Lecture 14:
Prototyping and Schematics
Breadboards have some limitations

- They have high parasitic inductance and capacitance, limiting high frequency signal transfer to about 50MHz.
- Wire connections aren’t exactly stable.
- Best for through hole parts.
- Maximum ratings in terms of current and voltage...can vary from board to board.

- That being said...you can create relatively complicated designs on a breadboard...they just become...unwieldy.
What will we cover today...

• There are “experts” throughout the room.
• Goal is to introduce everyone to Eagle
• Making a new part
• Creating a schematic
• Creating board files
• Exporting for printing (?)
• Tips

• Most of the slides based on the ECE445 tutorial.
Portable qPCR Machine
What is next?

• Assemble the PCB
• Program the microcontroller
• Test our setup
• Improve our setup
  • Use accurate lasers
  • Optional portability
  • Make a housing
Creating a new part...

- Using EAGLE 7.7
- You will need the data sheet.
- Find physical dimensions.

- EAGLE -> File -> New
- Create new library
- Save library

- Have to create three aspects of the part
  1. Device
  2. Symbol
  3. Package

Creating the symbol

- Edit symbol

- Add pins

https://www.youtube.com/watch?v=U36_et5Unxl
• Add an outline ‘Esc’ key to end

If you need to delete lines, use trash button.

• Name the pins

• From the data sheet

https://www.youtube.com/watch?v=U36_et5Unxl
• Add labels

• Make sure to add to the proper layer
• Name on names layer, value on values layer

More on layers:
Creating the package

- Select package

https://www.youtube.com/watch?v=U36_et5UnxI

- Note the grid
TPS799
Plastic Small Outline

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO-193 variation AB (5 pin).
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
• Add pads
• Use the “i” tool to adjust position.

https://www.youtube.com/watch?v=U36_et5UnxI
• Use the “i” tool to adjust position.

https://www.youtube.com/watch?v=U36_et5UnxI
• Add outline.

• Name pins.

https://www.youtube.com/watch?v=U36_et5UnxI
• Add outline.

• Name pins.
Create device

- Device
- Add symbol
- Package
Create device

- Connect
- Save
- Go to control panel to activate part
Actual circuit

Add all of your parts

RCL Library has many standard caps, etc.

- ptc-ntc  PTC and NTC Resistors
- quantum-... QUANTUM RESEARCH GROUP
- rcl  Resistors, Capacitors, Inductors
- recom-int... RECOM POWER SOLUTIONS
- rectifier  Rectifiers
- relay  Relays
Actual circuit

Unbelievable number of resistors
Actual circuit

Add ground
Actual circuit

Use wire tool to connect everything
Actual circuit

Switch to board
Actual circuit

Use move tool to move parts and to reduce board size.

Change gril to mil
Actual circuit

Use wire tool to connect.

Check wire width.

Put on the proper layer.

Rats nest to check...
Actual circuit

Vias
Actual circuit

Add ground plane
Name it ground
Use rats nest
Export to Gerber

https://www.youtube.com/watch?v=B_SbQeF83XU
Tips from Danny

* Extending pads, 0.5mm surface mount
* Put components on one side of the board
* Trace length, shorter for high speed
* For high speed, length must be the same
* For manufacturing, put components perpendicular
* Don’t use BGA (very hard) or LGA (really very hard) packages
* Outline helps with non-native packages, allows you to center pins
* Rats nest will fill in all of the polygons
* Airwire, missing trace
* Manufactures will have a page on capabilities, that will tell you how to program your DRC
* Make sure your ground planes are connected
* 4-layer makes life easier, stack (top to bottom) RF and signal/GND/pos supply/signals...$50 vs $5
* Might be something stupid, and copper is really touching, but worth correcting
* Passing DRC is a good way to sanity check your board
* To see them better, turn off all layers, except unrouted
* Labeling, makes your life easier, can be critical for assembling house
* Test points on every crucial signal, right in the middle, EAGLE test point library
Tips from Danny

* there are two packages for each part
* one for hand soldering (bigger), one for machine soldering (smaller)...can cause parts to “tombstone” if you use hand soldering for machine soldering
* build a board in modules
* many students will just try laying things out...modular makes less overwhelming

* trace spacing covered by DRC, 6mil at least
* high speed signals should have uncut ground planes underneath them (100s MHZ)
  - digital signals can have return current issues
  - analog is sensitive....keep away from high speed switching and power supplies....put analog off on its own.
* should you isolate analog and digital ground planes...probably not, causes more problems than it solves
* for parts that have ground on bottom for heat, via in and pads underneath components
* understand where current is going for switching power supplies, buck converters create two current loops, make sure they are small....Google, Buck converter current loops