SOLAR WINDS

SOLID STATE AIR COOLING WITH THERMAL STORAGE

Solar Winds

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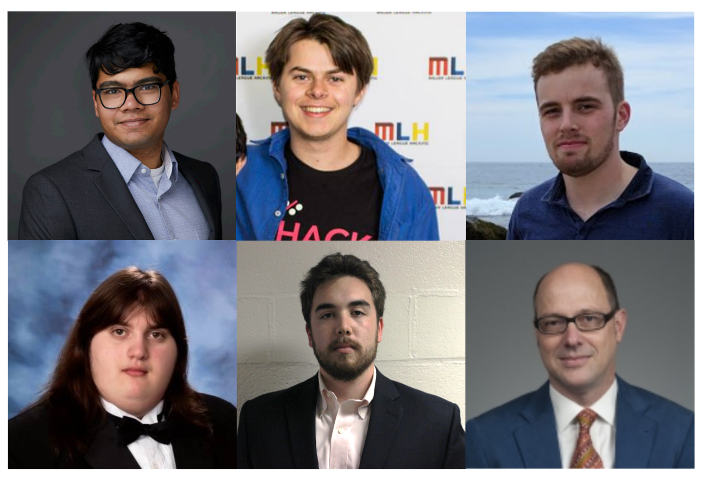
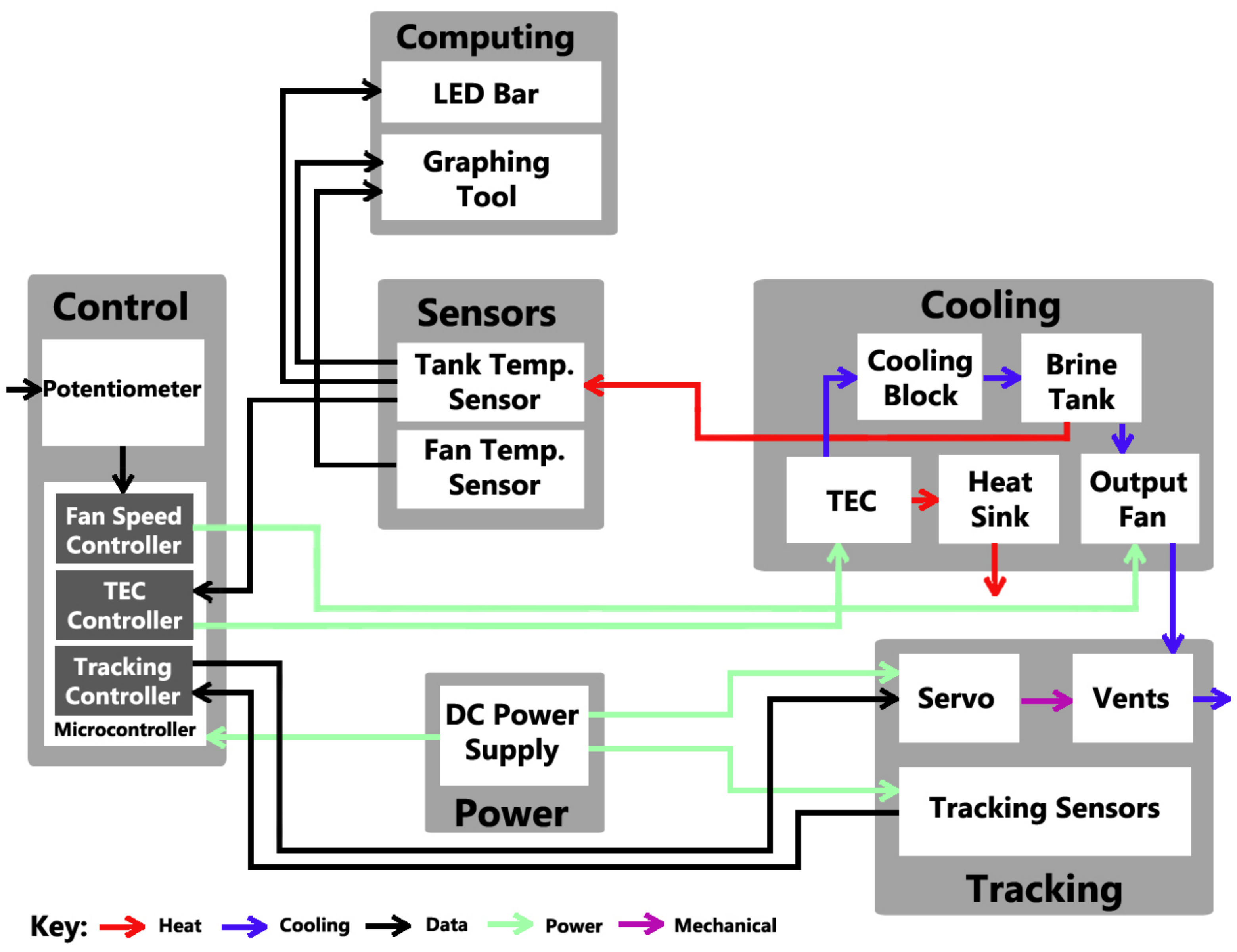


