Georgia Tech

CREATING THE NEXT

Design Document

Mad Hatter Box

Team #A3: Caleb Chang, Bain McHale, Nickolas Lee, & Andrew Tillery

Date: November 13th, 2022

Table of Contents

Revision Record

Date	Author	Comments
Sep 9, 2022	Andrew Tillery	Document Created (system design and hierarchical design)
Sep 9, 2022	Andrew Tillery	Added Project Description
Sep 19, 2022	Nickolas Lee	Began formatting design document to match our project. Added hierarchical design to Design Document.
Sep 19, 2022	Nickolas Lee	Began Interface Description
Sep 25, 2022	Andrew Tillery	Added Team Assignments, Software Design, and Team Schedule
Sep 25, 2022	Nickolas Lee	Finished Interface Description
Sep 25, 2022	Nickolas Lee	Added Electrical Subsystem and simulated frequency response.
Sep 25, 2022	Nickolas Lee	Added the input subsystem and “simulation” results and updated box design.
Sep 25, 2022	Bain McHale	Updated Project Description with latest mockup and removed section about box shaking
Sep 25, 2022	Bain McHale	Added initial Mechanical Sub-System content
Sep 25, 2022	Caleb Chang	Formatting
Oct 16, 2022	Bain McHale	Update mockup image in project description
Oct 16, 2022	Bain McHale	Update Mechanical Subsystem to show new box design, motor torque calculations, and motor driver
Oct 16, 2022	Andrew Tillery	Add Scrum list
Nov 13, 2022	Caleb Chang	Updated power section.
Nov 13, 2022	Bain McHale	Updated mockup images and mechanical subsystem section.
Nov 13, 2022	Nickolas Lee	Updated input and sound sections.

Project Description

We have designed a box modeling the Mad Hatter's head. He has a rotating arm that raises his hat while audio plays of the Mad Hatter laughing maniacally. His eyes glow red.

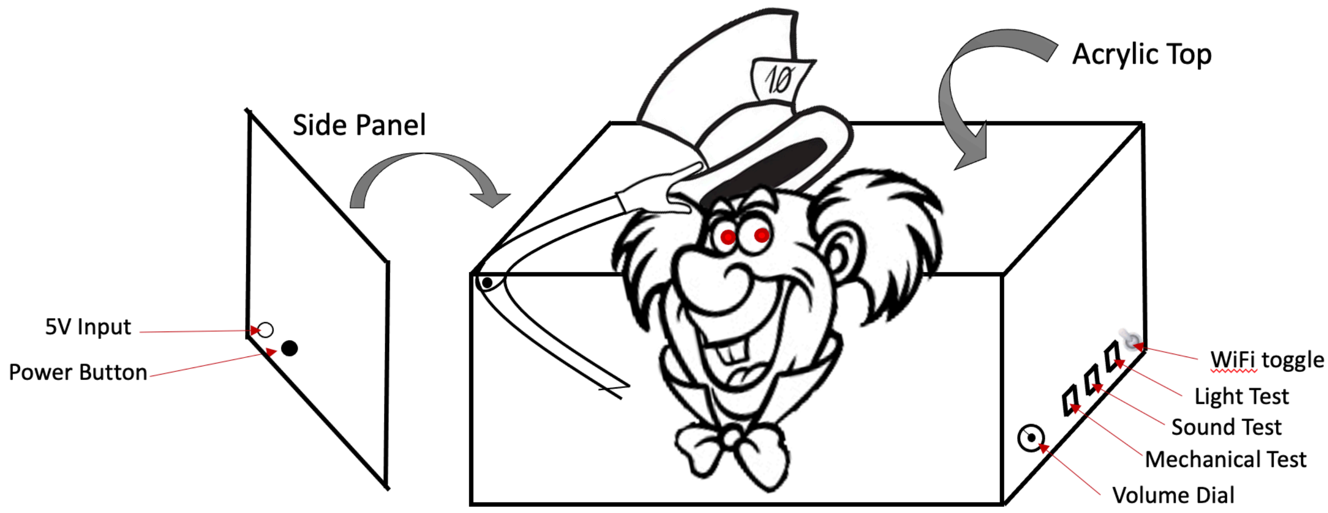
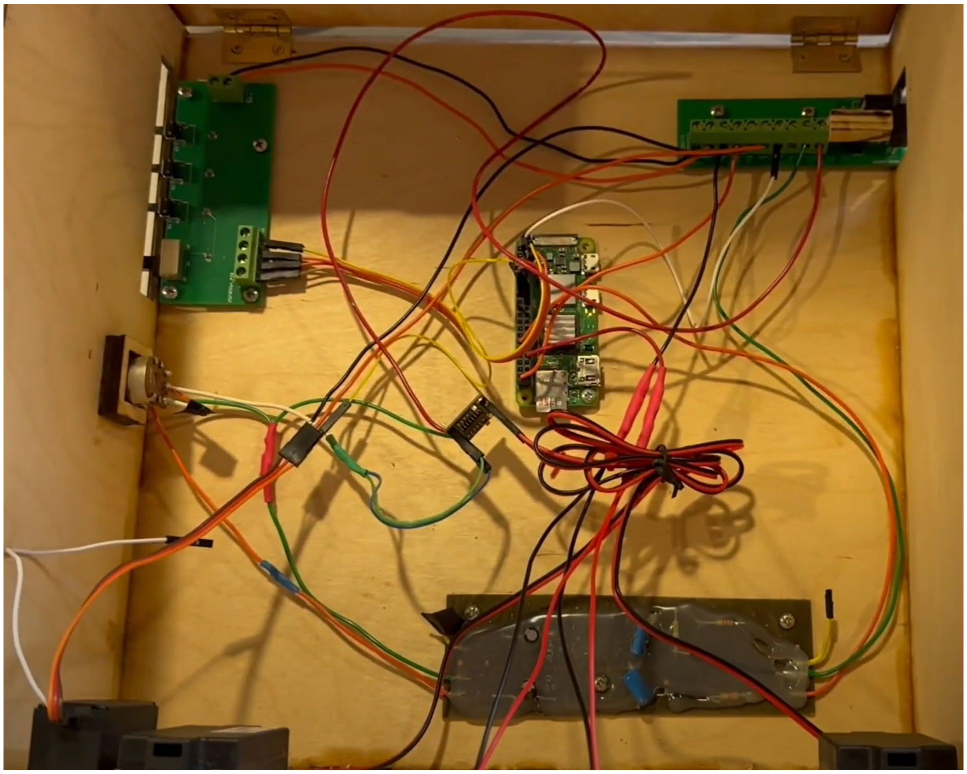


