Pressing Matters

Fall 2024 Design Review Presentation

What are we trying to solve?

- Screen printing electrodes for flexible, wearable biosensors
- Electrodes are screen printed by hand, which can be time consuming and wastes expensive conductive ink
- The goal of this project is to build a desktop-sized printer that automates this process while minimizing wasted ink.

Results of Market Survey

- Existing printers sold commercially for lab applications can cost thousands of dollars
- Ultimately the market for wearable sensors is massive and continues to grow
- Screen printed electrodes also used in water quality testing and sensing environmental contaminants

Customer Needs and Design Criteria

- Device can successfully squeegee onto stencil
- Squeegee motion is automated
- Controlled pressure on squeegee
- Control over volume of ink dispensed
- Accommodates 12in x 12in stencil
- Print time takes about 5-10 minutes
- Machine is easy to use
- Machine is easy to clean
- Device can cure stencil prints on plate (optional)

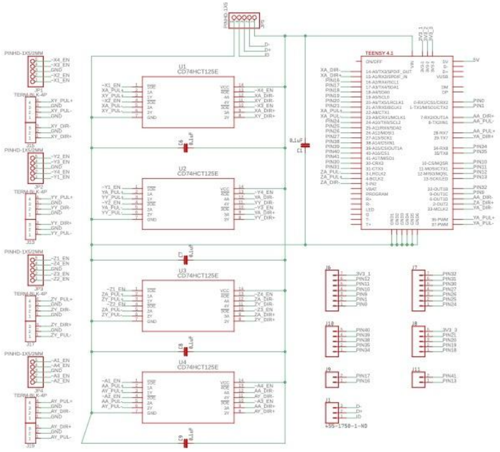
Standards/Regulatory Needs

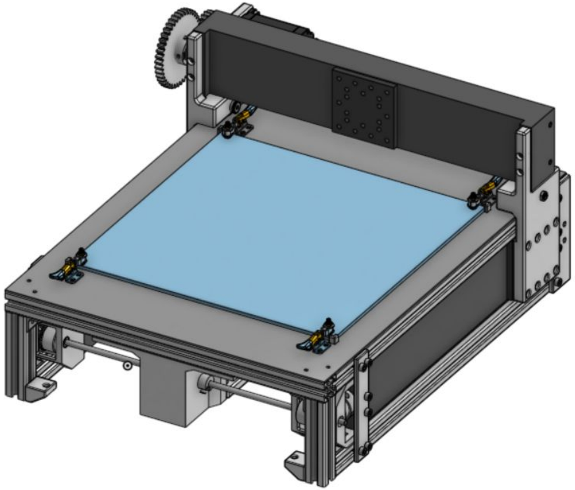
- Heating element must be covered (only applies if we include ability to cure print)
- Pressing motion must be contained to prevent injury
- Ink must be safely stored and uncontaminated
- Standard Electronics Communication Protocols
    - USB connection between Teensy and RaspberryPi

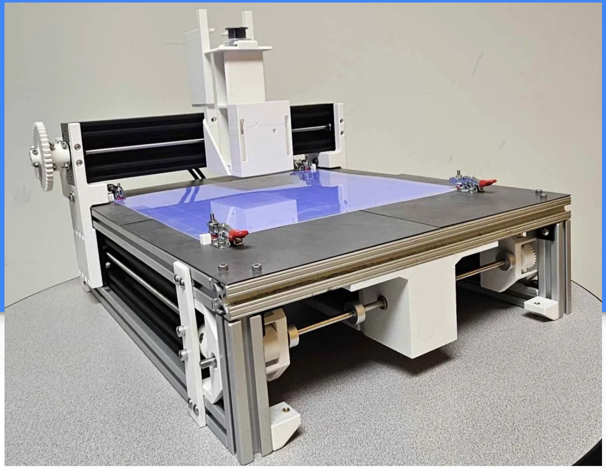
Targeted Final Specs

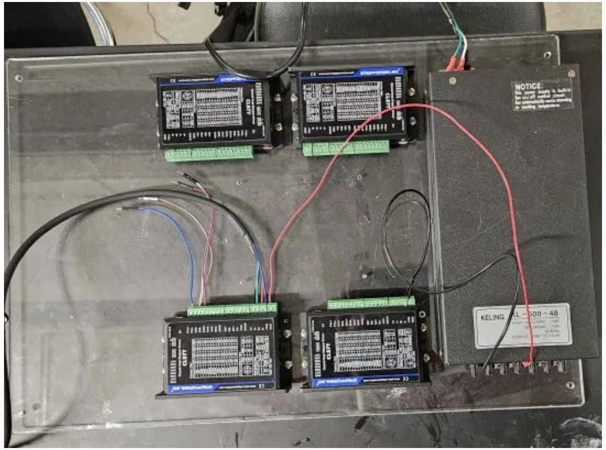
- Even pressure applied to each side of squeegee (2.5% force deviation)
- Minimize leftover ink (10% of dispensed ink wasted in each print)
- Final machine should have maximum dimensions 1.5ft x 1.5ft x 2.5 ft
- Printing time at or below 5 minutes
- Print should yield 95% successful electrodes
- Device should score 9/10 on a ease-of-use survey

Design Methodology









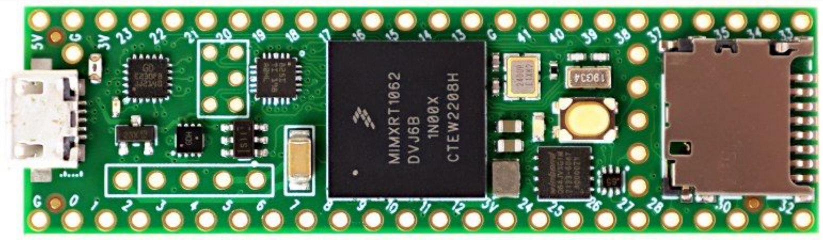
Design Decisions MECH

- Decided not to repurpose an existing 3d printer due to concerns about proprietary software and ability to provide downward force on squeegee
- 3d printed parts for rapid prototyping
  - PLA fairly reliable for most pieces
  - Will upgrade to higher quality materials if necessary
- Screw driven linear actuators chosen for fine movement control
  - This mechanism was chosen through a pugh scoring matrix of several designs

