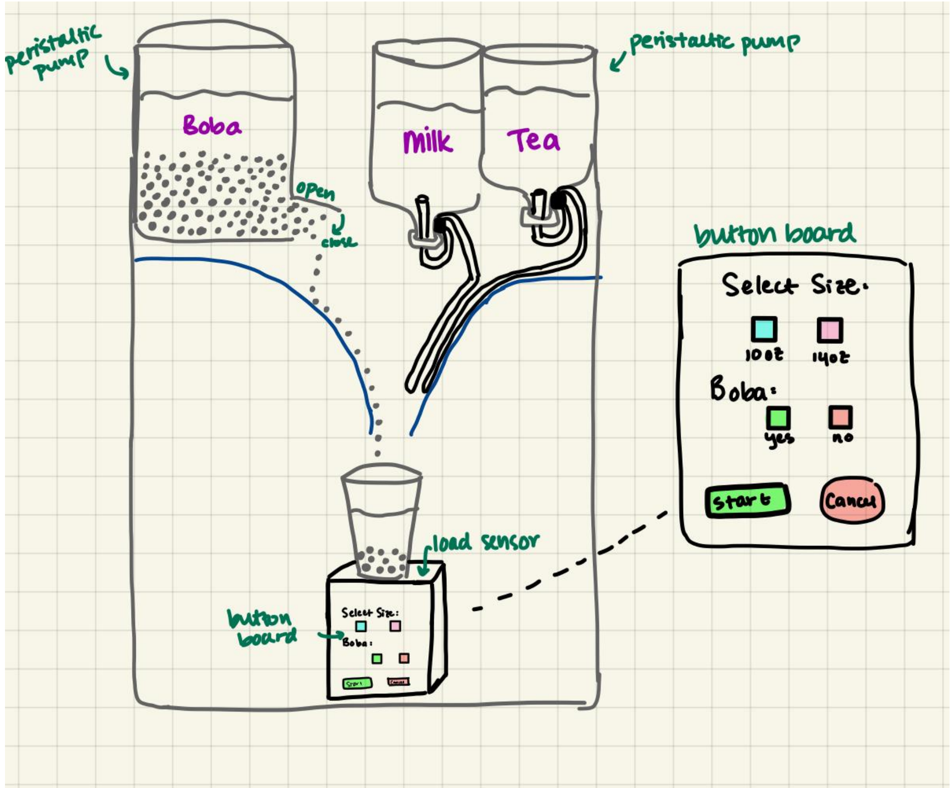
Bubble Tea Machine

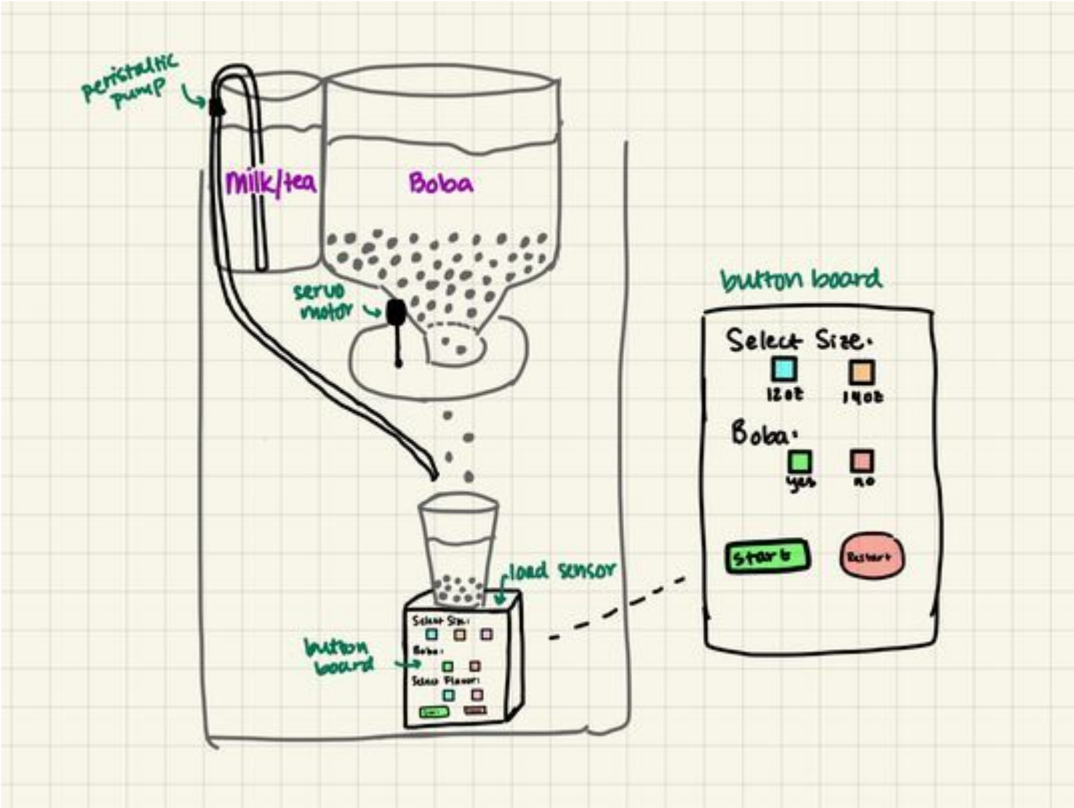
Team 30: Emily Hall, Saisita Maddirala, Tracy Tang

5/03/2022

Introduction

Original Design





Original Design - Overview

- **Power System**
  - 120VAC -> 12VDC -> 5VDC

- **I/O System**
  - 6 Buttons
    - 10 oz, 14 oz, Yes Boba, No Boba, Start, Restart
  - 6 LEDs for each button
  - Bubble Tea Machine starts making drink only when “Start” button is pressed
  - “Restart” button allows user to restart their order

- **Ingredient Dispensing System**
  - Milk/Tea Dispenser
    - Peristaltic Pumps (with food safe tubing)
    - Powered by L293D H-Bridge (schematic shown on the right)
    - Leaves pump on for 143 seconds for 10 oz and 258 seconds for 14 oz
  - Boba Dispenser:
    - Servo motor
    - Leaves servo open for 1 second
    - Powered by Servo Motor Trigger

Introduction

State	Description	Inputs accepted	Outputs
1	- Machine is powered on - Ready for size choice	- Size choice - Cancel	- Size LEDs - Cancel LED
2	- Ready for boba choice - Ready for cancel button press	- Boba choice - Cancel	- Boba LEDs - Cancel LED
3	- Ready for start button press - Ready for cancel button press	- Start button press - Cancel	- Start LED - Cancel LED
4	- Dispense boba, milk, and tea		- Boba motor - Milk pump - Tea pump

Original Design - Overview

Control System

The control system is composed of an ATmega328P, programmed with control logic to accept input out write outputs.

