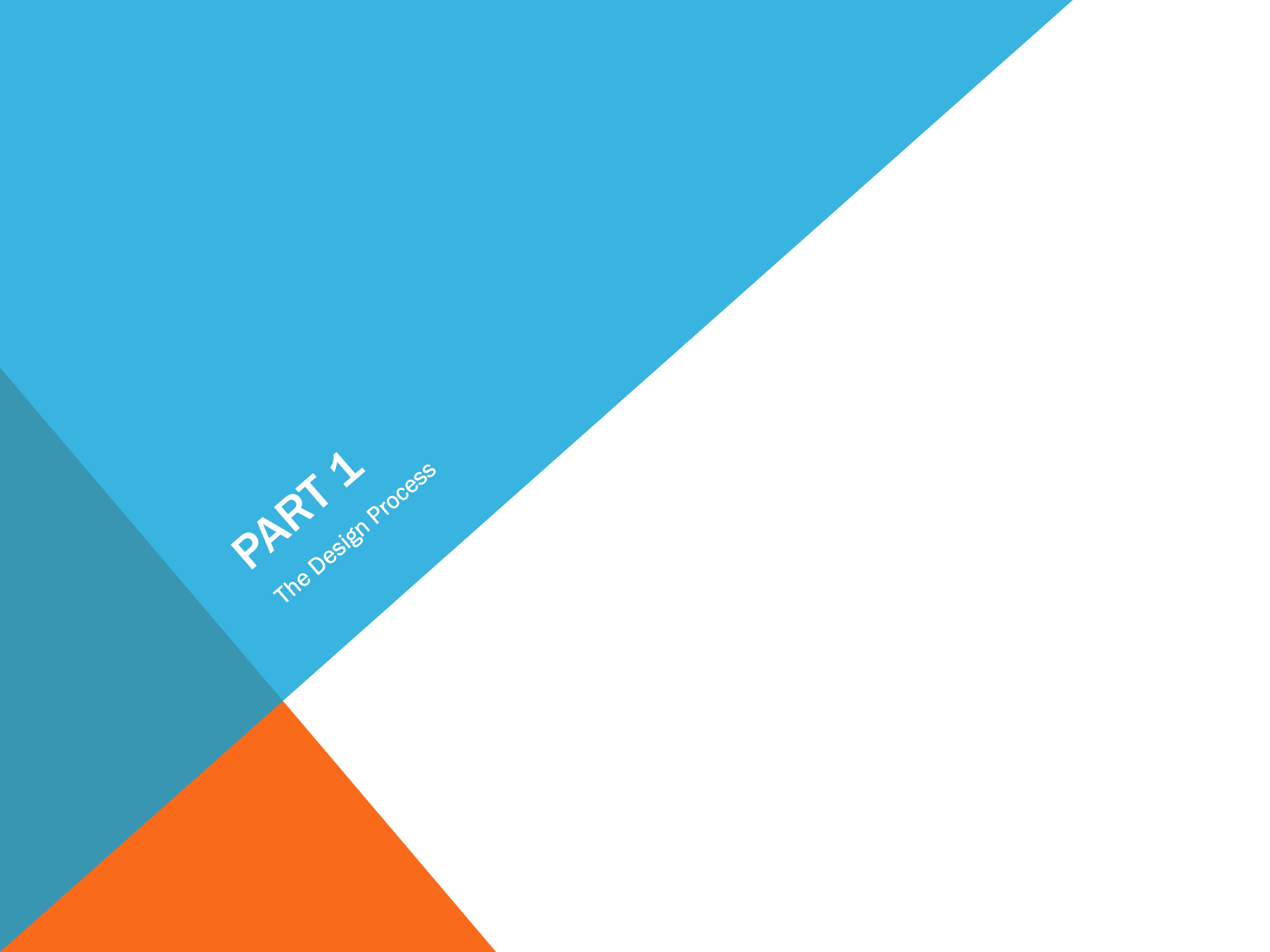


PCB DESIGN WORKSHOP

WEDNESDAY 15TH JUNE 2015
SYDNEY UNI MAKER CLUB
CALLA KLAFAS

TODAY'S TIMELINE

- Part 1: The Design Process
 - Finding a Design
 - Sourcing Components
 - Part 2: Schematic Design
 - Components
 - Placing Components
 - Part 3: PCB Layout Design
- 
- Decorative geometric shapes at the bottom of the slide, including an orange triangle on the left and a blue triangle on the right.



PART 1

The Design Process

SOFTWARE (EDA TOOLS)

Professional Leading

- Altium Designer (by Altium)
- OrCAD (by Cadence)

Maker Friendly – Free


- Eagle-CAD (by cadsoft)
 - Free with size and layer restrictions
- CircuitMaker (by Altium)
 - Came out in May '15. Derived from Altium. All projects are clouded and made open-hardware.



