Smart Vitamin Drink Mix

(Mana)

ECE 445 Design Document

Team # 68

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1. Introduction

1.1. Problem

There are many people who, on a day to day basis, simply aren't getting the correct amount of nutrients such as vitamins as they should due to trivial matters such as diet and not going out in the sun, amongst many others. Deficiencies in these important nutrients can lead to decrease in performance both physically and mentally and if too extreme can lead to further complications.

1.2. Solution

Our solution is a device that can make a powder mix of different supplements based off of the user's nutrients consumed during the day. The way the amount that would need to be supplemented would be calculated would be by inputting information regarding the user (such as how long they were outside, what types of food they had, etc.) into the app on the phone / laptop. There would be calculations made based on the information inputted and then depending on the calculations, a certain mix "recipe" will be sent over to the mix maker to make. After receiving the recipe, the mix maker would turn to align the whichever ingredient's compartment directly above the cup the user has placed. It will then proceed to measure and dispense the required amount of powder for that respective supplement. The mixer will repeat this step until all the required powders with their correct measure have been deposited into the cup. With this, the user can intake their custom mix of supplements for the day, thus solving our problem caused by deficiencies of these nutrients.

1.3. Visual Aid

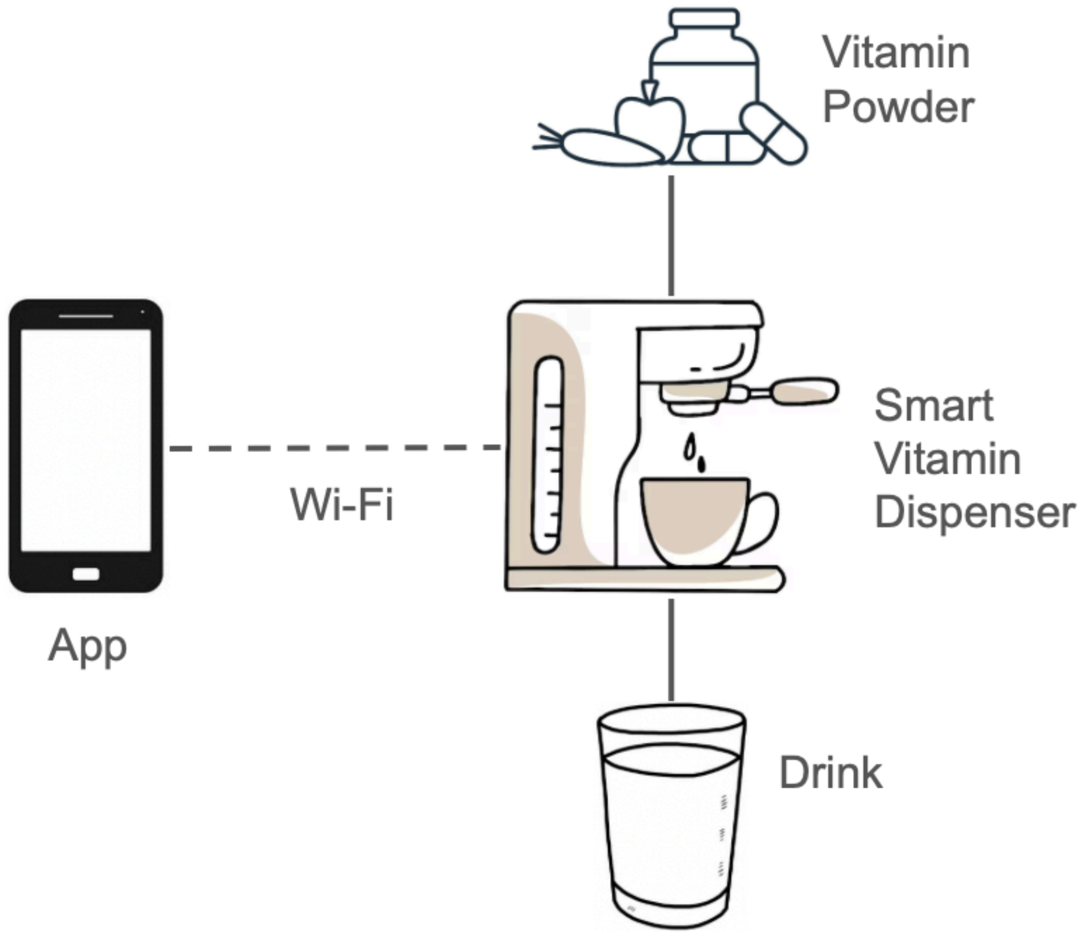

Figure 1. Visual Representation of Product

1.4. High-Level Requirements

- The supplement mix maker should be able to make the correct mix with a 15 mg margin for each ingredient.
- The mix maker should be able to wirelessly interface with applications on other devices and should receive the correct mix recipe 80% of the time.
- The user will be notified when any storage compartment is below 15% of capacity.

