Smart Firefighter Helmet

Design Review

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ECE 445

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1. Introduction

1.1. Statement of Purpose

The motivation behind this project is to improve safety for firefighters by creating a system that detects if they are being exposed to temperatures high enough to melt their equipment, then warns them through visual signals. Current firefighter suit technology has improved to the point where firefighters may be unaware they are in a potentially dangerous situation due to extremely high temperatures - this project aims to address that problem.

The system needs to be lightweight with a signal module. The system needs to be small and simple so that it will not obstruct the firefighter in any physical way, nor impede their vision. The system can give simple feedback to the firefighter about the surroundings and help the firefighter make safer decisions. The feedback to the firefighter will be given with LEDs and the sensing done with a thermistor. This system can help to save lives and reduce injuries to firefighters. Another added benefit is that firefighter equipment will not break down as much from exposure to high temperatures. This reduces the need for the fire department to purchase new equipment, saving them money.

1.2. Objectives

1.2.1. Goals and Benefits
- Heat warning system for firefighter helmets
- Lower firefighter deaths and injuries
- Communication of danger to other firefighters
- No user input

1.2.2. Functions and Features
- Reliable heat sensing.
- Visual alert system
- Wireless communication between firefighter helmets
- Device that is lightweight and visually unobtrusive
- Low cost
- Fits within SCUBA mask
2. Block Diagrams

2.1. Overall System

Figure 1: Top-Level System Block Diagram

2.2. Description of Blocks

2.2.1. Helmet

**Input:** Square wave sent over RF communication channel used to tell if another firefighter is in danger.

**Output:** Square wave sent over RF communication channel used to signal that a firefighter is in danger.

The helmet block is to define what actually goes into each helmet. This system will be distributed to a whole firefighter squad so there will be multiple units per squad. The full helmet module will include the sensor, heads up display, power supply, the microcontroller, and the wireless communication system.

2.2.2. Power Supply

**Input:** 3.6 volt input, 24 mA average current input from the batteries

**Output:** 5 volt output, 17 mA average current output, 85 mW output to the HUD, Microcontroller, communications, and sensor modules.
The power supply will supply each component block with the necessary power for the circuit components to operate. The power supply will consist of a single 3.6 volt lithium ion battery connected to a boost converter to keep the size of the overall design down. The power supply circuit will consist of a dc-dc boost converter to raise the power voltage to 5 volts, which will then be used to power the rest of the circuitry.

2.2.3. Sensors

Input: Temperature from the surroundings. Used to tell what the temperature is.
Output: An analog voltage that is sent to the microcontroller that is used to determine the temperature of the surrounding environment.

The sensor in this design is a thermistor. It is used to sense the temperature on the mask. The thermistor will need to be accurate to within 5 degrees Celsius and respond quickly to temperature change. The thermistor gives an analog output in the change in the value of resistance as the temperature changes. By measuring the resistance, it is possible to determine the temperature. There will be a constant voltage supplied to the thermistor and another resistor in series. As the resistance changes the voltage across the thermistor will also change. The voltage will be measured by the microcontroller. With the voltage across the thermistor, the known resistance of the series resistor, and the known voltage supplied to both the resistor and the thermistor the microcontroller will be able to calculate the resistance of the thermistor. From this calculation the temperature can be calculated using the characteristic equation of the thermistor. Given the temperature, a LED will turn on pending where the temperature lies in the given ranges. If the temperature is not dangerous the green LED will be on, if the temperature is moderately dangerous the yellow LED will be on, if the temperature is extremely dangerous the red LED will be on.

2.2.4. HUD

Input: LED control voltage from microcontroller to turn the LED to the appropriate color given the temperature from the sensors, Power signals to operate the LED.
Output: Colored LEDs that indicate to the firefighter what the current temperature range he is operating in.

