Glove For Programmable Prosthetic Hand

Electrical & Computer Engineering

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Team 55

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Overview

1. Problem
2. Solution
3. Project Demo
4. Hardware Design
5. Software Design
6. Creating the Demo
7. Verifications
8. Conclusions

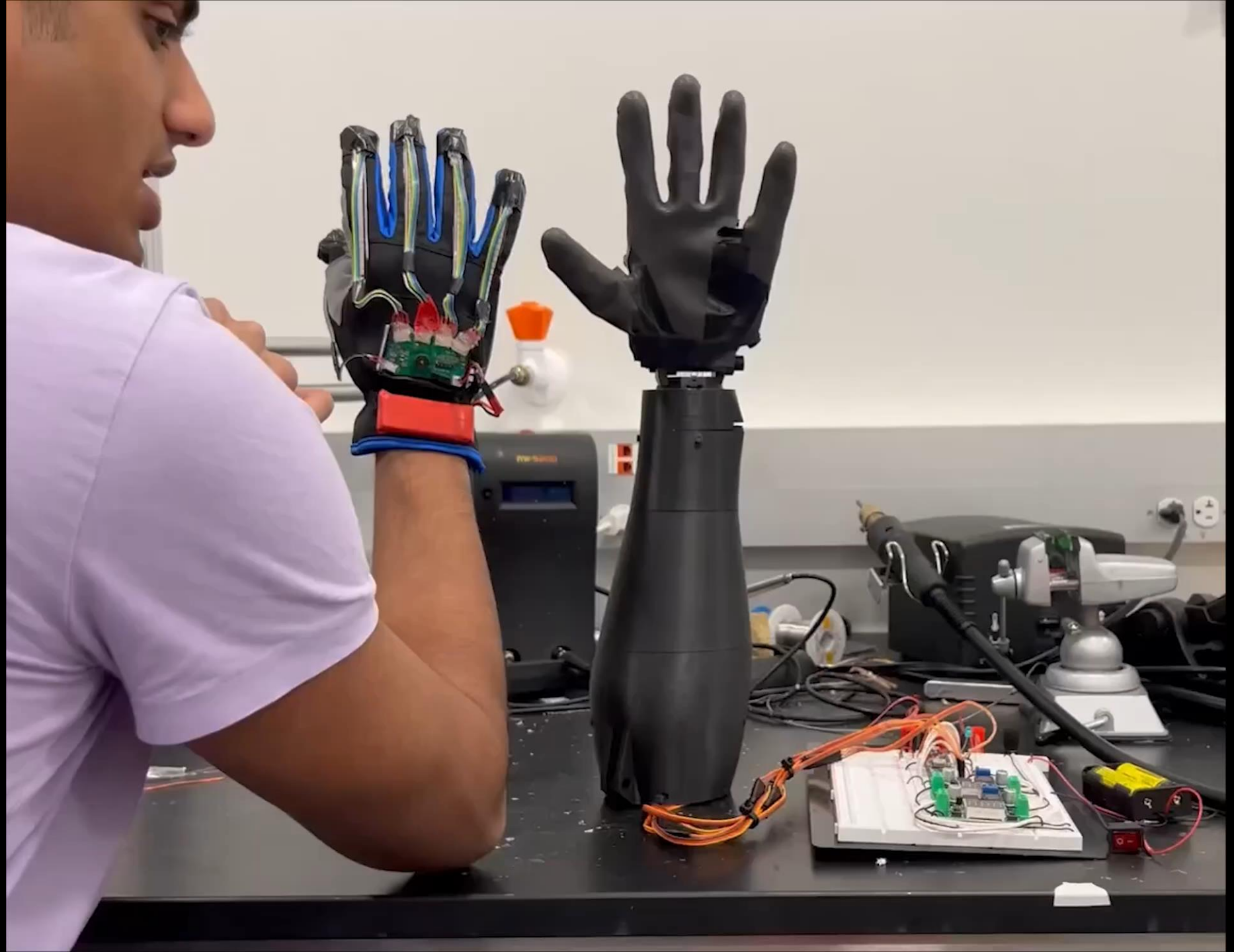
Problem

Budget prosthetic limbs offer basic level of control but lack finer control, this can be solved with a quality robotic hand but involves a much higher cost.

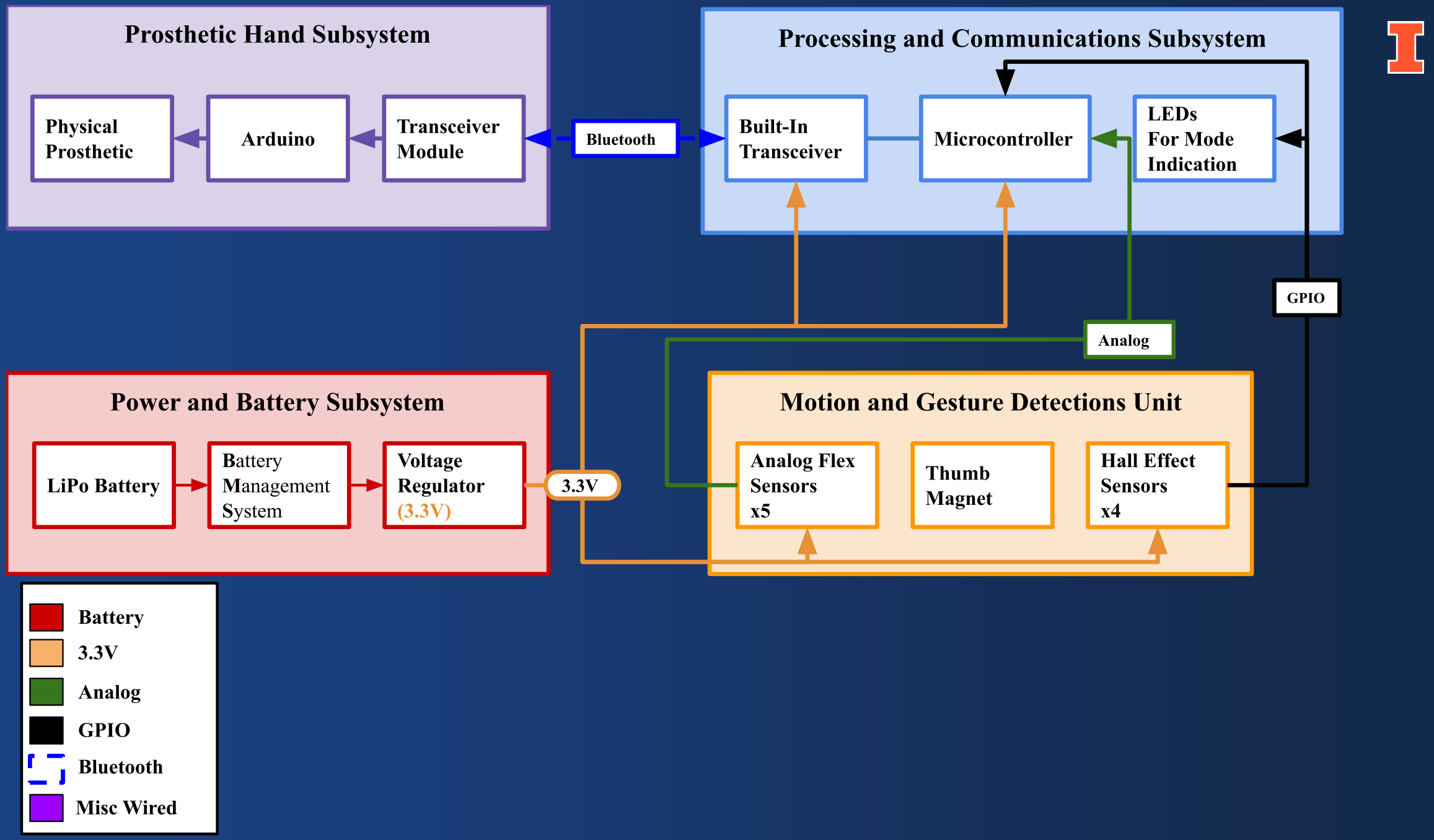
Our Solution

Using a hardware/software solution to measure organic hand positions and translate measurements to hand movements.