Abstract

THE motivation for this project is to reduce power draw (particularly due to cooling) on an electric grid during peak load times. The problem is storing power from an electric grid as thermal energy during non-peak load times. Our final result is a mobile cooling system that uses stored thermal energy to deliver directional cooling. Our product will have macroscopic impact as scheduled blackouts occur in developing countries. This project is a compelling solution of storing electrical power as thermal energy to deliver cooling.

System Block Diagram



Costs

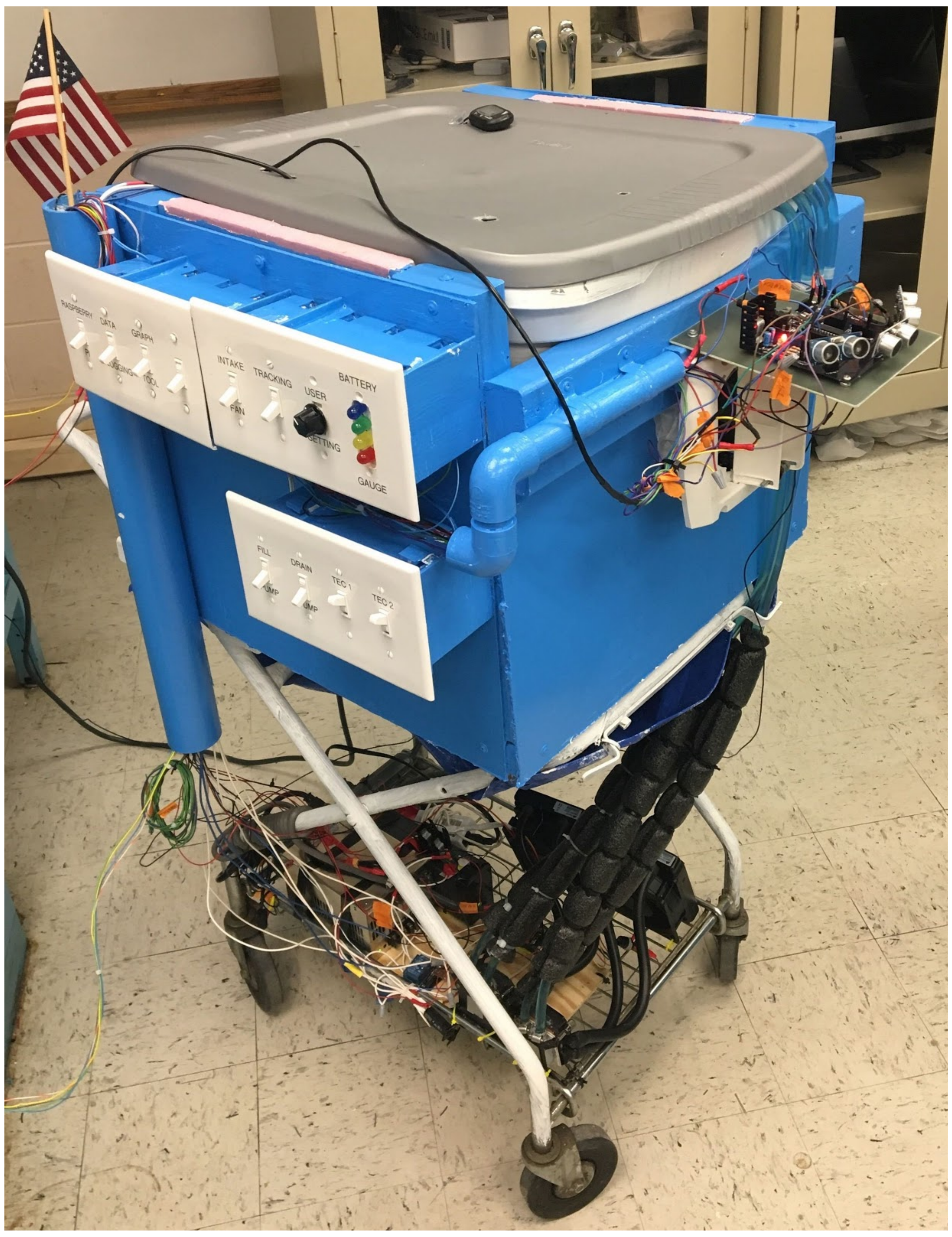
Part	Quantity	Development	Production (1000)
12V DC Power Supply	1	$20	$20
24V DC Power Supply	1	$35	$30
ATmega328	1	$1.96	$1.62
Closed Loop Coolers	2	$75	$75
Enclosure	1	$25	$25
Insulation	11.2 ft.^{2}	$6	$3
Thermocouple	1	$8	$5
PCB	1	$27	$13
PC High Volume Fan	1	$12	$8
Pump	2	$12	$9
Raspberry PI	1	$30	$22
TEC	2	$150	$138
Tubing	15 ft.	$3	$1.50
Total	**-**	**$404**	**$351**

