AUTOMATED COCKTAIL MIXER DESIGN DOCUMENT

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Contents

1. Introduction

1.1 Problem

Mixing cocktails and mocktails, whether at home or elsewhere, can sometimes be a difficult process. While even simple, two-ingredient cocktails exist, to have consistency when recreating them there must be precision and accuracy in measuring ingredients, and often these are liquid ingredients in small quantities, which can be easy to mess up. The average person may struggle to consistently mix drinks with the proper ingredient ratios without practice and jiggers or other measuring tools. This could lead to overpouring drinks which have more alcohol in them than expected, which can lead to overdrinking if not careful.

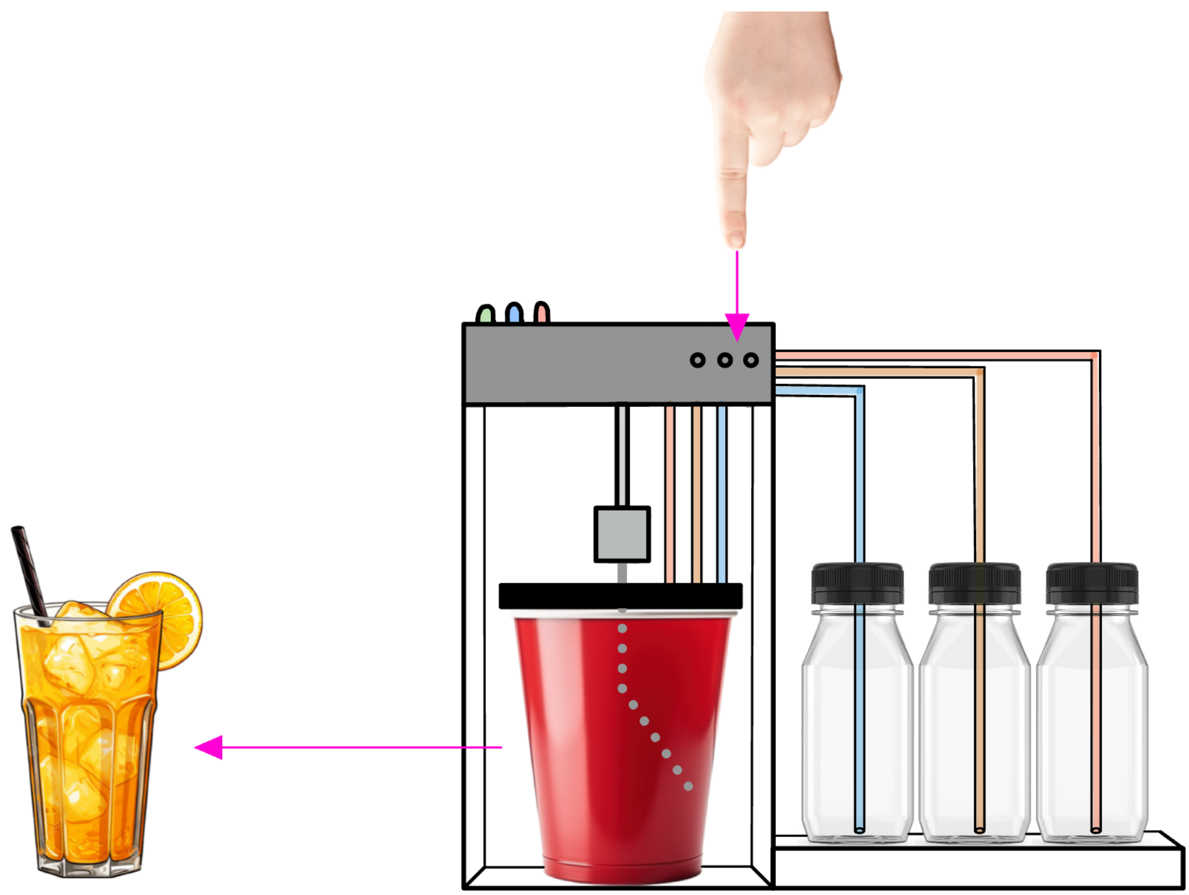
A solution to this issue lies in automating the process of measuring and mixing these drinks. Commercially available automated cocktail machines do exist presently, but the average consumer will almost certainly never adopt them due to high prices, ranging from several hundred to several thousands of dollars. Many of these products also require proprietary bottles or flavor pods, which limit usability and customization. There's a clear gap in the market for an affordable, compact, fully automated drink-mixing solution that doesn't rely on proprietary consumables and gives freedom to the user.

1.2 Solution

Our proposal centers on a cocktail and mocktail mixing machine controlled by a simple ESP32 microcontroller. The initial design for this system will allow the user to make their drink selection via a simple push-button input, verify the presence of a cup or glass via a weight sensor, then dispense the correct volume of each ingredient into the cup. After dispensing, an automatic stirring mechanism will lower itself into the cup, mix the drink, and then retract. LEDs will be used to communicate the status of the drink to the user, lighting up green once it is finished and lighting red if there is an issue.

The machine will be built around a central cup station with a load cell weight sensor underneath it. At least two liquid containers (cups or bottles) will be connected via vinyl tubing to individual peristaltic pumps for simplicity and accuracy. Each container will also sit on its own load cell to monitor liquid levels. When the user presses a button to select a drink, the microcontroller will first read the cup load cell to make sure there is a cup present. After reading the ingredient load cells to ensure there is enough to make the drink, the microcontroller will then activate the first pump, dispensing liquid while monitoring the load cell below the cup until the target weight for the recipe is reached. This process repeats for each ingredient in the recipe. Once all ingredients have been dispensed, a linear actuator motor will lower the stirring arm into the cup, and a second motor will rotate the stirrer for some length of time. The stirring arm will retract, and a green LED will turn on to signal that the mixing process has completed. If there are any issues at any point (no cup, not enough liquid) then a red LED will turn on.