Category	Detail 1	Detail 2	Detail 3	Detail 4
Container	Bottle clip	Threaded cap	Vent cap	Syringe
Dispenser	From housing	From tube		
Dispenser System	Peristaltic pump	Regular pump	Syringe-type plunger	~~gravity feed~~
Stencil Holder	~~Pen clamp~~	Single clamps		
Squeegee Pressure Z	Screw gears	~~Belt gantry~~		
Dispenser Movement	Belt	Screw gantry	rack and pinion	
Squeegee Movement X/Y	Screw gears	Belt Rotation		
Gantry Movement	Belt	Screw	Rack & pinion	
Cleaning Ability				
Tubes:	Ethanol flush			
Container:	Vibrator/ultrasonic	Ethanol flush		
Squeegee:	Removable	Ethanol dunk	Junk it	Wipe it
Bed:	Wipe it			

Design Decisions ELEC I

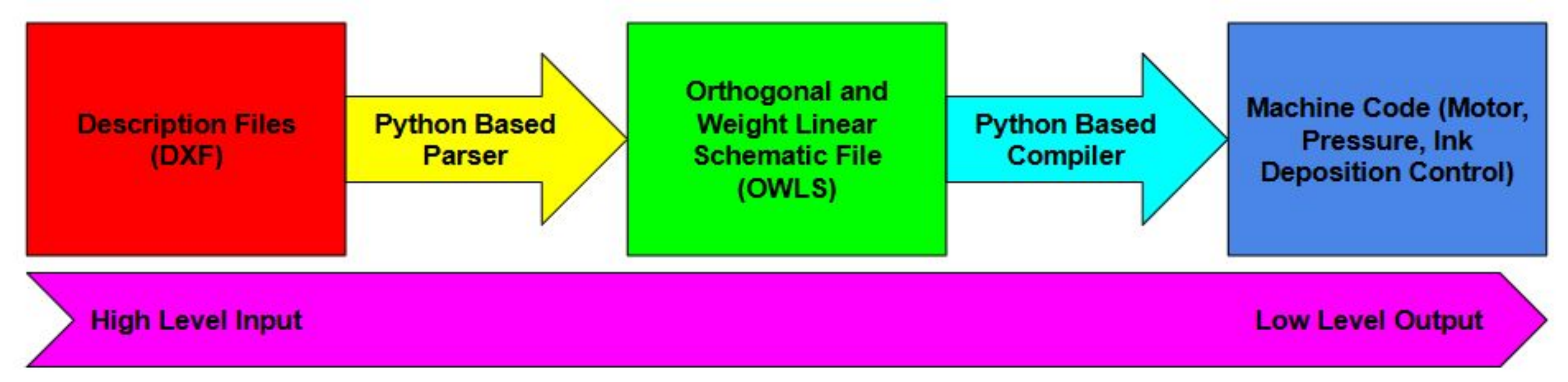
- Microcontroller
  - Teensy chosen over TI MSP Family
    - Teensy is more adaptable for motor control
    - MSP Family generally had less processing speed and memory
- Motors
  - Stepper Motors chosen over DC Motors
    - Stepper Motors offer more precise control
    - Closed Loop Stepper Motors were chosen

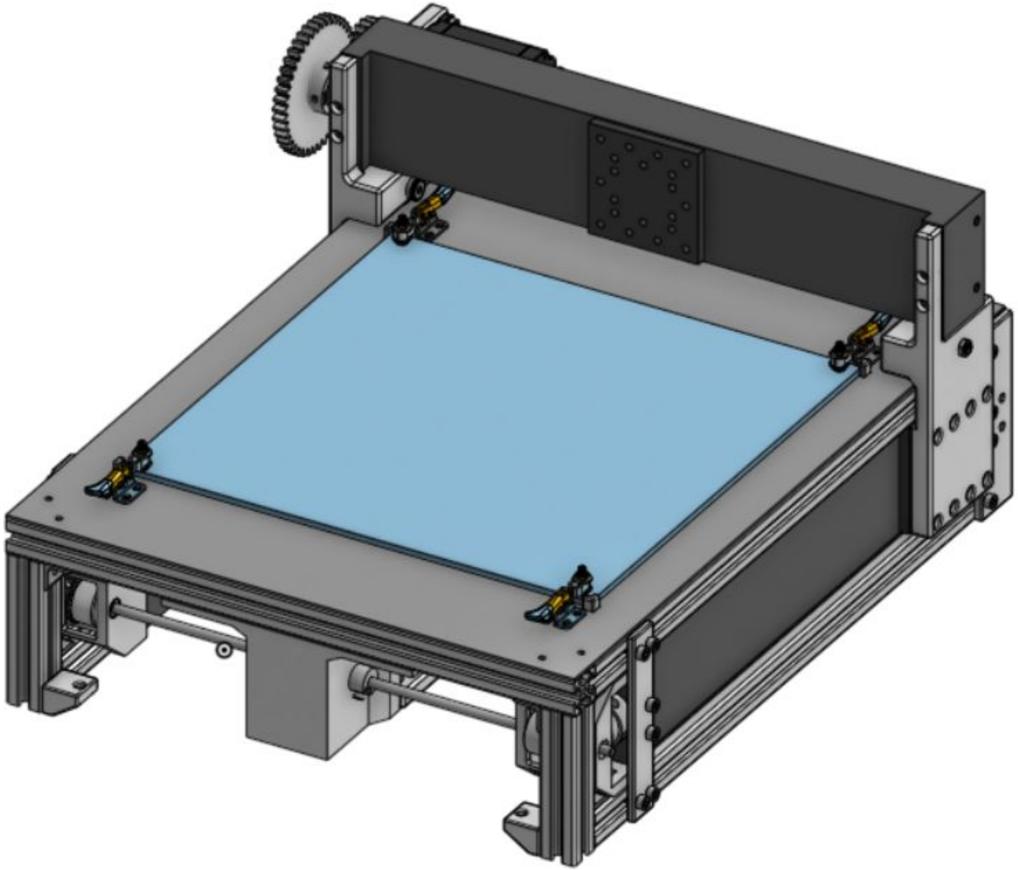


Design Decisions for ELEC II

- Stepper Motor Drivers
    - CLT57T chosen among a variety of similar drivers
        - High Quality driver and very well priced

