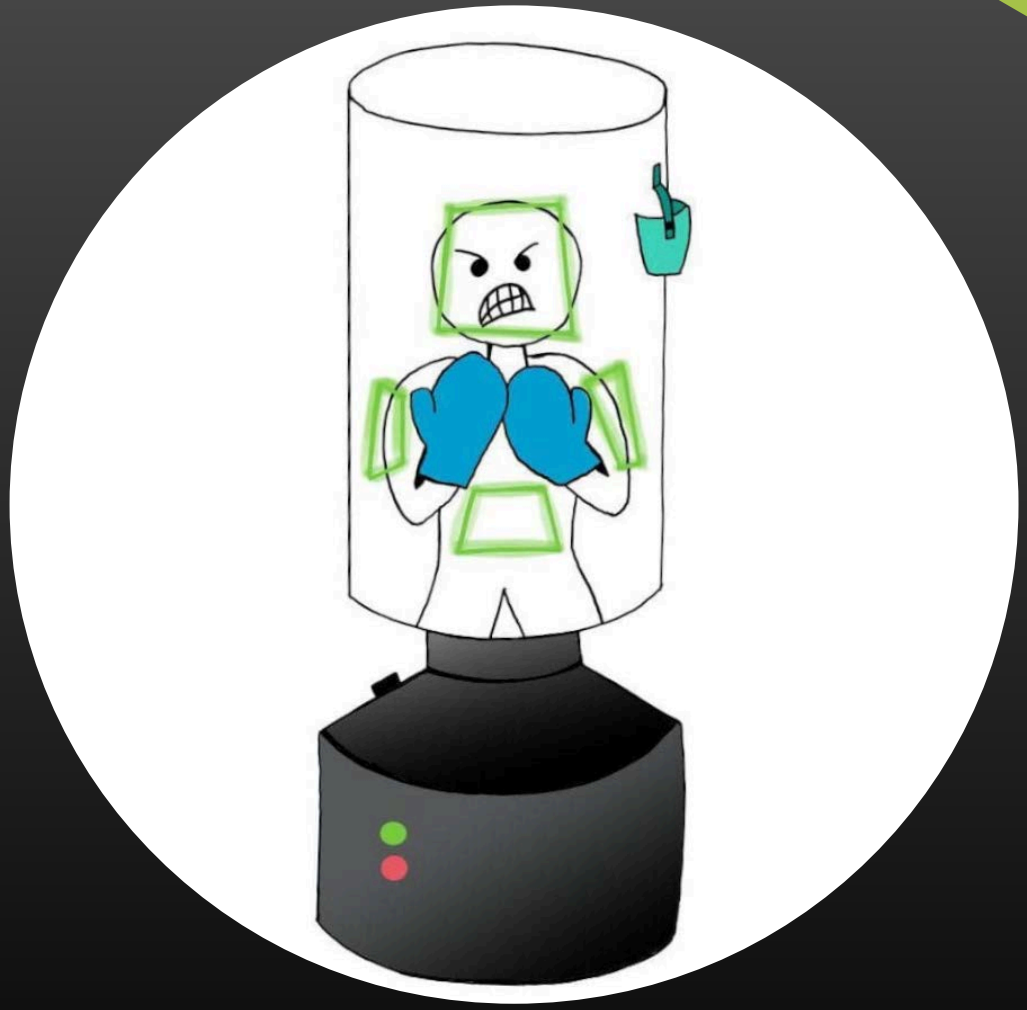


Interactive Self-Standing Training Bag

Group 22

Team Members

(listed clockwise from top left)

Nicole Karam Pannaci (EE):

Sensors and Crafting Lead

Hannah Clarke (EE):

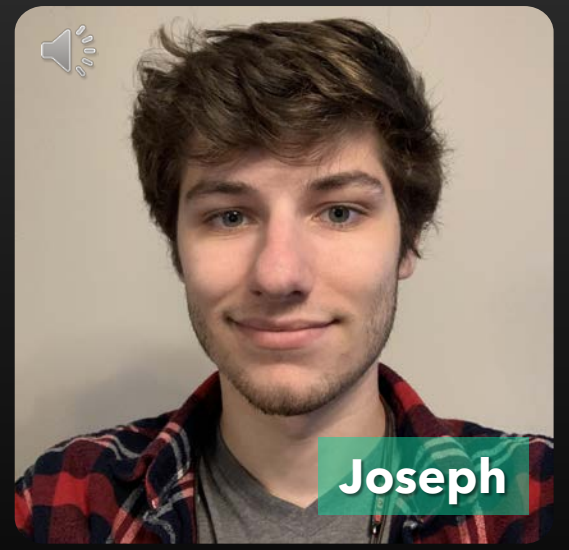
Software and Communications Lead

Joseph De La Pascua (EE):

Power and PCB Lead

Natesha Ramdhani (EE):

Design Concept and Indicator Lead



Overview

- Motivation and Goals
- Specifications, Requirements, Standards, and Constraints
- Design Concept
- Selected Components
- Software Design
- Administrative Content
  - Current Progress
  - Next Steps

Project Motivation and Goals

Project Motivation

Train Wherever User Needs To

- Train without a partner
- Train without needing to physically be at a special location
- Especially relevant due to CoVID-19 Quarantining!

Create Workouts and Track User Progress

- Enable specific workout goals for user
- Flexibility within workout structure
- Focus on workout instead of tracking own performance

Cost of Existing Products

- No monthly cost needed to use on its own
  - ~~Gym~~
  - ~~Dojo~~
  - ~~Personal Trainer~~

Existing Products

PADIPATA

- Hanging bag
- Covered in sensor material
- Retails for $25,000+
- New product, not many reviews
  - Not much knowledge about actual functionality as told by real users

FightClub

- Standing bag
- Must be used with connected boxing gloves or hand wraps
  - Only senses punches
- Package containing gloves retails for $1,219+
- Works with app
  - Separate paid membership needed

Goals and Objectives

Cost

Make device cost effective to produce and affordable for the consumer.

Interaction

Make device interactive for the user.

- Use indicators and sensors.
- Provide feedback to user.

Experience

Include multiple training modes to diversify the user's workout experience.

Specifications, Requirements, Standards, and Constraints

Overall Functional Specifications

Downtime Modes

Idle Mode

Ambient Mode

Off

Active Modes

Combination Generator (Side A)

Cardio Mode (Side B)

Reaction Mode (Side B)

Accuracy Mode (Side B)

Marketing Requirements
for device

DURABLE

AFFORDABLE

PORTABLE

INTUITIVE

VERSATILE

LONG-LASTING

Technical Requirements
for components

DURABLE

EFFICIENT

COMPATIBLE

AFFORDABLE

SIMPLE TO IMPLEMENT

LONG-LASTING

Constraints

Economic

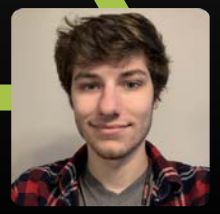
- Budget of $900
- Self-funded
- Running cost of electricity

Time

- Finished product by May 2021
- Mid-Project deadlines

Environment and Safety

- Low-power operation design
- Keeping weight as low as possible
- Heat of electric equipment

