Pin Art Pro

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Team 60

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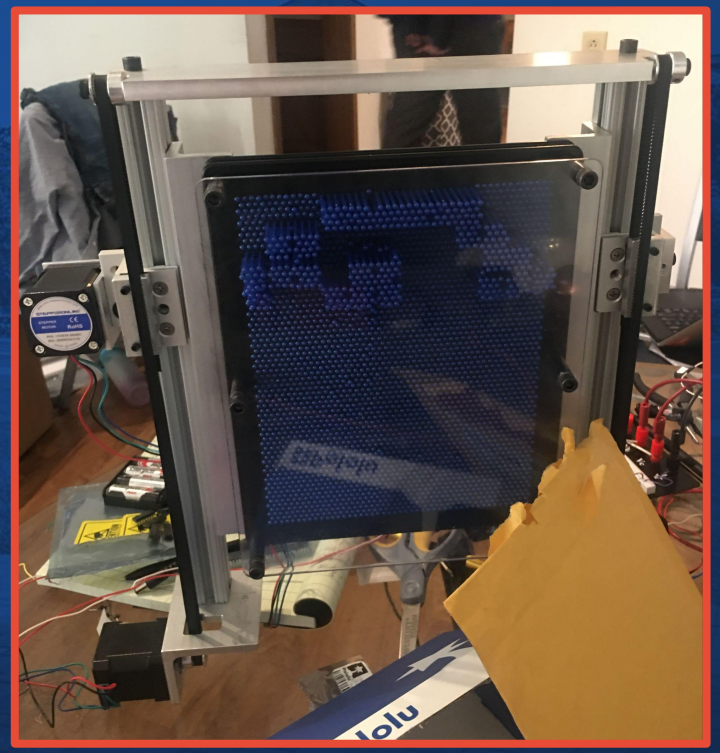
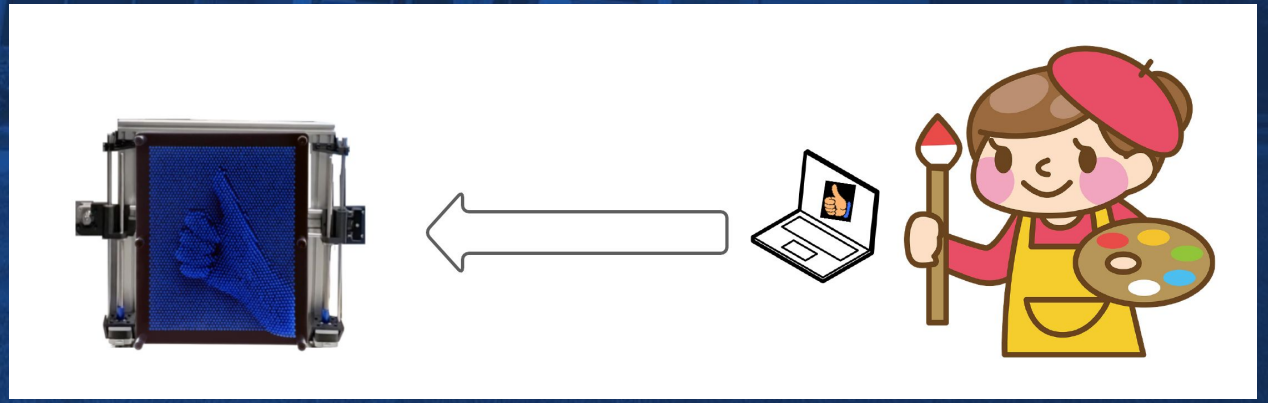
INTRODUCTION

Automated Rendering of Digital Images Onto Physical Medium



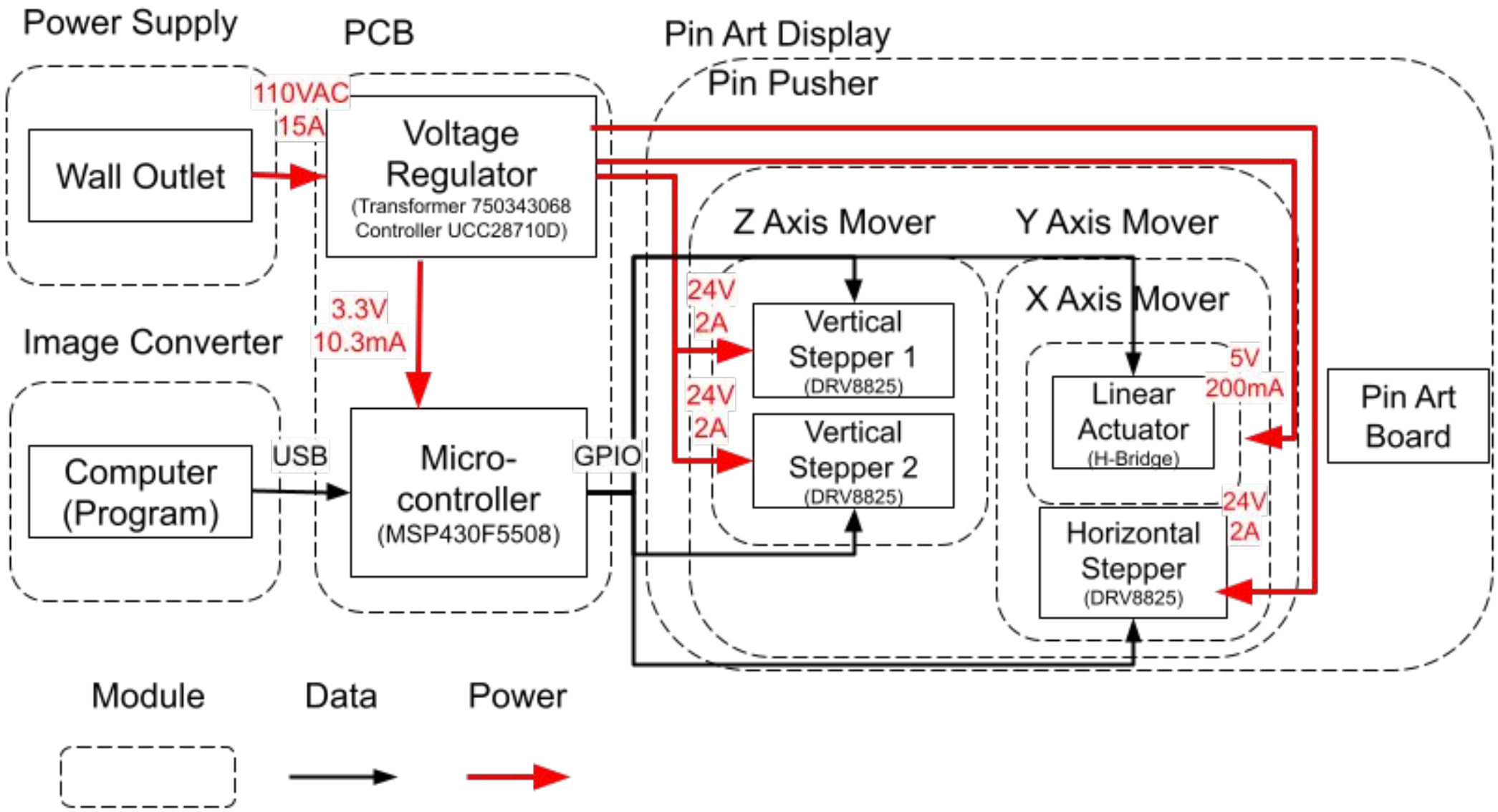
OBJECTIVE

- Allow artists an accessible medium for mechanized art
- Create tactile surface to visualize art