2. Design

2.1. Block Diagram

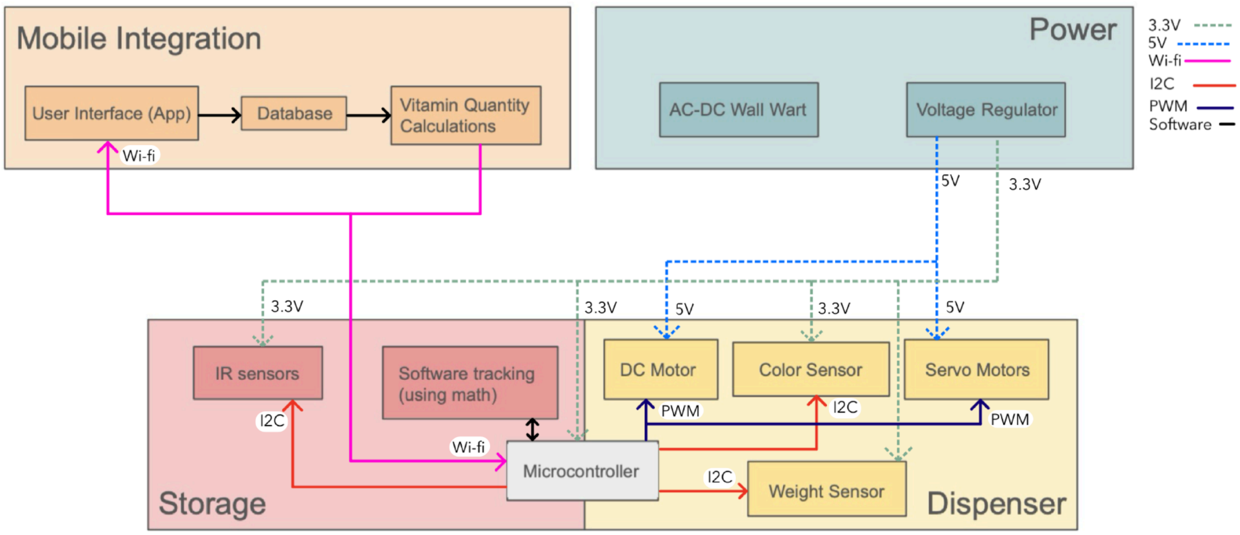

Figure 2. Block Diagram of System as a Whole

Mobile Integration

Represents the IOS mobile application and serves as an interface for the user to use the service. Provides recommendations to the user, takes input data, publishes control signals to Dispenser via wifi, and subscribes to storage metrics from Storage.

Storage

Stores and tracks all of the supplements within the hardware. Publishes capacity levels of each container and interacts with Dispenser when a control signal is published by Mobile Integration.

Dispenser

Accurately dispenses supplements from Storage using motors. Selects the correct container using a color sensor.

Power

Supplies power to components via the 3.3V and 5V rails.

2.2. Subsystem Overview

2.2.1. Mobile Integration

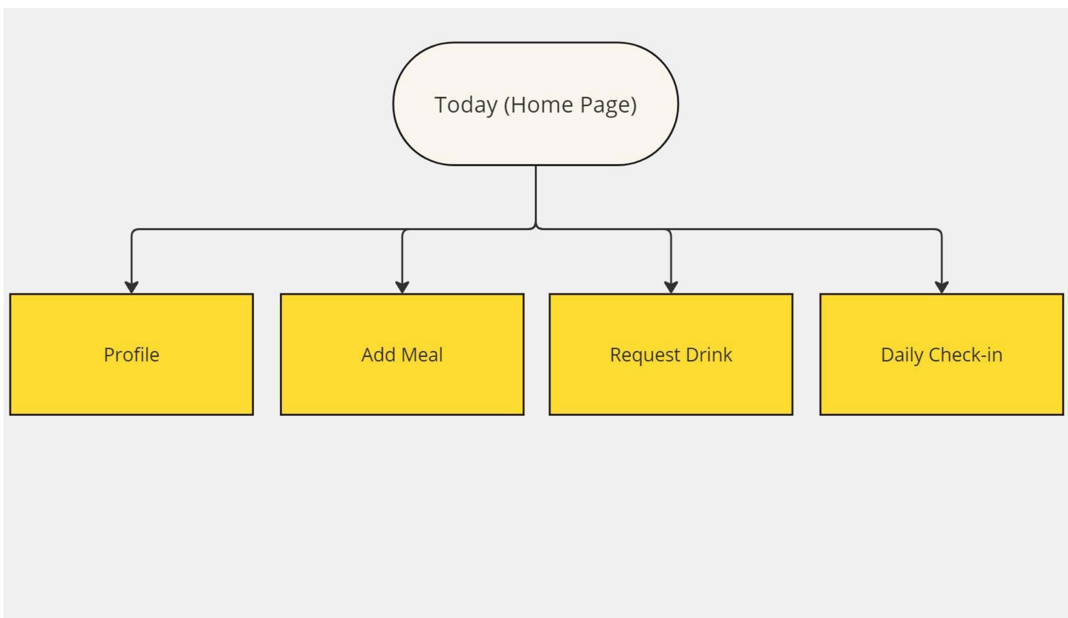

Figure 3. Mobile Integration Path Flow

The mobile app enables users to provide input data for our system, including capturing photos of their meals and completing surveys on how their body feels. This data, along with the user's personal information, is securely stored in the database. Additionally, the database holds nutrition facts for a wide range of common foods.

Using this input data and the stored nutrition information, the backend system generates a customized plan to address the specific nutritional gaps of each user. The plan takes into account the user's dietary input, health profile, and any deficiencies identified. This personalized plan aims to provide precise supplementation tailored to the user's unique needs.

The mobile app and the hardware component work in synergy to create a holistic user experience. The mobile app communicates with the hardware device over a Wi-Fi connection to send control signals for dispensing the user's daily supplements accurately and efficiently. This integration ensures that the users receive their required supplements conveniently and in a way that aligns with their supplement plan.

