Heating Glove – Development of Heating Properties of Smart Textile

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Overview

To develop a thermal insulating heating glove that provides and maintains comfortable body warmth under extreme cold temperature ranges reaching -20^{0}C.

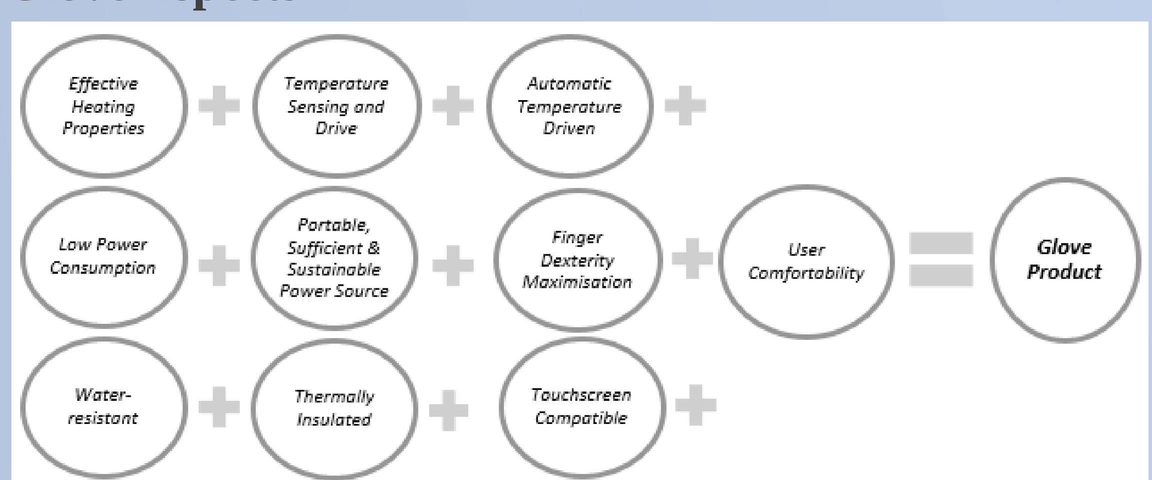
Introduction

- The end-product of this project has been specifically designed for situations dealt by researchers in Antarctica.
- Temperature ranges in the specified geographical area of Antarctica fall within -15^0 to -20^0C
- Main time of use of the glove is during away-from-base-camp daily field surveys which usually last for eight hours. Required 'time on' of the glove, within this timeframe is approximately an hour.
- In addition to heating requirements, designed glove must ensure normal finger dexterity and touchscreen compatibility for general use of field equipment
- Current heating alternatives used out on the field include non-lasting chemical generated heat and a very poor designed AA powered heating glove (does not heat up as promised).

Objectives

- Capable of having temperature rise above ambient of minimum 40^0C
- Capable of sensing skin temperature
- Capable of powering on and off depending on skin temperature
- Capable of drawing and consuming minimal power
- Incorporation of a portable but sufficient power source
- Maximises and aims to maintain normal finger dexterity
- Integration of water-resistant protection
- Incorporation of thermal insulating materials to maximise heat trapping
- Maintains touchscreen compatibility between fingers and electronics
- Glove texture is comfortable and suitable to skin