Electronics Design Flow





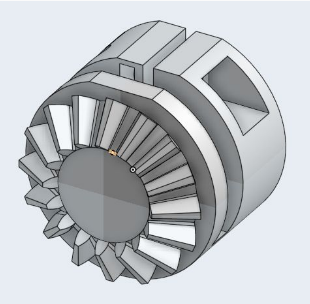
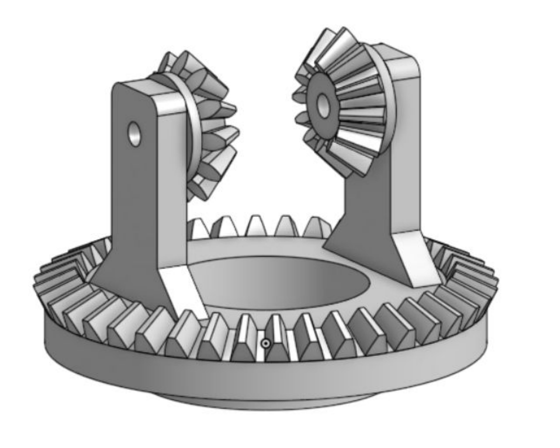
Main Assembly CAD – base, y-gantry with differential gearbox, sliding x-gantry

Cycle 2 Objectives

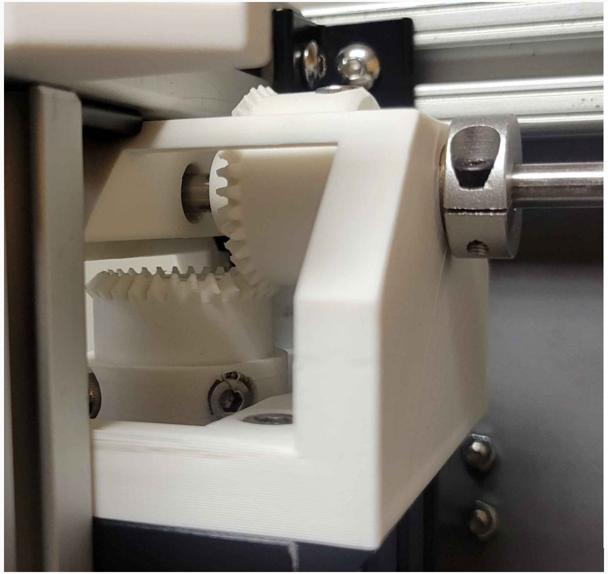
- Locked Differential on Y Gantry is functional
- Linear Actuators Move Mechanically Over X and Y Gantries (goal per axis)
- Electronics installed in undercarriage
- Teensy-driven motor control circuit assembled
- Preliminary code for running motors completed
- Custom PCB ordered
- Linear actuator ink dispenser parts 3D printed

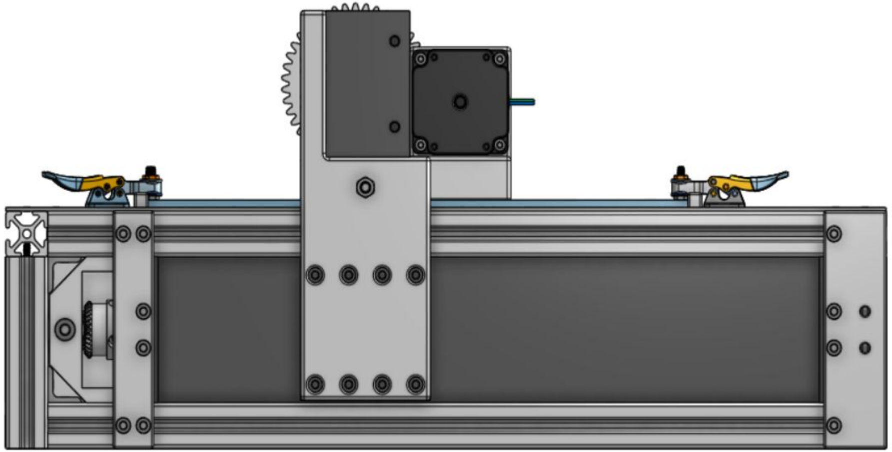
Locked Differential

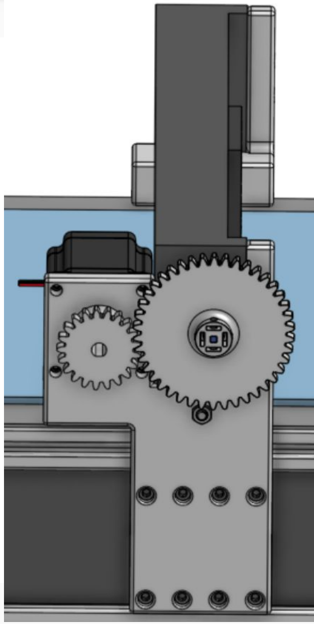
- Assuming even start position, assures equal movement of left and right sides of y-gantry


Linear Actuators - X and Y Gantry Movement







Electronics Undercarriage

- Plexiglass panel with heat inserts, holds all electronics in place
- Easily removable from base of machine
- Will add new screw holes as we add new components, will eventually have fans on sides of base for cooling air flow

