frasier

Meet the Team

Ajey Pandey
EE

Jason Sproviero
EE

Jayme Gordon
EE

Richard Kornitsky
EE

Nicholas McCarthy
EE

Problem Statement

- Cooling draws a significant amount of power
- Cooling is a “peaky” load
  - Daily, cooling peaks around 3-4PM
  - Annually, cooling peaks in late summer
- Solar power makes peaky loads even peakier
  - Phenomenon known as the “duck curve”
- Grid-scale battery storage is in research phase
- Industry focus has been storing electrical (solar) power as electrical energy

Our Solution: Solar Winds

Store electrical power as thermal energy during non-peak load times

- Develop contained cooling system
- Store thermal energy in liquid solution
- Deliver cooling with stored energy

"Country Fair" Use Case

- Temperature is ~ 80° F
- User has a van or light-duty pickup truck
- Cooling system distributes air
- Noticeably cool small volume by ~ 3.5° F

Design Alternatives

- Compressor
  - Cons: Moving parts, Thermodynamics
  - Our design: Peltier cooler
- Ice Maker
  - Cons: Power demand, insulator
  - Our design: Brine
- Cold sink
  - This design: Attach heat sink to cold side of TEC and insert into tank
  - Cons: Difficulty interfacing, leakage, mounting, heat transfer
  - Our design: Water cooling block

Previous Specifications

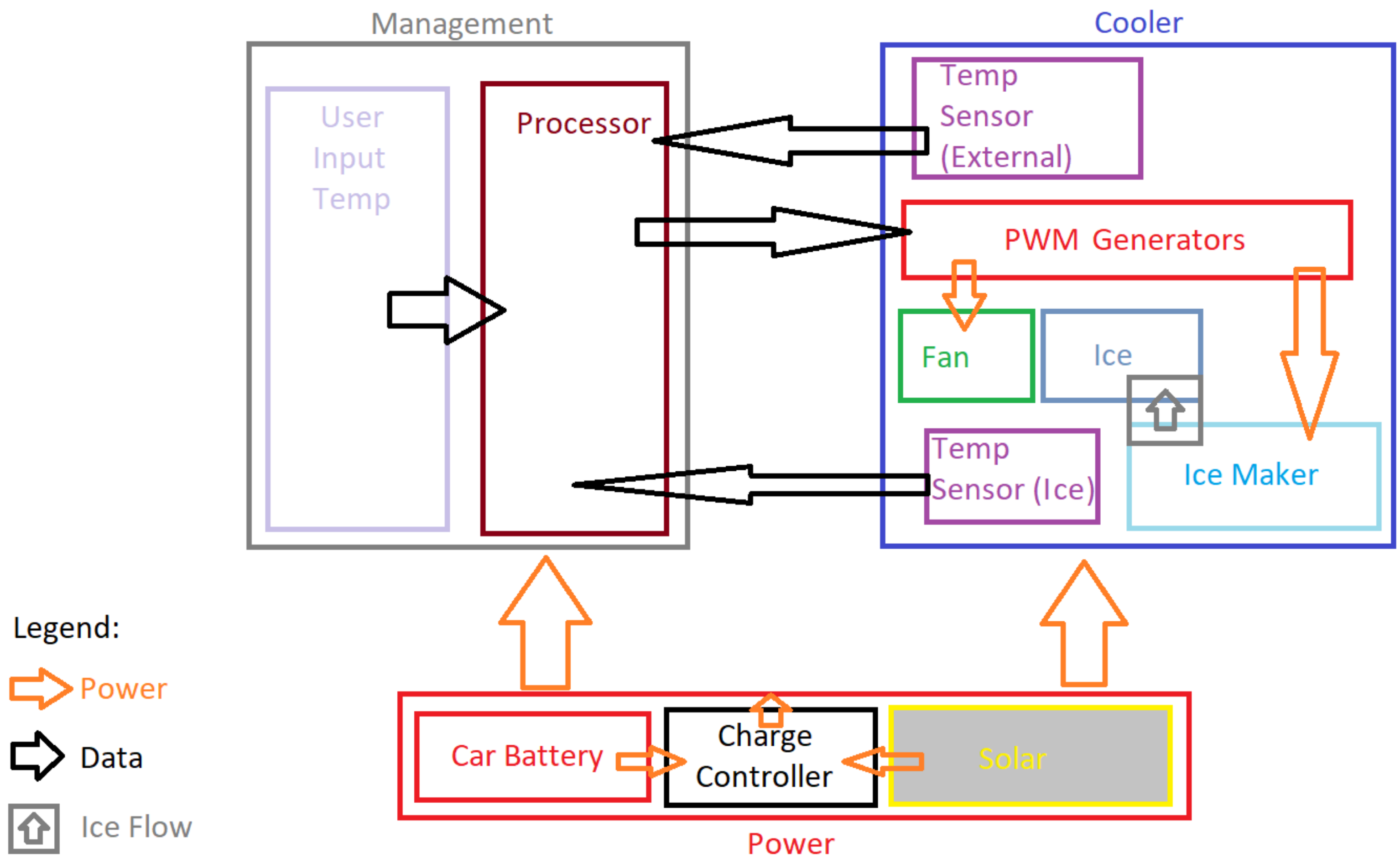
1. Store 3000 BTU of energy as ice or liquid cooling solution
2. Cool a 1 ft x 2 ft x 5 ft area by 3.5ºF for 1.5 hours
3. Store energy using photovoltaic input, with a DC power source as a backup
4. Fit a form factor such that two people can carry it into a van or light-duty pickup truck
5. Be constructed such that it can be disassembled with basic tools, like Phillips-Head screwdrivers or standard-size wrenches

