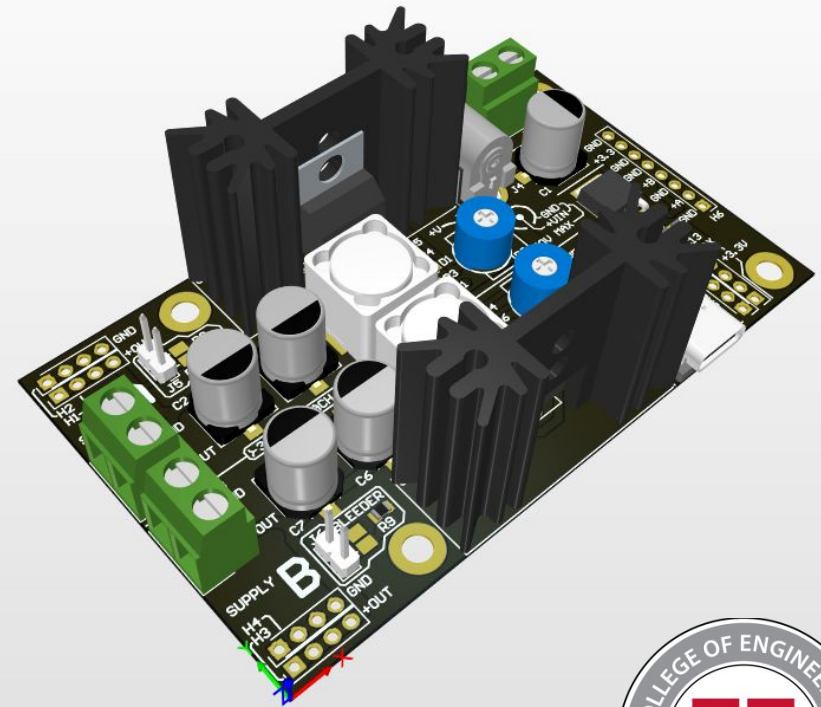
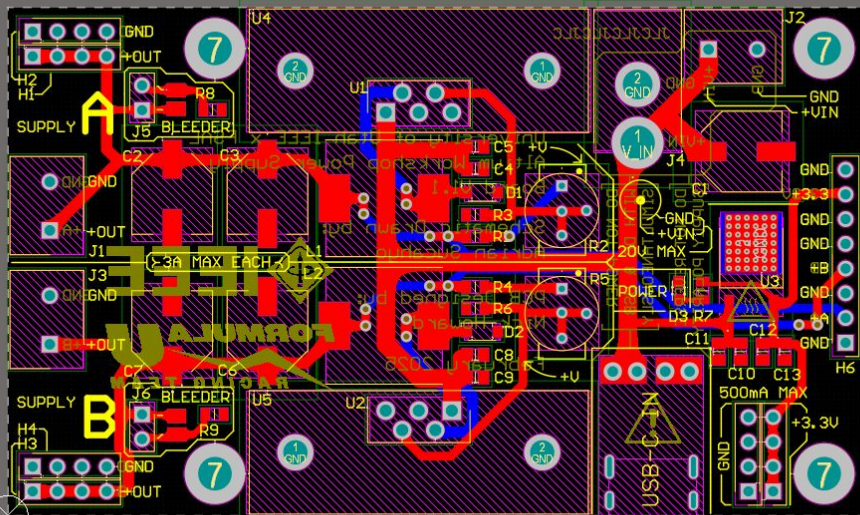


# IEEE x FSAE Altium Workshop Week 2: Introduction to Printed Circuit Board Design (Power Supply)



Hosted by: Nick Howard & Adrian Sucahyo



# Quick Note: Capacitors

- Capacitors store electric charge
- Useful for stabilizing voltages on a circuit board
  - Bulk capacitors supply current when supply is inadequate
    - Typically electrolytic
    - Supplies current for ~milliseconds
  - Decoupling capacitors provide *local* stability for rapidly changing loads (such as high-speed logic)
    - Typically tantalum/ceramic
    - Supplies current for ~microseconds/nanoseconds

