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Smart Medical Pill Dispenser

ECE 445

Design Document

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Introduction

Problem:

According to Census, the growth of the 65+ population is rapidly increasing seeing a 9.4% increase from 2020 to 2023. With people living longer lives, there are a few growing pains; largely medical troubles. With 54% of 65+-year-olds taking four or more prescription drugs (KFF) and 50% forgetting to take them on time, or at all, (NIH) we believe the way towards a healthier future for the growing post-retirement population, lies in automated medicine. Not only will this lead to healthier outcomes, but also major cost savings as the average 65+ year old spends around $800 per year (HPI Georgetown University). Currently, there are a few options in the market to automate taking and preparing the concoctions of medications a patient must take per week but they range from largely useless to extremely expensive. Pill organizers play the role of "meal prepping" for medication, however, not only do they become a chore but also depend on the user placing the right medication into the right compartment the right amount of times. Notice the number of "rights" needed for a pill organizer to work and consider the error rate of a pharmacist, a professional, being 1.6% (NIH), it slowly becomes obvious that automated pill dispensers are a necessity. However, this leads to the second leg of the problem, automated pill dispensers like Hero cost $540 per year and only work with 2.4 GHz WiFi. With 10.9% of 65+ year olds living in poverty (Census) and pills needing to be dispensed even during WiFi outages, it becomes clear that a solution that does not require internet and is cost-effective is a necessity.

Solution:

To solve the problem/s listed above we propose a simple solution. A cost-effective ($250) automated pill dispenser that takes in 4 types of pills, needs to be connected to the internet only during calibration and any updates made by the user, and requires a far more cost-effective monthly server charge ($5/month). Our smart medical pill dispenser will take in user's pills from the top in a funnel, one bottle at a time, and place them into their own compartments. After all (max 4 types) pills have been placed into the dispenser the user will navigate through a setup process that will ask them for the time, quantity, and type of pill they must take on any given day. The user will then be alerted via a web app (when connected by Bluetooth) and an LED as to when they must take their pills. Users will also be alerted of refills needed and if they forgot to take their medication. Lastly, the system will have an internal battery along with a charging brick to withstand power outages and will be allowed to update timing based on Bluetooth. The system automatically sorts pills into correct daily doses and dispenses them at the scheduled time, put simply.

Visual Aid:

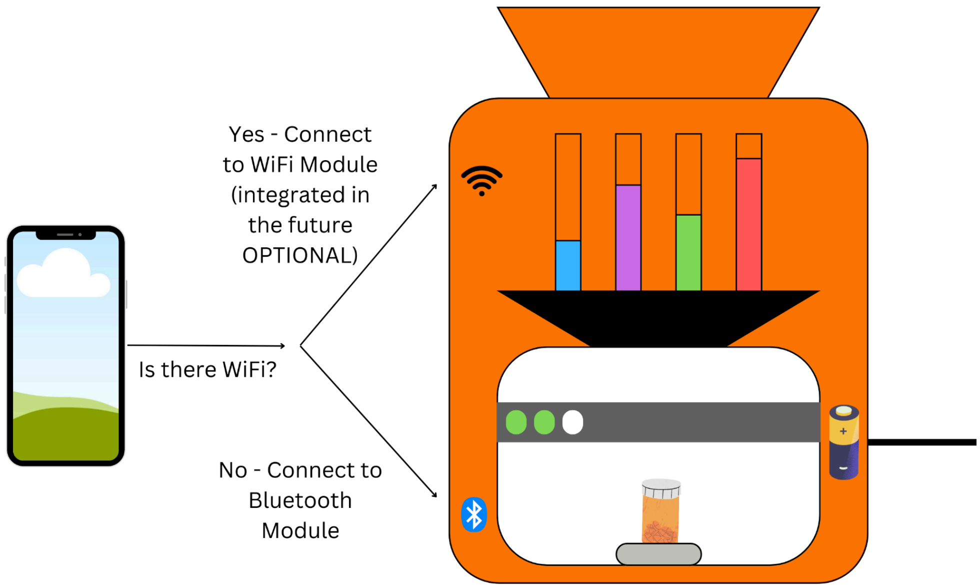

Figure 1: Visual Aid

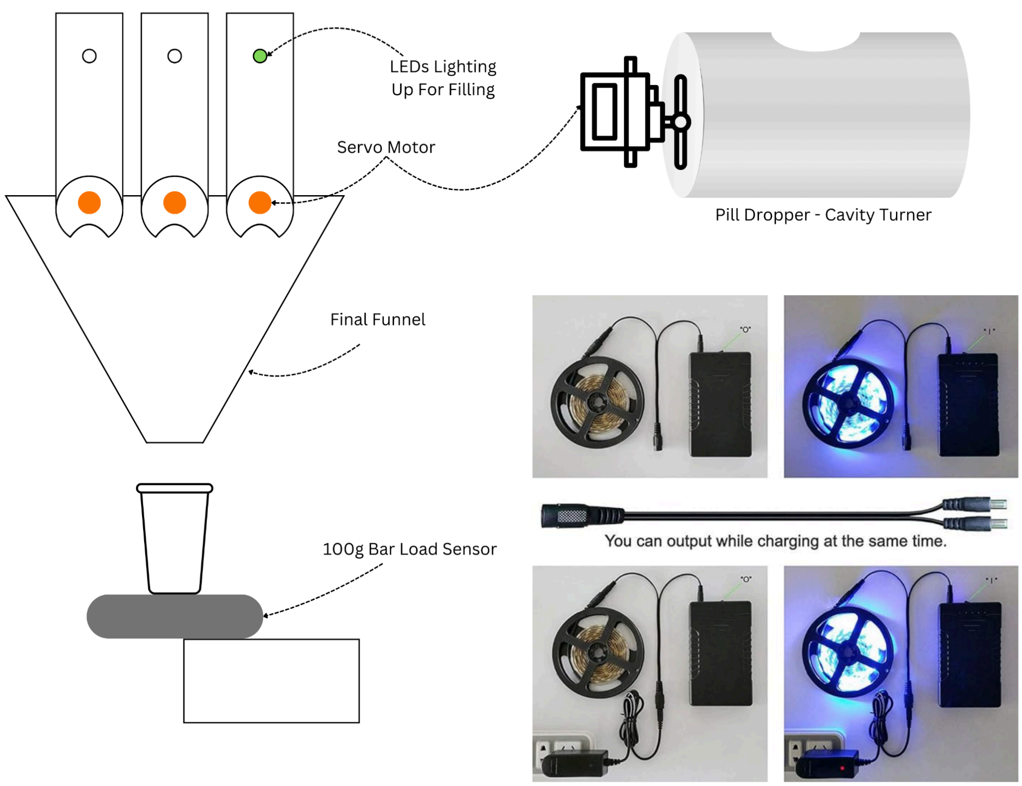

Figure 12: New Visual Aid

As shown in Figure 1 and Figure 12, the smart medical pill dispenser (SMPD) has a funnel at the top to compartmentalize different pills and a funnel at the bottom to dispense them all at once into the container of choice. Additionally, there is a plug for the tool, however, it is backed up with a battery to ensure proper dispensing even during outages. The phone is the main interface with which the user can customize their SMPD, with the program interface changing depending on whether the user is accessing the device through the internet or Bluetooth. Lastly, there are 3 LEDs on the device, one to indicate refills needed, another to indicate active dispensing, and last to indicate when a user has forgotten to take their pills. The PCB inside the SMPD will determine which pills are supposed to be dispensed based on the user-set configuration.

