Refill Dispensary

Team 18, Jason Paximadas (TA)

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ECE 445

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Introduction:

Problem Statement:

Plastic waste is a massive issue world-wide, particularly as it pertains to the packaging of food and other household goods.The United States Environmental Protection Agency estimates that in 2018, 14 million tons of plastic was consumed for packaging in the USA with about seventy percent of that ending up in landfills[1]. Plastic waste is detrimental to the environment as it doesn't decompose naturally on human time scales. End-user plastic waste is unnecessary because consumers own containers capable of being reused. Furthermore, consumers are often required to purchase a greater quantity of an item than they need.

Solution:

We propose a unique vending machine which will dispense precise quantities of goods into reusable containers. The machine can be small or large and still provide variety to customers. Competitor's designs have each type product in the machine having its own dispenser spot. This isn't a space-efficient design. Our machine allows multiple products to share a dispensing hole which helps us to keep the width of the machine to a minimum and build it vertically.

Another competitive feature we have is the ability to dispense unrelated products. For example, our competitors are building machines dedicated to dispensing one type of good in multiple brands like laundry detergent. Meanwhile, we are innovating on this concept by designing something that is able to be tailored to different areas and exist in a variety of places. One neighborhood might buy lots of quinoa and rice, but another one may demand pasta and cereal. Different types of goods should all be able to be stored in the same machine and fit the demand of an area. We expect that our machine will be able to be placed in corner stores, gas stations, and more while our competitors are limited to supermarkets due to their lack of variety and large size.

Visual Aid:

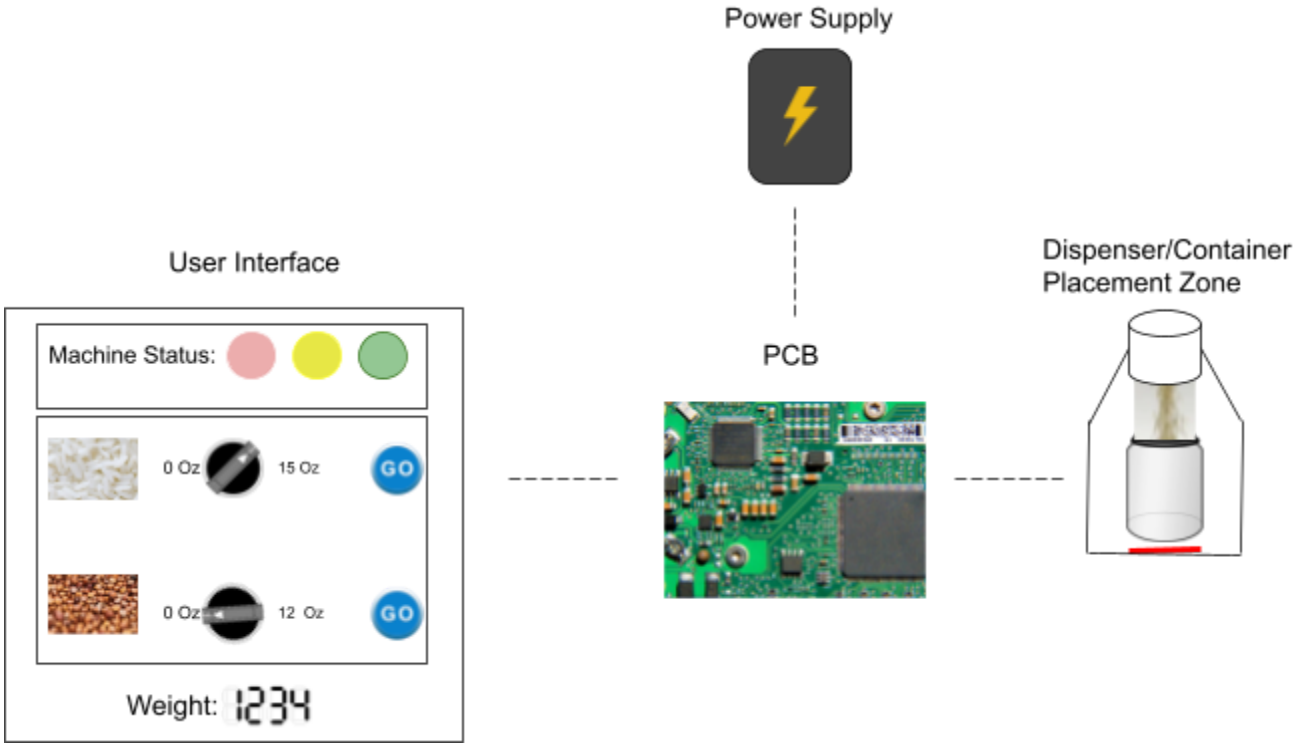

Figure 1: Mockup of Dispensing Machine

High level requirements:

1. The user is able to choose an item and quantity to get dispensed via buttons and rotary encoders. Before placing the order, the user will have some indication of the amount ordered within a +/- 10% tolerance.
2. The machine dispenses the proper item and is able to perform multiple orders in succession.
3. The machine will continue to properly deliver on orders when the items in stock get switched out.

Design:

Block Diagram:

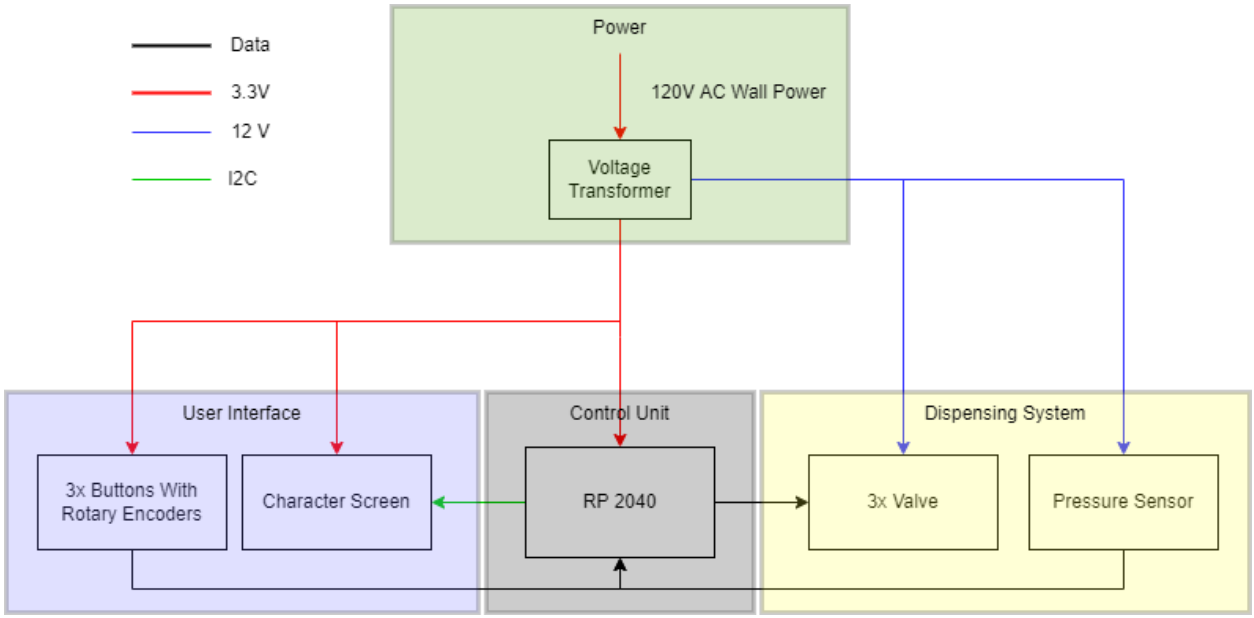

Figure 2: Block Diagram of Dispensing Machine

Subsystem Overview and Requirements:

Power:

We plan on using a 12V power supply that will be used to power the highest voltage components of our design, and then stepped down to 3.3V to power the rest of the devices. This power supply should be capable of delivering 1A continuously as 12 +/- 0.3 V.

Dispensing Subsystem:

Control valves are able to shut off quickly enough to guarantee that the 10% tolerance value for dispensed goods is achieved; factoring in the starting weight of the container, and any material left in the line. The valves will be solenoid valves that are rated for 12 V with ideally low current draw, around 0.5 amps. These will receive data signals from the microcontroller on when to open and close the valve. The microcontroller will be connected to a gate (MOSFET) that will allow it to interface with the higher voltage

components while outputting a lower voltage data signal around 3.3V. The solenoid will take inductive kickback into account to make sure that the valves are properly closed. Furthermore, our load cell will be connected to a Wheatstone bridge to ensure its correct operation. The load cell should be able to weigh items with a tolerance of 10g for weights up to 5 Kg.

User Interface Subsystem:

Overview:

The user interface will consist of an array of debounced rotary encoders that will feed in quantity data to the microcontroller. They will enable the user to choose the exact weight of product they want dispensed into their container. The user interface will also have a screen that will display the current weight selected, as well as the current weight in the container as measured by the load cell. Lastly, the interface will have a set of buttons that correspond to the items being dispensed as well as a row of status LEDs to show what process the vending machine is currently doing.

Requirements:

1. The screen should use an I2C connection and be capable of displaying the item to be dispensed as well as its quantity with appropriate units.
2. Status LEDs should be bright enough to inform the average user from 1 meter away.

Control Subsystem:

An RP2040 will be used as the main control unit in the dispensing machine. We chose this for a number of reasons. Firstly, the processor is cheap (around $1) and readily available, reducing the cost of making the vending machine. Secondly, we require one I2C connection as well as a max of 20 general pinouts which the RP2040 is capable of handling. Lastly, we need a processor fast enough to be able to handle data signals from the rotary encoders which alternate signals very fast, which would enable us to properly track the weight the user selected.

Tolerance Analysis:

The accuracy of the load cell in the Container Placement Zone will determine how well we deliver on the requested weight of the order from the user. We will also need to take into account how long it takes the dispensing subsystem to shut off and the weight added during that process. The equation for this is simply written as follows:

$$M_{Total} = M_{Container} + M_{Dispensed} + M_{In\ Line}$$

Equation 1: Total Mass of container

If we know the total mass as well as the mass in the container before anything is dispensed, and the mass that has been dispensed, we know how much is left to be dispensed and therefore in the line. We want to close the valve before we have reached the target weight on the scale as the material in the line will still flow into the container.

Flow rate(Kg/s) * Time(s) = Dispensed Mass(Kg)

Equation 2: Flow rate equation

If we can calibrate for each material's flow rate, we can know the time left for the material to flow out of the container. However, the flow rate may not be consistent for any given material, especially for viscous liquids and bigger solids. We will strive to precisely measure the flow rate of each material.

Ethics and Safety:

Ethics:

Ethics are of paramount importance to our project. Our design aims to reduce plastic waste in the environment, thereby complying with the sustainability clause of the IEEE code of ethics [2]. However, we recognize that shortcomings on our part may violate other provisions of the code. To that end, we promise to ensure that we will credit any work we may wish to build from.

Safety:

Our machine has a status bar which indicates to the user whether it may be used or not. There will also be directions posted on the machine for how to use it. On the exterior of the machine, warnings will be posted that include keeping the dispensing area clear, not hitting the *go* button until the container is placed and ensuring no body parts or clothing are in the Container Placement Spot etc. On the backend, we will have a series of checks that ensure there are no leaks or spillage that could damage the food inside. Additionally, in our design, we will make sure that food and wires or electricity do not mix. Finally, we will have some emergency shut-off button on the inside, in case a machine stocker runs into any issues.

Works Cited:

[1]“Containers and Packaging: Product-Specific Data,” *EPA*. [Online]. Available: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/containers-and-packaging-product-specific#PlasticC&P. [Accessed: 14-Sep-2022]

[2]“IEEE code of Ethics,” *IEEE*. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 14-Sep-2022].