LSU PROMASK 16

Final Design Review

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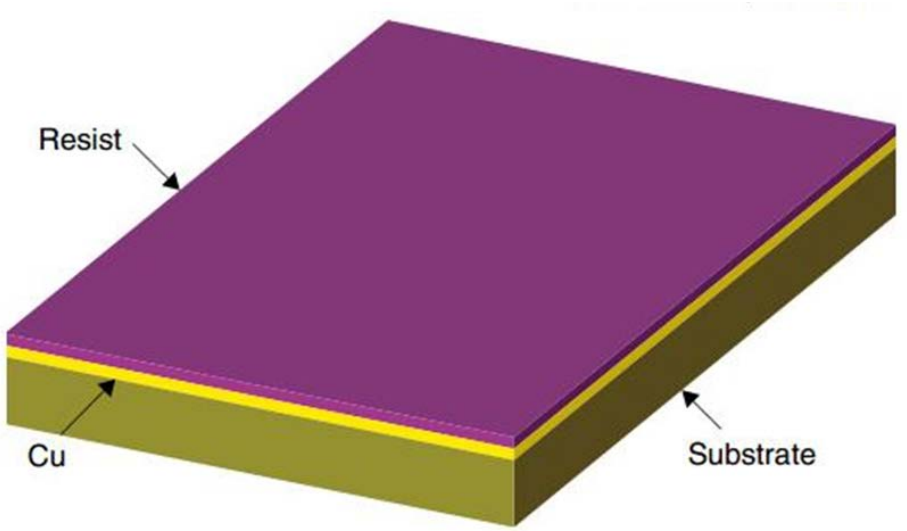
BACKGROUND

- Contemporary Fabrication
  - LPISM
  - Application
  - Production



https://nguyenhieuhobby.wordpress.com/2012/11/26/mot-so-khai-niem-trong-thiet-ke-mach-in/

Problem Statement

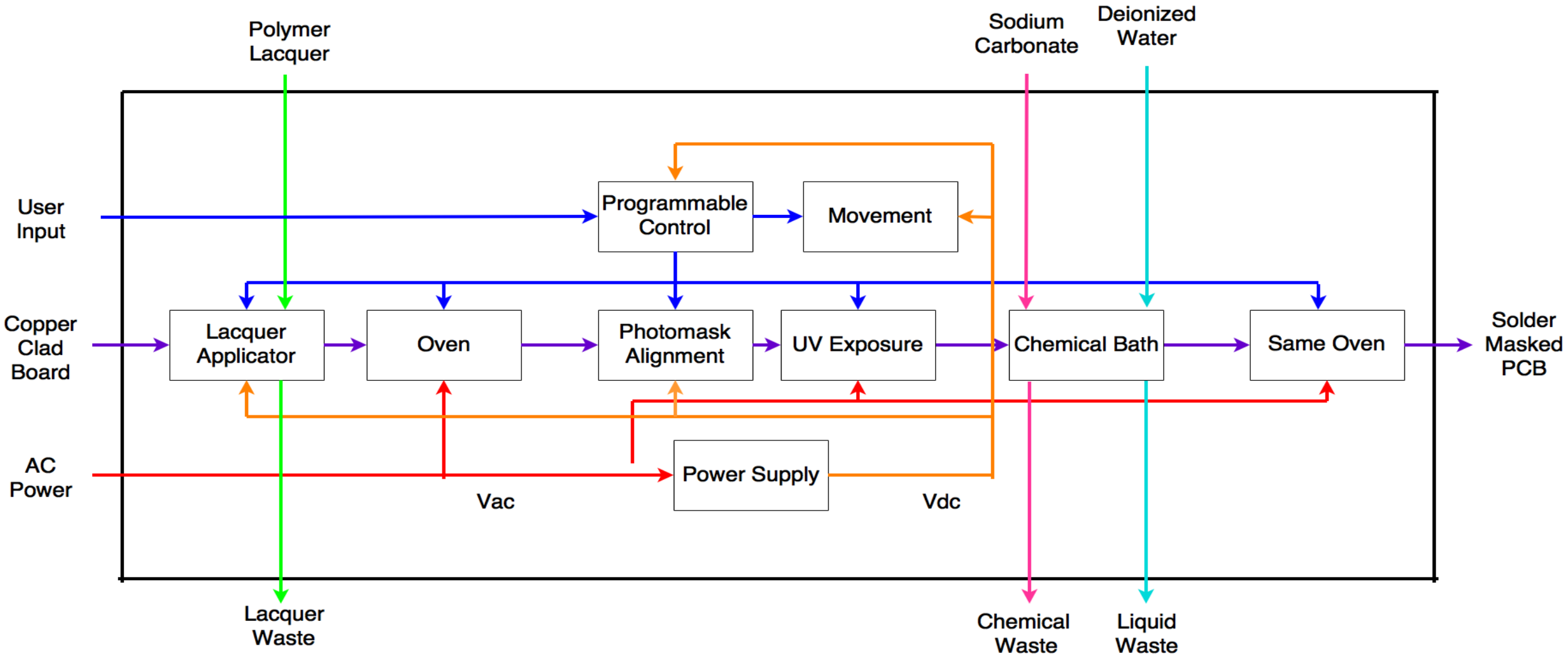
https://www.youtube.com/watch?v=Ps8aPpW_PEA

https://www.shutterstock.com/search/toxic+symbol

Process Summary

1. Lacquer Application
2. Exposing System
3. Chemical Rinse Bays
4. Thermal Curing System
5. Building Frame
6. Controls
7. Power
8. PCB Results
9. Project Budget Analysis

Overall Design Functionality



Marketing Requirements

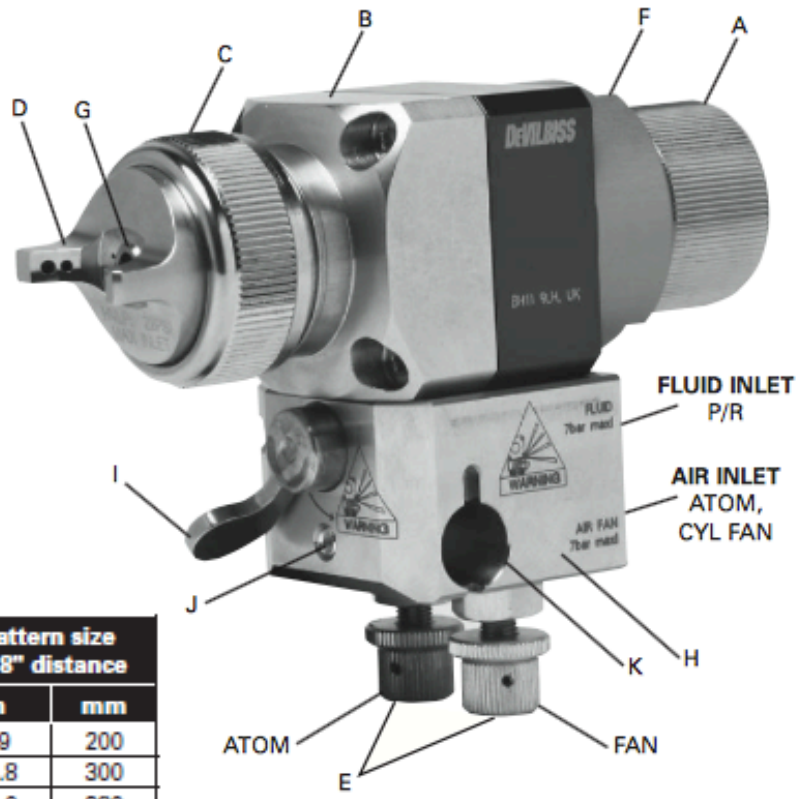
1. Chemical containment and safety
2. Desktop size through a compact design
3. Automated design
4. Industry level quality
5. Intuitive user interface
6. High reliability
7. Maintainability

Marketing Requirements		Justification
1, 3, 4, 6	Solde	d on qualification and performance of anent solder mask (IPC-SM-840C)
1, 3, 4, 6, 7	The s than	ven needs to function at high temperatures der to harden the solder mask enough
1,2, 3	The s	uring process the UV must be exposing y
1	The s carbo mask	recise etching technique to be fulfilled.
4, 7	The s	rials of system must be quality of main manufacturers
1, 2, 3	The s latera	ms need to fit compactly in lab onment.
3, 6, 7	The s	y connect to wall outlets in lab environment.
5, 6, 7	The s users	users of machine's functionality operation.

Lacquer Application System

DeVilbiss Trans-Tech Spray Gun

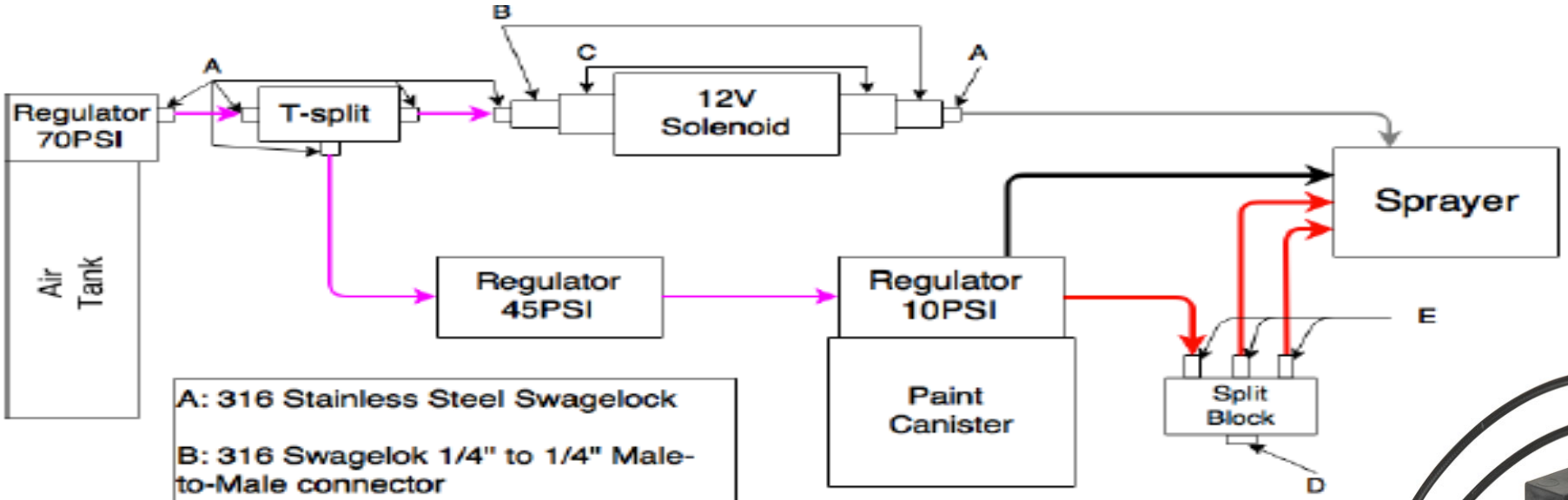
- Full automation capabilities
- More variables to manipulate to adjust spray output