Figure 1: Our final mockup of the Mad Hatter

Team Assignments

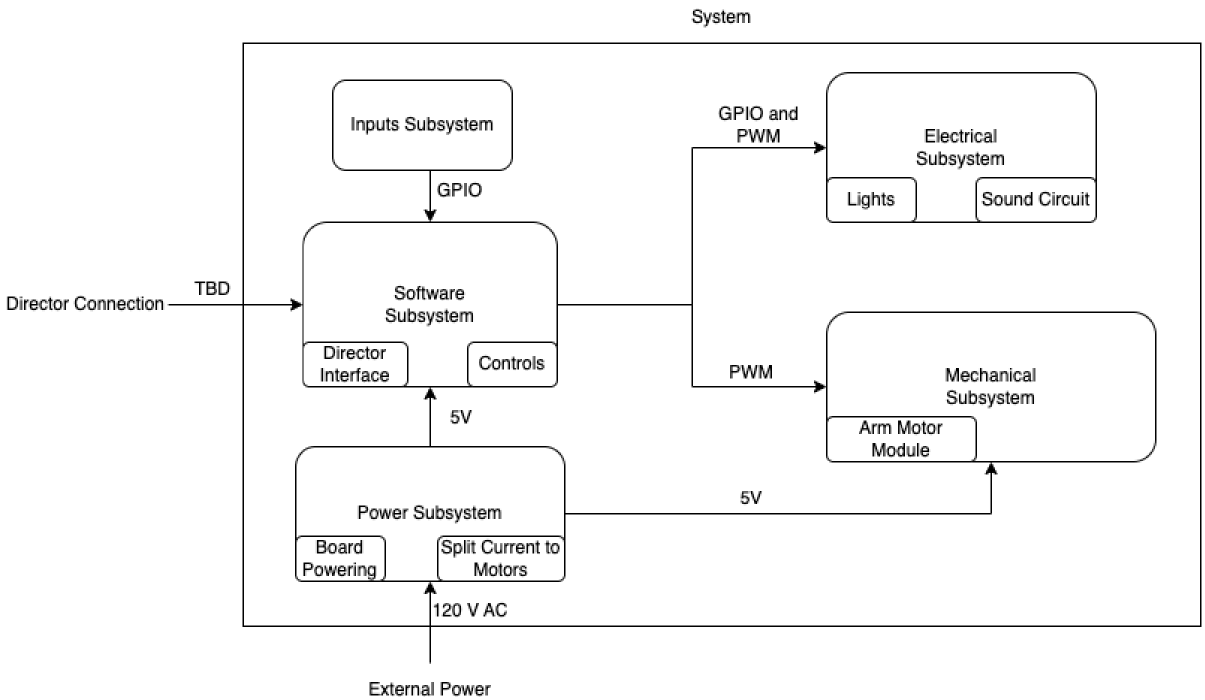
Caleb Chang – EE – Electrical Lead
Bain McHale – CompE – Mechanical Lead
Nickolas Lee – EE – Power & Inputs Lead
Andrew Tillery – CompE – Software Lead, Team Leader