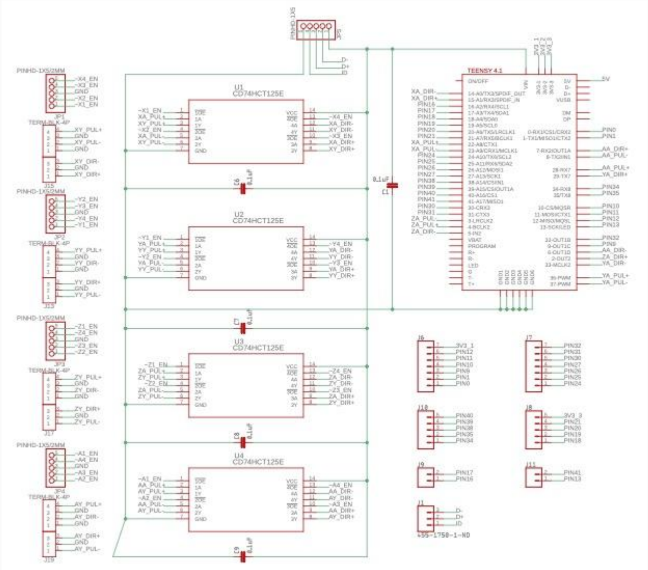
Motor Control and Movement

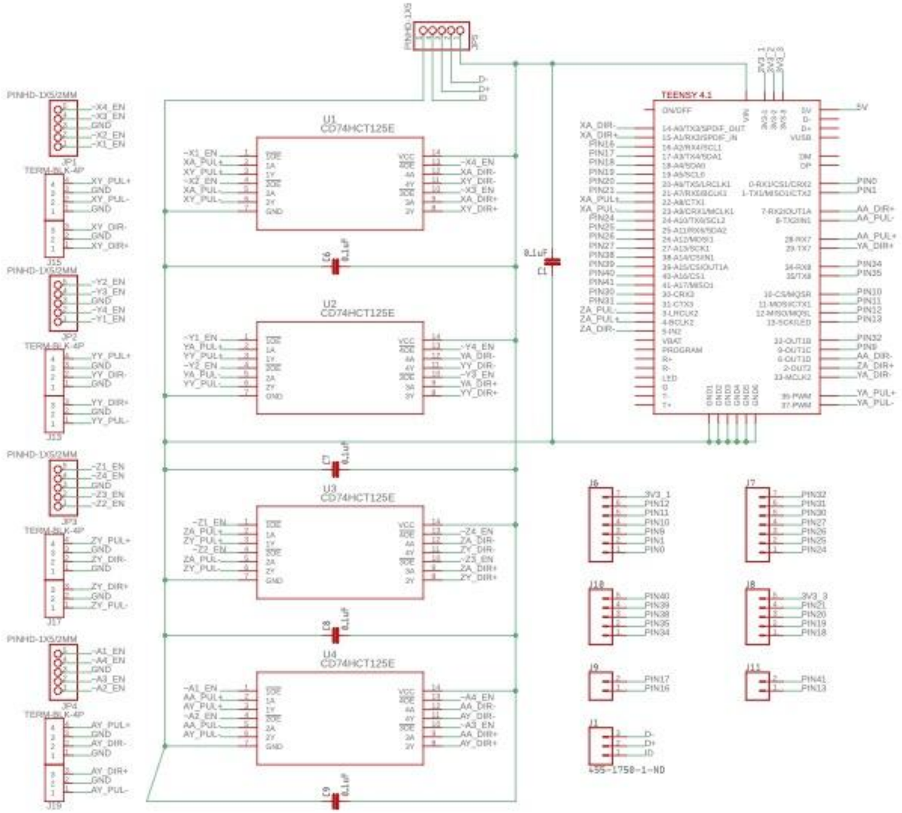
- This goal has not been met
  - Current Problem: Missing Component (UCD74HCT125E Buffer)
- Solution to Solving this Problem
  - Get component and implement into system
- Preliminary Code Written
- Wiring completed
  - Implemented in Electronics undercarriage

Custom PCB - Overview I

- Customized PCB to fit required specs
- Features connections for:
  - Teensy 4.1 Microcontroller
  - CD74HCT125E Logic Buffer
  - Bypass Capacitors
  - Screw Terminal Connectors for Motor Wires
  - Header Pins for expanded Input and Output Access