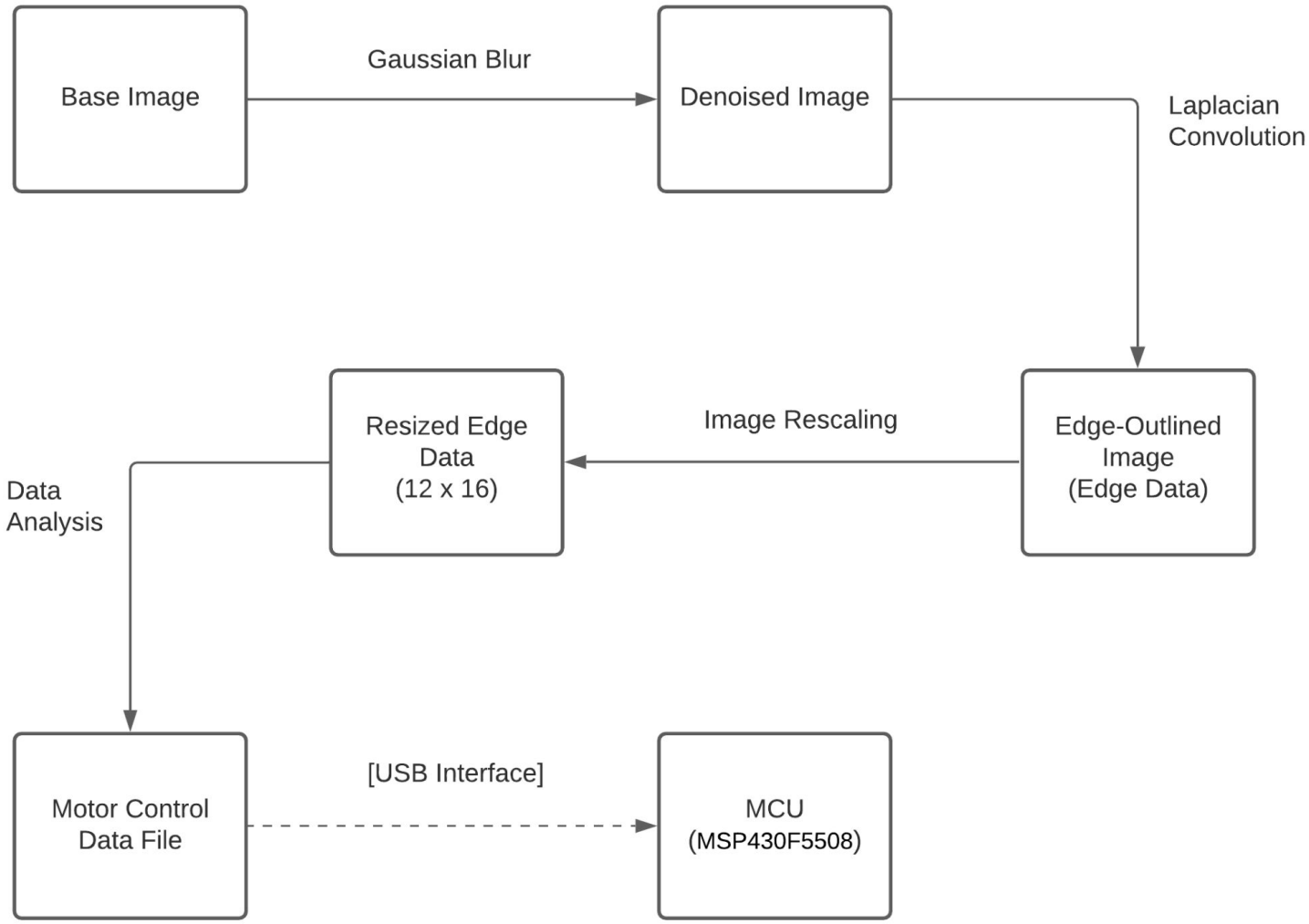


Design

Block Diagram of System



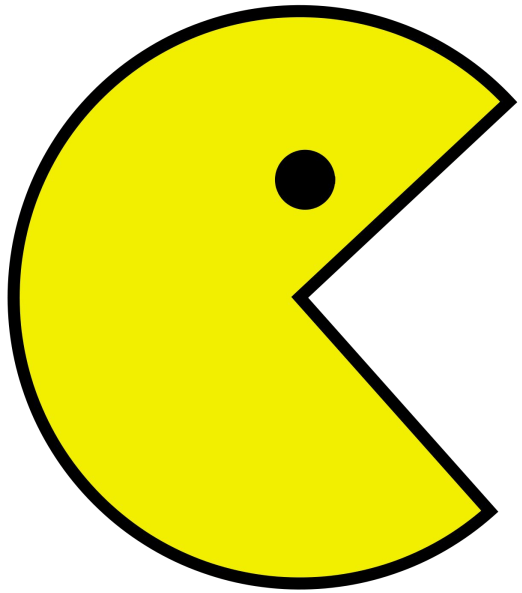
Software - Generating Motor Data

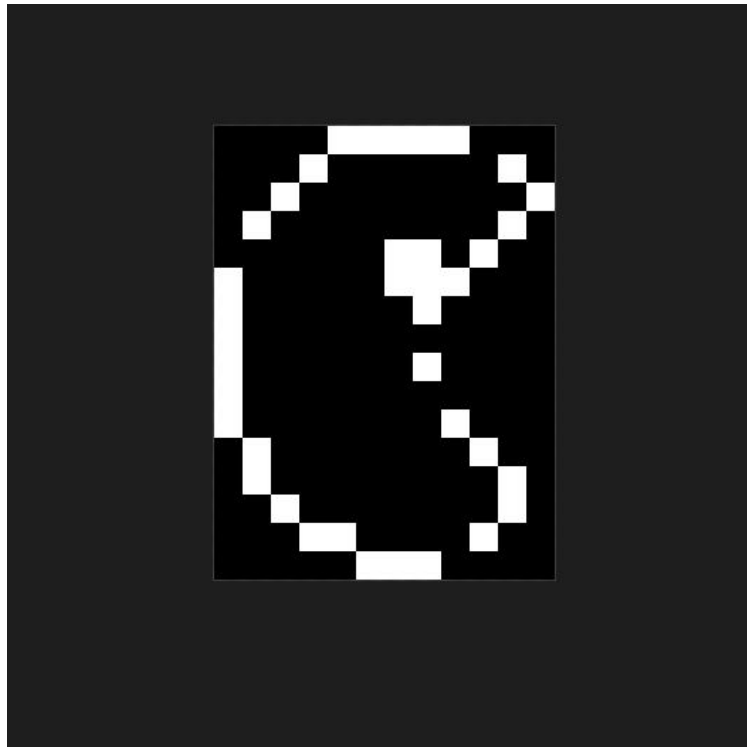


Implemented using Python OpenCV

Software: Requirements and Verification

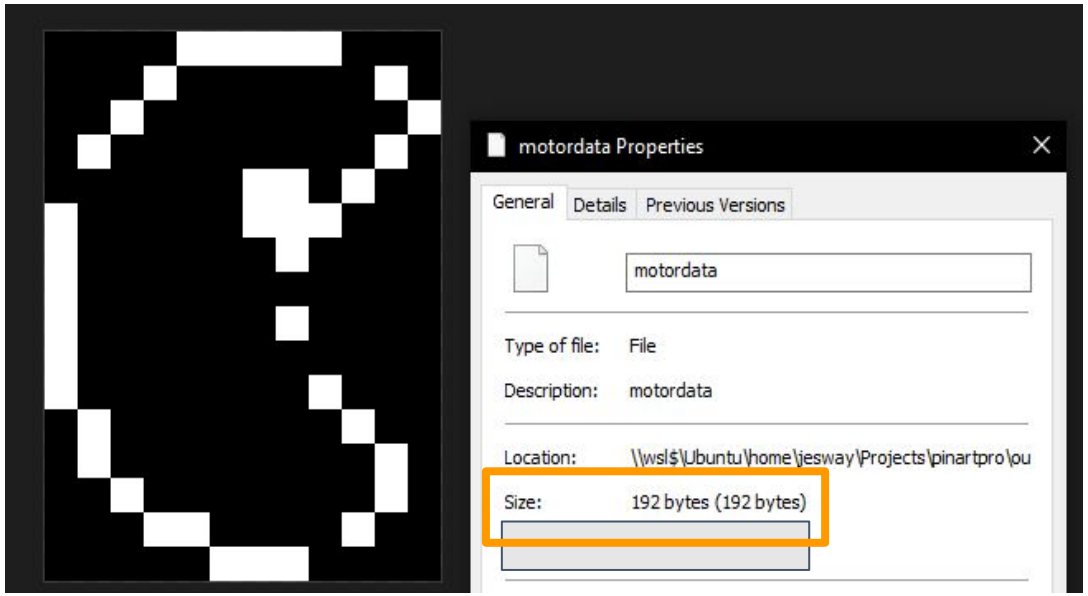
Requirement: Arbitrary Image -> Motor Data File Creates Visually Recognizable Output





Software: Requirements and Verification

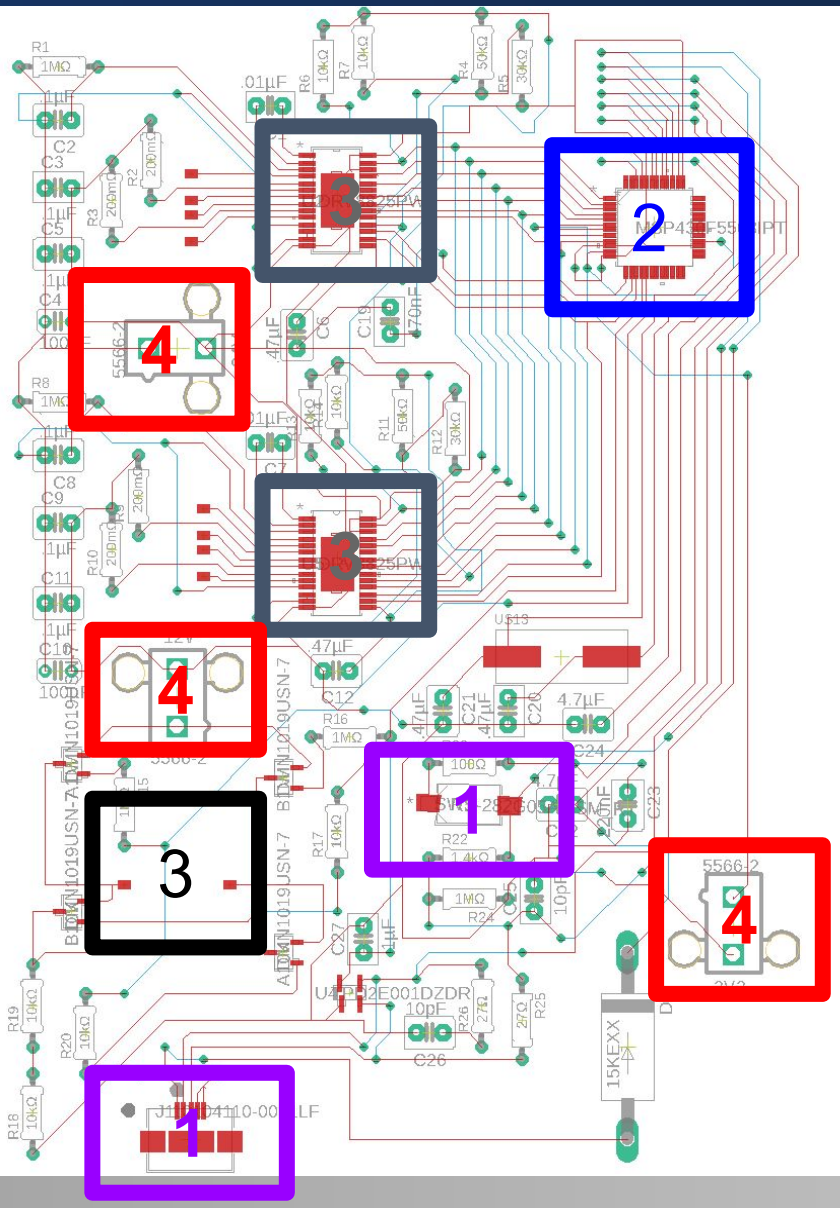
Requirement: Motor Data Must Fit Onto Memory of Microcontroller



Microcontroller	Available Memory (KB)
MSP430F5508	4
Arduino Uno Rev. 3 (Backup)	2