A	Needle travel adjusting knob – 18 positions per 1 turn
B	Gun head – stainless steel
C	Air cap ring
D	Air cap
E	Air valve (fan / atom)
F	Spray gun body – anodized aluminum
G	Fluid tip – stainless steel
H	Manifold – stainless steel
I	Manifold locking lever
J	Support tightening screw
K	Spray gun mounting hole – 1/2" diameter
P/R	Fluid inlet, fluid return

Air cap	Type	Air Flow		Pressure at Inlet		Fluid Flow		Pattern size @ 8" distance	
		SCFM	l/min	psi	bar	oz/min	ml/min	in	mm
SP-100-430-K	Conventional	12	340	50.7	3.5	6.7 - 9.5	200 - 280	7.9	200
SP-100-443-K	Conventional	12.2	345	43.5	3.0	6.7 - 10.1	200 - 300	11.8	300
SP-100-497-K	Conventional	18	510	50.7	3.5	6.7 - 20.2	200 - 600	15.0	380
SP-100-500R-K	HVLP Round Spray	6.8	200	16.0	1.1	.6 - 5.0	20-150	1.6	40
SP-100-507-K	H V L P	19	385	40	1.4	4.4 - 6.5	130 – 190	10.6	270
SP-100-510-K	Trans-Tech	10	283	29	2.0	5.4 - 7.5	160 - 220	10.6	270
SP-100-513-K	Trans-Tech	18.8	531	43.5	3.0	6.7 - 20.2	200 - 600	13.8	350
SP-100-522-K	Trans-Tech	14.5	410	29	2.0	6.7 - 20.2	200 - 600	13.8	350
SP-100-590-K	Trans-Tech	7.7	218	29	2.0	1.6 - 5.0	50 -150	6.0	150
SP-100-591-K	Trans-Tech	12.3	350	29	2.0	1.7 - 5.1	50 -150	4.5	115
KK-5090-507	HVLP Test Kit – includes cap, gauge & tube								

http://www.devilbiss.com/Portals/2/Repository/SB-2-584-G.pdf



A: 316 Stainless Steel Swagelock

B: 316 Swagelok 1/4" to 1/4" Male-to-Male connector

C: 1/8" Male NPT x 1/4" Female NPT Brass Straight Adapter

D: 1/4" plug

E: 1/4" NPS to 1/4" NPT

Pink line: pink vinyl tubing

Black line: 1/4" id fluid hose

Red line: 1/4" id air hose

Grey line: white vinyl tubing

Pneumatic Connection Diagram

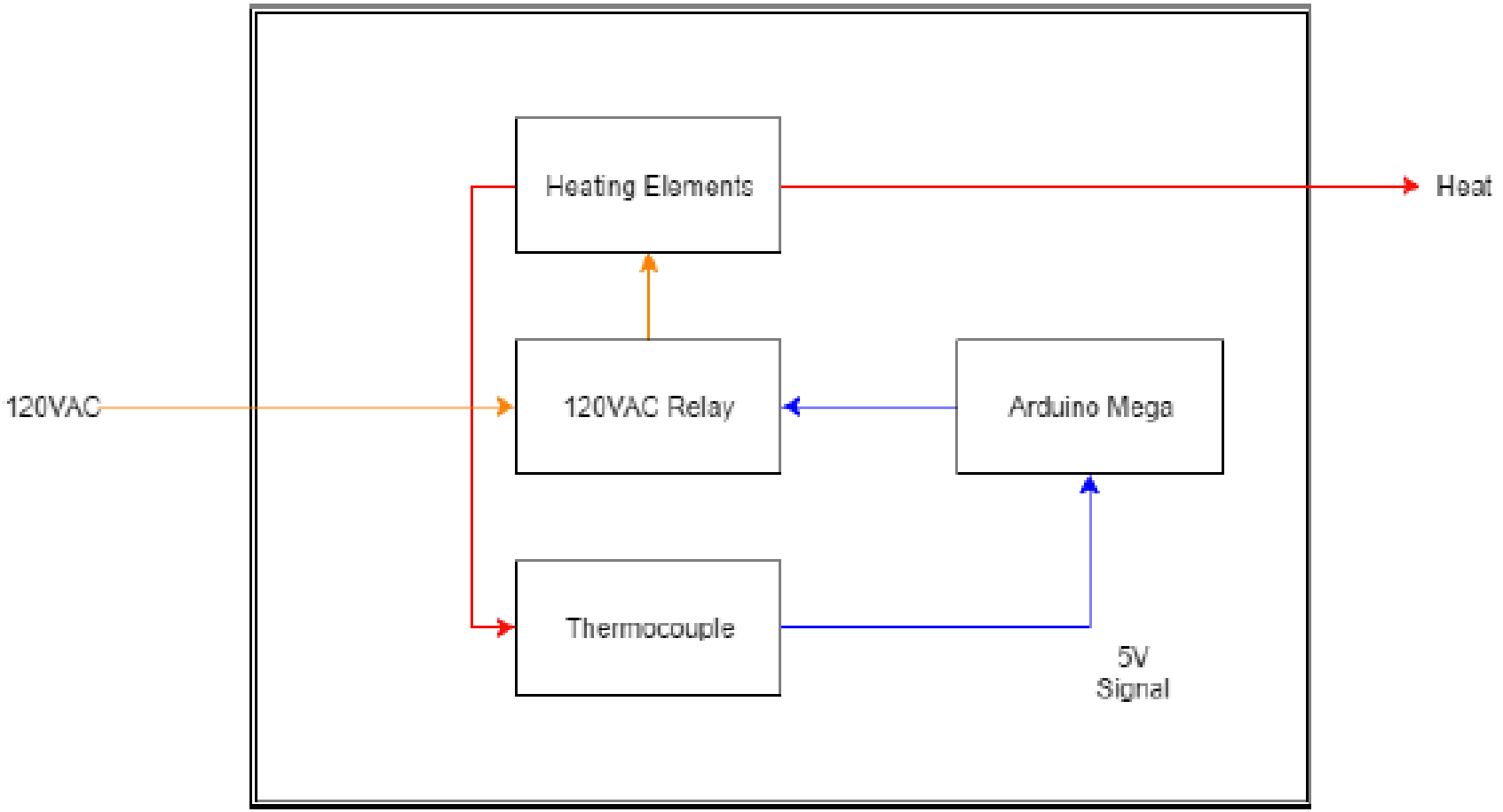
12V Solenoid

http://www.lesker.com/newweb/gas_liquid_management/jpg/photo/Photo-HD-VA_SE120A4SC410.jpg

10" Actuator

Oven System

https://www.walmart.com/ip/Mainstays-4-Slice-Toaster-Oven-Black/53986434



$P = V * I$

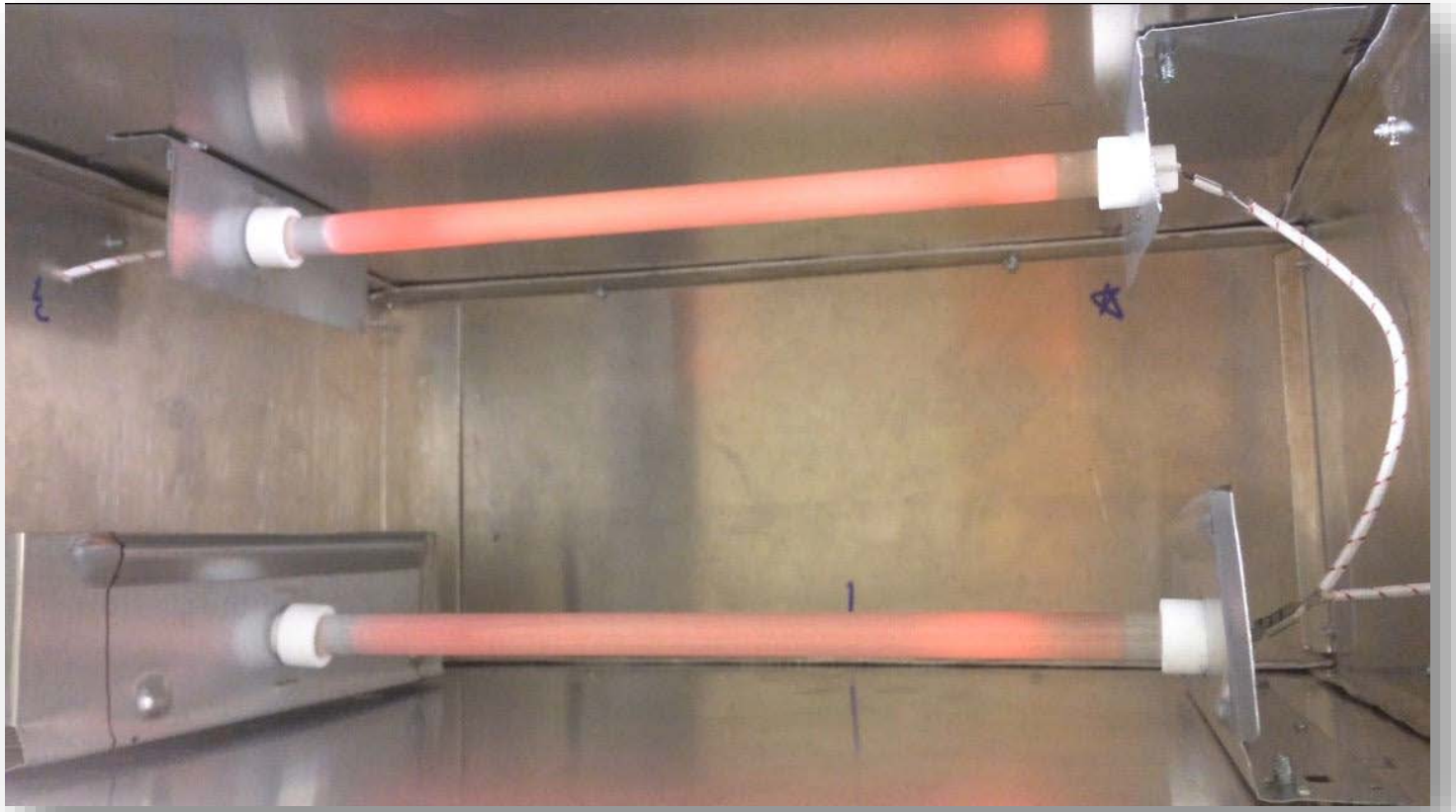
$P = 1000\ W$

$V = 120\ VAC$

$I = 8.33\ A$

(maximum current draw)