Revised Specifications

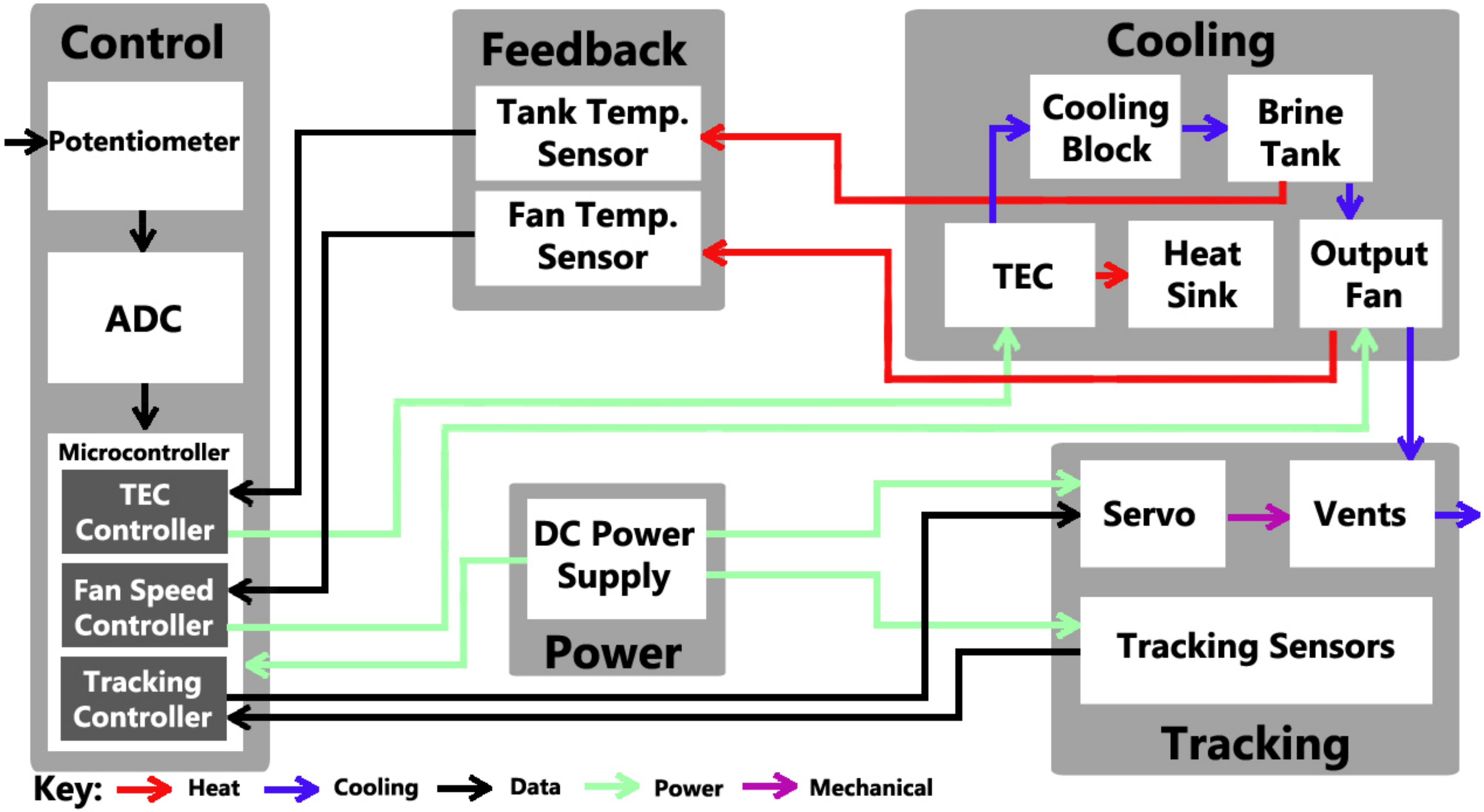
- Energy storage scaled down by a factor of 5 to demonstrate critical functionality
- Previous BTU specification was calculated without thermodynamics knowledge

1. Cool 2 cubic foot area by 3.5º F for 1.5 hours
2. Store electrical power as thermal energy during non-peak load times
3. Fit a form factor such that two people can carry it into a van or light-duty pickup truck