Specifications

Requirement	Specifications	Value
portable	dry weight	< 150 lb
	size	< 20 cuft
cooling	air cooling	3.5° F
responsive	water cooling	< 6 hours

System Overview

- Thermoelectric coolers cool water to store thermal energy
- Fan moves air over water to output cool air
- Sonar sensors provide directionality to servo motor to provide directional cooling
- Sensors collect system data such as air and water temperatures
- Power source agnostic to allow integration of charge controllers
- Charge controller can be easily integrated to system to allow solar power

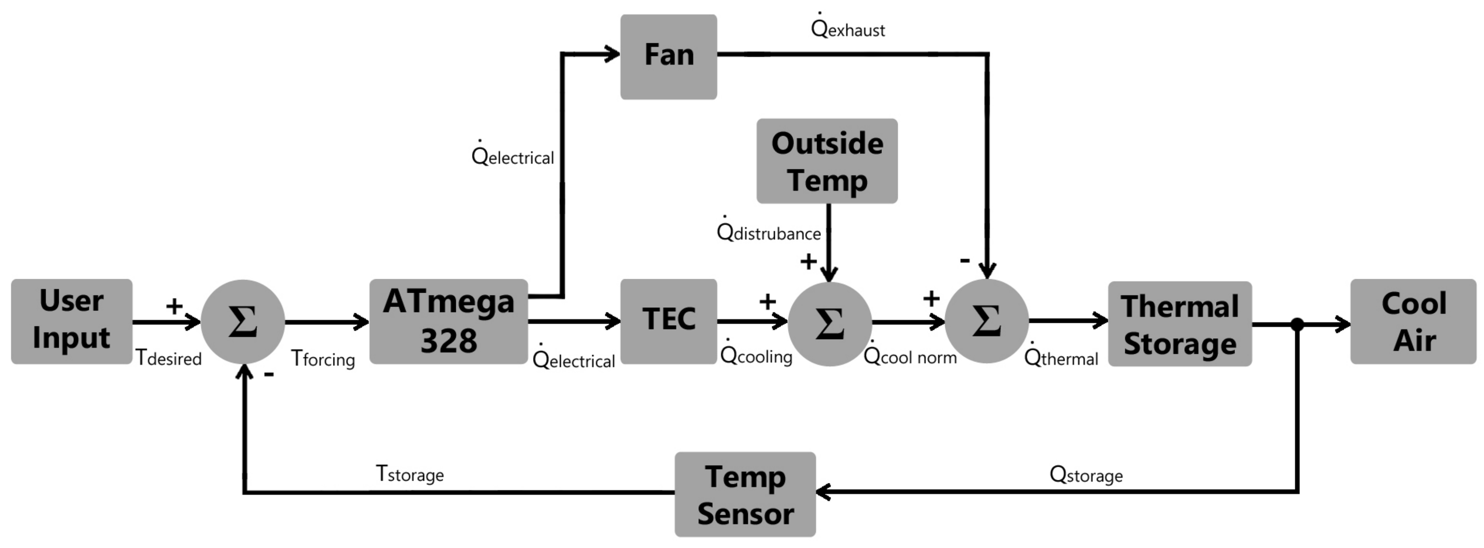


