

NEW PROJECT: SUBSTATION

Logan Farrens,CSE=,105,TRM=,20250105,PRJ=,03,SCO=,??,DAT=,YYYYMMDD,COMMENT=,Project selected -- build a substation for the room's miniature three-phase AC power system

Due YYYYMMDD (All-Lab Day 07) -- grading, Construction Standards, conformance/functional criteria, prototype design, define deliverables, identify parts for Tony to order, contact Galen for PCB file and project journal

Due YYYYMMDD (All-Lab Day 08) -- edit Galen's original PCB design in KiCad (power trace width, CT connection points) ; journal entry

Due YYYYMMDD (All-Lab Day 09) -- place PCB order (if not week before) ; journal entry

Due YYYYMMDD (All-Lab Day 10) -- set up plywood frame for substation PCBs ; journal entry

Due YYYYMMDD (All-Lab Day 11) -- run cables for three-phase power, work on Trip/Close pushbutton station ; journal entry

Due YYYYMMDD (All-Lab Day 12) -- work on populating PCBs with components ; journal entry

Due YYYYMMDD (All-Lab Day 13) -- work day ; journal entry

Due YYYYMMDD (All-Lab Day 14) -- construction completed ; journal entry

Due YYYYMMDD (All-Lab Day 14) -- Construction Standards inspection passed (-??% for retries)

Due YYYYMMDD (All-Lab Day 14) -- Conformance tests passed (-??% for retries)

Due YYYYMMDD (All-Lab Day 14) -- Functional tests passed (-??% for retries)

Due YYYYMMDD (All-Lab Day 15) -- Submit Project Journal (includes schematic, code, test data, daily work entries, etc.)

Due YYYYMMDD (All-Lab Day 15) -- Test-point/code challenge (-??% for retries)

Due YYYYMMDD (All-Lab Day 15) -- additional = e-docs (+??%), abstract (+??%), BOM (+??%), UserGuide (+??%), impeccable (+??%)

Design features

--> Utilizes Galen Bennett's PCB made for SEL, functioning as a three-phase breaker using three latching relays

--> ???

--> STRETCH GOAL = shrink footprint of PCB to take up less space?

Functional test criteria

- > Substation must be able to take in power from at least two three-phase generators
- > Substation must be able to export power to at least two different three-phase loads
- > Trip/close pushbuttons for all circuit breakers must be accessible from standing height on floor

Conformance test criteria

- > Sturdy terminal blocks provide connection points for all three-phase power conductors
- > Wood mounting base for substation has room for future CTs (6 toroidal transformers PER breaker!)
- > Substation should be mounted on highest level of rack to be out of reach
- > All typical wiring and soldering standards apply (see Construction Standards in course document)

Explain how project is graded and identify deadline dates

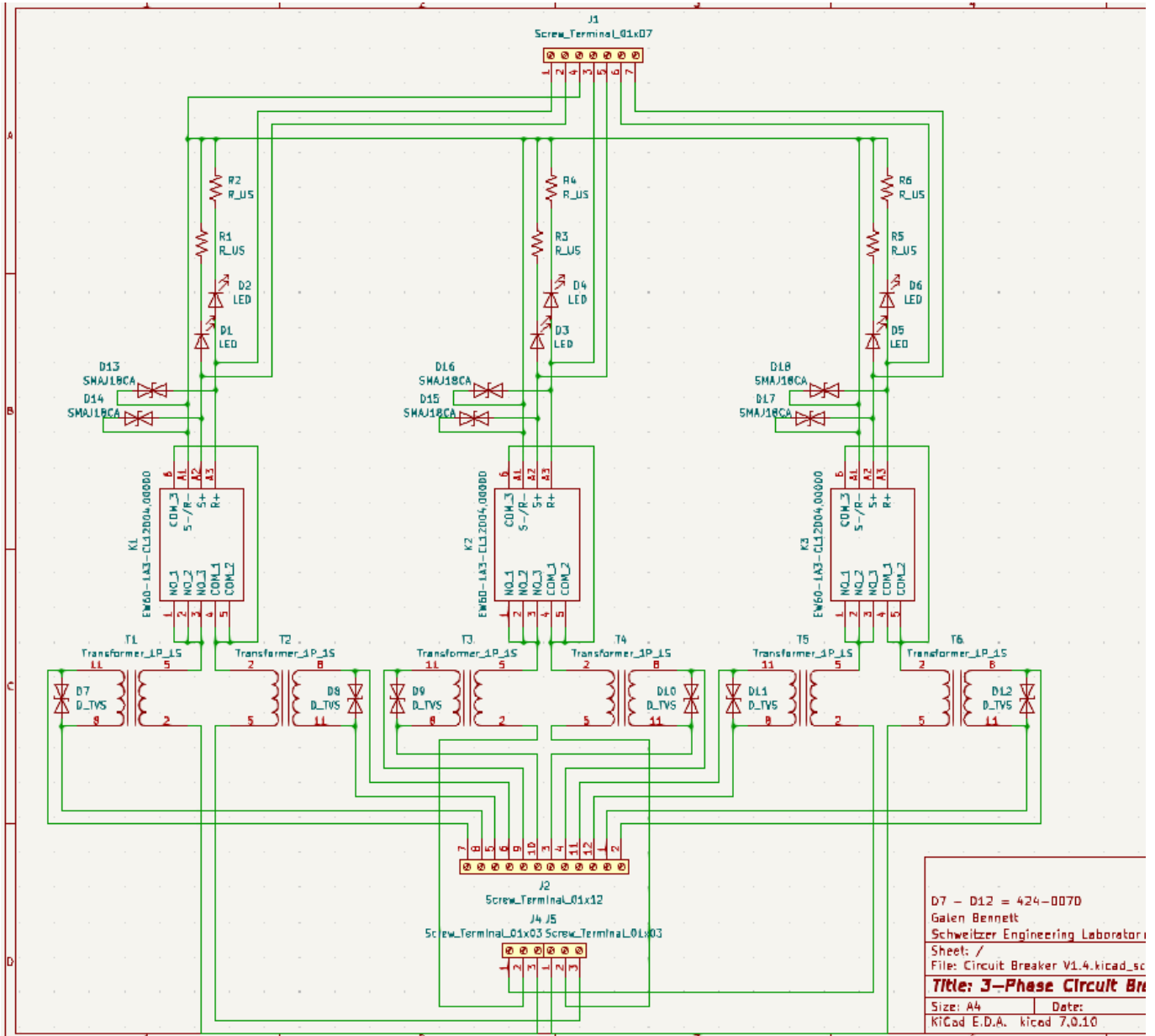
course grade is an average of all project grades based on completion of deliverables

if a project is not complete on or before the deadline a failing grade will be recieved for that course

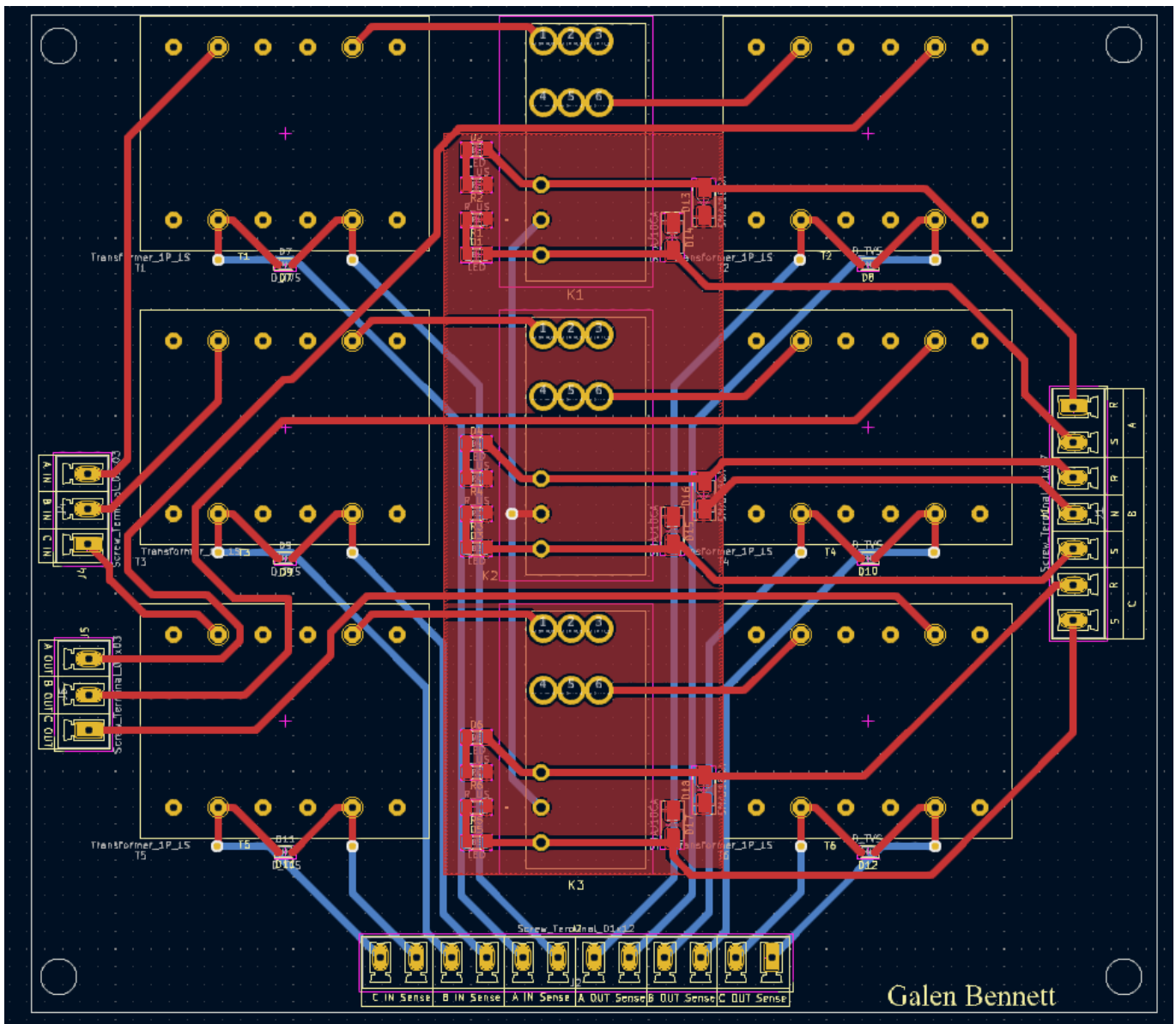
5% will be taken from project grade each day a deliverable is not met