Need 18 gauge wire

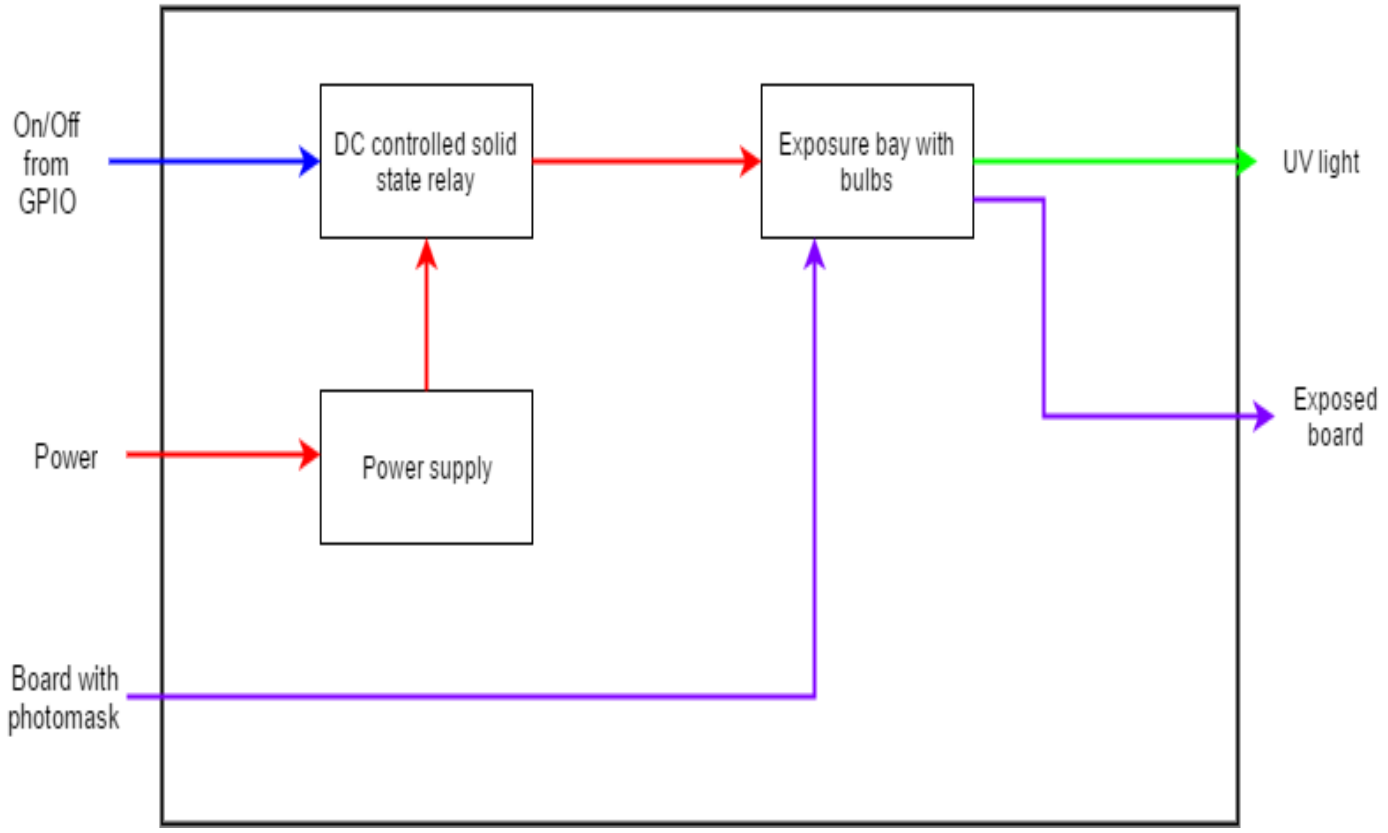


UV Exposure System

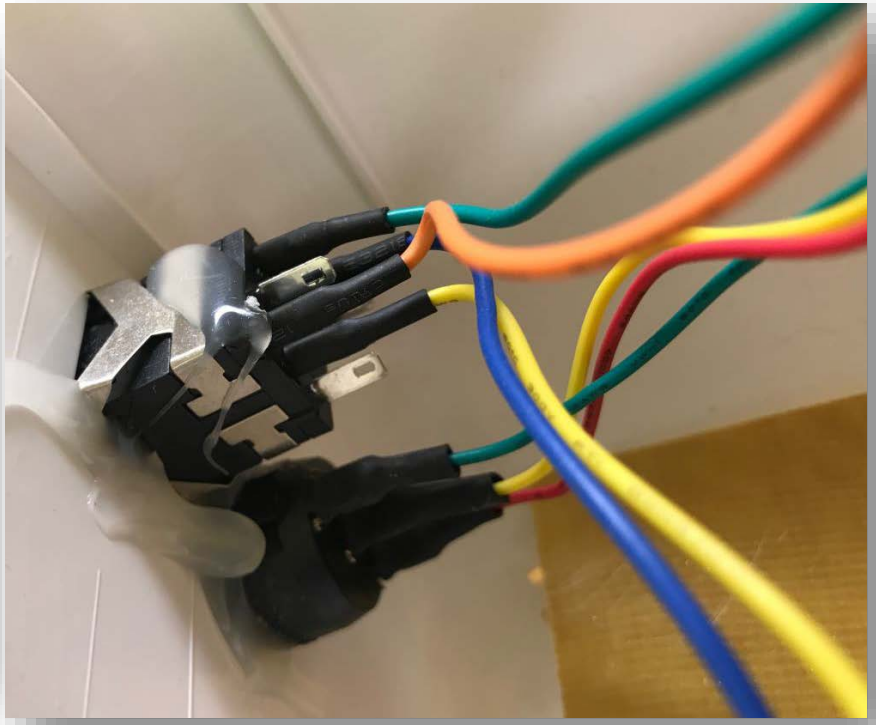
- 72W for 8 Bulbs
- 365-400nm requirement
- Slight modification to accept board frame

http://widgetlove.com/media/catalog/product/cache/1/image/32c3d0b93e1123322b0ba6dc090e7386/s/k/sku_h776801_1.jpg

UV Exposure

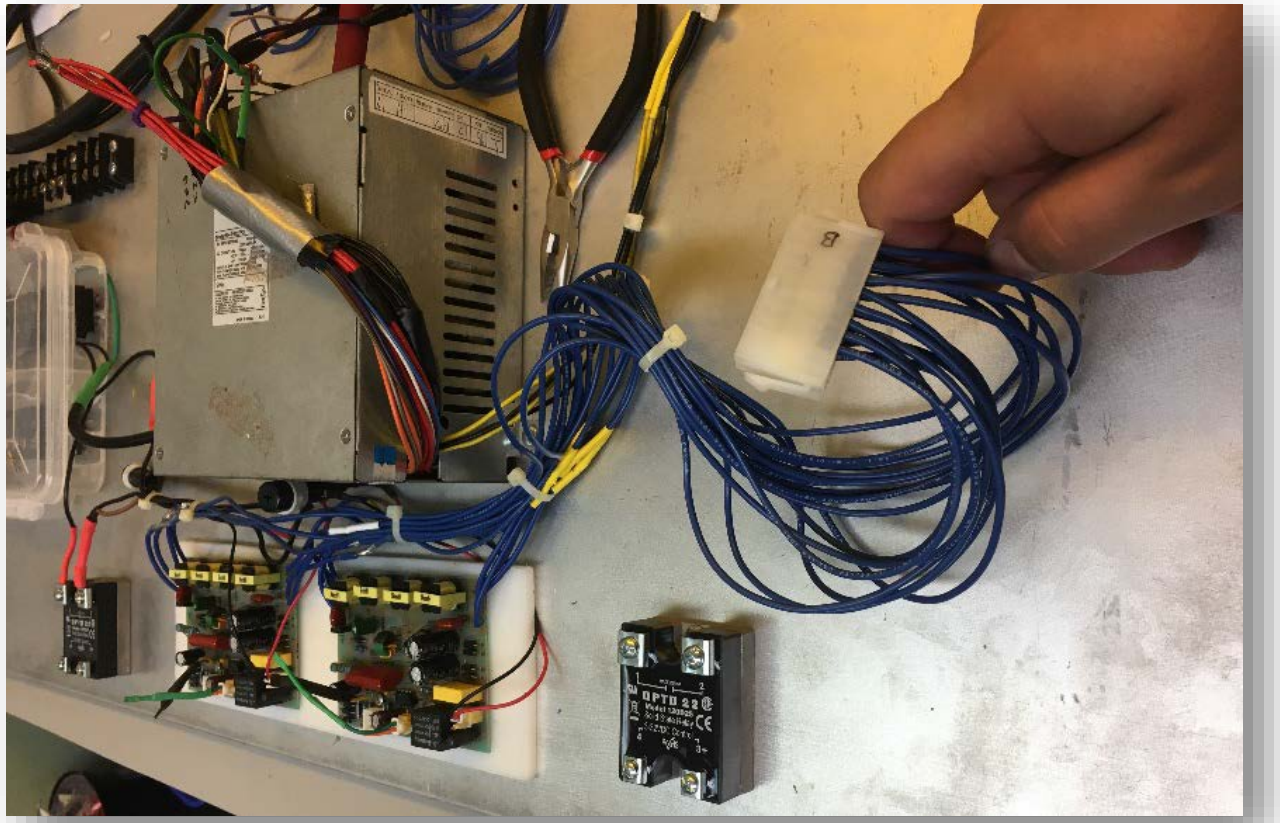

On/Off from GPIO
DC controlled solid state relay
Exposure bay with bulbs
UV light
Exposed board
Power
Power supply
Board with photomask