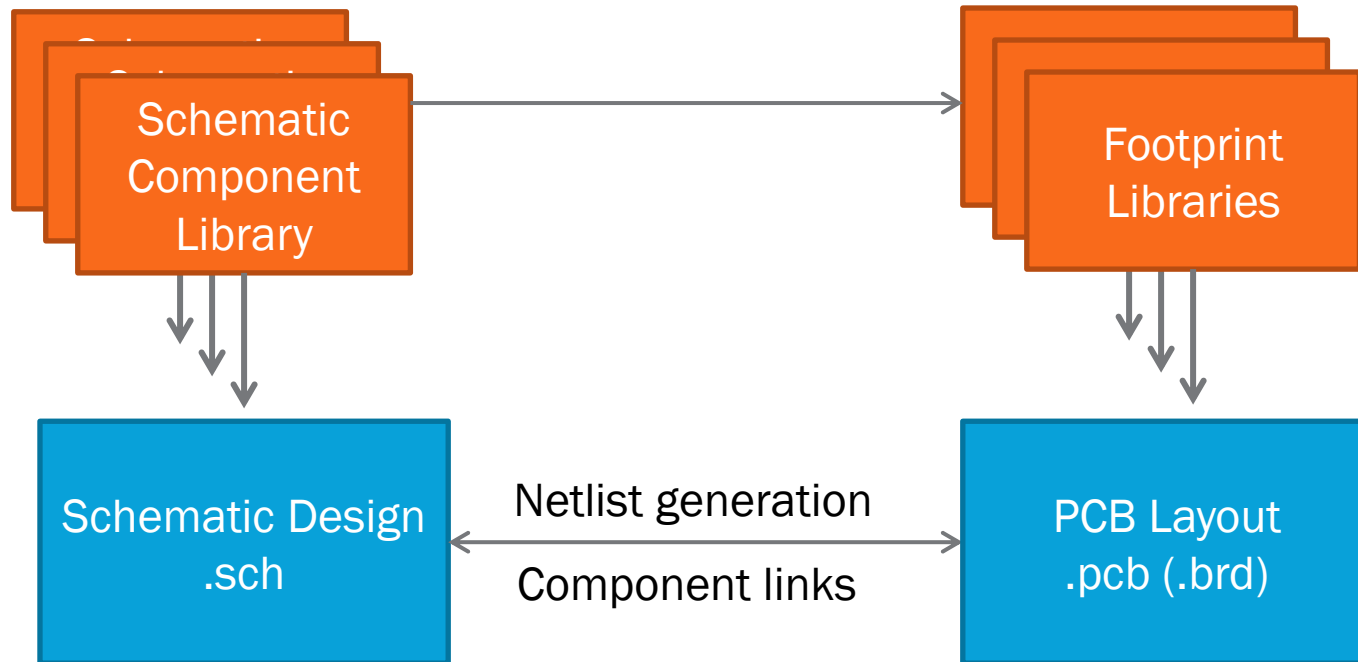
EAGLE
www.cadsoft.de



THE DESIGN PROCESS

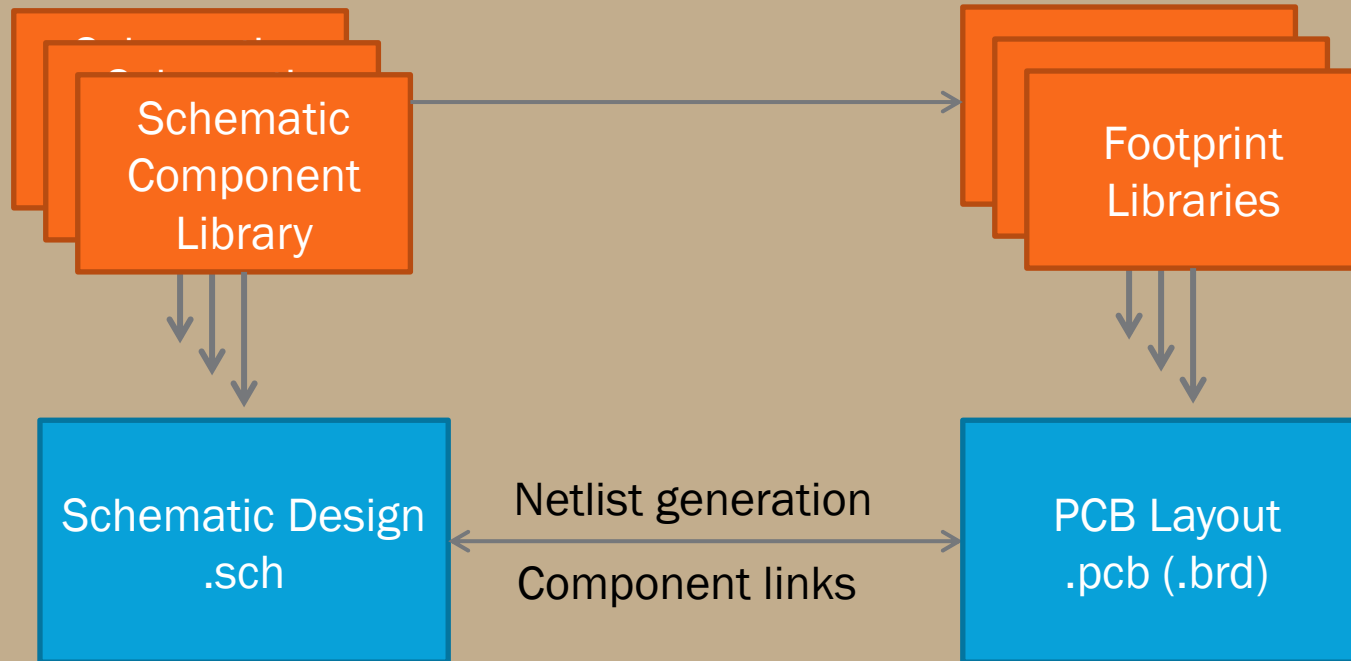
- 1) Research/design/draft a circuit you would like to build
 - 2) Source components
 - 3) Place components into schematic
 - 4) Check your manufacturer's specifications
 - 5) Set Design Rules
 - 6) Import components into PCB
 - 7) Route board
 - 8) Run Design Rule Check
- 

