



UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

The Beer Pong Mat

Team 20

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Team



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Project Software
Co-Leader



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Agenda

The Problem
The Solution
Design and Changes
Success Metrics
Challenges Faced
Ethical Concerns
Conclusions

The Problem

1. Cups during a beer pong game may be shifted, underfilled, spilled, or tilted in ways that give one team an unfair advantage
2. It is easy to lose track of the score, how many games each team has won, or who's turn it is



The Solution

We built a beer pong mat for college kids & beer pong enthusiasts. This mat ensures cups are properly placed and filled, and provides a simple scorekeeping display.



High Level Requirements

Portability:

Allows the game to be played anywhere

Mat should be reducible in size by at least 50% and have ability to be placed on any flat surface

Mat shouldn't need to be plugged into wall outlet

Accuracy:

Allows for accurate placement and filling of cups as well as accurate scorekeeping

Cup indentations should be precisely measured, weight sensors should have a tight tolerance (<10 g) to ensure cup weights are within the acceptable range (137 - 250g)

LCD screens should display information with no more than a 1 second delay

Intuitiveness:

Minimal user adoption time

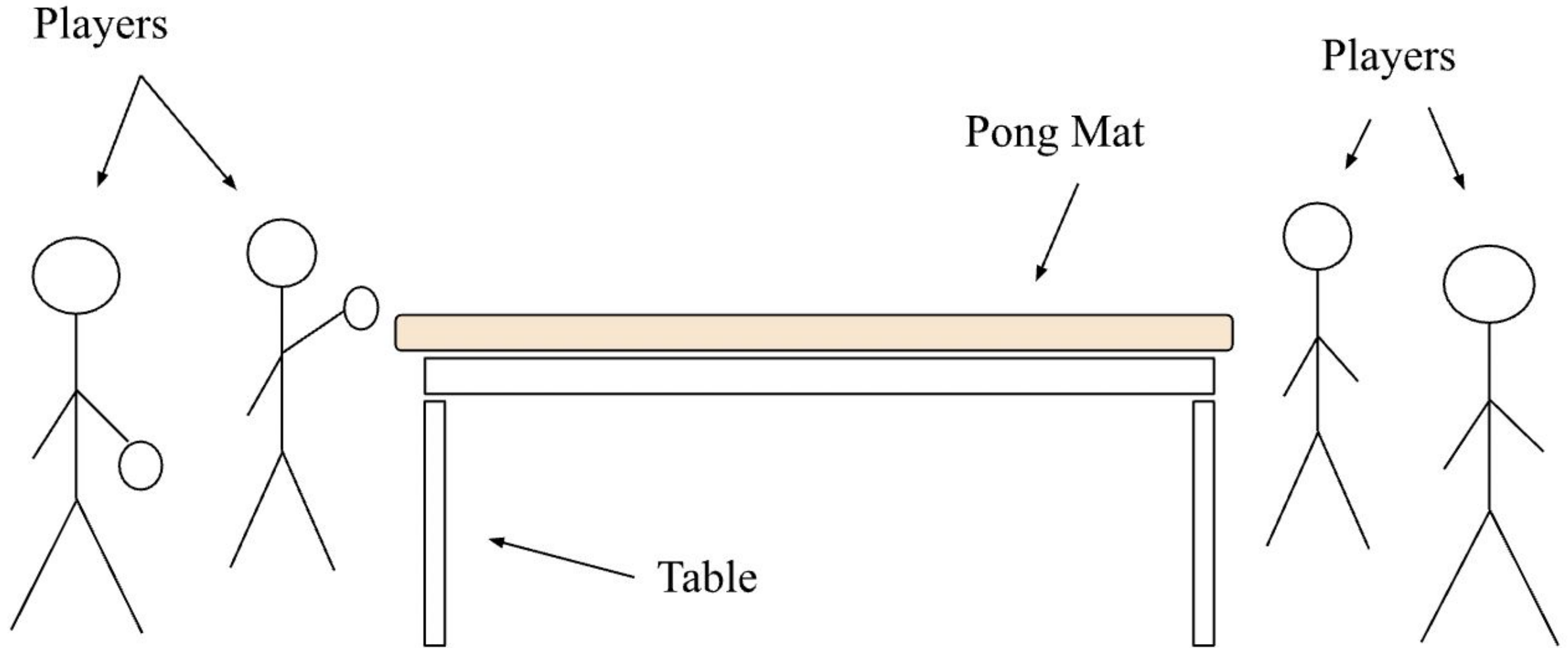
Mat should have simple, easy to understand user interface

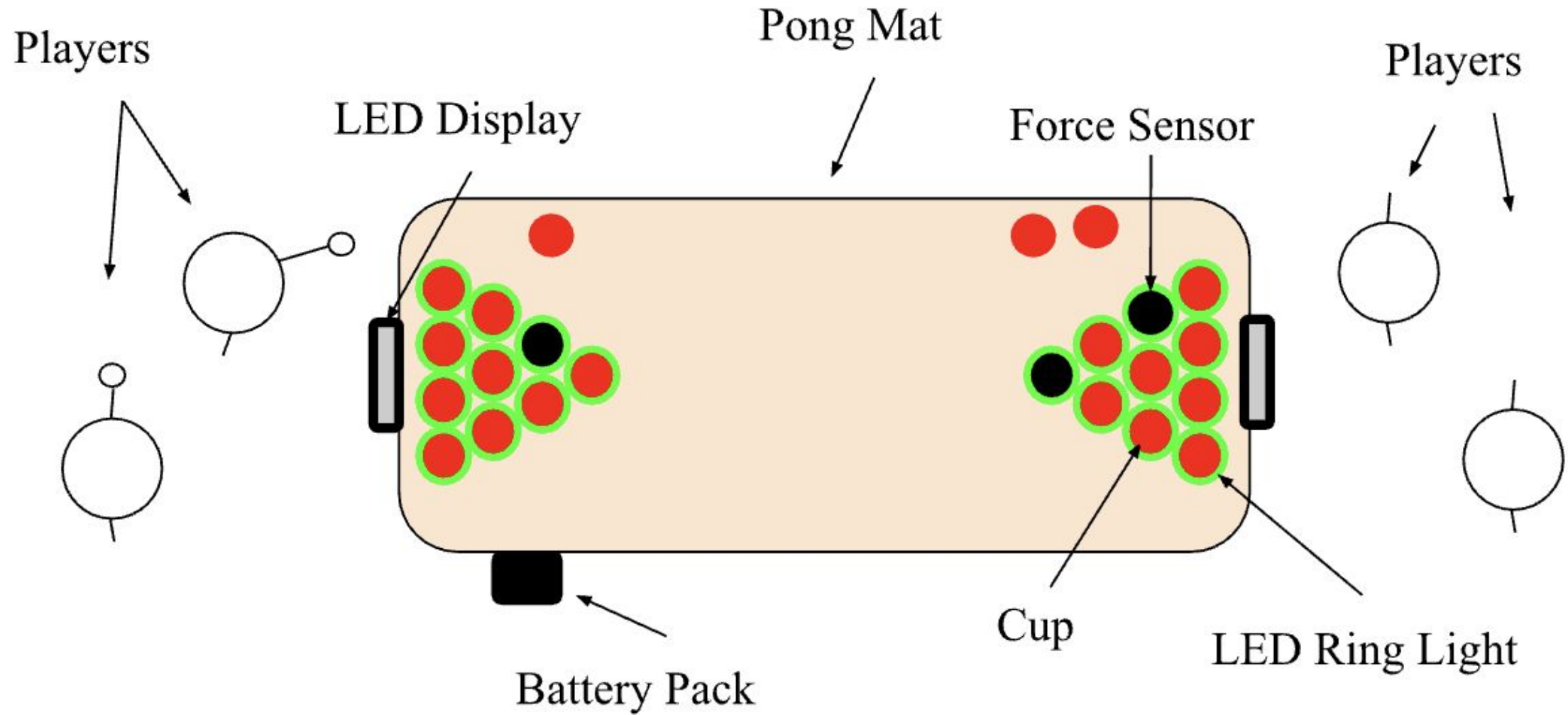
Number of button presses to update the score and restart the game should be minimized