2.2.2. Storage

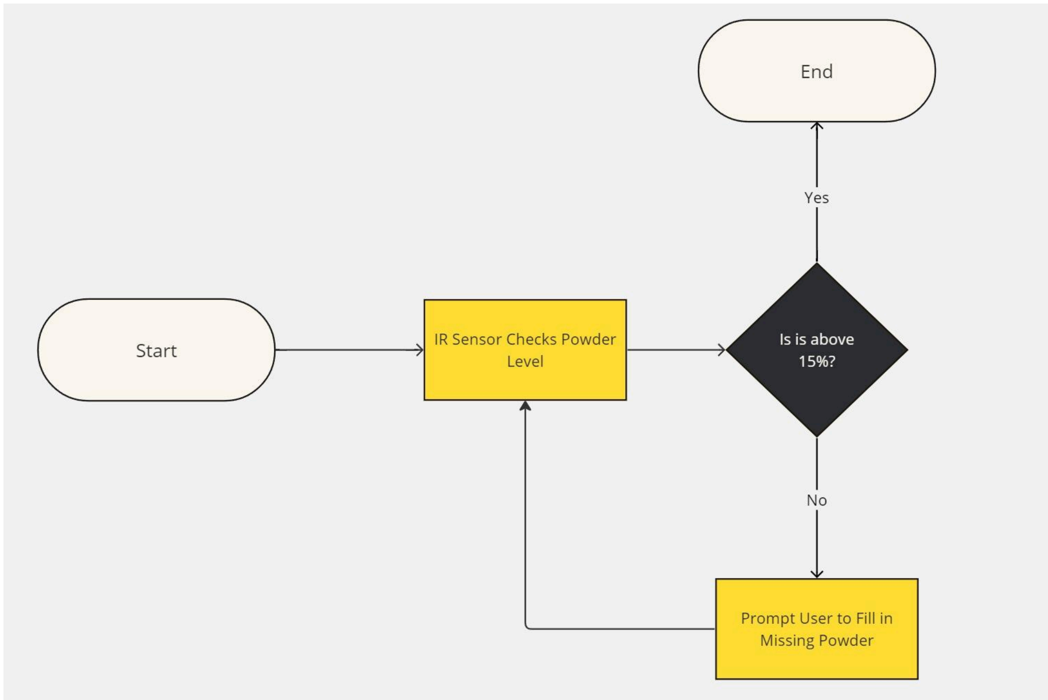

Figure 4. Storage IR Sensor Flowchart

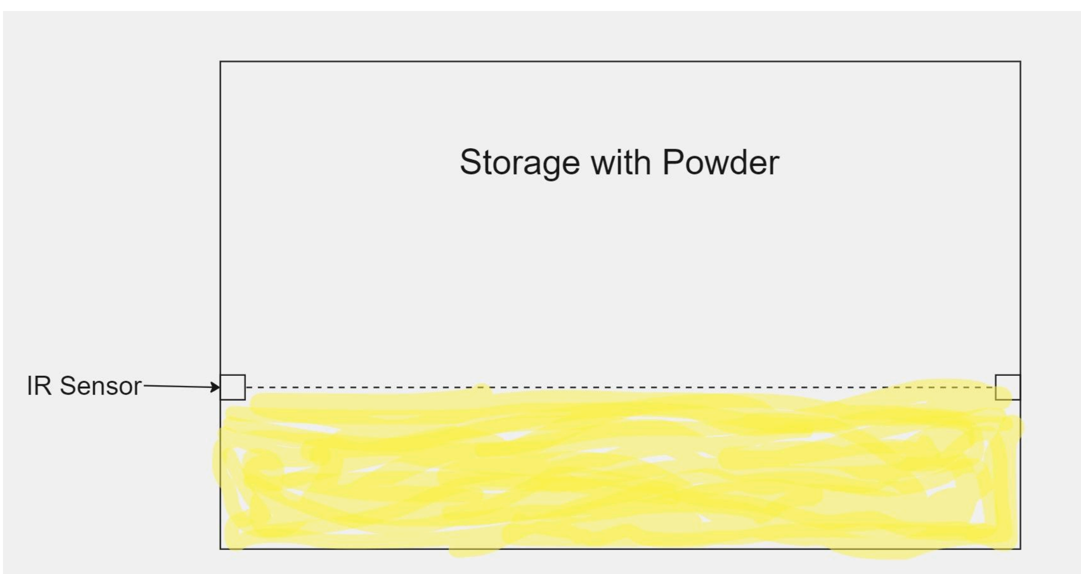

Figure 5. Storage IR Physical Design

The storage subsystem should be able to track the quantity of powder remaining in each of the containers. From there, it will report back to the app if the quantity of powder is low, and the user will be notified of this. We plan to preload a set amount of powder in each container. From there, we will track how much powder has been dispensed and subsequently subtract it from the original amount. This data will be sent back to the app to be kept in a database. We also plan to implement a hardware failsafe where we will use IR break beam sensors to detect when the container has reached critically low levels. In this subsystem, the IR break beam sensors will be powered continuously as they take very little power and it is essential that they are powered continuously as they function as a fail safe.