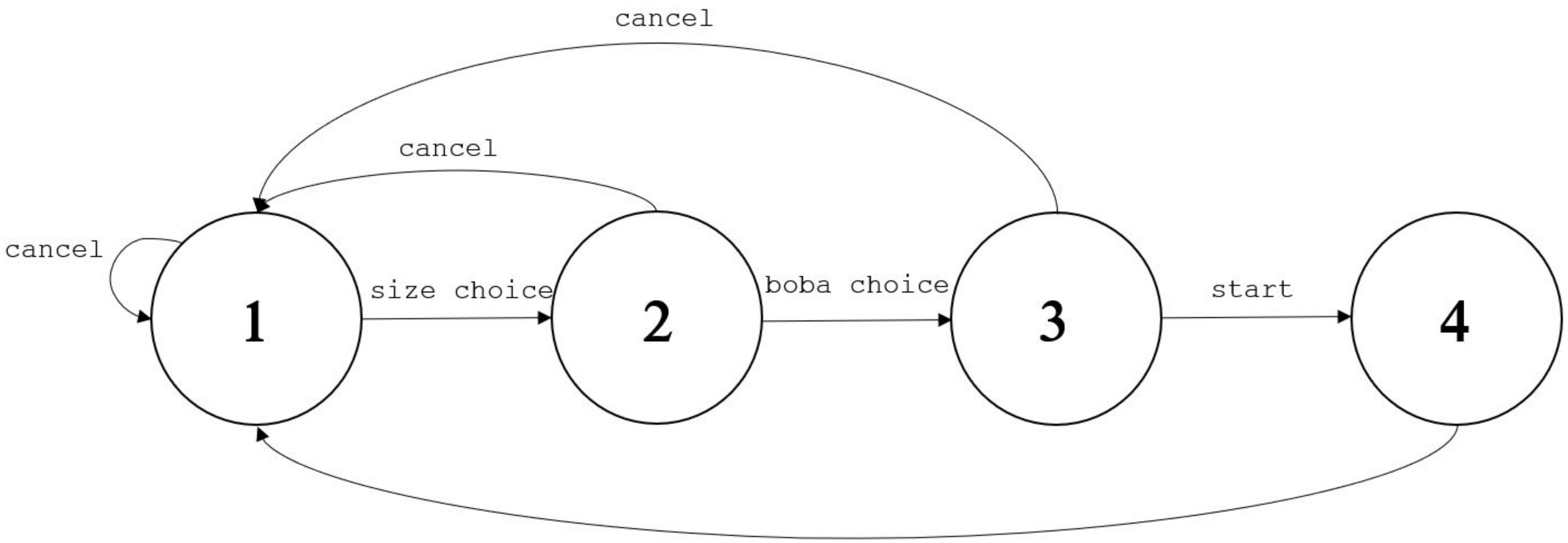
Our ATmega238P has:
six inputs:
- two size options (10oz and 14oz)
- a ‘boba’ button
- a ‘no boba’ button
- a ‘start’ button
- a ‘restart’ button

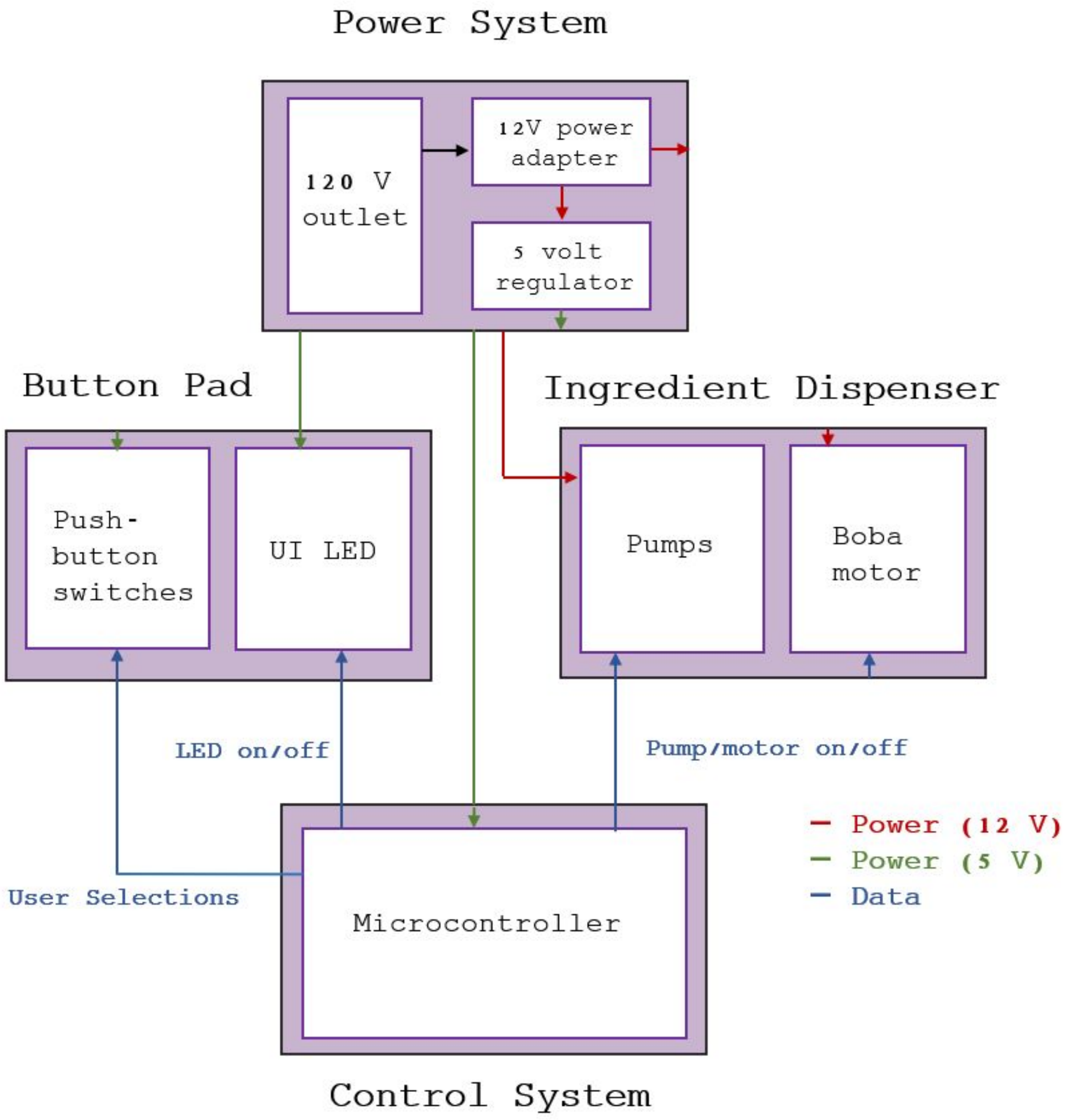
eight outputs:
- 6 indicator LEDs
- liquid pump signal
- boba motor signal

Original Design - Overview

Control System

- Goes through multiple states for button presses/LED output
- Load Cell Sensor sends control signal for boba motor