- Able to store ~150 BTU in 3 hours, using 5 gallons of tap water
- Budget constraints prevented PV integration, but power input (24V DC) matches PV standard

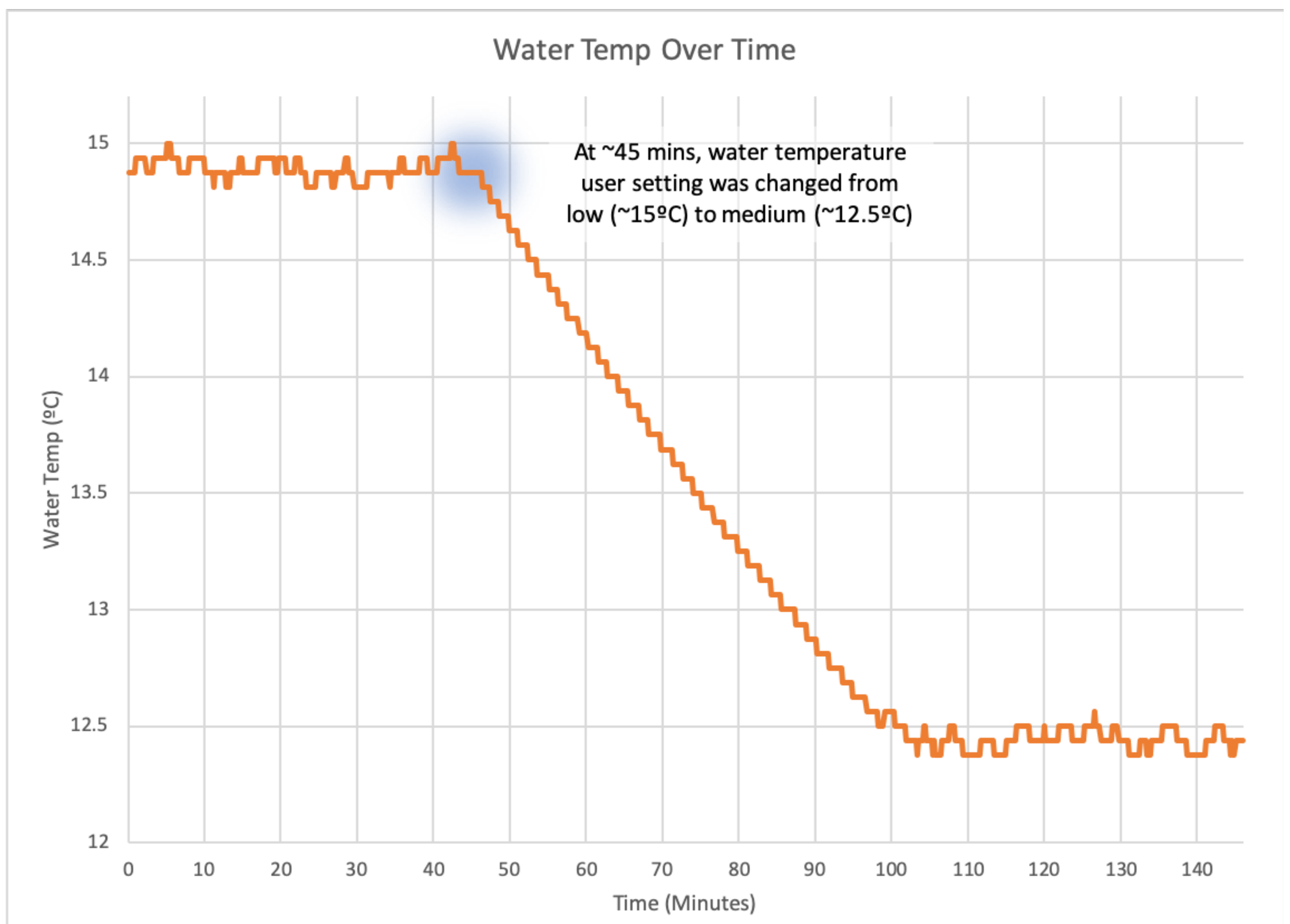
Acknowledgement

Our team thanks our advisor, Stephen Frasier, for his insight, guidance, inspiration and candid feedback. Our team appreciates Francis Caron for his support of our team. We thank Jay Taneja for being both our evaluator and educator in energy systems. We conclude our acknowledgements by thanking Christopher Hollot for being both our evaluator and Interim Dean.