A larger picture of the PCB and Schematic are in the following slides

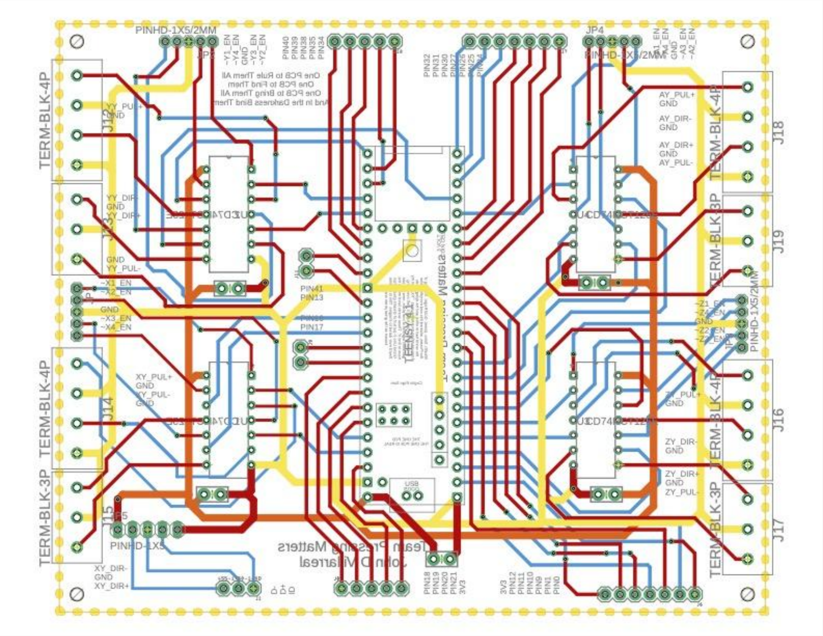


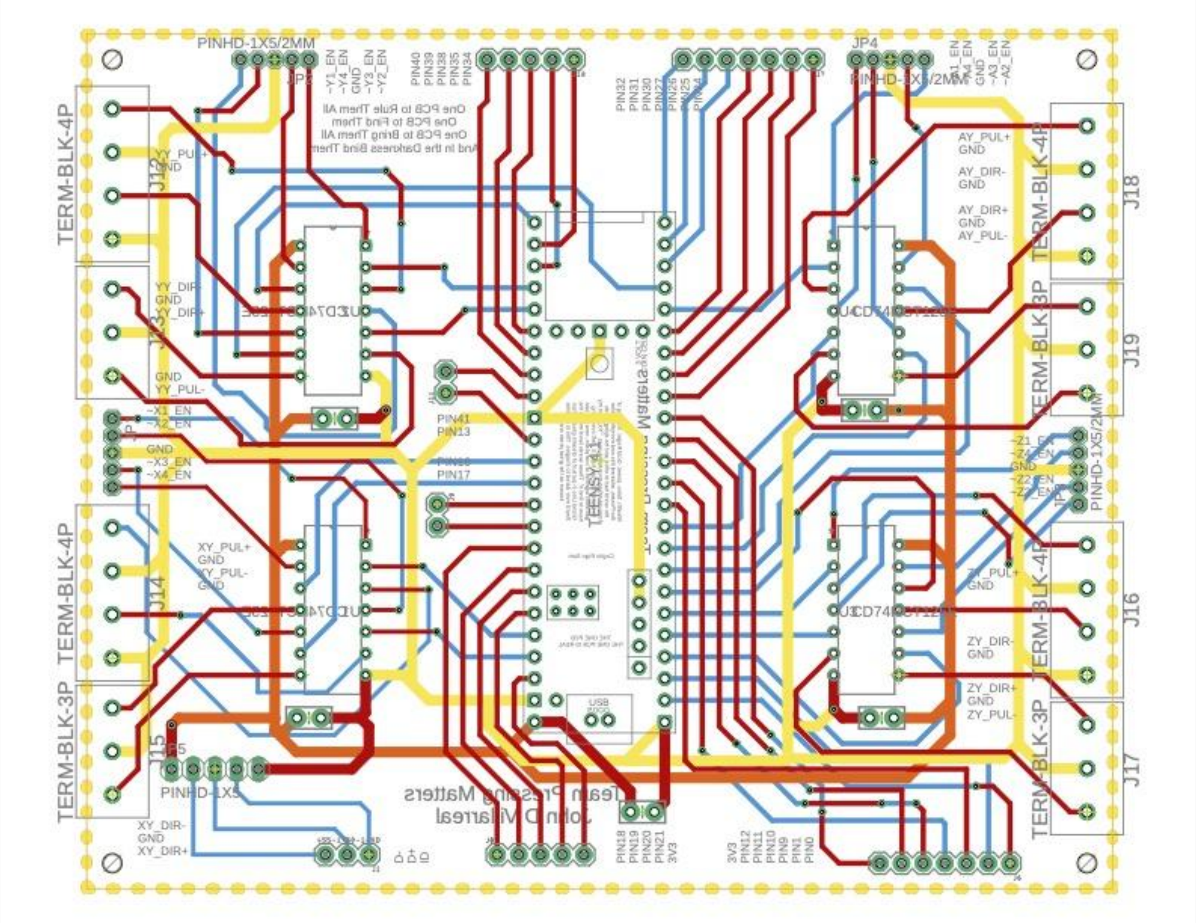


PCB Schematic

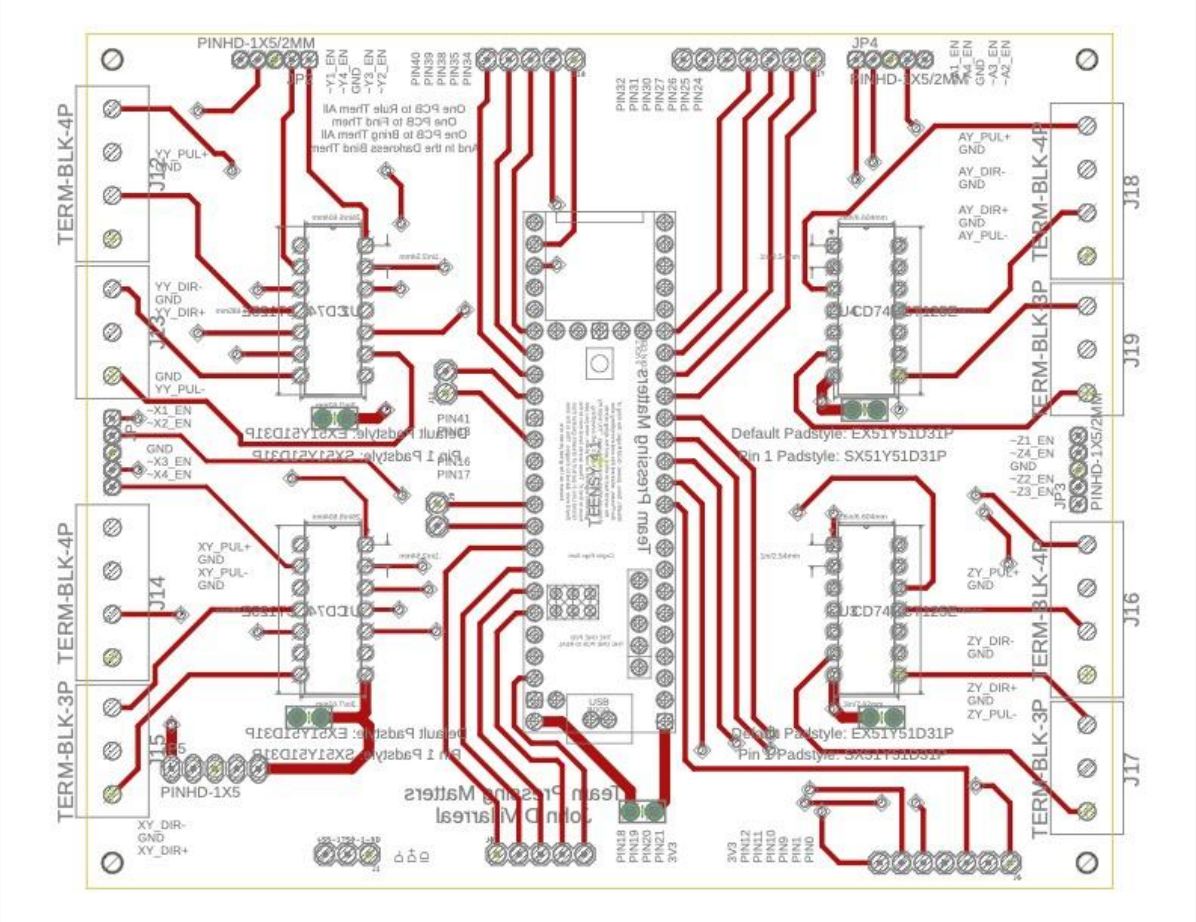
Custom PCB - Overview II

- The custom PCB is divided 4 layers
    - Top Layer (Red)
        - Primarily for Signal Routes
    - Ground Plane (Yellow)
        - Provides EMI Protection
        - Saves space on the top and bottom of the board
    - Power (+5V) Plane (Orange)