The heads up display (HUD) consists of one RGB LED and one Red LED. The RGB LED cycles its color on based on what the temperature of the mask is. The red LED turns on or off based on the input from the wireless communication channel. All this information is processed in the microcontroller which will implement the physical voltage changes. The RBG LED will be green if the firefighter is not within a dangerous ambient temperature zone. This zone is defined to be within 0 - 150 degrees Celsius. The LED will turn yellow to indicate a dangerous zone which is defined to be between 150 - 180 degrees.
Celsius. The RBG LED will turn red if the firefighter has entered an extremely hazardous zone defined to be any ambient temperature above 180 degrees Celsius. All of these temperature zones were chosen based on research that was conducted on the safety of the firefighter’s helmets. The red LED will turn on and flash if another firefighter has entered into a hazardous zone, the 180 degrees Celsius or higher zone.

2.2.5. Microcontroller and Wireless Communication

**Input:** Digital signal from other helmets to alert the firefighter to the other firefighters’ current conditions, Power signals to turn on the given electronics, Voltage from sensors to determine the temperature range the firefighter is operating in.

**Output:** control voltage to LED so that it displays the given color for the temperature range the sensors are in, digital signal to the other helmets communicating if the firefighter is in danger.

The microcontroller is used to process information from the sensors and to make decisions on which LED is to be on at any given time. The microcontroller to be used is the Atmel ATtiny87 and will take the analog voltage from the sensor and convert it into a digital signal, a 16-bit binary value. This value will be compared against pre-calculated voltage values to determine the temperature range that the helmet is in. This voltage will determine what color the LED is to be. The description for temperature to LED color is described above. The microcontroller is coded in C. The microcontroller will also send and receive signals from other helmets through its wireless communication circuit. Both of these signals are digital. These signals will communicate to the microcontroller if there is another firefighter in danger. If there is a 1 received, a digital high signal between 4.3v and 5v, the microcontroller will interpret that as communicating that another firefighter is in danger and will activate the correct LED. If there is a 0 received, a digital low signal, then no one is in danger. The microcontroller will send a 1 if its sensor is in the danger zone as to alert the other firefighters. The wireless communication system will be how the processor communicates with other firefighters’ helmets to get information on the conditions they are in. This will be implemented with a simple transmitter and receiver circuit and two small antennas. The communication will be done at 418 MHz as specified by the components we chose. This is well outside other major communication channels and will not have too much interference. The two chips we are using for transmitting and receiving are TXM-418-LC and the RXM-418-LC. The antennas we are going to use are the ANT-418-CW-RAH. The reason being that we want a small maneuverable antenna for the inside of the helmet. There is little room inside the firefighter helmet so we need a small antenna. The transmitted and received signals will both be digital signals, so there is no need for an analog to digital converter. This is because we only need to know if another helmet is in danger or to tell if a helmet is in danger. If a 1, a high signal, is on the
communication channel then we will know that there is a helmet that is in the danger zone. This will allow the firefighters to help the other firefighter that is in the hazardous area. The circuit will be continuously transmitting and continuously receiving. The continuous receiving and transmitting is needed so that there is no delay in communicating when another firefighter has entered a hazardous area.

![Diagram]

**Figure 2:** Atmel ATtiny87 interfaces to other components

Reference [1]
<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RXD, RF receive</td>
<td>to DATAOUT of RXM-418-LC</td>
</tr>
<tr>
<td>2</td>
<td>TXD, RF transmit</td>
<td>to DATAIN of TXM-418-LC</td>
</tr>
<tr>
<td>5, 15</td>
<td>AVCC/VCC, analog/digital power supply</td>
<td>to regulated supply (+5V)</td>
</tr>
<tr>
<td>6, 16</td>
<td>AGND/GND, analog/digital ground</td>
<td>to ground supply</td>
</tr>
<tr>
<td>10</td>
<td>PA7, Analog-to-Digital Conversion</td>
<td>to thermistor</td>
</tr>
<tr>
<td>11</td>
<td>PB7, Analog-to-Digital Conversion</td>
<td>to thermistor</td>
</tr>
<tr>
<td>12</td>
<td>PB6, GPIO</td>
<td>to green pin of RGB LED</td>
</tr>
<tr>
<td>13</td>
<td>PB5, GPIO</td>
<td>to blue pin of RGB LED</td>
</tr>
<tr>
<td>14</td>
<td>PB4, GPIO</td>
<td>to red pin of RGB LED</td>
</tr>
<tr>
<td>19</td>
<td>PB1, Power On/Power Down</td>
<td>to Power On/Power Down of RXM-418-LC</td>
</tr>
<tr>
<td>20</td>
<td>PB0, GPIO</td>
<td>to red warning LED</td>
</tr>
</tbody>
</table>

