UNIVERSITY of WASHINGTON
BOTHELL

# Capstone Summer 2020: IR Theremin


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SCHOOL OF STEM, ELECTRICAL ENGINEERING
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UNIVERSITY OF WASHINGTON BOTHELL

Hexabitz IR Theremin Team

Presents,

# MODULEACAPELLA

# Height Adjustable Wheelchair

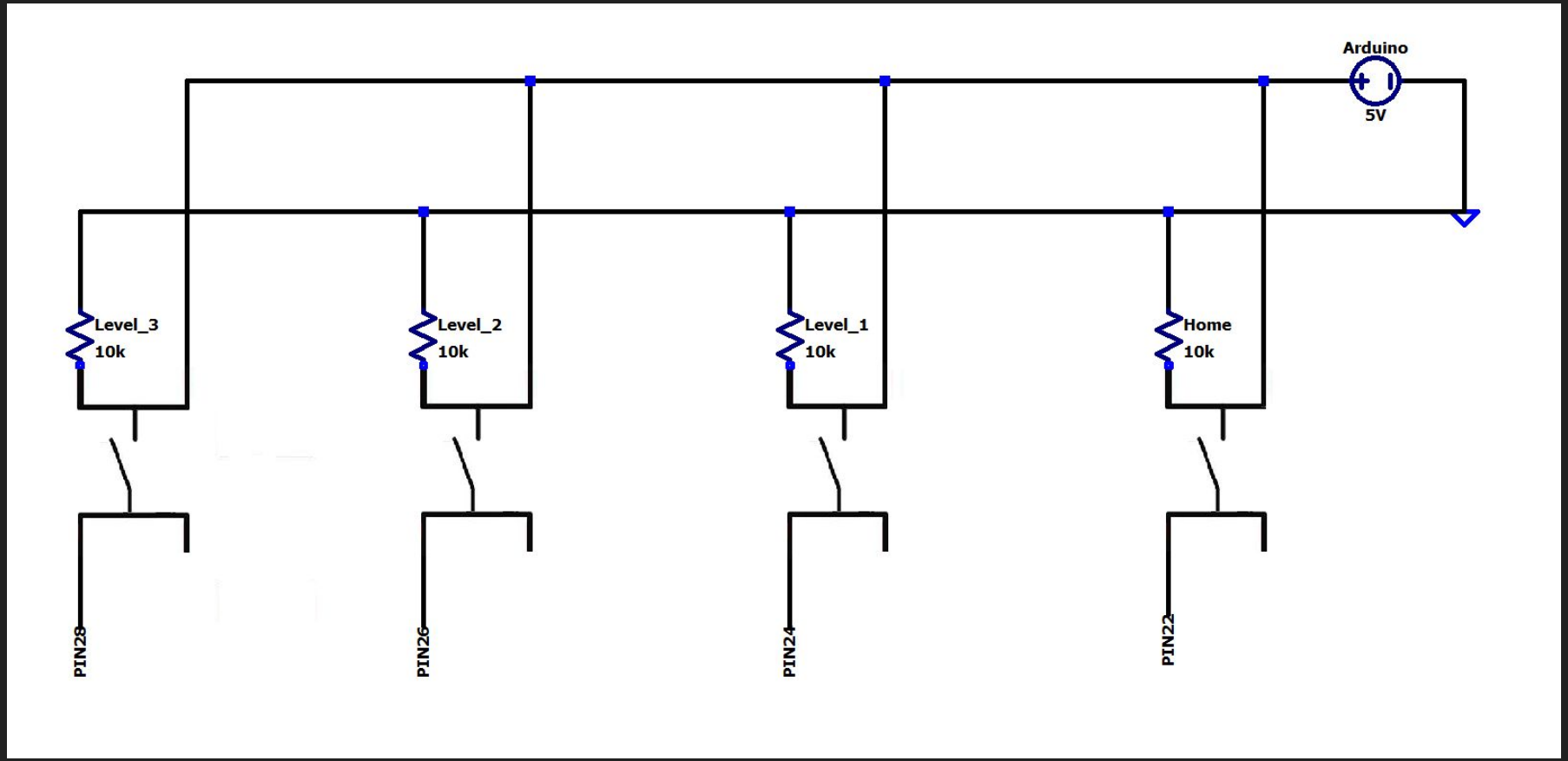
- Reducing strain injuries caused by overbearing load on patients upper bodies attempting to use the facilities.

**HOW?**

# Past Development (Electrical)

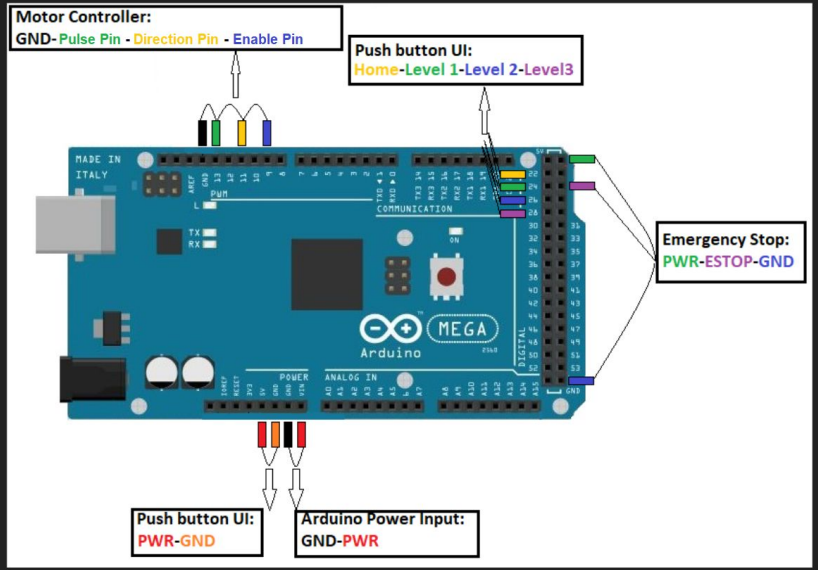
- 4-Push Button Panel has been designed and installed to adjust wheelchair height
- Emergency Stop Panel has been designed and installed
- 4-Push Button Panel, Emergency Stop Panel, Motor Controller, and Arduino has been assembled