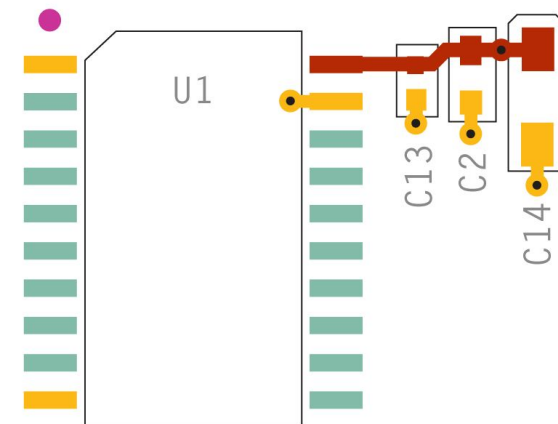


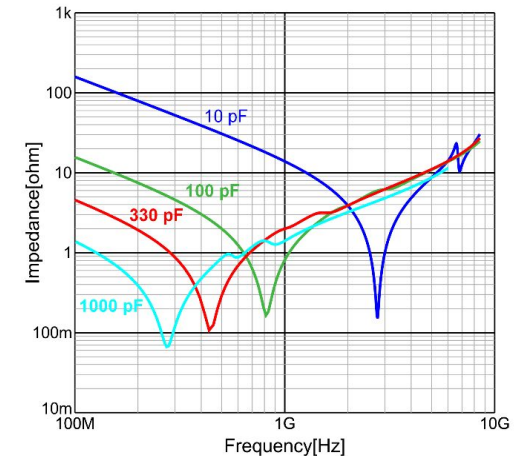
Image credit: Eric Schrader & Sierra Circuits

<https://www.protoexpress.com/blog/decoupling-capacitor-placement-guidelines-pcb-design/>



# Quick Note: Capacitors

- Capacitors are not ideal!
  - Equivalent Series Resistance (ESR)
  - Equivalent Series Inductance (ESL)
  - Equivalent Parallel Resistance (EPR)
- Due to ESL, capacitors can *self resonate*
  - Beyond the resonance frequency, capacitors will act like inductors!
- To maximize decoupling performance, *multiple capacitors of various values* are often connected in parallel
  - 100nF + 1uF + 10uF, for example
- If you're not too concerned about high frequencies on your board (~MHz), just use a single decoupling capacitor
- If very high frequencies are of concern (MHz-GHz), use multiple decoupling capacitors.



Legend for the graph above:  
[X] GJM1555C1H100GB01, |Z|, DC0V, 25degC (Blue)  
[X] GRM1555C1H101GA01, |Z|, DC0V, 25degC (Green)  
[X] GRM1555C1H331GA01, |Z|, DC0V, 25degC (Red)  
[X] GRM1555C1H102JA01, |Z|, DC0V, 25degC (Cyan)

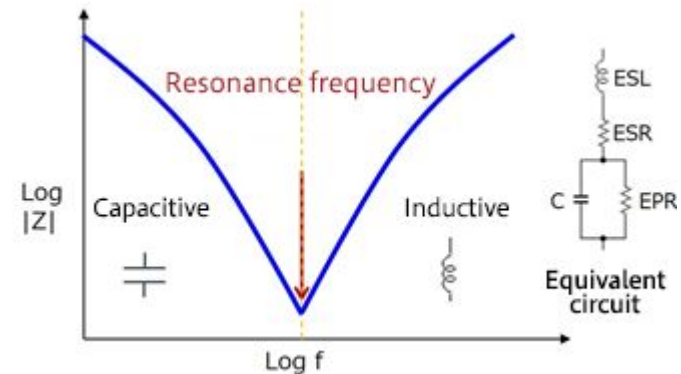


Image credit: Tech Web & Egor Gurov

<https://techweb.rohm.com/product/nowisee/7549/>

[https://www.researchgate.net/figure/Simple-ceramic-capacitor-model\\_fig2\\_335195168](https://www.researchgate.net/figure/Simple-ceramic-capacitor-model_fig2_335195168)