2.2.3. Dispenser

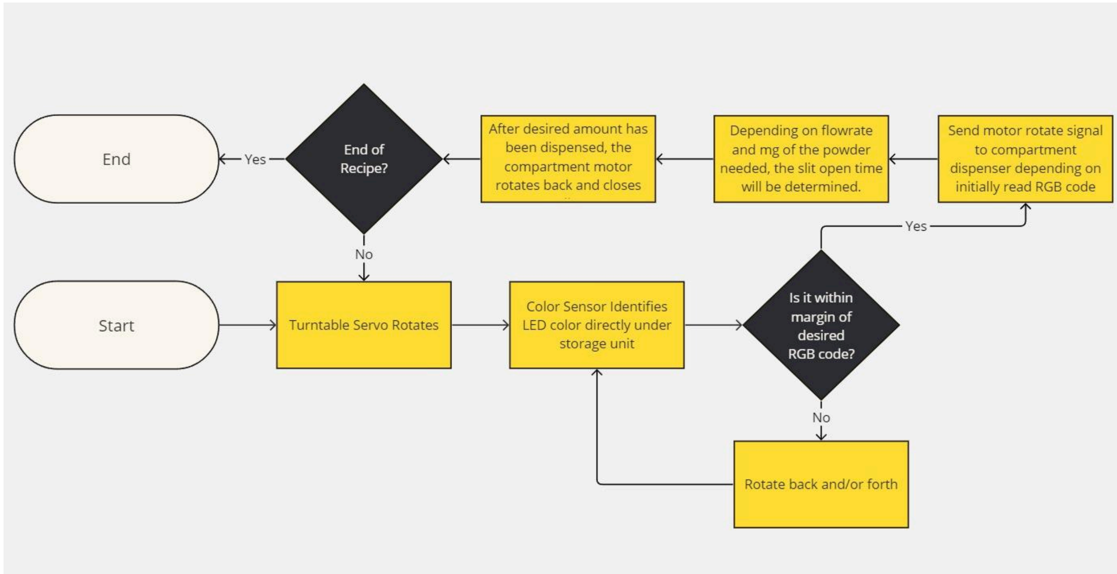

Figure 6. Powder Dispensing Process Flowchart

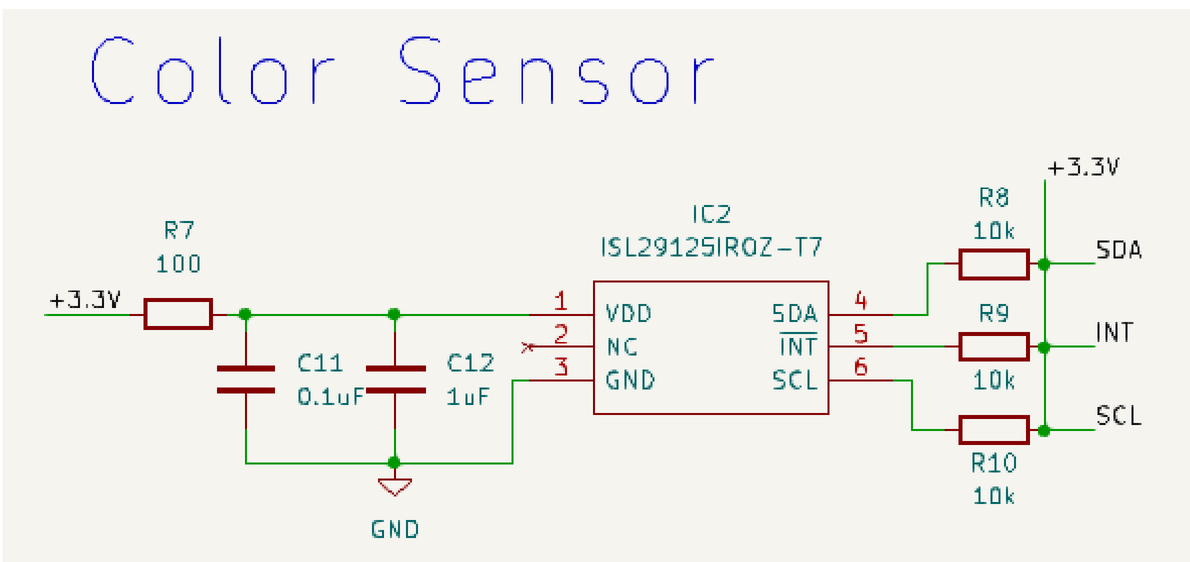

Figure 7. Color Sensor Schematic

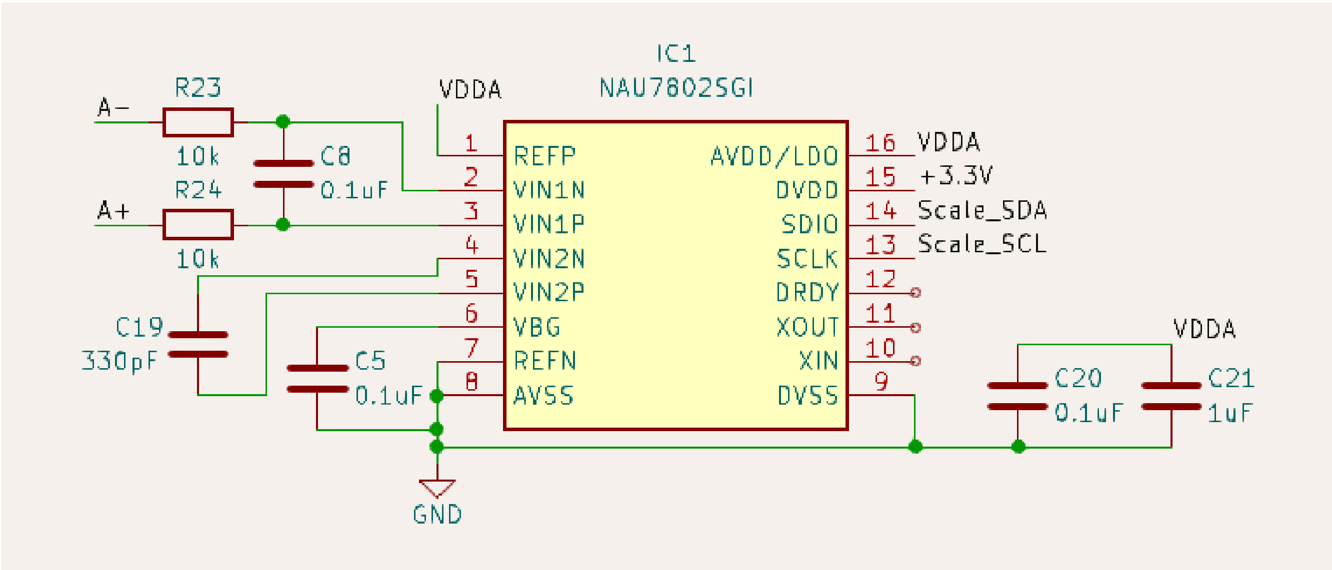

Figure 8. Load Cell Driver Schematic

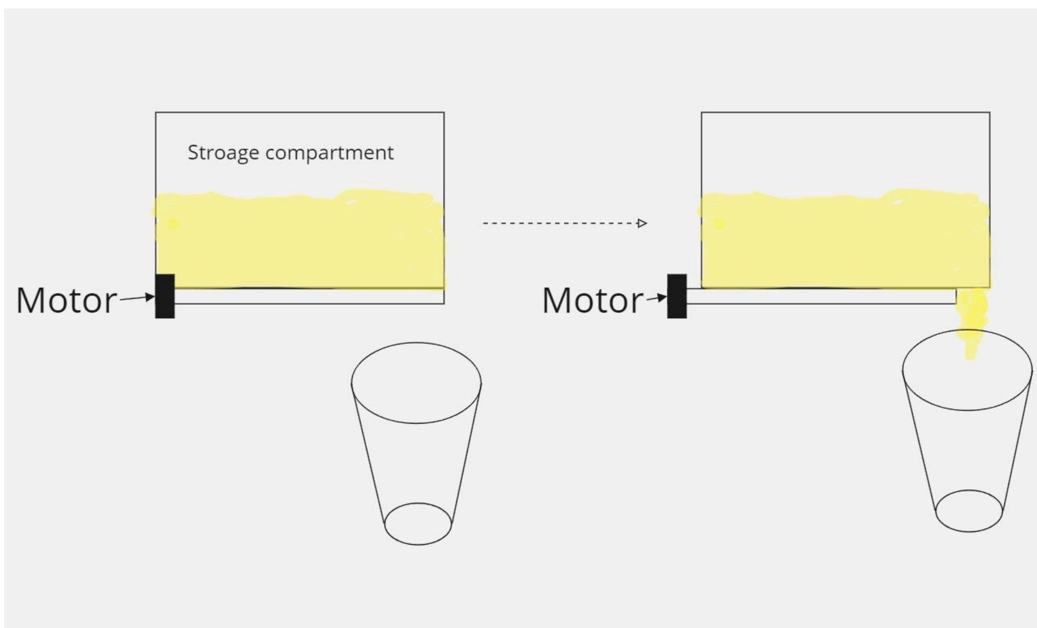

Figure 9. Dispensing Powder from Storage Physical Design

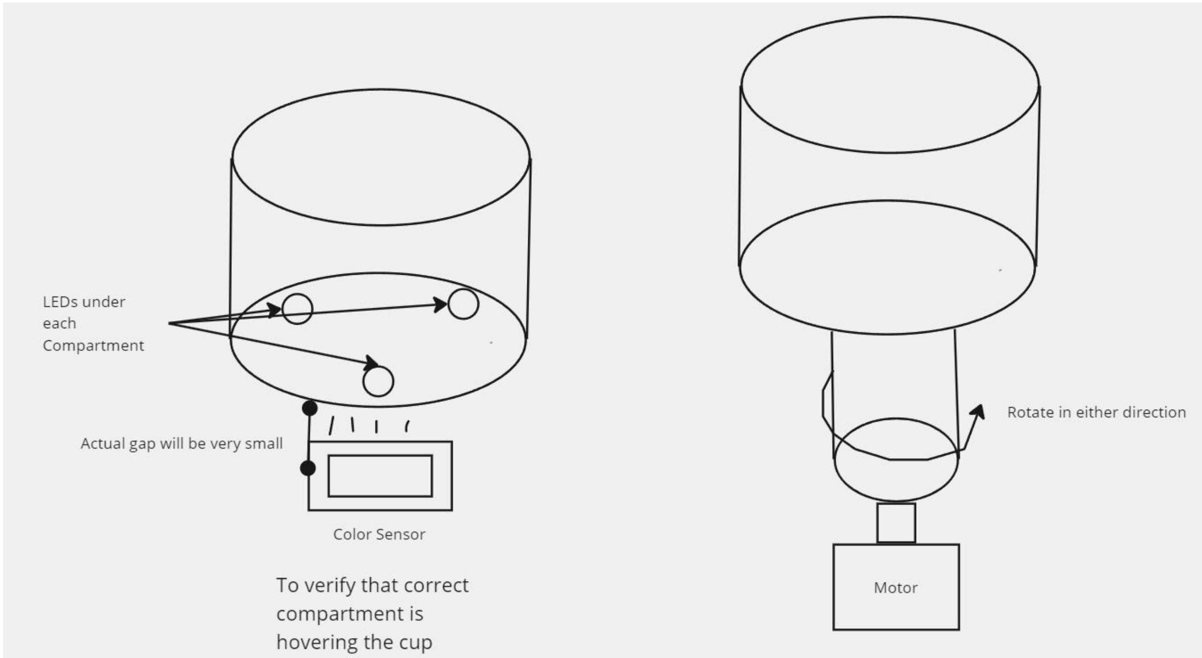

Figure 10. Compartment Validation and Rotating Mechanism Physical Design

The dispenser subsystem is what controls how much powder is dispensed into the drink. The first step of the process involves the color sensor. On each compartment, there will be a LED which a color sensor will detect. Vitamin A, as an example, will be mapped to the color red on the microcontroller. When the app sends data to the microcontroller about the vitamin that is needed, the servo motor for the turning mechanism will turn until the color sensor detects that it has hit teh color red. From there, it will stop moving and then move onto the next step. There will be a servo motor which will snap the cover off the dispenser, allowing powder to be dispensed for a certain amount of time. This amount of time will be determined beforehand by measuring the rate of flow of the specific powder out of the container. After one compartment is done dispensing, the system will move on to the next one if necessary and the process will repeat again until finished. We also will have a load sensor incorporated into the system to verify the amount of powder we are actually dispensing. The color sensor will be constantly powered due to its low power consumption, however the servo motor will only be powered when necessary. There is no risk in drawing more power than the system can supply due to servo motors not having to be powered simultaneously.