ALL LAB DAY 07

Today I chose to start the substation project from the STC power station adding on to my previous MOTOR/GENORATOR project. Luckily Gallen Bennett had created a PCB layout and substation project already before for a similar project that SEL had him do. I will be using his previous design and slightly modifying it for larger current transformers and larger trace width on the PCB. These are both for the sake of the high currents my system will be exposed to. I started by getting Galens files and journal transfered to me and finding a good current transformer from his journal.



schematic of substation by Galen Bennett



PCB layout by Galen Bennett

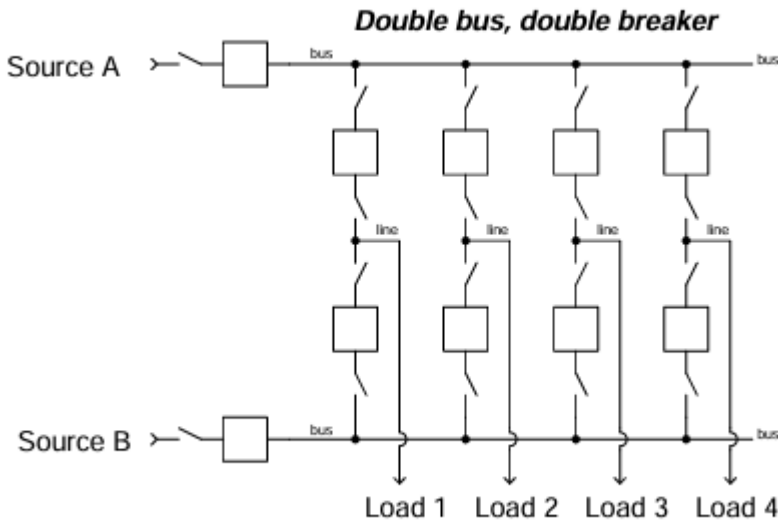
<https://www.digikey.com/en/products/detail/triad-magnetics/VPL2-4000/4835106?s=N4IgtTCBcDa1G4AcA2YC0AWADNkBdAvkA>

looks like this is the transformer that I want to use based off of Galens journal

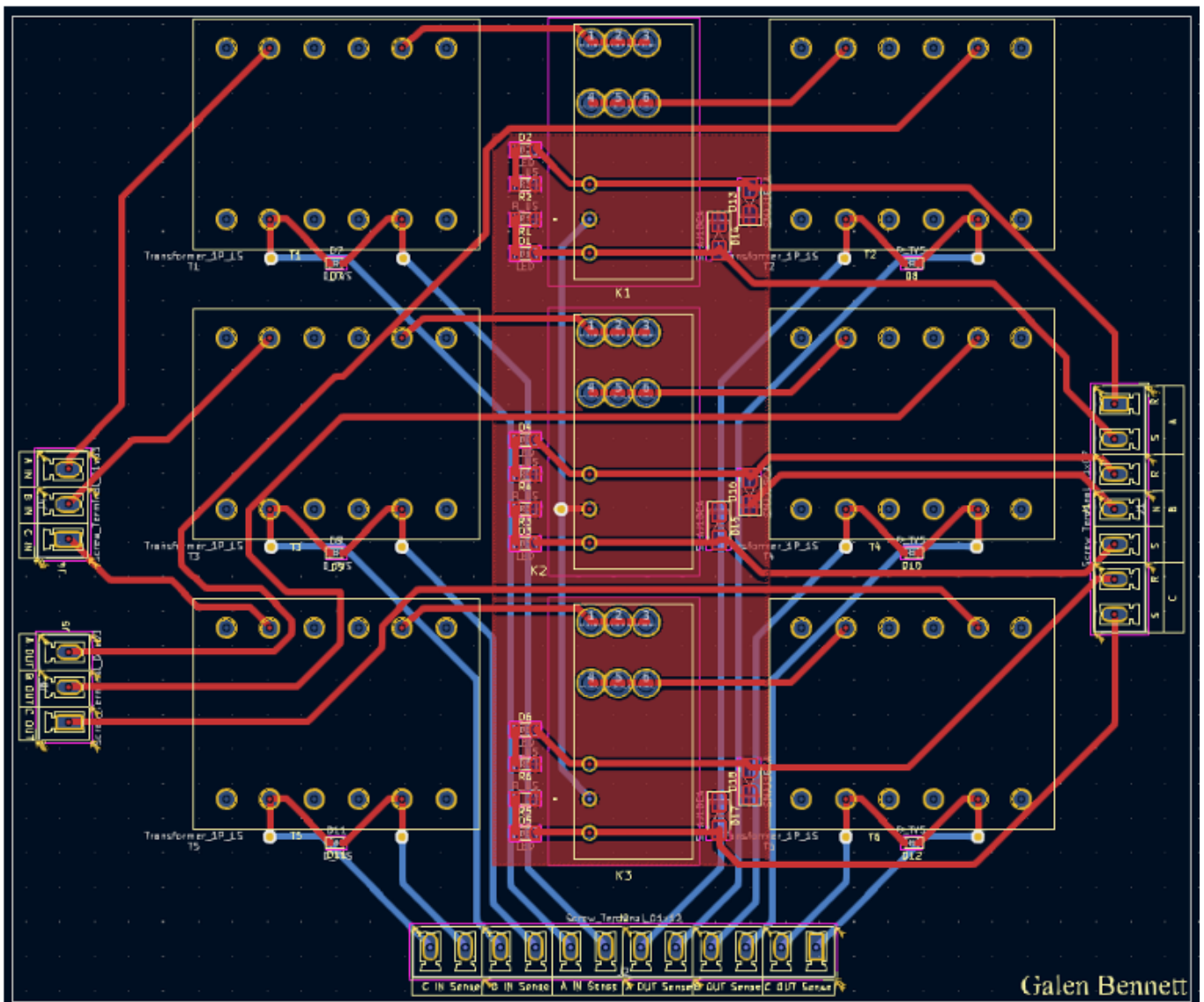
<https://www.te.com/usa-en/product-2071366-2.datasheet.pdf>

and this is the relay I should use

One thing to note on this project is substations aren't something i've specifically covered before meaning that I need to do some research over the next week or so to get a better grasp of this foreign design.