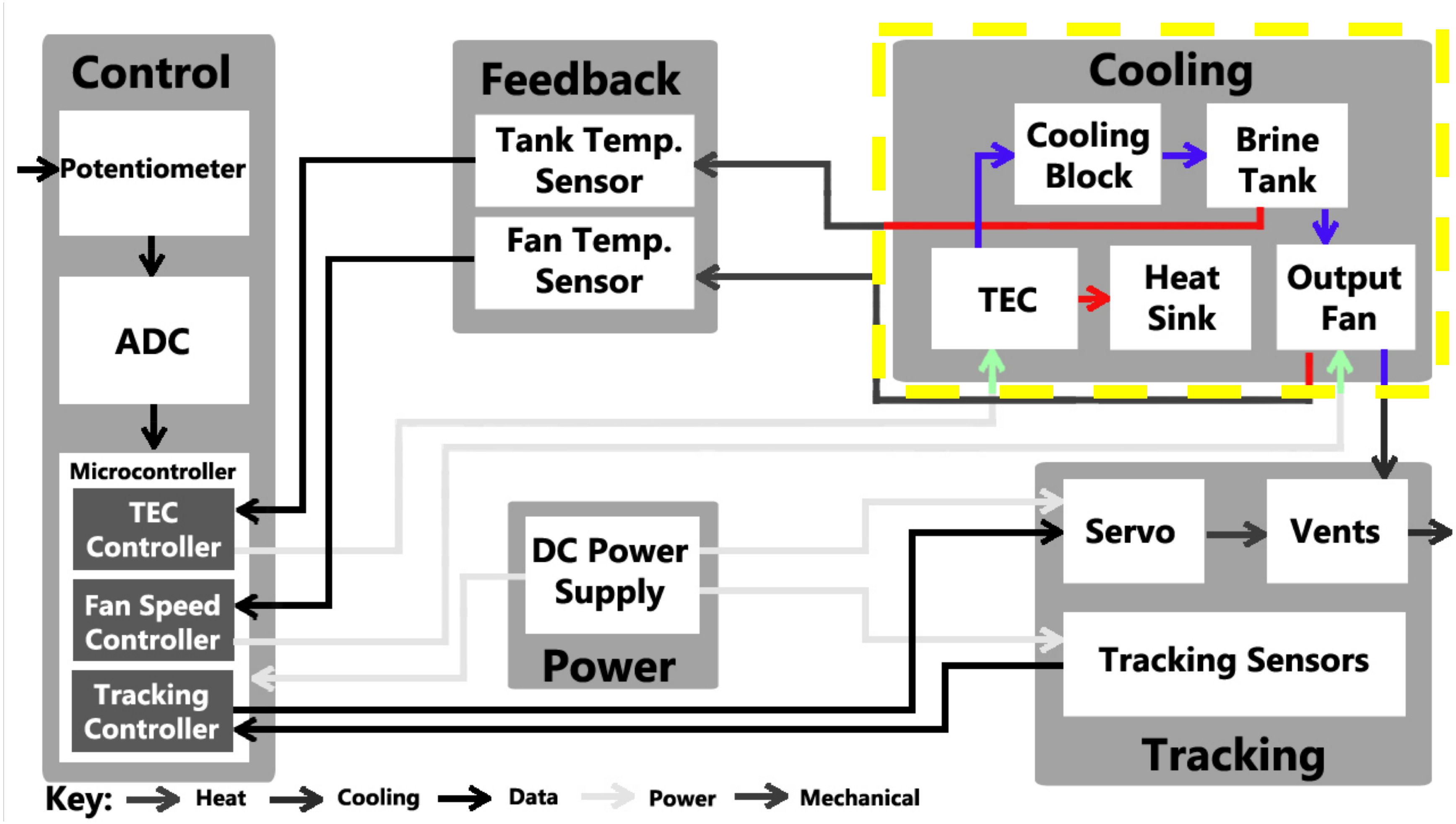
Previous Block Diagram



Redesigned Block Diagram



Redesigned Block Diagram



Changes in Implementation

Our solution: Store electrical power as thermal energy during non-peak load times

- Replace ice with brine

    Brine demonstrates energy storage

- Scale down thermal energy storage

    Demonstrating functionality of solution does not rely on storage quantity

- Change source of electrical power

    Functionality of solution does not rely on power source

Plans To Implement Each Block

Cooling Block

Objective:

Circulate brine through pumping system to cooling block

Parts:

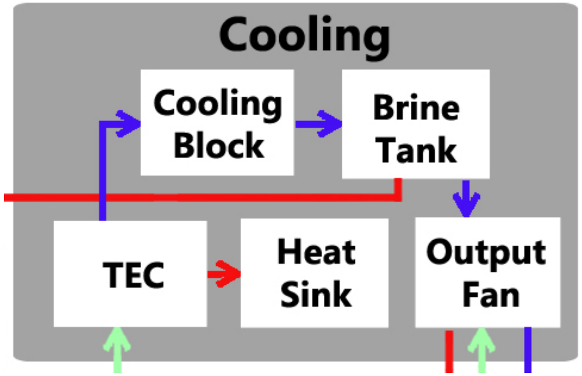
Thermoelectric Cooler: Laird HiTemp 387001828 (ET series)

Chosen operating conditions: 24V, 192W

Maximum operating conditions: 46V, 300W

Cooling block: DIYhz Aluminum Radiator (40mm x 40mm x12mm)

Liquid Cooler Heat Sink: CORSAIR Hydro Series H60 120mm



Control Block

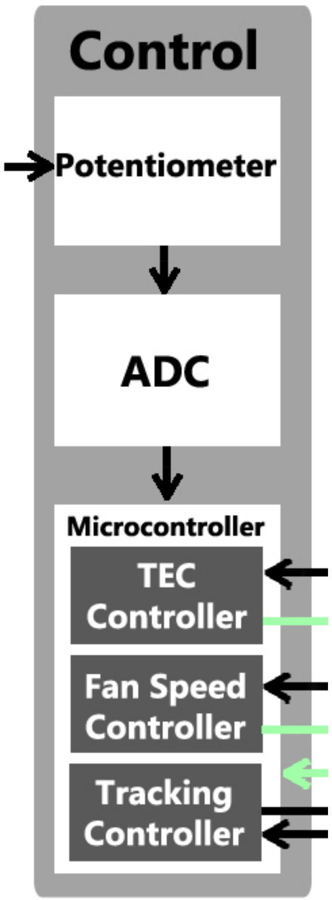
Objective:

User control of cooling

Parts:

User Input: Control circuitry

Microcontroller: ATmega328



Feedback Block

Objective:

Report data from cooling system to microcontroller

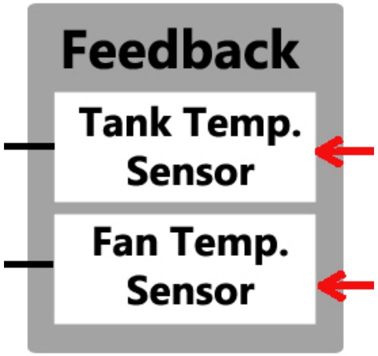
Parts:

Tank temperature sensor: DS12B20 integrated circuit

Selection criteria: Waterproof

Fan temperature sensor: LM35 integrated circuit

Selection criteria: Readily available



Tracking Block

Objective:

Develop array of sensors to

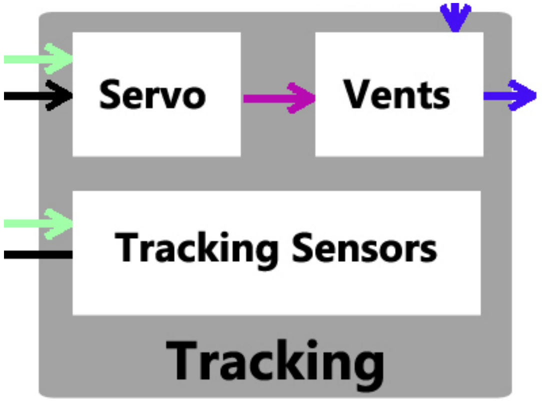
track user

Parts:

Servomotor: Direct vents towards user

Interrupt: Allow user to manually interrupt

Sensors: Detect user motion



Power Block

Objective:

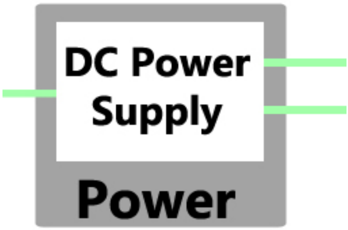
Provide power to each block

Parts:

Power Supply:

Chosen operating condition: 24V

Maximum operating conditions: 200V,16.5A, 3300W



MDR Deliverables (Previously Proposed)

1. Store 3000 BTU of energy as ice or liquid cooling solution. This will be measured by measuring temperature of ice/cooling solution of a known specific heat, then calculating energy from the temperature differential.
2. Cool a 1 ft x 2 ft x 5 ft area by 3.5ºF for 1.5 hours. This will be measured with a thermometer outside the cooler. We project this will require 2000 BTU/hour to achieve.
3. Fit a form factor such that two people can carry it into a van or light-duty pickup truck.
4. Provide a paper design on sensors to enable directionality and prediction.