        - Saves space on the top and bottom of the board
    - Bottom Layer (Blue)
        - Primarily for Signal Routes

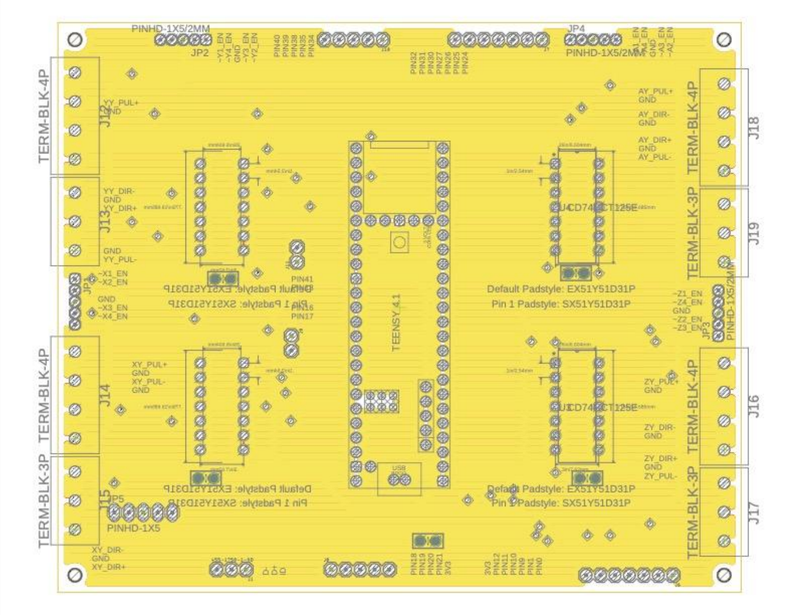



PINHD-1X5/2MM
JP4
TERM-BLK-4P
TERM-BLK-3P
J12
J13
J14
J15
J16
J17
J18
J19
TEENSY3.1
Team Pressing Matters
John D Villarreal
One PCB to Rule Them All
One PCB to Find Them
One PCB to Bring Them All
And in the Darkness Bind Them
AY_PUL+
AY_DIR-
AY_DIR+
AY_PUL-
YY_PUL+
YY_DIR-
YY_DIR+
YY_PUL-
XY_PUL+
XY_PUL-
XY_DIR-
XY_DIR+
ZY_PUL+
ZY_DIR-
ZY_DIR+
ZY_PUL-
GND
PIN41
PIN13
PIN17