# Printed Circuit Boards (PCBs)

- Stack of conductive and nonconductive layers used to connect electrical components in a circuit
- Used in nearly all electronics
- Components are soldered to the PCB on one or both sides
- Cheap to produce and can be rapidly manufactured

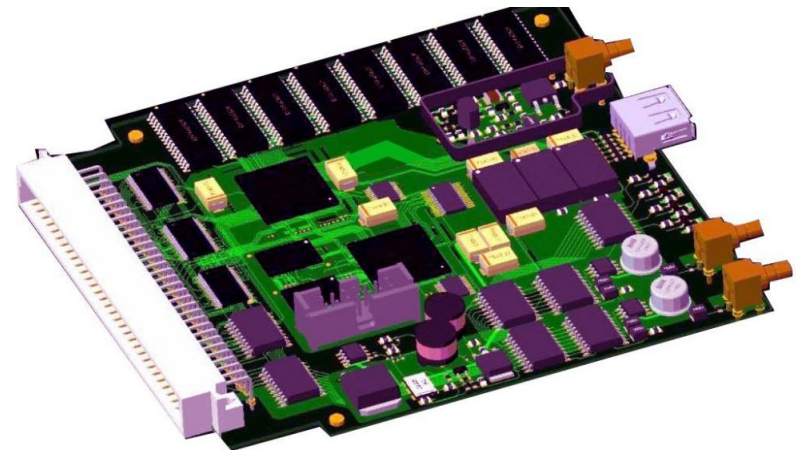
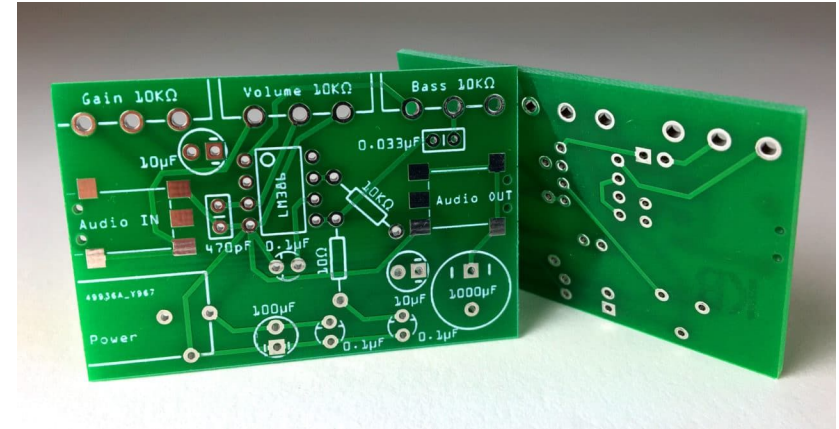