Internal Components



The robot was made of various subsystems. Here we can see the processing unit, power unit, input unit, sound unit, and the motor of the mechanical unit. Each system is explain in the following pages.

Hierarchical Design



Interface Description

Interface	**Connection Point 1**	**Connection Point 2**	**Connection Type**	**Description**
Director to Controller	Director	Raspberry Pi	Wi-Fi	The director will send queues to the system via Wi-Fi.
Input Interface to Controller	Buttons	Raspberry Pi	GPIO	The buttons will be mounted on a circuit board and their signals will be read by the uController via GPIO.
AC to DC	120 V AC	AC/DC Converter	Wall outlet to converter	120V AC power will be converted into 5V DC via a converter and then distributed into the system.
Lights	Controller	Lights	GPIO to lights	The uController will supply 20mA to the LED to light up.
Arm Motion Control	Controller	Relay	PWM	The motion control will trigger the relay to pass power into the motor.
Arm Motion Power	Relay	Motor	2 Wire	Power and Common will supply a relay that will power the motor.
Power Distribution Block	AC/DC Converter	Distribution Terminals	2 wire	Power and common will be distributed via screw type terminals.
Motor Relay	Power Distribution Block	Relay pins	2 wire	The relay will pass through 5 V and the gate will be controlled by GPIO on the microcontroller.
Sound	uController	Amplifier Board	Audio out pins 13 &18	The amplifier board will filter the sound and amplify it for the speakers.
Speakers	Amplifier Board	Speakers	Signal and ground	2 speakers will receive respective signals of audio and ground from the amplifier board.

Sub-System Designs

Mechanical Sub-System

The mechanical subsystem encompasses the building of the box, avatar, and motion control for the motors.

The box and avatar are made from laser cut wood. The mechanical lead has worked with PIs to learn how to use the laser cutters in the IDC. The box is connected using finger joints. The three sides and the bottom have wood glue holding them together. The top is made of acrylic and removable. The back hatch is attached with hinges so that it can be lowered when to maximize accessibility of components. There are stoppers inside the box so the back hatch closes the correct amount, and a hasp can be latched with a stopping pin to prevent the back from hinging down.