2.2.4. Power

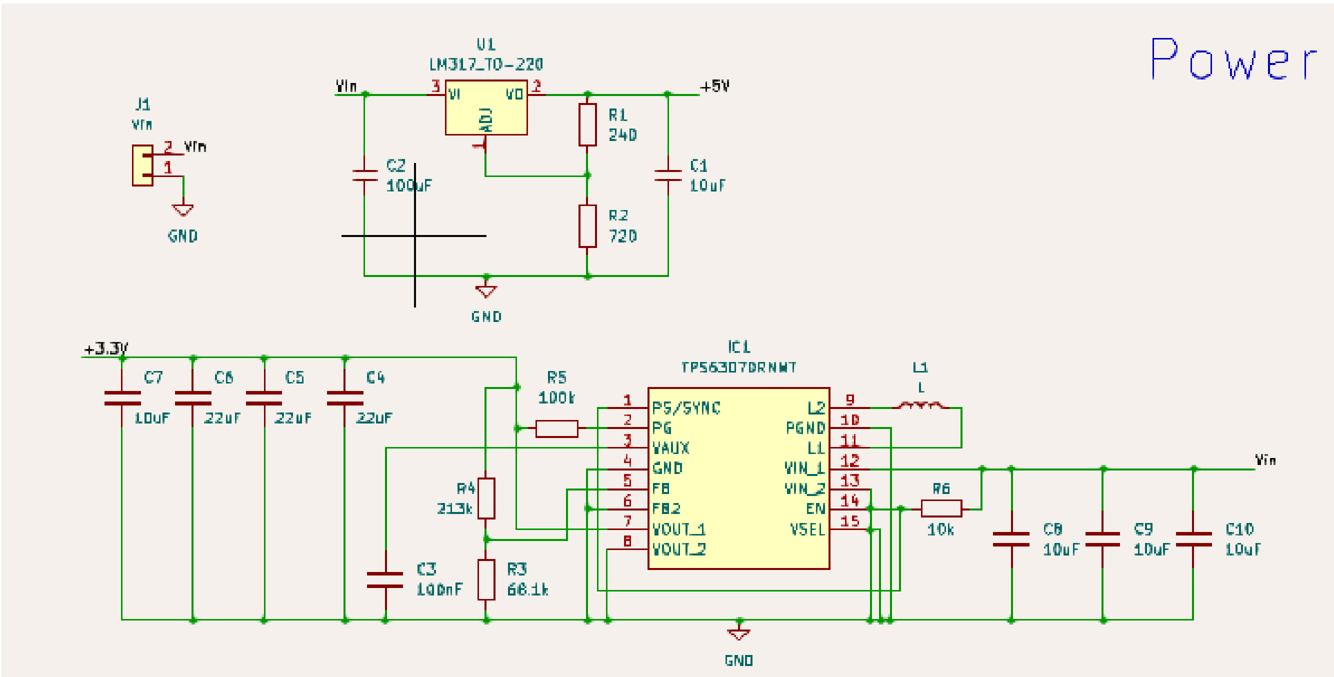

Figure 11. Power Unit Schematic

The power subsystem is going to be used to power the hardware side of the device. Since this device is designed to be used stationary at home, we will be using a simple 12VDC ‘Wall Wart’ power adapter. We will be utilizing 2 power rails: one for 5V and one for 3.3V applications. The servo motors will be requiring 5V of power and therefore we will use a linear regulator to construct the step down as it is able to stay within thermal limits, while being able to reduce part count. For the other components, we will utilize a buck converter to step the voltage down to 3.3v. The reasoning behind this is due to thermal limitations with the linear regulator chip. Therefore to optimize the design, we will be using both a linear regulator as well as a buck converter for our power needs.

2.3. Subsystem Requirements

2.3.1. Mobile Integration

<table>
<tr><th>Requirements</th><th>Verification</th></tr>
<tr><td>1. When prompted with an input food item, the database must return:

1 JSON File

*Micronutrients Present (units in IU and mg)
- Vitamin C
- Vitamin B3
- Vitamin B6

Macronutrients Present
- Protein (grams)
- Carbohydrates (grams)
- Fat (grams)
- Calories (kCals)
With a success rate of 90%
*Specific micronutrients chosen for MVP for higher daily upper limits</td><td>1. Using the mobile app, submit a meal (i.e. pasta, chicken, etc.)
2. Verify that the app returns the macro and micronutrients of the meal
3. Repeat for all foods stored in the database
4. Verify that 90% of the foods requested returned a valid JSON file</td></tr>
<tr><td>2. When prompted to make a drink, the system must be able to accurately recommend a list of supplements based on what the user is lacking in their diet with an 80% success rate.</td><td>1. Using the mobile app, submit 2 sample meals
2. Request today’s drink mix
3. Verify that the app analyzes today’s meals and returns the vitamins and minerals that weren’t present in today’s meals
4. Verify that the app returns a blend that supplement what the user was lacking
5. Repeat 10 times and verify that step 4 held true 8 out of the 10 times.</td></tr>
<tr><td>3. When a drink order has been confirmed in the mobile app, the software must be able to communicate with the hardware by sending control signals over wifi with an 80% success rate</td><td>1. Verify that the app is paired with the device
2. Request today’s drink mix
3. Verify the doses are accurate and within the safe range
4. Confirm and request the drink
5. Verify that the device processes the request and dispenses a drink
6. Repeat 10 times and verify that step 5 held true 8 out of the 10 times.</td></tr>
</table>

2.3.2. Storage

Requirements	Verification
1. System must be able to recognize when a compartment has reached 15% of its capacity	1. Put excess amount of powder (well over 15% of compartment capacity) into the storage compartment 2. Check log for verification that the sensor registers powder as above threshold. 3. Remove powder until it is below 15% of compartment volume. 4. Check log for verification that the sensor doesn't register any powder as above threshold. 5. Repeat for any remaining compartments.
2. System must be able to correctly identify when a container is running low 80% of the time	1. Repeat Requirement 1's verification procedure's steps 1-4 10 times. 2. Verify that 8 of the 10 tests were successful. 3. Repeat steps 1-2 for any remaining compartments.

2.3.3. Dispenser

Requirements	Verification
1. System must be able to dispense each powder within a 15 mg tolerance	1. Send a signal to dispense 30mg of powder from the desired storage compartment. Leave all other compartments aside from the desired one empty. 2. Let the dispensing process reach completion. 3. Check log for weight sensor and note down change in weight from before and after dispensing process. 4. Check the difference from 30mg and the value noted in step 3 and ensure said difference is within our desired 15mg tolerance. 5. Repeat steps 1-4 for remaining storage compartments.
2. System must be able to rotate and align onto the correct storage compartment.	1. Send a signal to dispense powder from the desired storage compartment. 2. Let the machine rotate until reaching full stop. 3. Check log for color sensor and make sure it is within 10% of RGB value for the LED's intended RGB value. 4. Repeat steps 1-3 for all containers with different start positions for turn mechanism and different external lighting factors.

