

“Spicer” Automatic Spice Dispenser

GROUP 10

Motivation

- To create an efficient way to maintain spices organized and available in a home kitchen.
- Eliminating the need to manually search even an organized spice rack to get a single spice.
- Experimental new gadgets are appealing to us.

Goals and Objectives

- Creating an automatic turntable which can be rotated via voice commands and hand gestures.
- Creating a mobile app which can interface with the new device and control the majority of its functionality, chiefly spice selection.
- Creating a specialized dispensing mechanism for the serving of spices selected by the user.

Specifications

- Chassis must respond to hand gestures in under 5 seconds.
- Shall dispense a tablespoon of spices in under 15 seconds.
- Chassis shall hold 4 spices at a time.
- Chassis shall weigh under 25 pounds.
- Chassis rotation speed must be at 8 seconds per rotation.
- User will be able to request spices through a mobile application.
- System must detect hand gestures within 2 meters of camera.

What is Spicer?

- Spicer is an automated spice turntable & dispenser for home kitchen use.
- It also includes:
 - A mobile application from which to control the device
 - A camera & Machine Learning model for hand gesture controls



System Responsibilities

Responsibility	Primary Lead	Secondary Lead
App Software	Marcos Barros	Nicholas Campbell
MCU Software	Adrian Garcia	Nicholas Campbell
Bluetooth Communication	Nicholas Campbell	Adrian Garcia
Raspberry Pi Communication	Adrian Garcia	Nicholas Campbell
Hardware Design	Jacob Wood	Adrian Garcia
Physical Design	Adrian Garcia	Jacob Wood
Parts Procurement	Jacob Wood	Adrian Garcia

Spicer Mechanics

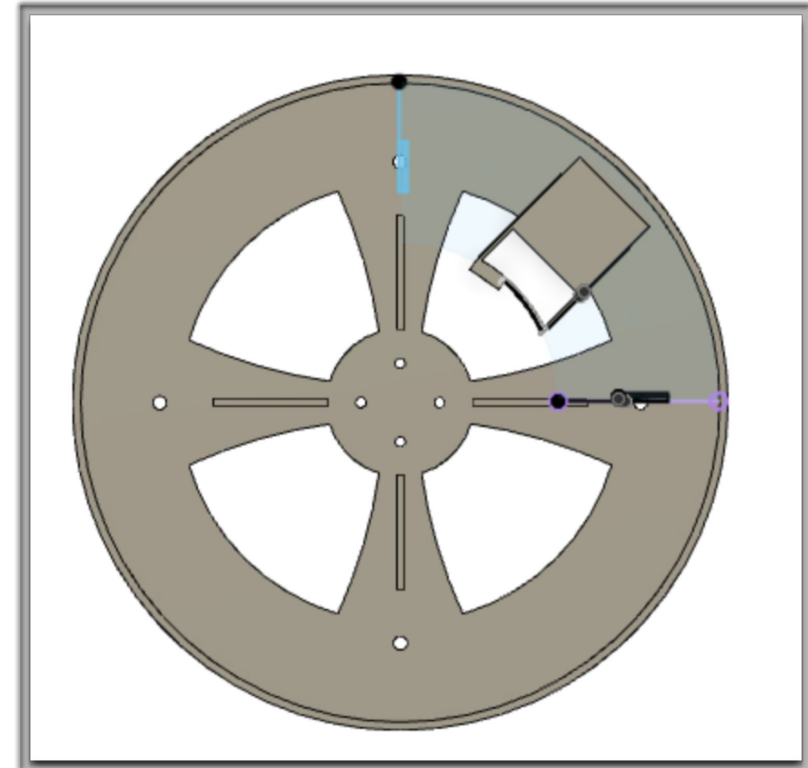
- Spicer, while made for an Electrical & Computer Engineering project, includes many mechanical components.
- These can be grouped into two main sections, the Rotational System and the Dispenser System.

Rotational System

- A Machilift 25GA370 DC 6V Motor is used to turn a pair of gears, one attached to the motor, and one attached to the axel.
- The motor is positioned on a custom 3D-Printed adapter that is drilled into the surface of the chassis
- The motor rotates on commands from, and sends feedback to, a Texas Instruments MSP-430FR6989