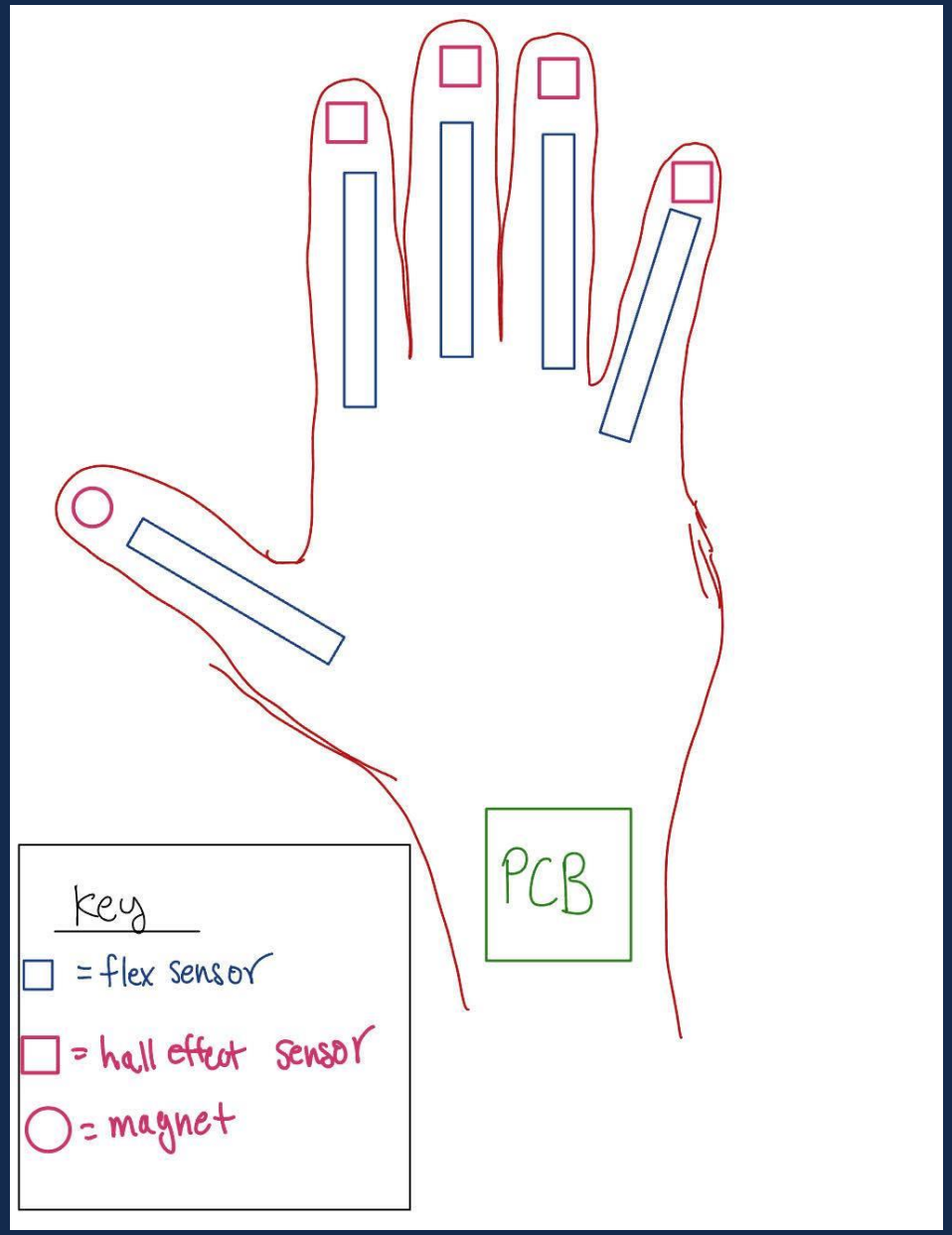
Project Demo

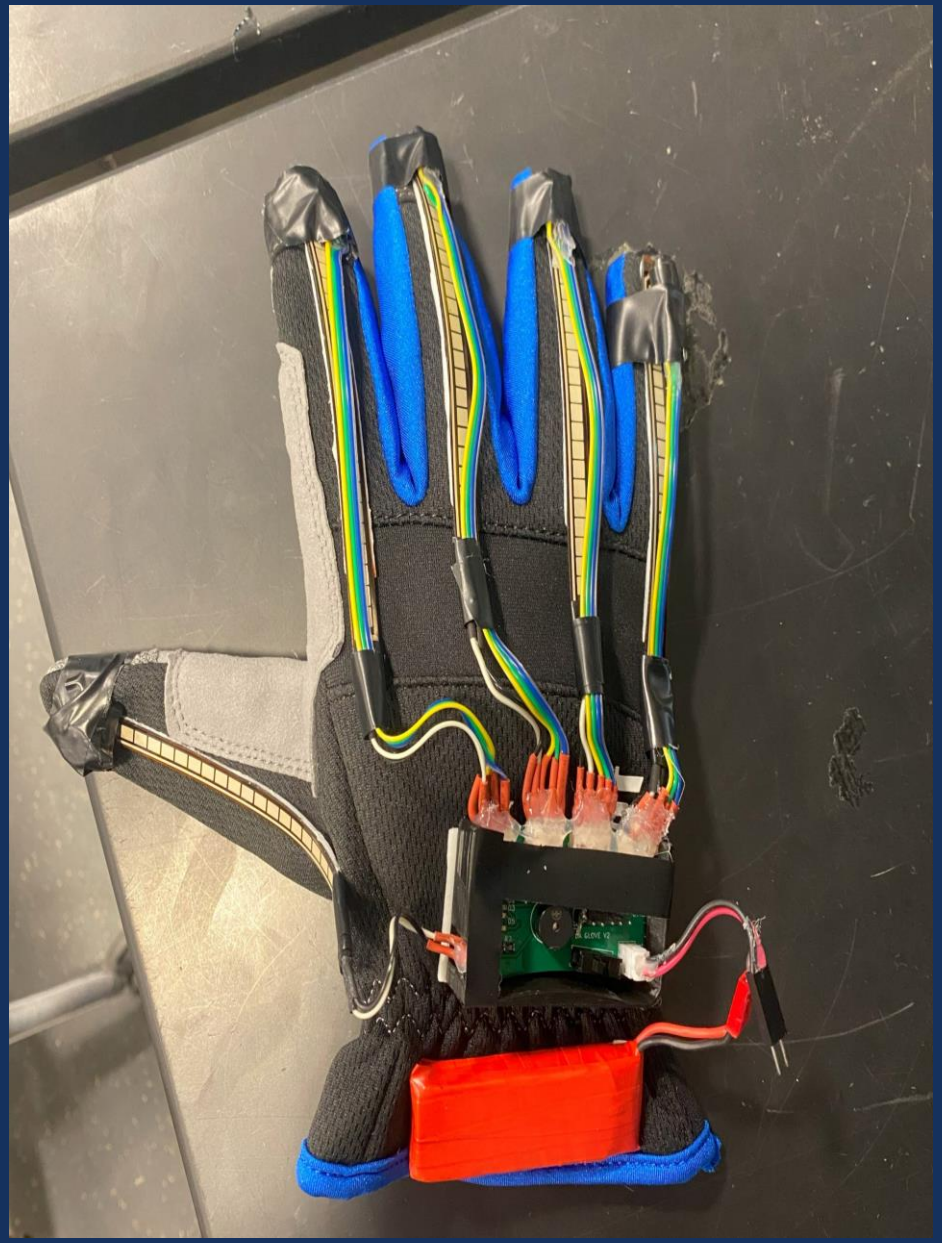


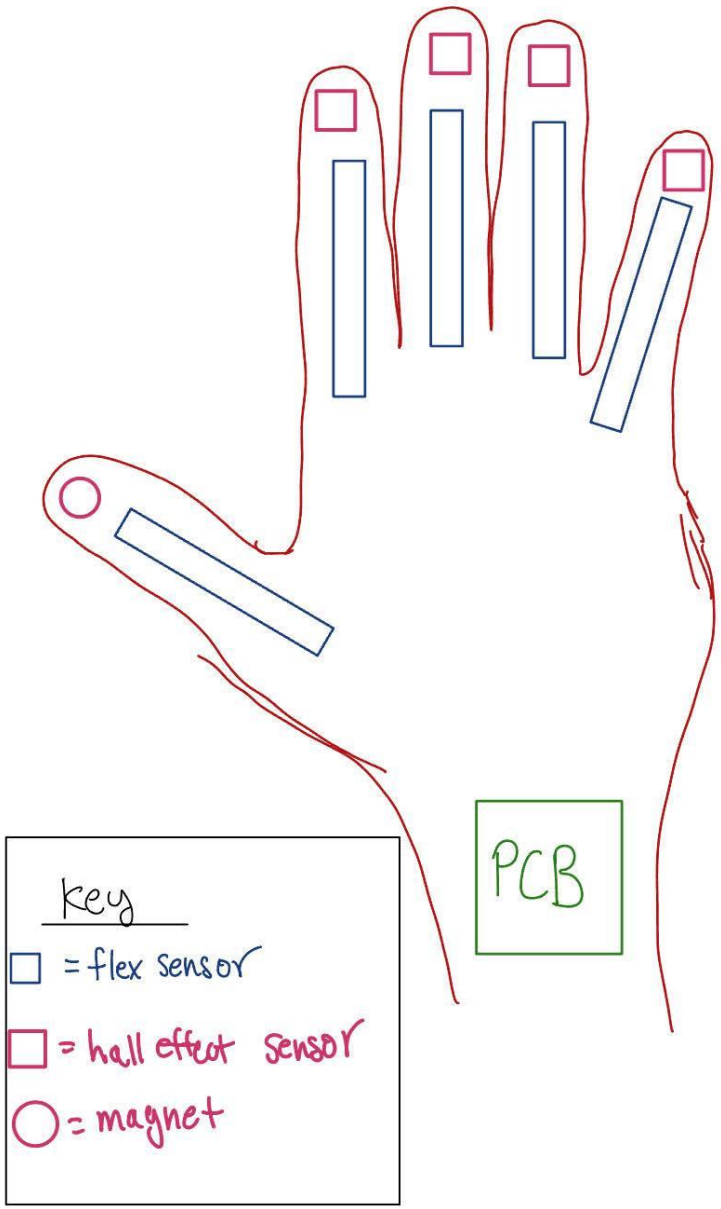
Hardware Design


Prosthetic Hand Subsystem
Physical Prosthetic
Arduino
Transceiver Module
Bluetooth
Processing and Communications Subsystem
Built-In Transceiver
Microcontroller
LEDs For Mode Indication
GPIO
Analog
Power and Battery Subsystem
LiPo Battery
Battery Management System
Voltage Regulator (3.3V)
3.3V
Motion and Gesture Detections Unit
Analog Flex Sensors x5
Thumb Magnet
Hall Effect Sensors x4
Battery
3.3V
Analog
GPIO
Bluetooth
Misc Wired

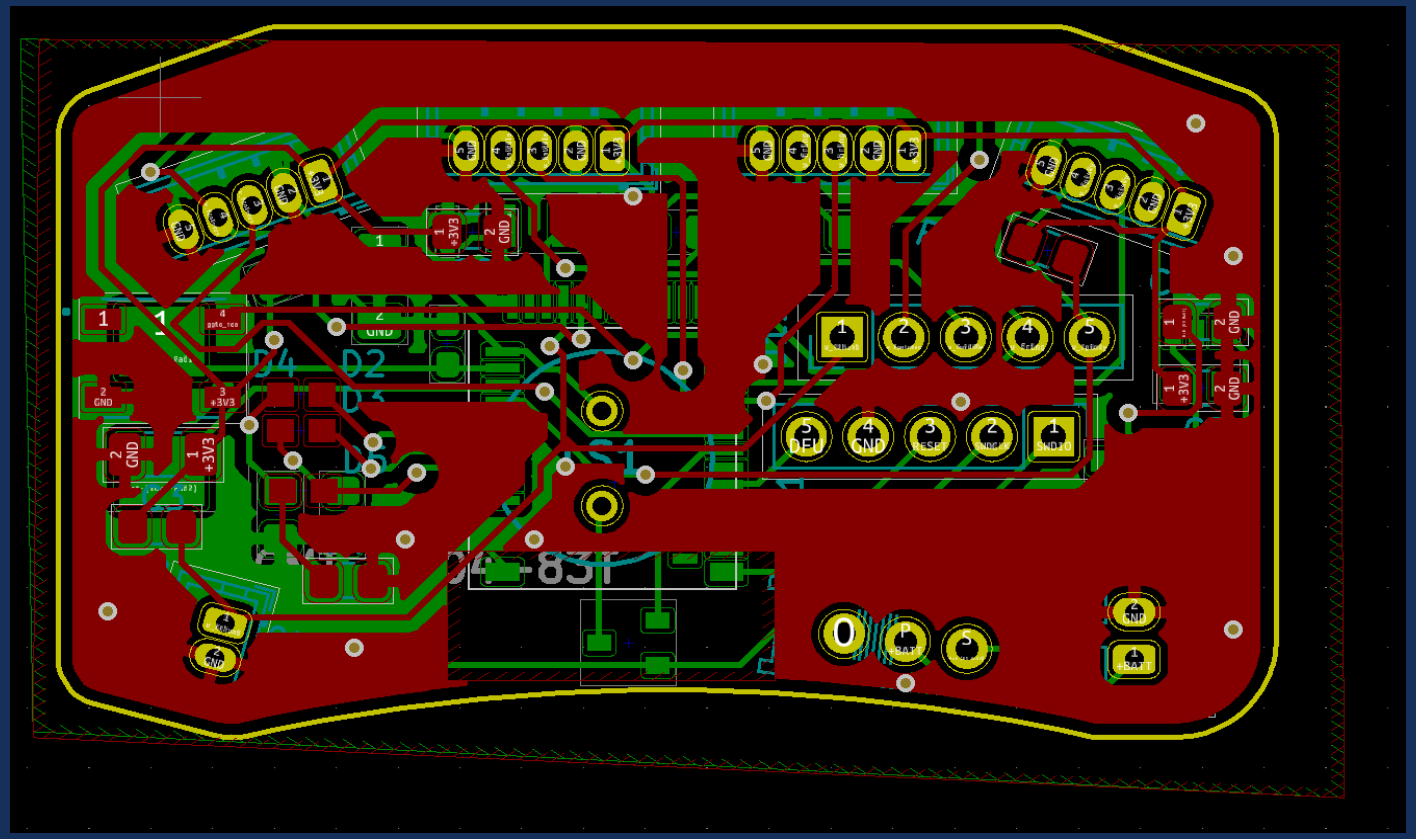
Product Realization



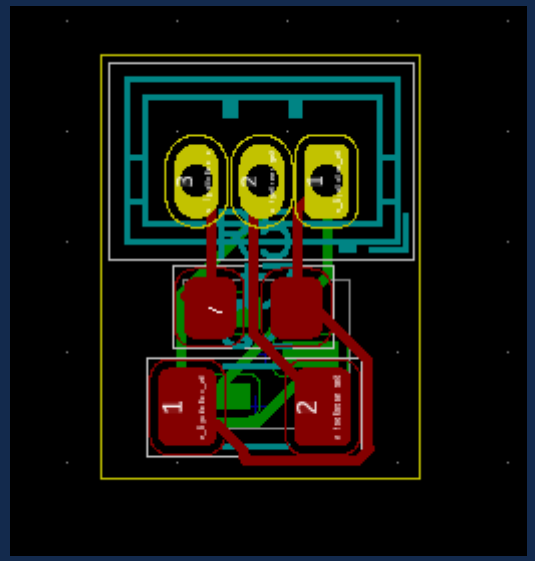



PCB
Key
= flex sensor
= hall effect sensor
= magnet

PCB Design

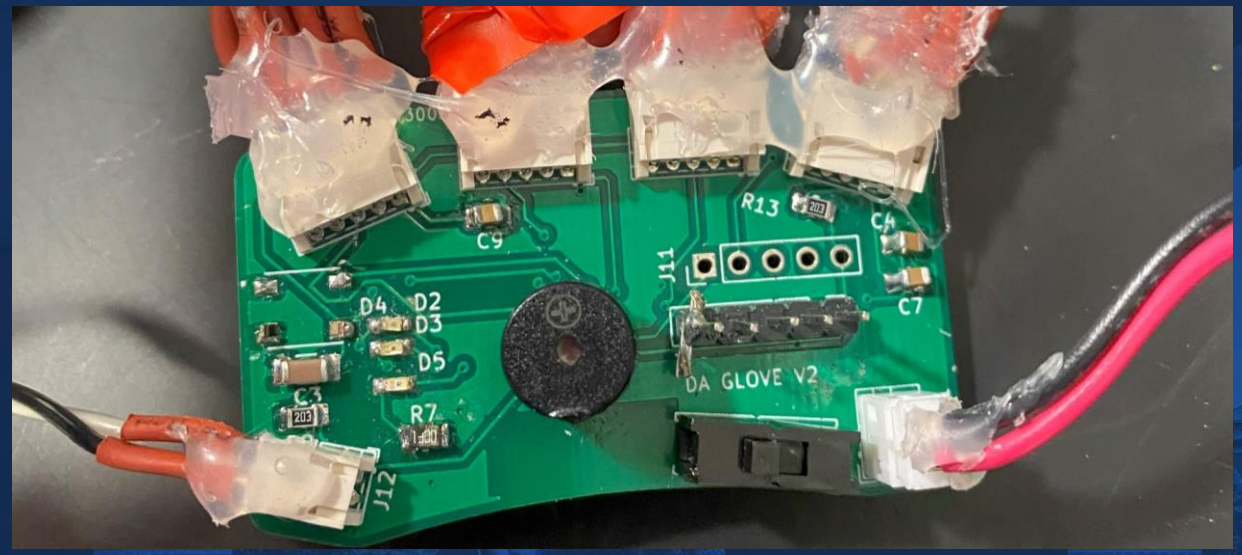


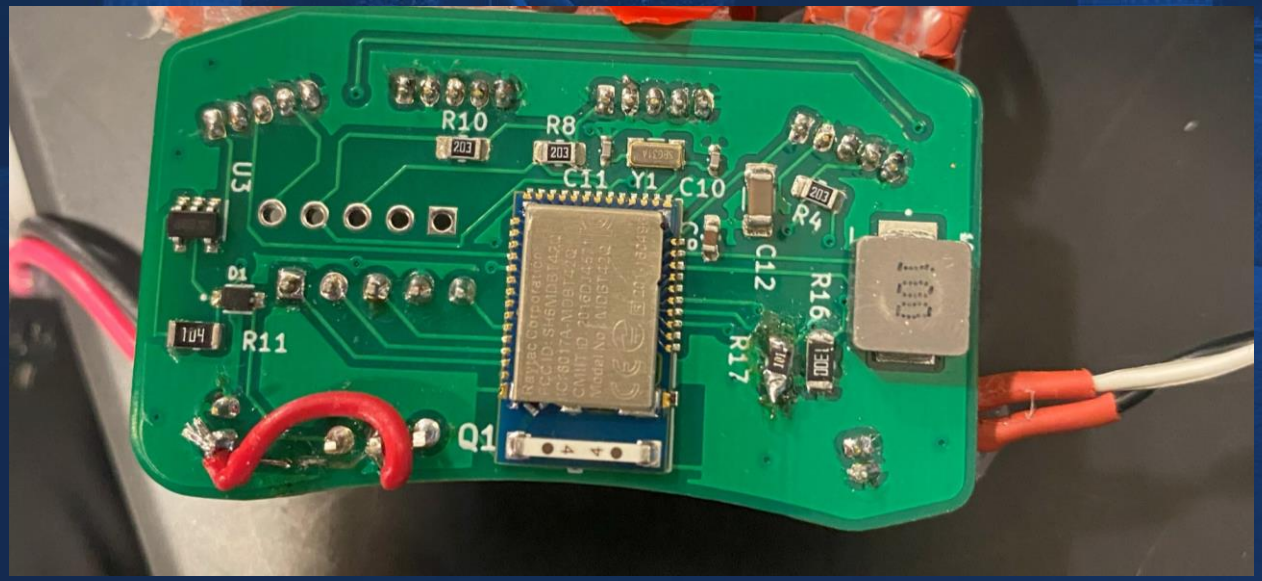
Hand PCB x 1 : Mounted on back of hand

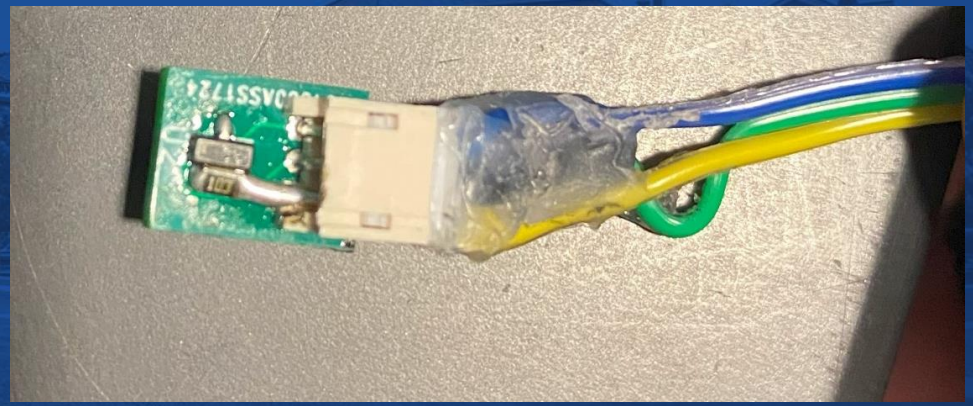


Finger PCB x 4 : Mounted on back of Pointer, Middle, Ring, Pinky

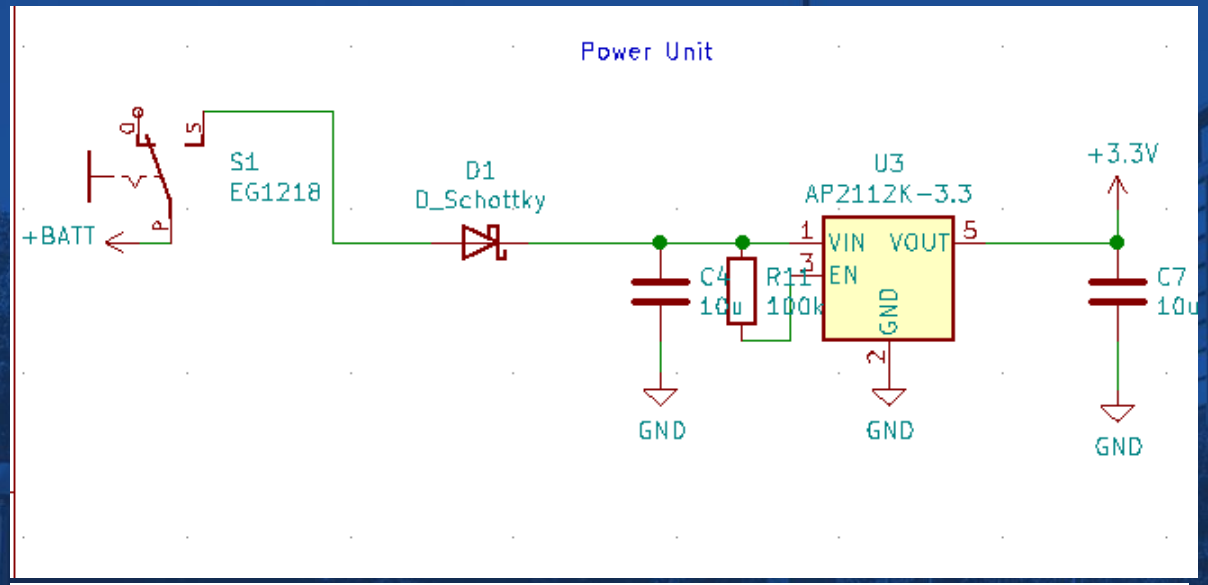
Manufactured PCB