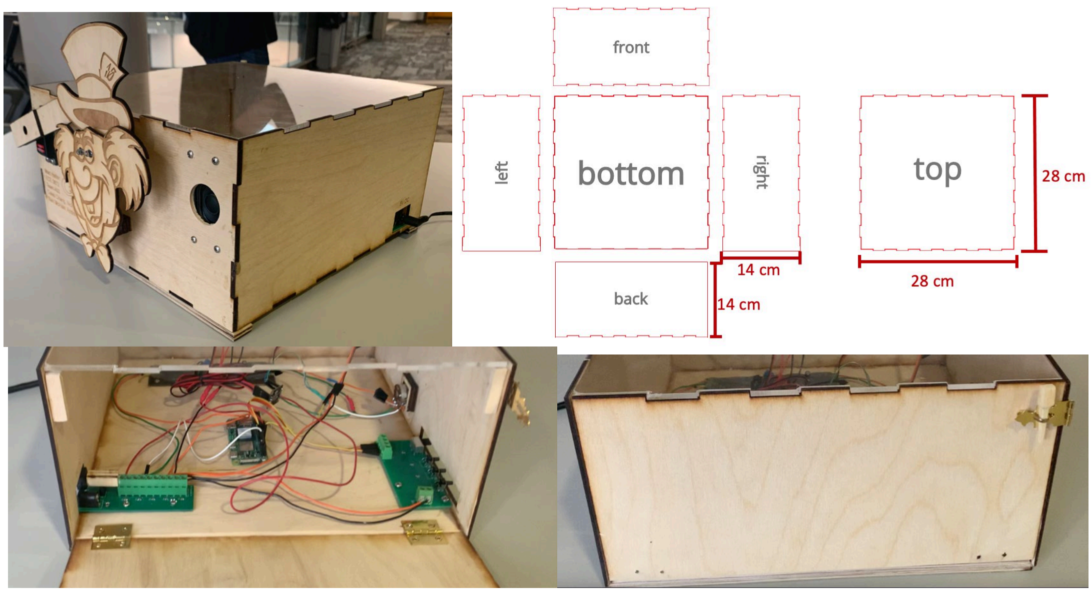


Figure 2: The final box, layout for laser cutting, back opened, and back closed.

For movement, the system uses an Adafruit analog feedback servo motor. The analog feedback pin is not in use for the device, but this was the servo motor that the shop had available for us to use. The motor is mounted on the front of the box with screws.

Figure 3: Adafruit feedback servo motor.

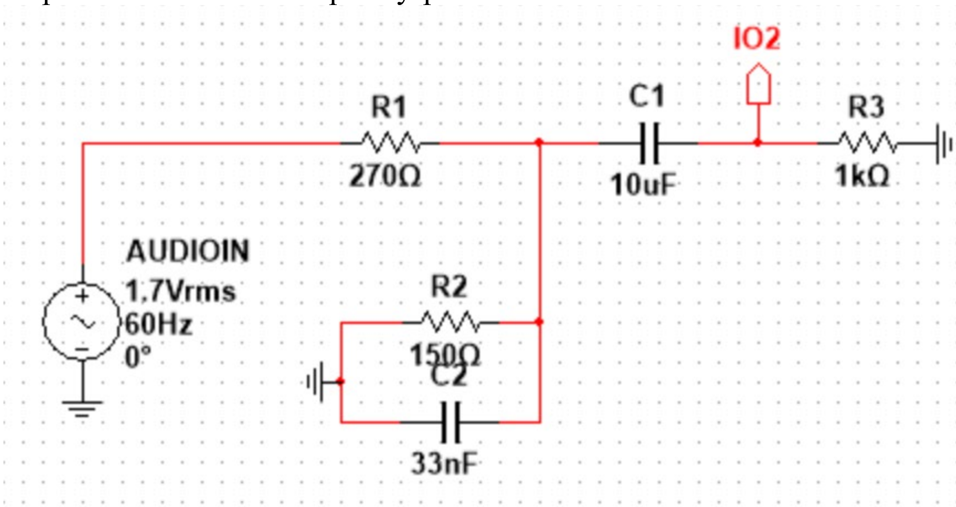
In order to attach the motor to the hat for it to be lifted, one of the preset servo attachments had to be used. To accommodate this, wood was laser cut to fit perfectly around the attachment, then the attachment, once embedded in the wooden arm, was connected to the motor.

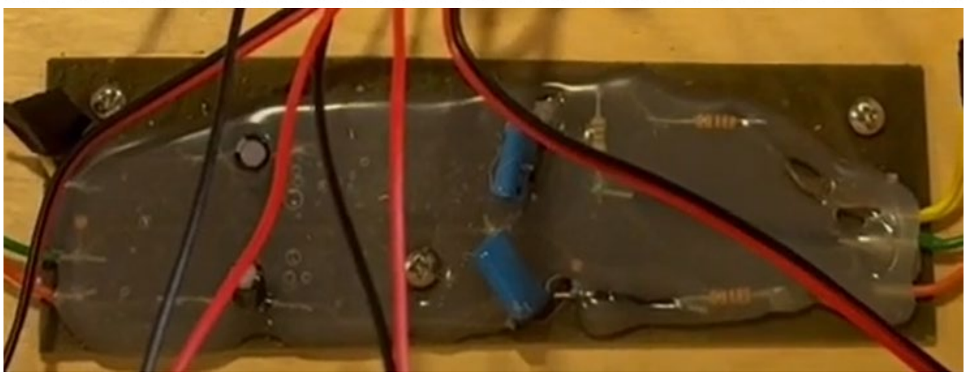
Figure 4: The motor attachment being embedded in a wooden cutout and the arm finalized with the attachment inside.