Disassembly

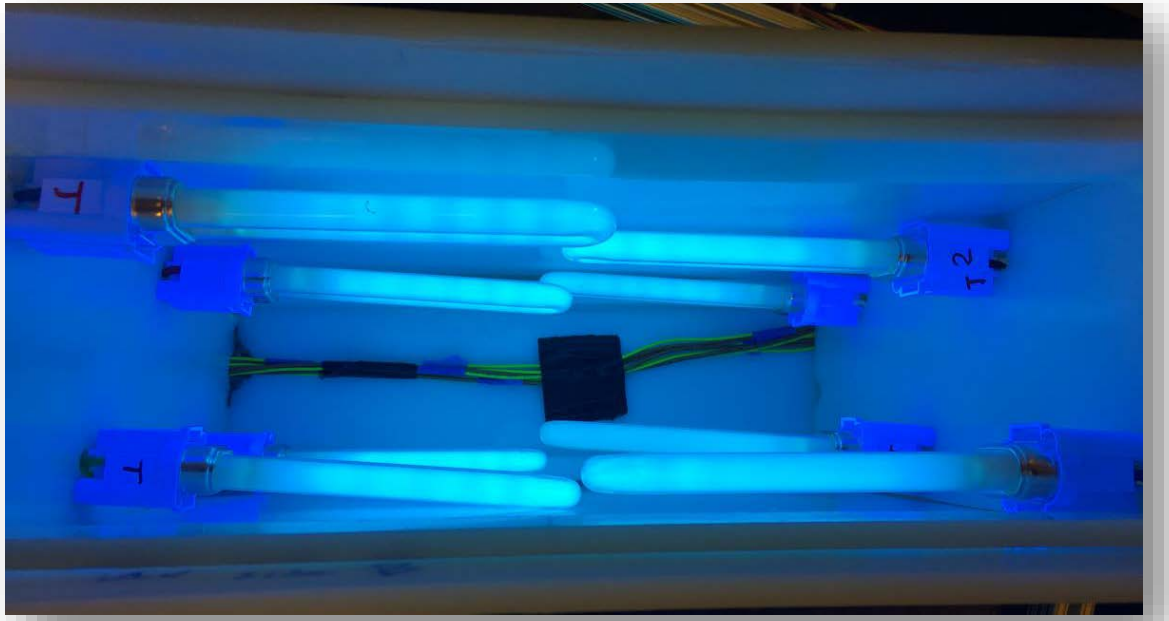


Molex Connector

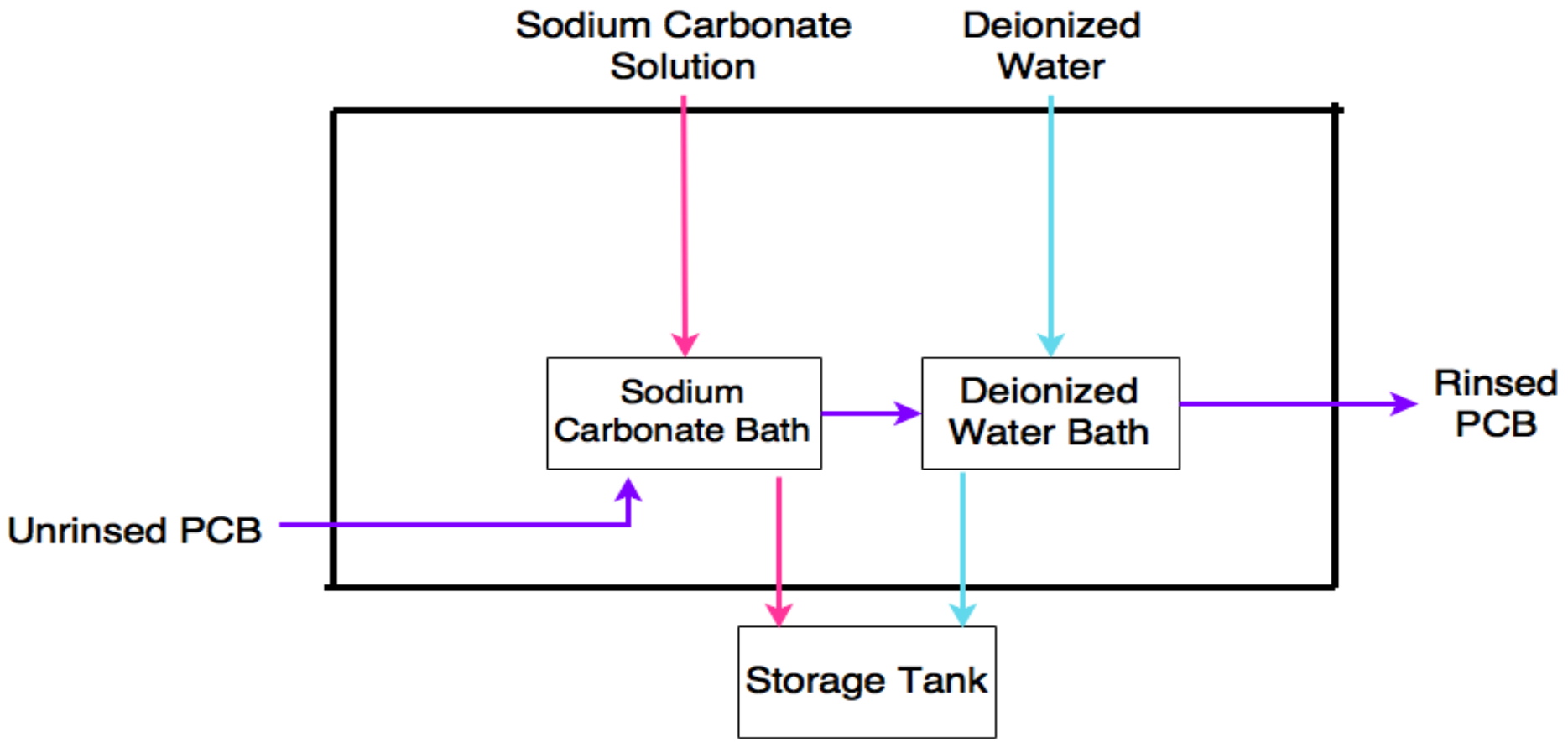
- Easy to disconnect and remove the entire UV system.



UV Results



Chemical Bath and Rinse Bay



Solution

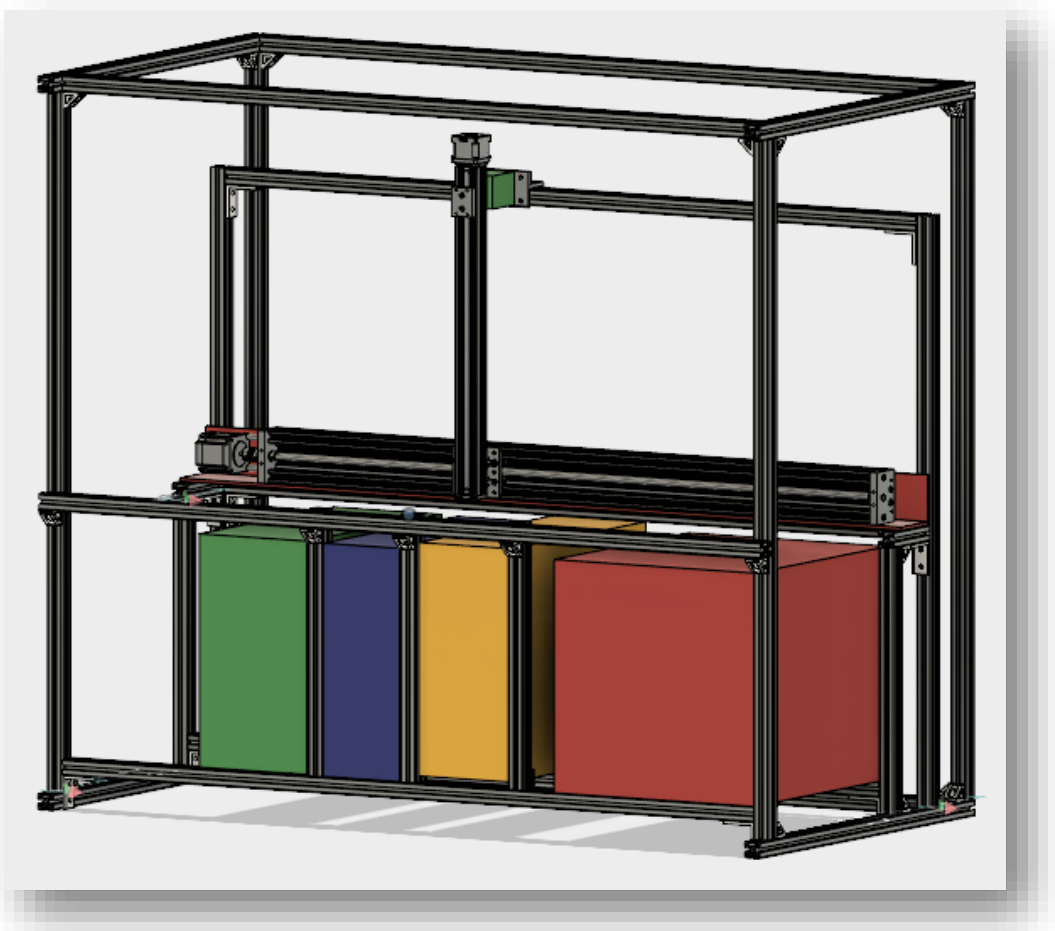
- The lacquer data sheet called for at least a 1% sodium carbonate solution with a pH of 10.6 or higher.
- We used a soda ash/ water mixture and pH testing strip to achieve these requirements.

Leak Test

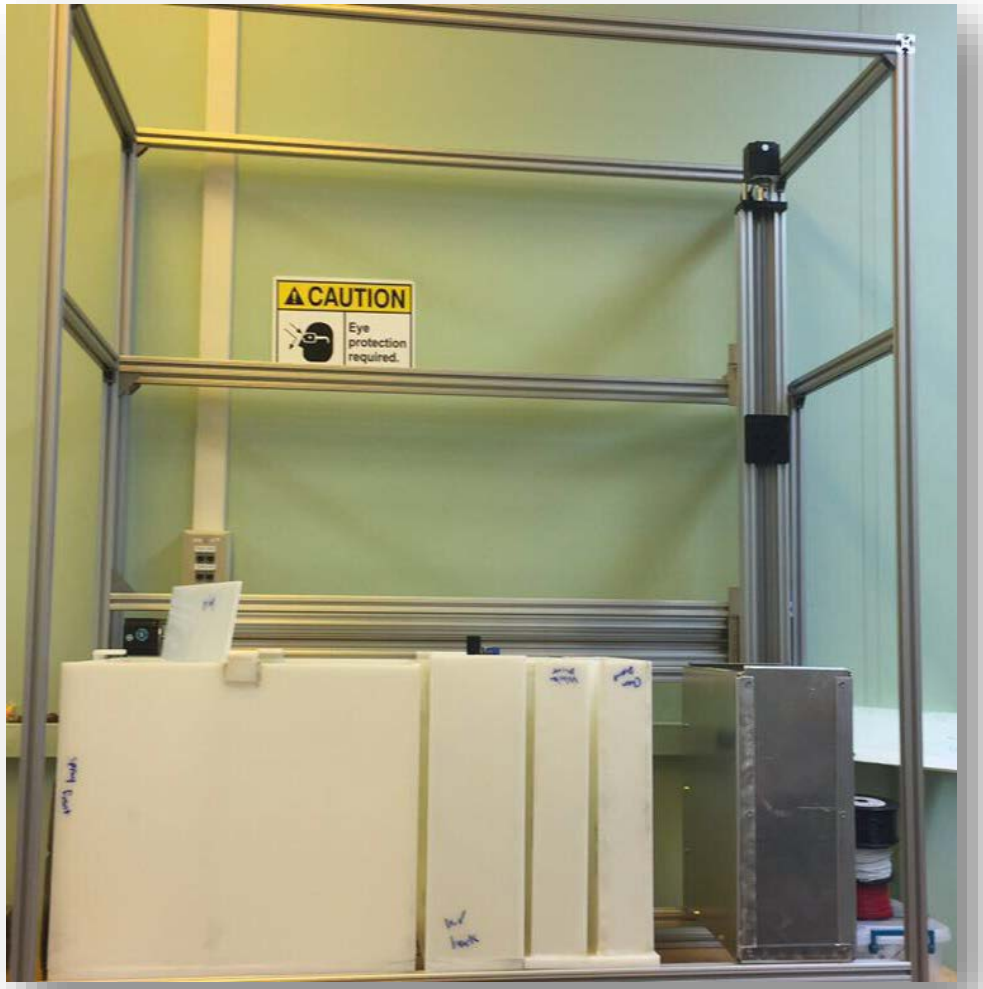
Tank Fabrication

http://www.polyzone.com/media/catalog/product/cache/1/thumbnail/9df78eab33525d08d6e5fb8d27136e95/h/d/hdpe_sheet.jpg