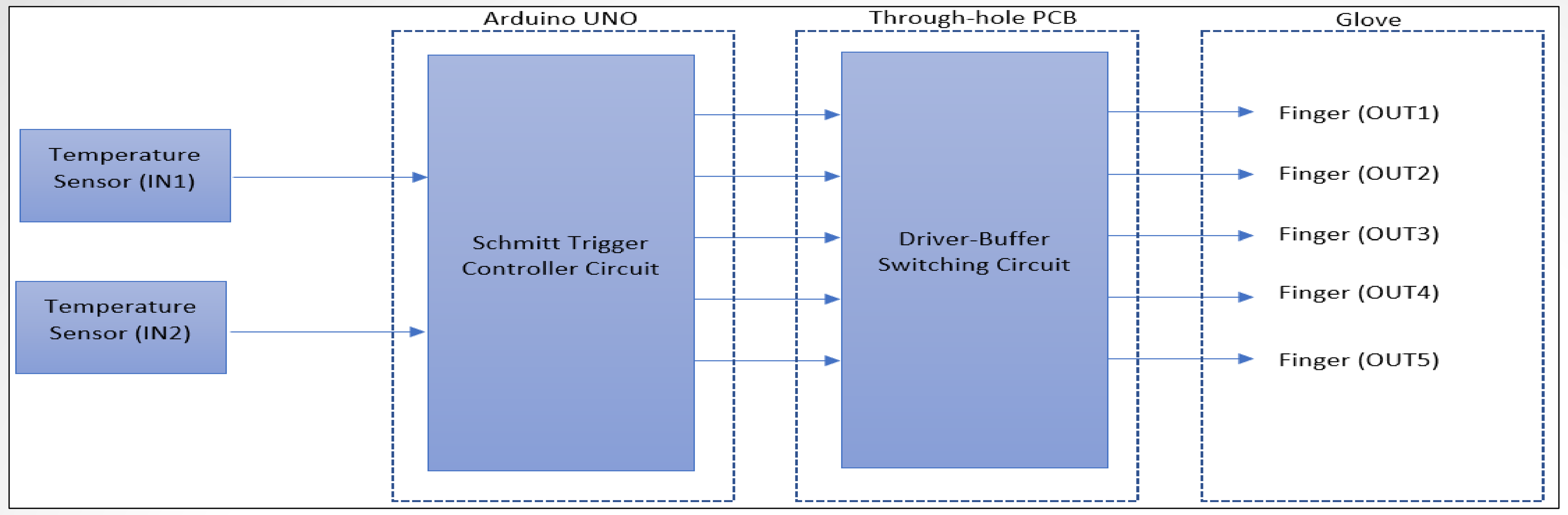
Glove Aspects



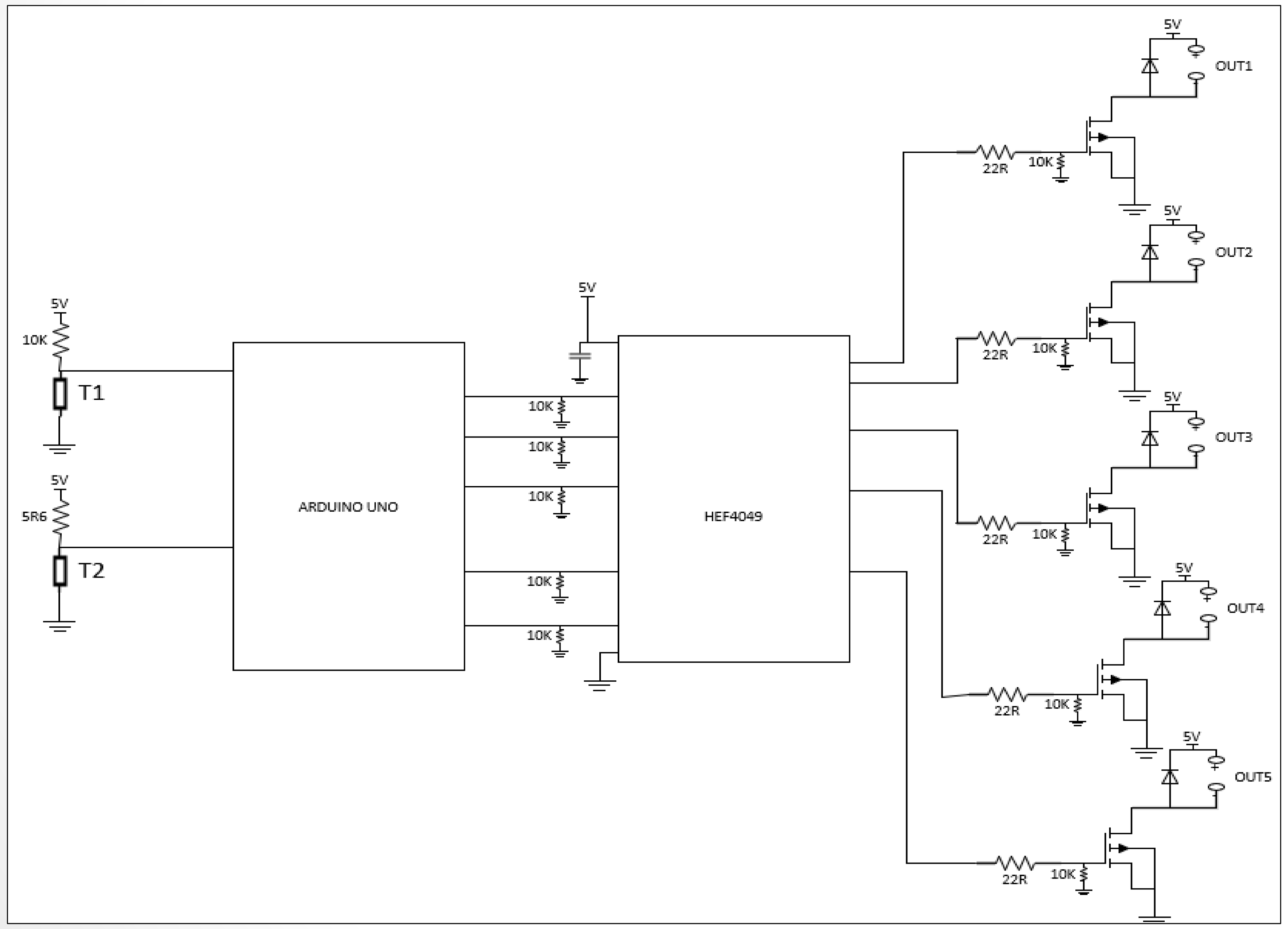
Method

- Incorporation of a thin three-layered glove model allowing finger dexterity:
  1. Innermost Layer
     - Provides user comfortability
     - Protection/separation layer between skin and components
     - Base layer for temperature sensing components (thermistors)
  2. Element Layer
     - Use of Merino-Insulated Carbon Nanotube Yarn (CNT) to ensure effective heating properties
       - Due to time constraints, Carbon Fibre Tow (CFT), an alternative with similar conductive and thermal properties is used for a *proof of concept* model
     - CFT parallel connection to main circuit board to limit current and ensure each finger is regulated with same voltage levels
     - CFT is laid on the back of the hand due to its lowest temperature ranges out of the rest of the hand
  3. Outermost Layer
     - Water-resistant
     - Touchscreen compatible
     - Thermal insulation
- Incorporation of Schmitt-Triggering Controller and Driver-Buffer Switching Circuit
  - Sets thresholds to turn power on and off (limiting power consumption) depending on the temperatures sensed by the temperature sensors