The mechanical subsystem will be connected to the software via a software generated PWM signal from the microcontroller. It will be connected to a 5V and GND signal from the power terminal block.

Electrical Sub-System

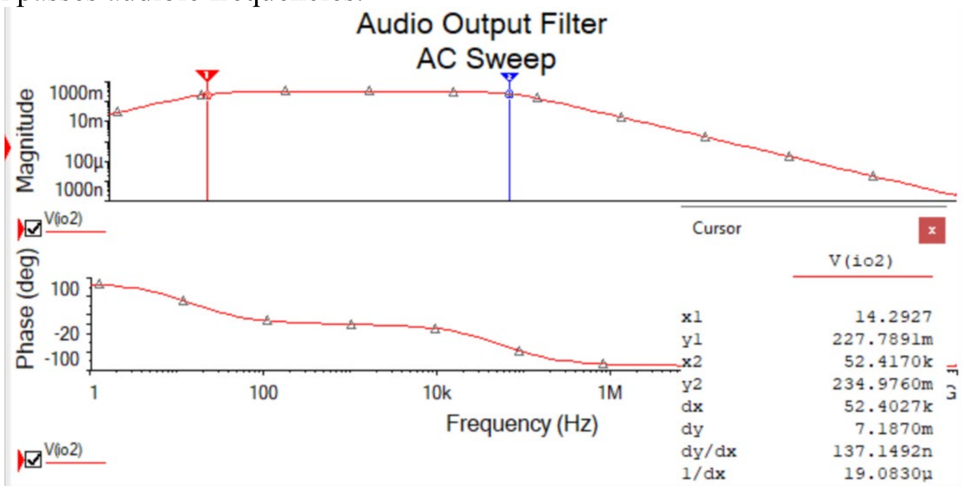
We will be using GPIO for our sound system. The audio produced via these pins will be distorted, the low notes will be too low and the high notes will be very distorted, so we will be first filtering our circuit using the following circuit. Source : [Raspberry Pi Zero Audio Circuit – othermod](https://othermod.com/raspberry-pi-zero-audio-circuit/) - https://othermod.com/raspberry-pi-zero-audio-circuit/





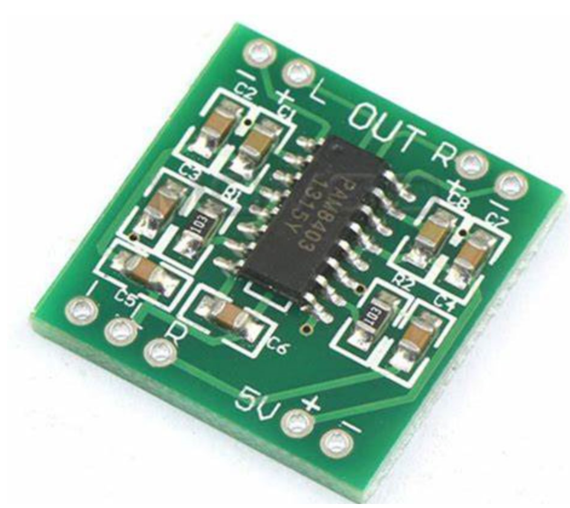
This is the band pass filter with parallel channels for stereo sound. The Protomat broke while fabricating this PCB, I had to solder the traces and cut it out with a bandsaw. It was functional but not aesthetically pleasing.

The simulated frequency response of this circuit is show next. As you can see it is a bandpass filter which passes audible frequencies.



We will be using a dual channel log potentiometer.

From the potentiometer we are using a dual channel 3 watt amplifier that runs off the PAM8403 chipset.