Image credit: Circuit basics & Sierra circuits

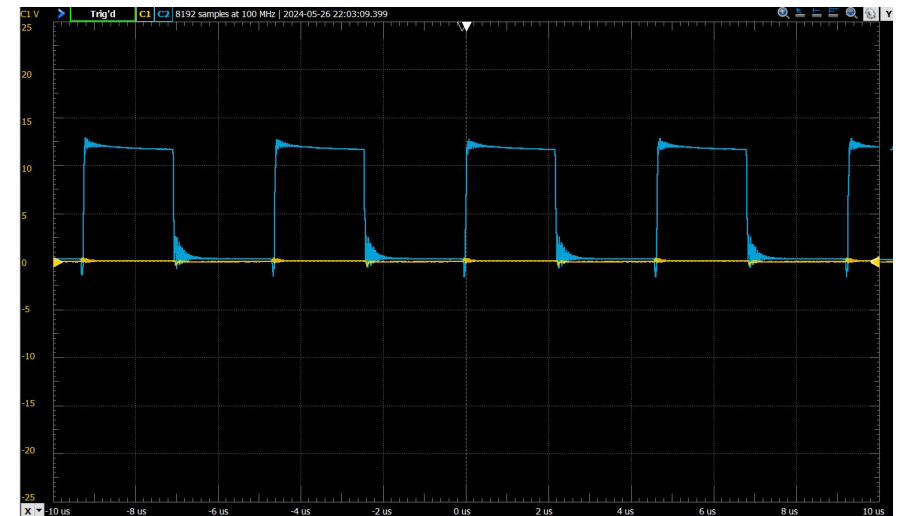
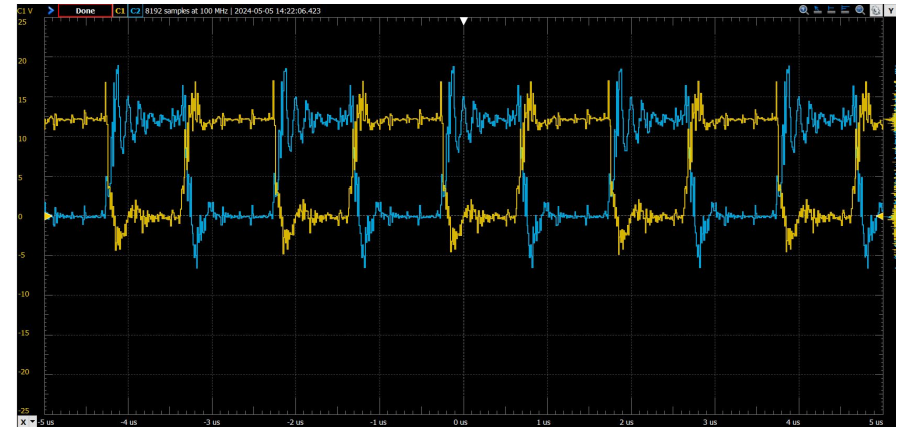
<https://www.circuitbasics.com/make-custom-pcb/>

<https://www.protoexpress.com/blog/10-best-pcb-layout-design-tools-recommended-by-pcb-designers/>



# Why use PCBs?

- PCBs are the industry standard for connecting electronics
- Superior performance when compared to perfboards or breadboards
- Easy to assemble
- Relatively cheap
- Durable
- Occupy minimal space





# PCB Composition

- PCBs consist of many layers
- The substrate provides mechanical support and structure. Typically made of FR-4 (flame-retardant fiberglass)
- Copper layers electrically connect components and provides cooling
- Solder masks shield and insulate the copper layer
- Silkscreens are used to print symbols/text on the board surface

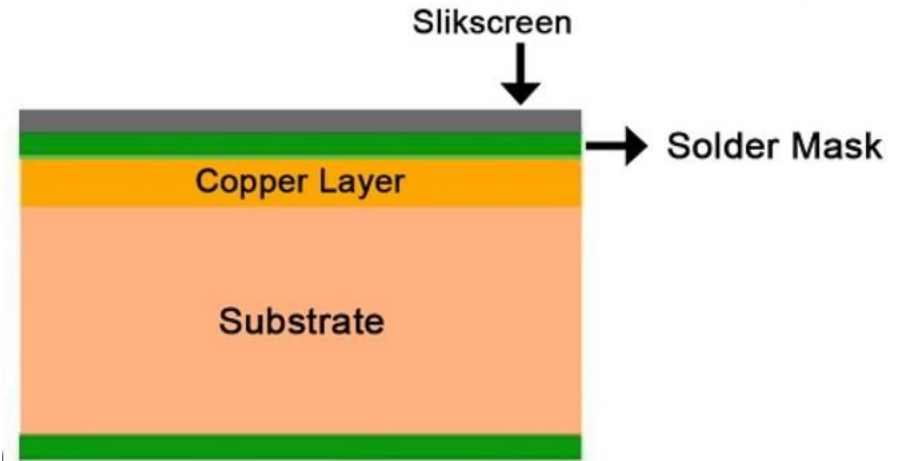


Image credit: Elecrow

<https://www.elecrow.com/all-about-multilayer-pcbs-you-should-know-printed-circuit-board>