The entire system will be housed in a compact and portable enclosure, targeting a low total cost that makes it affordable for the average consumer.



1.3 Visual Aid

Figure 1: Automated Cocktail Maker Visual

1.4 High-level requirements

To solve our problem our cocktail maker must satisfy 3 conditions.

1. The cocktail maker must dispense each ingredient to within ±5 grams of the target weight/volume specified by the recipe, as measured by the load cell beneath the drink cup.
2. The cocktail maker must detect the presence of a cup (weight threshold of 50 g) and verify that there is sufficient liquid in each ingredient container (minimum weight required by recipe plus extra 20% margin) before beginning the mixing process, halting and turning on the red LED within 3 seconds if there are any issues.
3. The complete drink mixing cycle, from button press until the stirrer is retracted, should be completed in under 150 seconds for a standard two-ingredient recipe.

2 Design

In this section we will discuss the design of our cocktail. There will first be a block diagram mapping out our design and the different subsystem we will use. Then we will go into descriptions for each subsystem to explain how they work, how they interact with each other, and components they will use to achieve proper functionality. Then we will discuss requirements to explain what the expected performance of each subsystem is and to give more specifics on what is required of them. Lastly, we will discuss some tolerance analysis and other calculations we will do so that our cocktail machine works as intended.

2.1 Physical Design

For the physical design of our cocktail maker, we should use different things to our advantage like gravity to make certain aspects as simple as possible. Our tubing will not follow all the way into the cup but instead will rest a few inches above the cup as to not interfere with the linear actuator and gear reduction motor used for the stirring mechanism. We will also have the pumps be located towards the top end of the tubing so that when a pump is deactivated most of the liquid will fall back into the liquid housing containers and only a small portion towards the end will fall into the user's glass (See Figure 3).

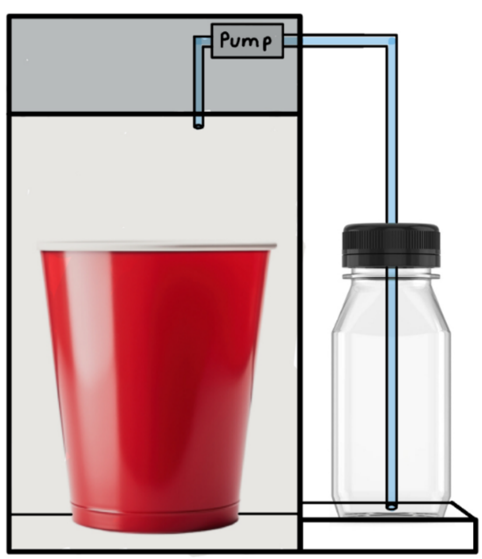


Figure 2: Pump Placement on Tubing

The linear actuator will be located above and slightly off center from the user cup. The gear reduction motor in charge of stirring will be attached to this linear actuator with a slight angle to allow it to be in the center of the glass. This design will allow for the linear actuator to remain out of the way, but the gear reduction motor will still be position so that when lowered it is in the user glass (See Figure 3).

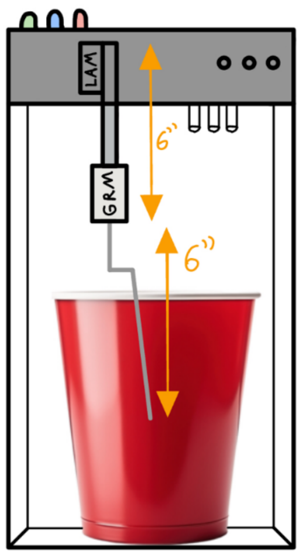


Figure 3: Linear Actuator and Gear Reduction Motor Placement

Lastly, the load cells will be placed under the glass and liquid housing containers, the LEDs will be placed at the highest point possible on the design to stop anything from obstructing their view and the same with the button (look at Figure 1 for reference).