Preliminary Design



Frame Assembly



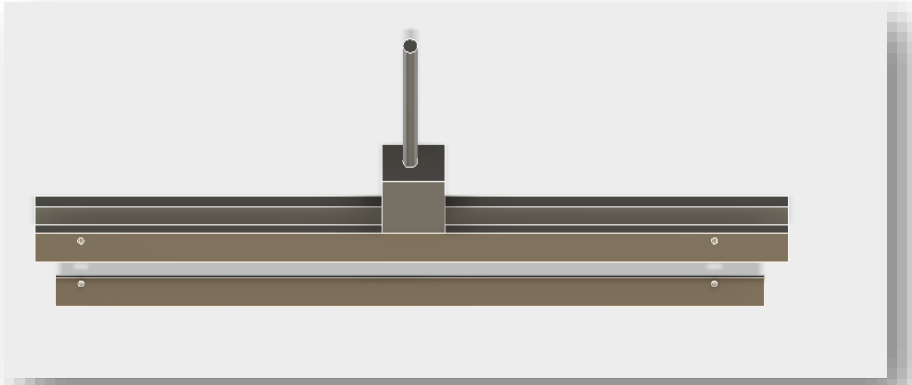
Frame Components

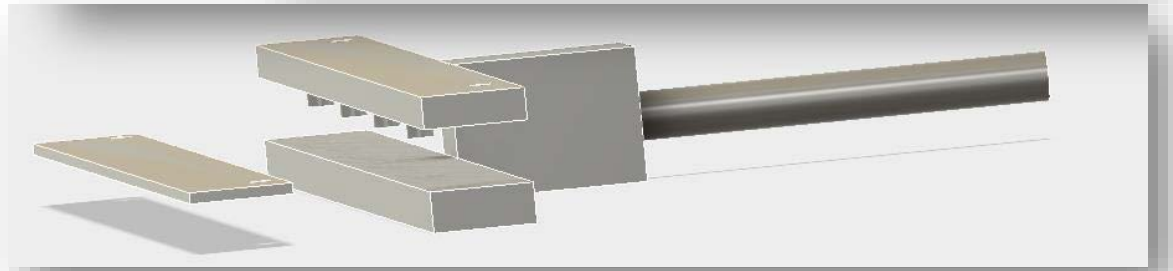
http://ecx.images-amazon.com/images/I/519k6gG55sL._SX342_.jpg

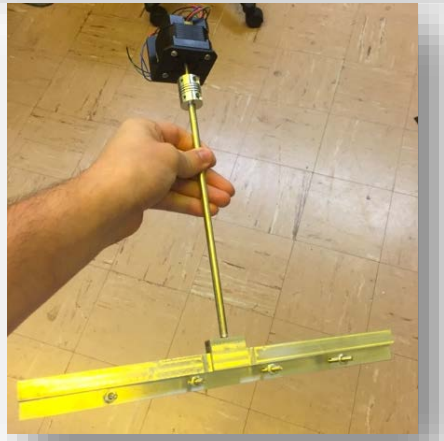
https://8020.net/shop/14061.html

https://8020.net/shop/14058.html

Miscellaneous Fabrication



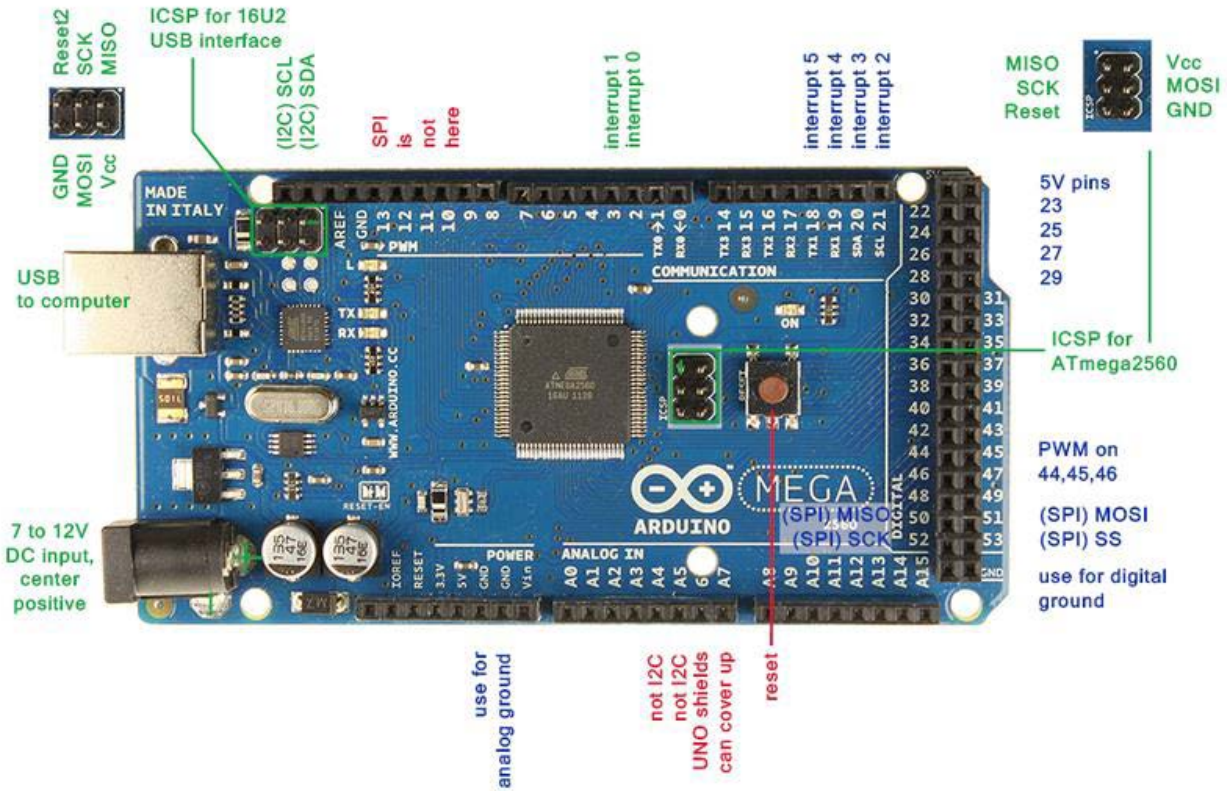




Microcontroller (Arduino Mega2560)

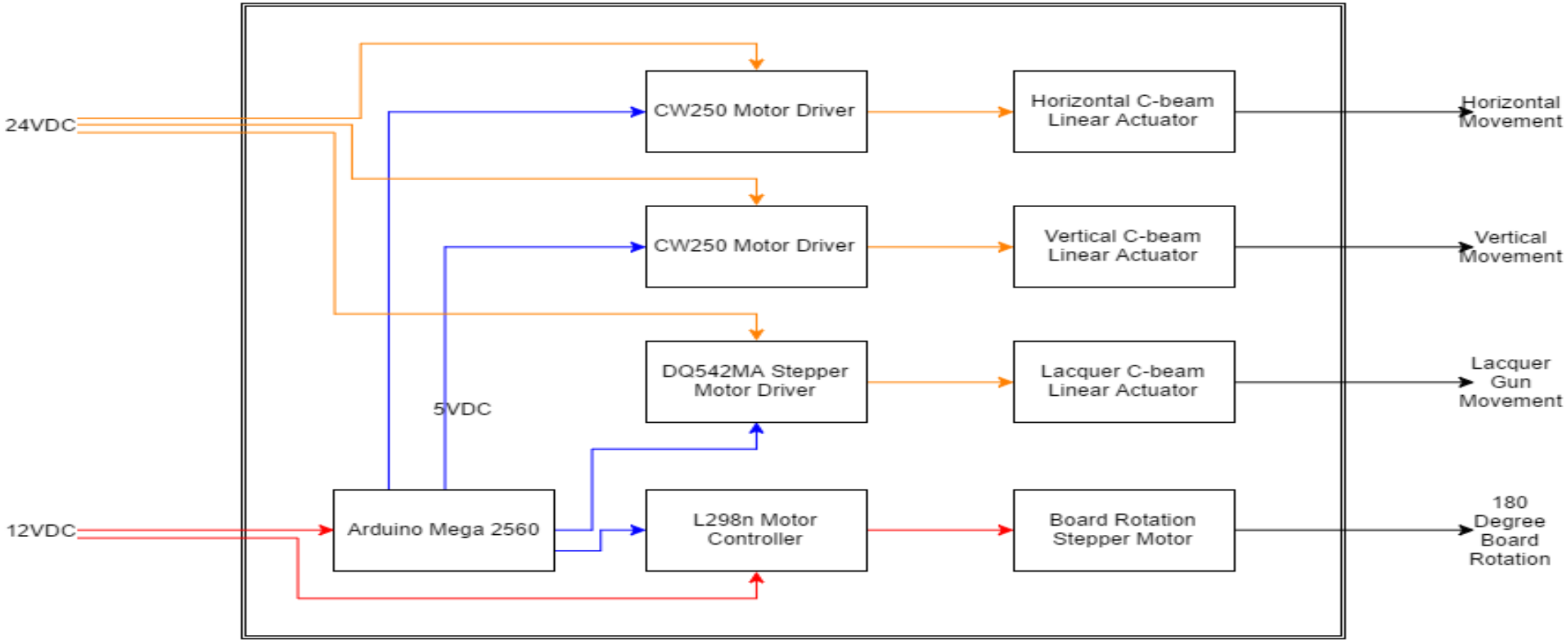
Technical specs

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Length	101.52 mm
Width	53.3 mm
Weight	37 g



https://arduino-info.wikispaces.com/MegaQuickRef

Microcontroller Movement Control



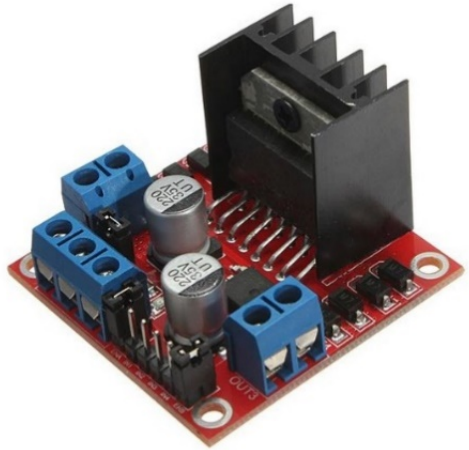
Motor Control

CW250 Driver

https://www.circuitspecialists.com/cw230.html

- DC Power Input: 24V~36V
- DC Current: 0.9A~3.0A
- Logic: 5V (~20mA)