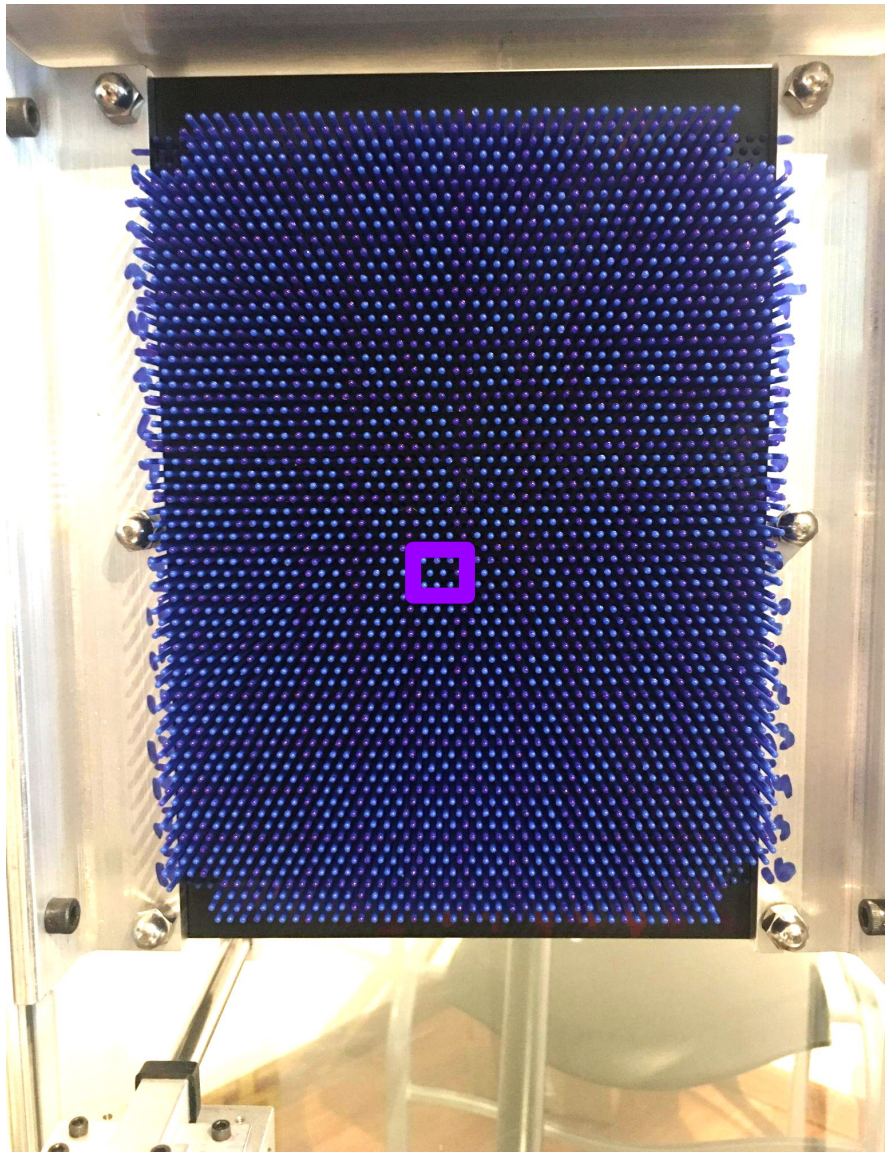
Control System PCB

1.) **Software interacts with microcontroller through Micro-USB clocked by 24MHz Oscillator Crystal**

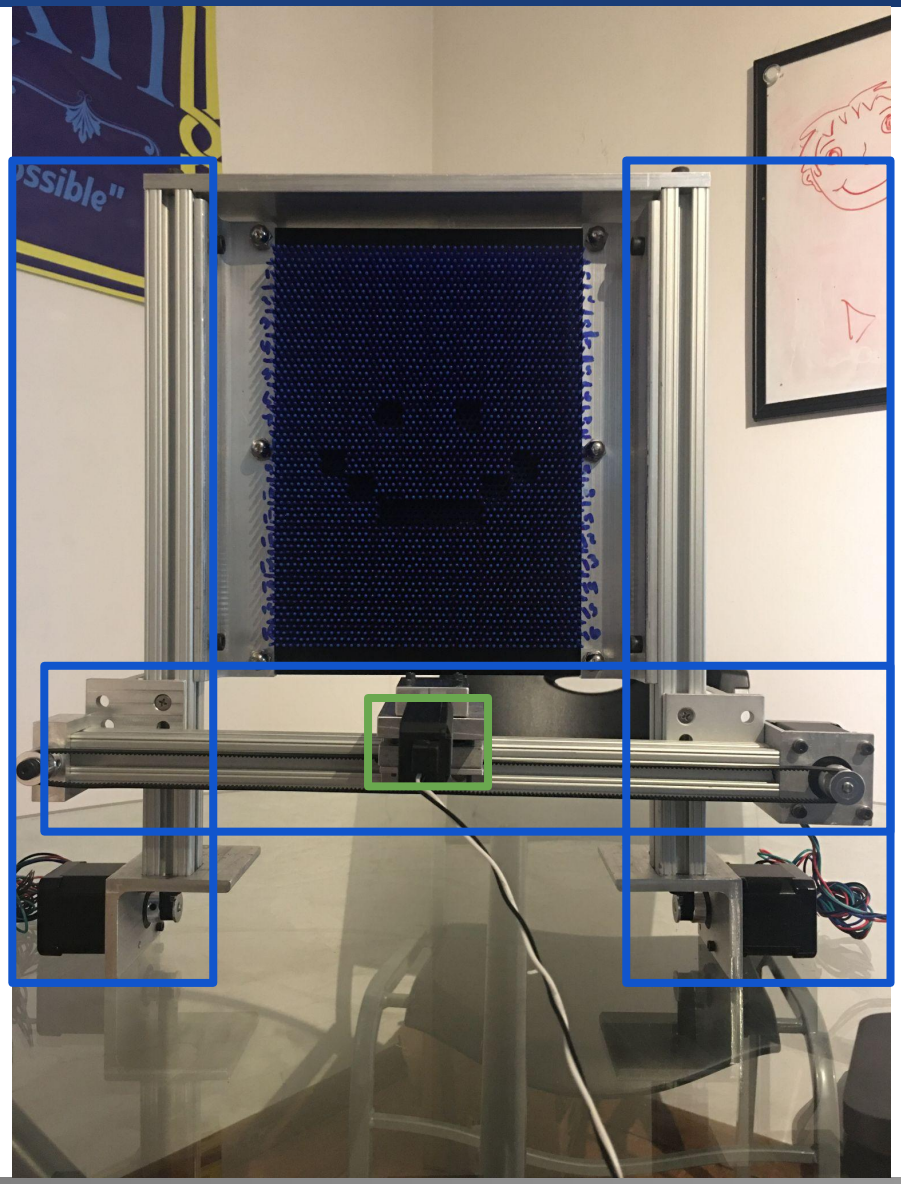


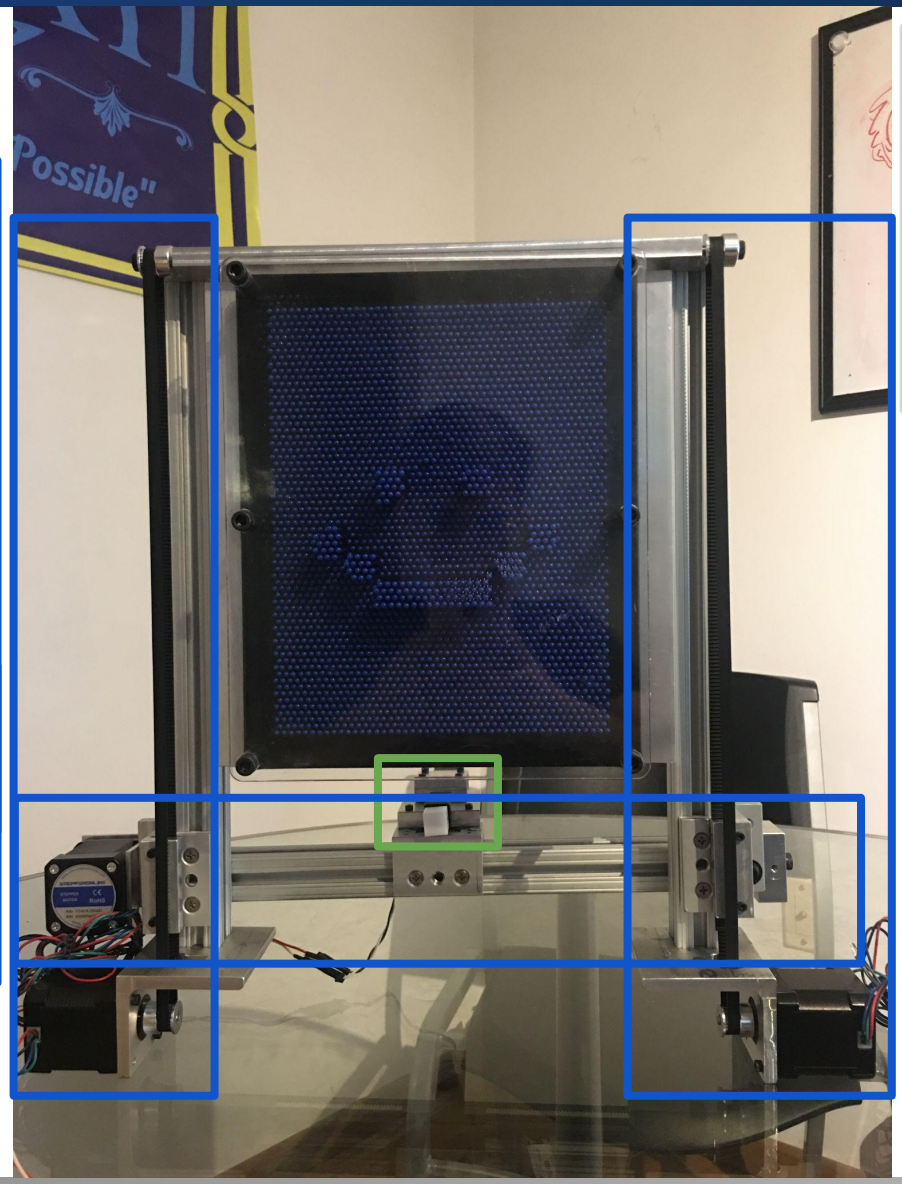
Pushpin Grid

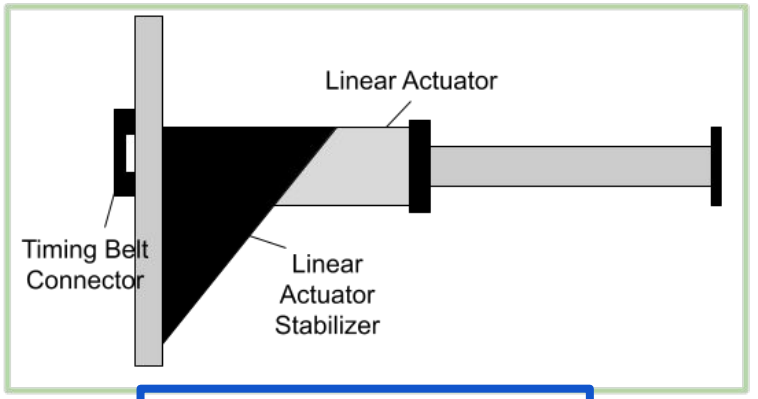
1	2	3	4	5	6	7	8	9	10	11	12
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											