Rotational System

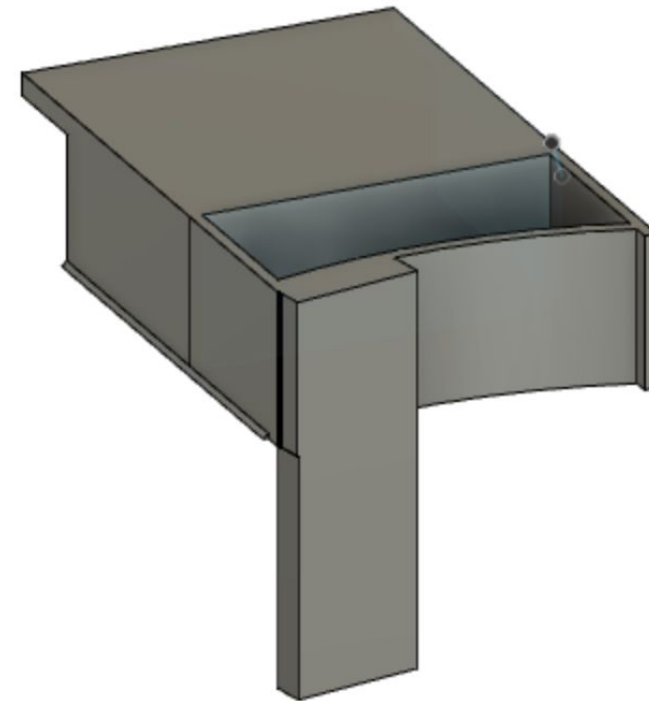
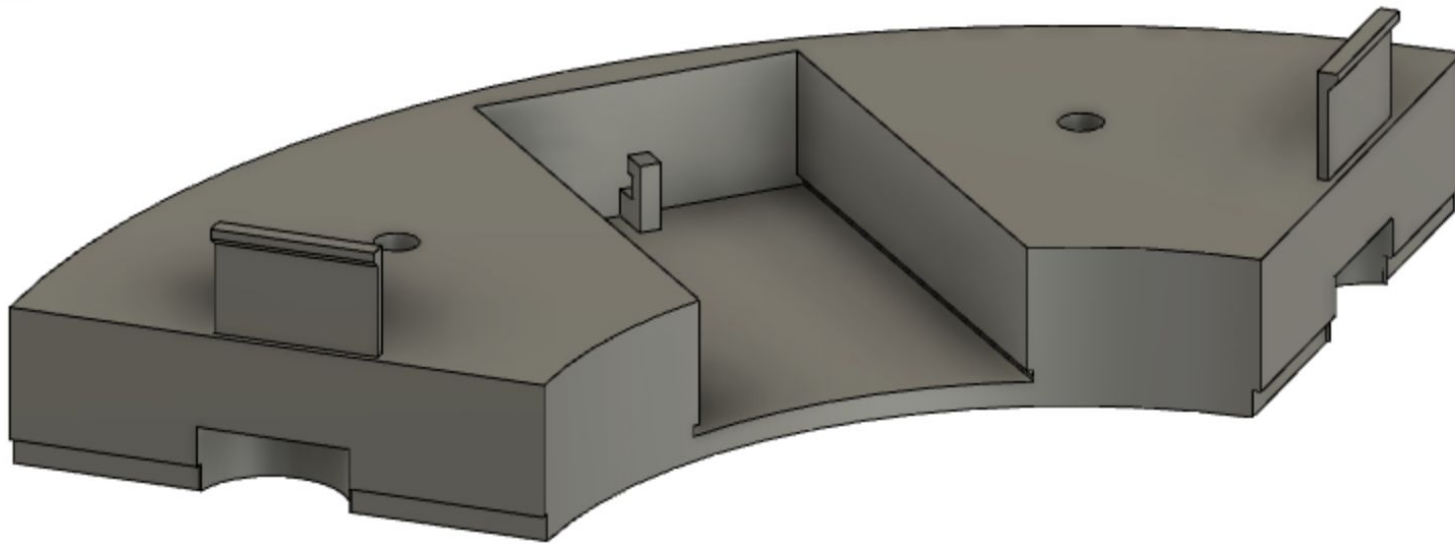
- Attached to the circuit is also an Adafruit VL53L0X Time of Flight sensor, which is used to determine the exact position of the device for more precise movement than the encoders would allow.
- When the sensor is blocked by one of the cross shaped supports, the device will shut off the motor, after a ~ 10 degree offset.



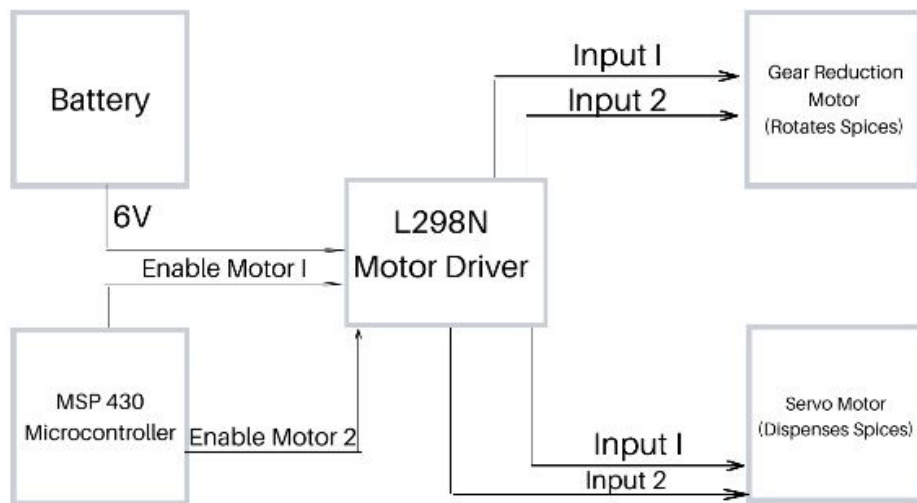
Dispensing System

- The Dispenser Mechanism relies upon a Futaba S3004 Servo Motor to pull the actual dispenser.
- The Servo rotates and pulls a paddle that is aligned with another paddle on the dispenser proper.
- Once this second paddle is pulled, a teaspoon-sized container will be pulled forward along with it, until the teaspoon area is aligned with a funnel, allowing spice to be dispensed.
- After this, the servo returns the dispenser to its original spot, and the process is repeated.