High-Level Requirements List:

- 98.4% Pill Dispensing Accuracy (given the pills filled in initially are correct)
- The SMPD alerts the user within 5 seconds of the scheduled times
- Refill alerts are sent out when the compartment is left with ~10% of pills

Design

Block Diagram:

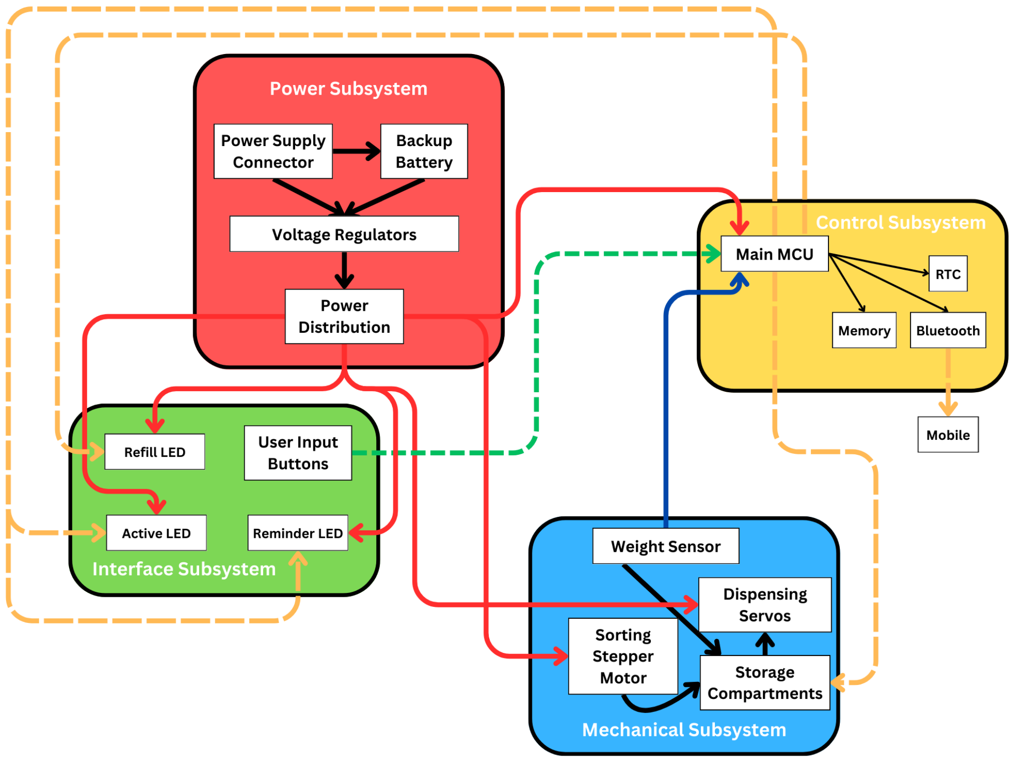

Figure 2: Block Diagram

The power subsystem takes in 12V from an outlet plug or a battery pack depending on if the outlet is active. The battery pack charges up using the same plug as it is using a 2 to 1 wire that takes in power from the outlet and directly powers the machine and the battery pack at the same time. The wire also reroutes the power if the outlet is removed, giving us an inherently recharging backup battery. The MCU we are using is the ESP32-WROOM module, which has built-in Bluetooth, wifi, and RTC. The RTC drifts by about 1 minute per month, however, since it recalibrates every time the user pairs their phone with the device, the drift gets fixed often. The mechanical subsystem uses a servo motor to turn the compartments, or the top funnel depending on which final design we implement due to machine shop constraints. It also has access to 3 servo motors that rotate the cavity spindles and 2 servo motors that work as shakers, to remove any jamming that may occur. Lastly, we have the weight sensor at the bottom which checks to make sure all the pills that needed to be dispensed did so. The final subsystem consists of 3 LEDs and 1 User Button that allows for Bluetooth pairing.

Physical Design:

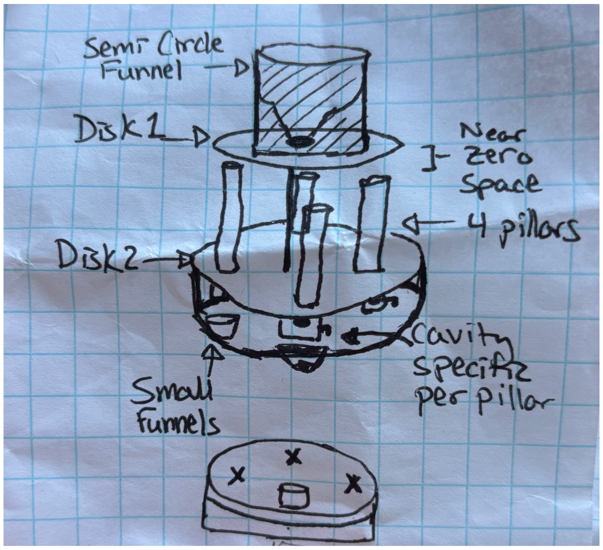

Figure 3: Full Body Design

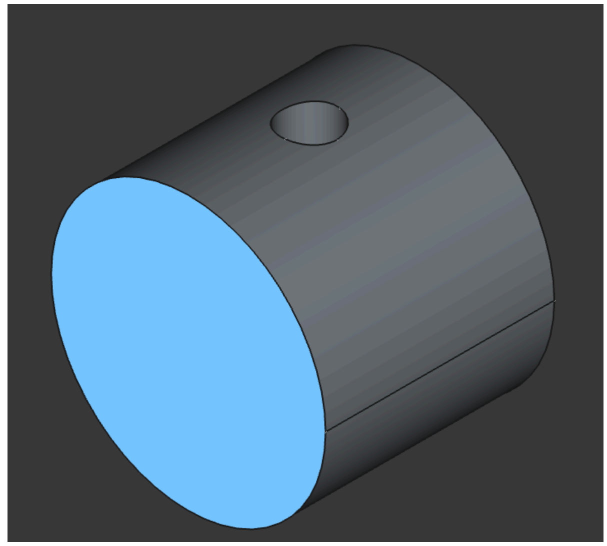

Figure 4: Cavity Turners

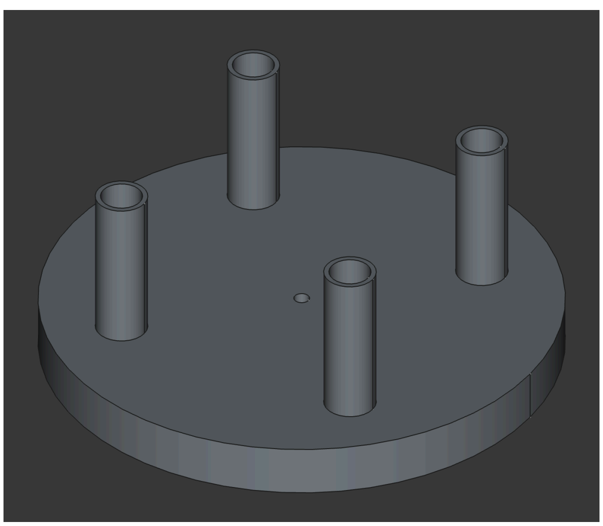

Figure 5: Disk 2 with Compartments

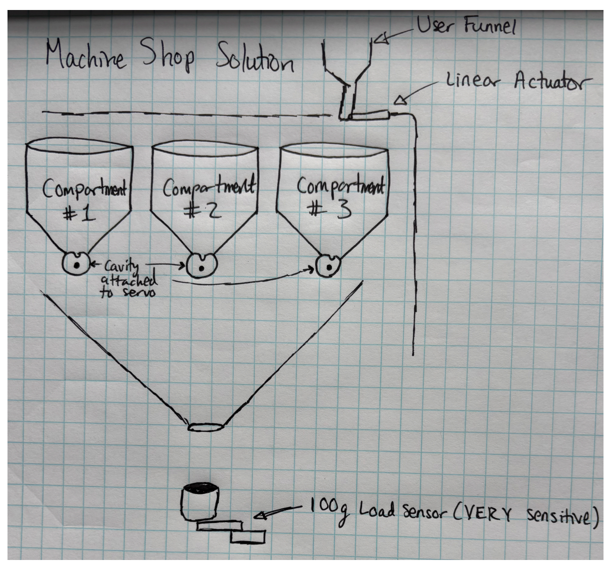

Figure 6: Machine Shop Design

The figures above describe the two designs currently being experimented with. The machine shop solution proposes placing 3 compartments next to one another horizontally and dropping each into a larger funnel to one final cup. To make refilling easier, we would need to include a linear actuator that would point to which compartment the pill that must be refilled, is contained. The alternative design is our original proposed solution of 4 rotating compartments each with a pill-specific cavity turner at the bottom all dropping to a final funnel. However, this poses issues with wires being tangled, for which we would need a slip ring, additionally, it would need to be 3D printed as the machine shop can not create it.