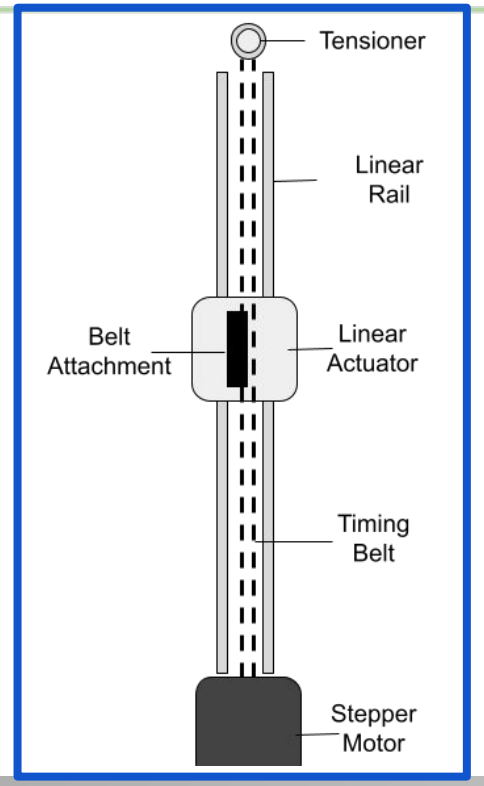


Mechanics

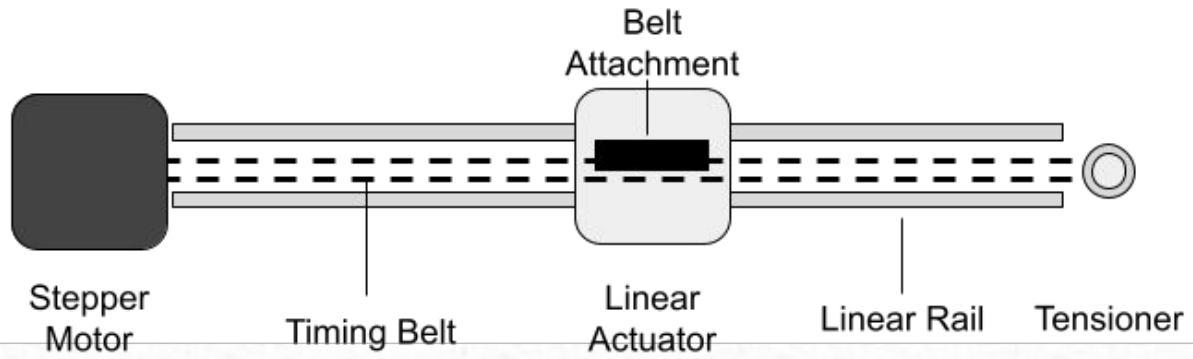




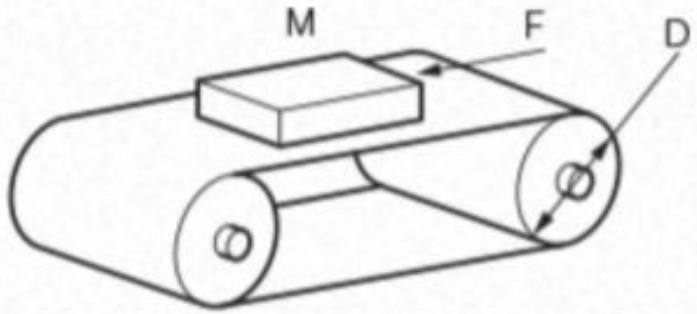

Linear Actuator
Timing Belt Connector
Linear Actuator Stabilizer


Tensioner
Linear Rail
Belt Attachment
Linear Actuator
Timing Belt
Stepper Motor

Stepper Motor - Calculations



Torque by Friction Force of Conveyor and External Force: T



https://www.mikipulley.co.jp/EN/Services/Tech_data/tech26.html

D : Diameter of the roller [m] = .0477
M : Mass of the load [kg] = .5 (horizontal) 2 (vertical)
g : Gravitational acceleration[m/s^2] = 9.8
μ : Friction coefficient of the conveyor = .1
F : External force [N] = 0 (horizontal), 4.9 (vertical)

$$T = \frac{1}{2} D(F + \mu Mg)[N \cdot m]$$

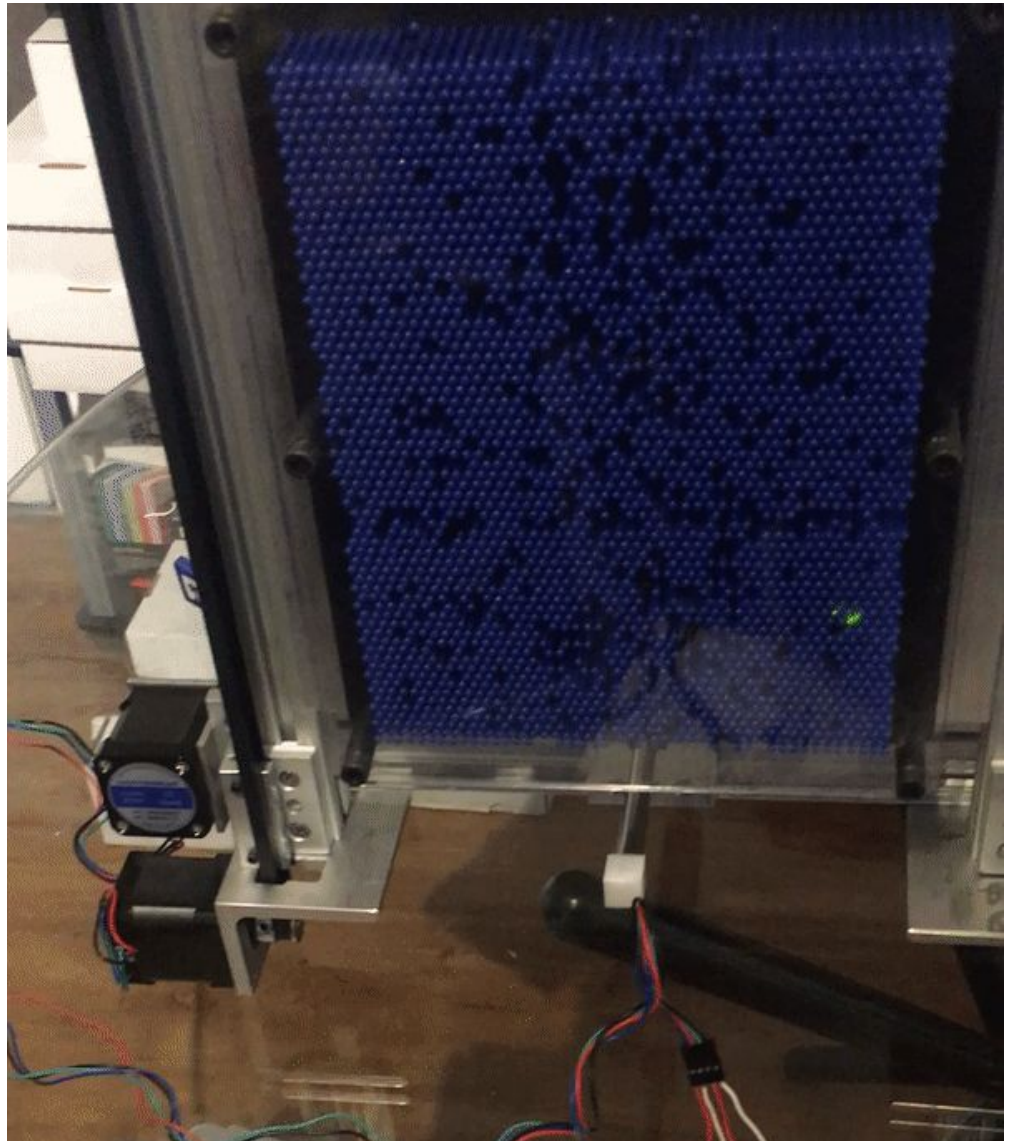
(Normally, μ : approximately 0.05 to 0.1)

Torque Required (horizontal)
T = 1.169Ncm

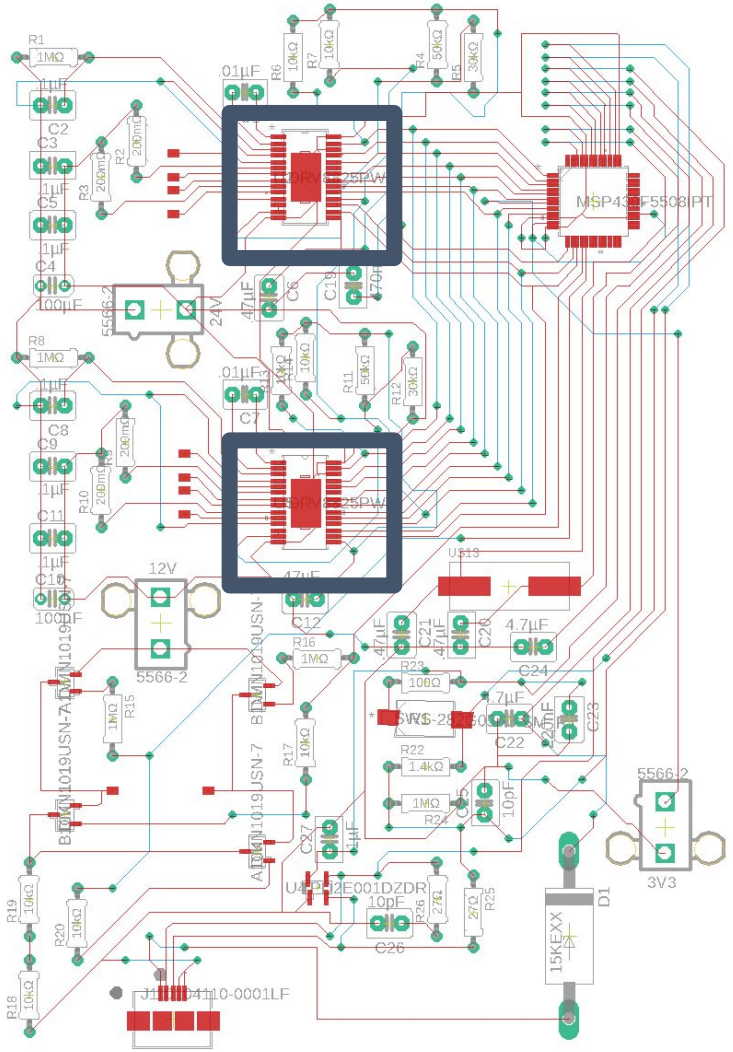
Torque Required (vertical)
T = 51.42Ncm (total) T = 25.71Ncm(per)