Original Design



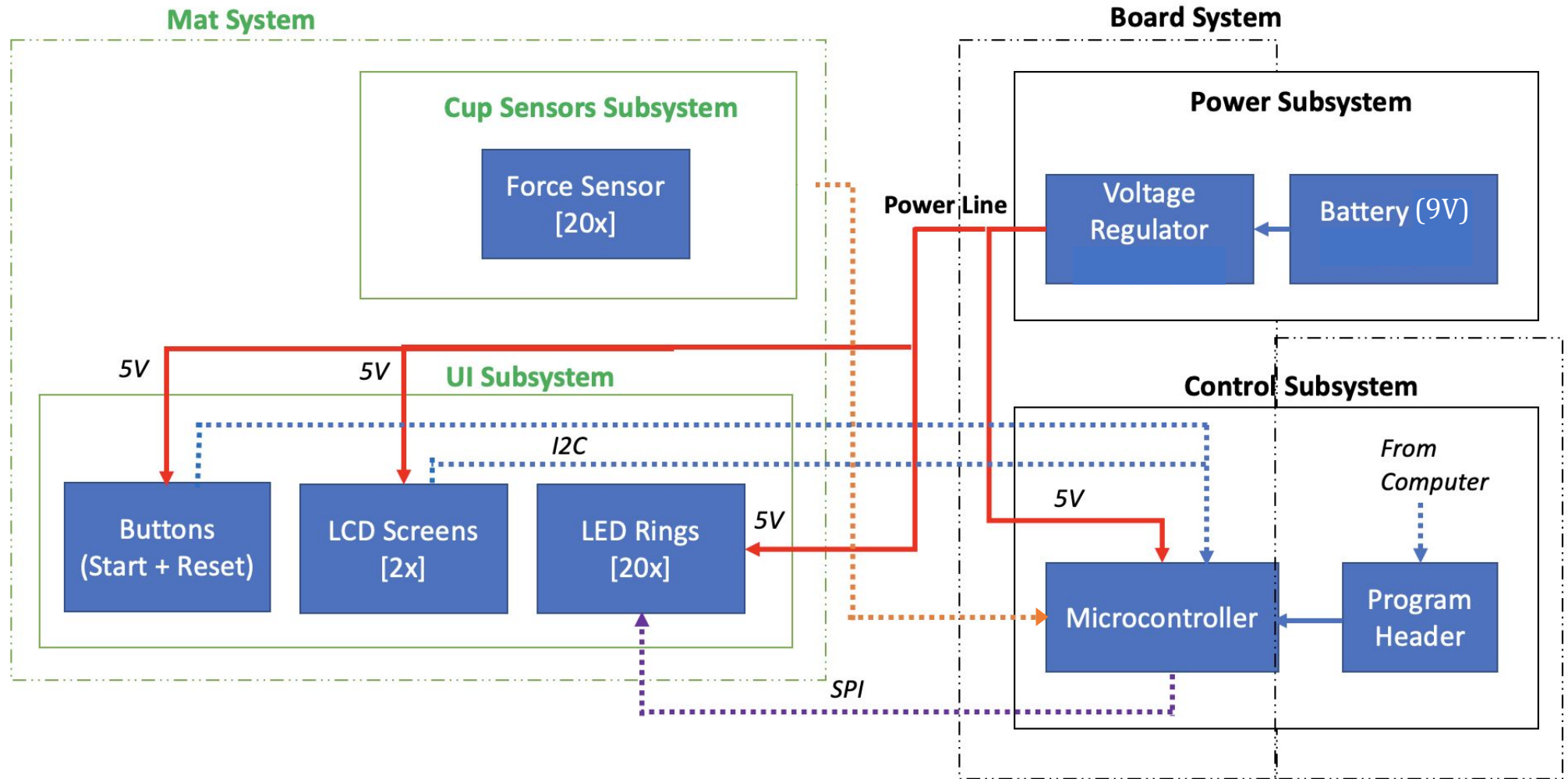


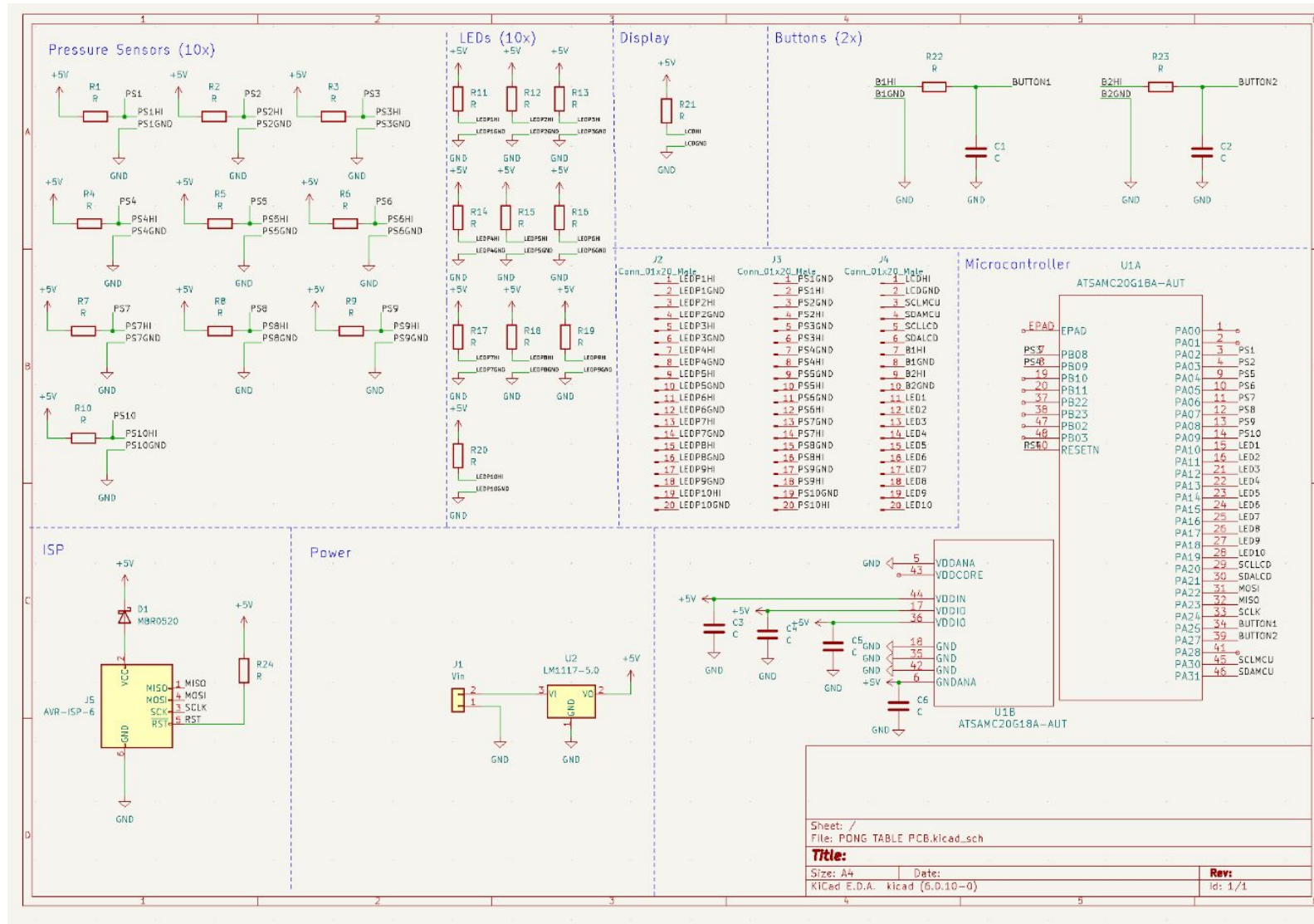


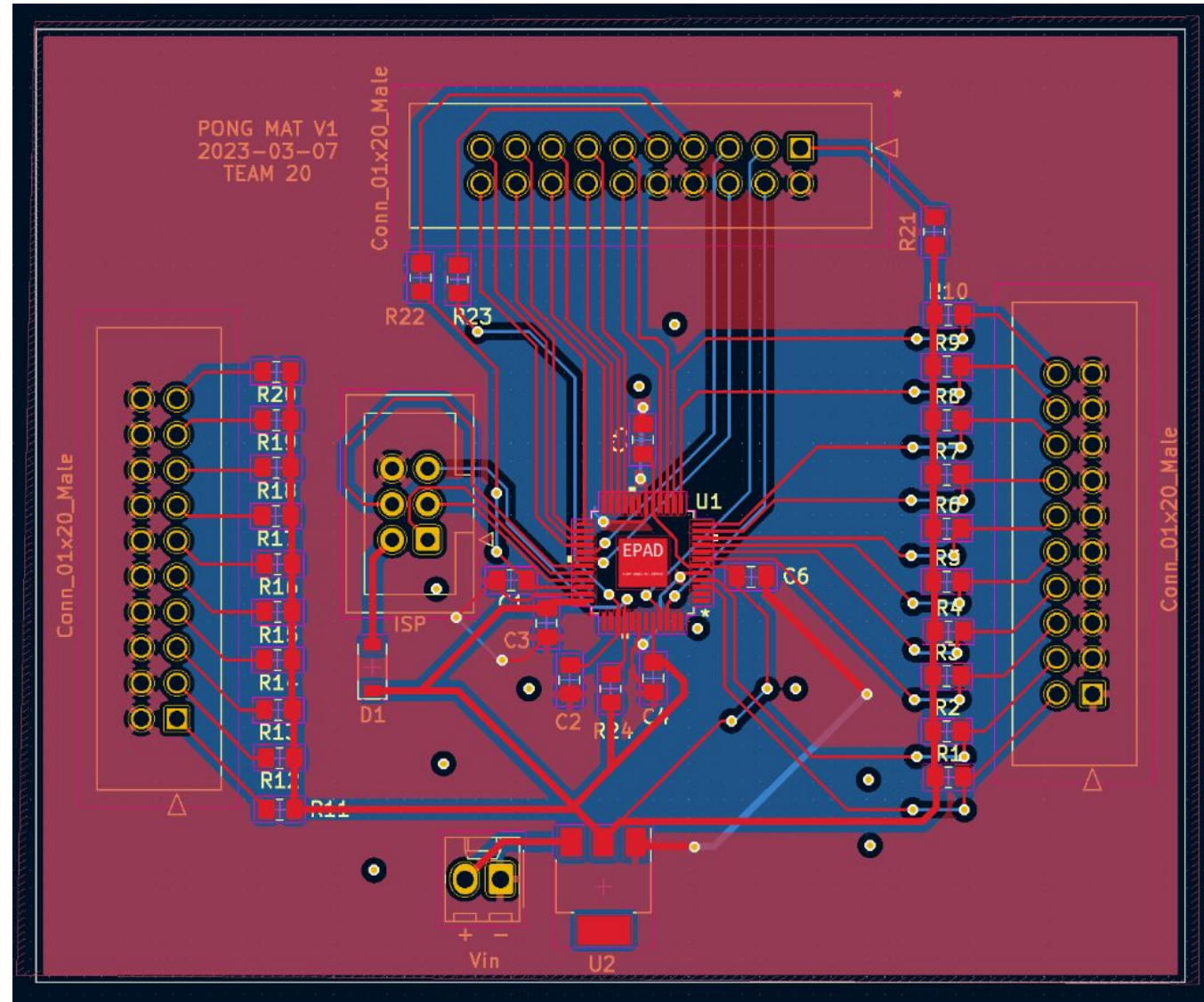
Original Block Diagram



Lines:
Red: Power
Blue/Purple: Output from Microcontroller
Orange: Input to Microcontroller



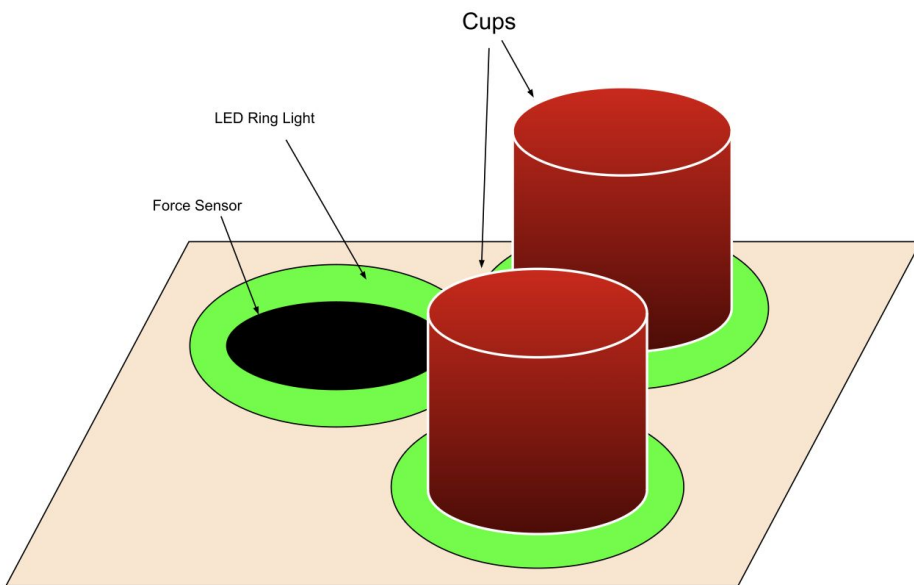
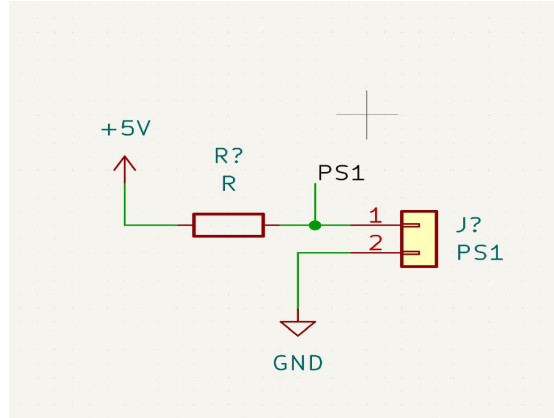