2.2 Block Diagram

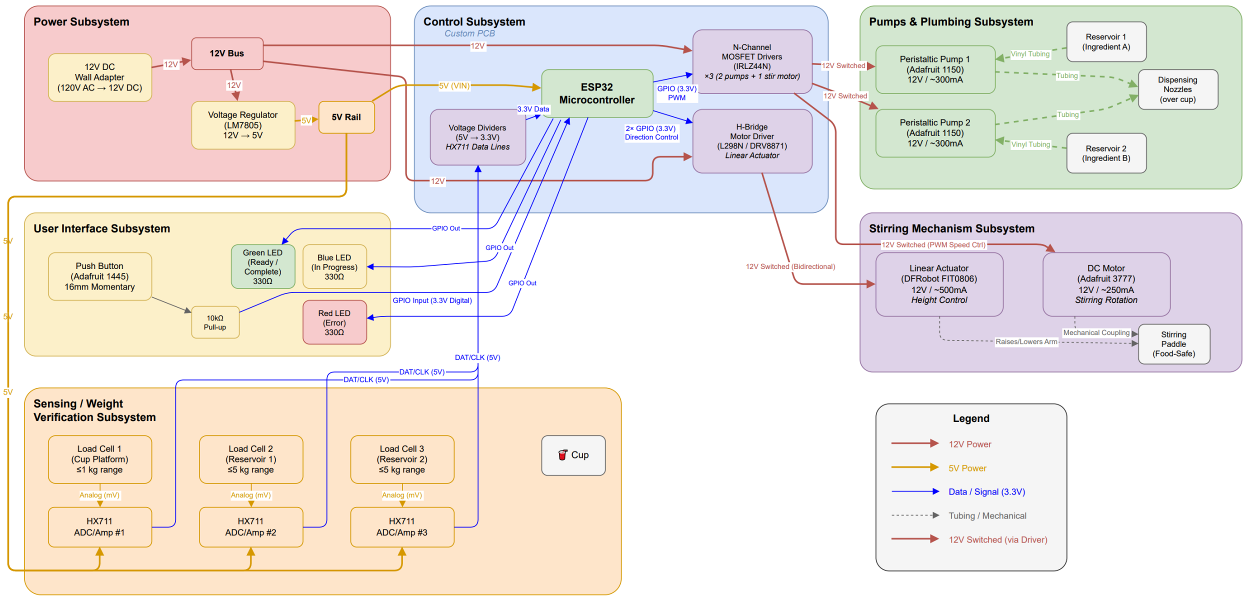


Figure 4: Full System Block Diagram

2.3 Subsystem Descriptions and Requirements

2.3.1 [User Interface]

The user interface oversees allowing the user to interact with and command the automated cocktail machine to allow the user to initiate the making of a drink. The user interface will interact with the Control Subsystem through GPIO which will then handshake with the Status and Weight Verification Subsystem which will give feedback on the state of the machine.

For our user interface we will use a simple pushbutton that is hardcoded to a specific cocktail. Upon the user pressing this button, a signal will be sent to the microcontroller letting it know a drink has been requested. The microcontroller will then verify if a drink can be made by checking if the Status and Weight Verification Subsystem is in a stable state. If so, the microcontroller will send a signal to the first pump to start working, a blue LED will be lit up to notify the drink is in progress of being made, and the user's input of pressing the button will have been successful. If verification is unsuccessful then a red LED will light up to notify failure and the user's input will have been unsuccessful.

For potential expansion we would add more pushbuttons that are hardcoded to make other cocktails. Eventually if all is working well and time permits, we will expand to a more complex user interface where the user would have a menu of sort to interact with.

Table 1: User Interface Requirements and Verification

Requirements:	Verification:
• When plugged in, the user presses a button, and an LED status indicator will light up notifying the user of success or failure.	• Ensures that the user glass is in position by reading an appropriate value from the load cell under the user glass. • Checks the values of load cells for each ingredient needed for the cocktail to make sure there is enough for the requested drink.
• The red LED lights up if any issue occurs before or during the drink making process. • The blue LED lights up when the cocktail maker is in the process of making a drink.	• Check if the two steps in the first requirement fail/succeed in producing the wanted values. • Check if the values from the liquid housing containers or the user's glass are changing at the expected rates when dispensing the liquids. • Make sure the linear actuator goes to its work and home position properly.
• The green LED lights up when a drink has been made. • The green LED turns off after the user glass has been removed from a successful drink.	• Check all status bits for successful values • Check if the linear actuator is in its home position. • Check if the blue LED is currently on to turn on green. • Check if green LED is currently on and load cell under user glass returns no weight to turn off green.

2.3.2 [Stirring Mechanism]

The Stirring Mechanism oversees the process of mixing all the ingredients for the required cocktail together. This is done using a linear actuator and a gear reduction motor. The stirring mechanism will interact with the Control Subsystem through GPIO which will handshake with the Status and Weight Verification Subsystem to make sure the stirring process can be started and that it is properly completed. This subsystem will also be connected to the Power Subsystem to provide power for both the linear actuator and the gear reduction motor.

Once all liquids are transported from the liquid housing containers into the glass the user will eventually drink from, the ingredients must be incorporated together in some way. To do this we will make a stirring mechanism that has two different motors both of which are controlled by the microcontroller. The first motor (a linear actuator) will oversee the height of the arm that will be used to stir. The arm originally must be out of the way for the user to put the glass in. So, this motor will lower the stirring arm to be at an appropriate height to mix the liquids in the glass. The second motor (gear reduction motor) will rotate the stirring arm to perform the mixing process. The second motor will only turn on once it receives a signal from the microcontroller that the first motor has moved from its home up position to its working down position and is no longer moving. The height motor will only move in two scenarios. The first is the microcontroller sends a signal that all the ingredients have been successfully transported into the glass. The second condition is upon receiving a signal from the microcontroller that the stirring arm motor is done and the motor can now be raised again. Once back in the home position, a signal will be sent to the microcontroller that the linear actuator is back home, and the green LED can be lit up. Both motors require 12V DC power which will be supplied from our Power Subsystem directly without the need to first send the voltage through a voltage converter. The linear actuator motor will be controlled through the DRV8871DDAR motor driver, whereas the stirring motor will be driven through a simple n-channel MOSFET circuit.

Table 2: Stirring Mechanism Requirements and Verification

Requirements:	**Verification:**
• The linear actuator must give enough vertical clearance (at least 50 mm) to move the stirring paddle from above to into the user glass.	• Buy a linear actuator rated for the required length (must be exactly what is needed since linear actuators only go to home and work positions). • Measure travel distance to ensure linear actuator performs as expected.
• The gear reduction motor must rotate the stirring paddle at 50-100 RPM to mix the drink with spilling during mixing process.	• Buy a gear reduction motor rated for 50-100 RPMs. • Test independently that motor functions at correct RPM • Test for max RPM that can be used without spilling. • Test for needed time for thoroughly mixed drink.