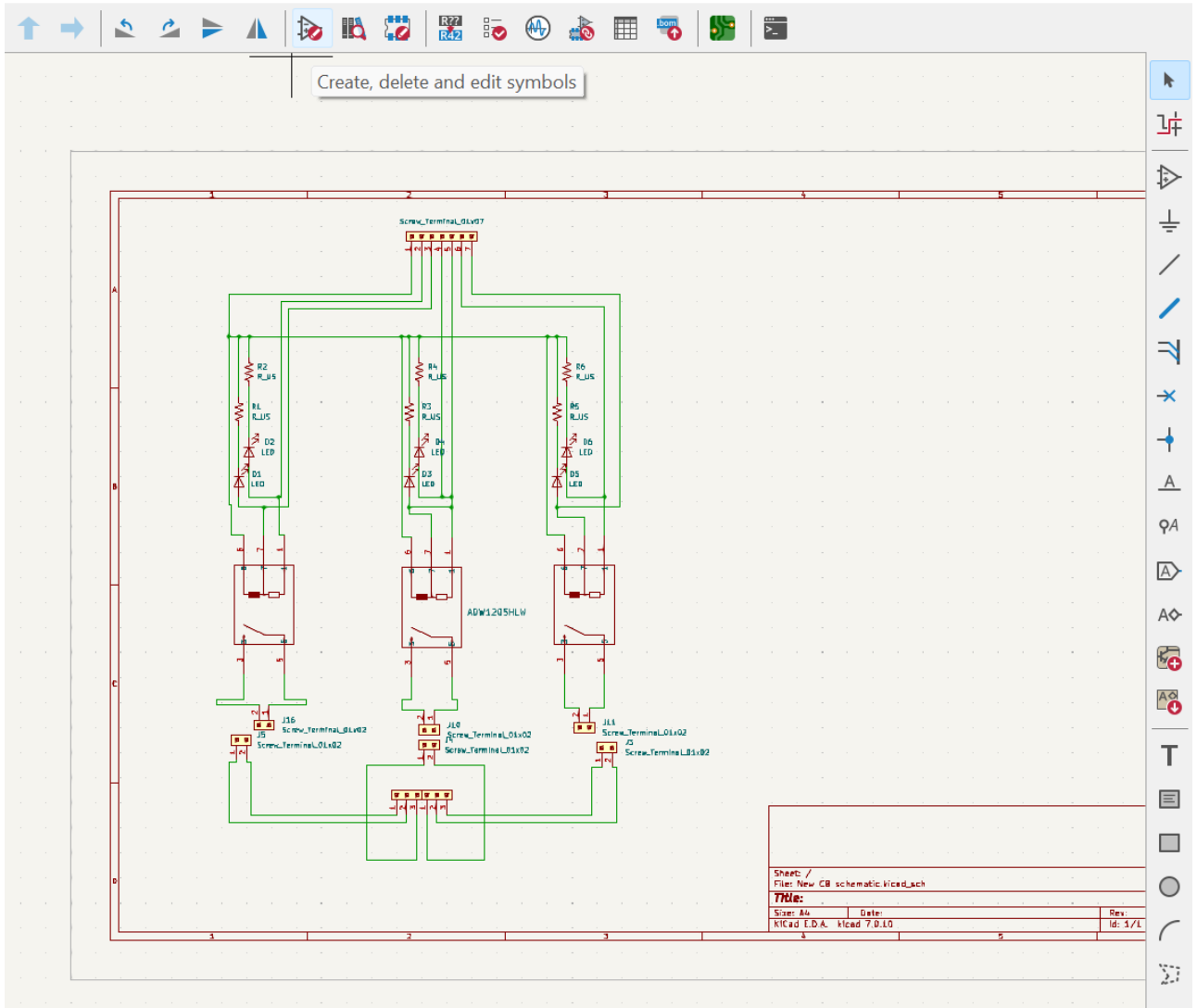
Tony just recommended to me that I check his module for trace ampacity and make the traces as big as possible. Then get rid of the blue traces as they are the secondary off the transformer that we won't be using anymore. Basically i'm just making a common jumper for when we plug the real transformers in.



All LAB DAY 08

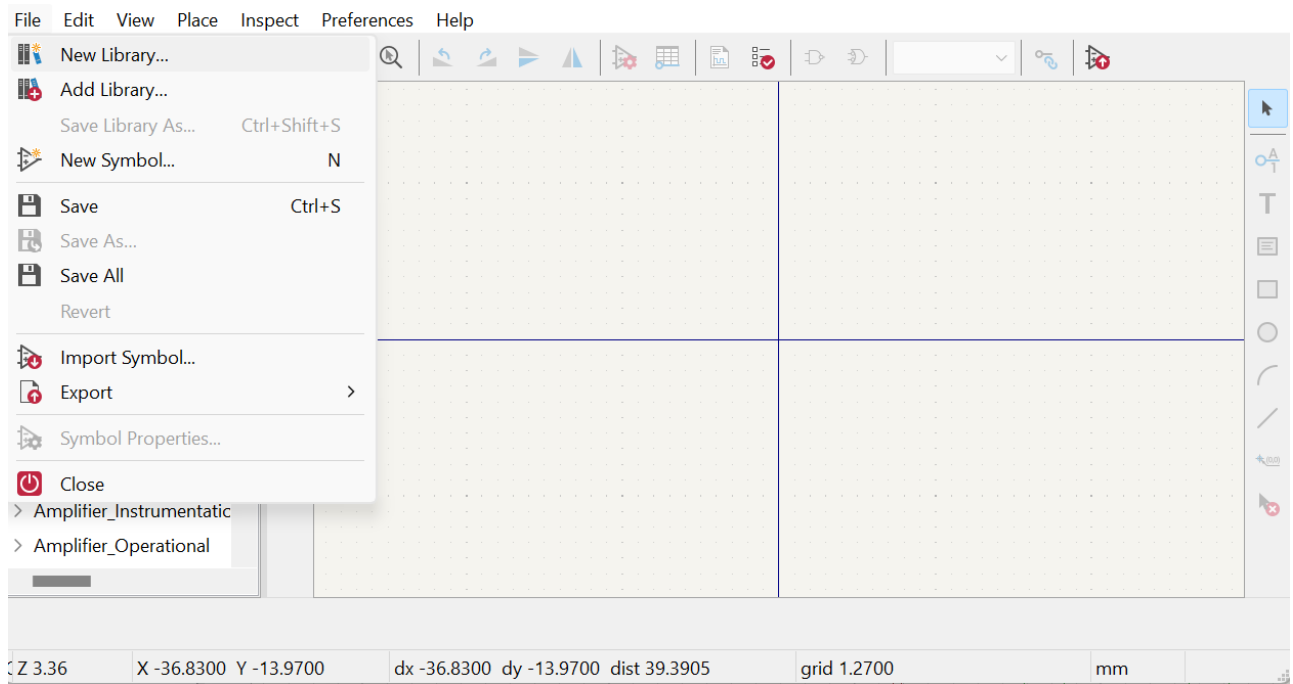
Today and yesterday were very challenging as I had to get a Ki Cad File off of the internet and then into my schematic here are the steps nessacary for the future.

1. symbol editor



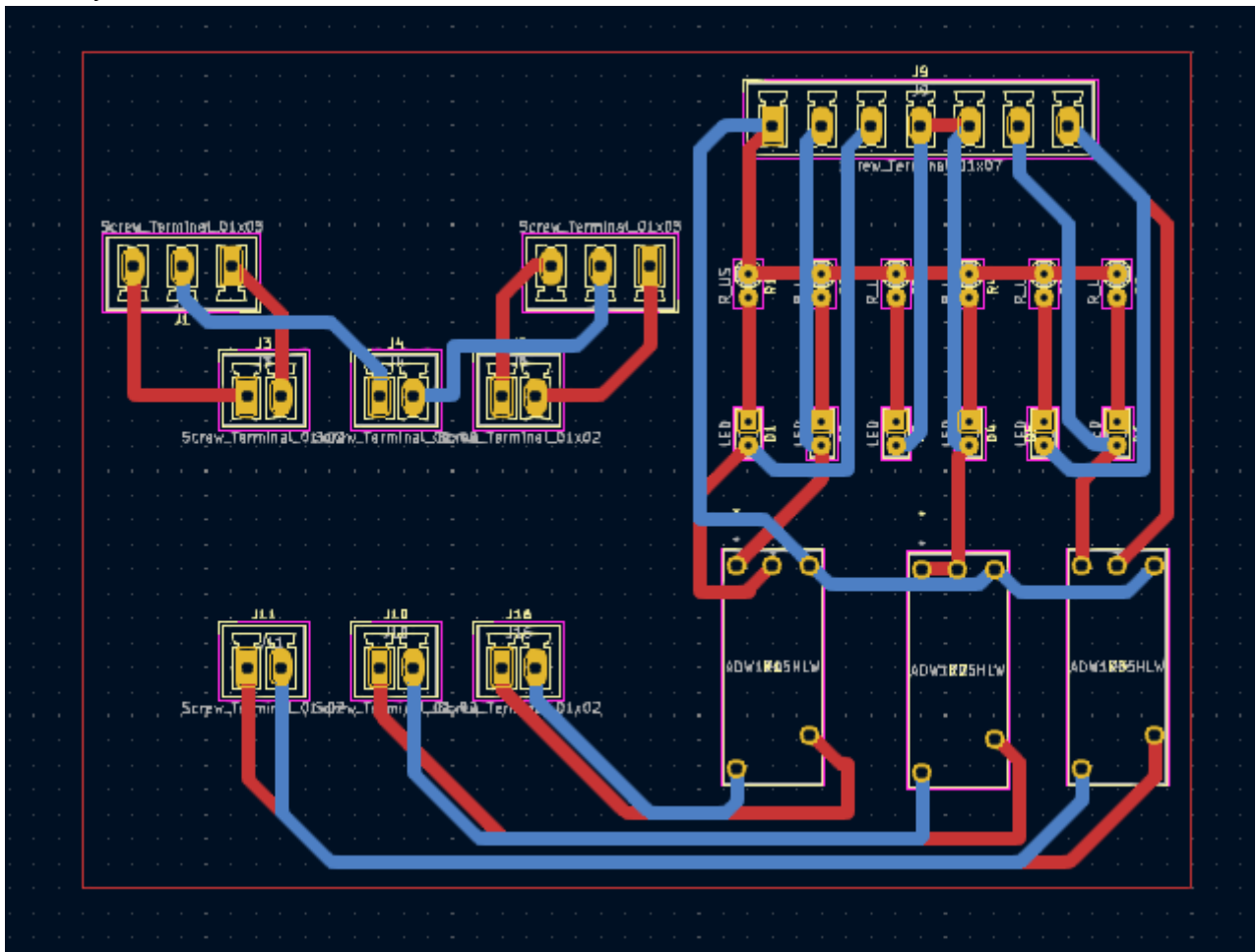
click on the symbol editor

2. new library



press on file in the top left corner and then press new library. Choose project for a single project or global if you want it on multiple documents.