Torque Available (per)
T = 50Ncm

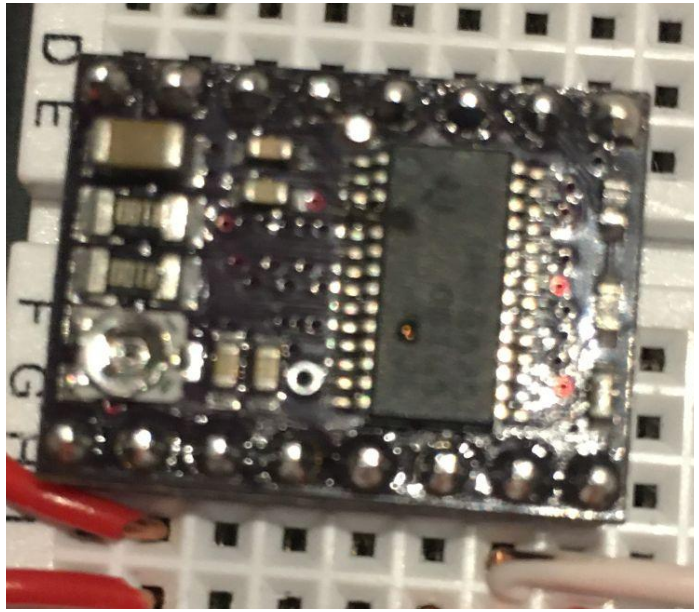
Stepper Motor - Success & Challenges



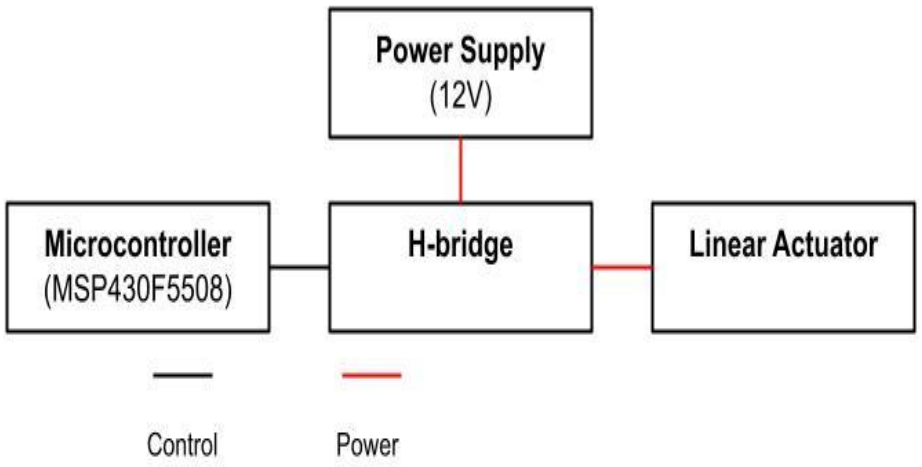
Needed 3 motor drivers, PCB had 2



Fried breakout board when testing



Linear Actuator - Operation



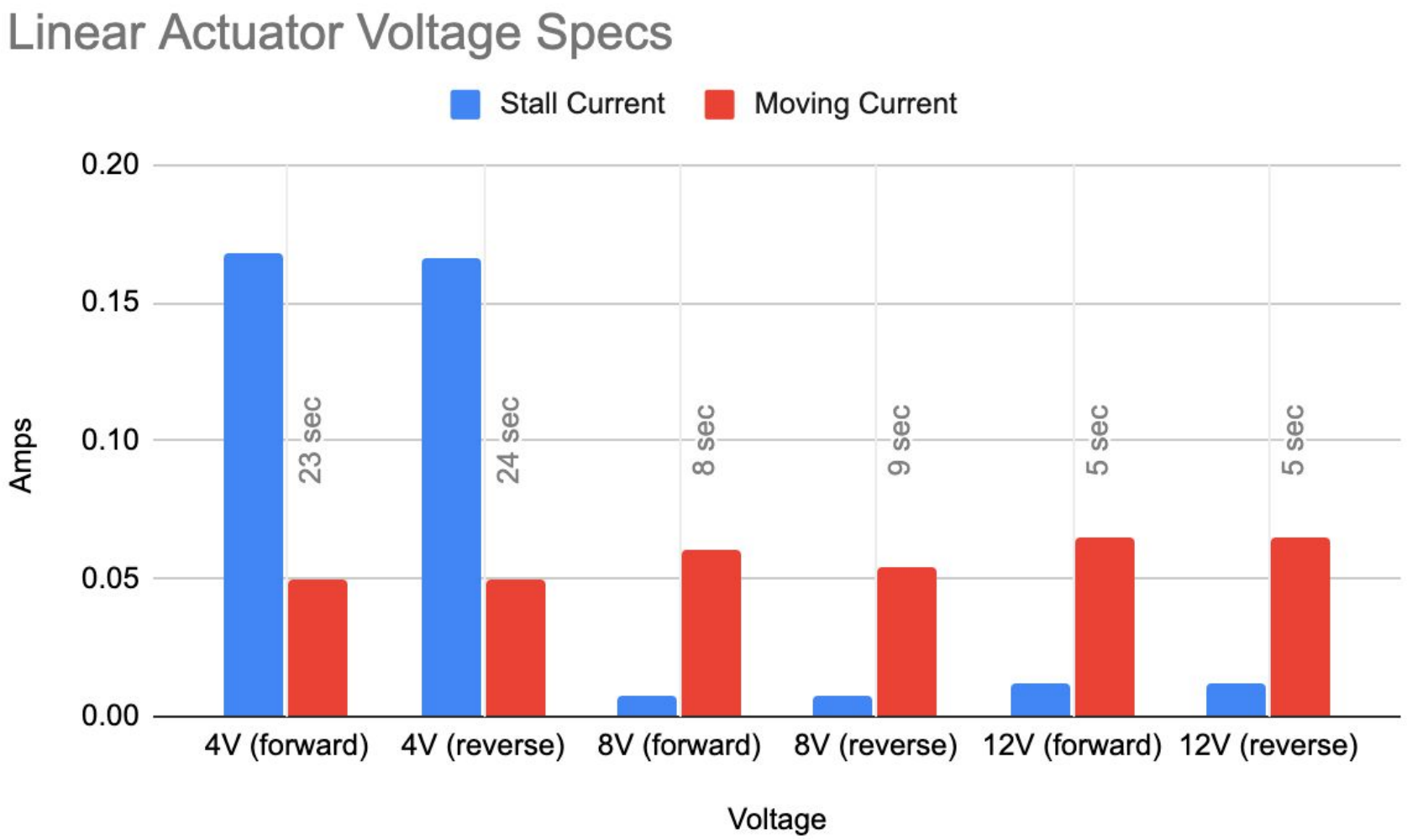
Basics

- 2-input device
- Movement controlled by potential difference
- Input voltage from +/-3.3V to +/-12V
- Affects movement speed and force

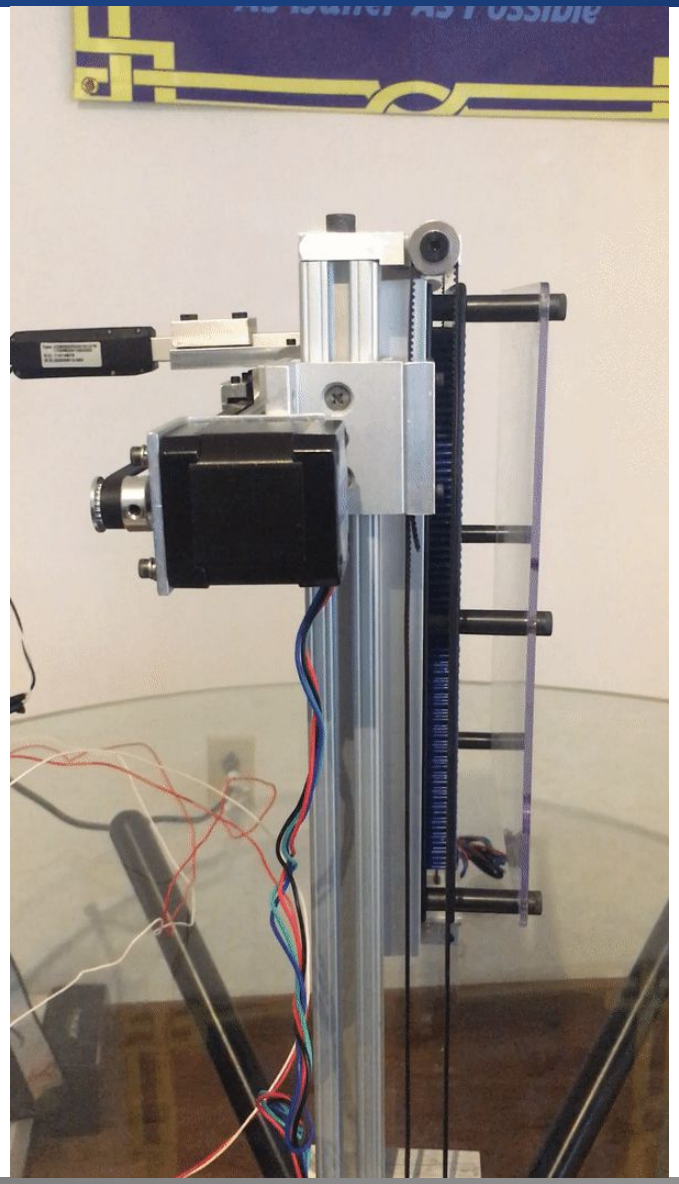
Linear actuators consume large amounts of power