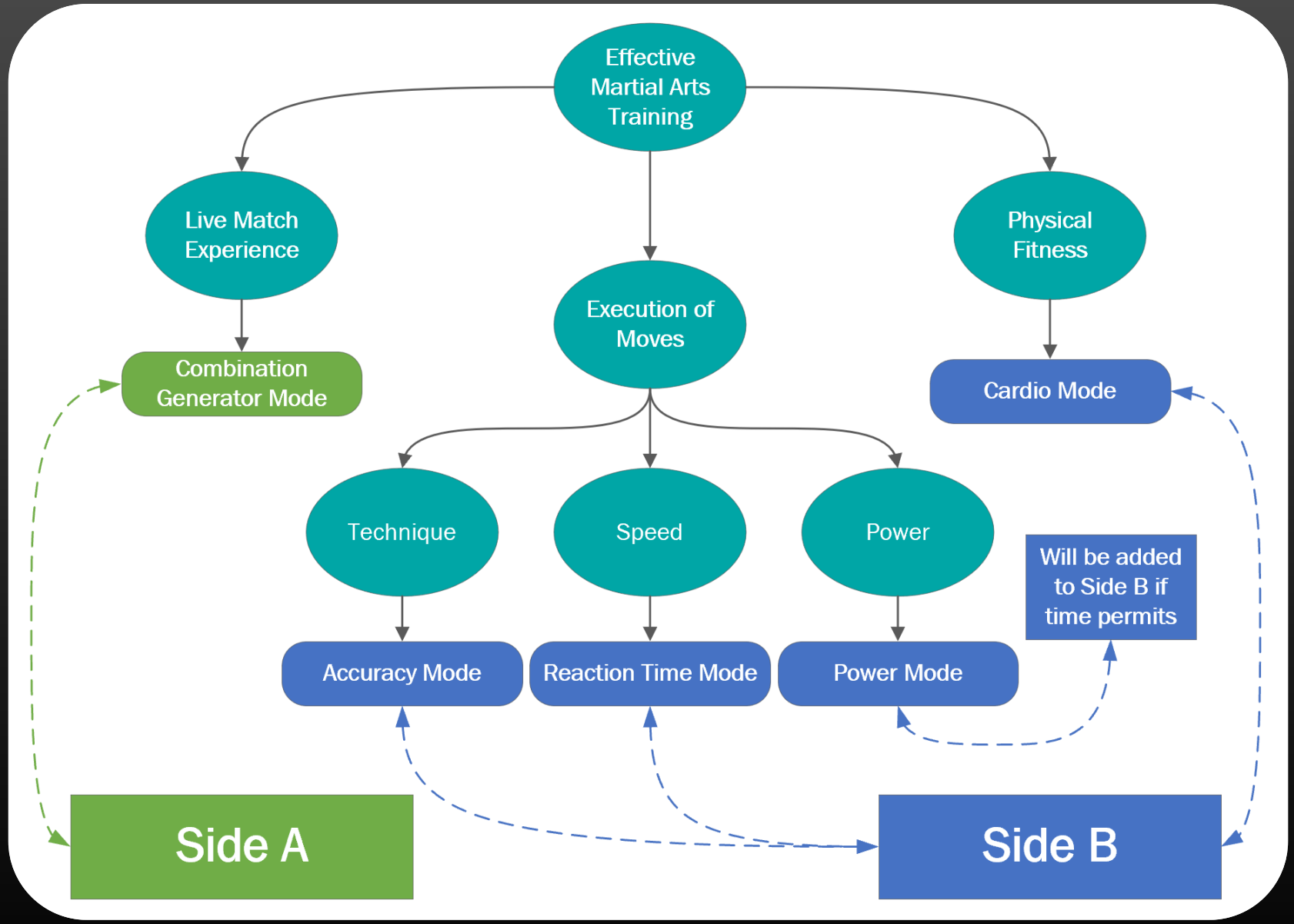


Related Standards

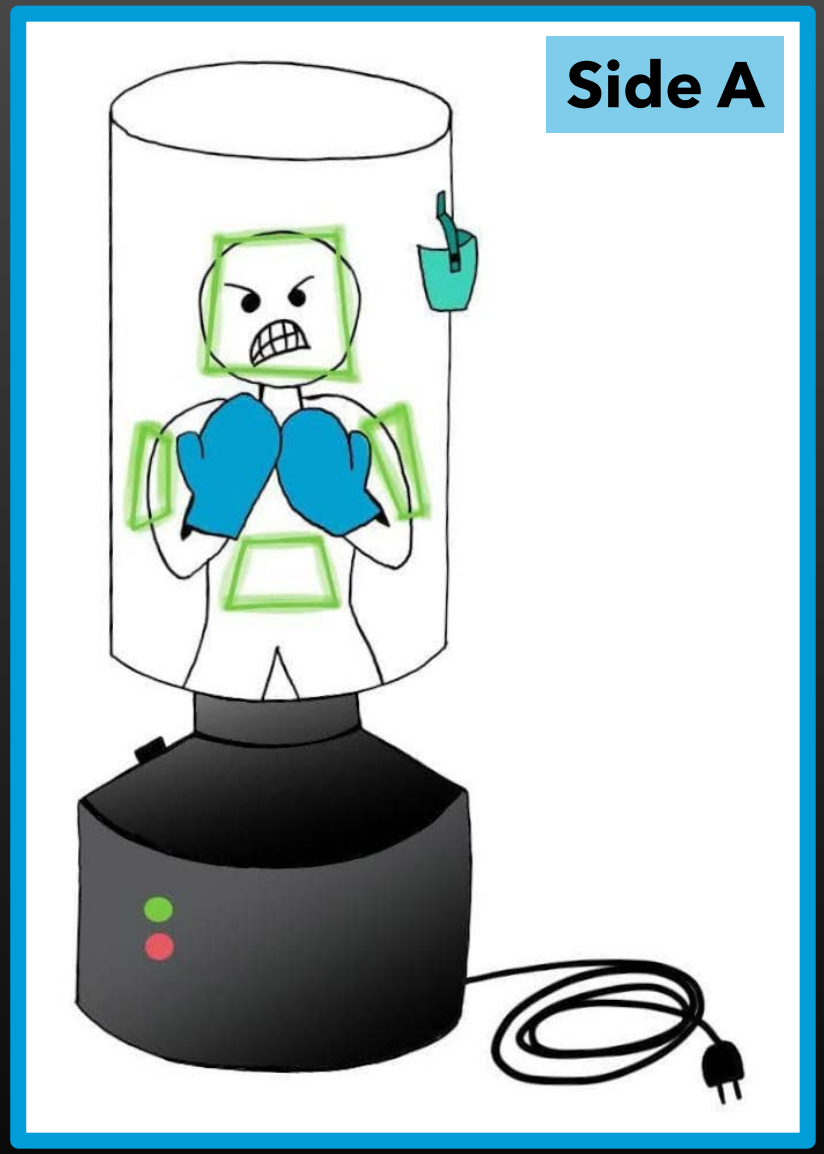
- **Power Supply**
  - IEC 60906-2:2011
  - 3-prong ground plug (NEMA 5-15R and 5-15P)
  - Provides grounding and electrical noise immunity
- **Regulation Workout Bag Standards**
  - ASTM F2276-10(2015)
  - Age Restriction, Documentation on assembly and build, adequate warning labels, indoor setting
- **PCB Standards**
  - IPC-221B: Generic design requirements for Printed Circuit Boards and Component Mounting
- **IEEE 802.15.4**
  - Physical Layer and MAC Sublayer
  - RF Parameters

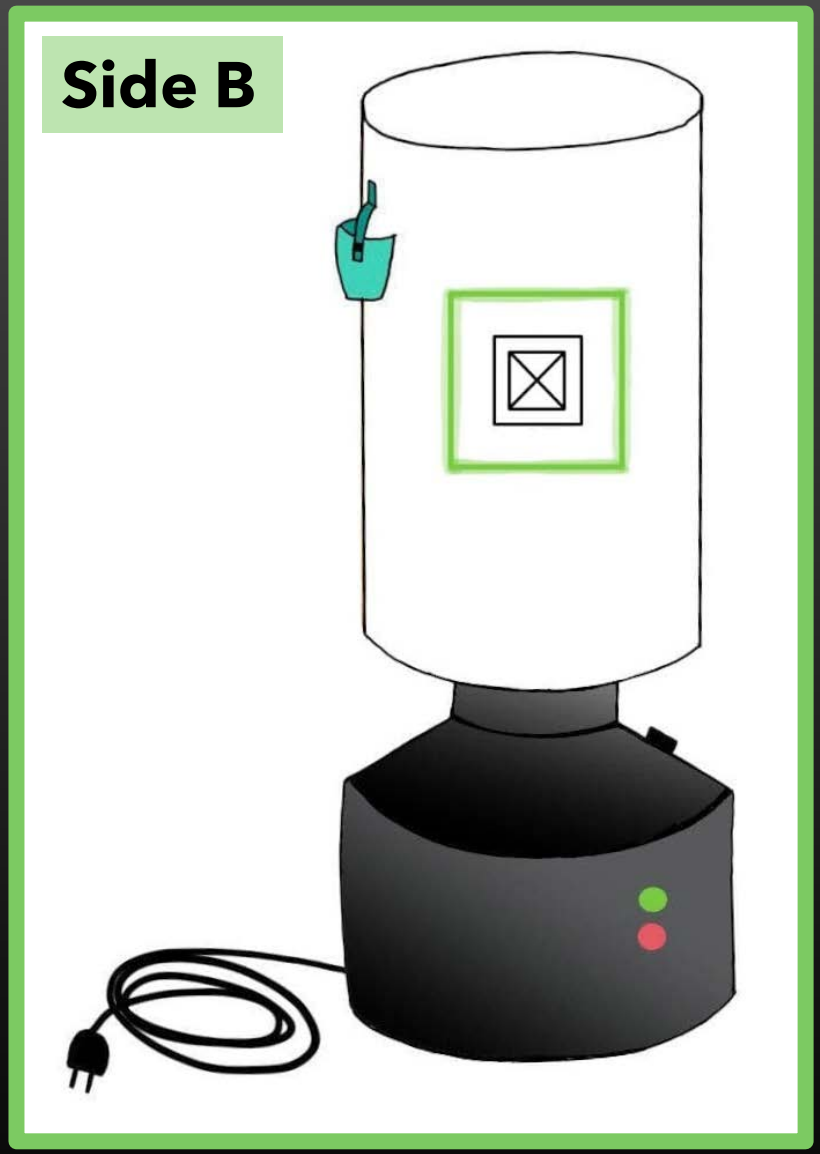
Design Concept

Overall Design



Base Design Concept Sketches





Remote (UI) Design Concept Sketch

Device Modes

	Cardio Mode	Reaction Time Mode	Accuracy Mode	Combination Generator Mode	Ambient Mode
Side Used	Side B	Side B	Side B	Side A	Both
User's Goal	Hit target as many times as possible within specified time period	Hit target ASAP once indicator goes off	Hit target as close to center marking as possible	Hit designated target of grid within specified time period	Enjoy the LED display ☺
Difficulty Options	Change duration of session	Change consistency of hit prompt timing	Change threshold of "accurate" hit	Change duration and consistency of mode timing	N/A
Stats Reported to User	Total hits Session time Avg. time per hit Hits per second	# of hits landed Shortest time Longest time Avg. time per hit	M/L accurate hit L/S hit time Avg. accuracy Avg. time per hit	Total hits Total possible hits Hit success ratio	N/A