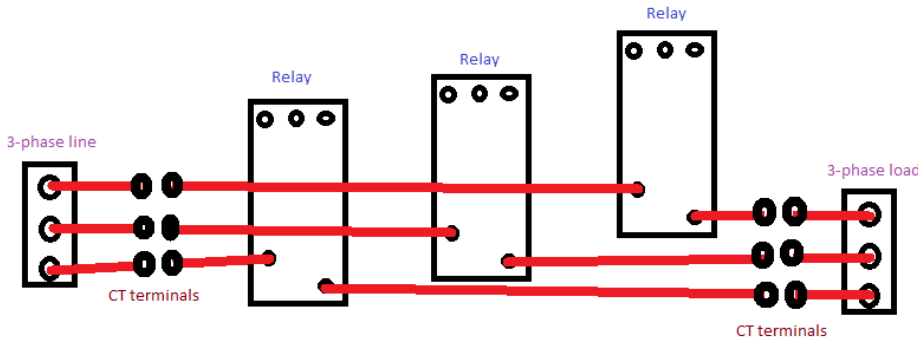
3. name and create library next you need to name the "library" that you will be using your name is a good idea
4. select your library that you choose
5. select symbol file



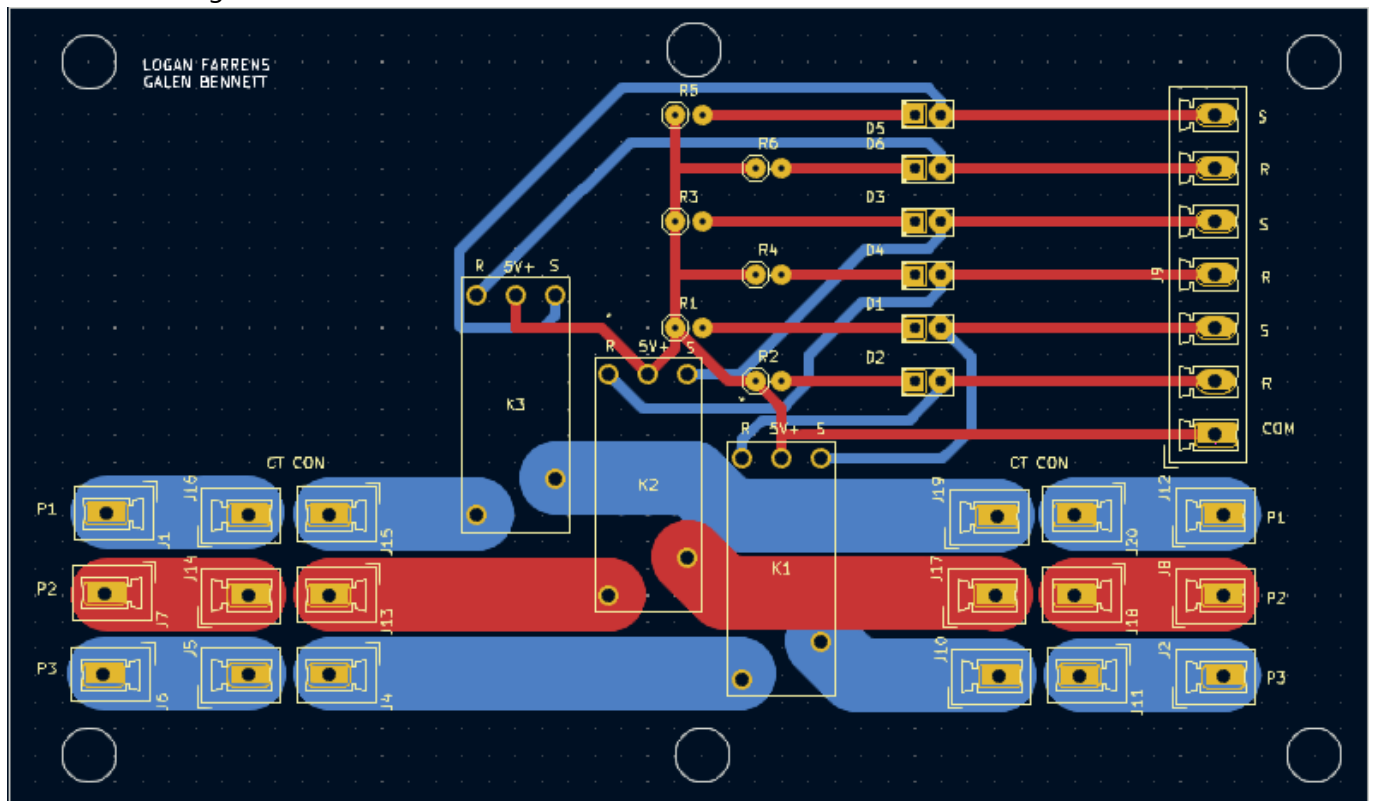
today I was able to get a layout of the PCB done with thicker traces. Towards the end I learned that I do need larger traces where the three phase output comes in and out. I will work on fixing these over the next couple days but I did meet my requirements for the deliverable as far as i'm concered for the day.

ALL LAB DAY 09

The last couple of days i've been working on a better layout for my PCB. Tony was very helpful in giving me a good idea on how to route my traces to have them as thick and straight as possible.