**Table 3**: Atmel ATtiny87 Pin Connections

### 2.2.6. Other Helmet’s Systems

**Input**: Square wave sent over RF communication channel used to tell if another firefighter is in danger.

**Output**: Square wave sent over RF communication channel used to signal that a firefighter is in danger.

The other helmets will have the same system implemented in them. These two systems will be communicating with each other. Each helmet will send warning signals if their firefighter is in a dangerous situation. The helmet module can communicate with the other helmets using the warning signal so that the firefighter can know the status of the other firefighters in their squad.
3. Detailed Electrical Schematics; Wiring Details

3.1. High Level

Figure 4: Top-Level Circuit Schematic
3.2. Microcontroller:

![ATtiny87 Circuit Schematic](image)

**Figure 5**: Atmel ATtiny87 Circuit Schematic  
Reference [1]
3.3. RF Module:

**Figure 6: RF Module Circuit Schematic**
Reference [3, 4]

**TXM-418-LC** resistor choice:

The resistor R1 is used for a level pull down. That is used to lower the output power of the transmitter. The main reason to do this is to keep the system operating in an effective range. See Reference [4] for data sheet.

**RXM-418-LC** resistor choice:

The resistor R2 is used for a voltage pull down. This to pull the operating voltage down from 5v to 3.3v. The power supply will be providing 5v, and the RXM chip operates at 3.3v. This resistor value was specified in the data sheet. See Reference [3] for data sheet.
3.4. Thermistor Sensors

![Thermistor Sensor Circuit Schematic](image)

**Figure #**: Thermistor Sensor Circuit Schematic

3.5. Power Module

![Power Module Circuit Schematic](image)

**Figure 7**: Power Module Circuit Schematic [12]
4. Supporting Calculations

4.1. Component Selection: Thermistor Series Resistance

In accordance with the specifications for the microcontroller, the maximum voltage level able to be detected was chosen to be 1.1 volts. Additionally, the threshold temperatures of the lens exterior for the warning region and the danger region were chosen to be 150 degrees Celsius and 180 degrees Celsius respectively. As the thermistor is to measure the internal temperature of the lens, it was necessary to map these external lens temperatures to the internal lens temperatures using Figures 8 and 9.

![Figure 8: Facepiece thermocouple temperatures during a radiant panel exposure of 15kW/m². Reference [5]](image)
The corresponding lens interior temperature for the warning level of 150°C was determined to be 70°C, and the lens interior temperature for the danger level of 180°C was determined to be 115°C. It was determined that the maximum voltage of 1.1 volts should only be measured by the microcontroller at the lens interior temperature of the danger level at 115°C.

At an input voltage of 5 volts and an approximate thermistor resistance of 1130 ohms, the thermistor circuit series resistance was:

\[
\frac{5 - 1.1}{5} = \frac{R}{R + 1130}
\]

Basic ohm’s law to calculate the theoretical operational current.

\[
I[amps] = \frac{5 [volts]}{(4006.36 + R_{th}) [ohms]}
\]

For the typical resistances expected by the thermistor at these temperatures, the calculated expected current never exceeded the maximum current as specified in the datasheet. Both of these current curves are plotted below in Figure 10.
4.2. Component Selection: Power Supply Feedback Resistors

The feedback resistors in the power supply were required to be suitably large enough to prevent a significant drop in the output voltage yet small enough to prevent leakage current from trickling through the feedback pin on the converter chip. The suggested method for finding suitable relative resistance values for this particular part is as such:

\[ V_{FB} = R_2 \left( \frac{V_{out} - I_{FB}R_1}{R_1 + R_2} \right) \]

The typical feedback voltage accepted by the converter component was listed as 1.26 volts, and the feedback current used was the maximum possible current of 20 nA. The output voltage desired was 5 volts. As this equation only related the feedback resistances to each other, a moderately high value of 20 kOhms was picked for the value of the first resistor, R1. The second resistor was thus calculated to be 6.74 kOhms.