# Push Button Panel Circuit Diagram

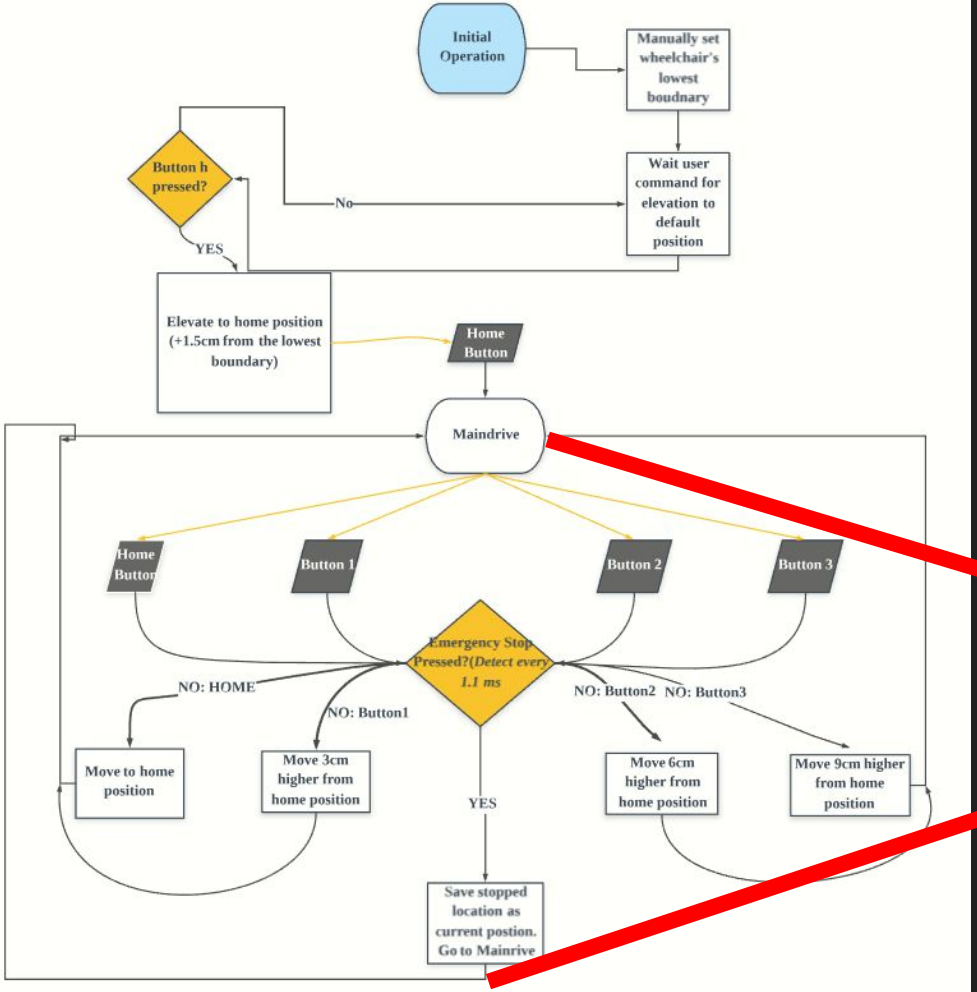


# Past Development (Software)

- Initial Operation Stage has been created to avoid damage in gearbox (1.5cm Elevation)
- Emergency stop function has been implemented



# Software Flowchart (Before)




Open Loop

# Edge Cases


# Another Approach: Multifunction Toilet Wheelchair

Past Development:

- Wheelchair allowing patients to access toilets without the need of leaving their wheelchair was developed.
- Crossbars with underside clearance was installed.
- Screw Jack Drivetrain used to raise and lower the lift is installed.
- Level circuitry, emergency stop button, and code
- 3D-printed mechatronic prototype

# What to improve

- Accessing the facilities, through the seat.
- Lifting mechanism
  - Slow (appr. 2.8 cm/min, 1.437 rps)
  - Inefficient height control
  - Creates unwanted strain on upper extremities
  - Modular
- Better efficiently update position value using EEPROM with Arduino and tackle software edge cases