Subsystems:

Mechanical Subsystem

The mechanical subsystem is responsible for dispensing the pills accurately. This is done by filling the compartments correctly so that when the pills are dispensed, the incorrect prescriptions aren't dropped out. The mechanical subsystem also consists of a 100g load sensor, which is highly sensitive, and can check on a per pill basis if the correct pills fell through. Finally, the mechanical subsystem also consists of a stepper motor, which may be replaced with 3 LEDs or a linear actuator, all of which serve the same purpose of pointing the user as to which compartment they must refill. This is so that the user doesn't have to continuously remember which compartment contains which pill after first setting up through the web app. The LEDs would light up the compartment, the linear actuator would move a funnel to the top of a compartment, and the stepper motor would rotate the compartments to be under the input hole. The decision on which one is chosen will be entirely dependent on which design (machine shop or 3D) can be made first and in time to test/demo.

It works with:

- **The control subsystem** for activation and dose scheduling.
- **The interface subsystem** for user alerts and notifications.

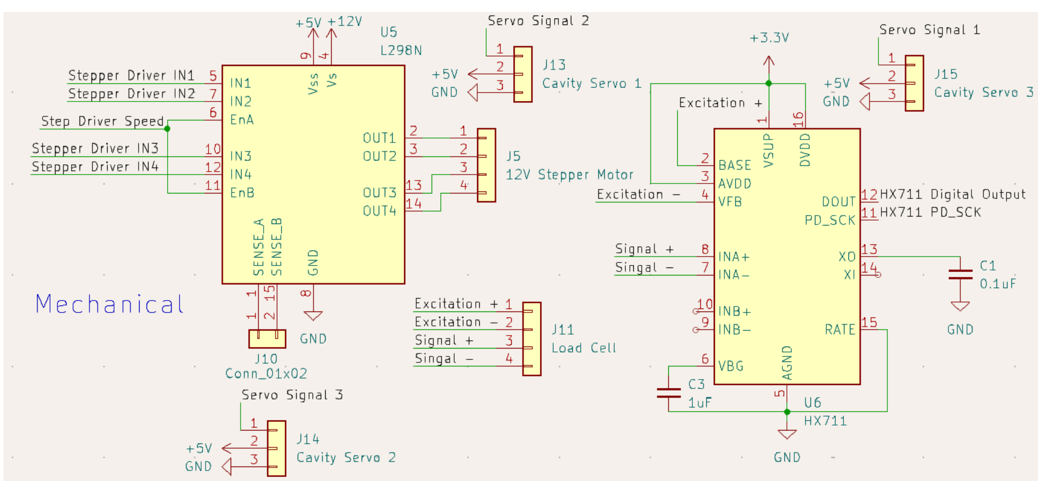

Figure 7: Mechanical Subsystem

We used the L298N stepper motor driver because it enabled us to not only control direction but also speed. This stepper driver is also available in the Electronic Shop Self Help Drawers allowing for rapid testing, and cheaper parts. We also used the 100g load sensor instead of the widely used 10kg load sensor, so that we can have far more accurate readings, since the 10kg has +/- 50g readings. We used

HX711 since it was the industry standard and was simple to use. Additionally since it usually comes on boards, we were able to test it and use it for the breadboard demo far faster.

Requirement	Verification	Acceptance Criteria
Dispense pills with an accuracy of 98.4% (assuming correct initial loading)	● Load a known number/weight of pills. ● Trigger multiple dispensing cycles. ● Measure dispensed weight/count using a precision scale and visual inspection.	Dispensing error rate is ≤1.6% over repeated tests.
The 100 g load sensor measures the pill weight within +/- 0.5 g.	● Compare sensor readings against known weights. ● Perform multiple measurements to assess repeatability.	Sensor readings fall within +/- 0.5 g of the reference weight.
Servo/stepper motors used for compartment rotation must position the dispensing mechanism with a positional error less than 2°.	● Monitor motor rotation with angular measurement tools ● Record any deviations from the target angle.	Positional error is consistently <2°.

Power Subsystem

The power subsystem is responsible for not only powering the full circuit, but ensuring minimal heat dissipation and a quick switch to a back up battery which also recharges. This is done through a Talentcell backup battery and outlet charger that has 2 heads and 1 input cable attached. This allows the battery to be constantly charged, on slow charging to preserve battery health, and also power the main power subsystem. However, when the outlet charger is removed or power goes out, the battery instantly takes over through the cable. Additionally the power subsystem consists of a 5V voltage regulator and a 5 to 3.3V voltage regulator, which powers the full device. The voltage regulators also drop voltage in steps, so that less heat is dissipated. Lastly the battery is kept a good distance away form the pill compartments, so in case of ever over heating, it will not lead to any damage of the pills.

It works with:

- **The mechanical subsystem** to power the stepper motor directly and the servos (5V)
- **The interface subsystem** to power the LEDs and buttons indirectly via the ESP32
- **The control subsystem** to power 3.3V to ESP32 and CP2102

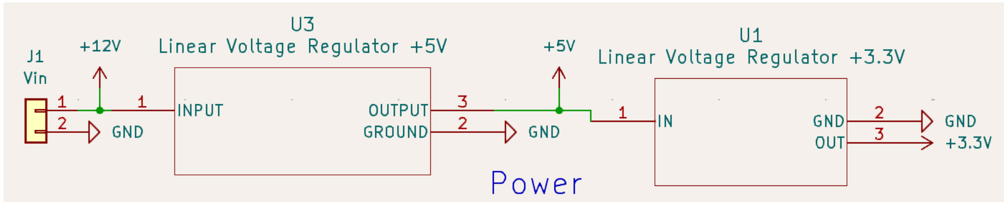

Figure 8: Power Subsystem

We used the LM3940IT and LM7805AC because they were both available in the Electronic shop self help drawers. The Vin consists of a 2.1 x 5.2 power port that connects with our outlet charger and battery backup. Not only was this affordable, but also meant we could test multiple times even if we shorted a chip or cut a wire.

Requirement	Verification	Acceptance Criteria
The power subsystem supplies regulated 5 V and 3.3 V rails within +/- ~6% tolerance under a load up to 100 mA.	• Use a digital multimeter to measure output voltages under various load conditions. • Verify stability during operation.	5 V rail within 4.75–5.5 V and 3.3 V rail within 3.00–3.60 V.
Transition from external power to the backup battery must occur within 5 seconds with no interruption to system operation.	• Simulate a power outage. • Use an oscilloscope or timer to measure the switchover interval. • Confirm continuous operation during the transition.	Backup power is engaged in ≤5 second.
The battery provides continuous power for 4 hours under nominal load conditions.	• Run the device under typical load conditions until the battery is depleted. • Record the operating duration.	Operating time meets or exceeds 4 hours.

Control Subsystem

The control subsystem consists of the ESP32-WROOM module with bluetooth and wifi capabilities along with CP2102 connected to a Micro USB 2.0 B port for programming. The control subsystem is what gives usability to the full product. It not only allows a user to schedule pill dispensing, but also manages when they must be refilled, through the load sensors outputs, which tracks pill counts. It also tracks the time through the ESP32's internal RTC which through pairing with the phone's clock, constantly fights off any drift it accumulates (around 1 minute a month). Additionally the control subsystem lights up the interface and manages bluetooth pairing. The CP2102 is connected to the ESP32-WROOM with autobootloading enabled, so that we dont need to press the IO0 and RESET buttons.

It works with:

- **The mechanical subsystem** to trigger pill sorting and dispensing.
- **The interface subsystem** for user notifications and inputs.
- **The power subsystem** for stable operation.

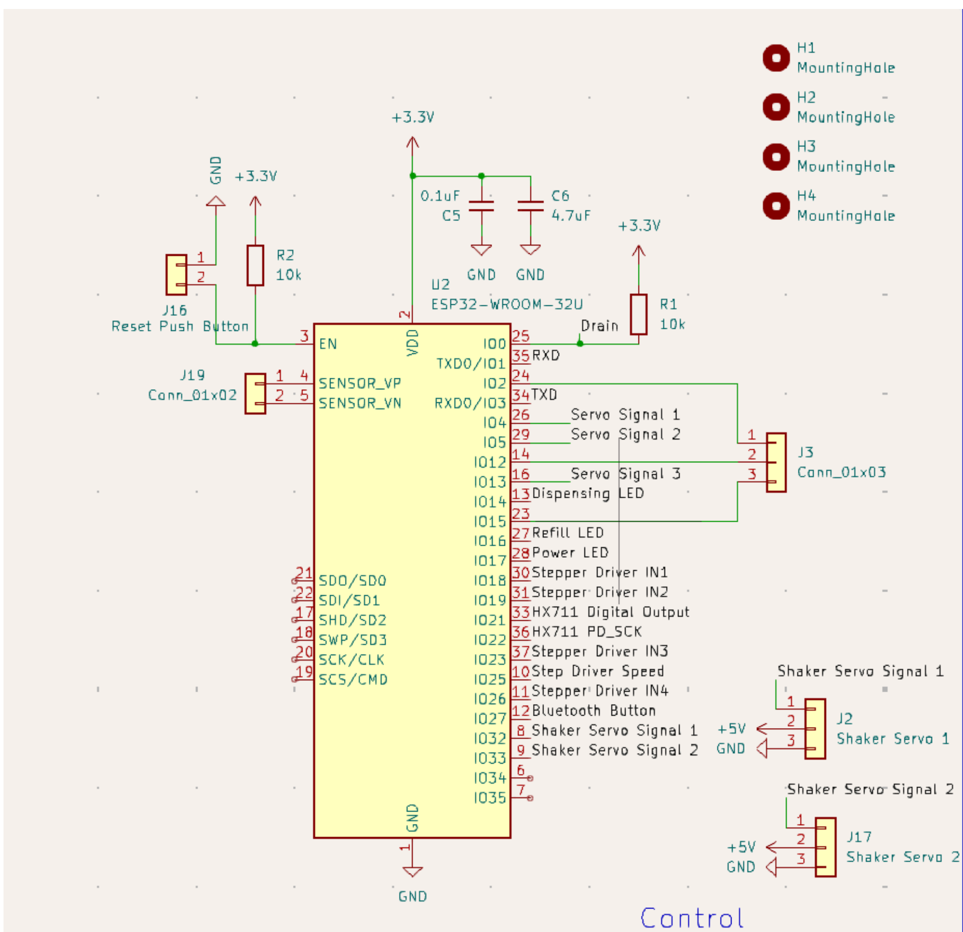

Figure 9: Control Subsystem (Microcontroller)

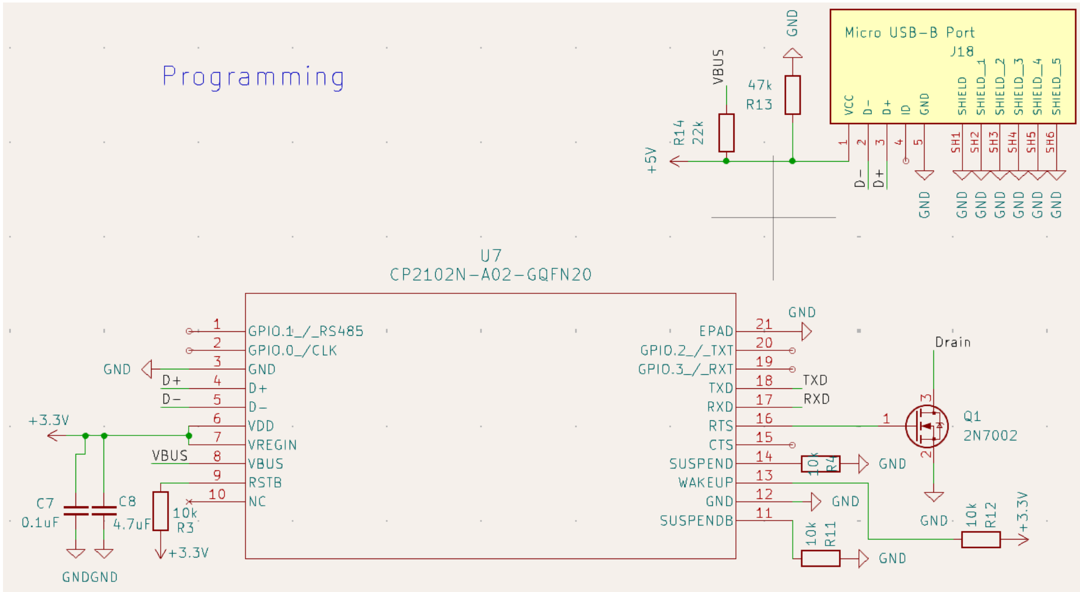

Figure 10: Control Subsystem (Programming)

We used CP2102N because it was the same USB to UART bridge used on the ESP32 Dev board that we did our breadboard demo on. The micro USB-B port was the same one offered in the excel sheet to order parts through TAs. The ESP32-WROOM was used instead of the original ATmega since it didn't require an external HC-05 for bluetooth nor a DS3231 for RTC. Additionally, the ESP32-WROOM came with WiFi capabilities giving us easy upgrade optionality, and far more GPIO pins. Instead of setting up buttons to the GPIO0 and RTS we instead chose to create an auto-bootloading schematic which would speed up development time.

Requirement	Verification	Acceptance Criteria
The control subsystem initiates a dispensing event within 5 seconds of the scheduled time.	• Use a timer/oscilloscope to capture the interval between the scheduled event and actual dispensing. • Log the delay over multiple test cycles.	Dispensing is triggered within 5 seconds in at least 95% of tests.
The ESP32's internal RTC maintains time accuracy within +/- 1 minute per month, with recalibration with each Bluetooth pairing.	• Monitor RTC drift over an extended period. • Perform a Bluetooth pairing and compare the RTC against a reference clock. • Repeat to confirm consistency.	RTC drift remains within +/- 1 minute per month after calibration.

Communication between the control subsystem and other subsystems achieves 100% command execution reliability.	• Log all transmitted and received commands during continuous operation. • Validate that each command sent is correctly executed.	No lost or wrong commands during a 24-hour test period.

Interface Subsystem

The interface subsystem is primarily used as a quick reference for the user. The user can find far more information through the web app. The web app not only tells the user each pill's quantity remaining, but also lets them determine the schedule, as to when they must take their pills and provides notifications regarding any refills or errors that may occur. The physical interface consists of a single button which bluetooth pairs the mobile device to the SMPD, giving the user access to their SMPD's web app. The physical interface also consists of 3 LEDs, which indicate power, need for refill, and active dispensing.

This subsystem works with:

- **The control subsystem** for status updates and notifications.
- **The power subsystem** for reliable operation.

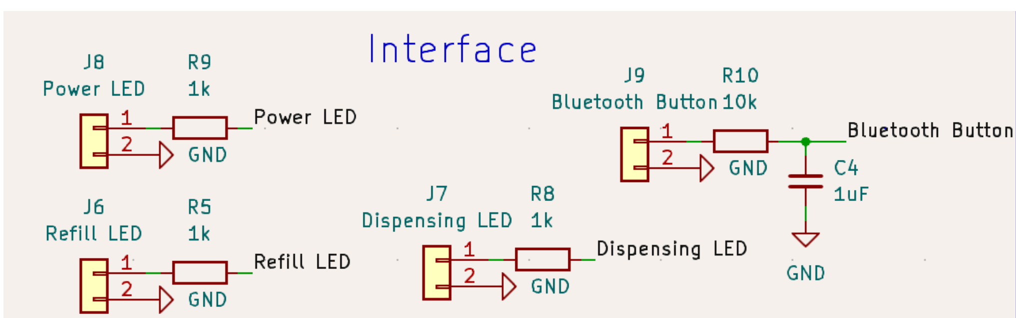

Figure 11: Interface Subsystem

We used simple push buttons and LEDs so as to not make the interface subsystem difficult to implement. The structure was extremely similar to that used in our CAD assignment earlier in the semester.

Requirement	Verification	Acceptance Criteria
The interface alerts the user (via LED and web app) within 5 seconds of a scheduled dispensing event.	• Time the interval from the scheduled event to the activation of the LED and web app alert. • Conduct multiple trials.	Notification occurs within 5 seconds in at least 95% of tests.

The Bluetooth pairing button registers a press reliably with a debounce time under 50 ms.	● Use a logic analyzer to monitor the button press and system response. ● Repeat across several trials.	Successful pairing in 99% of attempts with a debounce delay <50 ms.
The three LED indicators clearly show system statuses (power, dispensing, refill) under different lighting conditions.	● Test LED visibility in different lighting conditions.	LEDs provide status indication in all tested lighting environments.

Hardware Design

The ESP32-WROOM runs at 3V - 3.6V, which allows our 3.3V rail to be sufficient. The ESP32-WROOM will also have a 0.1uF capacitor and a 4.7uF capacitor going to ground close to the VCC pin, to be used as decoupling capacitors. Additionally the CP2102 requires 3V - 3.6V as well, which once again allows our 3.3V rail to be sufficient. Being that we are using the Micro USB 2.0 B port, we will also be connecting VBUS on the port to the CP2102 but only through a 22k resistor and 47k resistor going to ground, to avoid providing too much power. The power subsystem consists of voltage regulators which are on the PCB itself, and the battery pack which is as close to outside the device as possible. The device would be 3D printed with PETG filament for final production, to be food grade safe.

Requirement	Verification	Acceptance Criteria
The PCB must maintain stable voltage regulation and minimal noise on the 3.3 V rail during operation.	● Use an oscilloscope to measure voltage stability during load changes.	Voltage levels remain within specified limits.
All decoupling capacitors (0.1 µF and 4.7 µF) must be placed within 0.5 inches of the ESP32 VCC pins.	● Visually inspect the PCB and review design files.	All capacitors are positioned correctly.
The 3D printed components shall be produced using food-grade PETG and are structurally sound.	● Perform mechanical stress tests on printed parts. ● Verify material certification.	Parts pass stress tests without failure and meet food safety guidelines

Software Design

The software takes the role of at home pharmacist. It begins by asking the user to set the 4 pills they will be taking, asks to weigh the pills, asks for the shape of the pill, and asks for the number of pills. It then instructs them to begin filling and let the device know when they are done filling the pills. From here on out if the user ever wants to refill a prescription they can just choose the refill option, choose from a dropdown of the pills currently assigned, and instantly be shown which compartment to refill. The web app then instructs the user to set the schedule for each pill so that it can inform them when they need to take a medication, and dispense the correct quantity. Lastly the user is taken to their personal dashboard, which shows the quantity of pills remaining, their recent notifications, the last prescription they took and their next. The software also consists of an activity log which runs on the microcontroller which is used for development.

Requirement	Verification	Acceptance Criteria
The software setup process must capture pill type, quantity, and schedule with an input error rate of less than 1%.	● Conduct usability tests with multiple users. ● Record and analyze data entry accuracy. ● Use automated unit tests where applicable.	Input error rate remains below 1% across test sessions.
The scheduling algorithm must trigger dispensing events with a maximum delay of 5 seconds relative to the planned schedule.	● Simulate scheduled events and use time-stamped logs to measure actual trigger times. ● Repeat the test under varied conditions.	Dispensing events are triggered within 5 seconds in at least 95% of cases.
The activity log shall record all system events (e.g., user actions, dispensing events) without data loss.	● Validate log entries during extended operation tests. ● Cross-reference logged events with expected activity.	100% of events are logged accurately and are retrievable for review.

Commonly Overlooked R&V

These are answers to the questions mentioned in the rubric. The solutions offered are not a priority, and will only be implemented assuming time allows for it.

- Circuit protection: How will your circuit handle a sudden short/open?
  - We would use a TVS diode.
- Input/Output protection: What would happen if a user inserted a plug or battery in backward?
  - We would use a Schottky diode on the 12V Vin.
- Environment: Will your project function in hot or cold conditions? In the rain?
  - We will test the 3D-printed parts in extremely hot and cold environments in the lab.

Tolerance Analysis:

The mechanical subsystem of our project is responsible for the operation of various components that will enable us to accurately dispense and control every part of our project. The most critical aspect that we have is the dispensing mechanism that should operate within +/- 2 degrees of their intended position and that load sensor correctly verifies dispensed contents within an acceptable accuracy range.
For the tolerance analysis aspect, we will determine the total worst-case error in the position accuracy along with the load cell measurement. This will comprise of two sections:

- First, the worst-case error in the compartment positioning using the 12V Stepper motor
- Second, the worst-case error in verifying dispensed contents with the 100g Load sensor will be checked

- <u>Load Cell Amplifier - HX711 (24-bit ADC Module)</u>

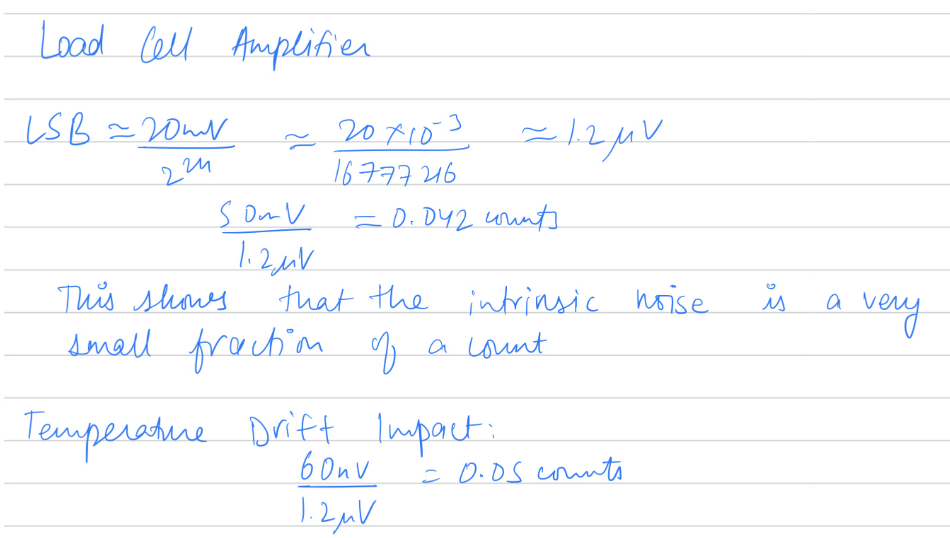

Figure 12: Load cell amplifier tolerance analysis

  - Tolerance
    - The analog front end of the HX711 is very precise but it is not ideal (no component really is). It features an on-chip low noise PGA. Key tolerances

include extremely low noise(on the order of 50nV RMS at the 10SPS setting) and minimal offset drift. For example, at a gain 128 the input noise is about 50 nV and the temperature drift of the offset is about +/- 6 nV/degrees Celsius, with gain drift of about 5 ppm/degrees Celsius. The HX711 does not really specify a fixed "gain error" percentage in its datasheet, but any initial gain/offset error is expected to be small and it is typically taken out by calibration.

- Error Margins
  - In practice, the above tolerances mean that the HX711's readings may fluctuate by a few counts due to noise and may shift slightly with temperature. The noise level translates to about +/- 1-2 counts of jitter at full scale, which is an error on the order of 0.001% of full-scale. These are pretty small, but in a 100 g load cell system, they might correspond to a few hundredths of a gram of variation. Calibration is essential in this device. We can do this by zeroing out the offset and using known weights to set the scale, any fixed offset or slight gain error is accounted for, ensuring the weight measurements remain as accurate as possible within the load cell's own tolerance.
- Implementation Considerations
  - We will be using proper decoupling and stable excitation to achieve the HX711's rated performance. The datasheet's typical application shows 0.1µF and 1 µF capacitors on the analog supply. These will help reduce noise and stabilize the internal regulator output. We will also try to use the lower output rate (10 SPS) for improved noise performance unless fast response is needed. We also need to ensure the reference voltage to the load cell is stable as variations in excitation directly scale the output. To summarize, the tolerances of the component are tight enough that with good design practices, the weight readings will be consistent and repeatable.

- Load Sensor - 100 g Load Cell

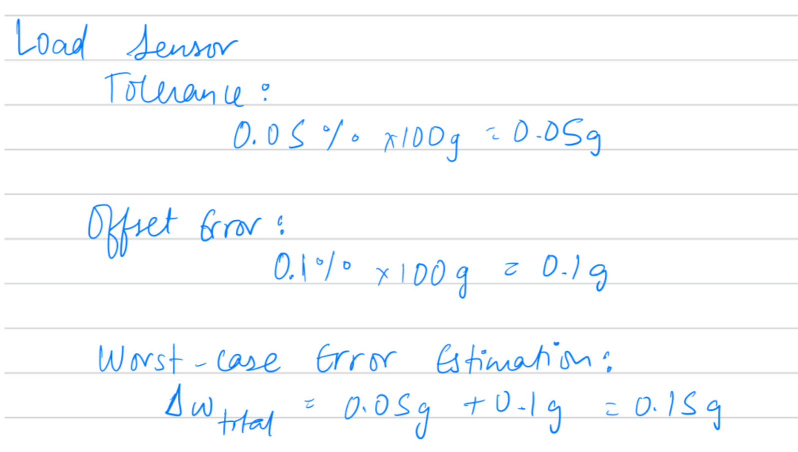

Figure 13: Load sensor tolerance analysis

- Tolerance
  - This Load cell has a very high precision. The manufacturer specifies a full-scale accuracy of +/- 0.05% of reading. More detailed specs on it show that other specs

such as non-linearity, hysteresis, and repeatability are each within +/- 0.05% of full-scale, and the combined error is also 0.05% full-scale. In other words, at 100 g full load, the max deviation due to these factors is about 0.05g. The zero output offset is rated at 0.1% FS. The load cell can handle overloads up to 150% of capacity without permanent damage, but beyond the 100 g limit, the reading is not guaranteed accurate, and above 150 g, it could be damaged or go out of calibration.

- Error Margins
  - A 0.05% full-scale accuracy would mean that the weight measurements may deviate by 0.05g at the full load because of the sensor's mechanical characteristics. This includes minor non-linearities and hysteresis, where readings may slightly differ depending on whether the weight is being approached from the top or from the bottom. Creep can cause readings to drift by 0.05% over 3 minutes under a sustained load. Even temperature changes can change the accuracy by ~ 0.1% FS shift per 10 degrees Celsius. Overall these errors are minimal, resulting in only a few hundredths of a gram of uncertainty.
- Implementation Considerations
  - To ensure accurate readings with a load cell, we must mount it securely and apply force only in the intended direction to avoid any errors. Off-center loading or twisting can introduce some inaccuracies beyond the specified correction of 0.1% FS. After assembly, calibrate it using known weights to eliminate offset and scale factor errors. Temperature variations may require two-point calibration at the temperature we are operating at for extreme accuracy. We must use the HX711's regulated voltage source to prevent fluctuations in output.

- Stepper Motor - 12 V Bipolar Stepper

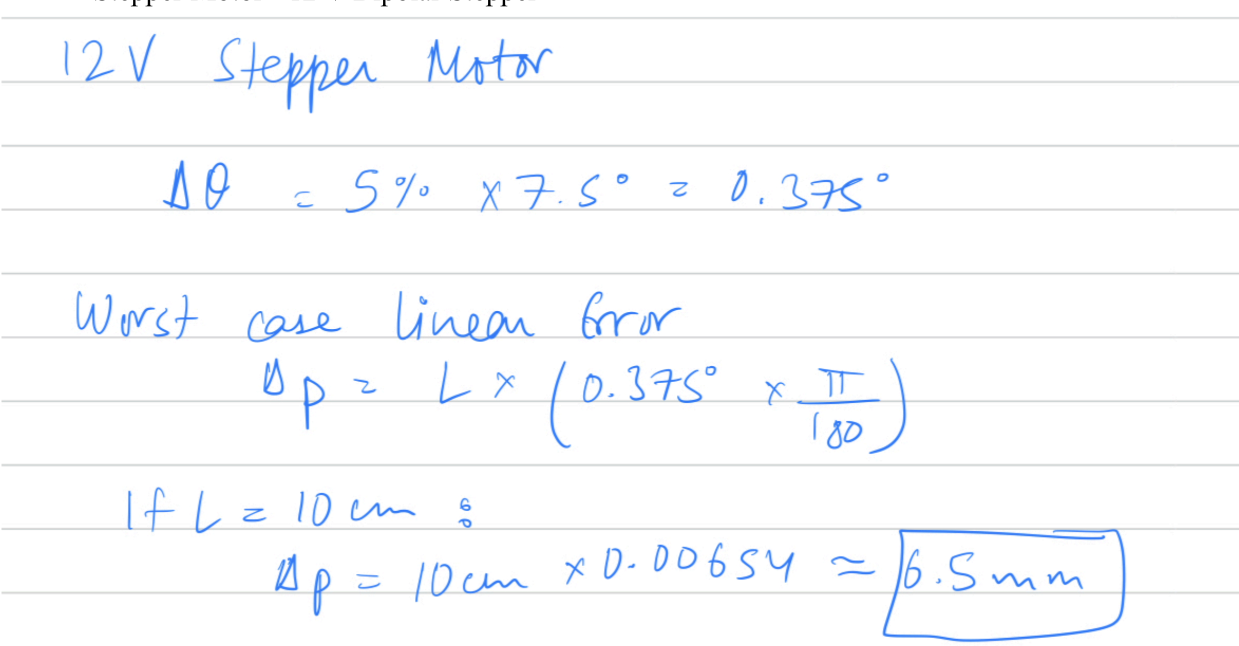

Figure 13: 12V Stepper Motor Tolerance Analysis

- Tolerance

- The small bipolar stepper motor has a step angle accuracy of 5% per step under no-load conditions. This error is non-cumulative, meaning small deviations do not accumulate over multiple steps. Manufacturing tolerances include 10% variation in coil resistance along with a 20% in inductance, which could affect the current draw and response.

  - Error Margins
    - With a 7.5 degree step angle, a 5% tolerance would mean each step can deviate by ~0.375 degree, resulting in actual movements being somewhere in the range of 7.125-7.875 degrees per tep. Since this is non-cumulative, a 48 step revolution still remains close to 360 degrees but short-term positioning errors of ~0.4 degree per step may occur. This can result in minor misalignment up to a millimeter.
  - Implementation Considerations
    - We will avoid open-loop positioning for crucial alignments to account for step angle tolerance. While small step errors are usually acceptable, micro stepping through can improve smoothness and reduce linear displacement errors, though it probably will enhance the +/- 5% step accuracy. We must provide a 12V supply, ensuring that it can handle up to 800mA if both coils are energized.

- Wi-Fi Microcontroller - ESP-WROOM-32U

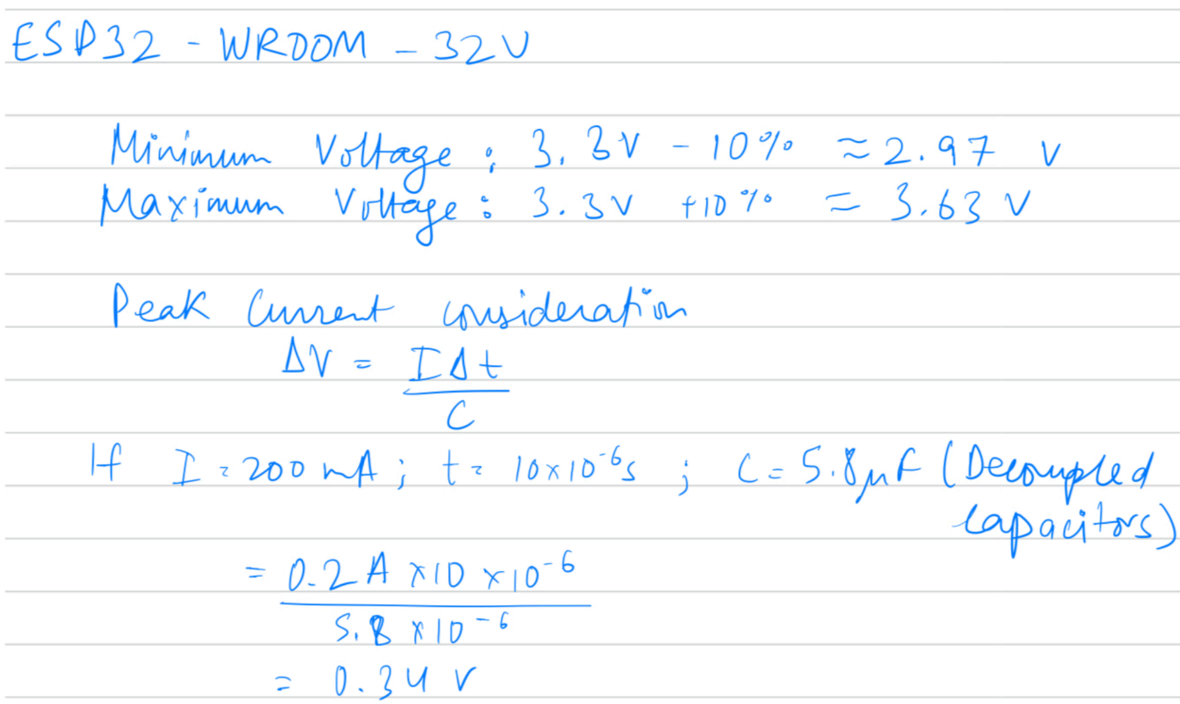

Figure 14: ESP32-WROOM Tolerance Analysis

  - Tolerance
    - This module includes a Wifi/Bluetooth module, a 40 MHz crystal, and a 4 MB flash. It uses a 3.3 V supply, which requires a +/- 10% tolerance for stability. RF performance would depend on the 40 MHz crystal, typically 10-20 ppm for accurate wifi tuning. The 12-bit ADC also has significant variation due to non-linearity and reference voltage differences, requiring the right kind of

calibration for accurate readings. Physically, the dimensions have a +/- 0.2mm tolerance.

- Error Margins
  - The tolerances for this component mainly relate to power stability and timing accuracy. It requires a 3.3V supply within 10%; voltage under 3.0V can cause brownouts. Regulators must also be placed to handle peak loads to prevent instability. The 10-20 ppm crystal ensures minimal Wi-Fi frequency error, though minor RF tolerances may slightly affect the performance it can have wirelessly. The ESP32's ADC has a 5% inaccuracy without calibration, but that's not very critical if using an external HX711 for weight sensing.
- Implementation Considerations
  - We must ensure a stable 3.3 V supply with proper decoupling as we will talk about later and a regulator that can handle the peaks. The module operates between -40 to +85 degrees Celsius, but as the temperature gets high, the output may reduce. But, as long as power is stable and guidelines are followed, the tolerances shouldn't impact performance.

- USB-UART Bridge - CP2102N-A02-GQFN20R

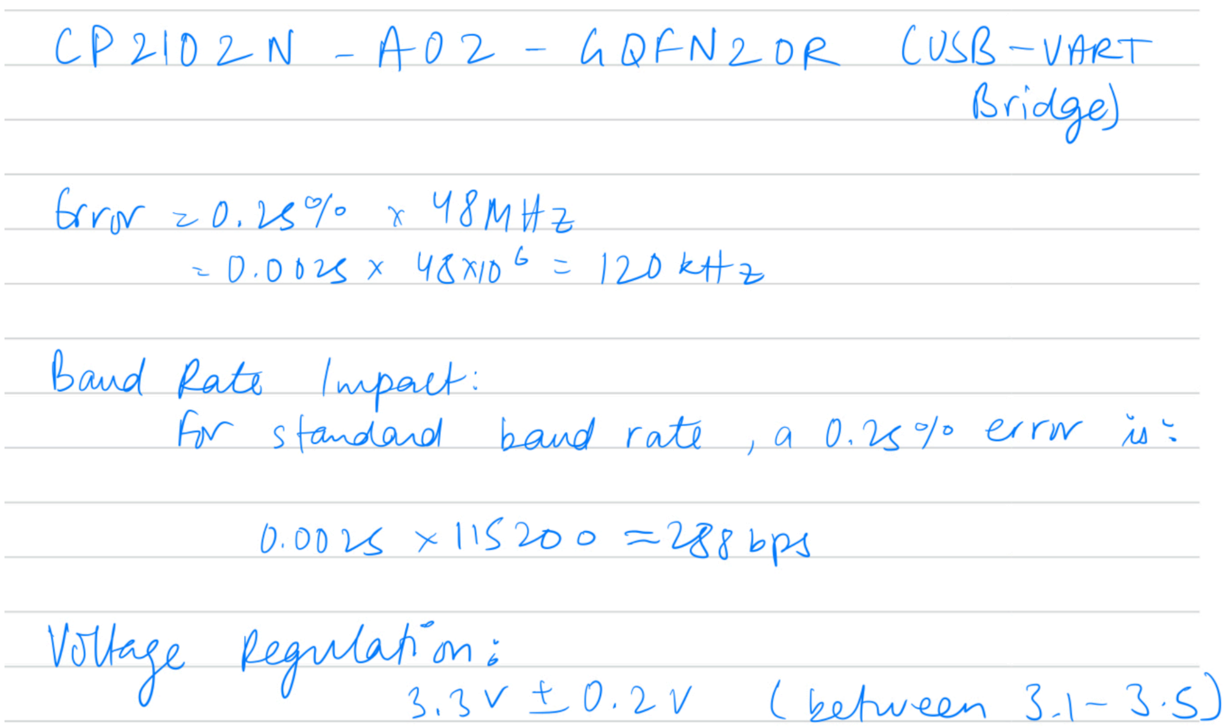

Figure 15: CP2102 Tolerance Analysis

- Tolerance.
  - The CP2102 operates using a 3.3V rail, however, can handle voltages ranging from 3.0 to 3.6 volts. Within this range, correct digital logic levels and USB to UART conversions will occur.

        - The CP2102's internal oscillator which generates UART baud rates, will require to be set to 115200. Typically there is an error rate of +/- 2%, however, this doesn't form any major issues.
    - Error Margins
        - Variations in the supply voltage within 3-3.6V will have minimal effect on the CP2102's performance.
        - The inherent oscillator tolerance may introduce a baud rate deviation of up to +/- 2%. This error margin is small, ensuring that auto-bootloading and data transfers between the CP2102 and the ESP32 remain reliable.
        - The conversion process through the CP2102 introduces noncumulative. propagation delays typically on the order of a few microseconds.
    - Implementation Considerations
        - A stable 3.3 V supply is critical for the CP2102's performance. To achieve this, decoupling capacitors will be placed as close as possible to the CP2102's power pins.
        - Since the CP2102 is enabled to use auto-bootloading for the ESP32-WROOM module, timing must remain consistent.

Cost and Schedule

Cost Analysis:

1. Labor for 3 Engineers given an average salary of $109,176 across 2080 hours, results in $52.49/hour which across 120 hours of labor for this project results in $18,896.40

Description	Part Number	Manufacturer	Price	Quantity	Extended Price	Link
Load Cell Amplifier	HX711	Paialu	$9.26	1	$9.26	link
Load Sensor	100g	Eujgoov Store	$8.14	1	$8.14	link
12V Stepper Motor	ROB-10551	MERCURY	$8.95	1	$8.95	link
ESP32-WROOM-32U	1965-ESP32-WROOM-32U-N4CT-ND	Espressif Systems	$6.39	1	$6.39	link
CP2102N-A02-GQFN20R	336-5885-ND	Silicon Labs	$5.59	1	$5.59	link
5.5/2.1mm DC Power Jack (Female)	80115	Tenergy Power	$1.35	1	$1.35	link
TalentCell Rechargeable 12V DC Output Lithium-ion Battery Pack	YB1203000	Talent Cell	$22.99	1	$22.99	link
Servo-Stock Rotation	HS-318	Hitec	$11.99	5	$59.95	link
On-Off Power Button / Pushbutton Toggle Switch	1684	Adafruit	$1.95	2	$3.90	link
MOSFET - 2N7002MTF	2N7002MTFCT-ND	Onsemi	$0.51	1	$0.51	link

CONN RCPT USB2.0 MICRO B SMD R/A	10118194-0001LF	Amphenol	$0.41	1	$0.41	link
L298N	497-1395-5-ND	STMicroelectronics	$11.78	1	$11.78	link
LM3940IT	LM3940IT-3.3/NOPB-ND	Texas Instruments	$2.27	1	$2.27	link
LM7805AC	LM7805ACT-ND	Onsemi	$0.75	1	$0.75	link
3D Printing	PETG Filament	SCD	$81.62	1	$81.62	link
0.1uF Capacitor	1276-1002-1-ND	Samsung Electro-Mechanics	$0.08	3	$0.24	link
1uF Capacitor	1276-1184-1-ND - Cut Tape (CT)	Samsung Electro-Mechanics	$0.06	2	$0.12	link
4.7uF Capacitor	1276-1044-1-ND - Cut Tape (CT)	Samsung Electro-Mechanics	$0.76	2	$1.52	link
PCB	2 Layer	PCBWay	$5.00	1	$5.00	link
10k Resistor	2019-RK73H1JTTD1002FCT-ND	KOA Speer Electronics, Inc.	$0.10	7	$0.70	link
1k Resistor	311-1.0KJRCT-ND - Cut Tape (CT)	YAGEO	$0.14	3	$0.42	link
47k Resistor	311-47.0KHRCT-ND	YAGEO	$0.10	1	$0.10	link
22k Resistor	P22KDCCT-ND	Panasonic Electronic Components	$0.10	1	$0.10	link
Sub Total (Parts Only)	$232.06					
Total (with labor)	$19,128.46					

Schedule:

Week Number	Aditya Perswal	Aryan Gosaliya	Aryan Moon	Everyone
03/03 Week	Design PCB with Buzzer & Actuator and order parts	Write code for breadboard demo and testing	Wire breadboard using schematic from PCB order 1	PCB Order Design Document
03/10 Week	Design 3D Models to print for the final demo	Solder PCB1 and integrate precise weight-sensing	Solder PCB 1 and determine how to best move wiring through the final product	PCB Order
03/24 Week	Print out 3D parts and assemble the final design	Create logic for dispensing one type of pill at a time and tracking to make sure proper dispensing occurred	Print out 3D parts and assemble the final design	Fix PCB and Fix PCB design for third order
03/31 Week	Solder PCB 2 and Fix any issues with 3d parts assembly	Solder PCB 2 and fix any issues with 3d parts assembly	Ensure the interface subsystem works appropriately with the final logic	PCB Order and Fix PCB design for fourth Order
04/07 Week	Write logic for refilling whether we use a stepper motor or linear actuator	Write logic for scheduling and refilling	Integration tests	PCB Order
04/14 Week	Fix existing bugs	Integration tests	Integration tests	Team Contract Assessment
04/21 Week	Fix any errors and smooth out the demo process	Fix any errors and smooth out the demo process	Fix any errors and smooth out the demo process	Mock Demo Prep
04/28 Week	Create PowerPoint and Final Papers	Create PowerPoint and Final Papers	Create PowerPoint and Final Papers	Mock Presentation Prep
05/05 Week	Review PowerPoint and Final Papers	Review PowerPoint and Final Papers	Review PowerPoint and Final Papers	Final Papers

Ethics and Safety

As for ethics and safety, our team is going to ensure the product is safe to use and HIPAA compliant. This will require that the device be made with food-safe PLA or PETG filament as we plan to 3d print it. Additionally, the cloud infrastructure we build will need to remain HIPAA compliant by only using GCP/AWS/Azure's HIPAA-focused services. We will continuously document our development process to ensure any 3rd party can verify our statements. Additionally, we are guided by the ethical guidelines as written in the IEEE Code of Ethics and ACM Code of Ethics. Our entire team has also completed the University's Division of Research Safety's safety training. We have also read through the safe battery usage and safe current limits guidelines. We will treat everyone with respect and kindness, showcasing empathy and understanding. Our team will ensure that our project is built to strict networking safety guidelines, to ensure no user data can be stolen, and comply with any relevant licensing terms for all the software we use. Lastly, we will ensure that any training needed in the future is taken immediately and with the utmost focus.

During the proposal, a few concerns came to mind. One, our design may lead to the jamming of pills, which could lead to the incorrect amount being dispensed, but registering as the correct amount. To mitigate this risk we are weighing the pills at the end of the disposal instead of at each chamber so that the user can be alerted if the wrong number of pills falls, and be told which one to add to their current concoction manually. Second, the design being built by the machine shop doesn't have a top, nor does the changed rotating funnel idea we are considering. To mitigate this issue we are going to place "caps" on top of the openings and direct the user to which one they need to lift and refill by hand. This will stop any foreign objects from entering the compartments. Third, being that the pharmacist has a 98.4% success rate, and we are aiming for 98.4% as well, it was made clear to us that the final disposal would only be 96.8% of the time correct, so we have made a prerequisite of using the device to be that we assume the filling is with the correct prescriptions. Fourth, we will be keeping the battery pack in a bottom chamber separated from the pill compartments, to ensure any heating doesn't lead to the pills being harmed. We have also used voltage regulators that drop 12V to 5V and from 5V to 3.3V rather than 12 to 3.3V to decrease the heat dissipated. Fifth, since we are using the ESP32-WROOM's internal RTC which drifts at 1 minute a month, we will recalibrate it every time the user pairs through Bluetooth with the device. This will counteract the drift every few hours. Lastly, to decrease the chance of jamming, we incorporated shakers that constantly shake the chamber of pills to ensure that they don't jam, however, we are going to test to find the right speed/force they should shake at, to avoid breaking any pills.

Citations

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