• The stirring process must take no more than 45 seconds.	• Make sure the raising and lowering of the linear actuator does not take too long for product bought. • Ensure that the gear reduction motor we buy has enough RPM to mix the drink thoroughly in allotted time. • Give extra buffer time for the transmission of signals. • Time whole process to make sure standard met.
• The stirring paddle must be made of food-safe material and small enough to fit in a standard cup.	• Check food safe materials list and buy a paddle made of those materials. • Take measurements of glass circumference and make sure paddle doesn't make contact when rotating around the user glass.

2.3.3 [Pumps and Plumbing System]

The Pumps and Plumbing Subsystem will be in charge of transporting the liquids from the liquid housing containers to the user's glass. This will be done using self-priming pumps connected to tubing that will suck the liquids from the housing containers and deposit them into the user's glass. This subsystem will communicate with the Control Subsystem which will handshake with the Status and Weight Verification Subsystem to ensure liquid properly transfers. The pumps will also be powered by our Power Subsystem.

Once a drink is verified that it can be made, we need a system to transport the ingredients from the liquid housing containers to the user's final glass. To do this we will use some clear tubing as plumbing to guide the liquids and pumps to control the flow of liquid from the housing to the final glass. The pumps will be self-priming so they don't constantly need to hold liquid and will work one at a time in a sequential order only starting to dispense a liquid once the other has finished. The pumps will be connected to the microcontroller which will send start and stop signals based on how much liquid has been dispensed so far. The microcontroller will get the amount of liquid dispensed based on the values from weight sensors in the Status and Weight Verification System. It will check both the weight of the user glass and the currently active liquid housing container to ensure these values are matching correctly. Once reaching the specified threshold value, the microcontroller will tell the pump to turn off. The pumps themselves will be hooked up to our Power System to provide 12V power.

For potential expansion we could add another pump and tubing which will allow for cocktails with more than 2 ingredients to be made.

Table 3: Pumps and Plumbing System Requirements and Verification

Requirements:	Verification:
• Each pump must deliver a flow rate of 100 mL/min. • The pumps must be self-priming.	• Check the ratings for the pumps to make sure they achieve at least 100 mL/min and are self-priming. • Test the pumps independently to make sure they work as required.
• Tubing must be easily removable for cleaning.	• Test to make sure tubing can be removed and installed within 30 seconds. • Ensure that to remove tubing no other component besides the tubing needs to be touched. • Have specific holes/notches for tubing so they “snap” into place when installing them.

2.3.4 [Control Subsystem]

The Control Subsystem is the central processing and routing hub for the entire cocktail machine. It consists of an ESP32-S3-WROOM microcontroller module, and a custom PCB designed in KiCad which houses the microcontroller, all driver circuits, connectors, and other passive components. The PCB integrates every electrical interface in the system: three NMOS driver subcircuits (for two pumps and the stirring motor), one H-bridge driver subcircuit for the linear actuator, three HX711 sensor interfaces for the load cells, the pushbutton debounce circuit, LED outputs, power regulators, and programming headers.

The ESP32-S3-WROOM was selected thanks to its high amount of GPIO pins, 240 MHz processor, and popular support. It operates at 3.3V and is powered by the AMS1117-3.3 voltage regulator on the PCB. A 6-pin programming header provides access to the programming pins for firmware uploading through a USB-UART bridge.

Table 4: Control Subsystem Requirements and Verification

Requirements:	Verification:
• The ESP32 must poll button input and read all weight HX711 channels at a rate of at least 10 samples per second.	• Configure the HX711 modules in the 80 SPS mode. In the main loop, read all three channels sequentially and print timestamps over serial. Confirm each channel produces ≥ 10 new readings per second.
• The PCB must include n-channel MOSFET driver circuits for each pump and for the rotary stirring motor, with gate resistors and pull-down resistors to prevent floating gates.	• Use a multimeter in continuity to verify the 100Ω resistor is in series between each GPIO net and the corresponding MOSFET gate, and the 10kΩ is between each gate and GND. Verify that a flyback diode is present across each motor terminal.
• The PCB must include an H-bridge driver with control inputs from two ESP32 GPIO pins for the linear actuator.	• With the actuator connected, set ACTUATOR_1 high and ACTUATOR_2 low, confirming the actuator extends. Reverse the signals and confirm the actuator retracts.

2.3.5 [Status and Weight Verification System]

The Status and Weight Verification Subsystem oversees the process of verifying that the cocktail maker can make a cocktail, is properly making a cocktail, and letting the user know the current state of their drink. This is done using load cells under each liquid container. These values are constantly measured to check if they return desired values. If so, then the drink can start/continue being made. If not, the drink making process will stop/not start. The status of the drink will be represented by one of 3 LEDs. The Status and Weight Verification Subsystem is directly connected to the Control Subsystem which will then send signals to all other subsystems based on the values of the load cells. It will also be connected to the Power Subsystem, and the load cells will require 5V power from the converter.

Before making a drink, we must know if certain criteria are met so we don't just start randomly dispensing liquid onto the counter. We also need some way to track how much liquid has been transferred from the liquid housing containers to the user's glass. Lastly, the user should know the state the cocktail maker is currently in to know if something is wrong, if the cocktail is made, or if the cocktail is in the process of being made. This is what the status and weight verification subsystem is for. This subsystem will consist of 3 LEDs (green, red, blue) and initially 3 weight sensors (1 for the user glass and 1 for each of the liquid housing containers). The green LED will be lit when a cocktail is properly made, the blue LED will be for when the cocktail is in progress of making a drink, and the red LED will be for when there is some sort of issue so a cocktail can't be properly made. No user input will be accepted if any of these LEDs are on. The weight verification sensors have multiple uses. The first thing is upon receiving a user input the microcontroller will check the values of the weight sensors. It will check the user glass weight sensor to make sure a glass is there to catch the liquids. It will also check the other weight sensors to make sure there is enough liquid in the containers for the requested drink. Then we use these weight sensors to make sure the correct amount of liquid is taken from the liquid housing containers and is dispensed into the user's glass by having these sensors communicate with each other through the microcontroller. We will also require an amplifier to be connected to each weight sensor for proper use. This subsystem will also be connected to our power system to supply the required 5V.