MDR Deliverables (Updated)

- Energy storage scaled down by a factor of 5 to demonstrate critical functionality
- Previous BTU specification was calculated without thermodynamics knowledge

1. Cool 2 cubic foot area by 3.5º F for 1.5 hours
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MDR Deliverables (Updated)

- Energy storage scaled down by a factor of 5 to demonstrate critical functionality
- Previous BTU specification was calculated without thermodynamics knowledge

1. ✔ Cool 2 cubic foot area by 3.5º F for 1.5 hours
2. ✔ Fit a form factor such that two people can carry it into a van or light-duty pickup truck
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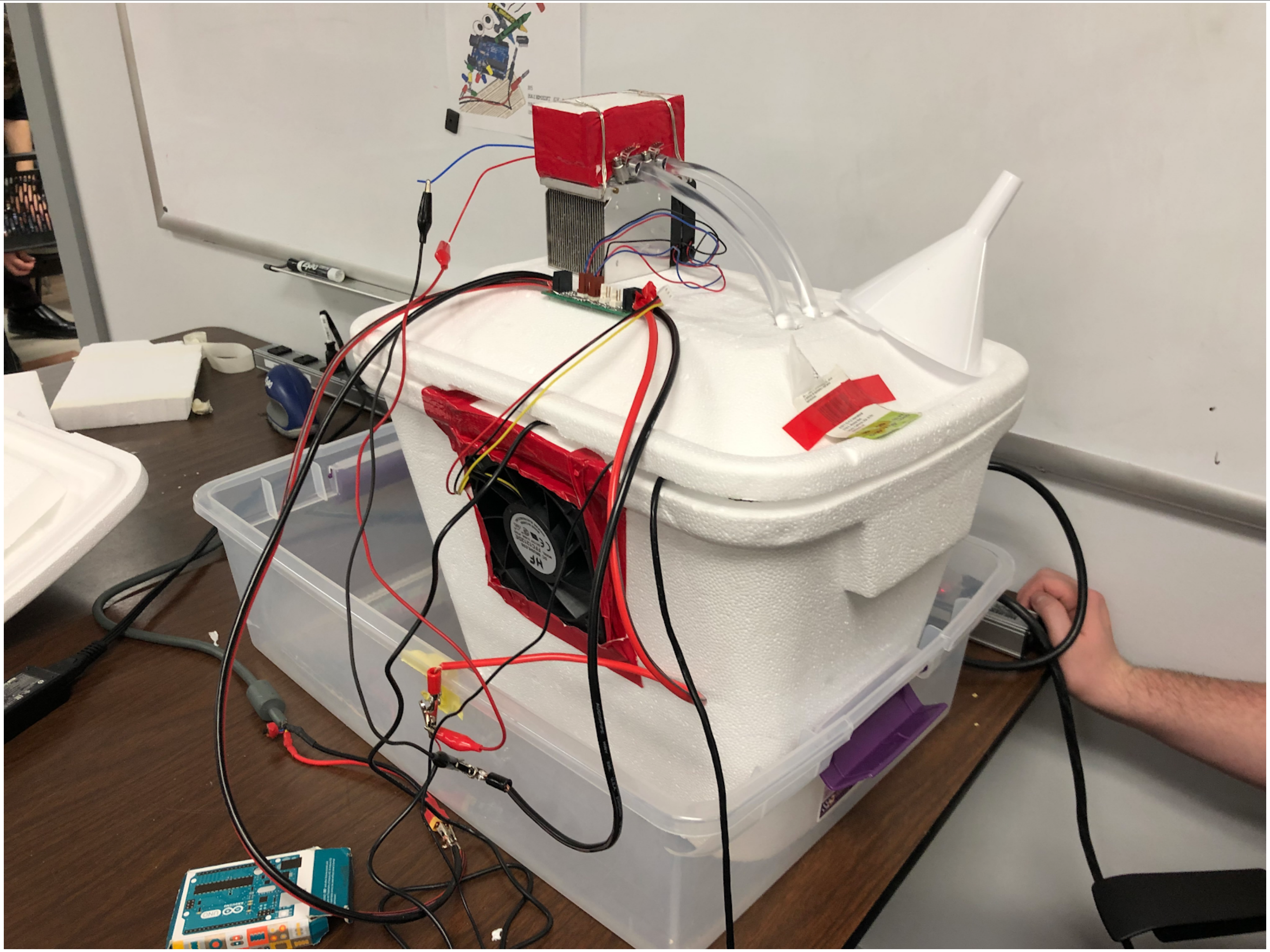
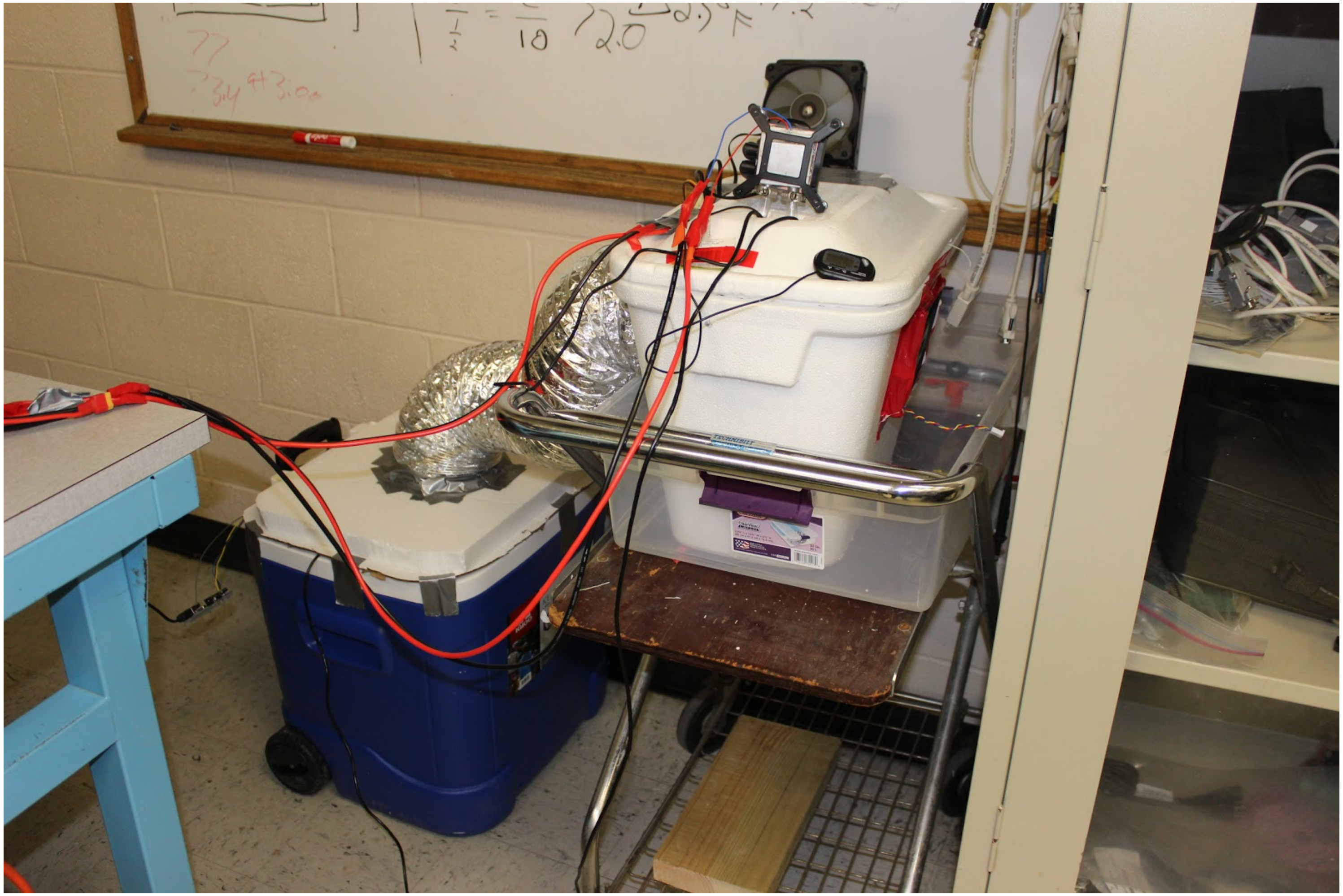
Demo of MDR Deliverables