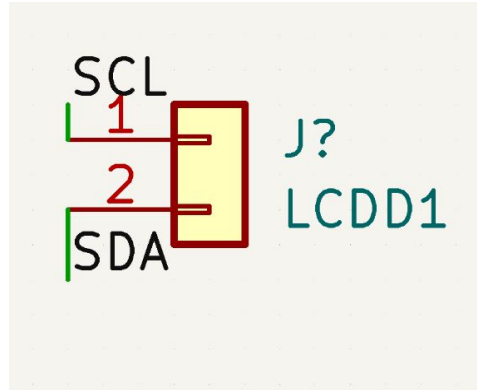
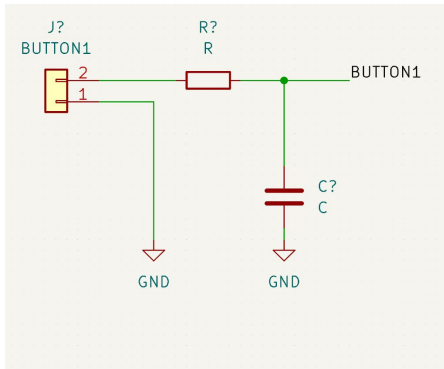
Subsystem Overview

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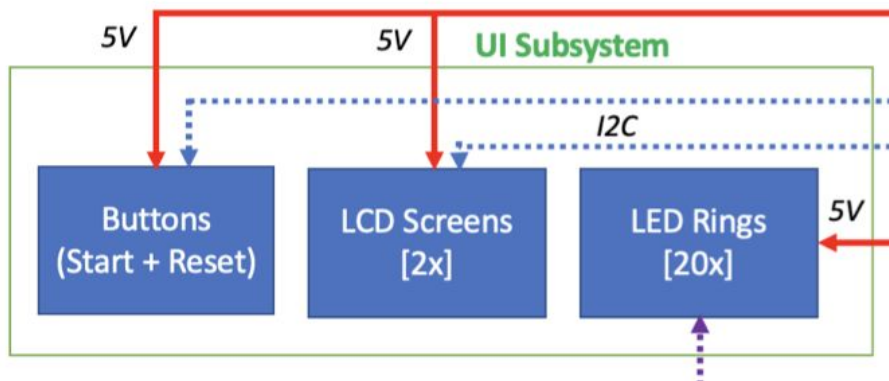
Subsystem Description

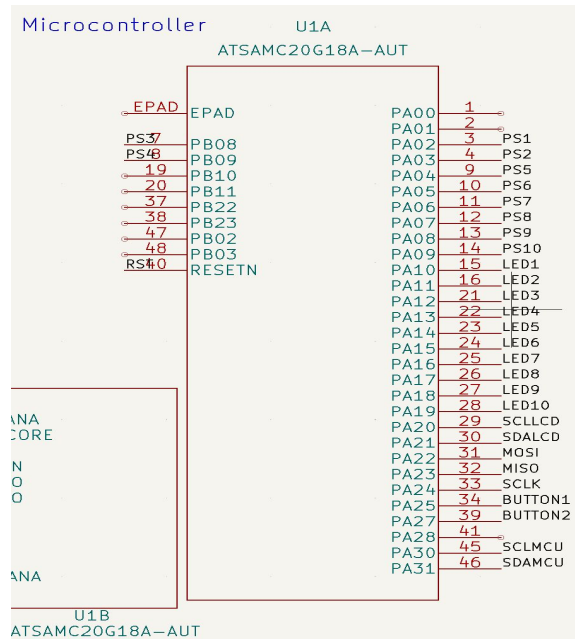
- This subsystem is made up of one component: a force-sensitive resistor (FSR)
- FSRs used to sense weight of cup
- Different weights in a cup change resistance of FSR
- Voltage divider circuit connected to analog read pin on MCU senses changes in resistance, and therefore weight
- Twenty of these subsystems exist within our design, one for each cup



Subsystem Description

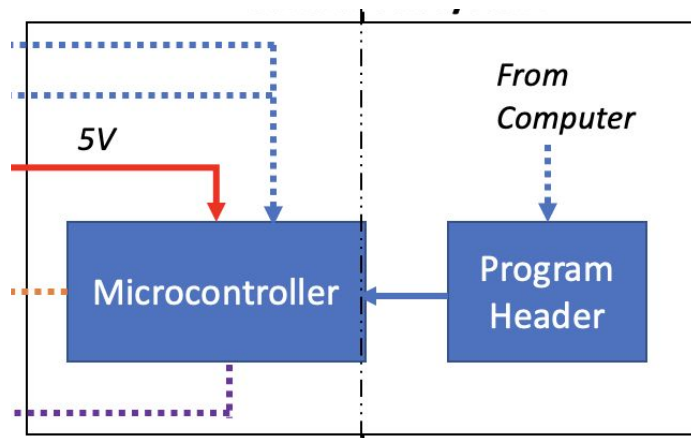
- This subsystem is made up of three components: the LED rings, the LCD displays, and the buttons
- 20 LED rings, one for each cup
- LED rings shine green when weight of cup is acceptable, red otherwise
- LCD display shows the score of the game
- Buttons are used to increase score or reset game