\[ 1.26 = R_2 \left( \frac{5 - 20 \times 10^{-9} \times 20,000}{20,000 + R_2} \right) \]

\[ R_2(1 - 0.252) = 20 \text{ k}\Omega \times 0.252 = 6.738 \text{ k}\Omega \]
5. Modular Requirements and Verification Plan

### 5.1. Power Supply

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
</tr>
</thead>
</table>
| Check power supply voltage output is 5 volts with +/- 10% tolerance | 1. Measure power supply output with multimeter to determine average output voltage  
2. Measure power supply output with oscilloscope to determine voltage ripple |
| Check power supply current output is 24mA with +/- 10% tolerance | 1. Measure power output with multimeter to determine power  
2. Measure power supply output with oscilloscope to determine current ripple |

### 5.2. Thermistor Temperature Processing

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
</tr>
</thead>
</table>
| Accurate temperature sensing with sensitivity of +/- 5 degrees Celsius. | 1. Apply a controlled-temperature soldering iron to the thermistor.  
2. Measure thermistor resistance and compare to expected resistance values on thermistor datasheet to find temperature  
3. Compare measured thermistor temperature to fixed soldering iron temperature |
| Thermistor resistance changes with temperature with a response time of 15 seconds. | 1. Measure thermistor resistance and compare to expected resistance values on thermistor datasheet to find temperature  
2. Move thermistor to temperature-controlled environment  
3. Record amount of time that passes before thermistor displays the resistance corresponding to the environment temperature |

### 5.3. Heads-Up-Display Updating

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
</tr>
</thead>
</table>
| LED updates within 15 seconds of entering a new temperature zone | 1. Turn on device to check green LED  
2. Subject the thermistor to a temperature within an arbitrary zones using either a heat gun or a soldering iron.  
3. Use a stopwatch to time how long it takes for the LED to update. |
5.4. Communication/Other HUD Updating

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other helmet’s LED updates within 30 seconds of first helmet entering a new</td>
<td>1. Turn on both devices</td>
</tr>
<tr>
<td>temperature zone</td>
<td>2. Subject one device’s thermistor to a temperature within the danger zone</td>
</tr>
<tr>
<td></td>
<td>using either a heat gun or a soldering iron</td>
</tr>
<tr>
<td></td>
<td>3. Use a stopwatch to time how long it takes for the red LED of the other</td>
</tr>
<tr>
<td></td>
<td>helmet to start blinking</td>
</tr>
</tbody>
</table>

6. Tolerance Analysis

The most important specification to meet is the accuracy of the temperature sensors and the response time of the entire system. The module needs to be able to accurately sense the outside temperature to within +/- 5 degrees Celsius and needs to alert the firefighter within 15 seconds. These specs were determined by the firefighters themselves through Firefighter Williams at the Champaign Fire Department. To test this spec, the thermistor will be subjected to a known temperature. An oscilloscope or voltmeter can be used to measure the voltage. Once the voltage is measured it can be converted into a temperature and compared to the known temperature value. The thermistor will be subjected to multiple heat tests using various equipment such as a heat gun, soldering iron, and a blow dryer. The actual temperature will be measured with a thermometer for the comparison value. The response time test will occur simultaneously with the heat tests, with a stopwatch being used to measure the amount of time it takes between the device entering a dangerous zone and the LED turning red.
7. **Software Flowchart**

Figures 11 and 12 provide a software flowchart of the Atmel ATtiny87 microcontroller. Incoming RF warnings are handled as interrupts, blinking the second red LED appropriately. In order to prevent a device from detecting its own RF warning, the software only updates its red LED if it is not currently sending a warning. If a device is currently sending a warning to the other device, then the status of its red LED is not updated.