L289N Module



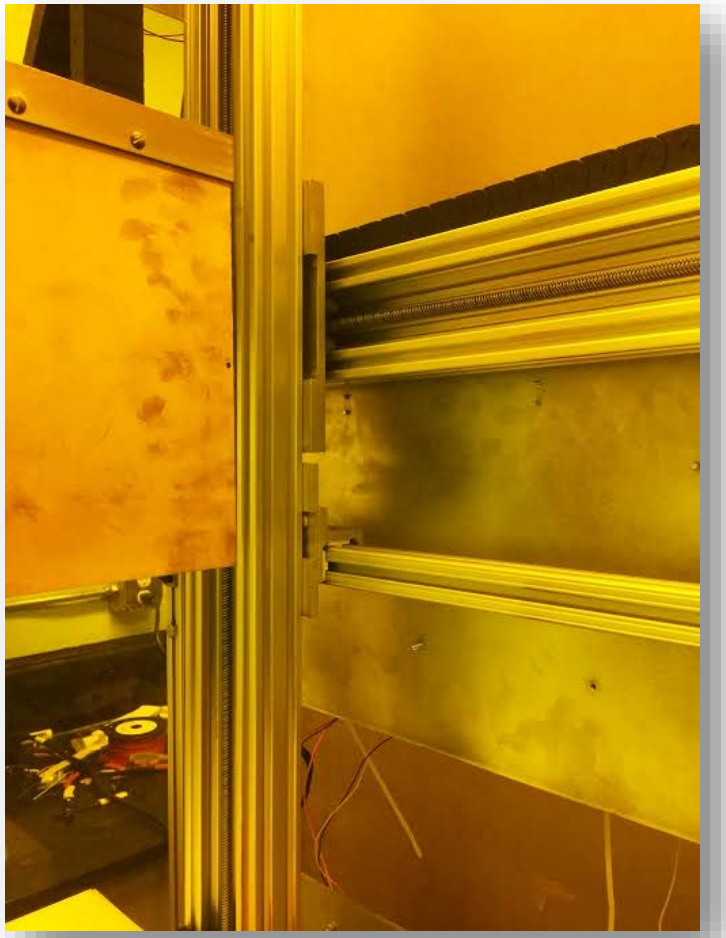
//www.instructables.com/id/Arduino-Modules-L298N-Dual-H-Bridge-Motor-Controll/

- DC Power Input: 5V~35V
- DC Current: up to 2A
- Logic: 5V (0~36V)

Horizontal and Vertical Movement

- C-Beam 1000mm
- NEMA 23 stepper
- CW250 Driver

http://openbuildspartstore.com/c-beam-linear-actuator-bundle/



PCB Rotation

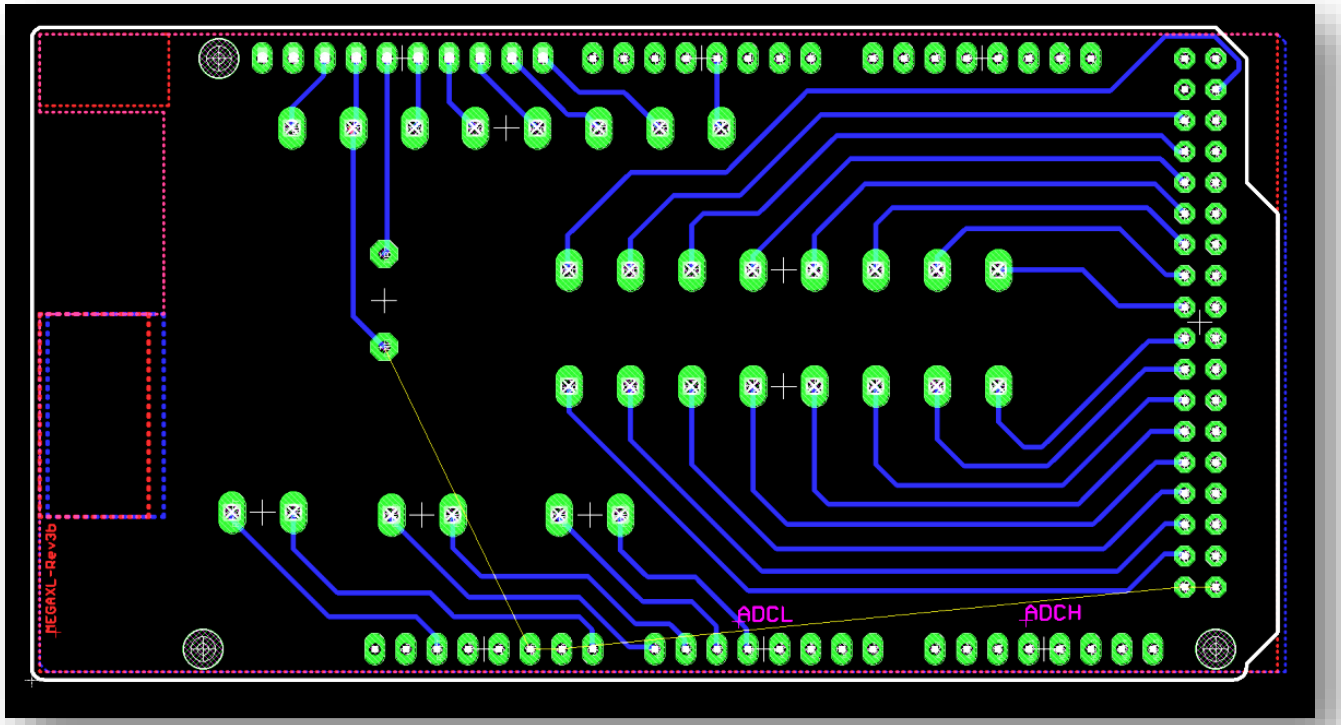
- NEMA 17 Stepper
- Motor Bracket
- Mounted to C-Beam Arm

http://www.soprolec.com/shop/161-large/stepper-motor-nema-17-022nm.jpg

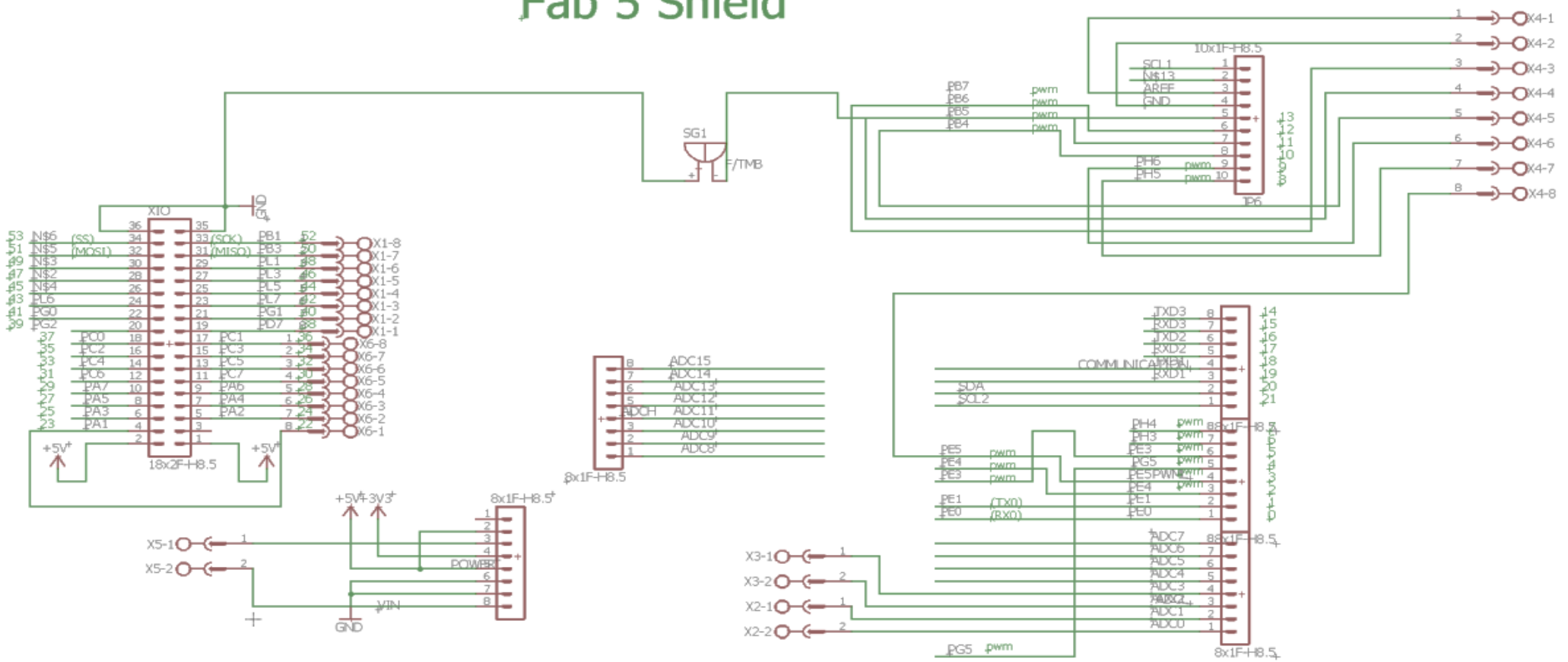
http://www.omc-stepperonline.com/images/st-m1.jpg

Arduino Shield PCB

- Fits directly on top of Arduino Mega 2560
- Allows phoenix connectors to be used
- Simplifies wiring
- Adds an alarm to the system