THE DESIGN PROCESS

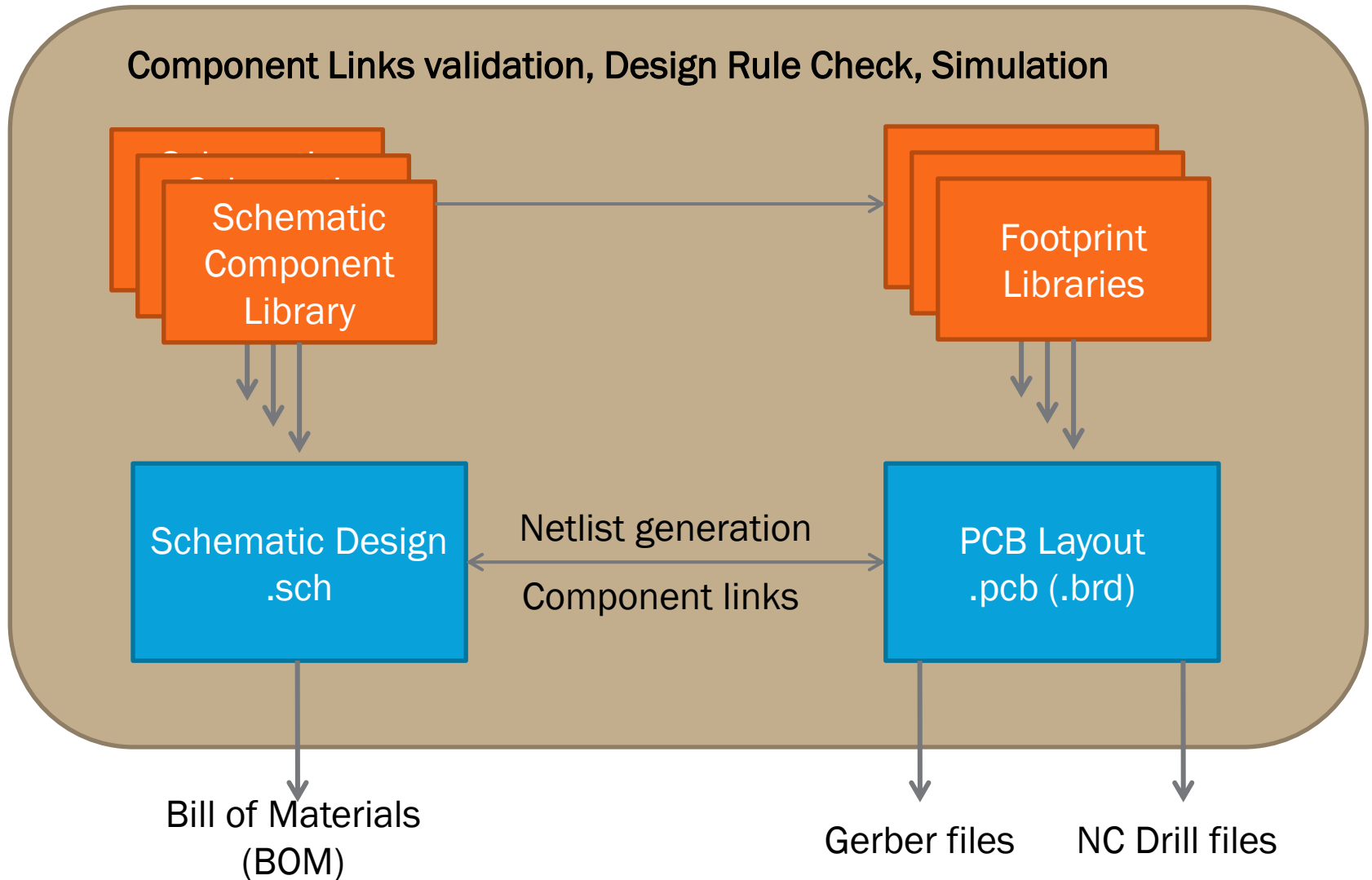


THE DESIGN PROCESS

Component Links validation, Design Rule Check, Simulation



THE DESIGN PROCESS



1. RESEARCH/DESIGN/DRAFT A CIRCUIT YOU WOULD LIKE TO BUILD

Open Source Hardware

- It has never been more easy to have access to many different design files and tutorials:
 - Adafruit
 - Sparkfun
 - SeeedStudio
 - Pololu
- Today we'll be taking an open source design by Limor Fried (Lady Ada from Adafruit)



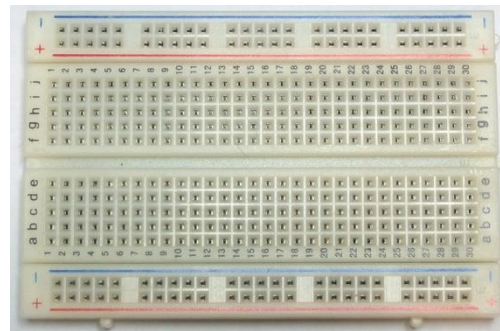
EXAMPLE: ADJUSTABLE BREADBOARD POWER SUPPLY

Why?

- Because we don't want to use one of these:

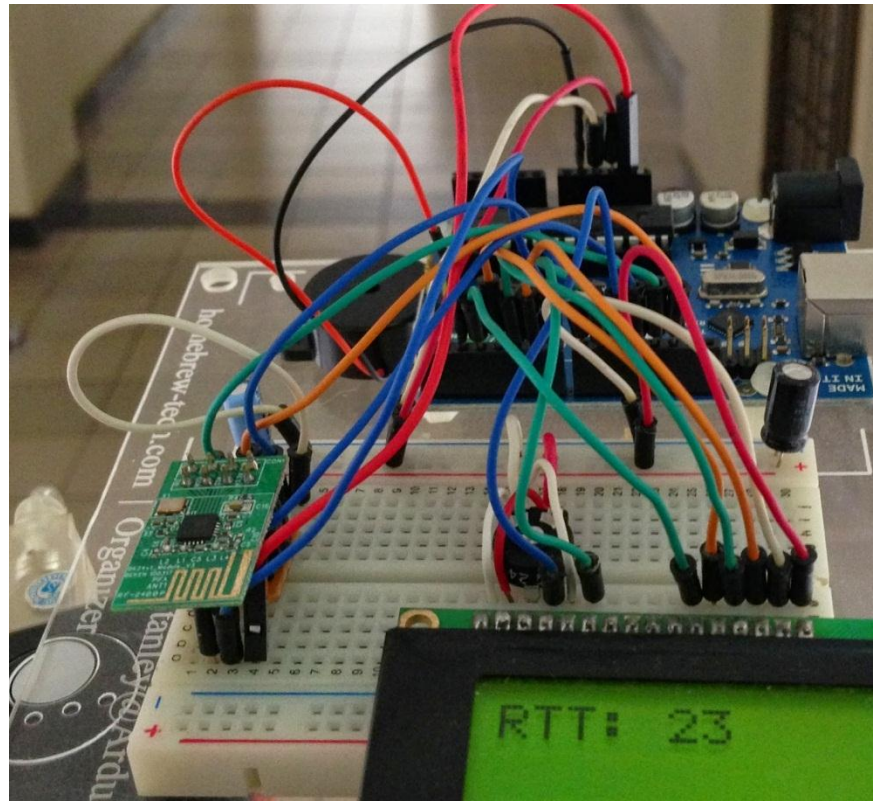


- Just to get a bit of power to this:



EXAMPLE: ADJUSTABLE BREADBOARD POWER SUPPLY

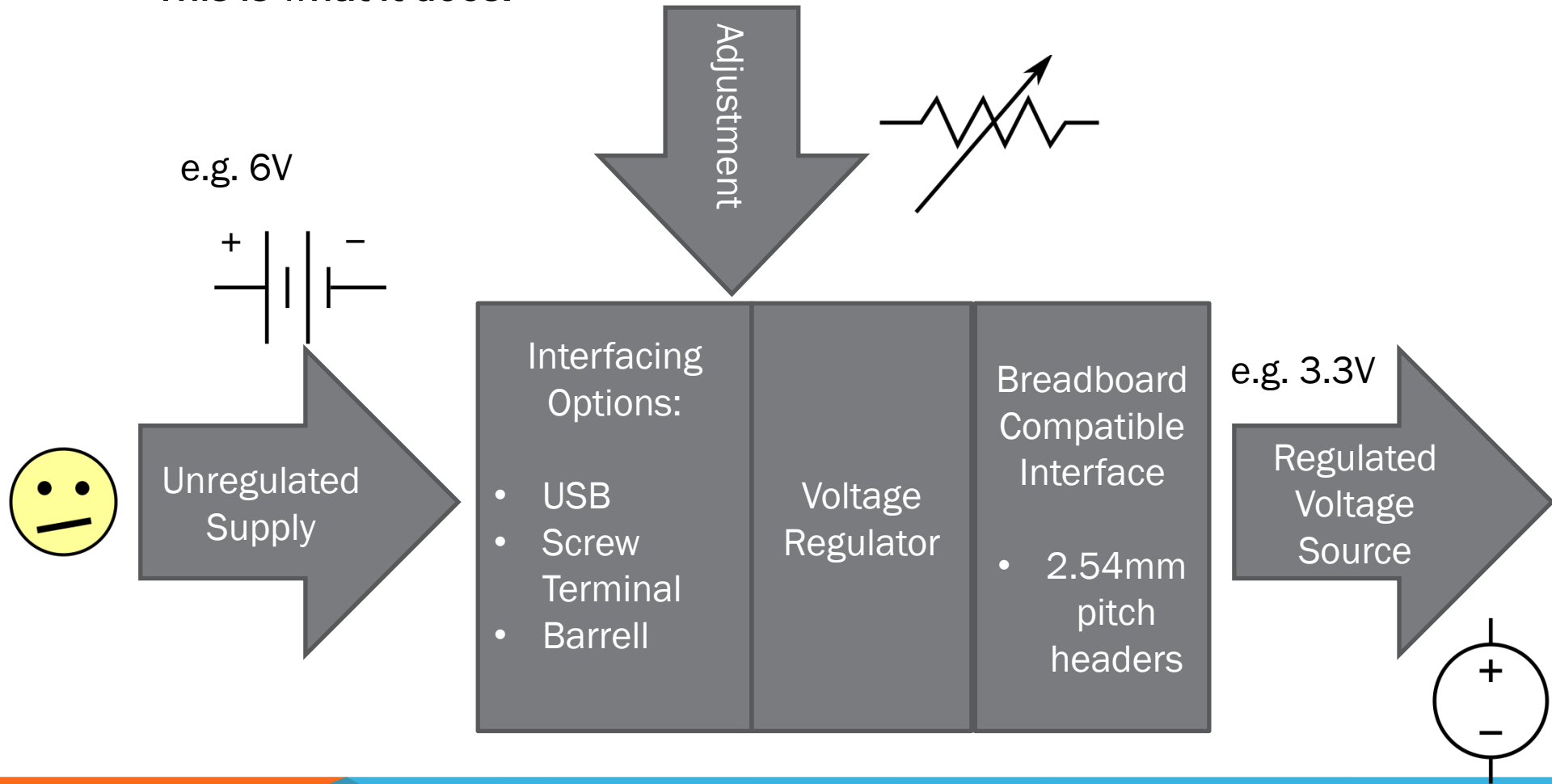
And sometimes your handy Arduino is engaged with another project..