For potential expansion we could get extra weight sensors to allow for cocktails with more than 2 ingredients.

Table 5: Status and Weight Verification Subsystem Requirements and Verification

Requirements:	**Verification:**
• The cup platform load cell must support about 1 kg to account for both a cup and up to 350 mL of liquid.	• Test the weight of the user glass and a little over 350 mL of liquid on multiple scales to ensure weight does not go over 1 kg and cross check this with read load cell value.
• The ingredient container load cells should have 5 kg capacity to support larger ingredient quantities.	• Test the weight of the liquid housing containers full of liquid on multiple scales to ensure weight does not go over51 kg and cross check this with read load cell value.
• The cup detection threshold should be set at 50 g, and the	• Program the threshold value to 50g on the user glass load cell.

system should have the capability to distinguish between an empty platform and the 50 g threshold.	• Make sure cup is sufficiently heavier than 50g. • Test items around 50g on load cell to guarantee accuracy.
• Each ingredient container load cell should be able to verify that the container contains at least 120% of the required ingredient weight.	• Program the required amount of liquid in each housing container to be 120% of a single cocktail requirement. • Test liquids across multiple scales to make sure load cell gets an accurate reading.
• During dispensing, the microcontroller must read the cup load cell and the ingredient load cells to stop the pump within 5 g of the target weight.	• Program the pumps to stop slightly early to allow certain liquid not currently in glass to fall from tubing. • Measure weight of actual stop time versus after extra liquid falls into glass to get exact stop weight.

2.3.6 [Power System]

The power subsystem is in charge of providing all electrical energy to the system. It needs to deliver stable power at the correct voltages to ensure reliable operation of every component in the system, including the microcontroller, sensors, motors, and pumps. This means the Power Subsystem directly connect to all other subsystems in our design to power all devices, except it will not be directly connected to the User Interface, but it will indirectly power the User Interface subsystem.

The function of the Power System is to convert the AC wall power to the DC voltages required by the system. A 12V DC wall adapter will provide the primary supply, while an onboard voltage regulator will step this down to 5V and then also down to 3.3V for the sensor amplifiers and the ESP32 processor. The 12V rail will also directly power the pumps and motors through their respective driver circuits.

Table 6: Status and Weight Verification Subsystem Requirements and Verification

Requirements:	Verification:
• The 12V DC wall adapter must supply at least 3A of current to support the simultaneous	• Use a multimeter to measure the voltage the wall adapter converts to and make sure we read 12V.

operation of one pump, the linear actuator, the rotary motor, and overhead for the rest of the system.	• With a multimeter measure the current supplied by the wall adapter to make sure it is at least 3A. • Measure each component individually to make sure it is getting the proper current required.
• The 5V voltage regulator must supply at least 300 mA at 5V to power at least three HX711 amplifier boards and provide power to the ESP32 microcontroller.	• With a multimeter measure the voltage from the voltage regulator to ensure 5V is being provided to the 3 HX711s and the ESP32 microcontroller. • Measure the current at the HX711s and the ESP32 microcontroller to ensure they achieve 300mA at 5V.

2.4 Tolerance Analysis

2.4.1 [Proper Amount of Liquid Transferred]

The main source of external error that our design introduces that we must account for involves the pumping of ingredients from the liquid housing containers to the user glass. For example, let's say we want 100 mL of a specific liquid. We can't tell the pump to stop pumping when 100mL has been added to the user glass. If we do this then we will have some liquid that is still in the plumbing that will eventually end up in the drink due to gravity. To counteract this, we must send the signal for the pump to stop slightly before 100 mL has been added to the user glass. Therefore, we are accounting for the fact that extra liquid from the tubing will fall into the glass due to gravity. We will approach this problem in two ways. First, we will come up with a predictive equation that using variables listed below will let us know the volume we should stop dispensing to get our desired volume. We can also test this manually by, for example, stopping at 93 mL and seeing what we end this. We would perform this experiment many times to reduce variance.

$$F * t = V \quad (1)$$

$$L = D - V \quad (2)$$

With Variables:

- V ~ volume of post pump tubing

- F ~ flowrate [up to 100mL per minute]
- t ~ time
- L ~ coded weight sensor value which shuts the pumps off
- D ~ desired ingredient amounts

2.4.2 [Kink in Tubing]

Another source of external error is that because we are using plastic tubing, at times there may be kinks that prevent the liquid from properly being transported. There are two ways we could combat this. The first is to have a timer in the program for each pump with each drink that has a max limit. We know how much time it should take for the liquid to be transported so if after that much time plus a little extra for accommodation, if the correct amount of liquid has not been dispensed in the user glass, then the red LED will light up to signify an issue. While this issue works, if the pump time is expected to take a minute, if you have a kink at second 5 then the pump runs for about an entire minute before finally stopping. Another option would be to check the weight of the user glass at certain intervals to see if the expected progress in liquid transportation is being made. If not, then once again light up the red LED to signify something went wrong.