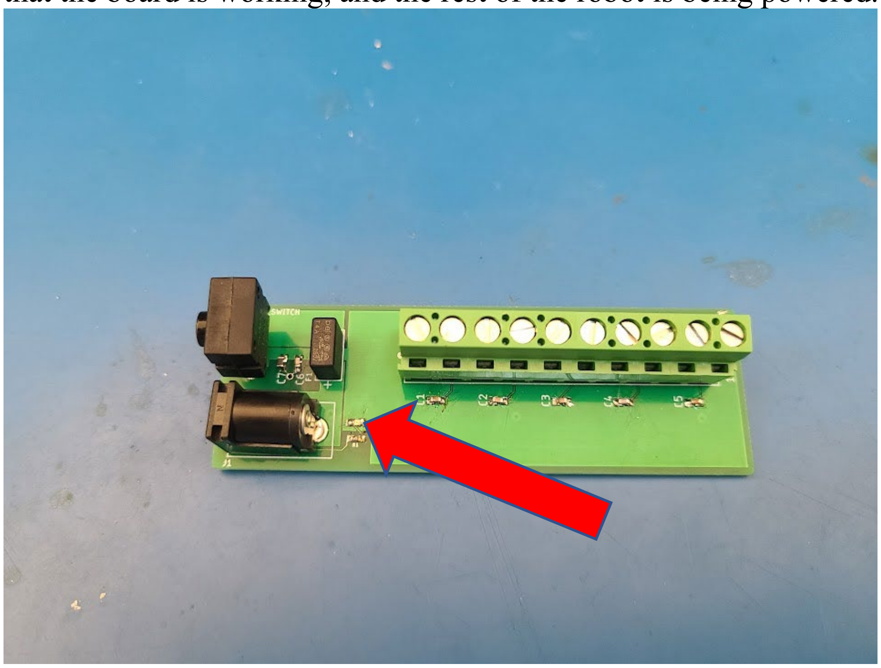


Power Sub-System

From the power budget, worst case power usage is around 15 Watts. We will account for derating and possible expansion by using a power supply with 20 Watts of output power.

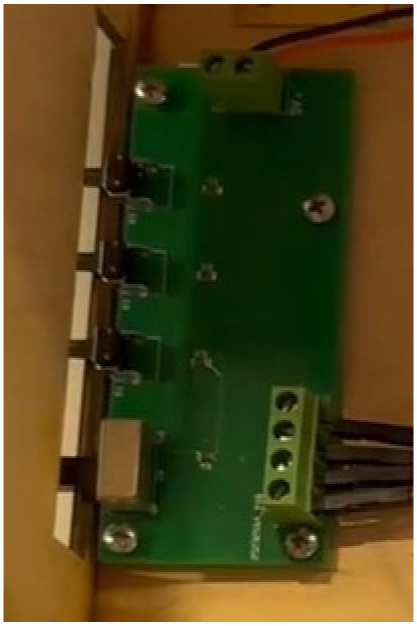
Device	Maximum Power Needed(W)	Description
Sound System	6	2 3 Watt Speakers.
Raspberry Pi	3	Raspberry Pi 02 W - 3 Watts and Full Load
Lights	1.5	About .3 Watts per LED 4 - 5 LEDs needed
Motor	3	3 Watts at full load
Total	13.5	

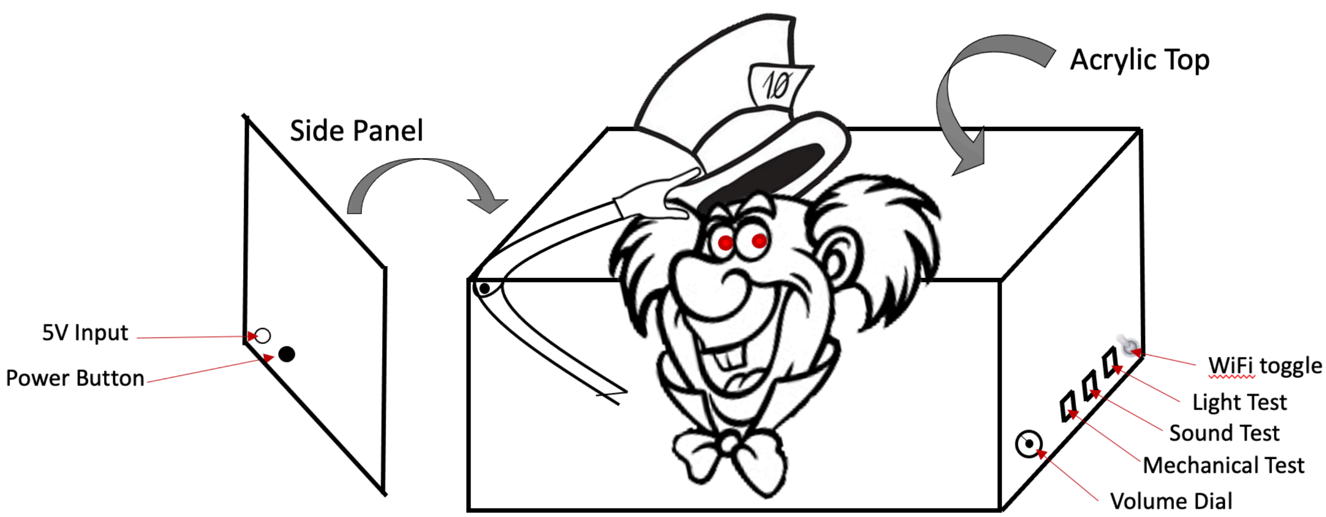
The power board has 5 pairs of power/ground to power the entire robot. It also has a fuse attached to prevent any overcurrent. There is status LED (pointed to by the red arrow) to show that the board is working, and the rest of the robot is being powered.