FRAGILE

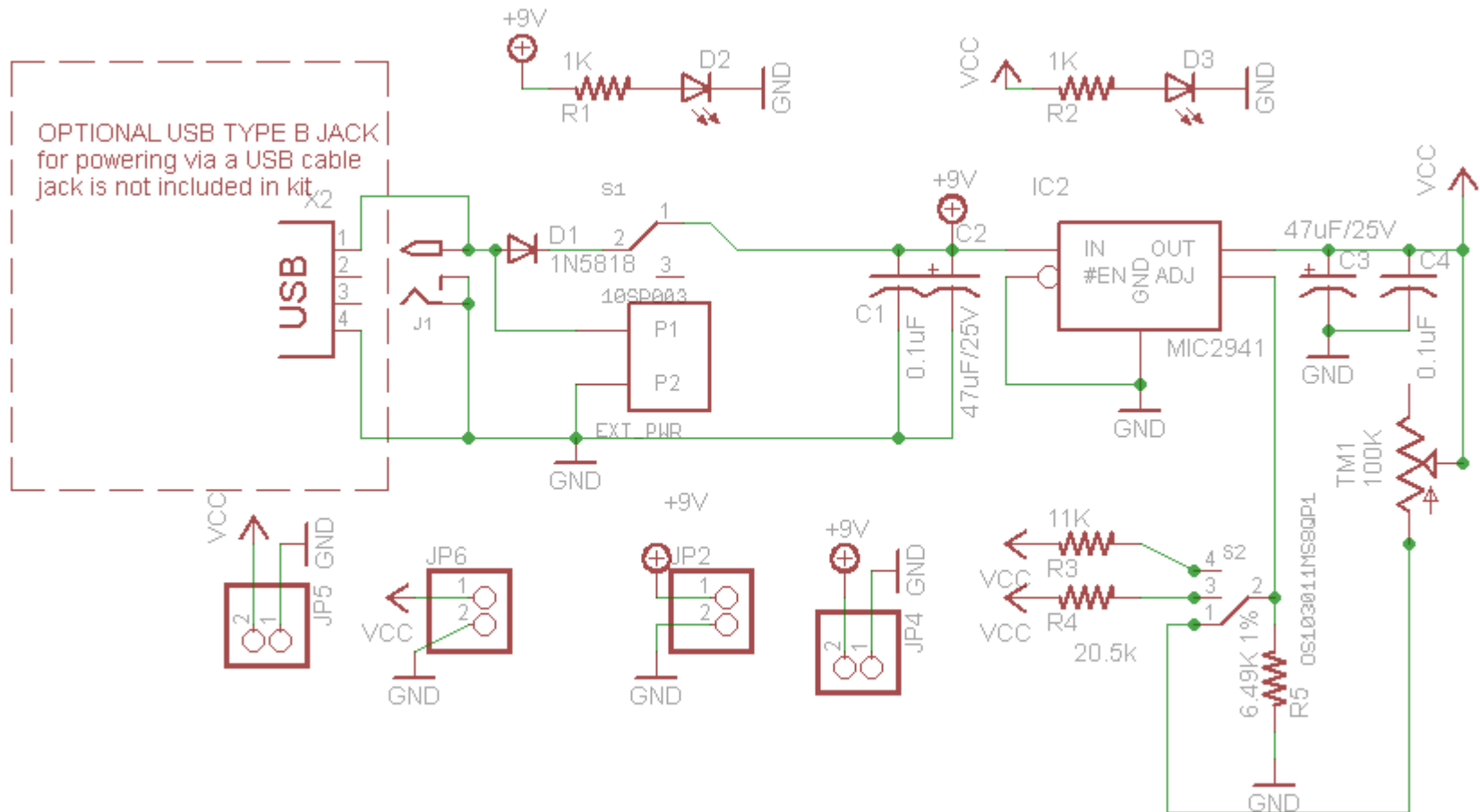
EXAMPLE: ADJUSTABLE BREADBOARD POWER SUPPLY

This is what it does:



EXAMPLE: ADJUSTABLE BREADBOARD POWER SUPPLY

We'll be using this as our reference:



2. SOURCE COMPONENTS

Mise en place approach:

- Collect all your component **datasheets** in one folder. (these are your maps if you get lost!)
- Find out who stocks your component, or otherwise whether there are similar alternatives **in stock**
- Many components come with a few **packaging** options. You'll need to decide which suite your needs.



2. SOURCE COMPONENTS

Datasheets


- Priceless information (google model numbers)



Paul Horowitz's databook collection

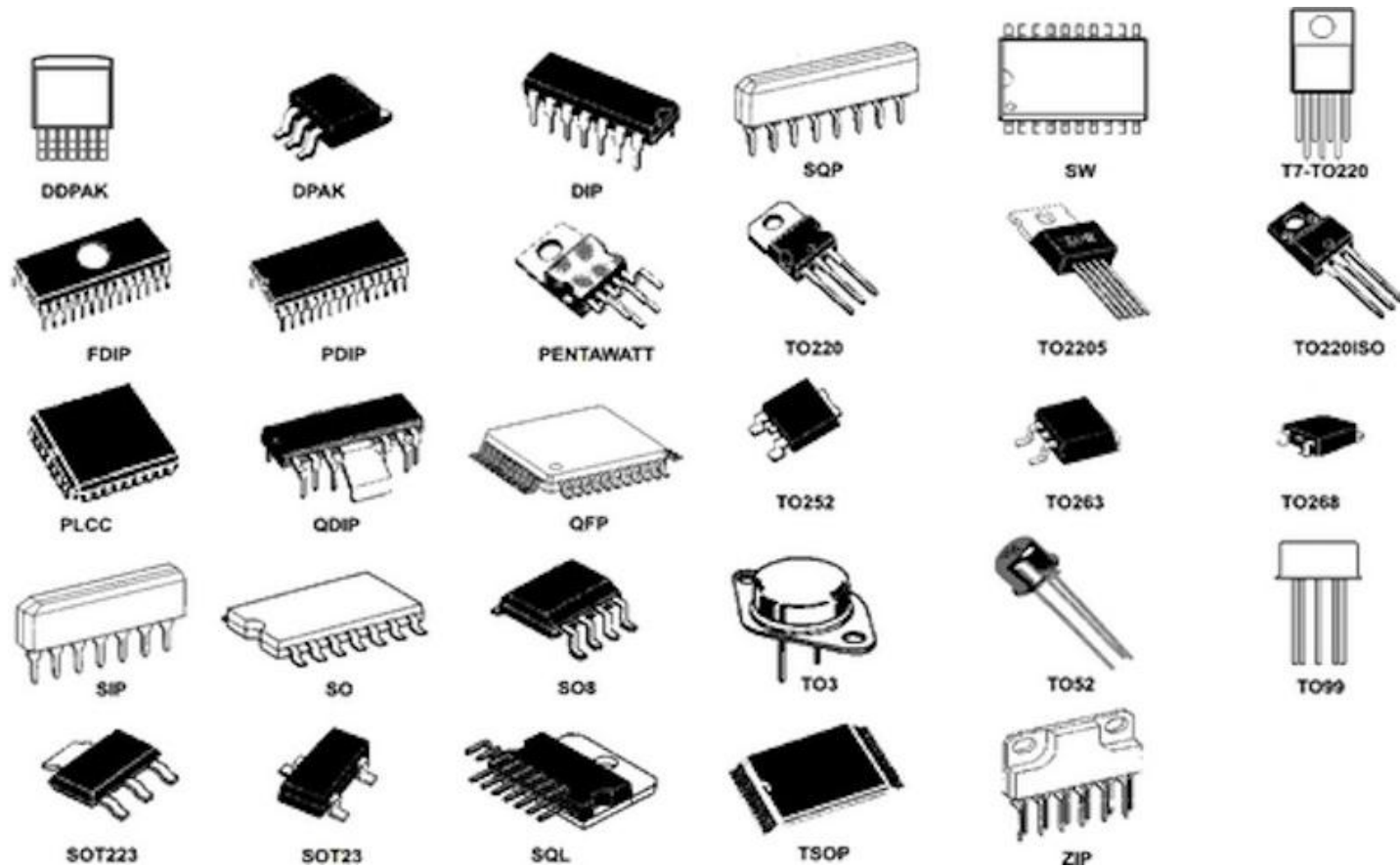
2. SOURCE COMPONENTS

Supplier catalogues:

- Element14
 - RS Components
 - DigiKey
 - Mouser
- 
- Ask our uni on how to get academic discounts. Student discounts are available as well.
- eBay : affordable Chinese grey market, susceptible to counterfeit chips
 - Sometimes Adafruit and Sparkfun have sourced some unique components and products that are exclusive.
 - Catalogue reading helps you learn a great skill at interpreting specifications, and filtering out important details

2. SOURCE COMPONENTS

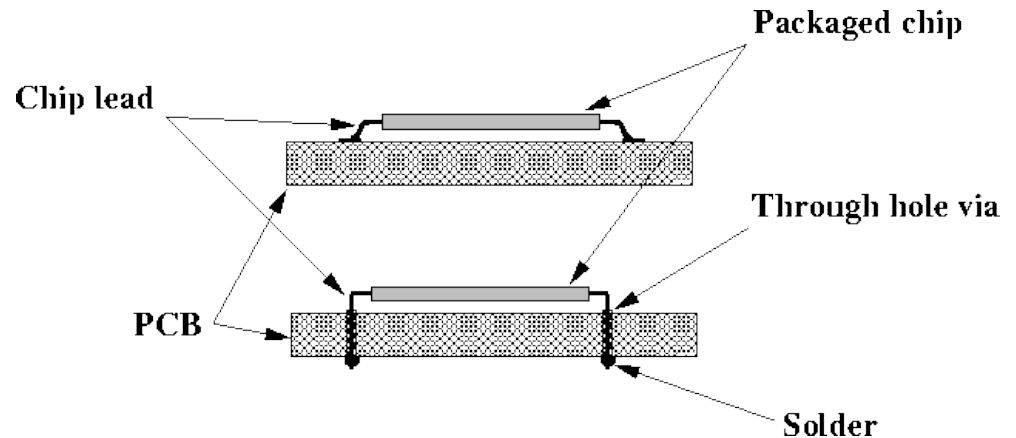
Which packaging?



2. SOURCE COMPONENTS

Which packaging?

- What can you solder?
 - Through-hole
 - Surface mount
- How small do you want your circuit?
- How hot will your component get?
 - Certain cases provide thermal relief
- How many of PCBs do you want made?
 - Pick and place machines make SMD faster



2. SOURCE COMPONENTS

Online component databases and libraries

- A recent progression
- Most EDA software have a online portal to component databases with live stock information from popular suppliers.
- Seeedstudio have a similar service



3. PLACE YOUR COMPONENTS INTO A SCHEMATIC

1. Open up a new Project
2. Open a new schematic
3. Save these files into your desired folder
4. Get familiar with you workspace:
 - Handy workspace panels:
 - Project
 - Inspector ← very useful
 - List
5. Learn some shortcuts so you looks like a LoL or Dota gamer

3. PLACE YOUR COMPONENTS INTO A SCHEMATIC

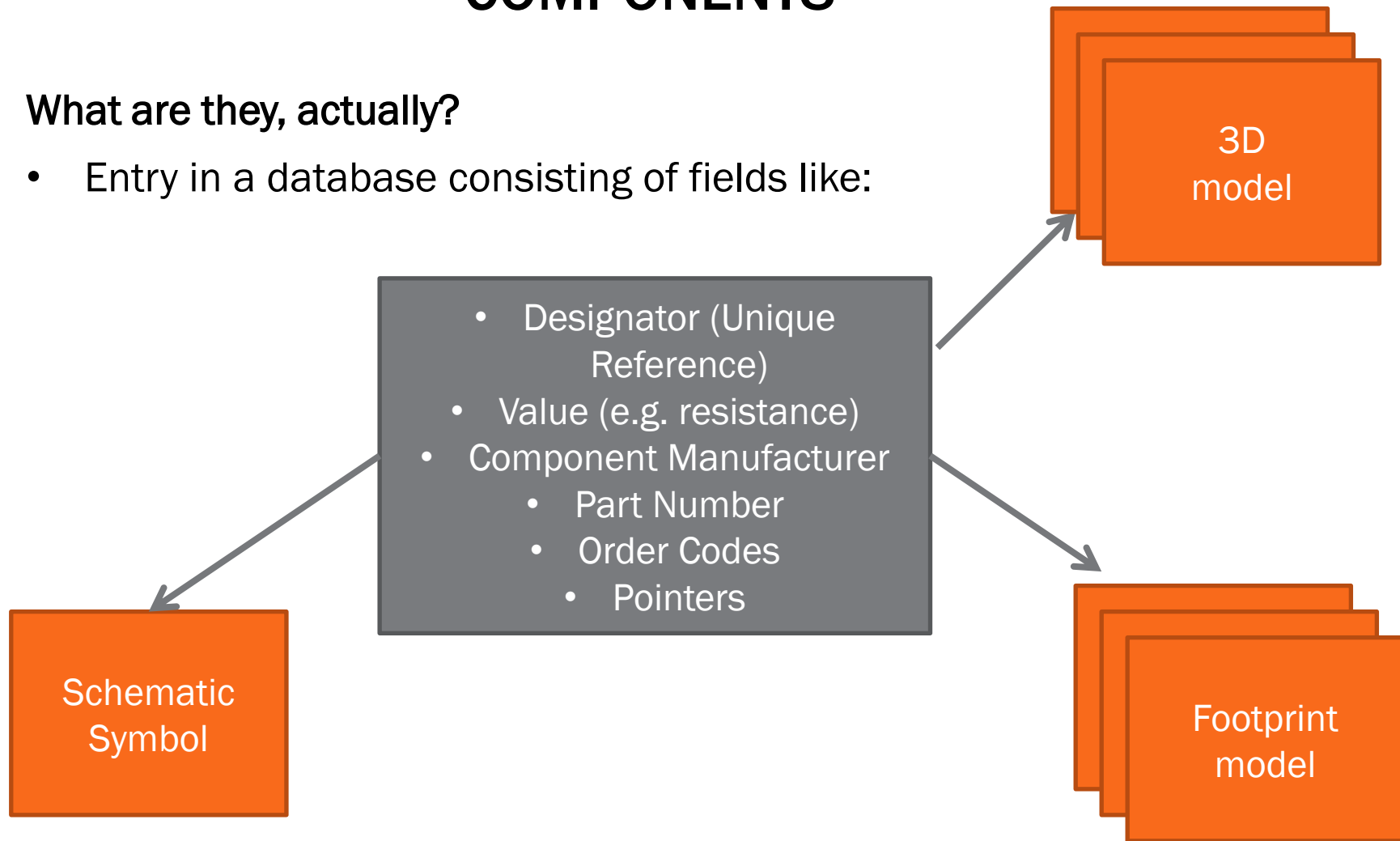
P	Place	
P, P	Place	Part
P, W	Place	Wire
P, N	Place	Net Label
P, T	Place	Text
Spacebar	Rotate 90 deg while moving object	
X or Y	Flip horizontally, vertically	