# Types of Stepper Motors

HT17- less than .54 N*m of holding torque

HT23 - .59 to 1.90 N*m of holding torque

HT24 - .86 to 2.50 N*m of holding torque

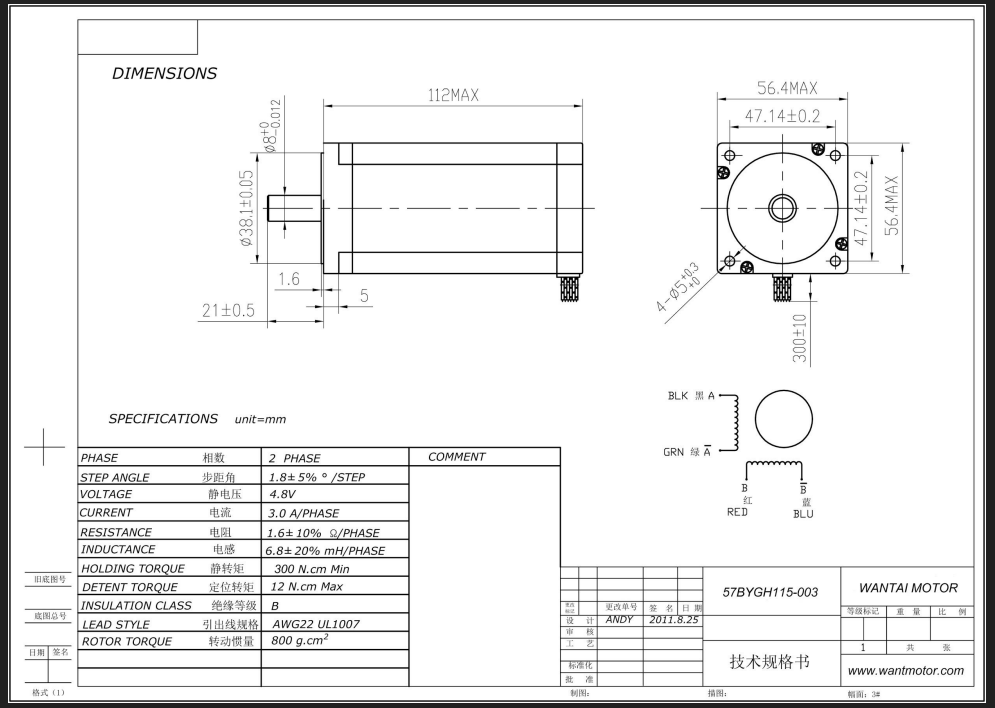
Required for a 91 kg human

.7062 N*m

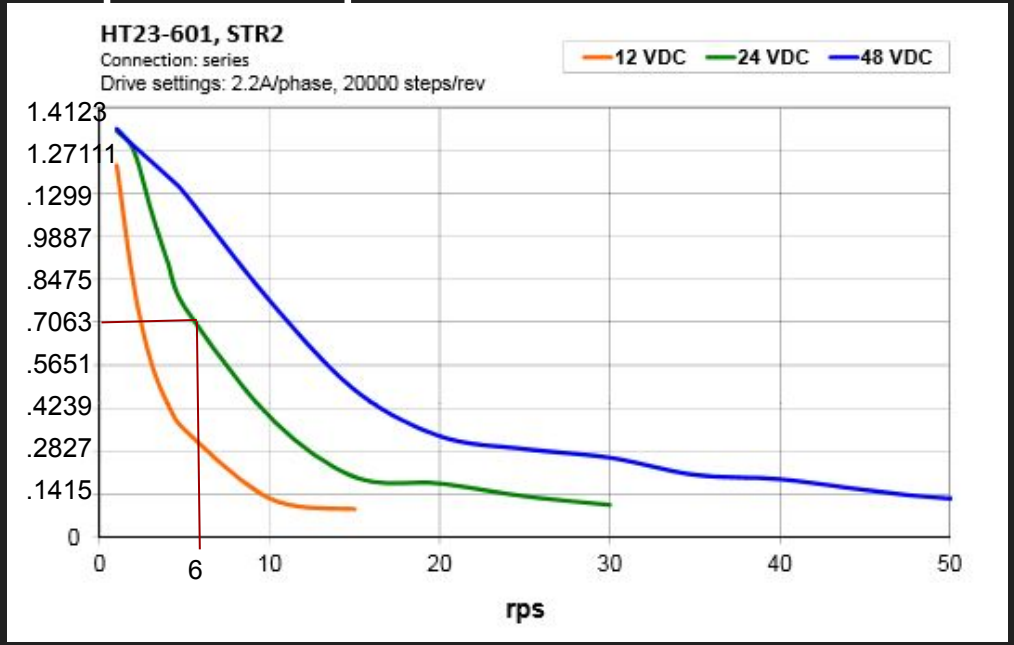
# Choices

HT23,  specifically the HT23-601

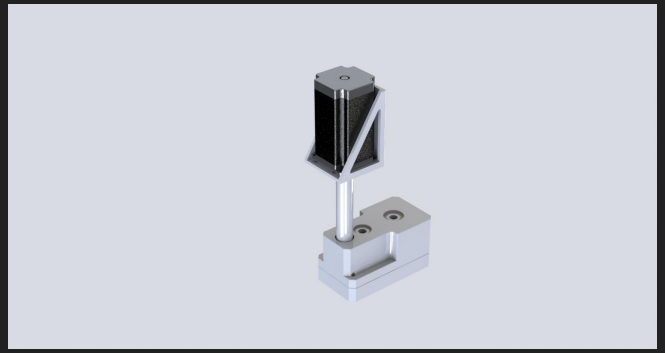
- 1.8996 N*m