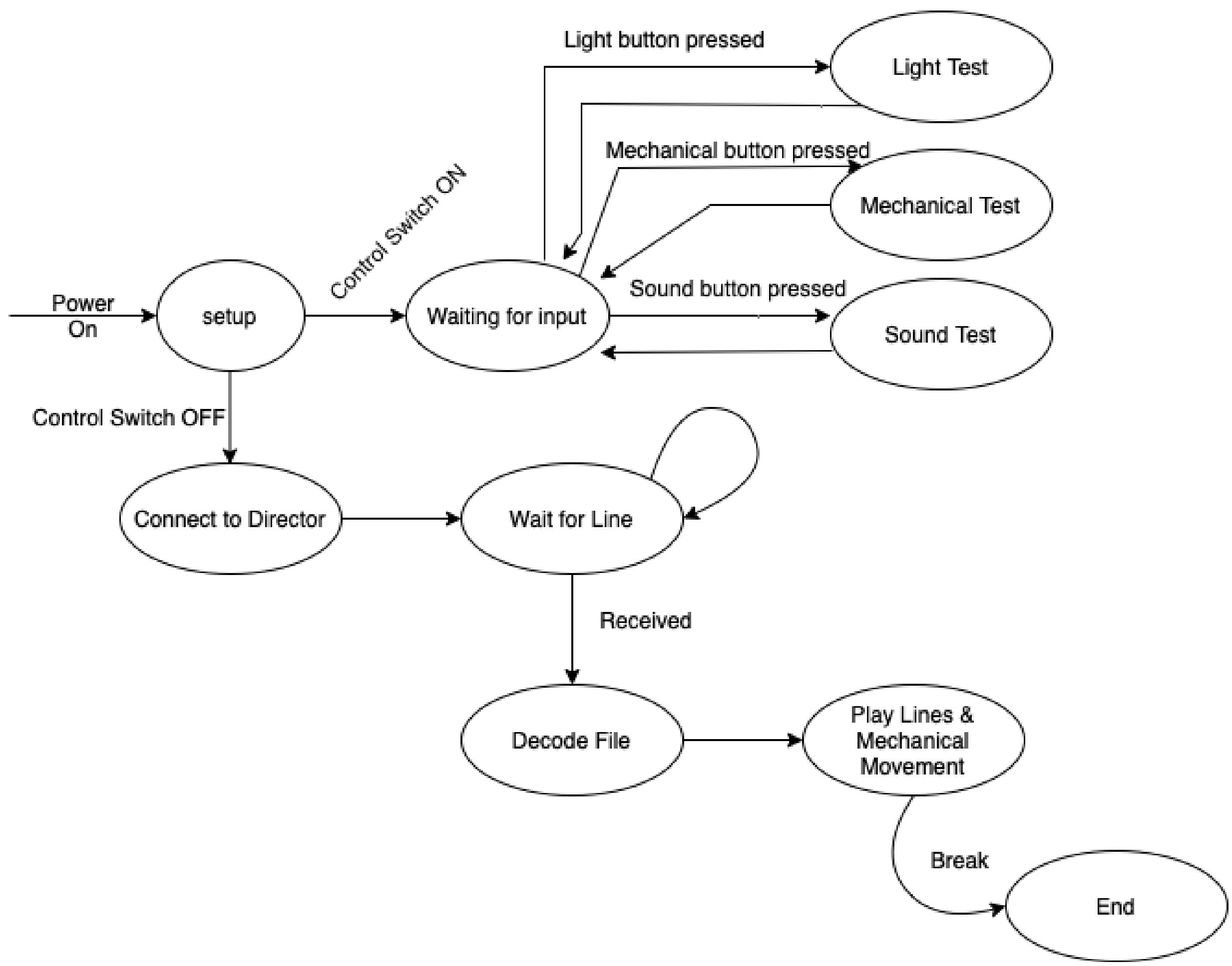
Inputs Sub-System

The Input PCB has 3 buttons and 1 switch. We chose to have the input subsystem be normally closed by pulling up all the signals to 5 V until they are pressed. There are 3 buttons and 1 switch. The switch toggles between director and test mode. The buttons trigger various tests. We chose to use screw terminals for easy maintenance.