Components and Hardware Implementation

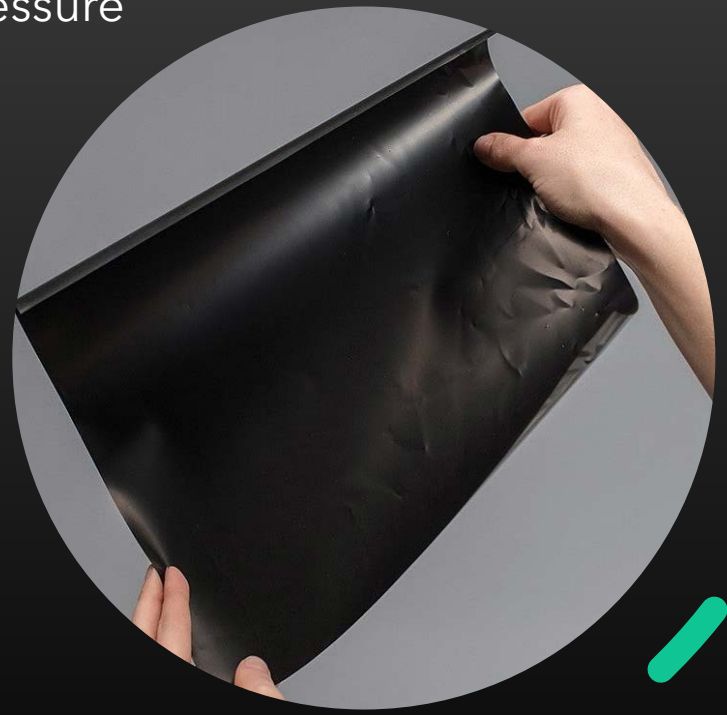
Sensor Specifications

Sensors must be able to:

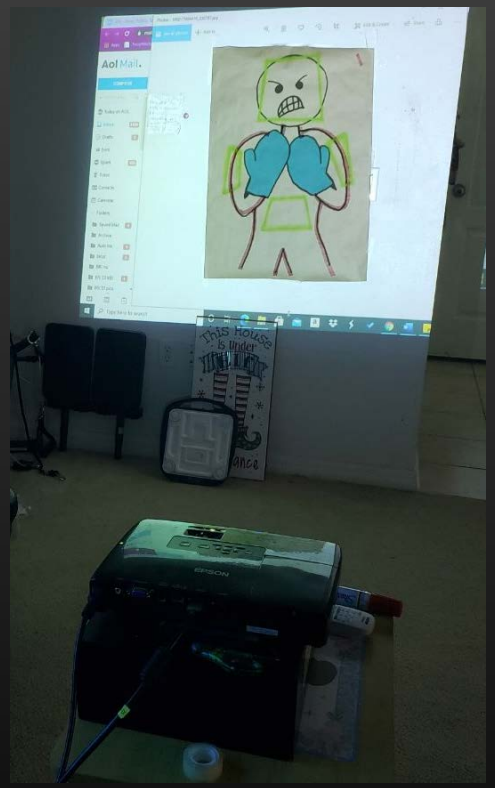
1. Withstand the force of many punches and kicks.
2. Detect rapid hits in multiple locations.
3. Count sequential hits in the same area.
4. Detect location of hits relative to designated target.
5. Consume minimal amount of power.
6. Cover entire sensing area with no more than four units.

Textile Pressure Sensor Materials

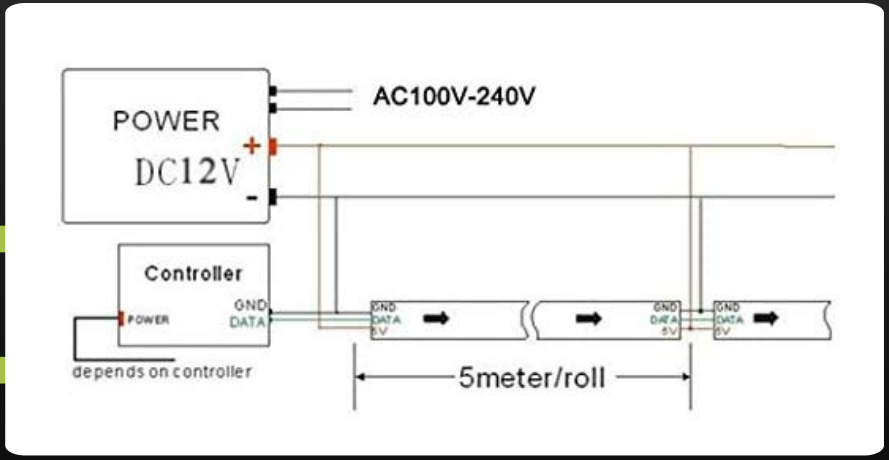
- Velostat: Pressure-Sensitive Conductive Sheet
  - Sheet Dimensions: 11" x 11" (28cm x 28cm) before shaping
  - Surface Resistivity : < 31,000 ohms/sq.cm, changes with pressure
  - Temperature Limits : -45°C to 65°C
- Shapeable Foam Sheet
- Conductive Thread (Stainless Steel)
- Conductive Material
- Fusible Interfacing
- Standard Needle and Thread
- Soldering Materials
- Stencils for Sensor Shapes



Textile Pressure Sensor Construction



Indicator: Addressable LED Strip



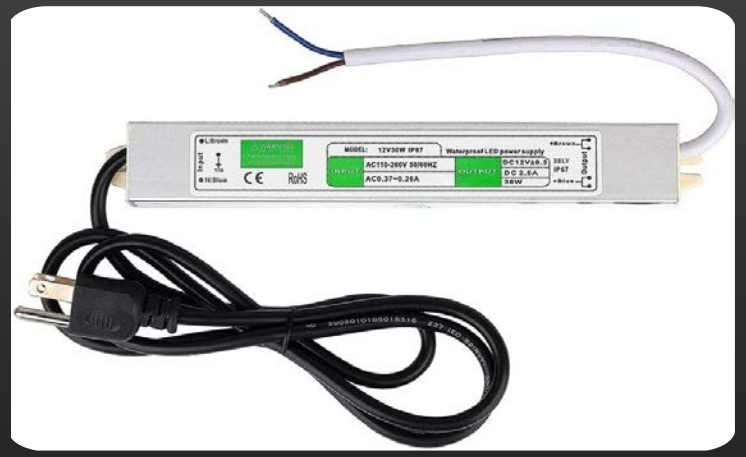
Requirements for Indicators:

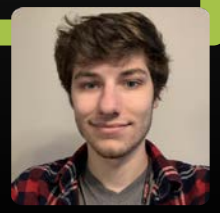
- Multicolor Programmable Units
- Cut and Connect in Various Shapes
- Durable and Water Resistant
- Cost-Effective

WS2811 Strip:

- 5m reel for $25.99
- IP67 Waterproof Rated with Silicone Sheath
- Addressable Units of 3 RGB LEDs