Block Diagram

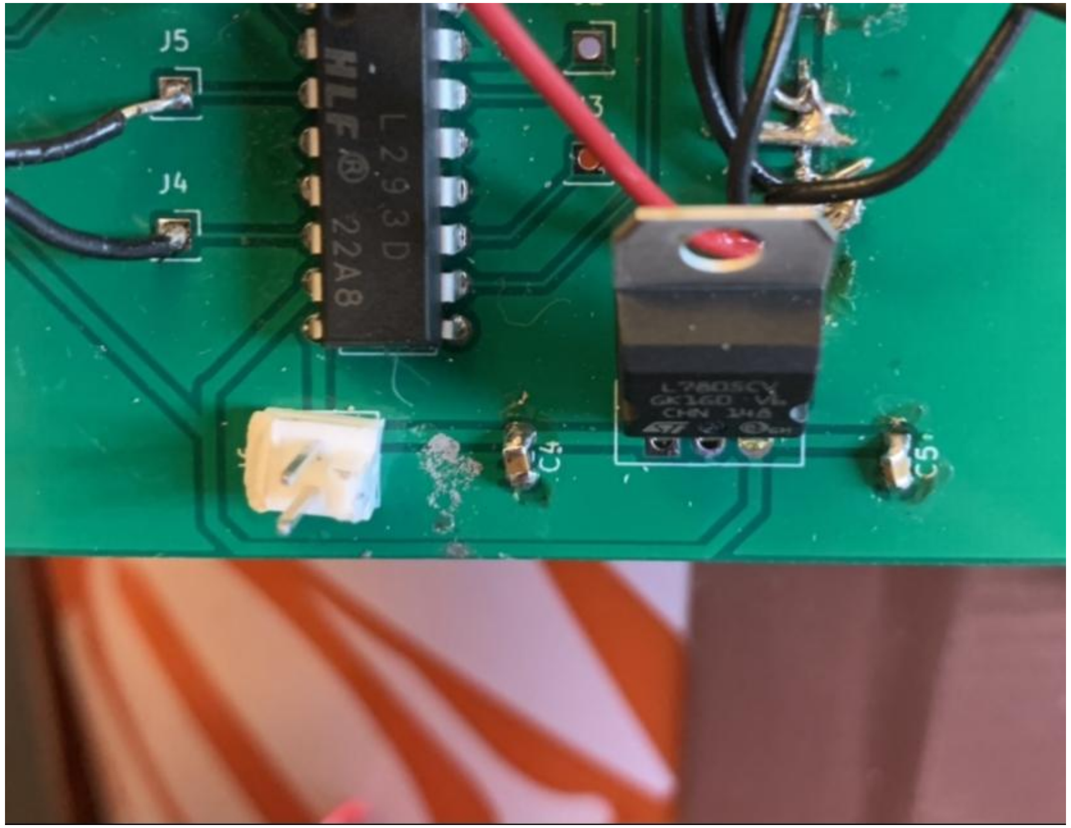
High Level Requirements

- The device must provide the user with many combinations of size and ingredients. We will have two size options (10 oz, and 14 oz), and an option for no boba. Each combination will be allowed, giving the user 4 possible drink options.

- The device must be able to dispense pre-calculated amounts of liquid and boba into the cup.

- The device must start/cancel under the appropriate conditions. It should start only if the “start” button is pressed. The machine should stop the order if the “cancel” button is pressed.

Subsystem Overview



Power System

Same as original design

We used a 12V Power Adapter that is plugged in to the wall and connected it to a 5v regulator:

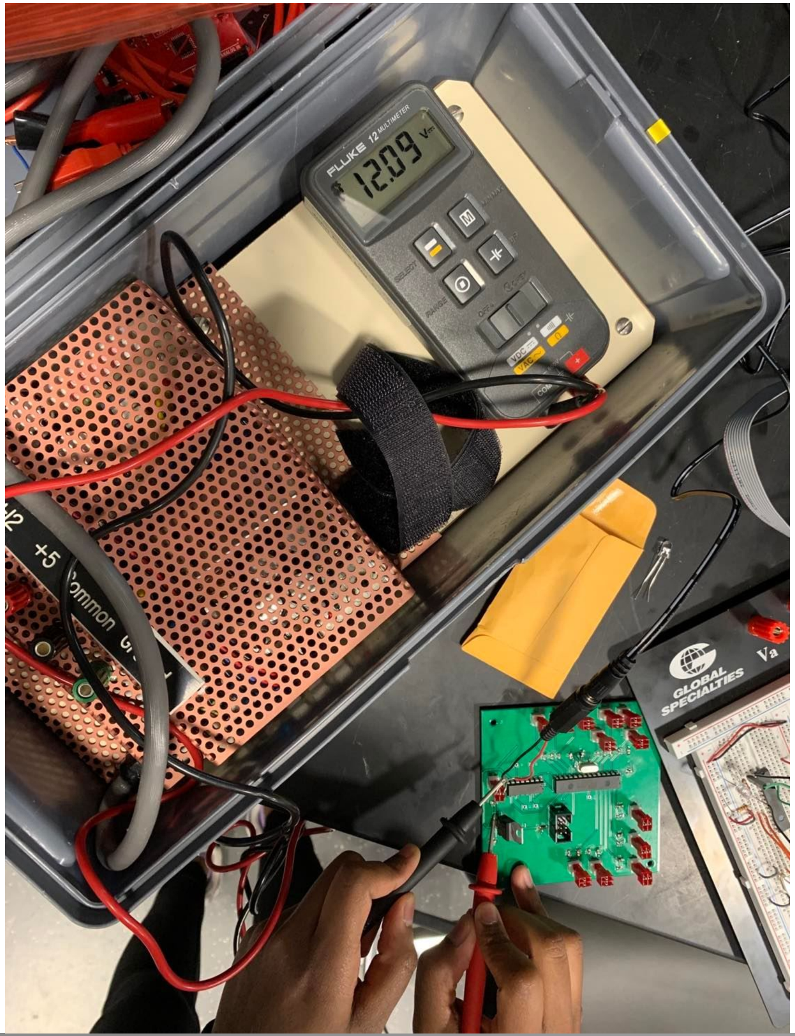
- 5V required for MCU, buttons/LEDs, load cell, servo motor
- 12v required for peristaltic pumps