- $94.34

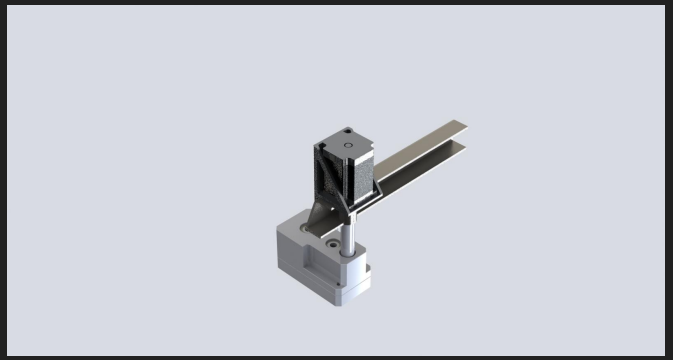


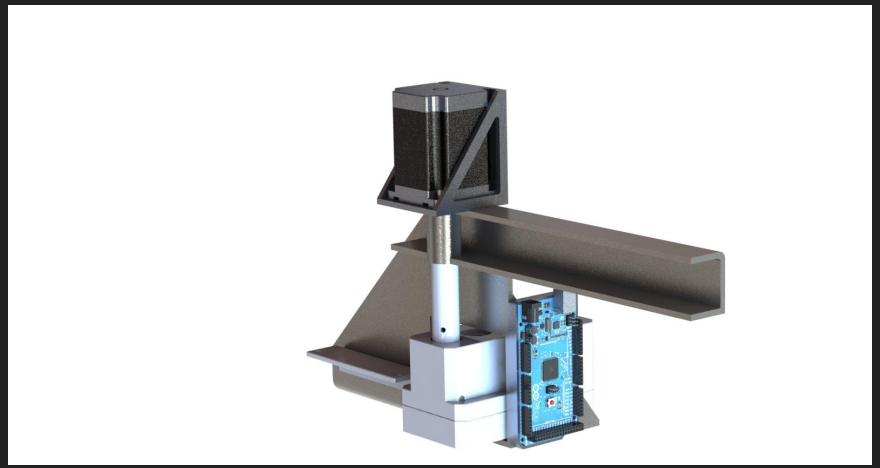
# Torque vs rps



# Initial Design

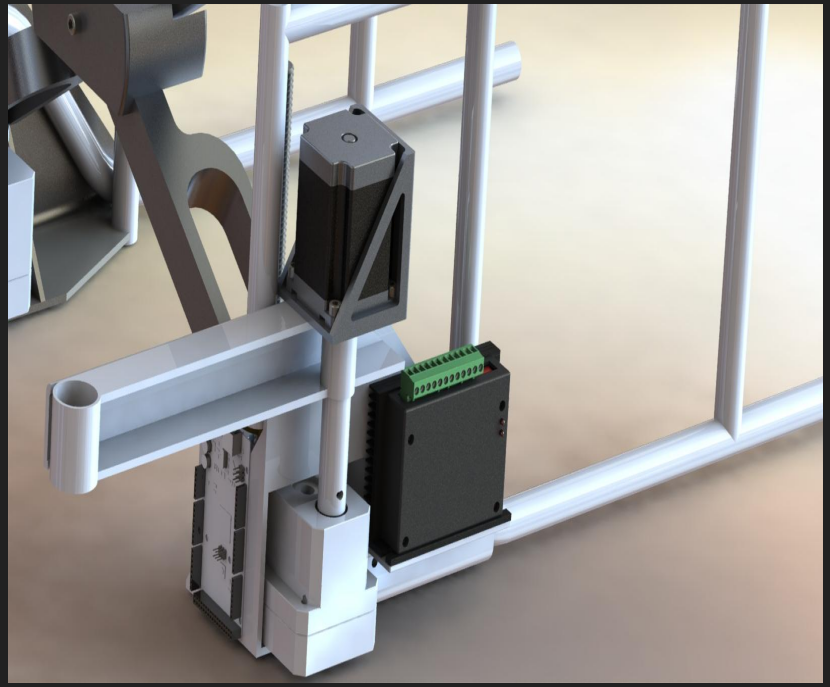




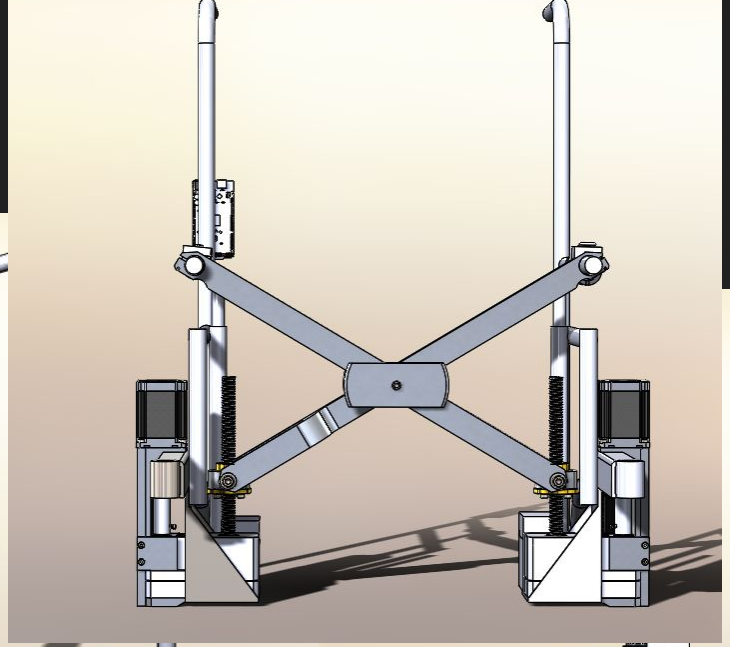


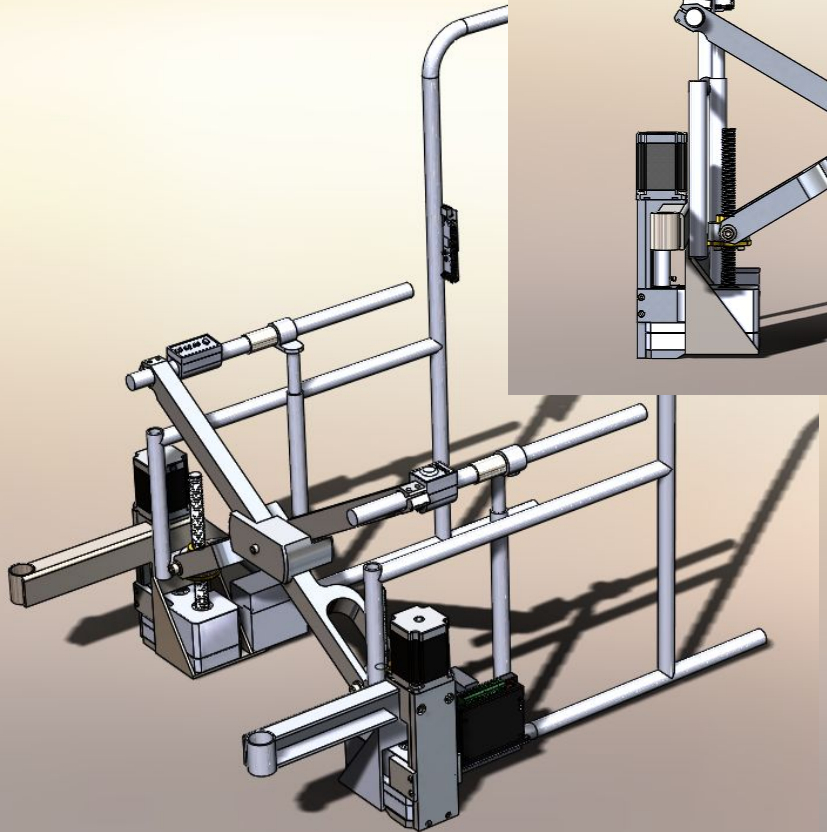
# 2nd Iteration

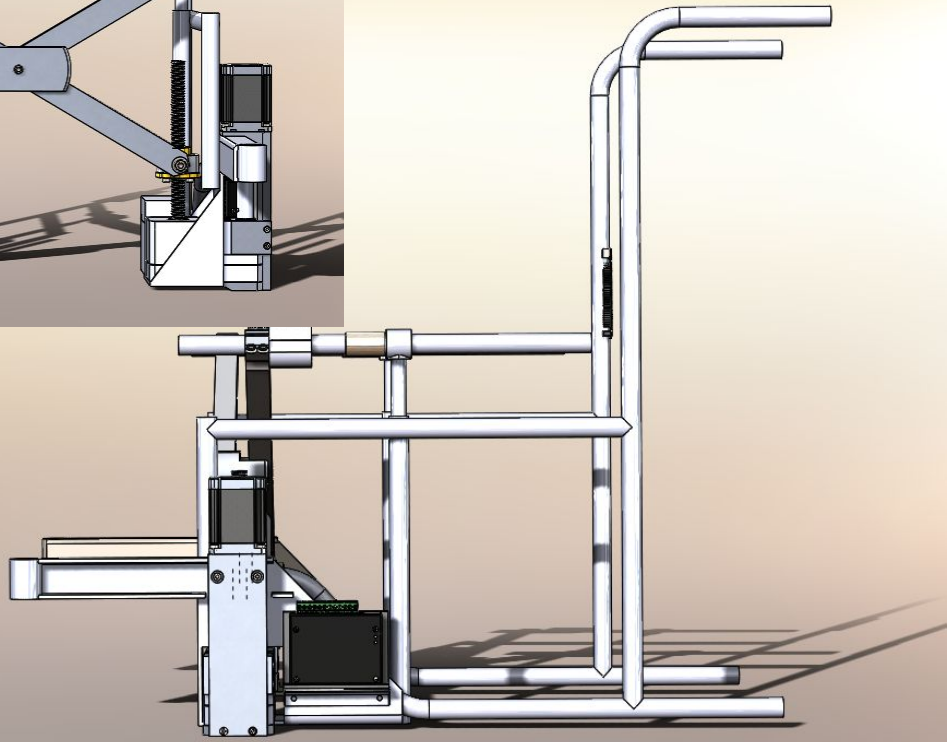
# 2nd Iteration mount connection



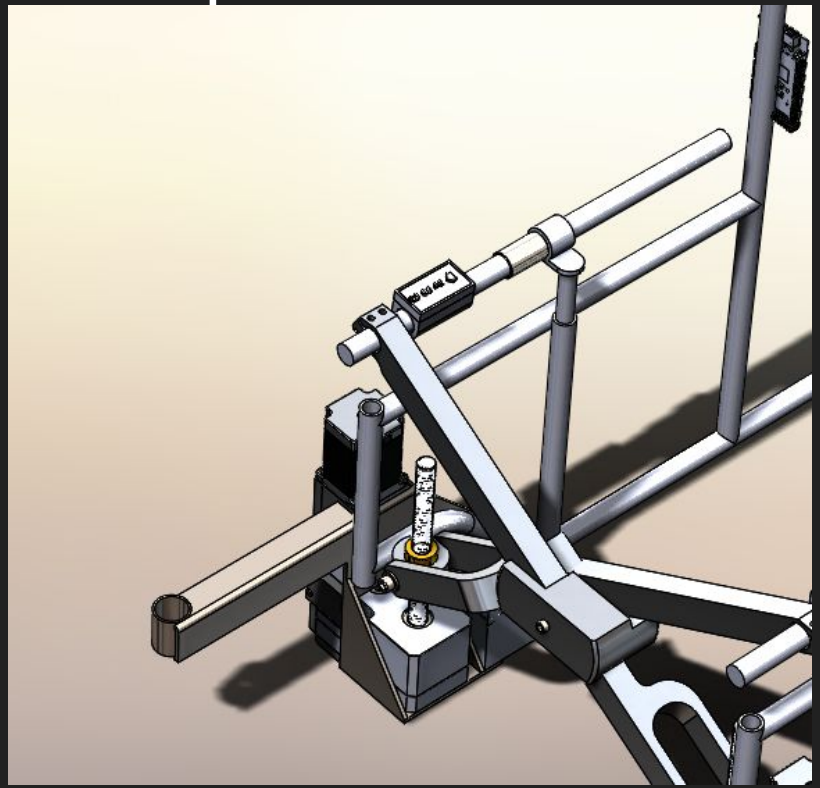