Link to LED Strip: https://amzn.to/36gvCdD



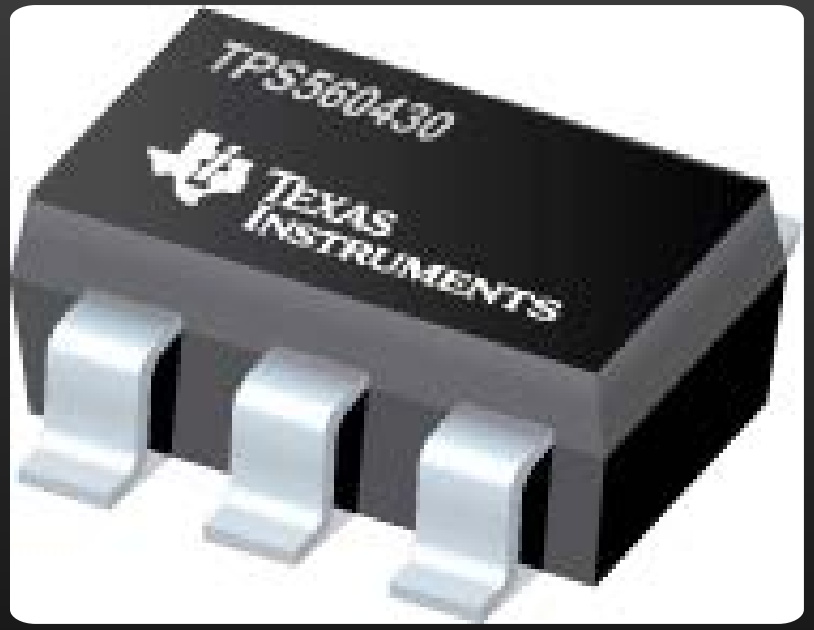


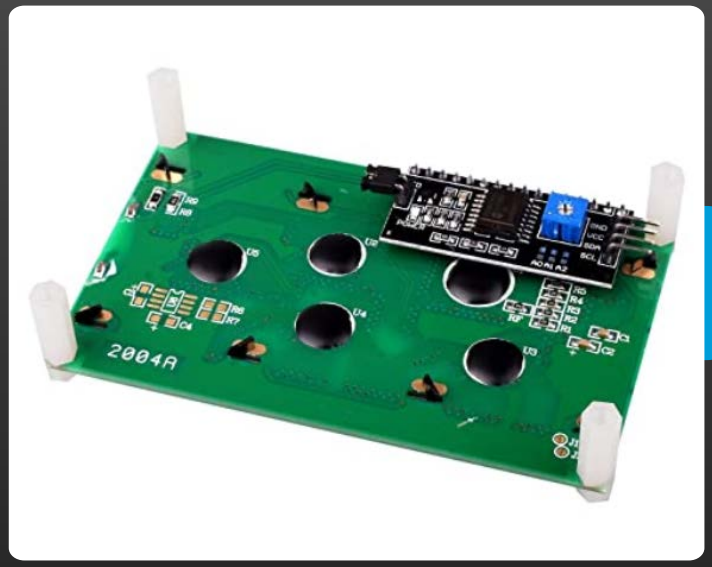
Power Generation

- **Base System**
  - 120 V 60 Hz AC / 12 V DC LED driver transformer.
  - 12V DC, 8.3 A Output Signal
- **UI Handheld**
  - 6V battery holder from LampVPath.
  - Holds 4 AA batteries
  - Generates a 6V DC signal.

Power Conversion

- **AC/DC**
  - Included with the base transformer unit.
- **DC/DC:** Texas Instruments TPS560430
  - multi-input and multi-output DC/DC converter
  - covers all required power conversion conditions.





UI Components

1) LCD

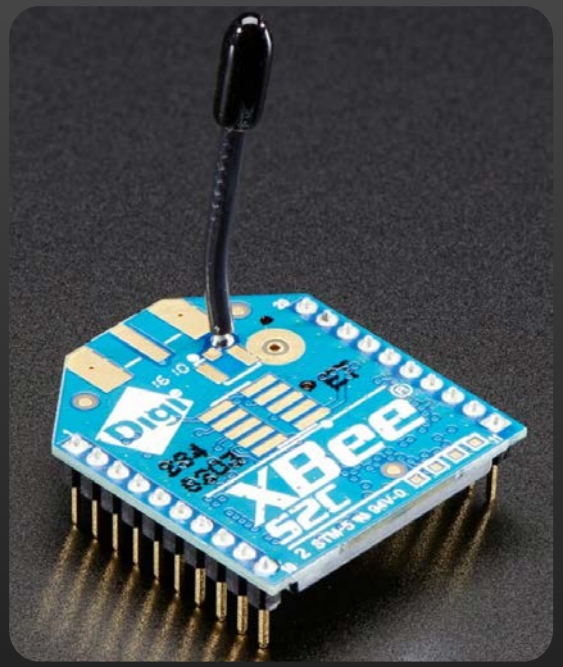
- HD44780: 20x04 display
- PCF8574T: 8-bit I/O expander for I2C bus
- 2 wire I2C serial communication
- 1 hot and 1 ground
- Operates at 5V
- Small enough to fit on remote
- Large enough to fit user results on one screen

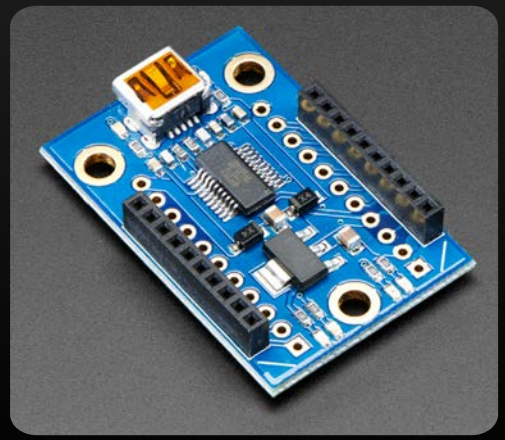
UI Components

2) XBee

- XBee S2 – chip or wire antenna
- XBee USB adapters: required for configuration

- **Pros**
  - Low power consumption (2mW while transmitting)
  - Plenty of range (indoor at 40m)
  - Sufficient data rate to keep low power (40kpbs)
- **Cons**
  - Requires manual configuration
  - Not compatible with previous generations of XBee chips





UI Components

3) User Input

- **Push Buttons:** push to close circuit, release to open circuit, waterproof, large enough for finger, small enough to fit 4 on the remote
- **On/Off slide switch:** provides stability to remain in the on position while user is interacting with base (remote will experience movement)

4) Power Supply

- **4xAA batteries:** provides 6V with 9600mAh, enough to withstand larger current drawn from LCD backlight; provides enough voltage for LCD, processor chip, and XBee antenna

MCU Selection

Standards for MCU Selection

- Have sufficient input lines for all sensors and communication necessary.
- Have sufficient output lines for all indicators and communication necessary.
- Communicate with the UI system to provide raw data.
- Require internal ROM and RAM.
- If possible, use MCU for both base and UI

Main Contenders

- FPGA
- TI MCU
- **AVR MCU**
- DSP MCU
- (Raspberry Pi)

MCU Selection Top Two

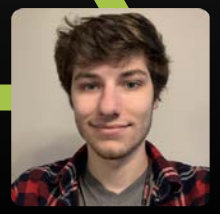
TI MCU (MSP430F6459)

- **RAM:** 66KB
- **Pins:** 74
- **I2C:** 3
- **UART:** 3
- **SPI:** 6

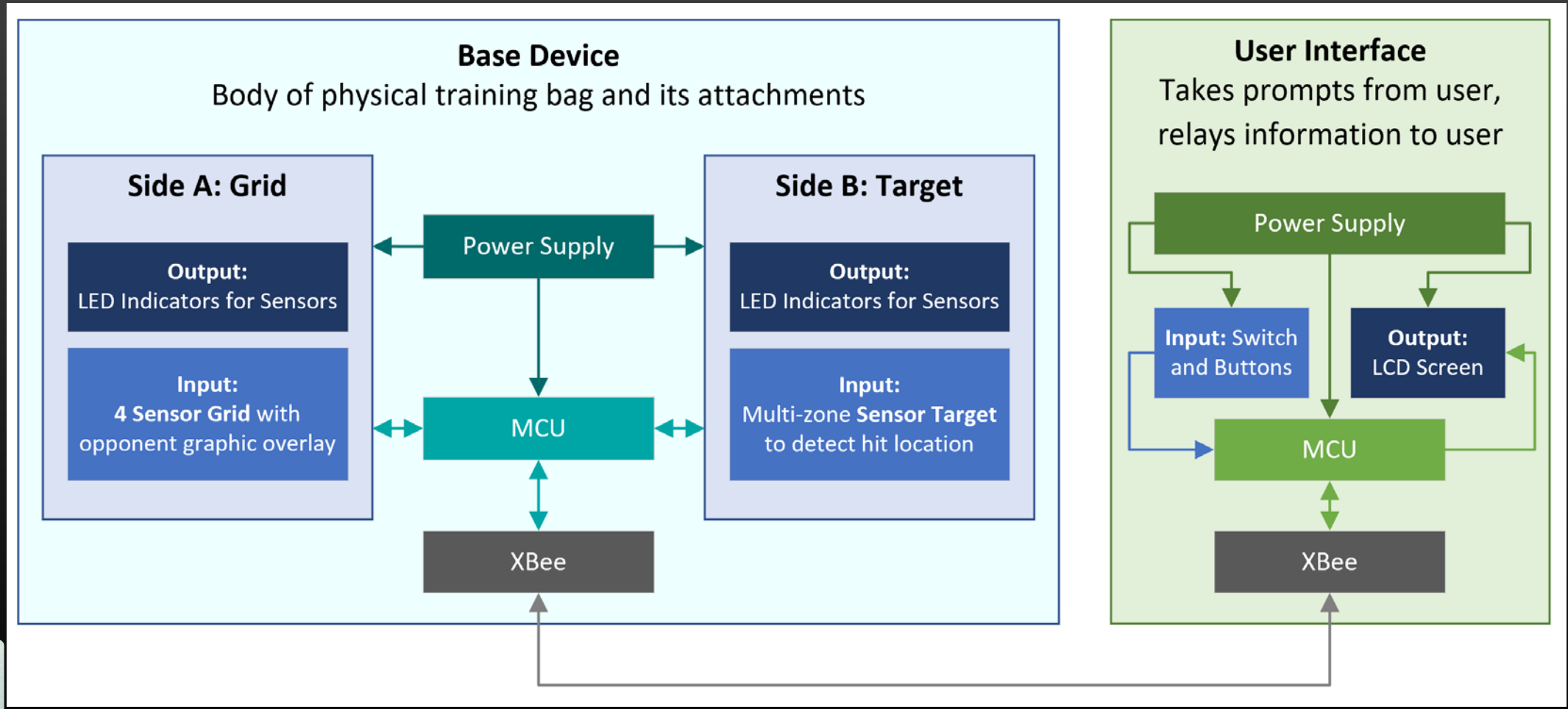
AVR MCU (ATmega2560):