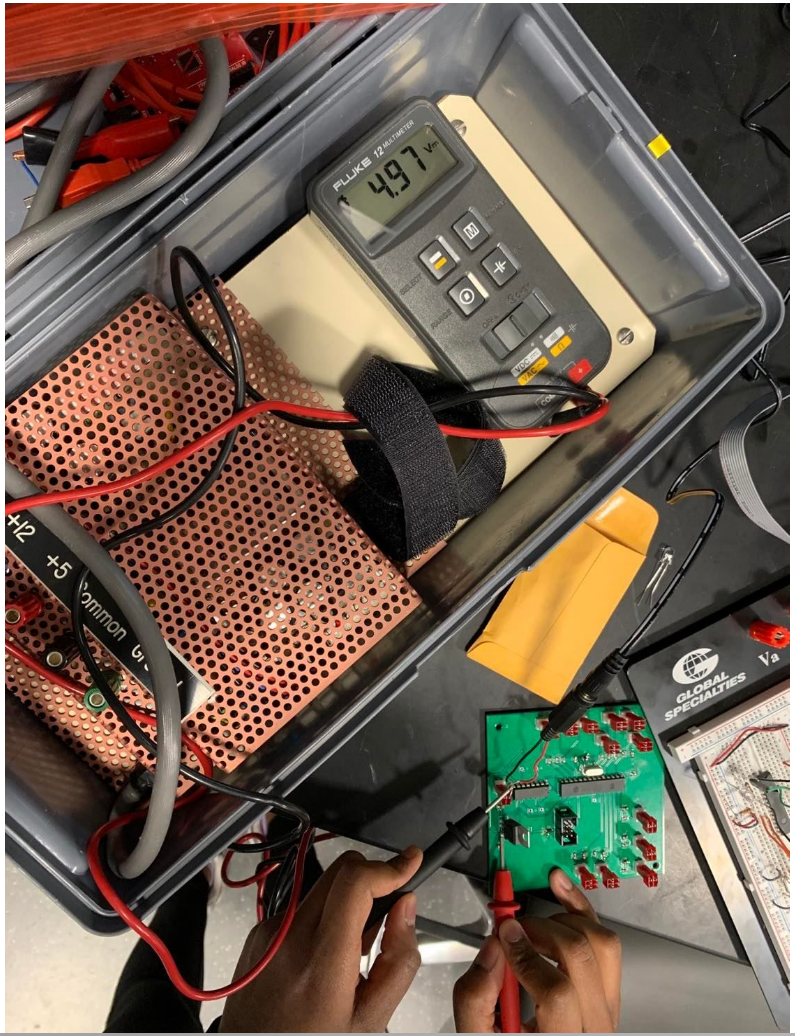
Subsystem Overview

Requirement	Verification
1. Bubble Tea Machine must plug into the wall and receive 12VDC ± 5% from the power supply.	1A.Cut off the end of the power supply and use an oscilloscope to check that the output voltage of the power supply stays within 5% of 12V.
2. Voltage regulator must send 5v ± (1.5-4)% to the microcontroller, Servo Motor, and load cell sensor/Hx711 amplifier.	2A. Use an oscilloscope to check that 5v ± (1.5-4)% is outputted from the voltage regulator. Check Vo from figure 4.
3. Voltage regulator must supply 150-300 mA to Peristaltic Pumps and microcontroller.	3A. Connect Vout to Vin in Figure 4. 3B. Change R1 from Figure 4 so that the output current is the appropriate amount for each component. 3C. Probe Vo from figure 4 and measure current with the adjusted resistors to ensure the current supplied is 150-300 mA.

Power System RV Table

Power System Results



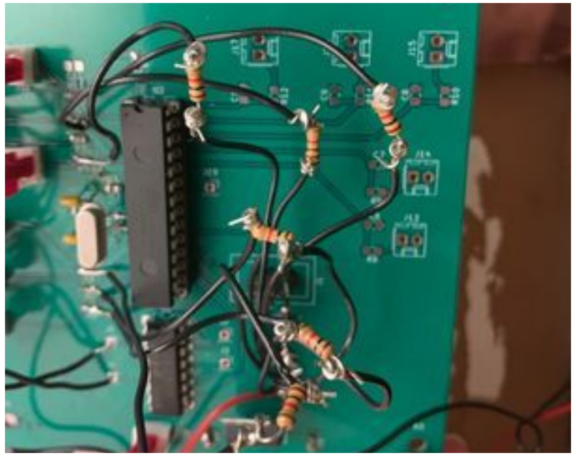


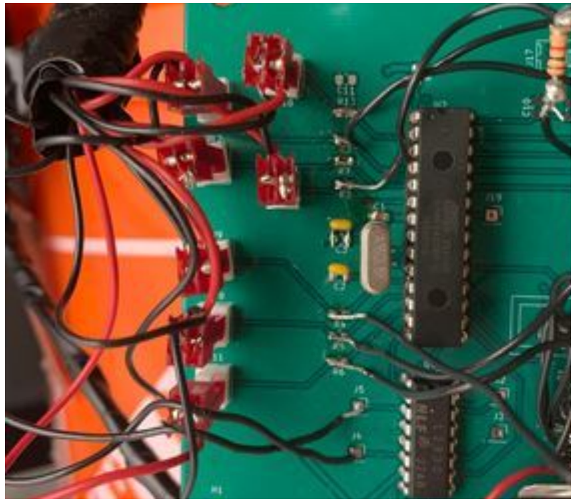
I/O System - Final Product

Small Changes:

The I/O system still has 6 buttons but now only 1 LED:

- 6 buttons
  - 10 oz, 14 oz, Yes Boba, No Boba, Start, Restart
- 1 LED
  - slow blinking : waiting for size choice
  - medium blinking : waiting for boba choice
  - fast blinking : waiting for “Start” button press
  - off : machine making drink