**Figure 11:** Atmel ATtiny87 microcontroller temperature sensing and outgoing alert algorithm

**Figure 12:** Atmel ATtiny87 microcontroller incoming alert algorithm
# 8. Project Completion Schedule; Division of Responsibility

<table>
<thead>
<tr>
<th>Week</th>
<th>Rob:</th>
<th>Steven:</th>
<th>Tim:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/8</td>
<td>• Complete ‘Introduction’ and ‘Design’ of Proposal</td>
<td>• Complete ‘Requirements and Verification’ of Proposal</td>
<td>• Complete ‘Cost and Schedule’ and ‘Tolerance Analysis’ of Proposal</td>
</tr>
<tr>
<td></td>
<td>• Begin Microcontroller Software Development</td>
<td>• Submit Proposal</td>
<td>• Begin RF Circuit Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Begin sensing unit and power unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete ‘Requirements and Verification’ of Proposal</td>
<td></td>
</tr>
<tr>
<td>2/15</td>
<td>• Complete ‘Circuit Schematic’, ‘Safety Statement’, and number every page of Mock Design Review</td>
<td>• Complete ‘One Calculation’, ‘One Plot, and ‘Citations’ of Mock Design Review</td>
<td>• Complete ‘Block Diagram’, ‘One Block Description’ and ‘R&amp;V for one Module’ for Mock Design Review</td>
</tr>
<tr>
<td></td>
<td>• Continue Developing Microcontroller Software</td>
<td>• Continue Developing sensing unit and power unit</td>
<td>• Continue Developing RF unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/22</td>
<td>• Continue Developing Microcontroller Software</td>
<td>• Continue Developing sensing unit and power unit</td>
<td>• Continue Developing RF unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/29</td>
<td>• Modify microcontroller and thermistor design based on Design Review feedback</td>
<td>• Modify power unit design based on Design Review feedback</td>
<td>• Modify RF unit design based on Design Review feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 3/7  | • Begin prototype testing of microcontroller and thermistor sensing unit  
   • Begin PCB layout of microcontroller and thermistor sensing unit | • Begin prototype testing of power unit  
   • Begin developing thermistor-SCBA mask interface, and PCB layout of power unit | • Begin prototype testing of RF unit  
   • Begin PCB layout of RF unit |
| 3/14 | • Modify microcontroller and thermistor sensing unit design based off prototype testing  
   • Alter PCB layout of microcontroller and thermistor sensing unit according to modified designs | • Modify power unit design based off prototype testing  
   • Alter PCB layout of power unit according to modified designs | • Modify RF unit design based off prototype testing  
   • Alter PCB layout of RF unit according to modified designs  
   • Submit SCBA PCB module for fabrication |
| 3/21 | Spring Break | Spring Break | Spring Break |
| 3/28 | • Assemble microcontroller and thermistor sensing unit components of PCB  
   • Develop mounting system for PCB to fit inside mask | • Assemble power unit component of PCB  
   • Confirm functionality of thermistor-mask interface | • Assemble RF unit of PCB  
   • Confirm PCB plus mounting system fits inside mask  
   • Submit altered PCB module for fabrication if necessary |
| 4/4 | ● Assemble microcontroller and thermistor sensing unit components of PCB if necessary  
● High temperature device testing: confirm correct operation of microcontroller and sensing unit | ● Assemble power unit component of PCB if necessary  
● High temperature device testing: confirm correct operation of power unit | ● Assemble RF unit of PCB if necessary  
● High temperature device testing: confirm correct operation of RF unit |
| 4/11 | ● High temperature device testing: confirm correct operation of microcontroller and sensing unit | ● High temperature device testing: confirm correct operation of power unit | ● High temperature device testing: confirm correct operation of RF unit |
| 4/18 | ● Confirm microcontroller and sensing unit ready for demo | ● Confirm power unit ready for demo | ● Confirm RF unit ready for demo |
| 5/2 | ● Confirm ‘Introduction’ and ‘Design’ components of Final Report complete  
● Submit Final Paper | ● Confirm ‘Verification’ and ‘Costs’ components of Final Report complete | ● Confirm ‘Conclusions’ and ‘References’ components of Final Report complete  
● Confirm overall layout and styling correct |
9. Cost Analysis

9.1. Labor

<table>
<thead>
<tr>
<th>Name</th>
<th>Hourly Rate</th>
<th>Total Hours Invested</th>
<th>Total = Hourly Rate x 2.5 x Total Hours Invested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rob Madsen</td>
<td>$32.5</td>
<td>150</td>
<td>$12,187.5</td>
</tr>
<tr>
<td>Tim Sutyak</td>
<td>$32.5</td>
<td>150</td>
<td>$12,187.5</td>
</tr>
<tr>
<td>Steven Lim</td>
<td>$32.5</td>
<td>150</td>
<td>$12,187.5</td>
</tr>
<tr>
<td>Total</td>
<td>-----</td>
<td>450</td>
<td>$36,562.5</td>
</tr>
</tbody>
</table>