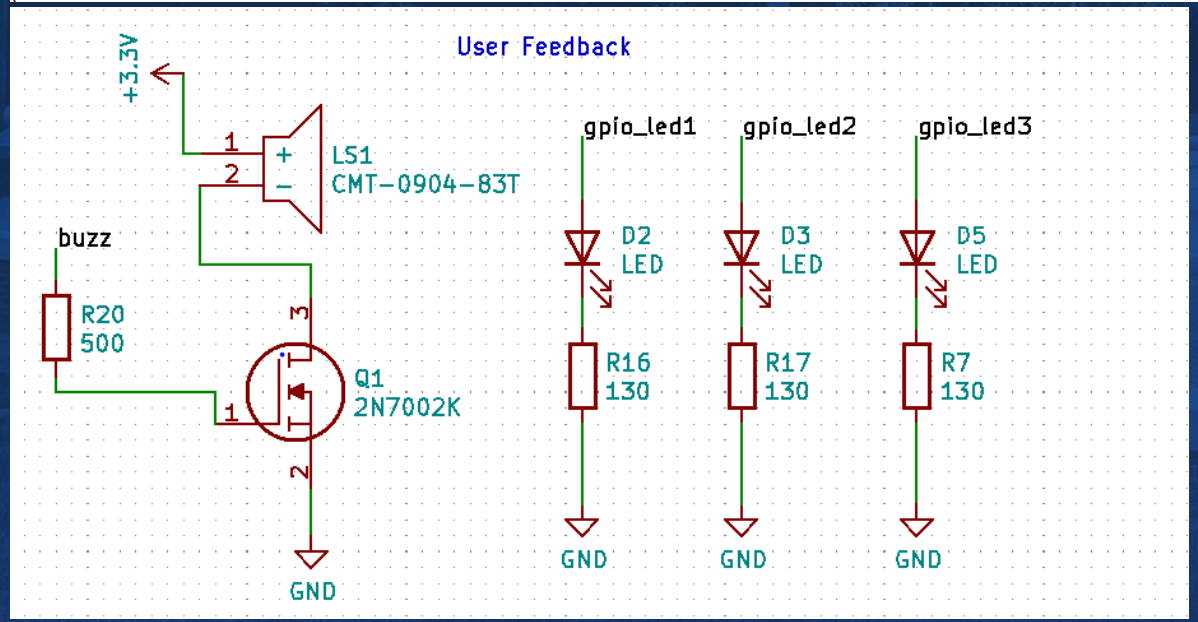


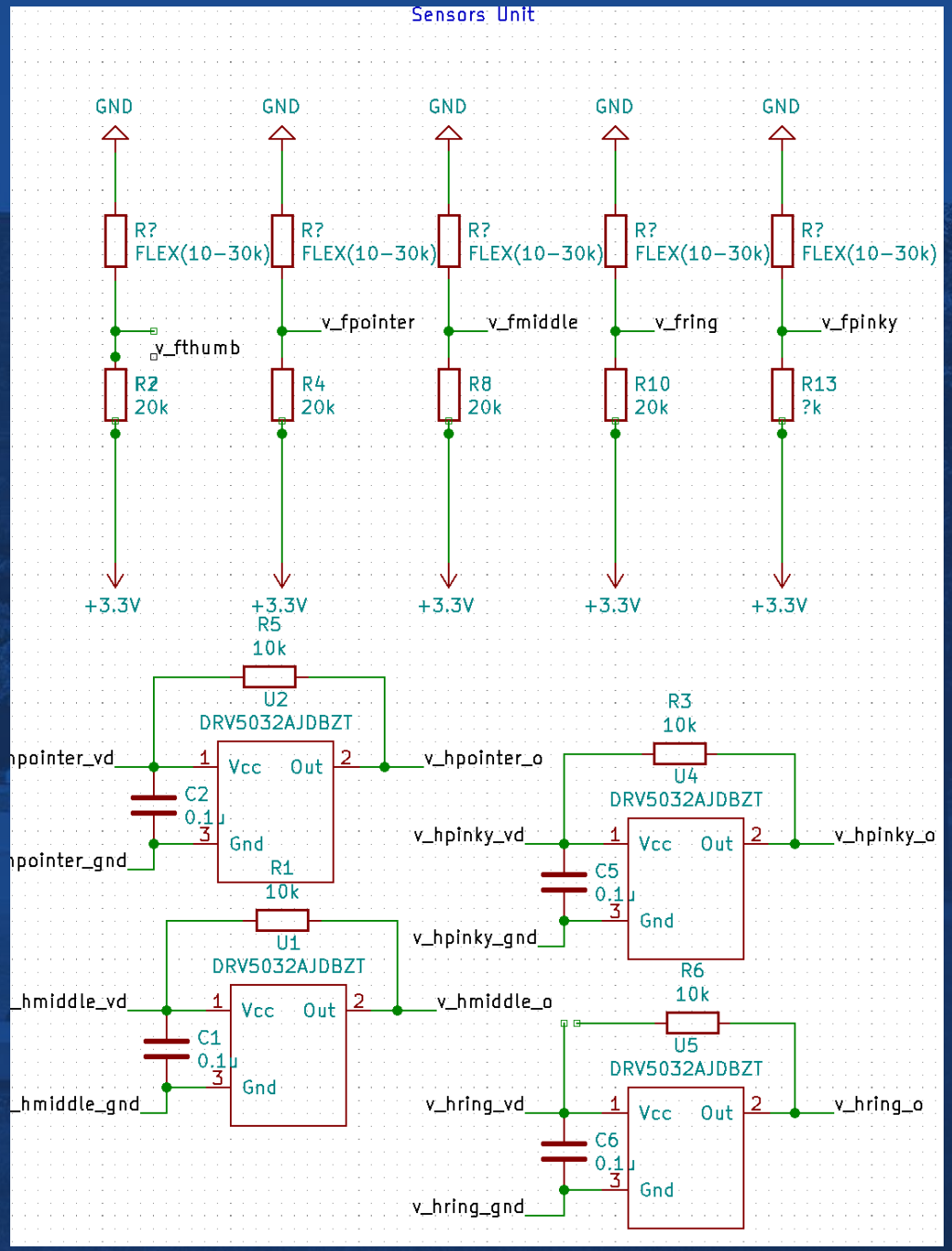




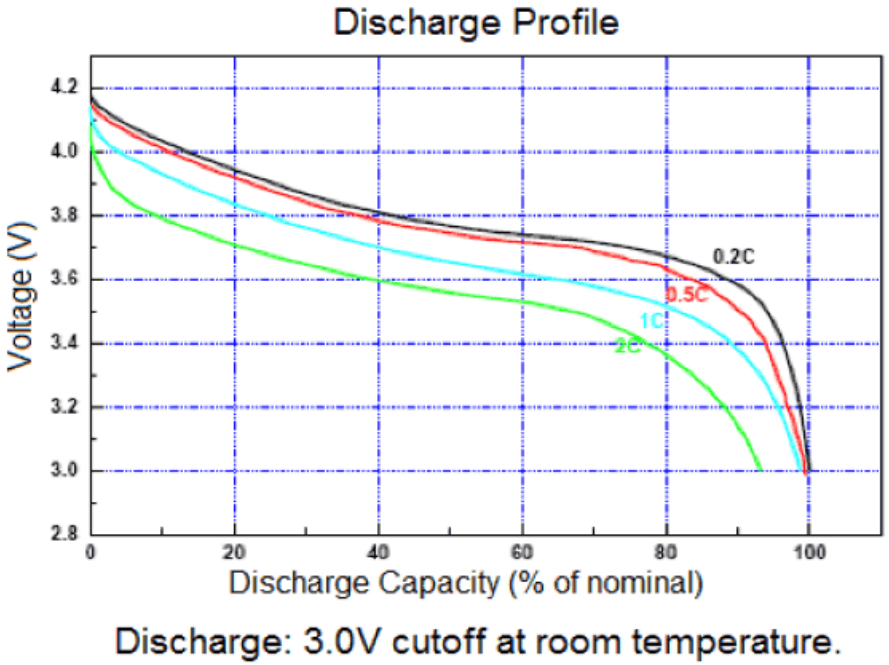
Circuit Sub-Systems







Battery Solution (LiPo)



Discharge: 3.0V cutoff at room temperature.

Powers system in mirroring mode for ~40 Hours theoretically

Charges from External Charger

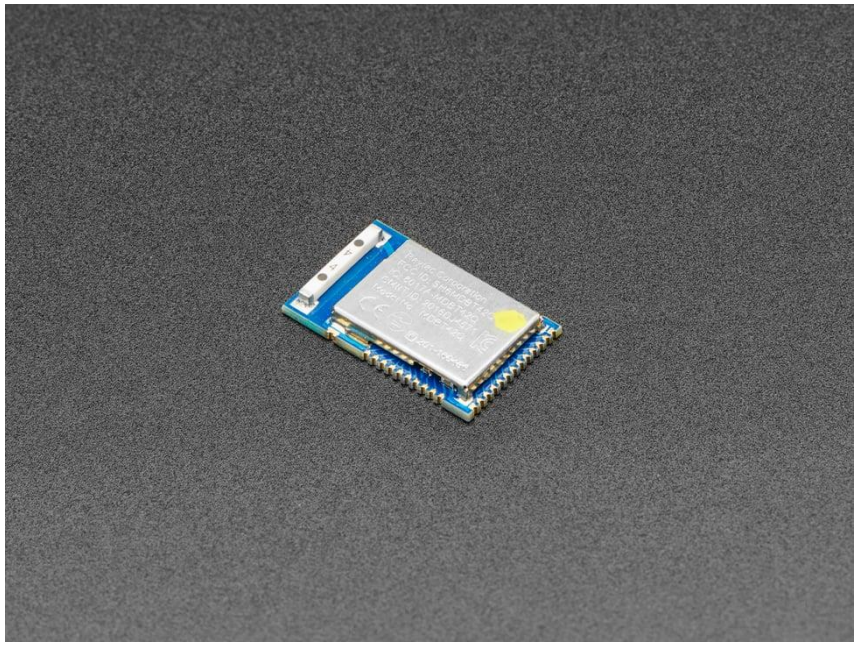
Operates higher than Schottky (0.175 V) + LDO Dropout (0.1 V) for most of discharge range

