ECE ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Solar/Motion Powered Shoe Heater

ECE 445

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Professor Singer (TA Igor Federov)

Introduction

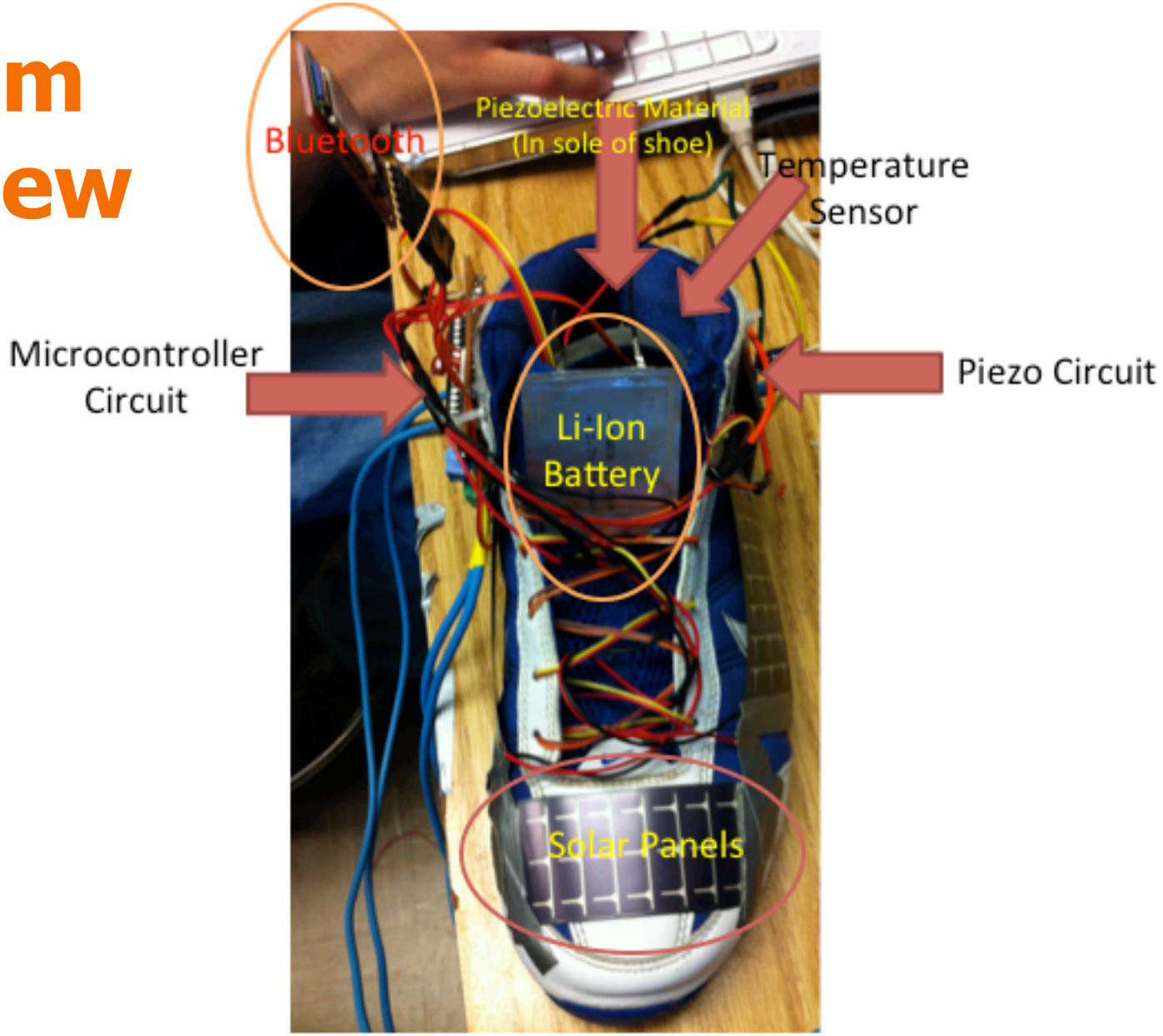
- Warmth and comfort are essential for outdoor winter activities

- Implementing sustainable/ renewable energy to warm shoe interior

Objectives

- User friendly
- Energy efficiency
- Temperature monitoring
- Real-time app updates

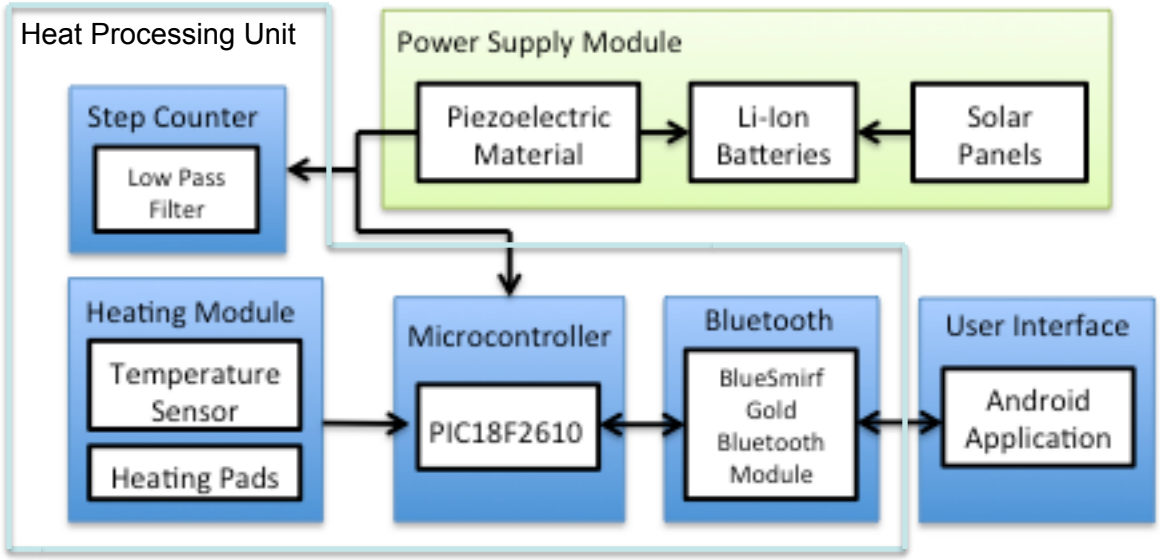
System Overview



System Overview

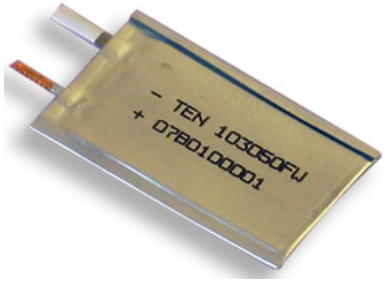
- Hardware
  - Power supply module, heat processing unit
- Software
  - Android application