2.4.3 [Loss of Connection or Power]

Lastly, another source of external error is if something goes wrong with the machine losing power or the USB C of the microcontroller accidentally getting unplugged. If this were to happen at any process during the making of the drink, the drink should be scrapped and if another drink is wanted the process should start from square 1. To do this, if the blue LED is ever on and we lose power or connection, upon regaining power a flag bit will be set to turn on the red LED. This flag bit will only be cleared once the user glass is removed from the sensor as this would mean that the drink is scrapped.

3. Cost and Schedule

While we are still only students, there is still a cost for us making this project. Not only will we have actual physical parts that we must order, but we will also pour many hours into this project which cost money as instead of working for a salary we are instead working on our senior design project.

3.1 Cost Analysis

3.1.1 [Labor]

In our team contract we spell out that each team member is required to work on the project for at least 8 hours per week. Through the first couple weeks it is apparent this is an underestimate of the actual time spent per person on the project for the week and the real number is probably around 12 hours per person per week. Some weeks it will be less and on deadline weeks it will be more, but for a weekly average 12 is pretty accurate this far. Also, as the project gets toward its completion, we imagine the work will ramp up a bit so an extra 30 hours total will be added per partner. We will say these 12 hour weeks started the week the initial project proposal was due so (These 12 hour weeks will be done for 12 weeks total).

$$hours\ per\ partner = 12\frac{hours}{week} * 12\ weeks + 30\ hours = 174\ hours\ per\ partner$$

$$total\ group\ hours = 3\ partners * 184\frac{hours}{partner} = 522\ total\ group\ hours$$

With each of our expected hourly rates after graduation being around $40/hour we can use this to get a total cost of our own labor.

$$group\ labor\ cost = 522\ group\ hours * 40\frac{dollars}{hour} = \$20{,}880\ in\ group\ labor$$

Aside from our own labor, we also talked to the machine shop about having them do some of the assembling for us and creating the rigid body of our cocktail maker. For these numbers we will assume it will take 2 machine shop workers 3 days to complete this aspect of our project. Assuming they make about $35/hour we can get a total cost for machine shop labor.

$$machine\ shop\ labor\ cost = 2\ workers * 3\frac{days}{workers} * 8\frac{hours}{day} * 35\frac{dollars}{hour} = \$1{,}680$$

From this we can get our total cost of labor by summing up the group and machine shop labor costs

$$total\ labor\ cost = \$20{,}880 + \$1{,}680 = \$22{,}560$$

3.1.2 [Parts]

Table 7: Parts List

Description	Manufacturer	Quantity	Price Per	Link
12V 6” 220 lbs Linear Actuator	RVMARINEPAT	1	$39.99	Link

12V 85 RPM Gear Reduction Motor	Greartisan	1	$14.99	Link
ESP32-S3-WROOM *	Hosyond	1	$18.99	Link
Micro USB Connector *	Molex	1	$0.93	Link
AC/DC 12V Wall Mount Adapter	Ruactor	1	$15.04	Link
3 Amp Fuse	Littelfuse Inc.	1	$2.37	Link
Red, Green, Blue LEDs	Gebildet	1	$9.99	Link
Drink Selection Buttons *	C&K	2	$2.84	Link
Push Buttons*	Same Sky	2	$0.10	Link
Power Switch *	E-Switch	1	$0.57	Link
Screw Terminals *	Amphenol Anytek	5	$0.64	Link
5 kg Load Cell	Adafruit Industries	3	$3.95	Link
Self-Priming Pumps *	BRINGSMART	2	$18.97	Link
¼" Clear Tubing (9.8 ft)	Yesallwas	1	$5.99	Link
Voltage Regulator (LM2596S-5)	UMW	1	$3.32	Link
Voltage Regulator (AP2112K-3.3TRG1) *	Diodes Incorporated	1	$0.22	Link
Barrel Jack	Switchcraft Inc.	1	$11.39	Link
H-Bridge Motor Driver (DRV8871DDA)	Texas Instrument	1	$2.73	Link
HX711 Amplifier	Soldered Electronics	3	$5.45	Link
PCB Board (100mm x 100mm) *	SchmalzTech LLC	1	$6.49	Link
33uH Inductor	Bourns Inc.	1	$0.67	Link
680uF Capacitor (THT)	Panasonic Electronic Components	1	$0.82	Link
220uF Capacitor (THT) *	Nichicon	1	$0.44	Link
100uF Capacitor (THT) *	Nichicon	1	$0.60	Link
Capacitor – 0.1uF/50V (0805) *	KYOCERA AVX	6	$0.35	Link
Capacitor – 33uF/10V (0805) *	TDK Corporation	1	$0.87	Link
Capacitor – 1uF/25V (0805) *	Murata Electronics	2	$0.16	Link
Capacitor – 10uF/50V (0805) *	Murata Electronics	2	$1.19	Link
Diode – CDBA540-HF (DO214AC) *	Comchip Technology	7	$0.45	Link

MOSFET – IRLML0030TRPBF (SOT23) *	UMW	3	$0.23	Link
Resistor - 10kΩ 5%(1/8W) (0805) *	YAGEO	10	$0.10	Link
Resistor - 150Ω (0603) *	Stackpole Electronics Inc	3	$0.10	Link
Resistor - 1kΩ (0603) *	YAGEO	6	$0.10	Link
Resistor - 1MΩ / 1% / (1/8W) (0805) *	YAGEO	1	$0.12	Link
Resistor - 33KΩ 1%(1/8W) (0805) *	YAGEO	1	$0.10	Link
Wire to Board Header *	Molex	5	$0.13	Link
Total			$223.04	