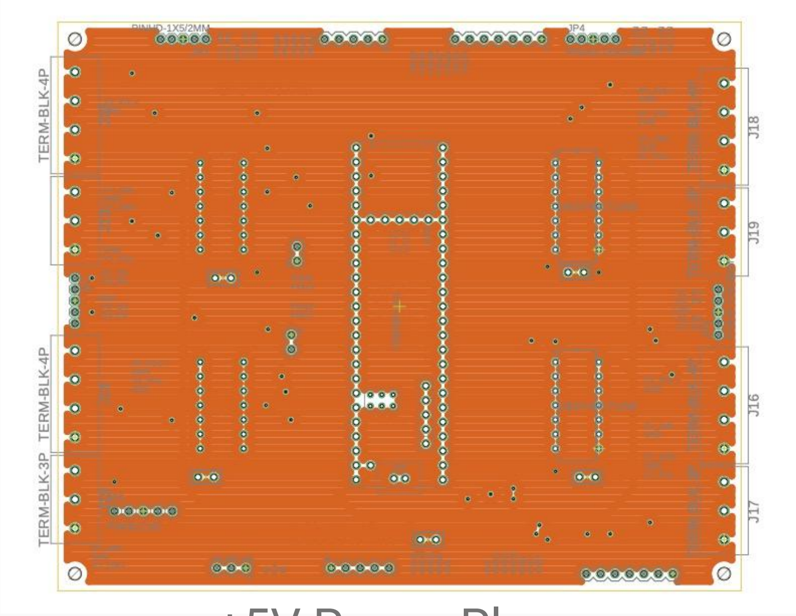
PCB Layout



PCB Layout: Top Layer

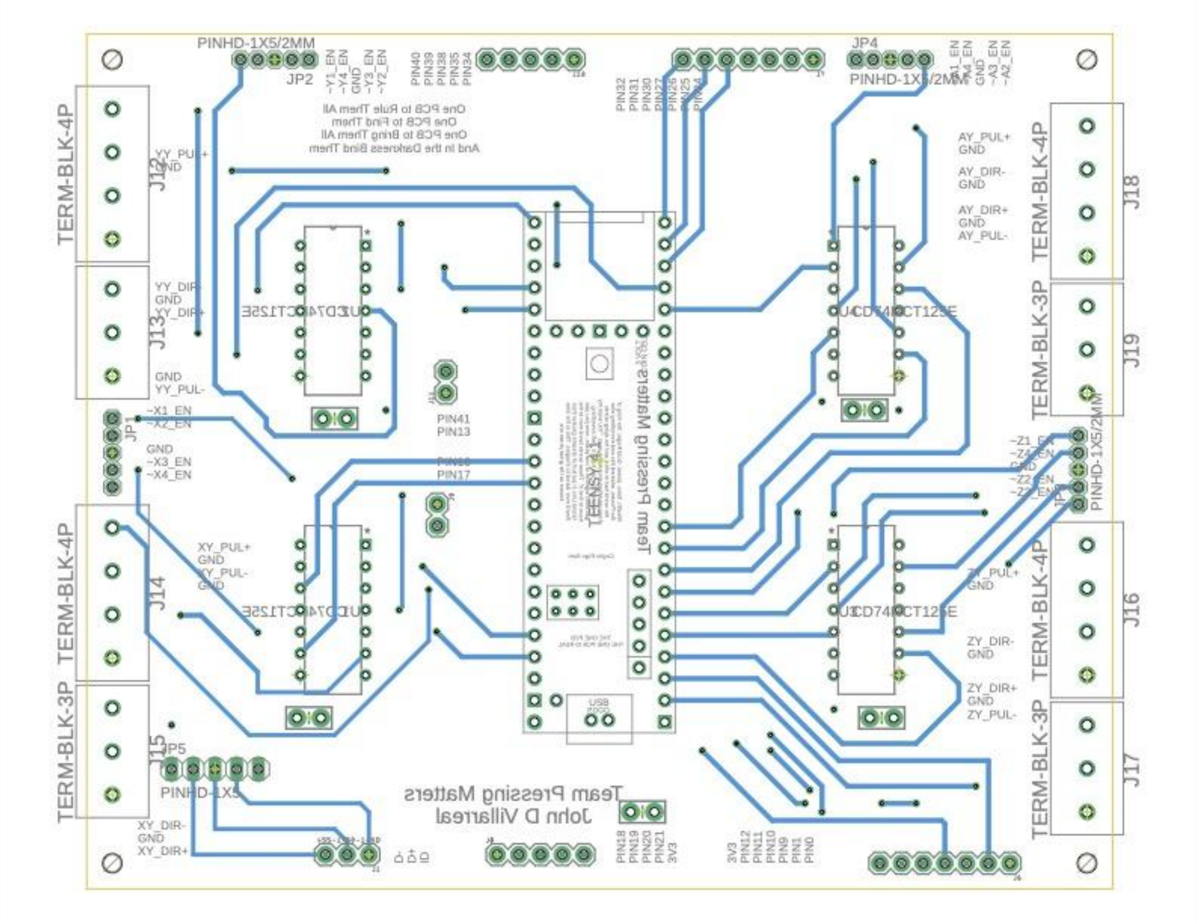


Ground Plane



+5V Power Plane

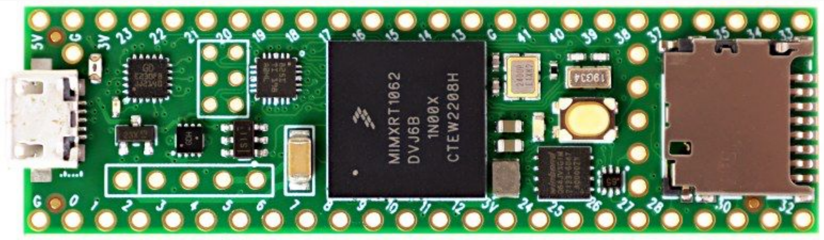
PCB Layout: Plane Layers



PCB Layout: Bottom Layer

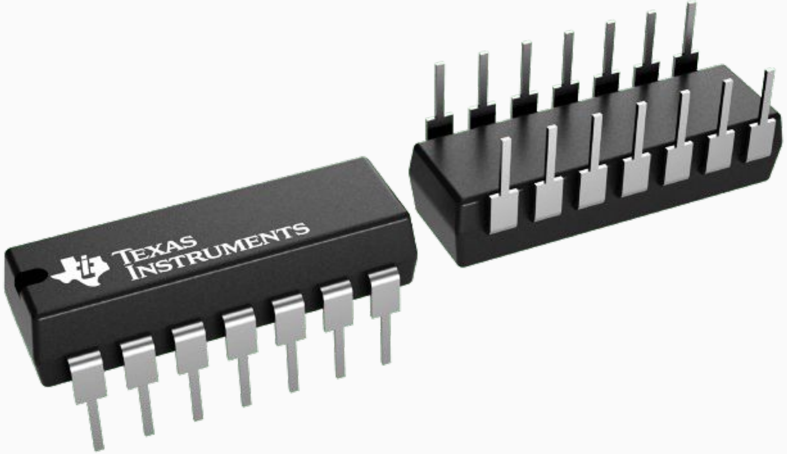
Custom PCB - Teensy Microcontroller

- Teensy Microcontroller acts as the brain of the PCB
- Sends low voltage signals to the Voltage Buffers to be used to control the motors
- Connects to additional Header Pins for increased accessibility for other components
    - This allows for expansion in the future



