Automatic Seasoning Dispenser

ECE 445 Design Document - Fall 2019

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1 Introduction

1.1 Problem and Solution Overview

Cooking is a fundamental skill that allows one to prepare a source of nourishment. Cooking a great tasting dish can also have a significant mental effect, providing enjoyment and satisfaction from the right combination of seasonings and spices. However, adding too much of certain seasonings can throw off the flavor profile of a dish, completely ruining a meal and turn a satisfying experience into a disgusting one. This effect is especially pronounced when one over-does the amount of salt or pepper.

As a solution to this problem, we propose an automated seasoning dispenser. Instead of having to tediously and meticulously collect the correct amount of salt and pepper for the recipe you are trying to create, our device will allow you to input the precise amount of each of those seasonings required and will dispense the correct amounts sequentially. The device will allow the user to input how much of either salt or pepper to dispense and will provide visual confirmation through an LCD panel. The device will also make use of replaceable and reusable seasoning bottles to reduce the cost the user would need to incur to keep the device full of seasonings.

Our product will be able to dispense two seasonings (salt and pepper) to demonstrate that we are able to differentiate between the different motors in our product and dispense accurate amounts for each; however, it will be possible to add more dispensing units to future iterations of the device that can hold other seasonings.

1.2 Background

The idea of an automatic spice dispenser is not a completely new one. Efforts have been made by other companies to accomplish similar tasks. However, these products only solve part of the problem that our device is innovating upon, or introduce new problems in place of the solved ones. KitchenArt's Select-A-Spice allows the user to dispense spices in ¼ teaspoon increments; this works well for recipes that use small amounts of many seasonings but proves to be a hindrance if you need multiple tablespoons of a seasoning, for example. Furthermore, the device requires the user to manually dispense each seasoning by turning a dial, which can prove to be annoying for complex recipes. [1] TasteTro has a system that automates the dispensing process, but requires the user to purchase their custom spice bottles once one runs out. [2] These spice cartridges are often expensive to account for the technology within them, such as alerts to indicate a refill is needed.

Our product will improve on both of these designs. The microcontroller in our device allows the user to dispense large amounts of spices with less effort than the Select-A-Spice; the user will not have to turn a dial twelve times to get one tablespoon of pepper. Furthermore, our design will allow the user to replace their own seasonings, reducing the cost to both us and the user and improving upon the TasteTro's solution.

1.3 Visual Aid

The proposed product would be placed in the user's kitchen next to any other appliances they may have. The product would be only require a wall outlet for power, as well as salt and pepper to fill the included cartridges with. The user would fill the device with the seasonings. Then, the user would then specify how much of each seasoning to dispense, after which the user would tap the "Dispense" button. In no time, the seasonings will be dispensed precisely as chosen using the user interface.

Figure 1: Visual Aid for Automated Seasoning Dispenser

1.4 High-level Requirements List

- The device must be able to dispense precise amounts of up to two dry seasonings, with increments as precise as ¼ of a teaspoon with a tolerance of ±10% of the given measurement.
- The device must allow users to refill and replace the seasonings as they choose; the device will also alert the user when a refill is needed in any one of the seasoning cartridges.
- The device must be able to dispense ¼ of a teaspoon of a seasoning in under 1 second. It follows that each seasoning must take no longer than 12 seconds to dispense the maximum amount of 3 teaspoons.

2 Design

2.1 Block Diagram

The product will be composed of four units: the power unit, the sensor unit, the control unit, and the mechanical unit. The power unit is responsible for converting 120V AC power from a wall outlet into a 12V source for powering motor drivers and a 5V source for powering the remaining components as well providing a logic level for the motor drivers.

The control unit is responsible for facilitating interaction between the user and the device, as well as for running the subprogram required for dispensing the seasonings. The 20x4 character LCD display will communicate with the microcontroller over the I2C protocol and the push buttons will simply be analog voltage signals.

The sensor unit provides the control unit with information about the amount of seasoning dispensed as well as how much seasoning is left within each seasoning cartridge. The weight sensor communicates over a digital line, sending bits sequentially to the microcontroller while the seasoning level sensors output an analog voltage for the control unit to interpret.

Finally, the mechanical unit is responsible for driving the stepper motors that allow the augers to dispense seasonings when the process is started. The microcontroller sets the direction of the stepper motors over a digital line using a 5V logic level and controls the step using PWM signals.

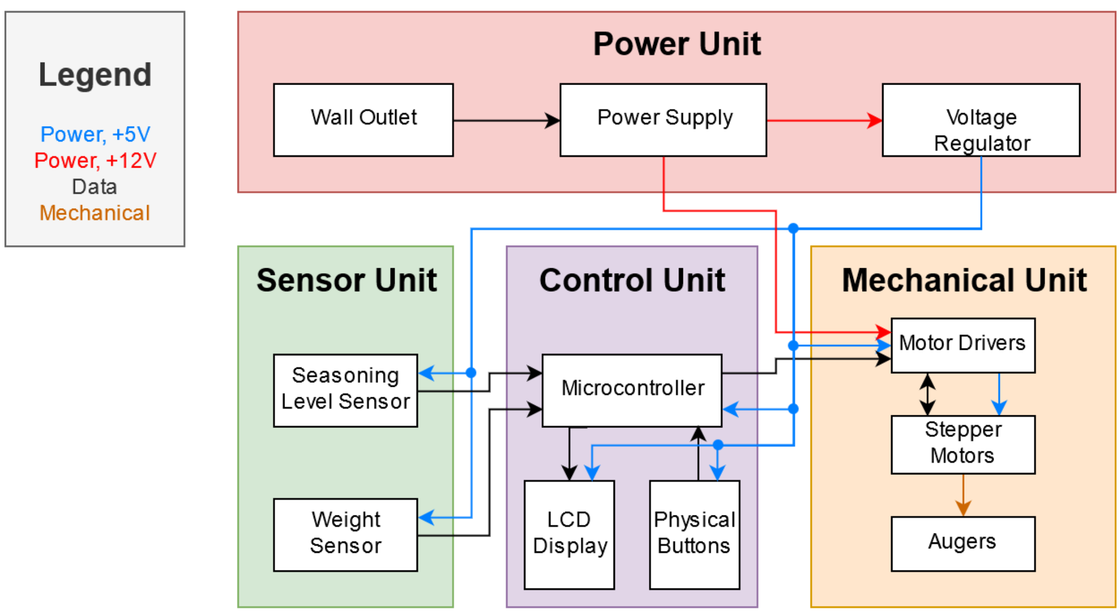

Figure 2: Block Diagram

2.2 Physical Design

Our physical design will consist of an enclosure that will be 12in x 12in x 18in (LxWxH) in size. On the front, there will be a 20x4 character LCD display to allow the user to visualize the commands they are inputting, as well as four physical buttons ("increment", "decrement", "select", and "dispense") so that the user can input commands. There will also be a cut out on the front to allow the user to place a bowl to dispense the seasonings into; the load cell will be placed underneath the bottom plate so that the bowl and its contents can be weighed. Two motors and their respective augers will be placed inside the device, to which the cartridges that hold the seasonings can be screwed into. The device will take power from a wall outlet.

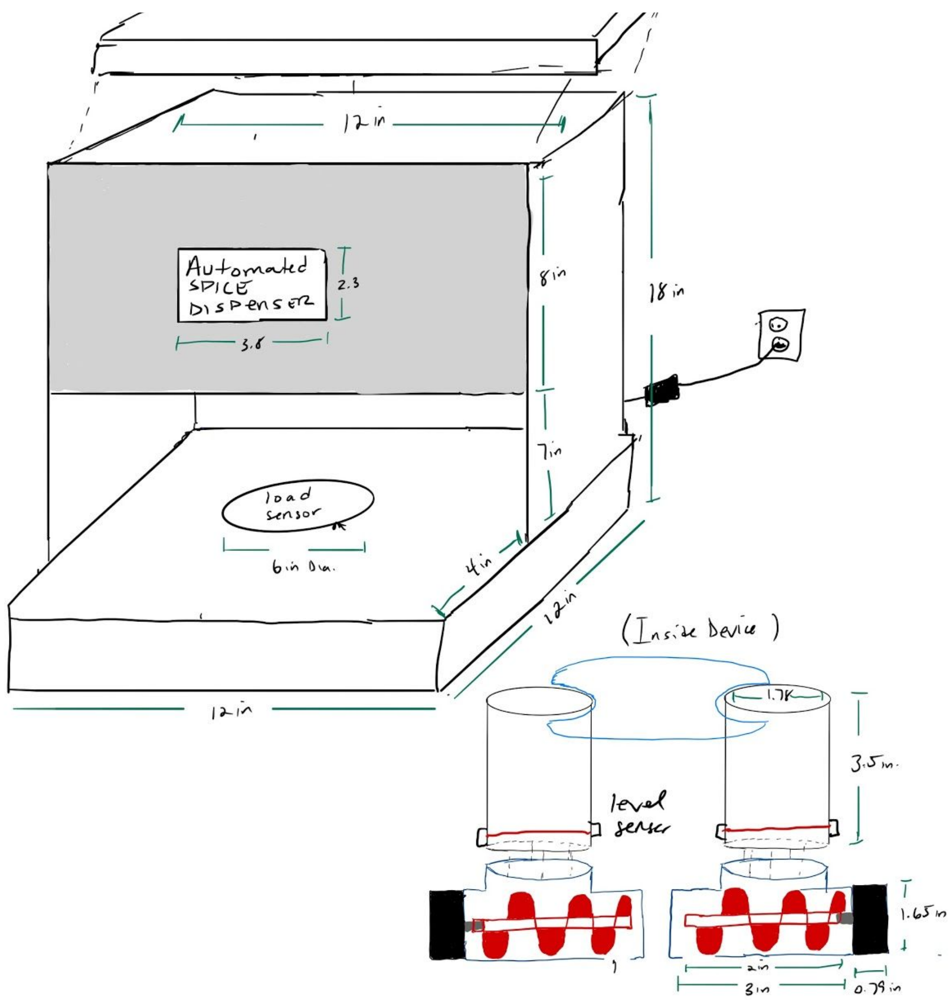

Figure 3: Physical Design Concept

2.3 Block Design

2.3.1 Power Unit

The power unit of our design will provide the circuit and the different components with all its voltage and current needs. The power unit consists of two components: the AC/DC converter and the 5V Buck converter.

2.3.1.1 120V-12V AC/DC Converter

The 120V-12V AC/DC Converter will be used to convert 120VAC power from the wall outlet to the 12V DC Voltage that will be used to power the circuit. The power specifications of the converter was chosen to provide a reasonable amount of flexibility for the circuit and its components. The converter will be able to supply 5 Amps of current at a 12V DC output which should provide all the necessary power requirements for any component within the circuit.

Table 1: Requirements and Verification of AC/DC Converter

Requirements	Verification
Power supply provides 12V ± 0.2V when on and provides 0V when off.	1. Probe the output of the power adapter with a multimeter. a. When the button is pressed and device is off, the multimeter should read 0 V. b. When button is pressed and device in on, the multimeter should read 12 V.

2.3.1.2 DC-DC Buck Converter

The primary function of the Buck Converter is to provide a steady 5V output to the modules that require 5V to operate. The buck converter will accept the 12V from wall adapter and step the voltage down to a steady output of 5V. The. 5V output of the buck converter will be used to provide power to the load sensor module, the stepper motor drivers, and the LCD display.

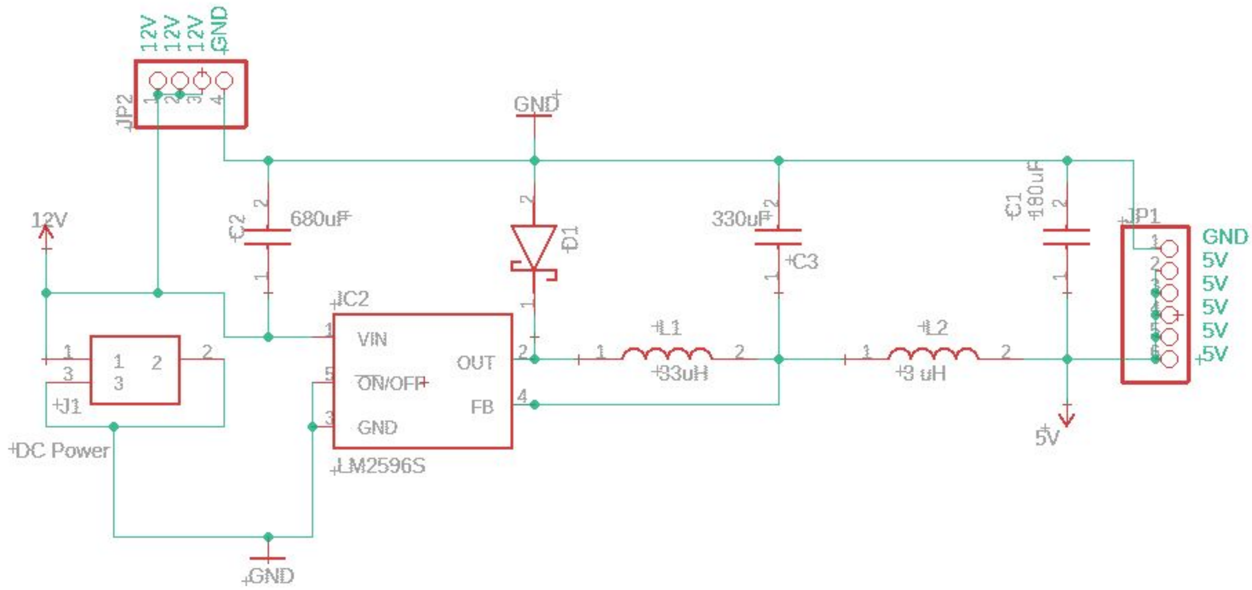

Figure 4: Circuit Diagram for DC-DC Buck Converter

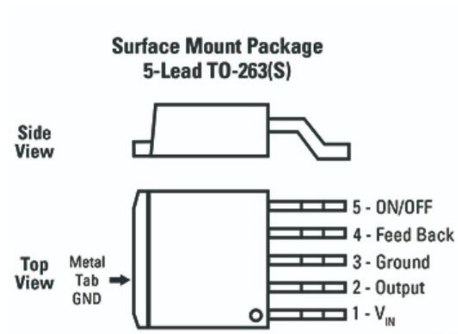

Figure 5: Pinout Diagram of LM2596S

Table 2: Requirements and Verification of Buck Converter

Requirements	Verification
Output of the Buck converter must be between 4.95 V and 5.05 V for any input from 11.5V - 12.5V	1. Connect the voltage output(Vout) of the converter to an oscilloscope and connect the input voltage(Vin) to a DC voltage supply. 2. Apply a DC sweep from the oscilloscope and from 11.5V - 12.5V and confirm that the output stays within 4.95V - 5.05V

Must limit output current to the stepper motor to 1.5A ± 0.2A	1. Connect multimeter leads to the output terminal of the buck converter. 2. Confirm that the current draw is only 1.5A ± 0.2A

2.3.2 Sensor Unit

The sensor unit is used to measure how much seasoning has been dispensed in grams. This is accomplished by a load cell placed underneath the plate where a bowl or cup would be placed to hold the dispensed seasonings. The sensor unit also determines if a seasoning cartridge is low on seasoning; this is done by phototransistors placed next to the clear cartridges; if enough ambient light is detected (after the amount of seasoning in the cartridge has dropped), the photoresistor will signal that it is time to refill the cartridge.

2.3.2.1 Seasoning Level Sensor

The seasoning level sensor consists of a single photoresistor per seasoning cartridge. Because each seasoning cartridge will be transparent, it is simple to detect if a cartridge must be replenished. The photoresistor will be placed near the bottom of the cartridge and if enough seasoning is dispensed, ambient light will be detected from the product's surroundings causing the photoresistor to output a high voltage to denote this.

In software, once this signal is set high, a prompt will be displayed on the LCD display until the user has refilled the seasoning and indicated as such. Through testing, we can also determine what light levels correspond to what levels of empty-ness in the cartridge, and write indicators for the UI to tell the user how full the cartridge is.

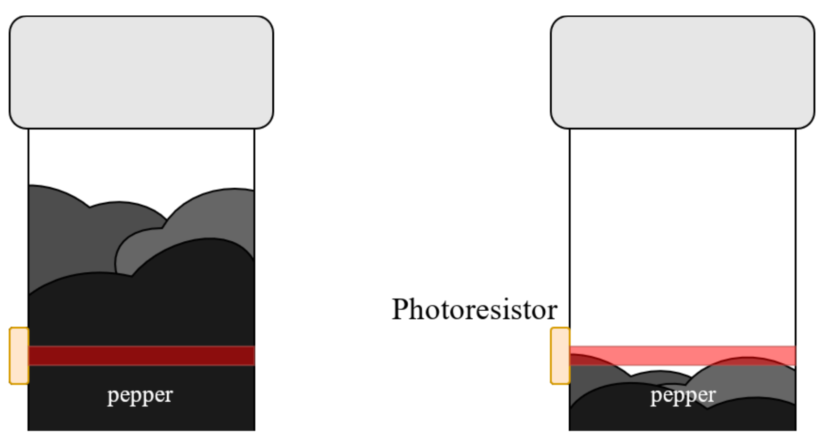

Figure 6: Pictorial representation of the seasoning level sensor. The left image would produce a low voltage signal as the pepper prevents light from reaching the photoresistor attached to the container. The right image would produce a high voltage signal as no pepper occludes the photoresistor.

Table 3: Requirements and Verification of Seasoning Level sensor

Requirements	**Verification**
The photoresistor must output greater than 2.5V when enough ambient light is detected and close to 0V when little to no ambient light is detected.	1. We will expose the photoresistor to many lighting conditions simulating a seasoning cartridge with various amounts of seasoning inside of it. 2. We will use a multimeter to determine the resistance produced by the photoresistor in these conditions.

2.3.2.2 Weight Sensor

The weight sensor consists of a mini load cell, chosen to be the TAL221, as well as an amplifier circuit based on the ADS1231 ADC chip. The load cell will be capable of detecting up to 100g of weight, allowing enough wiggle room to detect the weight of a light bowl as well as multiple tablespoons of each seasoning.

The ADS1231 serves two purposes: to amplify the low voltage output from the load cell, and to convert that analog signal into a digital signal. This is because our microcontroller reads analog values within a range of [0,1023]; this is only 10 bits of data, which only allows for 500mg accuracy. The ADC1231 converts the analog signal into a digital signal with 24 bits of the data, allowing for greater accuracy when reading the load cell data.

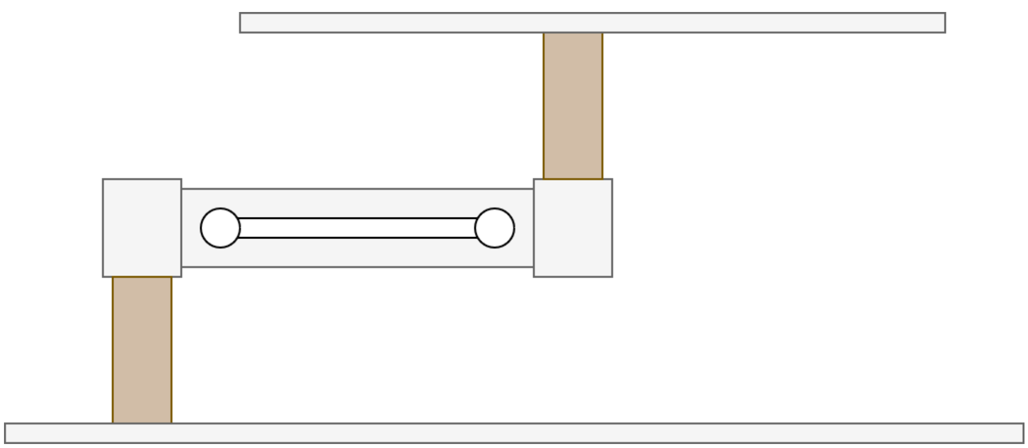

Figure 7: Weight sensor mechanism with no weight added to upper plate. No compression or tension in joints of load cell if assuming weightless plates.

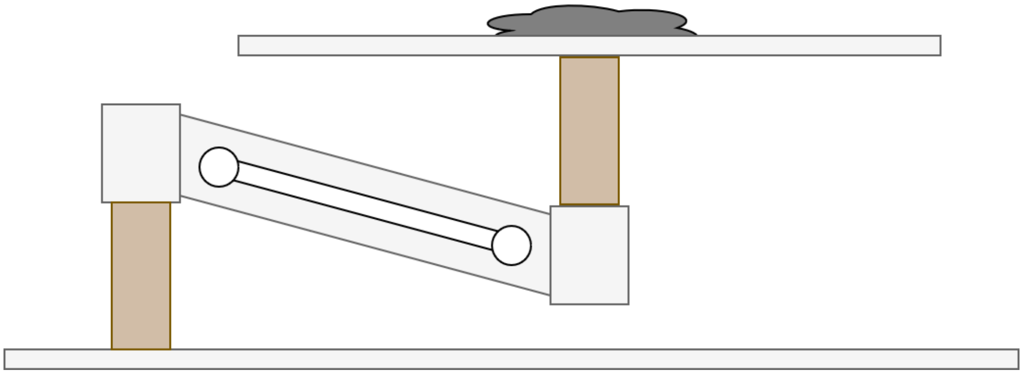

Figure 8: Weight sensor mechanism with arbitrary weight added to upper plate. Compression and tension are measured in both joints, which is used to determine the force applied by the object.

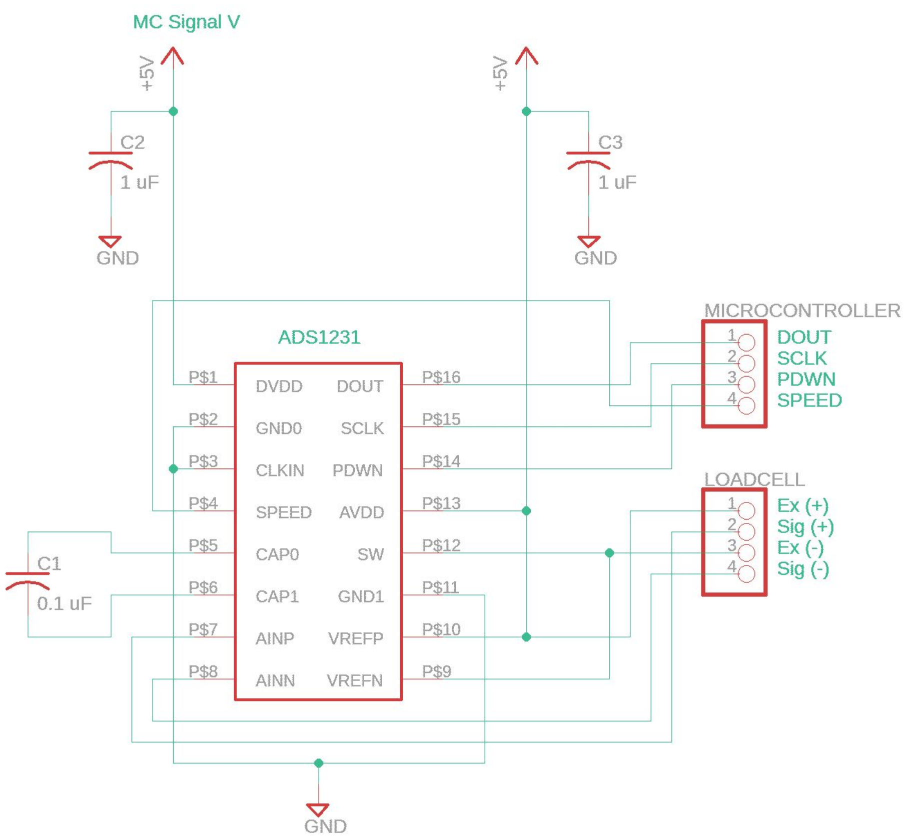

Figure 9: Circuit Diagram for Weight Sensor

Table 4: Requirements and Verification of Weight Sensor

Requirements	Verification
The load cell must be able to measure within +/- 100mg of the actual weight of an object.	1. The load cell will be connected to the amplifier circuit shown above, which will be connected to an Arduino with a program running that outputs the data read on the DOUT pin. 2. Items of varying weights (50mg to 100g) will be placed on the load cell, and the value given on the DOUT pin will be compared to the actual weight of the item for accuracy.

2.3.3 Control Unit

The control module handles all user-device interactions through the use of push buttons It is responsible for processing all data being read from the sensor unit's components. The control unit is also responsible for sending control signals to the mechanical unit to start and stop the dispensing of seasonings.

2.3.3.1 Microcontroller

The microcontroller chosen for this product is the ATmega328p. It handles all user inputs through physical push buttons on the front panel of the device. It also reads the values from the seasoning level sensor. These signals are simply analog voltage signals. The microcontroller reads the weight of objects placed on the load cell as 24-bit values sent bit-by-bit over a digital pin. It communicates with the LCD Display over the I2C protocol, reducing the amount of pins it uses. The microcontroller communicates with the motor drivers with one PWM signal for step control and one regular digital signal for direction control each.

Table 5: Requirements and verification for the microcontroller.

Requirements	Verification
The microcontroller must be able to output PWM wave at a frequency such that 10 full rotations of a stepper motor are completed in under 5 seconds.	1. Begin with standard Arduino PWM functions (at 490Hz frequency) to control the stepper motor. 2. Write custom PWM functions using the Arduino delay functions until frequency is attained where the requirement is met.

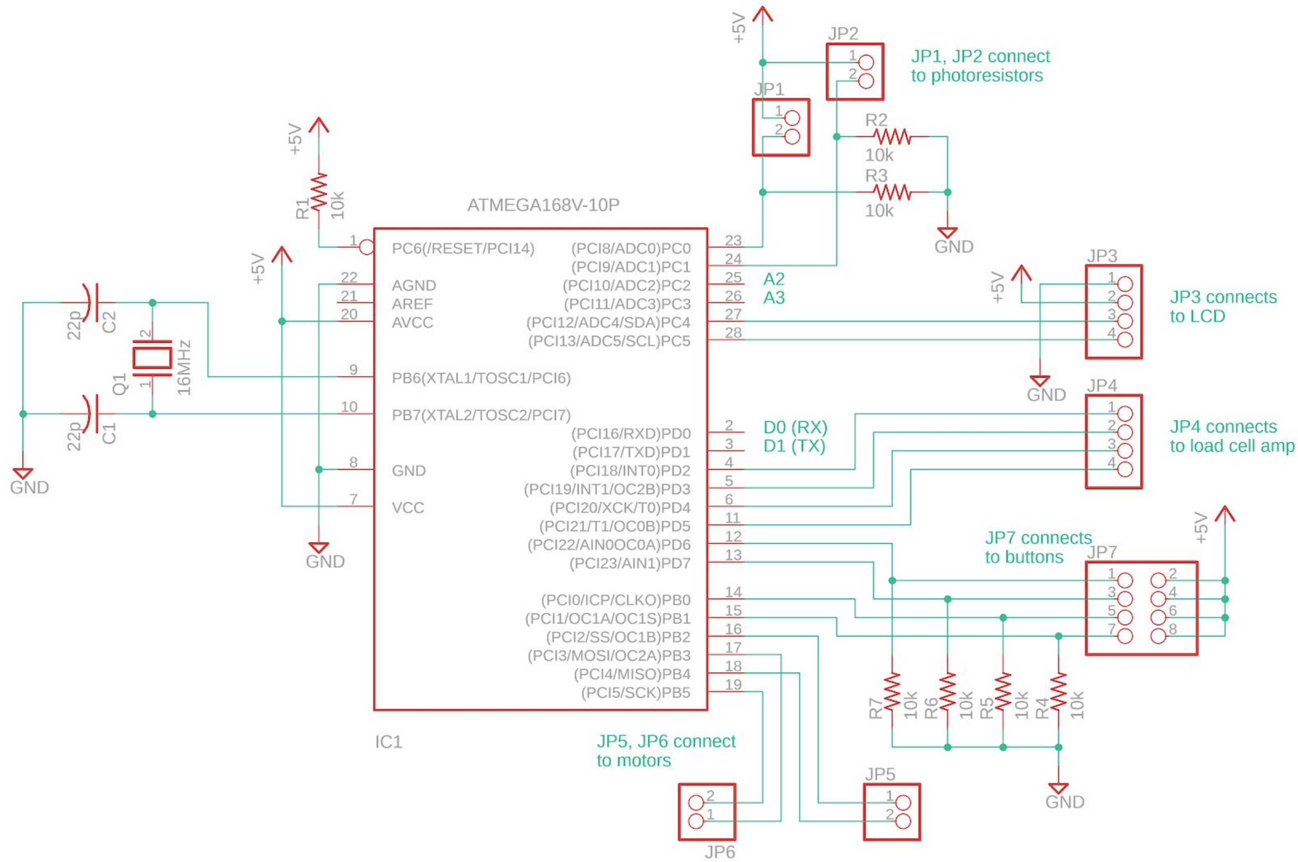

Figure 10: Microcontroller Circuit. Note:ATmega168V used in schematic, but the pin diagram is identical to the microcontroller we are using, the ATmega328p.

2.3.3.2 LCD Display

The LCD display serves as the main point of interaction between the user and the device. It is a simple way of allowing the user to see how much of each seasoning is set to dispense, as well as to edit these amounts. It will be a 20x4 character display, which is adequate for displaying the small amount of information we need. The LCD display does not require any additional circuitry to connect to our microcontroller; its complexity is based on the software written to write to it. Therefore, no requirements are needed for this device.

All figures related to this component were generated with the tools provided at [3].

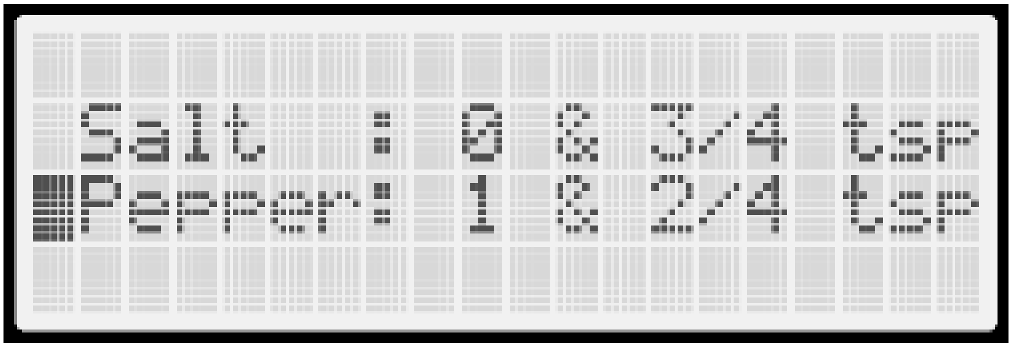

Figure 11: Edit screen. The blinking cursor on the left-hand side denotes which seasoning is currently being edited. Pressing the "select" button will switch between salt and pepper.

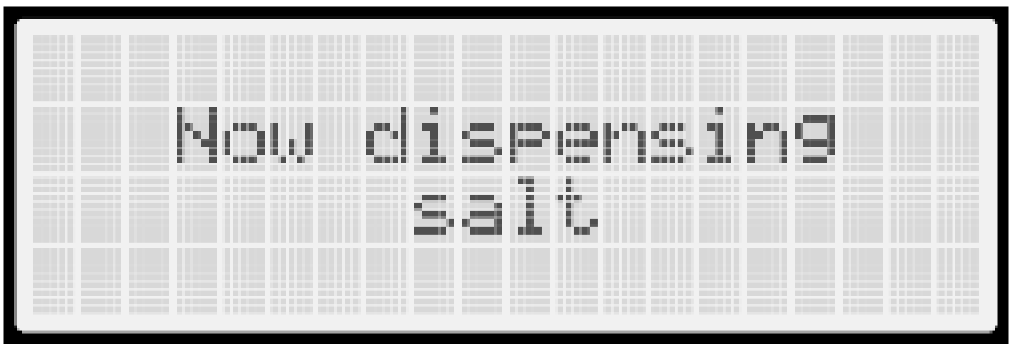

Figure 12: Dispensing screen. The seasoning name will change to whichever seasoning is being dispensed at the time.

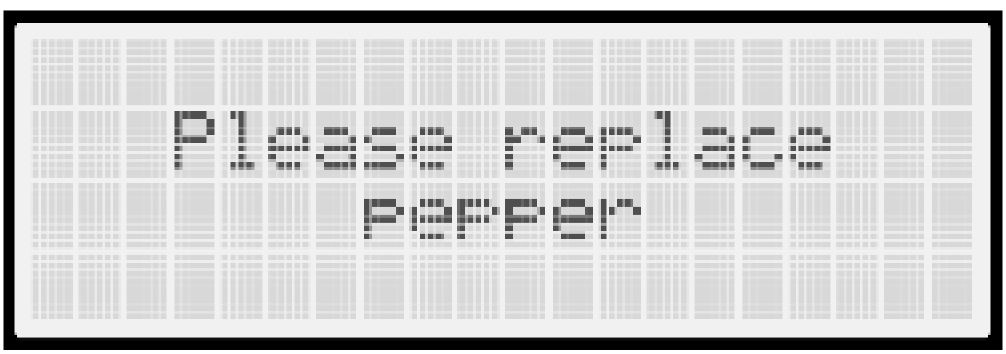

Figure 13: Replace seasoning screen. The seasoning name will change to whichever seasoning must be replaced. If both need to be replaced, will list both on the same line separated by a comma.

2.3.3.3 Physical Buttons

The physical buttons allow the user to increment or decrement the amount of salt or pepper they would like to dispense, as well as choose which seasoning they are editing the amount for (“increment”, “decrement”, and “select” buttons, respectively). There will also be a button for beginning the dispense program (the “dispense” button); this totals to four physical buttons for our product.

2.3.4 Mechanical Unit

The mechanical unit is responsible for driving the stepper motors and for turning the augers, which will allow for seasonings to be dispensed.

2.3.4.1 Stepper Motor Control

The stepper motor control will be designed using the A4988 motor driver chip. Each chip will be able to drive one stepper motor, therefore our stepper control unit will consist of two separate A4983 modules. The use of the A4988 is important because it has a wide input voltage range and it can deliver up to 2 amps of continuous current to the stepper motor windings. Since the stepper motors have a rated current of 1.5 amps, the A4988 motor driver is a good choice to drive the motors. The A4988 motor driver also provides the capability of controlling the stepper motors with just two input pins each of the Arduino Uno. This reduced the required amount of pins by half compared to other motor drivers. The driver we designed takes 5V as a reference for the digital logic signals STEP and DIR. The rising edge of a pulse signal to the STEP pin, will create output signals coming from the OUT1A, OUT1B, OUT2A, and OUT2B pins that represents a full step. The DIR pin determines the direction of the step. The Arduino will send voltage pulses to the motor driver and the speed of the motors will be controlled based on the timing between pulses. The overall schematic with connections to the microcontroller and power unit can be seen in Figure 14.

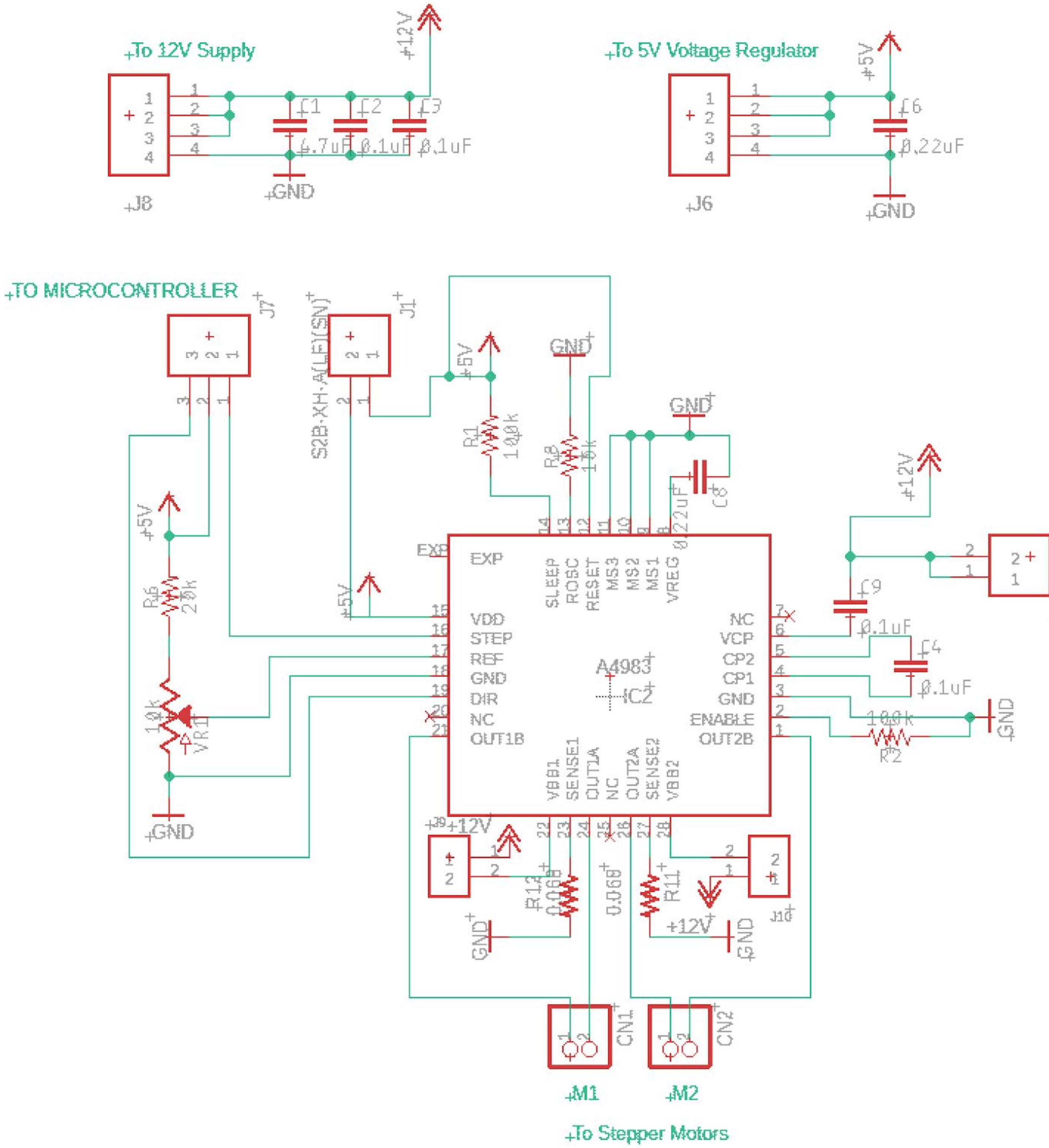

Figure 14: Circuit Diagram for A4988 Motor Driver

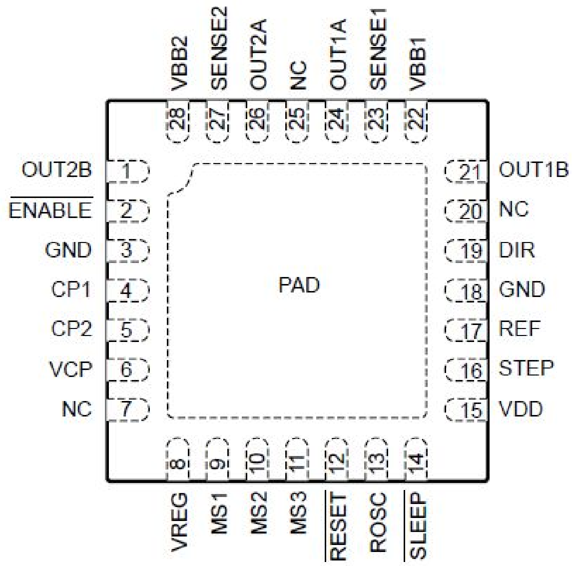

Figure 15 : Pinout for A4988 Motor Driver

Table 6: Requirements and Verification for Stepper Motor Control

Requirements	Verification
Must be able to separately control 2 stepper motors.	1. Connect 12VDC and 5VDC inputs to the stepper motor control using a function generator and connect the output to the two motors. 2. Give the equivalent of a single rotation using the square wave function of the generator to simulate a microcontroller. 3. Ensure motor completes a single rotation. 4. Repeat steps 2-4 for second motor.
Must be able to step motors at a rate equivalent to ≥30rpm for 12 seconds	1. Connect 12VDC and 5VDC inputs to the stepper motor control using a function generator and connect the output to the two motors. 2. Mark a point on each of the motor shafts. 3. Record the motors. 4. Give the motor control a 5V square wave with a frequency of 100 Hz for 30 seconds. 5. Repeat steps 2-4 for the remaining motor. 6. Watch the recorded camera footage and ensure all motors completed 15 rotations.

One of the key components of the stepper motor driver is the Vref pin. This pin sets the reference voltage that is responsible for limiting the current to the motor. The reference voltage is set based on the following equation:

$$V_{REF} = \text{Rated motor current x 8 x Rsense} \qquad (1)$$

Since are stepper motors are rated at 1.5A, we can calculate the reference voltage as:

$$V_{REF} = 1.5 \text{ A x } 8 \text{ x } 0.1\Omega$$
$$V_{REF} = 1.2 \text{ V}$$

In full-step mode, both coils of the stepper motor will be active at the same time, therefore the current draw will be approximately 0.70 x 1.5A, which is 1A. This means that the stepper motor will be operating the stepper motors at a current significantly smaller than the motor's rated current, which should help the motor from being overworked and hot.

2.3.4.2 Stepper Motor

In our design we will be using two NEMA 17 stepper motors to dispense the spices. The motors well be holding the auger as well as a mounting hub for the auger in place. Therefore it is crucial that the stepper motor has an adequate holding torque for our design. The actual dynamic torque of the stepper motor when it is in motion has to be large enough to comfortably handle the weight of the auger, mounting hub, and spices. To handle this requirement, we chose to go with the STEPPERONLINE Nema 17 Stepper motors which will have a sufficient holding torque of 64 oz at a maximum current of 1.5A.

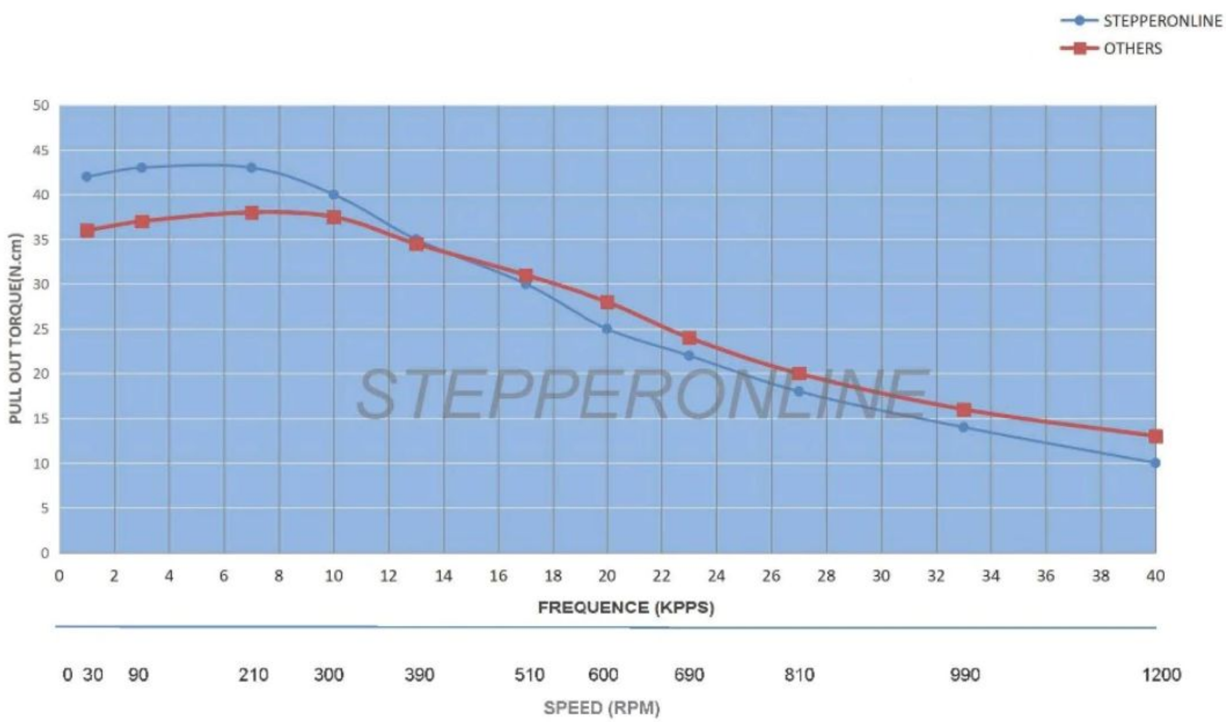

Figure 7:STEPPERONLINE Torque vs RPS compared to other Motors.

$$PPS = N \frac{Rotations}{Minute} * 200 \frac{Steps}{Rotation} * \frac{1}{60} \frac{Minute}{Second} \qquad (2)$$

The number of PPS, or Pulses Per Second, represents the number of voltage cycles of high and low signals that need to be sent to stepper motors to achieve the desired number of rotations.

Table 8: Requirements and verifications for the stepper motor.

Requirements	***Verification***
Draws ≤ 1.5A during when static	*1.* Connect 12VDC and 5VDC inputs to the stepper motor control using a function generator and connect the output to the two motors. *2.* Measure the current in the motor using a multimeter and ensure it falls in range of the requirement.

Must have a torque greater than 15N.cm at a speed of 30rpm.	1. Calculate the number of pulses per second(PPS) that is needed to achieve 30rpm using Equation 2. 2. Compare result with the provided Torque vs PPS chart and confirm torque is greater than 15N.cm.

2.3.4.3 Auger Design

For the auger design, we chose to make a custom 3d printed auger to fit our design needs. It will be printed using PET plastic which will ensure that it is foodsafe. The auger will screw directly onto a mounting hub attached to the stepper motor. The auger must be designed to be durable so that it won't break when the motors are spinning

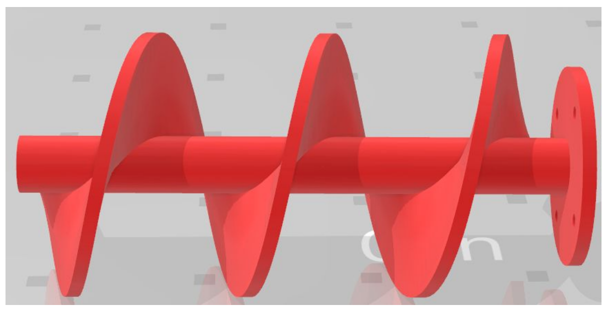

Figure 14: Dispensing Auger Design

2.4 Software

The software must allow the user to customize what spices are inside of the product's cartridges, as well as start the dispensing process. This can be split into two subprocesses: Control Mode and Dispense Mode.

2.4.1 Control Mode

Control Mode allows the user to change how much of each seasoning they want to dispense. They can use the "select" button to choose if they are editing the amount of salt or pepper to dispense, and can use the "increment" and "decrement" buttons to change the amount. These changes will be indicated on the LCD display. Furthermore, a blinking cursor will be placed next to the name of the spice being edited so the user knows which one is selected. Once the user is satisfied with their selections, they can hit the "dispense" button to enter Dispense Mode and dispense their salt and pepper.

2.4.2 Dispense Mode

Dispense Mode is responsible for dispensing each seasoning sequentially. The program powers the motor driver to begin rotating the corresponding auger until the load cell indicates that the precise amount of seasoning has been dispensed. Then, the program powers the next motor. Afterwards, the program reads from the photoresistors to determine if any of the seasonings have been lowered below their minimum levels. This prompt will stay on the screen until the user has refilled the cartridge and indicated this by pressing the “select” button. Finally, the program returns to Control Mode.

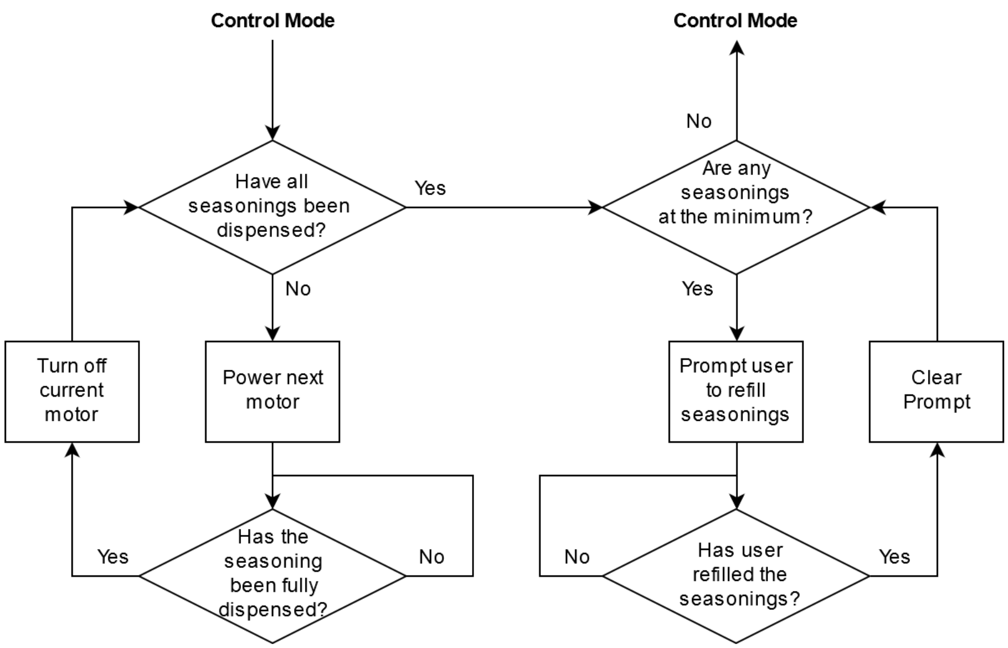

Figure 15: Dispense Mode subprogram flowchart.

2.5 Tolerance Analysis

When dealing with recipe spice measurements, the miscalculation of a measurement can ruin a food dish. Therefore, accurate measurements of the spices is the most crucial aspect to the success of our project. There has to be systems in place in our design that will ensure that the device is accurately dispensing the amount of spice that the user requests. One of the high-level requirements we want to achieve for our project is for the percent error of the dispenser to fall within ±10% of a given measurement. The three factors of our design that will influence this tolerance are the precision of the stepper motors, the precision of the weight sensor, and the dimensions of our dispenser. In this tolerance analysis, the precision of the weight sensor will be examined. It is important to examine the load cell’s sensitivity and calculate the minimum amount of weight that will cause a change in the load cell’s output.

The accuracy of the load cell is given as a percentage of the maximum rated output. This percentage is 0.05% with a maximum rated output of 0.6mV/V. Since we will be supplying the load cell with 5V from the voltage regulator, the maximum rated output of the load cell is calculated as:

$$\textit{Max. rated output of load cell} = 0.6\text{mV/V} * 5\text{V} = 3\text{ mV}. \qquad (3)$$

This equation means that at a full load of 100g, the max output of the load cell will not exceed 3mV. Since the rated output scales linearly, we can assume that the maximum load of 100g corresponds to 5V and a load of 0g corresponds to 0V. Since the ADS1231 has a gain of 128, the maximum rated output after amplification is:

$$\textit{Max. rated output after amplification} = 3\text{mV x } 128 = 384\text{ mV} \qquad (4)$$

The ADS1231 has 17.4 noise-free bits, so we take the first 17 bits of the 24-bit output. We can then find the resolution of the digital output voltage as:

$$\textit{Resolution of digital output voltage} = \frac{5V}{2^{17} bits} = 38.1\text{uV} \qquad (5)$$

To calculate this as a percentage of the rated output, we can write:

$$\textit{Percentage of rated output} = \frac{38.1uV}{384mV} \text{ x } 100\% = 0.01\% \qquad (6)$$

Therefore, the resolution, or load sensitivity of the load cell is:

$$\textit{Resolution of Load Cell} = 0.01\% \text{ x } 100\text{g} = 0.01\text{g or } 10\text{mg}$$

With a resolution of 10mg, this would satisfy our high-level accuracy of 10%. The resolution is low enough that we could also use the 3.3V pin on the Arduino to power the amplifier board and it would lower the resolution to 15mg. This is insightful as we now know that we can safely lower the voltage to the amplifier and still have an ideal level of sensitivity from the load cell. This could potentially help with any concerns regarding heat dissipation when using the 5V input.

3 Cost and Schedule

3.1 Cost Analysis

3.1.1 Labor

Average hourly rate: $40

Number of hours to complete: 120

Machine Shop hours: 3

Cost per partner: $4920

Total labor cost = $9840

3.1.2 Parts

Table 9: Part costs for Design Project

Name	**$/unit**	**Quantity**	**Total Cost**
12V 5A AC/DC Power Supply	$28.18	1	$28.18
ATmega328p	$2.14	1	$2.14
Nema 17 Stepper Motor	$10.99	2	$21.98
Allegro A4988 Motor Driver	$3.11	2	$6.22
Load Cell	$10.00	2	$20.00
Load Cell Amplifier	$6.28	1	6.28
Buck Converter 5V	$5.72	1	$5.72
LCD Display	$12.99	1	$12.99
Fixed Inductor 33uH	$2.26	2	$4.52
Universal Mounting Hub	$7.49	2	$14.98
		Total	**$123.01**

3.1.3 Grand Total

Grand Total = $9963.01

3.2 Schedule

Table 10: Detailed Schedule of Project checkpoints

Date	**Pawel**	**Elliott**
9/30	Have ADS1231 amplifier schematic done.	Have Buck converter and motor driver schematics complete.
10/7	Improve Design Document to reflect changes for new plan.	Improve Design Document to reflect changes for new plan.

		Try to get PCBs complete for early bird order.
10/14	Verify all sensor and control unit components, as well as in designed circuits. Have control unit and sensor unit PCBs complete for early bird order.	Verify all power and mechanical unit components, as well as in designed circuits. Have auger and motor chassis 3D printed.
10/21	Write dispense mode software so that auger and load cell system can be tested.	Have power unit PCB complete for first round order. Finalize physical design requirements with ECE shop. Order spice bottle in accordance with measurements from ECE shop.
10/28	Write user interaction code such that buttons control amounts and user can respond to refill prompt.	Solder components to ordered PCBs for all units (control, power, and sensor).
11/4	Optimize software for control and dispense modes.	Verify all modules work with microcontroller software.
11/11	Tie up loose ends. Get ready for mock demo.	Tie up loose ends. Get ready for mock demo.
11/18	Tweak software based on mock demo performance and feedback. Get ready for final demo.	Begin work on final project paper and related work. Get ready for final demo.
11/25	Fall Break	Fall Break
12/2	Work on final project report. Get ready for final presentation.	Work on final project report. Get ready for final presentation.
12/9	Work on final project report. Turn everything in.	Work on final project report. Turn everything in.

4. Discussion of Ethics and Safety

4.1 Ethics

We intend to produce an accurate system for dispensing dry seasonings. Although we would like to hit super accurate intervals for dispensing, we will not lie or embellish the limits of our product. We promise to follow IEEE Code of Ethics #3 to be as transparent with the device's users in regards to how precise our device can be in regards to the amounts it will dispense [4]. Our device will come into contact with the substances it dispenses; it is important that we do not harm the quality of the seasonings that pass through it and that our product does not cause harm to the user. We promise not to create a device that contaminates the user's seasonings with materials, whether they are deemed poisonous or not, therefore abiding by IEEE Code of Ethics #1 [4].

4.2 Safety

This project lends itself to a couple of safety concerns. First and foremost, we will be stepping down 120V AC power from a wall outlet to the required operating voltage of our device. Because of this, we will follow the lab safety guidelines to a tee to assure that we, and anyone else in the lab, are safe from potential electrical hazards. Second, placing this product in a kitchen environment means that there is always the possibility of liquid spills nearby. The device must be able to withstand minimal amounts of liquids being spilled on or around it so that it is considered safe in the kitchen.

We must strive to dispense accurate measurements of seasonings; without this constraint, our product does not deliver what it promises. If not for the reason of flavor, we need to dispense accurate amounts of each seasoning because it is possible to experience ill effects from consuming too much of such substances. For example, a large enough salt intake, which is often thought to be quite harmless, can cause coma or even death [5].

Since are device consists of plastic bottles that will be holding the spices, we must ensure that we are using the proper plastic materials for food consumption. For our purposes, we will be using PET plastic, which is listed as number one in the recycling triangle diagram. It is FDA approved for food safety which will further ensure the device is in compliance in regards to ethics and safety [6], [7]. Also, any other materials that come in contact with the spices will have to be produced of materials that do not promote bacteria growth. Furthermore, our device must be made of materials strong enough to resist chipping so as to not contaminate the spices being passed through, such that the user does not consume toxic substances with their dry seasonings.

4.3 Mitigating Risks

Our project requires us to work with dangerously high voltages within the power unit. We have completed the lab safety training required so that we know how to avoid harming ourselves from electrical burns or shocks.

Because our prototype will not be placed in a kitchen for demonstration, we do not believe our enclosure will need to provide any kind of water protection. This will also reduce the amount of effort the ECE Machine Shop will have to put into creating our enclosure. However, any commercially released version of this project will need to mitigate the degree that water can harm the device. To protect user from malfunction of the circuitry within the product, we will adhere to the IP65 standard. This standard protects the device from any low pressure water sprayed at the device from any direction [8]. This will protect the device from any accidental spills that may occur near the device, but not from being submerged underwater or subjected to having a faucet pointed at it; these are not the use cases intended for this device.

We will mitigate the chance of over-dispensing seasonings by using two systems to determine the amount we have dispensed. We will calculate the approximate amount of spins required for the augers to push ¼ of a teaspoon of a dry seasoning, which will be used as a baseline. The load cell will act as a second check, allowing us to assert that we have not over-dispensed each seasoning by giving an accurate measurement of the change in weight from from dispensing each seasoning.

We will use containers made from PET to house the seasonings within the device. As seen in [7], PET is a, "very strong and inert material that does not react with foods, is resistant to attack by microorganisms, and will not biologically degrade." Furthermore, PET is strong and resistant to impacts and shattering [9]; it is a strong enough material so as to not chip when in contact with seasonings or our augers.

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