# Pads, Traces, Vias, and Through-Holes

- Pads are used to solder components (holes in the solder mask)
- Traces electrically connect components
- Vias electrically connect different *layers*
- Through-holes pass through the entire board
- Plated through-holes (PTHs) are plated and non-plated through-holes (NPTHs) are not
- On two-layer boards, vias and PTHs are very similar, however vias are typically smaller and covered by the solder mask layer

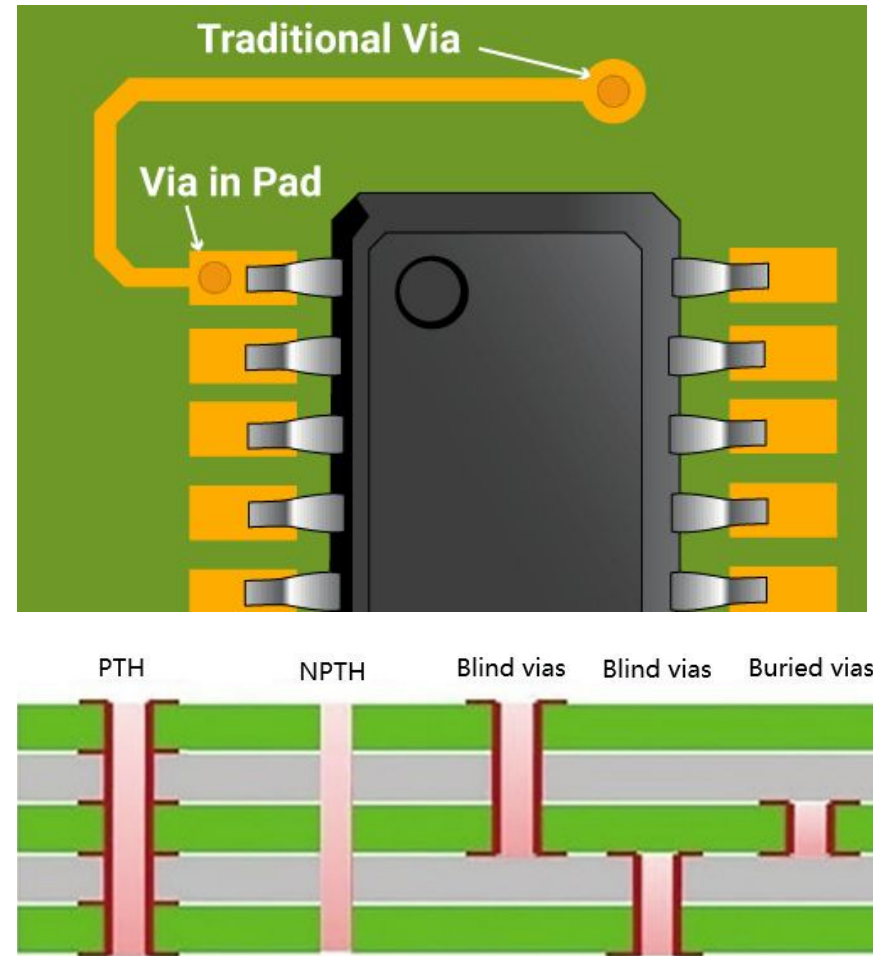


Image credit: Sierra Circuits & ankecircuit

<https://www.protoexpress.com/blog/what-is-pad-pcb-design-development/>

<https://www.ankecircuit.com/news/the-classification-and-function-of-holes-on-pcb/>