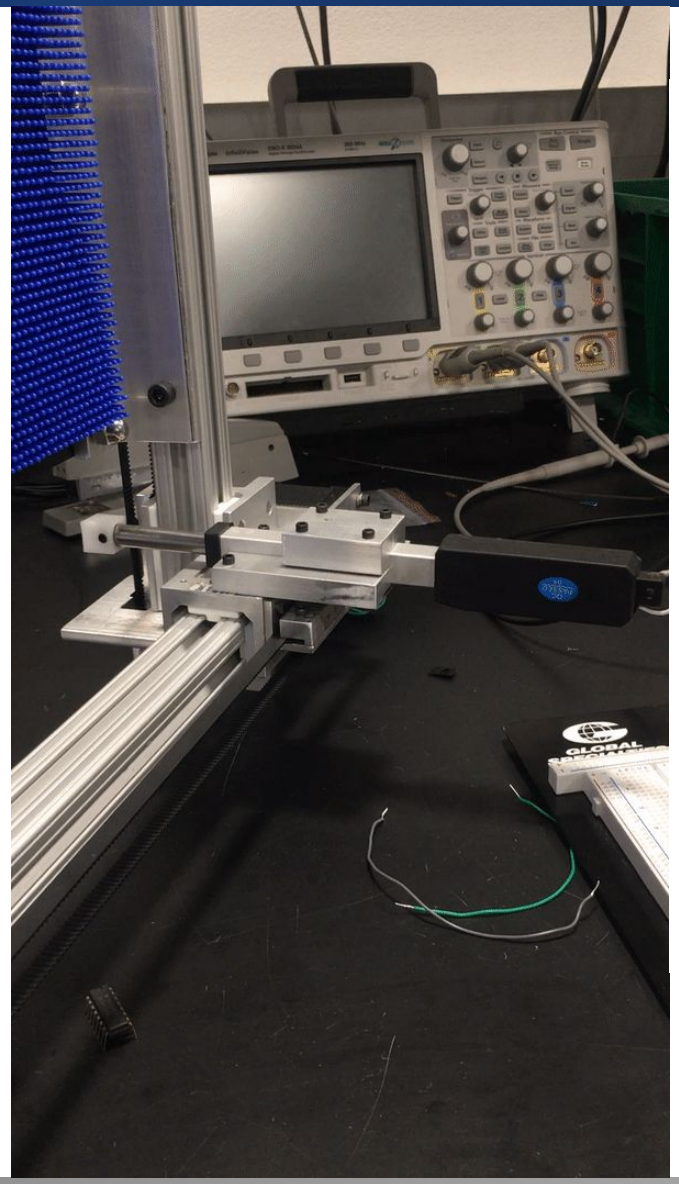
- Our microcontroller (MSP430F5508) can only output 4V, 2mA maximum

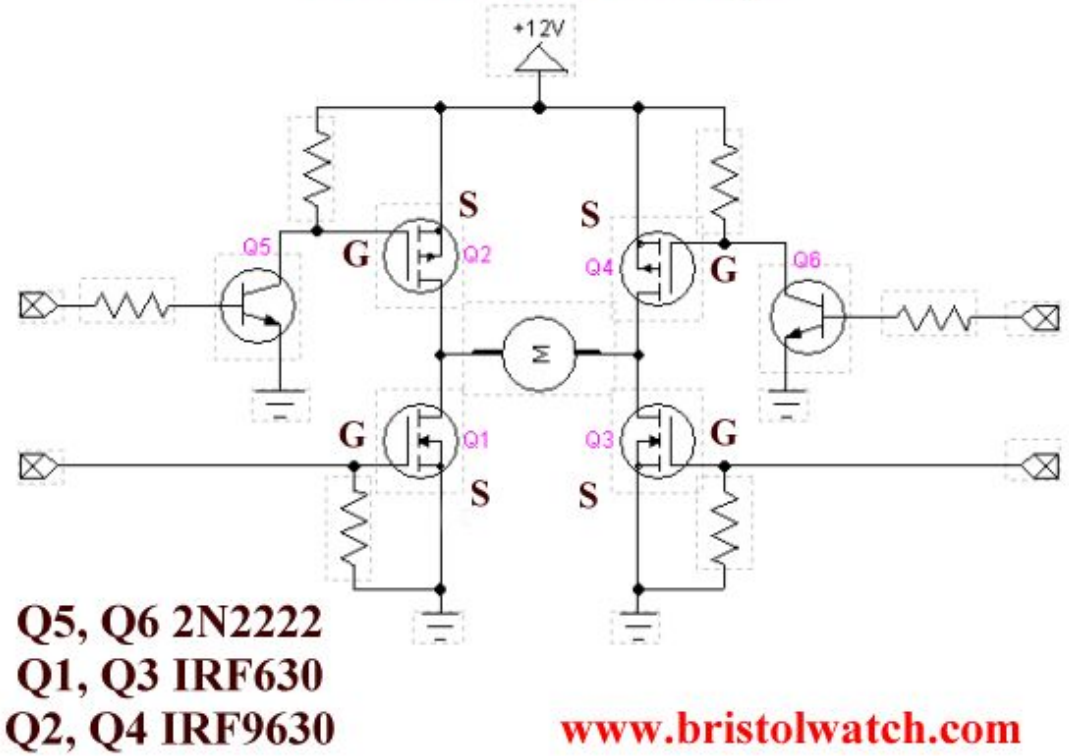
Linear Actuator - Operation



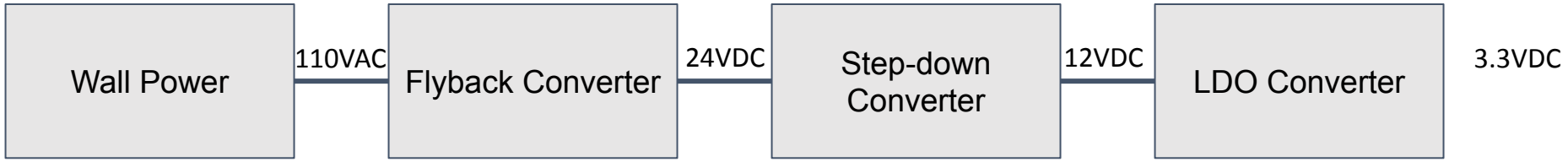
Linear Actuator - Success and Challenges







Power System - Overview



Basics

- 24VDC: stepper motors
- 12VDC: linear actuator
- 3.3VDC: microcontroller

The power system not only provides accurate voltage, but also enough power to drive components

- Many components (stepper motors, linear actuator) have high power requirements

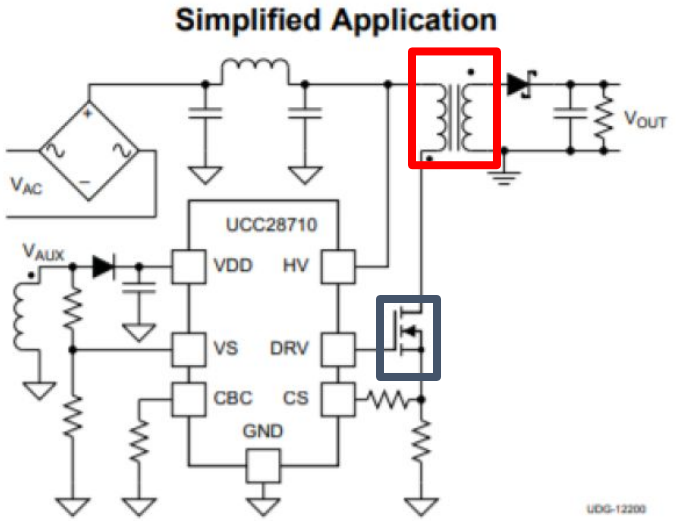
Power System - Calculations

$$I_{total} = I_{motors} + I_{actuator} + I_{micro} + I_{other} \quad (2.1)$$

$$I_{motors,max} = 2 \times I_{motor,phase} \quad (2.2)$$

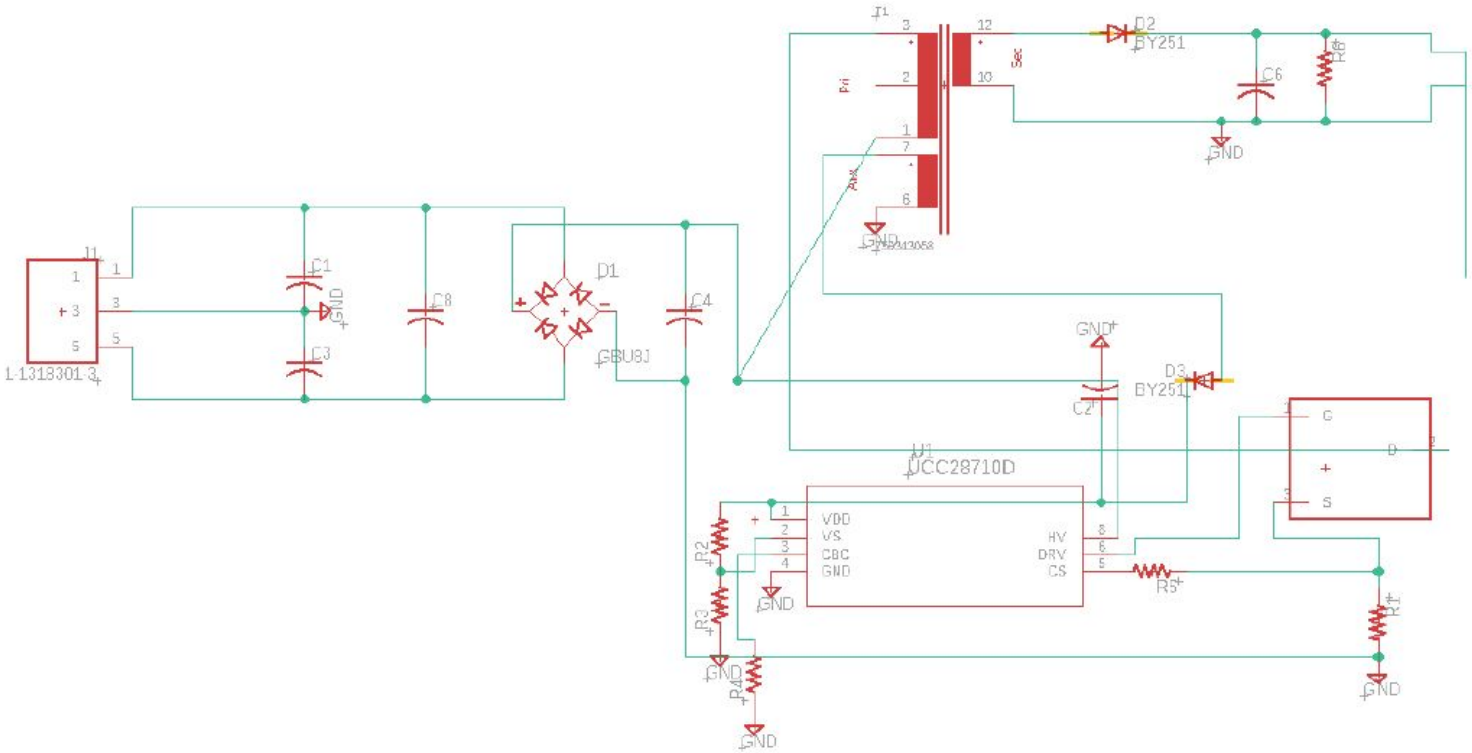
- **Flyback Converter: 5A**
- **Step-down Converter: 0.5A**
- **LDO Converter: 0.25A**