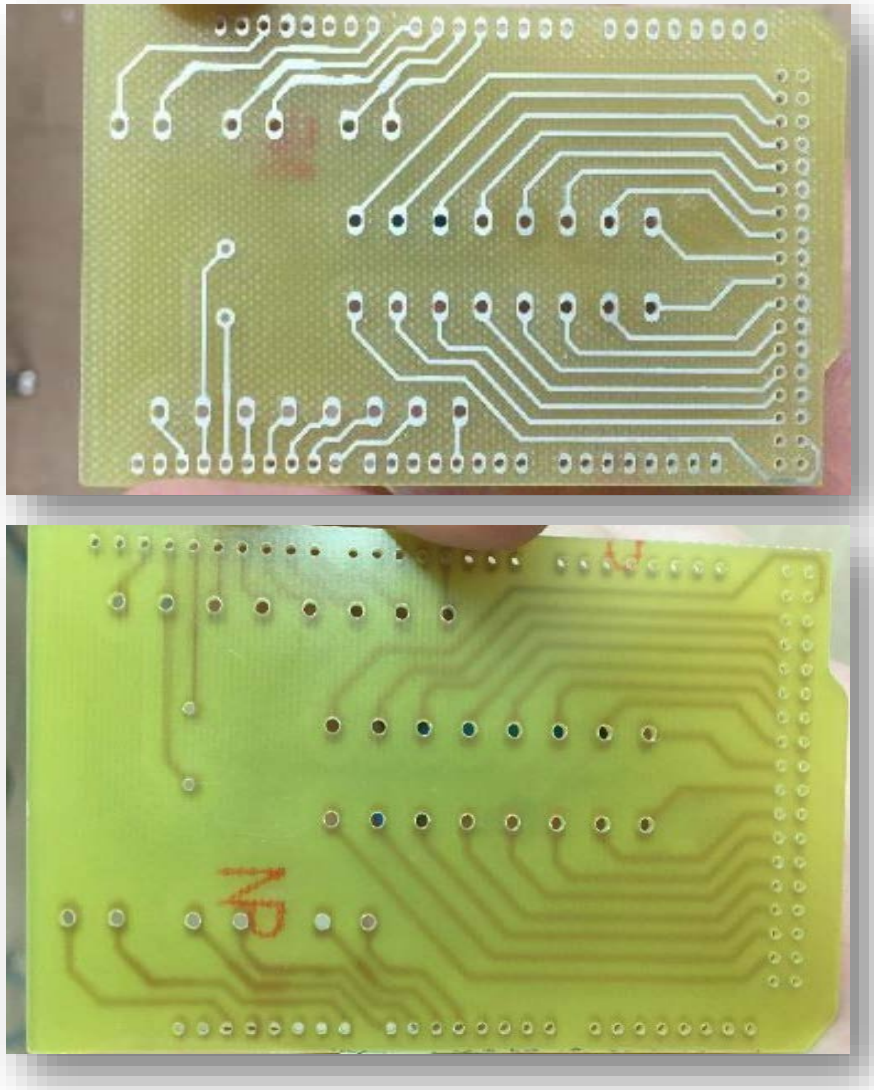


Arduino MEGA 2560
Fab 5 Shield

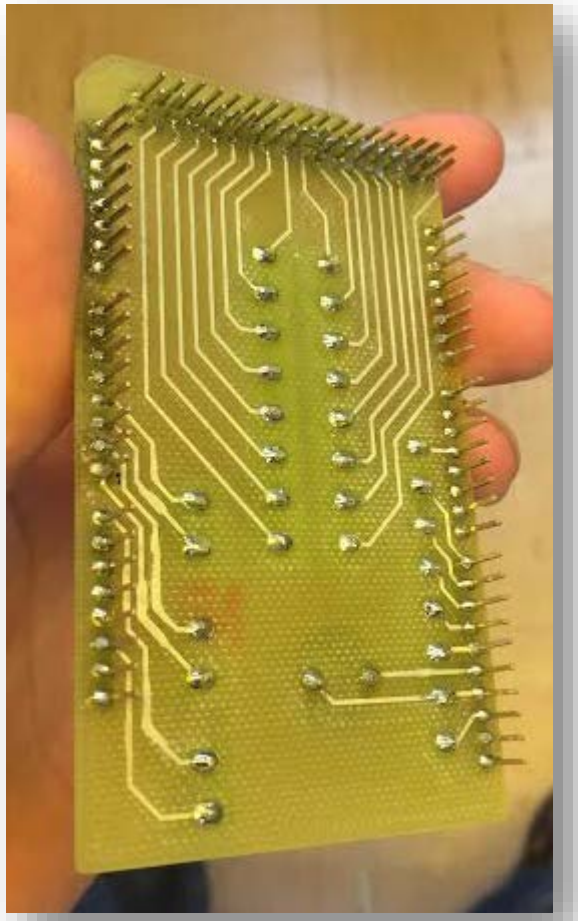


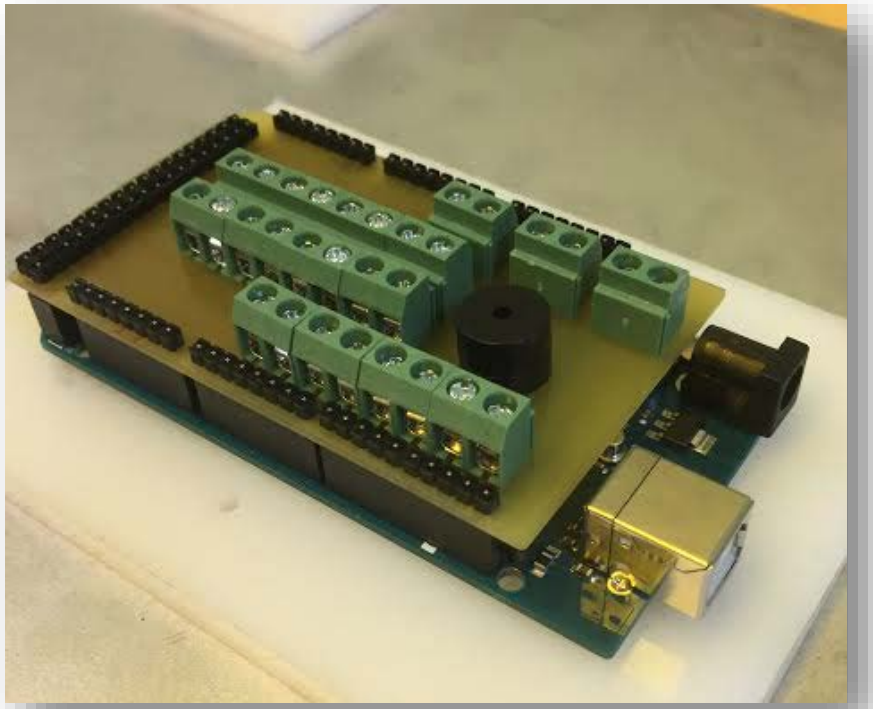
PCB Fabrication

- Milled in EE PCB Fabrication Lab
- Traces tinned to protect from oxidation
- Holes drilled for components



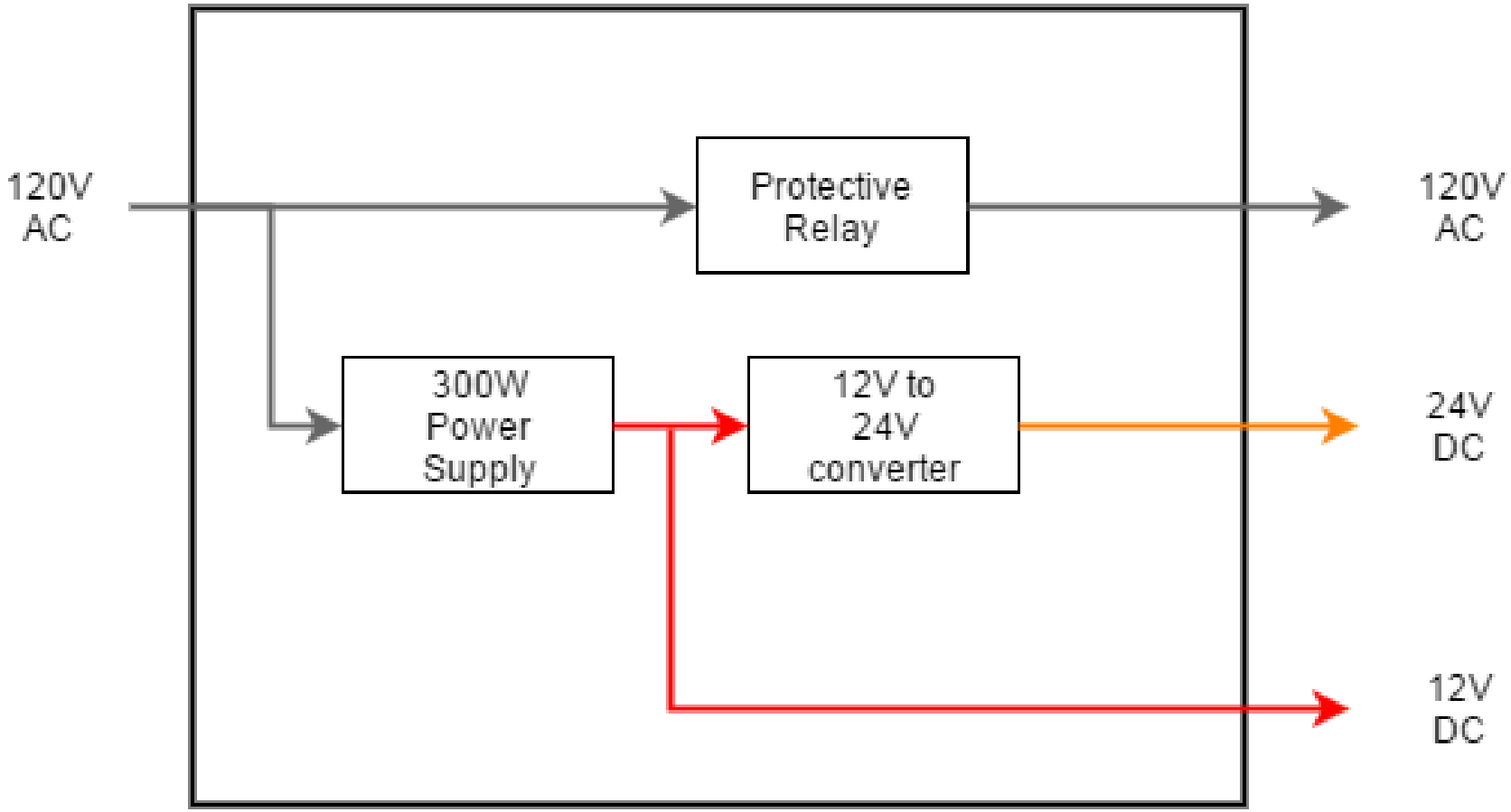
Soldering Components and Fitting





Power

Level 2



$$P = I * V$$

$$P = 20A * 120V$$

$$P = 2{,}400W\ maximum$$

DC controlled relays

- Opto-22 120VAC 25A SSR
- Opto-22 60VDC 3A
- 3VDC 20mA minimum driving signal
- Mega2560 full control

http://www.amazon.com/Opto-22-Control-Optical-Isolation/dp/B0058UX2YS/ref=sr_1_6?srs=3445179011&ie=UTF8&qid=1461471509&sr=8-6&keywords=dc