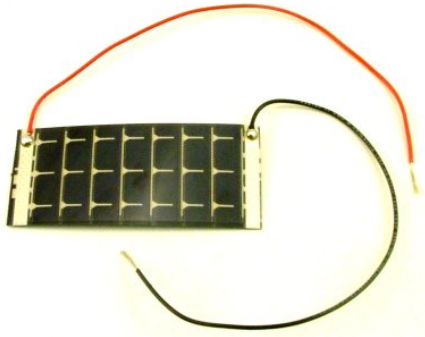
System Overview

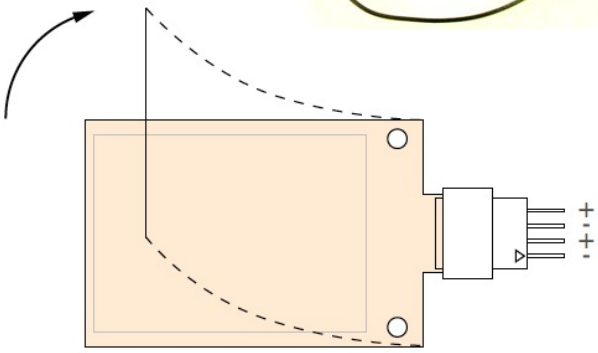


Power Supply Overview

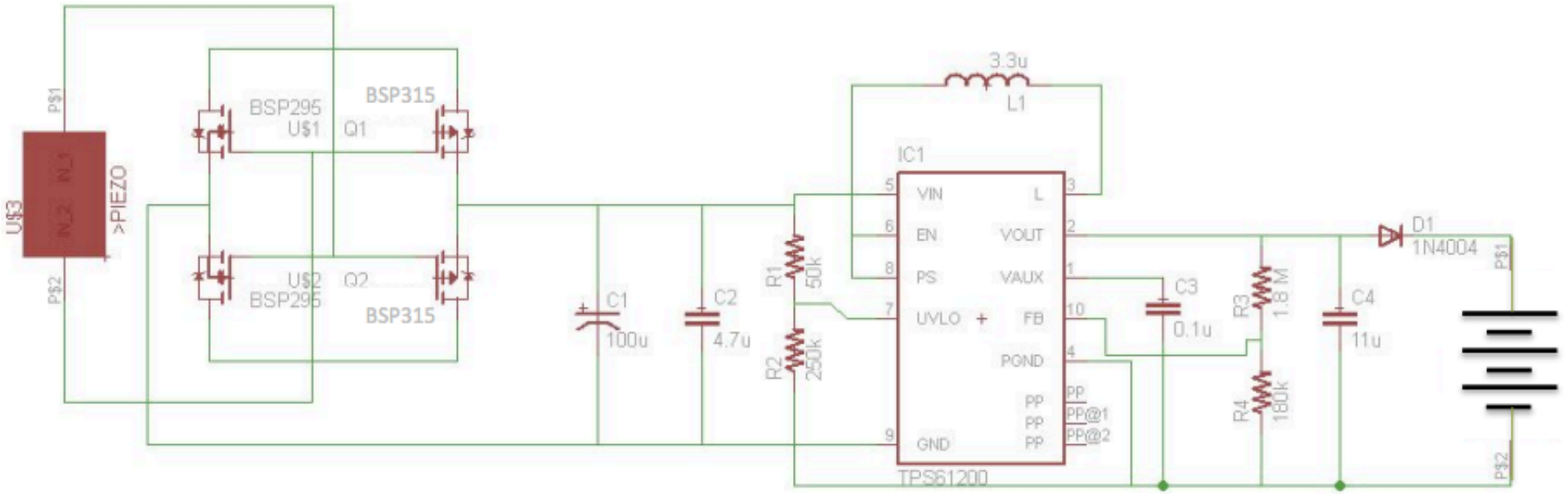
- (3) 3.7 V Polymer Li-Ion Rechargeable Batteries
  - Supplies 360mA
- (3) Solar Panels
  - Supplies 22mA
- (1) Piezoelectric material (PDVF)
  - Voltage/current are vibration dependent





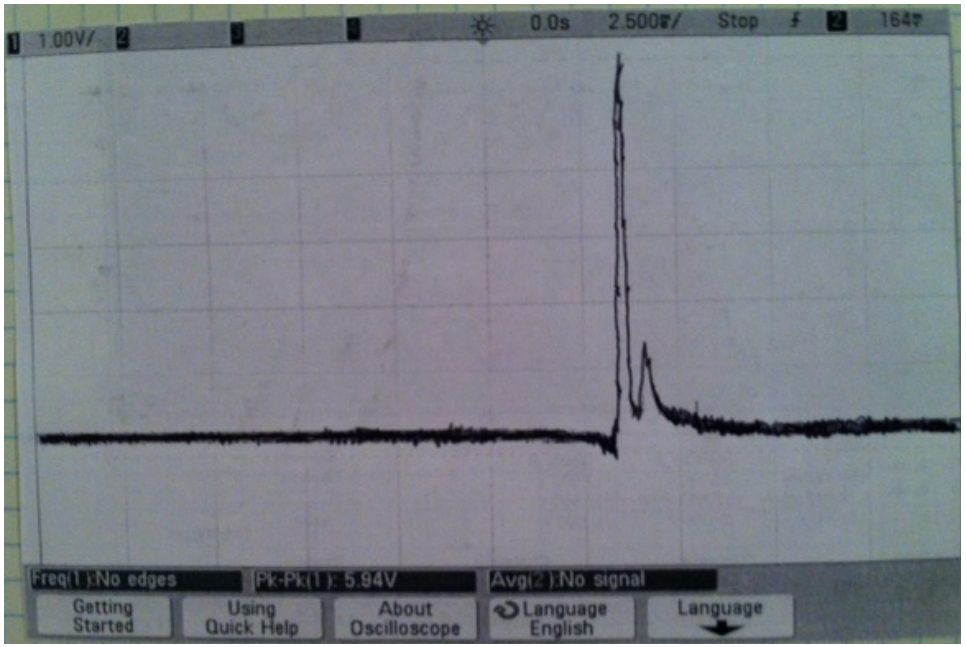


Piezoelectric Circuit (Schematic)