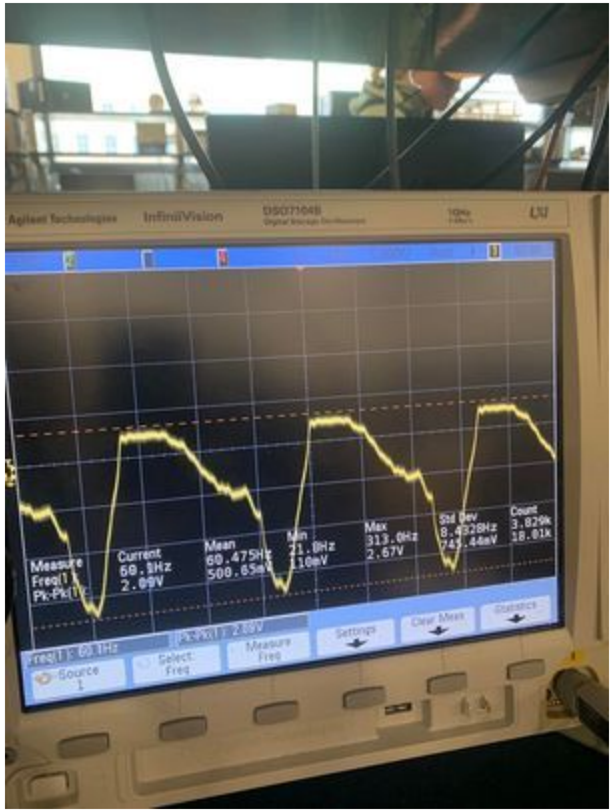


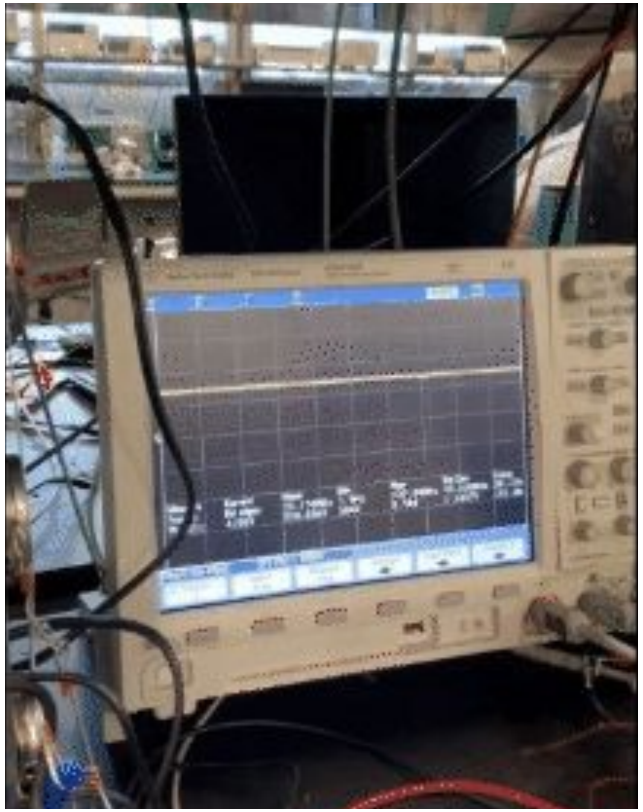
Subsystem Overview

Requirement	Verification
1. The push-button switches must send accurate signals to the appropriate ingredient containers.	1A. Connect the start signal from figure 5 (J19) to an oscilloscope and the start signal (pin 28) from figure 6 to a different channel on the oscilloscope. Check that these signals match. 1B. Check that the start_led from figure 6 turns on. 1C. Repeat 1A. For the 10oz button (J14), and the 14oz button (J16) from figure 5 to their respective signals/LEDs from figure 6.
2. The push-button switches receive 40-60 mA of current.	2A. Connect the 5V for the buttons to a 100Ω potentiometer. 2B. Change the potentiometer until it reaches 40-60 mA. 2C. Measure the current with a multimeter.

I/O RV Table

I/O System Results





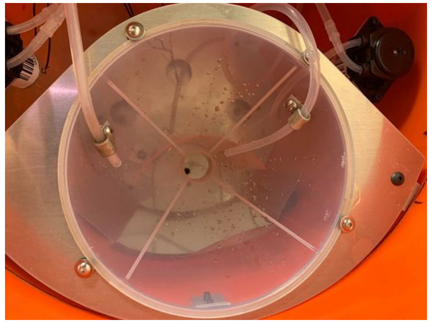
Changing buttons from analog to digital pins (more on this later)

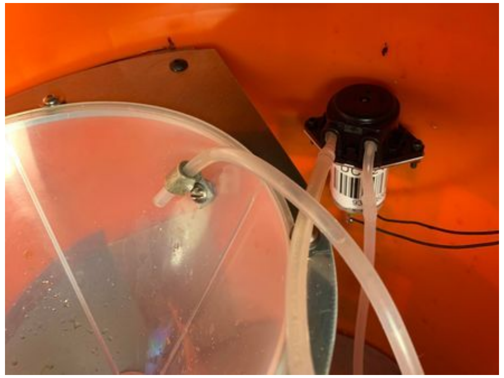
Ingredient Dispensing System

Small Changes:

- Milk/Tea dispenser:
  - Using only 1 pump instead of 2
  - H-Bridge can’t evenly dissipate current to both outputs (pumps)

- Boba Dispenser:
  - Servo motor uses an arduino library that presets an angle/positions the servo should go