# Final Design

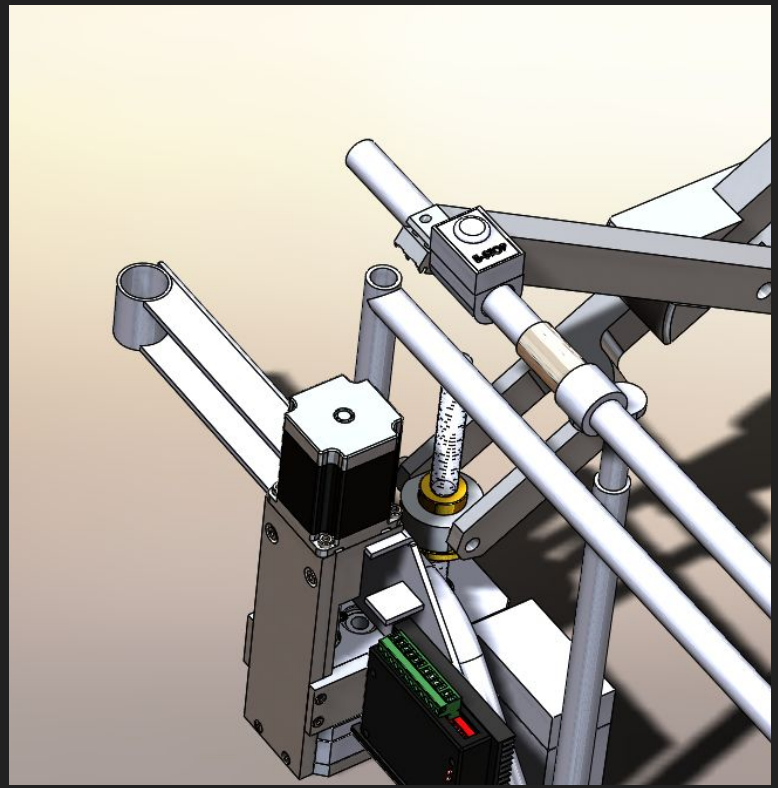




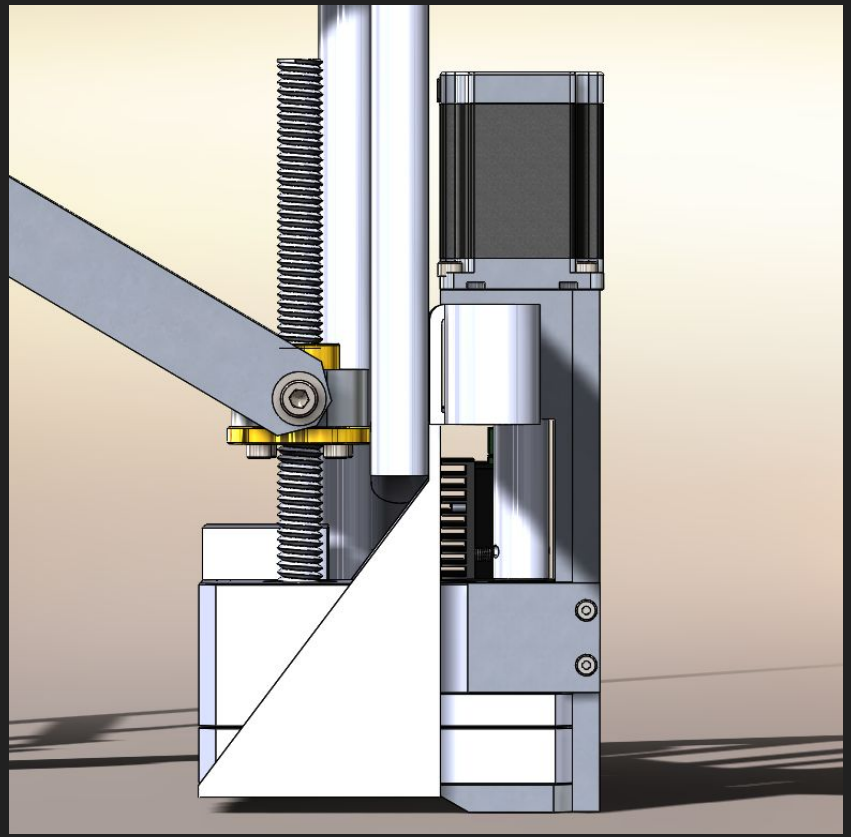


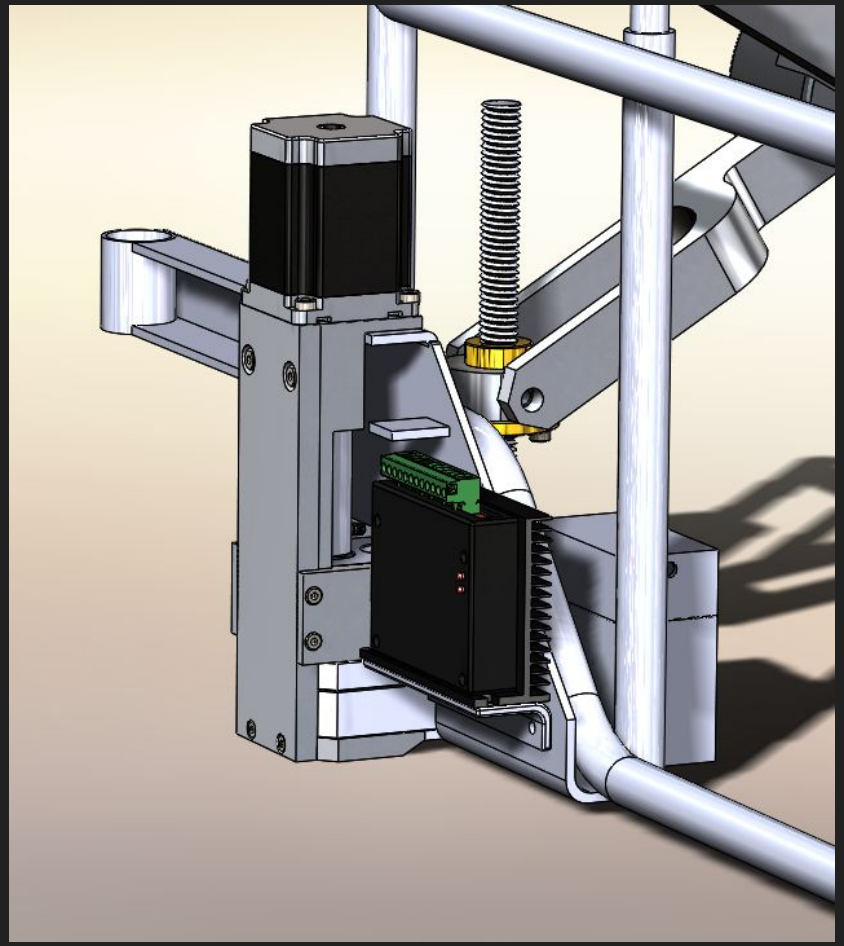
# Control placement





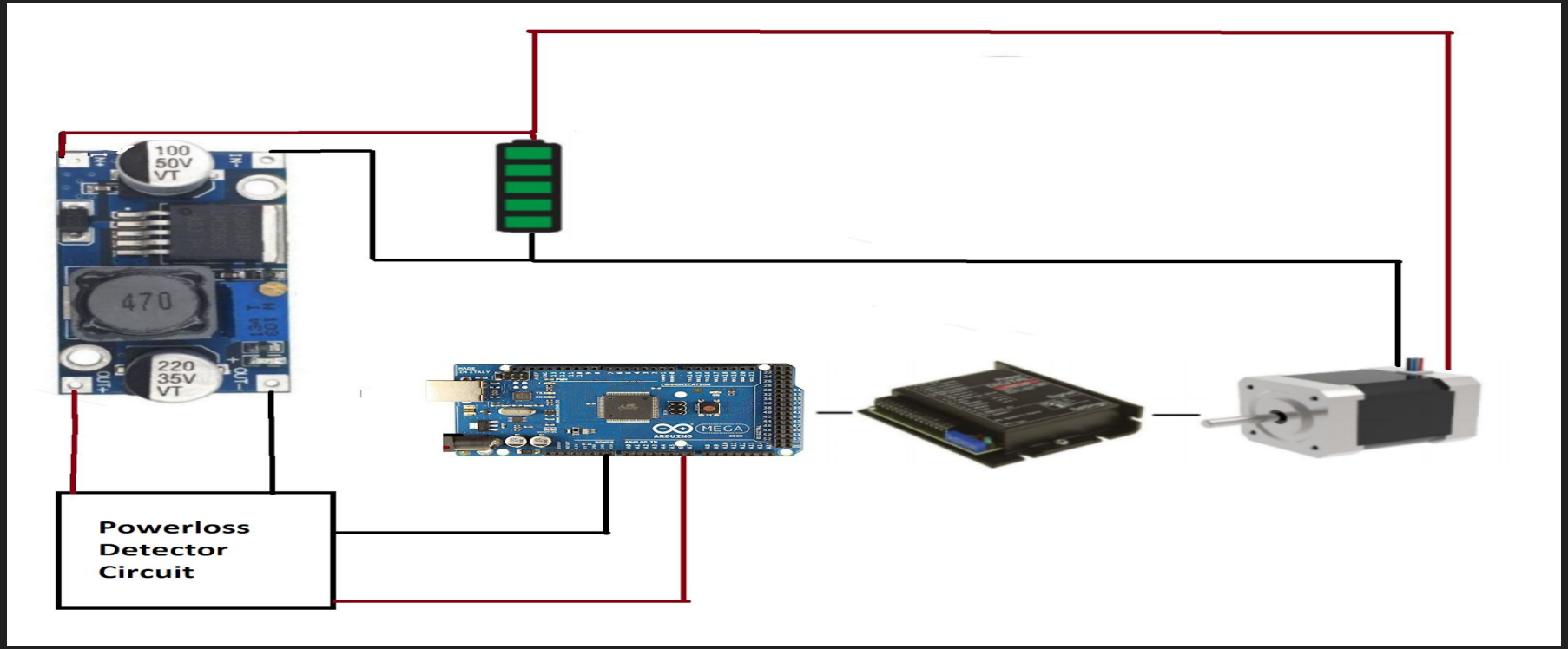
# Motor Mount





# Edge Cases


# Solution: Voltage Regulator & Power Loss Detector

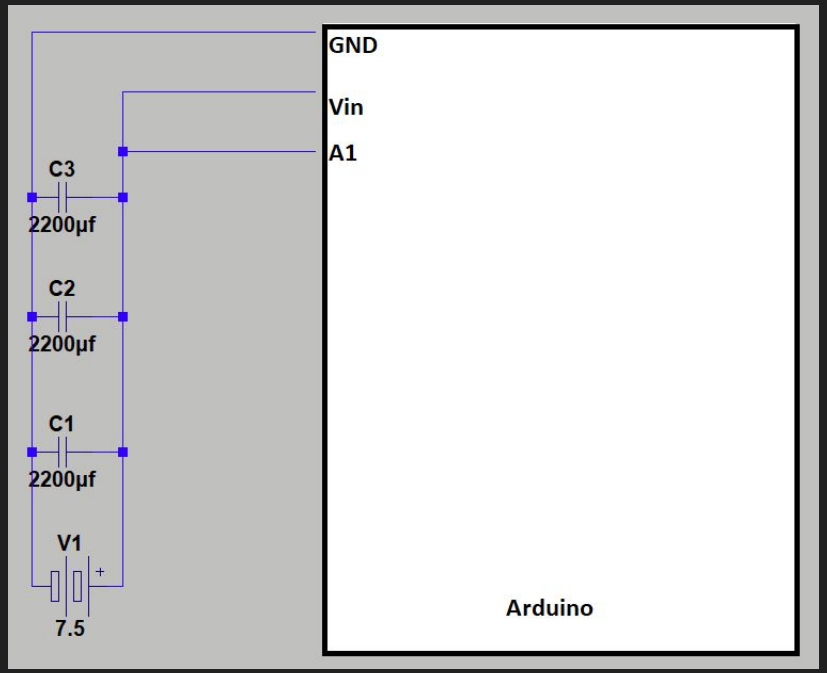


| Criteria | Unified Battery Supply & Voltage Regulator | Power Outage Detector | Both |
|---|---|---|---|
| **Edge Case [1]** | X | O | O |
| **Edge Case [2]** | X | X | O |
| **System Damage Upon Failure** | Potential damage to Arduino (Can be caused by broken voltage regulator) | X | Potential damage to Arduino (Can be caused by broken voltage regulator) |