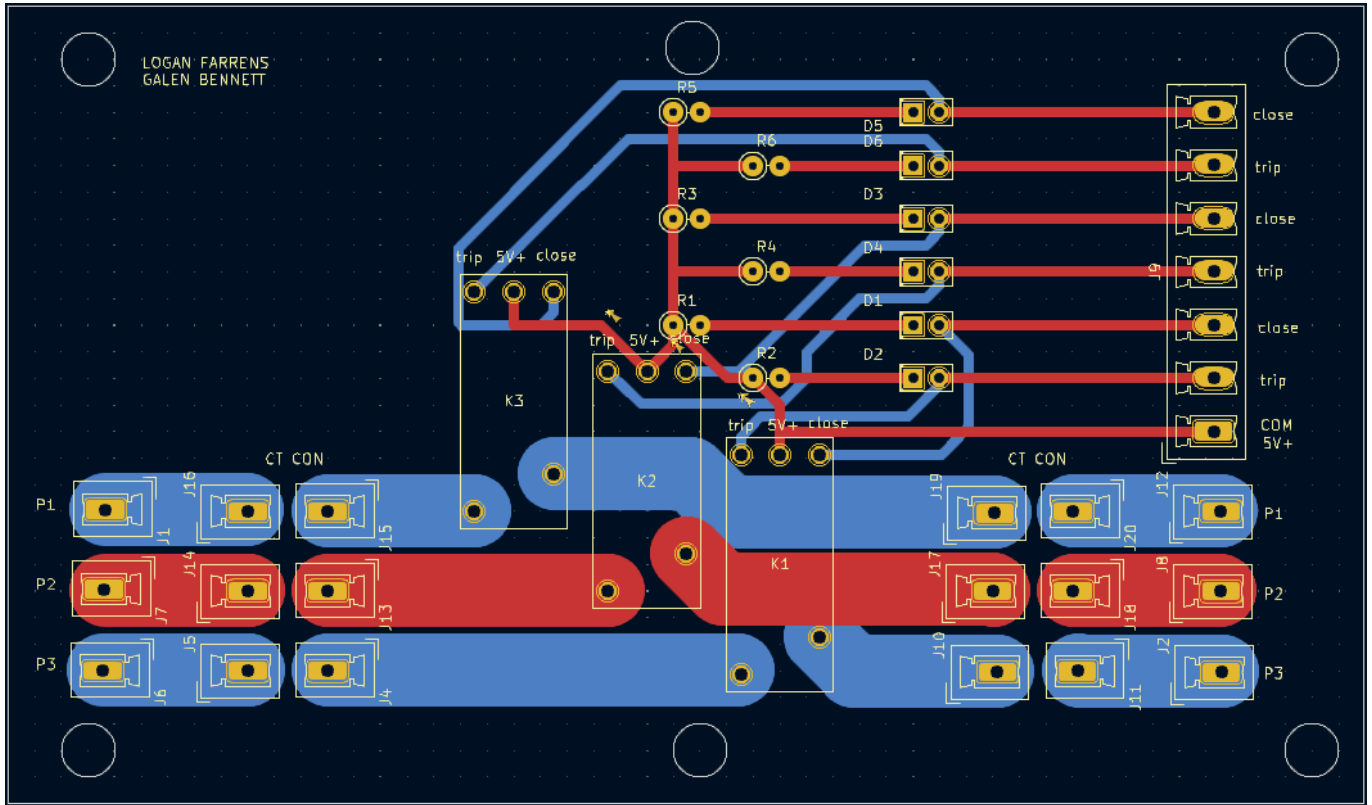


his idea worked great

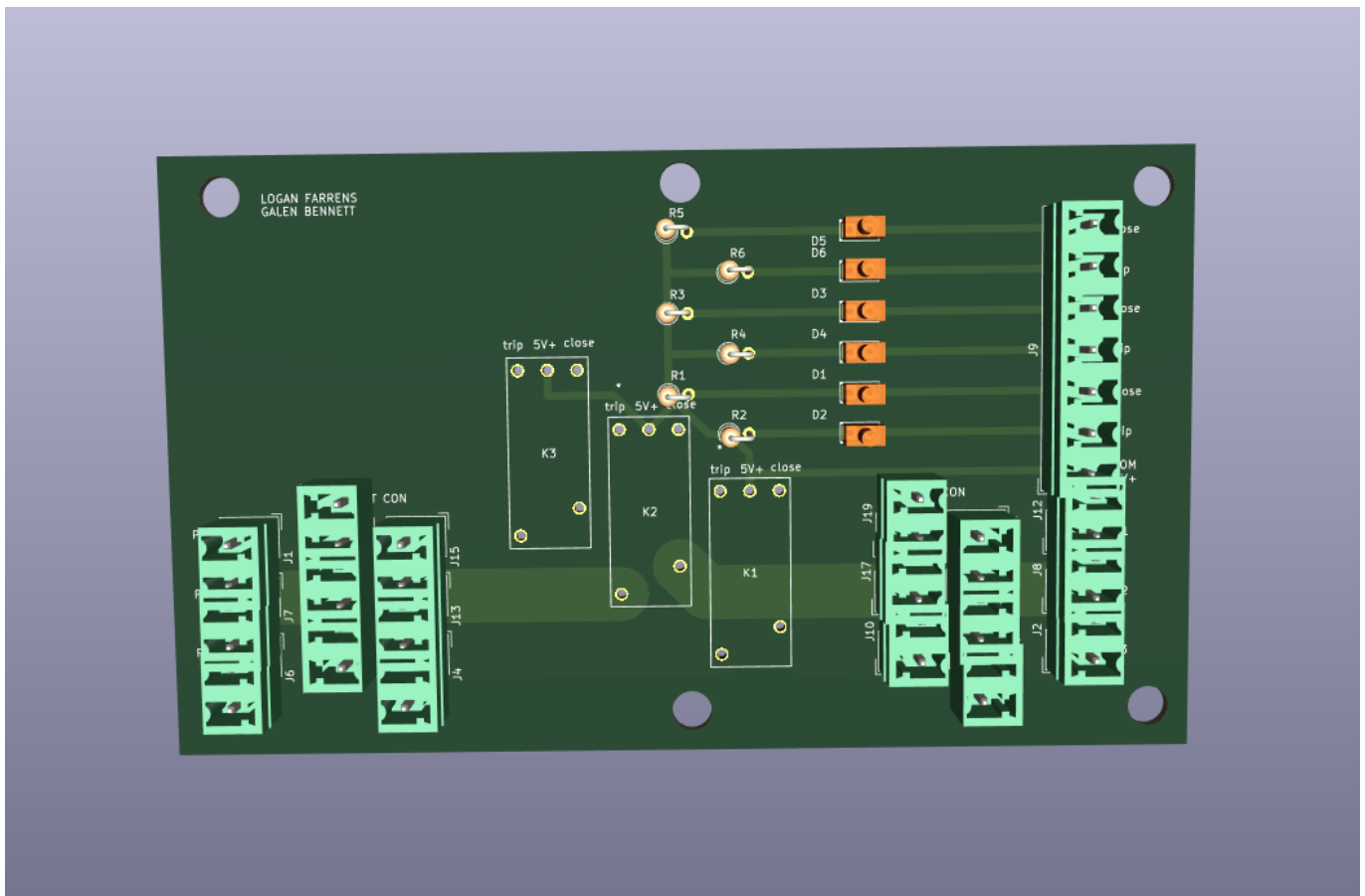


I finished up on the silkscreen, checked the gerber files and put in my order. It was DRASTICALLY cheaper than Galens PCBs because of the company we are ordering from which I was happy about.

Final PCB

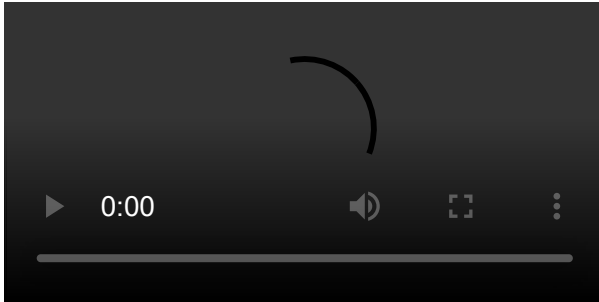


3D layout



relay schematic

https://download.datasheets.com/pdfs2/2024/5/2/17/2/51/947300/pns_/manual/270_fileversion.pdf



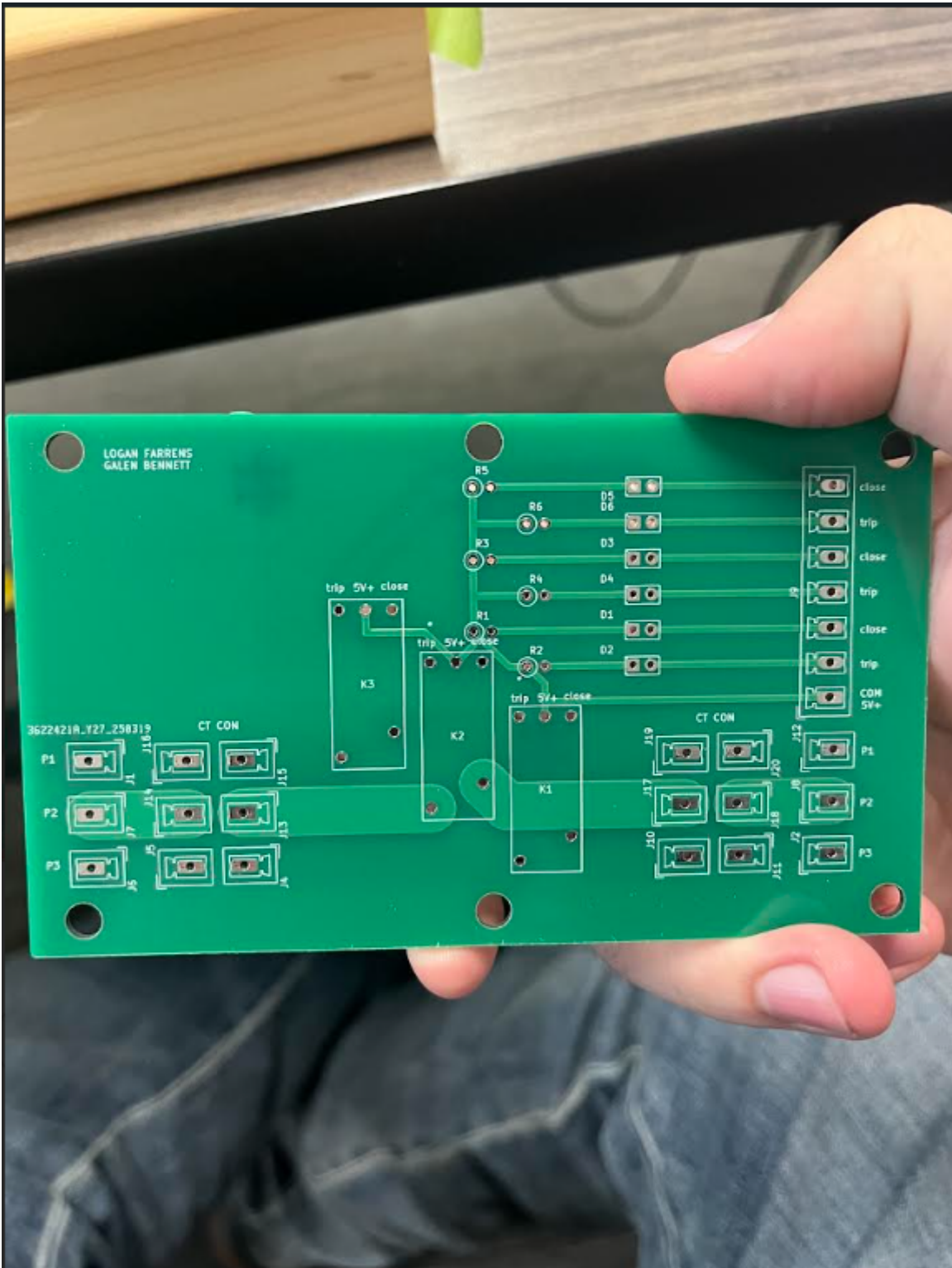
the schematic is poor so I had to wait till my relays got in to test what was set and reset this is a video to remember which just in case.