- **RAM:** 64KB
- **Pins:** 100
- **I2C:** 1
- **UART:** 4
- **SPI:** 5
- **Timers:** 6
- **Input voltage:** 1.8V to 5.5V

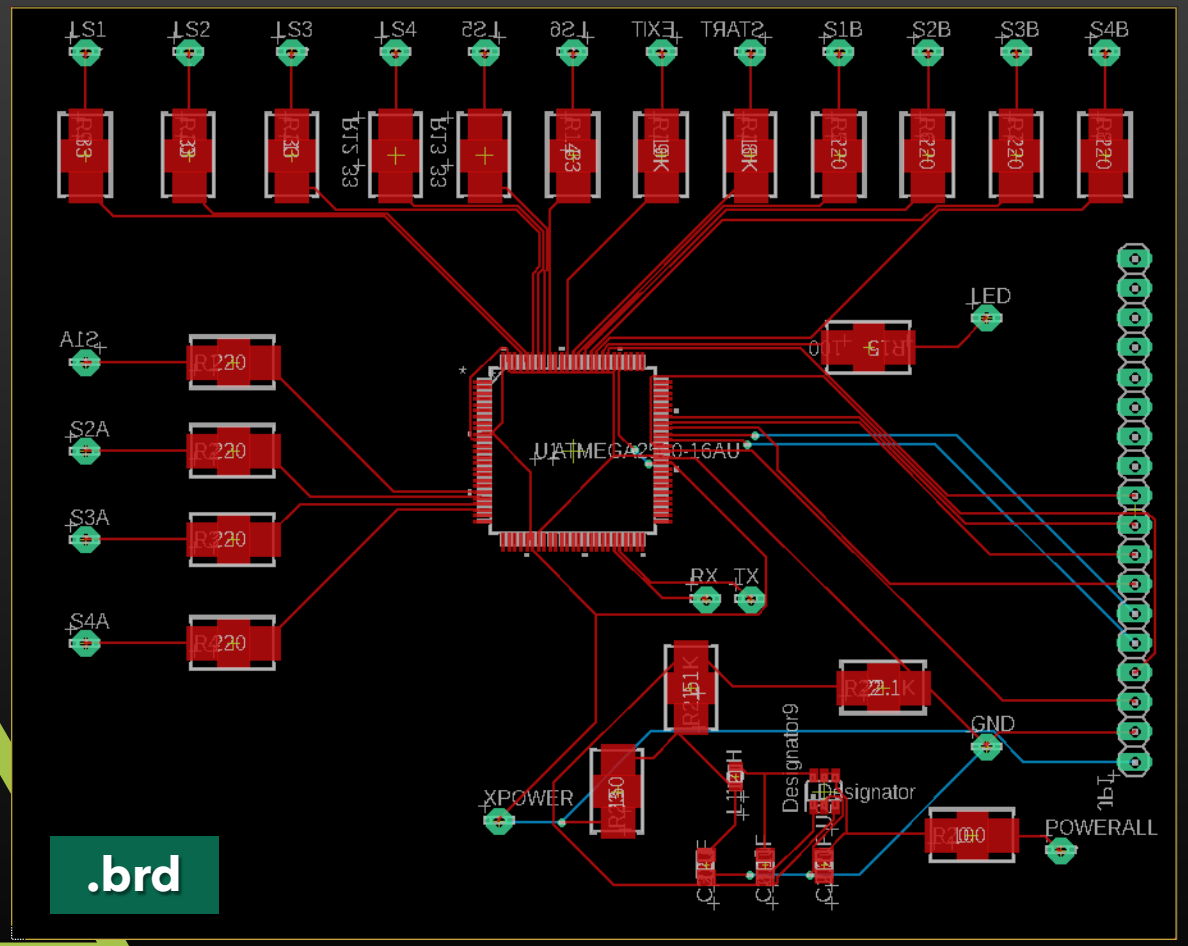
Supports function libraries that facilitate the software coding!

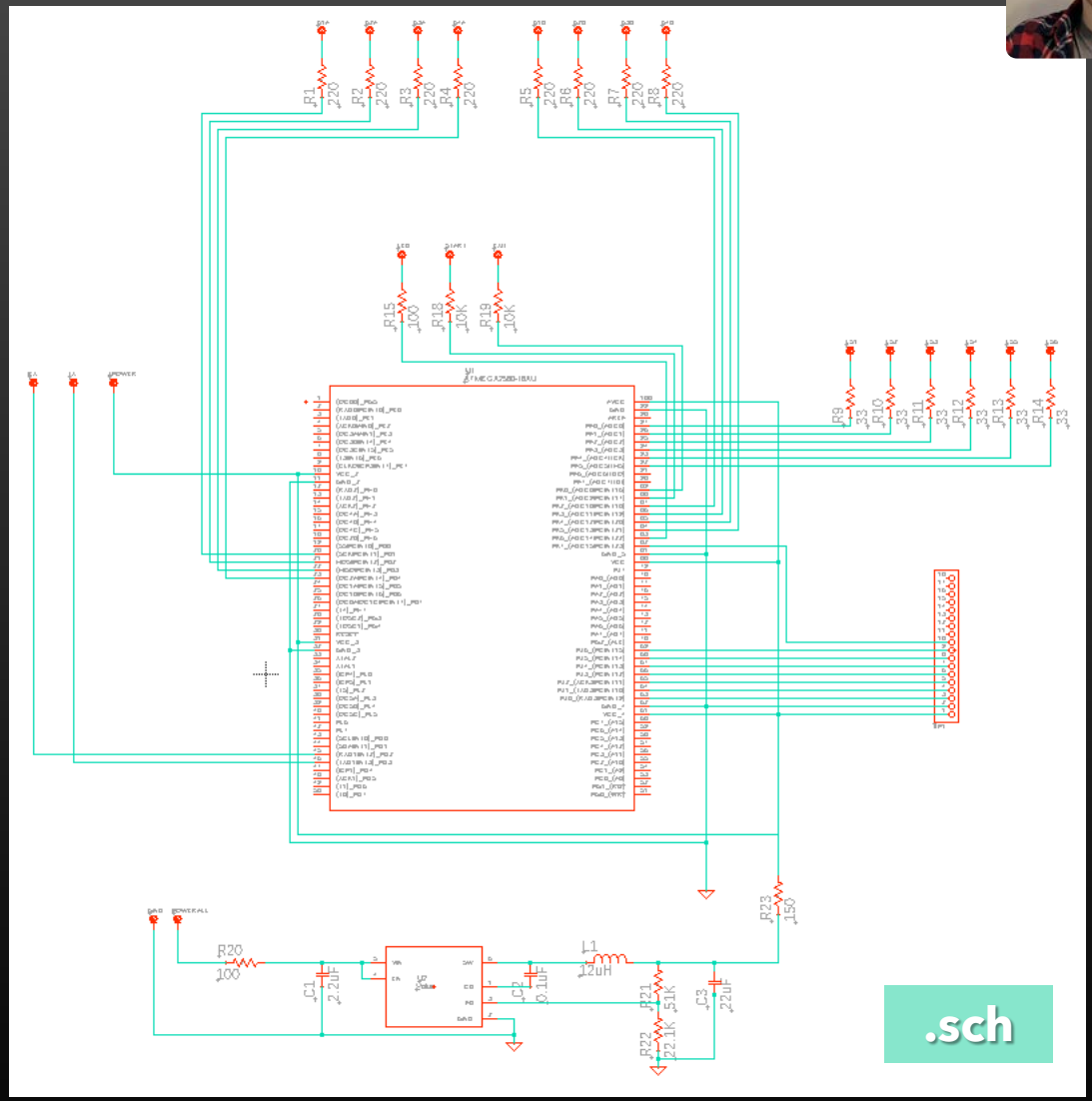


Hardware Connection Block Diagram

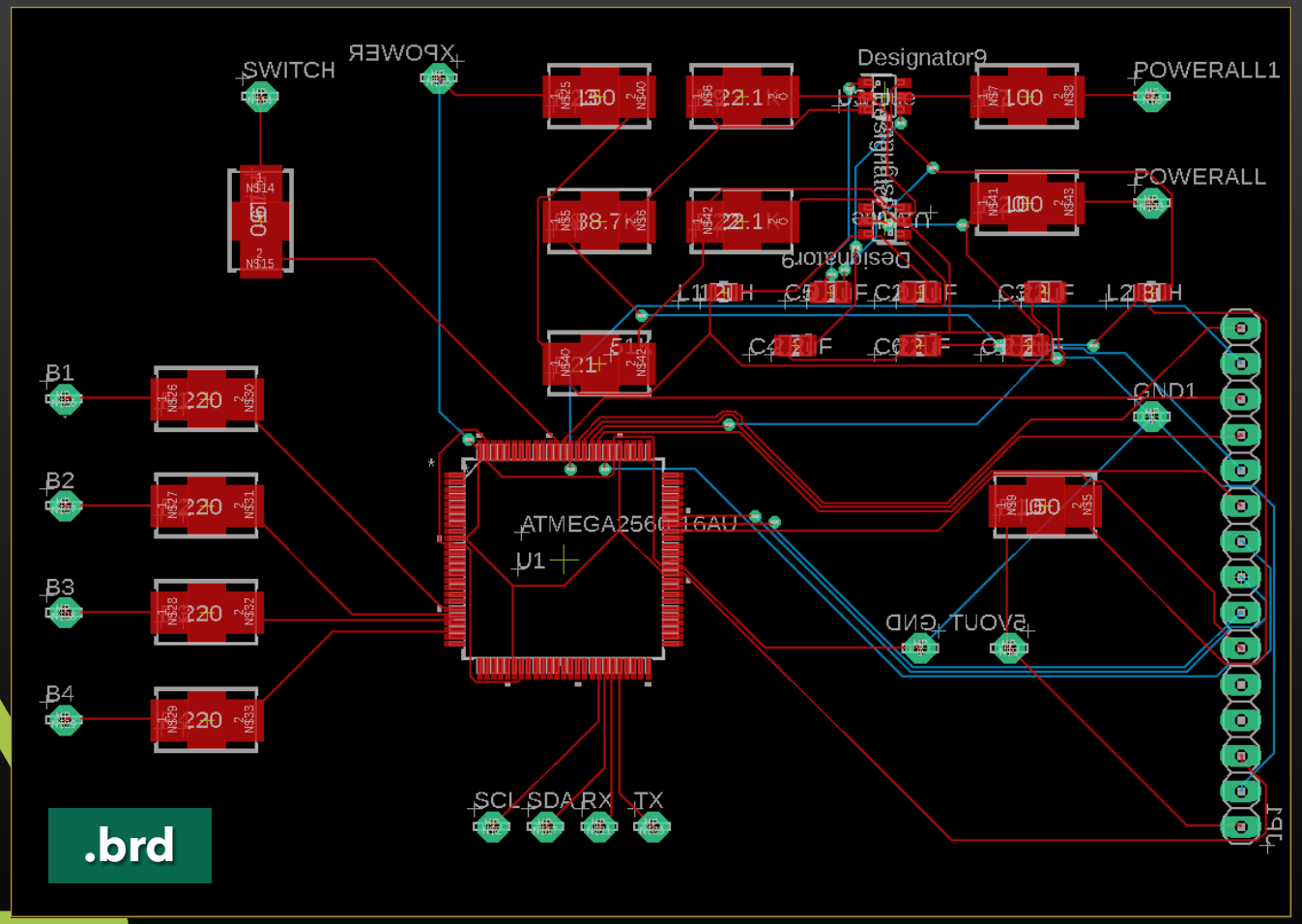


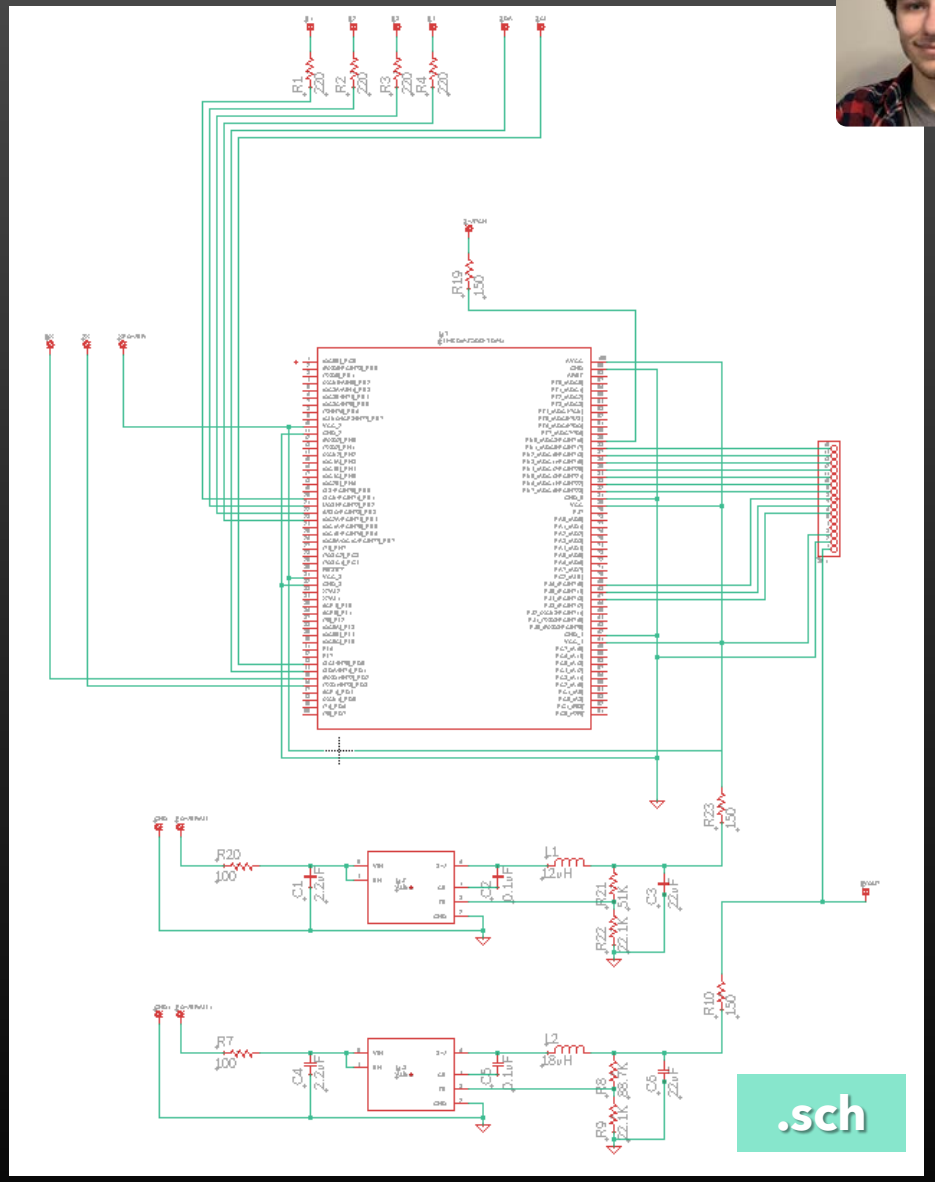
Base PCB

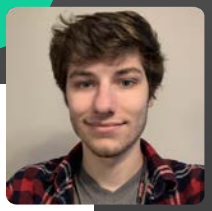

S1
S2
S3
S4
S1B
S2B
S3B
S4B
LED
S1A
S2A
S3A
S4A
RX
TX
GND
XPOWER
POWERALL
.brd


.sch

UI Remote PCB







Software Design

Interconnected web of interrupt service routines to handle actions.

Software Design Approach

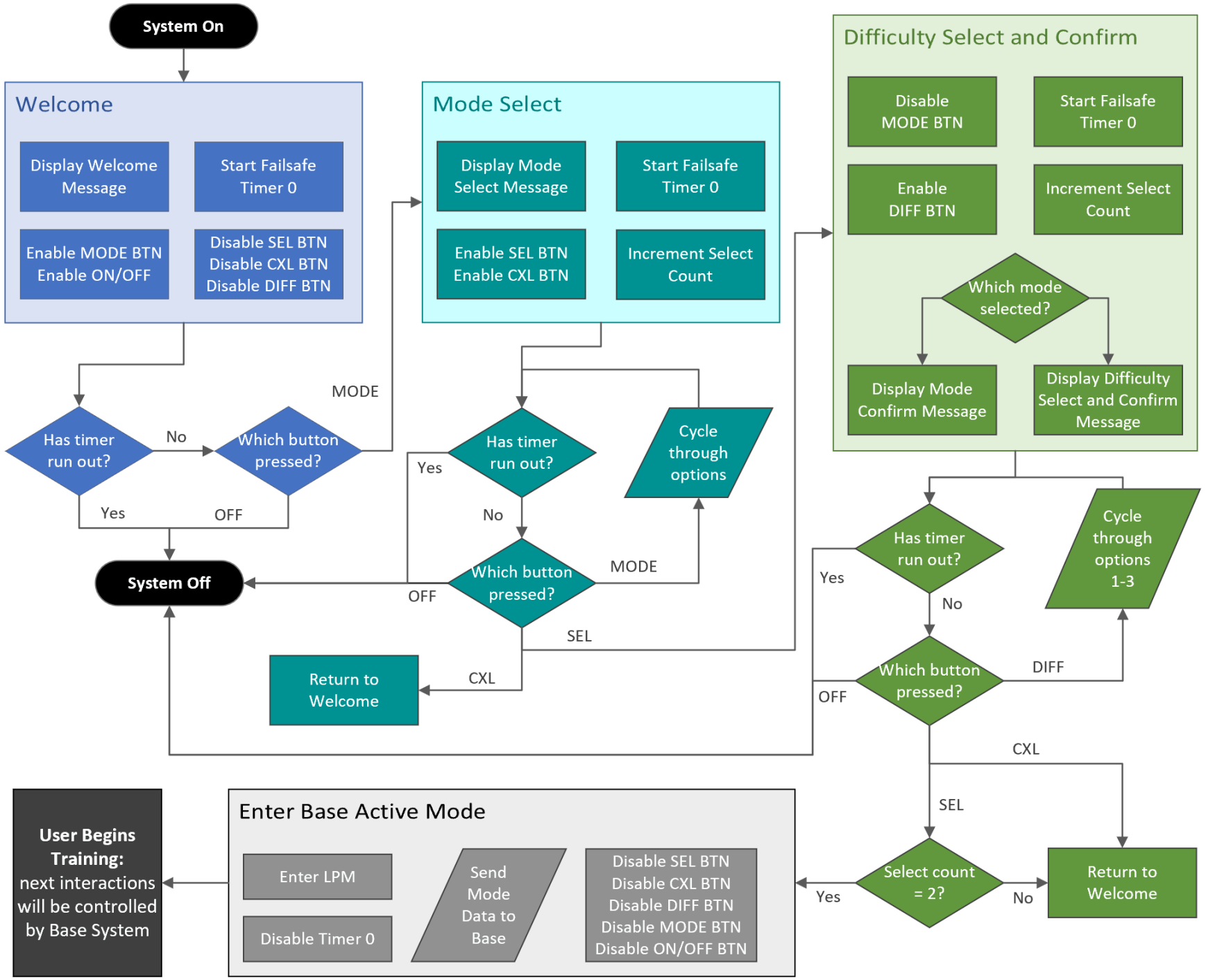
- **User Interface System**
  - Heavily dependent on user input through buttons
  - Relies on button ISR's to handle actions:
    - Enable/Disable specific button interrupts
    - Reset Timer values
    - Display instructions to User
    - Display Mode and Difficulty selection changes
    - Display correct screen when Cancel button is pressed
    - Trigger UART TX interrupt
  - Relies on UART RX ISR to display results at the end of the session
  - Relies on Timer ISR to prevent getting "stuck"

Software Design Approach

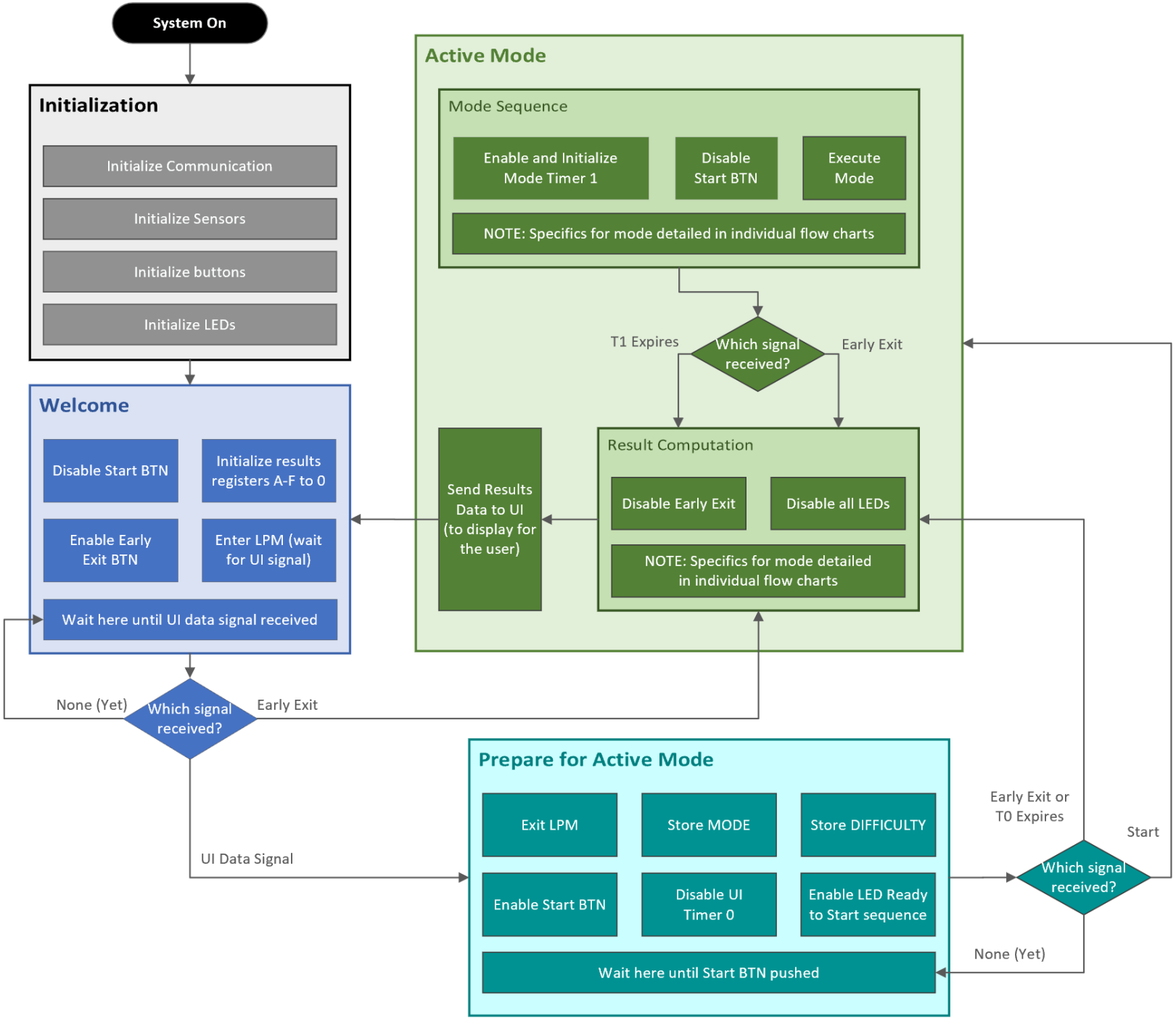
- **Base System**
  - Relies on user input to begin or cancel a session with Button ISR
  - Heavily dependent on pressure sensor ISRs and timer ISRs to handle actions:
    - Keeping score
    - Continue through the session, even without user interaction
    - Enable appropriate indicators for the mode of the session
    - End the session
  - Relies on UART TX ISR to send data back to the UI system

UI System Software Flowchart

Button/Switch Names:
ON/OFF = On/Off (Toggle Switch)
MODE BTN = Mode
DIFF BTN = Difficulty
SEL BTN = Select
CXL BTN = Cancel



Base System Software Flowchart



Administrative Content

Budget and Financing

Component	Price (USD)	Quantity	Total (USD)
Conductive Thread	5.99	2	11.98
Velostat/Linqstat	4.95	5	24.75
Conductive Fabric	4.95	2	9.90
Foam Sheet	9.74	1	9.74
Fusible Interfacing	2.99	1	2.99
LCD Screen	12.25	1	12.25
LED Strips	25.99	2	51.98
Arduino Uno	23.00	2	23.00
Punching Bag	120.00	1	120.00

Component	Price (USD)	Quantity	Total (USD)
Xbee Antenna	26.00	2	52.00
Xbee Explorers	12.00	2	50.00
Buttons	10.99	15/pack	10.99
120V AC to 12 V DC Converter	**14.00**	**1**	**14.00**
eBotot Mini DC/DC Converter	**9.00**	**6**	**9.00**
PCB Production	**3.00**	**10 (5 ea.)**	**30.00**
Miscellaneous/ Shipping	**50.00**	**n/a**	**50.00**

Total Cost ≈ $485

Important Project Milestones

Time	Task/Status
December 2020 (End of SD1)	Concept Complete
January 2021 (Beginning of SD2)	Prototype Design and Build
February 2021	Prototype and Testing
March through Mid-April 2021	Final Build and Testing
Remainder of April 2021 (End of SD2)	Finalize Results and Present to Panel

Work Distribution

GREEN (1): Lead

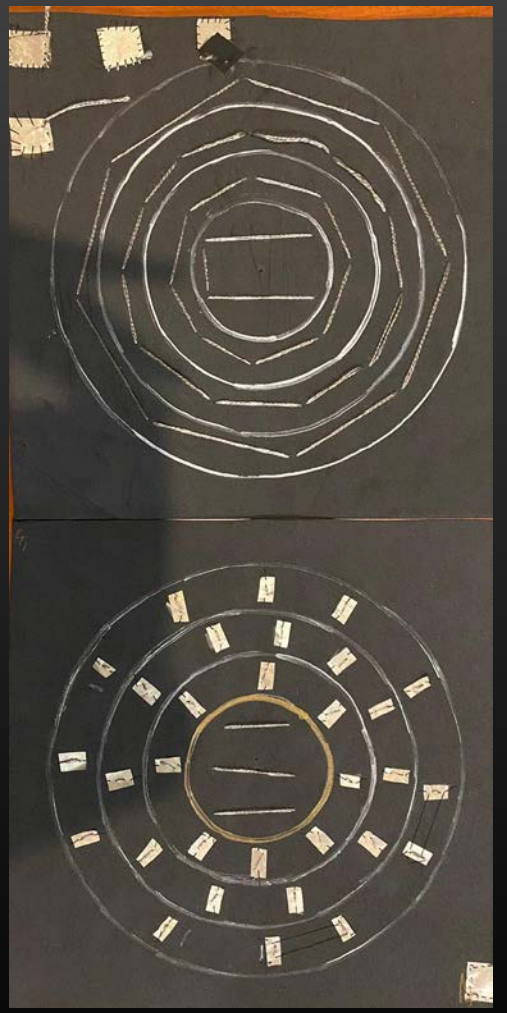
BLUE (2): Primary Assistant(s)

Task	Hannah	Joseph	Nicole	Natesha
Design	2		2	1
Sensors			1	2
UI	1			
Power		1		
Indicators				1
Software	1			2
MCU		1		
PCB		1		2
Sewing and Crafting			1	2
Video Editing		1	2	

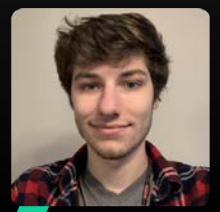
Project Progress: Hardware/Design

Single Side A Sensor

- All materials for sensors, power components, and LEDs acquired
- PCB redesign complete
- Sensors are built for both sides A and B
- ¾ sensors on Side A have been tested successfully on bag
  - Remaining sensor undergoing redesign
  - Side B testing recently begun
- Designing outer case for remote



Side B Sensor

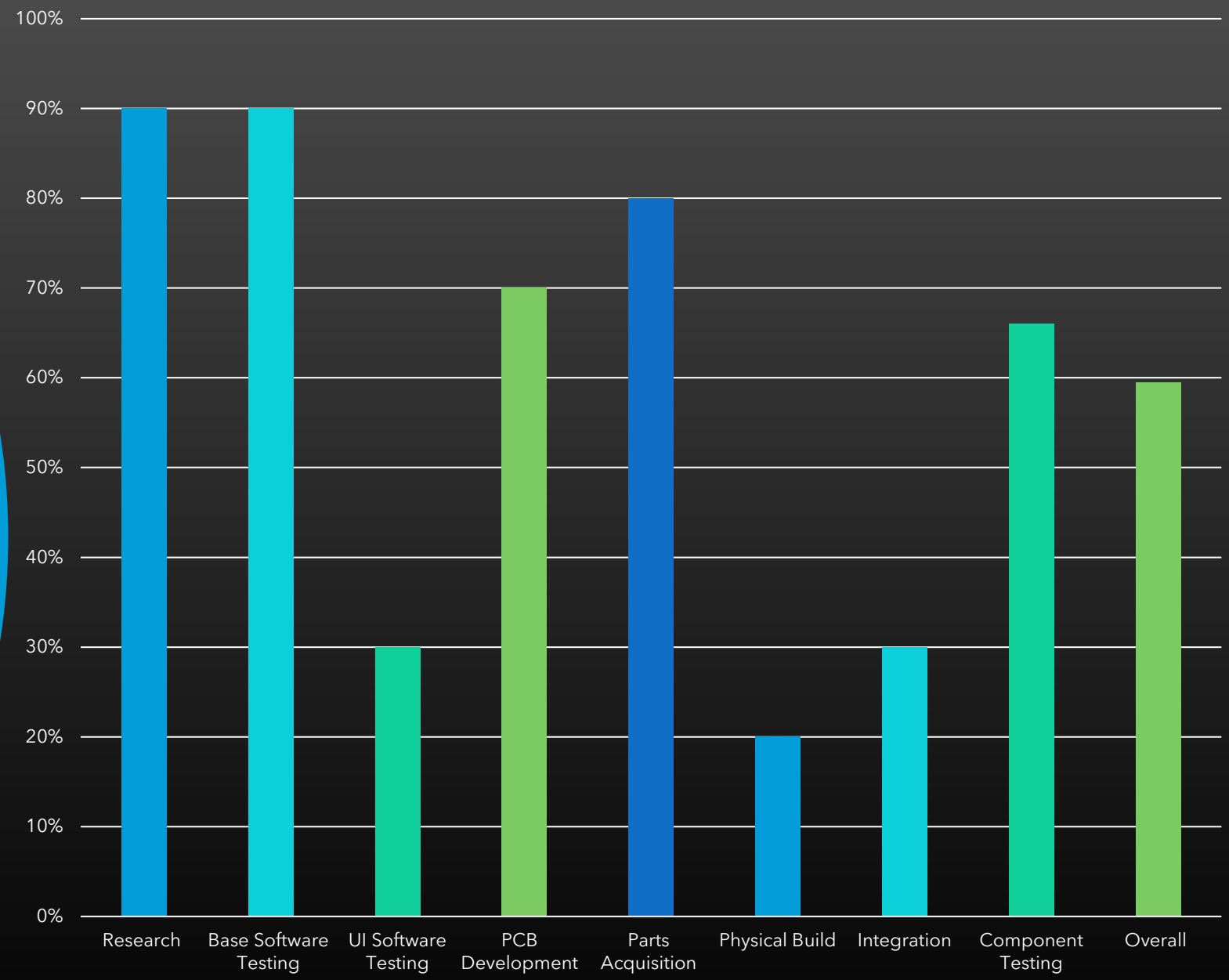


Project Progress: Software

- 90% of UI Hardware is acquired
  - PCB and On/Off Slide Switch remain
- 80% of UI prototype software is completed, integrated and tested
- 20% of Base prototype software is completed, integrated and tested
- UI and Base communication is completed, integrated and tested

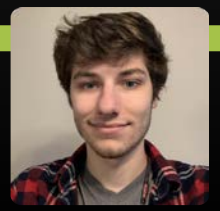
Transmission Shown Using XBee and LEDs (red sends to blue)

Project Progress Graph



Current Issues

- Need test method to accurately and consistently give readings with changing levels of voltage, current, and resistance
- Head sensor too large to give clear hit reading (redesign)
- Need method to cover sensors on bag and attach LED strips
- Waiting for delivery of PCBs and its basic circuit components
- Finalize location of and security for PCB on base



Next Steps

1. Receive and assemble PCBs for testing
2. Assemble covers and cases for base (bag and PCB) and remote
3. Finish bag (sensors; LEDs; attachments) and UI/base software
4. Integrate, test connection of hardware and software
5. Preliminary test of HW/SW with PCBs

Thank You!

Group 22 appreciates your time!