Software Design

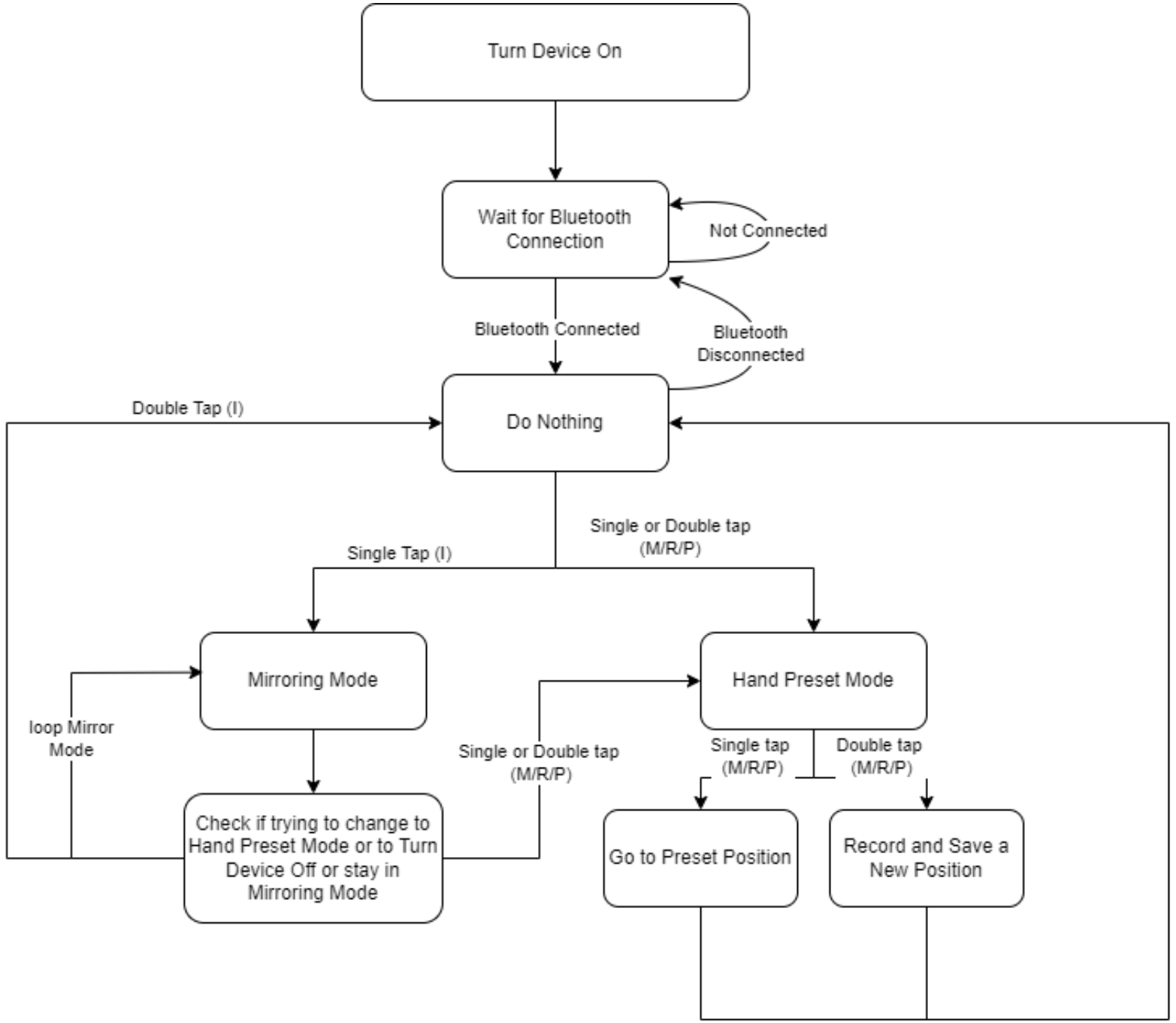
Adafruit NRF52832

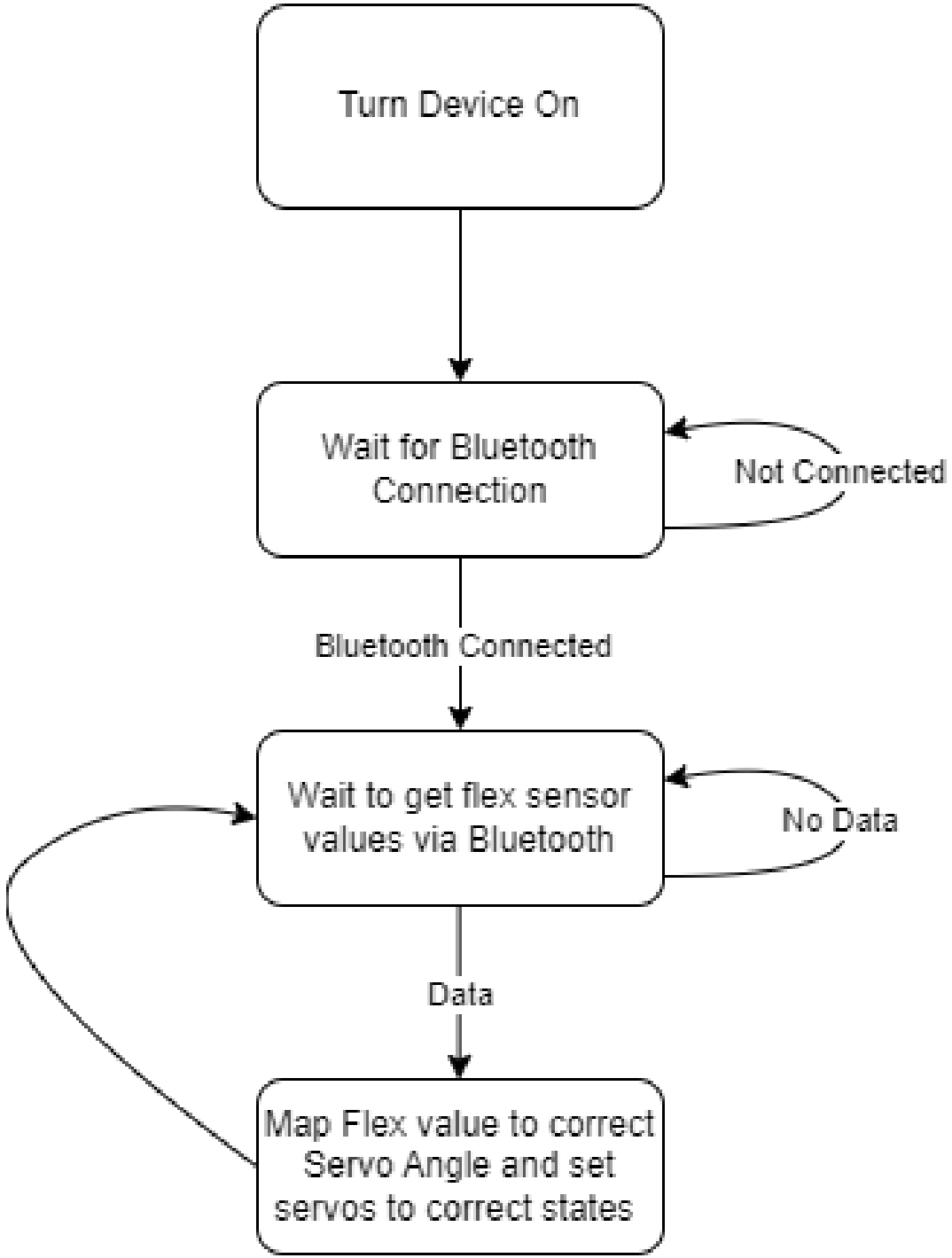
Why this Micro?

- Uses Low Power Bluetooth
- Has Libraries that lets us use Arduino IDE
- ADC’s allow high impedance sensors
- Low cost
- Built in antenna



Flow Chart Adafruit

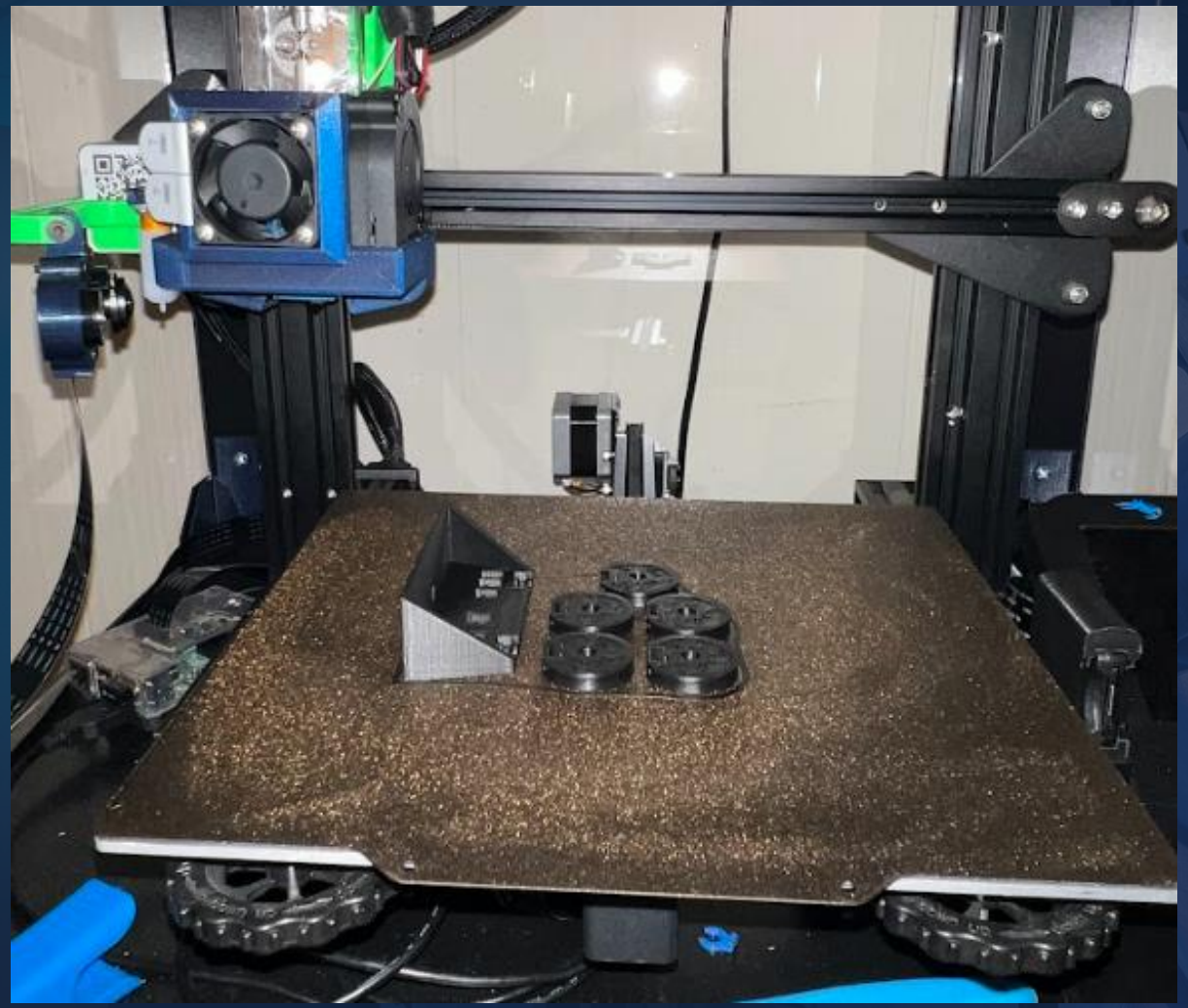


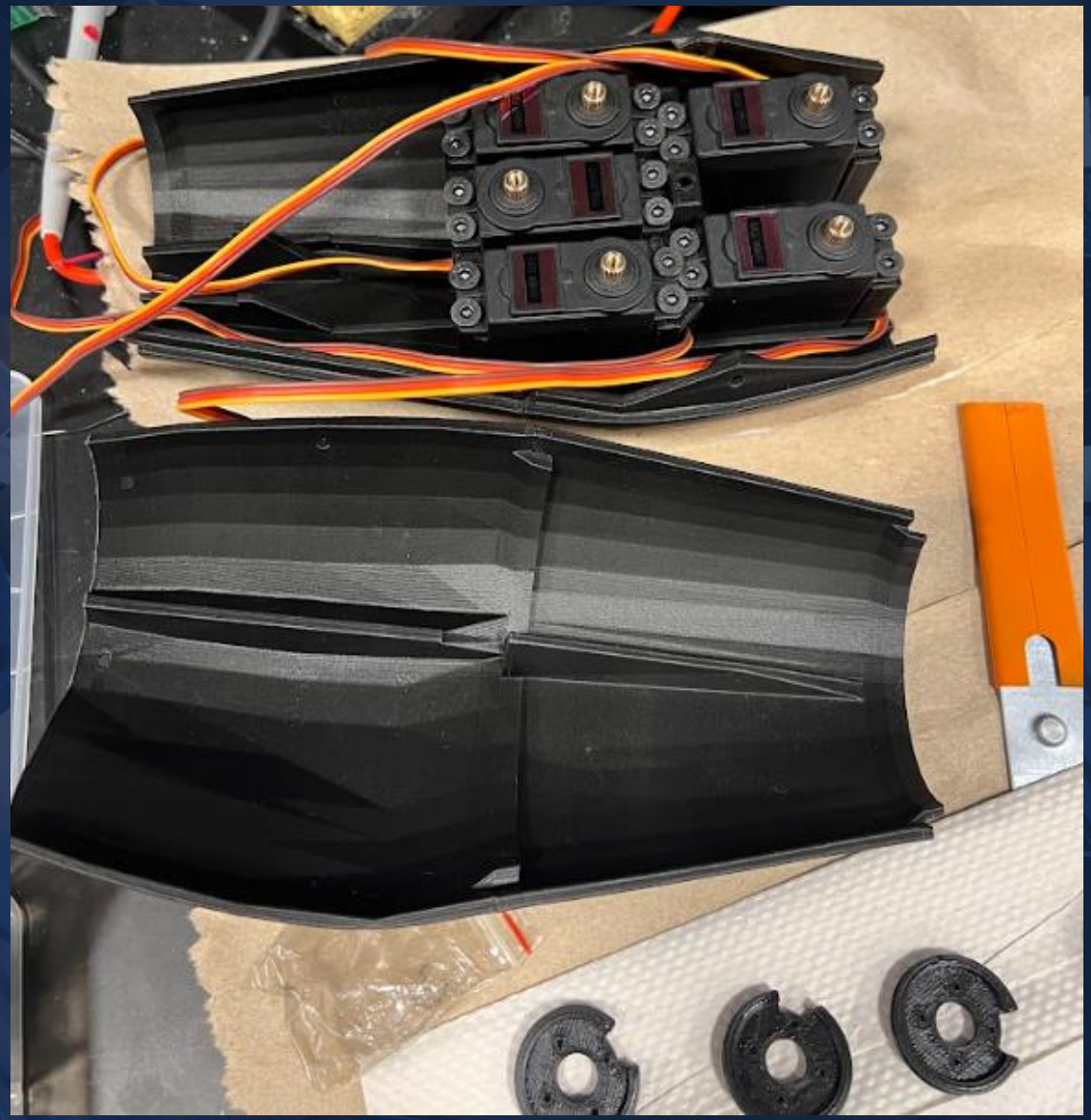


Flow Chart Arduino

Creating the Demo

Constructing the Hand

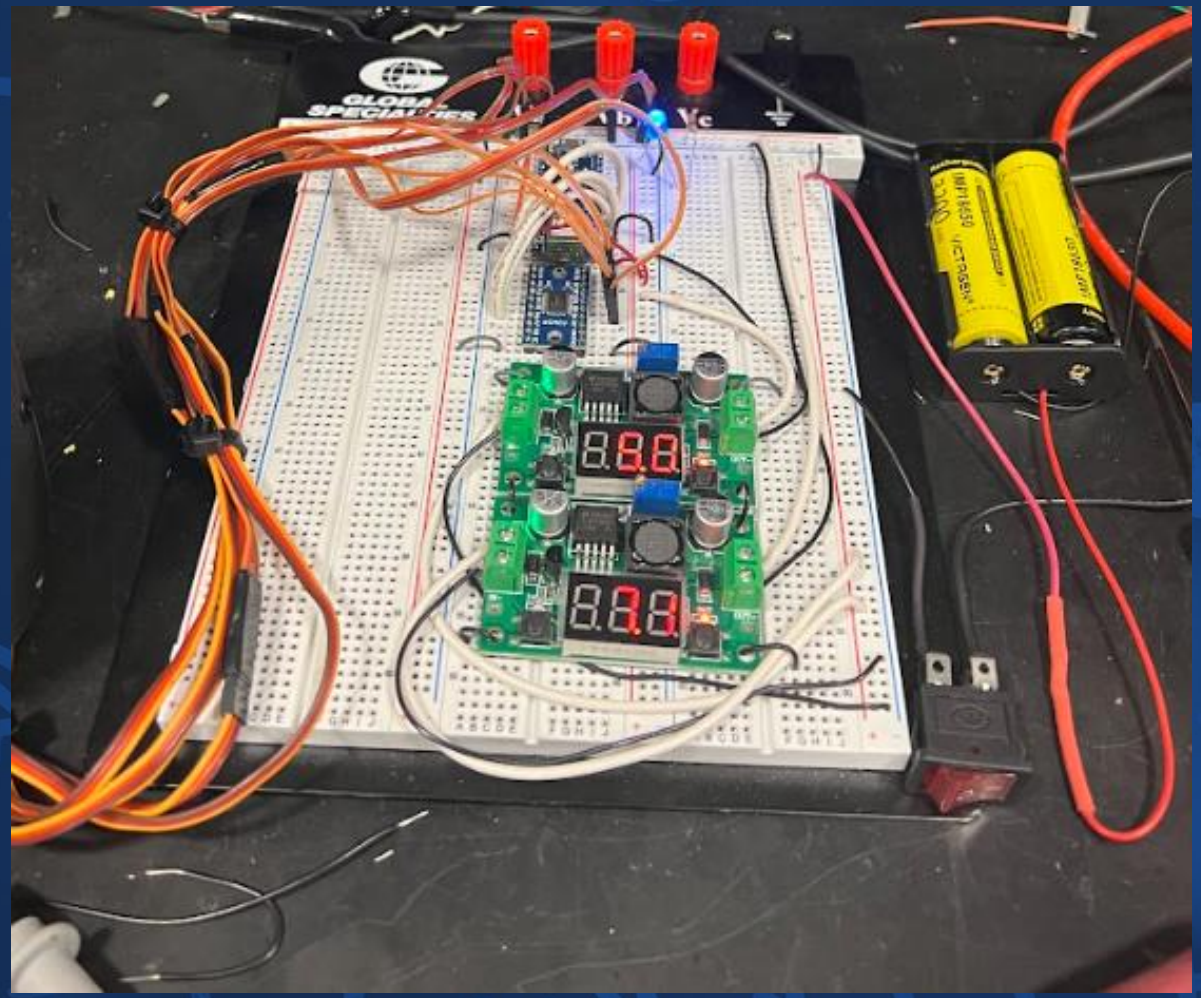


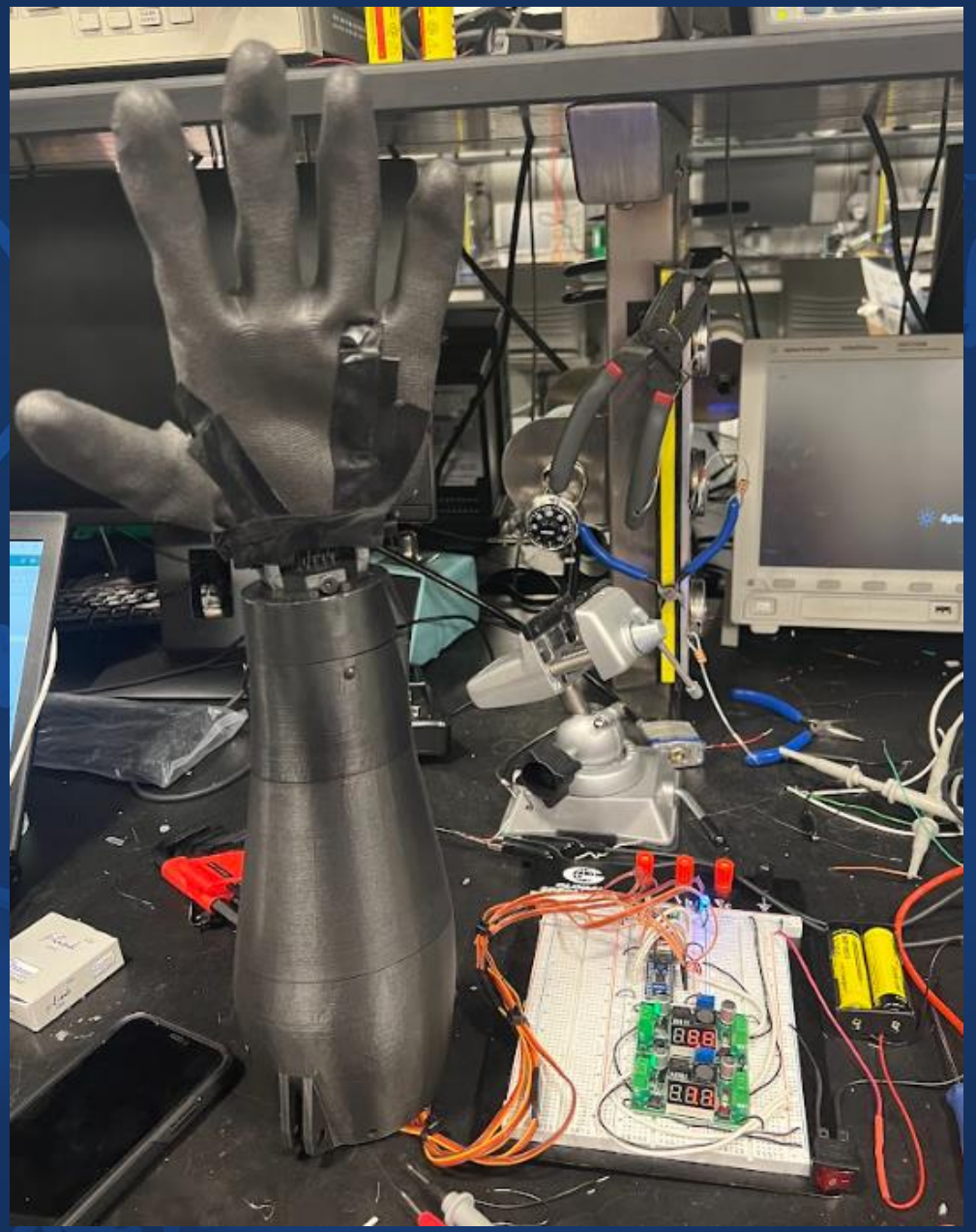


Constructing the Hand

Constructing the Hand

Controlling The Hand



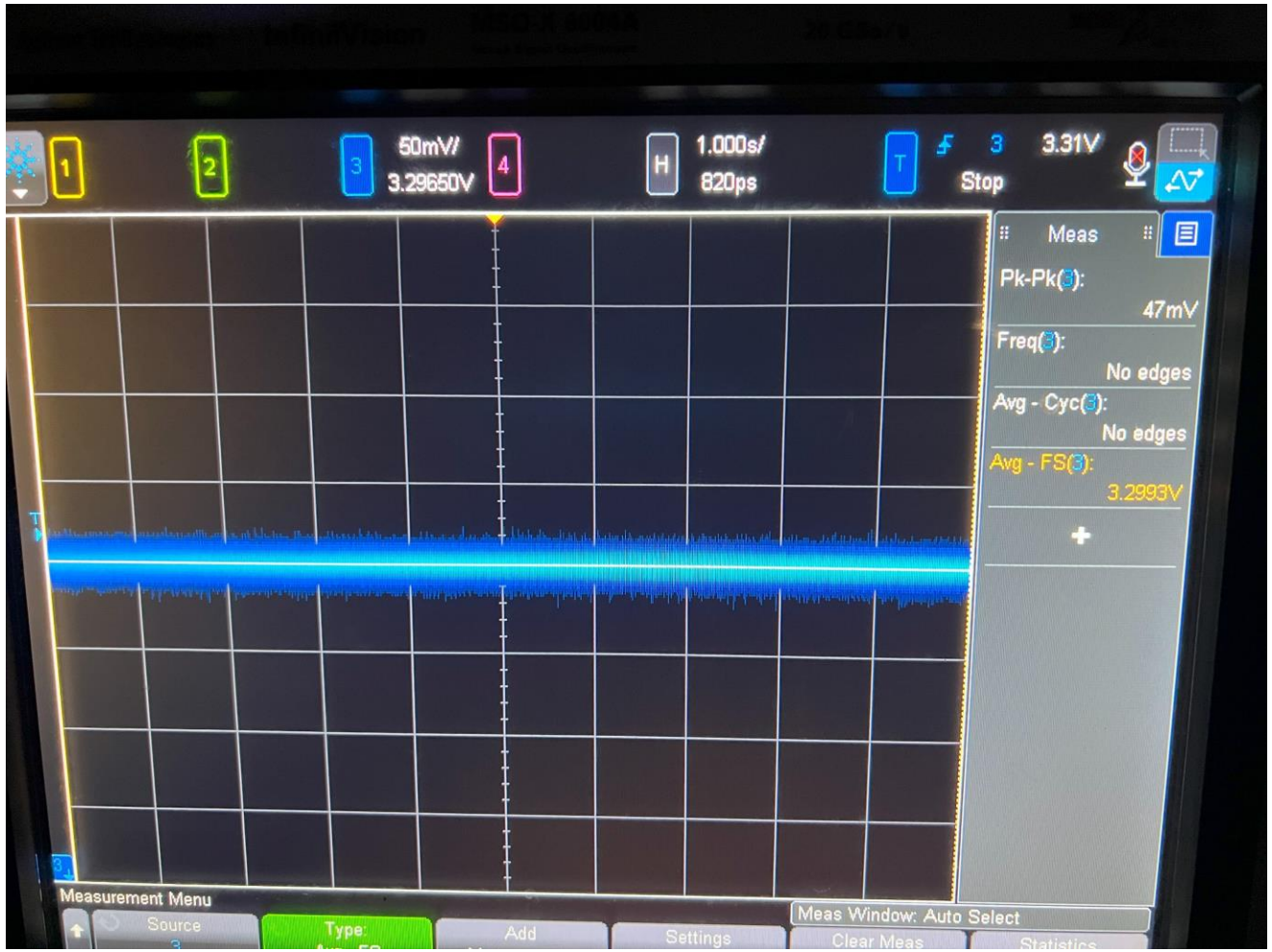


Verifications

LDO Output Measurements

Vout = 3.2993V (3.3V nominal)

Vripple = 47mV pk2pk < 1%



Energy Equations

$$Energy_{Battery} = Energy_{passive} + Energy_{BLE}$$

$$Energy_{passive} = Power_{passive} * time$$

$$Energy_{BLE} = Power_{BLE} * (T_{packet} * \frac{time}{T_{rate}})$$

T_{rate} = 60ms time between transmissions

T_{packet} = 200us time transmitting each packet

$E_{battery}$= 11,000J

Power Calculations

	Battery Voltage(V)	Battery Current	Power(mW)
Idle	4.168	19.12	79.69
Mirroring	4.168	35.2	146.71

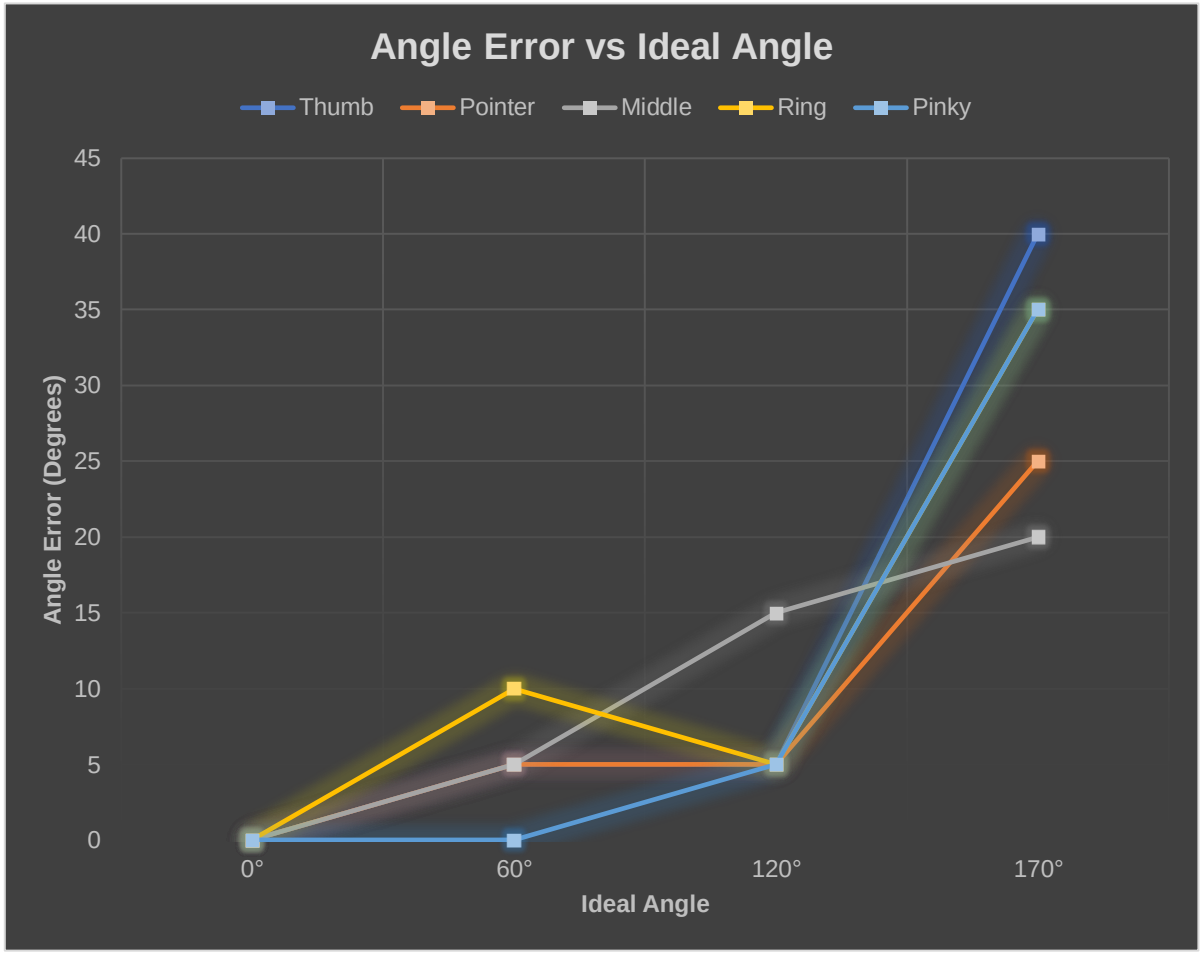
Passive(mW)	80
BLE(mW)	67

Solving for time we can power glove for approximately 38 hours.

LDO loses regulation closer to **30 Hours**.

Glove to Robotic Hand Accuracy