* Implies part will be obtained from machine shop

$$total\ cost = \$22{,}560 + \$223.04 = \$22{,}783.04$$

3.2 Schedule

Week	Tasks	Person
February 23rd – March 1st	Finish Design Document Finish PCB Design Find Parts to Order Order Parts **FIRST ROUND PCB ORDER**	Everyone Nick/Ben Dominic Everyone
March 2nd – March 8th	Design Review Start Programming with Dev Board PCB Design Updates Work on Breadboard Demo (Finish UI and Power System Breadboard Design) **SECOND ROUND PCB ORDER**	Everyone Dominic Nick/Ben Everyone
March 9th – March 15th	Work on Breadboard Demo (Finish Pump System Breadboard Design) Make sure all parts are up to spec Continue Dev Board Programming Breadboard Demo PCB Design Updates	Everyone Everyone Dominic Everyone Nick/Ben

	Give Machine Shop all parts **TEAMWORK EVALUATION DUE** **THIRD ROUND PCB ORDER**	Everyone
March 16th – March 22nd	NONE REQUIRED	Everyone
March 23rd – March 29th	Continue Programming (UI and Status and Weight Verification Subsystems Finished) PCB Design Updates **FINAL ROUND PCB ORDER**	Dominic Nick/Ben
March 30th – April 5th	Work on PCB Assembly Continue Programming Start Part Integration **INDIVIDUAL PROGRESS REPORT DUE**	Nick/Ben Dominic Everyone
April 6th – April 12th	Continue Programming (Stirring Mechanism and Pumps and Plumbing Subsystem Finished and Cocktail Program Finished) Final PCB Assembly Finished **TEAM CONTRACT ASSESSMENT DUE**	Dominic Nick/Ben
April 13th – April 19th	Full Assembly and Part Integration Debug	Everyone Everyone
April 20th – April 26th	Debug Work on Final Report **MOCK DEMO**	Everyone Everyone
April 27th – May 3rd	Debug Work on Final Report **FINAL DEMO** **FINAL PRESENTATION**	Everyone Everyone
May 4th – May 17h	Work on Final Report **FINAL PAPER DUE** **LAB NOTEBOOK DUE**	Everyone

4. Ethics, Safety, and Societal Impact

As soon to be engineers, we have the responsibility of designing systems which prioritize user safety, reliability, and responsible use. Thus, it is important we keep in mind and thoroughly evaluate our design to ensure that nothing might jeopardize these responsibilities.

4.1 Ethics

The first lens to look through when evaluating this design is an ethical one. The IEEE and ACM Codes of Ethics state that engineers should prioritize public safety and welfare, be honest about a systems limitation, avoid any deceptive practices, and have systems designed to minimize the risk of harm. Keeping all this in mind when reviewing the automated cocktail/mocktail makers design, there are two primary ethical responsibilities which stand out the most here.

Our first, and most obvious, ethical consideration is the responsible use of the product as it relates to its alcohol pouring abilities. While this system can dispense and mix alcoholic drinks, it should not promote any sort of unsafe or excessive consumption practices or misrepresent a drinks strength. To combat this, what our system will do is use weight sensors to measure out ingredients and effectively limit the amount of each liquid added to a cup within some defined tolerance. What this does is prevent any sort of accidental overpouring and can easily be tracked by documenting dispensing tolerances or accuracy. This sort of documentation, when all said and done, also provides users with a clear understanding of the system's limits so that they understand the measurements are approximate and should be treated as such. Also, with this device being capable of dispensing alcoholic beverages, we must consider the fact that there is a chance of misuse. Although we might not be able to eliminate intentional abuse of the system, or determine who may use it post purchase, it is our responsibility to make sure our design will minimize risk through quantity limits and controlled dispensing logic, and that we make it clear that this is intended strictly for adult use. While we acknowledge the fact that the user ultimately determines how the system is used, on the designer side it will not bypass any sort of legal safeguards regarding alcohol consumption and may require age verification measures in the future.

The second main ethical responsibility to consider is that of honest performance reporting. When testing and validating the dispensing accuracy of our machine, it is crucial we do so repeatedly and experimentally to report proper measured errors rather than ideal or theoretical values. By doing this we are letting users know that there is a chance their drinks do not reach a level of commercial certification accuracy, but that if anything it is quite close. Together, all of this aligns with the IEEE principle of truthful representation of system capabilities and limitations, as it makes it clear to users that the result will consistently be within some specific range of values. With the incorporation of the weight sensors and control software too, it also will follow fail-safe principles that are consistent with IEEE and ACM ethical guidelines. On the topic of ACM principles, since our system does not collect, store, or transmit any sort of personal data, and thus no behavioral tracking occurs besides the immediate functional operation, it easily remains in compliance regarding privacy and responsible data stewardship. Besides this, we will all follow good engineering practices by documenting our design decisions, testing procedures, and any failures to avoid misleading users about the system's reliability.

4.1.1 Specific Applicable Engineering Standards

- IEEE Code of Ethics
- IEEE 1012 – Verification and Validation
- IEEE 12207 – Software Lifecycle Process
- ACM Code of Ethics
- ACM 1.2: "Avoid Harm"
- ACM 1.6: "Respect Privacy"
- UL 62368-1 – Safety of Electronic Equipment
- FDA Food Contact Material Regulations (21 CFR 174-178)

4.2 Safety

Safety concerns for this project can be generally categorized into electrical ones, mechanical ones, and fluid ones. Starting first with the electrical considerations, all UL standards will be followed. The system will operate at low voltages using a 120 ac to 12-volt dc converter as the power supply for an ESP32 microcontroller, sensors, pumps, and motors. All components will be regulated and sized appropriately, proper insulation will exist where needed, and secure connectors will be used. All exposed conductors will also be covered and enclosed to reduce any sort of risk of contact with the liquids, and these two will also be physically separated. Bench testing will use a power supply to verify each subsection's functionality before being connected to the rest of the components, and connectivity will also be tested once components are soldered.