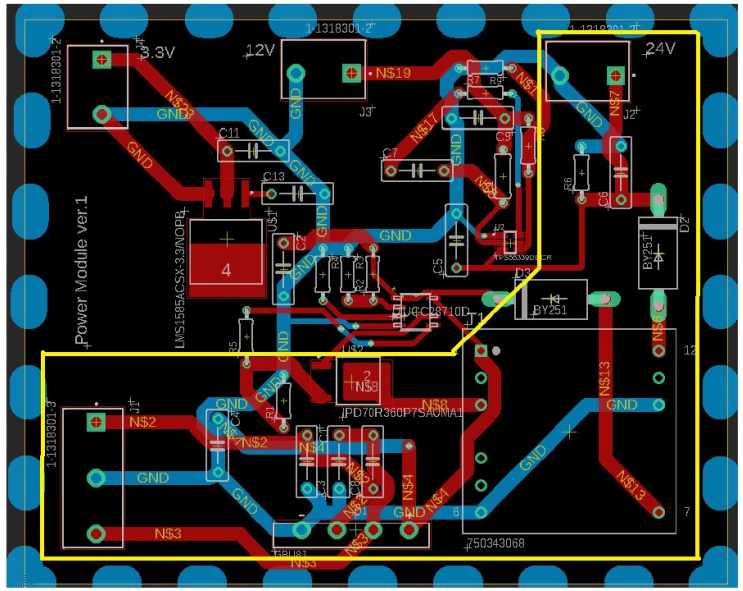
Power System - Flyback Converter



- **Simple, low cost switch-mode converter for AC/DC**
- **Provides mid-range power (10W - 100W)**
- **primary switch, flyback transformer**
- **DCM mode**
- **UCC28710D flyback controller**

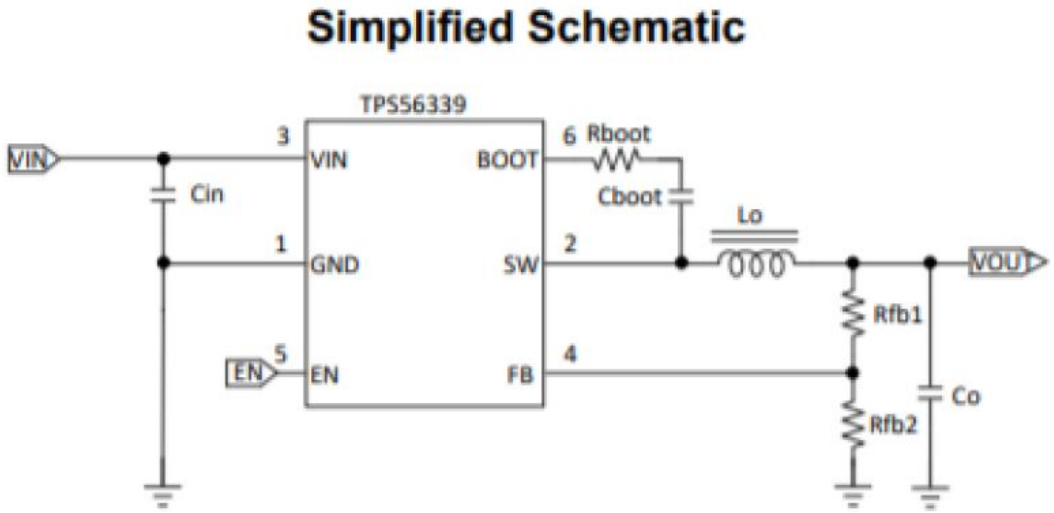
Power System - Flyback Converter





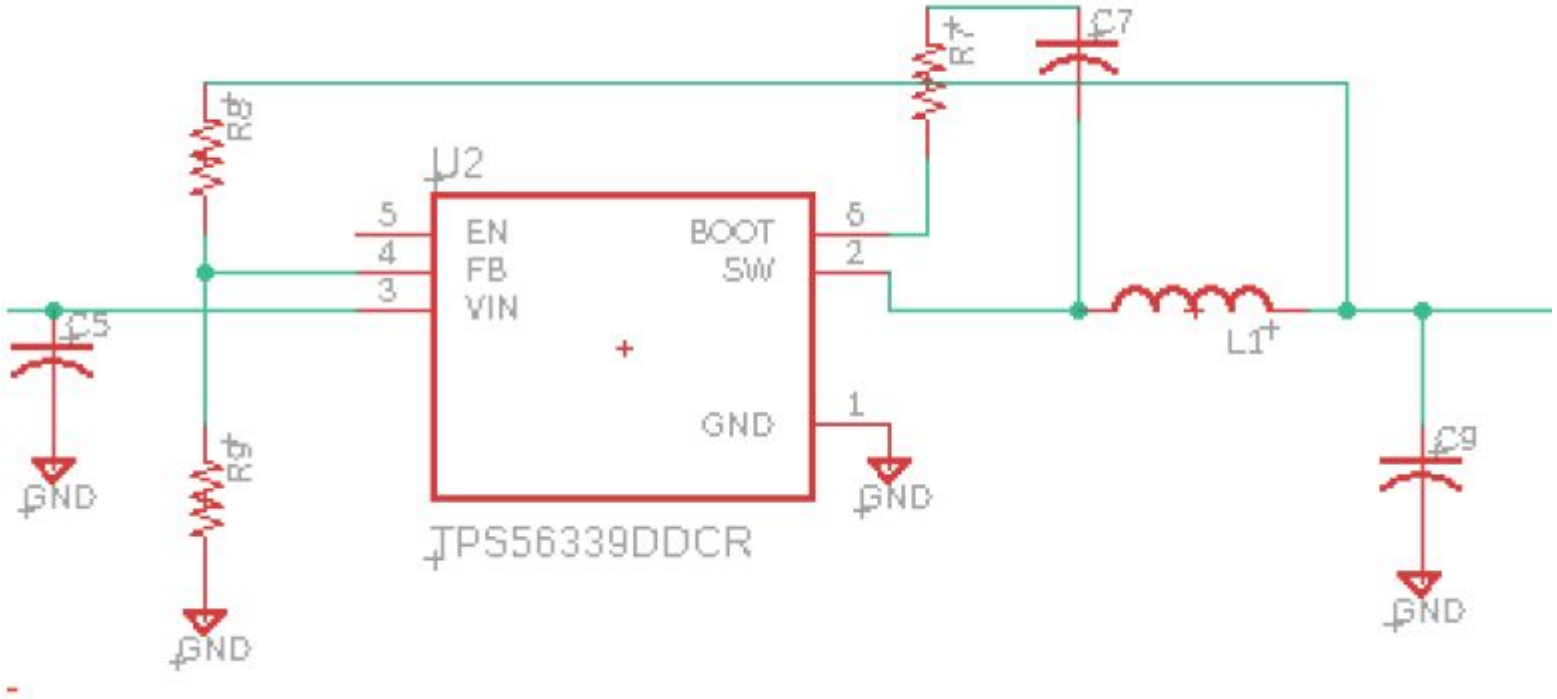
- **The design successfully outputs the expected voltage**

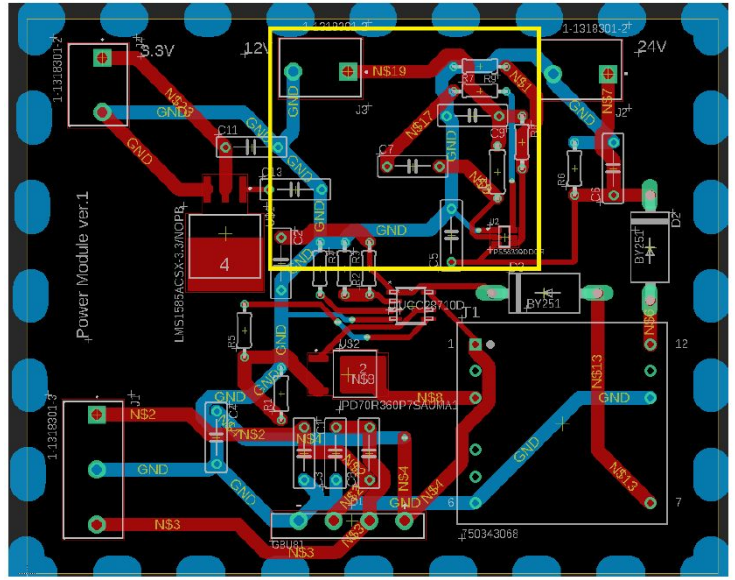
Power System - Step-down Converter



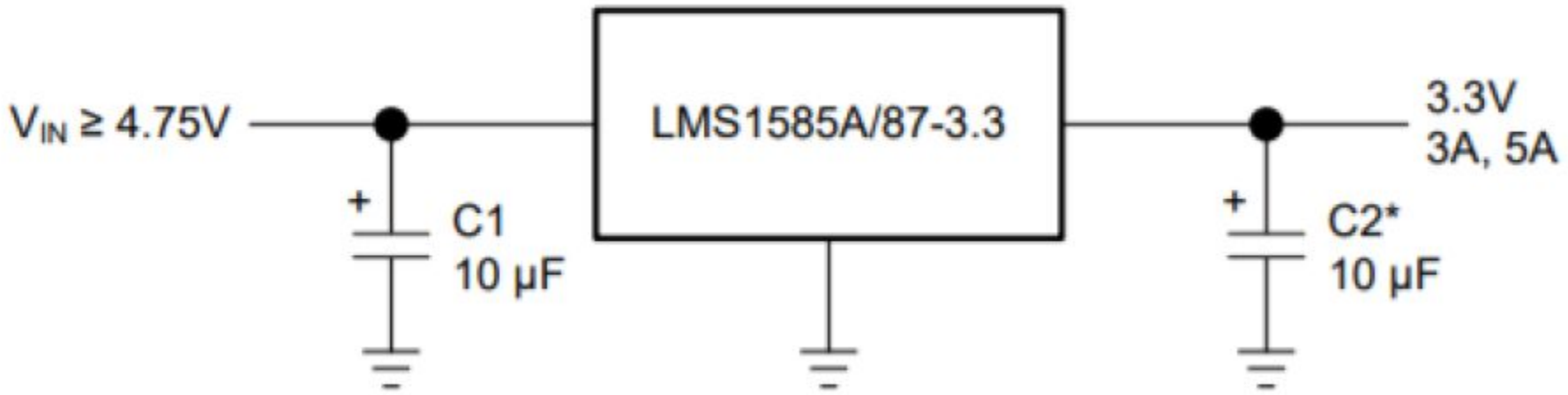
- **Buck converter**
- **Good power efficiency**
- **TPS56339 buck converter**