	Pos 1		Pos 2		Pos 3		Pos 4	
	Organic Finger	Robotic Finger	Organic Finger	Robotic Finger	Organic Finger	Robotic Finger	Organic Finger	Robotic Finger
Thumb	0°	0°	60°	65°	120°	115°	170°	130°
Pointer	0°	0°	60°	55°	120°	115°	170°	145°
Middle	0°	0°	60°	55°	120°	105°	170°	150°
Ring	0°	0°	60°	50°	120°	125°	170°	135°
Pinky	0°	0°	60°	60°	120°	115°	170°	135°



Frequency for Bluetooth

Frequency Measurement with Oscilloscope

- Probed battery current
- Saw current changed periodically
- Period was 16.5 Hz

Frequency Measurement with timer

- Adafruit Bluetooth app
- Saw number of packets transferred in 20 seconds
- Divided seconds by number of packets
- Got 16.5 Hz

Achieved our High Level Requirements

- Detect each of the 5 fingers' movement and move the digital/physical robotic hand appropriately
- We can detect 8 unique gestures (minimum requirement was for 4)
- Must have the ability to move to 3 preset positions and mirroring mode

Next Steps

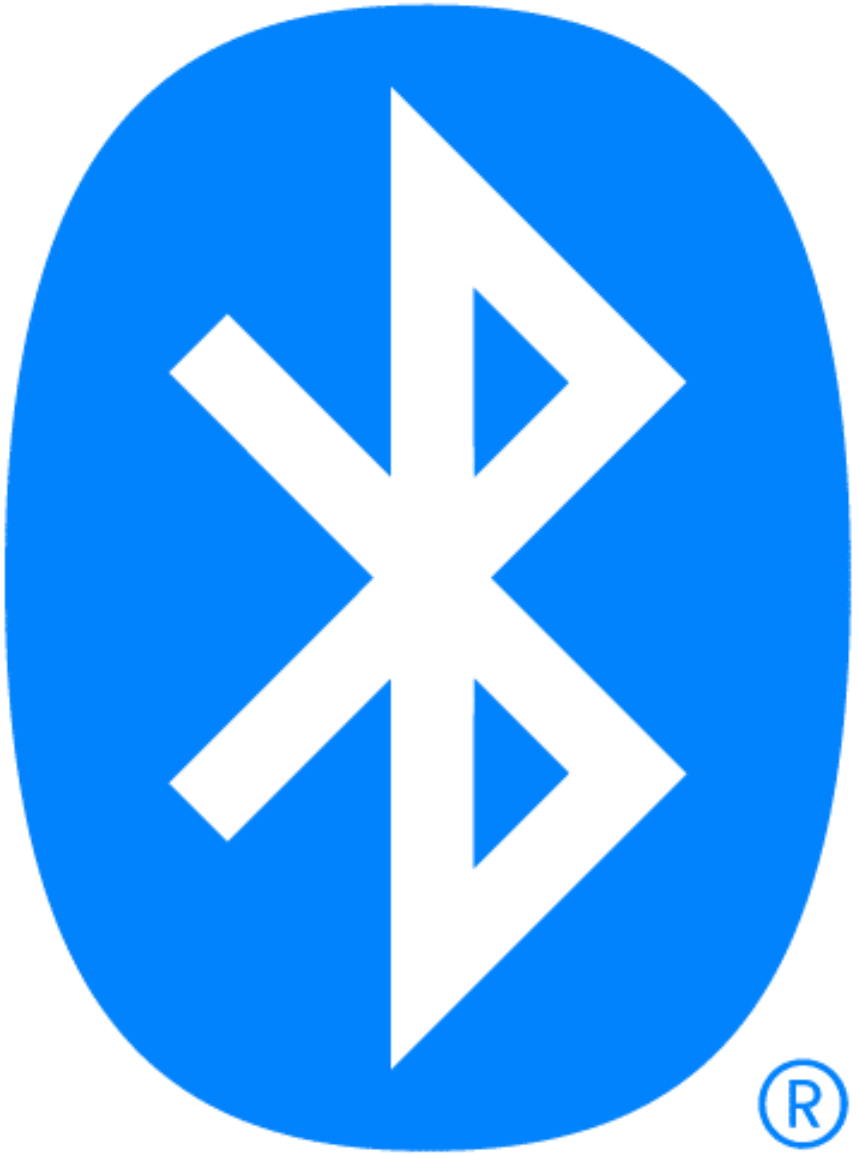
- Design our own Robotic Hand
- Get Pre-recorded mode to work
- Fabricate a better sensing glove
- Get the buzzer to work