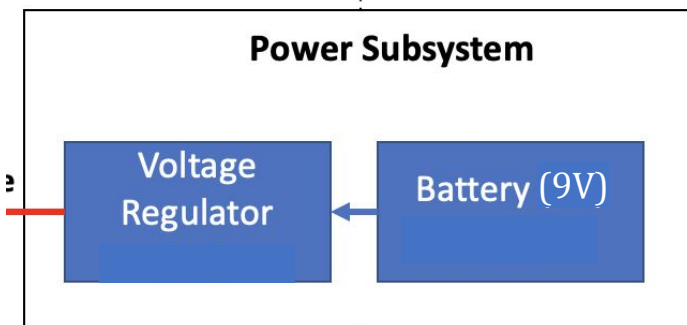
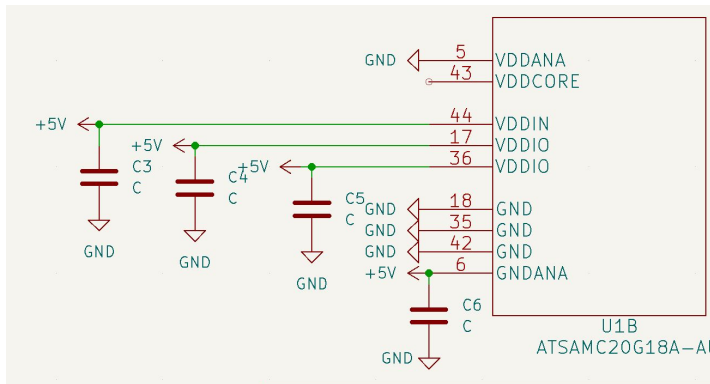
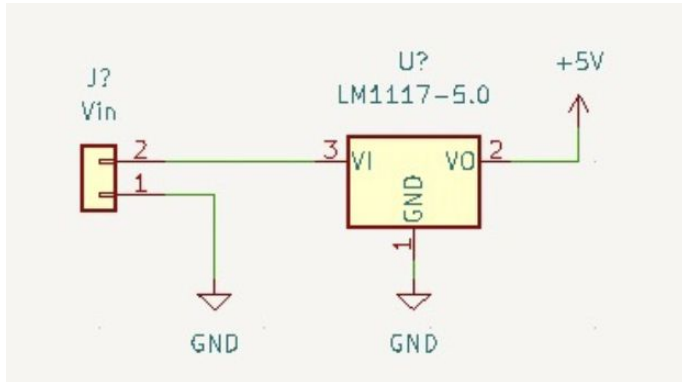




Subsystem Description

- This subsystem consists of the ATSAMC20G18A microcontroller
- MCU receives data from FSRs and buttons
- MCU communicates with LCD display via I2C
- MCU communicates with LED rings via SPI





Subsystem Description

- Mat is powered by one 9V battery
- Linear regulator on PCB steps down voltage to 5V
- Powers the microcontroller, LED rings, and LCD displays (buttons and FSRs are passive)
- Current-limiting resistors used with LED rings and LCD displays
- Bypass capacitors used with microcontroller



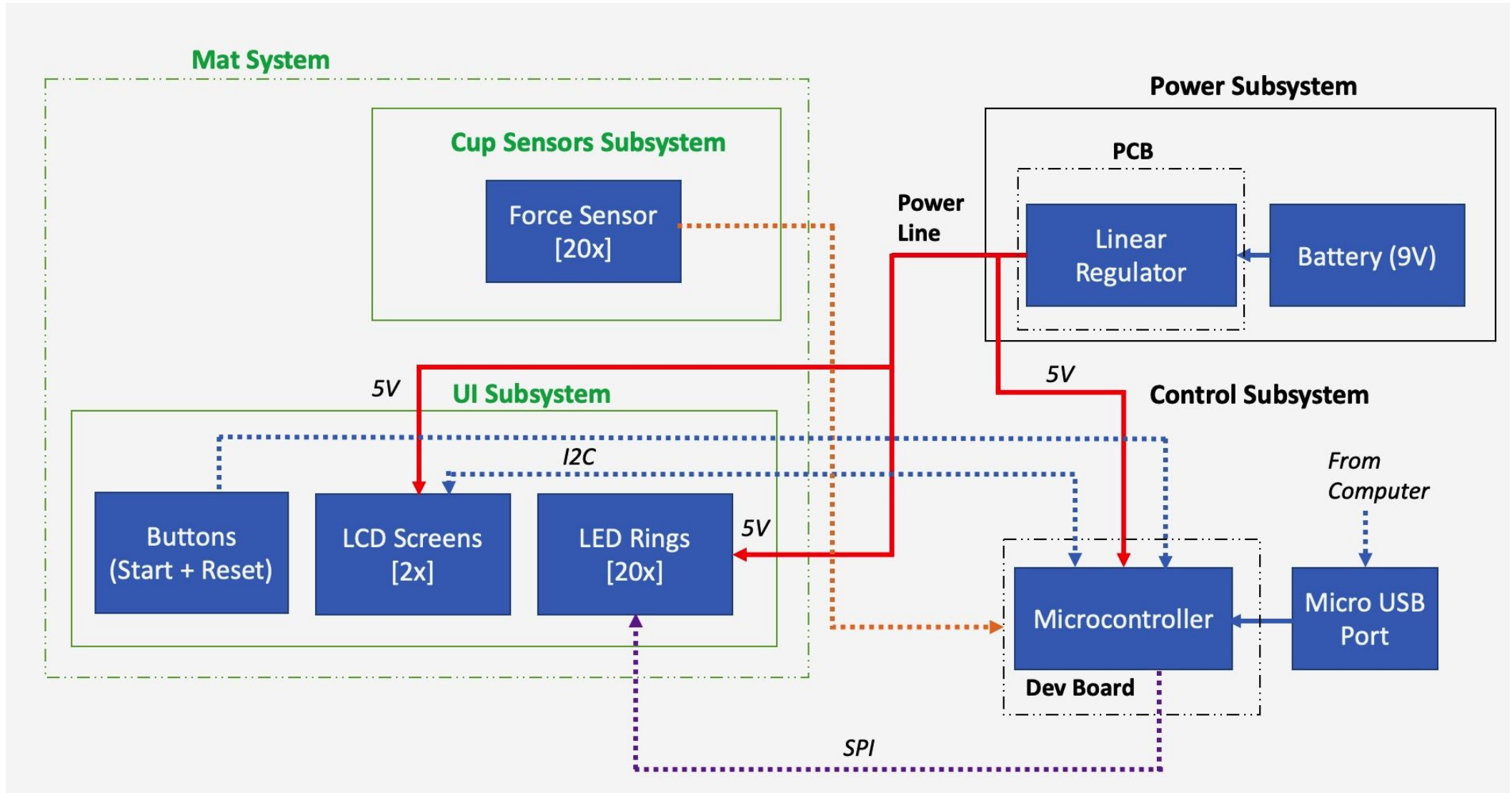
Design Changes

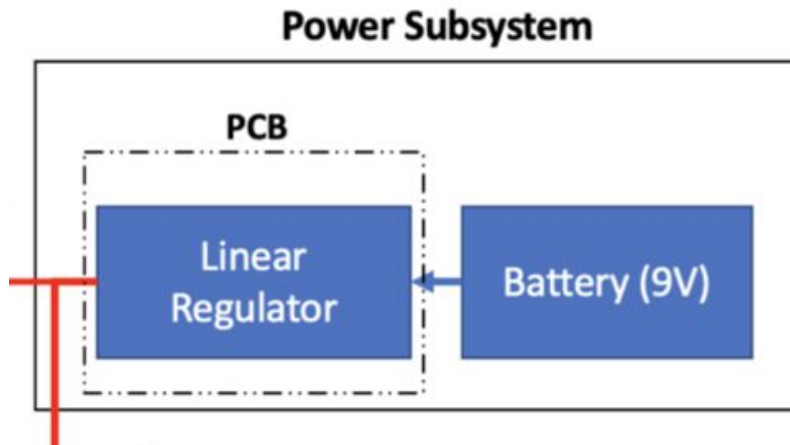
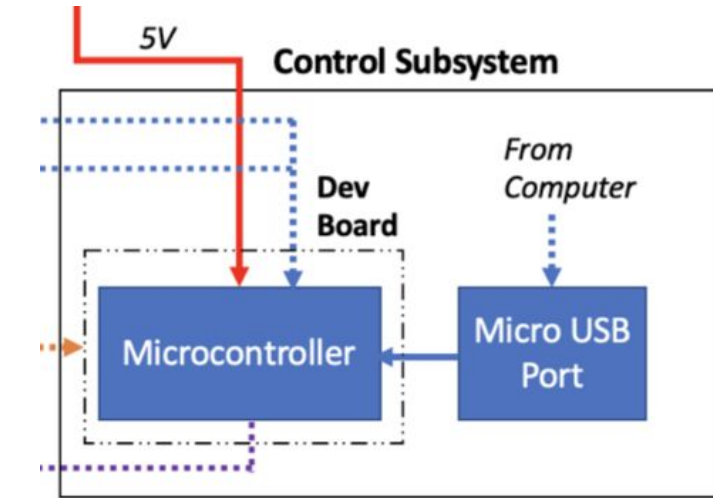
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Updated Block Diagram