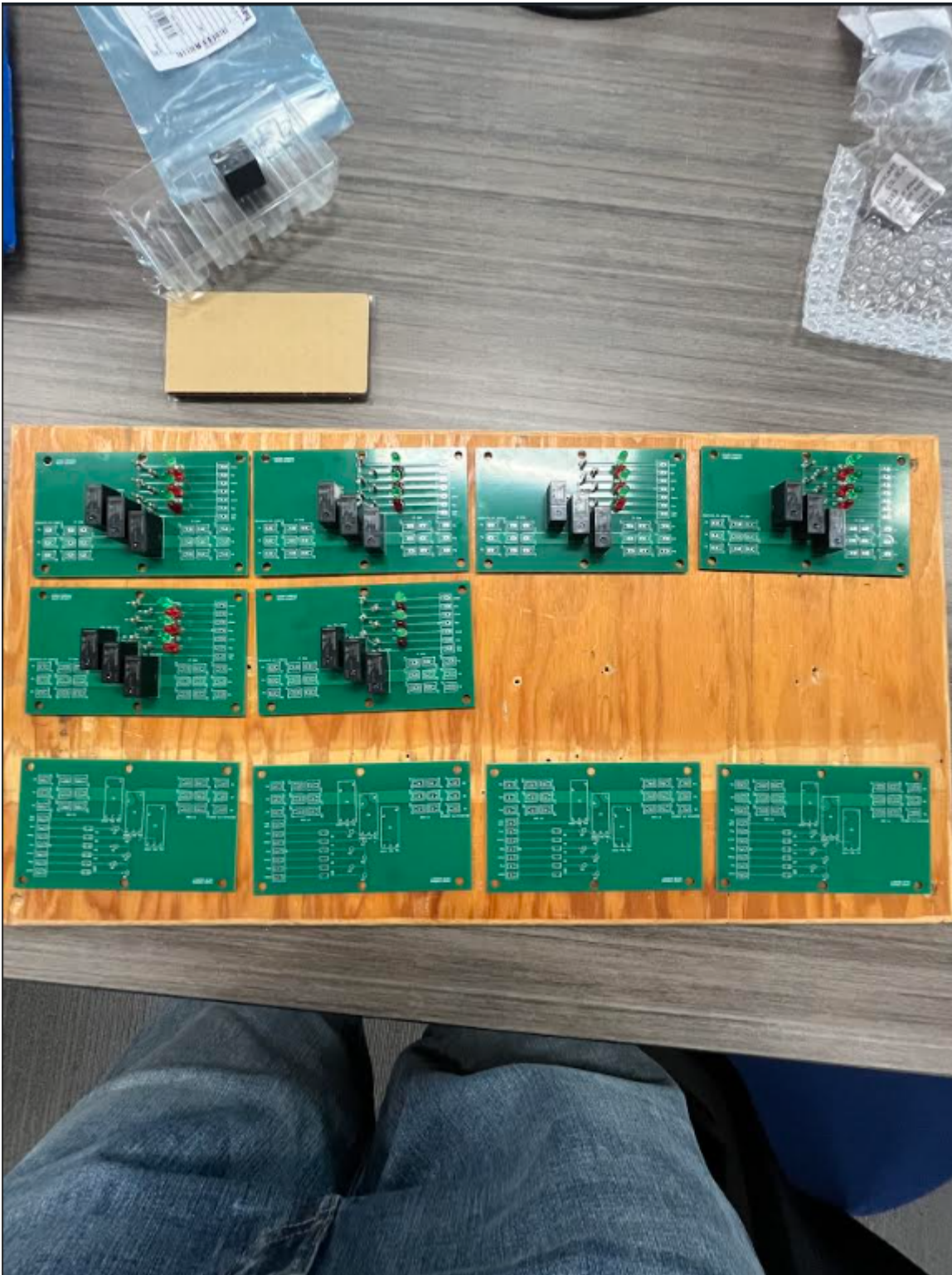
All LAB DAY 10

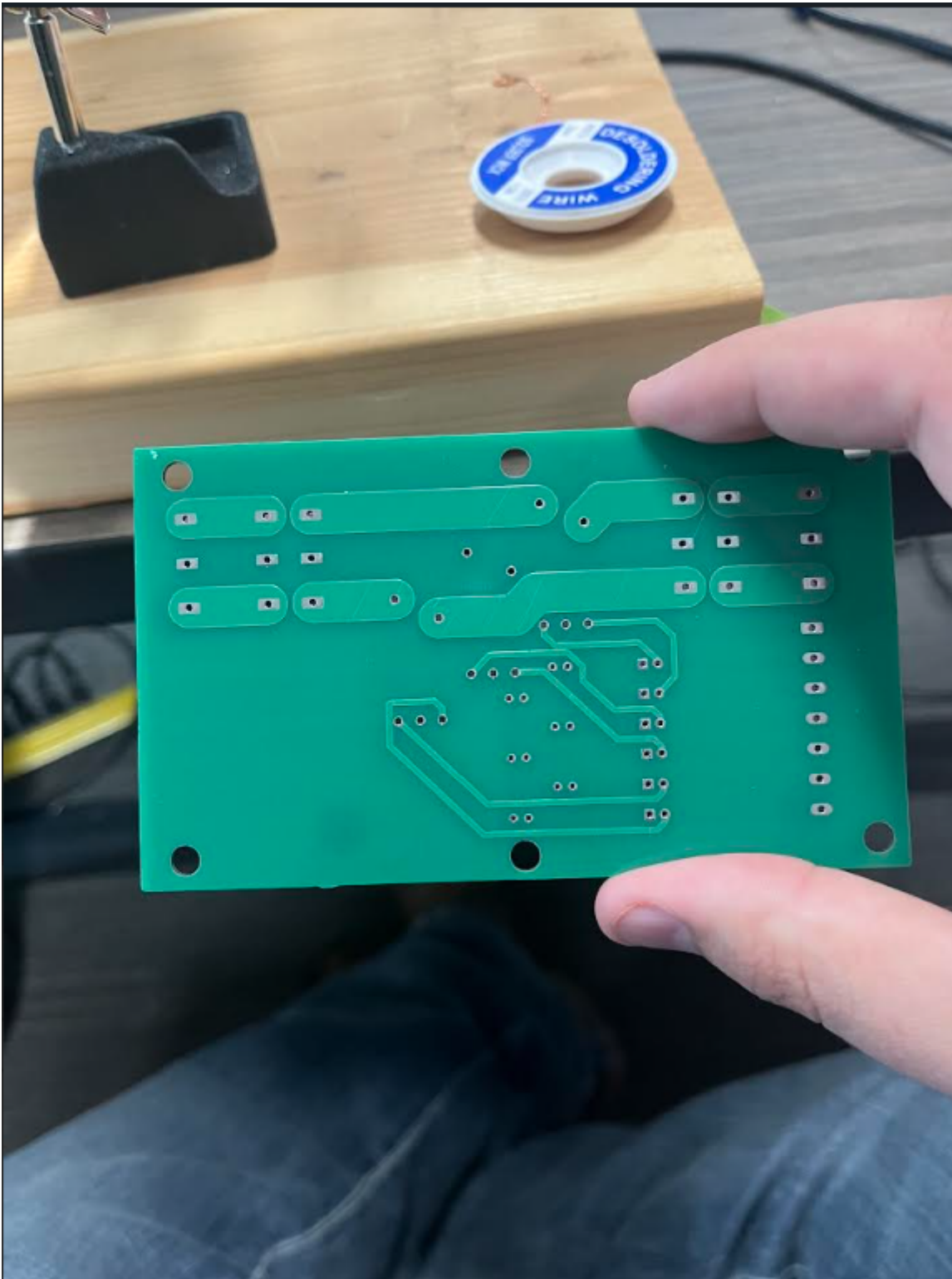
didn't have a whole lot that I could do today besides find the board that I wanted to choose I also used the time however to populate a PCB with buttons for the set reset find the scrap metal to mount that pcb to. later in the future once I get my pcbs and get the right sized ferules I can hook up my power.