# Device Packages and Footprints

- ICs are housed in a “package”
- Packages can be surface mount or through-hole
- Each package has a unique footprint
- Footprints are the arrangement of pads/through-holes used to attach and electrically connect a component to a PCB
- The pattern of pads on the PCB matches the pattern of leads on the package
- Pin 1 is identified on the package with a dot, line, or beveled edge
- Pin 1 is identified on the footprint with a dot, line, or arrow

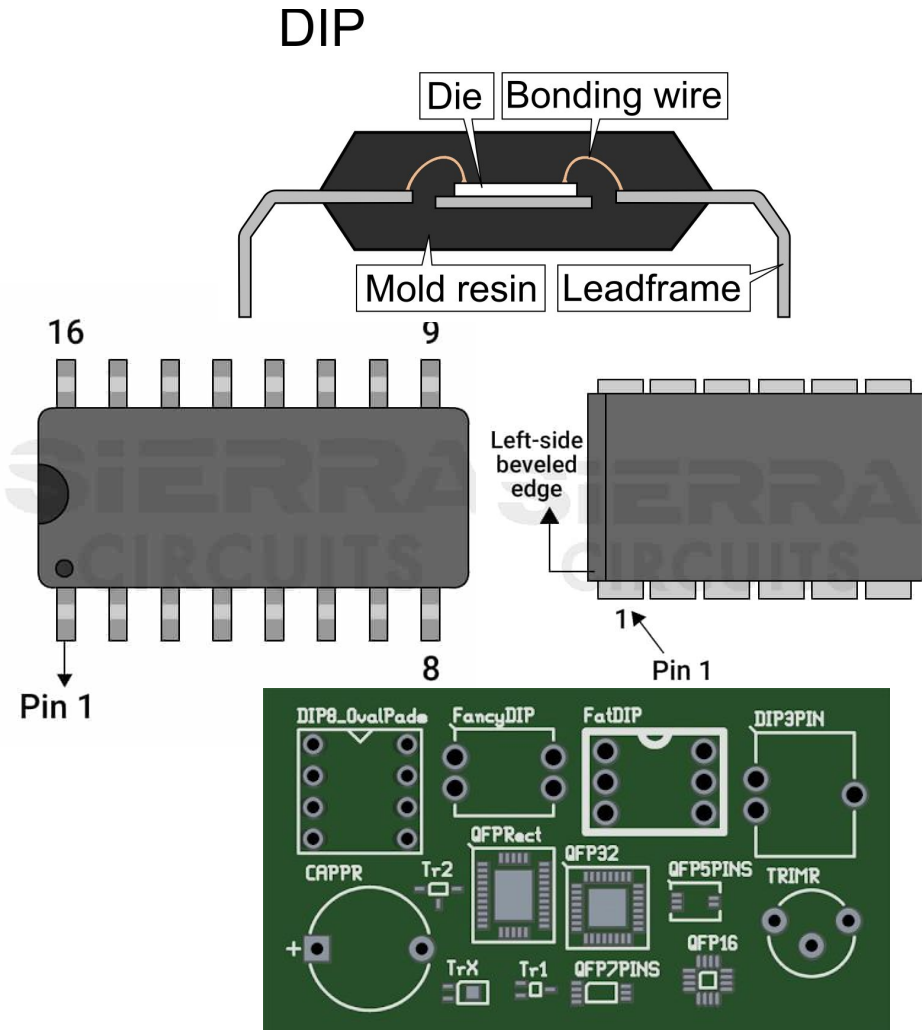


Image credit: Wikimedia commons, sierra circuits, & morepcb

[https://en.wikipedia.org/wiki/Integrated\\_circuit\\_packaging](https://en.wikipedia.org/wiki/Integrated_circuit_packaging)

<https://www.protoexpress.com/kb/how-to-add-and-identify-pin-1-marking-in-your-pcbs/>