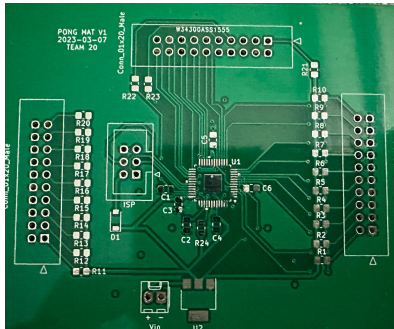
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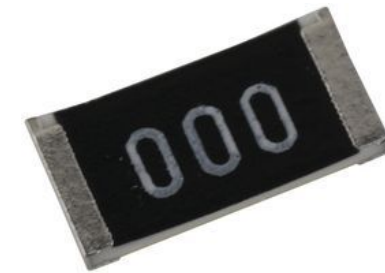
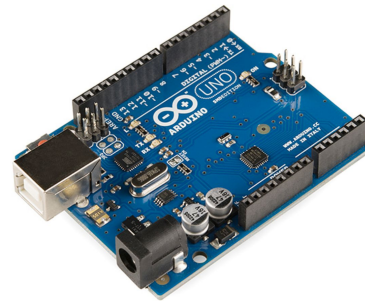


What we altered in our project

- Cup Sensor, UI, and Power subsystems were built and used as originally designed
- Control subsystem consisted of a dev board rather than the on-board microcontroller
- Dev board handled data, PCB handled power



PCB & Development Board



Current Limiting Resistors

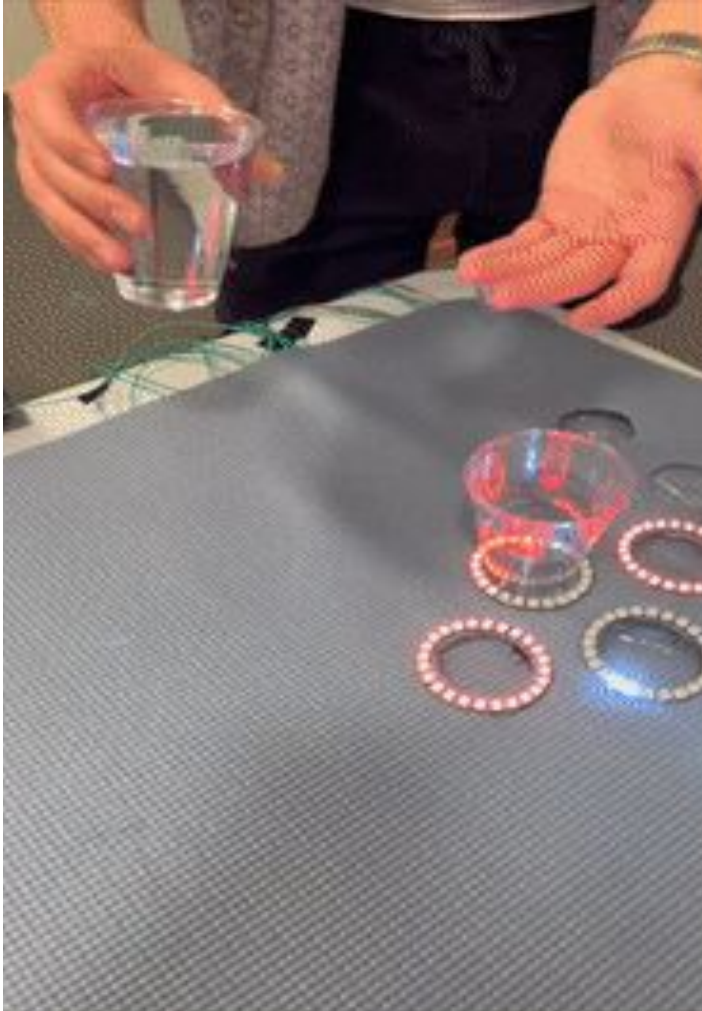


LED Pod vs LED Ring



Product Visuals

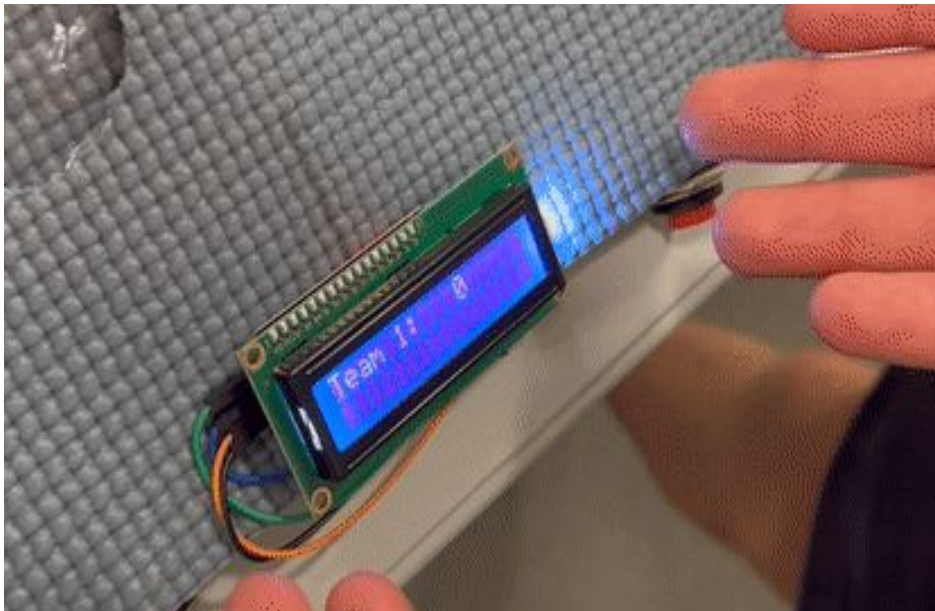
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LED Rings + Force Sensor

- The LED shines green when the proper amount of liquid is in the cup, and red otherwise.
- The pouring of water into the cup changes the pressure on the FSR, which changes its resistance, which changes the voltage read by the MCU
- The MCU reads the voltage from the voltage divider circuit and communicates through SPI to the LED ring to tell it to turn red or green

LCD Screen + Buttons



- The LCD screen keeps track of the score, which can be incremented with one button and reset with the other
- A button press is sensed by the MCU, which updates the LCD display through I2C protocol
- Low latency between buttons, MCU and LCD display allows for instantaneous updating of score