O: Solved, X: Not Solved

# Power Loss Detector Circuit Chosen

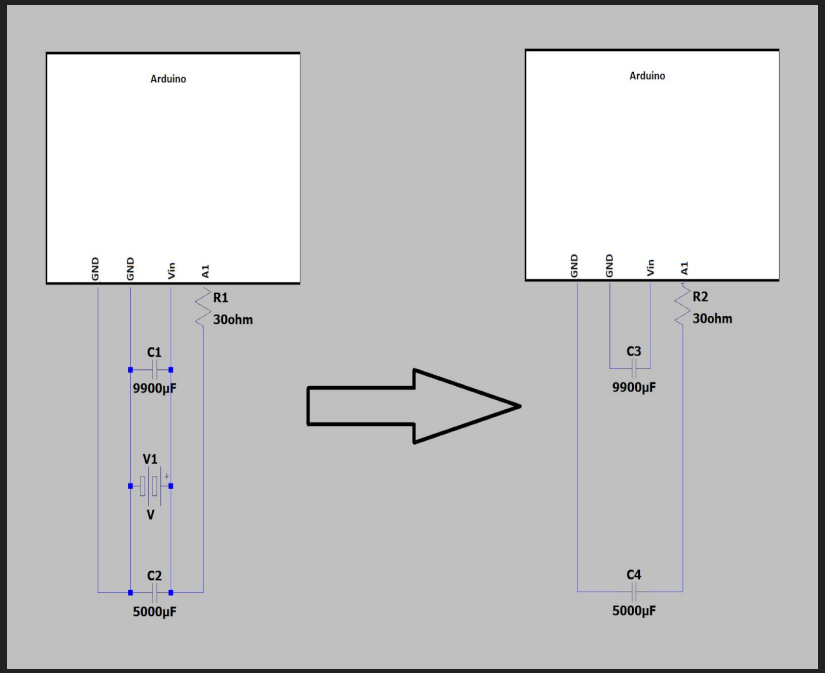
# Prototype A



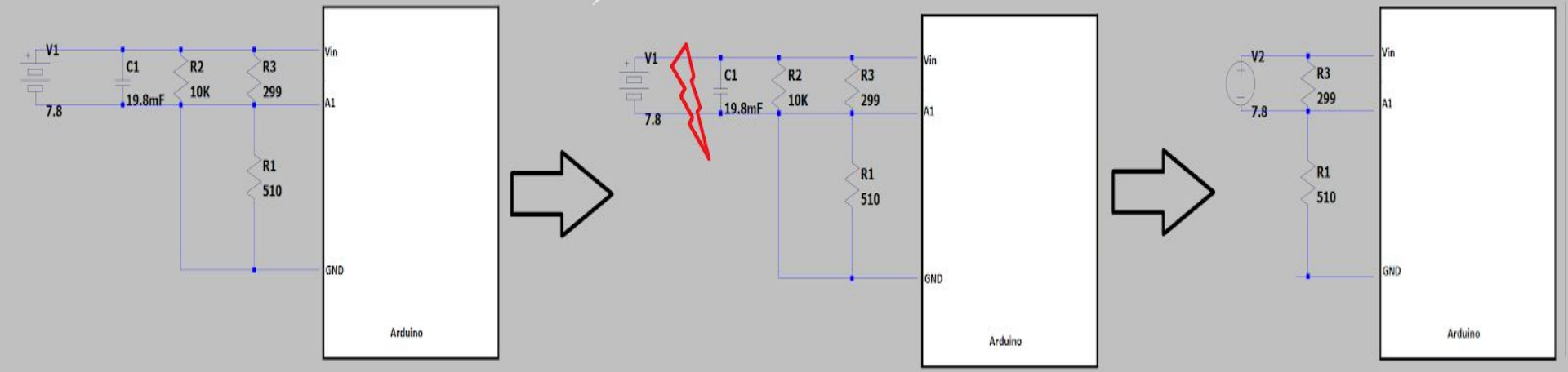

By adding three capacitors in parallel,  circuit is able to provide approximately 0.2seconds till Arduino turns off.
(6600uF*1.5V)/0.05A = 0.198sec.

- Arduino needs at least 5V to operate

# Prototype B




Causes Complexity




[Prototype C (Chosen)]

Capacitors are fully charged before the moment V1 disconnects from the circuit. This can be signified as $0^-$ of time.

- Arduino has embedded “analogRead()” method which can be utilized to measure 0~5V.
- When battery splits off from the circuit, C1 and R2 can be considered as a battery = 7.8V at time = $0^-$

Capacitors starts to discharge after the moment V1 disconnects from the circuit. This can be signified as $0^+$ of time.

- C1 and R2 behaves as a battery until Arduino receives below 5V (Least Operating Voltage)
- Circuit becomes Voltage Divider

$$Vs = Vin$$

$$V_{A1} = Vs \frac{R_1}{R_1 + R_3}$$

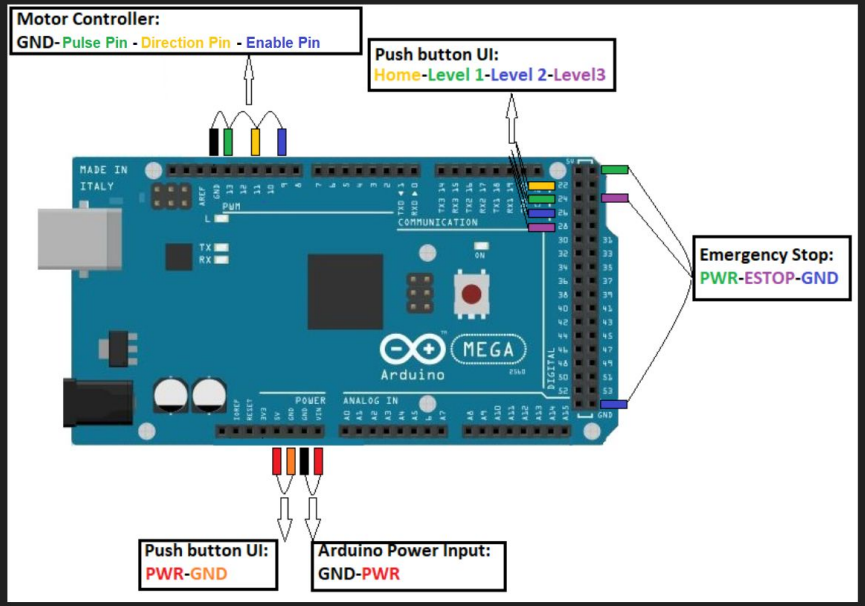
$$When\ Vs = 8V, \quad V_{A1} = 8 \frac{510}{299 + 510} = 5.043V$$