9.2. Parts

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Part Number</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermistor</td>
<td>135-103LAG-J10-ND</td>
<td>x2</td>
<td>$0.45</td>
<td>$0.90</td>
</tr>
<tr>
<td>4 KOhm Resistor</td>
<td>CMF204K0000GNEA-ND</td>
<td>x2</td>
<td>$0.05</td>
<td>$0.10</td>
</tr>
<tr>
<td>LED RGB</td>
<td>WP154A4SUREQBFZGW</td>
<td>x1</td>
<td>$1.78</td>
<td>$1.78</td>
</tr>
<tr>
<td>Red LED</td>
<td>LH R974-LP-1</td>
<td>x1</td>
<td>$.26</td>
<td>$.26</td>
</tr>
<tr>
<td>TX board</td>
<td>TXM-418-LC</td>
<td>x1</td>
<td>$7.00</td>
<td>$7.00</td>
</tr>
<tr>
<td>RX board</td>
<td>RXM-418-LC</td>
<td>x1</td>
<td>$14.00</td>
<td>$14.00</td>
</tr>
<tr>
<td>Antenna Whip</td>
<td>ANT-418-CW-RAH</td>
<td>x2</td>
<td>$9.00</td>
<td>$18.00</td>
</tr>
<tr>
<td>390 Ohm ¼ Watt resistor</td>
<td>CF14JT390R</td>
<td>x1</td>
<td>$0.10</td>
<td>$0.10</td>
</tr>
<tr>
<td>Surface mount SMA RP connector</td>
<td>CONREVSMA001-ND</td>
<td>x2</td>
<td>$2.76</td>
<td>$5.52</td>
</tr>
<tr>
<td>Component</td>
<td>Part Number</td>
<td>Quantity</td>
<td>Cost 1</td>
<td>Cost 2</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------</td>
<td>----------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Atmel Microcontroller</td>
<td>ATTINY87-A15XZCT-ND</td>
<td>x1</td>
<td>$1.45</td>
<td>$1.45</td>
</tr>
<tr>
<td>Simple Switcher Boost Regulator</td>
<td>LM2698</td>
<td>x1</td>
<td>$4.18</td>
<td>$4.18</td>
</tr>
<tr>
<td>20 uH Inductor</td>
<td>732-3765-ND</td>
<td>x1</td>
<td>$1.15</td>
<td>$1.15</td>
</tr>
<tr>
<td>6.75 kOhm Resistor</td>
<td>CMF556K7500BHBF-ND</td>
<td>x1</td>
<td>$0.21</td>
<td>$0.21</td>
</tr>
<tr>
<td>20 kOhm Resistor</td>
<td>RSB-20KRTR-ND</td>
<td>x1</td>
<td>$0.88</td>
<td>$0.88</td>
</tr>
<tr>
<td>13 kOhm Resistor</td>
<td>CF14JT13K0TR-ND</td>
<td>x1</td>
<td>$0.01</td>
<td>$0.01</td>
</tr>
<tr>
<td>4.7 nF Capacitor</td>
<td>445-173598-3-ND</td>
<td>x1</td>
<td>$0.05</td>
<td>$0.05</td>
</tr>
<tr>
<td>12 uF Capacitor</td>
<td>173D126X9006EV3-ND</td>
<td>x1</td>
<td>$1.61</td>
<td>$1.61</td>
</tr>
<tr>
<td>22 uF Capacitor</td>
<td>478-3305-1-ND</td>
<td>x1</td>
<td>$10.31</td>
<td>$10.31</td>
</tr>
<tr>
<td>Thermal insulation</td>
<td>Superwool 607 HT Paper</td>
<td>x1</td>
<td>$78.70</td>
<td>$78.70</td>
</tr>
<tr>
<td>AA Battery Holder</td>
<td>BCAAL</td>
<td>x1</td>
<td>$0.75</td>
<td>$0.75</td>
</tr>
<tr>
<td>AA Battery</td>
<td>439-1010-ND</td>
<td>x1</td>
<td>$7.24</td>
<td>$7.24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$159.34</strong></td>
<td></td>
</tr>
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</table>