<http://www.altium.com/files/learningguides/gu0104%20shortcut%20keys.pdf>

COMPONENTS

What are they, actually?

- Entry in a database consisting of fields like:





PART 3

PCB Layout

UNITS

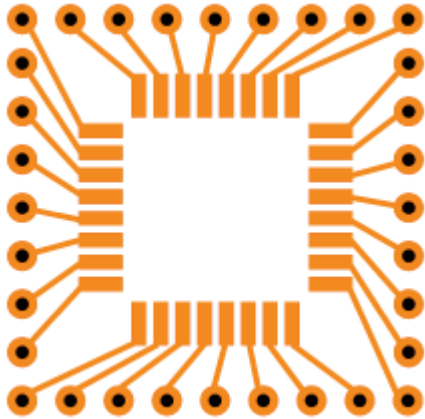
USA origins:

- 1 mil (pronounces “thou”) = 0.001 inch, = 0.0254mm
- oz

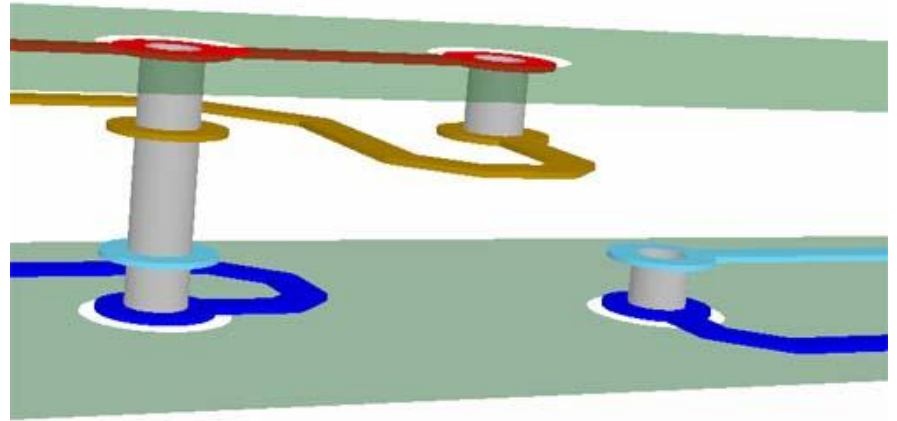
In Altium or Circuitmaker, press Q to switch between mil and mm.

PADS AND VIAS

PADS



VIAS

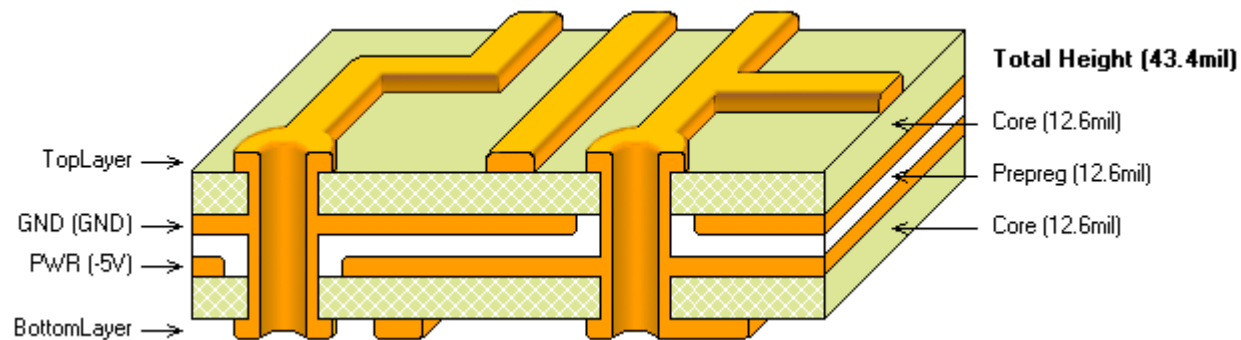


LAYERS AND STACKING

CAD Layer (conductive and nonconductive)

CAD Layer description

1	Top silkscreen/overlay (nonconductive)
2	Top soldermask (nonconductive) (inverted)
3	Top paste mask (nonconductive)
4	Layer 1 (conductive)
5	Sustrate (nonconductive)
6	Layer 2 (conductive)
...	...
n-1	Sustrate (nonconductive)
n	Layer n (conductive)
n+1	Bottom paste mask (nonconductive)
n+2	Bottom solder mask (nonconductive)(inverted)
n+3	Bottom silkscreen/overlay (nonconductive)