2.3.4. Power

Requirements	Verification
1. System must be able to supply 5VDC +/- 5% and 3.3VDC +/- 5%	1. Hook up power output of buck and LDO to digital multimeter and test voltage ratings. 2. Verify that from the buck converter output the voltage is between the range of 3.465~3.135 volts using an oscilloscope. 3. Verify that the linear regulator output voltage is between the range of 5.25~4.75 volts using oscilloscope.
2. System must be able to provide up to 1.5A of current while maintaining 12V	1. Place a 8 ohm resistance across the 12V rail and ground and measure the voltage across the resistor

2.4. Tolerance Analysis

Part	Quantity	Worst Case Current Draw @ 3.3V	Comments:
FeeTech FS5103R	1	850mA/180mA	Stall/Idle
TowerPro SG92R	3	650mA/10mA	Stall/Idle
Total		880mA	Only one will be running at a time, other 3 will be idle

Variable	Value
Input Voltage	12V
Output Voltage	5V
Output Current	880mA
Junction to case thermal resistance	5 C/W

$$T_{ja} = i_{out} \cdot (v_{in} - v_{out}) \cdot (\theta_{jc})$$

$$T_{ja} = 30.8°C$$

Our design hinges on the functionality of accurately dispensing powder. The mechanism behind this is the use of multiple motors. Because of this, it is vital that our motors are able to be consistently, and safely powered by our linear regulator (LM-317). With the LM-317 in the TO-220 package, the datasheet states that its recommended operating temperature @1.5A is 23.5℃. With our maximum current draw being almost half of that, it can be safely assumed that our linear regulator will not overheat and cause damage and malfunction to our motors. In addition, the range of operation is 0℃ - 125℃ so our temperature falls safely in that range.

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3. Cost and Schedule

3.1. Cost Analysis

Manufacturer	Part #	Quantity	Cost	Total	Description
ESPRESSIF	ESP32-S3-WROOM	1	$2.95	$2.95	Microcontroller with Wifi
FeeTech	FS5103R	1	$11.95	$11.95	Continuous Rotation Servo
TowerPro	SG92R	3	$5.95	$17.85	Micro Servo
Texas Instruments	TPS63070	1	$2.70	$2.70	Buck-Boost IC
STMicroelectronics	LM-317 TO-220	1	$0.76	$0.76	Linear Regulator
Renesas Electronics	ISL29125	1	$9.50	$9.50	RGB Color Sensor
Adafruit	2167	3	$2.95	$8.85	IR Break Beam Sensors
N/A	B0852HX9HV	1	$11.99	$11.99	12V 24W AC-DC
N/A	N/A	1	$40.00	$40.00	3D Printing
Yageo	RC0201FR-07240RL	1	$0.10	$0.10	240 Ohm
Vishay	D55342E07B720ARWS	1	$0.10	$0.10	720 Ohm
Yageo	RC0603FR-07100RL	1	$0.10	$0.10	100 Ohm
Yageo	RC0402JR-0710KL	4	$0.10	$0.40	10k Ohm
Yageo	RC0402FR-07100KL	1	$0.10	$0.10	100k Ohm
Yageo	RC1206FR-0768K1L	1	$0.10	$0.10	68.1k Ohm
Yageo	RT0603BRD07213KL	1	$0.14	$0.14	213k Ohm
Panasonic	EEE-1EA100SR	5	$0.32	$1.60	10uF, 25V
Panasonic	EEE-HB0J2220AR	3	$0.36	$1.08	22uF, 6.3V
Nichion	UUP1H0R1MCL1GS	2	$0.64	$1.28	100nF, 50V
Meritek	SRB50V1R0MD054	1	$0.04	$0.04	1uF, 50V
Murata Electronics	LQM21NN1R5K10D	1	$0.26	$0.26	1.5uH
N/A	N/A	3	$9,000.00	$27,000.00	Labor

Parts Cost: $111.85

Total Project Cost: $27,111.85

Calculation for Labor: 2.5 * $50/hr * 72 hours = 9000 per person

3.2. Schedule

Timeframe	Operations	Mobile App	Hardware
Week 1 (1/15)	Brainstorm Ideas		
Week 2 (1/22)	Brainstorm Ideas Revise Idea Proposals		
Week 3 (1/29)	Finalized on Project Idea Project Approved		
Week 4 (2/5)	Start Project Proposal Find parts		
Week 5 (2/12)	Revise Project Proposal Finalize Design Document	Write specs for mobile app	Brainstorm design Sketch out schematics
Week 6 (2/19)	Order Parts	Wireframe for UI	First draft of schematics
Week 7 (2/26)		Create Firebase db Compile list of food data Populate db with data	First draft of PCB Prototype on Breadboard Test Microcontroller Test Sensors
Week 8 (3/4)		Set up IOS app	Revise PCB Start Mixing Device code
Week 9 (3/11)		Set up Firebase user auth Set up onboarding ui	Test Mixing Device code on Breadboard Debug Mixing Device code Start working on CAD files
Week 10 (3/18)	Receive PCBs	Set up all pages and navigation Begin working on recommendation algorithm	Soldering PCBs 3D print CAD files
Week 11 (3/25)		UI testing Set up wireless	Test wireless interface Test PCB

		communication with hardware	Debugging
Week 12 (4/1)		Test if IOS app can consistently send accurate recipes to device	Fit electrical components into 3D printed components
Week 13 (4/8)	Buffer Week		
Week 14 (4/15)	Project Done Mock demos w/ TA		
Week 15 (4/22)	Project Demos		
Week 16 (4/29)	Project Demos		