Prototype MK-I



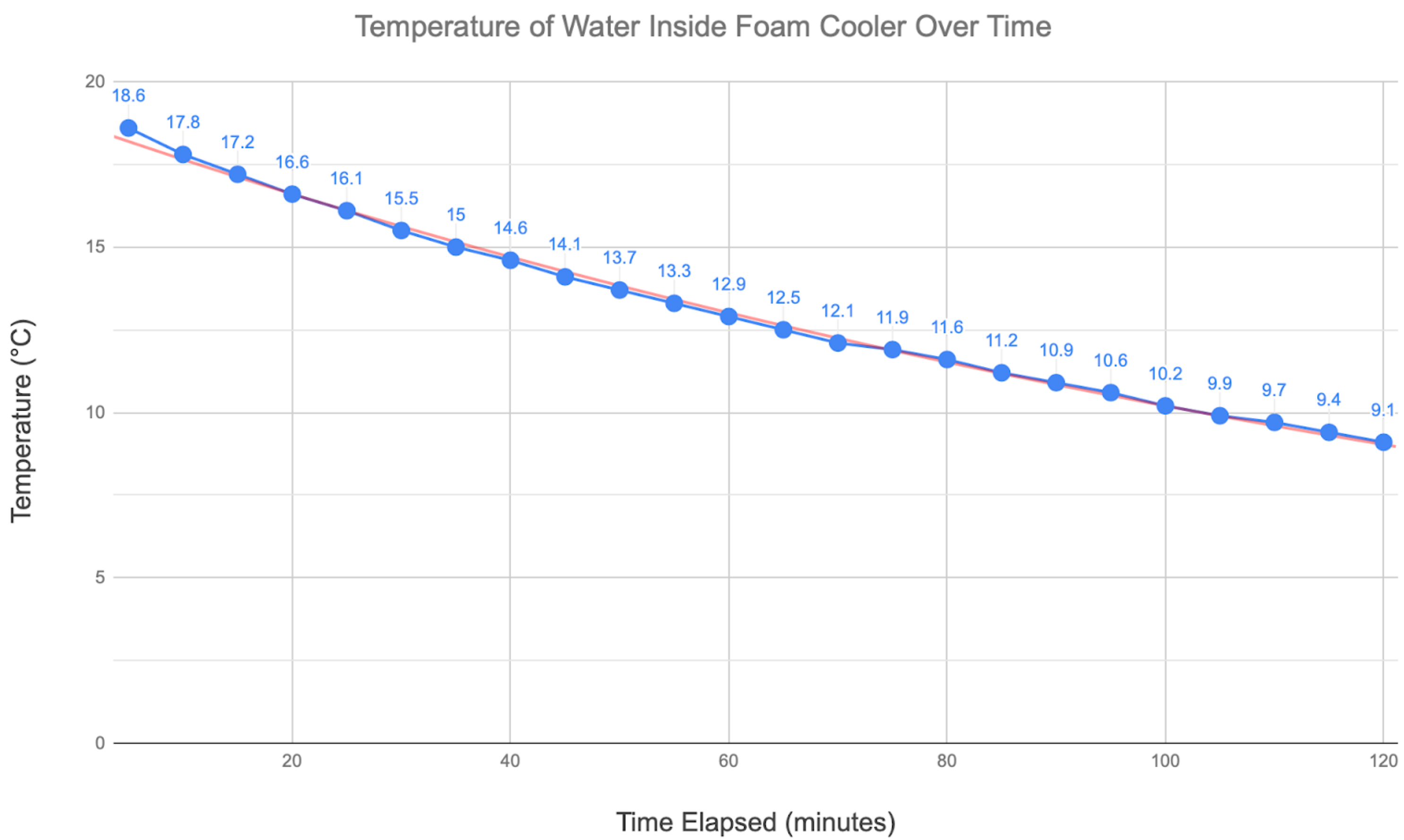
Prototype MK-II



Prototype MK-II

Testing Water Cooling

Parameters: 24 Volts to TEC, Output Fan off, 1 gallon water, 60 grams salt

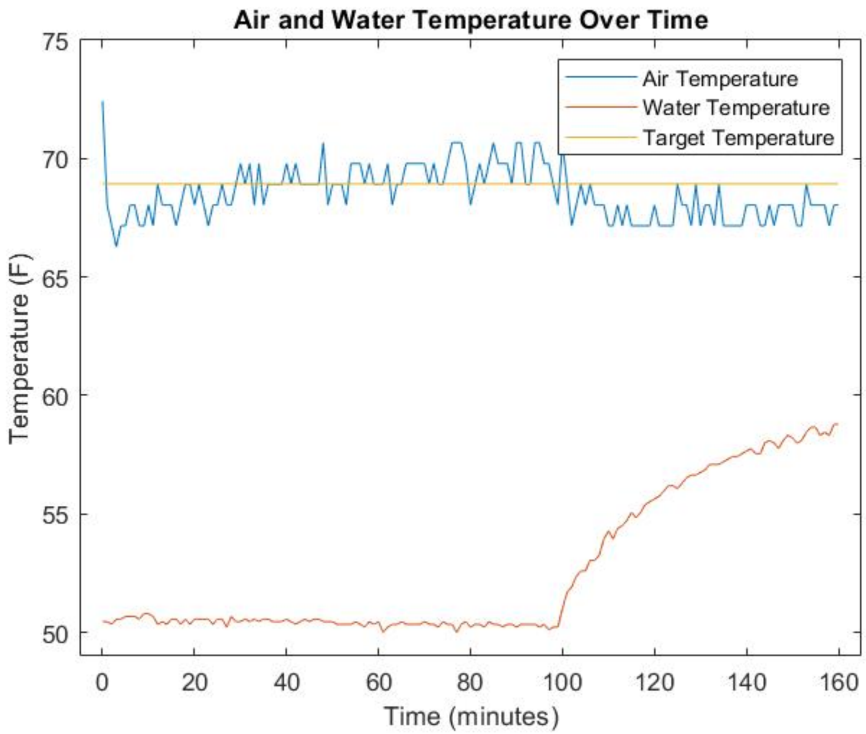


Testing Air Cooling