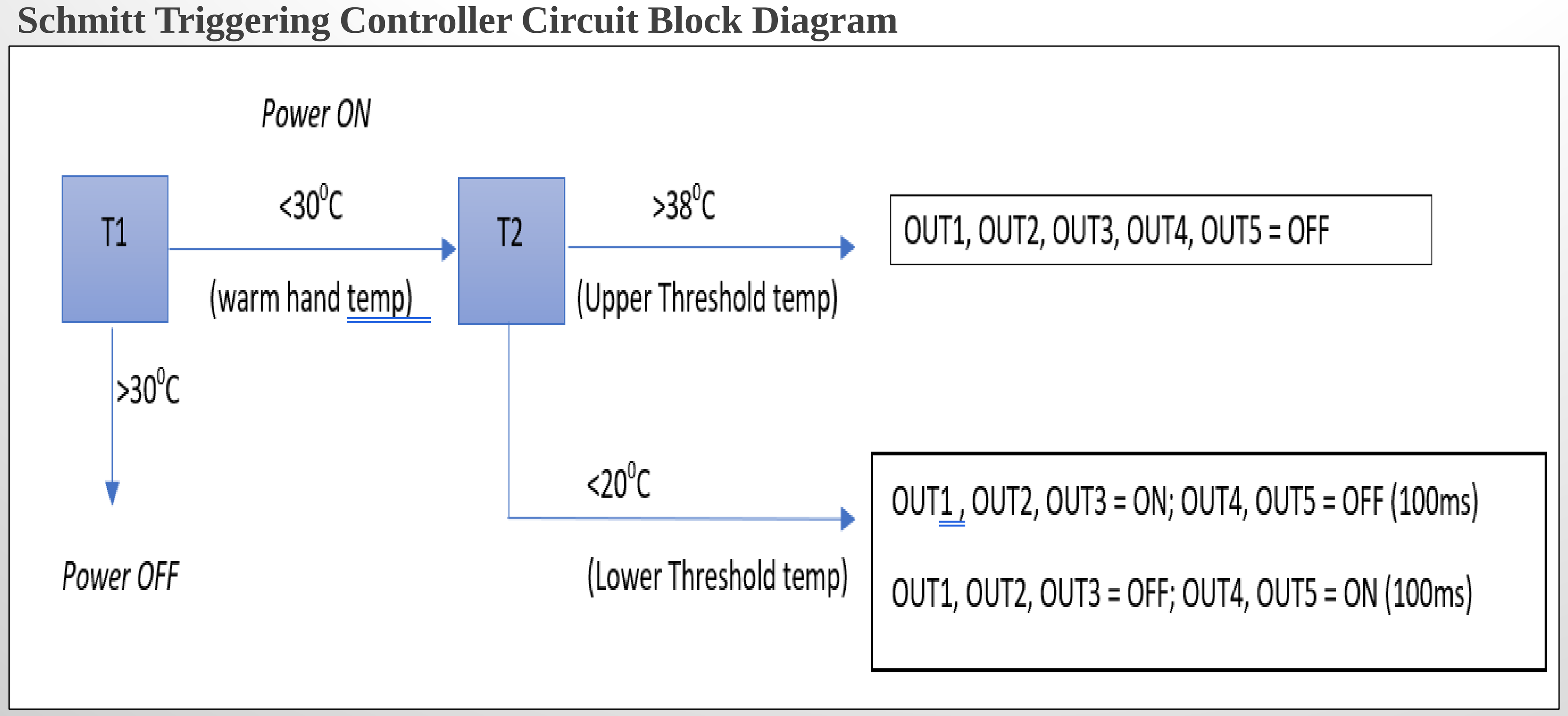
Methodology Block Diagram



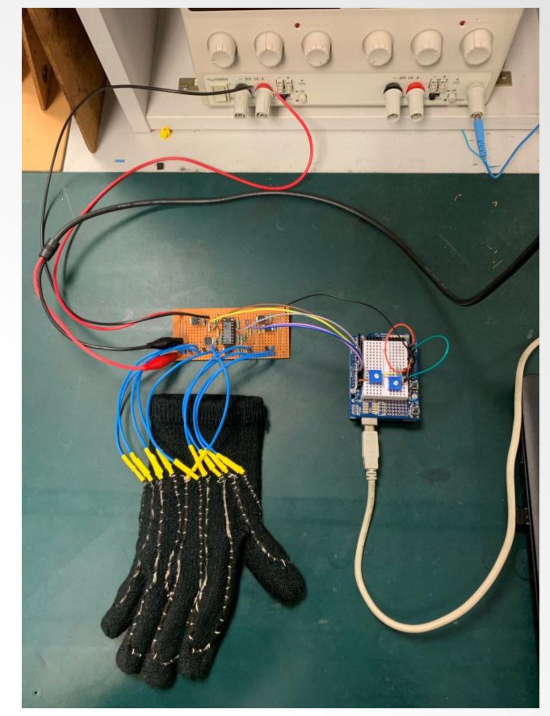
Actual Circuit



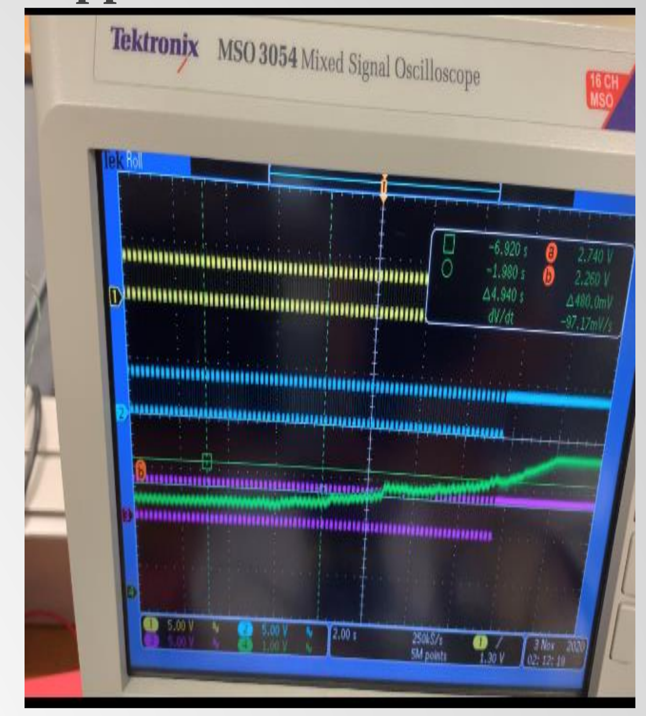
Schmitt Triggering Controller Circuit Block Diagram