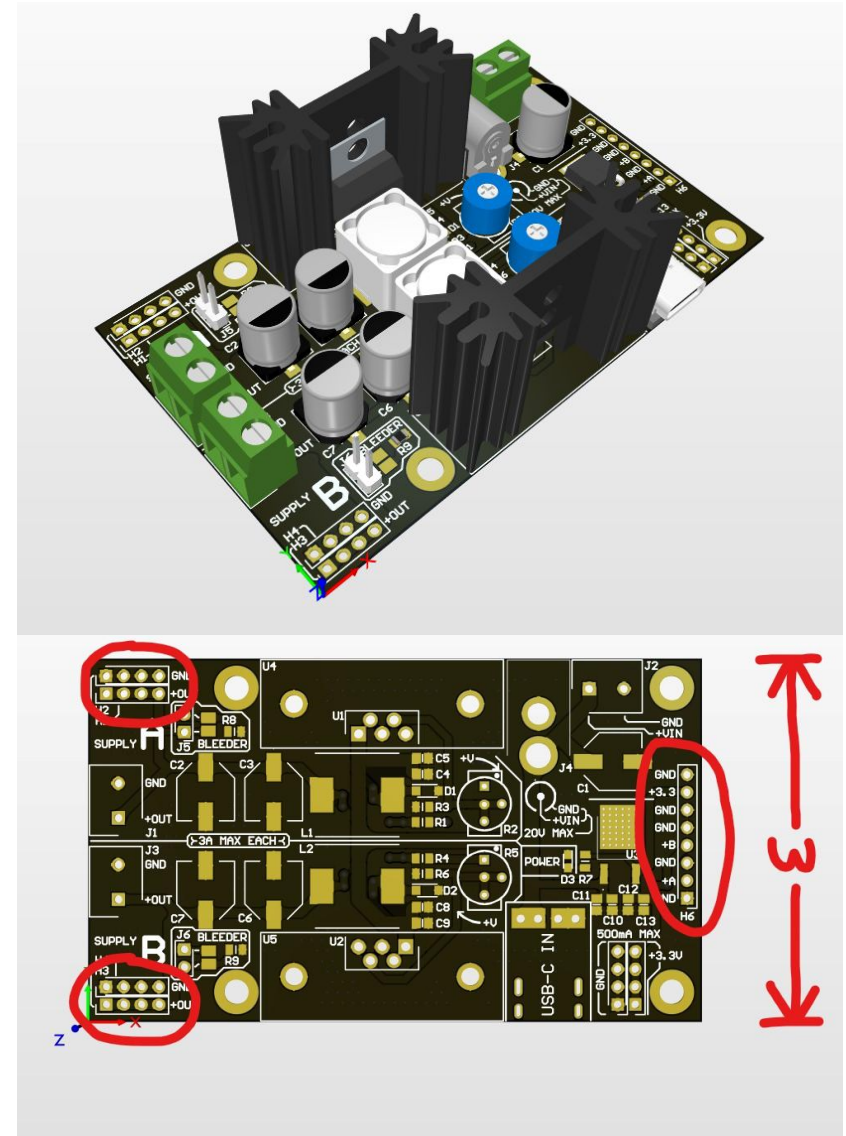
<https://morepcb.com/pcb-footprint/>





# Project Overview (Power Supply)

- Today we will begin work on the power supply PCB
- Please use the provided schematic to ensure functionality
- You are free to design the PCB however you like, although we **strongly** recommend using the same board width & header placements as the example board
- If you would like to add additional components (fuse, LEDs, additional headers, etc.) please talk to us
  - We likely cannot provide parts unique to your board





# Questions?



# Download Today's Project Files

- Navigate to the workshop GitHub and download today's files listed under **Week02**

**<https://github.com/AdrianSucahyo/IEEE-PCB-Workshop-Resources-2025>**