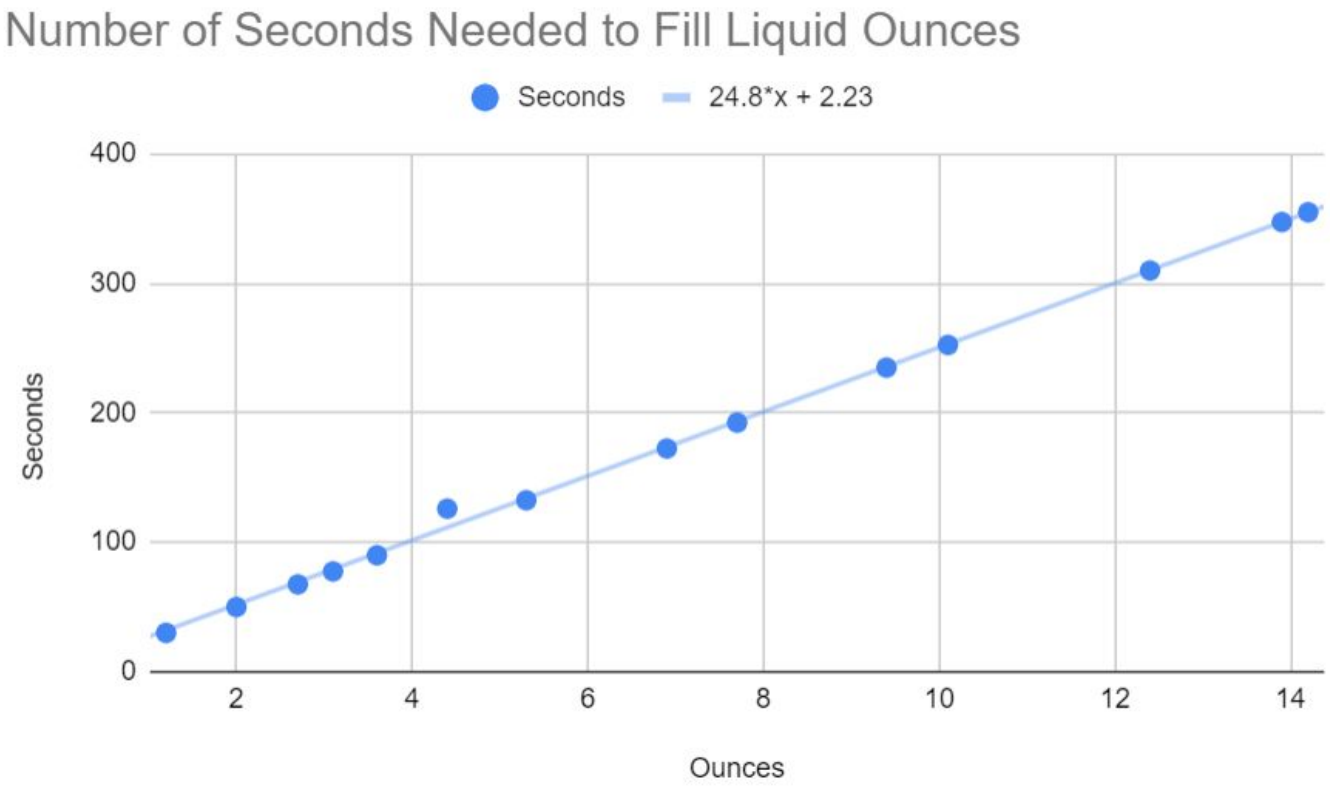


Subsystem Overview

Requirement	Verification
1. Servo motor must run when powered by the servo trigger.	1A. Connect servo motor output from servo trigger (figure 7) to a multimeter. 1B. Check that 5v±0.25 is being supplied.
2. The pumps (DC motor) must run when powered by the H-bridge.	2A. Connect Vcc2 (pin 8) from figure 8 to a multimeter. 2B. Check that 12v±0.25 is being supplied.
3. The Servo motor trigger should leave the door of the servo motor open for 7-10 seconds for the boba to be dropped.	3A. Connect the out pin of the servo motor trigger pin to the oscilloscope. 3B. Adjust the time potentiometer (potentiometer C) until open for 7-10 seconds. 3C. Ensure that the servo motor does not shut before the completion of seconds.
4. PWM signal is supplied to H-bridge accurately (circuit works).	4A. Connect PWM signal from figure 8 to oscilloscope. 4B. Check that the wave we see on an oscilloscope is an accurate PWM wave. 4C. Connect PWM signal (en1 in h-bridge) from figure 8. 4D. Check that the wave we see on an oscilloscope is an accurate PWM wave.
5. Servo motor receives 4-6 mA.	5A. Connect the 5V for the Servo Motor to a 100Ω potentiometer. 5B. Change the potentiometer until it reaches 4-6 mA. 5C. Measure the current with a multimeter.
6. Peristaltic Pumps receive 200-300 mA.	6A. Connect the 5V for the Peristaltic Pumps to a 100Ω potentiometer. 6B. Change the potentiometer until it reaches 200-300 mA. 6C. Measure the current with a multimeter.