$$When\ Vs = 7.5V, \quad V_{A1} = 7.5 \frac{510}{299 + 510} = 4.728V$$

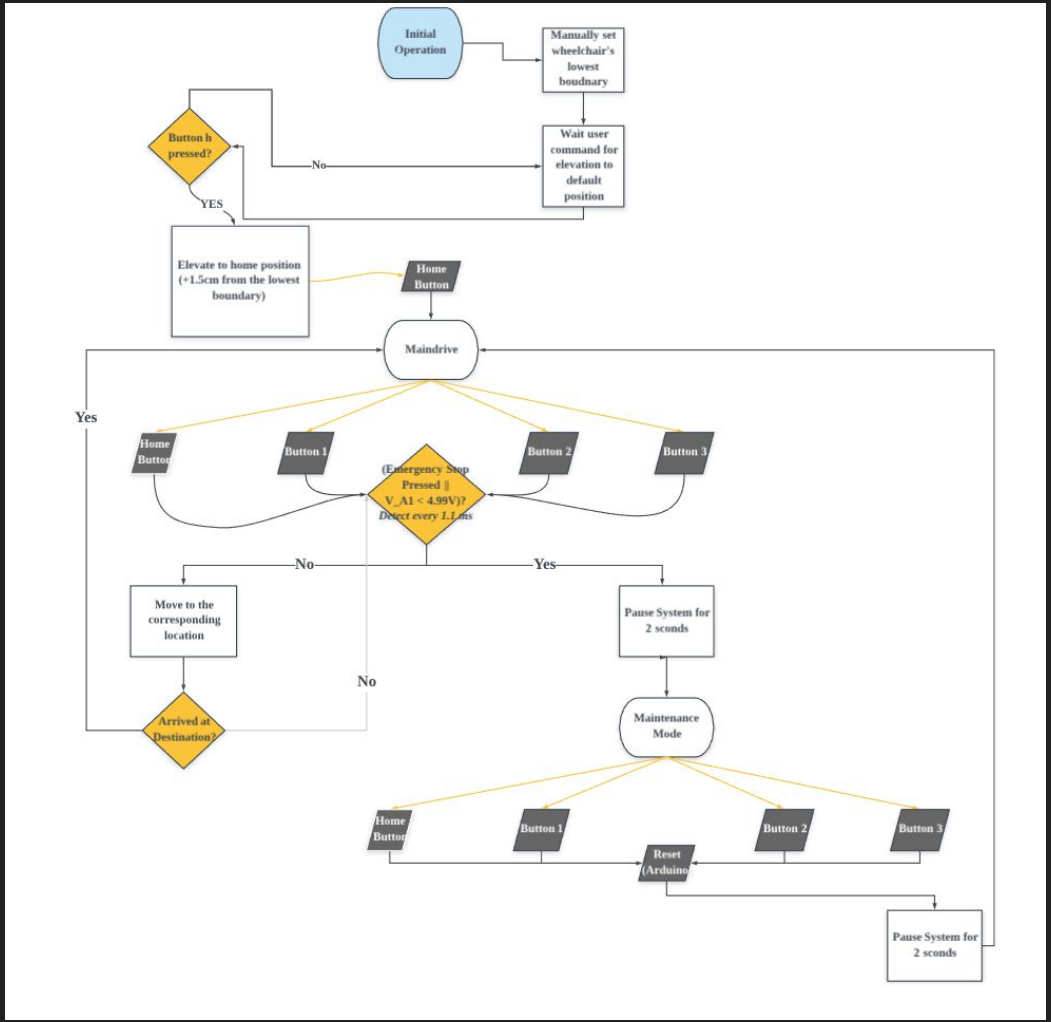
- Current System is chosen to stop working at instant when incoming voltage to A1 < 4.99V.
- When Vs = 7.9V, the system will trigger Maintenance Mode (To be Shown in next Flowchart)
- The value of which Arduino determines the status of power loss is highly flexible according to resistors used to make the circuit and the target value within the program.

# Arduino Pin Diagram

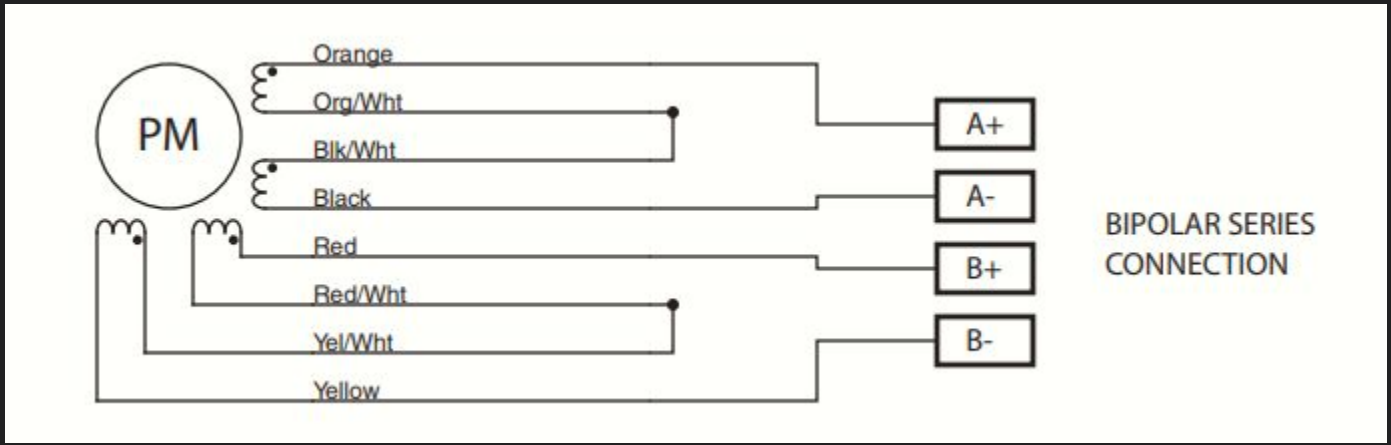
- Power Loss Detector Circuit has been designed and installed to Arduino to further aid patients by storing position data more frequently and accurately
- Pins plugged into Arduino is more converged and easier for access



# Software Flowchart



# Motor wiring diagram



# In action!

# What we solved!

- Milled Al 6016 mounts and shafts
- Power Loss Detector triggering when Incoming Voltage to Arduino < 7.9V has been designed and implemented
- Two-seconds delay before and after pushing buttons within maintenance mode has been designed and implemented to prevent the following scenario: users accidentally pressing buttons immediately after Maintenance Mode is triggered.
- Emergency stop has been implemented to stop the rotation of motor shaft during level transition
- Increased height adjustment speed from approximately 1.437 rps to 5 rps, increase
- Created a modular design with the new motor mount

# Future Improvements

New lifting mechanism removing seat “scissor action”

Additional gear reduction, reducing torque required for motor.