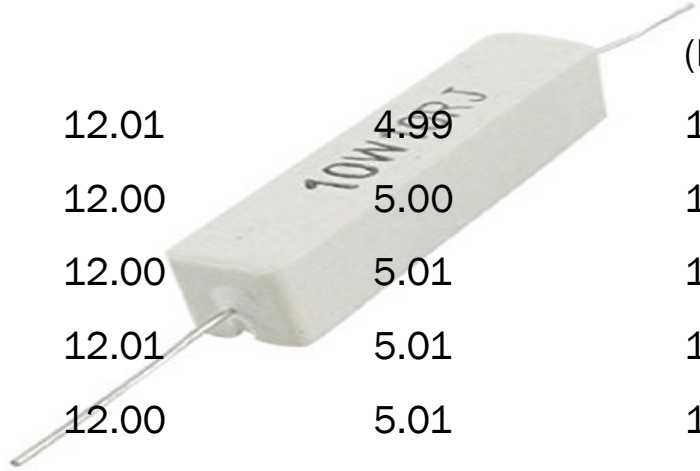
12-to-24 Voltage Regulator

- Supply 24V for NEMA-23 stepper motors
- Over Voltage and Short Circuit Protection

http://ecx.images-amazon.com/images/I/51upUZBHB1L.jpg

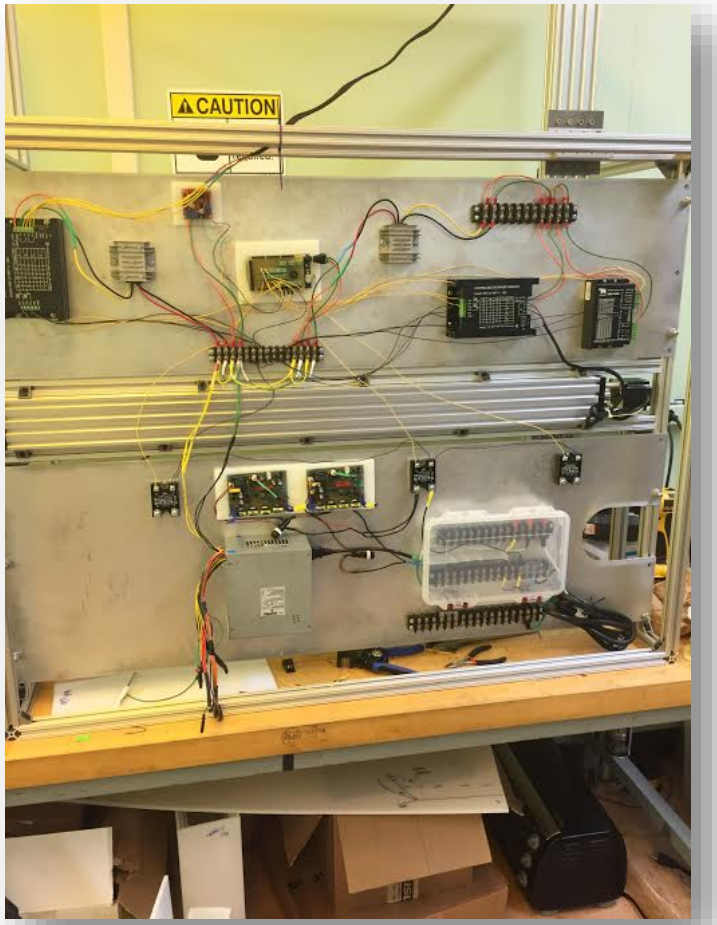
300W Power Supply

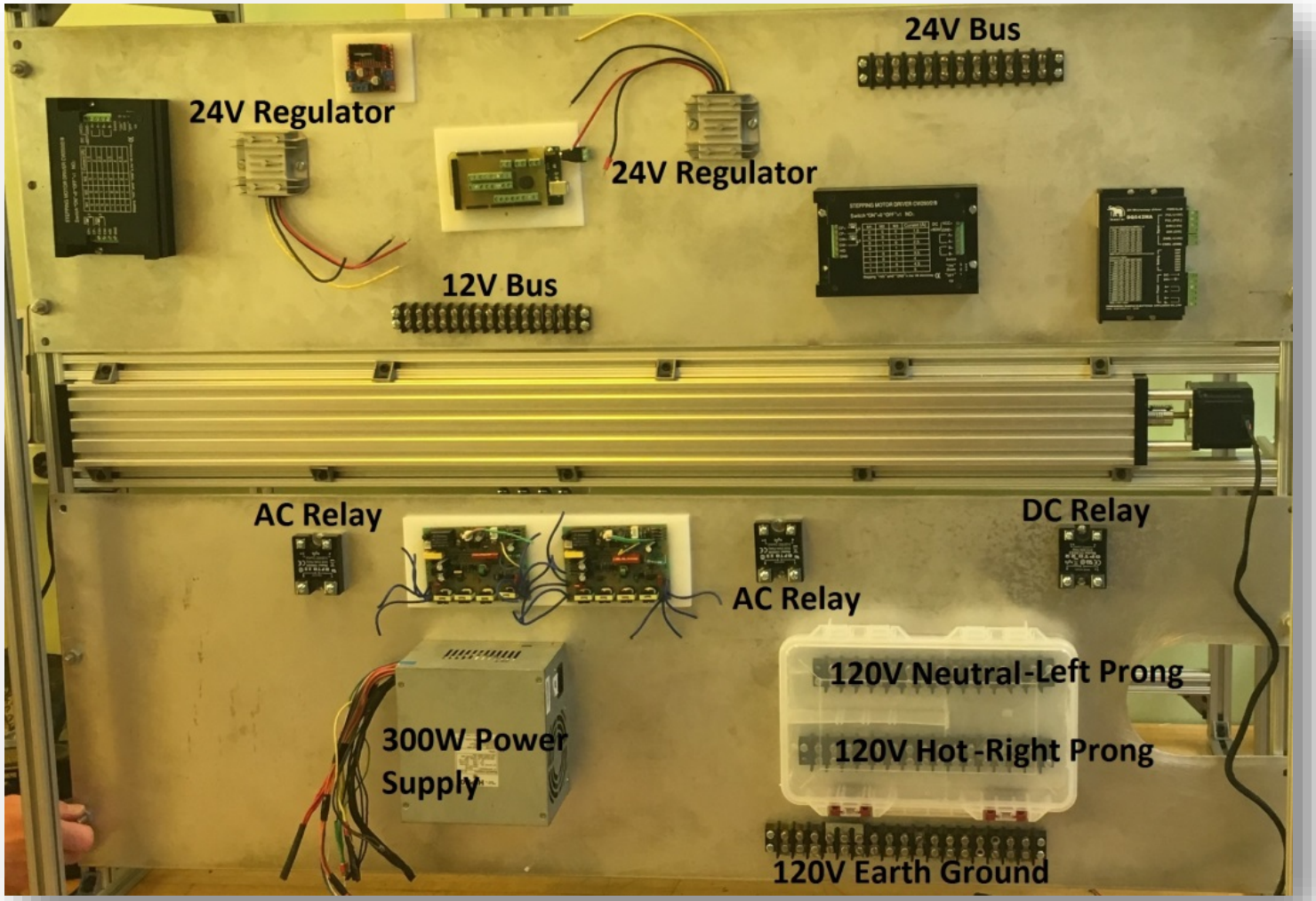
Time	12V Pole	5V Pole	Resistor (F)	Temp
0	12.01	4.99	108	
.25	12.00	5.00	114.8	
.50	12.00	5.01	120.5	
.75	12.01	5.01	127.9	
1.0	12.00	5.01	128.1	
1.25	12.00	5.00	132.1	



10W Wirewound Resistor
http://www.musikding.de/bilder/produkte/gross/10k-Drahtwiderstand-10W.jpg

Control Board



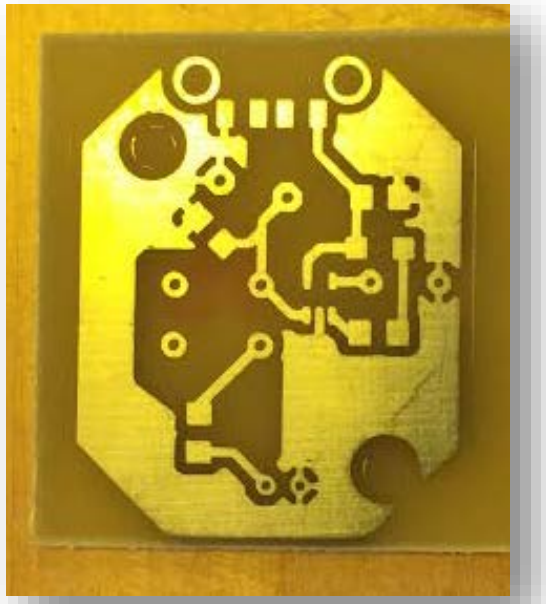


Final Process Specifications

Lacquer Application	• Left, right, and middle sprayed twice each • Time: ~5 minutes
Oven Tack Dry	• Heat: ~350F • Time: 10 minutes
Photomask Alignment	• Manual • Time: wait for user to press Continue
UV Exposure	• 4 bulbs on each side • Time: 30 seconds
Chemical Bath	• Agitation up and down • Time: 1.5 minutes
Water Rinse	• Sponges for removal of excess lacquer • Time: ~30 seconds
Oven Curing	• Heat: 350F • Time: 30 minutes

Results

- Milled and tinned board shown to left
- Solder mask coated board shown to right



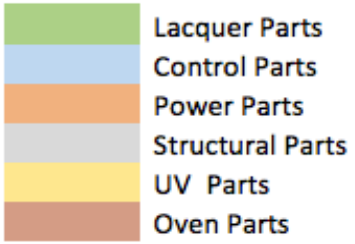
Finished Prototype

- Coated in orange acrylic plexiglass
- Vent placed on top to remove fumes
- Self-contained
- Removable front panel for maintenance
- Simple 2-button interface

Budget

- Original budget: $5000
- Final Expense Total: $2919.95
- Percentage of Budget Used: 58.4%

ITEM	COST
Lacquer gun setup	$1,382.90
Lacquer hose fittings	$59.42
Spare hose	$29.96
12V solenoid	$25.98
250mm C-Beam Linear Actuator Bundle	$121.95
lacquer	$42.00
Arduino Mega 2560	$45.95
5V buzzer	$2.85
CW250 stepper motor driver	$84.00
DQ542MA stepper motor driver	$39.95
L298n stepper motor driver	$6.99
12V barrel plugs	$6.99
1000mm C-Beam Linear Actuators	$314.90
Limit switches	$22.50
MAX6675 k-type thermocouple	$13.99
Arduino Mega protoshield	$14.95
Stepper motor coupler	$8.99
NEMA 17 stepper control	$38.81
AC Relays	$87.00
DC Relay	$17.00
12V-to-24V step-up regulator	$42.76
20A NEMA plug	$9.99
8020 aluminum extrusions	$389.98
M5 screws and t-nuts	$16.20
UV nail dryers	$53.98
replacement UV bulbs	$19.98
toaster oven	$19.98
TOTAL	$2,919.95



Performance Outcomes

Goal	Measure of Success	Weight	%	Score
Control of all subsystems	Microprocessor fully controls all motors, actuators, spray, lights, and oven	0.5	80	40
Even exposure of board to UV light	All unwanted lacquer is removed in the chemical rinse and desired mask stays	0.05	95	4.75
Remain within size requirements	Hardware is entirely contained in a 4’ tall, 2’ deep, and 6-8’ long system	0.1	100	10
Solder mask applied evenly	Measured thickness of board after application process should be 2.4-3 mils thicker than before	0.1	70	7
Control heating elements	Elements heat to desired temperature when microprocessor triggers solid-state relay contact to close	0.05	90	4.5
Contain all chemicals	Lacquer, sodium carbonate, and water containers are sealed tight so as not to leak	0.1	95	9.5
Maintainability	All parts are easily replaceable	0.1	80	8
	Total	1.0		83.75

Acknowledgements:

- Professor Scalzo
- Mr. Chris O'Loughlin
- Guoxiang Gu (4810 Mentor)
- Jean-Louis Cozic III
- LSU EE/ECE Department