Feedback Control



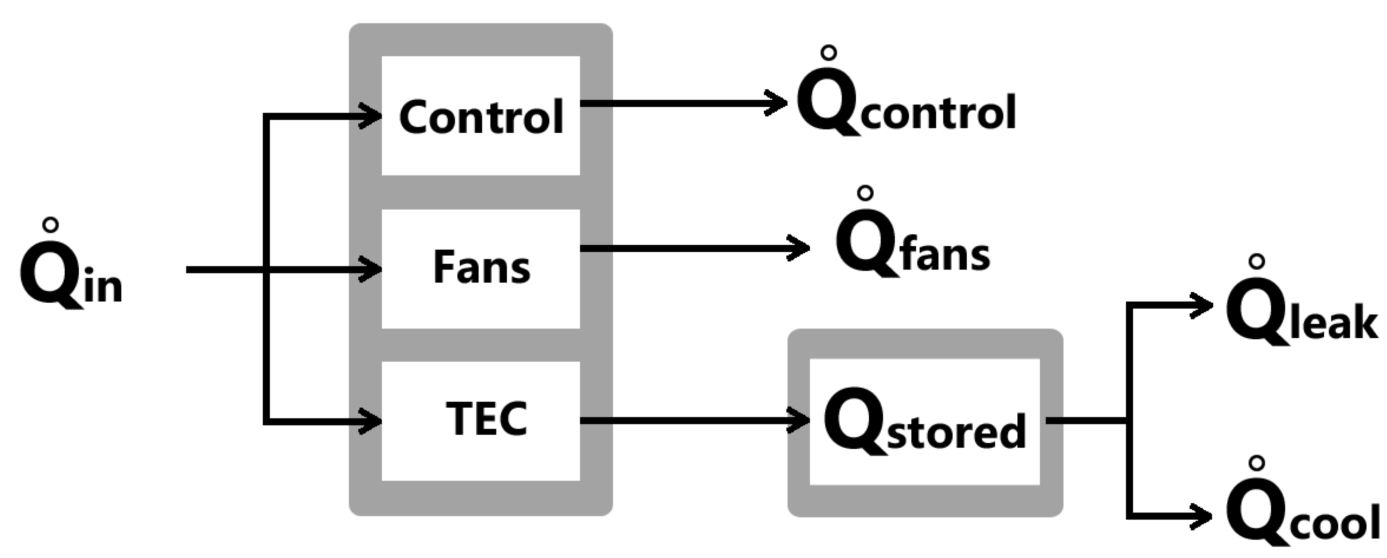
- Feedback controller reads water temperature data, compares to user-specified input temperature
- Power-switching relay controls TEC
- User input temperature controlled by potentiometer



Tracking

- Three ultrasonic sensors track users in front of cooling vent
- PCB tracks sensor user is closest to
- Servo motor moves vents toward user
- PCB controller uses running median tool to filter out noise from sensor