Dispensing System



Mechanical Flowchart



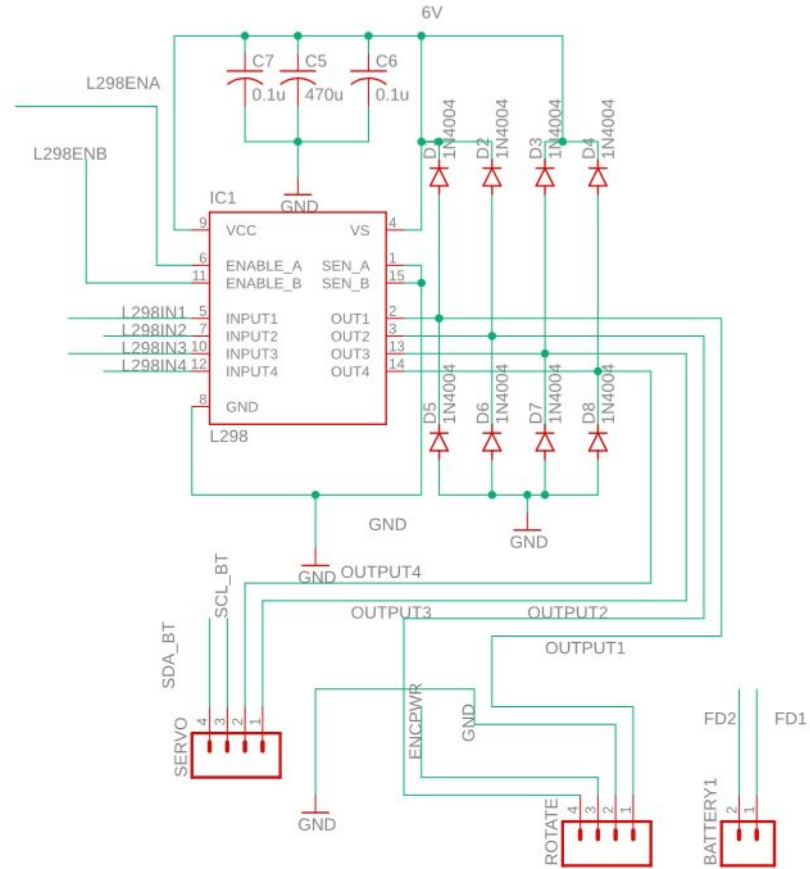
- The 6V gear reduction motors will spin at 12 rpms, and consume 3 Watts of power (0.5A) during use.

- L298N motor driver allows for a 4A output, which will give us plenty of room for adjustments. Since the motors may consume more power to rotate the spice rack.

- The Hall-Effect Encoder on the motors will communicate with the MSP430 to verify the position of the spice rack.

- The Futaba S3004 Servo Motor will consume a max of 6V and 1A (6W).

Mechanical Schematic



Spicer Electronics

- Spicer contains a group of microcontrollers to manage all its functionality.
- An MSP-430 controls motors & dispensing, an ESP32 controls Bluetooth Communication, and a Raspberry Pi.
- Of note are:
 - A hardware semaphore present between the ESP32 and the Raspberry Pi, to ensure no two commands are sent simultaneously through the same I2C bus.
 - A special adapter is made to accommodate the ESP32 above the MSP-430 without necessitating any more wiring between them.
 - This does not simplify the circuitry, but greatly reduces the complexity of the wiring.
 - A Google Coral Edge TPU is present for image processing acceleration.

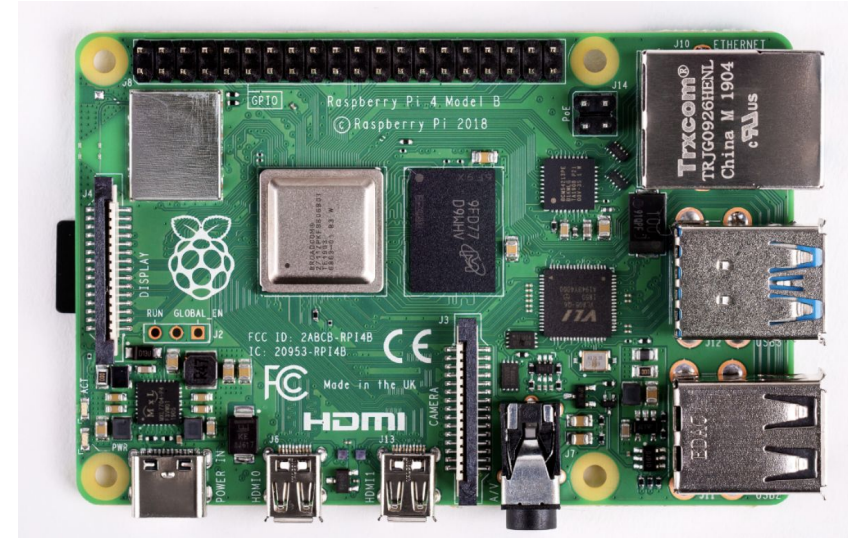
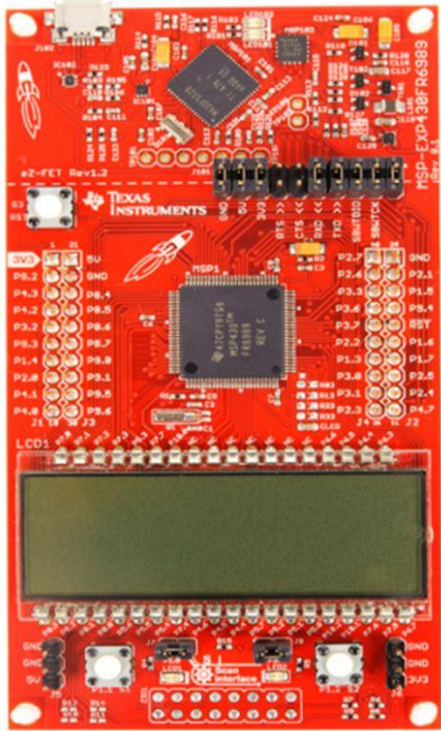
Spicer Electronics

- The Hardware Semaphore is implemented by using a pair of wires connecting two GPIO pins in the ESP32 and the Raspberry Pi.
 - The state of these pins is read in the software, and depending if the I2C bus is available a message can or cannot be sent.
- The Adapter for the MSP-430 and ESP32 was hand soldered for convenience of use in rebuilding and modifying the device, so things wouldn't have to be rewired upon every iteration.

Spicer Software

- The Software components for Spicer includes firmware on the MSP-430 and ESP32, a Raspberry Pi script for image processing and the mobile applications for controlling the device.
 - The MSP-430 acts as a listener for instructions from all sources, and, based on the code that was received sends the appropriate signals to the turning motor or to the dispenser servo.
 - The ESP32 is a listener to the Bluetooth signals from the mobile application, and also forwards state changes to the mobile application, to be kept in sync with the device state.
 - The Raspberry Pi script reads from the camera, frame by frame, and, using the Google Coral Edge TPU, runs it through a TensorFlow Lite Machine Learning model for hand gesture recognition.

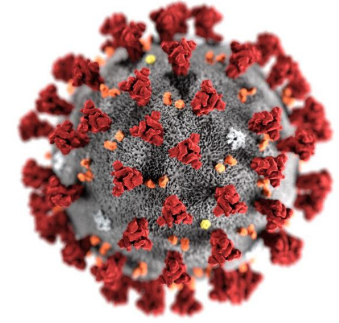
Spicer Software



Mobile Application

- We created a mobile application to give the user more ways to interact with the spice dispenser.
- The user will be able to request a specific spice stored in the dispenser in a specified amount through UI options, or through a voice request.
- The user will also be able to change the names of spice within each capsule in the app in the event that spices are switched out in the dispenser.

COVID-19 Limitations



- Due to Social Distancing limitations, we are unable to meet in person, and due to the online only nature of this semester, and due to housing being limited, some of us were forced to leave Orlando. This made meeting for integration impossible.
- Additionally, businesses and resources that would otherwise be available, such as for PCB soldering were not available for us to use.
- Finally, the manufacturing had to be done on a 3D printer, which greatly limited the size and precision of the design.

Expendable Features

- Due to the ongoing COVID 19 pandemic, there are some planned features which were designed and built, but could not be implemented in the final device due to integration issues, along with the separate locations of team members.
- These include:
 - Power Electronics that could not be implemented on the final prototype.
 - The React based Recipe lookup API.
 - The spice container measurement tool.
 - The LED bluetooth connection indicator.
 - The final PCB, while designed and manufactured, could not be soldered.

Power Electronics

PV Panel

- The PV panel will be used to charge the 6V battery when the user has no use for the spice rack.

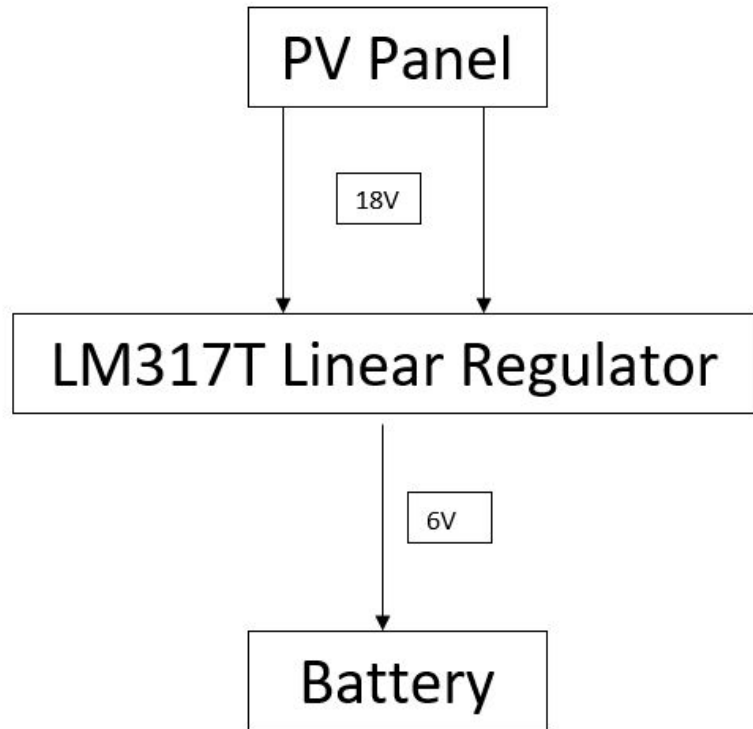
6V to 3.3V Step-Down

- A TPS62147 DC/DC Switching Regulator will allow for the 6V battery to output 3.3V and a current of 2A max, which will allow the MSP430 and ESP32 to be powered for communication.

6V to 5V Step-Down

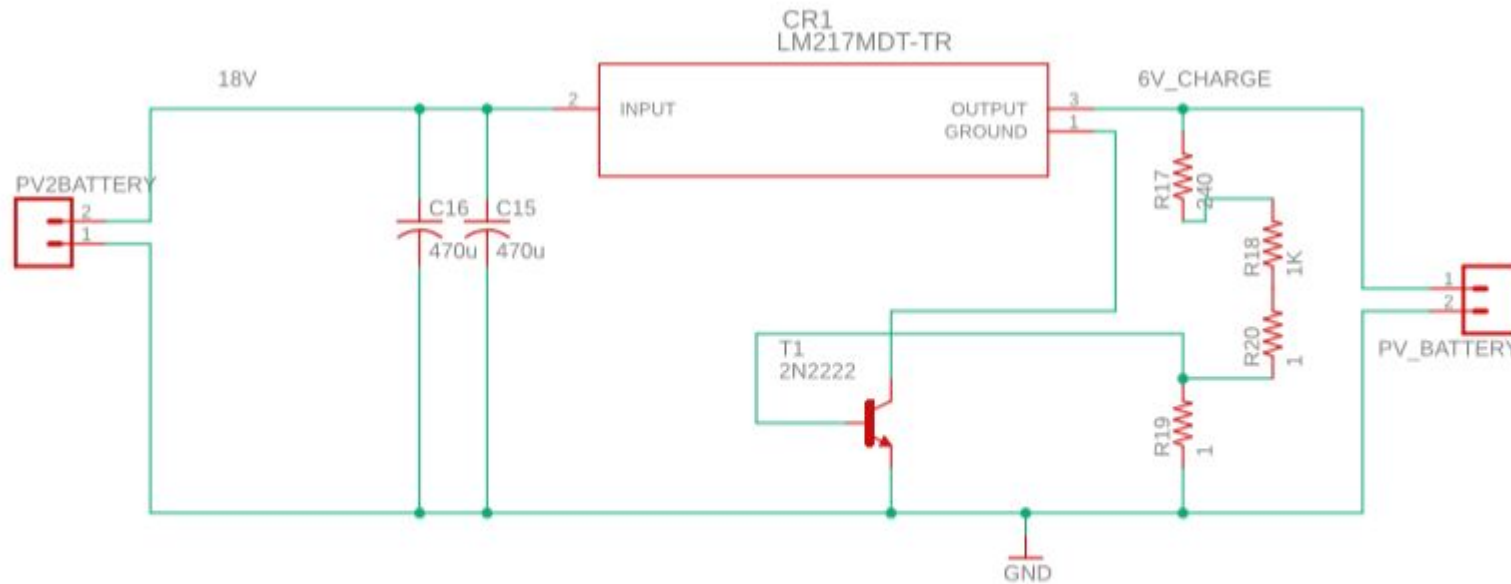
- A XC6201P502MR-G Linear Regulator will allow a 5V, 200mA max current output. This will power the sensors needed for rotating the spice rack.

PV Panel Charging



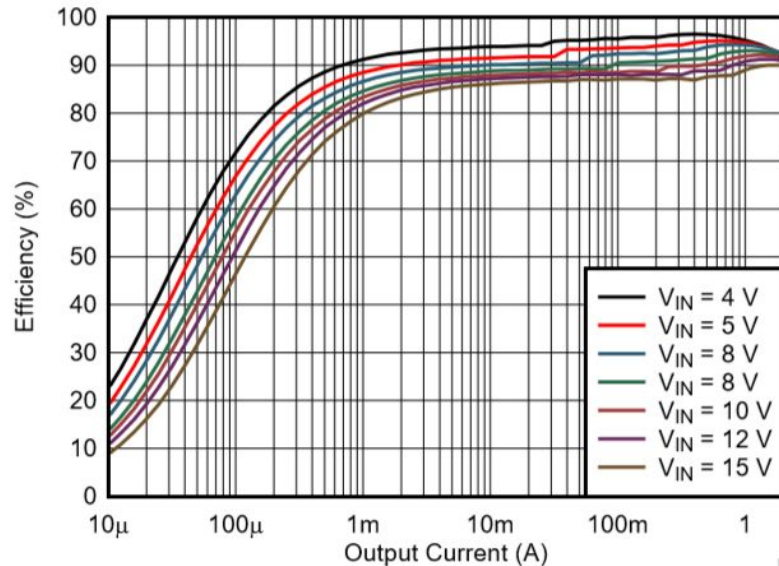
- The solar panel will output 4.2 Watts at 18V. This will give us a recharge time of 34 hours (charging a 6V 12ah battery). This may seem like a lot of time, but the user will only need the spice rack around 3 times a day. So there is no need to fully recharge the battery.
- The solar panel is 200mm by 130 mm (about 8in. by 5in.) and will fit perfectly on the top of the spice rack.

PV Panel Charging Schematic



6V to 3.3V Step-Down

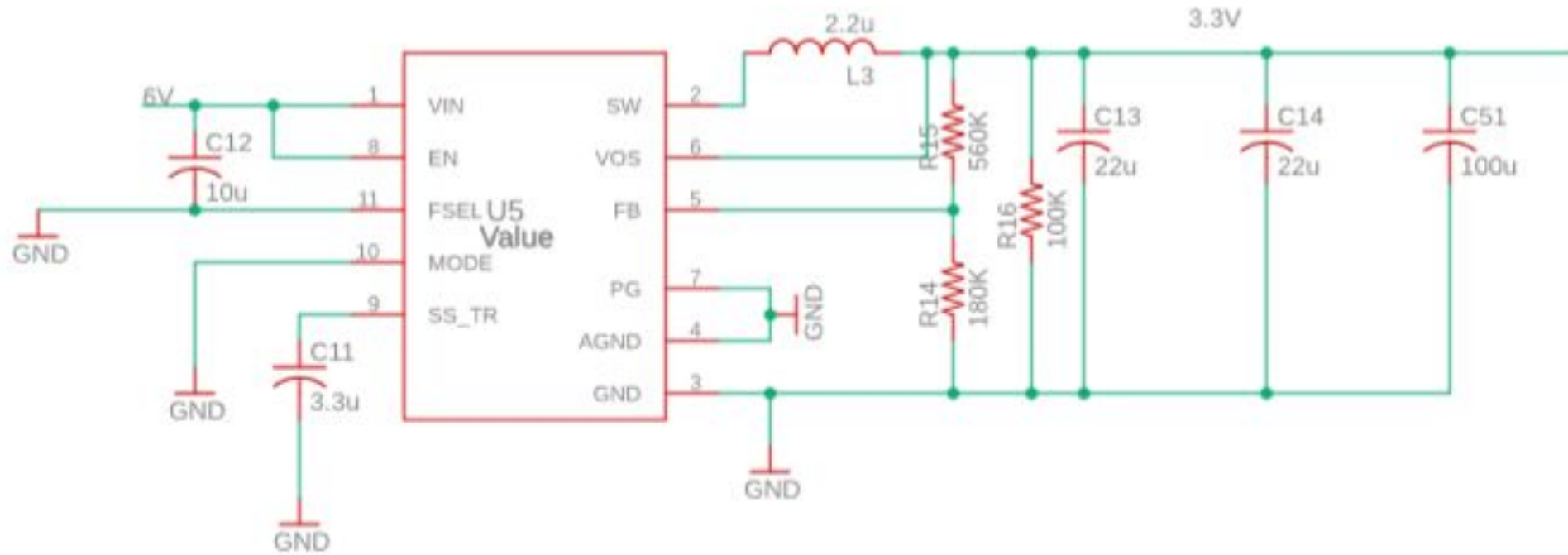
**Efficiency vs Output Current for $V_o = 3.3\text{ V}$;
 $f_{sw} = 1.25\text{ MHz}$; PFM**



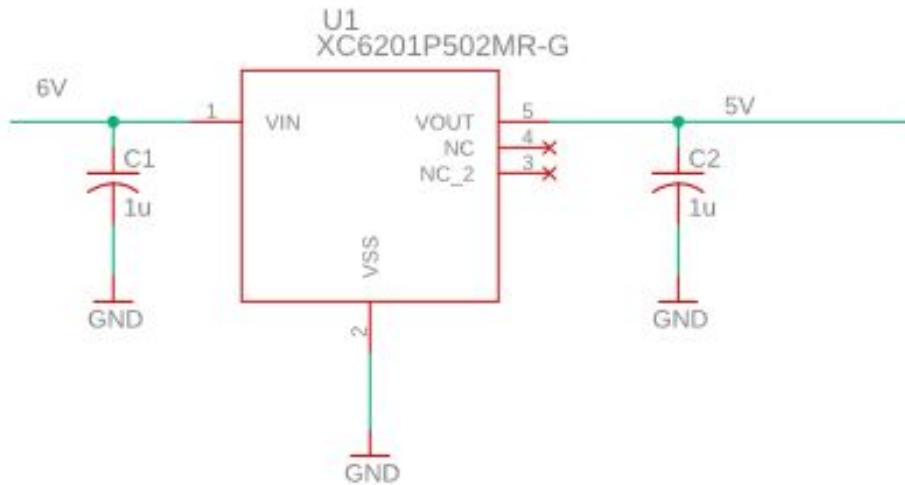
D041

- The TPS62147 is a step-down 6V to 3.3V DC/DC Switching Regulator with a 90% efficiency when the device is pulling more than 10mA ($P_{out}/P_{in} = 0.9$).
- Means the battery will be outputting a max of 1.22A, since the max output of this device is 2A.

Step-Down Schematic



6V to 5V Step-Down



- The XC6201P502MR-G will take an input of 6V and 200mA maximum current (linear regulator).
- Since it is a linear regulator the circuitry is quite simple but will consume more power (max power consumption of 1.2 Watts).

Recipe Lookup

- We attempted to implement a convenient way for users to request spices from an online recipe.
- We used the Edamam's Recipe Search API, which allows different applications access to information of millions of recipes online.
- The user would input a search query for recipes and some filter options. This information will then be used to send an API request for a list of matching recipes.
- We would have processed the results to highlight spices that match those which are stored in the dispenser, and trigger appropriate dispensing.

Spice Container Measurement

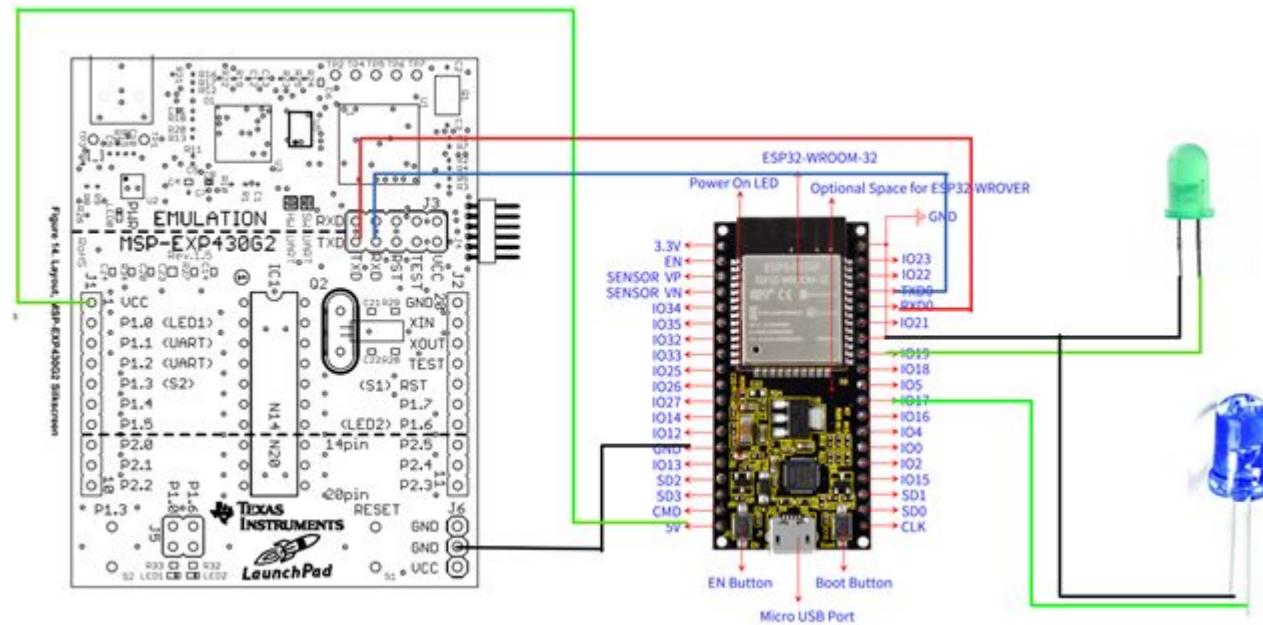
- It was desired to use light sensors to measure the height of spices within a container.
- A see-through container would allow for light to pass through until a spice blocked it, thus allowing us to measure how high the spice is piled up.
- However, due to manufacturing limitations, these see-through containers could not be made.
- Additionally, the light sensor was used in the mechanical component for turning.

LED Indicator

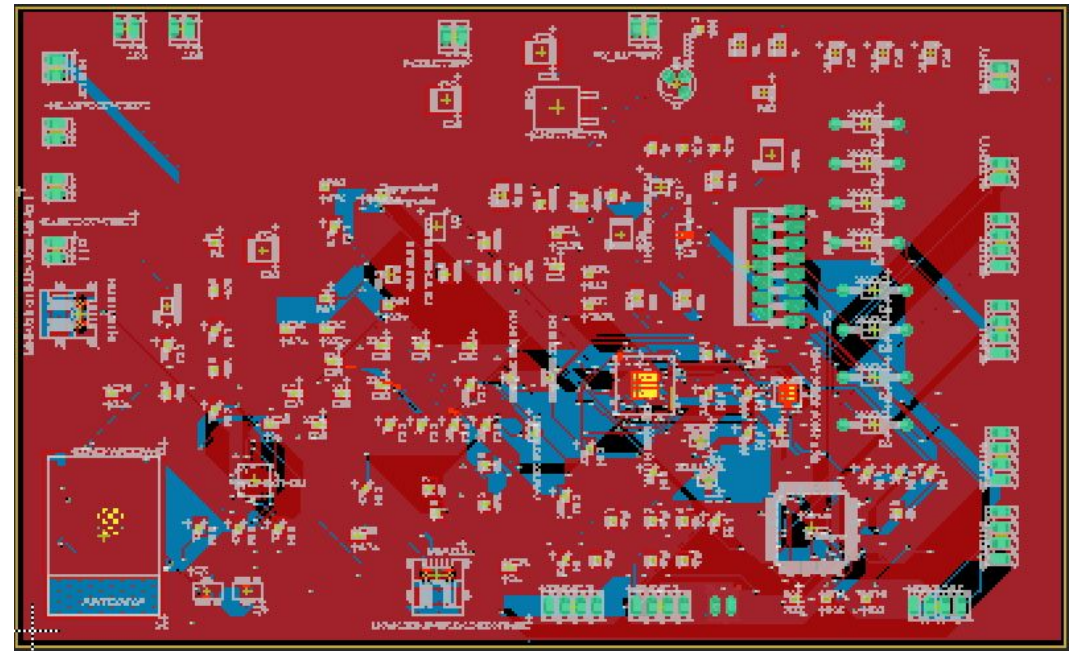
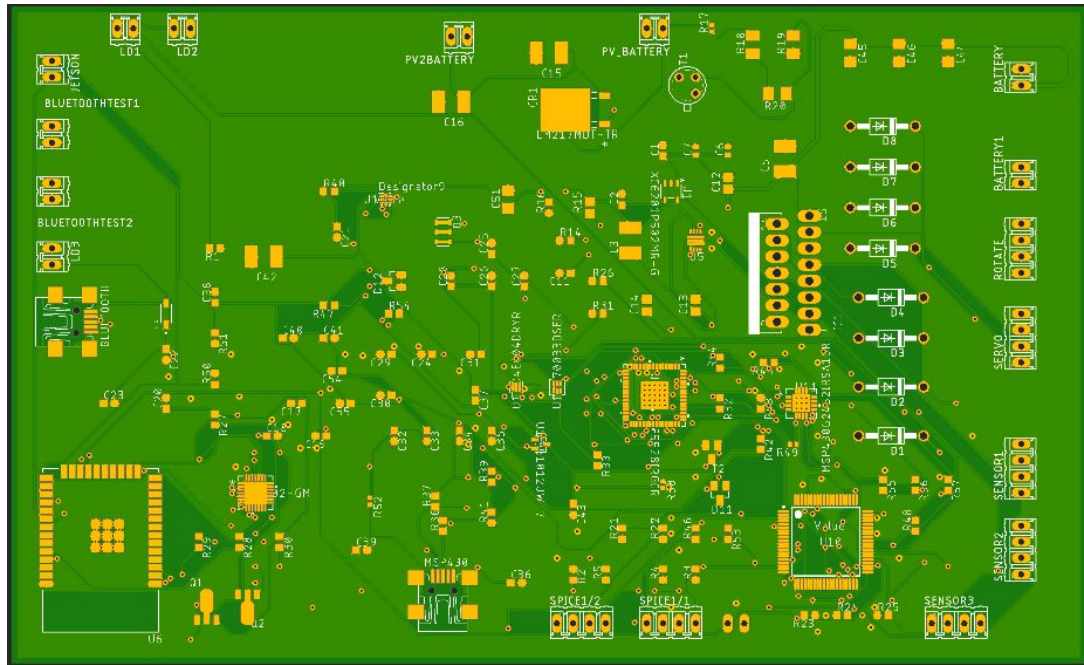
- An LED Indicator for bluetooth connectivity was made, but due to manufacturing constraints with the chassis, it could not be added early in the process.
- It would be possible to drill an area for the LED, and to add it to the circuitry, but due to time constraints, it could not be added.

LEDs

- The LEDs will be used to debug, visually.
- The purpose of the LED is to indicate what is going on in the device.



PCB



Questions?
