UCI Thermoelectric

Fall Design Review 2019

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UCI W.A.T.C.H. Team

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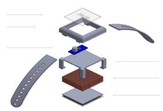
Background

- An average human body at rest emits about 350,000 J of energy per hour.
- The average surface area of the human skins is 1.7 m^2 (17,000 cm^2)
- Heat Flux of **5.7** $\boldsymbol{mW/cm^2}$.

- Effective Area of our wrist is about 10 cm^2.
- 57 mW of useful energy is harvestable!!!
- Sparks interest in creating wearable body heat powered- mobile electronics and sensors using TEGs.

- Past research for this project involved creating a prototype of a digital watch.
- Currently research seeks to design a UCI-LED patterned wearable badge.



Goal

Determine the feasibility of using body heat as a form of energy

Objectives

Design a LED-Badge that is powered by thermoelectric generators

- Investigate TEG performance through analytical modeling, numerical simulation, and experimental testing
- Apply engineering concepts to optimize systematic designs {Heat Transfer; Thermoelectric}

Specifications

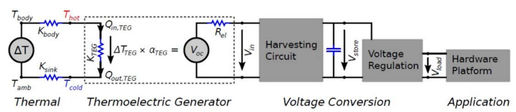
- The LED-badge consists of 15 LED's featuring the patterning of the letter "UCI ".
- Each LED consumes .048W at an operating voltage of 1.6V.

$$\boldsymbol{Power_{req}\ [W] = 15 \times 0.048 = 0.72]}$$
$$\boldsymbol{= I \times k \times \{(n_r * s_r) + (n_f * s_f)\} \times\ \Delta T\ -\ I^2 \times R_{int}}$$

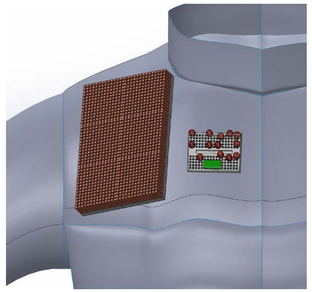
- n_r *is the number of rigid TEG's*
- n_f *is the number of flexible TEG's*
- s_r *is the Seebeck coefficient of the rigid TEG in* $[\mathrm{V/K}]$
- s_f *is the Seebeck coefficient of the flexible TEG.*
- *K is the Voltage boosting factor*

We require .72W to power up 15 LED's for patterning. We will be utilizing 3 flexible TEG's and using the power balance equation we can determine the number of rigid TEG's that is needed. Our ΔT is in the 5-10 range.

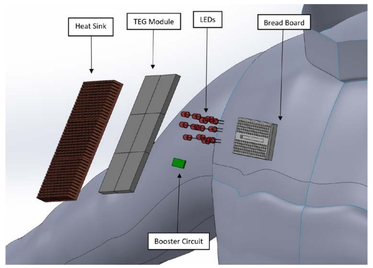
Design & Innovation



Equivalent circuit of the pathway from human body heat to a wearable hardware platform.
David, Sam. Body Heat Can Be the Source of Power for Wearable Devices, Informa, 2017.