Efficiency Analysis

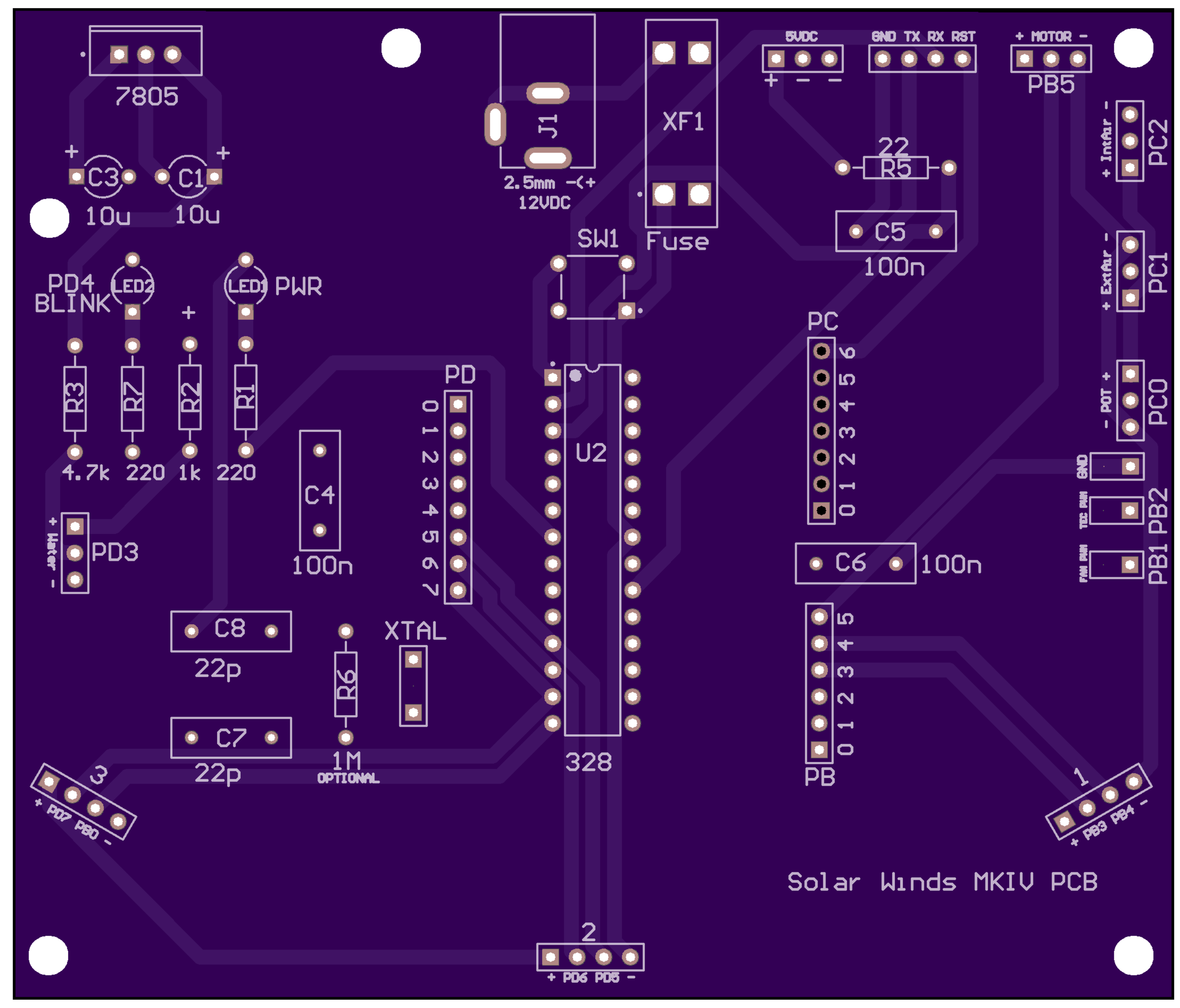


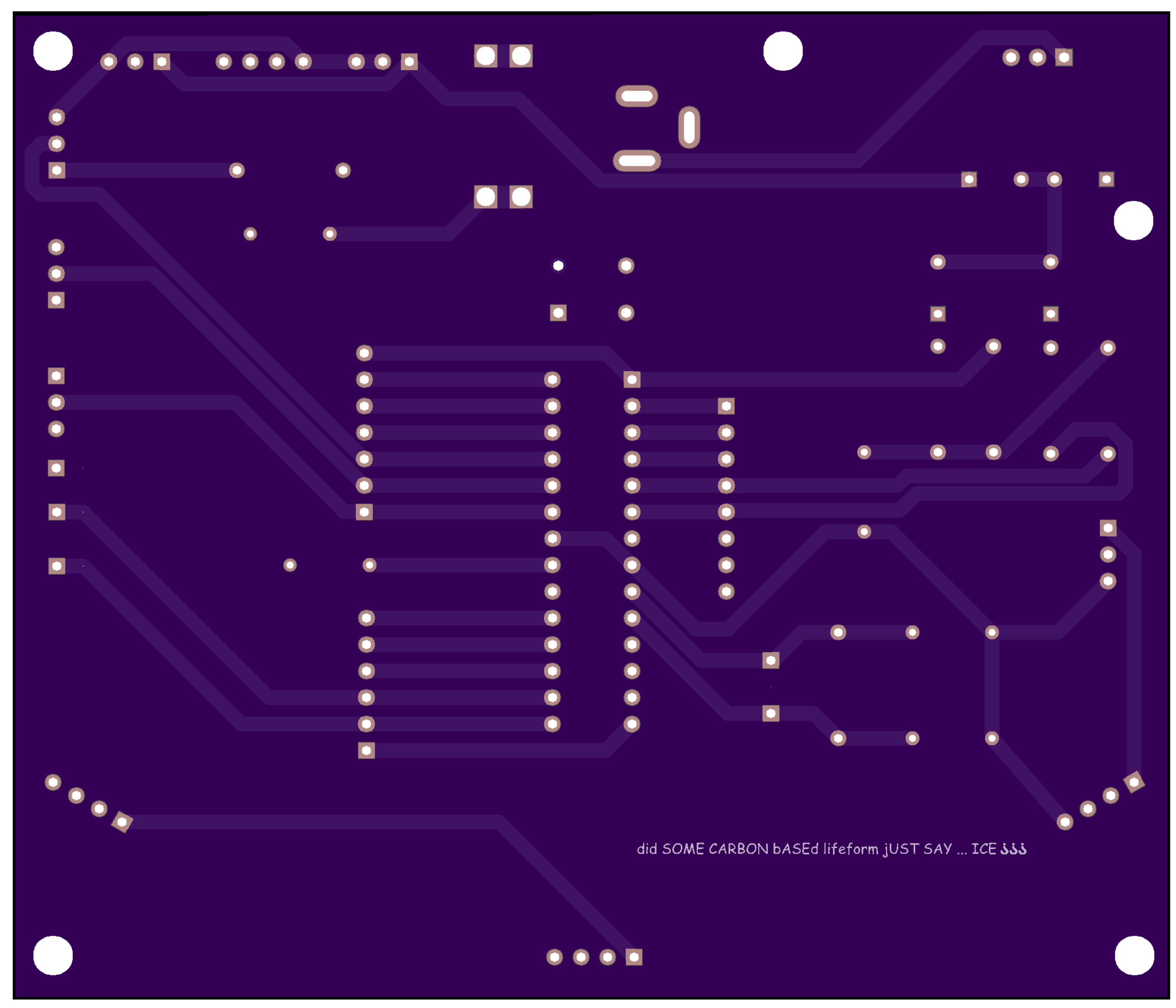
- Electrical power metrics can be measured with current meter
- Stored thermal energy can be measured through water temperature
- Stored energy leaks at rate of 7.5 BTU/hr
- Energy Efficiency Ratio (EER) = 0.26
- TECs often have EER around 2-3
- Air-conditioners usually have EER around 11-12
- More efficient circulation could improve efficiency

Results

Requirement	Specifications	Value	Actual
portable	dry weight	< 150 lb	60 lb
	size	< 20 cuft	20.8 cuft
cooling	air cooling	3.5° F	3.9°F
responsive	water cooling	< 6 hours	3 hours

Printed Circuit Board





Safety Measures

- Insulated all wires
- Installed precautionary drip tray (using tarp)
- Determined appropriate wire sizing and type
- Switching system to control components
- Installed fuses and circuit breakers

Further Design Improvement

- Replace radiator block on cool side of TEC with dedicated heat exchanger
  - Current radiator block system acts as heat exchanger with ε=~0.1
  - Dedicated heat exchangers would have much higher effectiveness values
- Adjust flow rate in cooling block
  - Flow-rate of refrigerant fluid greatly affects efficiency of heat exchangers
- Replace 2 TECs @ 8A each with 4 TECs @ 4A each
  - EER of TECs increases at lower individual load
- **Improvements could increase efficiency > 10**
- Balance efficiency improvements with cost considerations
  - More hardware makes system more expensive
- Integrate photovoltaic power
  - 24VDC solar panels + Charge controller
  - 500W-rated solar panel array should accommodate system