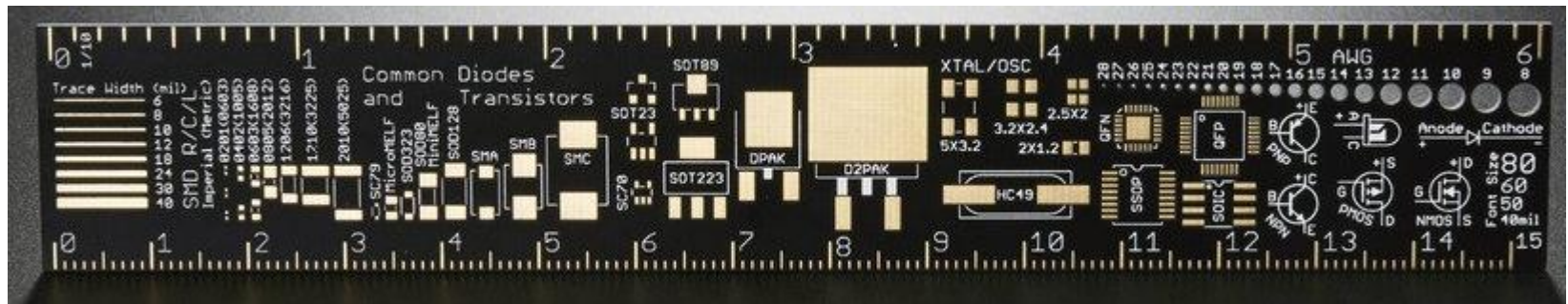


MECHANICAL & KEEP OUT LAYERS

- These layers are auxillary
- Sometimes mechanical layers can be used to indicate:
 - Outlines
 - Dimensions
 - Sections
 - area of custom components etc.
 - Keep out areas

RESEARCH YOUR MANUFACTURER

- Manufacturers will list their limitations on their website.
- It helps to check these and add them to your Design Rules
- What's the minimum trace width
- What's the copper thickness
- What's the minimum silk screen width
- Get to know what values are practical or ridiculous



<https://www.adafruit.com/products/1554>

TIPS

- Keep all signal traces the same size
- If using high power – thicker traces for lower resistance.
- Try to have top and bottom traces run orthogonal to avoid cross-talk.
- AVOID as many vias – expensive and cause inductances
- Auto-route ain't cool
- Typical through-hole header spacing (and breadboards) are 2.54mm pitch (or 100mil)
- Rooms can be annoying. You can remove these first.
- Avoid right angles when routing (45 degrees!)

HOTKEYS - PCB

Shift + S	Hightlights current layer
S, Y	<u>S</u> elects all objects on the current la <u>Y</u> er
P, T	<u>P</u> lace Interactive Rou <u>T</u> ing or (Trace)
+ or -	While in interactive routing to trace through layers
Shift + Space	Different routing angles (stick to 45 deg)
A, ...	Align components
V, F	View, Fit to window
Ctrl + M	Measure
R, P	Measure primitives
P, D	Place Dimension
Ctrl + Click	Find all with the same Net Name

<http://techdocs.altium.com/display/ADRR/PCB+Editor+Shortcuts>

IMPORT FROM SCHEMATIC TO PCB DESIGN

In the schematic window

Design > Update PCB

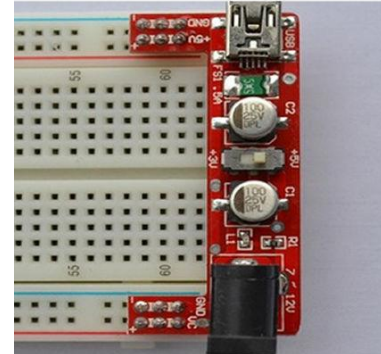
Select, Validate, Execute (this is where you could leave out rooms)

If you want to add/delete components:

Go back to your schematic, make the changes and Update PCB.



GETTING THE RIGHT FORM FACTOR



GETTING THE RIGHT FORM FACTOR

- Create a closed line shape on a spare Mechanical layer
- Select All on the layer (S, Y)
- Then define board shape from selection (D,S,D)
- Ways to setup precise measurements.
- Set the origin (E,O), and calculate precise coordinates
- Use the inspector to write coordinates.
- Measure centre distances between components, Ctrl+M
- Measure smallest distances between components (measure *primitives*) (R, P)

EXPORTING YOUR FILES

Run Design Rule Check (DRC) to check for any errors:

e.g. Overlapping components, Silk screen overlap with pads,
trace width too small.

Export Gerber Files

Select which layers to pick,

Export NC Drill files

A text file to tell where to drill holes.

Sometimes manufacturers will accept the original Altium project file,
especially if it is a prototyping shared panel service.



PLACES TO GET YOUR PCB (SHORT REVIEW)

- **Breadboard Killer:** www.breadboardkiller.com
 - Cheapest. Lead Time 8-12 business days.
- **PCB Zone:** www.pcbzone.net
 - Fastest. A quick as 1 day fabrication. Up to 5 working days.
Boutique in NZ.
- **PCB cart:** www.pcbcart.com
 - Longest: cost effective for large quantities. Also do assembly run. Quality may be of compromise
- **Entech:** www.entechelectronics.com.au
 - Best professional quality. Good for commercial production.
Certified for various production standards. Also do assembly.

WHAT WE DIDN'T GET TO COVER

- How PCBs are manufactured
- Test points
- Fiducials
- Bypass capacitors
- Power planes
- How to make more than 2-layer PCBs
- Making your own footprints and component libraries
- Making your own parts
- How to prepare your own panel



WHAT NEXT?

- If you are an owner Altium, or would like to have a students license (~130AUD), you can save your project and continue learning how to make some of the topics covered previously.
- If you want to make PCBs, and don't mind publishing your circuits open source, download circuitmaker @ circuitmaker.com. The environment is very similar. Some shortcuts may be missing, but all capabilities mentioned are available.