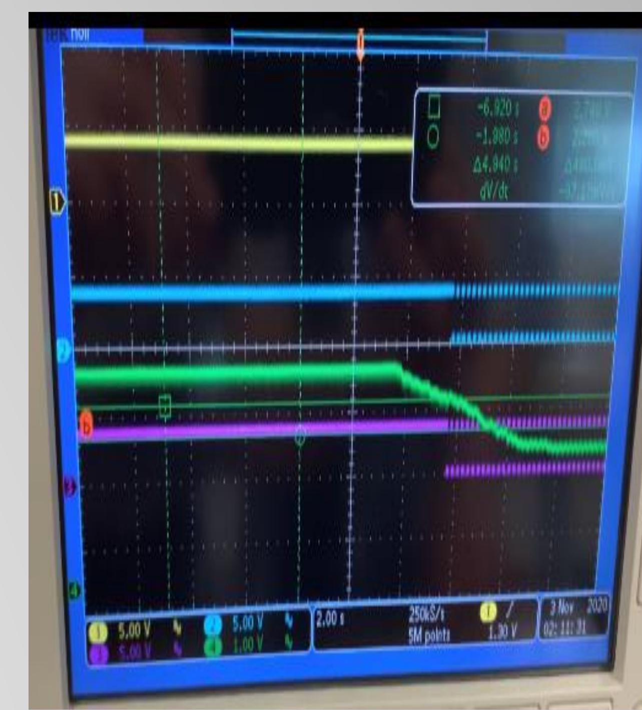
Test Setup



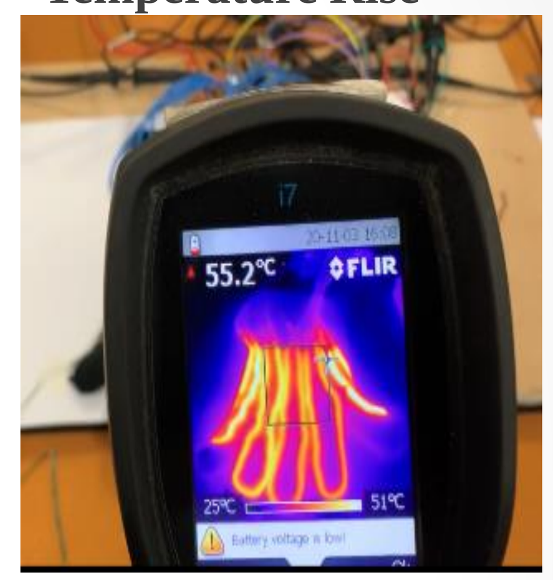
Upper Threshold Limit



Lower Threshold Limit

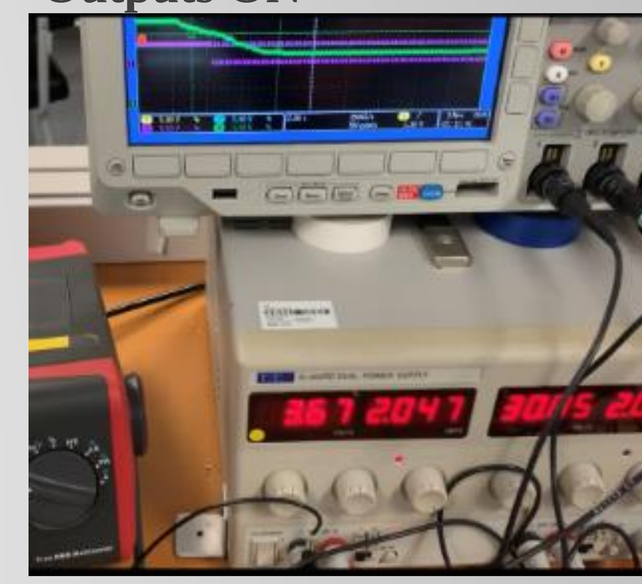


Temperature Rise



Outputs OFF

Outputs ON



Results

- Minimum change in temperature (compared to ambient room temperature of 23^{0}C) is observed to be 40^{0}C
- The highest power consumption of the glove when on (three fingers on two fingers off is:

$$V = 3.67V \qquad I = 2.047A$$
$$P = VI = (3.67)(2.0474) = 7.513W$$

- Thus, each finger consumes less than 2W of power
- To sustain the glove for two hours:

$$Battery\ Rating = I \times time$$
$$Battery\ Rating = 2.0474 \times 2$$
$$Battery\ Rating \sim 4Ahr$$

- Therefore, a 3.7V battery with current rating of 4Ahr is enough to support the glove for 2 hours
- It is observed, temperature rise across the fingers are different as the resistance for each strand is different.
  - With the pinkie finger being the hottest
  - However, by resistance and length, the thumb should be the hottest. Upon closer observation and further assessment, the termination point of the thumb is not properly done. Hence, the not-so-high temperature rise.

Conclusion

- Temperature changes above 40^0 C have been reached while integrating a design that maintains finger dexterity and portability
- With the highest total power consumption of less than 10W per hand (approximately 7.6W in total)
- Each finger consumes less than 2W of power.
  - Temperature increases along with resistance as they are relatively proportional
  - Resistance increases as length increases.
- A 3.7V battery with a 4Ahr current rating can support one hand for two hours.

Future Work

- Incorporation of Merino-Insulated Carbon Nanotube Yarn
- Proper assessment and evaluation of current to each strand
- Assessment of safety and health regulations
- Incorporation of a Variable Temperature Prediction Model for Schmitt Triggering outputs
- Incorporation into medical and spatial equipment
- Production of a marketable heating glove
- Incorporation of Wireless Power Transfer