Power System - Step-down Converter



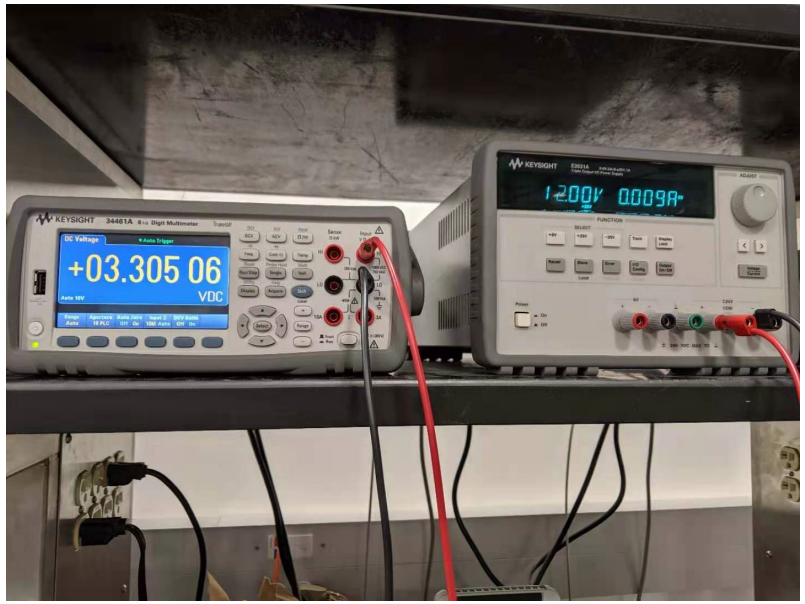


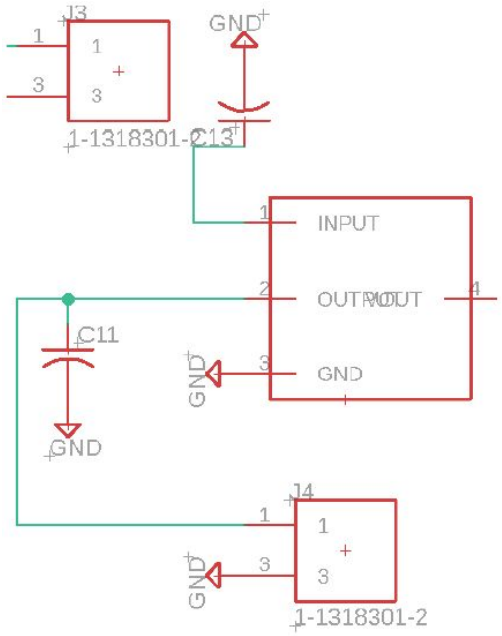
Power System - LDO Converter

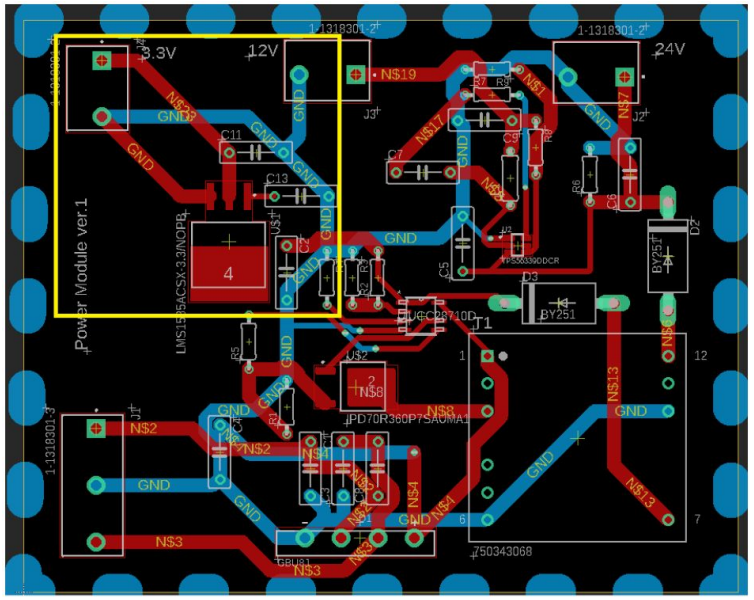


- **Voltage converter for low power**
- **LMS1585ACSX-3.3**
- **fixed voltage output (3.3V)**

Power System - LDO Converter







- **Successfully outputs the desired voltage**

Power System - Successes and Challenges

Successes

- **Flyback converter and LDO converter work individually**
- **LDO converter successfully powers other components**

Challenges

- AC/DC output voltage had large ripples
- The system did not provide enough output power
- Chip packagings are difficult to operate (TPS56339)
- Errors in inductance calculations

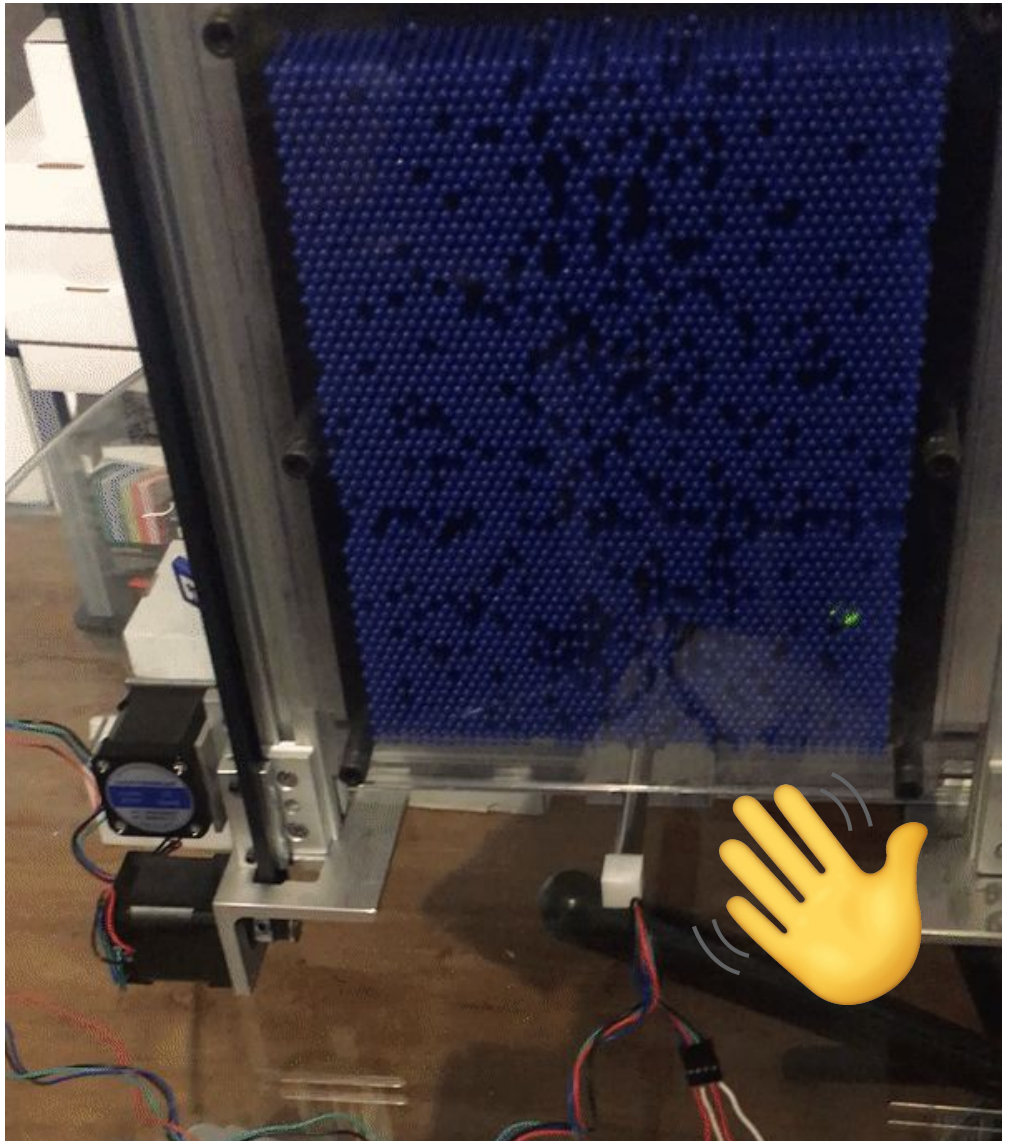
High-level Design Considerations

- Cleaner PCB design
- Utilize more simulation before implementation
- Use chips with packagings easier to use

ETHICS

Ethical Considerations

- **Safety**
  - USB-Associated ESD Concerns
    - Used ESD suppressing component
  - Stepper Motors could pinch hand
    - Set boundaries on movement through software
  - Linear Actuator can extend past board
    - Used less voltage to drive linear actuator so it stalls at edge
  - High voltages could electrocute user
    - Enclose our power system
    - Use connectors that are more stable



CONCLUSION

Conclusions

- **Mechanical, software, hardware, and power components tested and verified**
- **Integrated software with hardware and mechanical components**

Further Work

- Integrate H-Bridge Driver for Linear Actuator
- Use multiple linear actuators to shorten render speed
- Implement completely on PCBs

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