Parameters: 24 Volts to TEC, Output Fan on, 1 gallon water, 60 grams salt

Initial/Ambient Temperature: 72.4° F, Target Output Temperature: 68.9° F,

Average Output Temperature: 68.5° F



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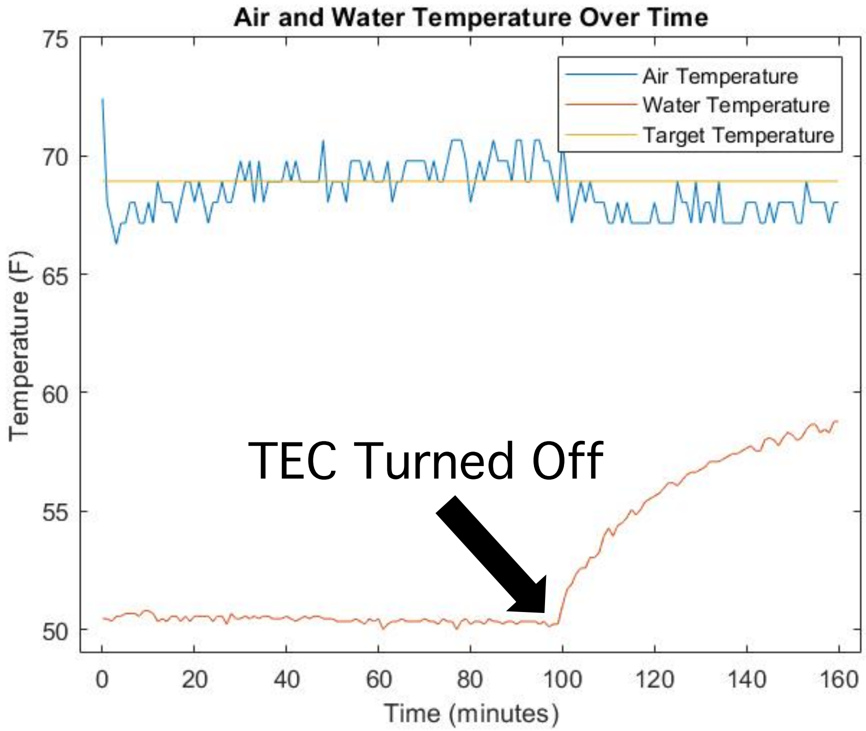
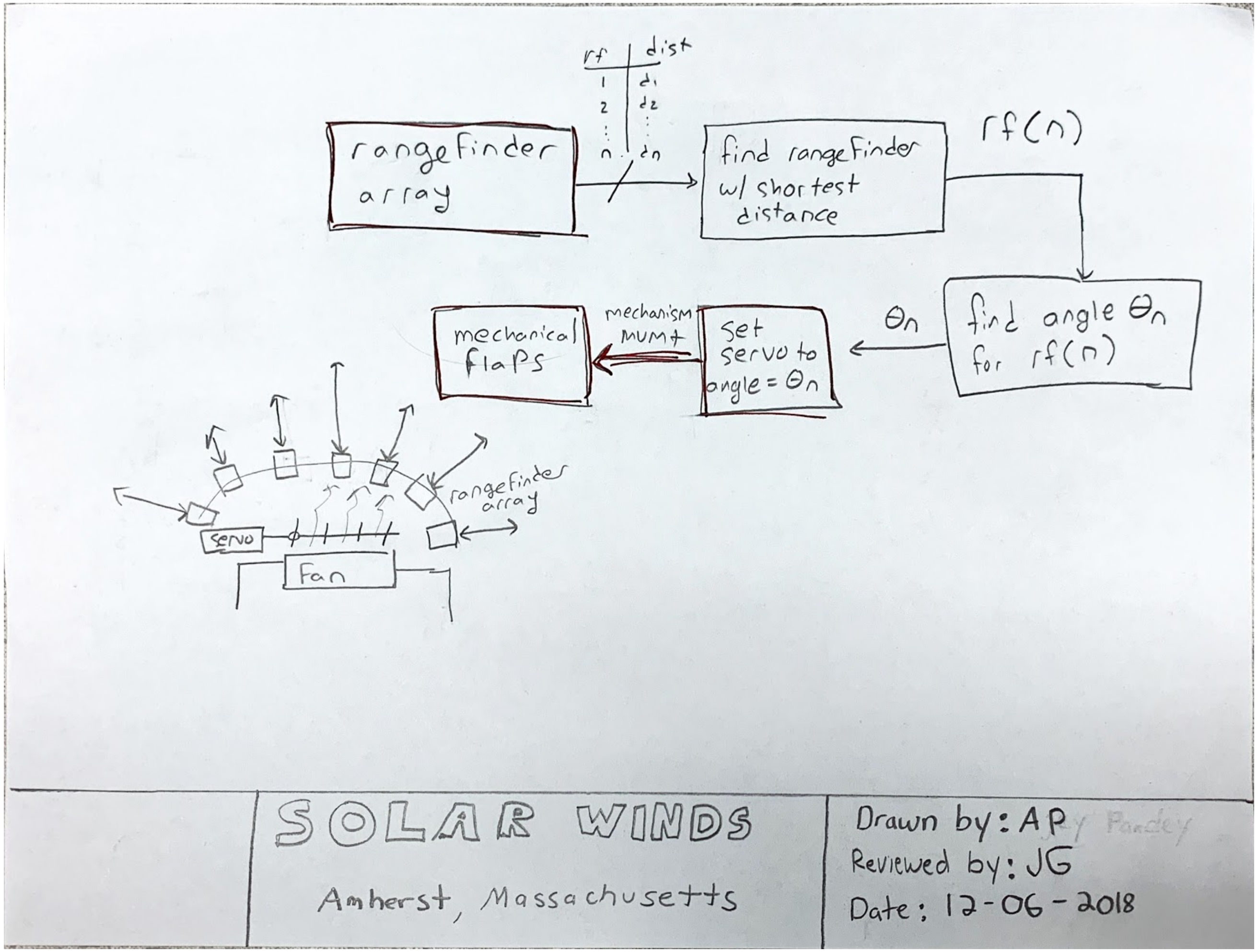


Paper Design on Sensors

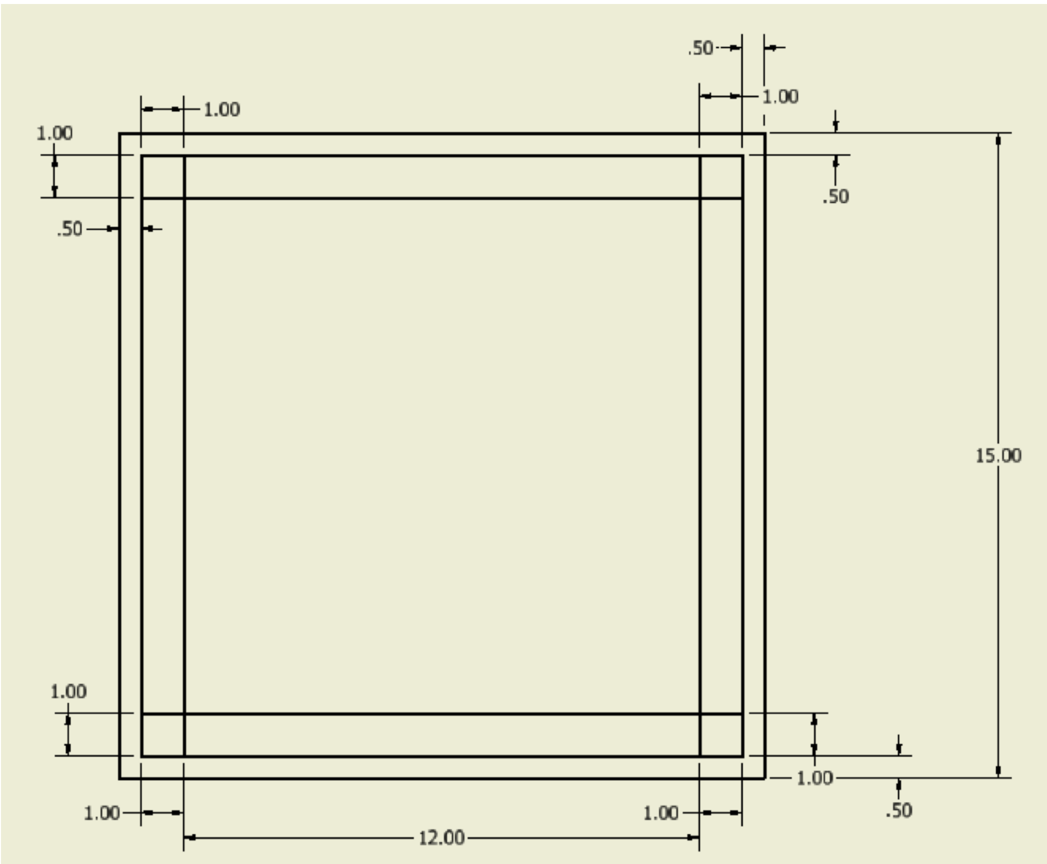


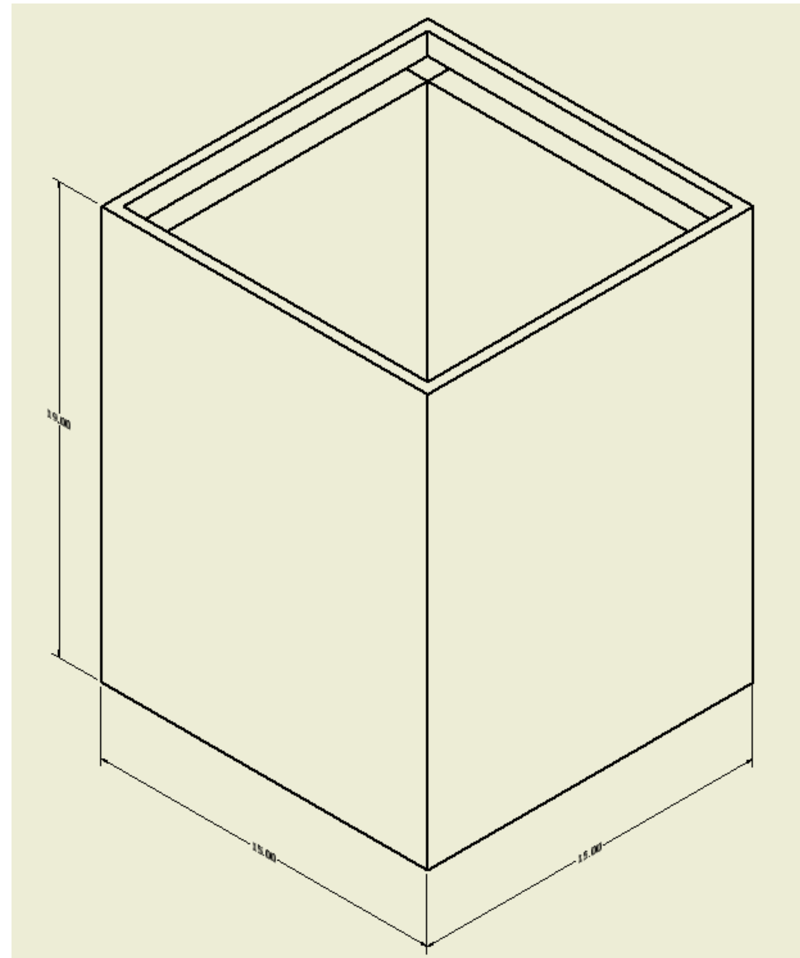
Proposed CDR Deliverables

- Demonstration of Complete System Functionality
  - Build custom cooler box - Jayme & Richard
  - Data collection tool - Jayme & Nick
  - Feedback loop & temperature control - Nick & Ajey
  - Printed circuit board (PCB) - Jason
  - Sensors for directionality & prediction - Ajey & Richard

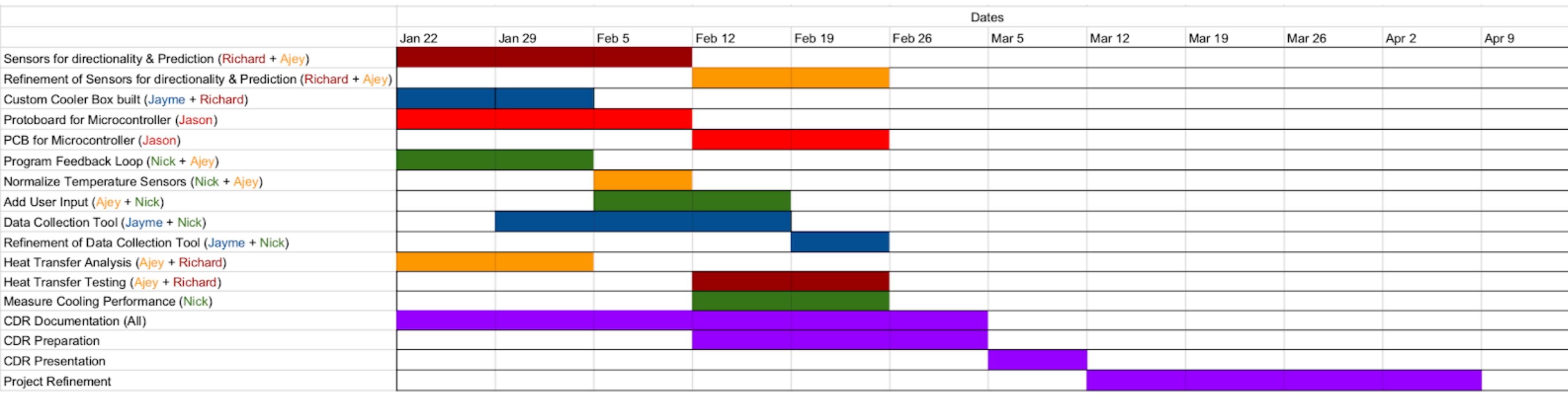
Leaking Foam Cooler

Solution: Custom Built Cooler





Gantt Chart


Dates
Jan 22
Jan 29
Feb 5
Feb 12
Feb 19
Feb 26
Mar 5
Mar 12
Mar 19
Mar 26
Apr 2
Apr 9
Sensors for directionality & Prediction (Richard + Ajey)
Refinement of Sensors for directionality & Prediction (Richard + Ajey)
Custom Cooler Box built (Jayme + Richard)
Protoboard for Microcontroller (Jason)
PCB for Microcontroller (Jason)
Program Feedback Loop (Nick + Ajey)
Normalize Temperature Sensors (Nick + Ajey)
Add User Input (Ajey + Nick)
Data Collection Tool (Jayme + Nick)
Refinement of Data Collection Tool (Jayme + Nick)
Heat Transfer Analysis (Ajey + Richard)
Heat Transfer Testing (Ajey + Richard)
Measure Cooling Performance (Nick)
CDR Documentation (All)
CDR Preparation
CDR Presentation
Project Refinement

Individual Responsibilities

Ajey - Sensors for directionality & prediction, program feedback loop, normalize temperature sensors, add user input, heat transfer analysis & testing

Jason - Protoboard & PCB for microcontroller

Jayme - Custom cooler box built, data collection tool

Nick - Program feedback loop, normalize temperature sensors, add user input, data collection tool

Richard - Sensors for directionality & prediction, custom cooler box built, heat transfer analysis & testing

THANK YOU