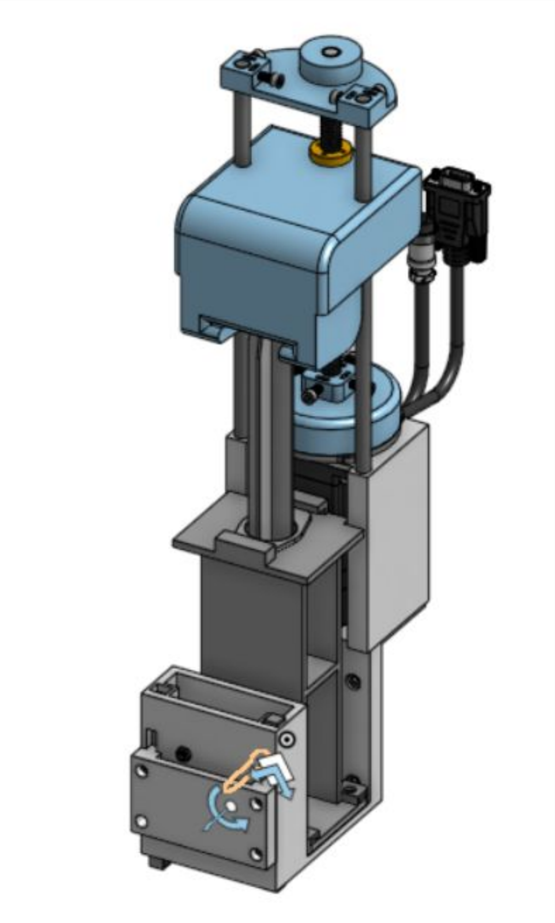
Custom PCB - CD74HCT125E Buffer

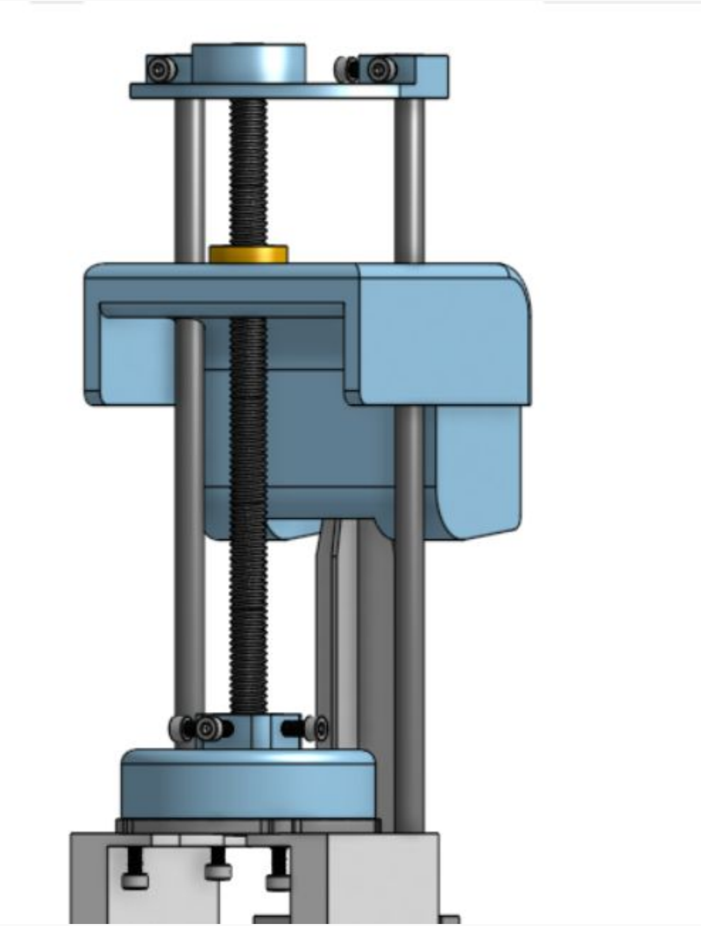
- Voltage Buffer receives signals from the Teensy and increases voltage of the signals
- The higher voltage signal is then sent to the Motor Drivers on the Electronics Undercarriage
- The PCB has 4 Buffers - One for each motor

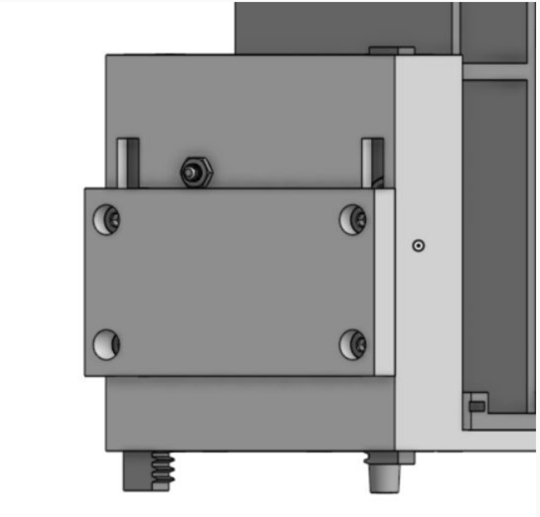


Ink Dispenser

- Racks and pinion move squeegee up/down on z axis
  - Downwards pressure needed for printing
- Ink loaded into syringe, screw-driven linear actuator pressed syringe plunger down to dispense ink
  - Ink is very viscous and should not leak but we may need to raise plunger a bit between dispensing ink over stencils to use pressure to hold it in
- Squeegee and syringe/ink dispenser move over x-axis on same toolhead







Current Tool Head Design – Work In Progress

Ink Dispenser (contd.)

- Tool Head needs major changes
  - Need to cut down on ink dispenser height
  - Limited motor placement due to magnetic interference
  - Squeegee motor does not currently have a place in the CAD
- Alt. design being considered
  - 12 in. long squeegee that does not need to move on x-gantry, just makes a single swipe
  - Not without its own issues

Plans for Spring Semester

- Finish tool head/ink dispenser redesign
- Identify and enter external design competition
- Full machine assembly
  - Nylon, possibly milled pieces to replace PLA printed parts
- Full electronics wiring and implementation
- Development of code for controlled ink dispensing
- Full System Testing beginning February 1st

Spring Semester Deadlines

- Design Completed with Full Construction: January 31
- Functional product: March 14
- Team's Project Completion Goal: April 11
- OEDK Showcase: April 17

Questions?