### 9.3. Totals

<table>
<thead>
<tr>
<th>Section</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$36,562.50</td>
</tr>
<tr>
<td>Parts x 2</td>
<td>$318.68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$36,881.18</strong></td>
</tr>
</tbody>
</table>
10. Ethical Analysis

This project will be done in accordance with the IEEE code of ethics.

1. To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

This project is being done with the intent to assist firefighters in combating fires and help reduce casualties caused by excessively high temperatures. It is our responsibility to design this device to be as helpful as possible with the least amount of hindrance or intrusion as possible. This project is not intended to help public as a whole. We will disclose any and all technical data concerning our project to any who wish to utilize it and inform them of any potential issues caused by either design or production.

2. To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;

We do not anticipate any conflicts of interest with this project, as there is little if any benefit to allowing firefighters to carry out their duties without as much knowledge of the environment as possible. Should any arise, we will inform any and all affected by these conflicts of interest, and will inform the end users of this project as well.

3. To be honest and realistic in stating claims or estimates based on available data;

All data reported will be done so in a manner that is as clear and concise as possible. There will be no fabrication of data, and any claims will be supported by measured data.

4. To reject bribery in all its forms;

Similar to the second point of the IEEE code, we do not anticipate any attempts to bribe us into mismanaging this project. Should any attempts arise, we will refuse any and all bribery and report these attempts immediately.

5. To improve the understanding of technology; its appropriate application, and potential consequences;

We will distribute technical specifications to our end users and any who desire to appraise them.

6. To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
As graduating students at the University of Illinois, we will continue to strive for technical excellence with this project, and will work with Illinois staff and other related experts to ensure that our project is one that can meet its goals and assist others in a competent manner.

7. **To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;**

We will seek out assistance for our project on a regular basis and consider every piece of advice regarding our project’s performance and safety. We will also strive to provide such advice should we be sought out for similar assistance. Should any major safety hazards be uncovered in our project, we will work to correct them with haste.

8. **To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;**

Our project design is intended work in conjunction with an already existing device created to be used by all. We will not tamper with this facet of the project and will not intentionally bar any from using our device.

9. **To avoid injuring others, their property, reputation, or employment by false or malicious action;**

We will not slander anyone or conduct ourselves with malicious intent towards others.

10. **To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.**

We will strive to uphold the IEEE code of ethics as we work on this project, and will encourage each other to uphold the code of ethics as well.

11. **Safety Statement**

The main objective of this project is to improve safety for firefighters by detecting if a firefighter is being exposed to temperatures too high for their equipment. It achieves this through two LEDs, the first relating to the firefighter’s safety and the second relating to other firefighters’ safety. When a green light is being emitted from the first LED, this signifies the firefighter is safe from the ambient temperatures. When a yellow light is being emitted from the first LED, this signifies the firefighter is being exposed to temperatures that could become dangerous, and alerts them to proceed with caution. When a red light is being emitted from the first LED, this indicates the firefighter is in danger and should leave the area immediately. The second LED only emits a red light. This signifies that another firefighter is in danger and other firefighters should be aware of this.
This device has an LED that indicates sufficient battery life, this prevents the firefighter from unknowingly entering a fire when the device is dead. In order to protect the internal circuitry, superwool thermal insulation will be used.

While this project is being created and worked upon, we will reduce the risk of accidents by maintaining a clean and dry workspace, and we will be neat and orderly when attempting to wire or solder. During all heat based testing, such as when using an oven to confirm thermistor functionality, proper protective gear will be worn, e.g. oven mitts.

This device will not be handling voltage levels above 5V, nor will any electrical current run through a human body during operation. Should an accident occur where a human body is used as a medium for electricity from this device, it is highly unlikely for a person to die from 5V, given that roughly 100mA of current is needed to induce death in a human. On a human under normal conditions, the maximum current one would be exposed to from this device would be would be 5mA.

12. References