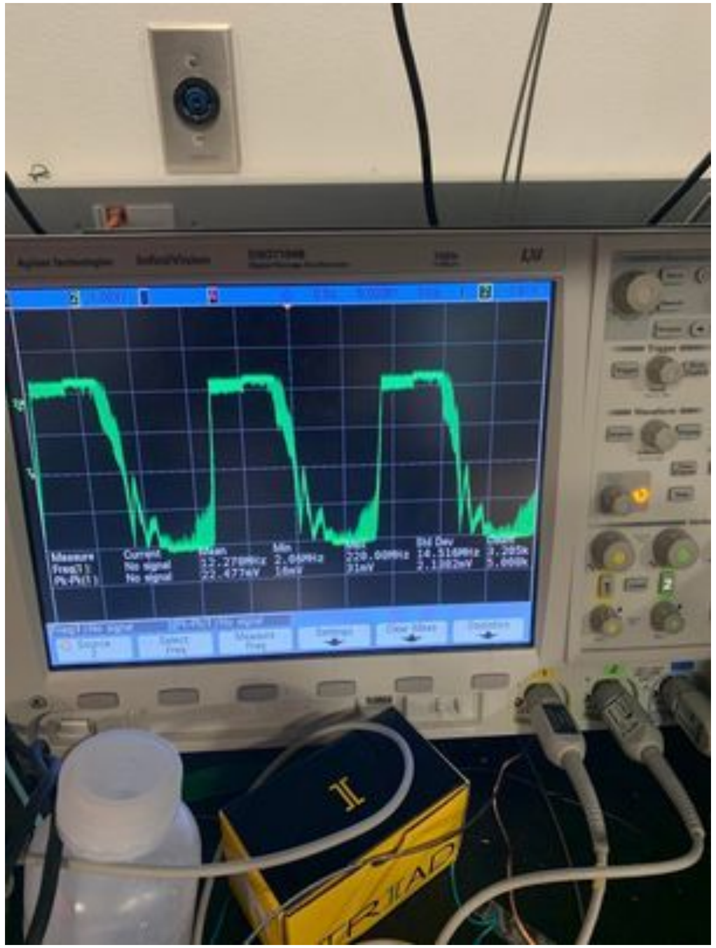
Ingredient Dispensing RV Table

Ingredient Dispensing System Results

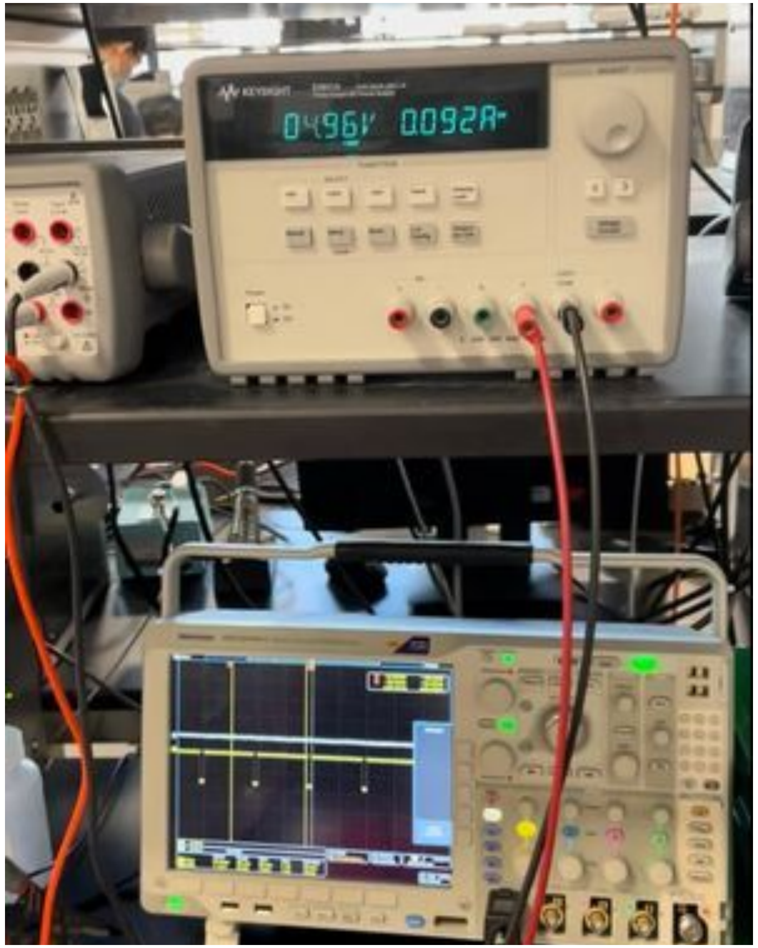


For Peristaltic Pumps

Ingredient Dispensing System Results

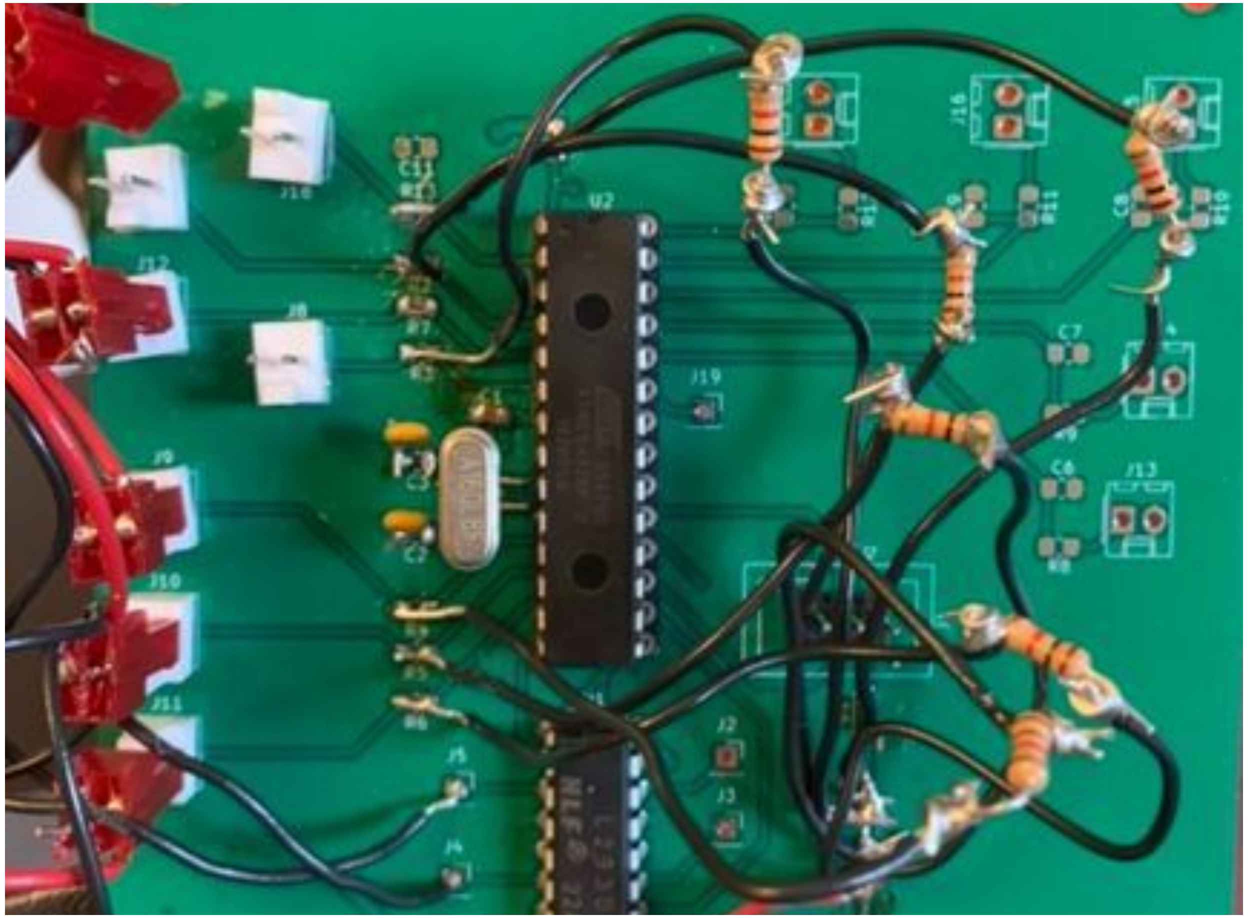


PWM signal sent to H-Bridge



PWM signal sent to servo

Subsystem Overview



Control System

Small Changes:

- 1 indicator LED (instead of 6)
- Analog buttons changed to digital buttons (replacing LEDs)
- Controls Servo position
- No more Load Cell Sensor
  - Hx711 amplifier hard to communicate with ATMega328P

Subsystem Overview

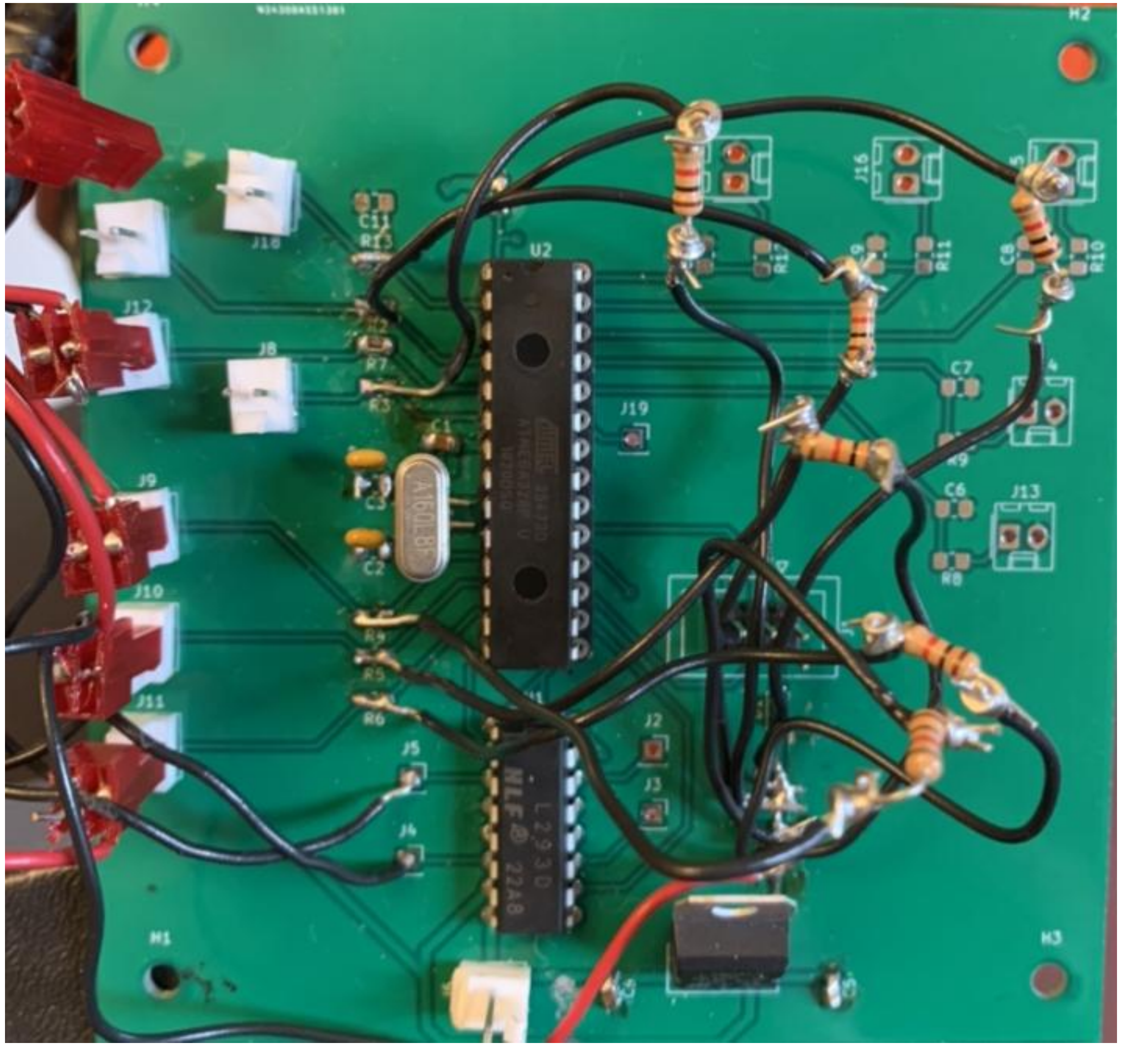
Requirement	Verification
1. Bubble tea machine should only start making the drink when the “start” is pressed.	1A. Connect boba_motor (pin3) signal (figure 6) to the oscilloscope. 1B. Ensure the signal is high when the start signal (figure 6) is high.
2. Bubble Tea Machine should ignore the “cancel” button once “start” has been pressed.	2A. Connect cancel_button (figure 5) to an oscilloscope. 2B. Connect the start_button (figure 5) to a different channel on the oscilloscope. 2C. Connect the cancel_led signal (figure 6) to a different channel on the oscilloscope. 2D. Ensure that the cancel_button signal is only high when the start signal is low and the cancel_led signal is high. Alternatively, we can make sure that the cancel_led is not on when the start_button is high and the cancel_led is on when the start_button is low.
3. Load Cell Sensor stays within appropriate voltages for each drink size. 10oz: (3mV±.75), 14oz: (3.9mV±.75)	3A. Hook up the green and white wires of the load cell sensor to a multimeter. 3B. Verify that the voltage difference is the appropriate amount for each ingredient and drink size. 10oz: (3mV±.75), 14oz: (3.9mV±.75)
4. The microcontroller receives 100-150mA.	4A. Connect the 5V for the microcontroller to a 100Ω potentiometer. 4B. Change the potentiometer until it reaches 100-150 mA. 4C. Measure the current with a multimeter.