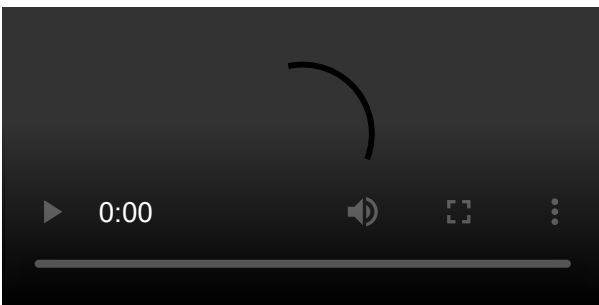
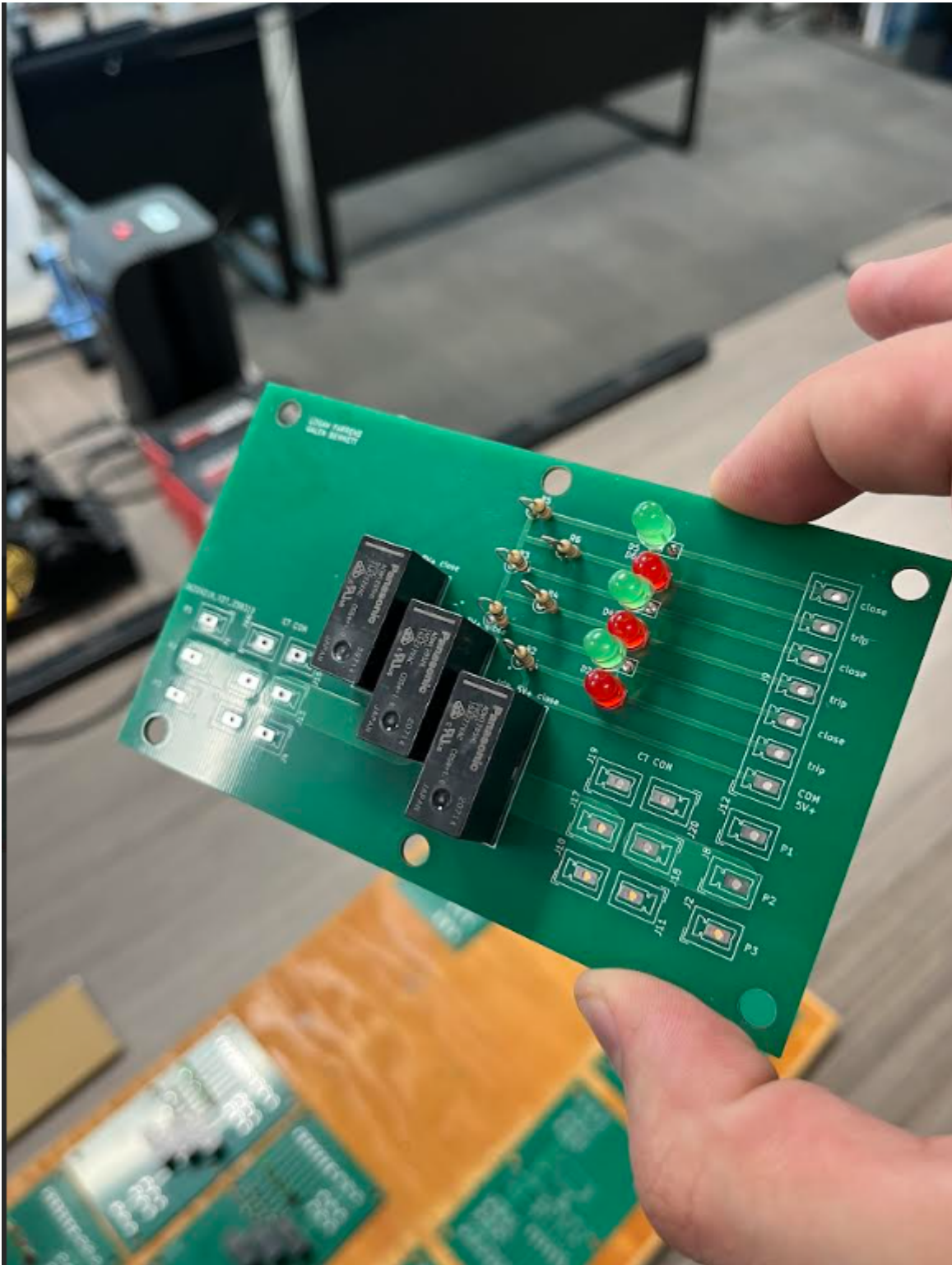
ALL LAB DAY 11

Today was EXTREMELY productive. I got my PCBs in and populated every single one. only one diode had to be replaced and a minor hiccup with the diode layout but it was easily fixed. below is a video showing the first pcb being tested along with pictures of all the pcbs completed.









ALL LAB DAY 12

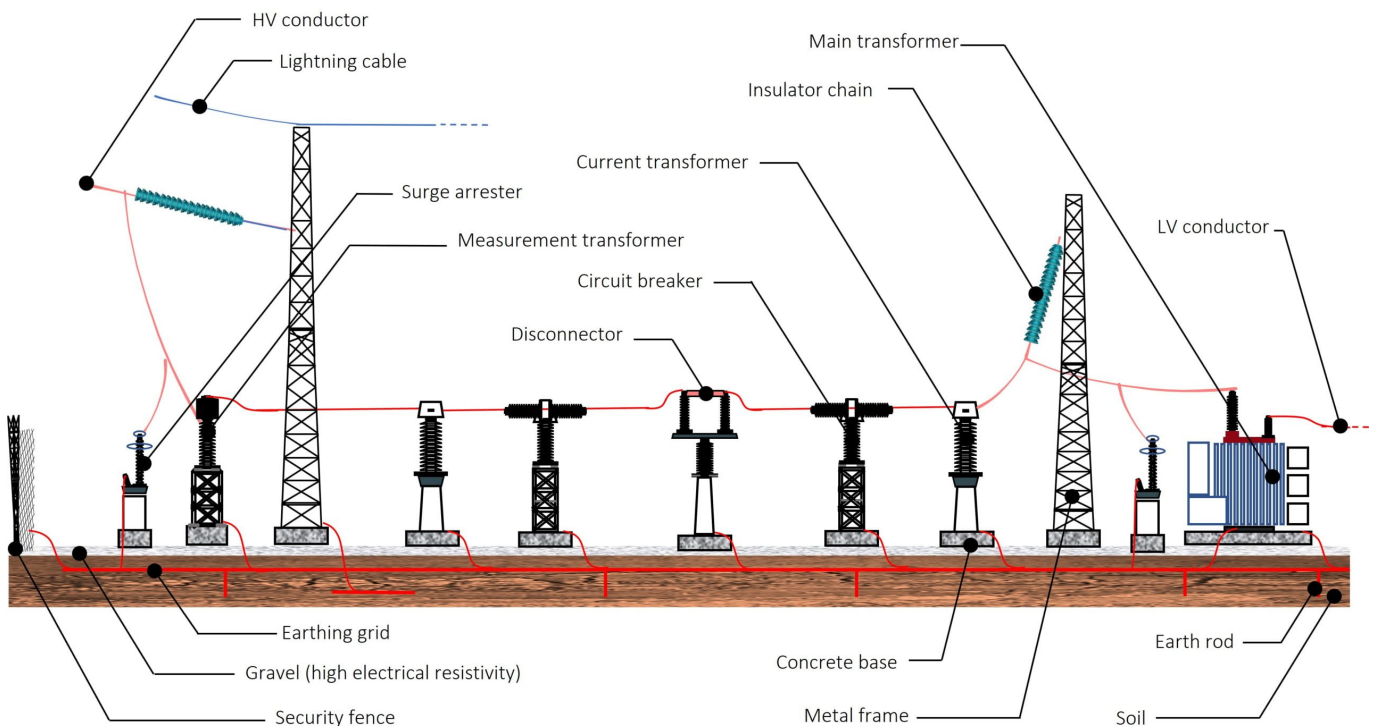
I am so close to being done, unfortunately did not finish today. I got my voltage regulator PCB mounted and finished, my pushbutton PCB mounted and finished now I just need to finish the PCB that will make my negatives of the trip/close common and tie it back to the regulator. Hoping to finish this Monday.

ALL LAB DAY 13

I worked on my project from Monday to Wednesday I didn't have problems I just Had TONS of wires to connect and that ate up a lot of time. something that contributed to this project being more successful than the last one was making schematics when I was in a stuck spot. It takes up maybe 30 min to an hour of time to do but it beats 3-4 hours of troubleshooting on top of making a schematic anyway because you need it for troubleshooting. I will certainly be using this tactic and making lots of schematics for future projects.