Since the product contains many moving components like pumps and various motors, mechanical safety considerations also come into play. Pinch or entanglement hazards are likely with moving components such as these, however simple fixes do exist to prevent them. To do so, we will enclose all moving parts, limit any/all motor speeds, and ensure that the motors of the stirrer only operate when the weight sensors actively detect that a cup is present. Additionally, the physical geometry of the stirrer will be created such that it avoids any sharp edges without compromising its effectiveness at mixing, and while testing our team will make sure that the power can be quickly disconnected if need be.

With this project relying on liquids being dispensed near electronics, any potential spill or leak risks need to also be managed and minimized. As stated earlier, fluid paths will be physically separated from all electronics wherever possible, and additional insulation will exist wherever it's needed. Ideally, they will be placed such that the sensitive electronics are above the tubes and thus isolated from any potential leaks from damaged tubes. The tubing which will carry the liquids will also be clamped where needed and positioned so that the liquids pour directly into the cup. On the topic of the liquid dispensing system, since this product will handle consumable liquids, all the tubing and containers interacting with it must be from food-safe materials. They also must be cleanable and non-reactive to follow the FDA's food-contact material guidance principles.

More generally now, while working through this project we will also obviously make sure to adhere to the ECE laboratory safety rules. A general project safety check can also be done prior to starting work each time, and it may consist of enclosure checks, leakage checks, and simple wiring checks. All in all, even though this design is theoretically the build of a prototype, the design process is still driven by relevant standards and best practices. As a prototype it is also not certified for any sort of commercial alcohol service environment. Either way, we acknowledge the fact that risks still do exist in this products design process, but they may be mitigated in the following ways:

4.2.1 Electrical Risk Mitigation

- Connect to a fused input outlet
- Verify grounding before turning any power on
- Testing is done with a current limiting bench supply first
- All power sources are disconnected before any soldering or rewiring is done
- Check the connectivity of each subsystem prior to powering it on

4.2.2 Mechanical Risk Mitigation

- Use a gear reduction motor to limit its torque and RPM
- Leave no exposed rotating shafts at any point
- Ensure an emergency power disconnect is accessible during testing and function
- Avoid any sort of tinkering or modifications in proximity to the system while it is actively running

4.2.3 Fluid Risk Mitigation

- Perform leak tests of tubes before using them near any electronics
- Complete a food safe cleaning procedure before using the system for the first time
- Ensure that the tubing is sanitized before each use
- Even though the system should automatically check whether a cup is present before running, always make sure that is in fact the case

4.2.4 General Testing Procedures

- Initial tests should be conducted without liquid to ensure the system activates and deactivates correctly without the risk of spilling
- Make sure to validate each system independently prior to testing the systems function as a collective whole
- Keep absorbent towels or pads nearby during any sort of tests involving fluids
- Do tests involving liquids in an appropriate setting far from other projects

4.3 Societal, Economic, Environmental, and Global Impact

4.3.1 [Societal]

Overall, this project contributes societally to public welfare by promoting consistent and responsible beverage dispensing, all while reducing human error commonly associated with manual alcohol measurements. Thus, in a societal context, our engineering solution creates an affordable automated drink mixer capable of improving consistency and accessibility in beverage preparation, while ideally helping to reduce measurement errors commonly present with manually pouring. On top of that, this is done without relying on some sort of proprietary consumable. At the same time, however, this sort of automated alcohol dispensing system could be misused or abused if the right safeguards aren’t in place. To reduce this risk, our design makes sure it requires user input per drink, enforces specific measured quantities, and prevents any continuous or uncontrolled dispensing or liquids. By integrating these safeguards, along with transparency in the systems abilities, this results in a design which aligns perfectly with engineering responsibilities prioritizing safety, reliability, and public welfare.

4.3.2 [Economic]

Looking at this solution from an economic perspective, we found that many of the existing products that function like our design are quite expensive and rely on using their branded consumables or pods. Our approach, on the other hand, emphasizes low costs. The machine itself comes with standard containers and no requirements for some proprietary additional components. Instead, once a consumer has the machine, they can select and purchase whichever liquids they want, from whatever provider they want. This effectively supports accessibility and user flexibility, allowing users to choose ingredients which align best with their financial preferences.

4.3.3 [Environmental]

Compared to most existing drink mixing machines, our engineering solution is more environmentally conscious. Most existing designs use disposable pods or cartridges, while our system is designed to reuse some standard plastic containers. In other words, our design effectively reduces packaging waste with sturdy repurposed plastic bottles. On top of that, the system will run at a low power level to ensure it doesn't use too much energy while plugged in to effectively minimize its carbon footprint. All together, these design decisions support the idea of responsible resource use and reduce the impact that this product will have on the environment over its life cycle, and if a user would like to dispose of the product at the end of its lifetime, all the materials on it should be safe to recycle.

4.3.4 [Global]

In theory, it can be argued that the underlying technology behind our design could in fact have a larger global impact. Since this is ultimately a low cost and closed loop fluid dispensing system, it could potentially have broader applications in both mixology education and even small-scale automation which goes beyond just beverages. Ultimately, with a transparent and well documented design process then it becomes easy for a user to understand the method by which these drinks are made and allows others to find easier ways to adapt the design for other contexts.

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