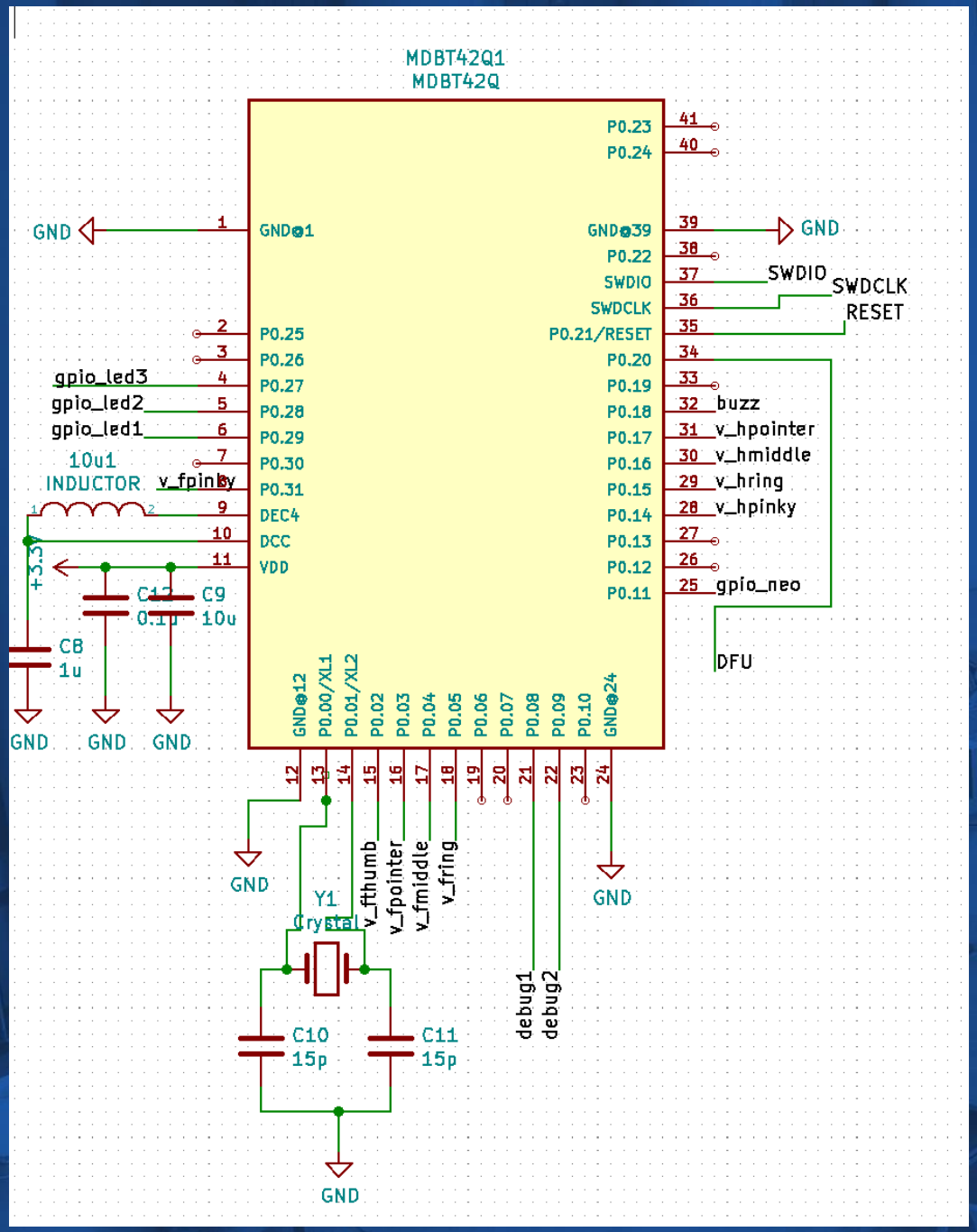
Thank you!
Questions?

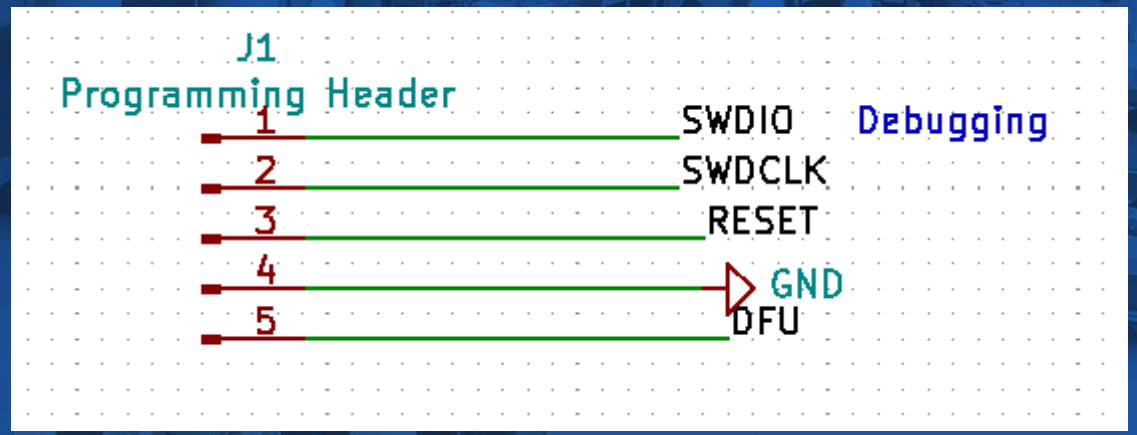
Appendix

Bluetooth

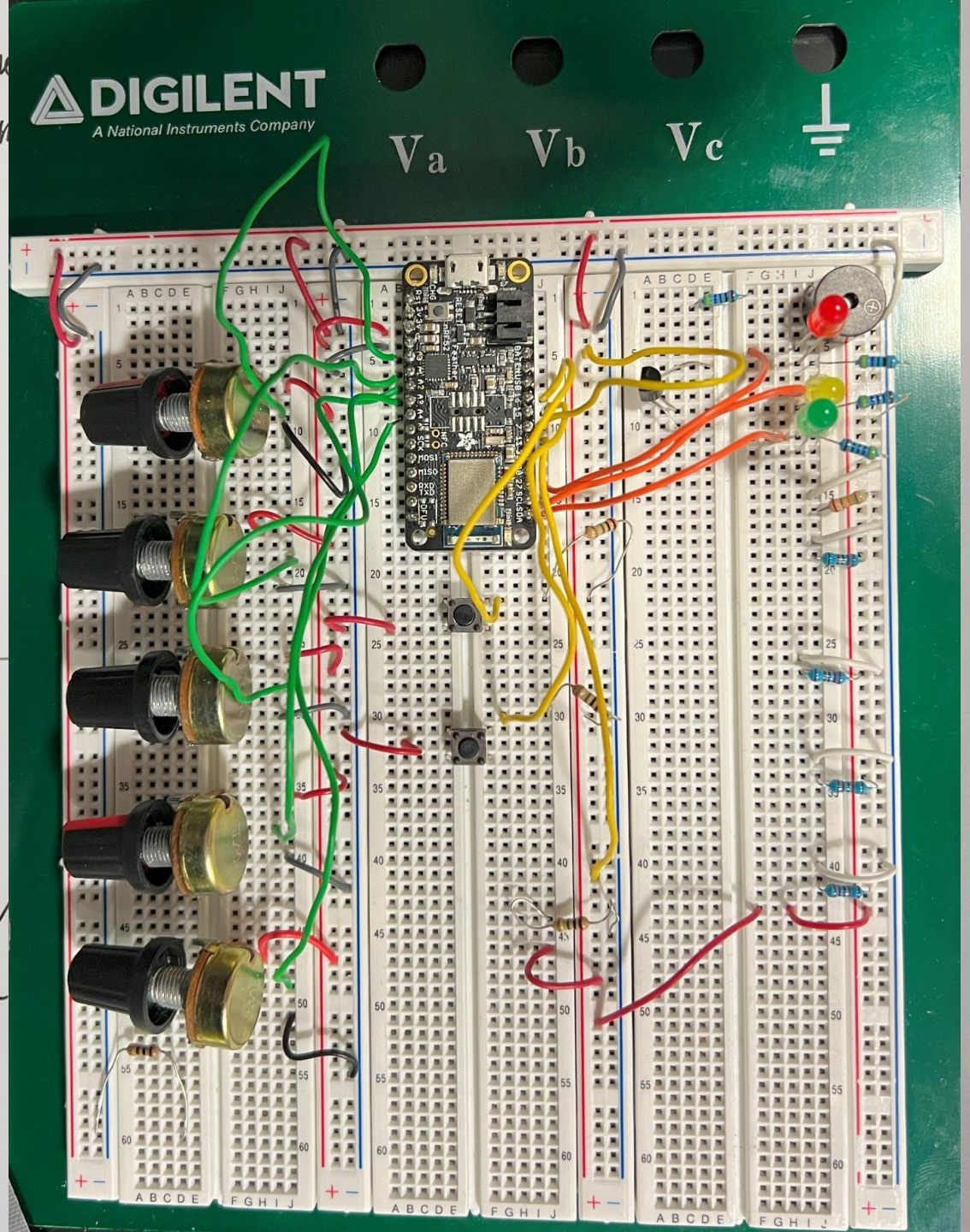
We Used Bluetooth Low Energy
•A wireless communication protocol that allows for data transfer between devices.
•Two types of devices:
peripheral device (sender)
central device (receiver).
•The peripheral device:
service with characteristics, which advertise the data under the characteristic.
•The central device:
connects to specific services and characteristics in order to receive the data it needs.




MDBT42Q1
MDBT42Q
GND
GND@1
P0.25
P0.26
gpio_led3
P0.27
gpio_led2
P0.28
gpio_led1
P0.29
10u1
INDUCTOR
v_fpinky
P0.30
P0.31
DEC4
DCC
VDD
+3.3V
C12
0.1u
C9
10u
C8
1u
GND
GND
GND
P0.23
P0.24
GND@39
GND
P0.22
SWDIO
SWDIO
SWDCLK
SWDCLK
RESET
P0.21/RESET
P0.20
P0.19
P0.18
buzz
P0.17
v_hpointer
P0.16
v_hmiddle
P0.15
v_hring
P0.14
v_hpinky
P0.13
P0.12
P0.11
gpio_neo
DFU
GND@12
P0.00/XL1
P0.01/XL2
P0.02
P0.03
P0.04
P0.05
P0.06
P0.07
P0.08
P0.09
P0.10
GND@24
GND
Y1
Crystal
v_fthumb
v_fpointer
v_fmiddle
v_fring
debug1
debug2
GND
C10
15p
C11
15p
GND


J1
Programming Header
1
2
3
4
5
SWDIO
SWDCLK
RESET
GND
DFU
Debugging

Prototyping Breadboard Used to Mimic PCB and Glove



Notes

- Bring demo to front of slides
- Schematic is too detailed
- Font is too small block diagram (make picture bigger)
- Overall drop more details the audience didn't do the project
- For schematics fonts too small
- Introduce one subsystem by one subsystem
- Show more testing results
  - Use tables graphs oscopes
- Show challenges how you got past it
- Future plans of project
- Focus more on delivery and final demo instead of specks
- Bring demo here to show it can grasp some objects
- Have a video where it can grab stuff
- Branding and marketing office for Grainger/ entire school go to box UIUC branded
- Better body language during presenting
- HAVE AN AGENDA SLIDE FIRST

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