Software Sub-System



The software sub-system will be controlled entirely within the chosen microcontroller, the Raspberry Pi Zero 2 W. It will receive signal inputs from the three buttons and one switch from the inputs sub-system, as well as a Wi-Fi signal from the director. The sub-system will output control signals to the mechanical and electrical sub-systems.

Simulations were completed to test GPIO and sound output. The tests confirmed that all necessary pins and alternate functions are working on the Raspberry Pi.

Team Schedule

	Week Number										
Task	1	2	3	4	5	6	7	8	9	10	11
Brainstorm	Caleb										
Design Top Level Block Diagram	Bain										
Design Software Block Diagram	Nickolas										
Proposal											
Preliminary Design - Mechanical		Bain	Bain	Bain	Bain						
Update Mockup and Add Dimensions				Bain							
Determien Stepper Motor (talk to shop)					Bain						
Lasercut cardboard hat & calculate weight					Bain						
Preliminary Design - Power		Nickolas	Nickolas	Nickolas	Nickolas						
Preliminary Design - Inputs		Nickolas	Nickolas	Nickolas	Nickolas						
Preliminary Design - Electrical		Caleb	Caleb	Caleb	Caleb						
Preliminary Design - Software		Andrew	Andrew	Andrew	Andrew						
Complete Software State Diagram				Andrew							
Obtain Raspberry Pi and any accessories					Andrew						
Preliminary Test Plan		Caleb	Caleb	Caleb	Caleb						
Preliminary Integrated Master Schedule		Andrew	Andrew	Andrew	Andrew						
Preliminary BOM ($15+ items)		Bain	Bain	Bain	Bain						
PDR											
Test and Price Components						Nickolas					
Finalize all components						Bain	Bain				
Final BOM (Data sheets, prices, part #'s)								Bain			
Final Design - Mechanical						Bain	Bain	Bain			
Allot size constraints and layout box						Bain					
Lasercut the wood for the box							Bain				
Lasercut acryllic for box								Bain			
Power - Final Design						Nickolas					
Power - Order parts						Nickolas					
Inputs - Final Design							Nickolas				
Inputs - Order Parts							Nickolas				
Electrical - Design Audio and Lights							Nickolas				
Electrical - Order Audio Parts and lights							Nickolas				
Electronics Sound Schematic						Caleb					
Electronics LED Schematic						Caleb					
Sound and Electronics Board Design							Caleb				
								Caleb			
Electronics board design Review and Fixes								Nickolas			
Test Necessary Raspberry Pi Functionality						Andrew					
Complete Code outline							Andrew	Andrew			
CDR											
Attach Hat to Motor									Bain		
Mount motor onto the box									Bain		
Test - Mechanical										Bain	
Build - Power									Nickolas		
Test - Power										Nickolas	
Build - Inputs									Nickolas		
Test - Inputs										Nickolas	
Build - Electrical									Caleb		
Test - Electrical										Caleb	
Build - Software									Andrew		
Test - Software										Andrew	
System Integration										Nickolas	
System Test											Caleb
Final Inspection and Demonstration											

10/10 — SCRUM List

Monday, October 10, 2022 11:59 AM

<u>Nick</u>

- [ ] Write up Pull up resistor justification along with PCB schematic
- [x] Bread board circuit
- [x] Order Parts
- [x] Find out what parts the parts shop has in 0603

<u>Andrew</u>

- [x] Enable ssh via USB
    - Ended up being unneccessary (Monday)
- [x] Update schedule
- [x] Update documents
- [x] Sound test
- [x] Light test

<u>Bain</u>

- [ ] Attach arm to hat in design
- [x] Send Caleb dimensions of the eyes
- [x] Finalize BOM for motor wiring components
- [ ] Update Design Doc to show motor driver
- [ ] Make simulation video

<u>Caleb</u>

- [ ] Finish BOM of power board
- [ ] order parts for power board
- [ ] finish Eye LED schematic and board
- [x] make LED test board simulation for Andrew
- [x] check shop for parts

Our team uses a weekly scrum list to track our progress against our schedule.