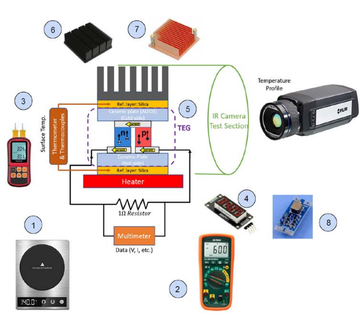


Thermoelectric LED-Badge Concept

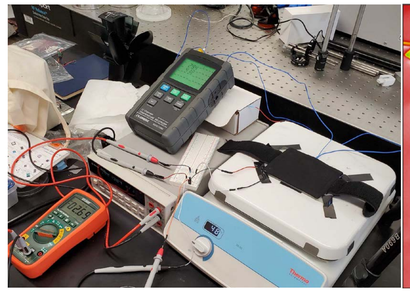


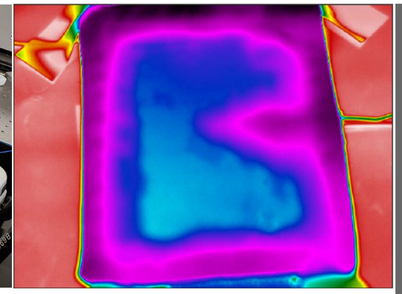
Exploded View

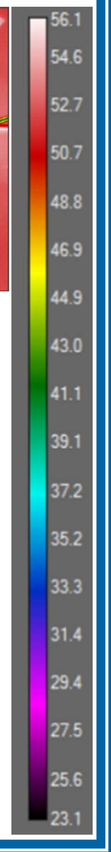
Current Status – Selective Component Testing



Experiment Schematics

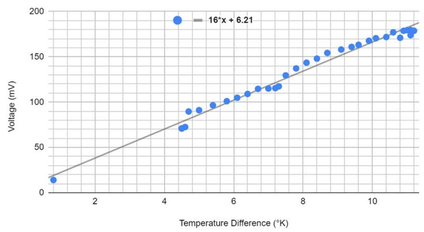




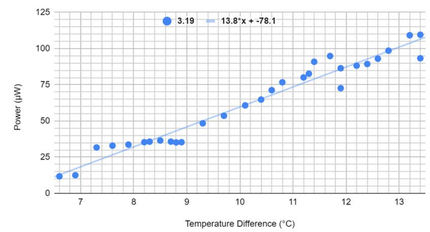


- Thermal and electrical characterization of the customized flexible TEG modules.
- Determine the Seebeck Coefficient from the slope of the Voltage versus temperature difference plot.
- Measure the power generation of the flexible TEG in a closed loop circuit, where the LED and voltage booster are modeled as a 10-ohm resistor.

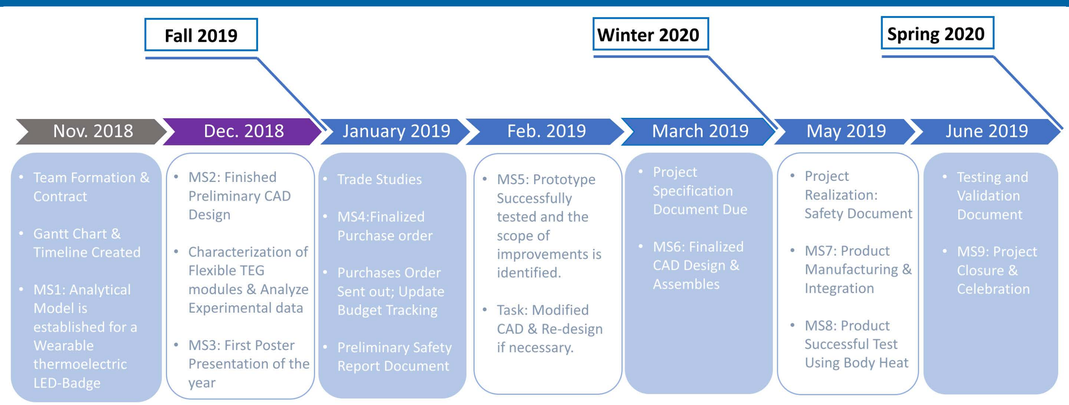
Voltage vs Temperature Difference



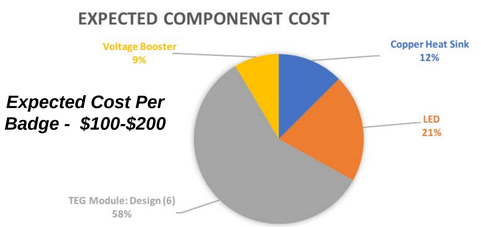
Power vs Temperature Difference



Timeline



Budget and Cost



Expected Cost Per Badge - $100-$200

Part Name	Vender	Value	Percent
Copper Heat Sink	Digi-Key	$39.13	12%
LED	Amazon	$64.35	21%
TEG Module	Digi-Key	$182.82	58%
Voltage Booster	Custom Thermoelectric	$26.75	9%