Success Metrics

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High Level Requirement 1: Portability

- Mat should be reducible in size by 50%
- Mat should not need to be plugged into wall outlet

Results

- Mat is foldable and can be reduced in size by 75%
- Mat is battery powered



High Level Requirement 2: Accuracy

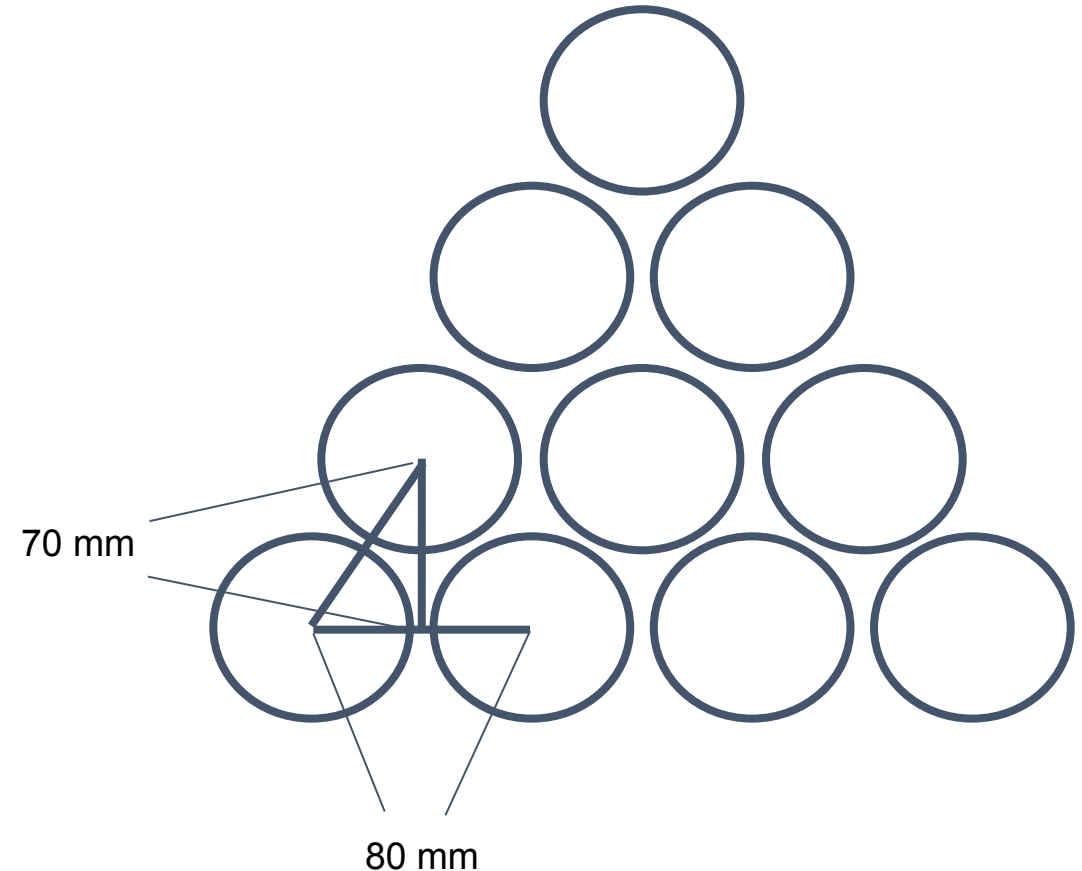
- Cup indentations should be cut precisely
- Weight sensors should have a tight tolerance to ensure cup weights are within the acceptable range
- LCD screens and LED rings should display information with no more than a 1 second delay

Results

- Measurements for proper indentation placement were made and used
- FSR tolerance measured to be within 10 grams, acceptable for our desired weight range of 137 grams to 250 grams
- Latency is a non-issue, LCD display updates almost instantaneously

Cup Placement

- Measurements were made to ensure cup formation is the exact same on both sides
- Mat is two feet wide, each cup has bottom diameter of 47.6 mm and top diameter of 79.4 mm so each cup in bottom
- Center of each indentation in a row is 80 mm apart from the next
- Each row is 70 mm higher than the last



Range of Liquids using the FSR

LEDs should depict red/green based on the varying ranges of liquid weights

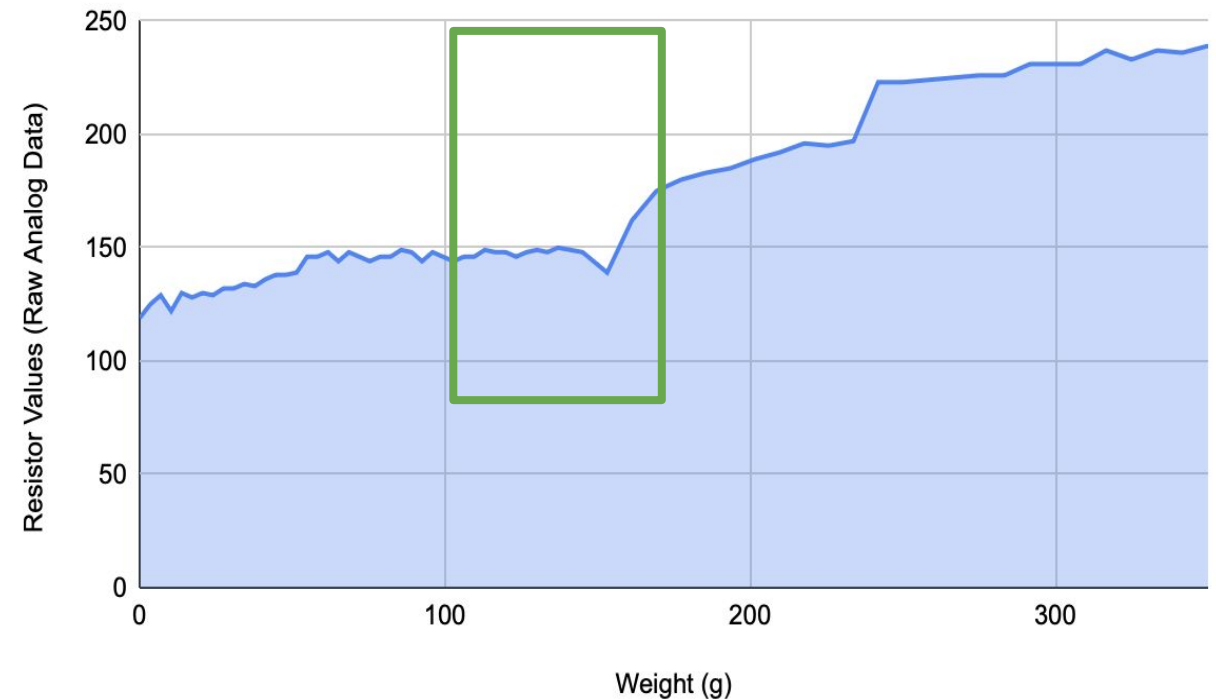
- Based on the weight of the cup and liquid, our FSRs were able to detect the differences in weights resulting in the LEDs changing colors from red to green and vice versa

Success Metrics

- Accuracy: FSRs should detect small changes in weights resulting in the LEDs shifting colors
- Response Time: Low latency response rates for the LEDs to change colors.

Weight vs Resistance Graph

Resistor Values (Raw Analog Data) vs. Weight (g)



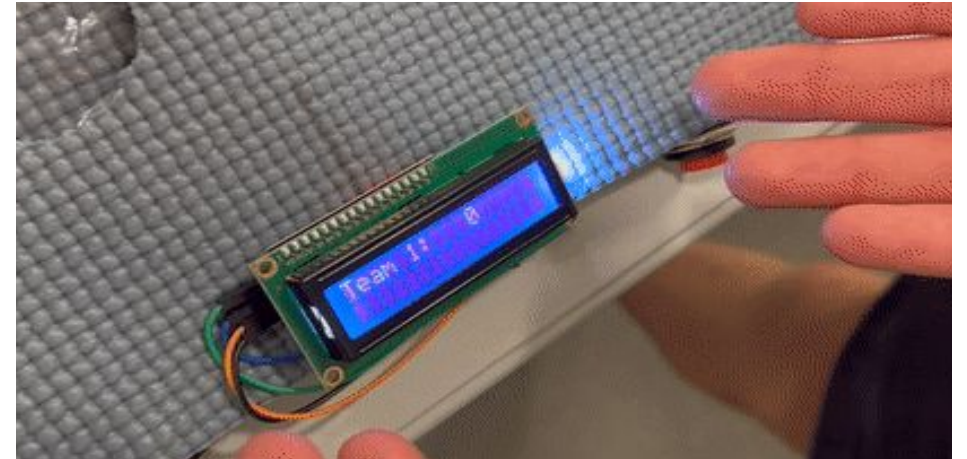
Low Latency

The data transfer between the LEDs, Buttons, and LCDs should be less than 1 second.

- To ensure that the game worked in sync, the data transfer between these components is imperative.

Success Metrics

- Response Time: high response times and low latency rates
 - A training program is used to measure the start and end time of each component using `micros()`

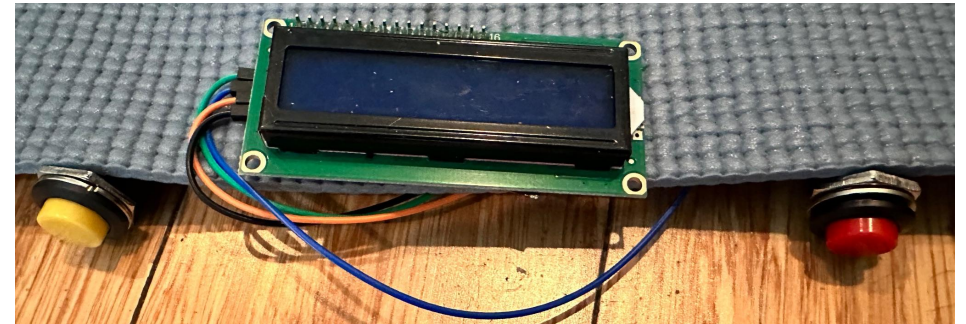


High Level Requirement 3: Intuitiveness

- Mat should have simple, easy to understand user interface
- Number of button presses to update the score and restart the game should be minimized
- Visual cup cutouts so users understood where to place the cups

Results

- We had 2 buttons per team to update score and restart the game
- We did not change any portion as to how the game is played to keep everything simple



Other Requirements

- All sensitive electronics must be waterproofed to prevent damage to equipment or harm to users
- Power supply (9V battery) must be capable of powering the project for at least an hour

Results

- Mat itself was tested to be waterproof, and plastic wrap was used to protect exposed components
- Single battery proved capable of powering whole system

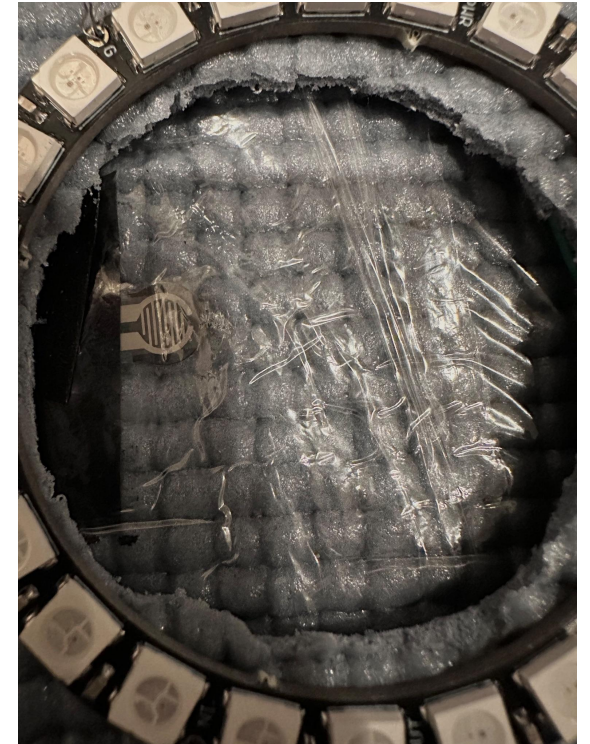
Waterproofing

The mat should be waterproof to account for spills and ensure that the cups remain in position throughout the game.

- The mat cutouts were able to fully hold the cups without movement
- The liquid spills didn't affect the systems and the game continued

Success Metrics

- Stability: The cups remain stable throughout the game
- Safety: The mat is waterproof





Challenges Faced

Problems Faced and Solutions

- Microcontroller
 - We were unable to program our microcontroller due to software issues
- Powering Issues
 - We had to troubleshoot the PCB multiple times to fix power issues
 - Multiple LED rings were burnt out due to improper voltage being used to power them
 - LEDs powered through PCB were not functioning properly due to current limiting resistors
- Logistics
 - Testing & part ordering was delayed and our verification schedule fell behind causing impromptu changes
 - Late testing caused multiple parts not to arrive in time for demo



Ethical Concerns

- Possible Encouragement of Binge Drinking
 - Beer pong is a drinking game, and our project is an accessory to that
 - We need to take measures to ensure that product is used in a safe manner
 - **Solution:** warning against dangers of binge drinking
- Risk of Water/Beer Damage
 - By the nature of the game of beer pong, this product will be used near liquids
 - Liquid coming in contact with electrical components could damage product or harm user
 - **Solution:** ensure that all sensitive electronic components are sufficiently waterproof



Conclusions and Recommendations for Future Work

Conclusions & What we learned

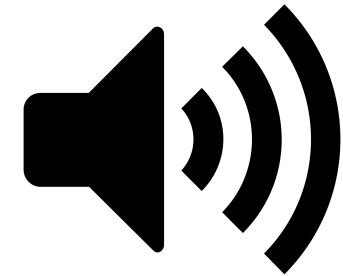
- Learned a great deal about PCB design and implementation, power systems, and product design
- Learned that things go wrong very often
- Given the chance to start over, we would:
 - Choose more reliable components
 - Properly encase PCB and development board
 - Choose a compatible microcontroller



1. Sensing when a ball hits a cup



2. Automated beer pong table rather than mat



3. Incorporate audio



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