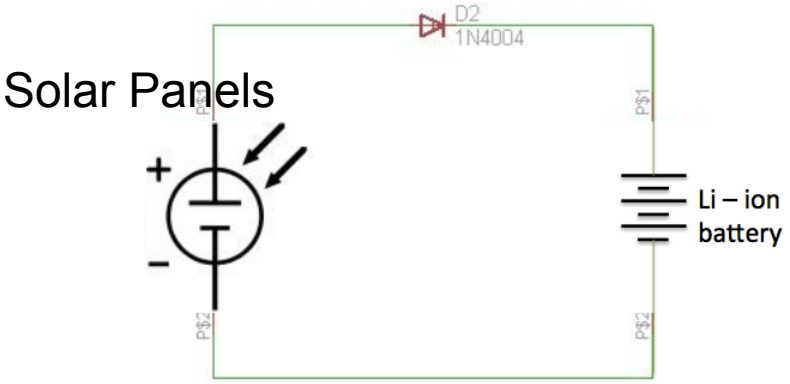
Piezoelectric Circuit Results

Open-Circuit



Rectified Output

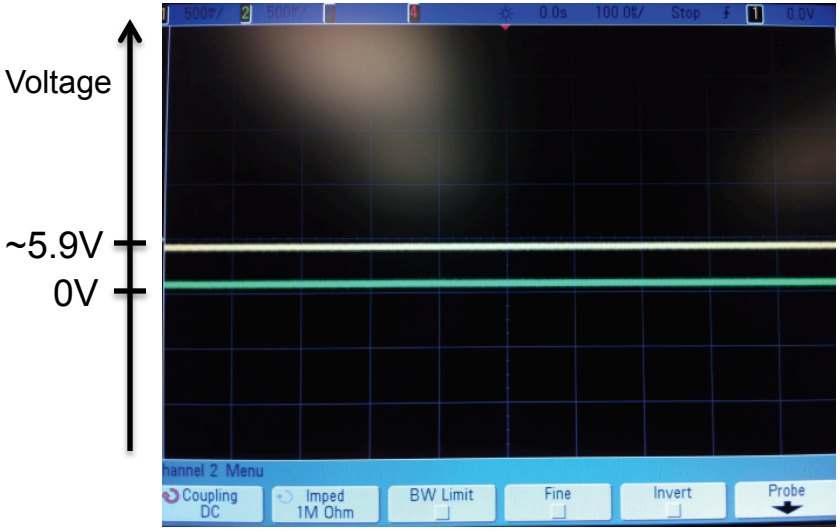
Solar Panel Circuit Testing



Schematic

- Shined light on solar panels
- Measured output on oscilloscope

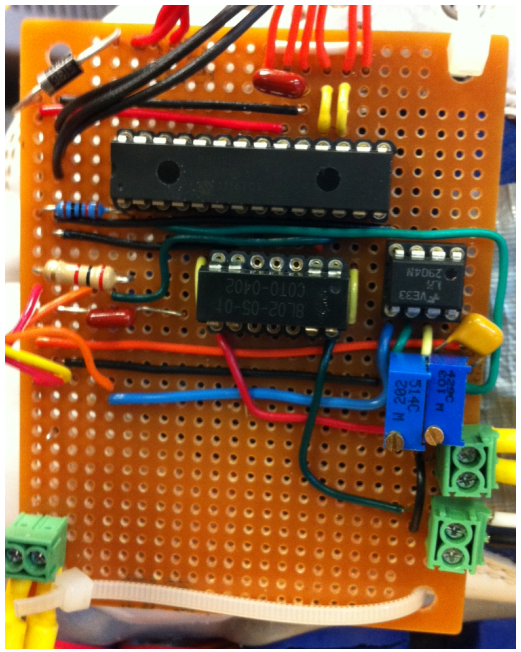
	Current (mA)	Voltage (V)
Open-Circuit	0	5.9
Closed-Circuit	22	4.2



Results

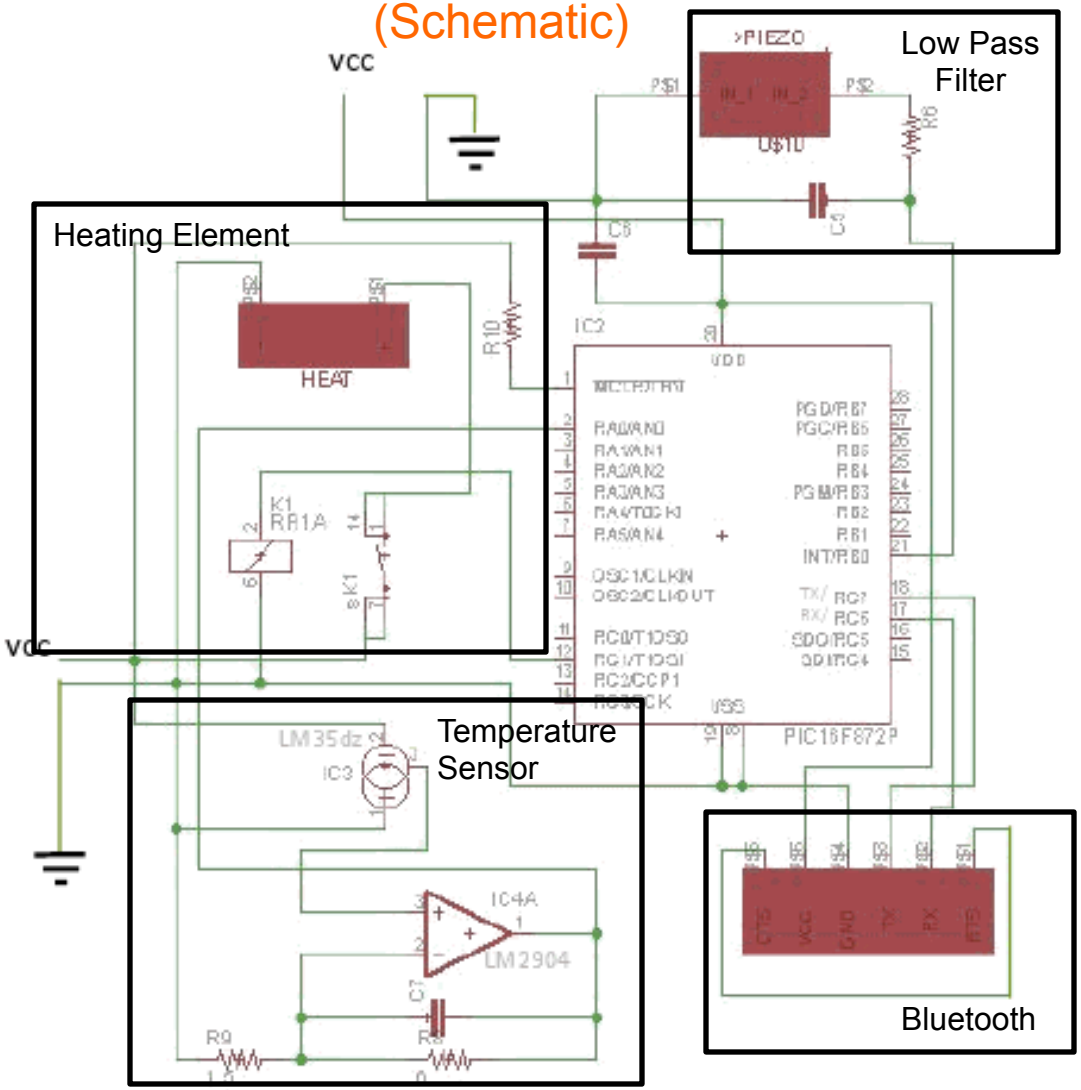
Heat Processing Unit

- PIC Microcontroller
- USART Serial Communication with mobile device
- Bluetooth Module
- Temperature Monitoring



Heat Processing Unit

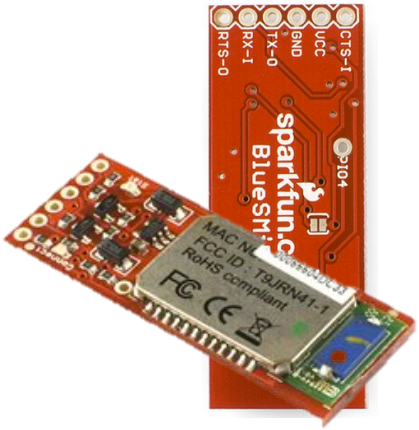
(Schematic)



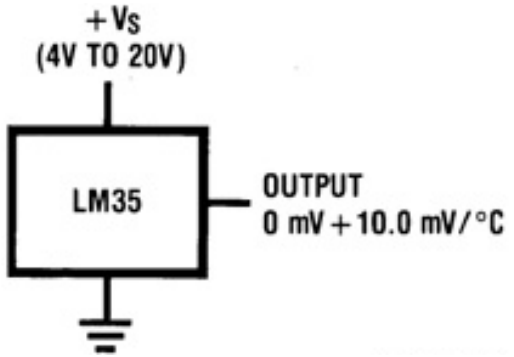
Heat Processing Unit Testing

- Bluetooth
  - Connectivity
  - Interface with PIC (Transmit/Receive)

BlueTerm



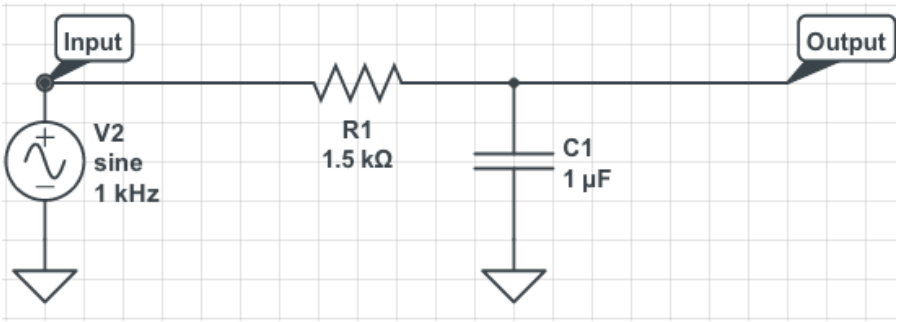
- Temperature Sensor
  - Heat sensor and read output voltage



Heat Processing Unit Test

- Step Counter (LPF)
  - Cut-off frequency (~ 100Hz)
    - R=1.5kΩ
    - C=1μF

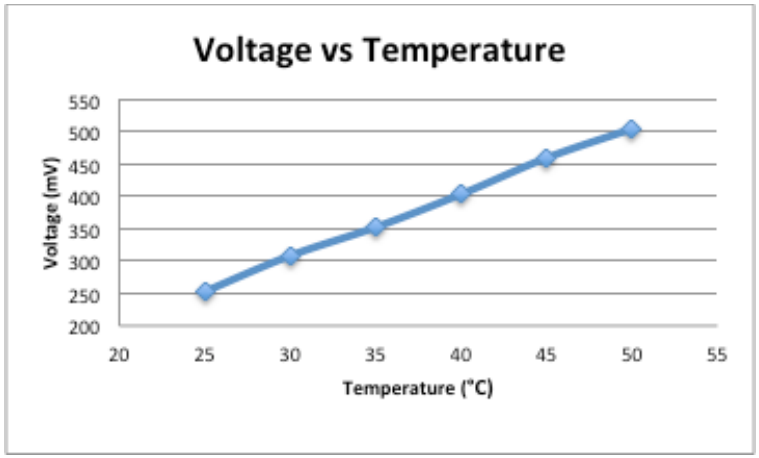
$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(1.5k)(1\mu)} = 106.1\ Hz$$



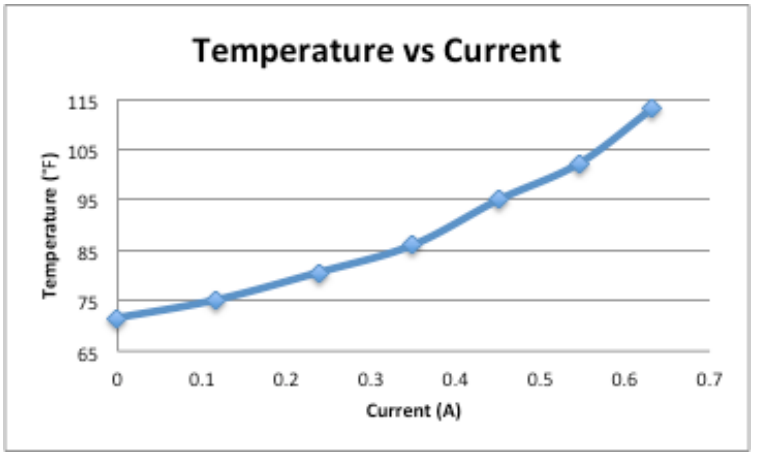
- Heating Pads
  - Rated at 5V

Heat Processing Unit Results

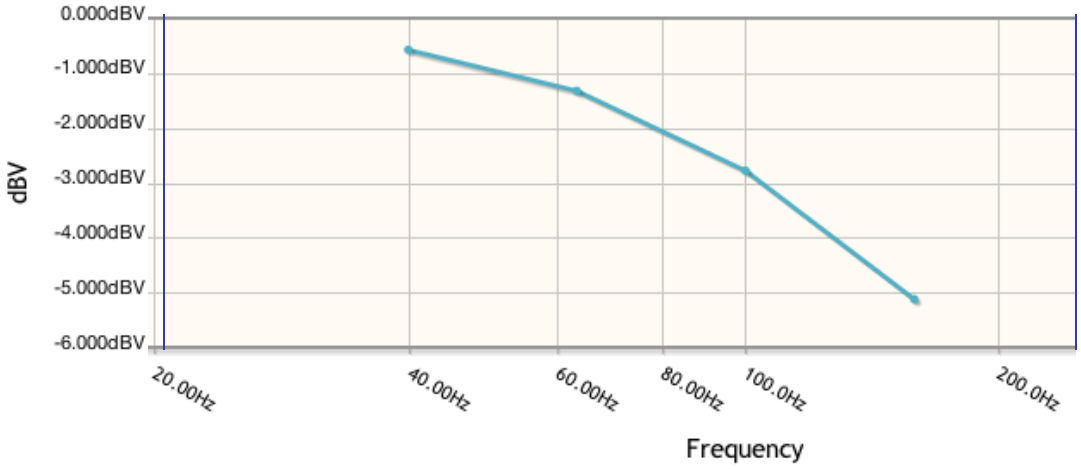
Temperature Sensor:



Heating Pads:

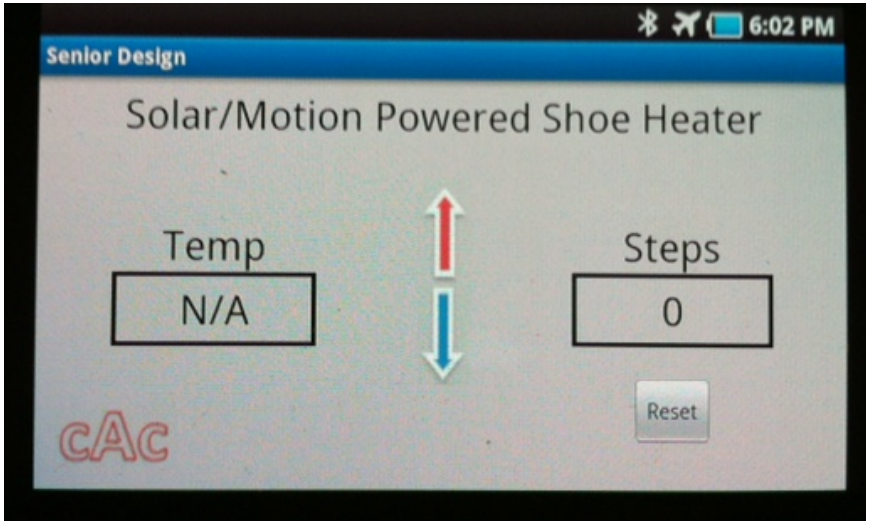


Low Pass Filter Plot



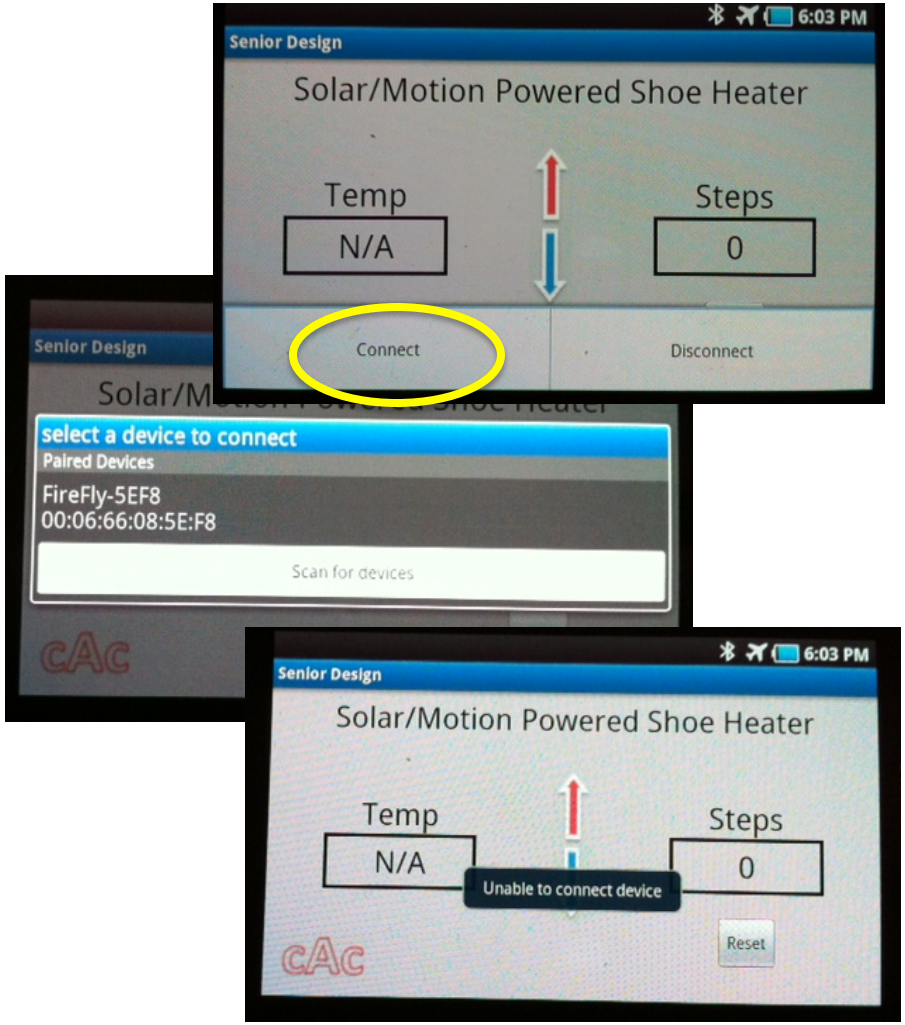
User Interface Overview

- User-friendly Interface
- Real time updates
- Reset button to manage step count
- Directional temperature control



User Interface Testing

- Connect to Bluetooth
- Temperature display
- Step counter reset



Complete System Testing

Requirements

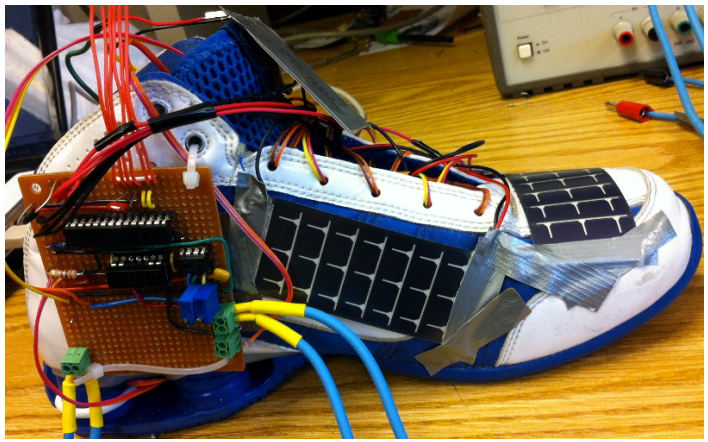
- Recharge batteries
- Power heat processing unit
- Heat shoe
- Count steps
- Real time update

Testing

- Discharged batteries
- Connect batteries to circuit
- Change and monitor temperature change using app
- Simulate walking gestures with shoe

System Results

- Batteries power circuit
- System connects to mobile device
- Pressing UP button increases temperature
  - Increase from 25°C to 31°C
- Displays real time temperature



Successes

Hardware

- Battery powered
- Piezoelectric circuit on PCB
- Heat processing unit on vector board
- Shoe implementation

Software

- Android Application with real time updates
- Transmit/Receive data at 9600 baud rate

Challenges

Hardware

- System wiring/soldering
- Power supply efficiency
- Design changes
- Maximizing heating

Software

- Transmit/Receive data at 9600 baud rate
- Interrupts and ADC

Recommendations

Hardware

- Place complete system on one PCB
- Power switch
- Current to heating pads
- Piezoelectric material
- Part selection

Software

- Desired temperature display
- User feedback
- Heating implementation


There's nothing worse than having COLD feet!
Questions?