Tasks and Status Updates shared amongst teammates using Linear

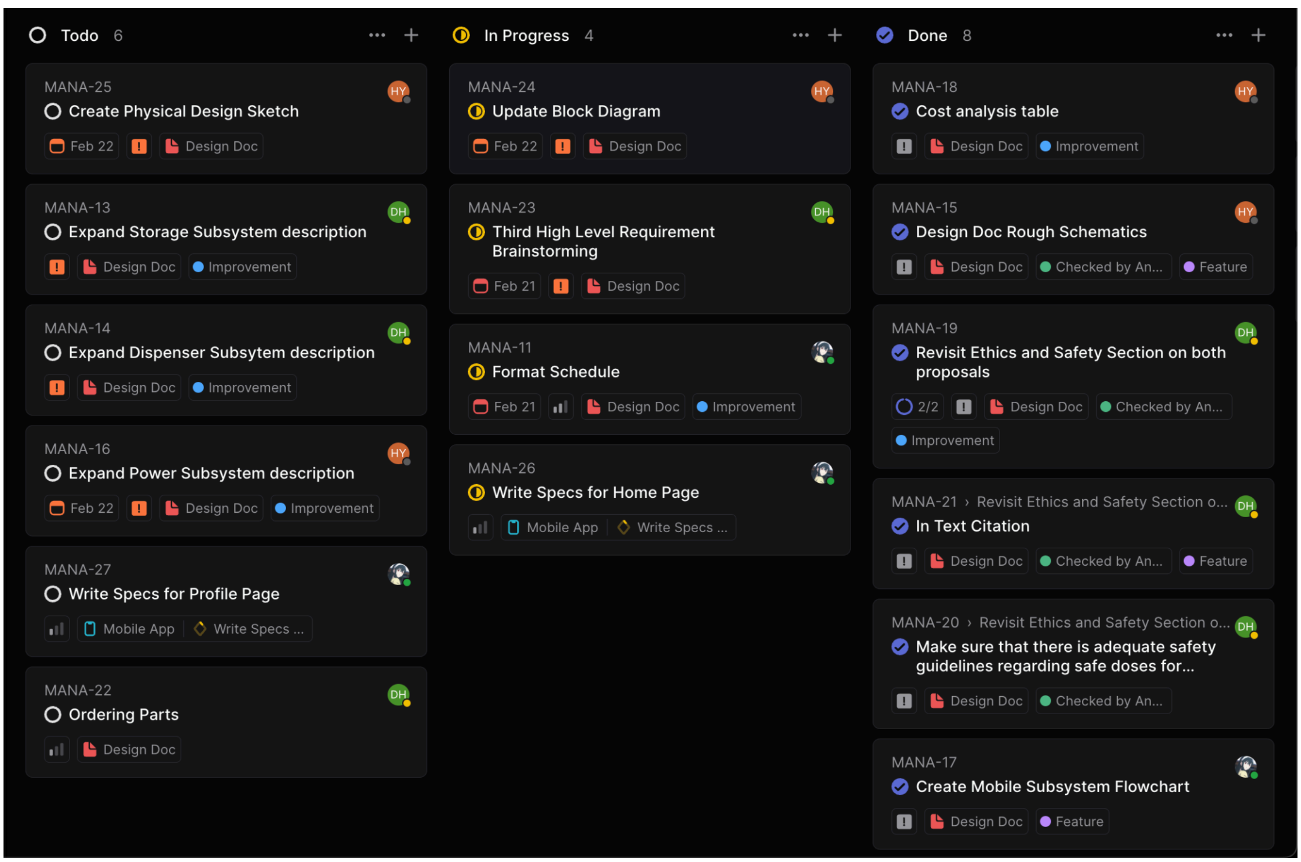

Figure 12. Week 5 Tasks on Linear

4. Ethics and Safety

A main concern regarding the ethics and safety of this product would definitely have to be the threat of possibly overdosing someone with nutrients that might not be necessary. This would be in violation of IEEE code of ethics 7.8.I.1 which states that, “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment,”[1], since it could potentially put someone in harms way and endanger anyone who would use the product. Another way someone could be harmed would be if the water in the cup which the mix gets deposited into splashed and managed to get onto any electrical components. This would also be in violation of the same code stated previously and it could potentially electrically shock someone. Our approaches to ensure that we don’t violate the code above would be by:

- Making sure that when calculating, we use whatever floor maximum for the recipes instead of the ceiling maximums, it is better if we underestimate in this case rather than overestimate as they will still be getting some boost that they need. Essentially per each calculation, we will be assuming worst case.
- Making sure any and all electrical components are covered or sealed by plastic to ensure it never comes in contact with water.

We will also keep each other responsible for making sure we all are upholding the ethics codes presented by IEEE and make sure to constantly keep thinking about how to keep our design as humanly friendly and safe as possible. This is in relation to section 7.8.III.10 of the code, “To strive to ensure this code is upheld by colleagues and co-workers. To support colleagues and co-workers in following this code of ethics, to strive to ensure the code is upheld, and to not retaliate against individuals reporting a violation," [1].

Since we are attempting to make a device that will create a product that will get consumed by our end users, we need to make sure that at the very least that the end product is edible and human safe. We would more specifically have to analyze and identify what dosages can be considered safe, not only regarding how much someone can intake in a day, but also at one instance. Below we have curated a list of the recommended values of various vitamins and minerals depending on the sex of the individual as well as the upper limit for each vitamin/mineral. Anything with a recommended intake that is less than 100 milligrams is not added to the short list.

Vitamin/ Mineral	Womens Recommended Intake	Mens Recommended Intake	Upper Limit
Vitamin C	75 milligrams	90 milligrams	2,000 milligrams
Choline	425 milligrams	550 milligrams	3,500 milligrams
Calcium	1,000 milligrams	1,000 milligrams	2,500 milligrams
Potassium	2,600 milligrams	3,400 milligrams	Unknown
Phosphorus	700 milligrams	700 milligrams	4,000 milligrams

Condensed Version of Table from [2]

Based on the gap between upper limits and recommended intakes, the vitamins/minerals listed in the table above would be the most suitable for our product as it allows for flexibility within what our threshold on how close to the actual value recipe, the amount we are dispensing needs to be. We do not want to cause any complications to anyone who would potentially use our product, and thus analyzing information like this is a very crucial step. Many other vitamins and minerals have recommended and upper limit values in the micrograms, and since we will be using rate of flow for our dispensing, it would be a wise choice to stray away from supplementing something that would require a high level of precision. As previously mentioned we would want to use a floor maximum for calculating how much we would want to dispense. An example of this would be assuming that the user (male) has had 60 mg of vitamin C for the day. Our main goal is to be able to make a device that helps people, not harm, which is why incorporating factors such as supplement overdose is of utmost importance.

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5. Citations

[1] IEEE, “IEEE Code of Ethics,” ieee.org, Jun. 2020.
https://www.ieee.org/about/corporate/governance/p7-8.html

[2] Harvard School of Public Health, “Vitamins and minerals,” hsph.harvard.edu, March. 2023.
https://www.hsph.harvard.edu/nutritionsource/vitamins/