Control System RV Table

Control System Results

Functionality

Functionality



PCB

Final Product

Video

Summary

- Boba machine prepares drink based on user's choices
- 6 buttons, 1 LED
- 1 pump for Milk/Tea with food safe Peristaltic Pumps
- Servo motor to release boba (powered by arduino library)
- MCU takes input from buttons, and goes through 4 states to send control signals to boba and pumps

Conclusion

Challenges

1. Analog pins

- trouble w/ using analog pins as digital inputs/outputs
- eliminate all but 1 LED
- happy w/ this decision

2. Interpreting load cell output

- load cell outputs millivolts based on weight (difference in resistance turned into voltages)
- very small difference (0.0001)
- Hx711 amplifier required (output: 24 bits of 2’s complement numbers)
- trouble aligning MCU to amplifier’s serial interface (data line must be low and 25-27 clk pulses required)
- manually simulate in code
- amplifier may need to be powered on/off

Challenges

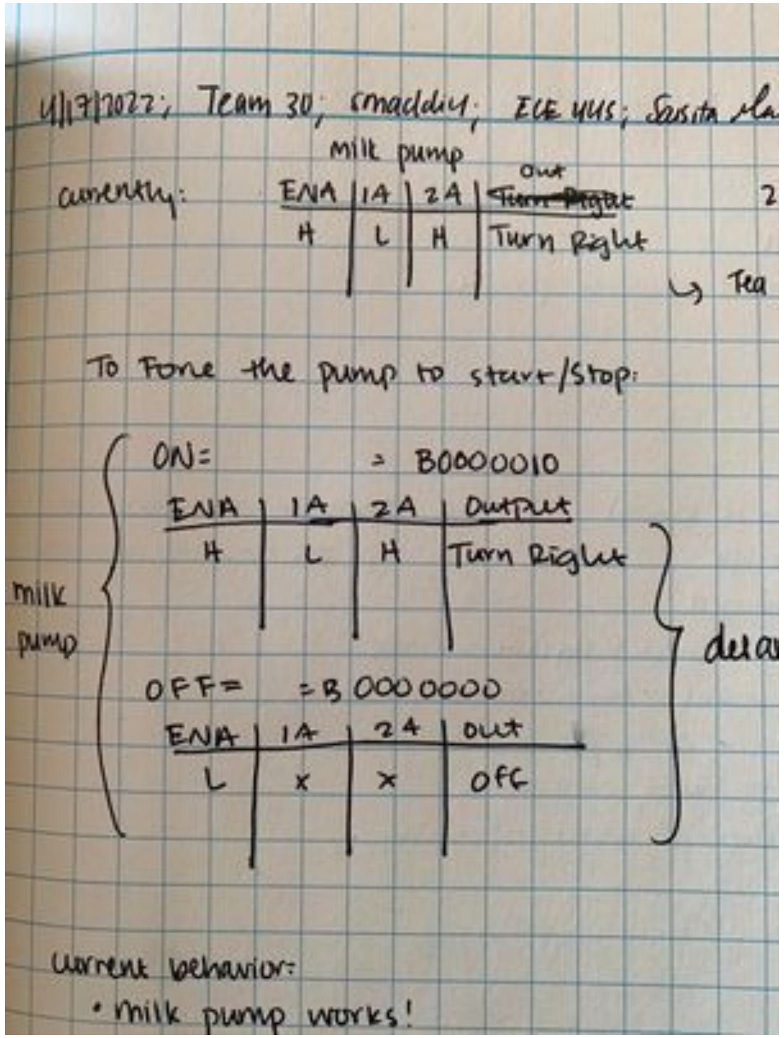
3. H-Bridge input pin

- on PCB, input forced to be High when it should be grounded
- pumps always on (bad)
- pumps run when EN is high and input low
- forced PCB to work by turning EN on and off
- input stays low at all times

EN	1A	2A	FUNCTION
H	L	H	Turn right
H	H	L	Turn left
H	L	L	Fast motor stop
H	H	H	Fast motor stop
L	X	X	Fast motor stop

L = low, H = high, X = don't care

L293D Function Table



Function Table for our working L293D

Conclusion

Successes

1. We ended up with a functioning bubble tea machine! It can successfully make a drink
2. While still an issue, the syrup leakage from the boba reservoir was not a huge downfall. We were really happy with how contained the boba was
3. Weight of the drink comes out pretty close to 10 and 14 ounces (cup is about 0.5 ounces)
4. We are really happy with the user input buttons. They are pretty, easy to read, and easy to press
5. All our high level requirements met

Conclusion

Lessons Learned

- handling liquid leakage is very tough to control
- boba syrup is very sticky
- buying from amazon for parts is not a great choice
- servo motor triggers are very fragile and burn out easily

Future Work

- program Hx711 amplifier with microcontroller
- add payment system to act as a vending machine
- adding syrup options
- make amount of boba released more consistent (motor to agitate boba)

Thank You

Questions?

The Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN