3 Subsystem Results

$$\delta = \left| \frac{v_A - v_E}{v_E} \right| \cdot 100\%$$

Equation 1: Formula for calculating percent error

3.1 Power

Requirement: Power supply capable of generating 500mA on 3.3V line at +/- 0.2V
Verification: While the machine is running, we will measure the voltage at the voltage transformer, as well as measuring the current drawn under load.
Results: The power supply worked as intended. We were able to measure a very consistent 3.289V on the 3.3V line. However, we were unable to test the current capacity on this line as it would have been difficult to break out a series connection from the voltage regulator.

Requirement: Power supply capable of generating 1A on 12V line at +/- 0.5V
Verification: While the machine is running, we will measure the voltage at the voltage transformer, as well as measuring the current drawn under load.
Results: We were able to measure an appropriate voltage on the 12V line. However, again it would not have been feasible to measure the current as creating a series connection was difficult.

Line	Recorded Voltage
12V	12.0995 V
12V to 3.3V	3.28983 V
5V to 3.3V	3.28974 V

Table 1: Voltage values for Power

3.2 Dispensing System

Figure 7: Solenoid Valves

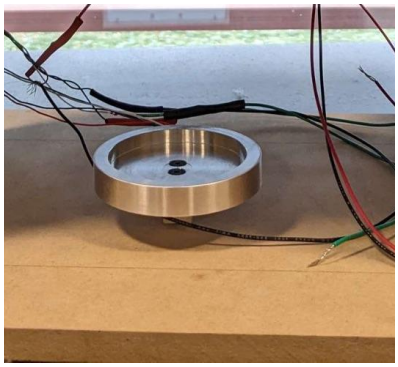


Figure 8: Load Cell + Cup Holder

Requirement: The load cell should be able to weigh items with a tolerance of 10 g for weights up to 5 kg.
Verification: We weighed several objects on our load cell and compared the values to a scale.

Trial #	Experimental Weight	Actual Weight	Percent Error
1	15.63 g	15.2 g	2.83 %
2	200.75 g	202.0 g	0.619 %

Table 2: Load Cell Accuracy Trials

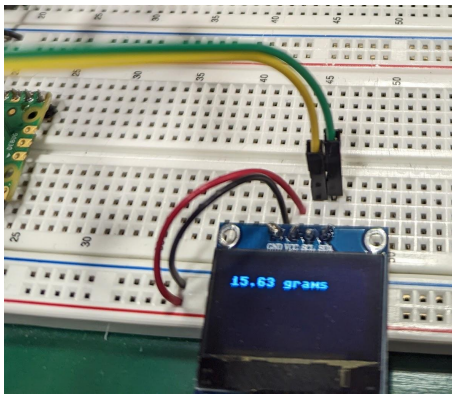


Figure 9: Trial 1 Experimental Results

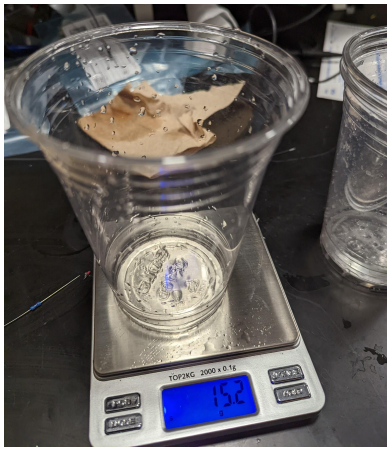


Figure 10: Trial 1 Actual Results

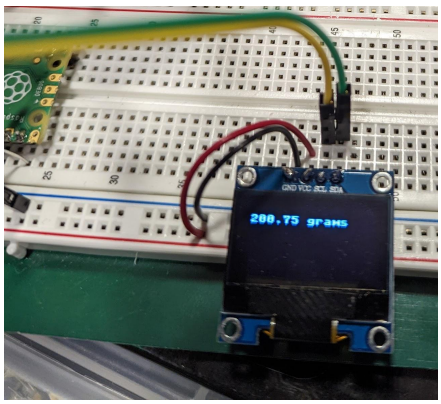


Figure 11: Trial 2 Experimental Results

Figure 12: Trial 2 Actual Results

Results: The load cell ended up being more precise than expected. The percent error ended up being very low.

Requirement: The value spun on the potentiometer is the amount that gets dispensed.
Verification: We selected several small values on the potentiometer and then waited for the amount to get dispensed and weighed the results. The small weights are due to the slow flow rate of the machine.

Trial #	Amount Requested	Actual Weight	Percent Error
1	12 g	13 g	8.33 %
2	13 g	15 g	15.4 %

Table 3: Dispensing System Accuracy Trials

Results: The user ends up getting slightly more than what they requested. However, this is acceptable as it is advantageous to the customer.

Requirement: Voltage across inductor should always be less than the specified maximum voltage (12V) of the BJT
Verification: Measure the voltage across the inductor before and after closing the BJT switch.

Component	Recorded Voltage (V)
Solenoid 1 Diode	11.158
Solenoid 2 Diode	11.176

Solenoid 1 Screw Terminal	11.318
Solenoid 2 Screw Terminal	11.202

Table 4: Voltage across the inductors

Results: The drop across the inductor is 0V when it is turned off. When it is on the drop is under 12V.

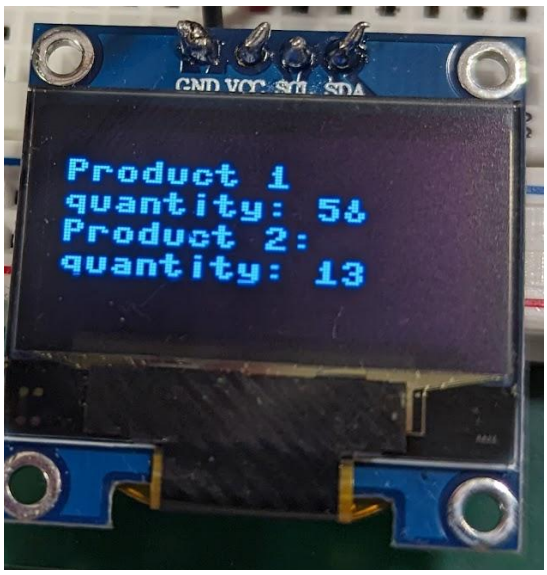
3.3 Control System

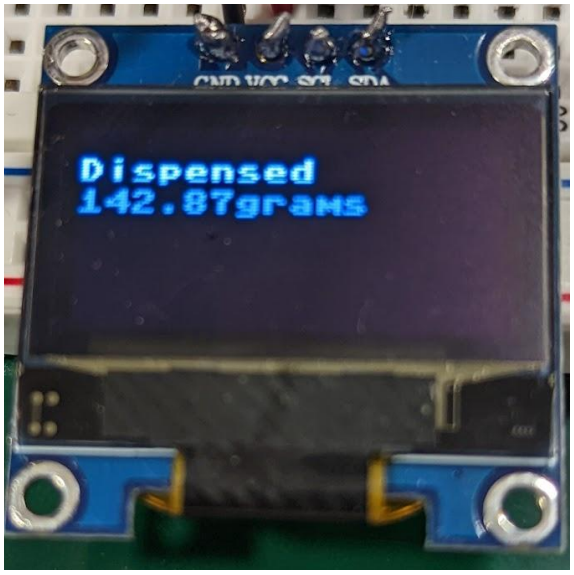
Requirement: The microcontroller's ADC should be precise enough to measure 250 unique values from the load cell.
Verification: To test this, we printed readings from the load cell with HX711 setup into the shell. We used our hands to apply variable force and watched the values go up.
Results: The Pico was able to read 65,536 different values, which goes far above this requirement.

Requirement: Microcontroller sends proper signals to other subsystems.
Verification: The correct text displays on the screen, the right item is chosen, machine status gets updated on the UI, and the proper item gets dispensed.
Results: As seen in the demo, we were able to dispense from both bottles by hitting the respective buttons and get results dispensed in the cup within the allowed tolerance. Additionally, the user saw the status LEDs change with the machine and screen text update throughout various parts of the process. Seeing the screen update can be seen in figures 9, 11, 13, and 14.

3.4 User Interface System

Requirement: 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.
Verification: Check that the correct text is displayed on the screen in 1 second after a button is pressed or a potentiometer is moved
Results: The screen displays different text for each state, as well as the amount selected and the amount dispensed, as seen in Figures 13 and 14. The screen is updated in real time as the amount selected and amount dispensed changes, with essentially no delay.





Figures 13 (left image) & 14 (right image): The left image shows the screen reflecting the potentiometer values during the selection state. The image on the right shows the actual quantity that got dispensed from an order.

Requirement: Status LEDS should match machine state within 1s of machine state changes.
Verification: Check the current machine state and see if the LED is the correct output. The amount of time required for the correct LED to turn on should be within 1 second of the state change.
Results: The LEDs changed almost instantaneously after a state change.

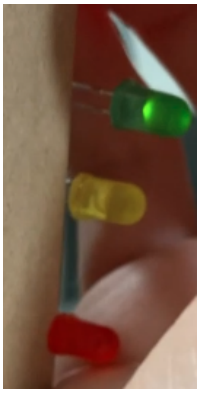


Figure 15: The Green LED is on - machine is ready for an order

Requirement: The machine should dispense the proper item.
Verification: Pressing a button will cause the machine to attempt to dispense the proper item.
Results: As seen in table 3 in section 3.2, after selecting 13 grams of a product to be dispensed, the machine dispensed 15 grams with a small amount of error.