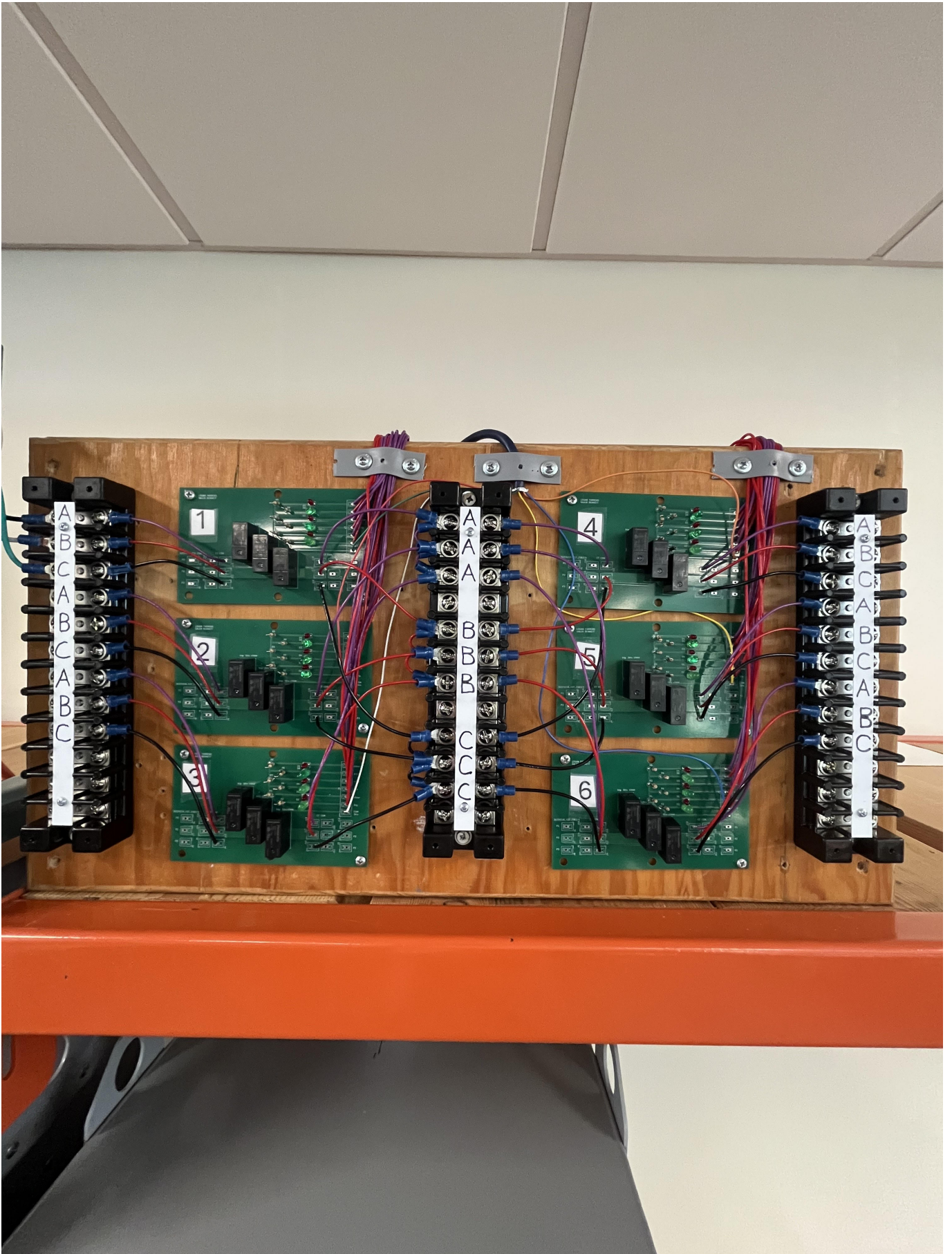
Abstract

this project is a substation to a electrical power plant its job is to maintain power to multiple loads at all times even when you need to work on one of the loads unpowered. You can do this because it allows you to shut off power to just that load.



this diagram shows you what ONE three phase system going into the substation looks like

my substation does not have the lightning cable, surge arrester, measurement transformer, current transformer or main transformer. these are both for safety and stepping up the voltage on High voltage systems and mine is very low voltage. Something my substation will have in the future is the current transformer which will monitor line current and cause the breaker to trip in overcurrent situations. Right now my substation only has the pushbuttons to trip and close so it is NOT protected under overcurrent situations.



in order to shut off a system press the red button corresponding with the system you wish to turn off this is the "trip" button. in order to turn it back on press the black button which is "close".



BOM

Column1	Column2	Column3
	quantity	price
PCBs	10	29.74
E cord	1	16.99
brackets	2	5
leds GRN	18	0.58
Leds RED	18	0.24
Relays	20	4.52
lrg scr trm	3	25
spade con	50+/-	38.49
sml scr trm	2	12.99
Total		546

User Guide:

in order to shut off one of the individual systems press the black button corresponding with the system you wish to turn off this is the "close" button. in order to turn it back on press the red button which is "trip".

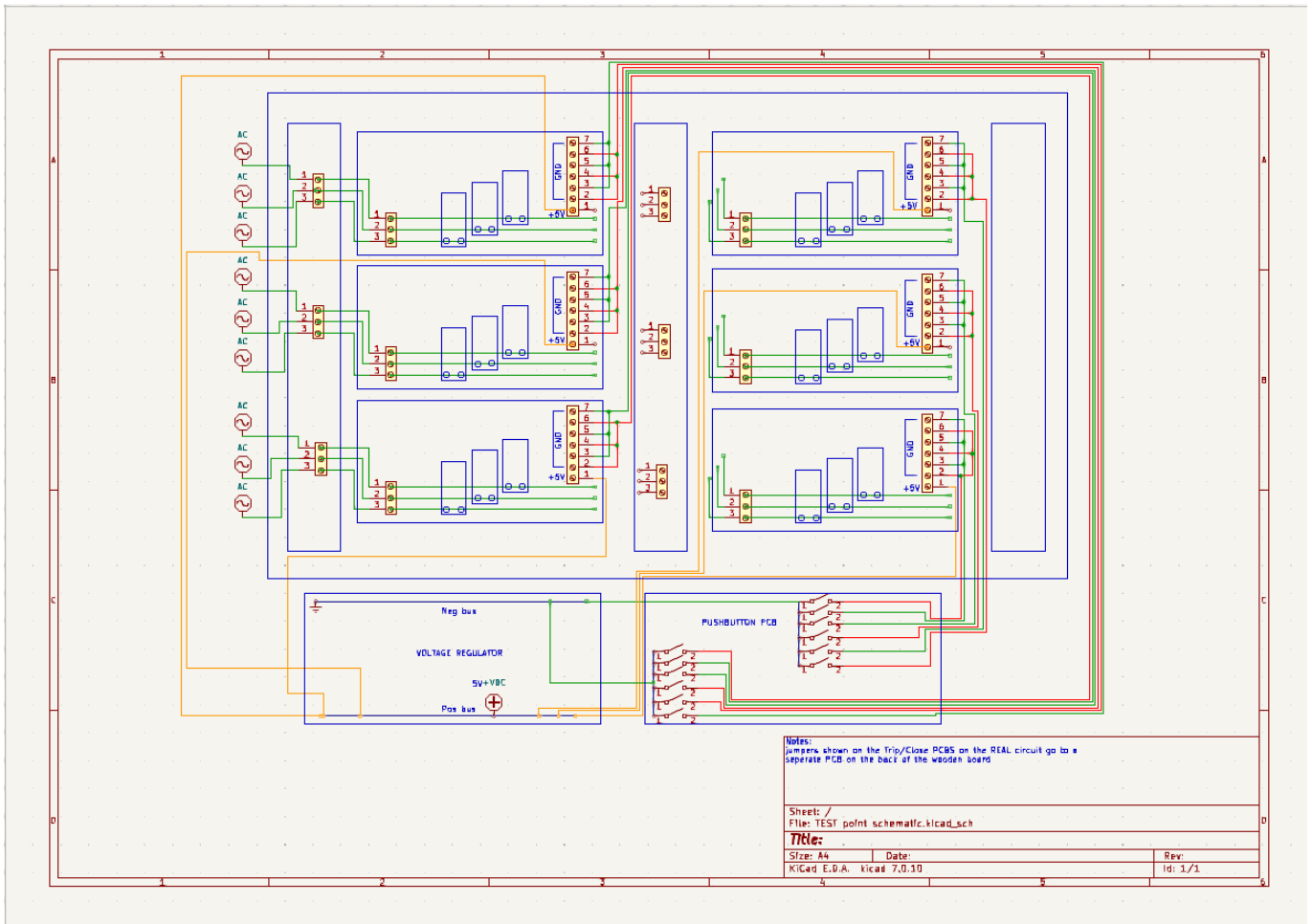
you can tell which system corresponds to which button because they are all numbered.

you can find this pushbutton system in the cabinet below the substation.



Final Schematics

Full System Schematic:



Circuit Breaker Schematic:

